COMPETENCY BASED EDUCATION

KENYA CERTIFICATE OF BASIC EDUCATION
SENIOR SCHOOL CURRICULUM

GRADE 11 BUILDING CONSTRUCTION NOTES



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STRAND 1.0: FOUNDATION OF BUILDING CONSTRUCTION

SUB-STRAND 1.1: CONSTRUCTION HAND POWER TOOLS

INTRODUCTION TO THE SUB-STRAND

Building construction involves several activities that require the use of specialised tools and equipment. These activities include drilling holes, grinding surfaces, driving screws, fixing nails, cutting construction materials, riveting metal components and breaking hard materials.

Traditionally, most construction operations were performed using manually operated tools. Technological developments have introduced powered hand tools that make construction work faster, easier, more accurate and more efficient.

In modern building construction workshops and construction sites in Kenya, powered hand tools are used by carpenters, masons, metal fabricators, plumbers, electricians, roofers and other construction workers.

These tools are particularly important when working with:

- Timber and timber-based products.
- Steel and other metals.
- Concrete and masonry.
- Aluminium and metal sheets.
- Plastics and plastic pipes.
- Tiles and other finishing materials.

Learning outcomes

By the end of this sub-strand, the learner should be able to:

1. Identify different construction hand power tools used in building construction.
2. Explain the functions and applications of various hand power tools.
3. Identify the main components of different construction hand power tools.
4. Describe the operations performed using powered hand tools.
5. Demonstrate appropriate care and maintenance of hand power tools.
6. Apply occupational health and safety precautions when handling powered hand tools.
7. Select appropriate hand power tools for specific construction operations.

1.1.1 CONSTRUCTION HAND POWER TOOLS

1. Meaning of construction hand power tools

Construction hand power tools are portable mechanical tools operated by hand and powered by electricity, rechargeable batteries, compressed air or other energy sources to perform specific construction activities.

They are designed to make work easier, reduce physical effort, improve accuracy and increase productivity during construction operations.

Unlike ordinary manual hand tools, powered hand tools use an energy source to produce mechanical movement such as rotation, vibration, reciprocating movement or impact.

Examples of construction hand power tools include:

1. Electric drills.
2. Angle grinders.
3. Power screwdrivers.
4. Nail guns.
5. Pneumatic hammers.
6. Rivet drivers.
7. Handheld power cutters.

2. Sources of power used to operate hand power tools

Construction hand power tools obtain their operating energy from different sources.

A. Electrical power

These tools use electrical energy supplied through an electrical cable connected to a power socket or suitable electrical supply.

Examples:

- Corded electric drills.
- Electric angle grinders.
- Corded circular saws.
- Electric screwdrivers.

B. Battery power

These tools use rechargeable batteries to supply electrical energy to an electric motor.

Examples:

- Cordless drills.
- Cordless impact drivers.
- Cordless nail guns.
- Cordless rivet drivers.

Advantages of battery-powered tools:

1. They are portable.
2. They do not require a direct electrical cable connection during operation.
3. They are convenient in areas without nearby electrical sockets.
4. They reduce cable-related tripping hazards.
5. They are suitable for many outdoor construction activities.

C. Compressed air

These tools use pressurised air supplied through a hose connected to an air compressor.

Examples:

- Pneumatic nail guns.
- Pneumatic hammers.
- Pneumatic rivet drivers.

Advantages of pneumatic tools:

1. They are suitable for repetitive operations.
2. Some models are relatively lightweight.
3. They provide consistent operating power when supplied with the correct air pressure.
4. They are useful in construction workshops and fabrication activities.

D. Fuel-powered energy

Some specialised portable cutting equipment uses petrol or other fuels to operate an internal combustion engine.

Examples:

- Petrol-powered concrete cutters.
- Portable petrol-powered masonry saws.

These tools are commonly used where high cutting power and mobility are required.

3. Characteristics of construction hand power tools

Construction hand power tools have the following characteristics:

1. **Portability:** Most are designed to be carried and operated by one person.

2. **Power-driven operation:** They use electricity, batteries, compressed air or fuel to perform their functions.

3. **Specific applications:** Each tool is designed for particular operations, such as drilling, grinding, cutting or fastening.

4. **Mechanical movement:** They contain moving components such as rotating shafts, gears, pistons and blades.

5. **Improved efficiency:** They perform many construction operations faster than manual tools.

6. **Accuracy:** They help produce consistent holes, cuts, joints and surface finishes when correctly operated.

7. **Ergonomic design:** They are generally designed with handles that provide a firm grip and comfortable operation.

8. **Safety requirements:** They require proper handling, protective equipment and adherence to operating instructions.

9. **Accessories:** Many tools use interchangeable accessories such as drill bits, blades, discs and screwdriver bits.

10. **Maintenance requirements:** They require regular cleaning, inspection, servicing and replacement of worn-out parts.

4. Importance of construction hand power tools

Hand power tools play an important role in modern building construction.

Their importance includes:

1. **Increasing working speed:** They perform construction operations faster, reducing the time required to complete tasks.

2. **Improving productivity:** Workers can complete more operations within a given working period.

3. **Reducing physical effort:** Powered tools reduce the manual force required during repetitive operations.

4. **Improving accuracy:** They help produce accurate holes, cuts and surface finishes.

5. **Improving workmanship:** Properly selected and operated tools produce neat and professional construction work.

6. **Handling hard materials:** Specialised tools can drill, cut and grind materials that are difficult to work on manually.

7. **Reducing material wastage:** Accurate drilling, cutting and shaping help minimise mistakes and unnecessary material losses.

8. **Supporting large construction projects:** They make repetitive construction activities easier to manage.

9. **Improving efficiency:** They reduce unnecessary delays and increase the speed of completing construction tasks.

10. **Promoting versatility:** Some tools can perform different related operations when fitted with appropriate accessories.

1.1.2 TYPES OF CONSTRUCTION HAND POWER TOOLS

A. DRILLS



Figure 1.2: Different types of electric drills used in building construction.

1. Meaning of a drill

A drill is a powered hand tool used to make cylindrical holes in different construction materials by rotating a cutting accessory known as a drill bit.

The drill bit cuts into the material as it rotates, gradually producing a hole of the required diameter and depth.

Drills are widely used in carpentry, joinery, metal fabrication, electrical installation, plumbing and masonry work.

2. Types of drills used in building construction

a) Cordless electric drill



A cordless electric drill is a portable drilling tool powered by a rechargeable battery.

Characteristics:

1. It does not require a direct electrical cable connection during operation.
2. It is easy to transport around construction sites.
3. It is suitable for working in areas without electrical sockets.
4. It can be used for drilling and driving screws, depending on the model.
5. It is available in different sizes and power capacities.

Uses:

- Drilling holes in timber.
- Fixing screws into wooden structures.
- Installing door hinges.
- Assembling furniture.
- Installing wall fittings using appropriate accessories.

b) Corded electric drill



A corded electric drill is a drilling machine powered by electricity supplied through an electrical cable.

Characteristics:

1. It provides continuous power when electricity is available.
2. It is suitable for prolonged drilling operations.

3. It is commonly used in workshops.
4. It is available in different motor capacities.
5. It requires a suitable electrical supply.

Uses:

- Drilling timber.
- Drilling metal sheets.
- Drilling holes for fasteners.
- Preparing holes for construction fittings.
- Carrying out general workshop drilling operations.

c) Hammer drill



A hammer drill is a powered drilling tool that combines rotational movement with a rapid hammering action.

The hammering action helps break hard masonry material as the drill bit rotates.

Uses:

1. Drilling holes in brickwork.
2. Drilling into masonry.
3. Drilling holes in concrete within the machine's capacity.
4. Installing wall plugs.
5. Preparing holes for wall anchors.

d) Rotary hammer drill



A rotary hammer drill is a powerful drilling tool that uses a specialised hammering mechanism together with rotary movement.

It is commonly used for drilling into concrete and hard masonry.

Uses:

1. Drilling holes in reinforced concrete within the tool's specifications.
2. Drilling holes for heavy-duty anchors.
3. Drilling into thick masonry walls.
4. Removing tiles and plaster using suitable chiselling attachments.
5. Performing selected demolition and renovation operations.

3. Main parts of an electric drill



Figure 1.3: Main components of a cordless electric drill.

The main components include:

1. **Motor:** Converts electrical energy into mechanical energy that rotates the drill bit.
2. **Chuck:** Holds the drill bit firmly during operation.
3. **Drill bit:** The cutting accessory that penetrates the material to produce a hole.
4. **Trigger switch:** Controls the starting and stopping of the drill.
5. **Forward and reverse selector:** Changes the direction of rotation.
6. **Speed control:** Regulates the speed of rotation.
7. **Handle:** Provides a firm grip and enables the operator to control the tool.
8. **Battery pack:** Supplies electrical energy in cordless models.

9. **Power cable:** Supplies electricity in corded models.

10. **Torque adjustment ring:** Regulates the turning force in drill-driver models.

11. **Ventilation openings:** Allow air circulation to cool the motor.

12. **Gearbox:** Transmits and regulates mechanical power from the motor to the chuck.

4. Uses of drills in building construction

1. Making holes in timber for screws and bolts.
2. Drilling holes in metal sheets and steel sections.
3. Preparing holes in masonry for wall plugs.
4. Installing electrical fittings and accessories.
5. Fixing door hinges and window fittings.
6. Preparing holes for plumbing brackets.
7. Assembling timber roof structures.
8. Fixing cabinets and wooden furniture.
9. Preparing holes for bolts and mechanical fasteners.
10. Installing wall anchors and other suitable fixings.

5. Care and maintenance of drills

1. Clean the drill after every use.
2. Remove dust and wood shavings from the chuck and ventilation openings.
3. Inspect the power cable for damaged insulation.
4. Check the battery for cracks, swelling or other defects.
5. Ensure the chuck holds drill bits firmly.
6. Replace blunt and damaged drill bits.
7. Lubricate components according to the manufacturer's instructions.
8. Avoid applying excessive pressure during drilling.
9. Store the drill in a dry and secure toolbox.
10. Allow the motor to cool after prolonged operation.
11. Use the correct drill bit for each material.
12. Disconnect the power supply or remove the battery before changing drill bits.

6. Safety precautions when using drills

1. Wear safety goggles.
2. Secure the workpiece using a clamp or vice.
3. Use the correct drill bit.
4. Inspect the drill before operation.
5. Hold the drill firmly.

6. Avoid touching the rotating drill bit.
7. Disconnect the electrical supply before changing accessories.
8. Keep loose clothing away from rotating components.
9. Avoid drilling into concealed electrical cables or water pipes.
10. Use appropriate respiratory protection when drilling materials that generate hazardous dust.

B. GRINDERS



Figure 1.4: Different types of grinders used in construction and fabrication.

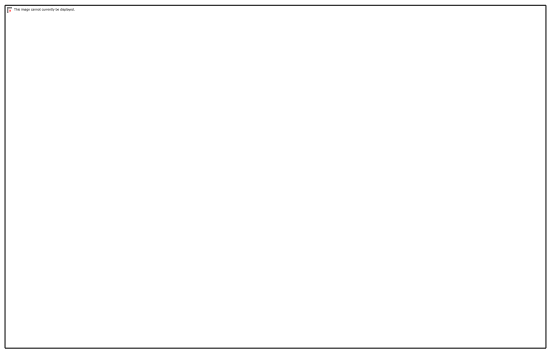
1. Meaning of a grinder

A grinder is a powered hand tool used to remove excess material, smooth surfaces, sharpen edges, remove rust or cut suitable materials using a rapidly rotating abrasive wheel or disc.

Grinders are widely used in metal fabrication, construction, welding, masonry and surface-finishing activities.

2. Types of grinders

a) Angle grinder



An angle grinder is a powered tool fitted with a rotating abrasive or cutting disc mounted at an angle to the motor shaft.

Uses:

1. Cutting suitable metal sections.
2. Removing rust from metal surfaces.
3. Grinding weld joints.
4. Smoothing rough metal edges.

5. Cutting suitable masonry materials using approved discs.
6. Preparing metal surfaces for painting.
7. Polishing surfaces using appropriate attachments.

b) Die grinder

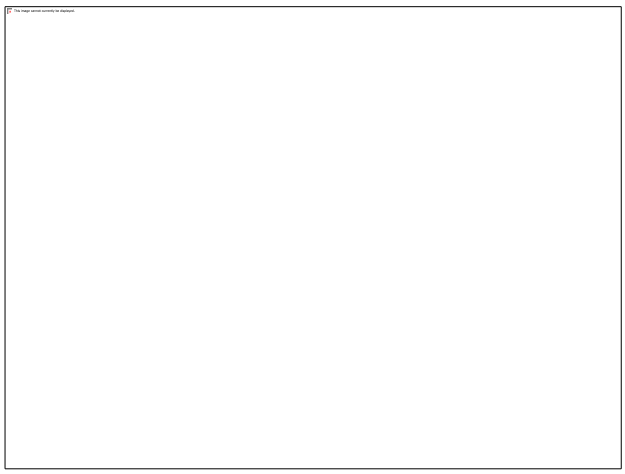


A die grinder is a small, high-speed grinding tool designed for precision grinding and finishing.

Uses:

1. Removing small amounts of metal.
2. Finishing metal surfaces.
3. Removing burrs from fabricated components.
4. Grinding small and intricate areas.
5. Working in confined spaces.

c) Straight grinder



A straight grinder is a powered grinding tool with a straight spindle arrangement.

Uses:

1. Grinding metal surfaces.
2. Removing excess material.
3. Deburring metal components.

4. Finishing fabricated parts.
5. Carrying out specialised workshop grinding operations.

3. Main parts of an angle grinder



Figure 1.5: Labelled components of an angle grinder.

1. **Electric motor:** Produces rotational power.
2. **Grinding disc:** Removes material from the workpiece.
3. **Disc guard:** Protects the operator from fragments and sparks.
4. **Side handle:** Provides additional grip and control.
5. **Power switch:** Starts and stops the machine.
6. **Spindle:** Holds and rotates the disc.
7. **Gear housing:** Contains the gears that transmit power.
8. **Ventilation openings:** Allow cooling air to circulate.
9. **Spindle-lock button:** Locks the spindle during disc replacement in applicable models.
10. **Power cable or battery:** Supplies operating energy.

4. Uses of grinders in building construction

1. Cutting suitable steel pipes and sections.
2. Removing rust and corrosion from metal surfaces.
3. Grinding welds to achieve smooth joints.
4. Smoothing rough metal edges.
5. Cutting reinforcement bars using suitable equipment and discs.
6. Removing excess material from metal components.
7. Preparing metal surfaces before painting.

8. Grinding suitable concrete surfaces.
9. Polishing metal components.
10. Shaping fabricated metal components.

5. Care and maintenance of grinders

1. Clean the grinder after every use.
2. Inspect discs for cracks and damage.
3. Replace worn-out or damaged discs.
4. Ensure the protective guard is correctly fitted.
5. Check the power cable and plug.
6. Clean the ventilation openings.
7. Check the side handle for tightness.
8. Use discs suitable for the machine's operating speed.
9. Store the grinder in a dry toolbox.
10. Disconnect the power supply before replacing discs.
11. Avoid dropping the machine.
12. Arrange professional servicing when necessary.

6. Safety precautions when using grinders

1. Wear safety goggles or a face shield.
2. Wear suitable hearing protection.
3. Ensure the protective guard is fitted.
4. Use the correct disc for the material.
5. Inspect the disc before operation.
6. Hold the grinder firmly using the designed handles.
7. Secure the workpiece.
8. Keep other workers away from flying sparks.
9. Never use a cracked or damaged disc.
10. Allow the disc to stop completely before placing the grinder down.

C. POWER SCREWDRIVERS



Figure 1.6: Different types of powered screwdrivers.

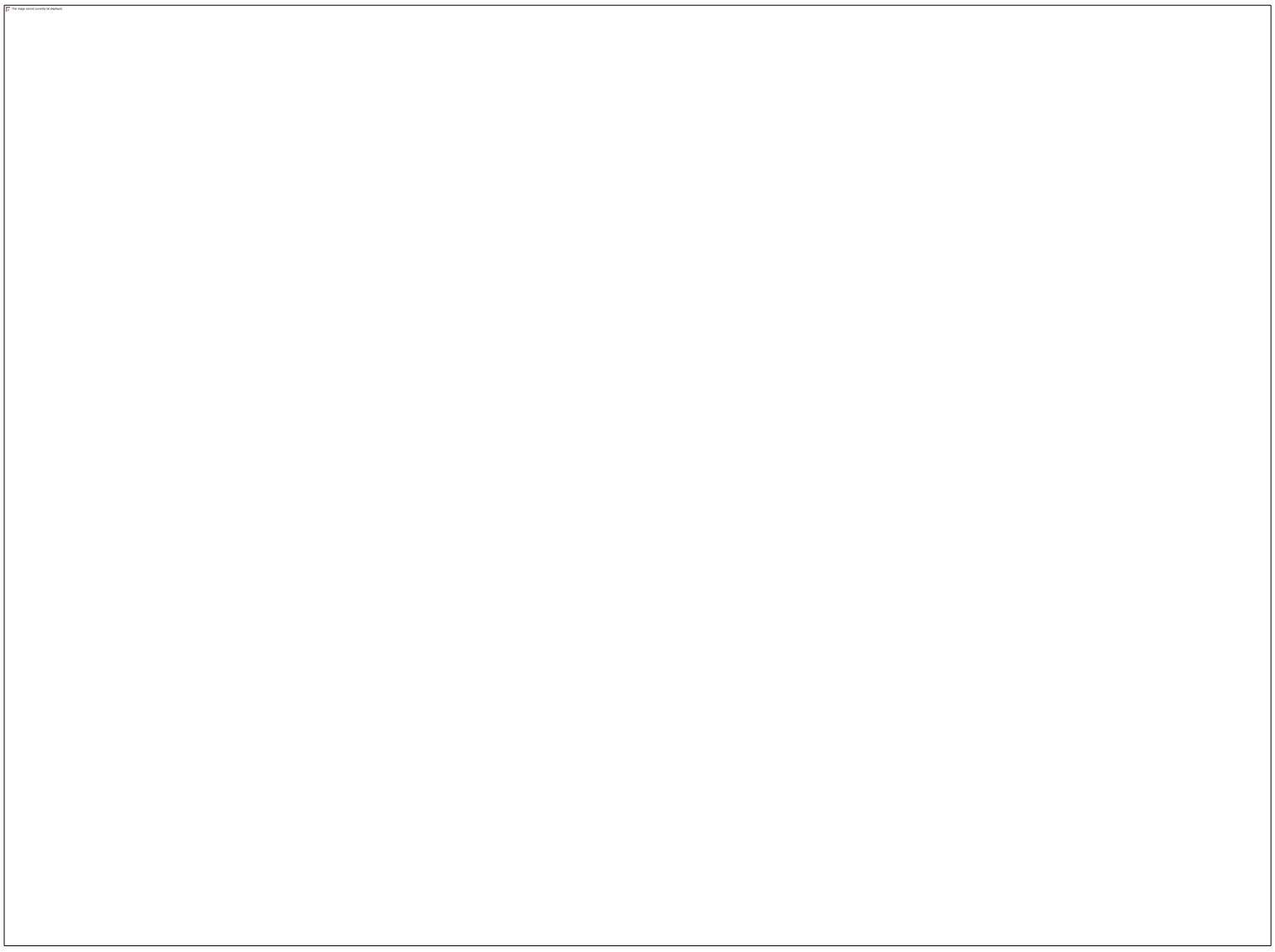
1. Meaning of a power screwdriver

A power screwdriver is a portable powered hand tool used to insert and remove screws from construction materials by means of rotational force.

It is powered by electricity or a rechargeable battery and is commonly used in carpentry, joinery, furniture assembly and building finishing.

2. Types of power screwdrivers

a) Cordless power screwdriver



This is a powered screwdriver that uses a rechargeable battery.

Uses:

1. Fixing screws into timber.
2. Assembling cabinets.
3. Installing door hinges.
4. Fixing wooden fittings.

5. Carrying out furniture assembly.

b) Corded power screwdriver



This screwdriver operates using electricity supplied through a power cable.

Uses:

1. Repetitive screw fastening.
2. Workshop assembly operations.
3. Fixing suitable construction boards.
4. Installing fittings.
5. General fastening operations.

c) Impact driver



An impact driver is a powered fastening tool that combines rotational movement with rapid impact action to produce high turning force.

Uses:

1. Driving long screws into timber.
2. Fixing heavy-duty fasteners.
3. Assembling timber structures.

4. Installing suitable roofing fasteners.
5. Performing demanding fastening operations.

3. Main parts of a power screwdriver

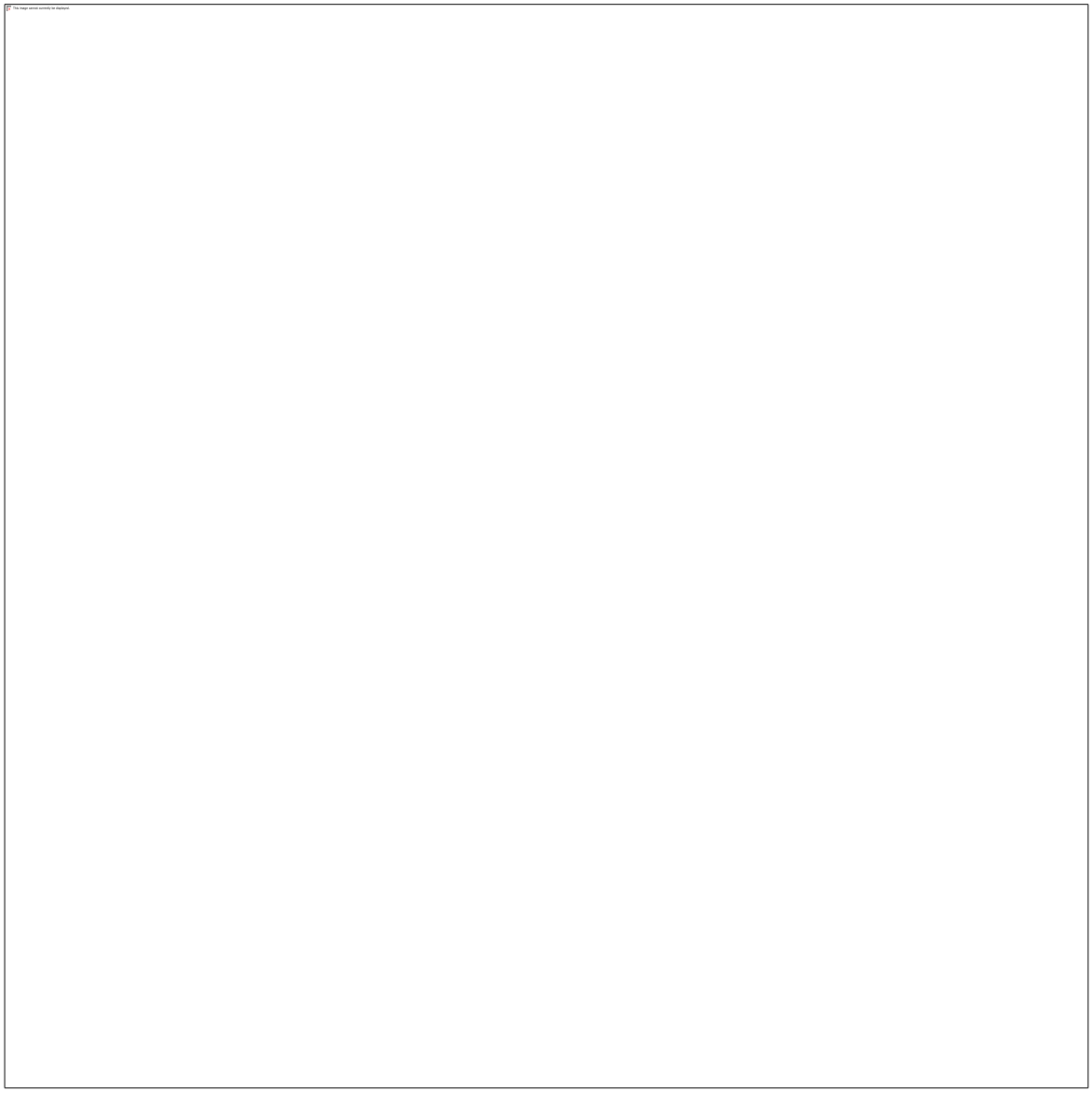


Figure 1.7: Main components of a cordless power screwdriver.

1. **Motor:** Produces the rotational movement.
2. **Bit holder:** Holds the screwdriver bit.
3. **Screwdriver bit:** Engages with the screw head.
4. **Trigger switch:** Controls operation.
5. **Direction selector:** Changes the direction of rotation.
6. **Speed control:** Regulates rotational speed.
7. **Handle:** Provides a firm grip.
8. **Battery:** Supplies electrical energy in cordless models.
9. **Gearbox:** Transmits power from the motor.
10. **Torque adjustment:** Controls the turning force in applicable models.

4. Uses of power screwdrivers in building construction

1. Fixing screws into timber structures.
2. Installing doors and window fittings.
3. Assembling cupboards and cabinets.
4. Fixing roofing accessories using suitable screws.
5. Installing electrical fittings.
6. Joining timber components.
7. Installing plasterboard and drywall panels.
8. Removing screws during renovation.
9. Assembling prefabricated components.
10. Fixing furniture and interior fittings.

5. Care and maintenance of power screwdrivers

1. Clean the tool after use.
2. Inspect the battery and charger.
3. Replace worn screwdriver bits.
4. Ensure the bit holder is secure.
5. Avoid applying excessive torque.
6. Keep ventilation openings clean.
7. Store the tool in a dry toolbox.
8. Charge batteries using recommended chargers.
9. Inspect electrical cables on corded models.
10. Disconnect the power supply before servicing.

D. NAIL GUNS

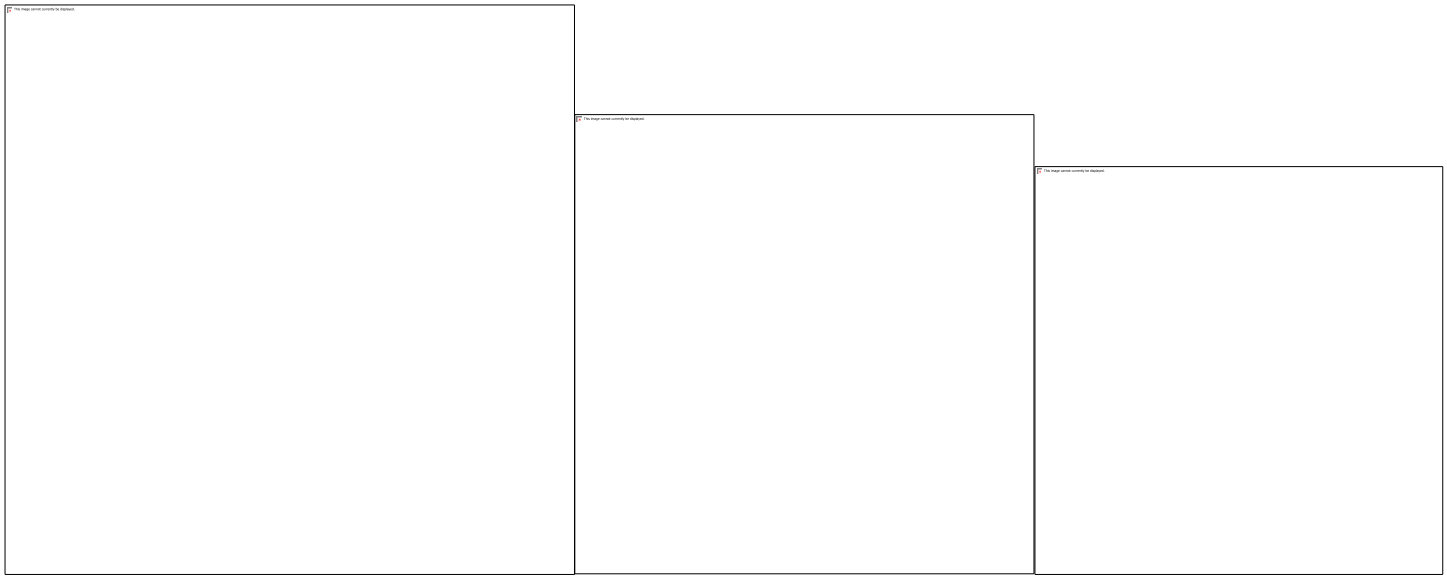


Figure 1.8: Different types of nail guns used in carpentry and building construction.

1. Meaning of a nail gun

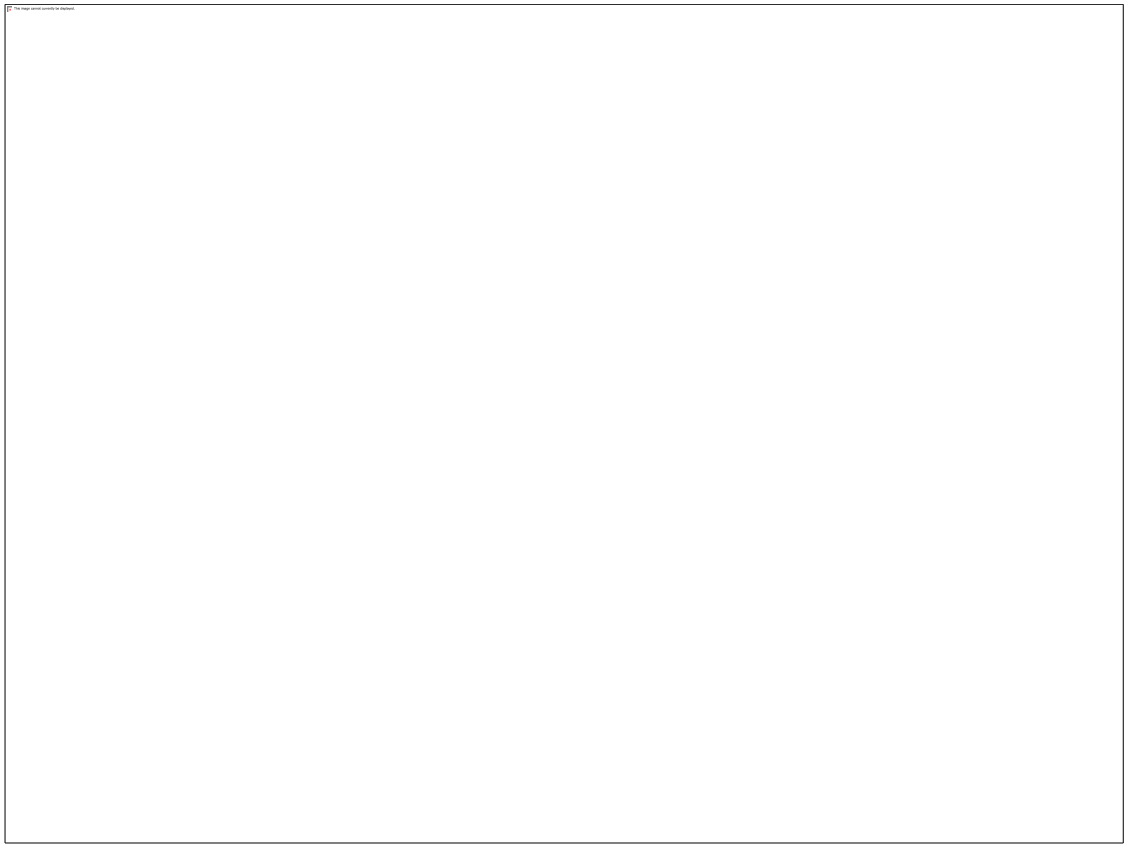
A nail gun is a powered hand tool designed to drive nails into construction materials quickly and accurately using mechanical, electrical or compressed-air force.

It reduces the need for repeated manual hammering and is particularly useful when fixing large numbers of nails during construction.

Nail guns are commonly used in carpentry, timber framing, roofing, flooring, furniture production and interior finishing.

2. Types of nail guns

a) Pneumatic nail gun



A pneumatic nail gun is a powered fastening tool that uses compressed air supplied by an air compressor to drive nails into materials.

Characteristics:

1. Operates using compressed air.
2. Requires an air compressor and connecting hose.
3. Can perform repetitive nailing operations.
4. Is commonly used in professional carpentry workshops.
5. Is available in different sizes for different nail types.

Uses:

- Fixing timber frames.

- Assembling roof trusses.
- Installing timber flooring.
- Fixing wooden wall panels.
- Assembling wooden furniture.

b) Cordless battery-powered nail gun

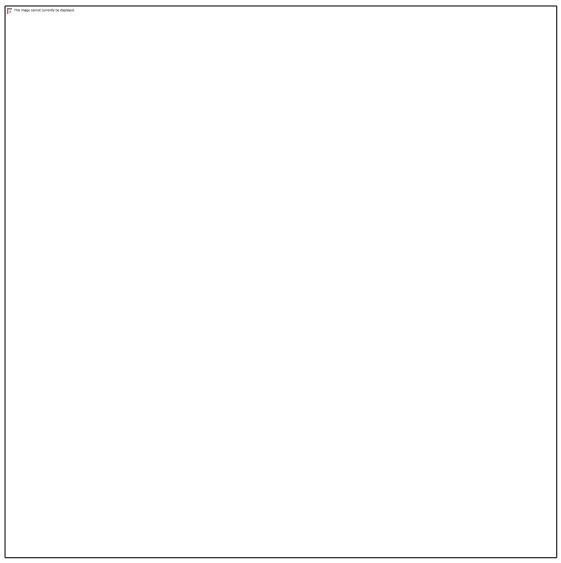


A cordless nail gun is powered by a rechargeable battery and does not require a direct electrical cable or external air compressor.

Uses:

1. Fixing timber components.
2. Installing wooden floorboards.
3. Fixing door and window frames.
4. Assembling wooden structures.
5. Carrying out carpentry and finishing operations.

c) Electric nail gun



An electric nail gun uses electrical energy to operate its nail-driving mechanism. Depending on its design, it may be corded or cordless.

Uses:

1. Fixing decorative timber mouldings.
2. Installing skirting boards.
3. Assembling furniture.
4. Fixing lightweight wooden panels.
5. Carrying out finishing carpentry.

3. Main parts of a nail gun

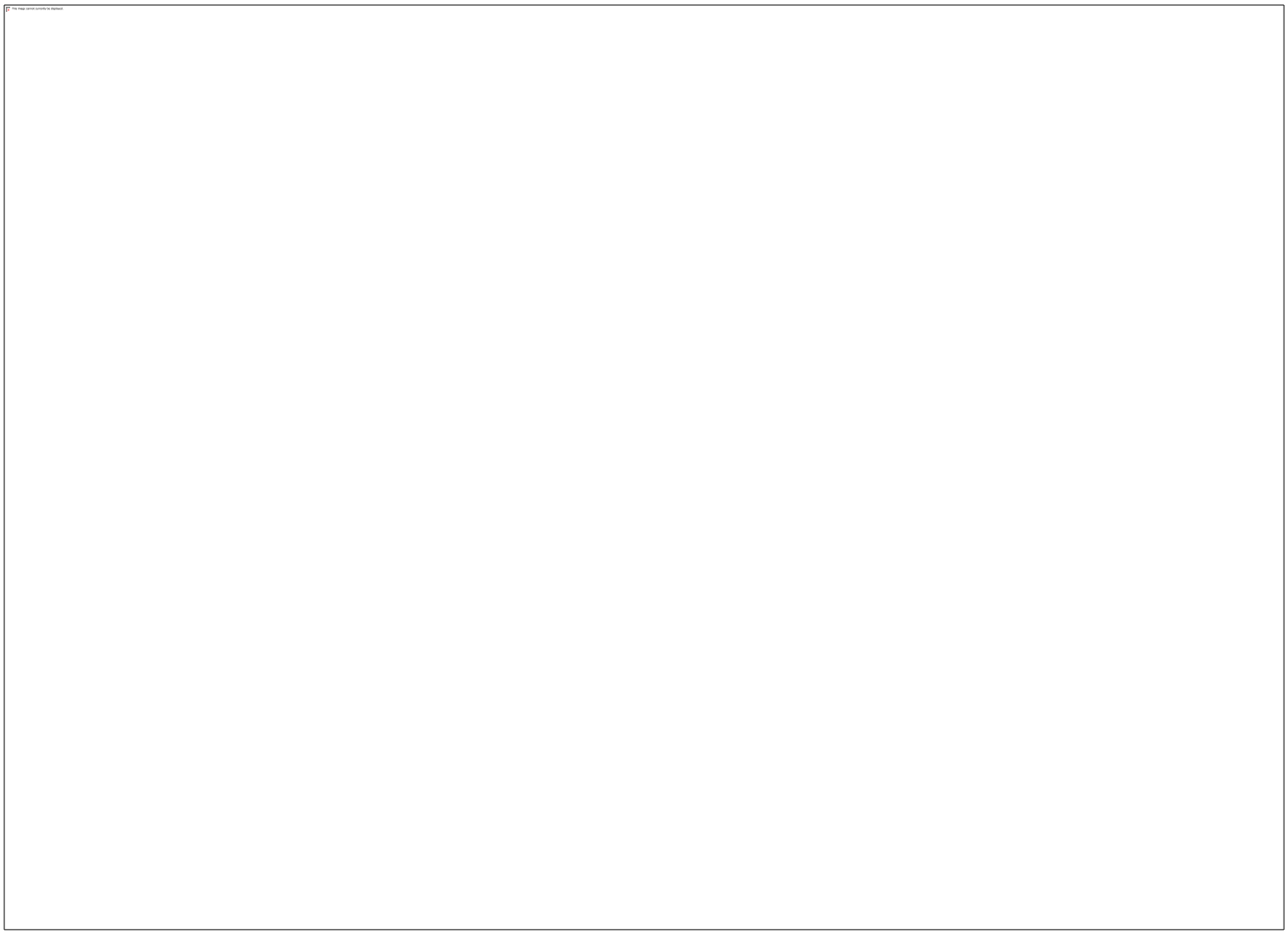


Figure 1.9: Main components of a pneumatic nail gun.

1. **Nosepiece:** Guides the nail towards the material.
2. **Trigger:** Activates the nail-driving mechanism.
3. **Magazine:** Holds nails before they are driven into the material.
4. **Piston or driving mechanism:** Provides the force required to drive the nail.
5. **Safety contact tip:** Helps prevent accidental firing when correctly operated.
6. **Handle:** Provides a firm grip.
7. **Air inlet:** Connects the pneumatic nail gun to the compressed-air hose.
8. **Depth adjustment:** Regulates nail penetration depth in models with this feature.
9. **Battery compartment:** Holds the rechargeable battery in cordless models.
10. **Exhaust outlet:** Releases used air in pneumatic models.

4. Uses of nail guns in building construction

1. Fixing timber frames during building construction.
2. Joining timber roof trusses.
3. Installing wooden floorboards.

4. Fixing ceiling battens.
5. Installing wooden wall panels.
6. Assembling wooden doors and window frames.
7. Fixing skirting boards.
8. Installing decorative mouldings.
9. Fixing plywood and other timber-based boards.
10. Assembling wooden furniture.

5. Care and maintenance of nail guns

1. Clean the tool regularly to remove dust and debris.
2. Inspect the magazine for damage.
3. Use nails of the correct size and type.
4. Check the trigger and safety contact mechanism.
5. Inspect pneumatic hoses for leaks.
6. Lubricate pneumatic models as recommended by the manufacturer.
7. Maintain the recommended air pressure.
8. Remove jammed nails according to the manufacturer's instructions.
9. Disconnect the air supply or remove the battery before clearing jams.
10. Store the tool in a secure, dry place.
11. Inspect the battery and charging system in cordless models.
12. Arrange professional servicing when necessary.

6. Safety precautions when using nail guns

1. Never point a nail gun towards another person.
2. Keep fingers away from the nosepiece.
3. Do not bypass the safety contact mechanism.
4. Wear appropriate eye protection.
5. Disconnect the air supply before clearing a jam.
6. Use the correct nail size.
7. Ensure the workpiece is properly supported.
8. Avoid placing hands behind the material being nailed.
9. Keep the trigger untouched when the tool is not in use.
10. Follow the manufacturer's operating instructions.

E. PNEUMATIC HAMMERS





Figure 1.10: Different types of pneumatic hammers.

1. Meaning of a pneumatic hammer

A pneumatic hammer is a powered hand tool that uses compressed air to produce rapid repeated impact movements for breaking, chipping, cutting, shaping or hammering materials.

The word *pneumatic* refers to the use of compressed air to generate mechanical movement.

A pneumatic hammer is connected to an air compressor through a flexible air hose. Compressed air enters the tool and drives an internal piston that produces repeated impact movements.

2. Types of pneumatic hammers

a) Pneumatic chipping hammer

A pneumatic chipping hammer is designed to remove small portions of hard materials through repeated impact.

Uses:

1. Removing hardened mortar.
2. Chipping concrete surfaces.
3. Removing old plaster.
4. Removing tiles and floor finishes.
5. Cleaning concrete surfaces.

b) Pneumatic demolition hammer

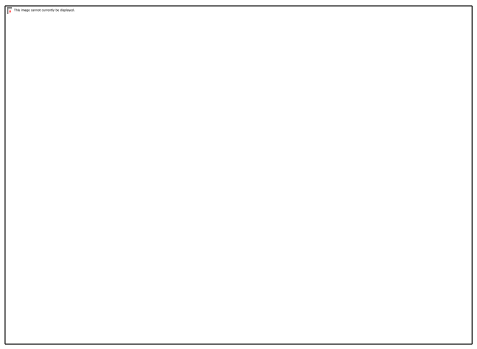


A pneumatic demolition hammer is a heavy-duty tool used to break hard construction materials through powerful repeated impacts.

Uses:

1. Breaking concrete during renovation.
2. Demolishing selected masonry sections.
3. Breaking concrete floors.
4. Removing concrete from selected areas.
5. Breaking hard masonry surfaces.

c) Pneumatic riveting hammer



A pneumatic riveting hammer is designed to produce repeated impact force during riveting operations.

Uses:

1. Installing suitable solid rivets.
2. Forming rivet heads.
3. Joining metal plates.
4. Assembling metal components.
5. Performing specialised metal fabrication operations.

3. Main parts of a pneumatic hammer



Figure 1.11: Main components of a pneumatic hammer.

1. **Hammer body:** Houses and protects the internal operating mechanism.
2. **Piston:** Moves rapidly under compressed-air pressure.
3. **Cylinder:** Provides a chamber in which the piston moves.
4. **Air inlet:** Allows compressed air to enter the tool.
5. **Trigger valve:** Controls the flow of compressed air.
6. **Chisel holder:** Holds the working attachment.
7. **Chisel or bit:** Performs the breaking, cutting or chipping operation.
8. **Handle:** Enables the operator to hold and control the tool.
9. **Exhaust outlet:** Releases used compressed air.
10. **Air hose:** Connects the hammer to the compressor.

4. Uses of pneumatic hammers in building construction

1. Breaking concrete during renovation.
2. Removing old concrete from surfaces.
3. Chipping hardened mortar from masonry.
4. Removing tiles and floor finishes.
5. Breaking selected sections of brickwork.
6. Removing unwanted concrete projections.
7. Chiselling grooves in suitable masonry.
8. Removing unwanted material during demolition.
9. Performing specialised riveting operations.
10. Preparing surfaces for further construction work.

5. Care and maintenance of pneumatic hammers

1. Clean the tool after every use.

2. Inspect the air hose for cracks and leaks.
3. Check all air connections.
4. Use the recommended operating pressure.
5. Lubricate the tool according to the manufacturer's instructions.
6. Inspect the piston and internal components during servicing.
7. Replace worn or damaged chisels.
8. Keep the air inlet free from dirt.
9. Drain moisture from the air compressor tank as recommended.
10. Store the tool in a clean and dry place.
11. Disconnect the compressed-air supply before servicing.
12. Have damaged components repaired by qualified technicians.

6. Safety precautions when using pneumatic hammers

1. Wear safety goggles or a face shield.
2. Wear hearing protection.
3. Wear suitable safety boots.
4. Check the air hose before operation.
5. Ensure all connections are secure.
6. Use the recommended operating pressure.
7. Hold the tool firmly.
8. Keep other workers away from flying fragments.
9. Disconnect the air supply before changing attachments.
10. Avoid pointing the tool towards other people.

F. RIVET DRIVERS



Figure 1.12: Different types of powered rivet drivers.

1. Meaning of a rivet driver

A rivet driver is a powered hand tool used to install rivets and permanently join two or more components by applying mechanical force to the rivet.

It is commonly used in metal fabrication, sheet-metal work, roofing accessories, ventilation duct installation and selected building construction activities.

Meaning of a rivet

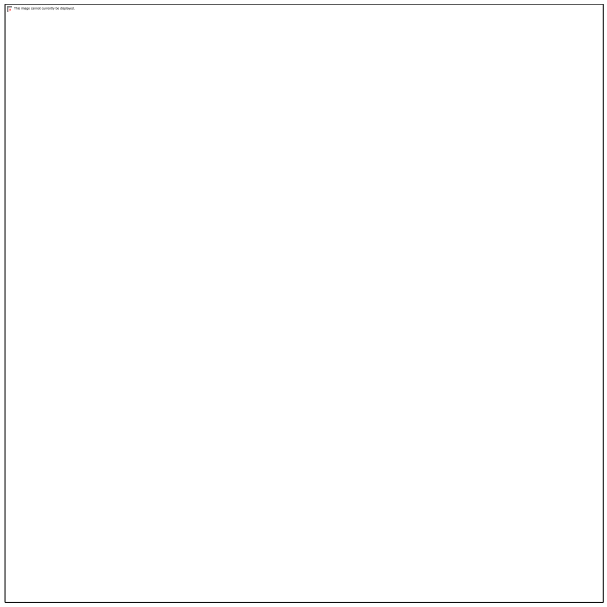
A rivet is a permanent mechanical fastener used to join two or more materials. It consists of a head and a shank that is deformed during installation to hold the materials together.



Figure 1.13: Examples of solid and blind rivets.

2. Types of rivet drivers

a) Pneumatic rivet driver

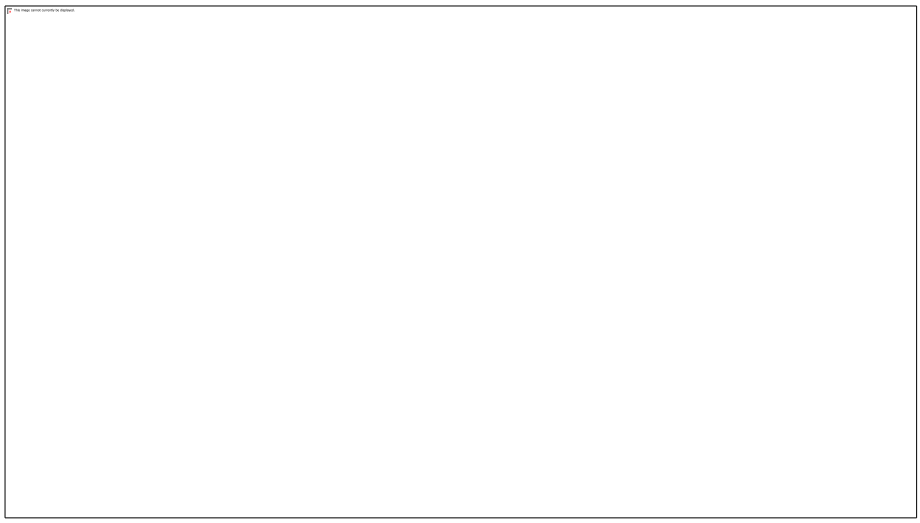


A pneumatic rivet driver uses compressed air to operate its riveting mechanism.

Uses:

1. Joining metal sheets.
2. Fixing aluminium panels.
3. Installing suitable metal cladding components.
4. Assembling ventilation ducts.
5. Joining metal brackets.

b) Electric rivet driver

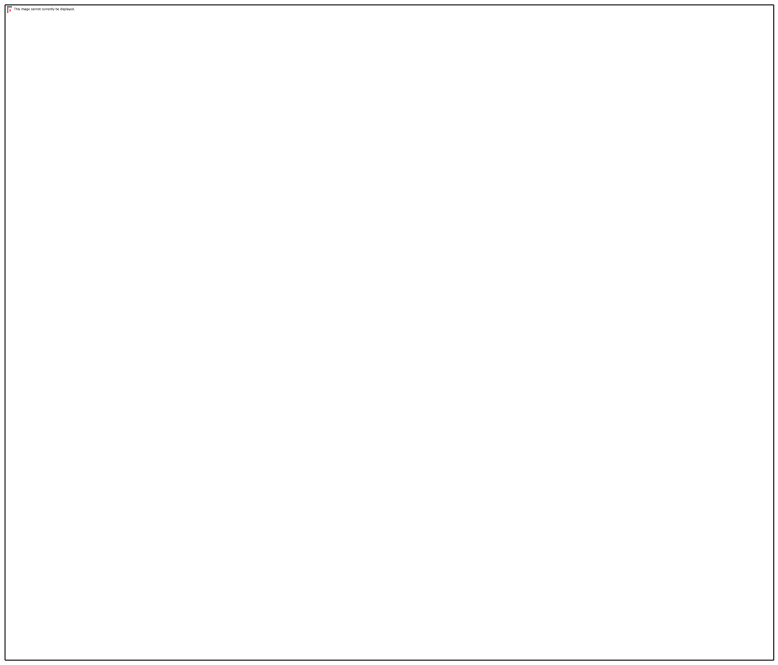


An electric rivet driver uses electrical energy to install rivets.

Uses:

1. Joining sheet-metal components.
2. Fixing metal panels.
3. Assembling metal structures.
4. Installing metal fittings.
5. Carrying out repetitive riveting work.

c) Cordless rivet driver



A cordless rivet driver uses a rechargeable battery to power the riveting mechanism.

Uses:

1. Installing rivets on construction sites.
2. Joining metal sheets.
3. Assembling aluminium components.
4. Repairing suitable metal structures.

5. Performing riveting in areas without convenient electrical connections.

3. Main parts of a powered rivet driver



Figure 1.14: Main components of a powered blind rivet driver.

1. **Motor or pneumatic mechanism:** Provides the force needed to operate the tool.
2. **Nosepiece:** Holds and guides the rivet.
3. **Trigger:** Activates the riveting mechanism.
4. **Mandrel gripping mechanism:** Holds and pulls the rivet mandrel in blind-rivet models.
5. **Jaw assembly:** Grips the mandrel.
6. **Handle:** Provides a firm grip.
7. **Battery or air inlet:** Supplies operating energy.
8. **Mandrel collection container:** Collects broken mandrels in models fitted with this component.
9. **Housing:** Protects the internal parts.

4. Types of rivets used in construction

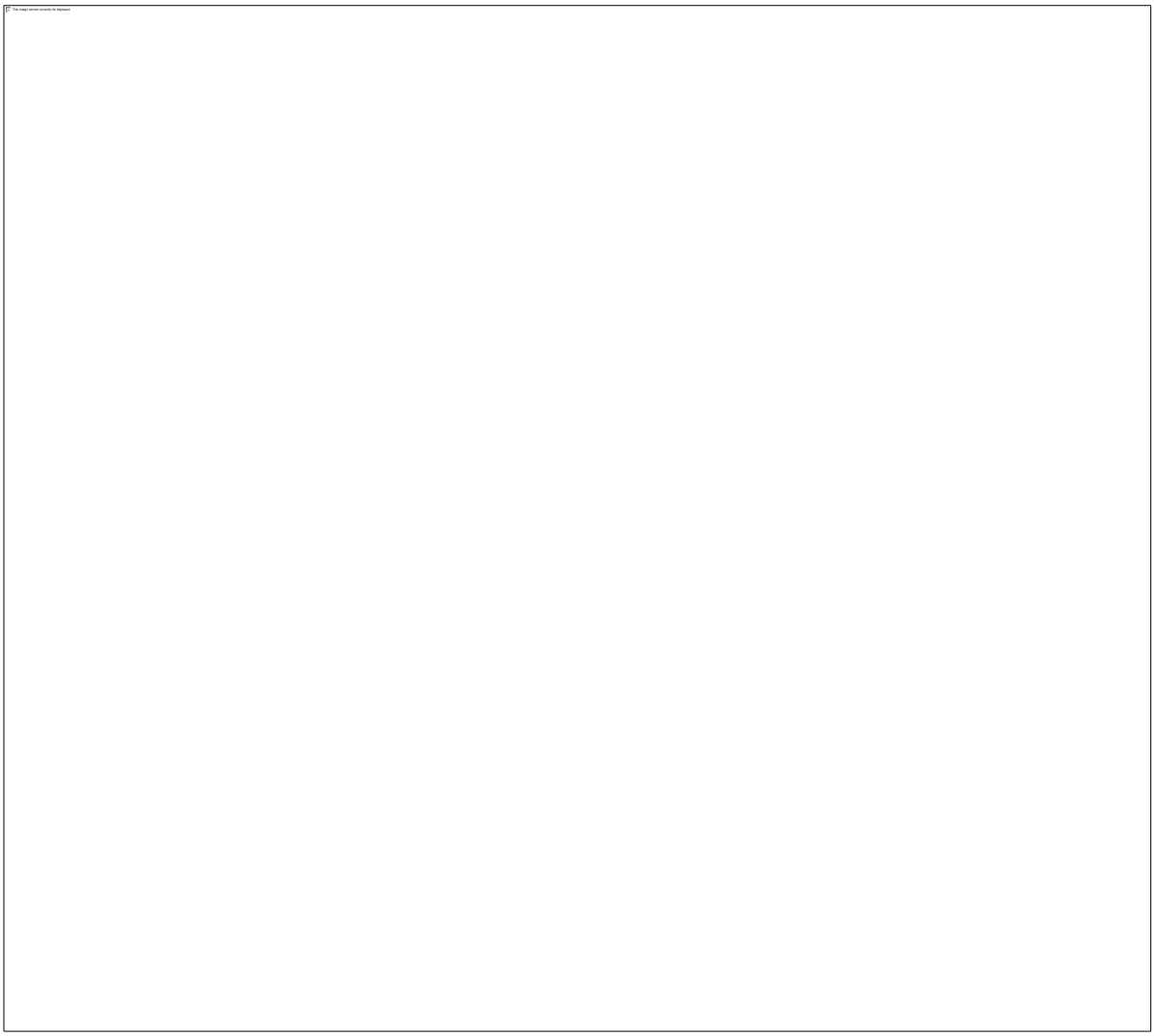
a) Solid rivets



Solid rivets have a solid cylindrical shank and are installed by deforming the projecting end to form a second head.

They are commonly used in suitable heavy-duty metal joining applications.

b) Blind rivets



Blind rivets are designed to be installed from one side of the workpiece using a special rivet tool.

They are particularly useful where the reverse side of a joint cannot easily be accessed.

c) Semi-tubular rivets



Semi-tubular rivets have a partially hollow end that deforms during installation.

They are used in suitable light and medium-duty fastening applications.

5. Uses of rivet drivers in building construction

1. Joining aluminium sheets.
2. Fixing metal cladding components.
3. Joining sheet-metal roofing accessories.
4. Assembling ventilation ducts.
5. Fixing metal panels.
6. Joining metal brackets.
7. Installing ventilation components.
8. Assembling metal frames.
9. Joining thin metal sheets in fabrication workshops.
10. Repairing suitable metal components.

6. Care and maintenance of rivet drivers

1. Clean the tool after use.
2. Inspect the nosepiece for wear.
3. Use the correct rivet size and type.
4. Remove trapped mandrels.
5. Inspect the gripping jaws for damage.
6. Check air hoses on pneumatic models.
7. Inspect batteries and charging systems.
8. Lubricate moving components as recommended.

9. Store the tool in a dry toolbox.
10. Avoid exceeding the tool's rated capacity.
11. Replace worn gripping components.
12. Arrange regular servicing.

G. HANDHELD POWER CUTTERS

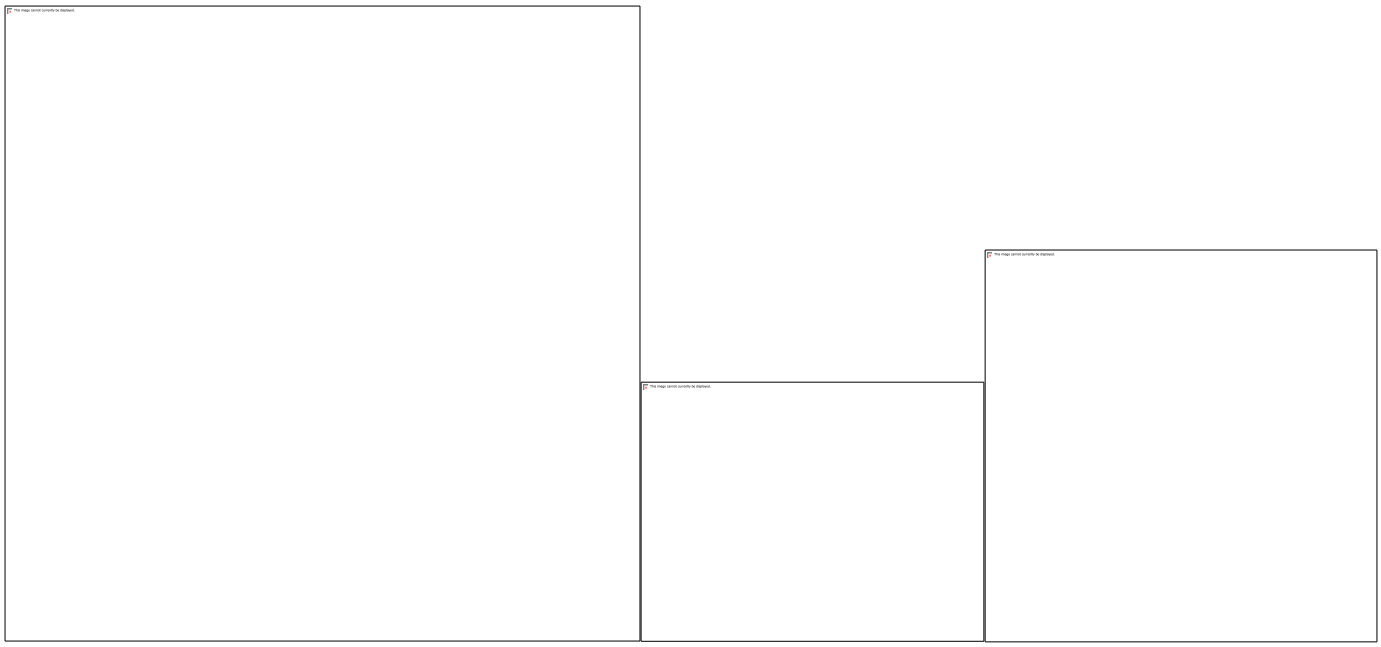


Figure 1.15: Different handheld power cutters used in building construction.

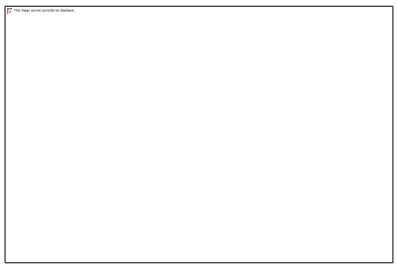
1. Meaning of handheld power cutters

Handheld power cutters are portable powered tools designed to cut construction materials into required shapes and dimensions using a moving blade, cutting disc or other suitable cutting attachment.

They are commonly used in carpentry, metal fabrication, masonry work, plumbing and finishing operations.

2. Types of handheld power cutters

a) Circular saw



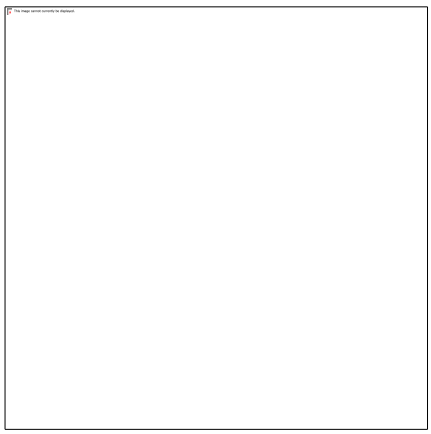
A circular saw is a powered cutting tool that uses a rotating circular toothed blade to cut materials, particularly timber and manufactured boards.

Uses:

1. Cutting timber to required lengths.
2. Cutting plywood sheets.
3. Cutting manufactured boards.

4. Cutting wooden roof components.
5. Preparing timber for joinery.
6. Cutting suitable boards for interior fittings.

b) Portable masonry cutter



A portable masonry cutter is a powered tool used to cut concrete, bricks, blocks, tiles and other masonry materials using a suitable cutting disc.

Uses:

1. Cutting concrete blocks.
2. Cutting bricks.
3. Cutting paving blocks.
4. Cutting suitable concrete sections.
5. Cutting masonry materials to specified dimensions.
6. Preparing openings in suitable masonry work.

c) Portable metal cutter



A portable metal cutter is designed to cut metal materials using a suitable blade or cutting disc.

Uses:

1. Cutting steel sections.
2. Cutting metal pipes.
3. Cutting aluminium sections.
4. Cutting metal sheets.
5. Preparing metal components for fabrication.

6. Cutting suitable reinforcement bars.

d) Jigsaw



A jigsaw is a powered cutting tool that uses a narrow reciprocating blade to cut straight, curved and irregular shapes.

Uses:

1. Cutting curved shapes in timber.
2. Cutting plywood.
3. Cutting plastic boards.
4. Making openings in suitable boards.
5. Cutting decorative wooden components.
6. Preparing irregular shapes for joinery.

3. Main parts of a handheld circular saw

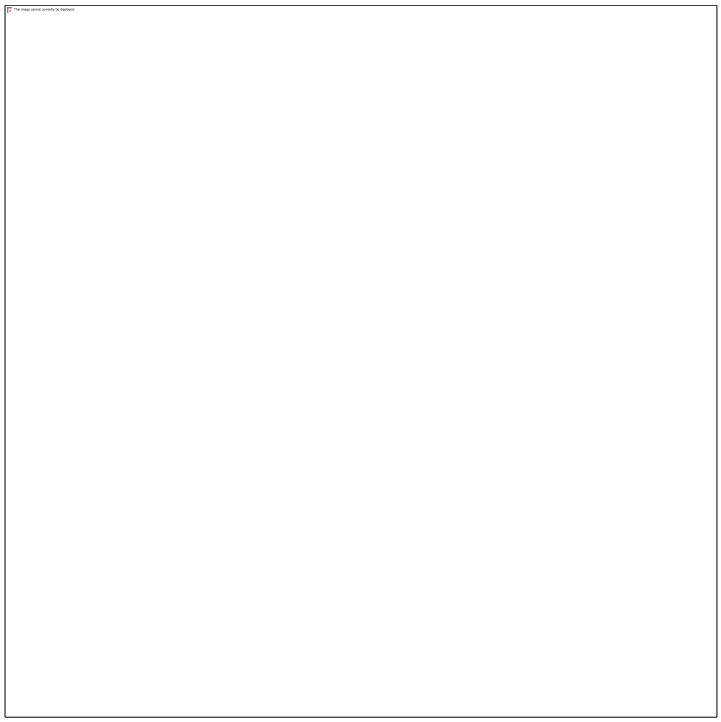


Figure 1.16: Main components of a handheld circular saw.

1. **Motor:** Produces the power needed to rotate the blade.
2. **Cutting blade:** Performs the cutting operation.
3. **Upper blade guard:** Covers the upper section of the blade.
4. **Lower blade guard:** Covers the exposed blade when it is not cutting.

5. **Handle:** Provides a firm grip.
6. **Trigger switch:** Starts and stops the saw.
7. **Base plate or shoe:** Supports the saw on the workpiece.
8. **Depth adjustment:** Regulates the cutting depth.
9. **Spindle:** Holds and rotates the blade.
10. **Power cable or battery:** Supplies energy.
11. **Dust extraction connection:** Collects dust in models equipped with this feature.

4. Uses of handheld power cutters in building construction

1. Cutting timber to the required lengths.
2. Cutting plywood and manufactured boards.
3. Cutting metal pipes and sections.
4. Cutting suitable reinforcement bars.
5. Cutting tiles using appropriate equipment.
6. Cutting bricks and masonry units.
7. Trimming wooden doors and panels.
8. Cutting plastic pipes.
9. Preparing materials for joinery.
10. Cutting construction components to specified dimensions.

5. Care and maintenance of handheld power cutters

1. Clean the machine after use.
2. Inspect blades for damage.
3. Replace blunt or damaged blades.
4. Ensure blade guards operate correctly.
5. Inspect electrical cables and plugs.
6. Keep ventilation openings clean.
7. Check batteries and chargers where applicable.
8. Lubricate components as recommended.
9. Use compatible cutting accessories.
10. Store the machine in a dry and secure place.
11. Disconnect the power supply before changing blades.
12. Have mechanical and electrical faults repaired by qualified technicians.

1.1.3 CONSTRUCTION OPERATIONS PERFORMED USING HAND POWER TOOLS

Different hand power tools perform specific operations during building construction. These operations include drilling, grinding, screwing, cutting, riveting and hammering.

A. DRILLING

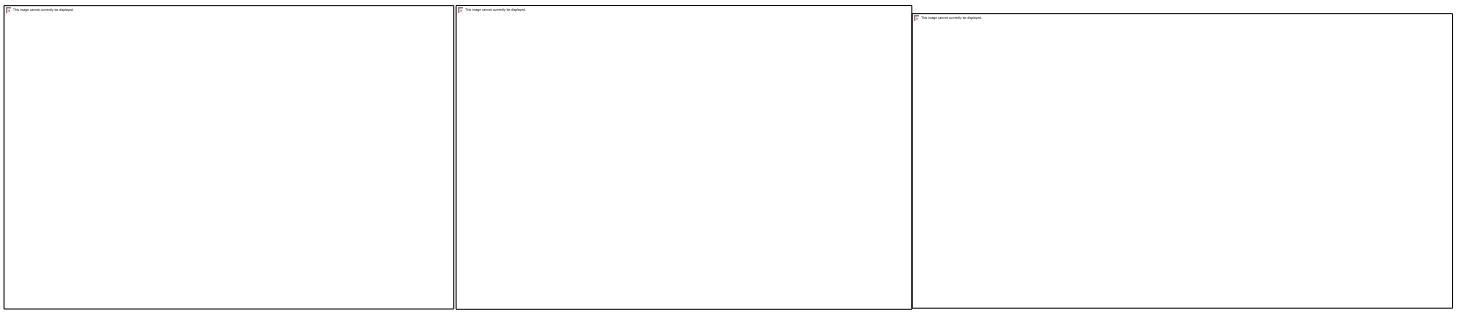


Figure 1.17: Drilling operations on timber, masonry and metal.

1. Meaning of drilling

Drilling is the process of making a cylindrical hole in a material using a rotating cutting tool known as a drill bit.

The drill bit cuts into the material as it rotates, producing a hole of the required diameter and depth.

2. Materials commonly drilled

1. Timber.
2. Steel.
3. Aluminium.
4. Concrete.
5. Brickwork.
6. Plastics.
7. Manufactured boards.

3. Tools used for drilling

- Cordless electric drills.
- Corded electric drills.
- Hammer drills.
- Rotary hammer drills.

4. Procedure for drilling holes

1. Identify the material to be drilled.
2. Determine the required hole diameter and depth.
3. Select a suitable drill bit.
4. Mark the position of the hole.
5. Secure the workpiece using a clamp or vice.
6. Insert the drill bit into the chuck.

7. Tighten the chuck securely.
8. Select the appropriate drilling speed.
9. Position the drill bit at the marked point.
10. Hold the drill firmly.
11. Start drilling while applying steady and controlled pressure.
12. Withdraw the drill bit carefully after completing the hole.
13. Switch off the machine.
14. Inspect the finished hole for accuracy.

5. Factors to consider when drilling

1. Type and hardness of the material.
2. Required hole diameter.
3. Required hole depth.
4. Type and sharpness of the drill bit.
5. Speed of rotation.
6. Availability of cooling or lubrication where necessary.
7. Stability of the workpiece.
8. Safety of the working environment.

6. Importance of drilling in building construction

1. Facilitates installation of bolts and screws.
2. Enables fixing of electrical fittings.
3. Supports installation of plumbing brackets.
4. Helps in assembling timber structures.
5. Facilitates installation of wall anchors.
6. Supports fabrication of metal components.
7. Provides holes for mechanical connections.

B. GRINDING

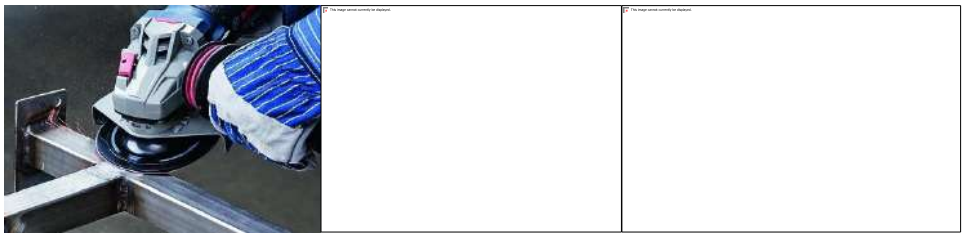


Figure 1.18: Grinding metal, removing rust and finishing concrete surfaces.

1. Meaning of grinding

Grinding is the process of removing small amounts of material from a workpiece using an abrasive wheel or disc that rotates at high speed.

It is mainly used to smoothen, shape, sharpen or finish construction materials.

2. Materials commonly ground

- Steel.
- Aluminium.
- Other suitable metals.
- Concrete and masonry using appropriate accessories.
- Certain stone surfaces.

3. Tools used for grinding

1. Angle grinders.
2. Die grinders.
3. Straight grinders.

4. Procedure for grinding

1. Identify the surface that requires grinding.
2. Select the correct grinding disc.
3. Inspect the disc for cracks and damage.
4. Fit the disc correctly.
5. Ensure the disc guard is properly positioned.
6. Secure the workpiece.
7. Wear appropriate protective equipment.
8. Start the grinder and allow it to reach the required operating speed.
9. Hold the machine firmly.
10. Apply controlled pressure to the workpiece.
11. Move the grinder steadily across the surface.
12. Avoid excessive pressure.
13. Switch off the machine after completing the operation.
14. Allow the disc to stop completely before placing the grinder down.

5. Importance of grinding in building construction

1. Removes unwanted material.
2. Smoothens rough metal surfaces.
3. Removes rust and scale.
4. Improves the appearance of fabricated components.
5. Removes excess weld material.
6. Prepares surfaces for painting.
7. Helps in shaping metal components.

8. Improves the quality of metal joints and finishes.

C. SCREWING

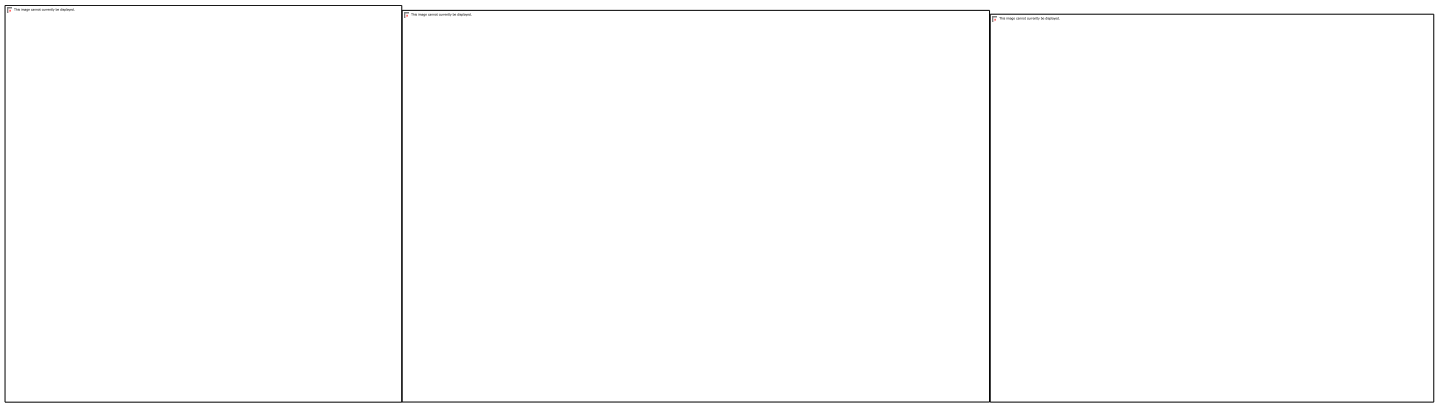


Figure 1.19: Screwing operations using powered screwdrivers.

1. Meaning of screwing

Screwing is the process of joining or fastening materials by inserting a threaded fastener called a screw into a material using rotational force.

A screw has a threaded body that enables it to hold materials together when properly inserted.

2. Materials commonly joined through screwing

1. Timber.
2. Plywood.
3. Manufactured boards.
4. Metal sheets.
5. Plasterboard.
6. Plastic components.

3. Tools used for screwing

- Cordless power screwdrivers.
- Electric power screwdrivers.
- Impact drivers.

4. Procedure for screwing

1. Identify the materials to be joined.
2. Select the correct screw type and size.
3. Select a compatible screwdriver bit.
4. Mark the position of the screw.
5. Drill a pilot hole where necessary.
6. Insert the screw into the screwdriver bit.
7. Position the screw at the marked point.
8. Hold the tool firmly.

9. Operate the trigger to drive the screw.
10. Apply controlled pressure.
11. Stop when the screw is correctly seated.
12. Inspect the joint for tightness.

5. Importance of screwing in building construction

1. Joins timber components.
2. Facilitates installation of doors and windows.
3. Helps in fixing roofing accessories.
4. Supports cabinet and furniture assembly.
5. Facilitates installation of ceiling boards.
6. Allows components to be dismantled during repairs.
7. Provides secure fastening when suitable screws are selected.

D. CUTTING



Figure 1.20: Cutting timber, masonry and metal construction materials.

1. Meaning of cutting

Cutting is the process of separating a material into smaller pieces or shaping it to the required dimensions using a sharp blade or cutting disc.

2. Materials commonly cut

1. Timber.
2. Steel.
3. Aluminium.
4. Plastic pipes.
5. Plywood.
6. Tiles.
7. Bricks.
8. Concrete and masonry.

3. Tools used for cutting

- Circular saws.
- Portable masonry cutters.

- Portable metal cutters.
- Jigsaws.
- Angle grinders fitted with suitable cutting discs.

4. Procedure for cutting materials

1. Identify the material to be cut.
2. Measure the required dimensions.
3. Mark the cutting line accurately.
4. Select the correct cutting blade.
5. Inspect the blade and machine.
6. Secure the material firmly.
7. Check that the cutting area is free from obstructions.
8. Wear appropriate protective equipment.
9. Position the cutter correctly.
10. Start the machine according to the manufacturer's instructions.
11. Guide the blade steadily along the cutting line.
12. Avoid forcing the blade through the material.
13. Switch off the machine after completing the cut.
14. Allow all moving parts to stop before handling the tool.

5. Importance of cutting in building construction

1. Produces materials of the required dimensions.
2. Facilitates preparation of timber components.
3. Helps in cutting metal sections for fabrication.
4. Supports installation of pipes and fittings.
5. Facilitates preparation of masonry units.
6. Reduces unnecessary material wastage when measurements are accurate.
7. Improves the fitting of building components.

E. RIVETING



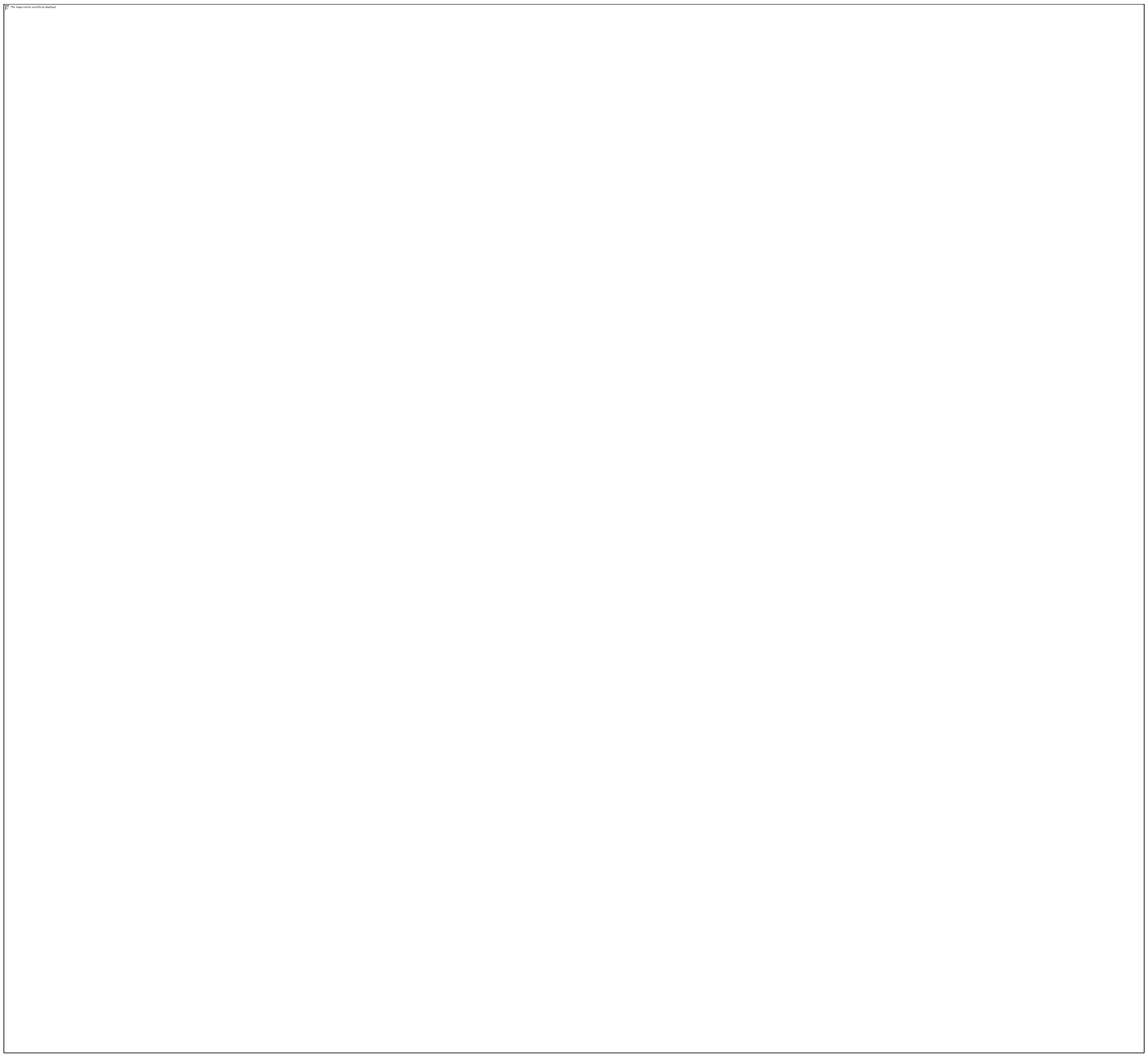



Figure 1.21: Riveting operations using different riveting methods.

1. Meaning of riveting

Riveting is the process of permanently joining two or more materials using a metal fastener known as a rivet.

The rivet is inserted through aligned holes in the materials and mechanically deformed to form a secure joint.

2. Types of riveting

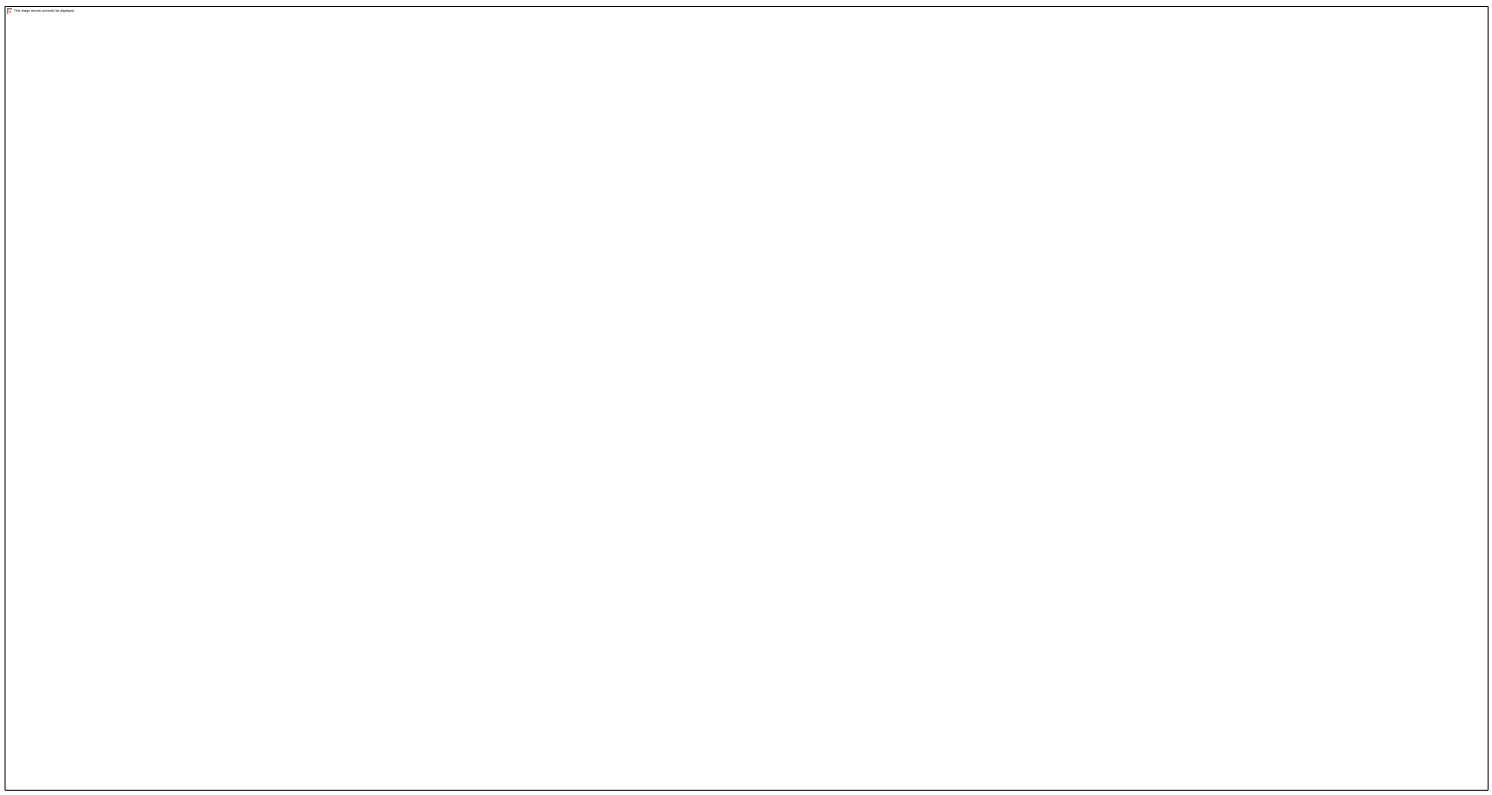
a) Solid riveting

Solid riveting involves inserting a solid rivet through prepared holes and deforming its projecting end to form a second head.



b) Blind riveting

Blind riveting involves installing a special rivet from one side of the workpiece using a rivet driver.



3. Tools used for riveting

1. Pneumatic rivet drivers.
2. Electric rivet drivers.
3. Cordless rivet drivers.
4. Pneumatic riveting hammers.
5. Appropriate manual riveting tools for solid rivets.

4. Procedure for riveting using a blind rivet driver

1. Select the appropriate rivet size and type.
2. Mark the positions of the rivets.
3. Drill holes of the recommended diameter.
4. Align the materials to be joined.
5. Insert the rivet through the prepared hole.
6. Fit the rivet mandrel into the rivet driver's nosepiece.
7. Position the rivet head firmly against the material.
8. Operate the tool to pull the mandrel.
9. Allow the rivet body to expand and secure the materials.
10. The mandrel breaks at the designed point.
11. Remove the tool and inspect the joint.

5. Importance of riveting in building construction

1. Joins metal sheets permanently.
2. Facilitates installation of metal cladding.
3. Supports fabrication of ventilation ducts.
4. Joins suitable aluminium components.
5. Helps in assembling metal frames.
6. Provides an alternative to welding in appropriate applications.
7. Facilitates repairs of certain metal components.

F. HAMMERING

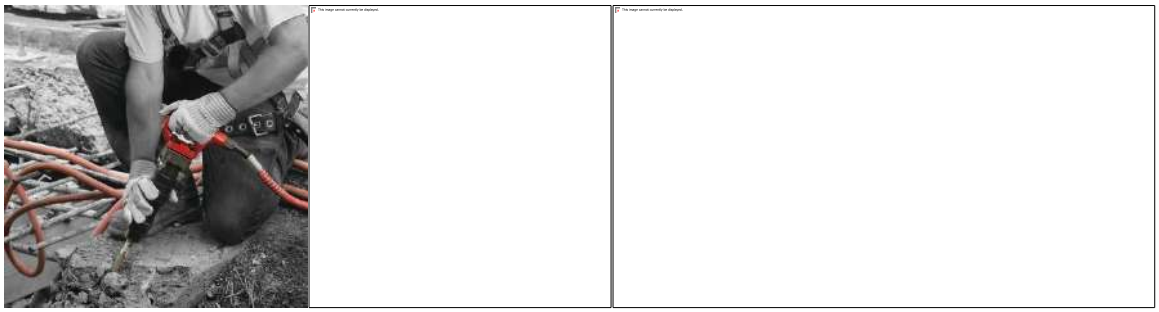


Figure 1.22: Hammering and chipping operations using pneumatic hammers.

1. Meaning of hammering

Hammering is the process of applying repeated impact force to a material or component to drive, shape, break, loosen or secure it.

In powered construction operations, pneumatic hammers use compressed air to produce repeated impact movements.

2. Materials commonly worked on

- Concrete.

- Brickwork.
- Mortar.
- Masonry.
- Metal components.
- Other suitable materials depending on the attachment.

3. Tools used for powered hammering

1. Pneumatic hammers.
2. Pneumatic chipping hammers.
3. Pneumatic demolition hammers.
4. Specialised pneumatic riveting hammers.

4. Procedure for pneumatic hammering

1. Identify the material and the required operation.
2. Select the correct hammer and attachment.
3. Inspect the hammer for damage.
4. Check the compressed-air hose and connections.
5. Confirm the recommended operating pressure.
6. Secure the workpiece or establish a safe working position.
7. Wear suitable protective equipment.
8. Connect the air supply securely.
9. Position the attachment at the working point.
10. Hold the tool firmly.
11. Operate the trigger to begin hammering.
12. Apply controlled pressure without forcing the machine.
13. Stop the machine after completing the operation.
14. Disconnect the air supply before maintenance or attachment changes.

5. Importance of powered hammering

1. Breaks concrete during renovation.
2. Removes old tiles and floor finishes.
3. Removes unwanted mortar.
4. Facilitates demolition of selected masonry sections.
5. Assists in shaping suitable materials.
6. Reduces manual effort during repetitive impact operations.
7. Improves productivity during suitable demolition tasks.

1.1.4 CARE AND GENERAL MAINTENANCE OF CONSTRUCTION HAND POWER TOOLS

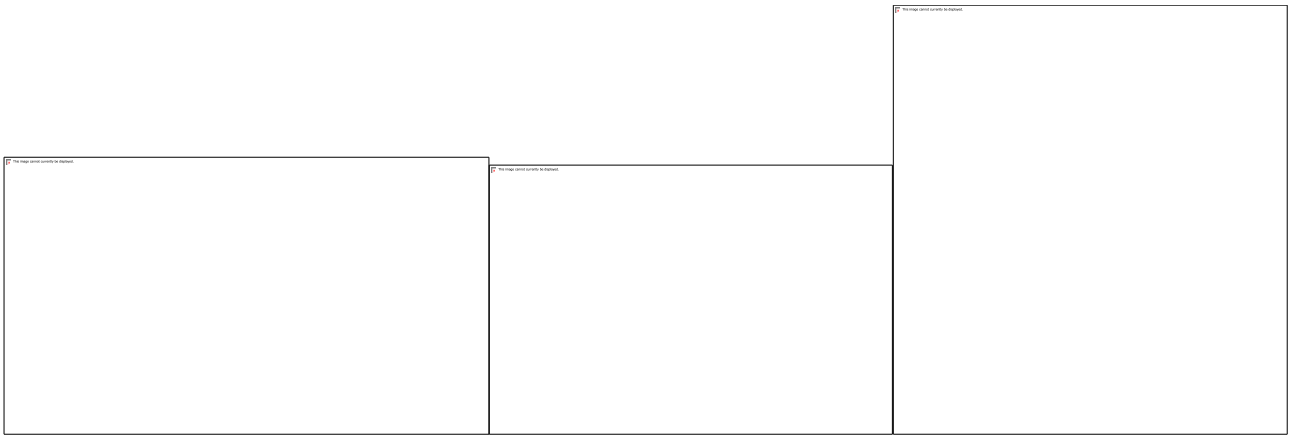


Figure 1.23: Cleaning, inspecting and storing construction power tools.

1. Meaning of tool maintenance

Tool maintenance refers to the activities carried out to keep tools and equipment in good working condition, prevent breakdowns, improve performance and extend their useful lifespan.

Construction hand power tools require regular maintenance because they contain electrical, mechanical and moving components that may wear out during operation.

2. General care and maintenance practices

A. Cleaning tools after use

- Remove dust, grease, concrete particles and wood shavings after every operation.
- Use appropriate cleaning materials.
- Keep ventilation openings free from dirt.
- Avoid exposing electrical components to water.
- Ensure tools are clean before storage.

B. Regular inspection

- Examine tools before and after use.
- Check for cracks, loose components and damaged handles.
- Inspect moving parts for excessive wear.
- Check protective guards and safety switches.
- Report defective tools immediately.

C. Lubrication

- Lubricate moving parts where recommended.
- Use the correct type of lubricant.
- Follow the manufacturer's maintenance instructions.
- Avoid applying excessive lubricant.
- Ensure pneumatic tools receive appropriate lubrication where required.

D. Electrical maintenance

- Inspect power cables for damaged insulation.
- Check plugs and electrical connections.
- Ensure switches operate correctly.
- Avoid using tools with exposed wires.
- Have electrical faults repaired by qualified technicians.

E. Battery maintenance

- Use the recommended battery charger.
- Avoid exposing batteries to excessive heat.
- Keep battery terminals clean and dry.
- Inspect batteries for swelling and physical damage.
- Store batteries according to the manufacturer's instructions.

F. Replacement of worn-out components

- Replace blunt drill bits.
- Replace damaged grinding discs.
- Replace worn cutting blades.
- Replace defective screwdriver bits.
- Replace damaged pneumatic hoses.
- Use accessories recommended for the particular tool.

G. Proper storage

- Store tools in dry and secure places.
- Use suitable toolboxes or storage cases.
- Keep tools away from moisture.
- Arrange tools properly to prevent damage.
- Store accessories separately where appropriate.
- Keep tools away from unauthorised users.

3. Importance of proper maintenance of hand power tools

1. **Extends tool lifespan:** Regular maintenance reduces premature wear and increases the useful life of tools.

2. **Prevents breakdowns:** Inspection helps identify defects before they cause serious equipment failure.

3. **Improves performance:** Properly maintained tools operate more efficiently.

4. **Promotes safety:** Maintenance helps prevent accidents caused by defective cables, damaged guards and loose components.

5. **Reduces repair costs:** Early identification of defects reduces expensive repairs.

6. **Improves workmanship:** Well-maintained tools produce accurate holes, cuts and finishes.

7. **Reduces material wastage:** Properly functioning tools reduce errors during construction operations.

8. **Increases productivity:** Workers spend less time dealing with equipment breakdowns.

9. **Saves time:** Reliable tools reduce unnecessary interruptions.

10. **Promotes responsible resource use:** Proper maintenance reduces the need for frequent replacement.

4. Maintenance schedule for construction hand power tools

Maintenance period	Activity
Before use	Inspect cables, guards, accessories and switches.
After use	Clean the tool and remove dust and debris.
Daily	Check general condition and report defects.
Weekly or as recommended	Inspect attachments, moving parts and connections.
Periodically	Carry out lubrication and servicing as specified by the manufacturer.
When necessary	Replace damaged components and defective accessories.

1.1.5 OCCUPATIONAL HEALTH AND SAFETY WHEN USING HAND POWER TOOLS

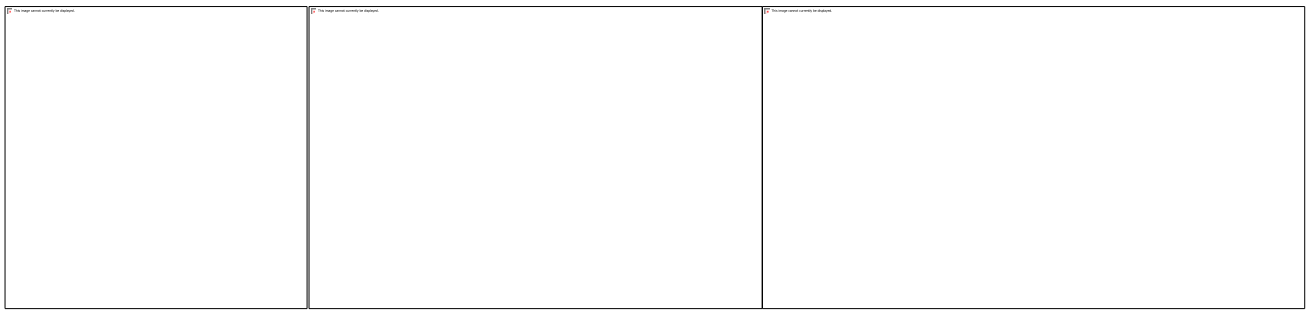


Figure 1.24: Personal protective equipment and safe operation of construction hand power tools.

The use of powered hand tools exposes construction workers to different occupational hazards. These include electric shock, cuts, burns, flying particles, excessive noise, vibration, dust and accidental contact with moving components.

Occupational health and safety measures are therefore necessary to protect workers and other people within the construction environment.

1. Common hazards associated with hand power tools

A. Electric shock

Electric shock occurs when a person comes into contact with an unsafe electrical current.

Causes:

1. Using tools with damaged electrical cables.
2. Operating electrical tools in wet conditions when they are not designed for such conditions.
3. Using defective electrical sockets.
4. Poor electrical connections.
5. Failure to use appropriate electrical protection.

Prevention:

- Inspect electrical cables before use.
- Use suitable protective electrical devices.
- Keep electrical connections dry.
- Do not use defective equipment.
- Ensure electrical repairs are performed by qualified personnel.

B. Cuts and injuries

These injuries may occur when workers accidentally come into contact with rotating blades, discs or cutting accessories.

Prevention:

- Keep hands away from moving parts.
- Use appropriate guards.
- Wear suitable protective equipment.
- Secure workpieces firmly.
- Switch off tools before making adjustments.

C. Flying particles

Grinding, cutting and drilling may produce particles that can injure the eyes and face.

Prevention:

- Wear safety goggles.
- Use suitable face shields.
- Keep other workers away from the work area.
- Ensure protective guards are fitted.

D. Excessive noise

Some powered tools produce high noise levels that may damage hearing after prolonged exposure.

Prevention:

- Wear suitable hearing protection.
- Reduce unnecessary exposure.
- Maintain equipment properly.
- Use quieter equipment where practicable.

E. Dust inhalation

Cutting, drilling and grinding certain materials may produce harmful airborne dust.

Prevention:

- Use suitable dust extraction systems.
- Apply appropriate dust suppression methods.

- Wear a suitable respirator.
- Maintain adequate ventilation.
- Avoid dry cutting where an approved dust-control alternative is required.

F. Vibration

Prolonged exposure to vibration from powered tools may affect the hands and arms.

Prevention:

- Select tools with suitable vibration-control features.
- Maintain equipment properly.
- Limit prolonged exposure.
- Follow recommended operating procedures.
- Use appropriate work-rest arrangements.

2. Personal protective equipment used when operating hand power tools

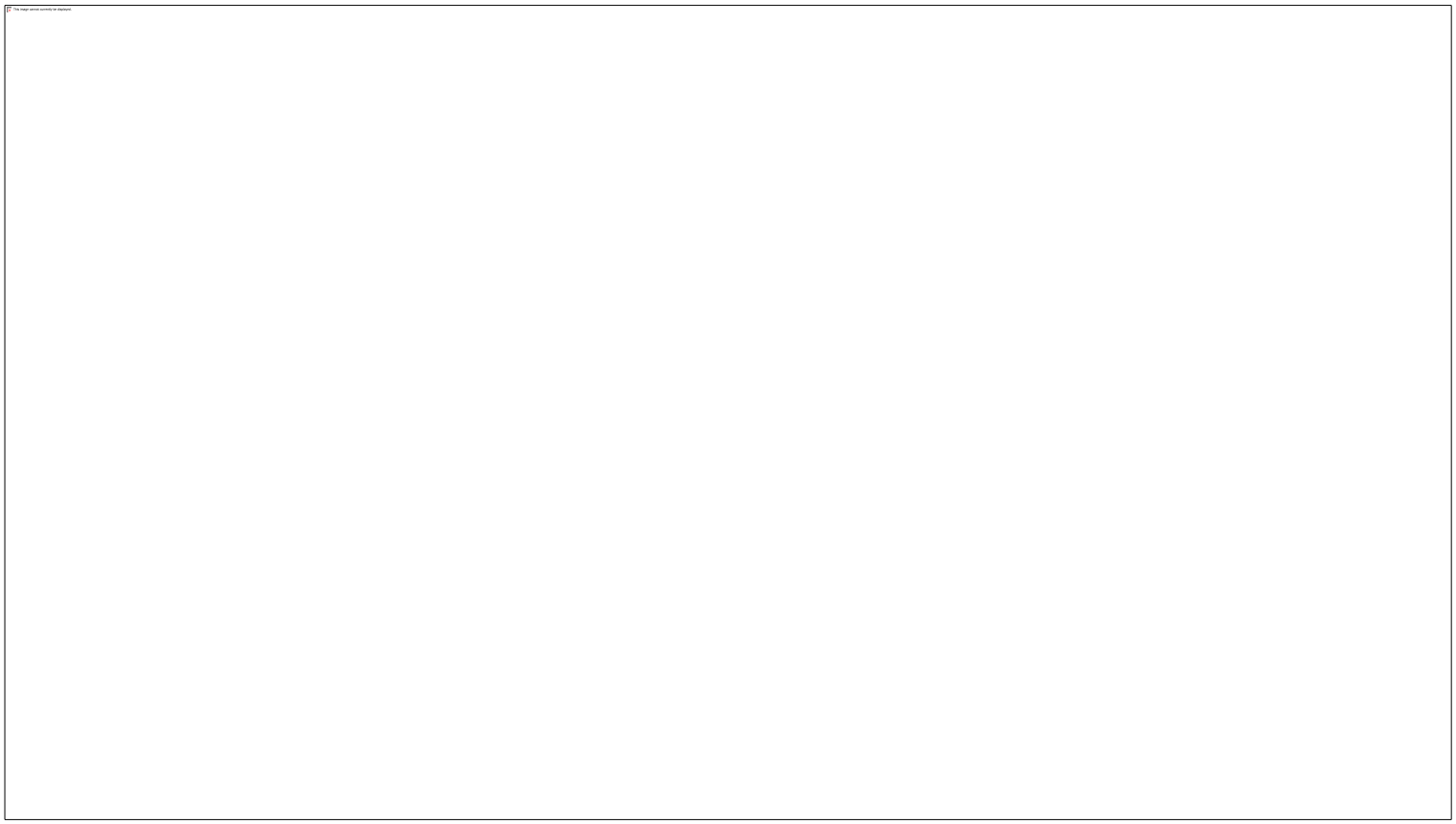


Figure 1.25: Common personal protective equipment used in building construction.

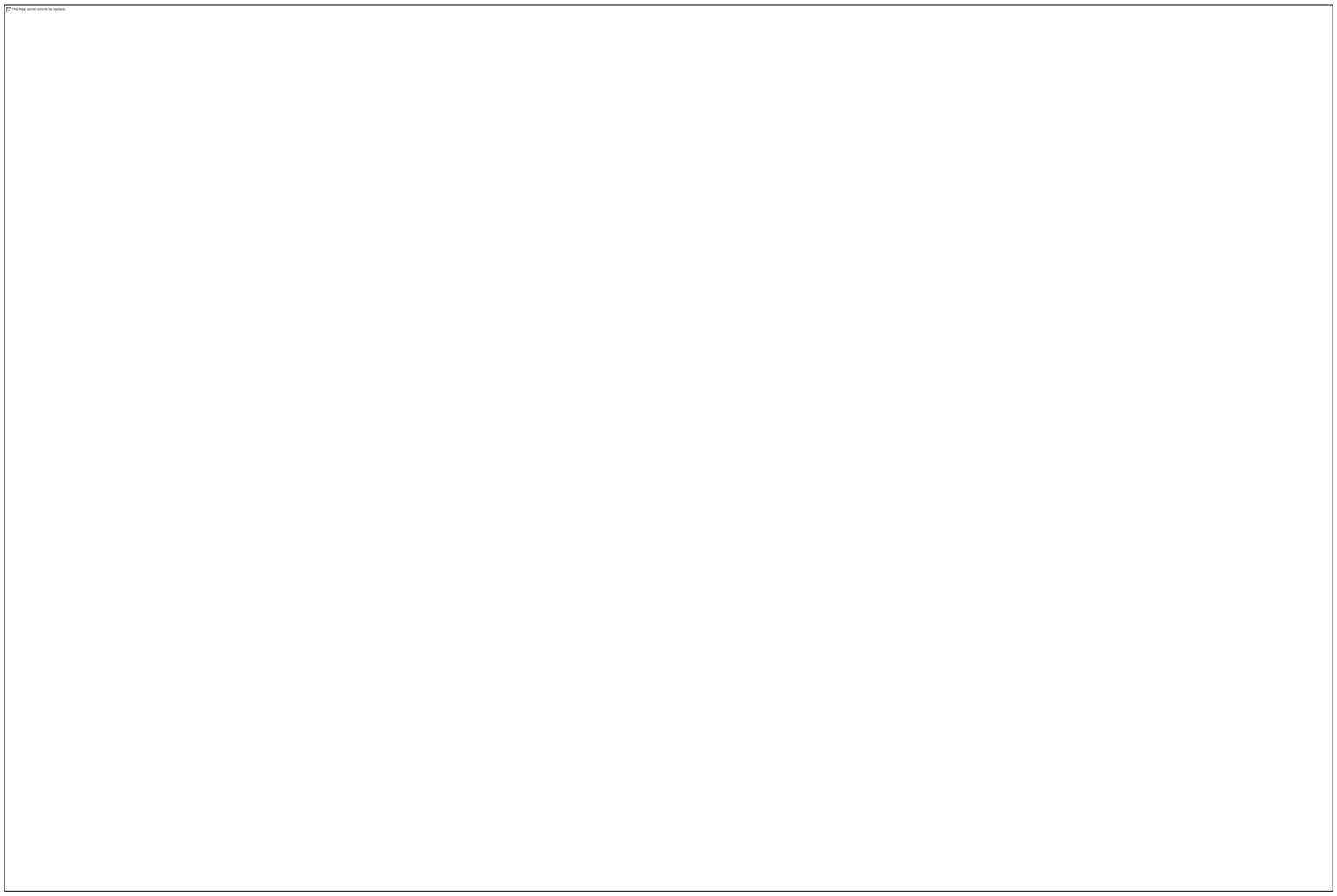
PPE	Function
Safety goggles	Protect the eyes from dust and flying particles.
Face shield	Protects the face from sparks and fragments.
Safety boots	Protect the feet from falling materials and sharp objects.
Ear defenders	Reduce exposure to excessive noise.
Suitable	Protects against hazardous airborne dust when correctly selected.

respirator	
Protective gloves	Protect the hands from appropriate mechanical hazards, provided they do not create an entanglement risk.
Overalls	Protect the body and clothing from dirt and debris.
Hard hat	Protects the head against falling objects.
Reflective vest	Improves worker visibility in construction areas.

3. General safety precautions when using hand power tools

1. Wear appropriate personal protective equipment.
2. Inspect tools before starting work.
3. Use the correct tool for each operation.
4. Read and follow the manufacturer's instructions.
5. Keep hands away from moving blades and rotating components.
6. Never operate tools with damaged cables.
7. Disconnect electrical tools before changing accessories.
8. Remove batteries before servicing cordless tools.
9. Disconnect compressed-air supplies before servicing pneumatic tools.
10. Secure materials before drilling, grinding or cutting.
11. Keep the working area clean and free from obstructions.
12. Avoid using unsuitable tools in wet conditions.
13. Never remove or bypass safety guards.
14. Avoid loose clothing and jewellery near rotating machinery.
15. Ensure adequate lighting and ventilation.
16. Use appropriate dust-control measures.
17. Keep unauthorised persons away from the working area.
18. Never leave running tools unattended.
19. Switch off tools after completing work.
20. Report defective tools immediately.

1.1.6 FACTORS TO CONSIDER WHEN SELECTING CONSTRUCTION HAND POWER TOOLS



Before selecting a hand power tool for a construction operation, the worker should consider the following factors:

1. **Nature of the task:** Select a tool designed for the intended operation, such as drilling, grinding, cutting or riveting.

2. **Type of material:** Consider whether the material is timber, steel, concrete, masonry or plastic.

3. **Power source:** Determine whether electricity, rechargeable batteries or compressed air is available.

4. **Tool capacity:** Select a tool with sufficient power to perform the intended task.

5. **Accuracy required:** Choose a tool capable of achieving the required dimensions and finish.

6. **Portability:** Consider whether the tool needs to be moved frequently around the construction site.

7. **Safety features:** Select tools with suitable guards, safety switches and protective mechanisms.

8. **Cost:** Consider the purchase price, operating expenses and maintenance costs.

9. **Availability of accessories:** Ensure that suitable drill bits, blades, discs and other attachments are available.

10. **Ease of maintenance:** Select tools that can be cleaned, inspected and serviced conveniently.

11. **Durability:** Choose tools made from quality materials that can withstand the intended working conditions.

12. **Operator skills:** Consider whether the worker has the necessary knowledge and competence to operate the tool safely.

1.1.7 COMPARISON OF CONSTRUCTION HAND POWER TOOLS

The following table summarises the tools studied and their main applications.

Power tool	Main operation	Common power source
Electric drill	Drilling	Electricity/battery
Angle grinder	Grinding and suitable cutting	Electricity/battery
Power screwdriver	Screwing and unscrewing	Electricity/battery
Nail gun	Driving nails	Compressed air/electricity/battery
Pneumatic hammer	Hammering and chipping	Compressed air
Rivet driver	Installing rivets	Compressed air/electricity/battery
Handheld power cutter	Cutting	Electricity/battery/fuel, depending on model

1.1.8 PRACTICAL LEARNING ACTIVITIES

These activities should be carried out in a properly equipped school workshop or an approved construction workshop under the supervision of a competent instructor.

Activity 1: Identification of construction hand power tools

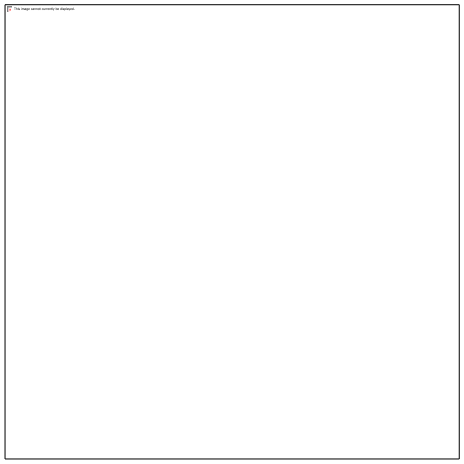


Learning activity:

Learners should:

1. Visit a building construction workshop.
2. Observe different hand power tools.
3. Identify each tool by name.
4. Identify the main components of each tool.
5. Record the power source of each tool.
6. Discuss the construction operations performed by each tool.
7. Present their findings to the class.

Activity 2: Demonstration of drilling



Learning activity:

Learners should:

1. Identify a suitable electric drill.
2. Identify different types of drill bits.
3. Select a suitable drill bit for timber.
4. Mark a drilling position on a timber sample.
5. Secure the timber using a suitable clamp.
6. Observe the instructor demonstrate drilling.
7. Inspect the resulting hole for accuracy and quality.
8. Discuss safety precautions.

Activity 3: Grinding demonstration

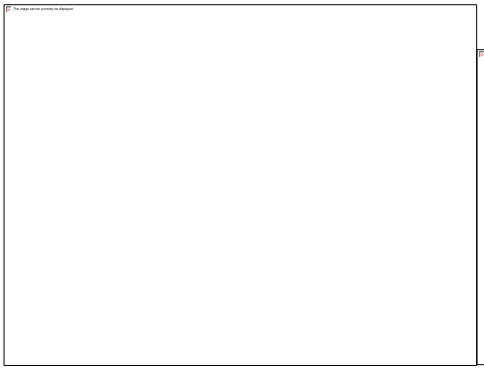
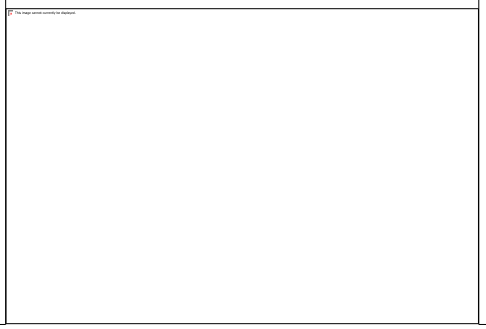
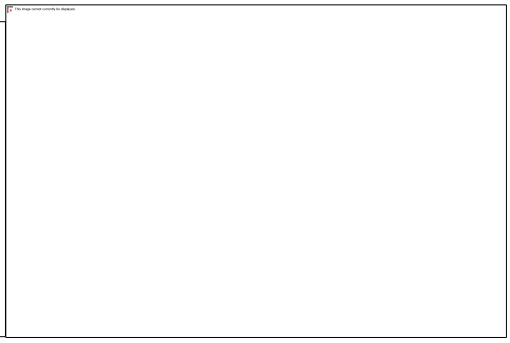


Learning activity:

Learners should:

1. Identify an angle grinder.
2. Identify its main components.
3. Observe different grinding discs.
4. Identify the safety equipment required.
5. Observe the instructor demonstrate grinding.
6. Examine the quality of the finished surface.
7. Discuss appropriate maintenance practices.

Activity 4: Demonstration of screwing and nailing

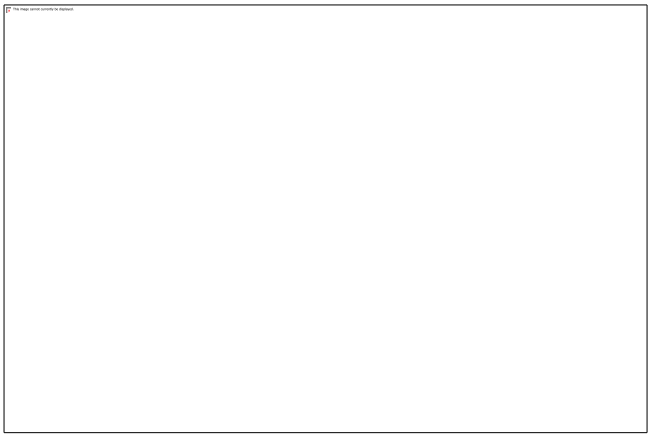




Learning activity:

Learners should:

1. Identify a power screwdriver and nail gun.
2. Identify their main components.
3. Observe how screws are inserted into timber.
4. Observe how nails are driven using a nail gun.
5. Compare the two fastening methods.
6. Discuss appropriate applications.
7. Identify safety precautions.

Activity 5: Riveting demonstration

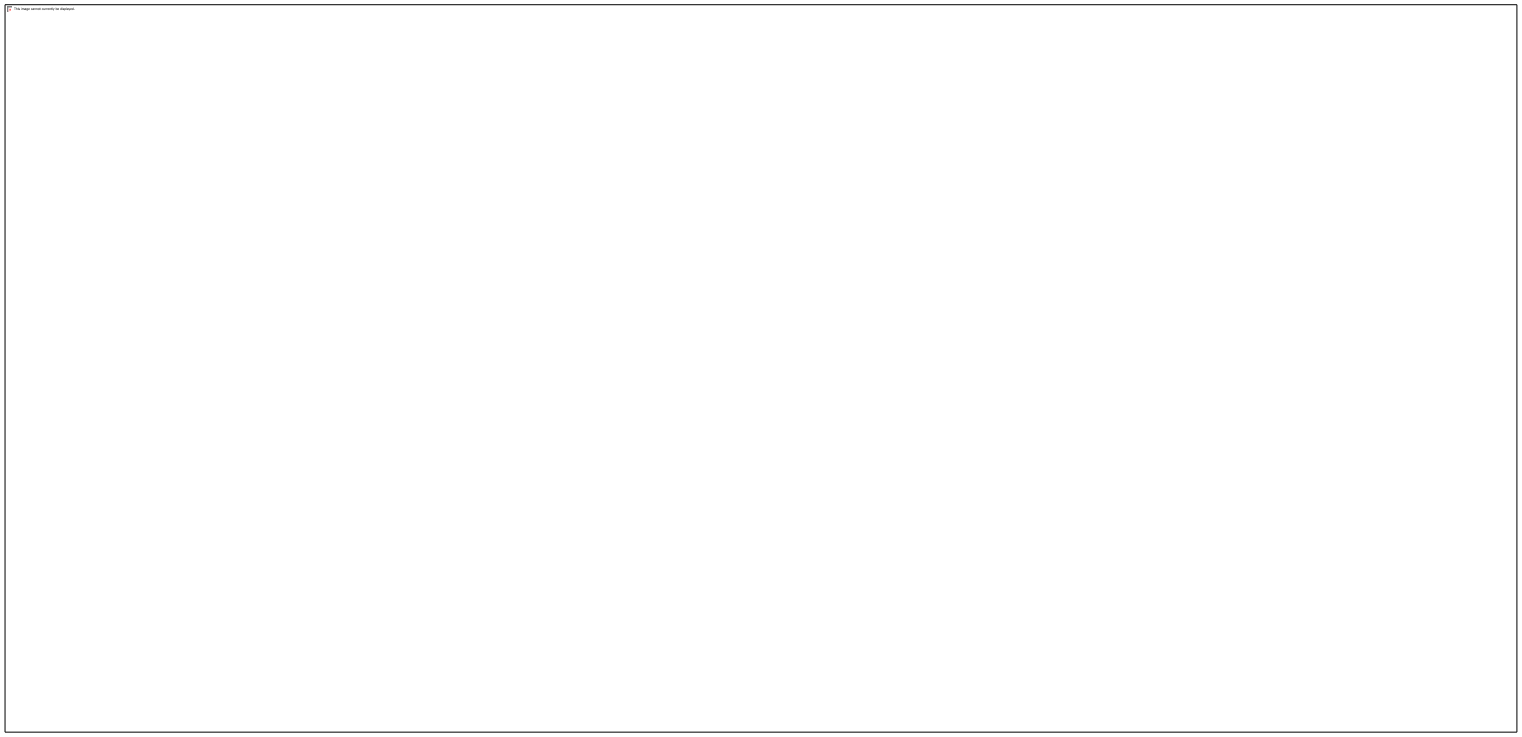


Learning activity:

Learners should:

1. Identify a rivet driver.
2. Observe different types of rivets.
3. Identify the components of a blind rivet.
4. Observe the preparation of holes in metal sheets.
5. Observe the instructor install a blind rivet.
6. Examine the finished joint.
7. Explain the importance of riveting.

Activity 6: Maintenance of power tools



Learning activity:

Learners should:

1. Identify tools requiring routine maintenance.
2. Inspect tools for visible defects.
3. Clean external surfaces.
4. Identify worn-out accessories.
5. Demonstrate appropriate storage procedures.
6. Prepare a simple maintenance record.
7. Explain the importance of proper tool maintenance.

REVISION QUESTIONS

STRAND 1.0: FOUNDATION OF BUILDING CONSTRUCTION

SUB-STRAND 1.1: CONSTRUCTION HAND POWER TOOLS

SECTION A: MULTIPLE-CHOICE QUESTIONS

Choose the correct answer from the alternatives provided.

1. Which of the following best describes a construction hand power tool?

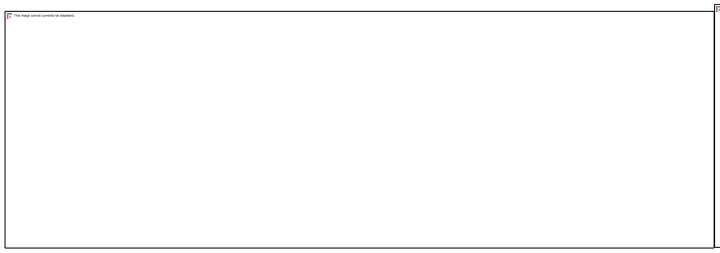
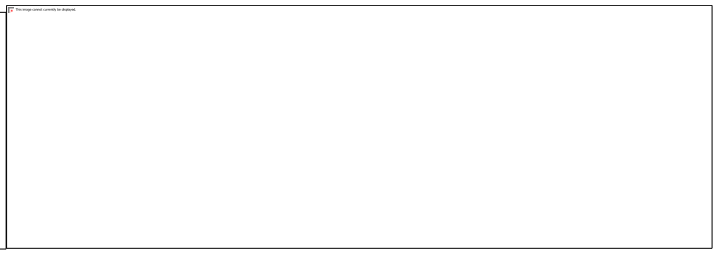
A. A tool operated exclusively using manual force.

B. A portable tool powered by electricity, batteries, compressed air or fuel.

C. A machine used exclusively for transporting construction materials.

D. An instrument used only for measuring building dimensions.

2. Which power tool is primarily used for making cylindrical holes in construction materials?

3. The component of an electric drill that holds the drill bit is known as the:

A. Trigger. B. Chuck. C. Handle. D. Motor.

4. Which type of drill combines rotational movement with a hammering action?

A. Hammer drill.

B. Power screwdriver.

C. Straight grinder.

D. Circular saw.

5. Which power tool is most suitable for removing rust from metal surfaces?

A. Nail gun.

B. Power screwdriver.

C. Angle grinder.

D. Rivet driver.

6. The main purpose of a disc guard on an angle grinder is to:

A. Increase the rotational speed.

B. Protect the operator from fragments and debris.

C. Increase the thickness of the disc.

D. Reduce the weight of the machine.

7. Which power tool is specifically designed to drive screws into construction materials?

A. Pneumatic hammer.

B. Power screwdriver.

C. Rivet driver.

D. Grinder.

8. A nail gun is mainly used for:

A. Making cylindrical holes.

B. Grinding metal surfaces.

C. Driving nails into materials.

D. Removing rust.

9. Which source of energy is commonly used to operate pneumatic hammers?

A. Solar energy.

B. Compressed air.

C. Manual energy.

D. Chemical energy from cement.

10. Which of the following tools is used to join metal sheets using rivets?

A. Circular saw.

B. Electric drill.

C. Rivet driver.

D. Angle grinder.

11. A circular saw is primarily used for:

A. Cutting timber and manufactured boards.

B. Driving nails.

C. Installing rivets.

D. Grinding welds.

12. Which component of a nail gun holds nails before they are driven into the material?

A. Chuck. B. Magazine.

C. Spindle. D. Base plate.

13. Which of the following tools commonly operates using compressed air?

A. Cordless screwdriver.

B. Pneumatic hammer.

C. Corded circular saw.

D. Electric drill.

14. The process of removing small amounts of material using an abrasive wheel is called:

A. Riveting. B. Screwing.

C. Grinding. D. Drilling.

15. Which of the following is an appropriate maintenance practice for an electric drill?

A. Storing it in a wet environment.

B. Using blunt drill bits.

C. Cleaning ventilation openings regularly.

D. Immersing it in water after use.

16. Before changing a grinding disc, the operator should:

A. Increase the motor speed.

B. Disconnect the power supply.

C. Remove the side handle.

D. Pour water into the motor.

17. Which PPE is particularly important for protecting the eyes during grinding?

A. Safety goggles or a suitable face shield.

B. Cotton apron only.

C. Safety boots only.

D. Reflective jacket only.

18. What is the main function of a drill bit?

A. Holding nails.

B. Making holes in materials.

C. Grinding metal.

D. Joining metal sheets.

19. Which factor should be considered when selecting a hand power tool?

A. Colour of the tool only.

B. Weight of the operator only.

C. Nature of the construction task.

D. Brand name only.

20. Which of the following is an advantage of using hand power tools?

A. They always eliminate workplace accidents.

B. They increase the speed and efficiency of construction operations.

C. They do not require maintenance.

D. They can perform all construction operations.

21. The process of permanently joining materials using metal fasteners called rivets is known as:

A. Grinding.

B. Drilling.

C. Riveting.

D. Cutting.

22. Which tool is suitable for making curved cuts in timber?

A. Jigsaw.

B. Pneumatic hammer.

C. Rivet driver.

D. Nail gun.

23. A blind rivet is particularly useful because it can be installed:

A. Only using a manual hammer.

B. From one side of the workpiece.

C. Without preparing a hole.

D. Only in concrete.

24. Why should the correct drill bit be selected before drilling?

A. To increase the weight of the drill.

B. To improve accuracy and produce the required hole.

C. To reduce the length of the drill.

D. To eliminate the need for maintenance.

25. Which of the following should be done when a pneumatic air hose is damaged?

A. Continue working at reduced pressure.

B. Cover the damaged section with paper.

C. Stop using the tool and replace or repair the hose appropriately.

D. Increase the air pressure.

26. Which operation involves driving a threaded fastener into a material?

A. Grinding. B. Screwing.

C. Riveting. D. Chipping.

27. Which of the following is a suitable reason for maintaining construction hand power tools?

A. To increase their weight.

B. To reduce their accuracy.

C. To extend their useful lifespan.

D. To increase the risk of breakdowns.

28. Which component of a handheld circular saw supports the machine on the workpiece?

A. Chuck.

B. Magazine.

C. Base plate.

D. Air inlet.

29. Which of the following is an important safety measure when using a nail gun?

A. Pointing the tool towards other workers.

B. Bypassing the safety contact mechanism.

C. Keeping fingers away from the nosepiece.

D. Leaving the trigger pressed when not working.

30. Which of the following best explains the meaning of tool maintenance?

A. Buying new tools every month.

B. Keeping tools in good working condition through inspection, cleaning and servicing.

C. Using tools without checking their condition.

D. Painting tools after every operation.

SECTION B: SHORT-ANSWER AND STRUCTURED QUESTIONS

1. Introduction to construction hand power tools

a) Define the term construction hand power tools. (2 marks)

b) State four sources of power used to operate construction hand power tools. (4 marks)

c) Give four characteristics of construction hand power tools. (4 marks)

d) State five advantages of using hand power tools in building construction. (5 marks)

2. Drills

a) Define a drill. (2 marks)

b) Identify four types of drills used in building construction. (4 marks)

c) State six parts of an electric drill. (6 marks)

d) Explain five uses of drills in building construction. (5 marks)

e) Describe five care and maintenance practices for electric drills. (5 marks)

3. Grinders

a) Define grinding. (2 marks)

b) Name three types of grinders used in construction. (3 marks)

c) Identify five main parts of an angle grinder. (5 marks)

d) Explain five uses of grinders in building construction. (5 marks)

e) State five safety precautions to observe when using an angle grinder. (5 marks)

4. Power screwdrivers

a) Define a power screwdriver. (2 marks)

b) Identify three types of power screwdrivers. (3 marks)

c) State five uses of power screwdrivers in building construction. (5 marks)

d) Explain five maintenance practices for power screwdrivers. (5 marks)

5. Nail guns

a) Define a nail gun. (2 marks)

b) Identify three types of nail guns. (3 marks)

c) State five components of a nail gun. (5 marks)

d) Explain five applications of nail guns in building construction. (5 marks)

e) State five safety precautions when operating a nail gun. (5 marks)

6. Pneumatic hammers

a) Explain the meaning of the term pneumatic. (2 marks)

b) Define a pneumatic hammer. (2 marks)

c) Identify three types of pneumatic hammers. (3 marks)

d) Explain five uses of pneumatic hammers in building construction. (5 marks)

e) State five maintenance practices for pneumatic hammers. (5 marks)

7. Rivet drivers

a) Define a rivet driver. (2 marks)

b) Explain the meaning of riveting. (2 marks)

c) Identify three types of rivet drivers. (3 marks)

d) State five uses of rivet drivers in building construction. (5 marks)

e) Describe the procedure for installing a blind rivet using a powered rivet driver. (6 marks)

8. Handheld power cutters

a) Define a handheld power cutter. (2 marks)

b) Identify four types of handheld power cutters. (4 marks)

c) State five components of a handheld power cutter. (5 marks)

d) Explain five uses of handheld power cutters in building construction. (5 marks)

e) State four maintenance practices for handheld power cutters. (4 marks)

9. Construction operations

a) Define each of the following terms:

i. Drilling. (2 marks)

ii. Grinding. (2 marks)

iii. Screwing. (2 marks)

iv. Cutting. (2 marks)

v. Riveting. (2 marks)

b) Differentiate between drilling and grinding. (4 marks)

c) Explain four factors to consider when selecting a power tool for a construction operation. (4 marks)

10. Care, maintenance and safety

a) Define tool maintenance. (2 marks)

b) State eight general maintenance practices for construction hand power tools. (8 marks)

c) Explain six reasons why proper maintenance of power tools is important. (6 marks)

d) Identify six types of personal protective equipment used when operating construction hand power tools. (6 marks)

e) Explain eight general safety precautions when using construction hand power tools. (8 marks)

1.1.11 SUMMARY OF THE SUB-STRAND

In this sub-strand, the learner has studied construction hand power tools, their components, applications, maintenance and safety requirements.

The major tools covered include:

Tool	Main function
Drill	Making holes in construction materials.
Grinder	Grinding, smoothing and suitable cutting operations.
Power screwdriver	Inserting and removing screws.
Nail gun	Driving nails into construction materials.
Pneumatic hammer	Breaking, chipping and hammering.
Rivet driver	Installing rivets to join materials.
Handheld power cutter	Cutting construction materials.

The learner has also acquired knowledge and skills in:

- Identifying different construction hand power tools.
- Understanding their components and functions.
- Selecting appropriate tools for specific construction operations.
- Performing drilling, grinding, screwing, cutting, riveting and hammering operations.
- Maintaining construction hand power tools.
- Applying occupational health and safety practices.
- Selecting appropriate personal protective equipment.

STRAND 1.0: FOUNDATION OF BUILDING CONSTRUCTION

SUB-STRAND 1.2: CONSTRUCTION PLANT

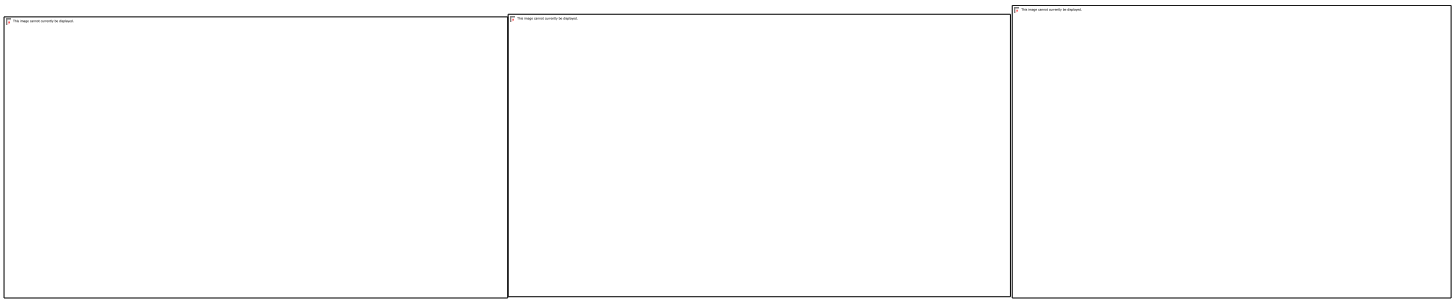


Figure 1.1: Examples of construction plant used in building and civil engineering works.

INTRODUCTION TO THE SUB-STRAND

Construction projects involve various activities that require specialised machinery and equipment to move materials, prepare construction sites, excavate foundations, transport construction materials, lift heavy loads, mix concrete and compact soil.

In small construction projects, some activities can be performed using manual labour and simple hand tools. However, large and complex projects require construction plant to improve efficiency, reduce manual effort, save time and achieve the required quality of work.

Construction plant is widely used in Kenya in:

- Residential building construction.
- Commercial building construction.
- Road construction and maintenance.
- Bridge construction.
- Dam and water infrastructure projects.
- Excavation of building foundations.
- Construction of drainage systems.
- Concrete production and placement.
- Site preparation and landscaping.
- Industrial and infrastructure development.

Examples of construction projects in Kenya that require construction plant include highways, residential estates, commercial buildings, schools, hospitals, bridges and water supply infrastructure.

Learning outcomes

By the end of this sub-strand, the learner should be able to:

1. Identify different types of construction plant used in building construction.
2. Classify construction plant according to their functions and applications.
3. Explain the functions of different construction plant.
4. Describe the use of construction plant in earthmoving, hauling, lifting, concreting and compacting operations.
5. Explain the importance of construction plant in building construction.

6. Identify environmental impacts associated with the use of construction plant.
7. Suggest appropriate measures for controlling environmental impacts caused by construction plant.
8. Demonstrate responsible and safe practices when working around construction plant.

1.2.1 MEANING OF CONSTRUCTION PLANT

1. Definition of construction plant

Construction plant refers to specialised machinery, equipment and mechanical installations used to carry out construction activities such as excavation, earthmoving, material transportation, lifting, concrete mixing, compaction and demolition.

Construction plant is designed to perform heavy, repetitive or specialised construction operations that would be difficult, slow or expensive to carry out using manual labour alone.

Examples include:

1. Excavators.
2. Bulldozers.
3. Graders.
4. Poker vibrators.
5. Concrete mixers.
6. Backhoe loaders.
7. Compactors.
8. Cranes.
9. Dump trucks.
10. Front loaders.

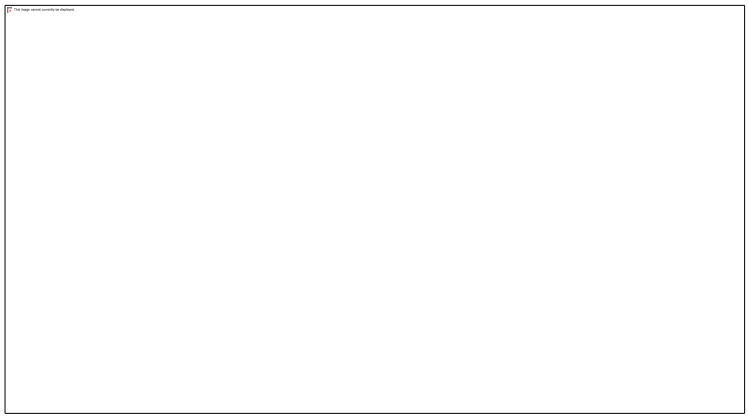


Figure 1.2: Construction plant and equipment used for different construction activities.

2. Characteristics of construction plant

Construction plant has the following characteristics:

1. **Mechanical operation:** Most construction plant operates using mechanical systems such as engines, hydraulic systems, gears, pumps and motors.

2. **High working capacity:** Construction plant can handle large quantities of materials within a relatively short period.

3. **Specialised functions:** Different machines are designed for particular construction activities, such as lifting, excavation, transportation and compaction.

4. **High power output:** Most heavy construction plant has powerful engines or motors to perform demanding construction operations.

5. **High productivity:** Construction plant enables workers to complete tasks faster than using manual labour alone.

6. **Large physical size:** Many types of construction plant are large and require adequate working and storage space.

7. **Skilled operation:** Most construction plant requires trained and competent operators.

8. **Maintenance requirements:** Construction plant requires regular inspection, servicing, lubrication and repair.

9. **Fuel or energy consumption:** Many machines use diesel, petrol or electricity, while some use hybrid or battery systems.

10. **Safety requirements:** Construction plant must be operated according to established safety procedures to prevent accidents.

3. Difference between construction plant and construction tools

Construction plant and construction tools are both important in building construction, but they differ in size, capacity and application.

Construction plant	**Construction tools**
Generally consists of machinery and specialised equipment.	Generally consists of hand-operated or portable equipment.
Performs heavy or large-scale operations.	Performs smaller or more specialised operations.
Often requires a trained operator.	Many tools can be operated by individual workers after appropriate training.
Usually has higher operating capacity.	Generally has lower working capacity.
Examples include excavators, cranes and bulldozers.	Examples include hammers, chisels and hand saws.

1.2.2 CLASSIFICATION OF CONSTRUCTION PLANT

Construction plant can be classified according to the type of work it performs, its mobility, method of operation and application on a construction site.

A. Classification according to function

This is the classification based on the main construction activity performed by the machinery.

1. Earthmoving plant

Earthmoving plant consists of machinery used to excavate, move, spread, level and remove soil, rock and other materials during construction.

Examples:

- Excavators.
- Bulldozers.
- Graders.
- Backhoe loaders.
- Front loaders.



Figure 1.3: Examples of earthmoving construction plant.

2. Hauling and transportation plant

Hauling plant consists of machinery used to transport construction materials from one location to another within or outside the construction site.

Examples:

- Dump trucks.
- Tipper trucks.
- Articulated dump trucks.
- Site transporters.



Figure 1.4: Hauling and transportation plant.

3. Lifting plant

Lifting plant consists of machinery used to raise, lower and move heavy construction materials and equipment vertically or horizontally.

Examples:

- Tower cranes.

- Mobile cranes.
- Crawler cranes.
- Truck-mounted cranes.
- Hoists.

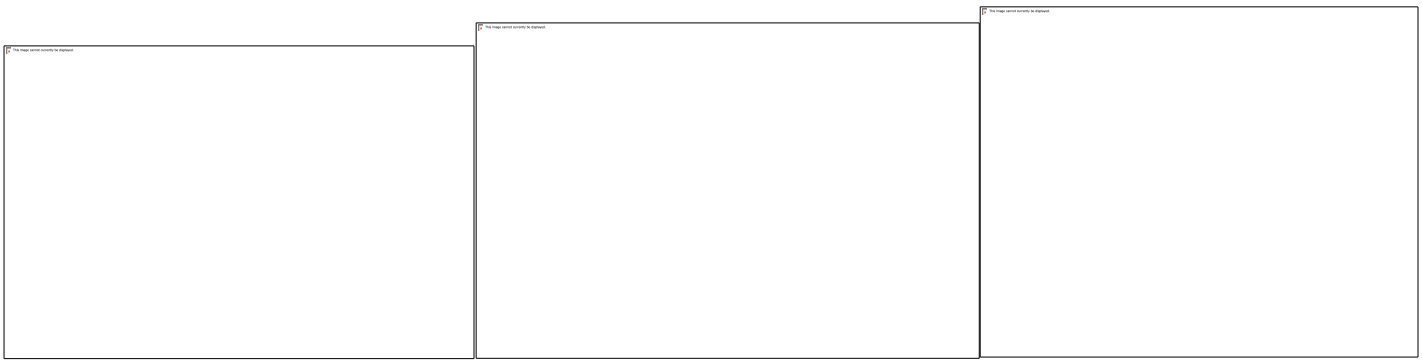


Figure 1.5: Different types of lifting plant.

4. Concreting plant

Concreting plant consists of machinery and equipment used in the preparation, transportation, placing and consolidation of concrete.

Examples:

- Concrete mixers.
- Concrete batching plants.
- Concrete pumps.
- Poker vibrators.
- Concrete placing equipment.



Figure 1.6: Machinery and equipment used in concreting operations.

5. Compaction plant

Compaction plant consists of machinery used to compress soil, gravel, asphalt and other construction materials to increase their density and stability.

Examples:

- Vibratory rollers.
- Smooth-wheel rollers.
- Sheep-foot rollers.
- Plate compactors.

- Rammer compactors.



Figure 1.7: Different types of compaction plant.

B. Classification according to mobility

Construction plant can also be classified according to how it moves from one working location to another.

1. Mobile plant

Mobile plant consists of machinery designed to move from one location to another during construction operations.

Examples:

- Excavators.
- Bulldozers.
- Graders.
- Dump trucks.
- Front loaders.
- Mobile cranes.

2. Stationary plant

Stationary plant consists of machinery designed to operate from a fixed position rather than move around the construction site during normal operation.

Examples:

- Fixed concrete batching plants.
- Stationary concrete mixers.
- Fixed crushing plants.
- Stationary concrete pumps.

3. Semi-mobile plant

Semi-mobile plant consists of equipment that can be relocated between working locations but is generally set up in a particular position during operation.

Examples:

- Mobile concrete batching plants.
- Portable crushing plants.

- Trailer-mounted compressors.

1.2.3 TYPES OF CONSTRUCTION PLANT AND THEIR FUNCTIONS

The following are major types of construction plant commonly used in building construction and related civil engineering works.

A. EXCAVATORS

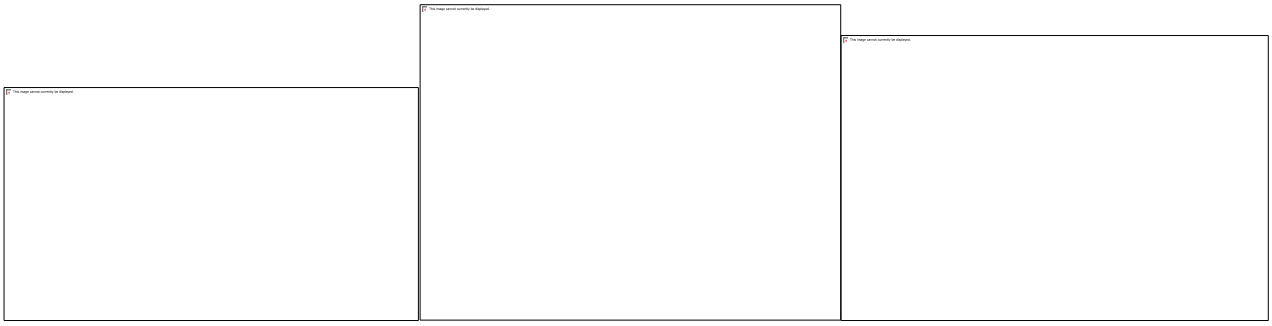


Figure 1.8: Hydraulic excavators used for excavation and earthmoving.

1. Meaning of an excavator

An excavator is a heavy construction machine used for digging, excavating, removing and loading soil, rock and other materials.

It operates using a hydraulic system that controls the movement of its boom, arm and bucket.

Excavators are commonly used during site preparation, foundation excavation, trench digging, demolition and material handling.

2. Main components of an excavator

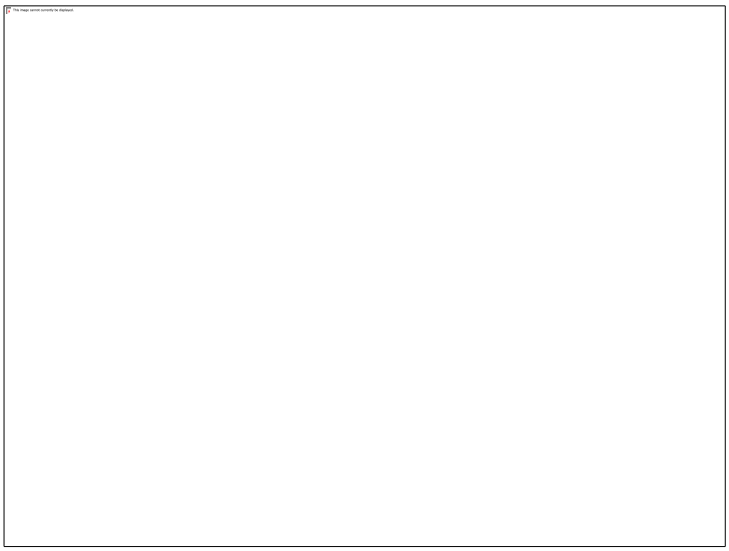


Figure 1.9: Main components of a hydraulic excavator.

1. **Boom:** The long structural arm attached to the upper part of the machine. It supports the arm and bucket and enables the machine to reach different working heights and distances.

2. **Arm or dipper:** Connects the boom to the bucket. It extends and retracts to control the digging reach.

3. **Bucket:** The attachment used for digging, scooping and carrying soil or other materials.

4. **Cab:** The enclosed operator's compartment where the machine is controlled.

5. **Hydraulic cylinders:** Produce the force required to move the boom, arm and bucket.

6. **Hydraulic hoses:** Carry pressurised hydraulic fluid between components.

7. **Engine:** Provides the power required to operate the machine.

8. **Tracks or wheels:** Support the excavator and enable it to move around the site.

9. **Counterweight:** Balances the machine and improves stability during operation.

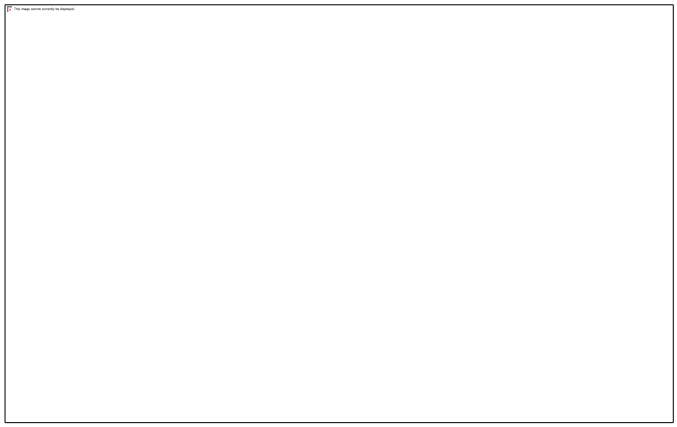
10. **Undercarriage:** Supports the lower part of the machine and contains the track or wheel system.

11. **Slew mechanism:** Enables the upper structure of the excavator to rotate relative to the undercarriage.

12. **Operator controls:** Allow the operator to control digging, movement and rotation.

3. Types of excavators

a) Crawler excavator

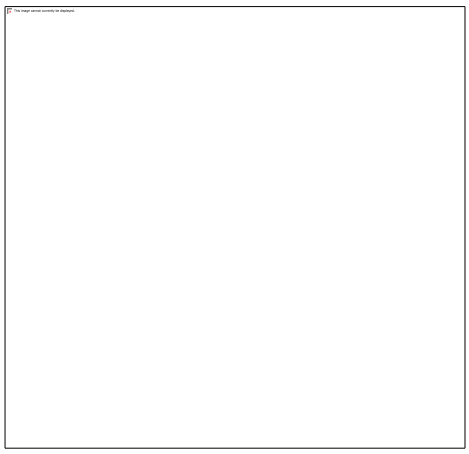


A crawler excavator is fitted with continuous tracks instead of ordinary wheels.

Uses:

- Excavating building foundations.
- Digging trenches.
- Working on uneven ground.
- Excavating large quantities of soil.
- Carrying out demolition operations using suitable attachments.

b) Wheeled excavator



A wheeled excavator is fitted with rubber tyres, enabling it to move conveniently on suitable firm surfaces.

Uses:

- Excavating on urban construction sites.
- Roadside drainage works.
- Utility trench excavation.
- Loading construction materials.
- Performing excavation on paved or firm ground.

c) Mini excavator



A mini excavator is a small excavating machine designed for restricted working spaces and smaller construction projects.

Uses:

- Digging small building foundations.
- Excavating drainage trenches.
- Landscaping.
- Digging service trenches.
- Working in confined construction areas.

4. Functions and uses of excavators in building construction

1. **Excavating foundations:** Used to remove soil when preparing trenches and pits for building foundations.

2. **Trench excavation:** Used to dig trenches for water pipes, drainage systems, sewer lines and electrical services.

3. **Site clearance:** Used to remove unwanted soil, vegetation and certain construction debris using appropriate attachments.

4. **Loading materials:** Used to load excavated soil, gravel and other materials into dump trucks.

5. **Demolition:** Specialised excavators fitted with suitable attachments can demolish selected building structures.

6. **Landscaping:** Used to reshape land, remove unwanted soil and prepare areas for landscaping.

7. **Ditch excavation:** Used to create drainage channels and ditches.

8. **Material handling:** Used to move materials around a construction site with suitable attachments.

9. **Rock breaking:** Can be fitted with hydraulic breakers for breaking rock and hard concrete.

10. **Pond and pit excavation:** Used to excavate ponds, pits and other ground features.

5. Advantages of excavators

1. They excavate large quantities of soil within a short period.
2. They reduce dependence on manual digging.
3. They improve productivity.
4. They can work in different ground conditions when appropriately selected.
5. They can perform several operations using interchangeable attachments.
6. They improve efficiency in foundation preparation.
7. They can reach relatively deep excavation areas.
8. They facilitate loading and removal of excavated materials.

6. Limitations of excavators

1. They have high purchase and operating costs.
2. They require skilled operators.
3. They consume fuel or electrical energy.
4. They may cause noise pollution.
5. They require adequate working space.
6. They may damage underground services if excavation is not properly planned.
7. They can cause soil disturbance and compaction.
8. They require regular maintenance.

B. BULLDOZERS

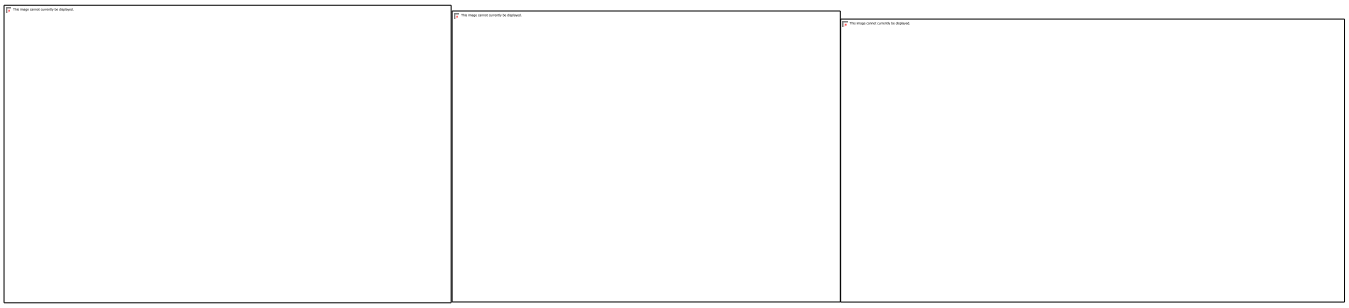


Figure 1.10: Bulldozers used for land clearing and earthmoving.

1. Meaning of a bulldozer

A bulldozer is a heavy construction machine fitted with a large metal blade at the front, which is used to push soil, sand, rocks and other materials from one location to another.

Most bulldozers are fitted with tracks that provide traction and stability when working on rough or soft ground.

Some bulldozers are fitted with a rear attachment known as a ripper, which is used to loosen hard soil and rock.

2. Main components of a bulldozer

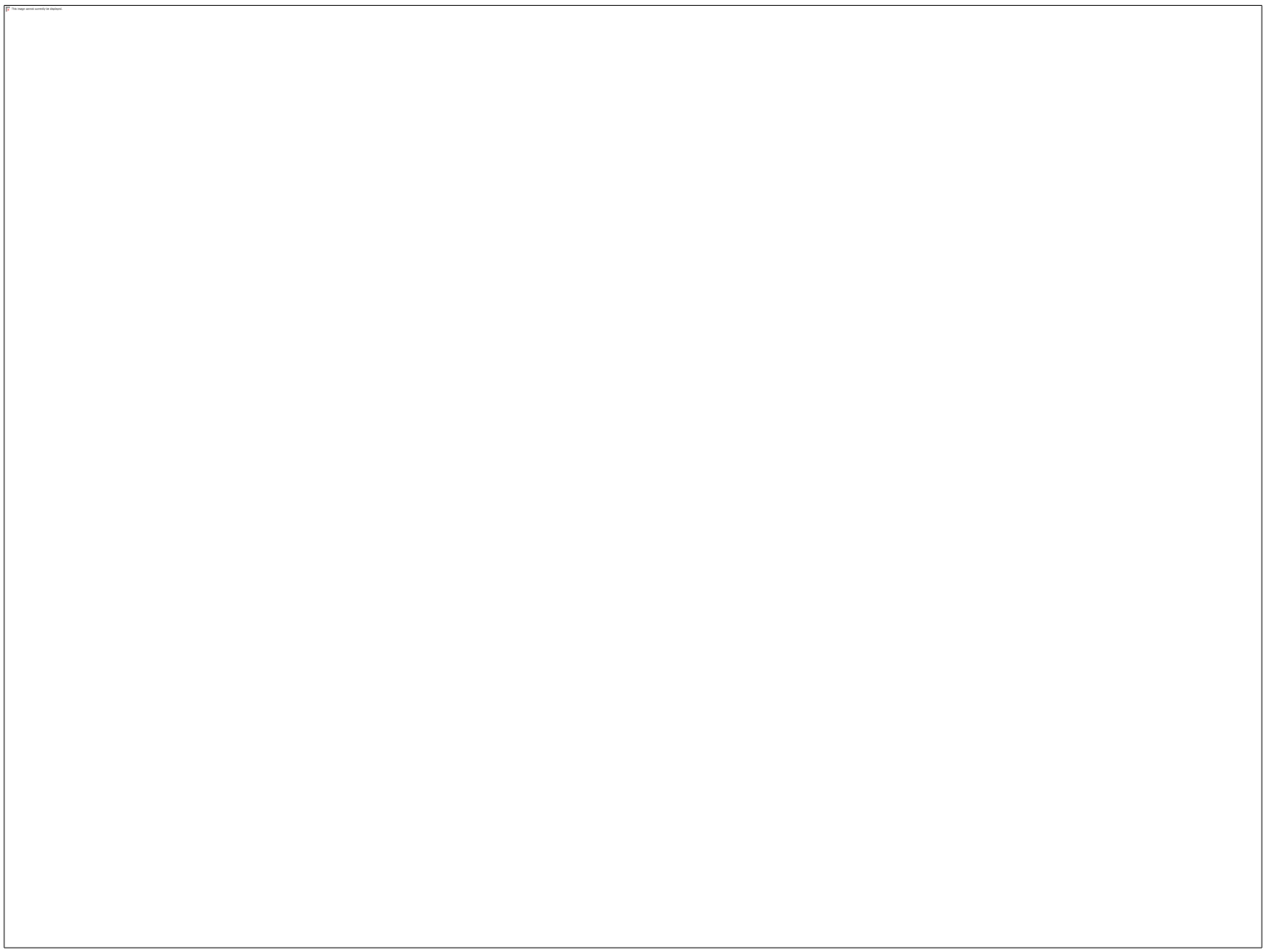


Figure 1.11: Main components of a crawler bulldozer.

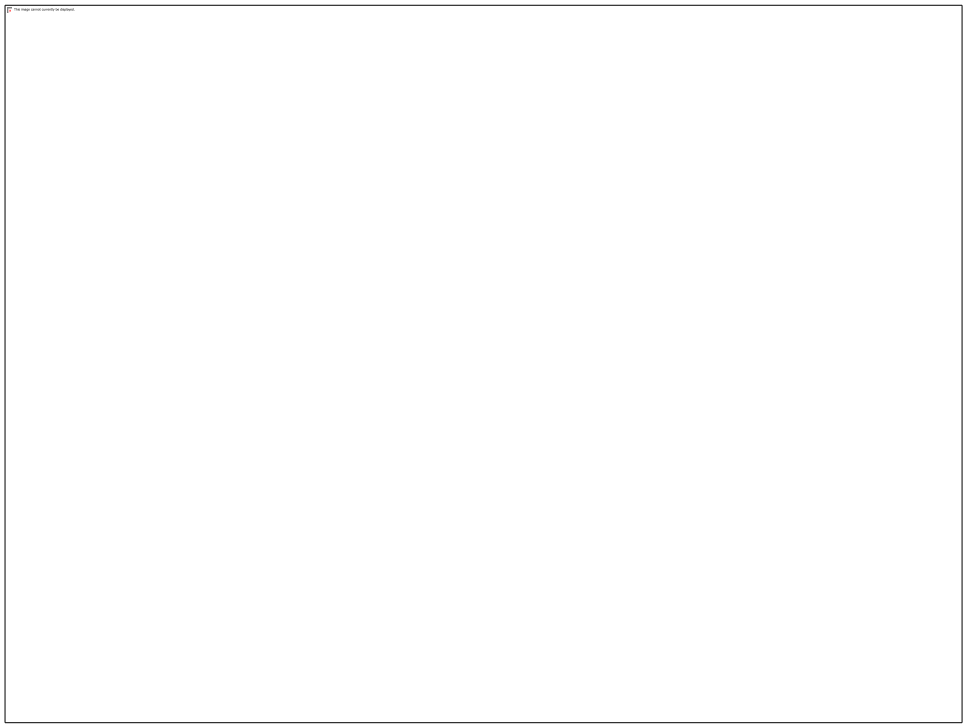
1. **Blade:** The large metal attachment at the front used for pushing and spreading materials.
2. **Engine:** Supplies the power required to move and operate the machine.
3. **Tracks:** Enable the machine to move over different ground surfaces while providing traction.
4. **Cab:** Provides the operator with a protected working space.
5. **Hydraulic cylinders:** Control the raising, lowering and tilting of the blade.
6. **Ripper:** A rear attachment used to loosen hard ground and rock.
7. **Undercarriage:** Supports the tracks and lower structure.
8. **Transmission system:** Transfers engine power to the tracks.

9. **Operator controls:** Enable the operator to control the machine's movement and blade.

10. **Counterweight:** Helps maintain machine balance in applicable models.

3. Types of bulldozer blades

a) Straight blade (S-blade)



A straight blade is relatively short and has a straight shape.

Uses:

- Fine grading.
- Spreading soil.
- Moving small quantities of material.
- Levelling construction surfaces.

b) Universal blade (U-blade)

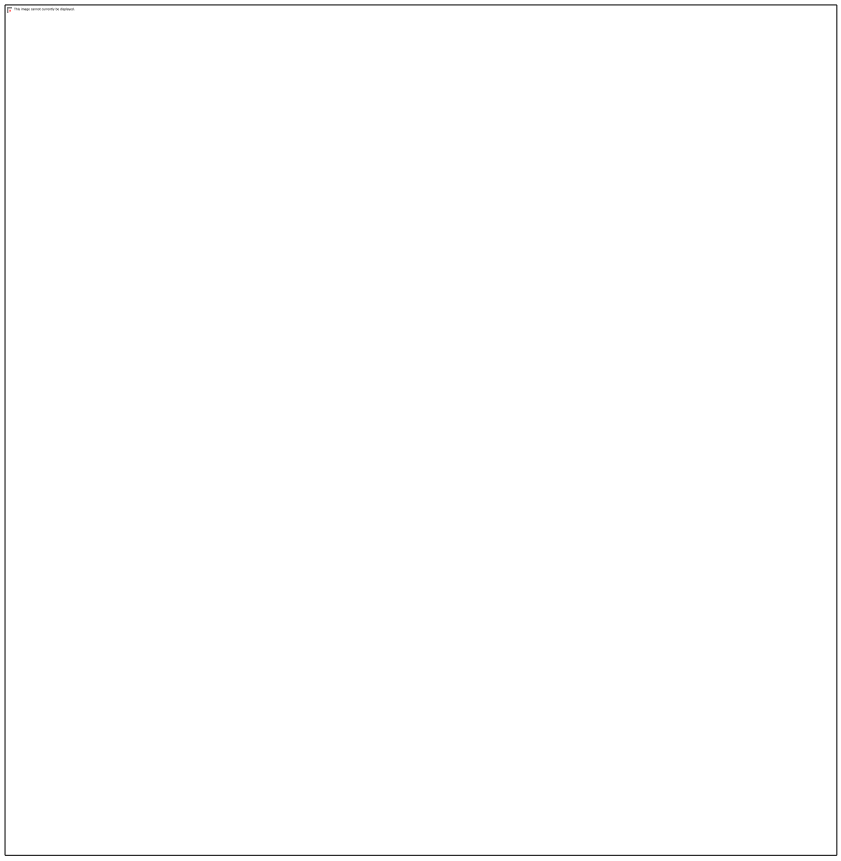


A universal blade has curved sides that help retain materials while pushing them.

Uses:

- Moving large quantities of soil.
- Pushing loose materials.
- Handling materials over relatively long distances.

c) Combination blade (S-U blade)



A combination blade combines characteristics of straight and universal blades.

Uses:

- General earthmoving.
- Pushing soil.
- Spreading construction materials.

4. Functions and uses of bulldozers

1. **Land clearing:** Removing vegetation, bushes and other surface obstructions during site preparation.
2. **Topsoil removal:** Removing the upper layer of soil before construction begins.
3. **Earthmoving:** Pushing soil from one location to another.
4. **Site levelling:** Spreading and levelling soil to prepare a construction site.
5. **Road construction:** Preparing road formation and moving earth materials.
6. **Backfilling:** Pushing suitable soil into excavated areas.
7. **Stockpile management:** Moving and spreading loose construction materials.
8. **Ripping hard ground:** Loosening hard soil and rock using a ripper attachment.
9. **Demolition support:** Pushing and clearing suitable demolition debris.
10. **Embankment preparation:** Helping form earth embankments and raised ground sections.

5. Advantages of bulldozers

1. They have high pushing capacity.
2. They are suitable for rough terrain.
3. They can clear large areas of land.
4. They reduce manual labour.
5. They improve site preparation speed.
6. They can operate with different blade attachments.
7. They provide good traction on suitable soft ground.

6. Limitations of bulldozers

1. They are expensive to purchase and operate.
2. They require trained operators.
3. They consume considerable fuel.
4. They produce noise and exhaust emissions.
5. They are not ideal for transporting materials over long distances.
6. They can disturb natural soil conditions.
7. They require regular servicing.

C. GRADERS

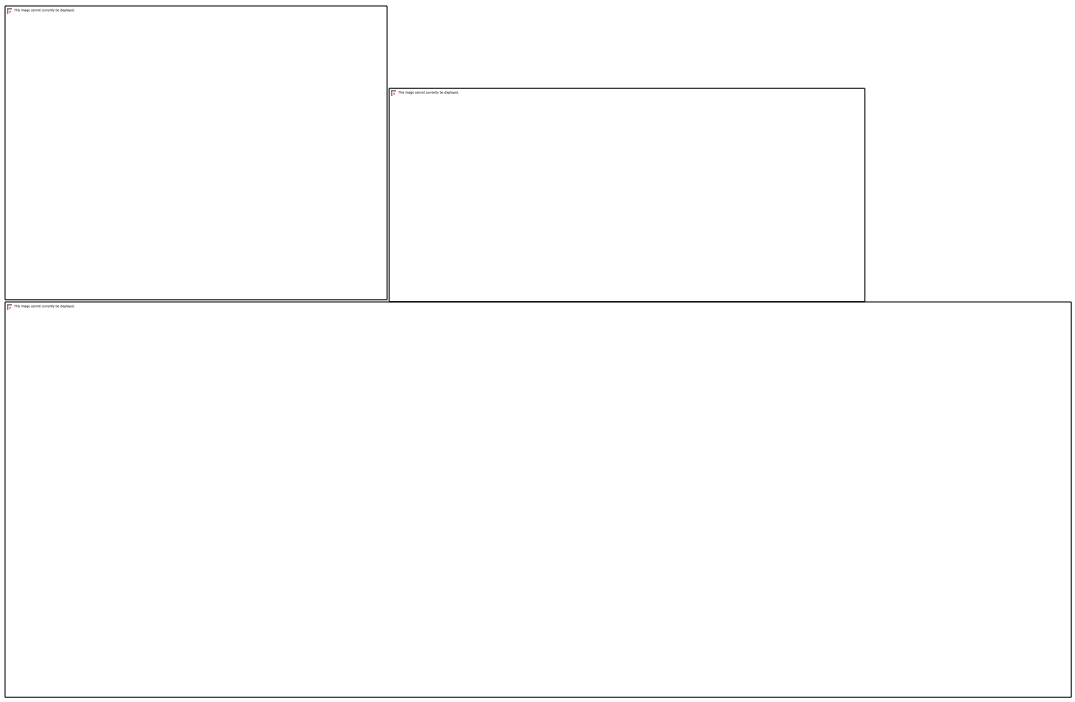


Figure 1.12: Motor graders used for levelling and finishing construction surfaces.

1. Meaning of a grader

A grader is a construction machine fitted with a long adjustable blade positioned between its front and rear wheels. It is mainly used for levelling, smoothing and shaping soil, gravel and other construction surfaces.

The blade can be raised, lowered, tilted and angled to achieve the required surface profile.

Graders are commonly used in road construction, site preparation, drainage formation and finishing earthworks.

2. Main components of a motor grader

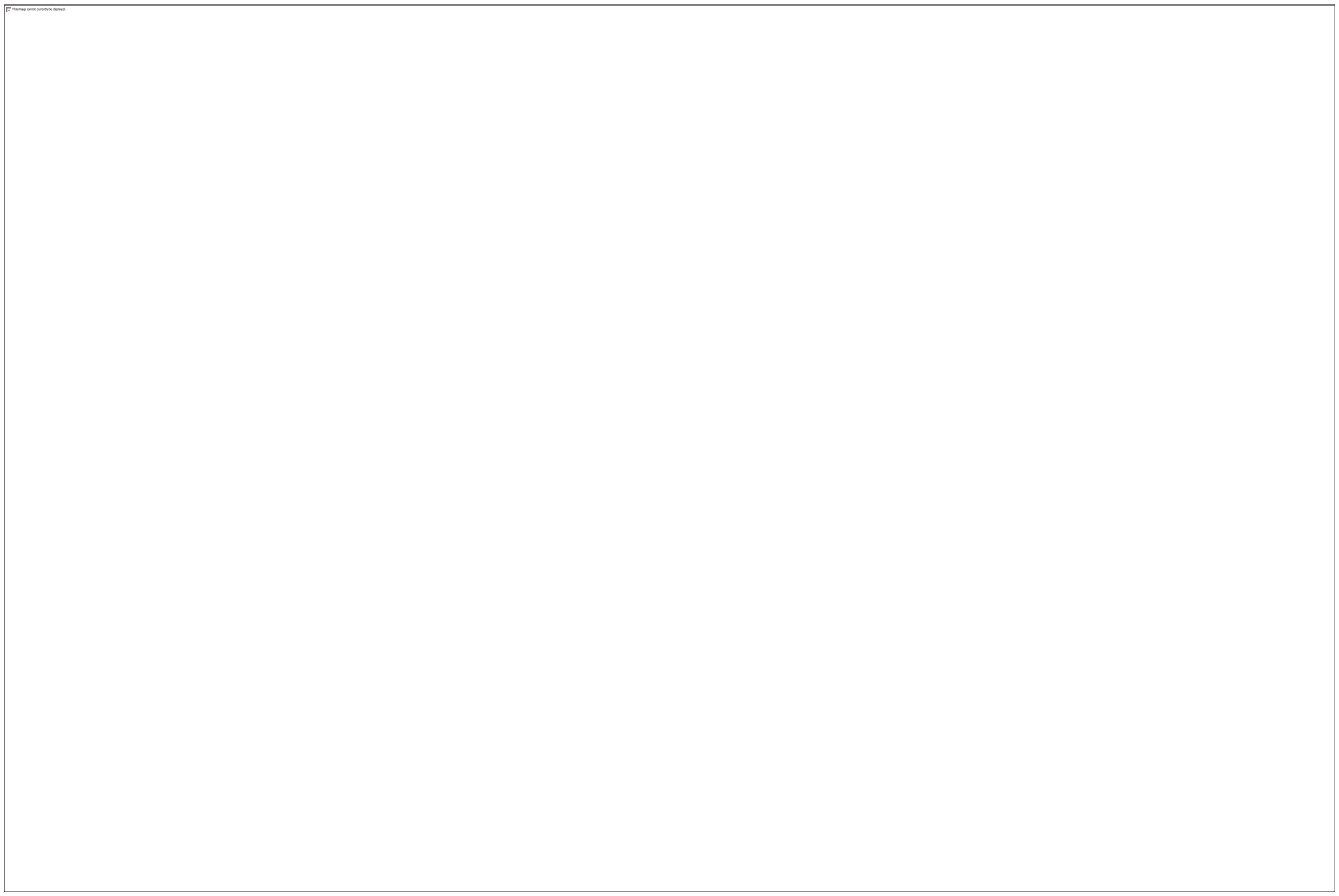


Figure 1.13: Main components of a motor grader.

1. **Moldboard blade:** The long adjustable metal blade used for cutting, spreading and levelling soil.
2. **Engine:** Provides the power required to operate the machine.
3. **Cab:** The operator's compartment containing controls and monitoring instruments.
4. **Front axle:** Supports the front wheels and helps guide the machine.
5. **Rear tandem wheels:** Provide traction and support the machine.
6. **Circle mechanism:** Allows the blade to rotate and change its working angle.
7. **Hydraulic cylinders:** Raise, lower and tilt the blade.
8. **Articulation joint:** Allows the front and rear sections of some graders to bend relative to each other.
9. **Scarifier:** A set of teeth used to loosen compacted soil or other hard surfaces.
10. **Steering system:** Controls the direction of movement.
11. **Transmission:** Transfers power from the engine to the driving wheels.

3. Types of graders

a) Motor grader

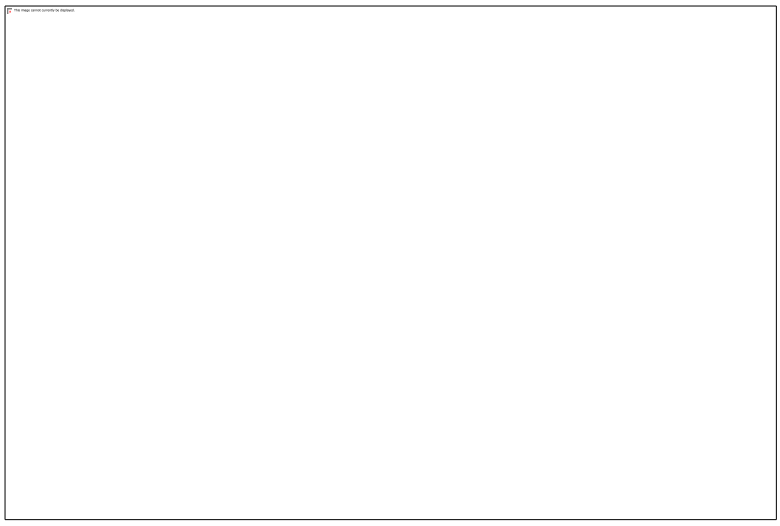


A motor grader is a self-propelled machine fitted with a long adjustable blade.

Uses:

- Levelling road surfaces.
- Shaping construction sites.
- Forming road camber.
- Preparing surfaces for compaction.
- Creating drainage gradients.

b) Towed grader



A towed grader is an attachment pulled by a tractor or another suitable towing machine.

Uses:

- Levelling unpaved surfaces.
- Spreading loose soil.
- Maintaining access roads.

- Carrying out light grading operations.

4. Functions and uses of graders in building construction

1. **Site levelling:** Used to produce an even surface before constructing buildings.

2. **Road preparation:** Used to level and shape surfaces before laying road materials.

3. **Formation of gradients:** Used to create appropriate slopes that direct surface water away from buildings and roads.

4. **Drainage formation:** Helps form drainage channels and road-side slopes.

5. **Spreading materials:** Distributes gravel, soil and other loose construction materials evenly.

6. **Surface finishing:** Produces smooth and even surfaces after major earthmoving operations.

7. **Camber formation:** Shapes road surfaces to facilitate drainage of rainwater.

8. **Ground preparation:** Prepares construction areas before compaction.

9. **Soil scarification:** Loosens compacted surface materials using a suitable attachment.

10. **Road maintenance:** Restores the shape and smoothness of gravel roads.

5. Advantages of graders

1. Produce relatively smooth and accurate surfaces.
2. Improve the quality of road formation.
3. Help create appropriate drainage gradients.
4. Reduce manual levelling work.
5. Improve construction productivity.
6. Distribute construction materials evenly.
7. Can perform different grading operations.

6. Limitations of graders

1. Require skilled operators.
2. Have relatively high operating costs.
3. Require adequate working space.
4. Consume fuel.
5. Generate noise and exhaust emissions.
6. Are not suitable for deep excavation.
7. Require regular inspection and maintenance.

D. POKER VIBRATORS

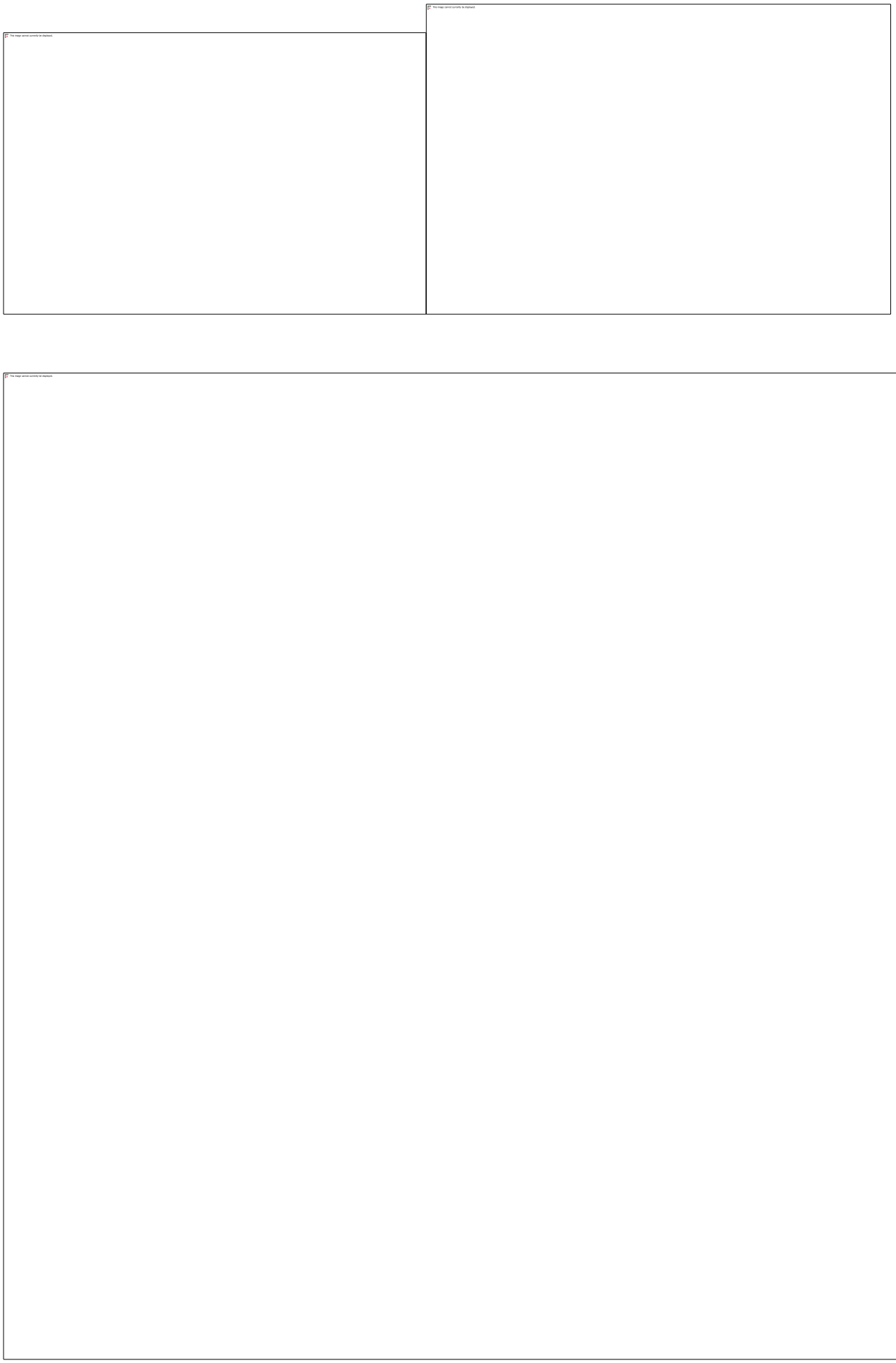


Figure 1.14: Poker vibrators used for compacting freshly placed concrete.

1. Meaning of a poker vibrator

A poker vibrator, also known as an internal concrete vibrator or immersion vibrator, is a powered construction tool used to compact freshly placed concrete by producing rapid vibrations through a vibrating head inserted into the concrete.

The vibrations help reduce trapped air pockets and allow the concrete to settle around reinforcement bars and inside formwork.

Poker vibrators are important in the construction of reinforced concrete foundations, columns, beams, slabs, walls and other structural elements.

2. Importance of vibrating concrete

Fresh concrete may contain trapped air pockets after mixing, transportation and placement.

If these air pockets are not properly removed, they may lead to:

- Honeycombing.
- Voids within concrete.
- Poor bonding around reinforcement bars.
- Reduced concrete density.
- Weak concrete sections.
- Poor surface finish.
- Increased permeability.

Vibration helps concrete particles rearrange and settle more closely together, improving consolidation when correctly performed.

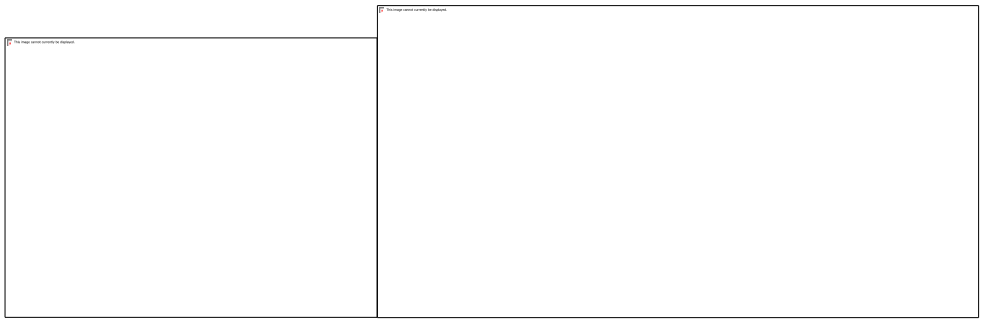




Figure 1.15: Comparison of poorly consolidated concrete and properly consolidated concrete.

3. Main components of a poker vibrator

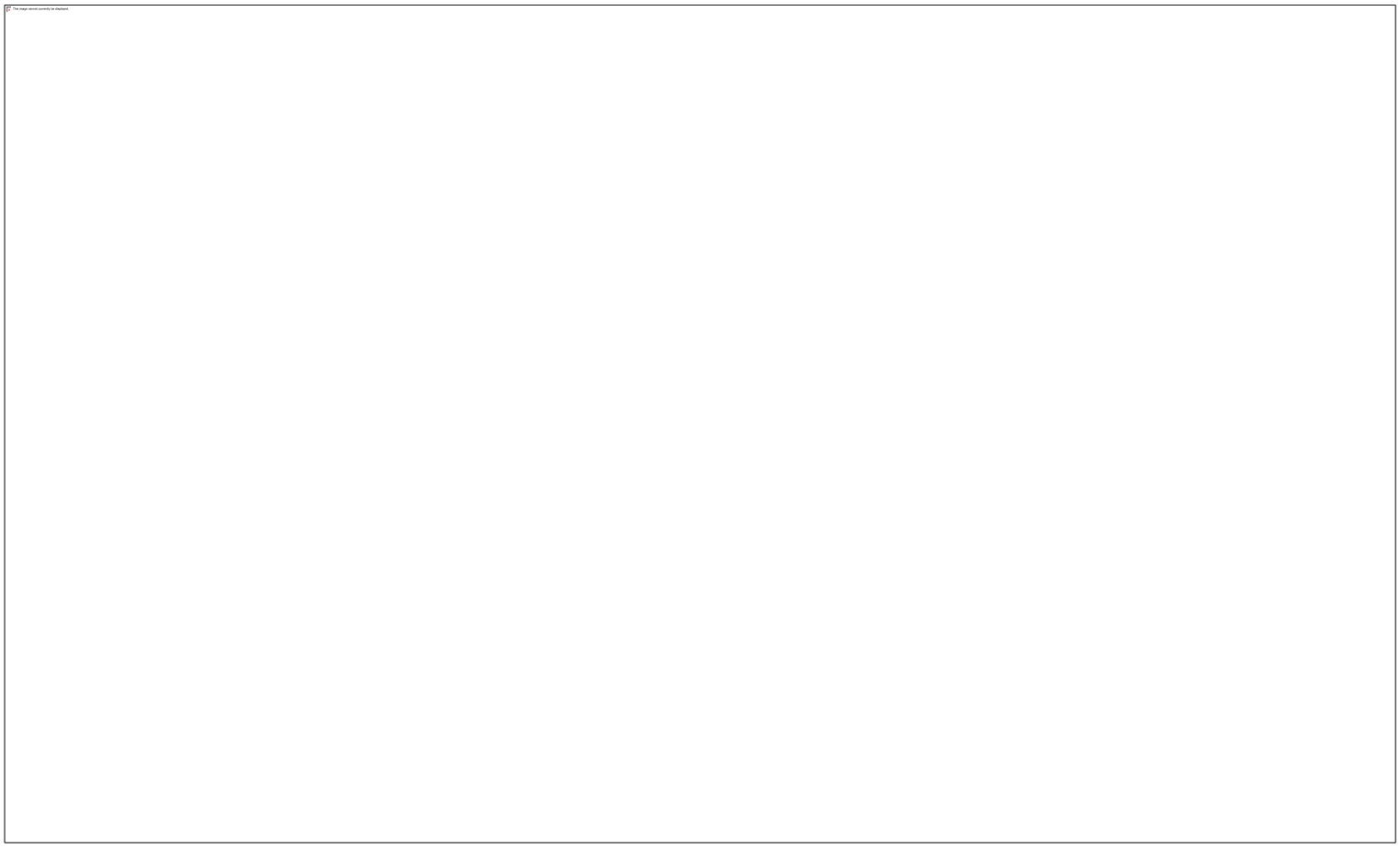


Figure 1.16: Main components of an internal concrete poker vibrator.

1. **Vibrating head or poker:** The metal cylindrical part inserted into fresh concrete to produce vibration.

2. **Flexible shaft:** Transmits mechanical movement from the drive unit to the vibrating head in applicable models.

3. **Motor:** Supplies mechanical power to operate the vibrating mechanism.

4. **Drive unit:** Produces the movement required to generate vibrations.

5. **Power cable:** Supplies electricity to electrically operated models.

6. **Handle:** Enables the operator to hold and control the equipment.

7. **Switch:** Starts and stops the vibrator.

8. **Protective housing:** Protects the internal components.

9. **Coupling:** Connects the vibrating head or shaft to the drive unit.

10. **Bearing assembly:** Supports moving components in applicable models.

4. Types of concrete vibrators

a) Internal vibrator (poker vibrator)



An internal vibrator is inserted directly into freshly placed concrete.

Uses:

- Compacting concrete in foundations.
- Consolidating concrete in columns.
- Compacting reinforced concrete beams.
- Consolidating concrete in walls.
- Compacting concrete in thick slabs.

b) External vibrator



An external vibrator is attached to the outside of formwork to transmit vibrations into the concrete.

Uses:

- Consolidating concrete in narrow formwork.
- Compacting concrete in precast units.
- Vibrating concrete where internal access is restricted.
- Consolidating concrete in selected wall and column forms.

c) Surface vibrator



A surface vibrator operates on the upper surface of freshly placed concrete.

Uses:

- Compacting suitable concrete floor slabs.
- Finishing concrete surfaces.
- Consolidating relatively shallow concrete layers.
- Preparing concrete floors for further finishing.

5. Functions and uses of poker vibrators in building construction

1. **Removing trapped air:** Helps release air bubbles trapped in fresh concrete.
2. **Concrete consolidation:** Helps concrete particles settle closely together.
3. **Reducing honeycombing:** Minimises voids caused by inadequate concrete compaction.
4. **Improving concrete density:** Produces properly consolidated concrete.
5. **Improving reinforcement coverage:** Helps concrete flow around reinforcement bars.
6. **Improving surface quality:** Reduces visible voids and improves the finish of concrete surfaces.
7. **Compacting foundation concrete:** Helps consolidate concrete in foundation bases and ground beams.
8. **Compacting column concrete:** Helps concrete fill spaces around reinforcement and within column formwork.
9. **Compacting beam concrete:** Ensures proper consolidation in reinforced concrete beams.
10. **Compacting slab concrete:** Helps consolidate freshly placed concrete in suitable slab construction.

6. Advantages of poker vibrators

1. Improve the quality of concrete consolidation.
2. Reduce trapped air pockets.
3. Help prevent honeycombing.

4. Improve the appearance of concrete surfaces.
5. Reduce manual effort.
6. Improve the consistency of concrete placement.
7. Help concrete surround reinforcement bars.
8. Increase the efficiency of concreting operations.

7. Limitations of poker vibrators

1. Require trained operators.
2. Require electricity or another suitable power source.
3. May cause noise and vibration exposure.
4. Require regular maintenance.
5. Incorrect use may cause segregation of concrete.
6. They must be selected according to the dimensions and reinforcement arrangement of the concrete element.

8. Care and maintenance of poker vibrators

1. Clean the vibrating head immediately after use.
2. Remove all hardened concrete from the equipment.
3. Inspect the flexible shaft for damage.
4. Check the power cable and electrical connections.
5. Inspect the motor housing.
6. Ensure the vibrating head is properly connected.
7. Store the equipment in a dry place.
8. Avoid bending or twisting the flexible shaft excessively.
9. Follow the manufacturer's lubrication instructions.
10. Arrange servicing when abnormal vibration or unusual noise occurs.

9. Safety precautions when using poker vibrators

1. Wear suitable protective equipment.
2. Inspect the electrical cable before operation.
3. Use appropriate electrical protection.
4. Avoid pulling the equipment by its cable.
5. Do not allow the vibrating head to remain operating unnecessarily in one position.
6. Avoid excessive vibration that may cause concrete segregation.
7. Disconnect the power supply before cleaning or servicing.
8. Keep cables away from wet concrete where possible and use equipment designed for the working conditions.

E. CONCRETE MIXERS



Figure 1.17: Different concrete mixers used in building construction.

1. Meaning of a concrete mixer

A concrete mixer is a construction machine used to combine cement, sand, coarse aggregates and water in the correct proportions to produce fresh concrete.

The machine uses a rotating drum or another mechanical mixing arrangement to distribute the materials and produce a reasonably uniform concrete mixture.

Concrete mixers are used in the construction of foundations, columns, beams, slabs, floors, walls and other concrete structures.

2. Main components of a concrete mixer

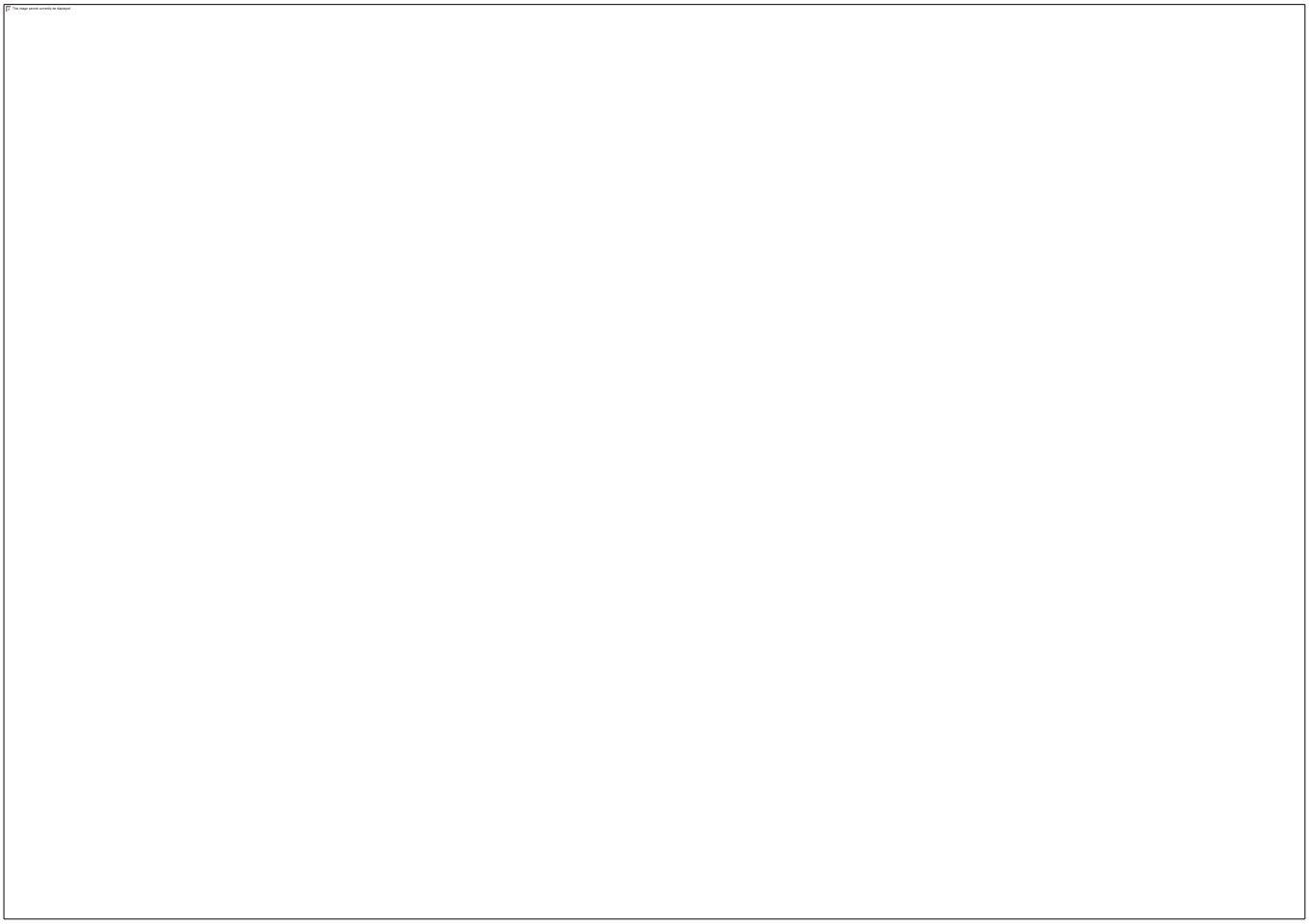
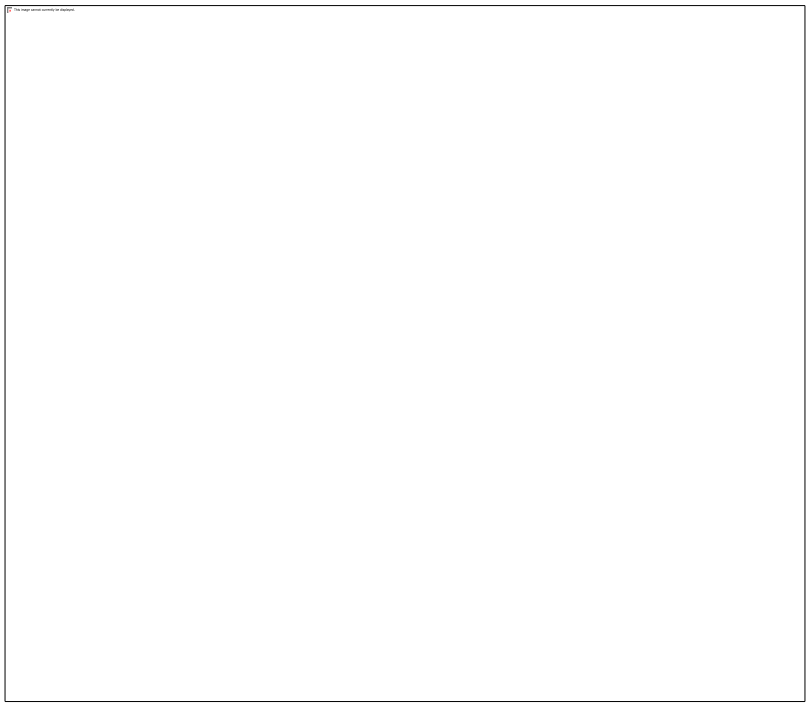


Figure 1.18: Main components of a portable drum concrete mixer.

1. **Mixing drum:** The container in which cement, sand, aggregates and water are mixed.
2. **Mixing blades:** Internal components that lift and turn materials as the drum rotates.
3. **Motor or engine:** Provides the power required to rotate the drum.
4. **Frame:** Supports the machine and its operating components.
5. **Drum opening:** Allows materials to be introduced into the mixer and concrete to be discharged.
6. **Tipping handle or wheel:** Helps the operator tilt the drum during discharge in applicable models.
7. **Drum rotation mechanism:** Transfers power to rotate the mixing drum.
8. **Wheels:** Allow the mixer to be moved around the site.
9. **Water supply arrangement:** Allows water to be added to the concrete mixture.
10. **Protective cover:** Protects selected moving and mechanical components.

3. Types of concrete mixers

a) Tilting drum mixer



A tilting drum mixer is a concrete mixer whose drum can be tilted to discharge the prepared concrete.

Uses:

- Mixing concrete for foundations.
- Preparing concrete for small building projects.
- Mixing concrete for floor slabs.
- Producing concrete for small columns and beams.

b) Non-tilting drum mixer

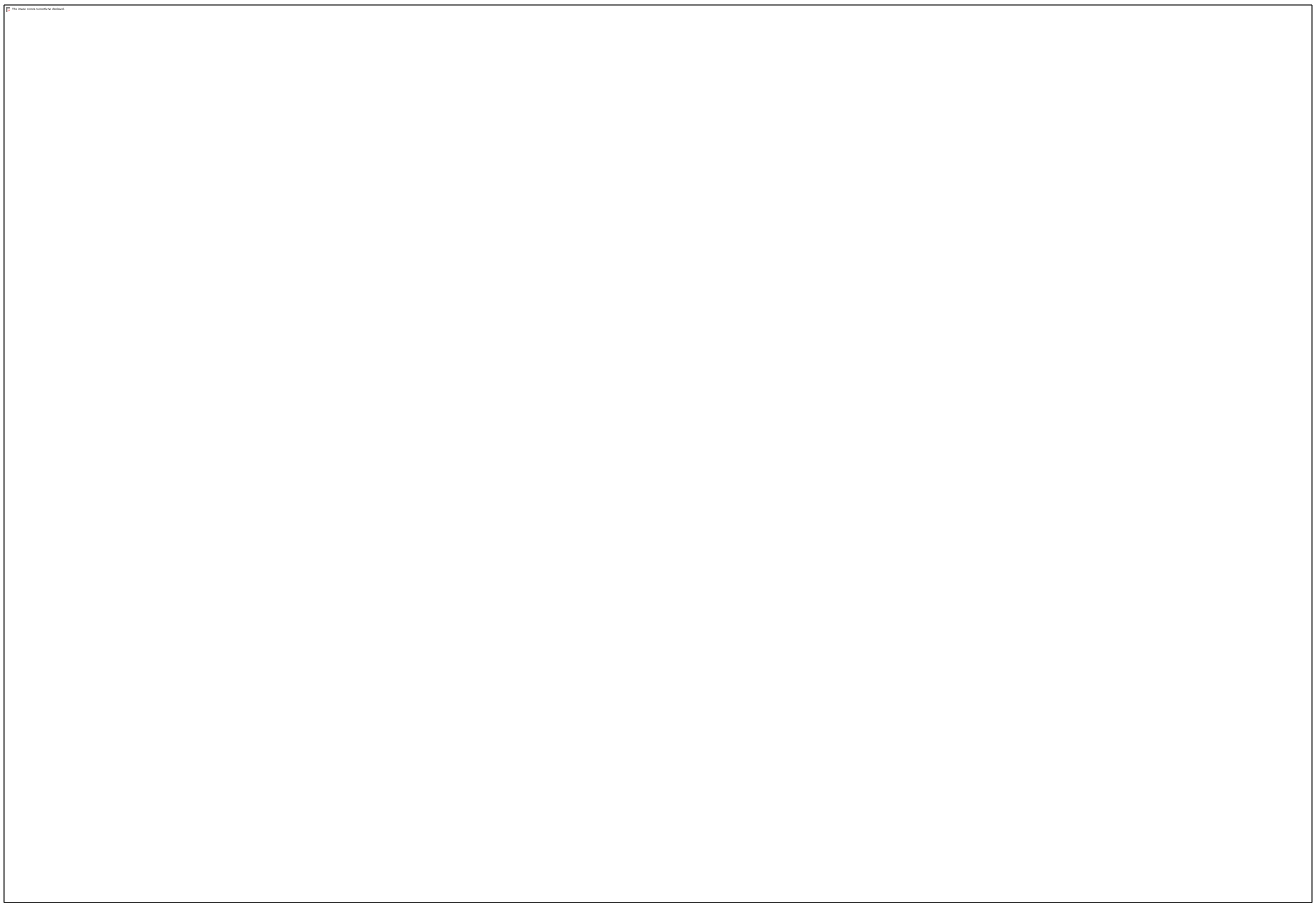


A non-tilting drum mixer has a drum that remains in a fixed position during operation. Concrete is discharged through a designated opening or arrangement.

Uses:

- Mixing concrete for building projects.
- Preparing concrete for small structural works.
- Producing concrete in construction workshops and sites.

c) Reversing drum mixer

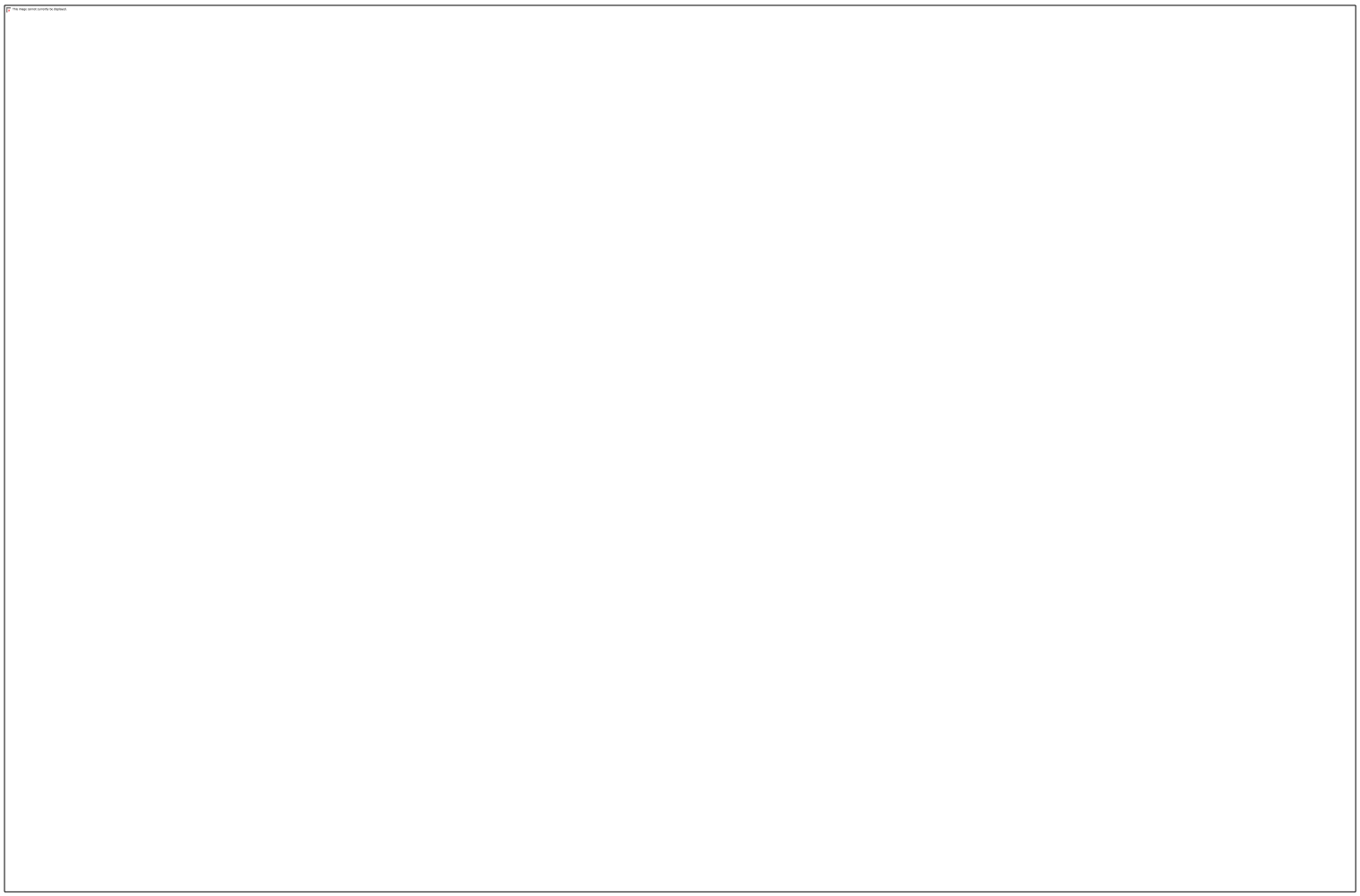


A reversing drum mixer uses opposite drum rotation directions for mixing and discharging concrete.

Uses:

- Mixing concrete for construction operations.
- Preparing batches of concrete.
- Producing concrete for different structural elements.

d) Transit concrete mixer



A transit mixer is a truck-mounted concrete mixer used to transport fresh concrete from a batching plant to a construction site while maintaining agitation.

Uses:

- Transporting ready-mixed concrete.
- Supplying concrete to large construction projects.
- Supplying concrete for bridges and roads.
- Supplying concrete for large building foundations and slabs.

4. Functions and uses of concrete mixers

1. **Mixing cement:** Combines cement with other concrete ingredients.

2. **Mixing aggregates:** Distributes sand and coarse aggregates throughout the mixture.

3. **Adding water:** Allows water to be incorporated into the concrete mixture in the specified proportion.

4. **Producing uniform concrete:** Helps achieve a consistent mixture when correctly loaded and operated.

5. **Preparing foundation concrete:** Produces concrete for foundation bases and ground beams.

6. **Preparing structural concrete:** Supplies concrete for columns, beams and slabs.

7. **Producing floor concrete:** Mixes concrete used in floors and pavements.

8. **Improving productivity:** Reduces the time and manual effort required to mix concrete.

9. **Supporting large construction projects:** Larger mixers and batching systems produce concrete in substantial quantities.

10. **Reducing inconsistent manual mixing:** Mechanical mixing promotes more uniform distribution of ingredients.

5. Advantages of concrete mixers

1. Save time during concrete preparation.
2. Reduce manual labour.
3. Improve the uniformity of concrete.
4. Increase concrete production capacity.
5. Reduce physical strain on workers.
6. Improve efficiency on construction sites.
7. Support the preparation of concrete in controlled batches.
8. Can be used for different concrete construction activities.

6. Limitations of concrete mixers

1. Require fuel or electricity.
2. Require regular cleaning.
3. Have purchase and maintenance costs.
4. Produce noise during operation.
5. May cause accidents if moving parts are exposed.
6. Require correct batching and mixing procedures.
7. Incorrect mixing can produce poor-quality concrete.

7. Care and maintenance of concrete mixers

1. Clean the mixing drum after every use.
2. Remove hardened concrete from the drum.
3. Inspect the mixing blades for wear.
4. Check the motor or engine.
5. Lubricate moving components as recommended.
6. Inspect the drive belts and gears.
7. Check electrical connections where applicable.
8. Inspect the wheels and supporting frame.
9. Keep the mixer on stable ground during operation.
10. Store the equipment in a suitable location.

8. Safety precautions when using concrete mixers

1. Ensure the mixer is positioned on firm and level ground.

2. Keep hands away from the rotating drum.
3. Do not wear loose clothing near moving parts.
4. Never clean the drum while it is operating.
5. Use appropriate PPE.
6. Keep unauthorised persons away.
7. Switch off and isolate the power supply before cleaning or maintenance.
8. Avoid overloading the mixer.
9. Ensure protective guards are fitted.
10. Do not attempt to repair moving components while the machine is operating.

F. BACKHOE LOADERS

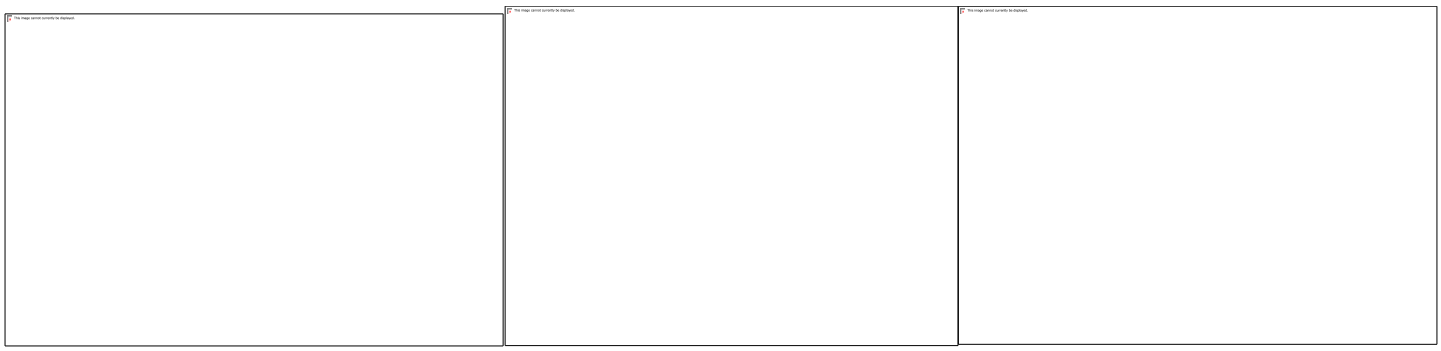


Figure 1.19: Backhoe loaders used for excavation and material handling.

1. Meaning of a backhoe loader

A backhoe loader is a versatile construction machine fitted with a loading bucket at the front and an excavating arm with a digging bucket at the rear.

It combines the functions of a front loader and an excavator, allowing it to perform several construction operations using one machine.

Backhoe loaders are commonly used in building construction, road maintenance, drainage installation, trench excavation and site preparation.

2. Main components of a backhoe loader

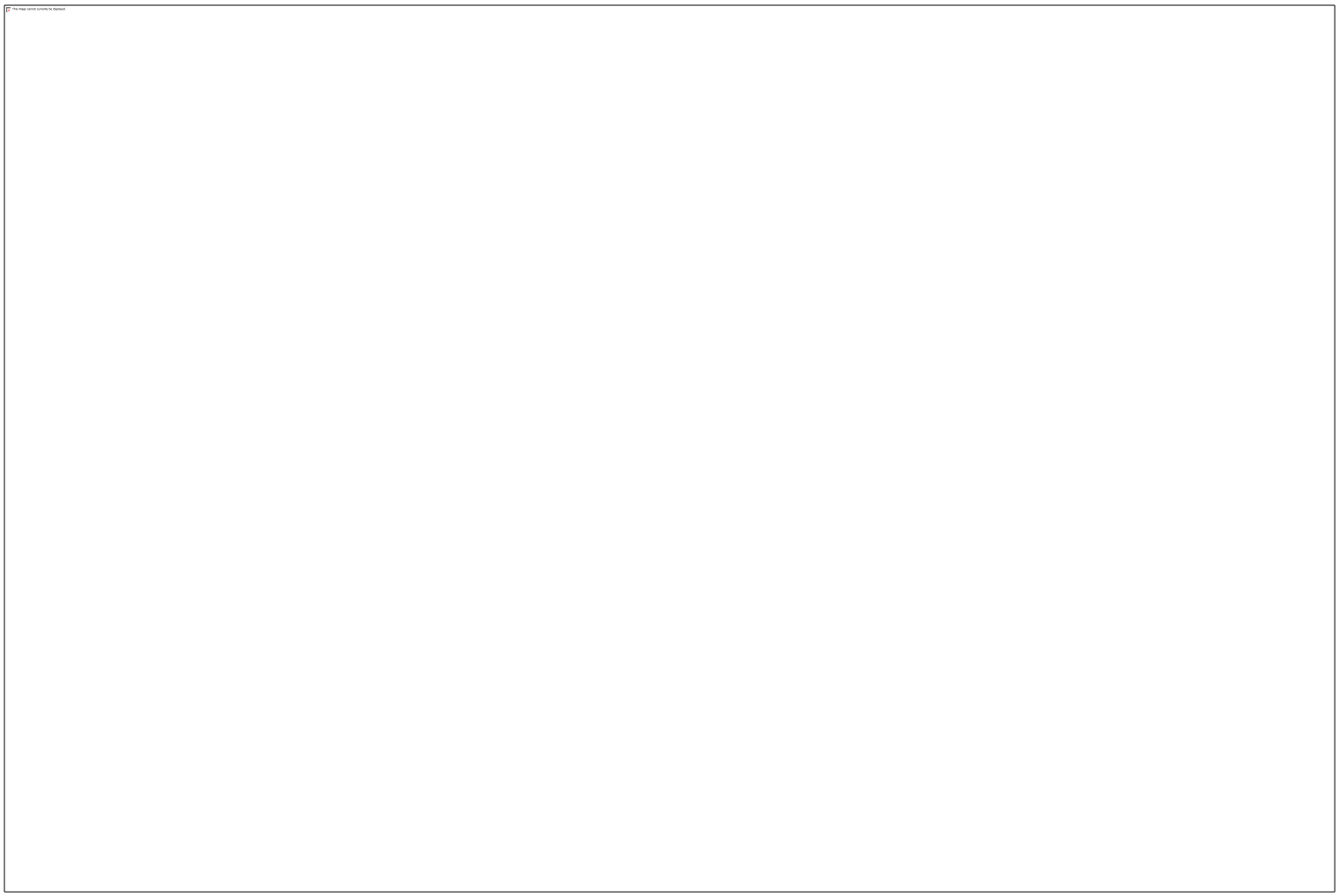


Figure 1.20: Main components of a backhoe loader.

1. **Front loading bucket:** Used to scoop, lift and transport soil, sand, gravel and other loose materials.
2. **Rear digging bucket:** Used to excavate trenches, pits and foundation areas.
3. **Boom:** Supports the rear excavating arm.
4. **Dipper arm:** Connects the boom to the digging bucket.
5. **Hydraulic cylinders:** Control the movement of the front loader and rear excavator attachments.
6. **Cab:** Houses the operator and machine controls.
7. **Engine:** Provides power to operate the machine.
8. **Wheels:** Support the machine and enable movement around the construction site.
9. **Stabiliser legs:** Provide additional stability during rear excavation operations.
10. **Hydraulic system:** Transmits power to operate the attachments.

3. Functions and uses of backhoe loaders

1. **Foundation excavation:** Digging trenches and pits for building foundations.
2. **Trench digging:** Excavating trenches for water supply and drainage pipes.
3. **Material loading:** Loading sand, soil and gravel into trucks.
4. **Backfilling:** Returning suitable soil into excavated trenches.
5. **Site clearance:** Removing loose debris and unwanted materials.

6. **Landscaping:** Shaping and levelling small areas of land.

7. **Road maintenance:** Repairing drainage channels and carrying out small earthworks.

8. **Material transportation:** Moving construction materials over short distances.

9. **Demolition support:** Breaking or removing selected materials using suitable attachments.

10. **Drainage construction:** Digging trenches and channels for drainage systems.

4. Advantages of backhoe loaders

1. Perform both excavation and loading operations.
2. Reduce the need for separate machines on small projects.
3. Are relatively versatile.
4. Can move between suitable working locations.
5. Are useful in restricted construction areas.
6. Reduce manual labour.
7. Support several construction activities.

5. Limitations of backhoe loaders

1. Have lower capacity than some specialised heavy excavators and loaders.
2. Require skilled operators.
3. Need regular maintenance.
4. Consume fuel.
5. Produce noise and emissions.
6. Require sufficient space to operate the rear excavating arm safely.

G. COMPACTORS



Figure 1.21: Different compaction machines used in construction.

1. Meaning of a compactor

A compactor is a construction machine or equipment used to increase the density of soil, gravel, asphalt and other construction materials by applying pressure, vibration or repeated impact.

Compaction reduces air spaces between soil particles, improving the stability and load-bearing capacity of the ground.

Compactors are important in foundation preparation, road construction, floor preparation, paving and backfilling.

2. Importance of compaction in construction

Proper compaction is necessary because loose soil may settle under the weight of a building or other structure.

Poorly compacted ground can result in:

1. Uneven settlement.
2. Cracking of floors.
3. Instability of foundations.
4. Formation of depressions.
5. Failure of pavements.
6. Poor support for structural loads.

3. Main components of a vibratory roller

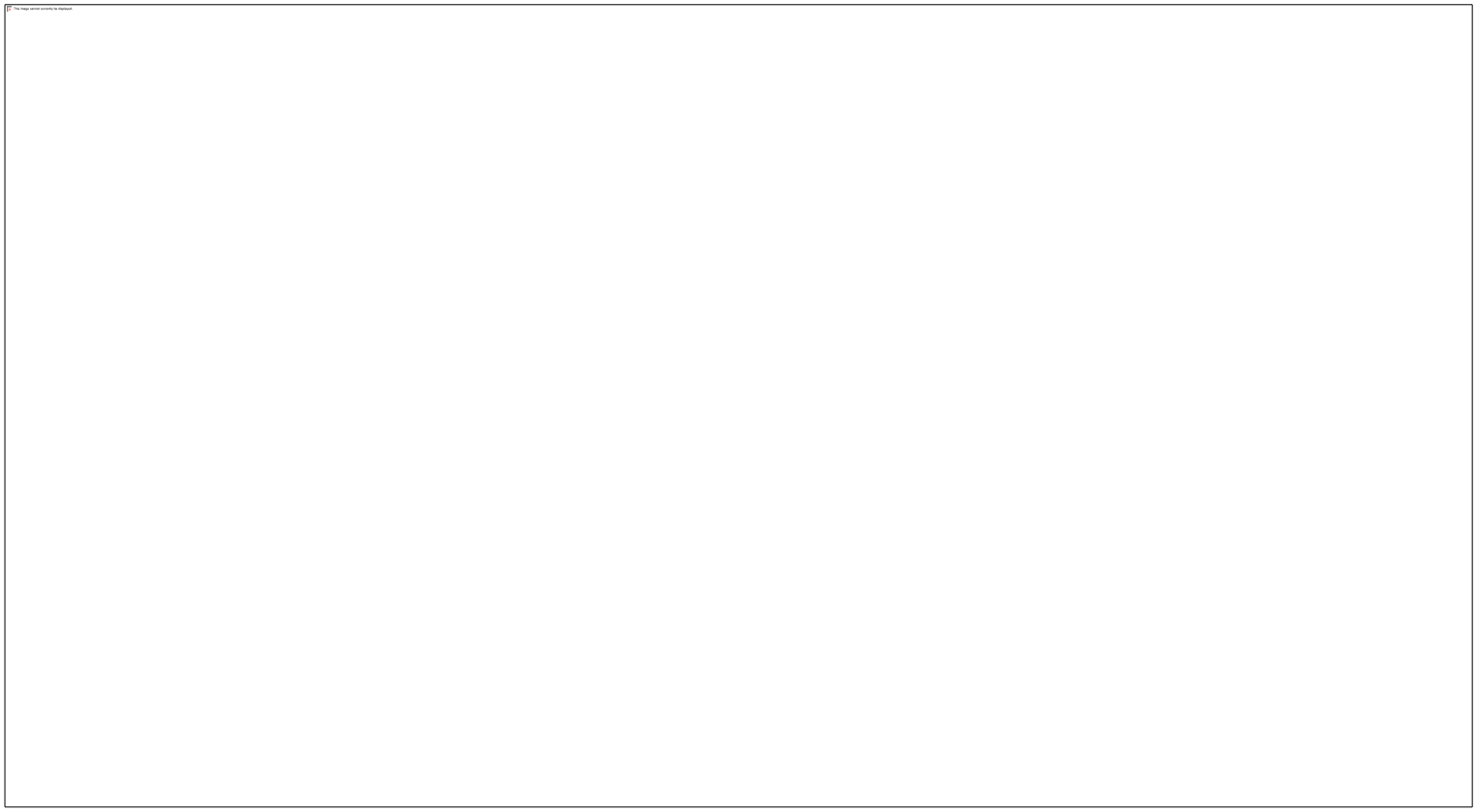


Figure 1.22: Main components of a vibratory roller.

1. **Compaction drum:** The heavy cylindrical component that applies pressure to the ground.
2. **Engine:** Supplies mechanical power.
3. **Vibration mechanism:** Produces vibrations that improve soil compaction.
4. **Cab:** Provides a working space for the operator.
5. **Tyres or rear wheels:** Support and propel the machine.
6. **Frame:** Supports the main components.
7. **Hydraulic system:** Controls movement and selected operating functions.
8. **Water tank:** Supplies water to the drum in some asphalt rollers to prevent material from sticking.
9. **Steering system:** Controls the movement of the machine.

10. **Operator controls:** Enable the operator to control vibration, speed and movement.

4. Types of compactors

a) Smooth-wheel roller



A smooth-wheel roller is a compaction machine fitted with smooth steel drums.

Uses:

- Compacting gravel.
- Compacting suitable soil layers.
- Compacting asphalt surfaces.
- Finishing road surfaces.

b) Sheep-foot roller



A sheep-foot roller has a drum fitted with projecting feet that penetrate and compact cohesive soils.

Uses:

- Compacting clay soils.
- Compacting cohesive earth.
- Preparing embankments.

- Compacting selected earth fills.

c) Plate compactor

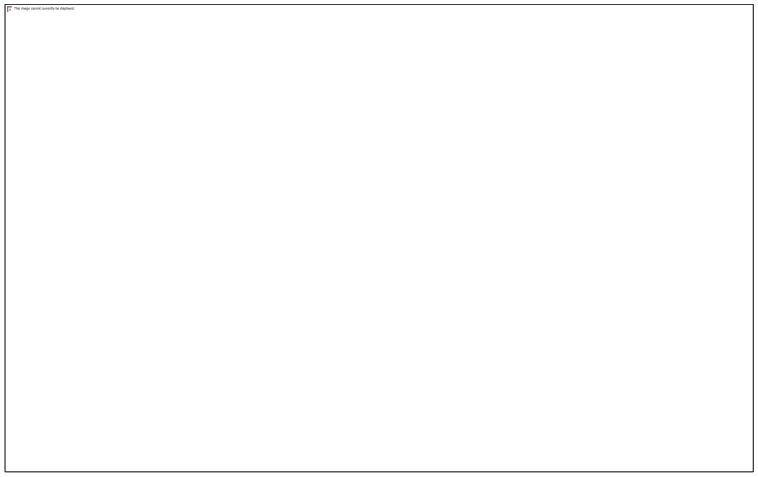


A plate compactor is a small machine with a vibrating metal plate that applies pressure to the ground.

Uses:

- Compacting soil in small areas.
- Preparing ground for paving.
- Compacting backfilled trenches.
- Compacting granular materials.
- Preparing surfaces around buildings.

d) Tamping rammer



A tamping rammer is a compacting machine that uses repeated impact force through a small footplate.

Uses:

- Compacting soil in narrow trenches.
- Compacting backfilled areas.
- Compacting soil around foundations.
- Compacting small confined spaces.

e) Pneumatic-tyred roller



A pneumatic-tyred roller uses several rubber tyres to apply pressure to construction materials.

Uses:

- Compacting asphalt.
- Compacting granular materials.
- Sealing road surfaces.
- Compacting selected soil layers.

5. Functions and uses of compactors in building construction

1. **Foundation preparation:** Compacting soil before placing foundation materials.
2. **Backfilling:** Compacting soil around foundations and structures.
3. **Road construction:** Compacting road subgrade, sub-base and base materials.
4. **Floor preparation:** Compacting ground before constructing concrete floors.
5. **Paving works:** Preparing and compacting ground beneath paving blocks.
6. **Trench compaction:** Compacting backfill in trenches for pipes and services.
7. **Embankment construction:** Compacting earth materials used in embankments.
8. **Asphalt compaction:** Compacting asphalt during road construction.
9. **Ground stabilisation:** Improving the density and stability of suitable construction materials.
10. **Reducing settlement:** Minimising future ground settlement when the correct compaction procedure is followed.

6. Advantages of compactors

1. Improve ground stability.
2. Increase soil density.
3. Reduce settlement.
4. Improve foundation support.
5. Increase pavement durability.
6. Reduce manual compaction work.
7. Improve construction efficiency.
8. Produce more uniform compacted surfaces.

7. Limitations of compactors

1. Require fuel or electricity.
2. Generate noise and vibration.
3. Require skilled operators.
4. May cause excessive ground vibration.
5. Require regular servicing.
6. Different compactors are suitable for different soil types and working conditions.

H. CRANES

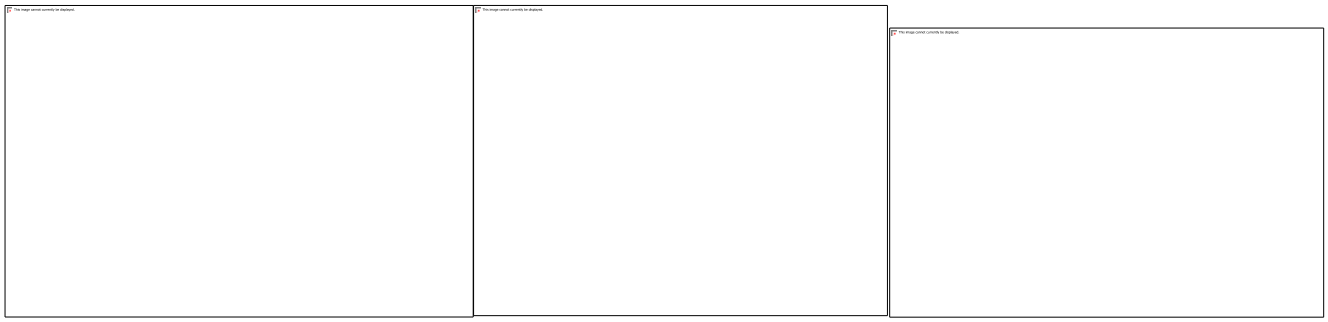


Figure 1.23: Different types of cranes used for lifting construction materials.

1. Meaning of a crane

A crane is a heavy lifting machine used to raise, lower and move heavy construction materials and equipment from one position to another.

It operates using mechanical, hydraulic or electrical systems and uses components such as booms, cables, pulleys, hooks and lifting attachments.

Cranes are important in the construction of multi-storey buildings, bridges, industrial structures, commercial buildings and other large construction projects.

2. Main components of a crane

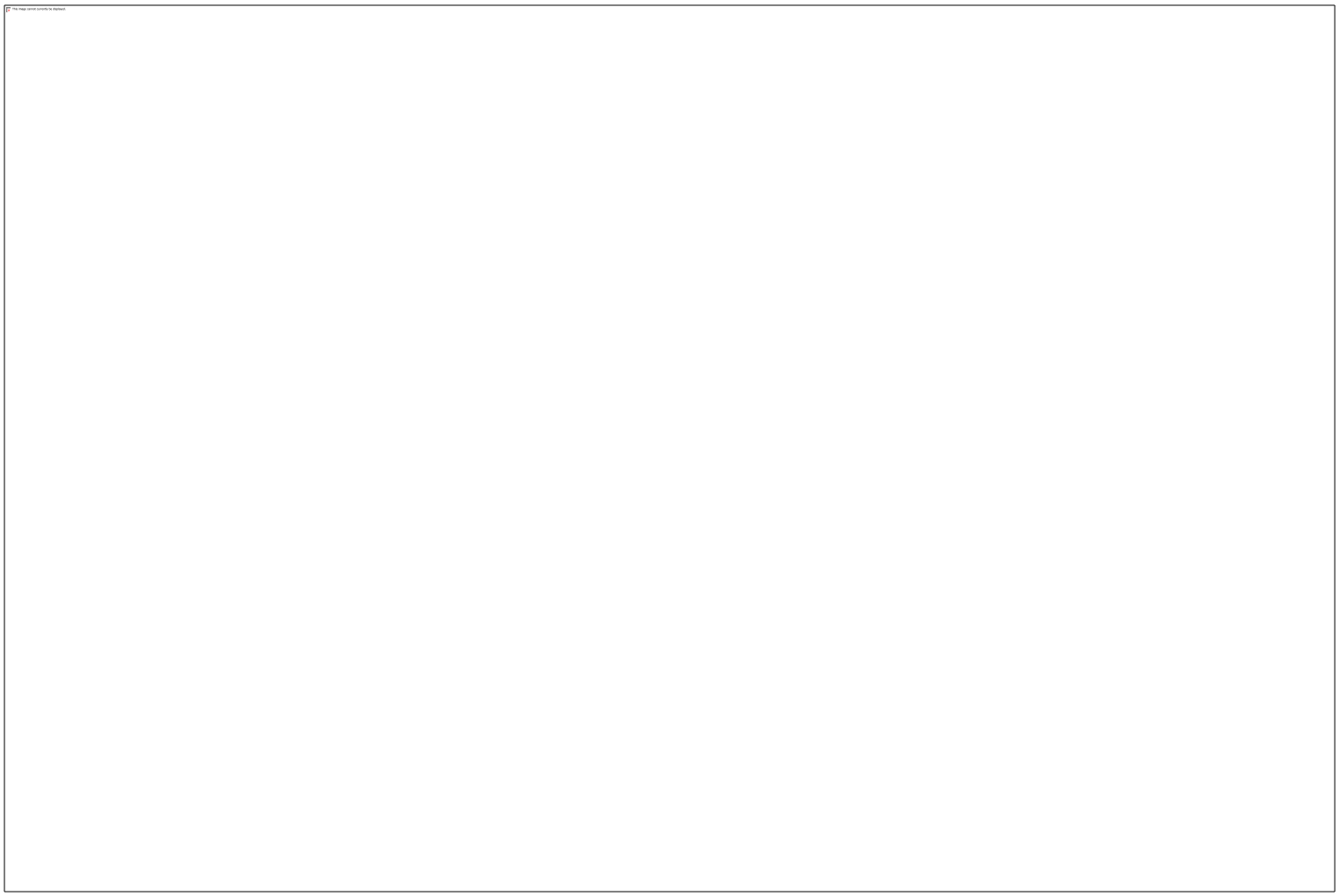


Figure 1.24: Main components of a tower crane.

1. **Mast or tower:** The vertical structural section that supports the crane and provides its height.

2. **Jib:** The horizontal or inclined arm that extends from the crane and supports the lifting arrangement.

3. **Counter-jib:** The shorter arm on the opposite side of the jib that supports counterweights and machinery.

4. **Counterweight:** Provides balancing force to help maintain crane stability.

5. **Hoist:** The mechanism used to raise and lower loads.

6. **Wire rope:** A strong steel cable used to lift and lower loads.

7. **Hook:** Holds lifting accessories or the load.

8. **Trolley:** Moves the lifting point along the jib in applicable tower cranes.

9. **Operator's cab:** Provides the operator with controls and visibility.

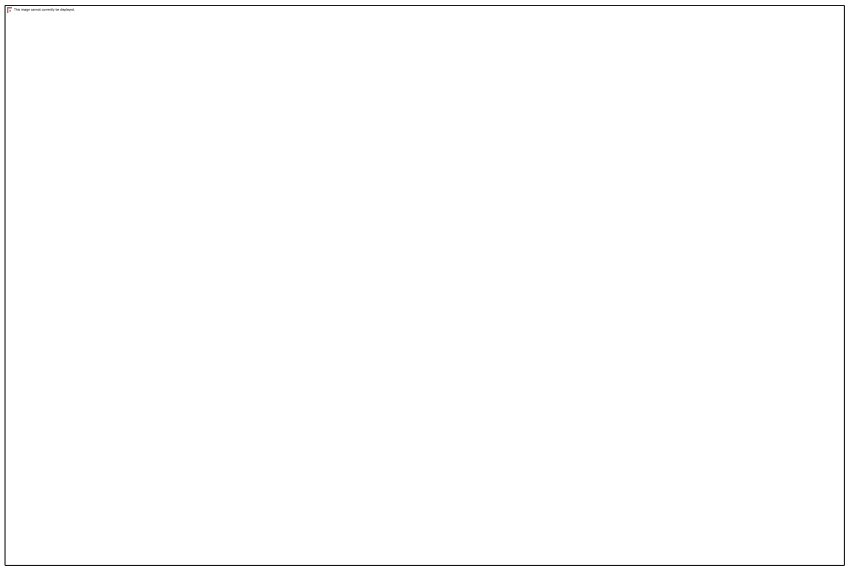
10. **Slewing mechanism:** Allows the crane's upper structure to rotate.

11. **Base or foundation:** Supports the crane and transfers its loads to the ground or supporting structure.

12. **Lifting controls:** Regulate lifting, lowering, rotation and movement.

3. Types of cranes

a) Tower crane



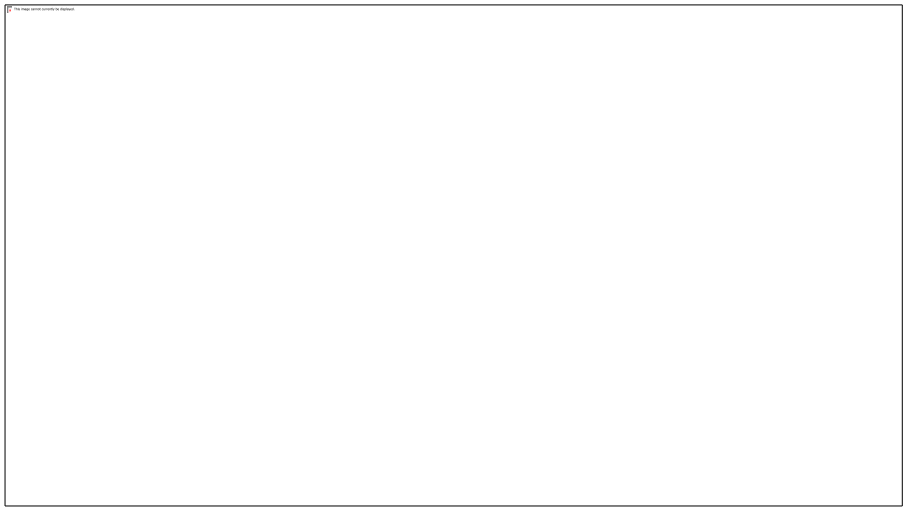
A tower crane is a tall crane commonly used in large building construction projects.

It is usually erected on a specially designed foundation or suitable supporting structure.

Uses:

1. Lifting steel reinforcement bars.
2. Lifting concrete formwork.
3. Moving construction materials to upper floors.
4. Lifting precast concrete components.
5. Transporting heavy building materials vertically and horizontally.
6. Supporting the construction of multi-storey buildings.

b) Mobile crane



A mobile crane is a crane mounted on a wheeled or tracked carrier, allowing it to move between working locations.

Uses:

1. Lifting heavy construction equipment.

2. Installing steel structures.
3. Lifting concrete components.
4. Loading and unloading heavy materials.
5. Erecting construction structures.
6. Supporting bridge and road construction.

c) Crawler crane



A crawler crane is mounted on continuous tracks and is designed to operate on suitable construction ground conditions.

Uses:

1. Lifting heavy structural components.
2. Installing large precast units.
3. Lifting equipment in major construction projects.
4. Supporting bridge construction.
5. Performing heavy lifting on suitable ground.

d) Truck-mounted crane



A truck-mounted crane is fitted onto a truck chassis and is used for lifting and transporting materials.

Uses:

1. Loading and unloading construction materials.
2. Lifting steel components.
3. Transporting building equipment.
4. Moving materials around construction sites.
5. Delivering heavy items to construction locations.

4. Functions and uses of cranes in building construction

1. **Lifting heavy materials:** Raising heavy construction materials to required heights.
2. **Transporting materials:** Moving loads horizontally from one position to another.
3. **Installing structural steel:** Lifting and positioning steel beams and columns.
4. **Lifting precast concrete:** Positioning precast slabs, beams and other components.
5. **Multi-storey construction:** Supplying materials to upper floors.
6. **Roof construction:** Lifting roofing materials and structural components.
7. **Bridge construction:** Positioning heavy bridge components.
8. **Loading and unloading:** Handling heavy materials delivered to construction sites.
9. **Machinery installation:** Lifting heavy mechanical and industrial equipment.
10. **Formwork handling:** Lifting and positioning large formwork systems.

5. Advantages of cranes

1. Lift loads that cannot be handled safely by ordinary manual labour.
2. Improve productivity in large construction projects.
3. Reduce the need for manual material handling.
4. Facilitate construction of multi-storey buildings.
5. Improve the movement of heavy materials.
6. Save time during structural installation.
7. Support the handling of large precast components.
8. Improve efficiency when correctly selected and operated.

6. Limitations of cranes

1. Have high purchase and hiring costs.
2. Require trained and competent operators.
3. Need careful load planning.
4. Require adequate space for operation.
5. Can cause serious accidents if overloaded.
6. May obstruct roads and pathways.

7. Require stable supporting ground or suitable foundations.
8. May produce noise and exhaust emissions.
9. Require regular inspection and maintenance.

7. Safety precautions when operating cranes

1. Never exceed the crane's rated lifting capacity.
2. Ensure loads are properly attached using suitable lifting accessories.
3. Inspect wire ropes, hooks and slings before use.
4. Ensure the crane is positioned on stable ground.
5. Use appropriate outriggers where required.
6. Keep workers away from suspended loads.
7. Use trained lifting personnel and designated signalers.
8. Avoid lifting loads over people.
9. Observe safe working distances from overhead electrical lines.
10. Follow the manufacturer's load charts and operating instructions.

I. DUMP TRUCKS

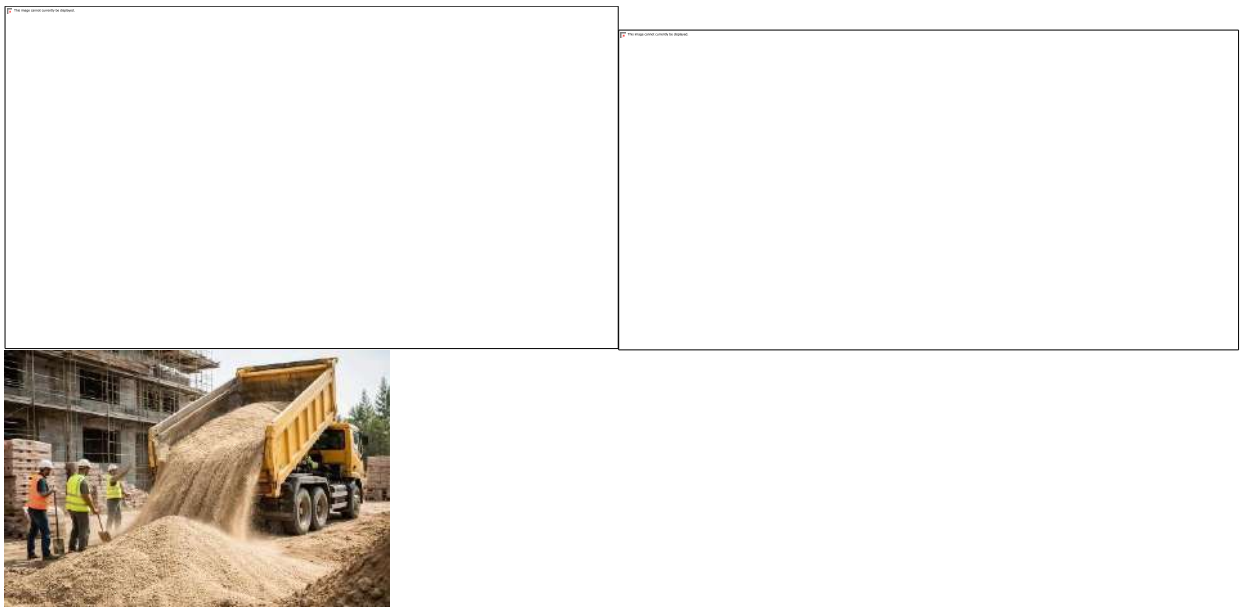


Figure 1.25: Different types of dump trucks used for transporting construction materials.

1. Meaning of a dump truck

A dump truck is a motor vehicle designed to transport loose construction materials and discharge them by raising its loading body.

The loading body is usually operated by a hydraulic system that tilts it to release materials at the required location.

Dump trucks are commonly used to transport soil, sand, gravel, crushed stones, demolition debris and other construction materials.

2. Main components of a dump truck

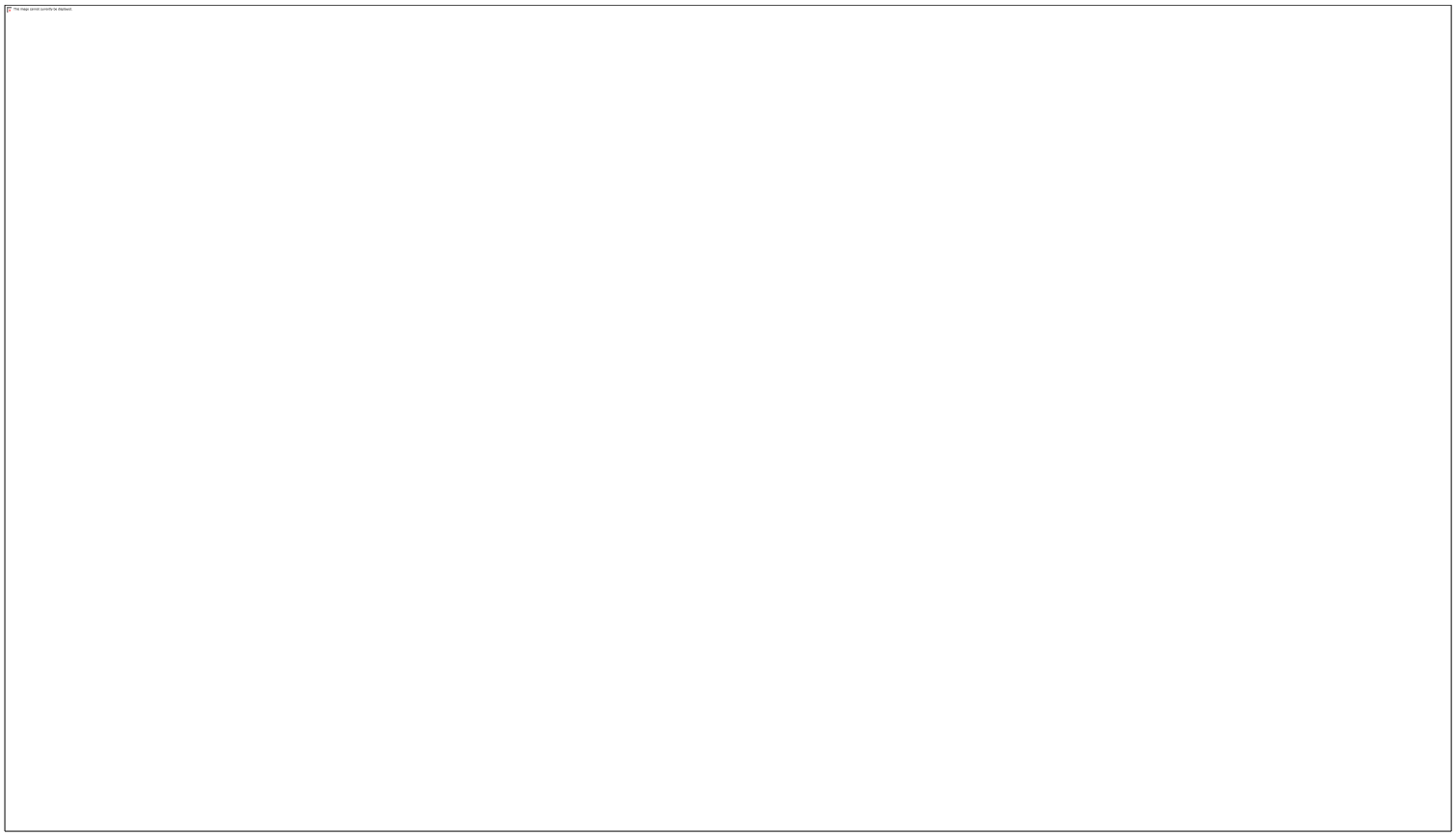
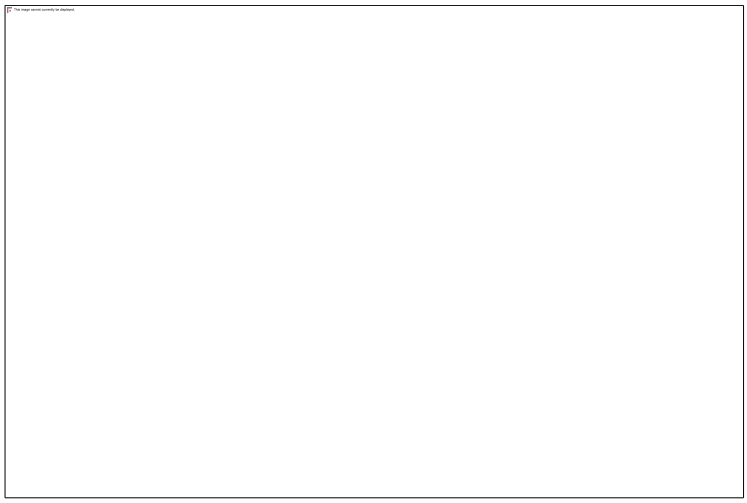


Figure 1.26: Main components of a dump truck.

1. **Loading body:** The container used for carrying loose construction materials.
2. **Cab:** The compartment in which the driver operates the vehicle.
3. **Chassis:** The main structural frame supporting the truck.
4. **Engine:** Provides the power required to move the vehicle and operate its systems.
5. **Hydraulic cylinder:** Raises the loading body during unloading.
6. **Tailgate:** The rear section that controls the discharge of materials.
7. **Wheels and tyres:** Support the vehicle and allow movement.
8. **Transmission system:** Transfers engine power to the driving wheels.
9. **Braking system:** Controls and stops the vehicle.
10. **Steering system:** Controls the direction of movement.
11. **Fuel tank:** Stores fuel for the engine.
12. **Exhaust system:** Directs exhaust gases away from the engine.

3. Types of dump trucks

a) Rigid dump truck

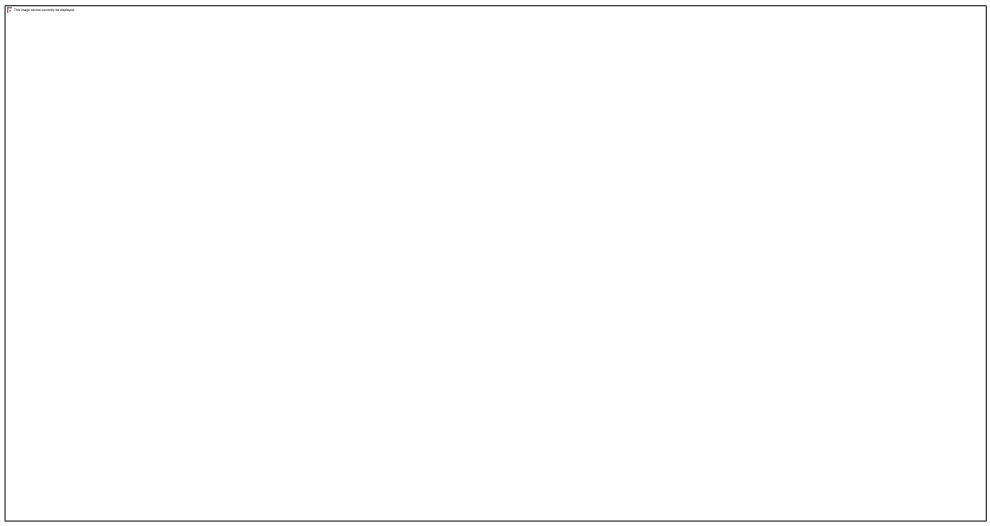


A rigid dump truck has a fixed chassis and is commonly used for transporting large quantities of materials over suitable haul roads.

Uses:

- Transporting excavated soil.
- Moving crushed stones.
- Carrying gravel.
- Transporting sand.
- Removing construction debris.

b) Articulated dump truck



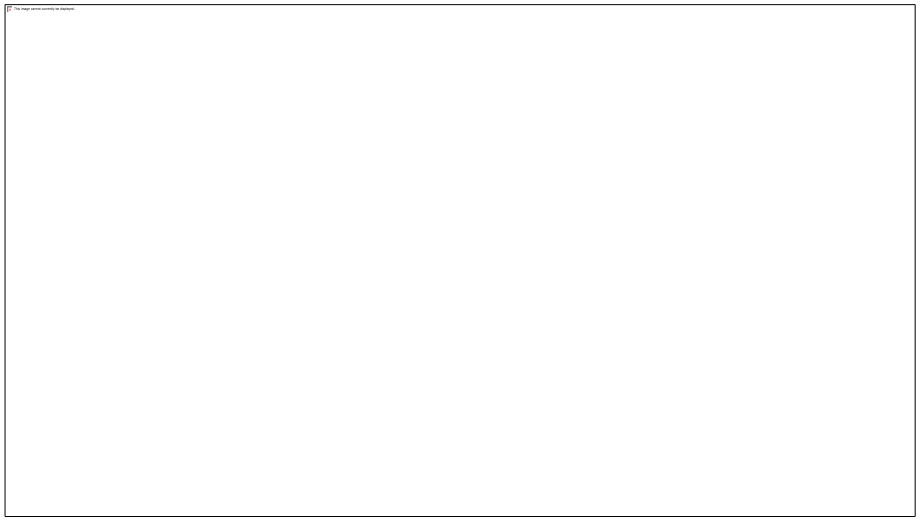
An articulated dump truck has a flexible joint between the front and rear sections, allowing it to manoeuvre on suitable uneven terrain.

Uses:

- Transporting soil on rough construction sites.
- Hauling materials over uneven ground.
- Moving excavated rock.

- Transporting construction aggregates.
- Supporting large earthmoving operations.

c) Tipper truck



A tipper truck is a road-going truck fitted with a tipping body for transporting and unloading loose materials.

Uses:

- Delivering sand to construction sites.
- Transporting ballast and gravel.
- Delivering hardcore.
- Removing excavated soil.
- Transporting construction waste to approved disposal facilities.

4. Functions and uses of dump trucks in building construction

1. **Transporting excavated soil:** Moving soil from excavation areas to designated disposal or storage locations.

2. **Transporting sand:** Delivering sand for mortar and concrete production.

3. **Moving gravel:** Carrying gravel for road construction and concrete works.

4. **Transporting crushed stones:** Delivering aggregates to construction sites.

5. **Removing demolition debris:** Carrying demolished materials to approved disposal locations.

6. **Hauling hardcore:** Transporting hardcore used in floor preparation and ground works.

7. **Supporting excavation:** Working together with excavators to remove excavated materials.

8. **Delivering construction materials:** Transporting loose materials from suppliers to project sites.

9. **Site clearance:** Removing loose debris and unwanted materials.

10. **Supporting road construction:** Transporting materials used in road subgrade, sub-base and base construction.

5. Advantages of dump trucks

1. Transport large quantities of materials.
2. Reduce manual handling.
3. Improve material transportation efficiency.
4. Save time on construction projects.
5. Facilitate excavation and earthmoving activities.
6. Reduce the need for repeated manual loading and unloading.
7. Can transport different types of loose materials.

6. Limitations of dump trucks

1. Require fuel and regular maintenance.
2. Produce exhaust emissions.
3. Generate noise.
4. Require suitable access roads.
5. Can obstruct traffic and pedestrian pathways.
6. May cause accidents when overloaded.
7. Require competent drivers.
8. Need appropriate loading and unloading areas.

7. Safety precautions when using dump trucks

1. Do not exceed the manufacturer's load capacity.
2. Secure the load during transportation.
3. Check tyres, brakes and lights before operation.
4. Use designated routes.
5. Avoid tipping on unstable or sloping ground.
6. Ensure sufficient overhead clearance when tipping.
7. Keep workers away from the unloading area.
8. Use a trained driver.
9. Avoid transporting materials that may spill onto public roads.
10. Follow site traffic management procedures.

J. FRONT LOADERS



Figure 1.27: Front loaders used for loading and moving construction materials.

1. Meaning of a front loader

A front loader, also known as a wheel loader, is a construction machine fitted with a large bucket at the front, which is used to scoop, lift, carry and load loose materials.

It is commonly used for handling sand, gravel, soil, crushed stones and other construction materials.

Front loaders are widely used in construction sites, quarries, material storage yards and road construction projects.

2. Main components of a front loader

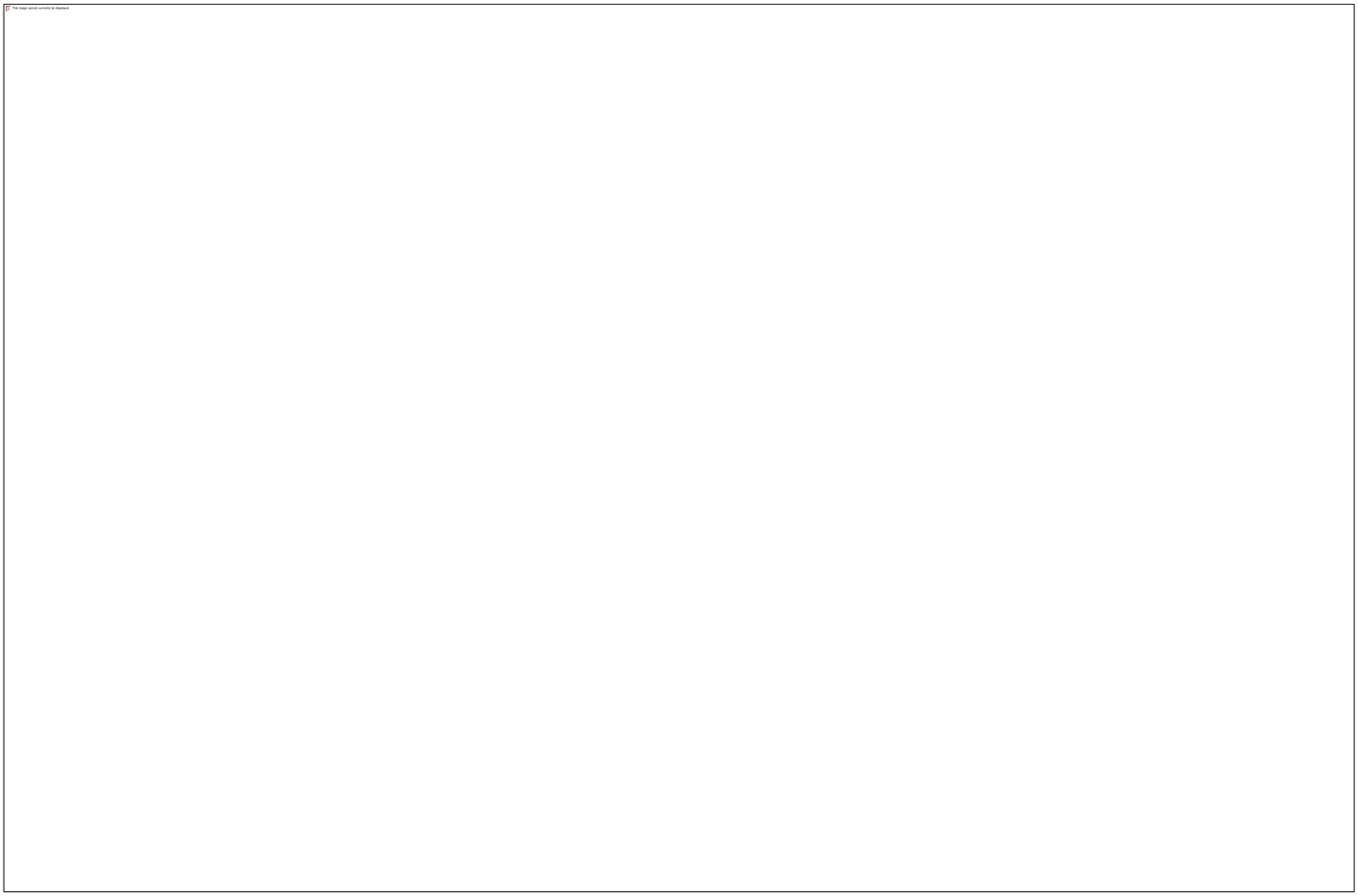


Figure 1.28: Main components of a front loader.

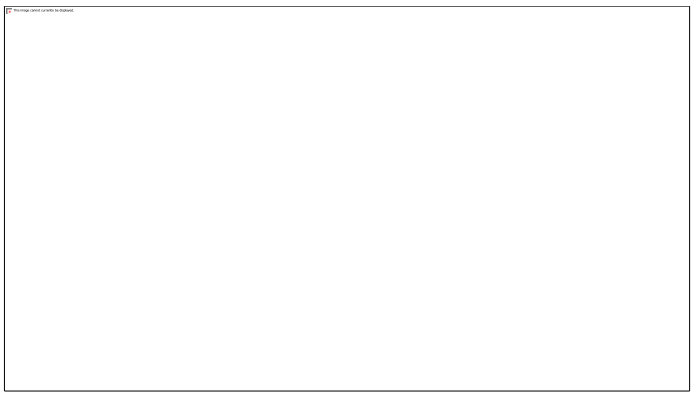
1. **Bucket:** Scoops and carries loose materials.

2. **Lift arms:** Support and raise the bucket.

3. **Hydraulic cylinders:** Provide the force needed to raise, lower and tilt the bucket.
4. **Cab:** Houses the operator and control systems.
5. **Engine:** Provides the power required to operate the machine.
6. **Tyres:** Support the machine and enable it to move.
7. **Articulation joint:** Allows the front and rear sections of applicable loaders to bend for steering.
8. **Transmission system:** Transfers power from the engine to the wheels.
9. **Counterweight:** Helps balance the machine during loading operations.
10. **Operator controls:** Control the movement of the loader and bucket.

3. Types of front loaders

a) Wheel loader

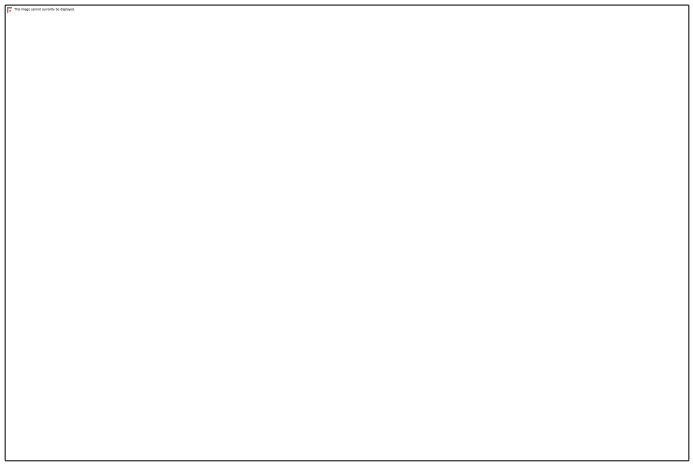


A wheel loader is fitted with rubber tyres and is designed to move on suitable firm surfaces.

Uses:

- Loading sand and gravel.
- Moving soil.
- Loading dump trucks.
- Handling construction aggregates.
- Clearing loose materials.

b) Compact wheel loader



A compact wheel loader is a smaller version of a wheel loader designed for more restricted working areas.

Uses:

- Handling materials in small construction sites.
- Loading sand and aggregates.
- Moving construction debris.
- Landscaping and site preparation.

c) Track loader



A track loader is fitted with continuous tracks instead of ordinary wheels.

Uses:

- Handling materials on soft ground.
- Loading soil.
- Clearing construction sites.
- Moving loose materials over suitable uneven terrain.

4. Functions and uses of front loaders in building construction

1. **Loading materials:** Loading soil, sand and gravel into dump trucks.
2. **Moving soil:** Transporting loose soil over short distances.
3. **Handling aggregates:** Moving crushed stones and ballast.
4. **Stockpile management:** Arranging materials in storage piles.
5. **Site clearance:** Removing loose debris and unwanted materials.
6. **Loading construction waste:** Collecting and loading suitable waste materials.
7. **Filling operations:** Supplying suitable materials for backfilling.

8. **Road construction:** Handling gravel and other road construction materials.

9. **Quarry operations:** Loading crushed stones and aggregates.

10. **Material distribution:** Moving construction materials to different working areas.

5. Advantages of front loaders

1. Have high material-handling capacity.
2. Load dump trucks efficiently.
3. Reduce manual handling.
4. Improve construction productivity.
5. Can handle different loose materials.
6. Are useful in material storage yards.
7. Can perform repeated loading operations.

6. Limitations of front loaders

1. Have high purchase and operating costs.
2. Require skilled operators.
3. Consume fuel.
4. Generate noise and exhaust emissions.
5. Require sufficient manoeuvring space.
6. Are not suitable for deep excavation.
7. Require regular maintenance.

1.2.4 CONSTRUCTION OPERATIONS PERFORMED USING CONSTRUCTION PLANT

Construction plant is selected according to the nature of the activity, the type of material and the scale of the project.

The major operations include earthmoving, hauling, lifting, concreting and compacting.

A. EARTHMOVING

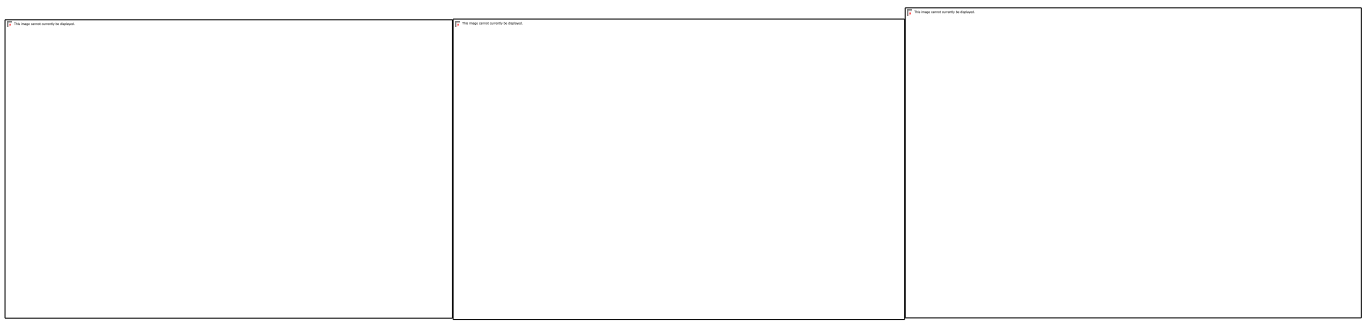


Figure 1.29: Earthmoving operations using construction plant.

1. Meaning of earthmoving

Earthmoving is the process of excavating, removing, transporting, spreading and reshaping soil, rock and other earth materials during construction activities.

It is carried out during site preparation, foundation excavation, road construction, drainage installation and landscaping.

2. Construction plant used in earthmoving

1. Excavators.
2. Bulldozers.
3. Graders.
4. Backhoe loaders.
5. Front loaders.
6. Scrapers.
7. Dump trucks.

3. Activities involved in earthmoving

a) Site clearing



Site clearing involves removing vegetation, bushes, unwanted structures and other obstructions from the construction area.

Construction plant used:

- Bulldozers.
- Excavators.
- Front loaders.

b) Topsoil removal



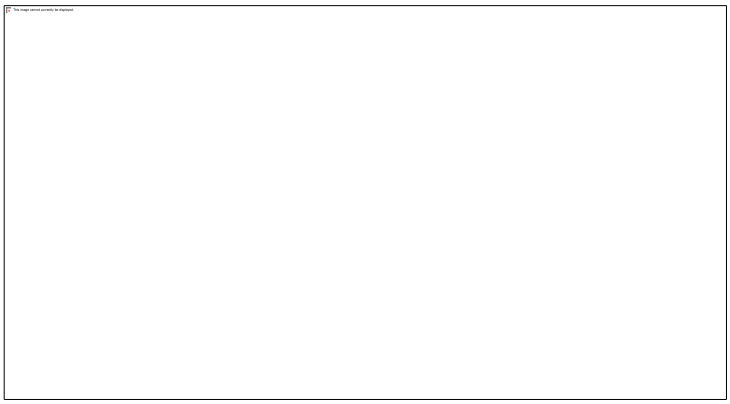
Topsoil removal involves stripping the upper layer of soil before carrying out construction work.

It helps remove organic material that may be unsuitable for supporting foundations.

Construction plant used:

- Excavators.
- Bulldozers.
- Front loaders.

c) Excavation



Excavation involves digging and removing soil to the required depth and dimensions.

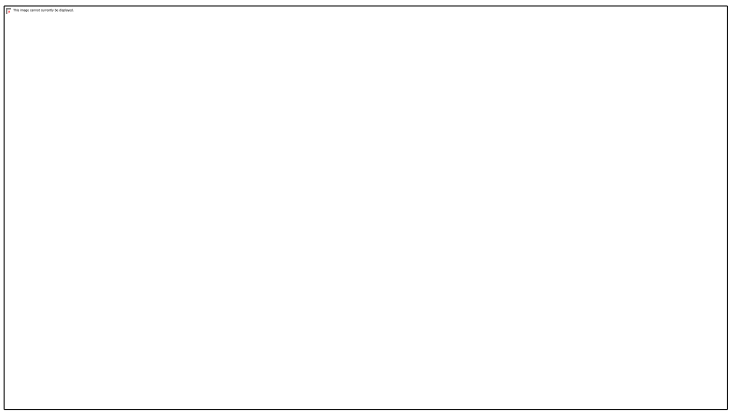
It is performed when preparing:

- Building foundations.
- Drainage trenches.
- Sewer lines.
- Water supply trenches.
- Basement areas.
- Pits and service ducts.

Construction plant used:

- Excavators.
- Backhoe loaders.
- Bulldozers for suitable earthmoving tasks.

d) Levelling and grading

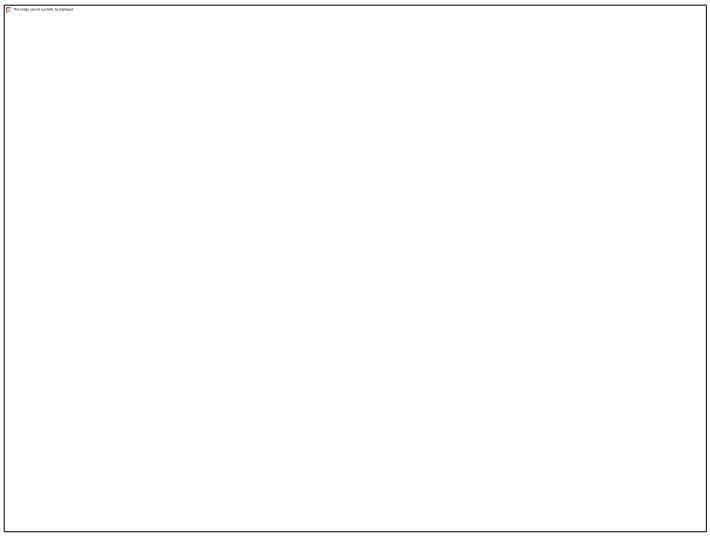


Levelling and grading involve adjusting the ground surface to achieve the required height, slope and profile.

Construction plant used:

- Motor graders.
- Bulldozers.
- Front loaders.

e) Backfilling



Backfilling involves placing suitable soil or other approved material into excavated spaces after the construction of foundations or installation of services.

Construction plant used:

- Excavators.
- Backhoe loaders.
- Front loaders.
- Dump trucks.
- Compactors.

4. Importance of earthmoving

1. Prepares construction sites for building work.
2. Provides space for foundations.

3. Facilitates installation of underground services.
4. Removes unsuitable soil.
5. Helps achieve the required ground levels.
6. Facilitates road and drainage construction.
7. Reduces manual excavation work.
8. Improves the efficiency of construction activities.

B. HAULING



Figure 1.30: Hauling operations using dump trucks and front loaders.

1. Meaning of hauling

Hauling is the process of transporting construction materials, excavated soil, rock, aggregates and other loads from one location to another using suitable transport machinery.

Hauling may take place within a construction site or between a construction site and an external material source or disposal area.

2. Construction plant used for hauling

1. Dump trucks.
2. Articulated dump trucks.
3. Tipper trucks.
4. Site transporters.
5. Wheel loaders for short-distance material movement.

3. Materials commonly hauled

- Excavated soil.
- Sand.
- Gravel.
- Crushed stones.
- Hardcore.
- Construction debris.
- Suitable demolition waste.
- Quarry materials.

4. Procedure involved in hauling construction materials

1. Identify the materials to be transported.
2. Select an appropriate transport vehicle.
3. Determine the required transportation route.
4. Inspect the vehicle before operation.
5. Load the materials safely.
6. Ensure the load does not exceed the vehicle's capacity.
7. Secure the load to prevent spillage.
8. Transport the materials along the designated route.
9. Unload at the approved location.
10. Inspect the unloading area and vehicle after operation.

5. Importance of hauling

1. Facilitates transportation of construction materials.
2. Removes excavated soil from foundation areas.
3. Supplies materials to different working locations.
4. Reduces manual transportation.
5. Improves construction productivity.
6. Supports earthmoving operations.
7. Facilitates disposal of construction waste.
8. Saves time on large projects.

C. LIFTING

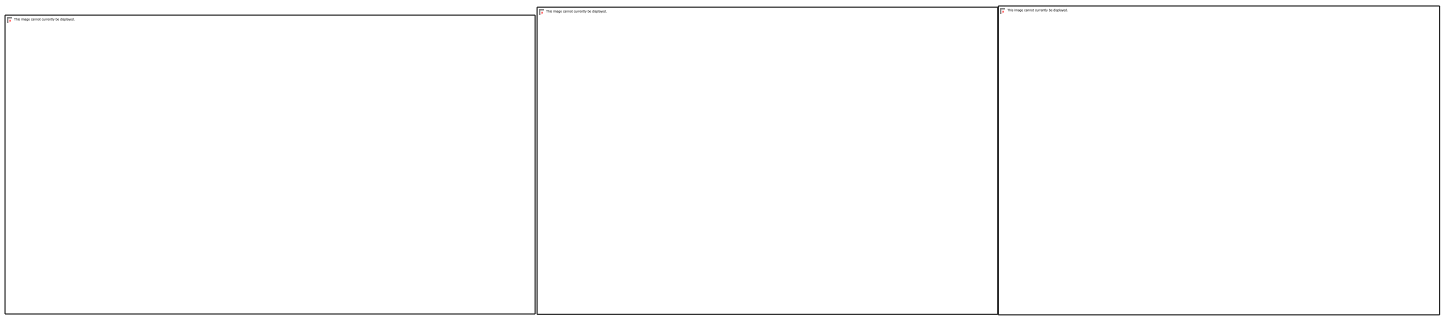


Figure 1.31: Lifting operations in building construction.

1. Meaning of lifting

Lifting is the process of raising, lowering or moving heavy materials and equipment from one level or position to another using specialised lifting machinery.

Lifting is important in multi-storey building construction, structural steel installation, precast concrete construction and industrial projects.

2. Construction plant used for lifting

1. Tower cranes.
2. Mobile cranes.
3. Crawler cranes.
4. Truck-mounted cranes.
5. Construction hoists.
6. Chain hoists.
7. Material lifts.

3. Materials commonly lifted

- Steel reinforcement bars.
- Structural steel beams.
- Concrete formwork.
- Precast concrete slabs.
- Roofing materials.
- Building blocks.
- Construction equipment.
- Mechanical installations.

4. General procedure for lifting construction materials

1. Identify the load to be lifted.
2. Determine the weight and dimensions of the load.
3. Select a crane or other suitable lifting machine.
4. Confirm that the machine has sufficient lifting capacity.

5. Inspect lifting accessories such as slings, hooks and wire ropes.
6. Prepare a suitable lifting area.
7. Attach the load securely.
8. Ensure workers are clear of the lifting area.
9. Raise the load carefully.
10. Move the load along the planned path.
11. Lower the load into the designated position.
12. Release the lifting accessories after the load is stable.

5. Importance of lifting operations

1. Enable transportation of heavy materials to upper floors.
2. Reduce manual handling of heavy loads.
3. Improve construction efficiency.
4. Facilitate installation of structural components.
5. Support high-rise building construction.
6. Improve the handling of precast concrete components.
7. Reduce the time required to move heavy materials.

D. CONCRETING

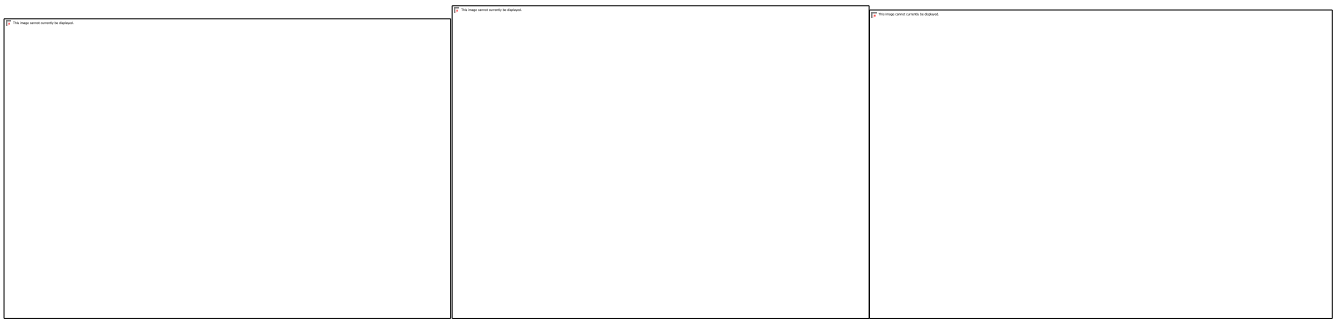


Figure 1.32: Different stages of concreting operations.

1. Meaning of concreting

Concreting is the process of preparing, transporting, placing, compacting and curing concrete to produce a required building component or structure.

Concrete is commonly used in the construction of:

- Foundations.
- Columns.

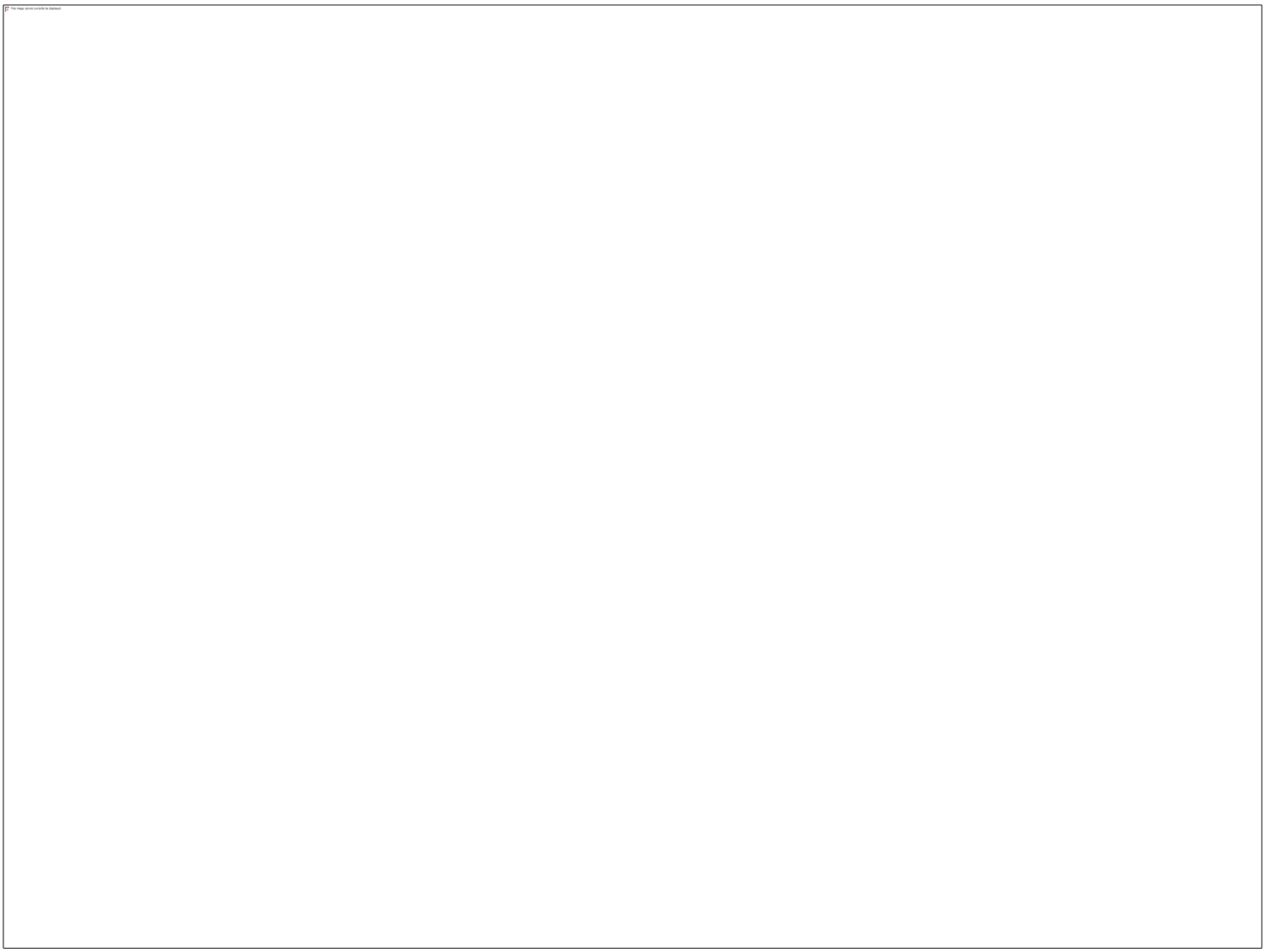
- Beams.
- Slabs.
- Floors.
- Staircases.
- Retaining walls.
- Drainage structures.

2. Construction plant used in concreting

1. Concrete mixers.
2. Concrete batching plants.
3. Concrete pumps.
4. Poker vibrators.
5. Concrete placing equipment.
6. Transit mixers.

3. Stages of concreting

a) Batching



Batching is the process of measuring concrete ingredients in specified proportions before mixing.

Materials include:

- Cement.
- Fine aggregates.
- Coarse aggregates.
- Water.
- Approved admixtures where required.

b) Mixing

Mixing involves combining the concrete ingredients to produce a uniform mixture.

Plant used:

- Concrete mixers.
- Batching and mixing plants.

c) Transportation



Transportation involves moving fresh concrete from the mixing location to the point of placement.

Plant used:

- Transit mixers.
- Concrete pumps.
- Suitable concrete transport equipment.

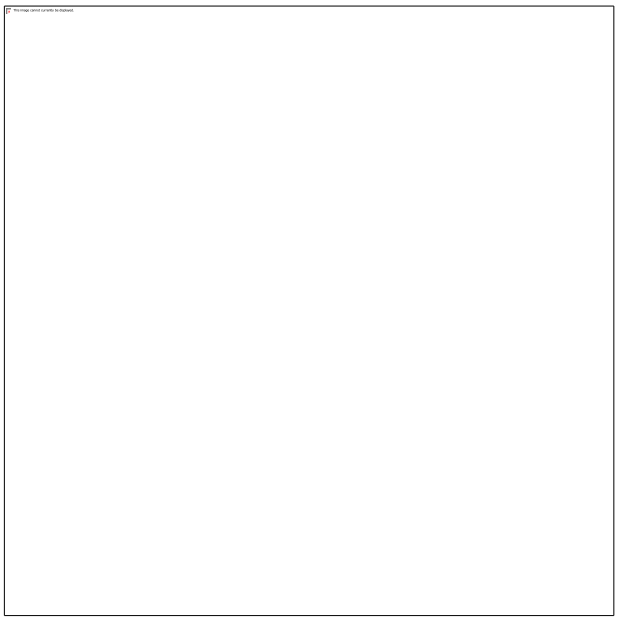
d) Placing

Placing involves depositing fresh concrete into prepared formwork or designated construction areas.

Plant used:

- Concrete pumps.
- Concrete buckets.
- Suitable placing equipment.

e) Compaction



Compaction involves removing entrapped air and consolidating freshly placed concrete.

Plant used:

- Poker vibrators.
- External vibrators.
- Surface vibrators.

f) Curing



Curing involves maintaining appropriate moisture and temperature conditions to allow concrete to develop its required strength and durability.

Methods include:

- Water curing.
- Wet covering using suitable materials.
- Applying approved curing compounds.
- Ponding on suitable horizontal surfaces.

4. Importance of concreting plant

1. Improves the speed of concrete production.
2. Reduces manual mixing.
3. Improves concrete uniformity.
4. Facilitates transportation of fresh concrete.
5. Helps place concrete in difficult-to-reach areas.
6. Improves concrete consolidation.
7. Reduces physical effort.
8. Supports construction of large concrete structures.

E. COMPACTING



Figure 1.33: Compaction of soil and construction materials.

1. Meaning of compacting

Compacting is the process of increasing the density of soil, gravel, asphalt or other construction materials by applying pressure, vibration or repeated impact.

The process reduces air voids within the material and improves its strength and stability.

2. Construction plant used for compacting

1. Smooth-wheel rollers.
2. Vibratory rollers.
3. Sheep-foot rollers.
4. Pneumatic-tyred rollers.
5. Plate compactors.
6. Tamping rammers.

3. Procedure for soil compaction

1. Identify the soil type.
2. Prepare the area to be compacted.
3. Remove unsuitable materials.
4. Spread the soil in suitable layers.
5. Adjust moisture content to the specified range.
6. Select the appropriate compaction machine.
7. Compact the material systematically.
8. Carry out the required number of passes.
9. Check the achieved compaction using suitable testing methods.
10. Repeat the process where necessary.

4. Importance of compacting

1. Increases soil density.
2. Improves the bearing capacity of the ground.
3. Reduces settlement.
4. Improves foundation support.
5. Improves road durability.
6. Reduces the formation of depressions.
7. Improves the stability of embankments.
8. Provides a firm base for floor construction.

1.2.5 IMPORTANCE OF CONSTRUCTION PLANT IN BUILDING CONSTRUCTION

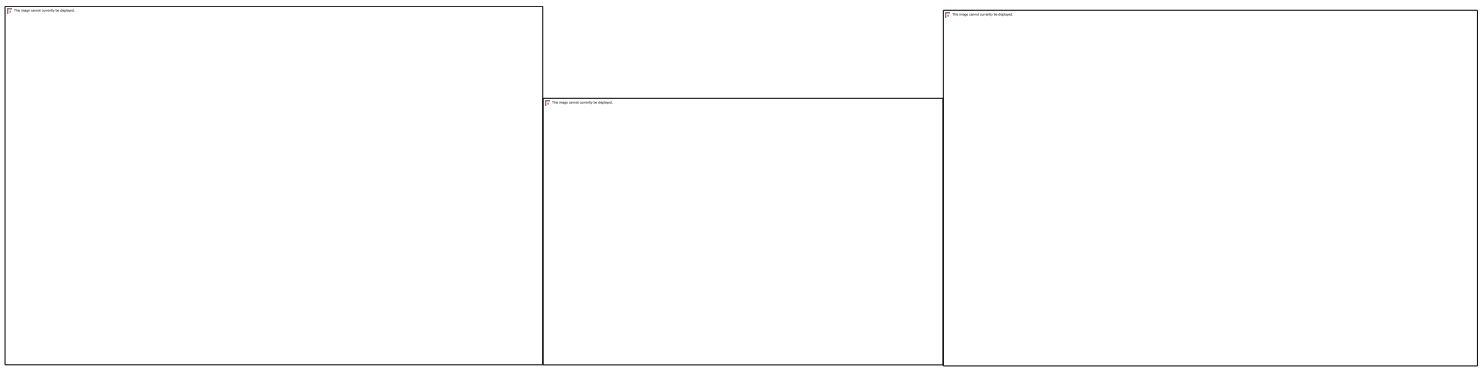


Figure 1.34: Construction plant improving efficiency in building projects.

Construction plant plays an important role in modern building construction because it enables workers to perform demanding activities more efficiently and accurately.

The importance includes:

1. Saves time

Construction plant performs operations faster than manual labour.

For example, an excavator can dig a large foundation trench within a shorter period compared with manual excavation.

2. Reduces manual labour

Heavy construction activities such as excavation, lifting and transportation can be performed mechanically, reducing physical effort.

3. Increases productivity

Machines can handle large quantities of materials, enabling construction workers to complete more work within a given period.

4. Improves construction quality

Appropriate construction plant helps achieve accurate levels, uniform concrete mixing, proper compaction and improved surface finishes.

5. Facilitates large-scale construction

Large buildings, highways, bridges and other infrastructure projects require machinery capable of handling heavy loads and large quantities of materials.

6. Improves efficiency

Different machines can work together to complete related construction operations.

For example, an excavator can dig soil, a front loader can load the excavated material and a dump truck can transport it away.

7. Reduces material wastage

Properly selected and operated machinery can reduce unnecessary material losses during excavation, transportation, mixing and placement.

8. Enables work in difficult conditions

Specialised machinery can operate on certain steep, rough, uneven or difficult construction surfaces where manual work would be challenging.

9. Improves material handling

Cranes, loaders and other equipment make it easier to lift, move and position heavy construction materials.

10. Improves safety when properly used

Mechanised operations can reduce workers' direct exposure to some heavy manual handling activities. However, machinery must be properly operated and controlled to prevent accidents.

11. Reduces project costs in suitable projects

Although construction plant involves purchase, hiring, fuel and maintenance costs, it can reduce total project costs through improved productivity and reduced labour time, particularly in large projects.

12. Supports technological development

Modern construction plant incorporates hydraulic systems, electronic controls, sensors, automated functions and improved energy efficiency.

13. Improves site preparation

Machinery such as bulldozers, graders and excavators helps prepare construction sites by clearing, excavating, levelling and shaping the ground.

14. Facilitates construction of high-rise buildings

Cranes and construction hoists enable the transportation of materials and equipment to upper floors.

15. Promotes timely completion of projects

Proper coordination and utilisation of construction plant help reduce delays and improve project scheduling.

1.2.6 ENVIRONMENTAL IMPACTS OF CONSTRUCTION PLANT

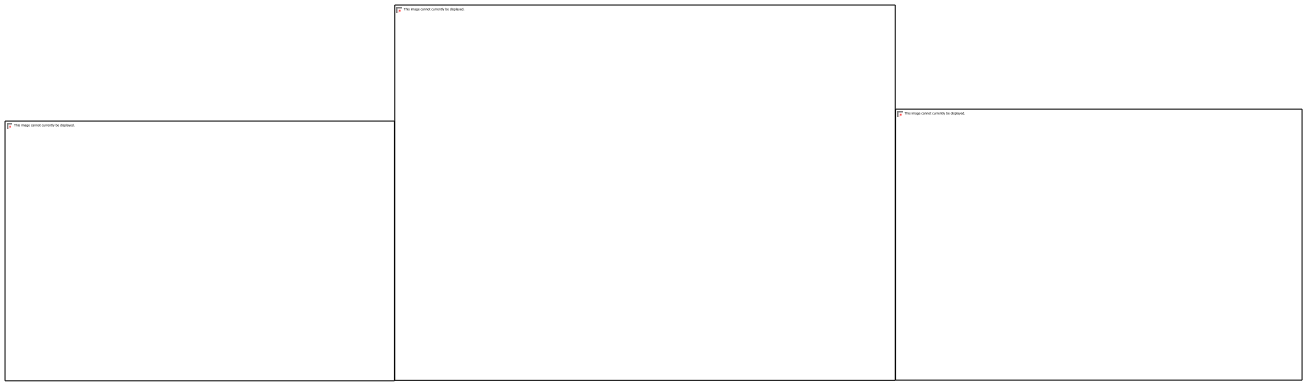


Figure 1.35: Examples of environmental challenges associated with construction machinery.

1. Meaning of environmental impact

Environmental impact refers to any positive or negative change caused to the natural or human environment as a result of an activity, process or development.

The operation of construction plant may affect air quality, water resources, soil conditions, human health, vegetation, wildlife and movement of people.

Construction machinery can improve project efficiency, but improper operation may cause environmental pollution and disturbance.

The main environmental impacts include:

1. Air pollution and emissions.
2. Noise pollution.
3. Ground vibration.
4. Oil and fuel spills.
5. Obstruction of roads and pathways.
6. Soil degradation and compaction.
7. Dust generation.
8. Water pollution.
9. Destruction of vegetation.
10. Waste generation.

A. AIR POLLUTION AND EMISSIONS

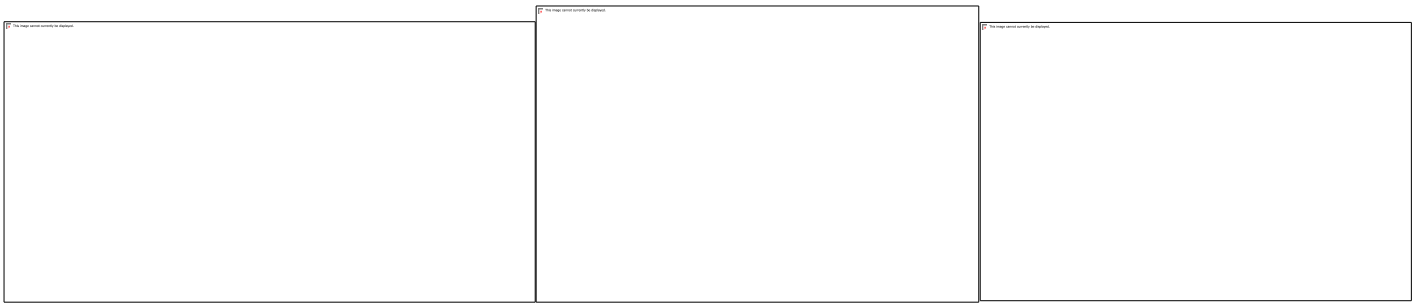


Figure 1.36: Exhaust emissions from diesel-powered construction plant.

1. Meaning of air pollution

Air pollution is the contamination of the atmosphere by harmful substances such as gases, smoke, dust and fine particles.

Many construction machines use diesel or petrol engines that release exhaust gases during operation.

2. Types of emissions from construction plant

a) Carbon dioxide (CO_2)

Carbon dioxide is produced when fossil fuels such as diesel and petrol are burned.

Effects:

1. Contributes to global warming.
2. Contributes to climate change.
3. Increases the carbon footprint of construction activities.
4. Affects environmental sustainability.

b) Carbon monoxide (CO)

Carbon monoxide is a poisonous gas produced by incomplete combustion of fuel.

Effects:

1. Reduces the ability of blood to transport oxygen.
2. Can cause headaches and dizziness.
3. Can cause serious poisoning.
4. Can be fatal at high concentrations.

c) Nitrogen oxides (NOx)

Nitrogen oxides are gases produced during high-temperature fuel combustion.

Effects:

1. Contribute to the formation of ground-level ozone.
2. Irritate the respiratory system.
3. Contribute to acidification.
4. Reduce air quality.

d) Particulate matter

Particulate matter consists of tiny airborne particles produced by diesel combustion, soil disturbance and construction activities.

Effects:

1. Causes respiratory irritation.
2. Reduces air quality.
3. Can worsen respiratory conditions.
4. Settles on nearby surfaces and vegetation.

3. Sources of emissions on construction sites

1. Diesel-powered excavators.
2. Bulldozers.
3. Dump trucks.
4. Front loaders.
5. Graders.
6. Cranes using combustion engines.
7. Concrete mixers powered by fuel engines.
8. Other fuel-powered construction equipment.

4. Measures for controlling air pollution and emissions

1. **Regular engine servicing:** Proper servicing helps engines operate efficiently and reduces excessive emissions.

2. **Using cleaner fuels:** Use fuels and energy sources that comply with applicable environmental requirements.

3. **Switching off idle machines:** Avoid unnecessary engine idling when machinery is not being used.

4. **Using electric machinery:** Where practical, electric plant can reduce direct exhaust emissions at the construction site.

5. **Proper machine selection:** Select equipment with suitable engine capacity for the intended work.

6. **Preventing fuel wastage:** Ensure proper handling and efficient use of fuel.

7. **Using modern equipment:** Select machinery with improved emission-control technology.

8. **Monitoring emissions:** Carry out appropriate inspections and maintenance.

9. **Reducing unnecessary movement:** Plan construction operations to minimise unnecessary machine travel.

10. **Dust suppression:** Use suitable water spraying and dust-control measures on exposed surfaces and access roads.

B. NOISE POLLUTION



Figure 1.37: Construction plant producing noise during operation.

1. Meaning of noise pollution

Noise pollution refers to unwanted or excessive sound that interferes with normal activities, causes discomfort or affects the health and well-being of people.

Construction plant may produce high noise levels from engines, exhaust systems, hydraulic mechanisms, vibrating components and impact operations.

2. Sources of noise from construction plant

1. Excavators.
2. Bulldozers.
3. Graders.
4. Dump trucks.
5. Concrete mixers.
6. Pneumatic hammers.
7. Compactors.
8. Cranes.
9. Concrete breakers.
10. Generators and compressors.

3. Effects of noise pollution

A. Effects on workers

1. Hearing damage: Prolonged exposure to excessive noise may cause permanent hearing loss.

2. Stress: Continuous noise can cause irritation and psychological stress.

3. Fatigue: Excessive noise may increase tiredness and discomfort.

4. Poor concentration: Noise can make it difficult for workers to concentrate.

5. Communication difficulties: Workers may fail to hear instructions and warning signals.

6. Increased accident risk: Important warning sounds may be masked by machinery noise.

B. Effects on surrounding communities

1. Disturbs residents living near construction sites.
2. Interferes with communication.
3. Disturbs learning activities in nearby schools.

4. Interrupts hospital and health facility activities.
5. Causes discomfort in nearby business premises.
6. Disturbs sleep and normal daily activities.

4. Measures for controlling noise pollution

1. **Regular machine maintenance:** Repair defective silencers, exhaust systems and loose components.

2. **Use of quieter machinery:** Select equipment designed to operate with reduced noise.

3. **Providing hearing protection:** Workers should use suitable earplugs or earmuffs.

4. **Restricting working hours:** Schedule noisy activities during appropriate working periods in accordance with applicable requirements.

5. **Installing noise barriers:** Use suitable barriers to reduce noise transmission to surrounding areas.

6. **Increasing separation distance:** Position noisy machinery away from sensitive areas where practicable.

7. **Switching off unused machinery:** Avoid unnecessary engine idling.

8. **Providing worker training:** Educate workers on noise hazards and appropriate control measures.

9. **Monitoring noise levels:** Carry out appropriate noise assessments.

10. **Planning construction activities:** Avoid unnecessary simultaneous operation of several noisy machines near sensitive locations.

C. GROUND VIBRATIONS

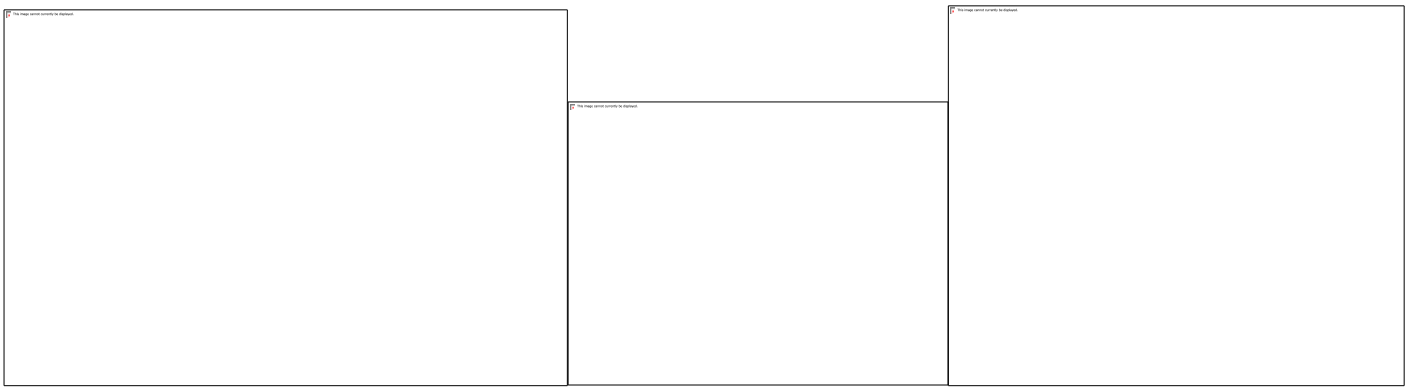


Figure 1.38: Construction plant generating ground vibrations.

1. Meaning of vibration

Vibration refers to repeated oscillatory movement of a body or material around a central position.

Ground vibration occurs when machinery transfers mechanical energy into the soil or surrounding structures, causing them to shake.

Some construction plant is specifically designed to produce vibrations, while other machines generate vibration as a by-product of their operation.

2. Sources of ground vibrations

1. Vibratory rollers.
2. Plate compactors.
3. Tamping rammers.

4. Pneumatic hammers.
5. Excavators fitted with hydraulic breakers.
6. Heavy dump trucks.
7. Piling equipment.
8. Heavy demolition machinery.

3. Effects of ground vibrations

1. **Building damage:** Excessive vibration may contribute to cracking or damage in vulnerable nearby structures.

2. **Ground disturbance:** Vibrations may disturb loose soil and certain ground materials.

3. **Discomfort:** People living or working nearby may experience discomfort.

4. **Equipment disturbance:** Sensitive equipment may be affected by excessive vibration.

5. **Worker health effects:** Prolonged exposure to hand-arm or whole-body vibration may cause health problems.

6. **Structural disturbance:** Existing weak structures may be affected by repeated vibration.

7. **Disturbance of nearby activities:** Vibration may interfere with sensitive work or operations.

4. Measures for controlling ground vibrations

1. Select machinery appropriate for the ground conditions.
2. Use the correct compaction equipment.
3. Avoid unnecessary vibration operations.
4. Maintain machinery properly.
5. Monitor vibration levels near sensitive structures.
6. Use alternative construction methods where vibration must be minimised.
7. Establish safe working distances.
8. Reduce unnecessary heavy vehicle movement.
9. Plan high-vibration operations carefully.
10. Inspect nearby structures where required before and during construction.

D. OIL AND FUEL SPILLS

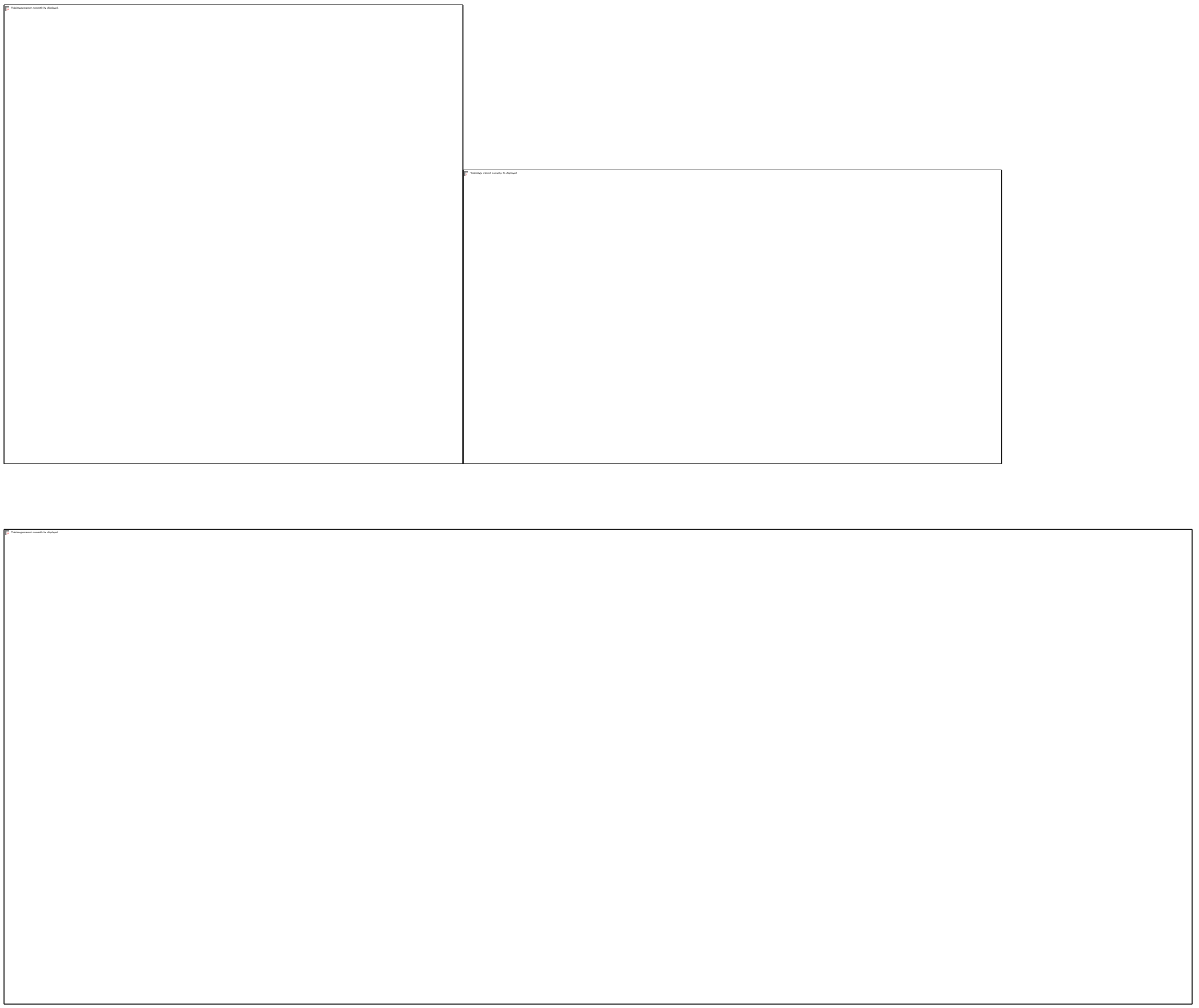


Figure 1.39: Oil and fuel leakage from construction machinery.

1. Meaning of oil and fuel spills

Oil and fuel spills occur when petroleum products or lubricating fluids escape from machinery, storage containers or fuel handling systems and enter the surrounding environment.

Construction plant uses various fluids, including:

- Diesel.
- Petrol.
- Engine oil.
- Hydraulic oil.
- Gear oil.
- Grease.
- Coolants.

Leaks may occur due to damaged hoses, loose connections, defective seals, careless refuelling and poor equipment maintenance.

2. Causes of oil and fuel spills

1. Damaged hydraulic hoses.
2. Leaking fuel tanks.
3. Poorly maintained engines.
4. Loose pipe connections.
5. Defective seals and gaskets.
6. Careless refuelling.
7. Overfilling fuel tanks.
8. Accidental damage to fuel containers.
9. Improper disposal of used engine oil.
10. Poor storage of lubricants.

3. Effects of oil and fuel spills

1. **Soil contamination:** Oil and fuel can contaminate soil and affect its quality.
2. **Water pollution:** Spilled petroleum products may enter rivers, streams, dams and groundwater.
3. **Harm to aquatic organisms:** Petroleum contamination may harm fish and other aquatic organisms.
4. **Damage to vegetation:** Contaminated soil may affect plant growth.
5. **Fire hazards:** Fuel and certain oils increase the risk of fire.
6. **Health hazards:** Contact with petroleum products may cause skin irritation and other health effects.
7. **Unpleasant conditions:** Oil spills create dirty and unsafe working environments.
8. **Economic losses:** Spills may require expensive clean-up and environmental restoration.

4. Measures for preventing and controlling oil spills

1. **Regular inspection:** Check fuel tanks, hoses and hydraulic connections for leaks.
2. **Proper servicing:** Maintain machinery according to the manufacturer's recommendations.
3. **Safe refuelling:** Refuel equipment in designated areas using appropriate procedures.
4. **Use of drip trays:** Place suitable drip trays under machinery where leakage may occur.
5. **Proper storage:** Store fuel and lubricants in suitable, secure containers.
6. **Spill kits:** Provide appropriate spill-control materials at construction sites.
7. **Immediate reporting:** Report oil and fuel leaks as soon as they are identified.
8. **Containment:** Prevent spilled oil from spreading into drains, waterways and surrounding soil.
9. **Proper disposal:** Dispose of contaminated soil, used oil and absorbent materials through approved waste-management procedures.
10. **Worker training:** Train workers on spill prevention and emergency response.

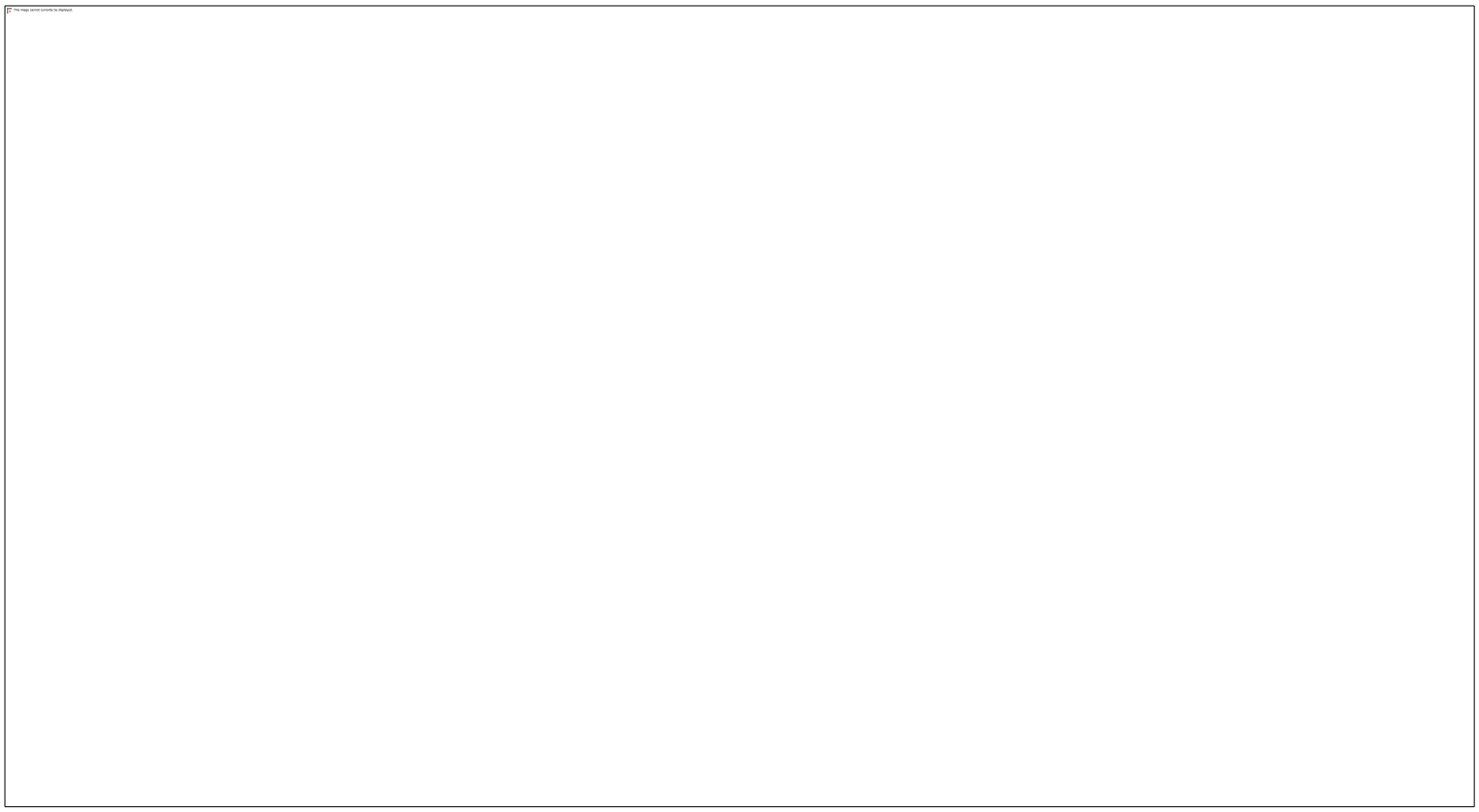
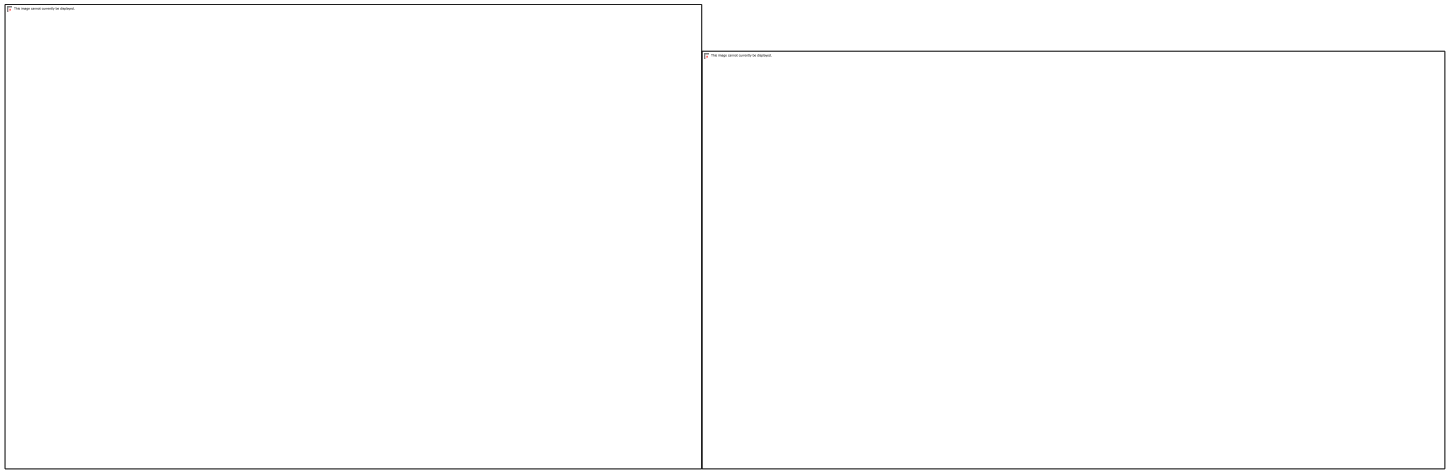


Figure 1.40: Spill-control materials used to manage oil and fuel leakage.

E. OBSTRUCTION OF ROADS AND PATHWAYS



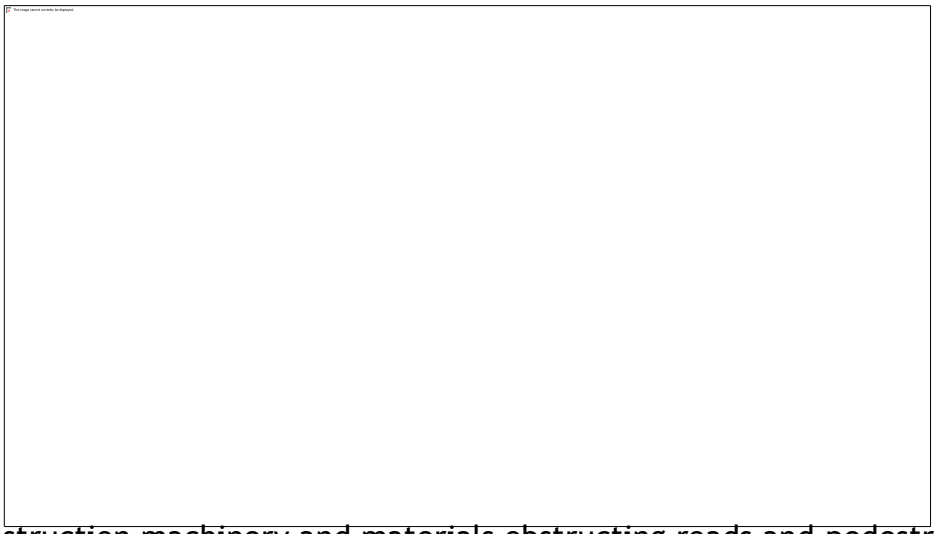


Figure 1.41: Construction machinery and materials obstructing roads and pedestrian pathways.

1. Meaning of obstruction of roads and pathways

Obstruction of roads and pathways occurs when construction machinery, vehicles, materials or construction activities block or restrict the movement of vehicles and pedestrians.

Construction plant may occupy large spaces, especially during excavation, material transportation, lifting and road construction operations.

2. Causes of obstruction

1. Parking dump trucks along access roads.
2. Positioning cranes across vehicle routes.
3. Excavating trenches across pedestrian pathways.
4. Leaving construction materials on roads.
5. Poorly planned delivery of materials.
6. Operating large machinery in narrow streets.
7. Blocking entrances to buildings.
8. Poor site traffic management.
9. Unplanned movement of heavy machinery.
10. Failure to provide alternative pedestrian routes.

3. Effects of obstruction of roads and pathways

1. **Traffic congestion:** Vehicles may experience delays because of restricted road space.

2. **Pedestrian inconvenience:** People may find it difficult to access buildings, schools and businesses.

3. **Accidents:** Pedestrians and motorists may be exposed to collision hazards.

4. **Restricted emergency access:** Ambulances, fire engines and other emergency vehicles may experience delays.

5. **Business disruption:** Restricted access may affect nearby commercial activities.

6. **Property access difficulties:** Residents and workers may be unable to access their premises conveniently.

7. **Increased travel time:** Road users may be forced to use longer alternative routes.

8. **Public safety risks:** Poorly controlled machinery movement may expose the public to dangerous situations.

4. Measures for controlling obstruction

1. **Proper site planning:** Designate appropriate areas for machinery operation, loading and parking.

2. **Traffic management:** Develop a traffic management plan before beginning construction.

3. **Alternative routes:** Provide suitable alternative routes for pedestrians and vehicles where necessary.

4. **Warning signs:** Install visible construction warning signs.

5. **Safety barriers:** Use suitable barriers and cones to separate the public from machinery.

6. **Controlled deliveries:** Schedule material deliveries to minimise congestion.

7. **Designated parking areas:** Provide specific parking and waiting areas for construction vehicles.

8. **Flag persons or traffic marshals:** Use trained personnel to guide traffic where required.

9. **Maintaining access:** Keep emergency access routes and essential pedestrian pathways available.

10. **Public communication:** Inform nearby residents and road users about planned temporary closures and diversions.



Figure 1.42: Proper traffic management and pedestrian protection during construction.

F. DUST POLLUTION

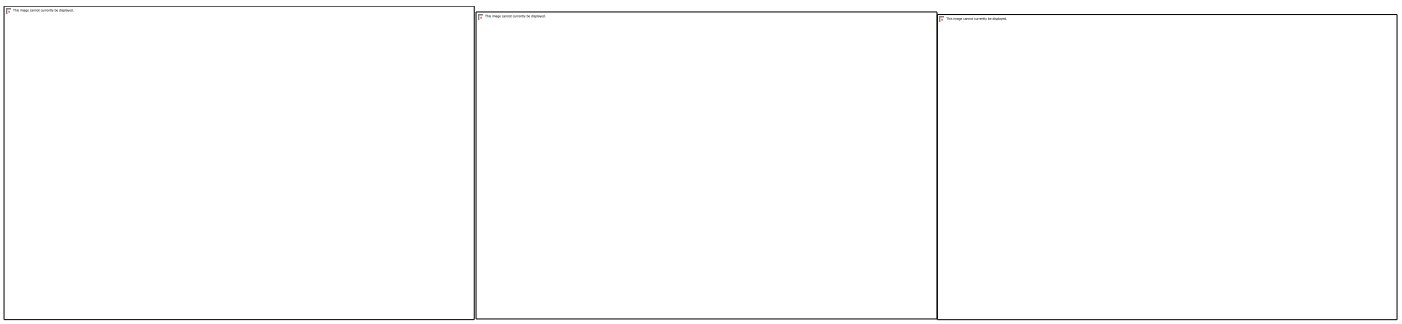


Figure 1.43: Dust generated during earthmoving and construction plant operations.

1. Meaning of dust pollution

Dust pollution is the presence of excessive fine solid particles in the air, usually resulting from activities such as excavation, soil movement, loading, transportation and demolition.

2. Sources of dust

1. Excavation of dry soil.
2. Bulldozing and grading.
3. Movement of dump trucks on unpaved roads.
4. Loading and unloading sand.
5. Crushing and handling aggregates.
6. Demolition activities.
7. Concrete and masonry cutting.

3. Effects of dust pollution

1. Causes coughing and respiratory irritation.
2. May worsen asthma and other respiratory conditions.
3. Reduces visibility.
4. Settles on nearby buildings and equipment.
5. Affects vegetation.
6. Creates uncomfortable working conditions.
7. May affect nearby schools, homes and businesses.

4. Measures for controlling dust pollution

1. Spray water on dusty access roads.
2. Cover transported loose materials.
3. Reduce vehicle speeds on unpaved roads.
4. Use suitable dust extraction systems.
5. Provide appropriate respiratory protection.
6. Maintain construction access roads.
7. Avoid unnecessary disturbance of exposed soil.
8. Schedule dusty operations appropriately.
9. Use approved dust-suppression methods.
10. Clean affected areas using suitable methods.

G. SOIL DEGRADATION AND COMPACTION

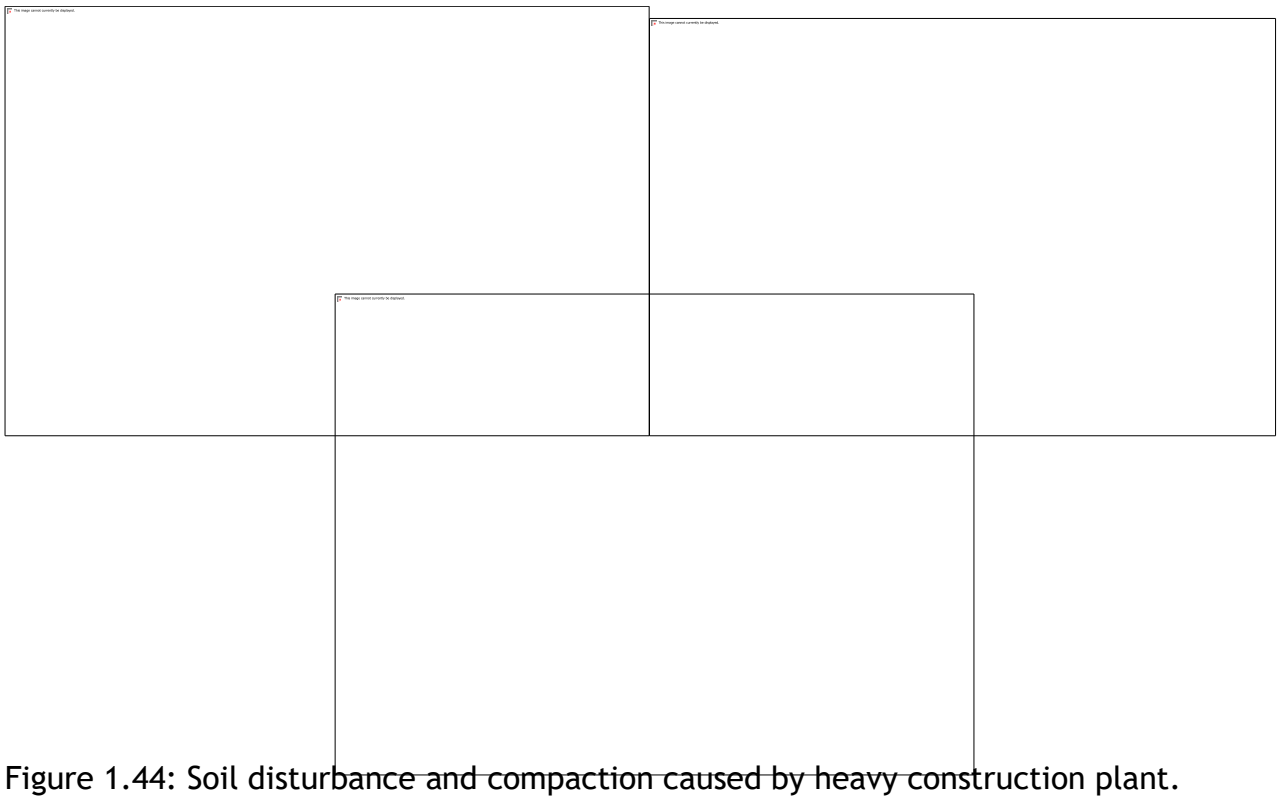


Figure 1.44: Soil disturbance and compaction caused by heavy construction plant.

1. Meaning of soil degradation

Soil degradation refers to the deterioration of soil quality due to physical, chemical or biological changes that reduce its ability to support plant growth and perform other environmental functions.

Heavy construction machinery may disturb natural soil layers, compact the ground and cause erosion.

2. Causes of soil degradation associated with construction plant

1. Excessive movement of heavy machinery.
2. Uncontrolled excavation.
3. Removal of topsoil.
4. Improper disposal of excavated materials.
5. Leakage of oil and fuel.
6. Poor drainage management.
7. Unnecessary vegetation clearance.

3. Effects of soil degradation

1. Reduces soil productivity.
2. Increases soil erosion.
3. Disturbs natural soil structure.
4. Reduces water infiltration.
5. May increase surface runoff.
6. Damages vegetation.
7. Affects the stability of surrounding land.

4. Measures for controlling soil degradation

1. Limit machinery movement to designated routes.
2. Remove and store reusable topsoil separately.
3. Avoid unnecessary excavation.
4. Provide proper site drainage.
5. Prevent oil and fuel spills.
6. Protect vegetation outside the construction area.
7. Restore disturbed areas after construction.
8. Carry out appropriate erosion-control measures.

1.2.7 GENERAL MEASURES FOR REDUCING ENVIRONMENTAL IMPACTS OF CONSTRUCTION PLANT

Environmental management should be considered before construction begins, during machinery operation and after completion of the project.

The following practices help reduce environmental impacts:

1. Carry out environmental assessments where required.

2. Select machinery appropriate for the project.
3. Maintain construction plant regularly.
4. Use fuel-efficient and cleaner machinery.
5. Avoid unnecessary engine idling.
6. Control noise through appropriate equipment and working schedules.
7. Monitor ground vibration near sensitive structures.
8. Prevent oil and fuel spills.
9. Provide suitable waste-management facilities.
10. Suppress dust on exposed surfaces and access roads.
11. Maintain safe pedestrian pathways.
12. Provide appropriate road diversions.
13. Protect nearby vegetation.
14. Prevent contaminated runoff from entering water sources.
15. Train machinery operators on environmental protection.
16. Observe applicable environmental laws and regulations in Kenya.
17. Restore disturbed land after construction.
18. Maintain records of environmental incidents and corrective actions.

Environmental management summary table

Environmental impact	Main cause	Appropriate control measure
Air pollution	Diesel and petrol exhaust	Maintain engines and use cleaner machinery.
Noise pollution	Engines and impact operations	Use quieter equipment and hearing protection.
Ground vibration	Rollers and pneumatic hammers	Monitor vibration and select suitable machinery.
Oil spills	Leaking fuel tanks and hydraulic hoses	Inspect equipment and provide spill kits.
Road obstruction	Poor machinery positioning	Plan traffic routes and provide diversions.
Dust pollution	Excavation and movement of dry materials	Spray water and cover loose materials.
Soil degradation	Uncontrolled machinery movement	Restrict machinery to designated routes.
Water pollution	Fuel spills and contaminated runoff	Prevent leaks and control site drainage.

1.2.8 CARE AND MAINTENANCE OF CONSTRUCTION PLANT



Figure 1.45: Inspection, servicing and maintenance of construction plant.

1. Meaning of maintenance of construction plant

Maintenance of construction plant refers to the activities carried out to keep machinery in good working condition, improve its performance, prevent breakdowns and extend its useful life.

Construction plant contains mechanical, hydraulic, electrical and structural components that require regular inspection and servicing.

2. General maintenance practices

A. Cleaning

1. Remove soil, mud and concrete deposits after use.
2. Clean the machine's external surfaces.
3. Remove dust from ventilation openings.
4. Clean the operator's cab.
5. Ensure moving components are free from unnecessary dirt.

B. Lubrication

1. Lubricate moving components as recommended.
2. Check engine oil levels.
3. Check hydraulic fluid levels.
4. Grease appropriate joints and bearings.
5. Use the recommended lubricants.

C. Inspection

1. Inspect the engine for visible defects.
2. Check hydraulic hoses for leaks.
3. Inspect tyres and tracks.
4. Check lifting cables and hooks on cranes.
5. Inspect the brakes and steering system.
6. Check electrical connections.
7. Examine structural components for cracks.

D. Servicing

1. Change engine oil at recommended intervals.
2. Replace filters when necessary.
3. Service hydraulic systems.
4. Inspect transmission systems.
5. Check cooling systems.
6. Service braking systems.
7. Arrange professional servicing according to the manufacturer's schedule.

E. Storage

1. Park machinery in designated areas.
2. Use secure storage facilities.
3. Protect equipment from harsh weather where necessary.
4. Prevent unauthorised operation.
5. Store equipment according to the manufacturer's instructions.

3. Importance of maintaining construction plant

1. Extends the useful life of machinery.
2. Reduces unexpected breakdowns.
3. Improves machine efficiency.
4. Reduces repair expenses.
5. Promotes workplace safety.
6. Reduces fuel wastage.
7. Minimises environmental pollution.
8. Improves construction productivity.
9. Reduces project delays.
10. Maintains the quality of construction work.

1.2.9 SAFETY PRECAUTIONS WHEN USING CONSTRUCTION PLANT

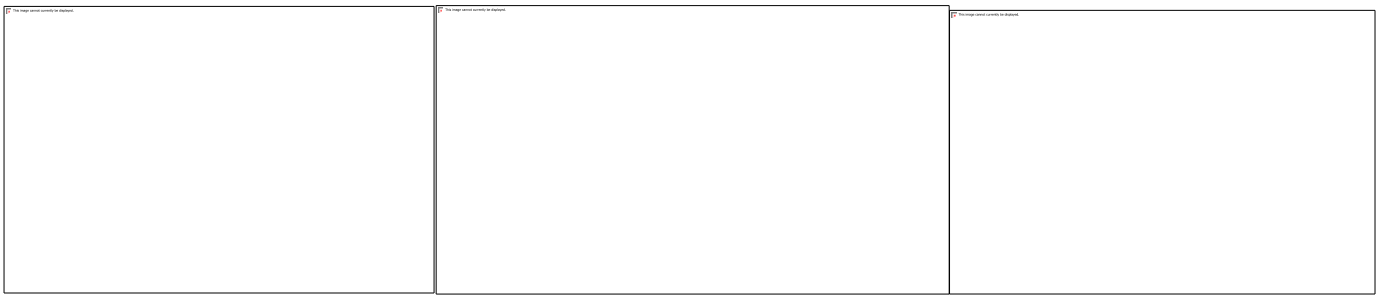


Figure 1.46: Safe working practices around construction plant.

Construction plant can cause serious accidents if it is improperly operated, poorly maintained or used without adequate safety precautions.

General safety precautions

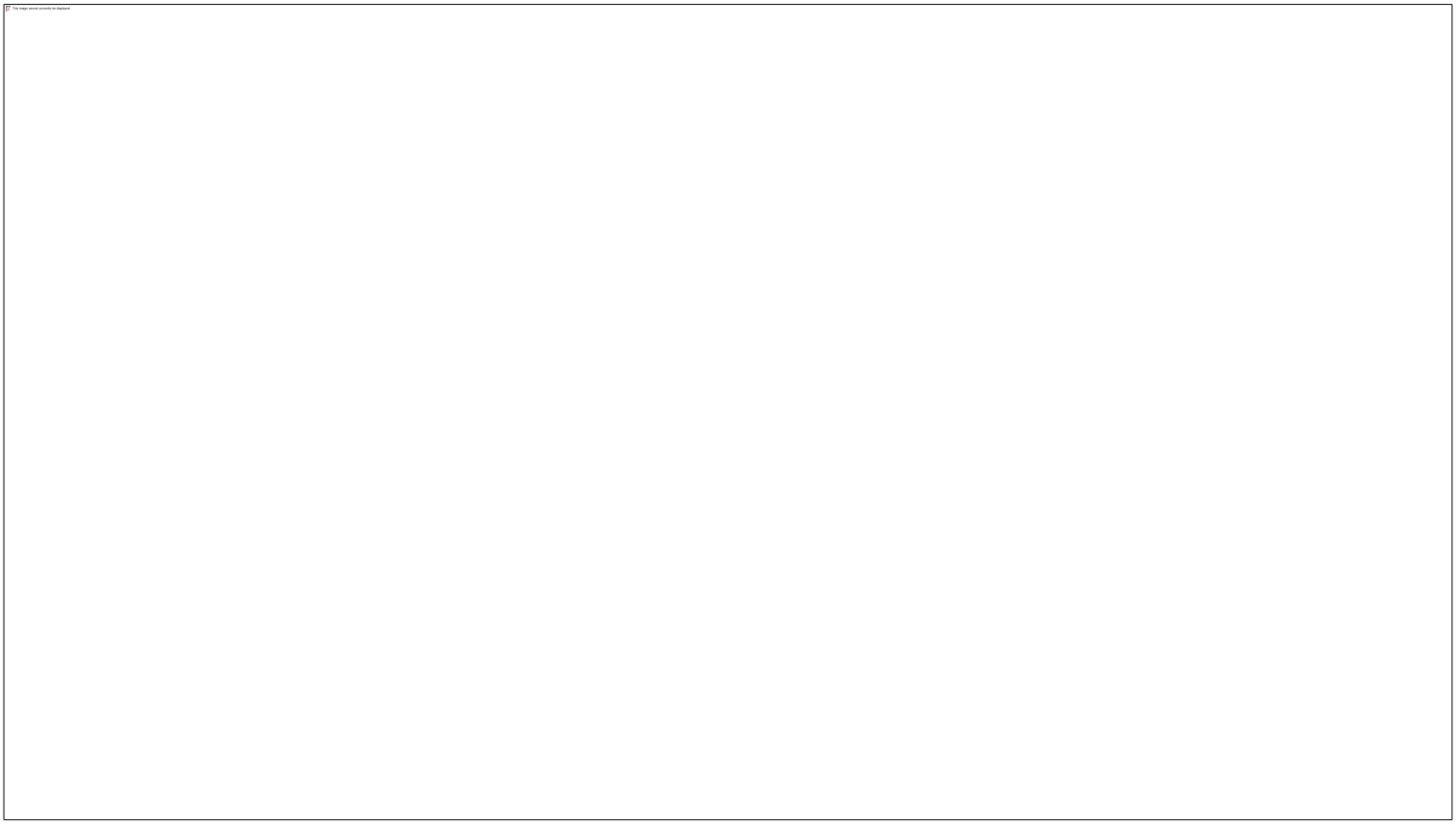
1. Ensure machinery is operated by trained and competent personnel.
2. Inspect machinery before operation.
3. Wear appropriate personal protective equipment.
4. Keep unauthorised persons away from machinery.
5. Observe the manufacturer's operating instructions.
6. Avoid operating defective machinery.
7. Ensure reversing alarms and warning devices are functional.
8. Maintain safe distances from moving machinery.
9. Avoid carrying unauthorised passengers.
10. Do not exceed the machine's rated capacity.
11. Ensure adequate lighting during operations.
12. Use designated machinery routes.
13. Avoid operating machinery on unstable ground.
14. Keep workers away from suspended loads.
15. Switch off machinery before maintenance.
16. Use suitable fire extinguishers where required.
17. Maintain clear communication between operators and ground workers.
18. Report accidents and defective equipment immediately.
19. Provide suitable emergency procedures.
20. Keep the construction site clean and organised.

Personal protective equipment used around construction plant



Personal protective equipment	Function
Safety helmet	Protects the head from falling objects.
Safety boots	Protect the feet from heavy objects and sharp materials.
Reflective vest	Improves visibility around moving machinery.
Safety goggles	Protect the eyes from dust and flying particles.
Ear defenders	Protect hearing from excessive noise.
Respirator	Protects against hazardous airborne particles when correctly selected.
Protective gloves	Protect the hands against appropriate mechanical and material hazards.

1.2.10 FACTORS TO CONSIDER WHEN SELECTING CONSTRUCTION PLANT



The selection of construction plant depends on several factors.

1. **Nature of the work:** Select machinery according to the construction activity, such as excavation, lifting, hauling or concreting.

2. **Size of the project:** Large construction projects may require high-capacity machinery, while small projects may require compact equipment.

3. **Type of material:** Consider whether the material is soil, rock, concrete, sand, gravel or metal.

4. **Working conditions:** Consider ground conditions, site accessibility, slopes and available working space.

5. **Availability of machinery:** Select equipment that can be obtained locally or hired when required.

6. **Purchase or hiring cost:** Compare the cost of purchasing machinery with hiring it for the required period.

7. **Operating cost:** Consider fuel, electricity, labour and maintenance expenses.

8. **Availability of skilled operators:** Ensure competent operators are available.

9. **Working capacity:** Select machinery with the appropriate capacity to perform the task efficiently.

10. **Environmental impact:** Consider noise, exhaust emissions, vibration and possible pollution.

11. **Safety requirements:** Select machinery with suitable safety features.

12. **Maintenance requirements:** Consider the availability of spare parts, servicing facilities and technical support.

13. **Project duration:** Consider how long the machinery will be required.

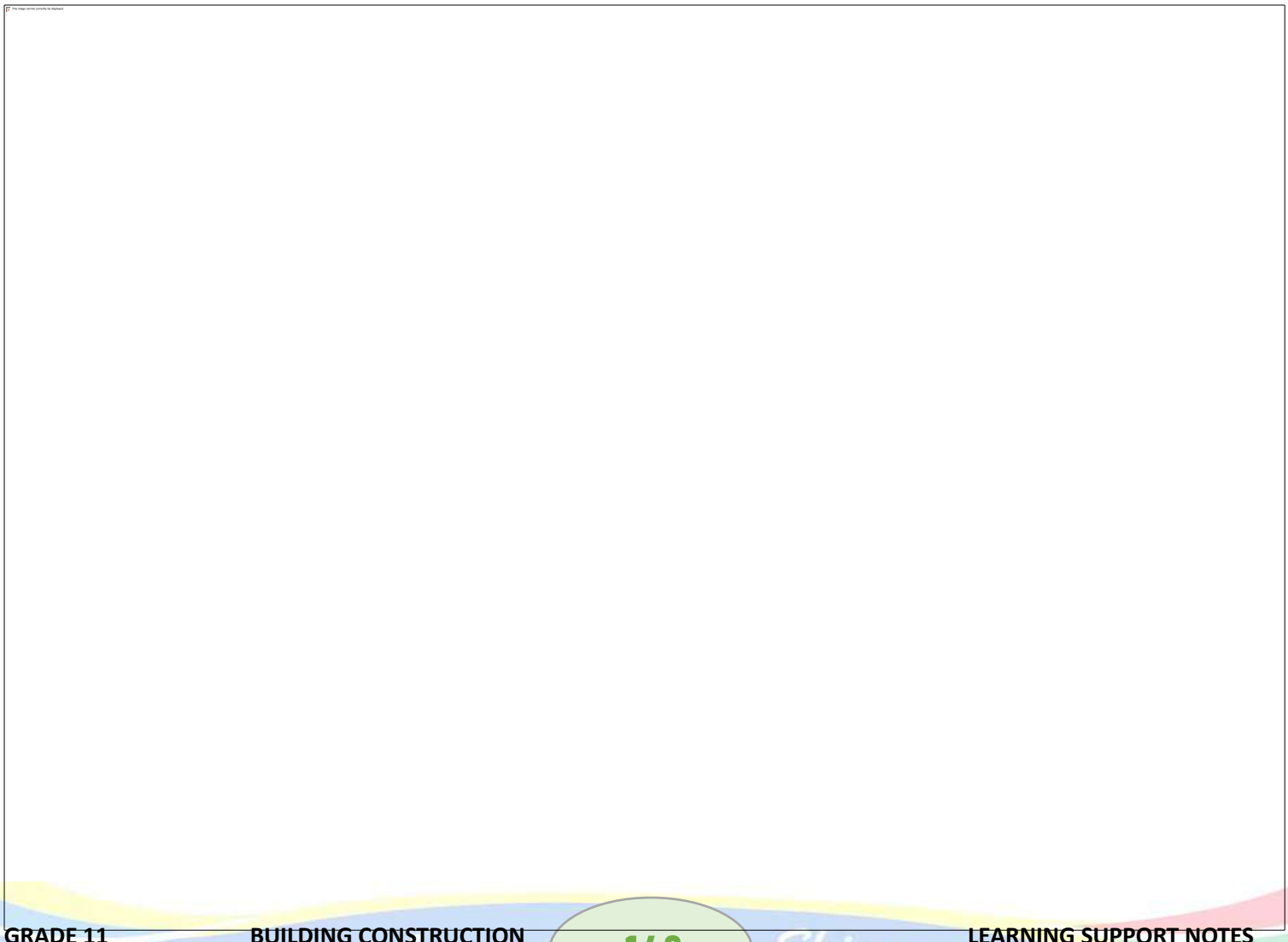
14. **Mobility:** Consider whether the equipment needs to move between different working locations.

15. **Energy source:** Consider the availability of diesel, petrol, electricity or other appropriate energy sources.

1.2.12 PRACTICAL LEARNING ACTIVITIES

These activities should be conducted through supervised demonstrations, approved workshop visits, construction site visits, videos and safe simulations.

Activity 1: Identification of construction plant

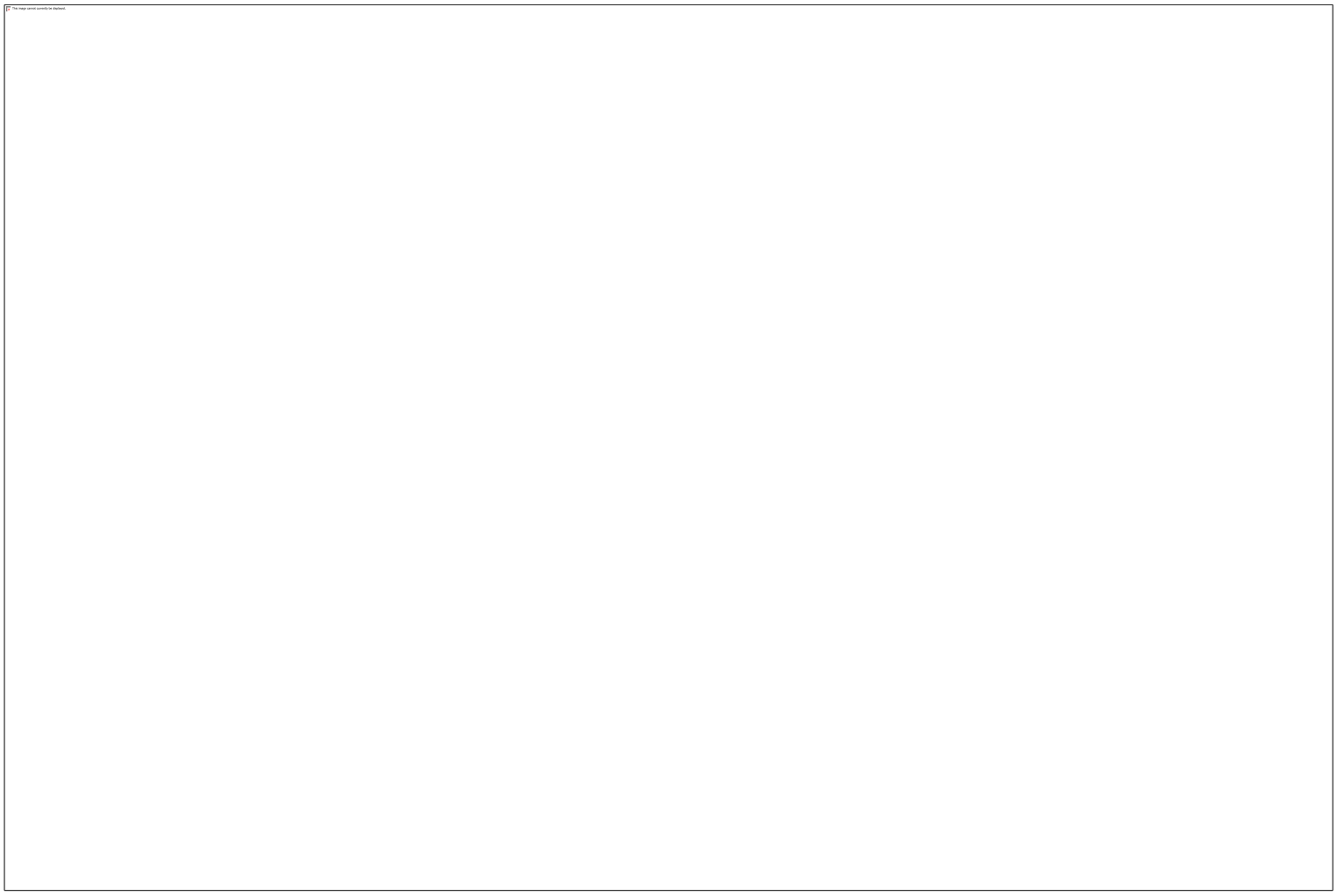


Learning activities:

Learners should:

1. Visit a construction site or machinery display area.
2. Observe different types of construction plant.
3. Identify the names of the machines.
4. Record their main components.
5. Identify the power sources.
6. Explain their functions.
7. Classify the machines according to their applications.
8. Present their findings to the class.

Activity 2: Demonstration of excavation

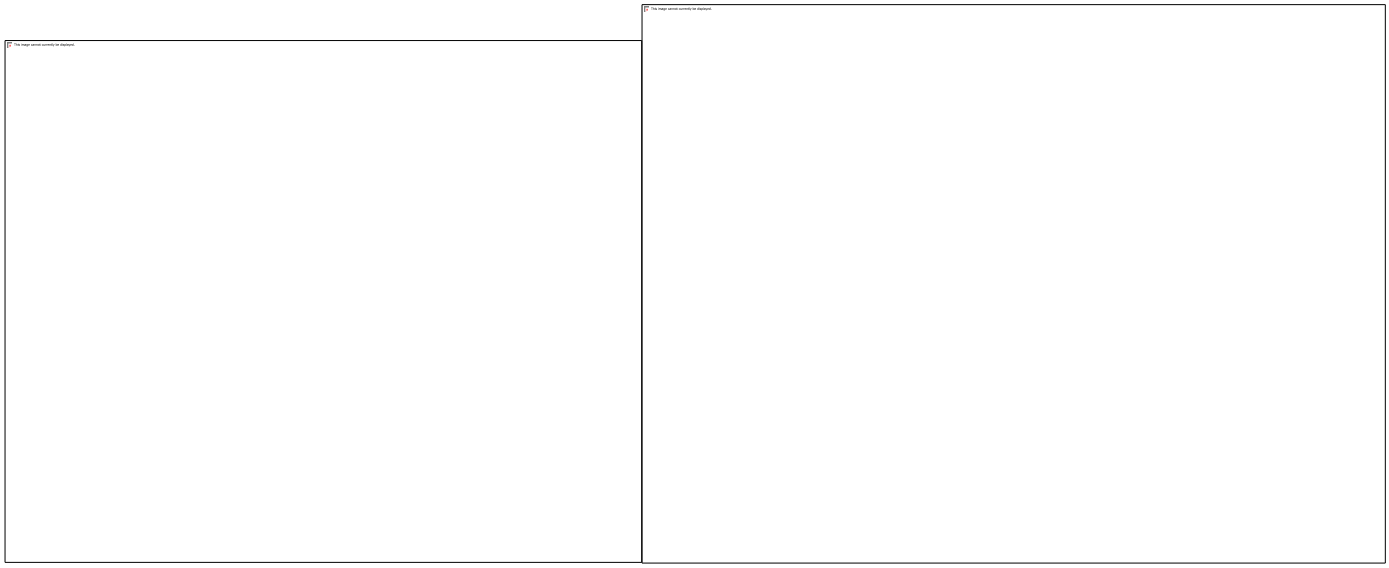


Learners should:

1. Identify an excavator.
2. Observe its major components.
3. Identify the boom, arm and bucket.
4. Observe how the operator controls the machine.
5. Explain how the excavator digs foundation trenches.

6. Identify safety precautions during excavation.
7. Discuss possible environmental impacts.

Activity 3: Demonstration of concrete mixing and compaction

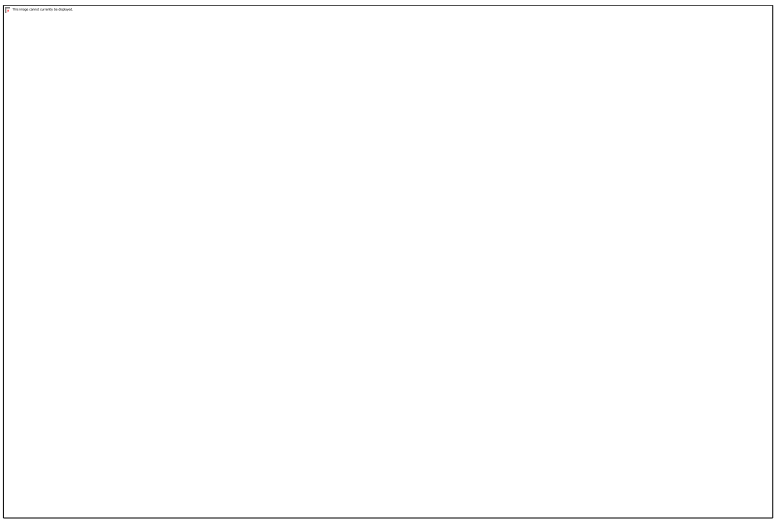




Learners should:

1. Identify a concrete mixer.
2. Identify its major components.
3. Observe how concrete ingredients are introduced.
4. Observe the mixing process.
5. Identify a poker vibrator.
6. Observe concrete compaction.
7. Explain the importance of proper consolidation.
8. Discuss safety measures during concreting.

Activity 4: Demonstration of soil compaction



Learners should:

1. Identify different compactors.
2. Observe their working mechanisms.
3. Compare a plate compactor with a roller.
4. Explain why soil compaction is necessary.
5. Identify suitable applications for different compactors.
6. Discuss the environmental effects of vibration.

Activity 5: Environmental impact assessment



Learners should:

1. Identify environmental impacts caused by construction plant.
2. Observe possible sources of noise and dust.
3. Identify potential sources of oil spills.
4. Discuss how construction machinery may obstruct roads and pathways.
5. Suggest measures for reducing environmental impacts.
6. Prepare a simple environmental protection checklist.

REVISION QUESTIONS

STRAND 1.0: FOUNDATION OF BUILDING CONSTRUCTION

SUB-STRAND 1.2: CONSTRUCTION PLANT

SECTION A: MULTIPLE-CHOICE QUESTIONS

Choose the correct answer from the alternatives provided.

1. Which of the following best defines construction plant?

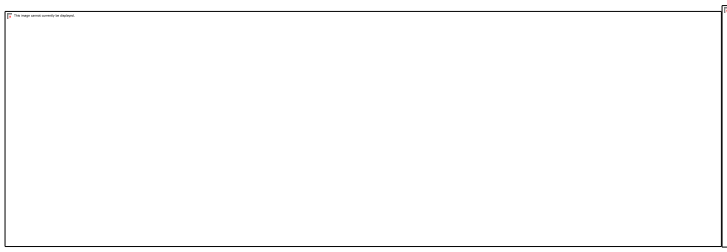
A. Small hand tools used exclusively for measuring materials.

B. Specialised machinery and equipment used to perform construction operations.

C. Materials used for decorating buildings.

D. Temporary structures used for storing construction materials.

2. Which of the following is mainly used for excavating building foundations?





3. The main function of a bulldozer blade is to:

A. Mix concrete.

B. Lift heavy loads.

C. Push and spread earth materials.

D. Compact fresh concrete.

4. Which construction plant is mainly used for levelling and shaping road surfaces?

A. Motor grader. B. Excavator.

C. Concrete mixer. D. Crane.

5. A poker vibrator is mainly used for:

A. Excavating foundation trenches.

B. Compacting freshly placed concrete.

C. Transporting construction materials.

D. Lifting reinforcement bars.

6. Which of the following machines is used to mix cement, sand, aggregates and water?

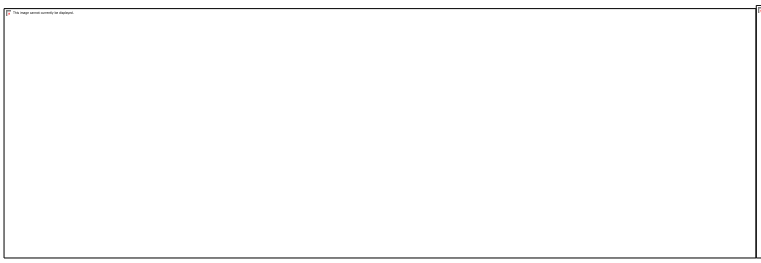
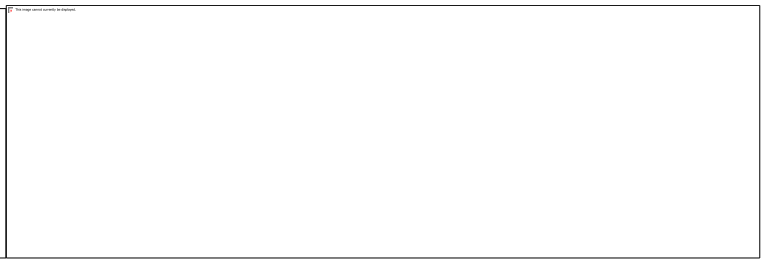
A. Bulldozer.

B. Grader.

C. Concrete mixer.

D. Dump truck.

7. Which construction machine combines the functions of an excavator and a front loader?

8. A sheep-foot roller is particularly suitable for compacting:

A. Steel reinforcement.

B. Clay soil.

C. Fresh concrete.

D. Roofing sheets.

9. Which construction plant is mainly used for lifting heavy materials to upper floors?

A. Dump truck.

B. Grader.

C. Tower crane.

D. Bulldozer.

10. The component of a dump truck that raises the loading body during unloading is the:

A. Steering wheel.

B. Hydraulic cylinder.

C. Chassis.

D. Exhaust pipe.

11. Which machine is most suitable for loading sand and gravel into a dump truck?

A. Poker vibrator. B. Front loader.

C. Grader. D. Tower crane.

12. The main function of a compactor is to:

A. Increase soil density.

B. Mix concrete.

C. Transport materials.

D. Lift structural steel.

13. Which of the following is an example of hauling plant?

A. Dump truck.

B. Poker vibrator.

C. Concrete mixer.

D. Tower crane.

14. Which construction plant is most appropriate for digging a narrow drainage trench on a relatively small construction site?

A. Backhoe loader.

B. Tower crane.

C. Concrete mixer.

D. Motor grader.

15. Which of the following is a component of an excavator?

A. Poker head.

B. Boom.

C. Mixing drum.

D. Moldboard blade.

16. The main purpose of a crane counterweight is to:

A. Increase engine speed.

B. Balance the crane during lifting operations.

C. Increase the length of the jib.

D. Reduce the size of the hook.

17. Which construction plant is used to transport excavated soil from a construction site?

A. Concrete mixer. B. Dump truck.

C. Poker vibrator. D. Grader.

18. Which of the following is a stationary construction plant?

A. Crawler excavator.

B. Mobile crane.

C. Fixed concrete batching plant.

D. Wheel loader.

19. Which of the following environmental impacts is associated with diesel-powered construction machinery?

A. Increased soil fertility. B. Air pollution.

C. Improved water quality. D. Reduced noise.

20. Carbon dioxide released by construction machinery contributes to:

A. Global warming.

B. Soil formation.

C. Increased rainfall in every location.

D. Concrete compaction.

21. Excessive noise from construction plant may cause:

A. Improved hearing. B. Hearing damage.

C. Increased soil fertility. D. Reduced fuel consumption.

22. Which of the following is a possible effect of excessive ground vibration?

A. Improved structural stability in every case.

B. Damage to vulnerable nearby structures.

C. Elimination of soil erosion.

D. Increased water quality.

23. Oil spills from construction plant may cause:

A. Soil and water contamination.

B. Increased soil productivity.

C. Improved air quality.

D. Reduced fire risk.

24. Which of the following is an appropriate method of controlling dust pollution?

A. Increasing vehicle speeds.

B. Spraying water on dusty access roads.

C. Removing all warning signs.

D. Leaving excavated soil uncovered.

25. Which of the following helps control noise pollution?

A. Removing machine silencers.

B. Operating machinery continuously.

C. Using suitable noise barriers.

D. Increasing engine speed unnecessarily.

26. Which of the following is an appropriate measure for preventing oil spills?

A. Ignoring leaking hydraulic hoses.

B. Regularly inspecting fuel tanks and hydraulic connections.

C. Refuelling carelessly.

D. Disposing of used oil into drainage channels.

27. Obstruction of roads and pathways by construction plant can result in:

A. Improved traffic flow.

B. Reduced pedestrian access.

C. Increased road capacity.

D. Improved emergency access.

28. Which of the following is an important factor when selecting construction plant?

A. Colour of the machinery only.

B. Operator's favourite brand.

C. Nature and size of the construction project.

D. Number of windows in the machine.

29. Which of the following is an important maintenance practice for construction plant?

A. Ignoring engine oil levels.

B. Cleaning, inspecting and servicing machinery regularly.

C. Operating machinery with damaged brakes.

D. Allowing hydraulic leaks to continue.

30. Which of the following best promotes environmental sustainability in construction plant operations?

A. Unnecessary engine idling.

B. Careless disposal of used oil.

C. Using efficient machinery and controlling emissions.

D. Dumping excavated soil into waterways.

SECTION B:

31: INTRODUCTION TO CONSTRUCTION PLANT

a) Define the term construction plant. (2 marks)

b) State five examples of construction plant used in building construction. (5 marks)

c) Explain five characteristics of construction plant. (5 marks)

d) Differentiate between construction plant and construction tools. (4 marks)

e) State four advantages of using construction plant in building construction. (4 marks)

32: CLASSIFICATION OF CONSTRUCTION PLANT

a) Explain the meaning of classification of construction plant. (2 marks)

b) Classify construction plant according to their functions, giving two examples under each of the following categories:

i. Earthmoving plant. (4 marks)

ii. Hauling plant. (4 marks)

iii. Lifting plant. (4 marks)

iv. Concreting plant. (4 marks)

v. Compaction plant. (4 marks)

c) Differentiate between mobile plant and stationary plant. (4 marks)

33: EXCAVATORS AND BULLDOZERS

a) Define an excavator. (2 marks)

b) Identify six main components of an excavator. (6 marks)

c) Explain five uses of excavators in building construction. (5 marks)

d) Define a bulldozer. (2 marks)

e) State five functions of bulldozers. (5 marks)

f) Explain four differences between excavators and bulldozers. (4 marks)

34: GRADERS AND BACKHOE LOADERS

a) Define a motor grader. (2 marks)

b) Identify five main components of a motor grader. (5 marks)

c) Explain five functions of graders in construction. (5 marks)

d) Define a backhoe loader. (2 marks)

e) Explain five uses of backhoe loaders in building construction. (5 marks)

f) State three advantages of using backhoe loaders. (3 marks)

35: CONCRETING PLANT

a) Define the term concreting. (2 marks)

b) Define a concrete mixer. (2 marks)

c) Identify six main components of a concrete mixer. (6 marks)

d) Explain five functions of concrete mixers in building construction. (5 marks)

e) Define a poker vibrator. (2 marks)

f) Explain five reasons why vibration is necessary during concrete placement. (5 marks)

g) State four safety precautions when operating a concrete mixer. (4 marks)

36: COMPACTORS

a) Define a compactor. (2 marks)

b) Identify five types of compactors used in construction. (5 marks)

c) Explain five functions of compactors in building construction. (5 marks)

d) State five benefits of proper soil compaction. (5 marks)

e) Explain three factors to consider when selecting a compactor. (3 marks)

37: CRANES

a) Define a crane. (2 marks)

b) Identify six components of a tower crane. (6 marks)

c) Identify four types of cranes used in construction. (4 marks)

d) Explain five functions of cranes in building construction. (5 marks)

e) State five safety precautions to observe when operating cranes. (5 marks)

38: DUMP TRUCKS AND FRONT LOADERS

a) Define a dump truck. (2 marks)

b) Identify five main components of a dump truck. (5 marks)

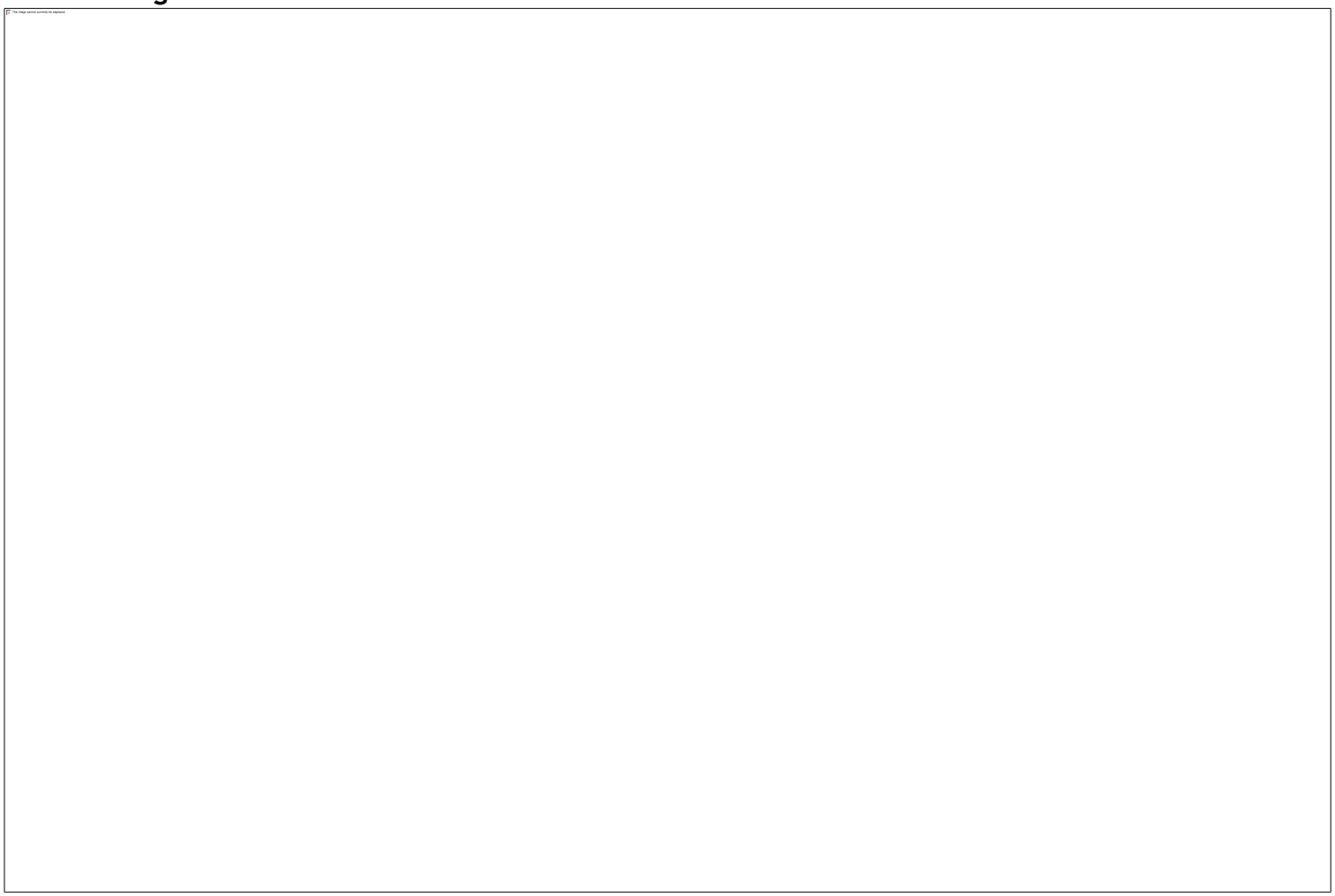
c) Explain five uses of dump trucks in building construction. (5 marks)

d) Define a front loader. (2 marks)

e) Explain five functions of front loaders. (5 marks)

f) Differentiate between a front loader and a dump truck. (4 marks)

39: The diagram below shows a front-end loader used in construction work.



Study the diagram carefully and answer the questions that follow.

(a) Name the parts of the front-end loader labelled M, N, O, P, Q, R, S and T. (8 marks)

(b) State one function of each of the parts labelled M, N, O, P, Q, R, S and T. (8 marks)

40: CONSTRUCTION OPERATIONS

a) Define each of the following terms:

i. Earthmoving. (2 marks)

ii. Hauling. (2 marks)

iii. Lifting. (2 marks)

iv. Concreting. (2 marks)

v. Compacting. (2 marks)

b) Identify four types of construction plant used in earthmoving. (4 marks)

c) Explain four activities involved in earthmoving operations. (4 marks)

d) State four types of construction plant used in lifting operations. (4 marks)

e) Explain four importance of hauling in building construction. (4 marks)

41: ENVIRONMENTAL IMPACTS OF CONSTRUCTION PLANT

a) Define environmental impact. (2 marks)

b) Explain five environmental impacts associated with construction plant. (10 marks)

c) State five sources of air pollution from construction plant. (5 marks)

d) Explain five effects of noise pollution on construction workers and surrounding communities. (5 marks)

e) State five measures for controlling oil and fuel spills on construction sites. (5 marks)

42: ENVIRONMENTAL MANAGEMENT

a) Explain the meaning of dust pollution. (2 marks)

b) State five causes of dust pollution on construction sites. (5 marks)

c) Explain five measures for controlling dust pollution. (5 marks)

d) Explain four effects of ground vibration caused by construction plant. (4 marks)

e) State four measures for reducing ground vibration. (4 marks)

f) Explain five effects of obstruction of roads and pathways by construction machinery. (5 marks)

g) State five measures for controlling obstruction of roads and pathways. (5 marks)

43: IMPORTANCE, MAINTENANCE AND SAFETY

a) Explain eight reasons why construction plant is important in building construction. (8 marks)

b) Define maintenance of construction plant. (2 marks)

c) State eight general maintenance practices for construction plant. (8 marks)

d) Explain six safety precautions when operating construction plant. (6 marks)

e) Identify six types of personal protective equipment used when working around construction plant. (6 marks)

44: APPLICATION AND PROBLEM-SOLVING

A contractor has been awarded a project to construct a three-storey residential building in Nakuru County. The project involves clearing the site, excavating foundations, transporting soil, preparing concrete, lifting materials and compacting the ground.

a) Identify the most appropriate construction plant for each of the following activities:

i. Clearing the site. (1 mark)

ii. Excavating foundation trenches. (1 mark)

iii. Transporting excavated soil. (1 mark)

iv. Loading sand and gravel. (1 mark)

v. Mixing concrete. (1 mark)

vi. Compacting freshly placed concrete. (1 mark)

vii. Lifting reinforcement bars to upper floors. (1 mark)

viii. Compacting soil around foundations. (1 mark)

b) Explain four advantages of using construction plant in the project. (4 marks)

c) Identify four environmental impacts that may result from the operation of the machinery. (4 marks)

d) Suggest four measures the contractor should implement to minimise the environmental impacts. (4 marks)

1.2.14 SUMMARY OF THE SUB-STRAND

Construction plant consists of specialised machinery and equipment used to perform various operations in building construction.

The main categories and examples studied are:

Category	Examples	Main function
Earthmoving	Excavators, bulldozers, graders, backhoe loaders	Digging, pushing and levelling soil.
Hauling	Dump trucks, tipper trucks	Transporting construction materials.
Loading	Front loaders	Scooping and loading loose materials.
Lifting	Tower cranes, mobile cranes	Raising and moving heavy loads.
Concreting	Concrete mixers, poker vibrators	Preparing and consolidating concrete.
Compacting	Rollers, plate compactors, rammers	Increasing material density.

Key environmental impacts

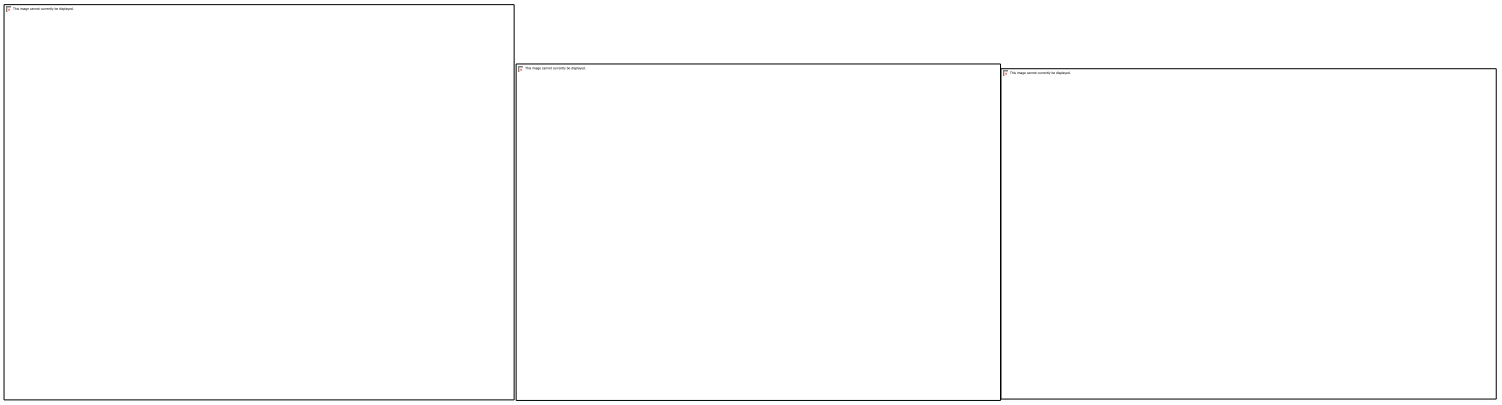
1. Air pollution and emissions.
2. Noise pollution.
3. Ground vibrations.
4. Oil and fuel spills.
5. Obstruction of roads and pathways.
6. Dust pollution.
7. Soil degradation.
8. Water pollution.

Key environmental control measures

1. Regular machinery maintenance.
2. Use of cleaner and more efficient machinery.
3. Noise reduction measures.
4. Vibration monitoring.
5. Prevention of oil and fuel spills.
6. Dust suppression.
7. Proper site traffic management.
8. Appropriate waste disposal.
9. Protection of vegetation and water resources.
10. Environmental awareness and training.

STRAND 1.0: FOUNDATIONS OF BUILDING CONSTRUCTION

SUB-STRAND 1.3: SITE ORGANIZATION



1.3.1 Introduction to Site Organization

Meaning of site organization

Site organization refers to the systematic planning, arrangement, coordination and management of the different facilities, equipment, materials, workers and activities within a construction site to ensure that construction work is carried out safely, efficiently and economically.

It involves deciding where different facilities and activities should be located before and during construction.

A well-organized construction site ensures that:

1. Construction activities are carried out smoothly.
2. Building materials are stored safely and properly.
3. Workers have access to essential facilities.
4. Construction machinery and equipment are positioned appropriately.
5. Accidents and injuries are minimized.
6. Time and construction costs are reduced.
7. Materials are not wasted or damaged.
8. Construction work complies with relevant safety and building regulations.

Example in the Kenyan context:

During the construction of a classroom block in a school in Kilgoris, the contractor must identify suitable locations for:

- A temporary site office.
- Cement and reinforcement storage.
- Sand and ballast storage.
- Water storage tanks.
- Access roads for delivery vehicles.
- Workers' sanitation facilities.

- Security at the site entrance.
- Areas for mixing concrete and preparing mortar.

All these facilities should be arranged to allow construction activities to proceed without unnecessary interference.

Importance of site organization

Site organization is important because it:

1. **Improves productivity:** Workers can easily access materials, tools and equipment, reducing unnecessary movement.
2. **Promotes safety:** Proper arrangement reduces accidents caused by falling materials, moving machinery and obstructed pathways.
3. **Reduces construction costs:** Proper storage prevents wastage, theft and damage to materials.
4. **Saves time:** Materials and equipment are placed near the areas where they are required.
5. **Improves supervision:** Site offices and designated working areas make it easier for supervisors to monitor activities.
6. **Promotes cleanliness:** Designated waste disposal areas prevent accumulation of rubbish.
7. **Improves communication:** Proper positioning of offices and communication facilities improves coordination.
8. **Promotes workers' welfare:** Workers can access clean water, toilets, washing facilities and rest areas.
9. **Ensures security:** Proper fencing, lighting and access control protect workers, equipment and materials.
10. **Ensures compliance:** The site can be managed in accordance with applicable Kenyan construction, occupational safety and environmental requirements.

1.3.2 Amenities on a Construction Site

Meaning of construction site amenities

Construction site amenities are the facilities, services and supporting structures provided within or near a construction site to support construction operations and meet the basic needs of workers, visitors and site management.

They provide the necessary conditions for effective working, safety, sanitation, communication and comfort.

Amenities are sometimes referred to as site facilities or temporary site facilities.

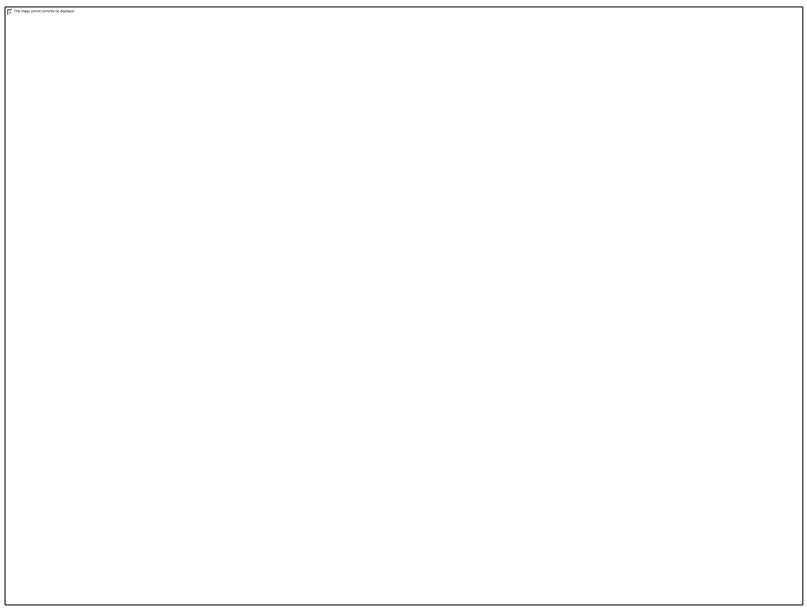
Types of amenities found on a construction site

The main construction site amenities include:

1. Access roads and pathways.
2. Material storage facilities.
3. Site offices.
4. Water supply facilities.
5. Electricity and power supply.

6. Security facilities.
7. Workers' welfare facilities.
8. Sanitation facilities.
9. First-aid facilities.
10. Waste management facilities.
11. Communication facilities.
12. Parking areas.
13. Workshop and equipment maintenance areas.

A. Access roads and pathways



Meaning

Access roads are temporary or permanent routes constructed or designated within and around a construction site to allow the movement of vehicles, machinery, workers and materials.

Functions of access roads

1. Allow delivery trucks to transport construction materials to the site.
2. Provide access for concrete mixers, excavators, cranes and other machinery.
3. Enable workers and visitors to move safely around the site.
4. Facilitate emergency access by ambulances and fire engines.
5. Reduce delays during the transportation of materials.
6. Connect different working areas within the site.
7. Provide routes for removing construction waste.

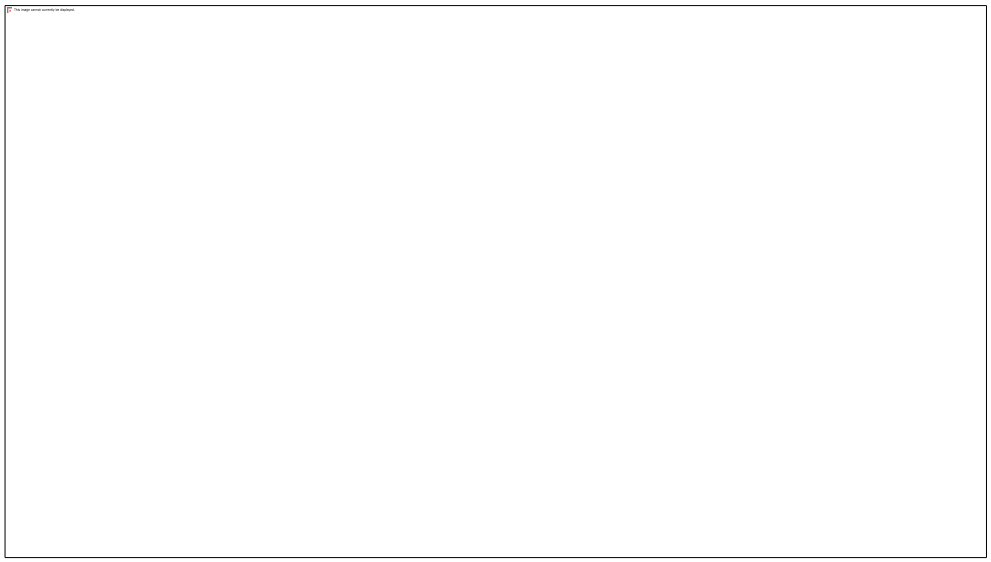
Factors to consider when establishing access roads

- The size and nature of vehicles expected on site.
- The strength and stability of the ground.
- The amount of traffic expected.

- The location of buildings and working areas.
- Proper drainage to prevent waterlogging.
- Safe separation of pedestrians and moving vehicles.
- Adequate road width and turning space.
- Dust control, especially on dry construction sites.
- Clear traffic signs and speed limits.

Example: On a construction project in Nakuru, a gravel access road may be provided for lorries delivering sand, cement and ballast.

B. Material storage facilities



Meaning

Material storage facilities are designated areas, stores or structures where construction materials are kept safely before they are used.

Types of material storage facilities

1. **Cement stores**
   - Used for storing cement bags.
   - Should be dry, waterproof and well ventilated.
   - Cement bags should be placed on raised wooden platforms.
   - Bags should be protected from moisture and direct contact with the ground.
   - Older cement should generally be used before newly delivered cement.
2. **Timber storage areas**
   - Used for storing timber, formwork materials and wooden boards.
   - Timber should be stacked neatly on level supports.
   - It should be protected from excessive moisture and direct soil contact.
3. **Steel reinforcement storage areas**
   - Used for storing reinforcement bars, steel sections and metal components.

- Steel should be stacked securely to prevent rolling or falling.
- It should be arranged according to diameter, length and type.
- Protection against excessive exposure to moisture helps minimize corrosion.

4. **Aggregate storage areas**
   - Used for storing sand, gravel and ballast.
   - Different types and sizes of aggregates should be stored separately.
   - The ground should be firm and preferably have a suitable hard surface.
   - Measures should be taken to prevent contamination by soil and rubbish.
5. **Equipment stores**
   - Used for keeping hand tools, power tools and small construction equipment.
   - Stores should be lockable and properly organized.
6. **Hazardous materials stores**
   - Used for keeping paints, solvents, fuels and other hazardous substances.
   - They should be appropriately ventilated, secured and labelled.
   - Incompatible substances should be stored separately.
   - Fire protection and spill-control measures should be provided.

Functions of material storage facilities

- Prevent damage to construction materials.
- Protect materials from rain, moisture and sunlight where necessary.
- Prevent theft and unauthorized access.
- Make it easier to identify and issue materials.
- Reduce wastage.
- Improve stock control and accountability.
- Ensure materials remain in usable condition.

C. Site offices



Meaning

A site office is a temporary building or designated room established at a construction site to provide working space for the contractor, engineers, architects, clerks of works, site supervisors and other management personnel.

Functions of a site office

1. Provides accommodation for site management.
2. Acts as a centre for planning and coordinating construction activities.
3. Provides space for keeping drawings, specifications and contract documents.
4. Provides a place for meetings between contractors, consultants and clients.
5. Facilitates communication between workers and management.
6. Provides a secure place for keeping site records.
7. Supports preparation of progress reports.
8. Provides a location for receiving visitors and inspecting project documents.
9. Facilitates supervision of construction activities.

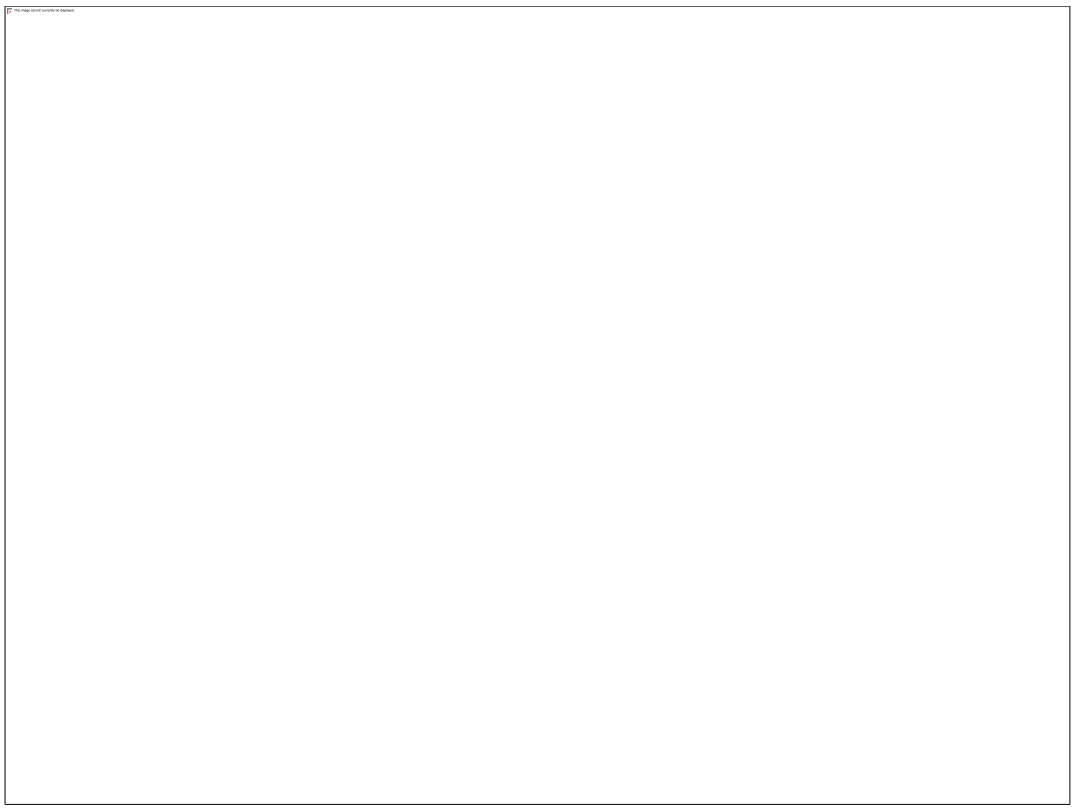
Facilities found in a site office

- Tables and chairs.
- Filing cabinets.
- Construction drawings.
- Computers and printers.
- Communication equipment.
- Lighting and electrical sockets.
- First-aid information.
- Notice boards.
- Internet facilities where available.

Factors to consider when locating a site office

- It should be easily accessible.
- It should be positioned where management can supervise the site.
- It should be away from excessive noise and dust.
- It should not obstruct construction activities.
- It should be secure.
- It should be accessible to visitors and consultants.

D. Water supply facilities



Meaning

Water supply facilities are systems and equipment provided to ensure a reliable supply of water for construction activities, cleaning, sanitation and workers' domestic needs.

Sources of water on construction sites

1. Public water supply.
2. Boreholes.
3. Water delivered by bowsers.
4. Water storage tanks.
5. Approved and suitable rainwater harvesting systems.
6. Other legally permitted water sources.

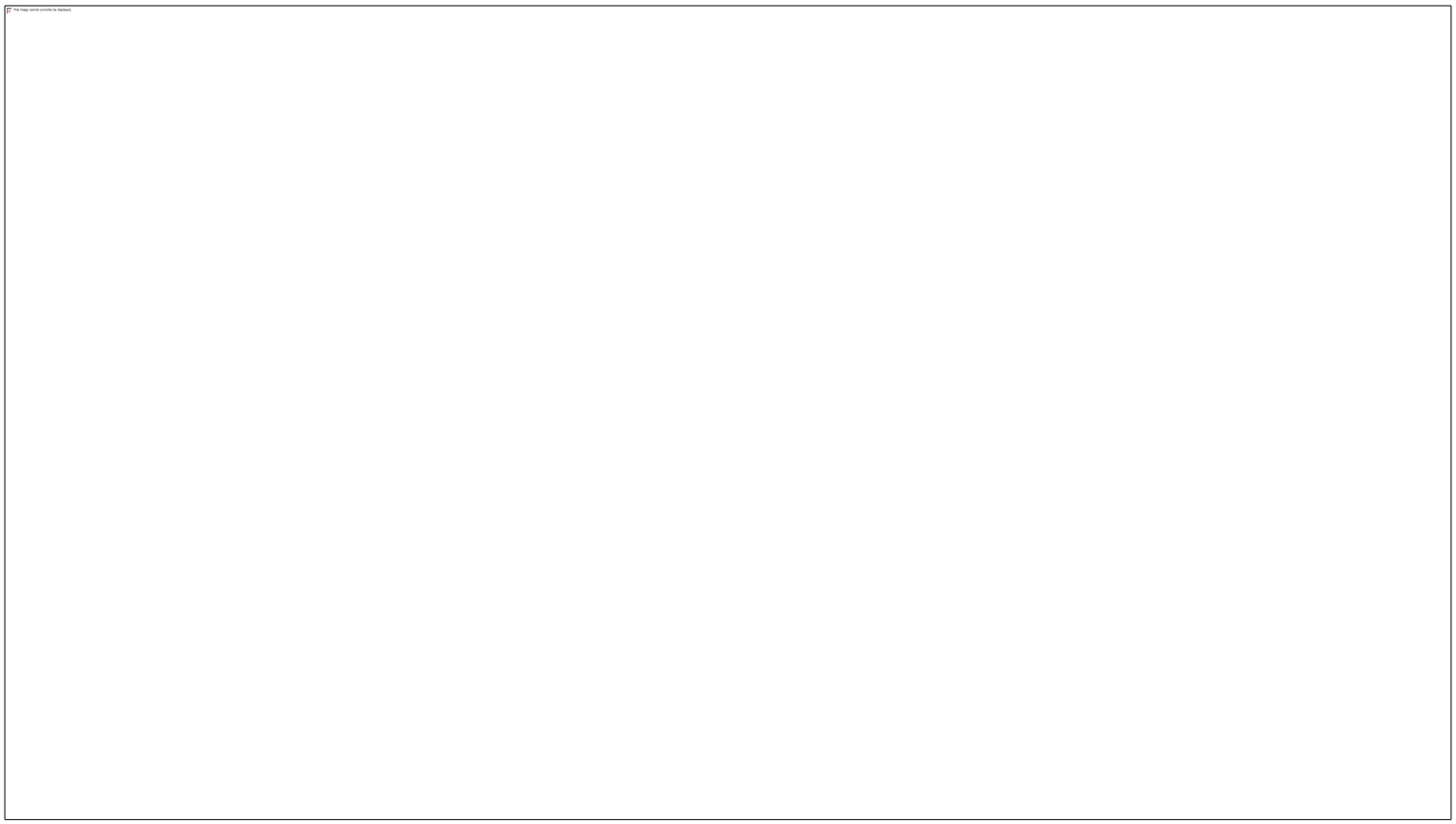
Uses of water on a construction site

1. Mixing concrete.
2. Preparing cement mortar.
3. Curing concrete.
4. Mixing plaster and rendering materials.
5. Washing construction tools and equipment.
6. Controlling dust.
7. Cleaning the site.
8. Providing drinking water for workers.
9. Supporting sanitation and handwashing.
10. Testing and other construction-related activities.

Requirements for water supply facilities

- Water should be sufficient for the site's needs.
- Drinking water should be safe and potable.
- Storage tanks should be clean and covered.
- Water pipes should be protected from damage.
- Separate arrangements should be made where necessary for drinking and construction water.
- Water storage should be located where it can be accessed easily.
- Proper drainage should be provided to avoid stagnant water.

E. Electricity and power supply facilities



Meaning

Power supply facilities are systems and equipment used to provide electricity or other forms of energy for operating machinery, tools, lighting and other construction activities.

Sources of power

1. Electricity from the national grid.
2. Generators.
3. Solar power systems.
4. Battery storage systems.

Uses of electricity on construction sites

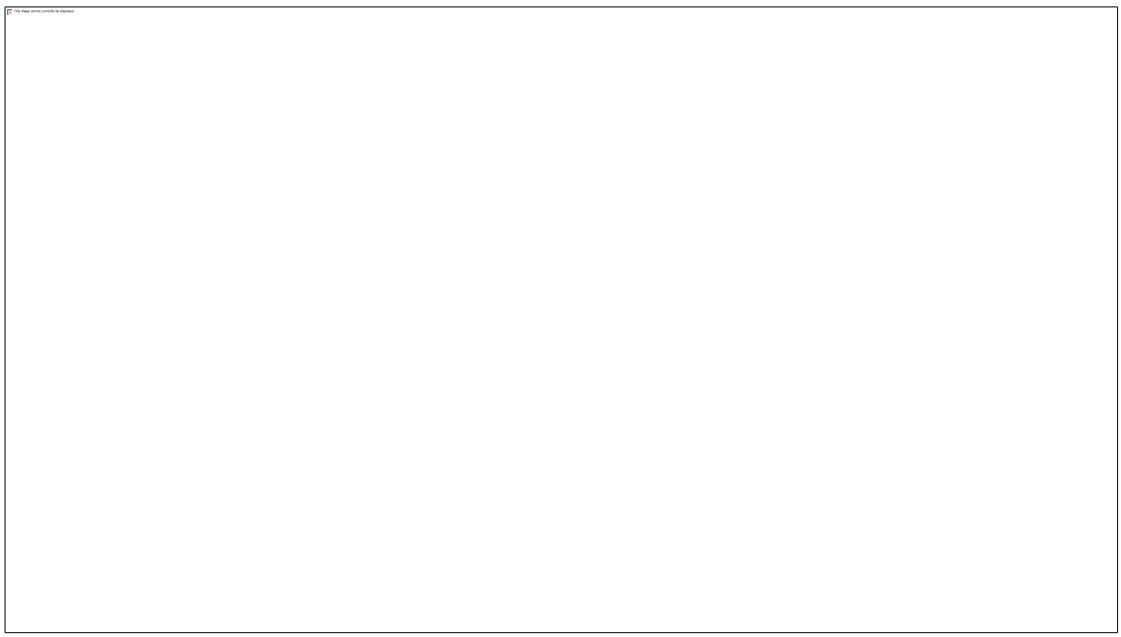
- Operating electric drills.
- Operating concrete vibrators.
- Running water pumps.
- Providing lighting.
- Operating cutting and grinding machines.
- Charging batteries.
- Powering computers and office equipment.
- Supporting welding operations using suitable equipment.

Requirements for safe power supply

1. Electrical installations should be carried out by qualified personnel.
2. Temporary distribution boards should be protected against unauthorized access.

3. Appropriate circuit protection should be installed.
4. Cables should be protected against mechanical damage.
5. Electrical equipment should be properly earthed where required.
6. Wet areas should have suitable electrical protection.
7. Damaged cables and sockets should not be used.
8. Generators should be placed in secure, adequately ventilated areas.
9. Electrical warning signs should be displayed where necessary.
10. Power should be isolated before carrying out repairs.

F. Security facilities



Meaning

Security facilities are structures, systems and arrangements provided to protect a construction site, its workers, materials, machinery and equipment from theft, vandalism, unauthorized access and other security threats.

Examples of security facilities

1. Perimeter fences.
2. Security gates.
3. Guardhouses.
4. Security lighting.
5. CCTV cameras.
6. Access control systems.
7. Security personnel.
8. Warning signs.
9. Locks and secure storage rooms.

10. Visitor registration points.

Functions of security facilities

- Prevent unauthorized entry.
- Protect valuable materials and equipment.
- Reduce theft and vandalism.
- Protect workers and visitors.
- Monitor movement into and out of the site.
- Protect neighbouring properties and the public.
- Assist in emergency control and evacuation.

G. Workers' welfare facilities



Meaning

Workers' welfare facilities are amenities provided to promote the health, comfort, dignity and well-being of people working at a construction site.

Examples and functions

1. **Rest shelters**
   - Provide workers with a place to rest during scheduled breaks.
   - Protect workers from excessive sunshine and rain.
2. **Changing rooms**
   - Provide space for workers to change into and out of protective clothing.
   - Help keep personal clothing separate from contaminated workwear.
3. **Drinking water points**
   - Provide clean and safe drinking water.
   - Help prevent dehydration, especially during hot weather.

4. **Handwashing facilities**
   - Enable workers to wash their hands after handling materials and using toilets.
   - Promote personal hygiene.
5. **First-aid facilities**
   - Provide immediate assistance to injured or ill workers.
   - Help manage minor injuries before further medical treatment is obtained.
6. **Eating areas**
   - Provide a clean place for workers to eat meals.
   - Reduce contamination of food by construction dust and chemicals.
7. **Washing facilities**
   - Enable workers to clean themselves after dusty or dirty activities.
   - Promote hygiene and comfort.
8. **Lockers**
   - Provide secure storage for workers' personal belongings.

H. Sanitation facilities



Meaning

Sanitation facilities are installations provided to ensure proper disposal of human waste and maintain cleanliness and hygiene within a construction site.

Examples

- Toilets and latrines.
- Urinals where appropriate.
- Handwashing stations.
- Washrooms.
- Wastewater drainage systems.
- Septic tanks or approved sanitation systems where applicable.

Functions

1. Prevent the spread of diseases.
2. Promote personal hygiene.
3. Prevent environmental contamination.
4. Provide privacy and dignity to workers.
5. Maintain cleanliness on the construction site.
6. Prevent uncontrolled disposal of human waste.

Requirements

- Facilities should be sufficient for the number of workers.
- They should be conveniently accessible.
- They should be properly maintained and cleaned.
- Handwashing facilities should be provided.
- Adequate privacy should be ensured.
- Suitable arrangements should be made for different users.
- Waste should be disposed of through approved systems.

I. Waste management facilities



Meaning

Waste management facilities are designated areas, containers and systems used to collect, separate, store and dispose of waste generated during construction activities.

Types of construction waste

- Timber offcuts.
- Broken bricks and blocks.
- Concrete debris.
- Scrap metals.
- Plastic packaging.

- Empty cement bags.
- Excavated soil.
- Hazardous waste such as chemical containers.

Functions

1. Maintain a clean working environment.
2. Prevent accidents caused by scattered materials.
3. Reduce environmental pollution.
4. Encourage reuse and recycling.
5. Prevent blockage of drainage channels.
6. Facilitate safe collection and disposal of waste.

J. Parking facilities

Parking facilities are designated areas for parking vehicles belonging to site management, workers, visitors and suppliers.

Functions

- Provide organized parking.
- Prevent unnecessary obstruction of access roads.
- Improve security of vehicles.
- Separate vehicle parking from active working areas.
- Facilitate easy movement of delivery vehicles and emergency vehicles.

K. First-aid facilities

Meaning

First-aid facilities are designated spaces and equipment provided for giving immediate medical assistance to workers who suffer injuries or sudden illness while at work.

Examples

- First-aid boxes.
- First-aid rooms where necessary.
- Stretchers.
- Emergency contact lists.
- Eye-washing equipment where required.
- Fire blankets and other emergency equipment.

Functions

1. Provide immediate treatment for minor injuries.
2. Help stabilize injured workers before referral to a health facility.
3. Reduce complications arising from workplace injuries.

4. Support emergency preparedness.
5. Promote occupational health and safety.

L. Communication facilities

Communication facilities are systems and equipment used to exchange information between workers, supervisors, contractors, consultants and other stakeholders.

Examples

- Mobile phones.
- Two-way radios.
- Computers.
- Internet connections.
- Notice boards.
- Public address systems.

Functions

1. Improve coordination of construction activities.
2. Enable supervisors to issue instructions.
3. Facilitate reporting of accidents and emergencies.
4. Support communication with suppliers.
5. Help monitor construction progress.

1.3.3 Factors to Consider When Organizing a Construction Site

Meaning

Factors to consider when organizing a construction site are the conditions, requirements and circumstances that influence the positioning, arrangement and management of facilities, equipment, materials and activities within a construction project.

The following factors should be considered:

1. Size and shape of the construction site

- The total area available determines the number and size of facilities that can be established.
- Irregularly shaped sites may require special arrangements.
- Limited spaces require careful positioning of storage and working areas.
- Adequate space should be left for movement of workers and machinery.

Example: A small residential plot in Kilgoris may require compact material stores and a small site office, while a large school construction project may require several storage areas and wider access roads.

2. Nature and type of construction project

- Different construction projects require different facilities.
- A high-rise building may require cranes, hoists and specialized equipment.
- Road construction requires extensive access routes, machinery and aggregate storage.

- Residential construction may require relatively smaller storage and office facilities.
- Industrial construction may require specialized workshops and hazardous-material storage.

3. Site location

- The site may be located in an urban, rural or remote area.
- Urban sites may have limited space and heavy traffic.
- Rural sites may have limited access to electricity and piped water.
- Remote sites may require additional water storage and power generation facilities.
- The availability of nearby services influences site arrangements.

4. Topography of the site

Topography refers to the physical features and surface characteristics of the land.

Considerations include:

- Whether the land is flat, sloping or uneven.
- The direction of surface water flow.
- The presence of valleys and depressions.
- The possibility of soil erosion.
- The stability of the ground.
- Areas that may be affected by flooding.

Importance: Facilities should be located on stable ground to prevent accidents, damage and waterlogging.

5. Soil conditions

- Weak or unstable soils may not support heavy storage areas or machinery.
- Waterlogged soils may make access roads difficult to use.
- Expansive soils may affect temporary structures.
- Loose soils may require ground improvement.
- Areas with suitable ground conditions should be selected for heavy equipment and material storage.

6. Accessibility of the site

- The site should have suitable access from a public road.
- Delivery vehicles should be able to enter and leave safely.
- Access routes should accommodate the expected size of vehicles.
- Emergency vehicles should be able to reach the site.
- Pedestrian routes should be provided separately where practicable.

7. Availability of water

- Adequate water is required for concrete mixing, curing and other construction activities.
- Drinking water should be available to workers.
- The availability of public water, boreholes or water bowsers should be assessed.
- Water storage facilities should be provided where necessary.

8. Availability of electricity and power

- The type of machinery and equipment determines the power requirements.
- The availability of electricity from the national grid should be established.
- Generators or alternative power sources may be necessary.
- Safe positioning of generators and electrical distribution equipment should be considered.

9. Safety and security requirements

- The site should be protected against unauthorized entry.
- Hazardous working areas should be identified.
- Fire risks should be considered.
- Emergency access and evacuation routes should be maintained.
- Security lighting should be provided where necessary.
- Workers and visitors should be protected from moving machinery and falling objects.

10. Environmental conditions

- The site layout should minimize environmental pollution.
- Dust-producing activities should be controlled.
- Noise should be managed.
- Waste disposal areas should be properly located.
- Drainage should prevent pollution of nearby water sources.
- Trees and other environmentally important features should be protected where practicable.

11. Number of workers

- The number of workers determines the size and number of welfare facilities.
- Adequate toilets, washrooms and drinking water points should be provided.
- Resting and changing areas should accommodate the workforce.
- Access routes should be sufficient for the expected number of people.

12. Storage requirements

- Different materials require different storage conditions.
- Cement requires dry storage.
- Sand and ballast require separate designated areas.
- Reinforcement bars require secure stacking.
- Fuel and chemicals require suitable controlled storage.

- Perishable or moisture-sensitive materials need appropriate protection.

13. Construction programme and sequence of activities

- The site should be organized according to the planned sequence of construction.
- Materials required early should be accessible.
- Temporary facilities may need to be relocated as construction progresses.
- Areas occupied by excavation, foundation and structural works may change over time.
- The layout should allow future construction activities to proceed without unnecessary obstruction.

14. Cost and available resources

- The cost of establishing temporary facilities should be considered.
- Available land, equipment, labour and materials influence the layout.
- Facilities should be economical without compromising safety.
- Reusable temporary structures may reduce costs.

15. Legal and regulatory requirements

- The site should comply with the National Building Code 2024.
- Occupational health and safety requirements must be observed.
- Environmental requirements should be followed.
- Necessary county government approvals should be obtained.
- Requirements of the National Construction Authority should be observed where applicable.

16. Neighbouring properties and the public

- Construction activities should not unnecessarily interfere with neighbouring properties.
- Public roads and footpaths should not be obstructed.
- Dust, noise and vibration should be controlled.
- Construction materials should remain within the approved site boundaries.
- Suitable barriers should protect members of the public.

17. Drainage and weather conditions

- The site should have adequate drainage channels.
- Water should not accumulate around storage facilities.
- Access roads should remain usable during rainy periods.
- Excavations should be protected against surface water.
- Rainwater should be directed away from sensitive working areas.

1.3.4 Layout Plan of a Construction Site

Meaning of a construction site layout plan

A construction site layout plan is a drawing that shows the planned arrangement and positioning of temporary and permanent facilities, access roads, storage areas, machinery, working spaces and other amenities within a construction site.

It is prepared to guide the contractor and site management in organizing construction activities.

A site layout plan is sometimes called a construction site organization plan.

Importance of a construction site layout plan

1. Shows the position of different facilities.
2. Guides the establishment of temporary structures.
3. Improves movement of workers and vehicles.
4. Identifies suitable material storage areas.
5. Helps prevent congestion.
6. Improves safety and security.
7. Facilitates supervision and coordination.
8. Helps in planning the delivery of materials.
9. Identifies emergency access routes.
10. Helps minimize unnecessary movement and handling of materials.
11. Supports efficient use of available land.
12. Helps identify potential hazards before construction begins.

Main components of a construction site layout plan

1. Site boundary

- Shows the limits of the construction site.
- Identifies the land available for construction activities.
- Helps establish where fencing and security barriers should be located.

2. Main entrance and exit

- Shows the points where vehicles and people enter and leave the site.
- Should be positioned to allow safe access from the public road.
- May include a security gate and visitor registration point.

3. Access roads

- Show routes used by construction vehicles.
- Connect the entrance to delivery, storage and working areas.
- Should allow safe movement of vehicles and machinery.

4. Main building under construction

- Shows the position of the proposed building.

- Helps determine the location of other facilities.
- Should allow sufficient working space around the building.

5. Material storage areas

- Show where different construction materials will be kept.
- Should be accessible to delivery vehicles and workers.
- Should not obstruct emergency routes.

6. Site office

- Shows the location of management and administrative facilities.
- Should be accessible to visitors and site supervisors.

7. Water storage facilities

- Show the position of tanks, water points and supply systems.
- Should be accessible for construction and welfare purposes.

8. Power supply facilities

- Show the location of generators, electrical distribution boards and related installations.
- Should be positioned safely and protected from unauthorized access.

9. Welfare and sanitation facilities

- Show the position of toilets, changing rooms, rest shelters, washrooms and eating areas.
- Should be conveniently accessible and maintained hygienically.

10. Security facilities

- Show the position of gates, guardhouses, fencing and security installations.

11. Waste collection points

- Show designated areas for collecting and sorting construction waste.
- Should be positioned to allow safe collection and removal.

12. Parking and loading areas

- Show where vehicles are parked and where materials are loaded or unloaded.
- Should not obstruct the movement of other vehicles.

13. Emergency facilities

- Show the position of first-aid facilities, fire extinguishers and emergency assembly points where applicable.

1.3.5 Building Code Requirements for Construction Site Organization in Kenya

Meaning of building code requirements

Building code requirements are the rules, standards and regulations that guide the planning, organization, construction and management of building projects to ensure safety, health, accessibility, environmental protection and structural quality.

In Kenya, construction site organization should comply with applicable national laws, regulations, approved standards and county government requirements.

Main legal and regulatory frameworks in Kenya

1. **National Building Code, 2024**
   - Provides requirements governing building design, construction and related building activities.
   - Promotes safety, health, accessibility and proper construction practices.
   - Guides the provision of suitable construction arrangements and facilities.
2. **Occupational Safety and Health Act, 2007 (OSHA)**
   - Provides for the safety, health and welfare of people at workplaces.
   - Requires employers and occupiers to take measures to protect workers.
   - Addresses workplace cleanliness, ventilation, lighting, sanitation and safe working conditions.
   - Provides for accident prevention and workplace risk management.
3. **Environmental Management and Co-ordination Act, 1999 (EMCA)**
   - Provides the legal framework for environmental management in Kenya.
   - Requires construction activities to address environmental pollution and degradation.
   - Supports proper waste management, pollution prevention and environmental protection.
4. **National Construction Authority Act, 2011**
   - Establishes the National Construction Authority (NCA).
   - Provides for regulation of the construction industry.
   - Includes requirements relating to registration and regulation of contractors and construction projects.
5. **Public Health Act (Cap. 242)**
   - Provides for protection of public health.
   - Addresses sanitation and prevention of conditions that may cause disease.
   - Supports proper disposal of waste and maintenance of hygienic surroundings.
6. **County government laws and regulations**
   - Govern development approvals and other local requirements.
   - May regulate access, temporary structures, drainage, waste disposal and use of public spaces.
   - Ensure that construction activities comply with local planning requirements.

Specific requirements for organizing a construction site

A. Site fencing and boundary protection

- Construction sites should have appropriate barriers or fencing to prevent unauthorized entry.
- Openings should be controlled through suitable gates.
- Warning signs should be displayed at appropriate locations.
- Dangerous areas should be isolated from workers and members of the public.
- Excavations and other hazardous areas should be adequately protected.

B. Access roads and pedestrian pathways

- Safe access should be provided for workers, visitors and construction vehicles.
- Routes should be kept free from unnecessary obstructions.
- Pedestrian movement should be separated from vehicle movement where practicable.
- Emergency access should be maintained.
- Appropriate traffic signs and warning signs should be provided.

C. Material storage

- Materials should be stored in designated and suitable areas.
- Materials should be protected against damage, theft and deterioration.
- Heavy materials should be stacked securely.
- Cement and other moisture-sensitive materials should be kept dry.
- Hazardous materials should be appropriately labelled and stored safely.
- Storage arrangements should not obstruct pathways and emergency exits.

D. Sanitation and hygiene

- Adequate toilet facilities should be provided for workers.
- Washing and handwashing facilities should be available.
- Clean drinking water should be provided.
- Sanitation facilities should be maintained in a clean and hygienic condition.
- Wastewater should be disposed of through suitable systems.
- Eating areas should be kept clean.

E. Electricity and power safety

- Temporary electrical installations should be properly installed.
- Electrical systems should be protected against overloads and faults.
- Exposed electrical conductors should be avoided.
- Electrical equipment should be maintained in safe working condition.
- Suitable protection should be provided against electric shock.
- Electrical installations should be handled by competent persons.

F. Fire safety

- Suitable fire extinguishers should be provided in appropriate locations.
- Fire escape routes should be kept clear.
- Flammable materials should be stored safely.
- Workers should be informed about fire emergency procedures.
- Smoking should be restricted in designated hazardous areas.
- Emergency contact information should be displayed.

G. Waste management

- Construction waste should be collected in designated areas.
- Waste should be separated according to its type where appropriate.
- Hazardous waste should be handled and disposed of safely.
- Waste should not be dumped into drainage channels or water bodies.
- Waste should be removed through appropriate disposal arrangements.

H. First-aid and emergency arrangements

- Appropriate first-aid supplies should be available.
- Workers should know how to report accidents.
- Emergency contacts should be displayed.
- Suitable arrangements should be made for transporting injured workers to medical facilities.
- Emergency routes should remain accessible.

I. Environmental protection

- Dust emissions should be controlled.
- Excessive noise should be minimized.
- Soil erosion should be prevented.
- Surface water should be properly managed.
- Construction activities should not unnecessarily damage neighbouring properties.
- Hazardous substances should not be released into the environment.

J. Workers' welfare

- Suitable resting facilities should be provided.
- Workers should have access to clean drinking water.
- Adequate sanitation should be maintained.
- Appropriate washing and changing facilities should be provided.
- Suitable facilities should be provided for workers' personal hygiene.

Important note for learners

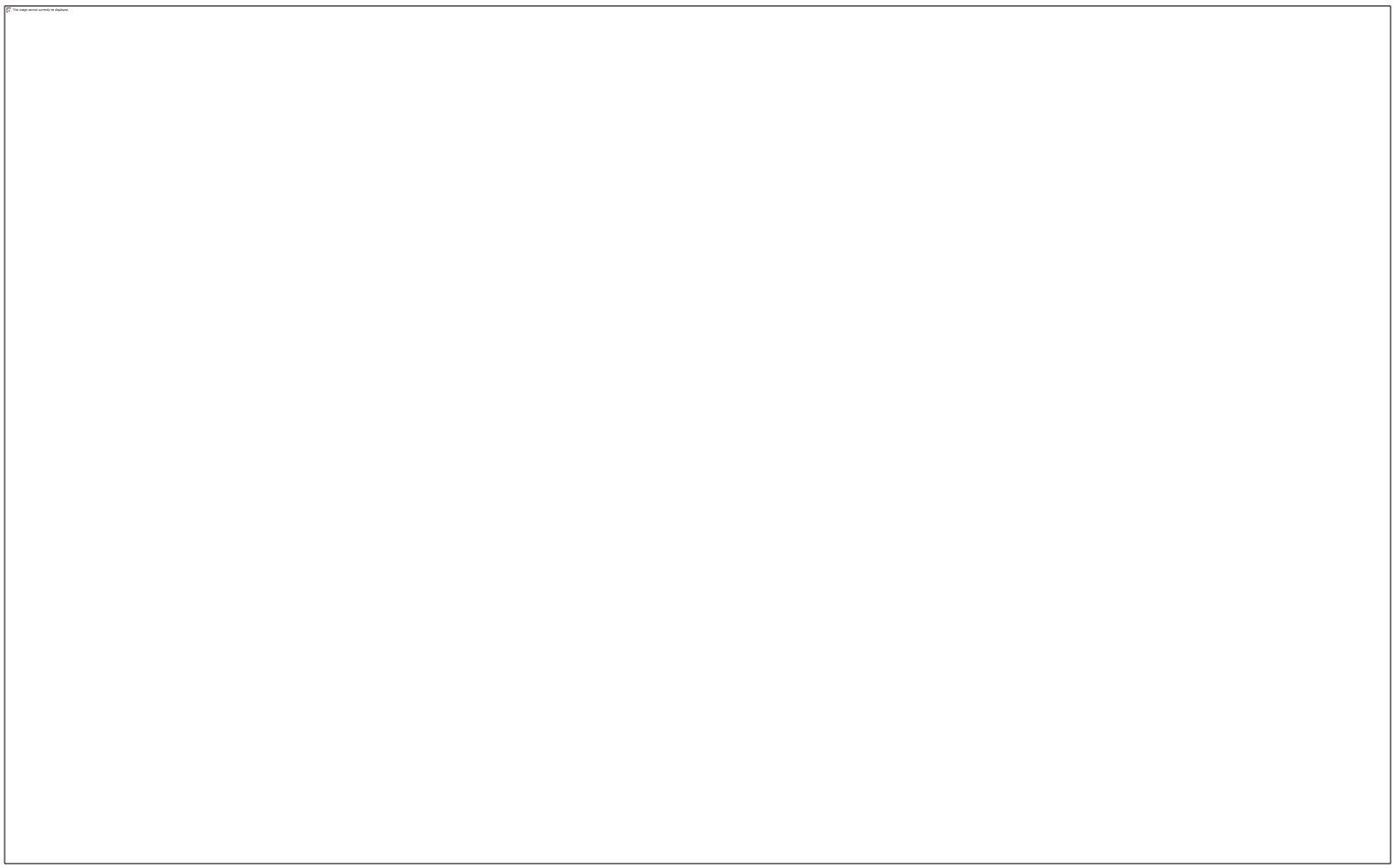
The exact requirements for a particular construction project depend on the applicable legislation, project size, site conditions, nature of work and directions of the relevant regulatory authorities. A site layout plan does not replace the required statutory approvals.

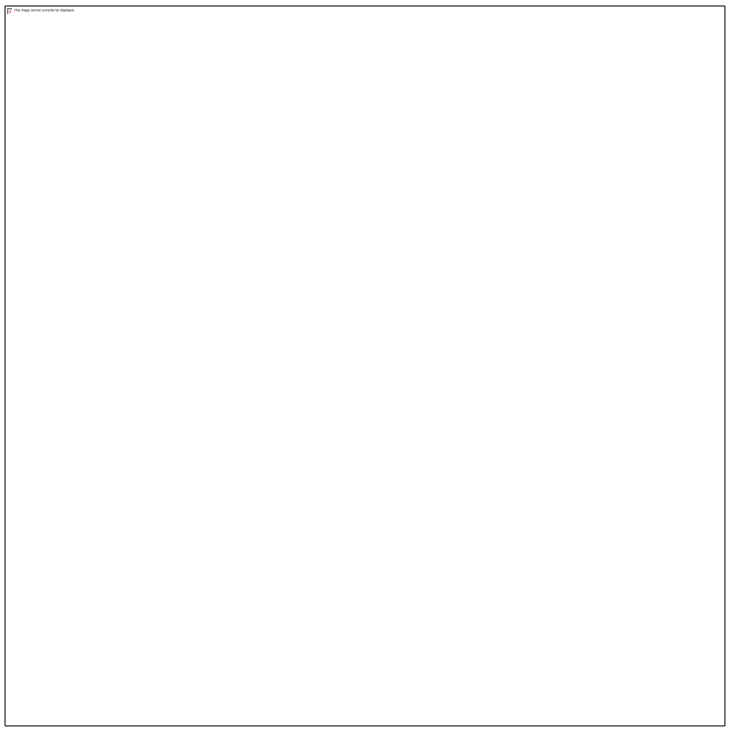
1.3.6 Drawing Tools Used in Preparing a Construction Site Layout Plan

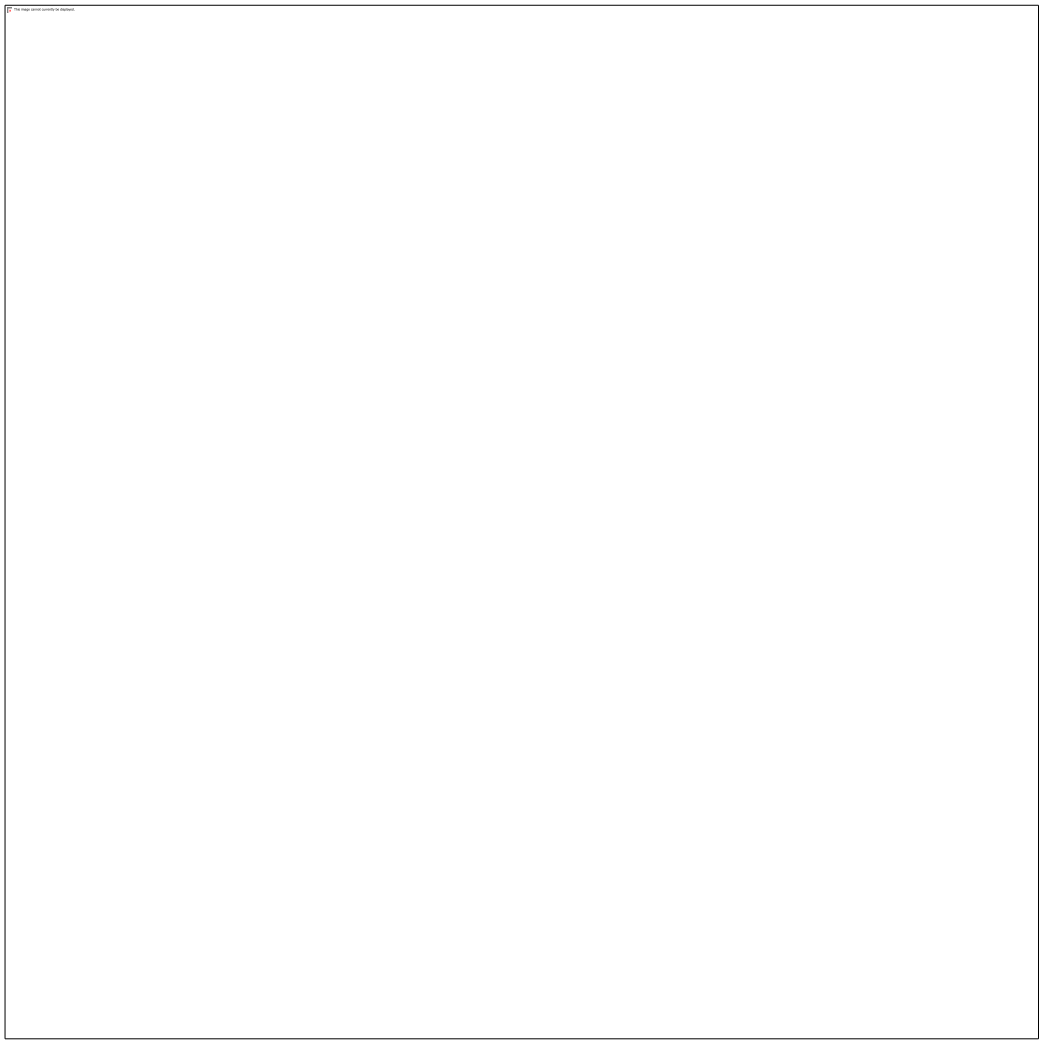
Meaning of drawing tools

Drawing tools are instruments and equipment used to prepare accurate technical drawings, plans, diagrams and layouts.

In building construction, drawing tools help learners and construction professionals represent the arrangement of facilities, structures and access routes on paper.

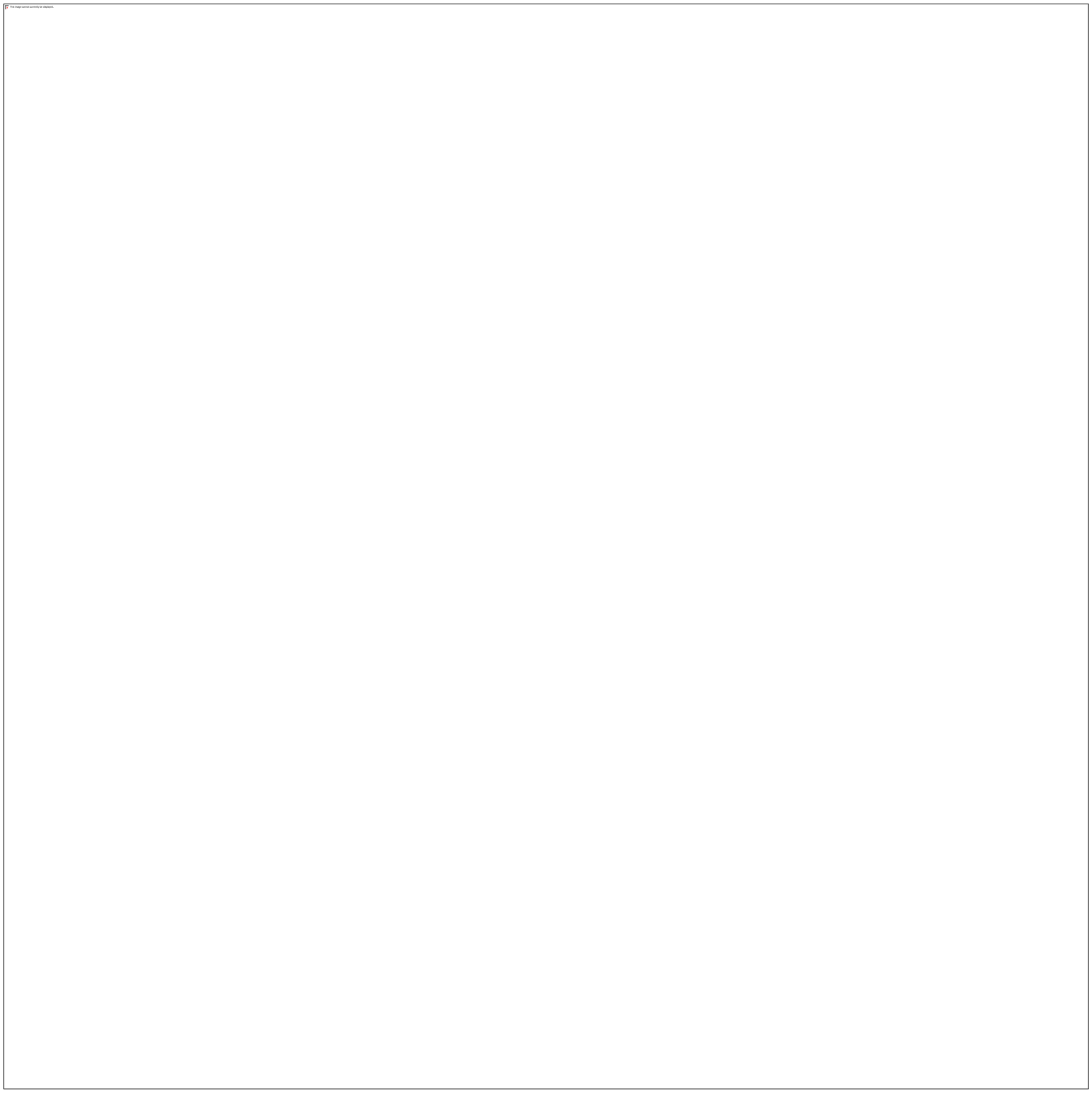






Common drawing tools and their uses

1. Drawing board



Definition: A drawing board is a flat, smooth surface used to support drawing paper during technical drawing.

Uses:

- Provides a firm working surface.
- Supports accurate drawing.
- Holds drawing paper in position.
- Provides a suitable base for using other drawing instruments.

2. T-square

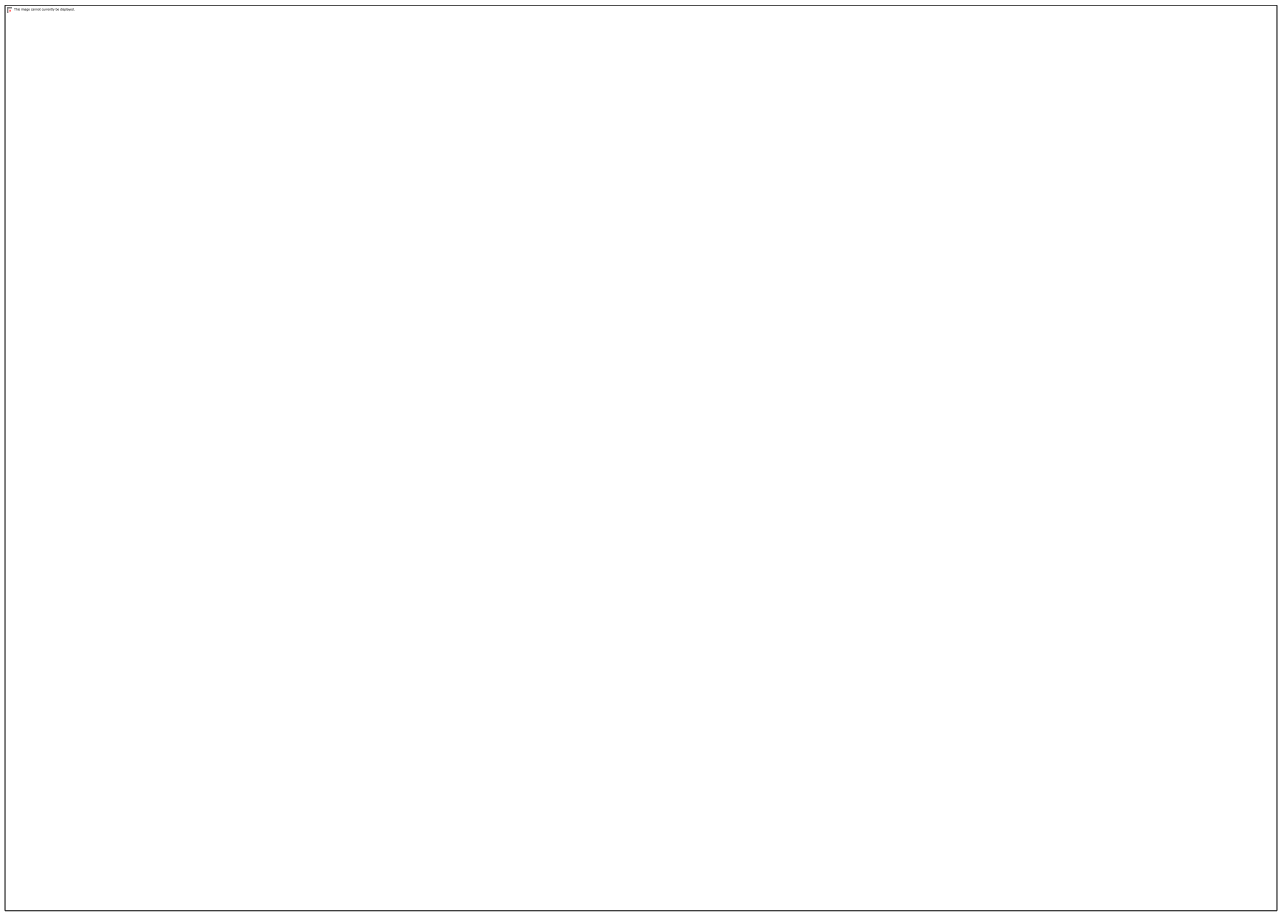


Definition: A T-square is a technical drawing instrument consisting of a long blade attached to a shorter head at right angles.

Uses:

- Drawing horizontal lines.
- Guiding set squares.
- Drawing parallel horizontal lines.
- Establishing straight reference lines.

3. Set squares



Definition: Set squares are triangular drawing instruments used for drawing lines at specific angles.

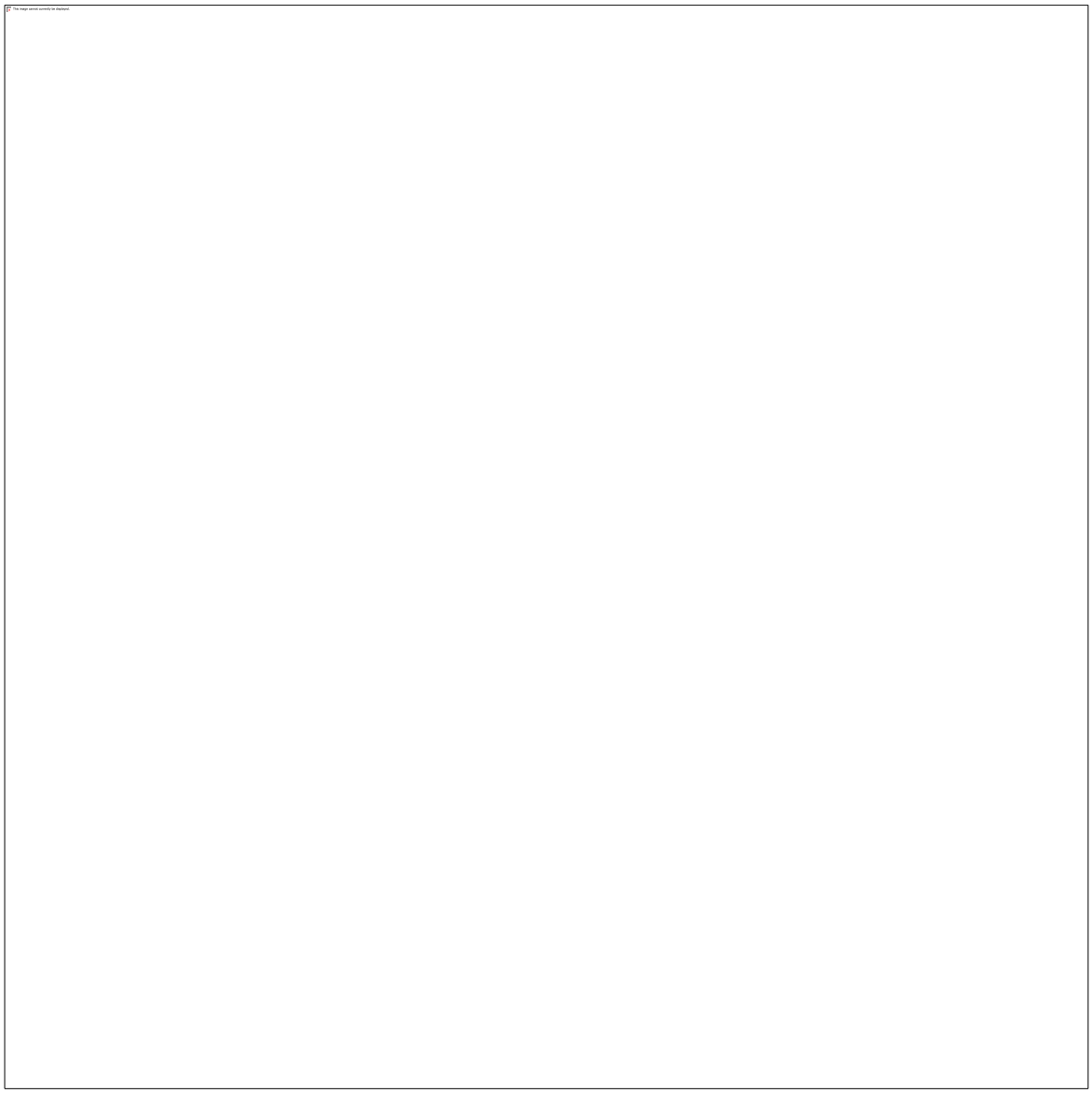
Types:

- 45° set square.
- 30°–60° set square.

Uses:

- Drawing vertical lines.
- Drawing perpendicular lines.
- Drawing inclined lines.
- Drawing lines at 30°, 45°, 60° and 90°.

4. Scale ruler



Definition: A scale ruler is a graduated instrument used to measure and draw dimensions according to a selected drawing scale.

Uses:

- Measuring distances on drawings.
- Reducing actual site measurements to drawing size.
- Enlarging dimensions where appropriate.
- Maintaining proportional accuracy.

Example of scale application

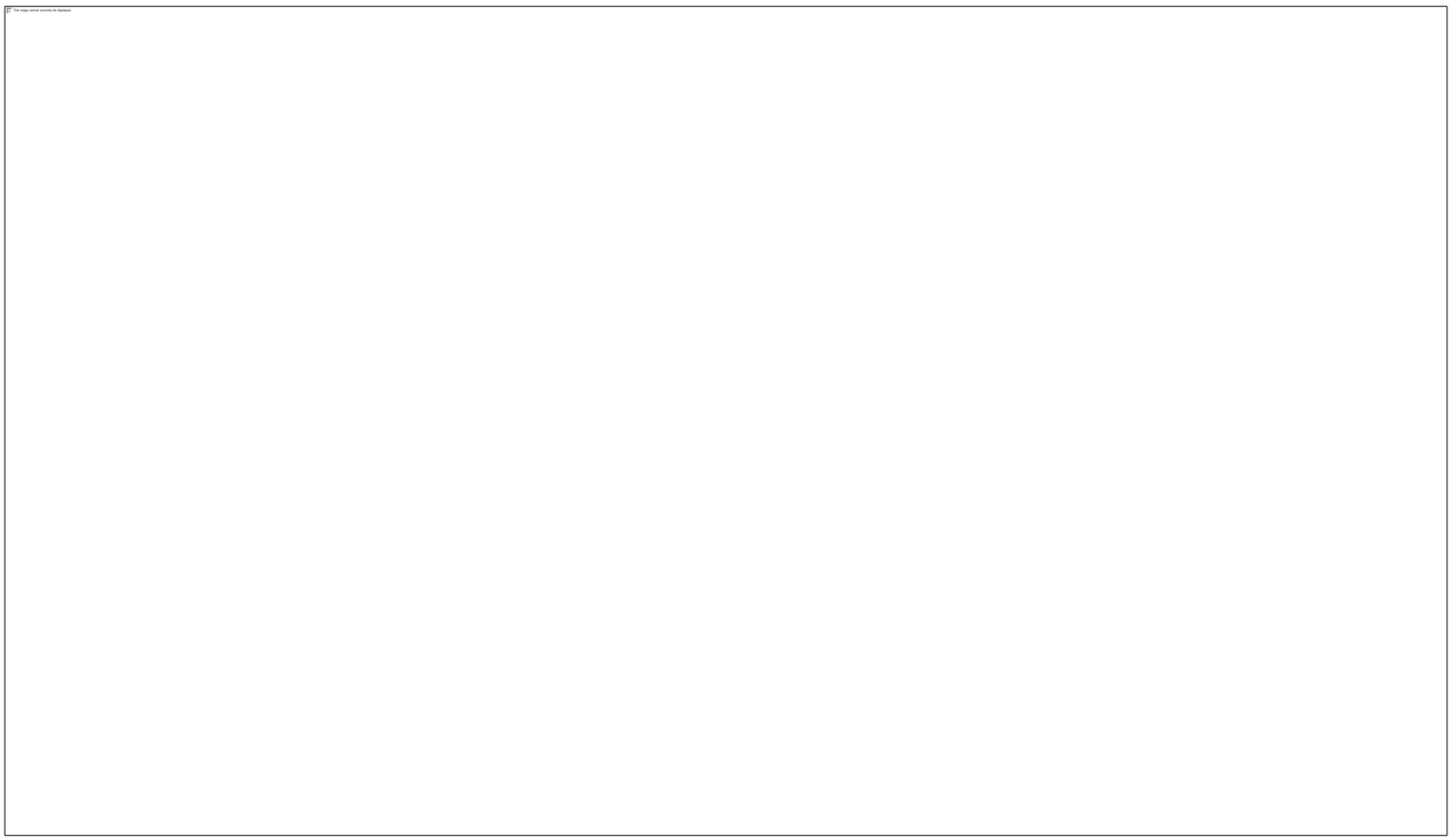
If a construction site measures 60 metres long and is represented using a scale of 1:500:

Drawing length=60×1000500Drawing length=50060×1000

=120 mm=120 mm

Therefore, 60 metres on the actual site will be represented by 120 mm on the drawing.

5. Pencil



Definition: A pencil is a writing and drawing instrument used for making lines, lettering and symbols.

Common grades:

- H: Hard pencil, produces light lines.
- 2H: Produces fine, light construction lines.
- HB: Produces medium lines.
- 2B: Produces darker lines.

Uses:

- Drawing outlines.
- Making construction lines.
- Writing dimensions and labels.
- Adding notes to drawings.

6. Eraser



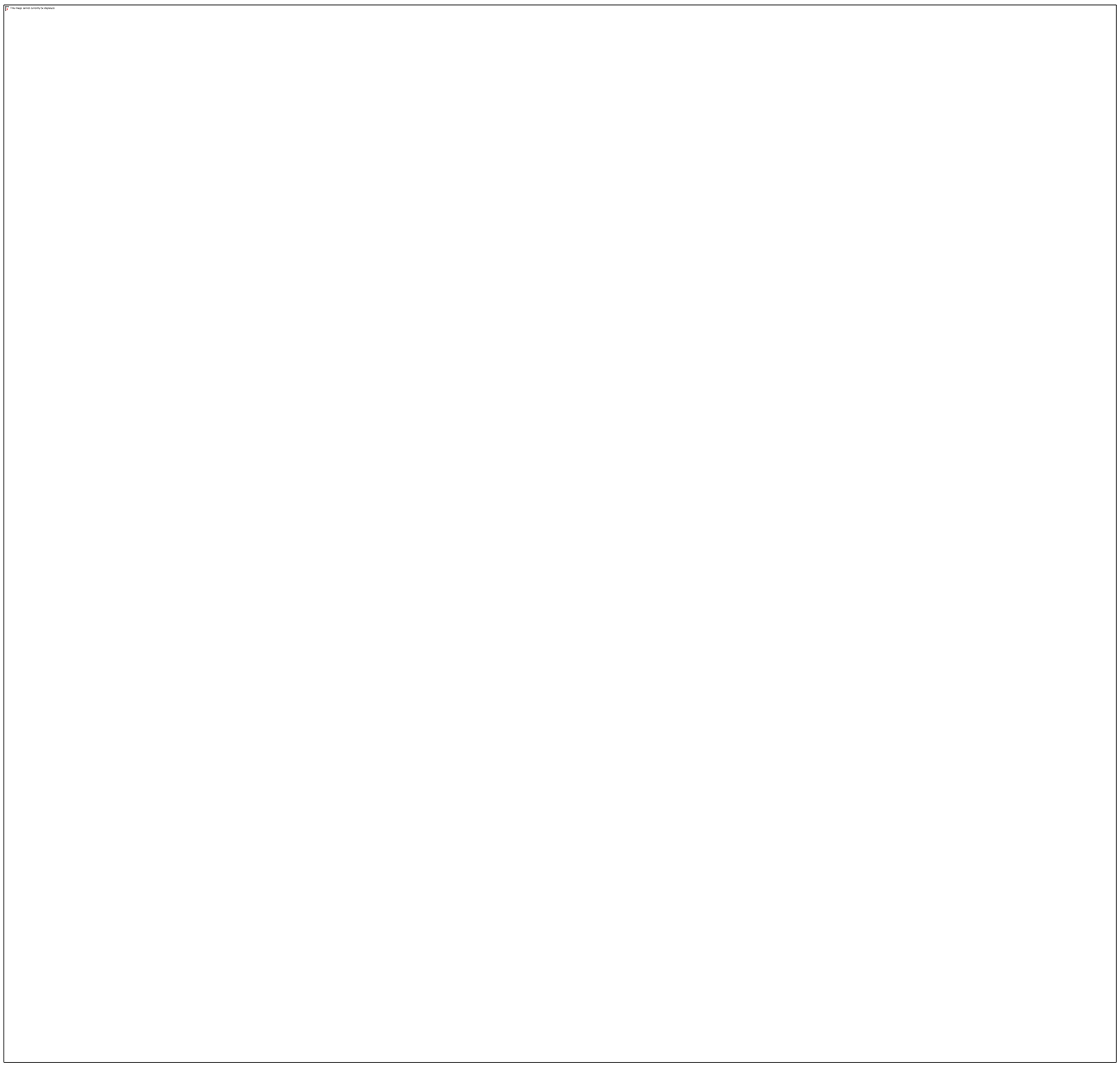
Definition: An eraser is an instrument used to remove unwanted pencil marks from a drawing.

Uses:

- Correcting drawing mistakes.
- Removing unnecessary construction lines.

- Cleaning drawings.
- Improving the appearance of the final plan.

7. Drawing compass



Definition: A compass is a drawing instrument consisting of two adjustable legs, one holding a point and the other a pencil or lead.

Uses:

- Drawing circles.
- Drawing arcs.
- Constructing circular features.

- Marking curved boundaries where required.

8. Divider

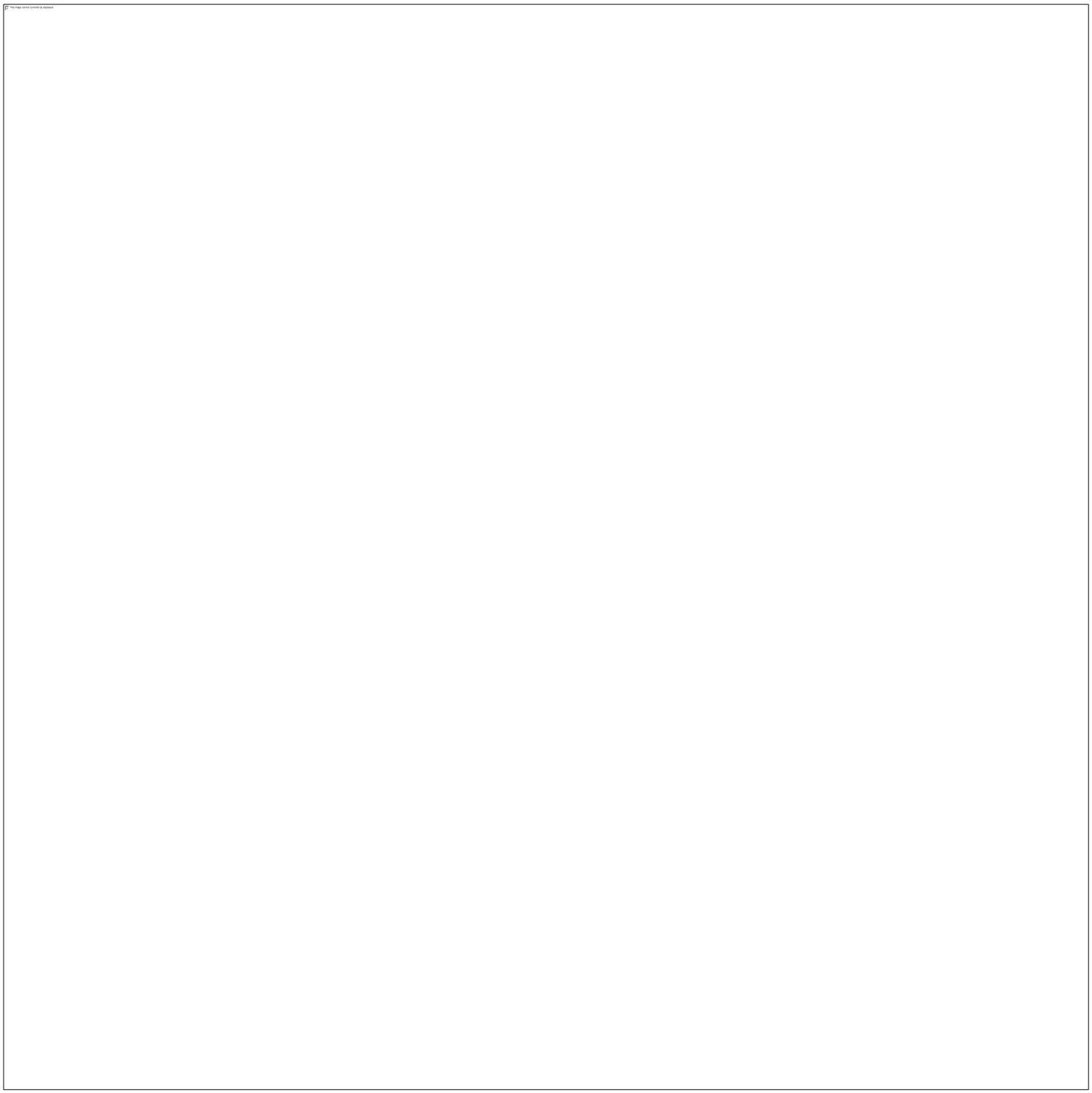


Definition: A divider is a drawing instrument with two pointed legs used for transferring and comparing distances.

Uses:

- Transferring measurements.
- Dividing lines into equal parts.
- Comparing distances on a drawing.
- Setting off equal intervals.

9. Protractor



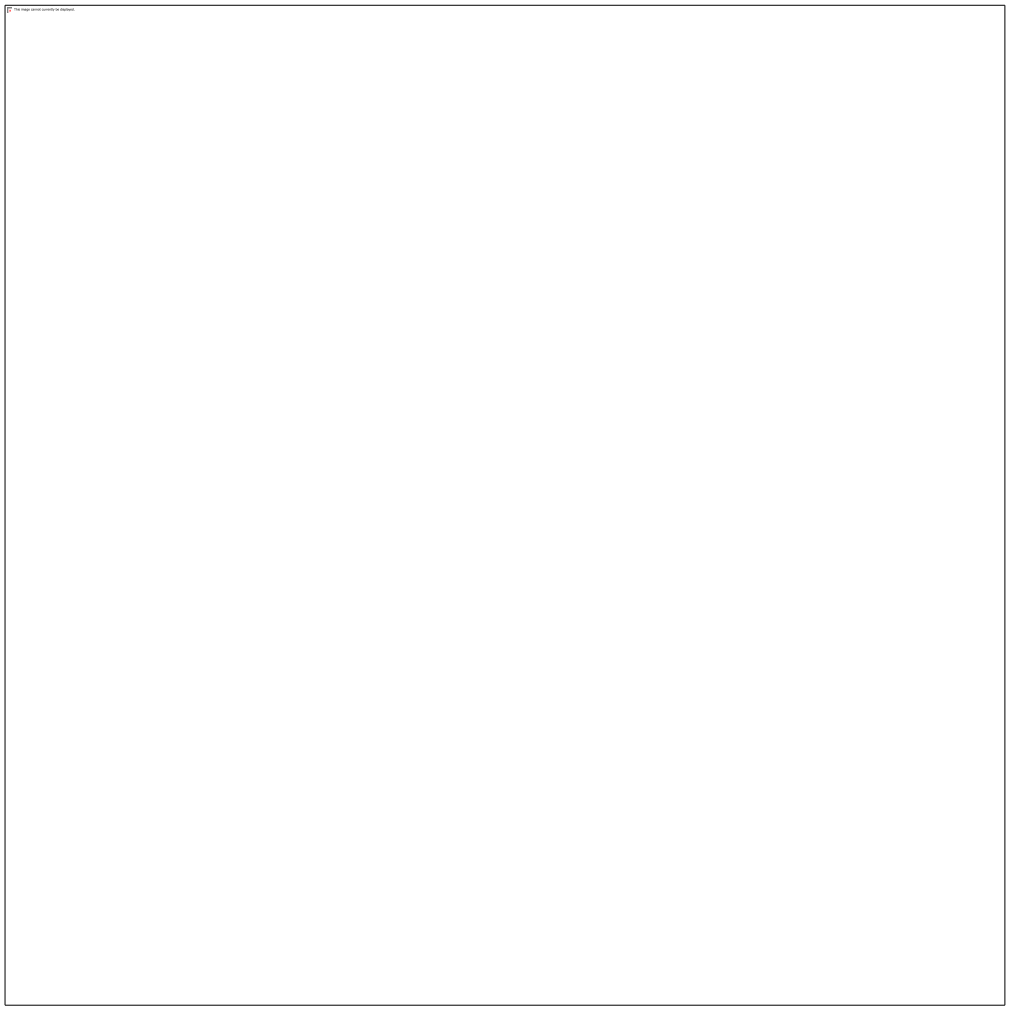
Definition: A protractor is a graduated instrument used to measure and construct angles.

Uses:

- Measuring angles.

- Drawing inclined access roads.
- Setting out angular boundaries.
- Checking the direction of lines.

10. Drawing paper

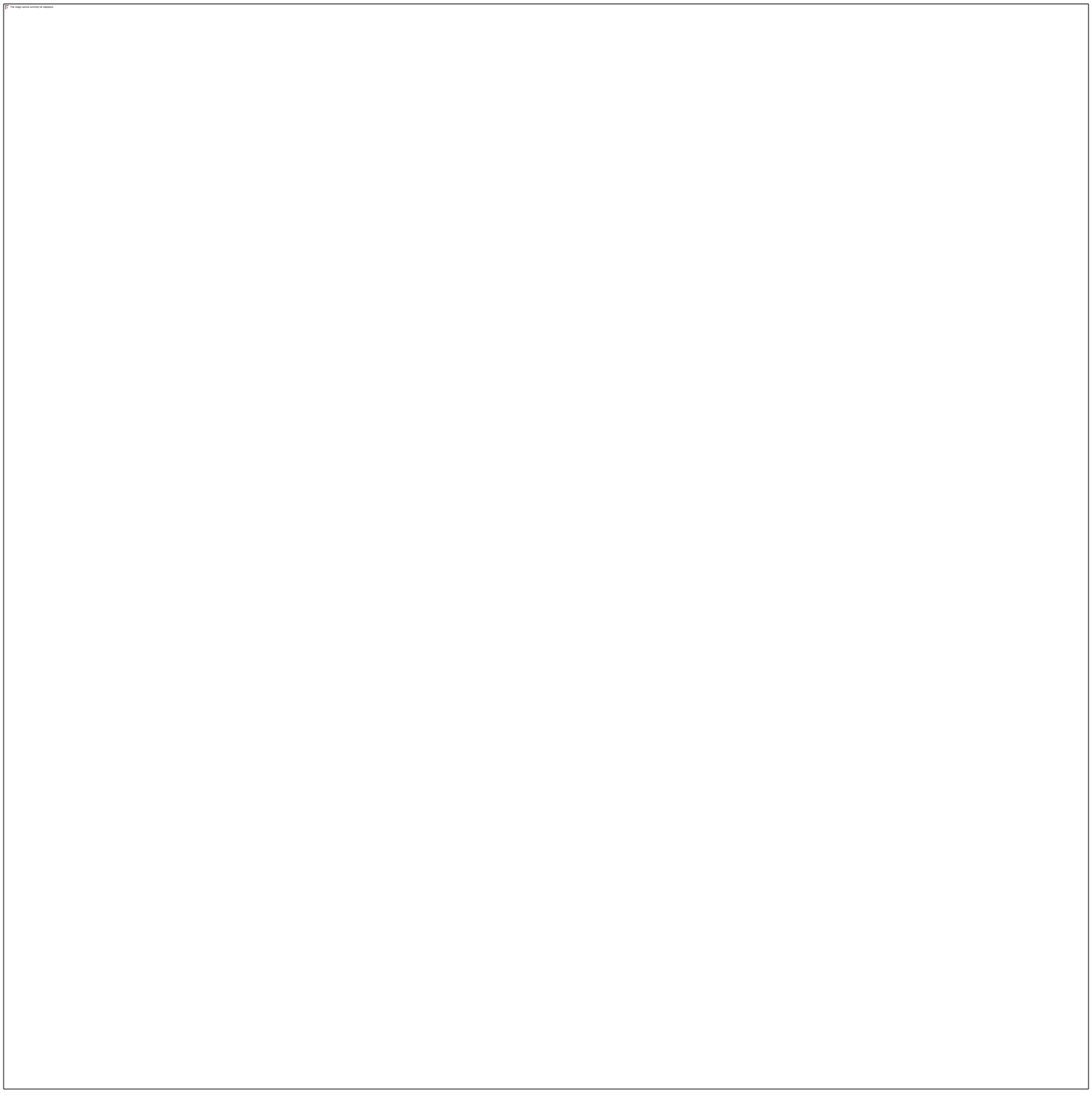


Definition: Drawing paper is a specially prepared sheet used for producing technical drawings.

Uses:

- Providing a surface for preparing site layout plans.
- Presenting dimensions and annotations.
- Producing plans for communication and construction purposes.

11. French curve

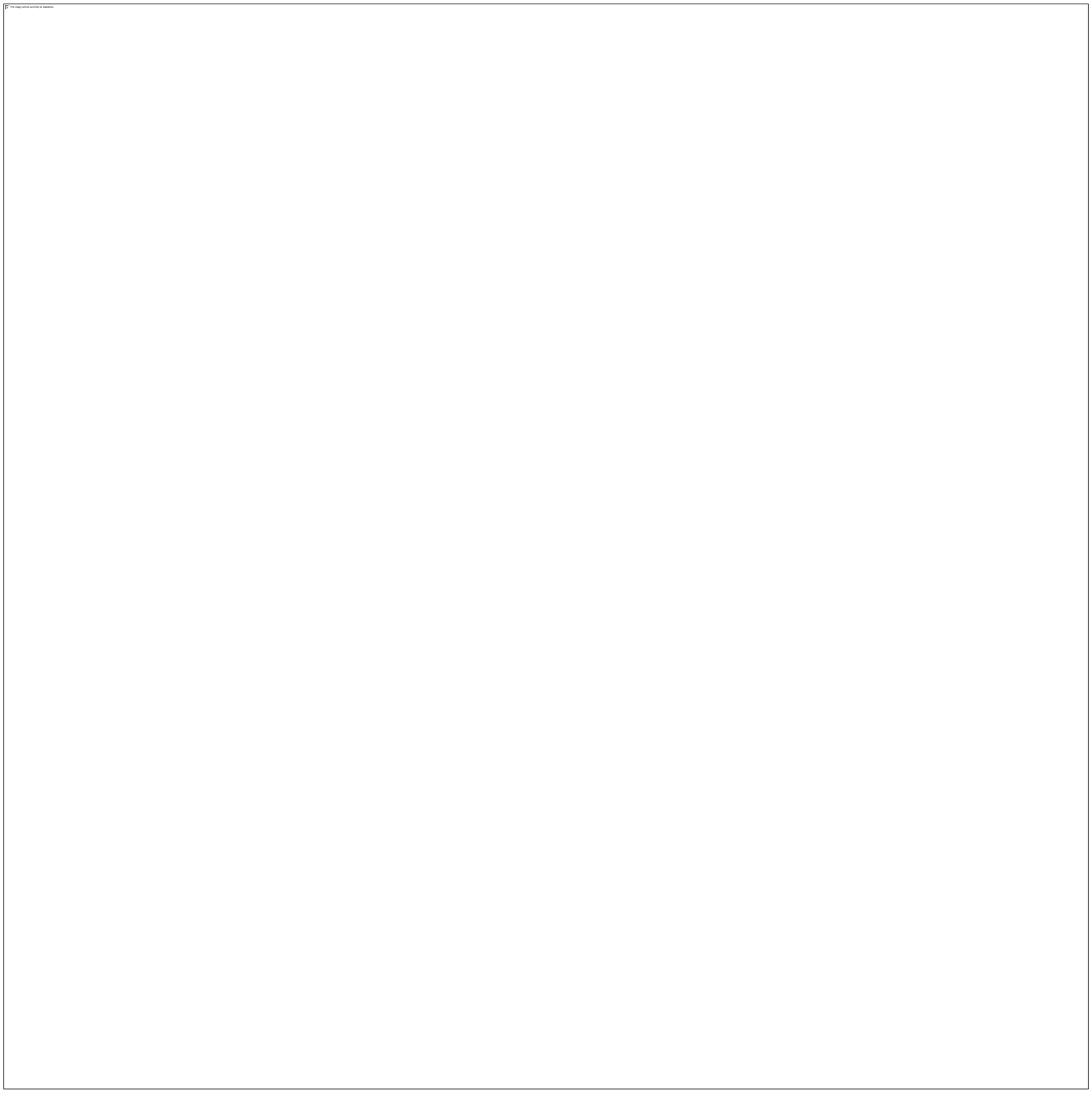


Definition: A French curve is a curved drawing instrument used to draw smooth irregular curves.

Uses:

- Drawing curved boundaries.
- Representing curved pathways.
- Drawing irregular landscape features.

12. Drawing clips and masking tape



Definition: These are accessories used to secure drawing paper to a drawing board.

Uses:

- Preventing movement of drawing paper.
- Maintaining accurate alignment.
- Keeping the drawing surface flat.

Summary table of drawing instruments

Drawing instrument	Main function
Drawing board	Supports drawing paper
T-square	Draws horizontal lines
Set squares	Draws vertical and inclined lines
Scale ruler	Measures scaled dimensions
Pencil	Makes drawing marks
Eraser	Removes unwanted marks
Compass	Draws circles and arcs
Divider	Transfers measurements
Protractor	Measures angles
Drawing paper	Provides drawing surface
French curve	Draws irregular curves
Drawing clips	Holds paper in position

1.3.7 Understanding and Interpreting a Construction Site Layout Plan

A construction site layout plan should communicate the position of facilities and activities clearly using appropriate symbols, labels, dimensions and drawing scales.

A. Common symbols used in a site layout plan

Symbols are simplified graphical representations used to identify different features on a drawing.

Examples include:

Site feature	Suggested representation
Site office	Rectangle labelled OFFICE
Main building	Large rectangle labelled BUILDING
Entrance gate	Opening in boundary with GATE label
Access road	Two parallel lines
Water tank	Circle labelled WT

Cement store	Rectangle labelled CS
Timber store	Rectangle labelled TS
Security post	Small rectangle labelled SP
Toilet	Small rectangle labelled WC
Parking	Rectangle labelled PARKING
Waste collection	Rectangle labelled WASTE
Generator	Rectangle labelled GEN
First-aid room	Rectangle labelled FIRST AID

Note: These are suggested illustrative symbols. A drawing should include a legend explaining all symbols used.

B. Important information shown on a site layout plan

A complete site layout plan should contain:

1. **Drawing title:** Identifies the drawing as a construction site layout plan.
2. **Project name:** Identifies the construction project.
3. **Site boundaries:** Show the limits of the site.
4. **Drawing scale:** Indicates the relationship between drawing dimensions and actual dimensions.
5. **North direction:** Shows the geographical orientation of the site.
6. **Access roads:** Indicate vehicle and pedestrian routes.
7. **Site facilities:** Show the location of offices, stores and welfare facilities.
8. **Dimensions:** Indicate important lengths and distances.
9. **Labels:** Identify different facilities and working areas.
10. **Legend:** Explains symbols used in the drawing.
11. **Date:** Indicates when the drawing was prepared or revised.
12. **Drawing number:** Helps in identification and record keeping.

C. Qualities of a good construction site layout plan

A good site layout plan should:

- Be neat and easy to interpret.
- Use an appropriate drawing scale.
- Show all important site facilities.
- Have clear labels and symbols.
- Show the north direction.
- Include relevant dimensions.
- Provide for safe movement of workers and vehicles.
- Show emergency access routes.

- Avoid unnecessary overcrowding of facilities.
- Reflect the actual site conditions.
- Be updated when significant site arrangements change.

1.3.8 Procedure for Preparing a Construction Site Layout Plan

Meaning

Preparing a construction site layout plan involves collecting site information, determining the position of facilities, selecting a suitable scale and representing the proposed arrangement using technical drawing instruments.

Step 1: Visit and inspect the construction site

- Visit the actual site before preparing the plan.
- Observe the shape and size of the land.
- Identify existing buildings and structures.
- Identify neighbouring properties.
- Identify existing roads and access points.
- Observe the direction of the slope.
- Identify trees, drainage channels and other physical features.

Step 2: Measure the site

- Establish the length and width of the site.
- Measure important boundaries.
- Identify the positions of existing structures.
- Record the dimensions accurately.
- Use appropriate surveying equipment where necessary.

Step 3: Identify the construction requirements

Determine the facilities needed on the site, including:

- Site office.
- Material stores.
- Access roads.
- Water supply.
- Electricity supply.
- Security facilities.

- Workers' welfare facilities.
- Sanitation facilities.
- Waste collection points.
- Parking areas.
- Emergency facilities.

Step 4: Select suitable positions for the facilities

- Locate the site office in an accessible area.
- Position material stores where deliveries can be made easily.
- Provide suitable space for machinery.
- Position sanitation facilities conveniently and hygienically.
- Locate water storage facilities where water can be distributed efficiently.
- Provide secure locations for valuable materials.
- Ensure that emergency routes are not obstructed.

Step 5: Select a suitable drawing scale

The scale should allow the entire site to fit on the drawing sheet while maintaining sufficient detail.

Common scales include:

- 1:50
- 1:100
- 1:200
- 1:500
- 1:1000

The selection depends on the size of the site and the amount of detail required.

Step 6: Prepare the outline of the site

- Draw the site boundary.
- Show the shape of the land.
- Indicate the main entrance.
- Mark existing structures.
- Show the north direction.

Step 7: Draw the position of the proposed facilities

- Draw the main building.
- Draw the site office.
- Indicate material storage areas.
- Draw access roads.
- Show the water storage area.

- Indicate the power supply area.
- Show welfare and sanitation facilities.
- Include parking and waste collection areas.

Step 8: Add dimensions and labels

- Indicate important measurements.
- Label all facilities clearly.
- Include road widths where relevant.
- Identify entrances and exits.
- Include the drawing scale.

Step 9: Prepare the legend

- List all symbols used.
- Explain the meaning of each symbol.
- Ensure that the symbols are consistent throughout the drawing.

Step 10: Check and complete the drawing

- Check the dimensions.
- Check the scale.
- Ensure that facilities do not overlap unnecessarily.
- Confirm that access routes are clear.
- Check that emergency facilities are accessible.
- Erase unnecessary construction lines.
- Complete the title block.

1.3.9 Practical Example: Drawing a Construction Site Layout Plan

Activity

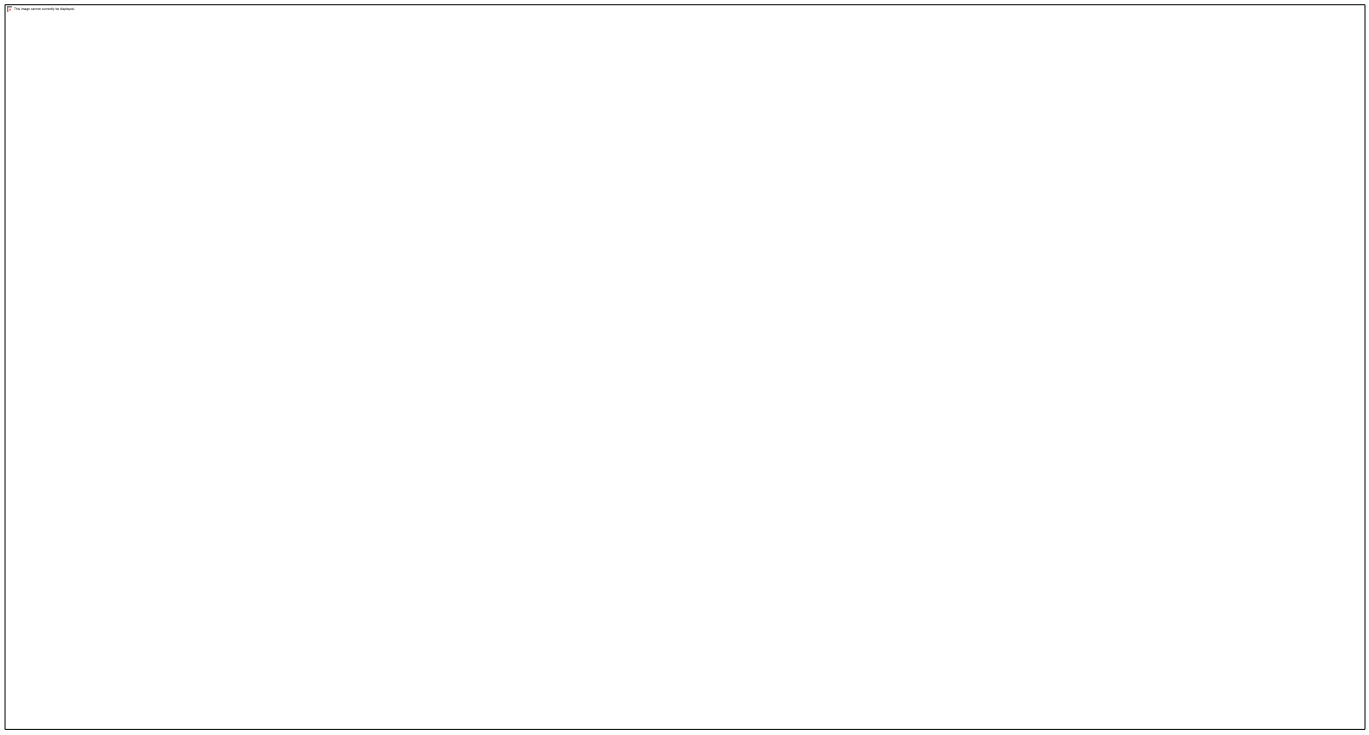
A contractor has been awarded a tender to construct a two-classroom block at a primary school in Narok County. The available construction site measures 60 metres by 40 metres.

The contractor intends to establish the following facilities:

1. Main classroom building.
2. Site office.
3. Cement store.
4. Timber and reinforcement storage.
5. Sand and ballast storage.
6. Water storage tank.
7. Generator.
8. Workers' toilets.

9. Security post.
10. Waste collection area.
11. Parking and loading area.
12. Main access road.

Proposed site arrangement



Suggested arrangement and reasons

Facility	Suggested position	Reason
Main entrance	Near the road frontage	Provides easy access
Security post	At the entrance	Controls movement
Site office	Near entrance	Easy supervision and visitor access
Classroom building	Main construction area	Provides adequate working space
Cement store	Secure, dry location	Protects cement from moisture
Timber store	Near construction area	Reduces transportation
Steel storage	Secure designated area	Protects reinforcement
Sand and ballast	Near mixing area	Reduces material handling
Water tank	Accessible central location	Supports construction activities
Generator	Secure, ventilated location	Supplies electricity safely
Toilets	Convenient, suitable location	Supports workers' hygiene

Waste collection	Designated collection area	Supports waste management
Parking	Near entrance but outside working routes	Prevents congestion

Example of scale calculation

Given:

- Actual site length = 60 metres.
- Actual site width = 40 metres.
- Drawing scale = 1:200.

Convert actual dimensions into millimetres.

Length:

60×1000=60,000 mm

Drawing length:

$$\frac{60{,}000}{200} = 300\ mm$$

Width:

40×1000=40,000 mm

Drawing width:

$$\frac{40{,}000}{200} = 200\ mm$$

Answer

The site should therefore be represented by a rectangle measuring **300 mm by 200 mm** on the drawing sheet.

Practical classroom activity

Activity: Preparing a site layout plan

Learners should work in groups to prepare a site layout plan for a proposed classroom construction project.

Requirements:

- Drawing board.
- Drawing paper.
- T-square.
- Set squares.
- Scale ruler.
- Pencils.
- Eraser.
- Protractor.

Procedure:

1. Assume a rectangular site measuring 50 m by 30 m.
2. Select a suitable drawing scale.
3. Draw the site boundary.
4. Indicate the main entrance and exit.
5. Draw the main building.
6. Position the site office.
7. Show the material storage facilities.
8. Indicate water and electricity supply facilities.
9. Show sanitation and welfare facilities.
10. Indicate security and waste collection points.
11. Add dimensions and labels.
12. Provide a north arrow and drawing legend.

Expected learning outcome: Learners should be able to prepare and interpret a simple construction site layout plan using appropriate drawing instruments.

1.3.10 Safety Precautions When Organizing a Construction Site

Safety precautions are measures taken to prevent accidents, injuries, damage to property and environmental hazards during construction activities.

The following precautions should be observed:

1. Fence the construction site appropriately.
2. Display warning signs at dangerous areas.
3. Provide safe pedestrian walkways.
4. Separate pedestrian routes from vehicle routes where practicable.
5. Store construction materials properly.
6. Avoid stacking materials at unstable heights.
7. Keep access roads free from obstructions.
8. Provide suitable fire extinguishers.
9. Keep emergency exits and access routes clear.
10. Provide appropriate personal protective equipment (PPE).
11. Ensure that electrical installations are safe.
12. Protect open excavations against accidental falls.
13. Provide adequate lighting.
14. Maintain clean and hygienic sanitation facilities.
15. Dispose of waste appropriately.
16. Provide first-aid facilities.

17. Secure machinery and equipment when not in use.
18. Control dust and noise.
19. Ensure that workers receive appropriate safety instructions.
20. Regularly inspect the site to identify hazards.

1.3.11 Challenges Experienced in Construction Site Organization

Construction site organization may be affected by various challenges.

Challenge	Possible solution
Limited site space	Plan facilities carefully and use available space efficiently
Poor road access	Establish suitable temporary access roads
Water shortages	Provide adequate water storage and approved alternative supplies
Power interruptions	Provide suitable backup power
Theft of materials	Improve fencing, lighting and access control
Poor drainage	Construct suitable drainage channels
Poor material storage	Provide designated and secure stores
Congestion	Separate pedestrian and vehicle movement
Poor waste disposal	Establish waste collection and removal arrangements
Inadequate sanitation	Provide sufficient and maintained welfare facilities
Unfavourable weather	Provide temporary protection for materials and work areas
Poor communication	Establish effective communication systems

1.3.12 Summary of the Sub-strand

Site organization is an important part of building construction because it determines how construction facilities, materials, equipment, workers and activities are arranged.

The main points covered include:

1. Meaning and importance of site organization.
2. Types and functions of construction site amenities.
3. Factors considered when organizing a construction site.
4. Preparation and interpretation of construction site layout plans.
5. Building code and legal requirements governing site organization in Kenya.
6. Drawing instruments used in preparing site layout plans.
7. Procedures for preparing a site layout plan.
8. Safety precautions and challenges associated with site organization.

A properly organized construction site promotes safety, productivity, efficient use of resources, environmental protection and successful completion of construction projects.

REVISION QUESTIONS

STRAND 1.0: FOUNDATIONS OF BUILDING CONSTRUCTION

SUB-STRAND 1.3: SITE ORGANIZATION

SECTION A: MULTIPLE-CHOICE QUESTIONS

Choose the correct answer from the alternatives provided.

1. What is meant by site organization in building construction?

A. The process of designing building foundations.

B. The systematic arrangement of facilities, materials, equipment and activities on a construction site.

C. The process of decorating completed buildings.

D. The preparation of architectural drawings only.

2. Which one of the following is an example of a construction site amenity?

A. Roof truss. B. Foundation footing.

C. Workers' toilet. D. Reinforcement bar.

3. The main purpose of providing access roads on a construction site is to:

A. Improve the appearance of the site.

B. Facilitate movement of vehicles and materials.

C. Increase the height of the building.

D. Reduce the size of the construction site.

4. Which facility is most suitable for protecting cement against moisture?

A. Open parking area.

B. Site entrance.

C. Covered and dry cement store.

D. Workers' rest shelter.

5. Which of the following is the main function of a site office?

A. Storing aggregates.

B. Providing administrative and management space.

C. Mixing concrete.

D. Disposing of construction waste.

6. Which of the following is a suitable source of water for a construction site?

A. Contaminated drainage water.

B. Untreated wastewater.

C. Approved public water supply.

D. Water collected from polluted surroundings.

7. Which facility is used to protect a construction site against unauthorized entry?

A. Water tank.

B. Security gate.

C. Cement store.

D. Parking area.

8. Which of the following is an important welfare facility?

A. Reinforcement store.

B. Generator house.

C. Workers' resting shelter.

D. Concrete mixing platform.

9. What is the main purpose of providing sanitation facilities on a construction site?

A. To store building materials.

B. To promote hygiene and prevent diseases.

C. To provide electricity.

D. To improve the appearance of buildings.

10. Which of the following factors should be considered when organizing a construction site?

A. Workers' favourite colours.

B. The contractor's personal interests.

C. Site topography and soil conditions.

D. The shape of construction tools only.

11. Which site condition may make the establishment of access roads difficult?

A. Flat and firm ground.

B. Waterlogged and unstable ground.

C. Well-drained ground.

D. Firm gravel surfaces.

12. Which facility should be located near the main entrance to control access?

A. Cement store. B. Security post.

C. Concrete mixing area. D. Workers' changing room.

13. The main purpose of a construction site layout plan is to:

A. Show the arrangement of facilities and activities on the site.

B. Show the interior decoration of a building.

C. Calculate the salaries of construction workers.

D. Determine the selling price of a completed building.

14. Which drawing instrument is mainly used to draw horizontal lines?

A. Compass. B. T-square.

C. Protractor. D. Divider.

15. Which instrument is used to measure and draw angles?

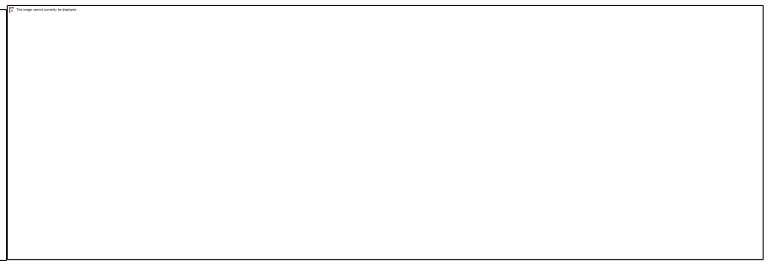
A. Eraser.

B. Drawing board.

C. Protractor.

D. Scale ruler.

16. Which drawing instrument is used to draw circles and arcs?

17. A drawing scale of 1:200 means that:

A. One unit on the drawing represents 200 similar units on the actual site.

B. Two units on the drawing represent 200 units on the actual site.

C. Two hundred units on the drawing represent one unit on the actual site.

D. One unit on the drawing represents two units on the actual site.

18. Which of the following should be included in a construction site layout plan?

A. Workers' personal identification numbers.

B. Contractor's family details.

C. Site boundaries and access roads.

D. Personal opinions of workers.

19. Which of the following is an appropriate way of managing construction waste?

A. Dumping waste into nearby rivers.

B. Burning all waste materials indiscriminately.

C. Collecting and separating waste in designated areas.

D. Leaving waste scattered around the site.

20. Which Kenyan legislation primarily addresses occupational safety and health at workplaces?

A. Occupational Safety and Health Act, 2007.

B. Companies Act, 2015.

C. Traffic Act.

D. Employment Act, 2007.

21. What is the function of a drawing legend?

A. To show the actual cost of construction.

B. To explain the symbols used in a drawing.

C. To determine the quality of cement.

D. To show the number of construction workers.

22. Which of the following is the most suitable storage arrangement for reinforcement bars?

A. Stacking them carelessly on access roads.

B. Keeping them in workers' rest shelters.

C. Stacking them securely in a designated storage area.

D. Storing them inside sanitation facilities.

23. Which of the following should be considered when locating a generator?

A. Its proximity to workers' eating areas.

B. Adequate ventilation and security.

C. Its position inside a toilet.

D. Its location on an emergency escape route.

24. Which of the following is an important environmental consideration during site organization?

A. Increasing uncontrolled dust emissions.

B. Blocking natural drainage channels.

C. Preventing soil erosion and pollution.

D. Dumping construction waste in public areas.

25. What is the purpose of providing a north arrow on a site layout plan?

A. To show the direction of geographical north.

B. To indicate the height of the building.

C. To show the thickness of the foundation.

D. To indicate the cost of materials.

26. Which of the following is a suitable way of reducing accidents involving pedestrians and vehicles?

A. Allowing vehicles to move through all working areas.

B. Separating pedestrian pathways from vehicle routes where practicable.

C. Removing all warning signs.

D. Storing materials on walkways.

27. Which facility provides immediate medical assistance to injured workers?

A. Cement store. B. First-aid facility.

C. Parking area. D. Generator house.

28. A site measuring 40 metres is represented using a scale of 1:200. What will be its drawing length?

A. 20 mm.

B. 100 mm.

C. 200 mm.

D. 400 mm.

29. Which of the following is an important consideration when positioning a site office?

A. Accessibility and ease of supervision.

B. Location inside an excavation.

C. Position within a vehicle turning area.

D. Placement directly beneath suspended loads.

30. Which of the following best describes a well-organized construction site?

A. A site with materials scattered everywhere.

B. A site without access roads.

C. A site with properly arranged facilities, safe access and organized storage.

D. A site without sanitation facilities.

SECTION B: STRUCTURED AND SHORT-ANSWER QUESTIONS

31: Introduction to Site Organization

a) Define the term site organization as used in building construction. (2 marks)

b) State six reasons why proper site organization is important in a construction project. (6 marks)

c) Explain four ways in which proper site organization contributes to the successful completion of a building project. (8 marks)

32: Amenities on Construction Sites

a) Define construction site amenities. (2 marks)

b) List ten amenities commonly provided on a construction site. (10 marks)

c) Explain the functions of the following facilities:

i. Site office. (3 marks)

ii. Material storage facilities. (3 marks)

iii. Access roads. (3 marks)

iv. Security facilities. (3 marks)

33: Water and Power Supply

a) Identify four sources of water for construction activities. (4 marks)

b) State six uses of water on a construction site. (6 marks)

c) Explain five safety requirements that should be observed when providing temporary electricity on a construction site. (10 marks)

34: Material Storage Facilities

a) Name five types of materials that require designated storage areas on a construction site. (5 marks)

b) Explain five requirements for proper storage of cement. (5 marks)

c) State five advantages of providing designated material storage facilities. (5 marks)

35: Workers' Welfare and Sanitation

a) Define workers' welfare facilities. (2 marks)

b) List six welfare facilities that should be provided on a construction site. (6 marks)

c) Explain six reasons why sanitation facilities are important on a construction site. (6 marks)

36: Factors Considered in Site Organization

a) State ten factors that should be considered when organizing a construction site. (10 marks)

b) Explain how the following factors influence site organization:

i. Topography. (2 marks)

ii. Soil conditions. (2 marks)

iii. Site accessibility. (2 marks)

iv. Availability of water. (2 marks)

v. Number of workers. (2 marks)

37: Construction Site Layout Plan

a) Define a construction site layout plan. (2 marks)

b) State eight components of a construction site layout plan. (8 marks)

c) Explain five reasons why a construction site layout plan is important. (10 marks)

38: Building Code Requirements

a) Identify four Kenyan laws or regulatory frameworks relevant to construction site organization. (4 marks)

b) State six safety requirements that should be observed when organizing a construction site. (6 marks)

c) Explain five environmental protection measures that should be implemented on a construction site. (10 marks)

39: Drawing Instruments

a) List ten drawing instruments used in preparing construction site layout plans. (10 marks)

b) Explain the functions of the following drawing instruments:

i. T-square. (2 marks)

ii. Set square. (2 marks)

iii. Scale ruler. (2 marks)

iv. Compass. (2 marks)

v. Protractor. (2 marks)

40: Preparation of a Site Layout Plan

a) Outline eight steps followed when preparing a construction site layout plan. (8 marks)

b) State six important details that should be included in a completed site layout drawing. (6 marks)

c) Explain three qualities of a good construction site layout plan. (6 marks)

41: Practical Application and Drawing

A contractor intends to construct a classroom block on a rectangular piece of land measuring 50 metres by 30 metres.

The proposed construction site requires the following facilities:

- Main classroom building.
- Site office.
- Cement store.
- Timber store.
- Sand and ballast storage.
- Water tank.
- Generator.
- Workers' toilets.
- Security post.
- Waste collection area.
- Parking area.
- Access road.

Required:

a) State five factors that should be considered when organizing the construction site. (5 marks)

b) Explain the appropriate location of five of the facilities listed above. (10 marks)

c) Using a suitable scale, draw a labelled construction site layout plan showing all the facilities listed. (15 marks)

42:

A construction company has started building a new classroom block in a rural school in Narok County. The contractor has delivered cement, timber, reinforcement bars, sand and ballast to the site. However, the materials have been scattered around the construction area. There are no proper access roads,

workers' toilets or designated storage facilities. Delivery trucks are interfering with pedestrian movement.

a) Identify six problems associated with the organization of this construction site. (6 marks)

b) Suggest six measures that the contractor should take to improve site organization. (6 marks)

c) Explain four dangers that may arise from poor site organization. (8 marks)

43:

A contractor is constructing a residential building in an area with unreliable electricity and water supply. The construction site is also located on sloping ground.

a) Suggest three alternative arrangements for ensuring a reliable water supply. (3 marks)

b) Identify three alternative sources of power that could be considered. (3 marks)

c) Explain four measures that should be taken when organizing a construction site on sloping ground. (8 marks)

d) State six safety precautions that should be observed during construction. (6 marks)

44:

A learner is required to prepare a site layout plan for a proposed construction project.

a) Explain the importance of using a drawing scale. (3 marks)

b) Differentiate between a T-square and a set square. (4 marks)

c) State five details that should appear in the title block of a site layout drawing. (5 marks)

d) A construction site measures 80 metres by 50 metres. Calculate its dimensions on a drawing prepared using a scale of 1:500. (4 marks)

PRACTICAL PROJECT

Project title: Preparation of a Construction Site Organization Plan for a Proposed School Classroom Block.

Expected competencies

By completing this project, learners should demonstrate the ability to:

- Identify construction site amenities.
- Select suitable positions for site facilities.
- Apply appropriate drawing scales.
- Use technical drawing instruments.
- Prepare a labelled site layout plan.
- Observe construction safety requirements.
- Communicate site organization decisions.

Assessment criteria

Assessment area	Marks
Identification of required amenities	10
Selection of suitable locations	10
Accuracy of measurements and scale	10
Use of drawing instruments	10
Neatness and presentation	5
Labelling and legend	5
Safety and environmental considerations	10
Total	60

Substrand 1.4: Appropriate Technology in Building: Building Materials

1.4.1 Introduction

Appropriate technology in building refers to the use of locally available, affordable and environmentally friendly materials and methods in construction. In Kenya, it means using materials like thatch, compressed earth blocks and bamboo, which are suitable for our climate, culture and economy.

Key Terms

Appropriate Technology: The use of suitable, simple and affordable methods and materials.

Building Material: Any substance used to construct a building.

Sustainable: Meeting present needs without compromising future generations.

1.4.2 Building Materials and Appropriate Technology

The following are building materials and technologies that are appropriate in our context:


Thatch


Compressed Earth Blocks


Rammed Earth


Bamboo


Interlocking Stabilized Soil Blocks


Recycled Waste Materials

1.4.3 Explanationof Each Technology

1. **Thatch**
   - Made from grass, reeds or palm leaves.
   - Used for roofing in rural areas.
   - Advantages: cheap, cool and locally available.
2. **Compressed Earth Blocks (CEBs)**
   - Blocks made from soil, sand and a little cement.
   - Strong, durable and reduce use of fired bricks.
3. **Rammed Earth**
   - Compacted soil in layers.
   - Produces strong walls with low cost.
4. **Bamboo**
   - Fast-growing, strong and flexible.
   - Used for frames, scaffolding and light structures.
5. **Interlocking Stabilized Soil Blocks**
   - Blocks with special shape, made from soil and stabilizer (cement/lime).
   - Easy to fit, good strength and less mortar.
6. **Recycled Waste Materials**
   - Using materials like plastic bottles, cans, tyres, and scrap wood.
   - Reduces waste and lowers construction cost.

1.4.4 Structures Constructed Using Appropriate Technologies

These technologies are used to build different structures such as:


Houses (thatch or CEBs)


Schools (Earth blocks)


Bridges (Bamboo)

1.4.6 Importance of the Technologies

- ✓ Cost effective – reduces construction costs.
- ✓ Environmentally friendly – uses local and recycled materials.
- ✓ Supports local economy – creates jobs.
- ✓ Suitable for our climate – cool and durable.
- ✓ Reduces waste – helps keep our environment clean.
- ✓ Promotes sustainable construction.

1.4.5 Model Building Structures Using Appropriate Technology

- A model house using CEBs and a thatched roof.
- A model classroom using bamboo frames.
- A model eco-friendly house using recycled materials.

In Summary

Appropriate technologies like thatch, compressed earth blocks, rammed earth, bamboo, interlocking stabilized soil blocks and recycled waste materials help us build strong, affordable and eco-friendly structures in Kenya.



Revision Questions

1. What is appropriate technology in building?
2. Name three building materials that are environmentally friendly.
3. Explain the advantages of compressed earth blocks.
4. Why is bamboo useful in construction?
5. How can recycled materials be used in building?
6. Suggest a building structure you can construct using appropriate technology.

STRAND 1.0: FOUNDATIONS OF BUILDING CONSTRUCTION

SUB-STRAND 1.4: APPROPRIATE TECHNOLOGY IN BUILDING

1.4.1 Introduction to Appropriate Technology in Building

Building construction has traditionally relied on materials such as burnt clay bricks, concrete blocks, natural stones, steel and timber. However, increasing construction costs, environmental concerns, scarcity of conventional materials and the need for affordable housing have encouraged the use of appropriate technologies.

In Kenya, appropriate building technologies provide opportunities to construct affordable, durable, environmentally friendly and locally suitable buildings using locally available materials and skills.

Examples include:

- Thatch roofing.
- Compressed earth blocks.
- Rammed earth construction.
- Bamboo construction.
- Interlocking stabilized soil blocks.
- Recycled waste materials in building construction.

These technologies can be applied in constructing houses, classrooms, community centres, agricultural buildings, sanitation facilities and other structures.

Learning outcomes

By the end of this sub-strand, the learner should be able to:

1. Explain the meaning of appropriate technology in building construction.
2. Identify building materials used in appropriate building technologies.
3. Describe different appropriate building technologies.
4. Explain how structures are constructed using appropriate technologies.
5. Develop simple models of structures using appropriate technologies.
6. Explain the importance of appropriate technologies in building construction.
7. Demonstrate creativity and innovation in using locally available and recycled materials.
8. Appreciate the importance of environmental conservation and sustainable construction.

Key competencies developed

- **Creativity and imagination:** Designing alternative building structures using locally available materials.
- **Critical thinking and problem-solving:** Selecting suitable construction technologies for different environments.
- **Communication and collaboration:** Working in groups to construct building models.
- **Digital literacy:** Using digital resources to investigate modern building technologies.
- **Environmental awareness:** Promoting recycling and responsible use of natural resources.
- **Learning to learn:** Exploring innovative methods of construction.

1.4.2 Meaning of Appropriate Technology in Building Construction

Definition of appropriate technology

Appropriate technology in building construction refers to the use of suitable, affordable, accessible, environmentally sustainable and locally adaptable methods, materials, tools and equipment to construct buildings that meet the needs of a particular community.

It involves selecting construction methods and materials that are appropriate to the local environment, available resources, economic conditions, skills and intended use of a building.

Appropriate technology does not necessarily mean using traditional or primitive construction methods. It can also involve modern innovations that are simple, economical, efficient and environmentally friendly.

Examples in Kenya:

1. Using thatch obtained from suitable local grasses to roof rural houses.
2. Manufacturing compressed earth blocks using locally available soil.
3. Constructing walls using rammed earth technology.
4. Using bamboo for lightweight building components.
5. Manufacturing interlocking stabilized soil blocks to reduce the use of conventional mortar.
6. Incorporating recycled plastic and other suitable waste materials into construction products.

Characteristics of appropriate building technology

Appropriate building technologies generally have the following characteristics:

1. **Affordability**
   - The technology should be economically accessible to the intended users.
   - It should reduce unnecessary construction expenses.
   - It should make use of available resources without compromising safety and quality.
2. **Use of locally available materials**
   - Materials should preferably be obtained from nearby sources.
   - This reduces transportation costs.
   - It encourages local production and employment.
3. **Environmental sustainability**
   - The technology should minimize environmental damage.

- It should encourage recycling and reuse of materials.
- It should promote responsible use of natural resources.

4. **Simplicity of construction**
   - Construction procedures should be understandable and manageable.
   - The technology should be suitable for available local skills.
   - It should not depend unnecessarily on complicated machinery.
5. **Durability**
   - Structures should withstand the expected environmental conditions.
   - Materials should be appropriately selected and treated.
   - Construction should follow suitable technical standards.
6. **Adaptability**
   - The technology should be suitable for different geographical and climatic conditions.
   - It should be adjustable to local construction requirements.
7. **Energy efficiency**
   - The technology should reduce unnecessary energy consumption during construction and building use.
   - It may improve indoor comfort and reduce the need for artificial heating or cooling.
8. **Ease of maintenance**
   - Materials and components should be reasonably easy to repair or replace.
   - Maintenance should be affordable and practical.
9. **Social acceptability**
   - The technology should meet the cultural and practical needs of the community.
   - It should be acceptable to the intended building users.
10. **Safety**
    - Buildings should provide adequate structural stability.
    - Materials should be suitable for their intended applications.
    - Construction should comply with applicable building regulations.

1.4.3 Meaning of Building Materials Used in Appropriate Technologies

Definition of building materials

Building materials are natural or manufactured substances used in the construction, finishing, protection and maintenance of buildings and other structures.

Appropriate building technologies make use of conventional, alternative and recycled materials depending on their suitability.

Categories of materials used in appropriate technologies

A. Natural building materials

These are materials obtained directly from nature and processed or used with limited industrial manufacturing.

Examples:

1. Earth.
2. Stone.
3. Bamboo.
4. Timber.
5. Grass.
6. Reeds.
7. Thatch.
8. Sand.
9. Clay.
10. Natural fibres.

B. Processed building materials

These are materials that undergo mechanical or chemical processes before being used in construction.

Examples:

1. Compressed earth blocks.
2. Stabilized soil blocks.
3. Treated bamboo.
4. Processed timber.
5. Cement-stabilized soil.
6. Manufactured roofing sheets.

C. Recycled building materials

These are materials recovered from waste products or discarded items and processed for reuse in construction.

Examples:

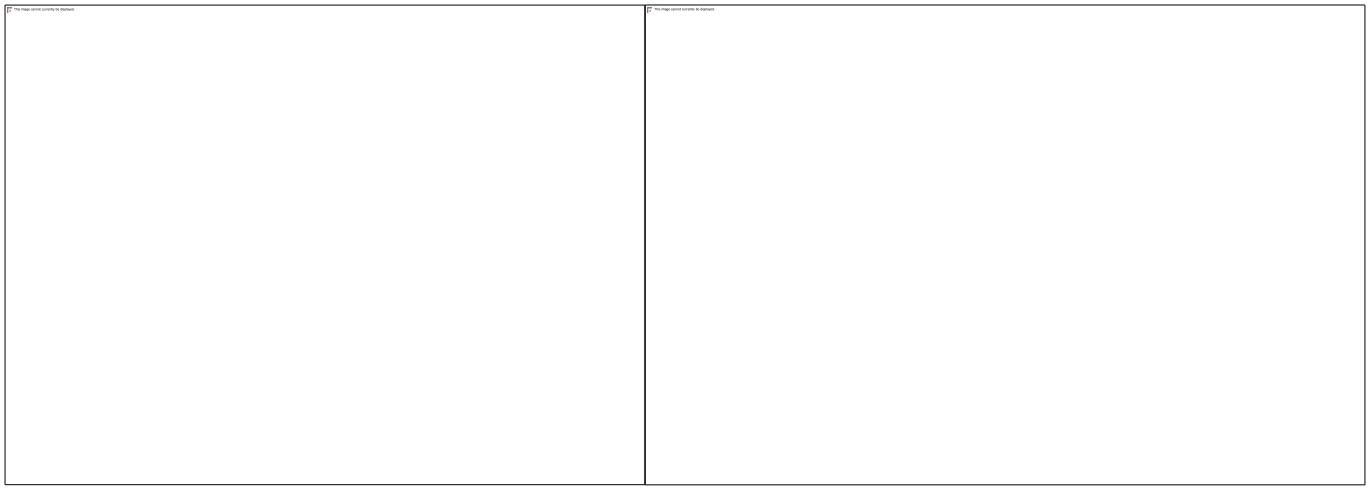
1. Recycled plastic.
2. Recycled glass.
3. Reclaimed timber.
4. Recycled metal.
5. Reused bricks.
6. Recycled rubber.
7. Recycled concrete aggregates.
8. Suitable agricultural waste products.

Factors to consider when selecting appropriate building materials

1. **Availability:** Materials should be readily available in the locality.
2. **Cost:** The purchase, transportation and installation costs should be considered.
3. **Strength:** Materials should have sufficient strength for their intended use.
4. **Durability:** Materials should resist deterioration under expected conditions.
5. **Weather resistance:** Materials should withstand rain, wind, sunlight and temperature variations.
6. **Fire resistance:** Materials should provide appropriate protection against fire.
7. **Water resistance:** Materials should be suitable for the amount of moisture they are likely to encounter.
8. **Maintenance requirements:** Materials should be easy and economical to maintain.
9. **Environmental impact:** Extraction, processing, transportation and disposal should be considered.
10. **Availability of skills:** Local workers should have access to the necessary knowledge and training.
11. **Building regulations:** Materials should comply with applicable standards and approval requirements.
12. **Intended use:** Materials should be suitable for the particular building component.

1.4.4 Types of Appropriate Technologies Used in Building Construction

A. Thatch Technology





Meaning of thatch technology

Thatch technology is a traditional building technology that involves using dried natural vegetation, such as grass, reeds, palm leaves and other suitable plant materials, to construct roofs and, in some cases, wall coverings.

Thatching is one of the oldest roofing technologies used by communities in different parts of Kenya and Africa.

In Kenya, thatched structures are commonly associated with traditional rural houses, cultural structures, eco-lodges, gazebos and community facilities.

Materials used in thatch construction

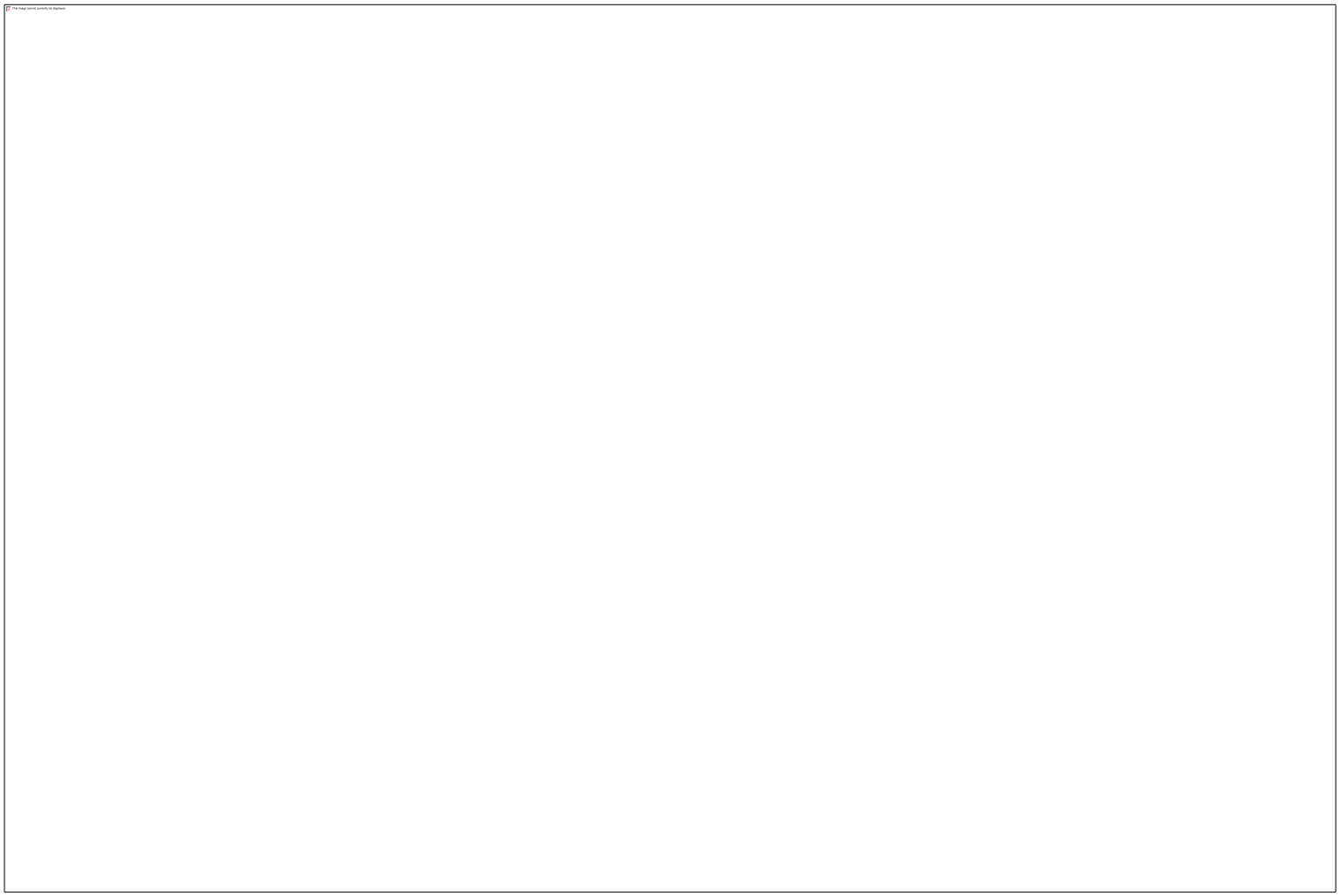
1. **Grass**
    - Specially selected long grasses are harvested and dried.
    - They are bundled together and arranged in overlapping layers.
    - The grass provides a protective covering against rain and sunlight.
2. **Reeds**
    - Reeds are long, hollow plant stems.
    - They can be bundled and arranged to form roofing coverings.
    - They are suitable where appropriate reed species are locally available.
3. **Palm leaves**
    - Palm leaves are dried and arranged in overlapping layers.
    - They provide roofing and decorative coverings.
    - They are commonly used in tropical regions.
4. **Bamboo**
    - Bamboo may be used to make supporting frames and roof structures.
    - It provides a lightweight structural framework when properly designed.
5. **Timber**

- Timber is used for rafters, battens, supporting frames and roof members.
- It should be appropriately selected and treated.

6. **Binding materials**

- Natural fibres, suitable ropes or corrosion-resistant wire may be used to secure the thatch.
- The binding materials should be durable and suitable for the environmental conditions.

Procedure for constructing a thatched roof



1. **Preparation of the roof structure**

- Construct a suitable supporting roof frame using properly selected structural materials.
- Ensure that the frame is adequately designed to support the weight of the thatch.
- Provide a suitable roof pitch to allow rainwater to drain.

2. **Selection of thatching materials**

- Select suitable grass, reeds or palm leaves.
- Materials should be mature, strong and free from excessive decay.
- Avoid using wet or badly damaged vegetation.

3. **Drying of materials**

- Dry the vegetation properly before installation.
- Drying reduces the likelihood of decay and deterioration.

- Properly dried materials are easier to handle and install.

4. **Preparation of bundles**
   - Arrange the vegetation into manageable bundles.
   - Make bundles of relatively uniform thickness.
   - Prepare sufficient bundles to cover the roof.
5. **Installation of the thatch**
   - Begin installation from the lower edge of the roof.
   - Fix the bundles securely to the roof framework.
   - Arrange successive layers so that the upper layers overlap the lower ones.
   - This prevents rainwater from entering the roof.
6. **Finishing the roof**
   - Complete the ridge using suitable thatching materials.
   - Trim projecting vegetation neatly.
   - Secure loose sections.
   - Inspect the completed roof for gaps and weak areas.

Uses of thatch technology

1. Roofing traditional rural houses.
2. Roofing cultural structures.
3. Constructing eco-lodges and tourist accommodation.
4. Roofing outdoor resting shelters.
5. Constructing gazebos.
6. Covering traditional community meeting structures.
7. Providing shade in recreational facilities.
8. Constructing temporary agricultural shelters.

Advantages of thatch technology

1. **Locally available materials:** Grass and reeds may be obtained from suitable local sources.
2. **Low initial material cost:** In areas where vegetation is readily available, material costs can be relatively low.
3. **Thermal insulation:** Thatch provides insulation that can help maintain comfortable indoor temperatures.
4. **Lightweight construction:** Properly installed thatch is relatively light compared with many conventional roofing materials.
5. **Environmental benefits:** Renewable plant materials can be used when harvested responsibly.
6. **Employment creation:** Thatching provides opportunities for local artisans and skilled workers.
7. **Cultural preservation:** It helps preserve traditional building knowledge and architectural identity.

8. **Aesthetic value:** Thatch gives buildings a natural and attractive appearance.
9. **Reduced industrial processing:** Some thatching materials require relatively little processing.
10. **Adaptability:** Thatch can be used in different building designs.

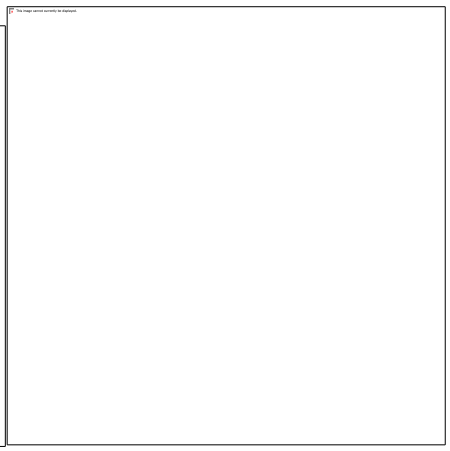
Disadvantages of thatch technology

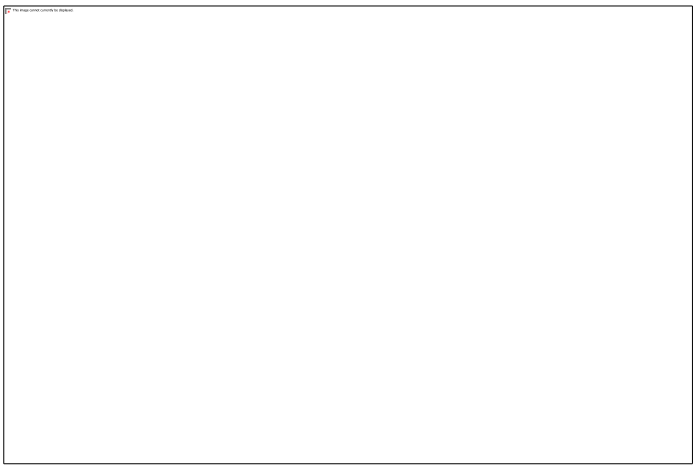
1. **Fire risk:** Dry vegetation can ignite easily.
2. **Maintenance:** Thatch may require regular inspection and replacement of damaged sections.
3. **Pest attack:** Some insects, rodents and birds may damage poorly maintained thatched roofs.
4. **Weather deterioration:** Strong winds and prolonged exposure to rain may damage the roofing.
5. **Limited lifespan:** The durability depends on the plant species, workmanship, climate and maintenance.
6. **Water leakage:** Poor installation or inadequate roof pitch may allow rainwater to penetrate.
7. **Material availability:** Suitable vegetation may be difficult to obtain in some areas.
8. **Insurance and regulatory challenges:** Some buildings may face additional fire-safety requirements.

Precautions when using thatch technology

- Use properly dried and suitable vegetation.
- Provide adequate roof slope.
- Construct a strong supporting framework.
- Ensure secure fixing of the thatch.
- Provide appropriate fire-safety measures.
- Keep the roof away from sources of ignition.
- Inspect the roof regularly.
- Replace damaged or deteriorated sections.
- Use suitable lightning protection where required by the building design.

B. Compressed Earth Block Technology (CEB)



Meaning of compressed earth block technology

Compressed Earth Block (CEB) technology is a building technology that involves compacting a suitable mixture of soil into strong, uniform blocks using a mechanical or manual compression machine.

The blocks are produced by applying pressure to prepared soil placed inside a mould.

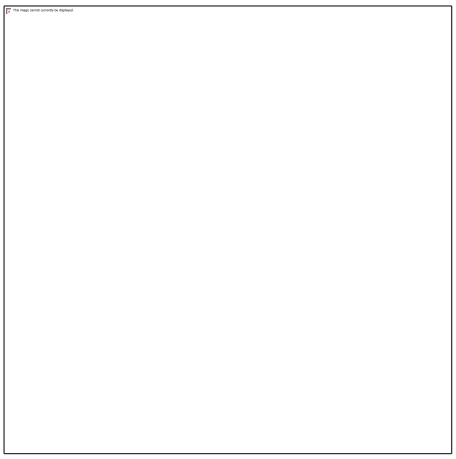
Depending on the intended application, the blocks may be used in their unstabilized or stabilized form.

Stabilized compressed earth blocks contain an added stabilizing material, such as cement or lime, to improve selected properties.

Materials used in manufacturing compressed earth blocks

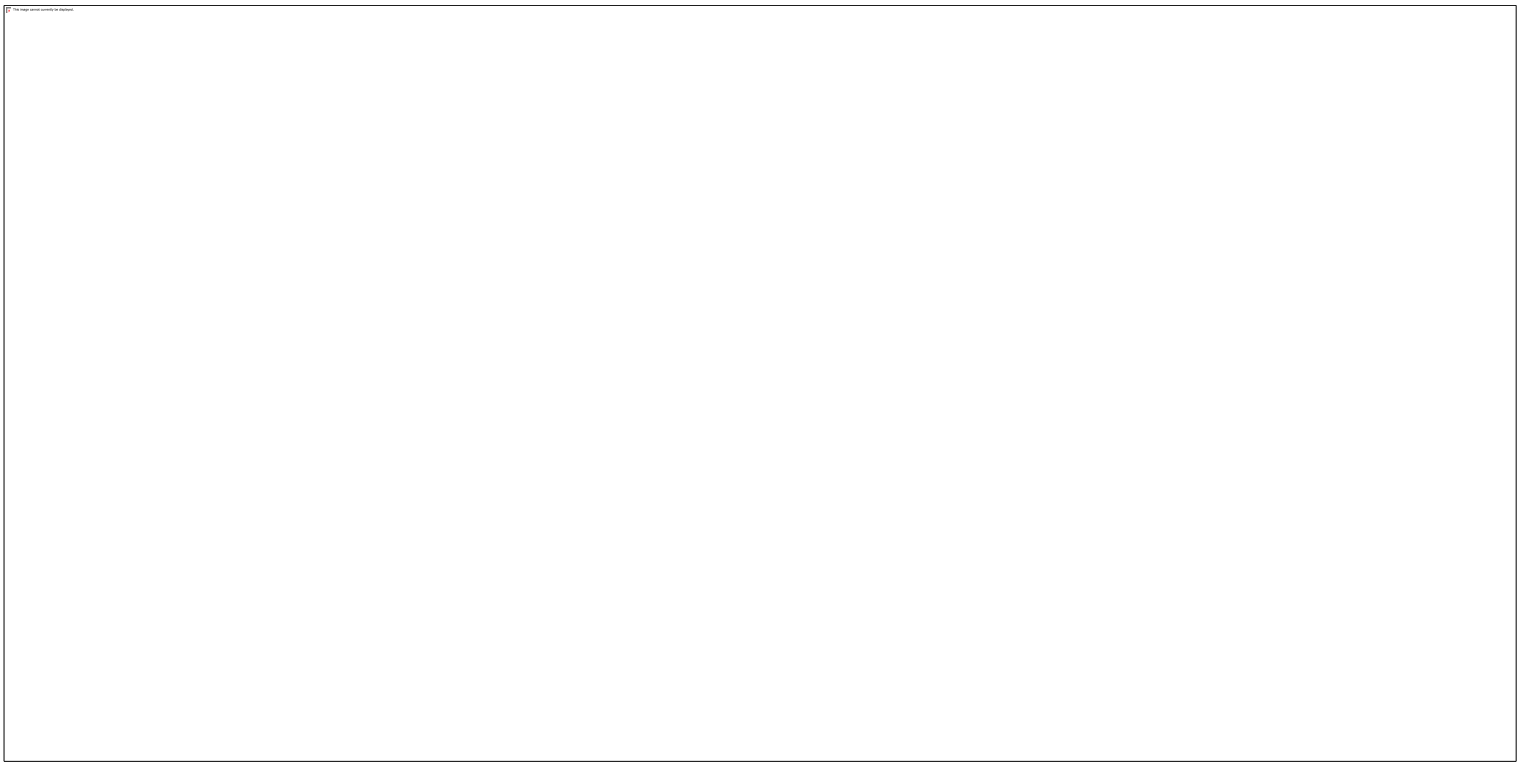
1. **Suitable soil**
   - Soil forms the main component of the blocks.
   - It should contain a suitable combination of sand, silt and clay.
   - The soil should be tested to establish its suitability.
   - Topsoil containing excessive organic matter should generally be avoided.
2. **Water**
   - Water is added to obtain suitable moisture content.
   - It helps the soil particles compact effectively.
   - Excessive water should be avoided because it may affect compaction and block quality.
3. **Cement**
   - Cement may be added as a stabilizer.
   - It improves the strength and water resistance of suitable soil blocks when properly proportioned and cured.
4. **Lime**
   - Lime may be used to stabilize suitable soils.
   - It can improve the engineering properties of some clay-rich soils.
5. **Other approved stabilizers**
   - Other suitable stabilizing materials may be considered following technical testing.

Equipment used in making compressed earth blocks



1. Block-making machine.
2. Soil mixing platform.
3. Shovels.
4. Hoes.
5. Wheelbarrows.
6. Sieves.
7. Measuring containers.
8. Watering cans.
9. Weighing equipment where required.
10. Protective equipment such as gloves, boots and dust masks.

Procedure for manufacturing compressed earth blocks



Step 1: Soil identification and selection

- Identify a suitable source of soil.

- Examine the soil characteristics.
- Avoid soil containing excessive organic matter.
- Carry out appropriate soil tests to establish suitability.

Step 2: Soil excavation

- Excavate soil from an approved source.
- Remove roots, stones and other unsuitable materials.
- Transport the selected soil to the block-making area.

Step 3: Soil sieving

- Pass the soil through an appropriate sieve.
- Remove large particles and unwanted materials.
- Ensure that the soil has a suitable particle size distribution.

Step 4: Measurement and mixing

- Measure the soil and stabilizer according to an established mix design.
- Mix the materials thoroughly.
- Add an appropriate amount of water.
- Ensure uniform distribution of the stabilizer.

Step 5: Filling the mould

- Place the prepared soil mixture into the compression machine.
- Distribute the mixture evenly.
- Avoid overfilling or underfilling the mould.

Step 6: Compression

- Apply pressure using a manual or mechanical block-making machine.
- Compact the mixture into a uniform block.
- Ensure that the block has the required dimensions and shape.

Step 7: Removal of the block

- Carefully remove the compressed block from the machine.
- Place it on a level surface.
- Avoid handling it roughly while it is still fragile.

Step 8: Curing

- Cure stabilized blocks according to the stabilizer manufacturer's instructions and approved specifications.
- Protect blocks from rapid drying, direct exposure and damage during early curing.
- Allow adequate curing time before use.

Step 9: Quality inspection

- Inspect the blocks for cracks and defects.
- Check dimensions and shape.
- Carry out appropriate strength and water-resistance tests.
- Reject blocks that do not meet the specified requirements.

Uses of compressed earth blocks

1. Construction of residential building walls.
2. Construction of classroom blocks.
3. Construction of community halls.
4. Construction of boundary walls.
5. Construction of office buildings.
6. Construction of agricultural structures.
7. Construction of suitable internal partitions.
8. Construction of other low-rise buildings where approved.

Advantages of compressed earth block technology

1. **Reduced material transportation costs:** Soil may be obtained near the construction site.
2. **Reduced use of fired bricks:** Production does not require firing in a kiln.
3. **Energy conservation:** It can reduce energy consumption associated with conventional fired-brick production.
4. **Uniform dimensions:** Machine compression produces blocks with relatively consistent dimensions.
5. **Good thermal performance:** Suitable earth walls can help moderate indoor temperature variations.
6. **Reduced mortar consumption:** Accurate block dimensions may reduce mortar requirements.
7. **Local employment:** Block production creates opportunities for local workers.
8. **Resource efficiency:** Suitable locally available soil can be utilized.
9. **Adaptability:** Blocks can be produced in different shapes and sizes using suitable moulds.
10. **Potential cost savings:** Overall savings may result where suitable soil, equipment and skills are available.

Disadvantages of compressed earth block technology

1. Not all soil types are suitable.
2. Soil testing is necessary.
3. Stabilizers may increase production costs.
4. Poor compaction can produce weak blocks.
5. Improper curing may reduce block strength.
6. Unstabilized blocks may be vulnerable to prolonged water exposure.

7. Production requires suitable equipment.
8. Poor workmanship can result in inconsistent block dimensions.
9. Some designs require additional surface protection.
10. Structural applications require proper engineering design.

Precautions when using compressed earth blocks

- Test the soil before production.
- Use an approved mix proportion.
- Ensure adequate compaction.
- Cure stabilized blocks properly.
- Protect walls against rising damp.
- Provide suitable roof overhangs and rainwater drainage.
- Use appropriate damp-proofing measures.
- Ensure foundations are properly designed.
- Obtain structural approval where required.

C. Rammed Earth Technology







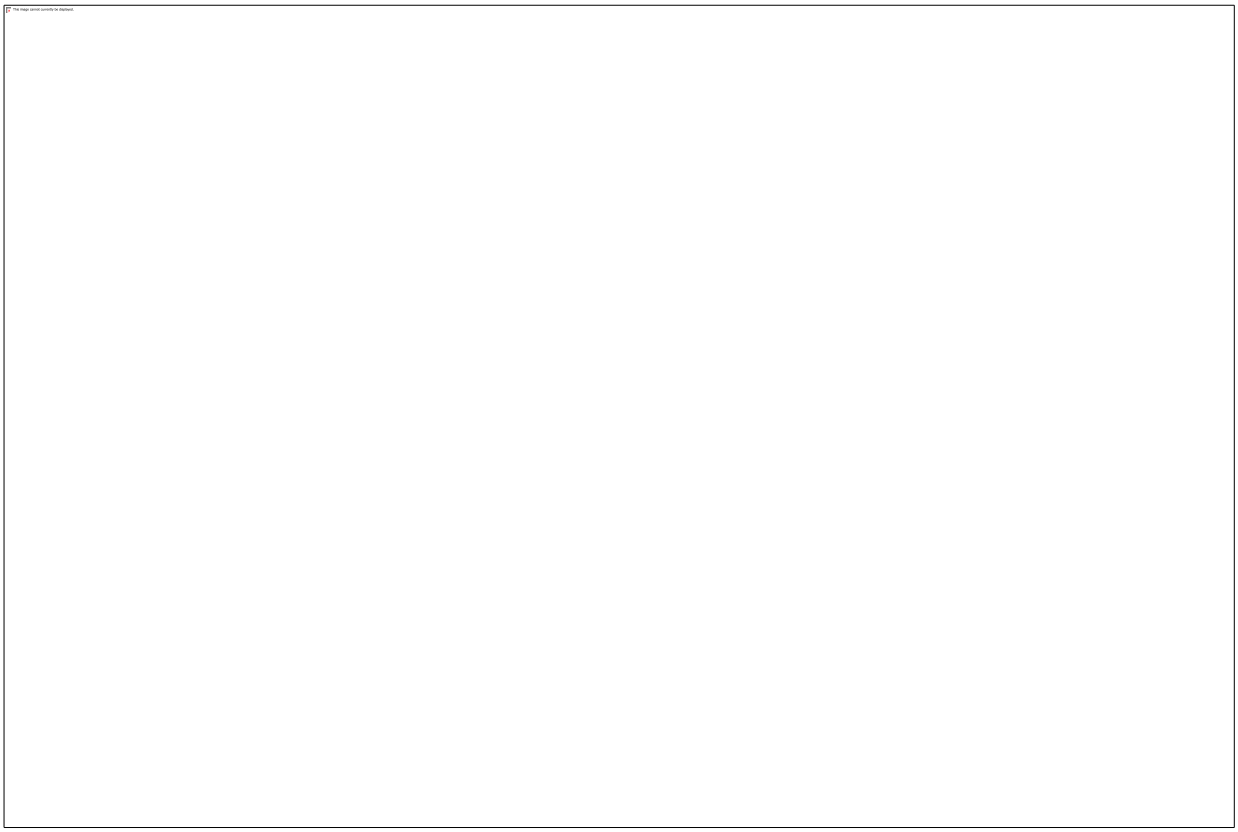
Meaning of rammed earth technology

Rammed earth technology is a building construction method in which a suitable moist soil mixture is placed in temporary formwork and compacted in successive layers to form strong, solid walls.

The soil is compacted using manual or mechanical rammers until the required density and wall strength are achieved.

The formwork is gradually moved or removed as the wall construction progresses.

Rammed earth construction is an ancient building method that continues to be used in modern sustainable architecture.



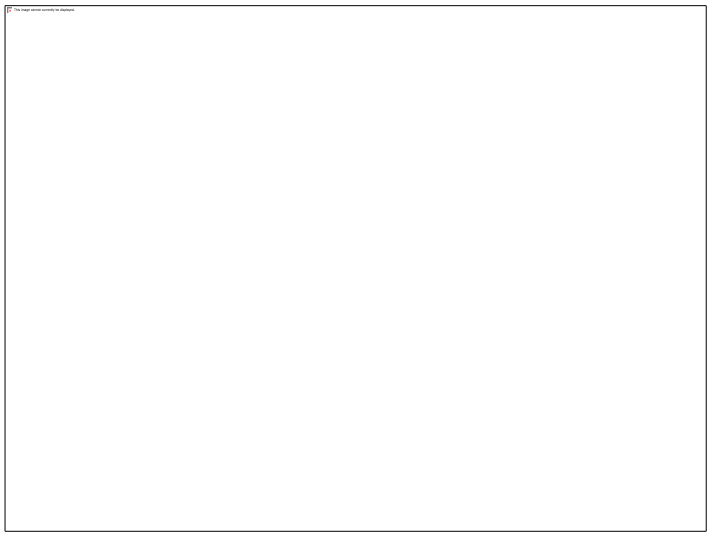
Materials used in rammed earth construction

1. **Soil**

- Forms the main component of the wall.
- Should have suitable particle-size distribution.
- It should be free from excessive organic matter and unsuitable impurities.

2. **Water**
   - Added to achieve suitable moisture content.
   - Helps the soil particles compact effectively.
3. **Cement**
   - May be added as a stabilizer to improve the properties of suitable soil.
4. **Lime**
   - Can be used as a stabilizing material for appropriate soil types.
5. **Formwork materials**
   - Timber, steel or other suitable materials are used to create moulds for the walls.
6. **Reinforcement**
   - Suitable reinforcement may be incorporated where required by the structural design.

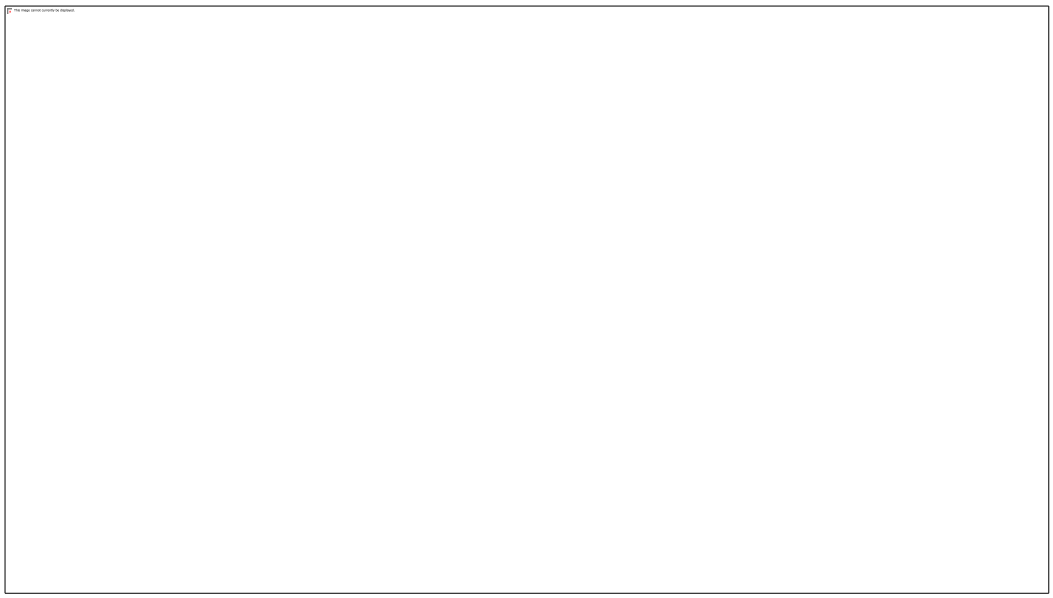
Tools and equipment used



- Shovels.
- Hoes.
- Wheelbarrows.
- Soil sieves.
- Measuring containers.
- Rammers.
- Mechanical compactors.
- Spirit levels.

- Plumb bobs.
- Formwork panels.
- Clamps and supports.
- Protective equipment.

Procedure for constructing rammed earth walls



Step 1: Preparation of the foundation

- Prepare a suitable foundation according to the building design.
- Ensure that the foundation is stable and level.
- Provide suitable damp-proofing and protection against ground moisture.
- The foundation should be designed to support the weight of the earth walls.

Step 2: Selection and preparation of soil

- Select suitable soil.
- Remove roots, organic matter and unsuitable particles.
- Sieve the soil where necessary.
- Test the soil to establish its suitability.

Step 3: Preparation of the soil mixture

- Mix the soil thoroughly.
- Add a suitable amount of water.
- Add stabilizer where required by the design.
- Ensure uniform distribution of the materials.

Step 4: Erection of formwork

- Set up strong and stable formwork.
- Ensure that the formwork has the required wall thickness.
- Secure the formwork against movement during compaction.

- Check the alignment and verticality.

Step 5: Placement of soil

- Place the prepared soil mixture inside the formwork.
- Spread it in relatively thin, uniform layers.
- Avoid placing excessive soil at once.

Step 6: Compaction

- Compact each layer using a hand rammer or mechanical compactor.
- Apply sufficient and uniform compaction.
- Continue until the layer reaches the specified density.
- Repeat the process for subsequent layers.

Step 7: Removal or movement of formwork

- Remove or reposition the formwork carefully at the appropriate stage.
- Avoid damaging the newly formed walls.
- Continue construction until the required wall height is achieved.

Step 8: Curing and protection

- Protect stabilized earth walls during curing.
- Prevent excessive drying and erosion.
- Provide appropriate surface protection where necessary.

Step 9: Finishing

- Inspect the wall for defects.
- Repair minor defects using compatible materials.
- Apply suitable finishes or protective coatings where required.
- Ensure that the wall has the required appearance and performance.

Uses of rammed earth technology

1. Construction of residential houses.
2. Construction of community buildings.
3. Construction of boundary walls.
4. Construction of suitable institutional buildings.
5. Construction of eco-lodges.
6. Construction of landscape walls.
7. Construction of suitable agricultural buildings.
8. Construction of architectural features.

Advantages of rammed earth technology

1. **Use of local soil:** Reduces the need to transport large quantities of conventional building materials.
2. **Reduced waste:** Soil can be used efficiently during construction.
3. **Thermal mass:** Thick earth walls help moderate indoor temperature changes.
4. **Durability:** Properly designed and constructed rammed earth walls can last for many years.
5. **Aesthetic appearance:** Earth walls provide a natural architectural finish.
6. **Reduced industrial processing:** Soil generally requires less processing than many manufactured building products.
7. **Environmental benefits:** It can reduce the demand for energy-intensive materials.
8. **Low maintenance potential:** Well-protected walls may require relatively little maintenance.
9. **Fire resistance:** Earth itself is non-combustible.
10. **Architectural flexibility:** Different textures and colours can be achieved using suitable soils.

Disadvantages of rammed earth technology

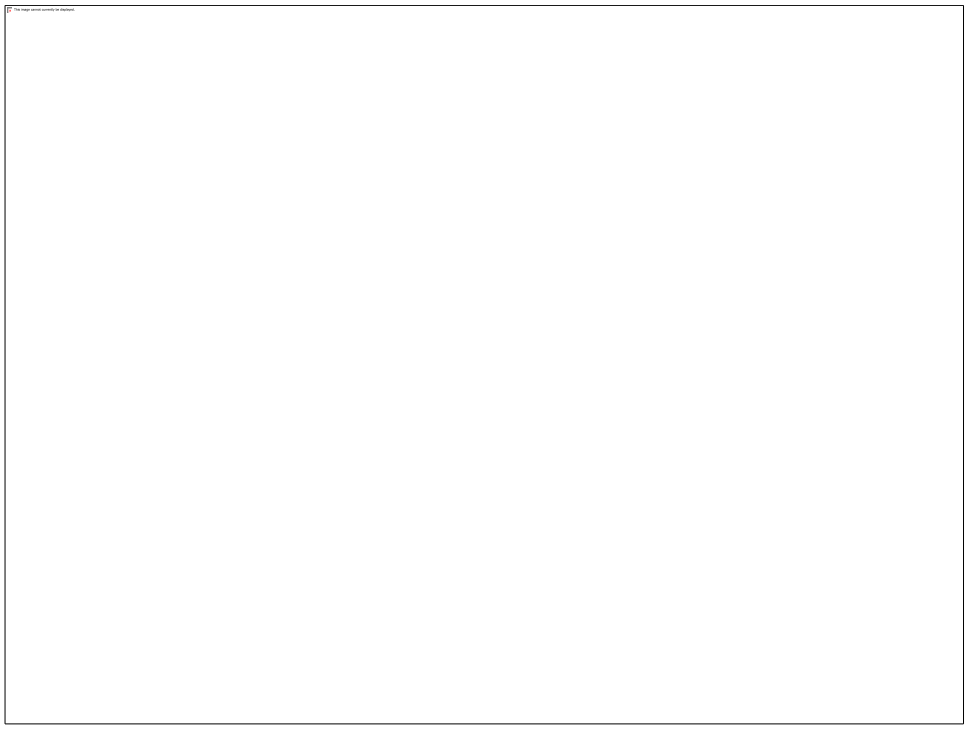
1. Requires suitable soil.
2. Poor-quality soil can produce weak walls.
3. Construction may be labour-intensive.
4. Strong formwork is required.
5. Construction can be affected by heavy rainfall.
6. Poorly protected walls may suffer erosion.
7. Openings for doors and windows require careful planning.
8. Additional structural measures may be necessary in areas with significant seismic or other lateral loading.
9. Skilled workmanship is required.
10. Transporting soil to the construction site may increase costs where suitable soil is unavailable locally.

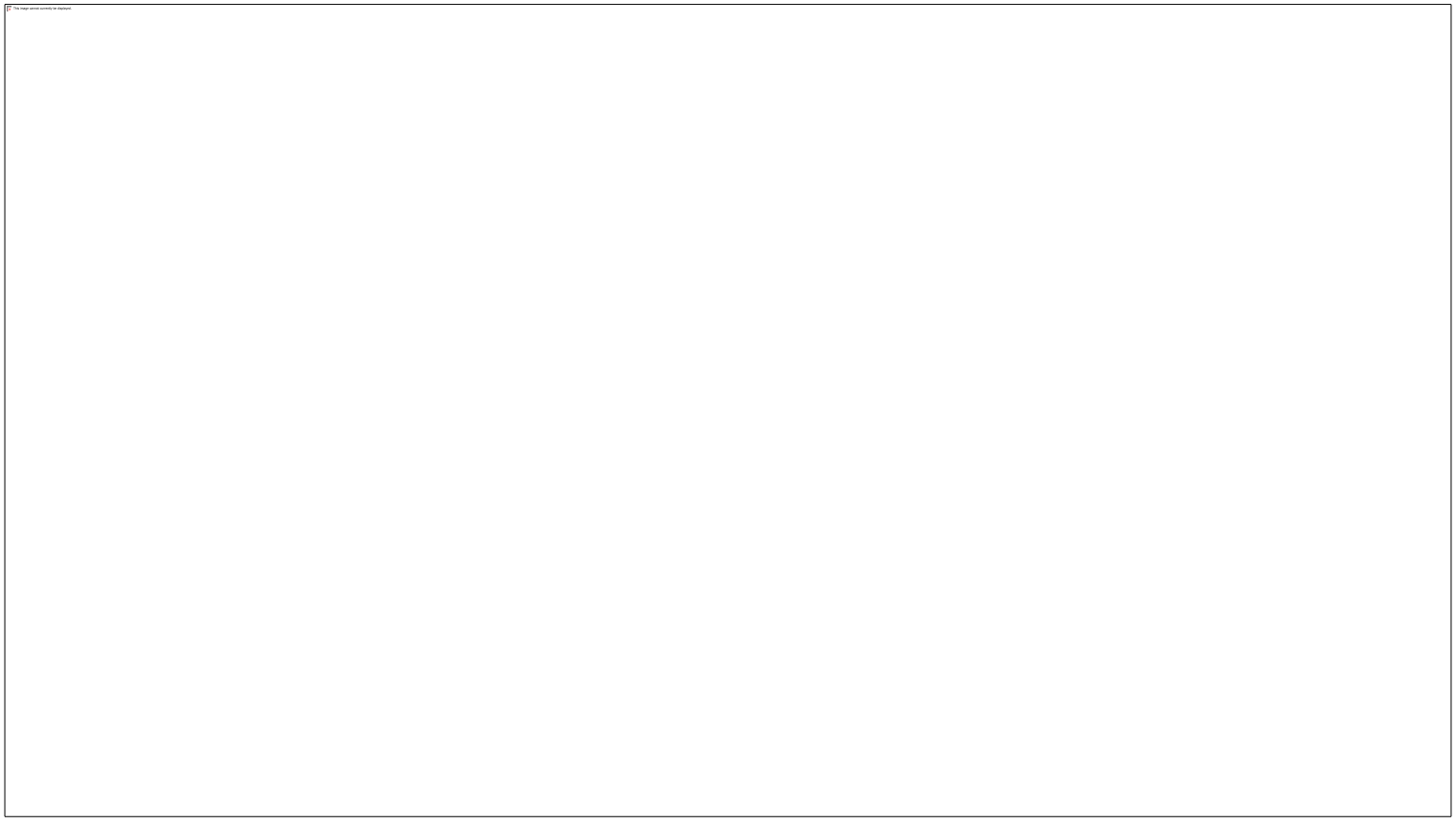
Precautions when using rammed earth technology

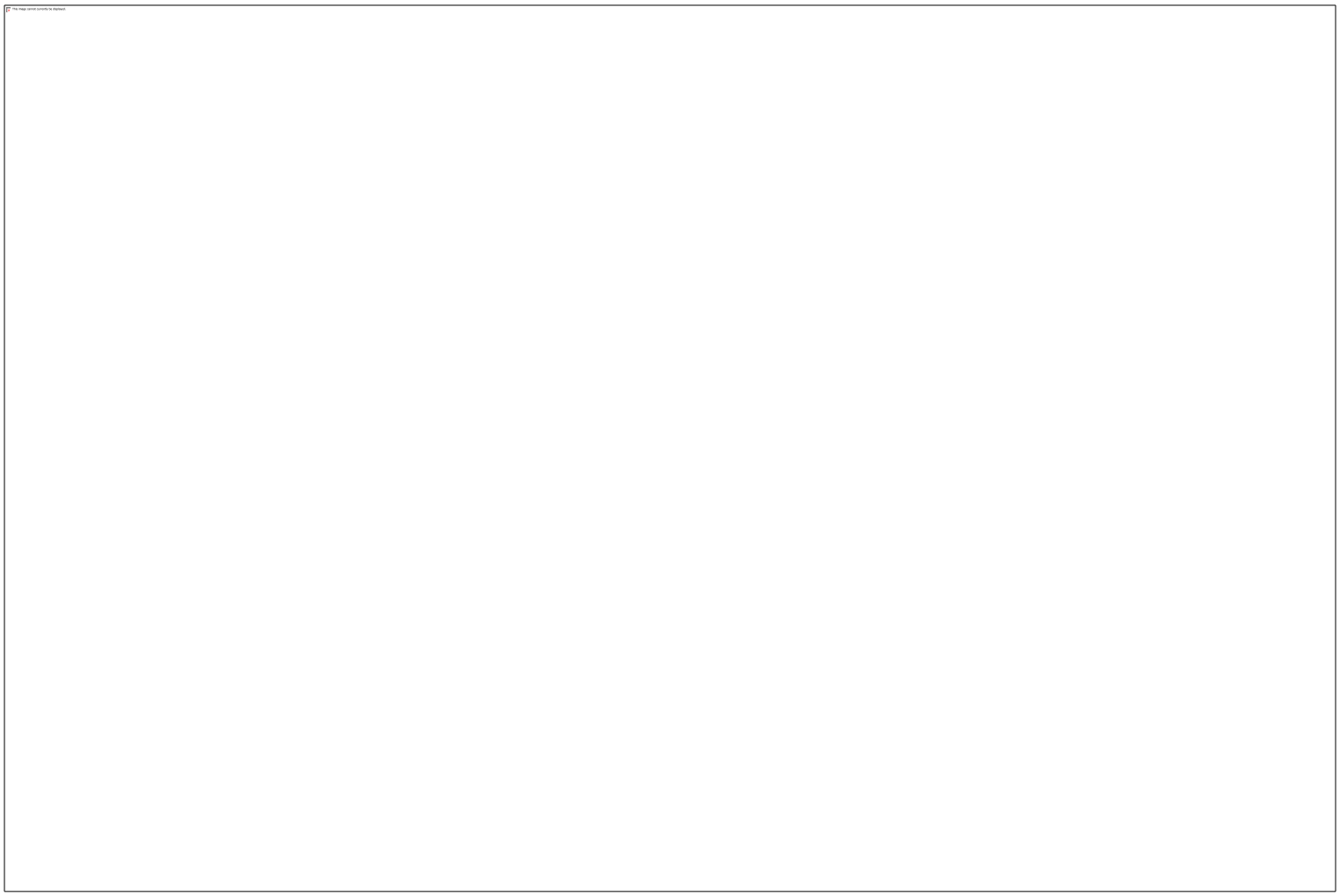
- Conduct soil suitability tests.
- Provide strong formwork.
- Compact the soil uniformly.
- Construct adequate foundations.
- Protect walls against moisture.
- Provide suitable roof overhangs.
- Ensure proper drainage around the building.
- Follow the approved structural design.
- Provide suitable lintels over openings.

- Inspect walls for cracks and defects.

D. Bamboo Technology







Meaning of bamboo technology

Bamboo technology in building construction refers to the use of bamboo culms and processed bamboo products as building materials for constructing structural and non-structural building components.

Bamboo is a fast-growing grass with a hollow or solid stem, depending on the species. It has been used in construction for many years because of its relatively high strength-to-weight ratio and versatility.

In appropriate conditions, bamboo can be used for roof structures, wall panels, flooring, partitions, ceilings and other building components.

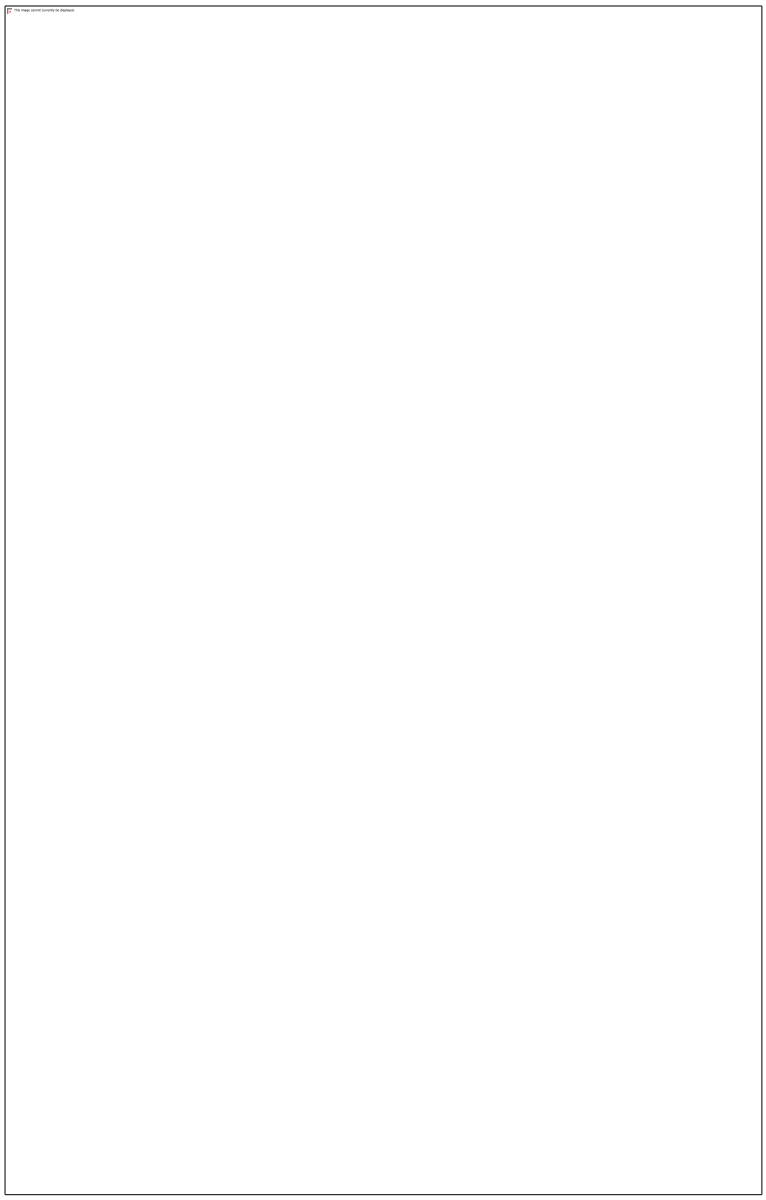
Characteristics of bamboo as a building material

1. It is lightweight.
2. It grows relatively quickly compared with many timber species.
3. It has a high strength-to-weight ratio.
4. It is flexible.
5. It can be cut and shaped using suitable tools.
6. It can be used in different architectural designs.
7. It is renewable when sustainably harvested.
8. It has a natural appearance.
9. It is available in different species and dimensions.
10. It requires appropriate treatment and protection before construction use.

Materials used in bamboo construction

1. **Bamboo poles**
   - Used for columns, beams, rafters and frames where suitably designed.
2. **Split bamboo**
   - Used for wall panels, screens, ceilings and decorative finishes.
3. **Bamboo boards**
   - Manufactured from processed bamboo.
   - Used for flooring, furniture and interior finishes.
4. **Binding materials**
   - Used for connecting and securing bamboo components.
5. **Bolts and screws**
   - Used in suitable mechanical joints.
6. **Protective treatments**
   - Used to reduce damage caused by insects, fungi and moisture.
7. **Concrete and steel**
   - May be used in foundations, supports and connections depending on the building design.

Tools and equipment used in bamboo construction



- Hand saws.
- Measuring tapes.
- Drilling machines.
- Hammers.
- Chisels.
- Knives and machetes.
- Clamps.
- Spanners.
- Bolts and fastening tools.
- Protective equipment.

Procedure for constructing using bamboo technology

Step 1: Selection of bamboo

- Select mature bamboo of suitable species.
- Avoid damaged, cracked or decayed poles.
- Choose poles with suitable dimensions for the intended use.

Step 2: Harvesting

- Harvest bamboo responsibly.
- Avoid damaging the entire bamboo clump.
- Use appropriate harvesting methods.

Step 3: Treatment

- Treat bamboo using suitable preservation methods.
- Reduce the risk of insect attack and fungal deterioration.
- Allow treated bamboo to dry appropriately.

Step 4: Preparation

- Measure and cut the bamboo to the required lengths.
- Remove unwanted branches.
- Smooth rough surfaces where necessary.

Step 5: Preparation of connections

- Prepare suitable joints and connections.
- Use appropriate bolts, screws, clamps or other designed connectors.
- Avoid weak connections that may split the bamboo.

Step 6: Assembly

- Assemble the bamboo framework according to the structural design.
- Position columns, beams and roof members.
- Check alignment and stability.

Step 7: Installation of other components

- Fix suitable wall panels, roofing materials, floors and partitions.
- Ensure that the components are securely connected.

Step 8: Finishing and inspection

- Apply suitable protective coatings where necessary.
- Inspect joints and structural members.
- Check stability and workmanship.
- Ensure that the building complies with applicable requirements.

Uses of bamboo technology

1. Construction of lightweight houses.

2. Construction of roof trusses.
3. Construction of columns and beams where structurally approved.
4. Construction of temporary shelters.
5. Construction of verandas and gazebos.
6. Construction of partition walls.
7. Construction of ceilings.
8. Construction of flooring using suitable processed products.
9. Construction of bridges designed for the expected loads.
10. Construction of furniture and decorative features.

Advantages of bamboo technology

1. **Renewable resource:** Bamboo can regenerate relatively quickly.
2. **Lightweight:** It is easier to transport and handle than many conventional materials.
3. **High strength-to-weight ratio:** Suitable species can support significant loads when correctly designed.
4. **Employment creation:** It creates opportunities in cultivation, harvesting, treatment and construction.
5. **Environmental benefits:** Sustainable bamboo production can reduce pressure on some timber resources.
6. **Flexibility:** Bamboo can be used in different architectural forms.
7. **Ease of handling:** It can be cut and shaped using suitable tools.
8. **Aesthetic value:** It provides an attractive natural appearance.
9. **Construction versatility:** It can be used in both structural and decorative applications.
10. **Potential cost savings:** Locally cultivated bamboo can reduce material transportation costs.

Disadvantages of bamboo technology

1. Untreated bamboo is vulnerable to insect attack.
2. Moisture can cause fungal deterioration.
3. Poorly designed joints may fail.
4. Bamboo can split during cutting and fastening.
5. Quality and dimensions may vary between poles.
6. Some species may be difficult to obtain.
7. Fire protection requires consideration.
8. Regular inspection and maintenance may be necessary.
9. Structural design requires appropriate technical knowledge.
10. It may require additional protection from ground moisture and direct weather exposure.

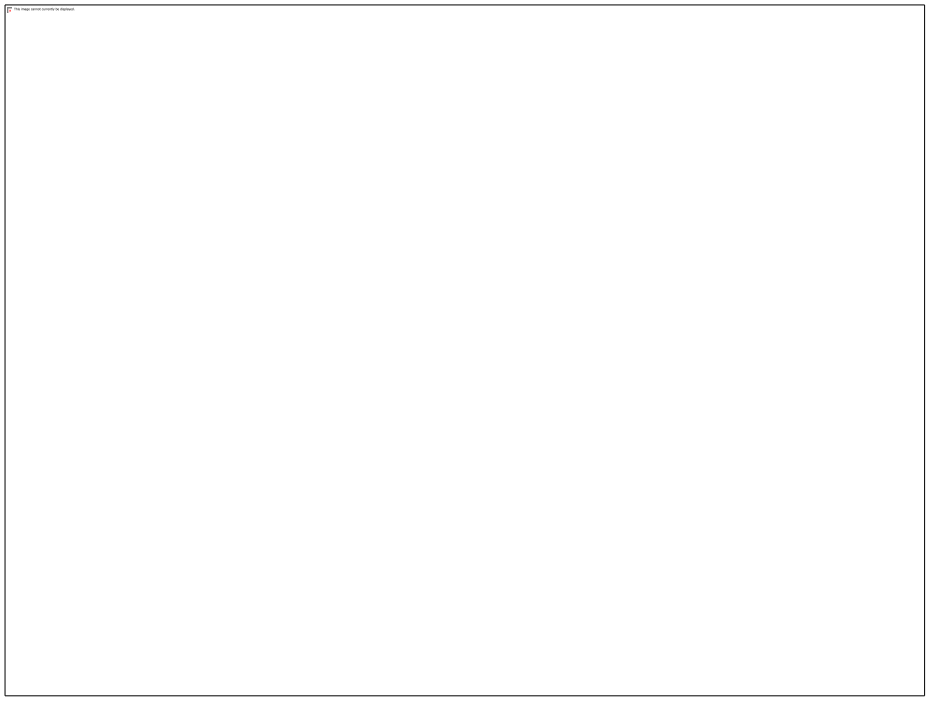
Precautions when using bamboo

- Select mature and suitable bamboo species.
- Use approved preservation treatments.
- Protect bamboo from prolonged contact with soil and moisture.
- Provide suitable roof protection.
- Use properly designed joints.
- Avoid overloading bamboo members.
- Inspect structural members regularly.
- Provide appropriate fire-safety measures.
- Ensure that structural applications are approved by competent professionals.

E. Interlocking Stabilized Soil Block Technology (ISSB)







Meaning of interlocking stabilized soil block technology

Interlocking Stabilized Soil Block (ISSB) technology is a building technology that involves manufacturing blocks from suitable soil mixed with a stabilizing material, such as cement or lime, and compressing the mixture into specially shaped blocks with interlocking features.

The blocks are designed with projections and recesses that fit into one another during wall construction.

The interlocking design helps maintain alignment and reduces the quantity of conventional mortar required between blocks, depending on the system used.

Important distinction: Interlocking stabilized soil blocks are a specialized type of compressed earth block. Their distinguishing feature is the interlocking shape that enables blocks to fit together.

Materials used in ISSB production

1. **Soil**
    - Forms the main component.
    - Should have suitable grading and properties.
2. **Cement**
    - Commonly used as a stabilizer.
    - Helps improve strength and resistance to moisture.
3. **Lime**
    - May be used as a stabilizer where suitable.
4. **Water**
    - Used to achieve the required moisture content for compaction.
5. **Other approved stabilizers**
    - May be used depending on the soil type and approved design.

Equipment used



- Interlocking block-making machine.
- Soil sieve.
- Shovels.

- Hoes.
- Wheelbarrows.
- Measuring containers.
- Mixing platform.
- Watering equipment.
- Protective equipment.

Types of interlocking blocks

1. **Single-interlocking blocks**
   - Have interlocking features on one or more surfaces.
   - Help maintain alignment between adjacent blocks.
2. **Double-interlocking blocks**
   - Have additional interlocking features.
   - Can provide more secure positioning depending on the block design.
3. **Corner blocks**
   - Designed for forming corners.
   - Help maintain proper wall alignment.
4. **Half blocks**
   - Used where shorter block lengths are required.
   - Reduce unnecessary cutting and wastage.
5. **Lintel blocks**
   - Specially shaped blocks used in suitable lintel systems.
   - Their use depends on the structural design.

Procedure for manufacturing ISSB

1. Select suitable soil.
2. Remove organic matter and unwanted materials.
3. Sieve the soil.
4. Measure the soil and stabilizer.
5. Mix the materials thoroughly.
6. Add the required quantity of water.
7. Place the mixture in the special interlocking mould.
8. Compress the mixture using the block-making machine.
9. Remove the block carefully.
10. Cure the blocks according to the specified requirements.
11. Test the blocks for strength and quality.

12. Store the blocks safely before construction.

Procedure for constructing walls using ISSB



1. Prepare a suitable foundation.
2. Ensure that the foundation is level and stable.
3. Provide appropriate damp-proofing.
4. Mark the wall positions.
5. Lay the first course accurately.
6. Fit subsequent blocks into the interlocking features.
7. Check alignment using a spirit level.
8. Maintain verticality using a plumb bob.
9. Provide openings for doors and windows.
10. Install suitable lintels and reinforcement where required.
11. Construct the wall to the approved height.
12. Complete the required finishes and protective treatments.

Uses of ISSB technology

- Residential houses.
- School classrooms.
- Community centres.
- Office buildings.
- Boundary walls.
- Agricultural buildings.
- Suitable institutional buildings.
- Other approved low-rise structures.

Advantages of ISSB technology

1. **Reduced mortar consumption:** Interlocking features reduce the need for conventional mortar in suitable systems.
2. **Fast construction:** Blocks can be assembled efficiently when properly manufactured.
3. **Uniform dimensions:** Machine production improves dimensional consistency.
4. **Cost efficiency:** Reduced mortar and local material use can lower construction costs.
5. **Environmental conservation:** It can reduce demand for fired bricks.
6. **Thermal performance:** Earth-based walls can help moderate indoor temperatures.
7. **Reduced material wastage:** Interlocking arrangements reduce unnecessary cutting.
8. **Local employment:** Manufacturing creates opportunities for local workers.
9. **Good appearance:** Blocks can provide an attractive natural finish.
10. **Adaptability:** Different block shapes can be manufactured for different construction requirements.

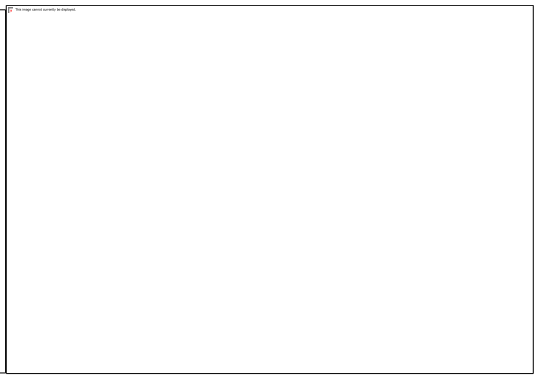
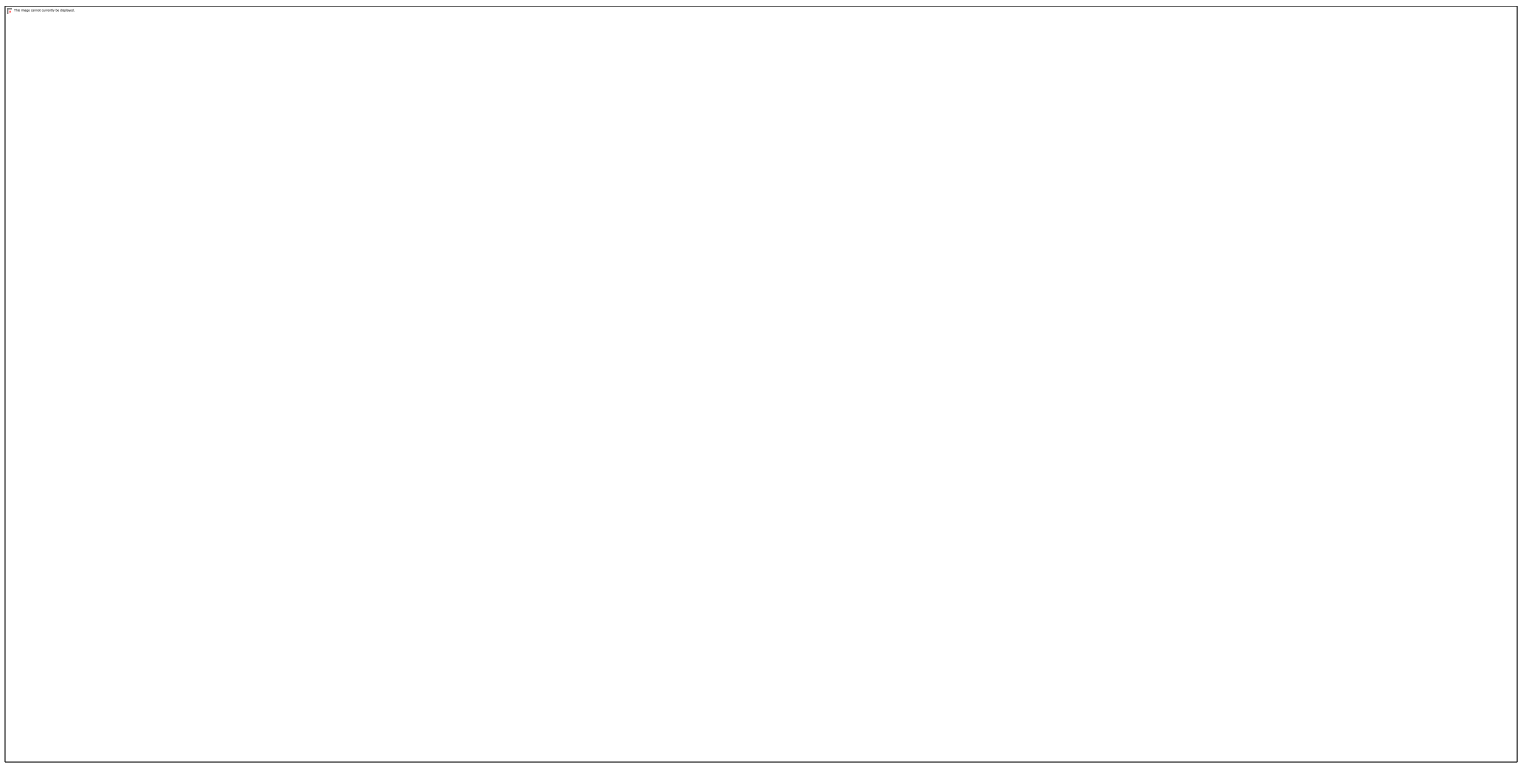
Disadvantages of ISSB technology

1. Requires suitable soil.
2. Production machines may be expensive.
3. Poorly manufactured blocks may not interlock correctly.
4. Soil testing is necessary.
5. Stabilizers increase production costs.
6. Poor curing may affect block strength.
7. Blocks may require protective finishes.
8. Not all block designs are suitable for every structural application.
9. Skilled workmanship is required.
10. Quality control is necessary during production and construction.

Precautions when using ISSB

- Use suitable soil.
- Maintain accurate mix proportions.
- Ensure proper compression.
- Cure blocks adequately.
- Check interlocking dimensions.
- Prepare a level foundation.
- Protect walls against moisture.
- Follow approved structural designs.
- Use suitable lintels and reinforcement.
- Carry out quality inspection.

F. Recycled Waste Materials Technology

Meaning of recycled waste materials technology

Recycled waste materials technology in building construction refers to the process of recovering, processing and reusing suitable discarded materials to manufacture new construction products or form components of buildings.

This technology aims to reduce the quantity of waste sent to disposal sites while conserving natural resources and reducing the environmental impact of construction.

It is an important part of sustainable construction and the circular economy.

Types of recycled waste materials used in construction

1. Recycled plastic

- Obtained from discarded plastic bottles, containers and other plastic products.
- Can be processed into suitable construction products.
- Some plastic products are used to manufacture paving units, panels and construction blocks.

2. Recycled glass

- Obtained from discarded glass bottles, windows and containers.
- Can be processed into suitable glass products.
- Crushed glass may be used as an aggregate in approved applications.
- Glass products can also be used in decorative finishes.

3. Reclaimed timber

- Obtained from demolished buildings, old furniture and discarded wooden structures.
- Can be reused in flooring, roofing, furniture and decorative finishes.
- It should be inspected for rot, insects and structural defects.

4. Recycled metals

- Obtained from discarded steel, aluminium and other metal products.
- Can be processed and reused in suitable construction components.
- Examples include metal roofing products, fittings and reinforcement products meeting the required standards.

5. Recycled rubber

- Obtained from discarded vehicle tyres and rubber products.
- Can be processed into suitable flooring, mats and other construction products.
- It may also be used in specialized paving applications.

6. Recycled concrete

- Obtained from demolished concrete structures.
- Can be crushed and processed into recycled aggregates.
- Suitable recycled aggregates may be used in approved construction applications.

7. Agricultural waste

Examples include:

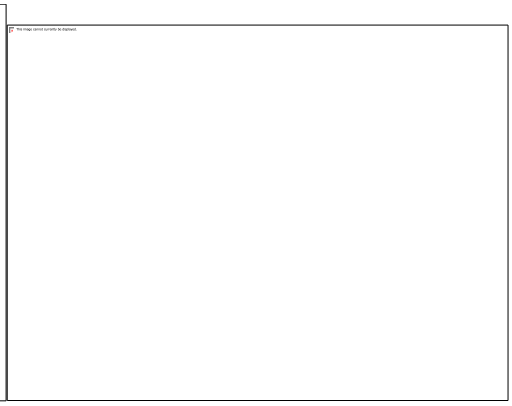
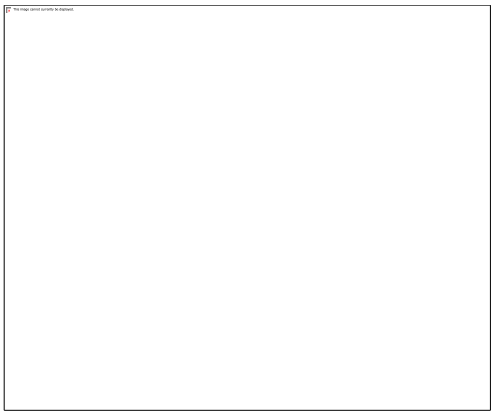
- Rice husks.
- Coconut fibres.
- Sisal fibres.
- Bagasse from sugarcane processing.
- Sawdust.

These materials may be used in suitable panels, insulation products, boards and other manufactured building components after appropriate processing and testing.

Methods of using recycled waste materials

1. **Reuse:** Using recovered materials again without major processing.
2. **Recycling:** Processing waste into new construction products.
3. **Crushing:** Breaking materials such as concrete and glass into smaller particles.
4. **Melting and remoulding:** Processing suitable plastics and metals into new products.
5. **Composite production:** Combining recycled materials with other substances to manufacture new products.
6. **Shredding:** Cutting waste into smaller pieces for use in approved applications.

Examples of structures constructed using recycled materials

1. Eco-friendly houses.
2. Recycled plastic paving structures.

3. Garden shelters.
4. Community environmental centres.
5. Interior partitions.
6. Reclaimed timber buildings.
7. Suitable decorative wall structures.
8. Landscaping features.
9. Suitable pedestrian walkways.
10. Non-structural architectural features.

Procedure for constructing using recycled materials

Step 1: Identification of suitable waste

- Identify waste materials that can be safely reused.
- Separate materials according to type.
- Avoid contaminated and hazardous waste.

Step 2: Collection

- Collect waste from approved sources.
- Transport it safely to the processing area.
- Ensure that materials are not mixed unnecessarily.

Step 3: Sorting

- Separate plastics, glass, metals, timber and other waste.
- Remove unsuitable materials.
- Identify materials that require special treatment.

Step 4: Cleaning

- Remove dirt and unwanted substances.
- Wash materials where appropriate.
- Dry materials before processing where necessary.

Step 5: Processing

- Crush, cut, shred, melt or otherwise process materials as required.
- Use suitable equipment.
- Observe safety precautions during processing.

Step 6: Manufacturing

- Convert the processed materials into suitable building products.
- Follow the approved manufacturing procedure.
- Maintain quality control.

Step 7: Testing

- Test the products for strength, durability, fire behaviour and other relevant properties.
- Confirm that the products are suitable for their intended use.

Step 8: Construction

- Use the recycled products in the appropriate building components.
- Follow approved construction procedures.
- Ensure that the final structure meets the required standards.

Advantages of recycled waste materials technology

1. **Reduces environmental pollution:** It reduces the amount of waste disposed of in the environment.
2. **Conserves natural resources:** It reduces demand for virgin raw materials.
3. **Reduces construction costs:** Suitable recovered materials may reduce material expenses.
4. **Creates employment:** Recycling and manufacturing create income-generating opportunities.
5. **Promotes innovation:** Encourages development of new construction products.
6. **Reduces landfill waste:** Diverts suitable waste from disposal sites.
7. **Supports sustainable construction:** Encourages efficient use of resources.
8. **Promotes environmental awareness:** Encourages communities to manage waste responsibly.
9. **Encourages entrepreneurship:** Creates business opportunities in recycling and building-product manufacturing.
10. **Supports the circular economy:** Materials remain useful for longer instead of being discarded.

Disadvantages of recycled waste materials technology

1. Some waste materials may contain harmful substances.
2. Sorting and processing may require additional equipment.
3. Product quality may vary.
4. Some recycled products may have limited structural applications.
5. Cleaning and processing can increase costs.
6. Some plastics and composites may present fire-related challenges.
7. Contaminated materials may pose health risks.
8. Testing and certification may be necessary.
9. Public acceptance may be limited.
10. Reliable collection and supply systems may be difficult to establish.

Precautions when using recycled materials

- Use materials from reliable sources.

- Separate hazardous and non-hazardous waste.
- Clean and process materials appropriately.
- Test products before construction use.
- Avoid using unapproved waste in structural components.
- Observe fire-safety requirements.
- Use suitable protective equipment during processing.
- Ensure that recycled products comply with relevant standards.

BRICKS AND BRICKWORK

A **brick** is a rectangular building material manufactured from clay, shale, concrete or other suitable materials and shaped into standard sizes for use in construction.

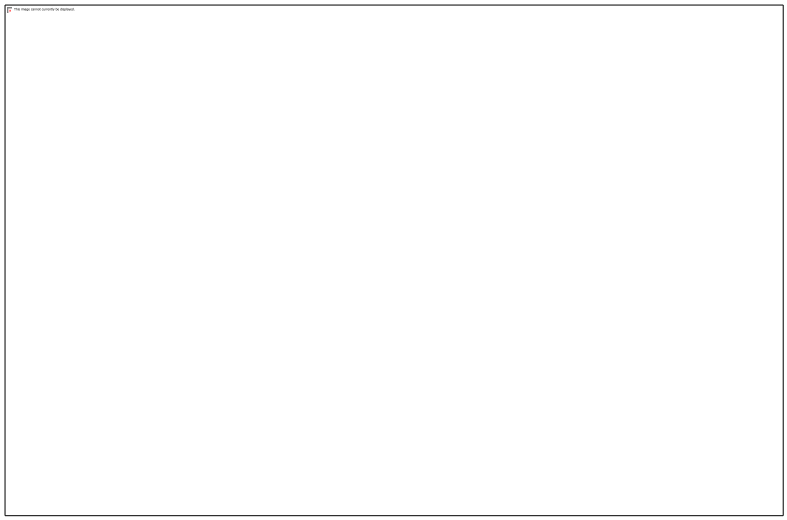
Bricks are commonly used in building walls, partitions, foundations, pavements and other structural components.

1.1 Raw Materials Used in Making Bricks

1. **Clay** – Provides the main material for manufacturing clay bricks.
2. **Sand** – Reduces shrinkage and cracking during drying.
3. **Water** – Makes clay workable during moulding.
4. **Shale** – Provides materials for manufacturing certain types of bricks.
5. **Cement** – Used in the manufacture of concrete bricks.
6. **Lime** – Used in some types of brick production.

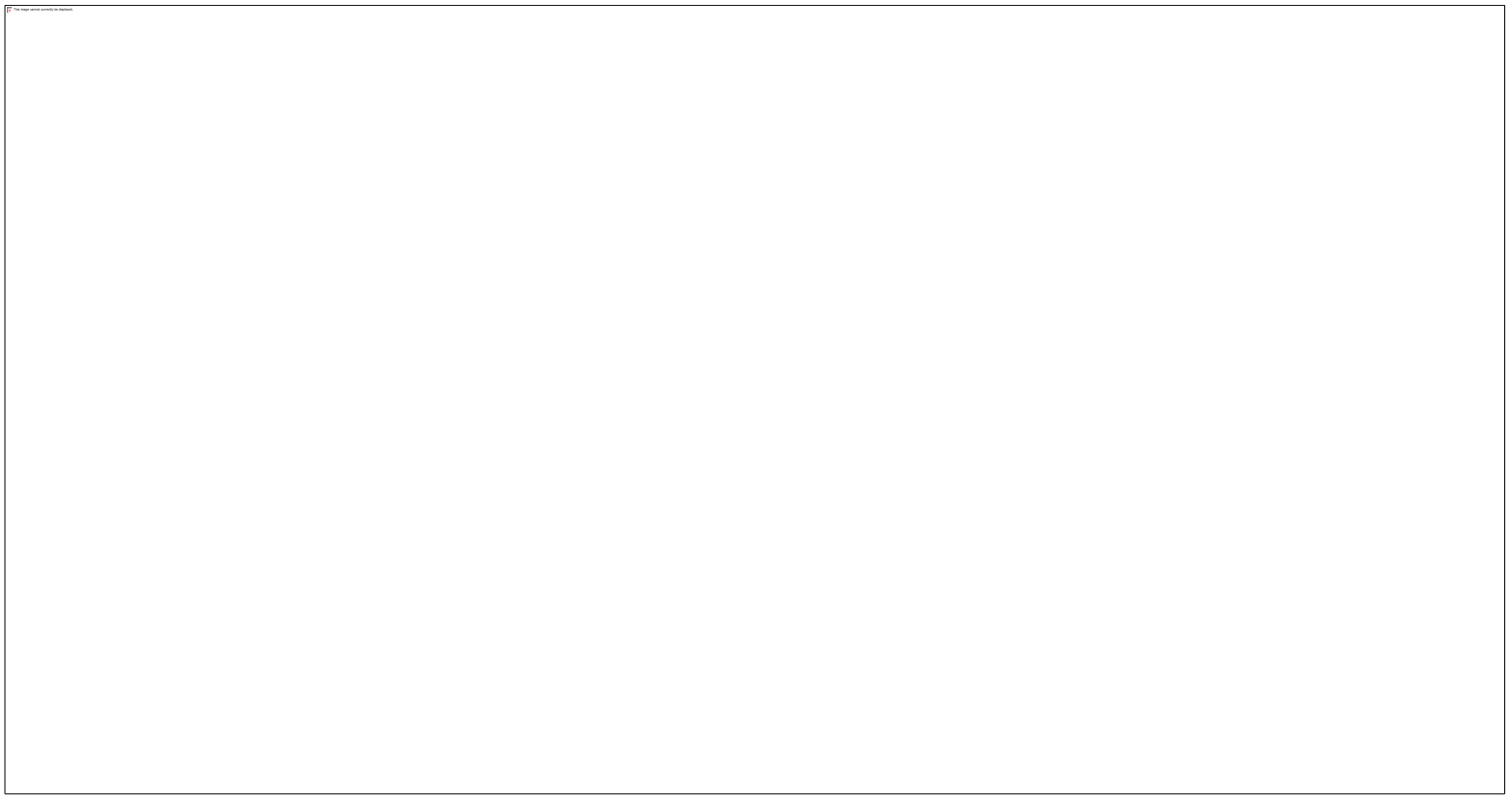
1.2 Types of Bricks

1. Burnt clay bricks



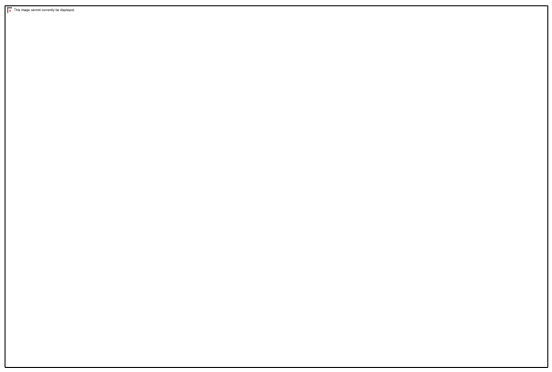
- Manufactured from clay.
- Dried and fired in a kiln.
- Strong and durable.
- Commonly used in wall construction.

2. Concrete bricks



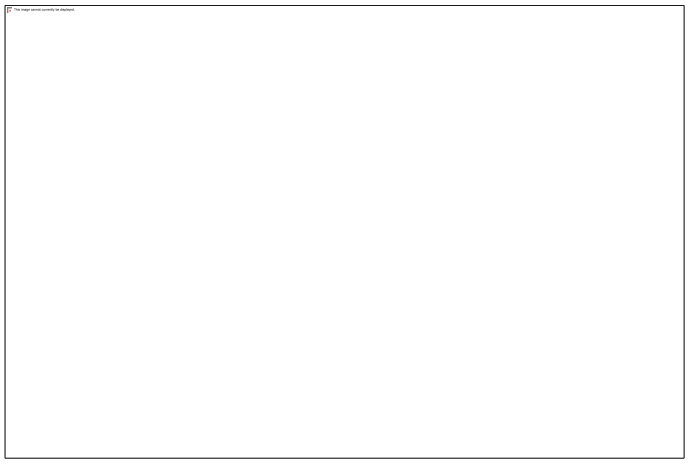
- Made from cement, sand, aggregates and water.
- Manufactured by moulding and compacting concrete.
- Available in different sizes and shapes.
- Used in walls and other construction works.

3. Engineering bricks



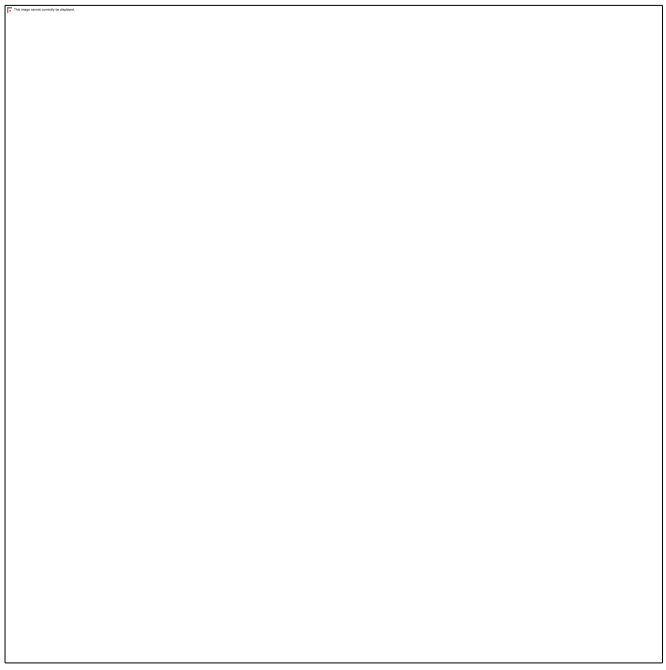
- Manufactured to achieve high strength and low water absorption.
- Suitable for demanding construction conditions.
- Used in foundations, retaining walls and areas exposed to moisture.

4. Facing bricks



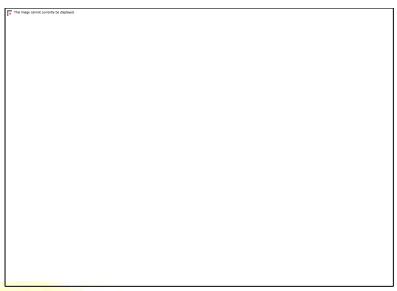
- Have an attractive appearance.
- Used on exposed wall surfaces.
- Available in different colours and textures.

5. Perforated bricks



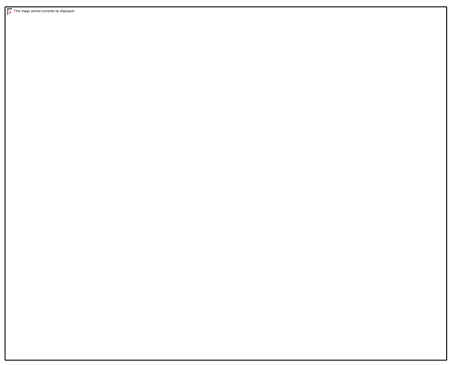
- Have holes passing through their bodies.
- Are relatively lighter than solid bricks of similar dimensions.
- Can provide improved thermal performance depending on their design.

6. Hollow bricks



- Have large cavities inside them.
- Reduce the overall weight of masonry.
- May improve insulation.

7. Fire bricks



- Manufactured to withstand high temperatures.
- Used in fireplaces, furnaces and kilns.

1.3 Methods of Manufacturing Clay Bricks

The manufacture of clay bricks involves the following stages:

1. Winning and preparation of clay

- Clay is obtained from suitable deposits.
- Stones and unwanted materials are removed.
- The clay is crushed and mixed to obtain uniform consistency.

2. Tempering

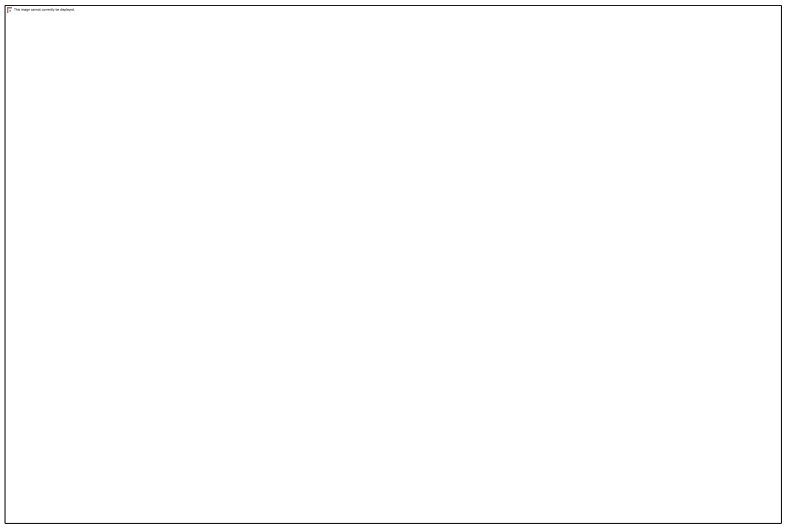
- Water is added to the clay.
- The clay is mixed thoroughly to make it plastic and workable.

3. Moulding



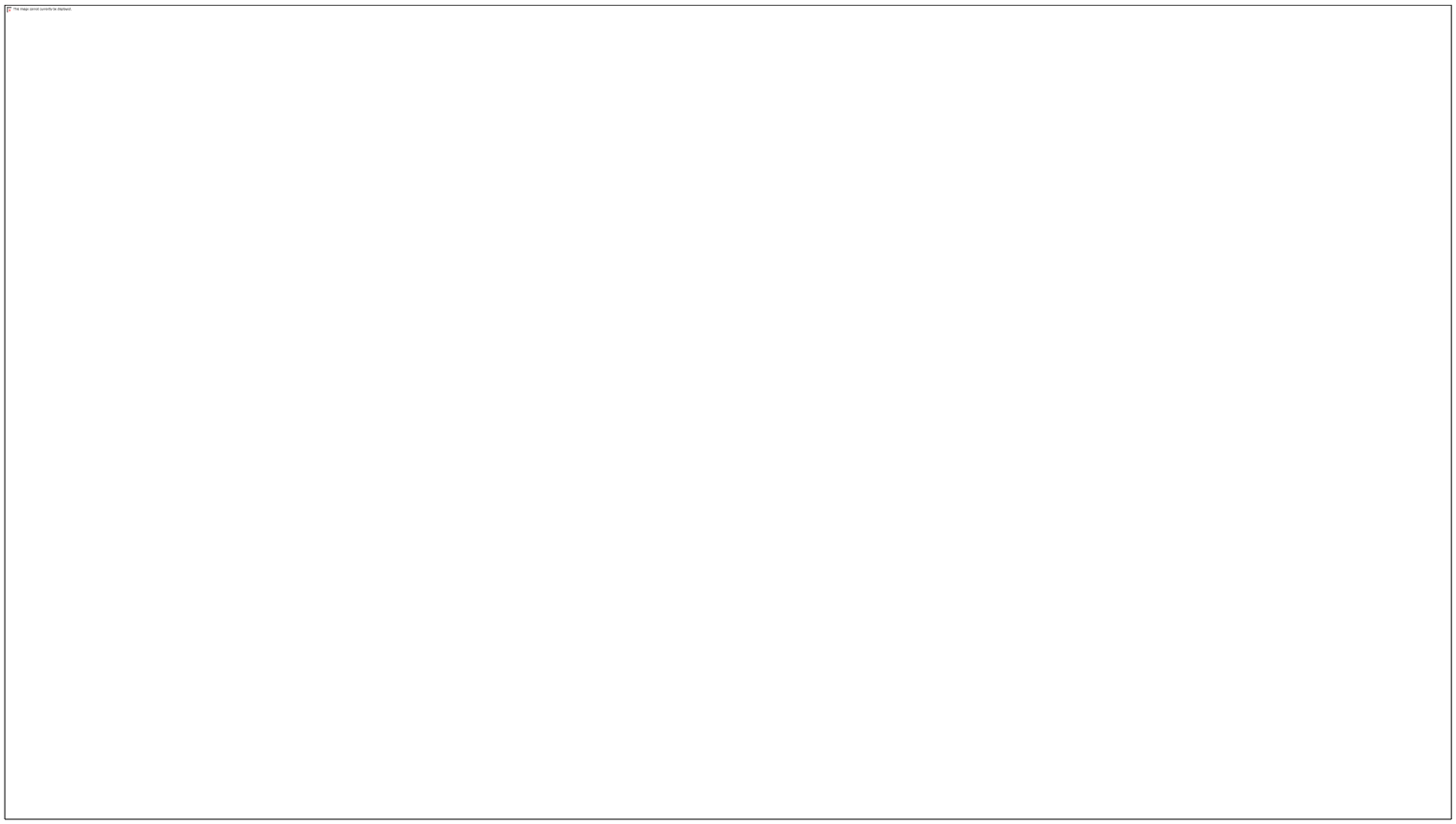
- Clay is shaped into the required brick dimensions.
- Moulding can be done manually or mechanically.

4. Drying



- The moulded bricks are dried to remove excess moisture.
- Drying helps prevent cracking during firing.

5. Burning or firing



- Dried bricks are heated in a kiln.
- Firing develops strength and durability.
- The firing temperature depends on the clay and manufacturing process.

6. Cooling and sorting

- Fired bricks are allowed to cool.

- They are inspected for defects.
- Suitable bricks are selected and stored for use.

1.4 Characteristics of Good Quality Bricks

A good quality brick should:

1. Have a uniform shape and size.
2. Have straight and sharp edges.
3. Be properly burnt.
4. Have a uniform colour.
5. Be free from cracks and major defects.
6. Have sufficient compressive strength.
7. Have low and controlled water absorption.
8. Produce a clear ringing sound when struck lightly against another brick.
9. Be durable under the intended exposure conditions.
10. Have a relatively uniform texture.

1.5 Tests Carried Out on Bricks

1. Visual inspection test

- Examines the colour, shape, size and general appearance.
- Helps identify cracks and visible defects.

2. Soundness test

- Two bricks are struck lightly against each other.
- A good, well-fired brick generally produces a clear ringing sound.

3. Water absorption test

- A brick is weighed dry.
- It is immersed in water for a specified period.
- It is removed, surface water wiped off and weighed again.
- The increase in mass is used to calculate water absorption.

Water absorption=Wet mass-Dry massDry mass×100Water absorption=Dry massWet mass-Dry mass×100

4. Compressive strength test



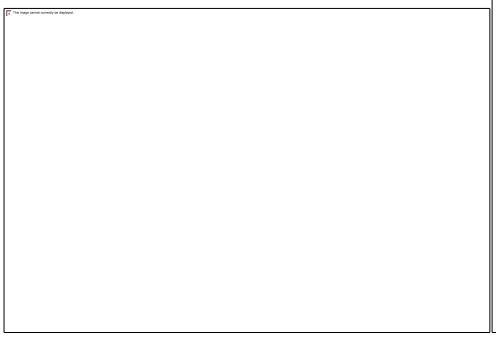
- A brick is placed in a compression testing machine.
- A gradually increasing load is applied.
- The maximum load before failure is recorded.

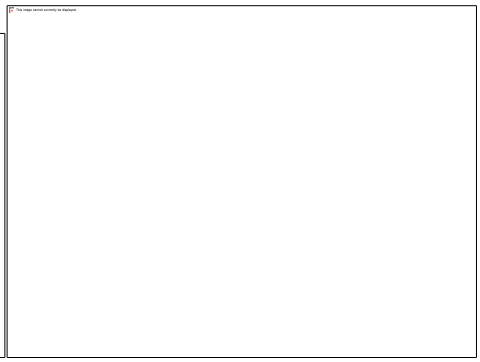
Compressive strength=Maximum loadLoaded areaCompressive strength=Loaded areaMaximum load

5. Efflorescence test

- Checks for the presence of soluble salts.
- White salt deposits may appear on the brick surface after moisture evaporates.

1.6 Common Defects in Bricks





Defect	Description
Cracking	Formation of cracks due to drying or firing problems.
Efflorescence	White salt deposits appearing on the surface.
Warping	Distortion of the original brick shape.
Underburning	Insufficient firing, resulting in weak bricks.
Overburning	Excessive firing, which may distort the brick.

Spalling	Breaking away of portions of the brick surface.

1.7 Uses of Bricks in Building Construction

1. Construction of external walls.
2. Construction of internal partition walls.
3. Construction of boundary walls.
4. Construction of fireplaces and chimneys.
5. Construction of paving surfaces.
6. Construction of arches.
7. Construction of retaining walls.
8. Construction of decorative wall finishes.

1.10 Advantages of Using Bricks

1. They are durable.
2. They are fire-resistant.
3. They provide good thermal mass.
4. They are readily available in many areas.
5. They require relatively little maintenance.
6. They provide an attractive appearance.
7. They are suitable for different building designs.

1.11 Disadvantages of Bricks

1. Some types are expensive to manufacture.
2. Bricklaying can be labour-intensive.
3. Bricks can absorb moisture.
4. Poor-quality bricks may crack or break.
5. Brick walls can be heavy.
6. Firing clay bricks requires energy and may contribute to environmental pollution.

1.12 Storage and Handling of Bricks

- Store bricks on firm, level ground.
- Stack bricks neatly to prevent collapse.
- Protect them from excessive moisture and contamination.
- Avoid throwing bricks during handling.
- Separate different brick types and sizes.
- Handle bricks carefully to minimise breakages.

1.4.5 Comparison of the Main Appropriate Building Technologies

Technology	Main material	Main construction method
Thatch	Grass, reeds and palm leaves	Layering and fixing vegetation
Compressed earth blocks	Suitable soil and optional stabilizer	Mechanical or manual compression
Rammed earth	Suitable soil and optional stabilizer	Compaction inside formwork
Bamboo	Bamboo culms and processed products	Cutting, joining and assembling
ISSB	Soil and stabilizer	Compression into interlocking shapes
Recycled materials	Plastic, glass, timber, metal and others	Reuse and processing into products

1.4.6 Structures Constructed Using Appropriate Technologies

Appropriate technologies can be used to construct different types of buildings and structures depending on their intended function, available materials, environmental conditions and structural requirements.

A. Residential buildings





Residential buildings are structures designed to provide accommodation for people.

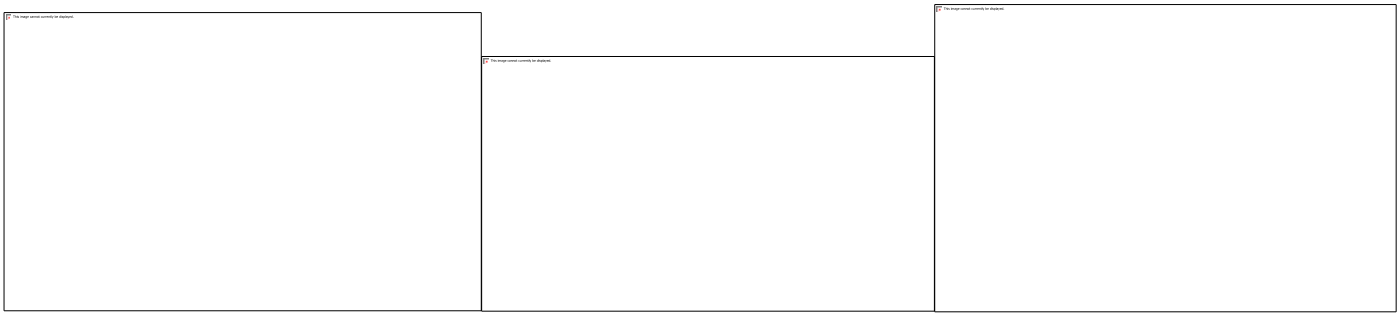
Appropriate technologies used include:

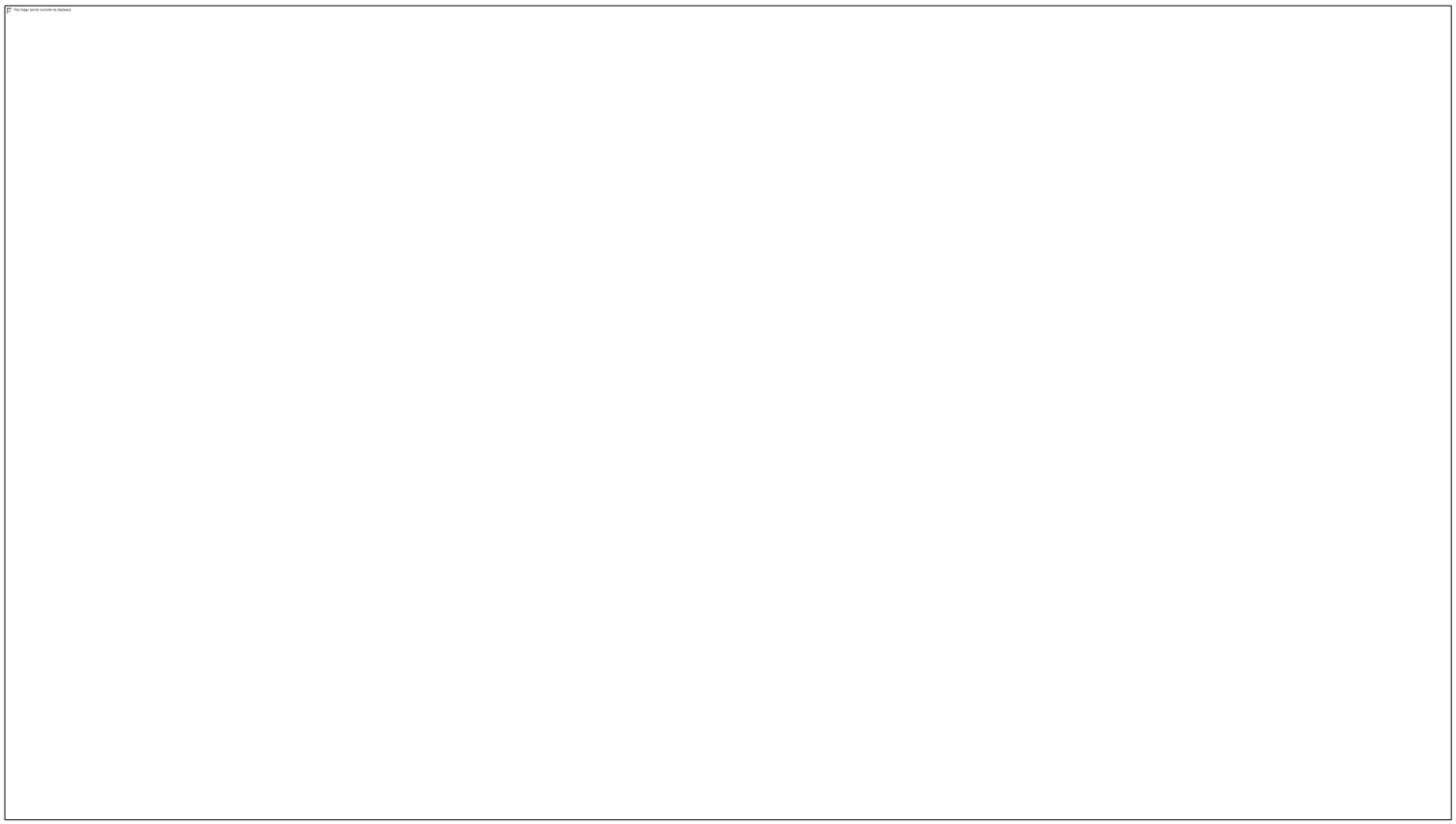
- Thatch roofing.
- Compressed earth block walls.
- Rammed earth walls.
- Interlocking stabilized soil block walls.
- Bamboo structural and decorative components.
- Recycled materials in suitable building products.

Benefits:

1. May reduce construction costs.
2. Can use locally available materials.
3. May improve indoor thermal comfort.
4. Encourage local construction skills.
5. Support environmentally responsible housing.

B. Educational buildings





These are structures used for learning activities, such as classrooms, libraries, workshops and community learning centres.

Appropriate technologies include:

- Stabilized soil block walls.
- Compressed earth block walls.
- Rammed earth walls.
- Suitable bamboo roofing components.
- Recycled materials for approved non-structural applications.

Benefits:

- Can reduce construction costs.
- Encourage the use of local skills.
- Promote environmental education.
- Can provide comfortable learning spaces when properly designed.

C. Agricultural buildings



Agricultural buildings are structures used to support farming and related activities.

Examples include:

- Granaries.
- Animal shelters.
- Farm stores.
- Poultry houses.
- Equipment sheds.
- Produce storage structures.

Appropriate technologies include:

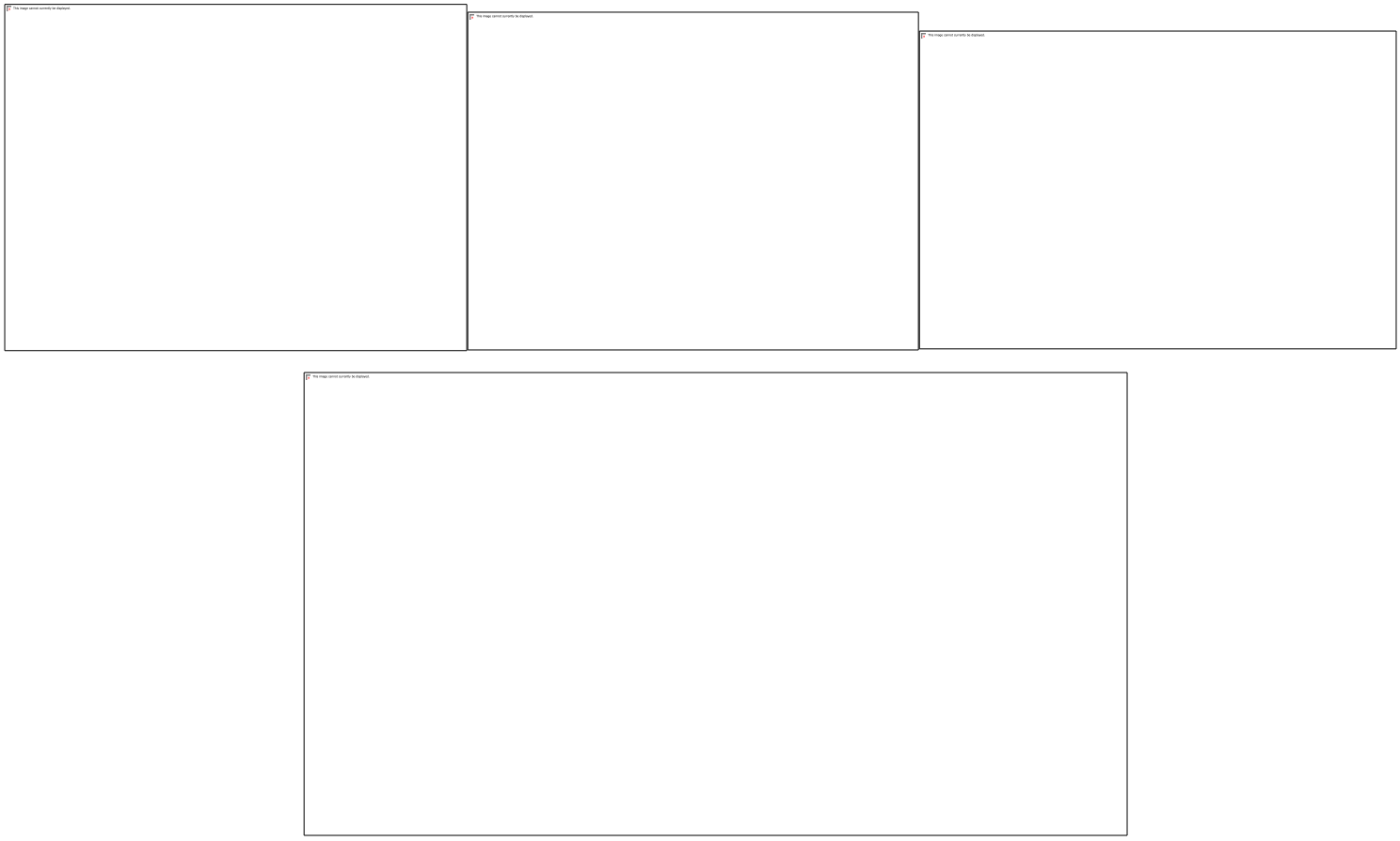
- Thatch roofing.
- Bamboo structures.
- Earth block walls.
- Recycled timber.
- Suitable recycled construction products.

Benefits:

1. Reduce costs for farmers.
2. Support the use of local resources.

3. Provide suitable storage and shelter.
4. Encourage sustainable agricultural development.

D. Community buildings



Community buildings are structures used by members of a community for meetings, social activities, training and other public functions.

Examples:

- Community halls.
- Youth centres.
- Cultural centres.
- Training centres.
- Social meeting shelters.

Appropriate technologies may include earth blocks, bamboo, thatch and recycled materials.

E. Bridges and walkways



Appropriate technology may also be applied in constructing pedestrian bridges and walkways.

Examples include:

- Bamboo pedestrian bridges.
- Reclaimed timber walkways.
- Recycled plastic paving products.
- Suitable earth-based pathway systems.

Important: Bridges and other load-bearing structures require professional structural design, appropriate materials testing and approval. The fact that a material is locally available does not automatically make it suitable for a bridge.

1.4.7 Model Building Structures Using Appropriate Technologies

Meaning of a model building structure

A model building structure is a small-scale representation of an actual or proposed building constructed to demonstrate its appearance, arrangement, materials, construction methods and structural components.

In building construction, learners develop models to understand how different materials and appropriate technologies can be applied in real construction projects.

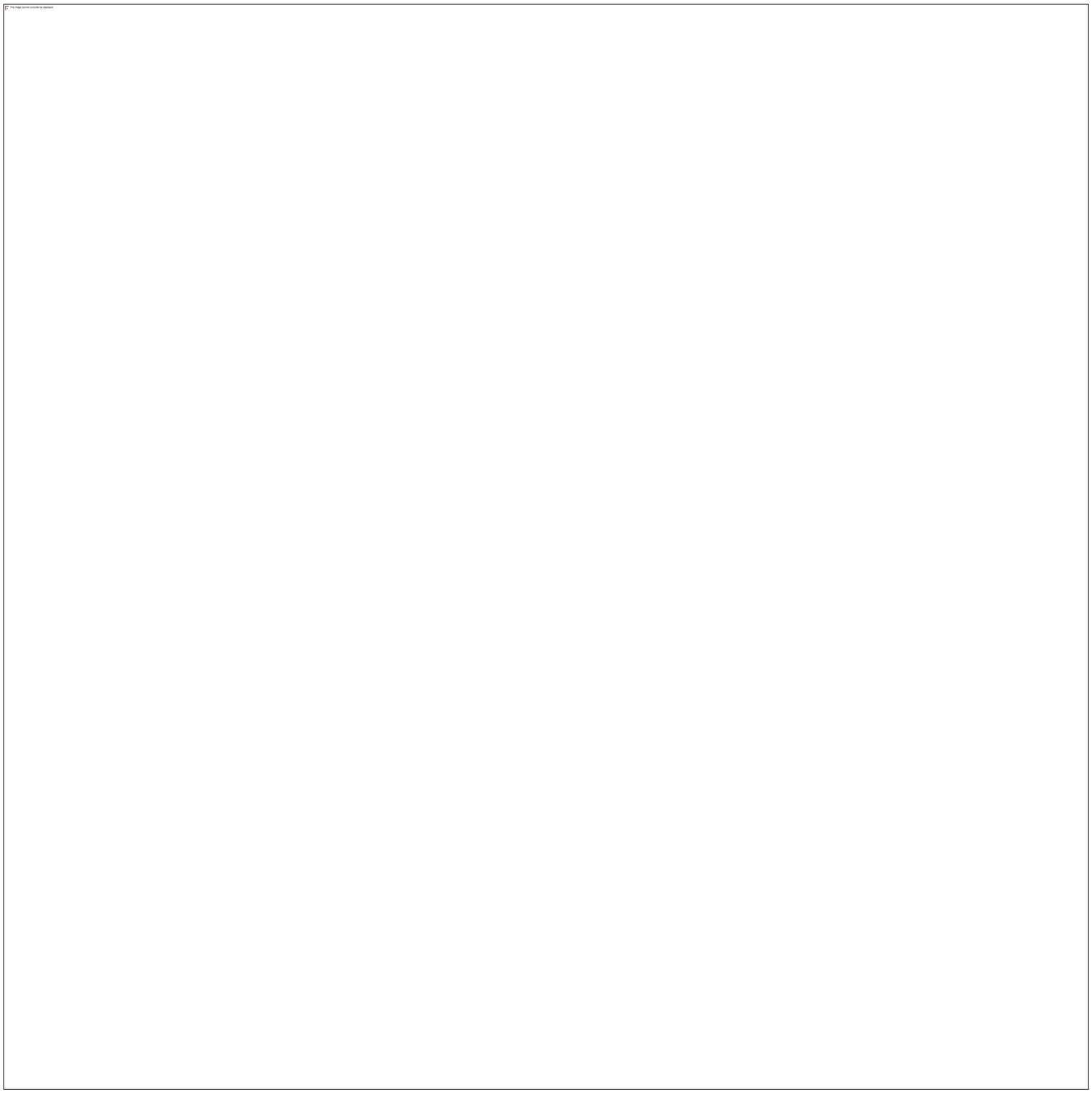
Model making provides practical experience in designing, measuring, cutting, joining and assembling construction materials.

Importance of constructing building models

1. **Develops practical skills:** Learners acquire experience in handling construction materials and tools.
2. **Promotes creativity:** Learners develop new ideas for designing affordable structures.
3. **Improves understanding:** Models help learners understand how different building components are assembled.
4. **Promotes teamwork:** Learners collaborate when designing and constructing models.
5. **Encourages innovation:** Learners explore alternative construction methods.
6. **Promotes environmental conservation:** Learners practise reusing and recycling materials.
7. **Develops problem-solving skills:** Learners identify and solve construction challenges.
8. **Improves accuracy:** Learners practise measurement, scaling and alignment.
9. **Develops entrepreneurship:** Learners identify opportunities for manufacturing and selling building products.
10. **Promotes appreciation of local materials:** Learners recognize the value of locally available resources.

Types of models that learners can construct

Model 1: A house using compressed earth blocks



Materials required

- Small compressed earth blocks or miniature soil blocks.
- Cardboard base.
- Suitable adhesive.
- Small timber pieces.
- Roofing materials.
- Measuring ruler.
- Pencil.

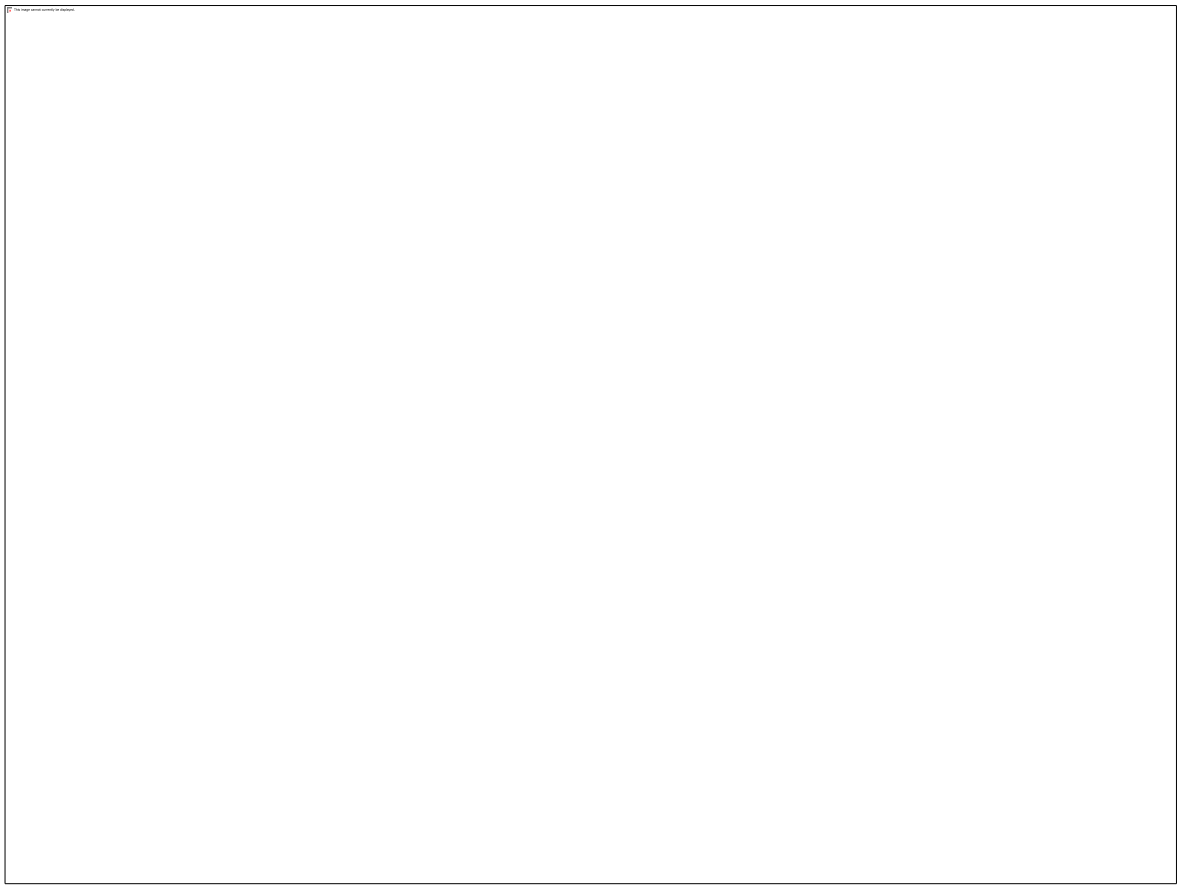
- Cutting tools.
- Paint where necessary.

Procedure

1. Prepare a drawing of the proposed house.
2. Select a suitable scale.
3. Prepare a firm cardboard or wooden base.
4. Mark the positions of the walls.
5. Prepare miniature earth blocks.
6. Arrange the blocks to form the external walls.
7. Leave openings for doors and windows.
8. Construct suitable miniature lintels.
9. Prepare the roof framework.
10. Install the selected roofing material.
11. Add doors and windows.
12. Finish and inspect the model.

Expected outcome: A miniature house demonstrating the application of compressed earth block technology.

Model 2: A house with a thatched roof



Materials required

- Cardboard.
- Small timber strips.
- Dry grass.
- Suitable adhesive.
- Thread or binding material.
- Ruler.
- Pencil.
- Scissors.

Procedure

1. Prepare a scaled drawing of the house.
2. Make a firm base.
3. Construct the wall framework.
4. Prepare the miniature walls.
5. Construct the roof framework.
6. Arrange dried grass into small bundles.
7. Attach the grass to the roof framework.
8. Overlap the grass to represent actual thatching.
9. Complete the ridge.
10. Add doors and windows.
11. Inspect the finished model.

Expected outcome: A model demonstrating the use of natural vegetation for roofing.

Model 3: A bamboo building structure



Materials required

- Small bamboo sticks.
- Cardboard base.
- String or suitable adhesive.
- Small wooden pieces.
- Ruler.
- Pencil.
- Scissors or cutting tools.

Procedure

1. Draw the proposed bamboo structure.
2. Prepare a suitable base.
3. Cut bamboo sticks to the required lengths.
4. Arrange the bamboo columns.
5. Fix the horizontal members.
6. Add diagonal bracing.
7. Construct the roof framework.
8. Attach suitable roofing material.
9. Check the stability of the model.
10. Complete the finishing.

Expected outcome: A model showing how bamboo can be used to construct a lightweight building framework.

Model 4: A model using recycled materials



Materials required

- Used plastic bottles.
- Cardboard.
- Reclaimed timber.
- Suitable adhesive.
- Clean recycled packaging.
- Small pieces of plastic.
- Measuring ruler.
- Scissors.

Procedure

1. Identify suitable recyclable materials.
2. Clean and sort the materials.
3. Prepare a design of the proposed structure.
4. Select a suitable model scale.
5. Prepare the base.
6. Use cardboard or other materials to form the walls.
7. Incorporate suitable recycled components.
8. Construct the roof.
9. Add doors and windows.
10. Complete the finishing and labelling.

Expected outcome: A model demonstrating how discarded materials can be converted into useful building components.

Model 5: A model using interlocking stabilized soil blocks



Materials required

- Miniature interlocking blocks.
- Cardboard base.
- Suitable adhesive.
- Ruler.
- Pencil.
- Small timber pieces.
- Roofing materials.

Procedure

1. Prepare a scaled design.
2. Prepare the base.
3. Mark the wall positions.
4. Arrange the first course of miniature blocks.
5. Interlock the subsequent blocks.
6. Construct the corners carefully.
7. Leave suitable openings.
8. Add miniature lintels.
9. Construct the roof framework.
10. Install the roofing material.
11. Inspect and label the completed model.

1.4.8 Importance of Appropriate Technologies in Building Construction

Appropriate technologies play an important role in improving construction practices and promoting sustainable development in Kenya.

1. Reduction of construction costs

- Locally available materials may reduce transportation expenses.
- Some technologies reduce the quantity of conventional materials required.
- Suitable block-making methods can reduce dependence on fired bricks.
- Recycled materials may reduce the cost of certain building components.
- Reduced material wastage helps control construction expenditure.

2. Promotion of environmental conservation

- Encourages responsible use of natural resources.
- Promotes reuse and recycling of waste materials.
- Reduces the amount of waste sent to disposal sites.
- Can reduce dependence on energy-intensive manufacturing processes.
- Encourages sustainable harvesting of renewable materials.

3. Creation of employment opportunities

- Provides work for local artisans.
- Creates opportunities for block manufacturers.
- Supports bamboo growers and processors.
- Creates employment in recycling enterprises.
- Encourages small-scale construction businesses.

4. Promotion of local industries

- Encourages the production of locally manufactured building materials.
- Supports small and medium-sized enterprises.
- Creates markets for locally available resources.
- Reduces unnecessary dependence on imported building products.

5. Conservation of energy

- Some appropriate technologies require less industrial processing.
- Earth-based construction can reduce the use of fired building products.
- Suitable building materials can improve indoor thermal comfort.
- Energy-efficient designs may reduce the need for artificial heating and cooling.

6. Reduction of construction waste

- Encourages the reuse of discarded materials.
- Promotes recycling of suitable construction products.
- Reduces wastage during construction.
- Encourages efficient material management.

7. Promotion of affordable housing

- Provides alternative construction methods.
- Can reduce material transportation and processing costs.
- Encourages local production of building materials.
- Makes some construction methods more accessible to rural communities.

8. Preservation of traditional knowledge

- Promotes traditional building skills.
- Preserves indigenous construction methods.
- Encourages the transfer of skills between generations.
- Supports cultural identity and heritage.

9. Adaptation to local climatic conditions

- Suitable thatched roofs provide insulation.
- Earth walls provide thermal mass.

- Properly designed natural materials can improve indoor comfort.
- Local materials can be selected to suit the surrounding environment.

10. Encouragement of innovation and creativity

- Encourages the development of new construction products.
- Promotes experimentation with locally available resources.
- Helps learners develop practical problem-solving skills.
- Supports research and technological advancement.

11. Reduction of transportation requirements

- Locally sourced soil, bamboo and other materials may reduce long-distance transportation.
- Reduced transportation may lower fuel consumption.
- It can reduce the environmental effects associated with transporting building materials.

12. Promotion of sustainable development

- Encourages responsible use of resources.
- Supports economic development.
- Promotes environmental protection.
- Improves access to suitable construction methods.
- Encourages intergenerational responsibility.

1.4.9 Challenges Facing the Adoption of Appropriate Building Technologies in Kenya

Although appropriate technologies have many benefits, their adoption may be affected by several challenges.

1. Limited technical knowledge

- Some construction workers may lack the necessary skills.
- Some contractors may not understand alternative construction methods.
- Lack of training can lead to poor workmanship.

Possible solution: Provide technical training and practical demonstrations.

2. Negative public perception

- Some people associate earth construction and thatched roofs with poverty.
- Some clients prefer conventional concrete and fired-brick buildings.
- There may be limited awareness of modern alternative technologies.

Possible solution: Promote demonstration projects and public awareness.

3. Limited availability of specialized equipment

- Some technologies require block-making machines.
- Bamboo processing may require specialized tools.
- Equipment may be expensive or difficult to obtain.

Possible solution: Encourage local manufacturing and affordable equipment-hire services.

4. Lack of standardization and quality control

- Poorly manufactured blocks may have inconsistent strength.
- Untreated bamboo may deteriorate.
- Recycled materials may have inconsistent properties.

Possible solution: Apply relevant Kenya Standards, product testing and quality-control procedures.

5. Limited availability of suitable materials

- Some regions may lack suitable soil.
- Suitable thatching grass may be scarce.
- Bamboo may not be readily available in every county.

Possible solution: Identify alternative suitable local materials and establish sustainable supply chains.

6. Weather-related challenges

- Heavy rainfall may damage poorly protected earth structures.
- Moisture can cause deterioration of untreated bamboo.
- Strong winds may damage poorly installed thatched roofs.

Possible solution: Use appropriate protective measures and climate-responsive designs.

7. Financing difficulties

- Some clients may find it difficult to finance alternative construction projects.
- Equipment and training may require initial investment.

Possible solution: Promote access to affordable financing and community-based production.

8. Regulatory and approval challenges

- Some alternative materials may require additional testing or technical approval.
- Designers may be unfamiliar with appropriate construction systems.

Possible solution: Work with qualified professionals and relevant regulatory bodies to demonstrate compliance.

1.4.10 Precautions When Using Appropriate Building Technologies

The following precautions should be observed:

1. Select materials suitable for the intended purpose.
2. Test materials before using them in construction.
3. Follow approved construction procedures.
4. Use appropriate tools and equipment.
5. Ensure that workers have the required skills.
6. Protect earth-based structures against excessive moisture.
7. Treat bamboo against insects and fungal attack.

8. Provide fire protection where necessary.
9. Ensure that foundations are properly designed.
10. Provide adequate drainage around buildings.
11. Use suitable structural connections.
12. Avoid using contaminated recycled materials.
13. Ensure that structural components meet the required strength.
14. Observe occupational health and safety requirements.
15. Obtain the necessary building approvals.
16. Carry out regular inspection and maintenance.

1.4.11 General Comparison of Appropriate Technologies

Technology	Main advantage	Main limitation	Common application
Thatch	Natural thermal insulation	Fire risk and maintenance	Roofing
Compressed earth blocks	Efficient use of suitable soil	Requires soil testing and compression equipment	Wall construction
Rammed earth	Strong, massive walls when properly constructed	Requires formwork and compaction	Wall construction
Bamboo	Lightweight and renewable	Vulnerable to pests and moisture if untreated	Frames and other components
ISSB	Interlocking arrangement reduces mortar use	Requires accurate block production	Wall construction
Recycled waste	Reduces waste and conserves resources	Quality may vary	Paving, panels and other approved components

1.4.12 Key Terms and Definitions

Term	Meaning
Appropriate technology	Suitable methods, materials and equipment adapted to local needs and conditions
Sustainable construction	Construction that considers environmental, social and economic impacts
Thatch	Dried vegetation used mainly for roofing
Compressed earth block	A block formed by compressing suitable soil in a mould
Rammed earth	Construction method involving compaction of soil in formwork
Bamboo technology	Use of bamboo and processed bamboo products in construction
Stabilizer	A material added to soil to improve its engineering properties
Interlocking block	A specially shaped block designed to fit into adjacent blocks

Recycled materials	Recovered materials processed or reused for new applications
Thermal insulation	The ability of a material or system to reduce heat transfer
Thermal mass	The ability of a material to absorb and store heat
Formwork	A temporary mould used to shape concrete or other construction materials
Curing	The process of maintaining suitable conditions for a material to develop its required properties
Circular economy	An approach that keeps resources and products in use for as long as possible

REVISION QUESTIONS

STRAND 1.0: FOUNDATIONS OF BUILDING CONSTRUCTION

SUB-STRAND 1.4: APPROPRIATE TECHNOLOGY IN BUILDING – BUILDING MATERIALS

SECTION A: MULTIPLE-CHOICE QUESTIONS

Choose the correct answer from the alternatives provided.

1. What is meant by appropriate technology in building construction?

A. Use of expensive imported materials in every construction project.

B. Use of suitable, affordable and locally adaptable construction methods and materials.

C. Use of machinery in all construction activities.

D. Use of traditional methods without considering safety.

2. Which of the following is a natural building material commonly used in appropriate technology?

A. Plastic cement. B. Bamboo.

C. Aluminium composite. D. Synthetic resin.

3. Which of the following materials is mainly used in thatched roofing?

A. Reinforcement bars.

B. Glass.

C. Dried grass.

D. Concrete.

4. The main purpose of drying grass before using it for thatching is to:

A. Increase its weight.

B. Reduce moisture and the likelihood of deterioration.

C. Change its colour.

D. Increase its water absorption.

5. Which technology involves compressing suitable soil into blocks using a machine?

A. Bamboo technology.

B. Thatch technology.

C. Compressed earth block technology.

D. Conventional stone masonry.

6. Which of the following materials is commonly used to stabilize compressed earth blocks?

A. Cement.

B. Paper.

C. Glass.

D. Plastic packaging.

7. What is the main difference between rammed earth and compressed earth block construction?

A. Rammed earth uses only timber.

B. Rammed earth is compacted in formwork to create walls.

C. Compressed earth blocks do not use soil.

D. Rammed earth requires no compaction.

8. Which equipment is commonly used to compact soil during rammed earth construction?

A. Paintbrush. B. Spirit level.

C. Rammer. D. Screwdriver.

9. Which of the following is a major advantage of bamboo as a building material?

A. It is always waterproof.

B. It is naturally immune to insects.

C. It has a relatively high strength-to-weight ratio.

D. It does not require any maintenance.

10. Why should bamboo be treated before construction use?

A. To make it heavier.

B. To improve resistance to insect and fungal attack.

C. To increase its moisture content.

D. To make it unsuitable for cutting.

11. What is the distinguishing feature of interlocking stabilized soil blocks?

A. They are manufactured entirely from steel.

B. They have specially shaped features that fit into adjacent blocks.

C. They are made from glass only.

D. They require no foundations.

12. Which of the following technologies can reduce the quantity of conventional mortar required in wall construction?

A. Interlocking stabilized soil block technology.

B. Thatch roofing technology.

C. Conventional timber flooring.

D. Sheet-metal roofing.

13. Which of the following is an example of recycled building material?

A. Newly quarried stone.

B. Freshly harvested bamboo.

C. Reclaimed timber.

D. Newly manufactured cement.

14. Which process involves converting discarded materials into new products?

A. Excavation. B. Recycling.

C. Demolition. D. Compaction.

15. Which of the following is an advantage of using compressed earth blocks?

A. They always require kiln firing.

B. They encourage the use of suitable locally available soil.

C. They cannot be used for walls.

D. They require no quality testing.

16. What is the main function of formwork in rammed earth construction?

A. To provide temporary support and shape for the compacted soil.

B. To provide electrical power.

C. To transport construction materials.

D. To dry bamboo.

17. Which of the following is an appropriate use of bamboo in building construction?

A. Manufacturing cement.

B. Constructing suitable lightweight building frames.

C. Producing reinforcement steel.

D. Manufacturing burnt clay bricks.

18. Which of the following is a major environmental benefit of recycling building materials?

A. Increased landfill waste.

B. Increased extraction of natural resources.

C. Reduced waste disposal and conservation of resources.

D. Increased uncontrolled pollution.

19. Which factor is most important when selecting soil for compressed earth block production?

A. Soil colour only.

B. Suitability of its engineering properties.

C. Its distance from the nearest town only.

D. Its smell.

20. Which of the following can improve the durability of a thatched roof?

A. Using wet grass.

B. Leaving loose bundles unsecured.

C. Proper installation and regular maintenance.

D. Removing all supporting members.

21. Which of the following is a disadvantage of untreated bamboo?

A. It cannot be cut.

B. It is vulnerable to insect and fungal attack.

C. It is always too heavy.

D. It cannot be joined.

22. Which technology involves placing soil in layers inside formwork and compacting each layer?

A. Rammed earth technology.

B. Thatch technology.

C. Bamboo flooring technology.

D. Glass recycling technology.

23. Which of the following is an example of an appropriate technology used in wall construction?

A. Thatch roofing.

B. Interlocking stabilized soil blocks.

C. Conventional glass glazing.

D. Aluminium roofing.

24. Which of the following is an important advantage of earth-based construction?

A. It always requires air conditioning.

B. It can provide good thermal mass.

C. It is unaffected by water.

D. It requires no technical knowledge.

25. What is the purpose of curing stabilized earth blocks?

A. To improve the development of their required properties.

B. To increase the amount of organic matter.

C. To make the blocks dissolve.

D. To reduce their dimensions.

26. Which of the following is an appropriate recycled material for producing some paving products?

A. Recycled plastic. B. Wet soil.

C. Fresh grass. D. Untreated leaves.

27. Which of the following is an important consideration when constructing with recycled materials?

A. Ignoring the source of the materials.

B. Using all waste without testing.

C. Checking the quality and suitability of the materials.

D. Avoiding safety precautions.

28. Which of the following is a social benefit of appropriate building technologies?

A. Reduction of local employment.

B. Creation of employment opportunities for local communities.

C. Increased dependence on imported labour.

D. Loss of traditional skills.

29. Which of the following is a suitable way of protecting earth walls against moisture?

A. Allowing water to collect around the foundation.

B. Providing suitable damp-proofing and drainage.

C. Removing roof overhangs.

D. Using untreated soil in wet areas without protection.

30. Which of the following best explains sustainable construction?

A. Constructing buildings without considering the environment.

B. Using the most expensive building materials.

C. Meeting present construction needs while considering future environmental, social and economic needs.

D. Using only imported materials.

SECTION B: STRUCTURED QUESTIONS

31: Introduction to Appropriate Technology

a) Define appropriate technology in building construction. (2 marks)

b) State eight characteristics of appropriate building technologies. (8 marks)

c) Explain five reasons why appropriate technologies are becoming important in the Kenyan construction industry. (10 marks)

32: Building Materials

a) Define building materials. (2 marks)

b) Classify building materials used in appropriate technologies into three main categories. (3 marks)

c) Give four examples under each category. (12 marks)

d) State three factors considered when selecting building materials for appropriate construction. (3 marks)

33: Thatch Technology

a) Define thatch technology. (2 marks)

b) List six materials used in constructing thatched roofs. (6 marks)

c) Describe the procedure followed when constructing a thatched roof. (8 marks)

d) Explain four advantages of thatch technology. (4 marks)

34: Compressed Earth Block Technology

a) Define compressed earth block technology. (2 marks)

b) Identify five materials used in manufacturing compressed earth blocks. (5 marks)

c) List six tools and equipment used in producing compressed earth blocks. (6 marks)

d) Describe the procedure for manufacturing compressed earth blocks. (7 marks)

e) State five advantages of compressed earth block technology. (5 marks)

35: Rammed Earth Technology

a) Define rammed earth technology. (2 marks)

b) State six materials used in rammed earth construction. (6 marks)

c) Explain the functions of formwork in rammed earth construction. (4 marks)

d) Describe the procedure followed when constructing rammed earth walls. (8 marks)

36: Bamboo Technology

a) Define bamboo technology in building construction. (2 marks)

b) State six characteristics of bamboo as a building material. (6 marks)

c) Identify six tools and equipment used in bamboo construction. (6 marks)

d) Explain four advantages and four disadvantages of bamboo technology. (8 marks)

37: Interlocking Stabilized Soil Block Technology

a) Define interlocking stabilized soil block technology. (2 marks)

b) State five materials used in manufacturing interlocking stabilized soil blocks. (5 marks)

c) Explain five stages involved in manufacturing interlocking stabilized soil blocks. (5 marks)

d) Describe the procedure for constructing a wall using interlocking stabilized soil blocks. (8 marks)

e) State five advantages of ISSB technology. (5 marks)

38: Recycled Waste Materials

a) Define recycled waste materials technology in building construction. (2 marks)

b) List eight recycled waste materials that can be used in building construction. (8 marks)

c) Explain five methods of processing waste materials for use in building construction. (10 marks)

d) State five advantages of using recycled building materials. (5 marks)

39: Structures Constructed Using Appropriate Technologies

a) Identify six types of structures that can be constructed using appropriate technologies. (6 marks)

b) Explain how appropriate technologies can be applied in the construction of residential buildings. (6 marks)

c) State four benefits of using appropriate technologies in constructing educational buildings. (4 marks)

d) Identify four appropriate technologies that can be applied in agricultural buildings. (4 marks)

40:

a) Define the term brick. (2 marks)

b) State four raw materials used in brick manufacturing. (4 marks)

c) Outline six stages involved in manufacturing burnt clay bricks. (6 marks)

d) Identify five types of bricks used in building construction. (5 marks)

e) State six characteristics of good quality bricks. (6 marks)

f) Explain four tests carried out to determine the quality of bricks. (8 marks)

g) Differentiate between a header and a stretcher. (4 marks)

h) Explain four types of brick bonds. (8 marks)

i) State five defects that may occur in bricks. (5 marks)

j) Give four advantages of using bricks in building construction. (4 marks)

41:

a) Define a model building structure. (2 marks)

b) State six reasons why learners should construct building models. (6 marks)

c) List eight materials and tools that can be used to construct a miniature house using recycled materials. (8 marks)

d) Outline the procedure for constructing a miniature house using bamboo technology. (8 marks)

42:

Explain ten ways in which appropriate technologies contribute to sustainable building construction in Kenya. (20 marks)

43:

a) State six challenges facing the adoption of appropriate building technologies in Kenya. (6 marks)

b) Suggest six measures that can be taken to promote the adoption of appropriate technologies. (6 marks)

c) Explain eight precautions that should be observed when using alternative building materials. (8 marks)

44:

A community group in Narok County intends to construct affordable houses using locally available materials. The group has access to suitable soil, bamboo, grass and recycled plastic materials.

a) Identify four appropriate technologies that the group can use. (4 marks)

b) Explain how compressed earth blocks can be manufactured using locally available soil. (6 marks)

c) Describe five ways in which bamboo can be used in the proposed houses. (5 marks)

d) Explain five environmental benefits of using the identified technologies. (5 marks)

45:

A contractor intends to construct a rural classroom block. Conventional building materials are expensive to transport to the construction site. Suitable soil is available locally.

a) Recommend two appropriate building technologies for the classroom walls. (2 marks)

b) Explain four factors that should be considered when selecting the technologies. (4 marks)

c) Describe the procedure for manufacturing suitable stabilized soil blocks. (8 marks)

d) Explain three measures that should be taken to protect the completed walls against moisture. (6 marks)

46:

A group of Grade 11 learners has identified large quantities of discarded plastic bottles, glass, timber and metal around their school.

a) Identify four ways in which the waste materials can be reused or recycled in building construction. (4 marks)

b) Explain five benefits of using recycled materials in construction. (10 marks)

c) State six precautions that should be observed when using recycled materials. (6 marks)

47:

Your teacher has asked your group to construct a miniature eco-friendly house using appropriate building technologies.

a) Identify five appropriate materials that can be used. (5 marks)

b) List five tools required for the activity. (5 marks)

c) Describe the procedure for constructing the miniature house. (6 marks)

d) Explain four skills that learners develop through this activity. (4 marks)

48:

A construction company is considering using thatch, bamboo, compressed earth blocks and interlocking stabilized soil blocks in a rural housing project.

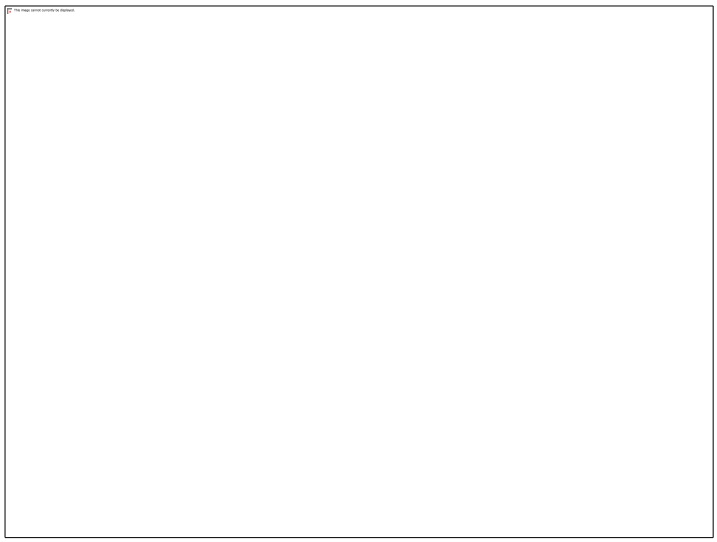
a) Differentiate between compressed earth blocks and interlocking stabilized soil blocks. (4 marks)

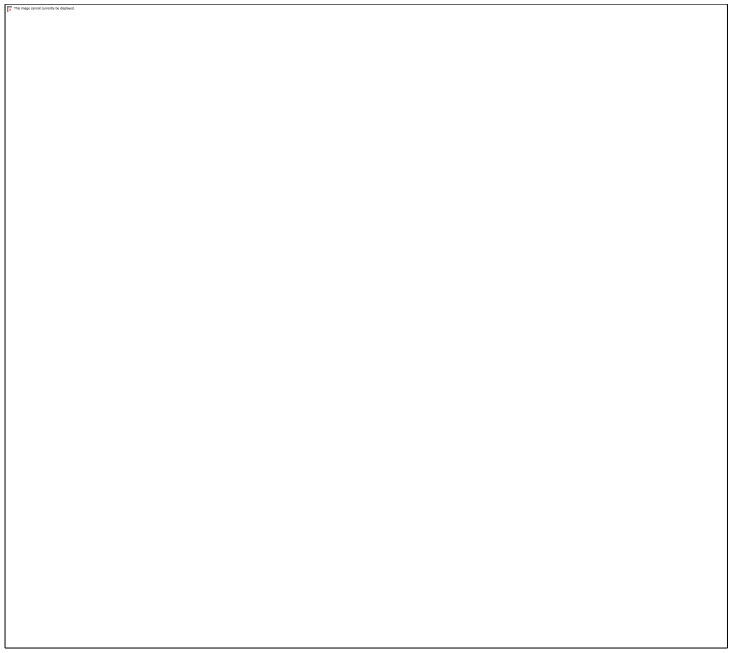
b) Explain three advantages of using thatch for roofing. (3 marks)

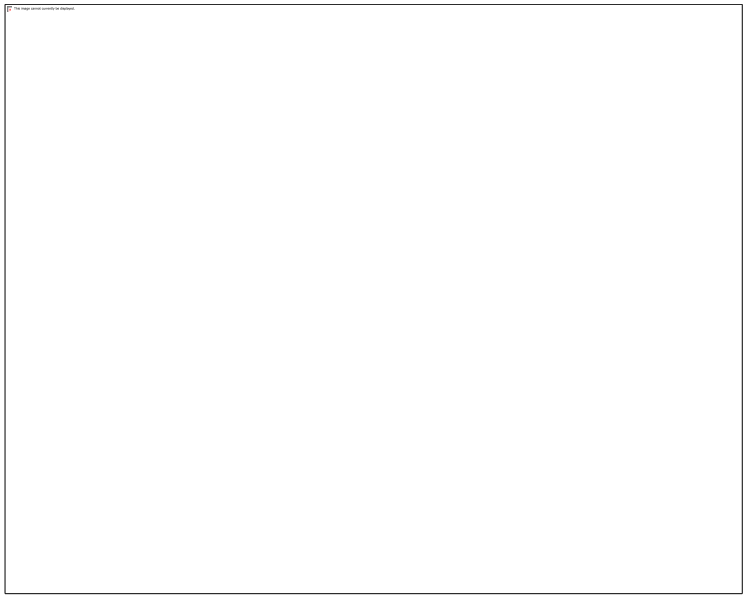
c) State three precautions when using bamboo in construction. (3 marks)

d) Explain five factors that should guide the selection of the most suitable technology. (10 marks)

PRACTICAL PROJECT: DESIGN AND CONSTRUCTION OF AN ECO-FRIENDLY MODEL HOUSE







Project objective: To enable learners to apply appropriate building technologies in designing and constructing a miniature eco-friendly house.

Materials

- Small earth blocks.

- Bamboo sticks.
- Dry grass.
- Cardboard.
- Recycled plastic materials.
- Reclaimed timber.
- Suitable adhesive.
- Recycled packaging materials.

Tools

- Ruler.
- Pencil.
- Scissors.
- Hand saw.
- Measuring tape.
- Cutting tools.
- Protective gloves.

Project procedure

1. Work in groups.
2. Identify the proposed building design.
3. Select suitable appropriate technologies.
4. Prepare a scaled drawing.
5. Collect and prepare materials.
6. Prepare the base of the model.
7. Construct the walls.
8. Prepare the roof framework.
9. Install the selected roofing material.
10. Incorporate suitable recycled components.
11. Complete finishing.
12. Present the model and explain the technologies used.

Suggested project assessment rubric

Assessment area	Marks
Identification of appropriate materials	10
Preparation of design	10
Accuracy of measurements	10
Application of appropriate technologies	15
Creativity and innovation	10
Quality of workmanship	10
Environmental considerations	5
Presentation and explanation	10
Total	80

STRAND 2.0: RELATED DRAWING

SUB-STRAND 2.1: ORTHOGRAPHIC PROJECTION

Introduction

Technical drawing is an important part of Building Construction because it enables builders, architects, engineers, quantity surveyors and other construction professionals to communicate ideas accurately before actual construction begins.

A building or construction component has length, width and height. To describe its shape and dimensions clearly on a flat sheet of paper, different drawing methods are used. One of the most important methods is **orthographic projection**.

Orthographic projection is used to represent three-dimensional objects using two-dimensional views. These views help a person understand the shape, size and arrangement of different parts of an object.

In this sub-strand, learners will develop the ability to interpret, arrange and draw orthographic views of shaped blocks using both first-angle and third-angle projection.

1.0 MEANING OF ORTHOGRAPHIC PROJECTION

1.1 Definition of orthographic projection

Orthographic projection is a method of technical drawing in which an object is represented on two-dimensional drawing planes by projecting its features using imaginary parallel lines that are perpendicular to the projection planes.

In simpler terms, **orthographic projection is a way of drawing the different sides of a three-dimensional object separately so that its actual shape and dimensions can be understood.**

The object is viewed from different directions, such as:

- From the front.
- From above.
- From the left side.
- From the right side.
- From below, where necessary.
- From the rear, where necessary.

Each view shows only the features visible from that particular direction.

Example: A rectangular concrete block has length, width and height. Its front view shows its length and height, while its top view shows its length and width. Its side view shows its width and height.

1.2 Understanding the main terms used in orthographic projection

a) Object

An object is the physical item or component being represented in a technical drawing.

Examples include:

- A concrete block.
- A brick.
- A timber piece.
- A door frame.

- A window frame.
- A staircase component.
- A roof truss member.
- A foundation block.
- A shaped building component.

b) Projection

Projection is the process of transferring the outline and features of an object onto a drawing plane using imaginary straight lines called projectors.

c) Projectors

Projectors are imaginary straight lines used to transfer points and edges of an object onto a projection plane.

In orthographic projection, the projectors are parallel to one another and perpendicular to the projection plane.

d) Projection plane

A projection plane is an imaginary flat surface onto which the view of an object is projected.

The main projection planes are:

1. **Vertical plane:** Used to obtain the front view.
2. **Horizontal plane:** Used to obtain the top view.
3. **Profile plane:** Used to obtain the side view.

e) Elevation

An elevation is a view of an object as seen from a particular side.

Examples include:

- Front elevation.
- Rear elevation.
- Left-side elevation.
- Right-side elevation.

f) Plan

A plan is a view of an object as seen directly from above.

In building construction, a floor plan shows the arrangement of rooms, walls, doors and windows when viewed from above.

g) End view

An end view is a view obtained by looking directly at the end of an object.

It is useful when an object has different shapes at its ends.

h) Profile

A profile is the outline or shape of an object as seen from a particular side.

2.0 PRINCIPLES OF ORTHOGRAPHIC PROJECTION

Orthographic projection follows specific principles that ensure technical drawings are accurate and easy to interpret.

2.1 Main principles

1. **Parallel projectors**
   - The imaginary projection lines are parallel to one another.
   - They do not converge towards a single point.
   - This helps maintain the actual proportions of the object in each view.
2. **Perpendicular projection**
   - Projectors meet the projection plane at right angles (90°).
   - This produces accurate two-dimensional views.
3. **Separate views**
   - The object is represented using different views.
   - Each view describes two dimensions of the object.
4. **Accurate dimensions**
   - The dimensions shown in each view correspond to the actual dimensions of the object, subject to the drawing scale.
   - The drawing should not be distorted by perspective.
5. **Correct alignment**
   - Related features in different views must be aligned.
   - For example, the front and top views share the same length.
6. **Use of drawing conventions**
   - Standard lines, symbols and projection arrangements are used.
   - This makes drawings understandable to different construction professionals.

2.2 How orthographic projection works

The process involves the following steps:

1. Select the object to be drawn.
2. Identify the direction from which the object will be viewed.
3. Imagine the object placed between the observer and the projection planes.
4. Project the visible edges onto the appropriate plane.
5. Record the outlines and important details.
6. Repeat the process for the other required viewing directions.
7. Arrange the views according to the selected projection system.

8. Add dimensions and other necessary drawing information.

3.0 ROLES OF ORTHOGRAPHIC PROJECTION IN DRAWING

Orthographic projection plays an important role in technical drawing and building construction.

3.1 Communicating construction information

- It enables construction professionals to communicate the shape and dimensions of building components.
- It reduces misunderstanding between designers, builders and clients.
- It provides a common method of interpreting technical information.

Example: A building contractor can use orthographic drawings to understand the dimensions of a concrete column before constructing it.

3.2 Showing the actual shape of objects

- It represents the different sides of an object accurately.
- It helps reveal features that may not be visible in a single view.
- It makes it easier to understand complex shapes.

3.3 Providing accurate dimensions

- It allows length, width and height to be shown separately.
- It supports accurate measurement and setting out.
- It helps prevent errors during construction.

3.4 Supporting the preparation of building drawings

Orthographic projection is applied when preparing:

- Floor plans.
- Elevations.
- Sections.
- Details of doors and windows.
- Foundation details.
- Staircase details.
- Roof construction details.
- Structural component drawings.

3.5 Guiding construction and manufacturing

- It helps artisans and technicians produce building components to the required dimensions.
- It guides the cutting and shaping of timber, metal and other materials.
- It assists in producing precast concrete components.

3.6 Supporting estimation of materials

- It provides information about the dimensions of components.
- It helps in calculating quantities of materials.
- It assists in preparing bills of quantities when used with other construction information.

3.7 Supporting inspection and quality control

- It provides a reference against which completed work can be checked.
- It helps identify differences between the designed component and the constructed component.
- It supports accurate supervision of construction work.

3.8 Reducing construction errors and wastage

- Clear drawings reduce incorrect measurements.
- They help prevent unnecessary cutting and alteration of materials.
- They improve the efficient use of construction resources.

3.9 Supporting record keeping

- Orthographic drawings provide a permanent technical record.
- They can be referred to during maintenance, renovation and future alterations.
- They help document the intended construction details.

3.10 Supporting computer-aided design

- Orthographic projection is used in CAD applications.
- It allows designers to produce accurate digital drawings.
- Digital drawings can be stored, edited, printed and shared.

4.0 TYPES OF ORTHOGRAPHIC PROJECTION

There are two main systems of orthographic projection commonly used in technical drawing:

1. First-angle orthographic projection.
2. Third-angle orthographic projection.

Both systems are used to represent three-dimensional objects using two-dimensional views. The main difference is the position of the object, observer and projection plane, which determines how the views are arranged on the drawing sheet.

4.1 First-angle orthographic projection

Definition

First-angle orthographic projection is a method of representing an object in which the object is positioned between the observer and the projection plane.

The object is placed in the first quadrant, with the front of the object facing the observer and the projection plane behind the object.

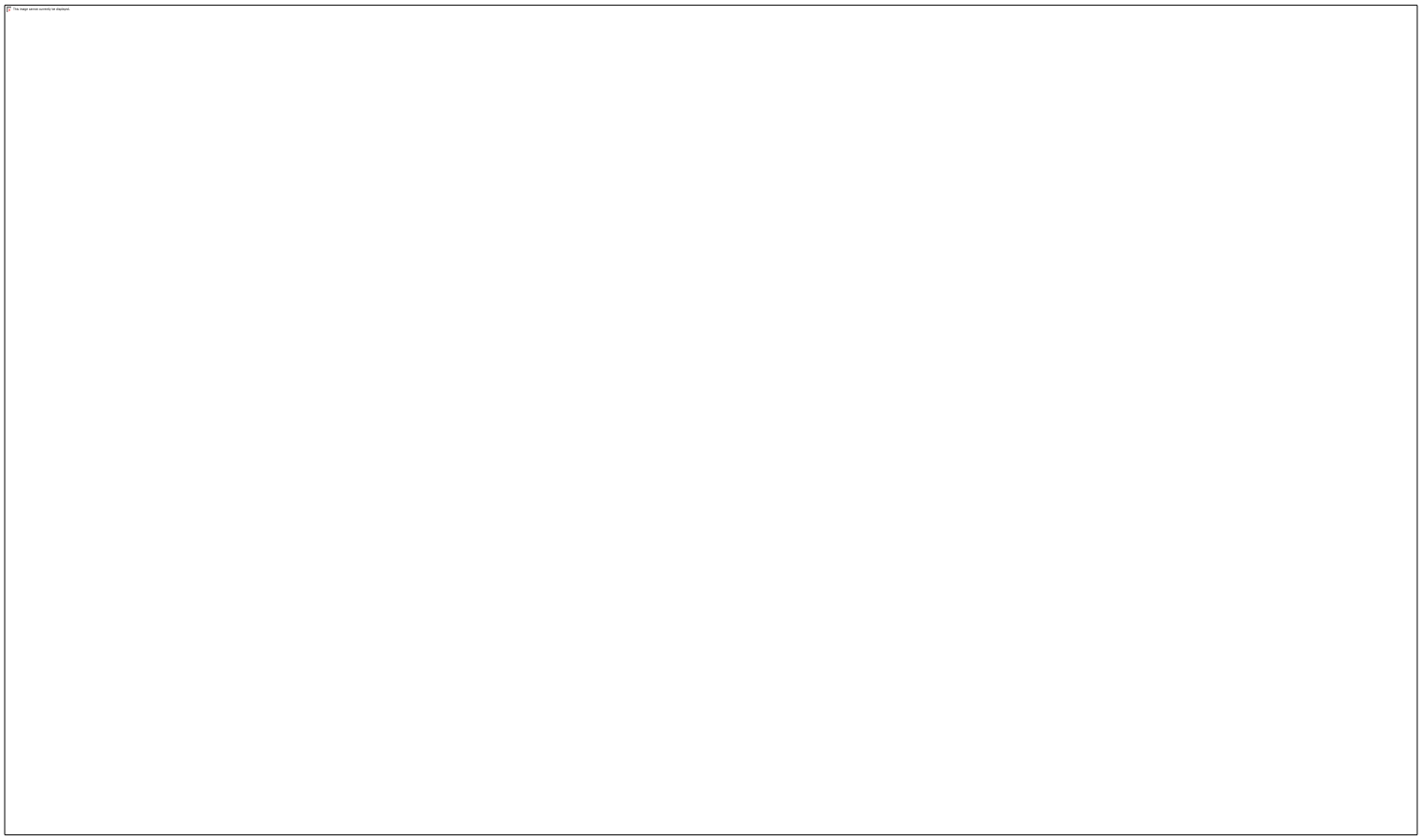
In this method, the views are arranged on the drawing sheet in positions opposite to the directions from which they are viewed.

Main characteristics of first-angle projection

1. The object is positioned between the observer and the projection plane.

2. The object is considered to be in the first quadrant.
3. The top view is placed below the front view.
4. The bottom view is placed above the front view.
5. The right-side view is placed on the left of the front view.
6. The left-side view is placed on the right of the front view.
7. The views are aligned according to their corresponding dimensions.
8. It is commonly used in many countries, including Kenya, where the relevant drawing convention is specified by the project or institution.

Arrangement of views in first-angle projection



The arrangement is as follows:

View	Position on drawing sheet
Front view	Centre
Top view	Below front view
Bottom view	Above front view
Right-side view	Left of front view
Left-side view	Right of front view
Rear view	May be placed in an appropriate position according to the drawing convention

Important: In first-angle projection, the view is placed on the opposite side of the front view from the direction from which the observer looks.

Example of first-angle projection

Suppose a learner is drawing a rectangular concrete block.

- The front view is obtained by looking at the block from the front.
- The top view is obtained by looking down at the block.
- The right-side view is obtained by looking at the block from its right side.

When these views are arranged using first-angle projection:

- The top view is drawn below the front view.
- The right-side view is drawn to the left of the front view.
- The left-side view is drawn to the right of the front view.

4.2 Third-angle orthographic projection

Definition

Third-angle orthographic projection is a method of representing an object in which the projection plane is positioned between the observer and the object.

The object is considered to be positioned in the third quadrant.

The views are arranged on the drawing sheet on the same side as the direction from which they are viewed.

Main characteristics of third-angle projection

1. The projection plane is positioned between the observer and the object.
2. The object is considered to be in the third quadrant.
3. The top view is placed above the front view.
4. The bottom view is placed below the front view.
5. The right-side view is placed on the right of the front view.
6. The left-side view is placed on the left of the front view.
7. The views are arranged according to their corresponding dimensions.
8. It is commonly associated with engineering drawing practice in countries such as the United States and Canada.

Arrangement of views in third-angle projection



The arrangement is as follows:

View	Position on drawing sheet
Front view	Centre
Top view	Above front view
Bottom view	Below front view
Right-side view	Right of front view
Left-side view	Left of front view
Rear view	May be placed in an appropriate position according to the drawing convention

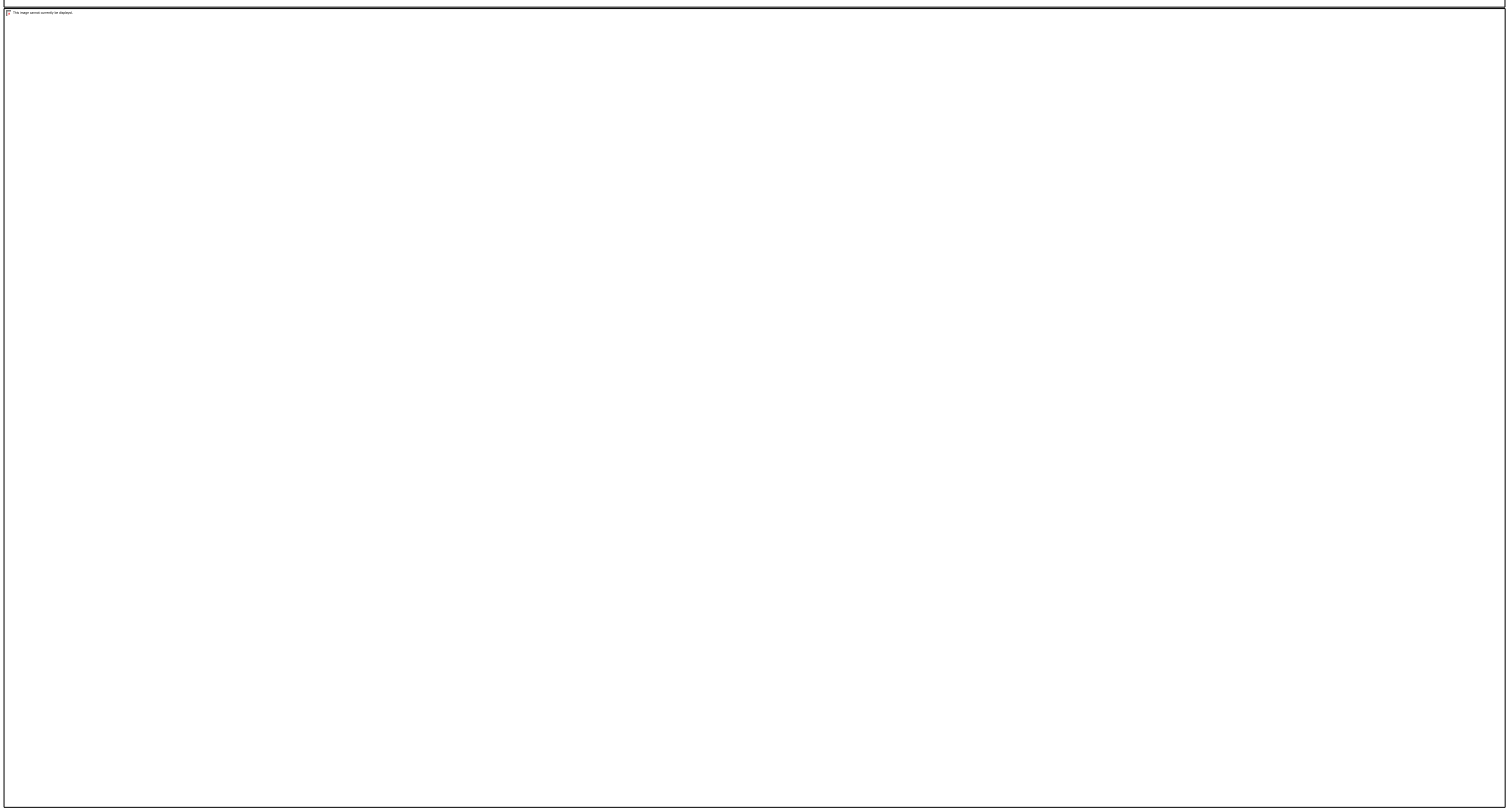
Important: In third-angle projection, the view is placed on the same side of the front view as the direction from which the observer looks.

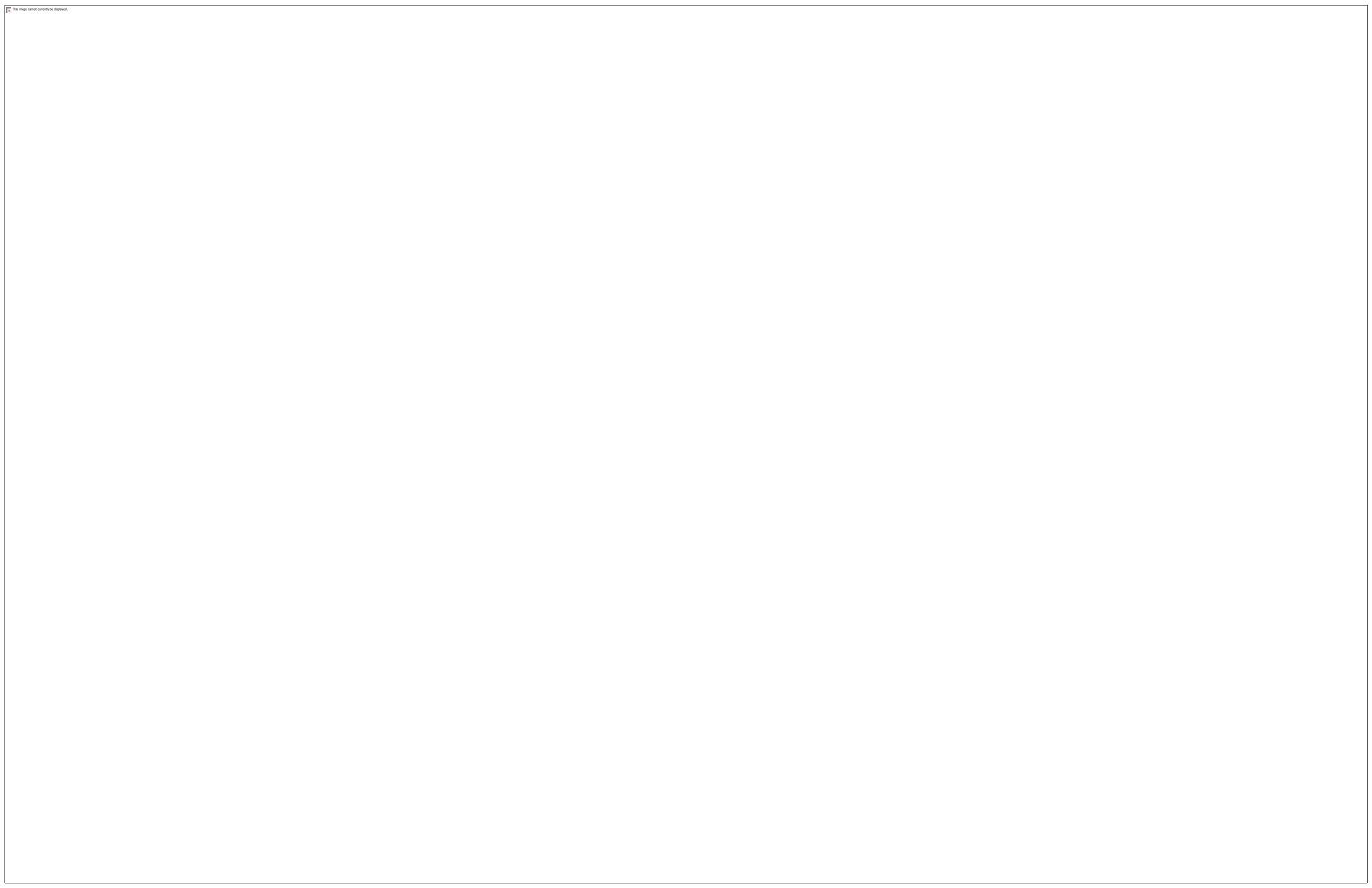
4.3 Differences between first-angle and third-angle orthographic projection

First-angle projection	Third-angle projection
The object is between the observer and the projection plane.	The projection plane is between the observer and the object.
The object is in the first quadrant.	The object is in the third quadrant.
Top view is below the front view.	Top view is above the front view.
Bottom view is above the front view.	Bottom view is below the front view.
Right-side view is on the left of the front view.	Right-side view is on the right of the front view.
Left-side view is on the right of the front view.	Left-side view is on the left of the front view.
Views are arranged opposite to the viewing	Views are arranged on the same side as the

direction.	viewing direction.
Commonly used in many international and European drawing practices.	Commonly used in the United States and Canada.







5.0 DIRECTION OF VIEW IN ORTHOGRAPHIC PROJECTION

5.1 Meaning of direction of view

Direction of view refers to the direction from which an observer looks at an object to obtain a particular orthographic view.

An object can be viewed from different directions to produce different views.

The main directions of viewing are:

1. Front direction.
2. Top direction.
3. Bottom direction.
4. Left-side direction.
5. Right-side direction.
6. Rear direction.

5.2 Front view

Definition

The front view is the view obtained by looking directly at the front of an object.

It is also called the front elevation.

Features of the front view

- It shows the length and height of an object.
- It normally provides the most descriptive view of the object.
- It should be selected to show the most important features.
- It is usually positioned at the centre of the orthographic drawing arrangement.

Example: When drawing a rectangular block, the front view shows its length and height.

5.3 Top view

Definition

The top view is the view obtained by looking vertically downwards at an object.

It is also referred to as the plan view.

Features of the top view

- It shows the length and width of the object.
- It reveals features on the upper surface.
- It helps describe the arrangement of projections, recesses and openings on the top surface.

Example: A learner looking down at a rectangular concrete block sees its length and width.

5.4 Right-side view

Definition

The right-side view is obtained by looking directly at the object from its right-hand side.

Features

- It shows the width and height of the object.
- It reveals features found on the right-hand side.
- It provides information that may not be visible in the front view.

5.5 Left-side view

Definition

The left-side view is obtained by looking directly at the object from its left-hand side.

Features

- It shows the width and height of the object.
- It reveals features found on the left-hand side.
- It helps describe the complete shape of the object.

5.6 Rear view

Definition

The rear view is obtained by looking directly at the back of an object.

Importance

- It shows features located at the back.
- It is useful when the rear of an object has important details.

- It helps describe objects that cannot be adequately represented using only three views.

5.7 Bottom view

Definition

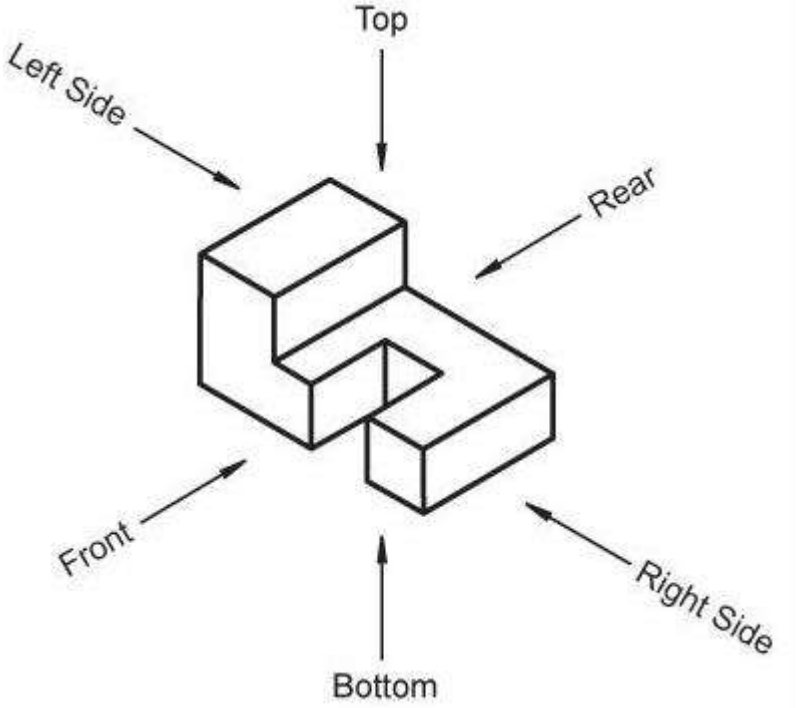
The bottom view is obtained by looking directly upwards at the underside of an object.

Importance

- It shows the shape of the underside.
- It is useful when the bottom surface contains important features.
- It may be required when drawing machine components or specially shaped building elements.

5.8 Summary of the views and dimensions shown

View	Direction of viewing	Main dimensions shown
Front view	From the front	Length and height
Top view	From above	Length and width
Bottom view	From below	Length and width
Right-side view	From the right	Width and height
Left-side view	From the left	Width and height
Rear view	From behind	Length and height



6.0 VIEWS OF SHAPED BLOCKS IN FIRST-ANGLE ORTHOGRAPHIC PROJECTION

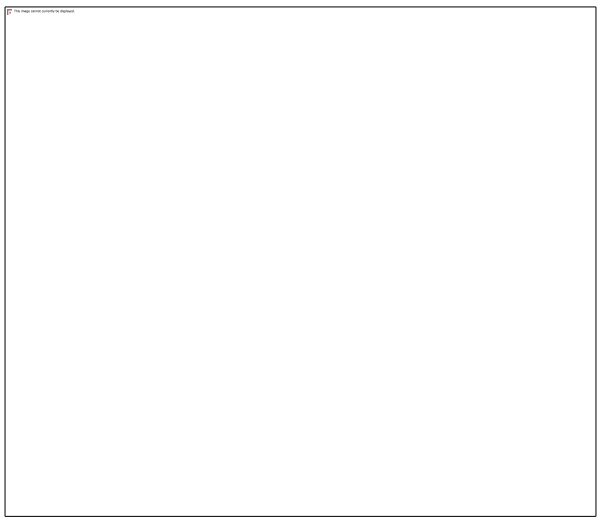
6.1 Meaning of a shaped block

A shaped block is a solid object that has been formed into a particular shape using different surfaces, edges, steps, slopes, projections or recesses.

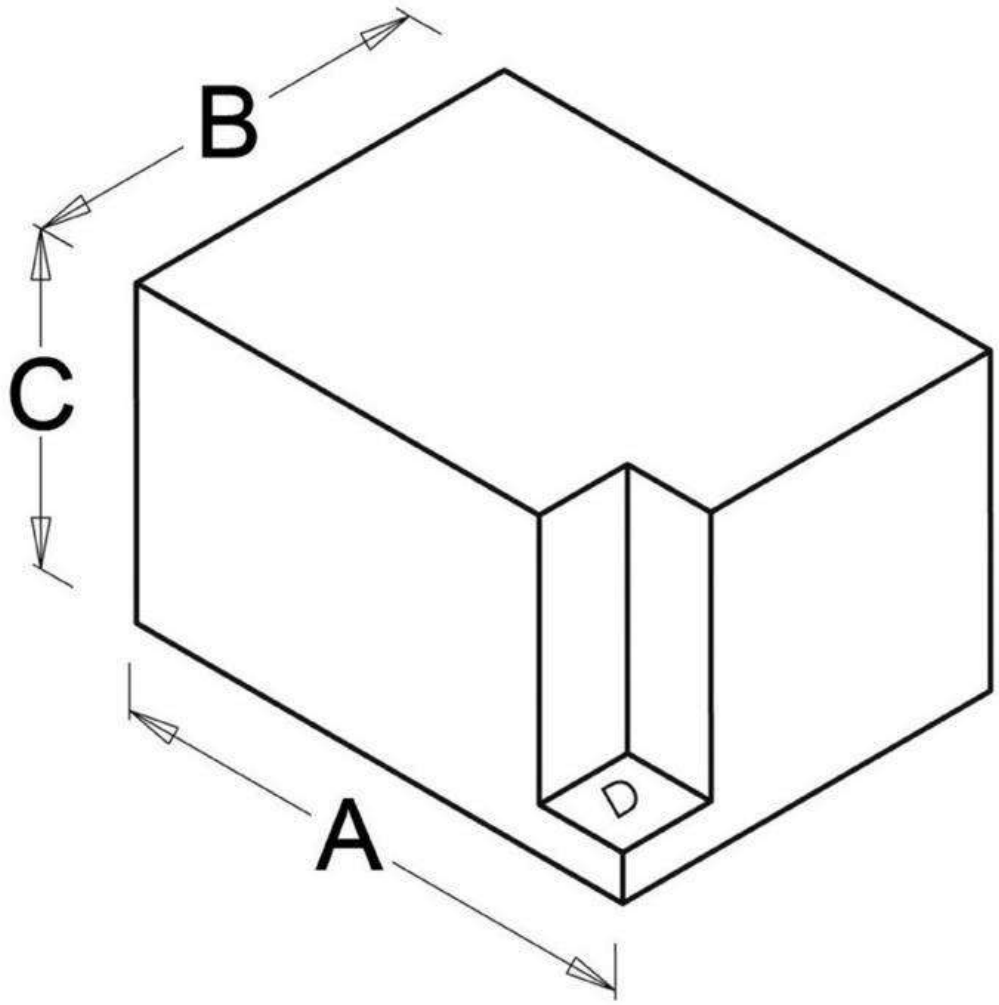
Shaped blocks are useful in learning orthographic projection because they help learners understand how three-dimensional objects are represented using two-dimensional views.

Examples of shaped blocks

1. Rectangular blocks.
2. L-shaped blocks.
3. T-shaped blocks.
4. Stepped blocks.
5. Blocks with rectangular slots.
6. Blocks with rectangular recesses.
7. Blocks with inclined surfaces.
8. Blocks with projecting portions.







6.2 Main views of a shaped block

A shaped block may be represented using three principal views:

- Front view.
- Top view.
- Side view.

These views are normally sufficient to communicate the shape of many simple objects.

A. Front view of a shaped block

The front view:

- Is obtained by looking directly at the front of the block.
- Shows the length and height.
- Reveals the front outline and any visible steps or projections.
- Is normally selected as the principal view.

B. Top view of a shaped block

The top view:

- Is obtained by looking vertically downwards.
- Shows the length and width.
- Reveals the arrangement of features on the upper surface.
- Shows visible edges and outlines of recesses or projections.

C. Side view of a shaped block

The side view:

- Is obtained by looking from either the left or right side.
- Shows the width and height.
- Reveals the side outline of the block.
- Helps identify changes in height, slots and projections.

6.3 Example 1: Orthographic views of a rectangular block

A rectangular block has the following dimensions:

- Length = 80 mm.
- Width = 50 mm.
- Height = 30 mm.

The three principal views are:

Front view

- A rectangle measuring 80 mm by 30 mm.

Top view

- A rectangle measuring 80 mm by 50 mm.

Right-side view

- A rectangle measuring 50 mm by 30 mm.



Explanation

The three views represent the same object from different directions.

- The front and top views share the same length.
- The front and side views share the same height.
- The top and side views share the same width.

These relationships are important when developing and drawing orthographic views.

6.4 Example 2: Orthographic views of an L-shaped block

An L-shaped block consists of two rectangular portions joined together to form an L-shaped profile.

The object may be viewed from the front, top and side to reveal its complete form.

Front view

- Shows the L-shaped outline if the object is positioned with its L-shaped face towards the observer.
- Reveals the height and length of the profile.

Top view

- Shows the footprint of the block.
- Reveals the length and width of the upper surfaces.

Side view

- Shows the width and height.
- Reveals the side profile of the block.



6.5 Example 3: Orthographic views of a stepped block

A stepped block is a solid object with two or more levels of different heights.

Features of a stepped block

- It has horizontal surfaces at different levels.
- It has vertical faces of different heights.
- It may have a uniform or varying width.
- It may be made from concrete, timber, stone or metal.

Views of a stepped block

1. **Front view**
   - Shows the stepped profile.
   - Reveals the different heights and horizontal lengths.
2. **Top view**
   - Shows the plan shape.
   - Reveals the arrangement of the upper surfaces.
3. **Side view**
   - Shows the width and the side profile.
   - May show a rectangular outline if the steps extend uniformly across the width.



6.6 Example 4: Orthographic views of a block with a rectangular slot

A rectangular slot is a narrow rectangular opening or recess formed in a block.

Features

- It may extend completely through the block.
- It may be formed on the top surface or on a side.
- Its position and dimensions must be represented accurately.

Views

- The front view shows the slot if it is visible from the front.
- The top view shows the slot if it opens onto the upper surface.
- The side view shows the slot if its opening or outline is visible from that direction.
- Hidden edges may be represented using dashed lines where required.

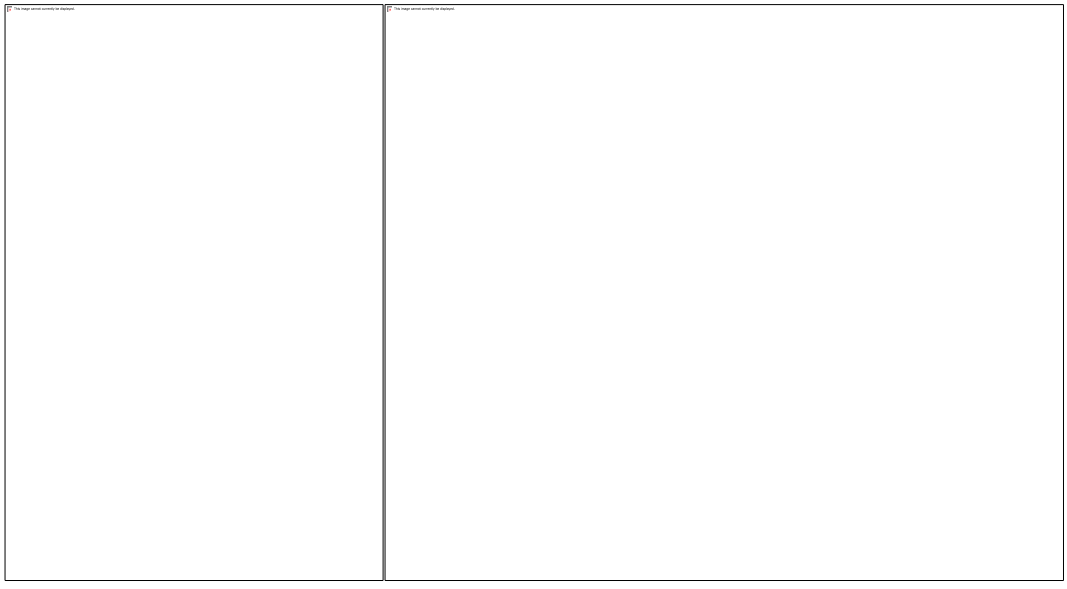


6.7 Example 5: Orthographic views of a block with a rectangular recess

A rectangular recess is a depression formed into the surface of a solid block without necessarily passing completely through it.

Views

- The front view shows the recess when viewed from the front.
- The top view shows the outline and position of the recess when it is on the top surface.
- The side view shows the depth or side profile where visible.
- Hidden edges may be used to represent parts that cannot be seen directly.



7.0 VIEWS OF SHAPED BLOCKS IN THIRD-ANGLE ORTHOGRAPHIC PROJECTION

7.1 Meaning

In third-angle projection, shaped blocks are represented using the same principal views as in first-angle projection. However, the positions of the views on the drawing sheet are different.

The object is viewed from the front, top, bottom or sides, and the views are placed on the drawing sheet according to the third-angle arrangement.

7.2 Arrangement of the three principal views

In third-angle projection:

1. The front view is placed at the centre.
2. The top view is placed above the front view.
3. The bottom view is placed below the front view.
4. The right-side view is placed to the right of the front view.
5. The left-side view is placed to the left of the front view.

7.3 Example 1: Rectangular block in third-angle projection

Consider a rectangular block measuring:

- Length = 80 mm.
- Width = 50 mm.
- Height = 30 mm.

The views are developed as follows:

Front view

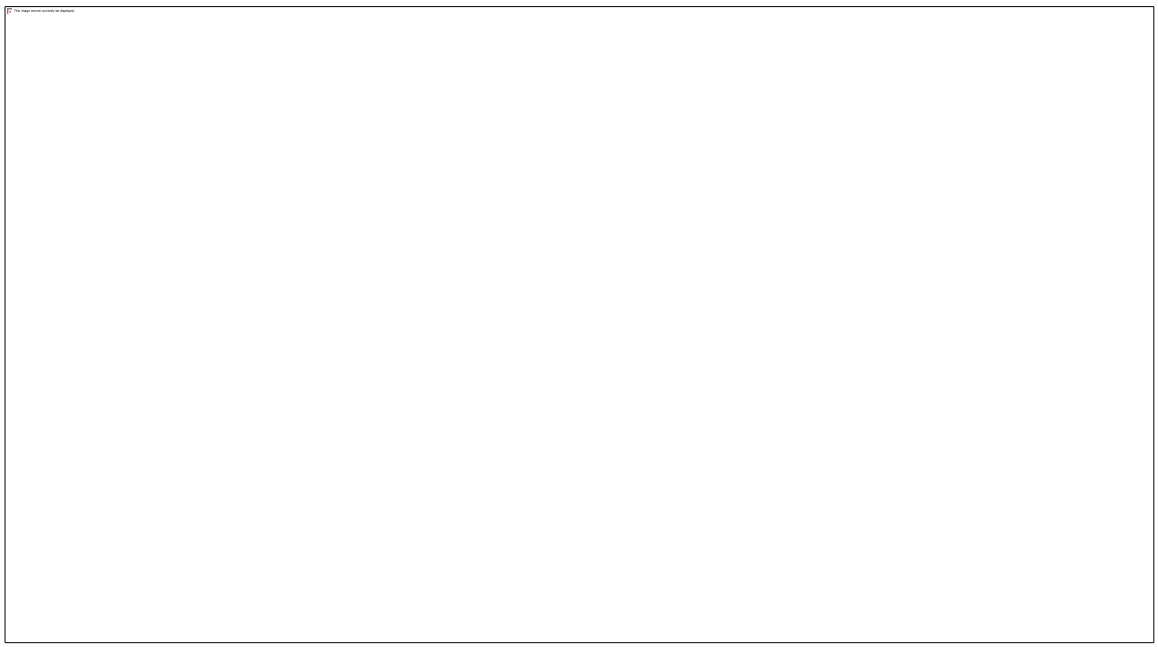
- Draw a rectangle measuring 80 mm by 30 mm.

Top view

- Draw a rectangle measuring 80 mm by 50 mm.
- Place it above the front view.

Right-side view

- Draw a rectangle measuring 50 mm by 30 mm.
- Place it to the right of the front view.



7.4 Example 2: L-shaped block in third-angle projection

The three views of an L-shaped block are developed by observing the object from the front, above and right side.

- The front view shows the L-shaped profile where the L-shaped face is selected as the front.
- The top view reveals the upper footprint.
- The right-side view shows the side profile.

The views are then arranged using the third-angle system.

7.5 Example 3: Stepped block in third-angle projection

To draw a stepped block:

1. Observe the block from the front.
2. Identify the different heights and horizontal lengths.
3. Draw the front view.
4. Project the upper surfaces and edges vertically to develop the top view.
5. Project the side edges to develop the right-side view.
6. Place the top view above the front view.
7. Place the right-side view to the right of the front view.
8. Check that all corresponding dimensions are aligned.

7.6 Important observation

The shape of an individual view does not change simply because the projection method changes. What changes is the **position of that view relative to the front view**.

For example, the top view of the same block:

- Is placed below the front view in first-angle projection.
- Is placed above the front view in third-angle projection.

8.0 SYMBOLS USED IN ORTHOGRAPHIC PROJECTION

8.1 Meaning of projection symbols

Projection symbols are standard technical drawing symbols used to indicate the projection system applied in a drawing.

They help a person reading a technical drawing identify whether the views have been arranged using first-angle or third-angle projection.

The symbols are based on the appearance of a truncated cone (a cone with its top cut off).

8.2 First-angle projection symbol

The first-angle projection symbol consists of:

- A side view of a truncated cone.
- A circular end view positioned to the left of the truncated cone's side view.



Interpretation:

- The circular view represents the end of the truncated cone.
- The other view represents its side.
- The position of the circle on the left identifies the first-angle projection symbol.

8.3 Third-angle projection symbol

The third-angle projection symbol consists of:

- A side view of a truncated cone.
- A circular end view positioned to the right of the truncated cone's side view.



Interpretation:

- The circular view represents the end of the truncated cone.
- The other view represents its side.
- The position of the circle on the right identifies the third-angle projection symbol.

8.4 Differences between the projection symbols

First-angle symbol	Third-angle symbol
Circular end view is on the left.	Circular end view is on the right.
Represents first-angle projection.	Represents third-angle projection.
Indicates first-angle view arrangement.	Indicates third-angle view arrangement.

Important drawing note: The projection symbol should be drawn clearly on a technical drawing, normally in the title block or an appropriate identification area. Use the symbol specified by the applicable drawing standard.

9.0 DEVELOPMENT AND ARRANGEMENT OF ORTHOGRAPHIC VIEWS

9.1 Meaning of developing orthographic views

Developing orthographic views is the process of obtaining the front, top and side views of a three-dimensional object and arranging them correctly on a drawing sheet.

It involves observing the object, identifying its dimensions and transferring its outlines onto the appropriate drawing planes.

9.2 Information required before developing views

Before beginning an orthographic drawing, the learner should identify:

1. The overall length of the object.
2. The overall width of the object.
3. The overall height of the object.
4. The position of projections.
5. The position of recesses.
6. The location of slots and holes.
7. The direction from which the front view will be obtained.
8. The projection system to be used.
9. The drawing scale.
10. The number of views required.

9.3 Procedure for developing orthographic views

The following procedure can be used when drawing a shaped block.

Step 1: Study the object

- Observe the object carefully.

- Identify its overall shape.
- Identify its different surfaces.
- Locate projections, steps, holes, slots and recesses.
- Determine the most informative side to use as the front.

Step 2: Identify the principal dimensions

Measure or obtain the dimensions of the object.

These include:

- Length.
- Width.
- Height.
- Depth of recesses.
- Width of slots.
- Position of holes.
- Height of steps.

All dimensions should be recorded before drawing.

Step 3: Select the drawing scale

A suitable scale should be selected depending on the size of the object and the drawing sheet.

Examples include:

- Full scale: 1:1.
- Half scale: 1:2.
- Quarter scale: 1:4.
- Enlarged scale: 2:1.

The selected scale must be applied consistently to all views.

Step 4: Draw the front view

- Draw the main outline using light construction lines.
- Include the visible steps, projections and recesses.
- Check the length and height.
- Darken the final visible outlines when the drawing is correct.

Step 5: Project the top view

- Use vertical projection lines from the front view.
- Transfer the length and positions of important features.
- Measure the width of the object.
- Complete the top view using the appropriate horizontal and vertical lines.

Step 6: Project the side view

- Transfer the height from the front view.
- Transfer the width from the top view.
- Use suitable projection lines to obtain the side view.
- Complete the visible outline and any important details.

Step 7: Arrange the views

Arrange the views according to the selected projection system.

For first-angle projection:

- Top view below the front view.
- Right-side view to the left of the front view.

For third-angle projection:

- Top view above the front view.
- Right-side view to the right of the front view.

Step 8: Add hidden details

- Use dashed lines to represent edges that are not visible from the direction of viewing.
- Ensure that hidden details correspond correctly across the views.
- Avoid unnecessary hidden lines that make the drawing difficult to interpret.

Step 9: Apply line thickness correctly

- Use thin lines for construction and projection lines.
- Use thick continuous lines for visible outlines.
- Use dashed lines for hidden edges.
- Use suitable centre lines for holes and symmetrical features.

Step 10: Check and complete the drawing

- Check that all views are aligned.
- Confirm that the dimensions agree.
- Erase unnecessary construction lines.
- Add dimensions where required.
- Include the projection symbol.
- Complete the title block.

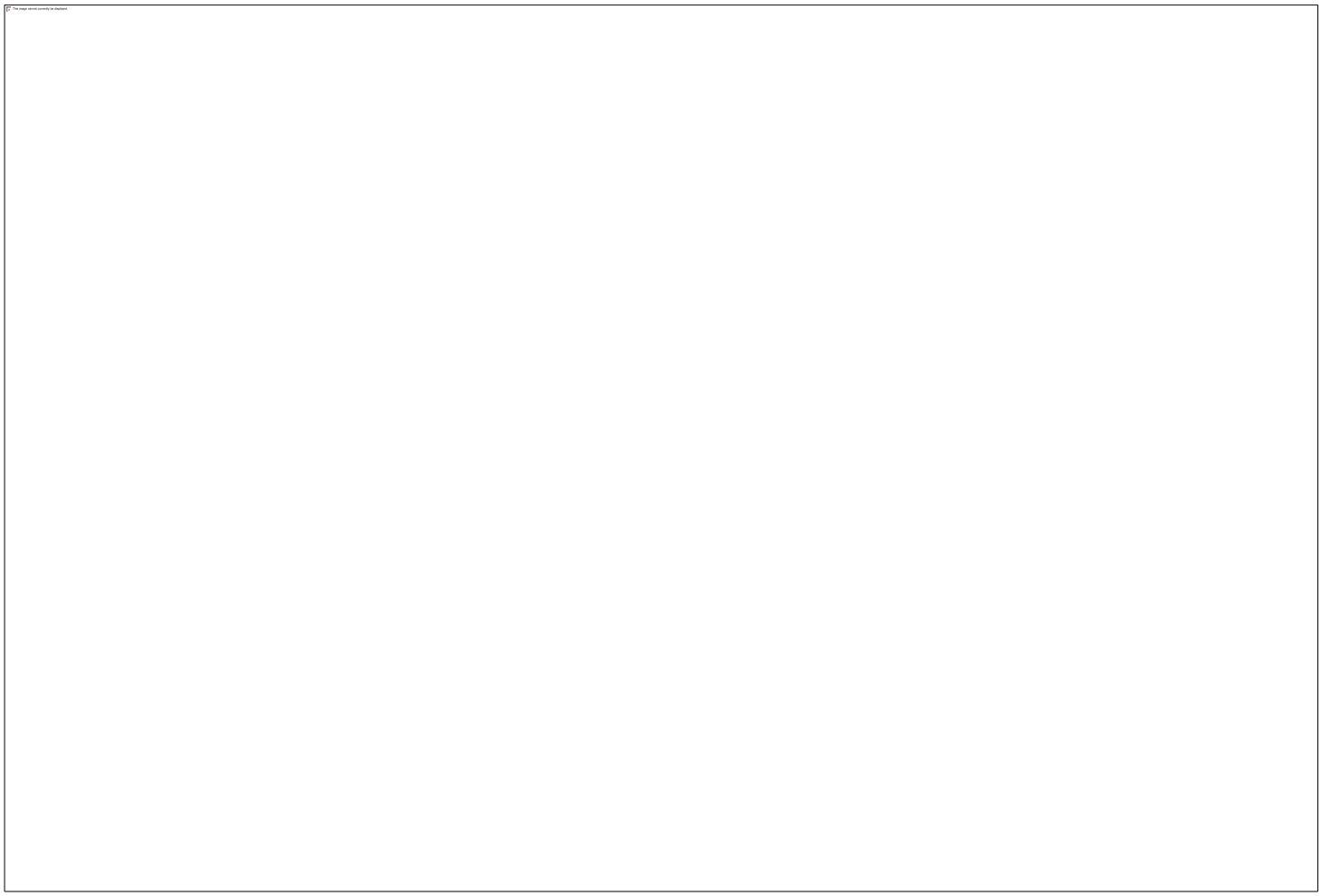
9.4 How views are related and aligned

The views in orthographic projection must be correctly aligned because they represent the same object.

The following relationships should be observed:

1. The front view and top view have the same length.
2. The front view and side view have the same height.
3. The top view and side view have the same width.

4. Corresponding features must occupy matching positions.
5. Projection lines should be used to maintain accuracy.

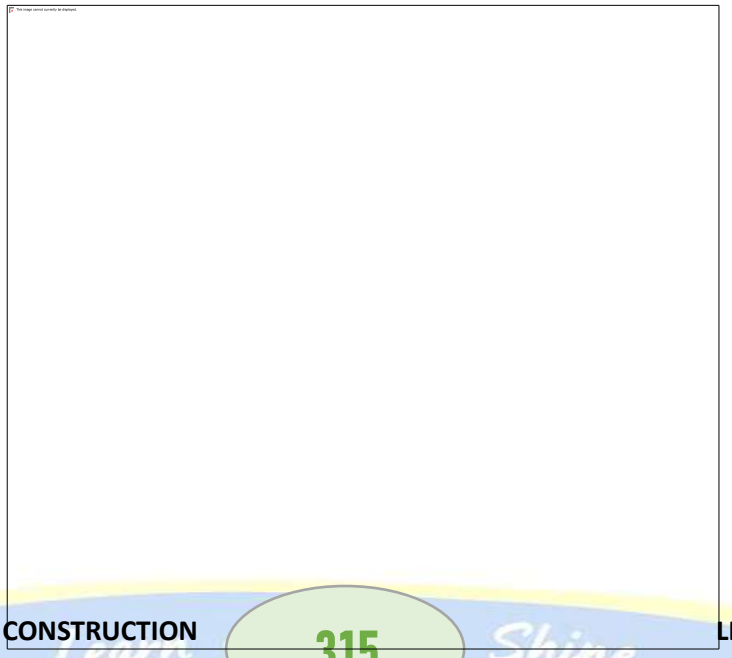


9.5 Transferring measurements between views

When developing three views, measurements must be transferred accurately.

- Length is transferred between the front and top views.
- Height is transferred between the front and side views.
- Width is transferred between the top and side views.

A 45-degree mitre line may be used in traditional technical drawing to transfer measurements between the top and side views.



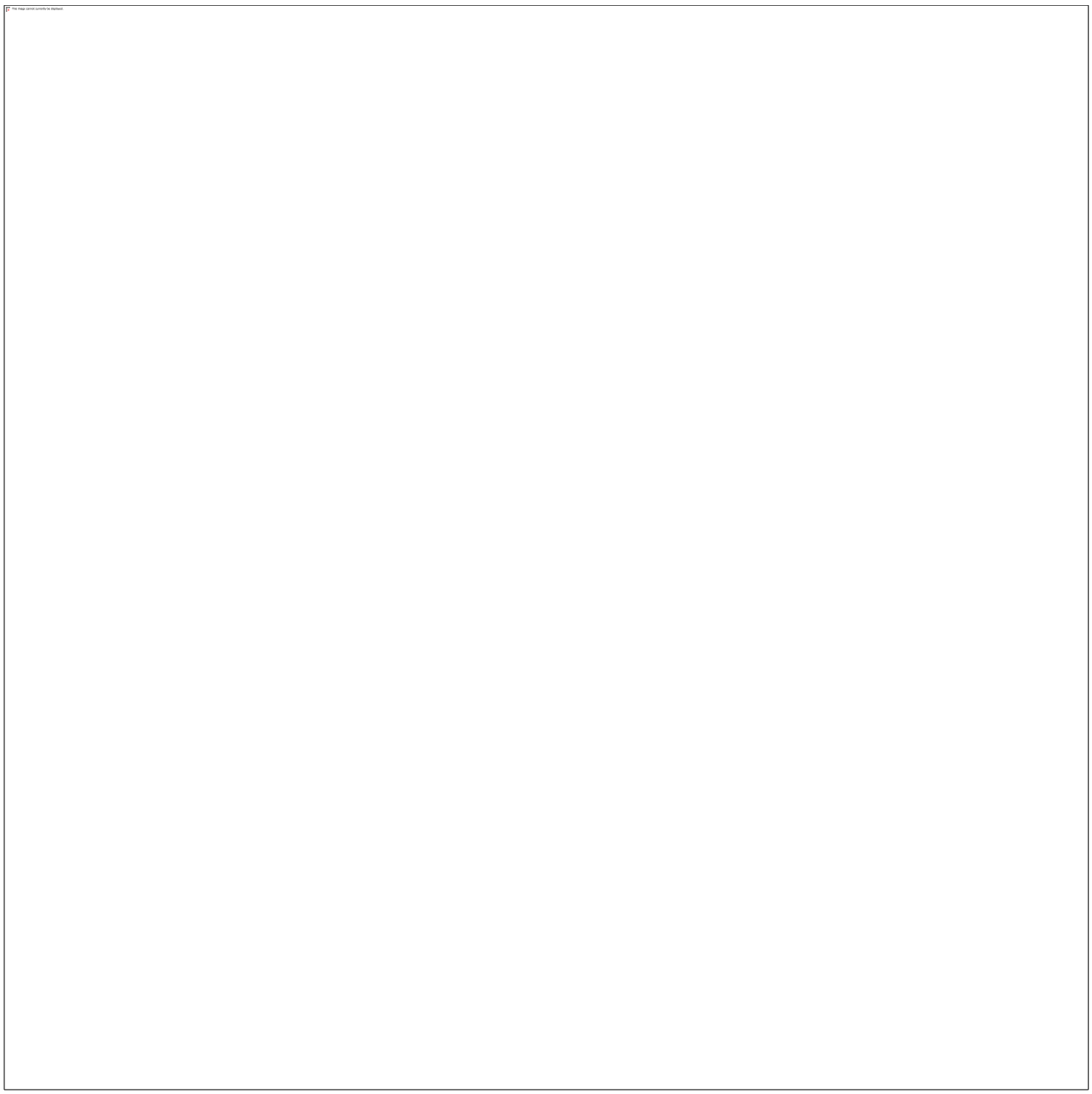
Importance of the 45-degree mitre line

1. It helps transfer measurements from the top view to the side view.
2. It maintains accuracy when developing the side view.
3. It reduces errors in transferring widths.
4. It helps keep corresponding features correctly positioned.

10.0 DRAWING INSTRUMENTS AND MATERIALS USED IN ORTHOGRAPHIC PROJECTION

Orthographic drawings require suitable drawing instruments to achieve accuracy, neatness and clarity.

10.1 Drawing board

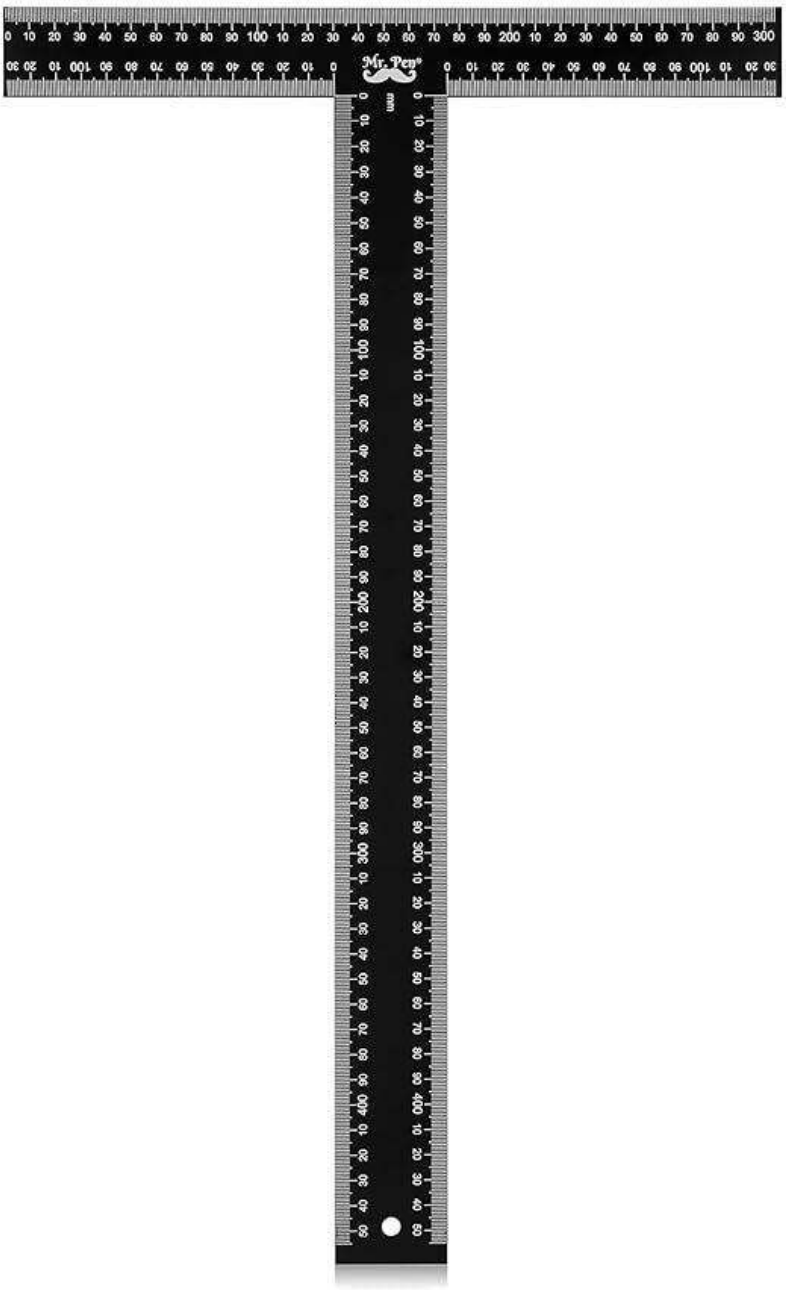


Functions:

- Provides a flat working surface.

- Supports the drawing paper.
- Helps produce accurate technical drawings.

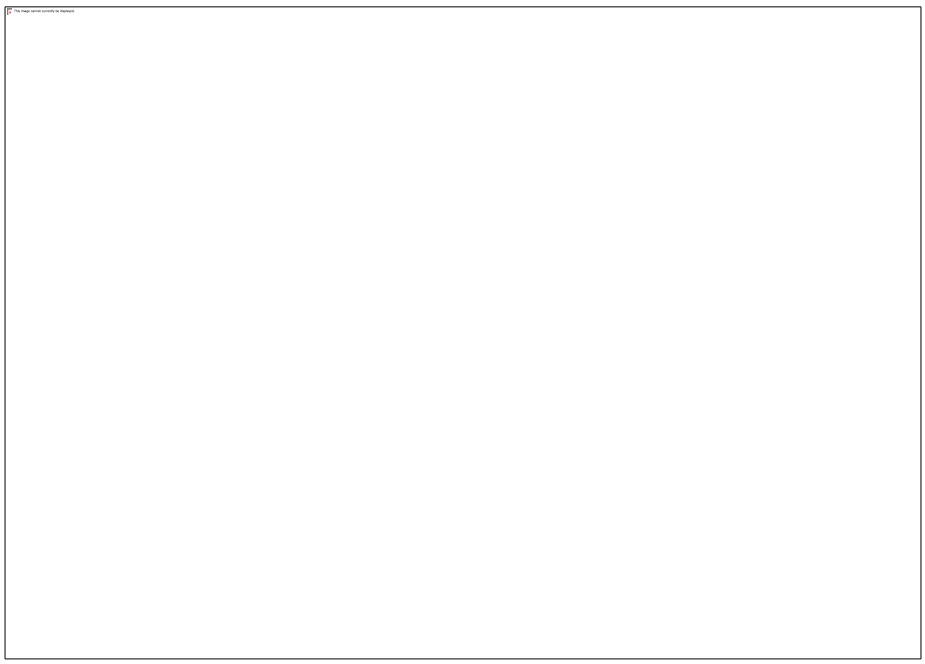
10.2 T-square



Functions:

- Used for drawing horizontal lines.
- Supports set squares when drawing vertical and inclined lines.
- Helps maintain straight and parallel lines.

10.3 Set squares



Functions:

- Used for drawing vertical lines.
- Used for drawing lines at 30°, 45°, 60° and 90°.
- Help construct accurate geometric shapes.

10.4 Scale rule



Functions:

- Used for measuring dimensions.
- Used for drawing objects to a selected scale.
- Helps reduce or enlarge dimensions accurately.

10.5 Drawing pencils



Functions:

- Used for drawing construction lines.
- Used for drawing visible outlines.
- Different grades provide different line darkness.

Common pencil grades include:

- 2H: Produces light and fine lines.
- H: Produces relatively light lines.
- HB: Produces medium-dark lines.
- B: Produces darker lines.

10.6 Drawing compass

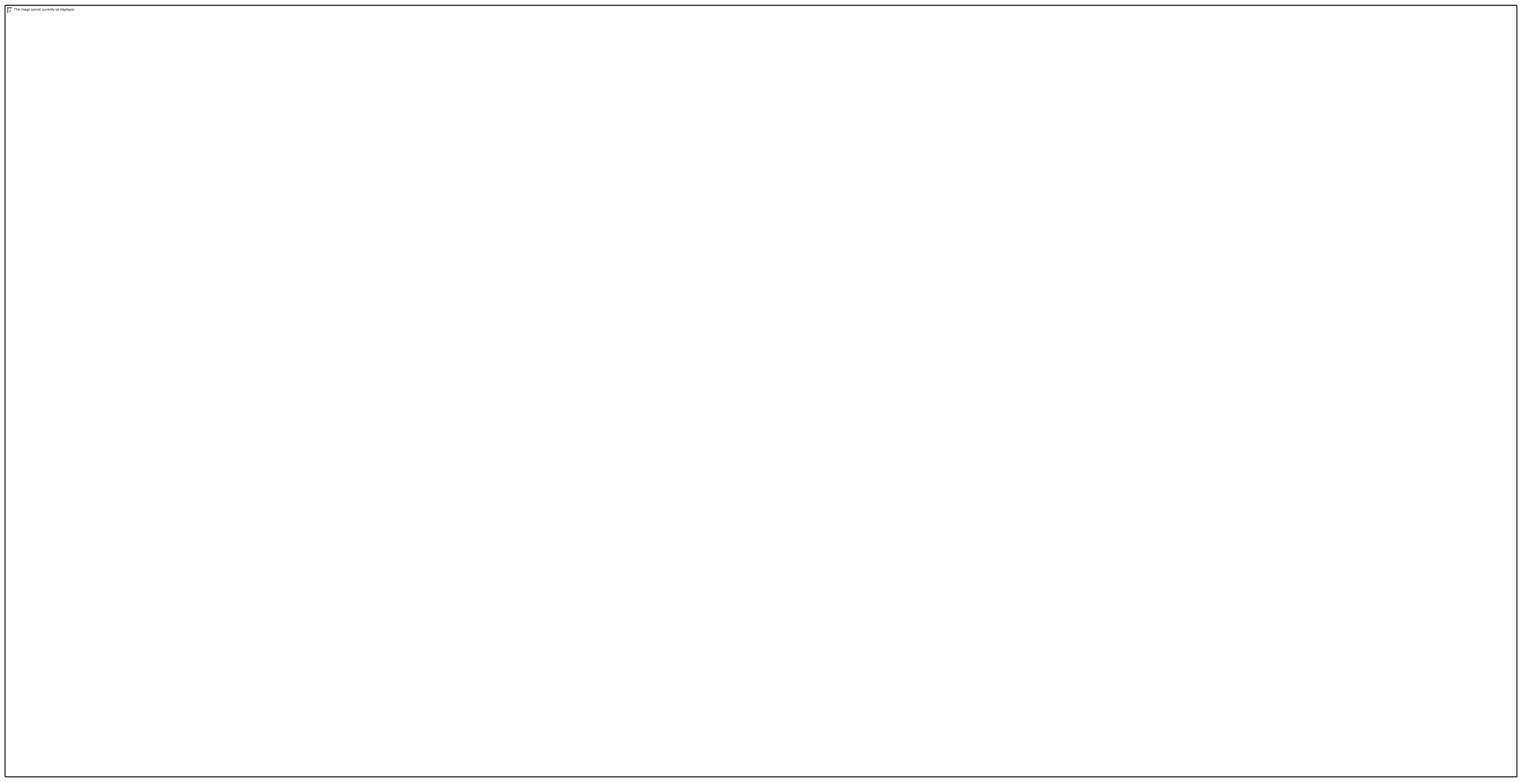


Functions:

- Used for drawing circles.

- Used for drawing arcs.
- Used for transferring distances where appropriate.

10.7 Protractor



Functions:

- Used for measuring angles.
- Used for setting out angles.
- Helps check inclined features.

10.8 Eraser

Functions:

- Removes unwanted pencil marks.
- Helps correct mistakes.
- Improves the neatness of the drawing.

10.9 Drawing paper

Functions:

- Provides the surface on which the drawing is produced.
- Holds drawing lines and dimensions.
- May be available in different standard sizes.

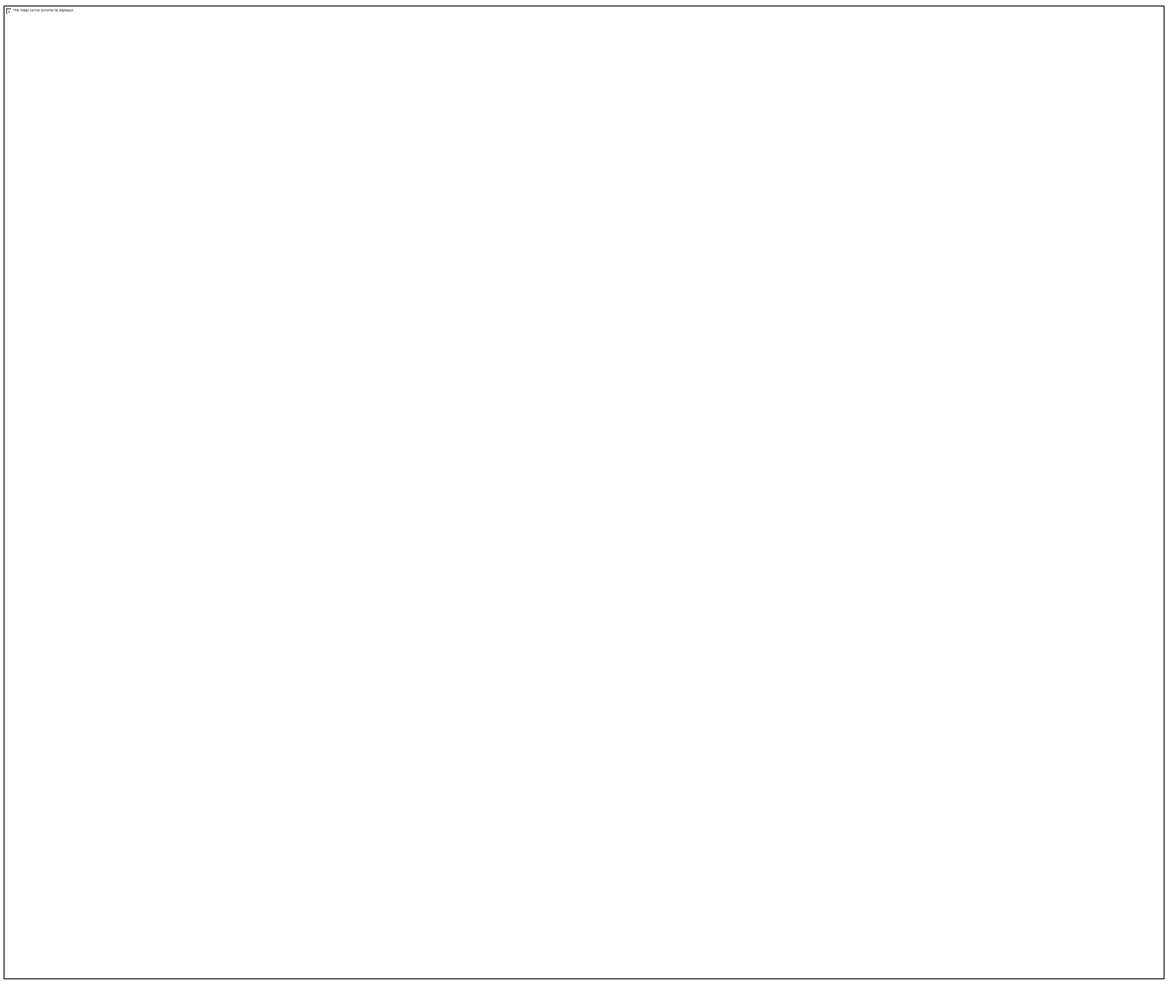
10.10 Drawing instruments care and safety

1. Keep instruments clean and dry.
2. Store sharp instruments safely.
3. Avoid dropping set squares and rulers.
4. Keep pencil points sharp.
5. Avoid excessive pressure when drawing construction lines.
6. Do not use damaged rulers or set squares.
7. Keep the drawing area organised.
8. Use instruments for their intended purposes.

11.0 TYPES OF LINES USED IN ORTHOGRAPHIC DRAWING

Different line types are used to communicate different features of an object.

Line type	Appearance	Main use
Continuous thick line	Dark, unbroken line	Visible outlines and edges
Continuous thin line	Light, unbroken line	Dimension lines, projection lines and extension lines
Dashed thin line	Short, regularly spaced dashes	Hidden edges and hidden details
Chain thin line	Long and short alternating dashes	Centre lines and axes of symmetrical features
Freehand thin line	Irregular continuous line	Short break lines
Zigzag thin line	Repeated zigzag pattern	Long break lines



11.1 Visible lines

- These are continuous thick lines.
- They represent edges and outlines that can be seen directly.
- They define the visible shape of the object.

11.2 Hidden lines

- These are usually thin dashed lines.
- They represent edges that cannot be seen directly from a particular viewing direction.
- They are useful for showing holes, slots and internal features.

11.3 Centre lines

- These are usually thin chain lines.
- They indicate the centre of circular or symmetrical features.
- They are useful when drawing holes, shafts and cylindrical components.

11.4 Dimension lines

- These are thin continuous lines.
- They indicate the distance between two points.
- They usually have arrowheads at both ends.

11.5 Extension lines

- These are thin continuous lines.
- They extend from the object to indicate the limits of a dimension.
- They help position dimension lines clearly.

11.6 Construction and projection lines

- These are thin light lines.
- They help transfer measurements between views.
- They are normally made less prominent than the final visible outlines.

12.0 DIMENSIONING IN ORTHOGRAPHIC DRAWING

12.1 Meaning of dimensioning

Dimensioning is the process of indicating the sizes and measurements of an object on a technical drawing.

It communicates the actual dimensions required when producing or constructing an object.

12.2 Common dimensions

1. Length.
2. Width.
3. Height.
4. Depth.
5. Diameter.
6. Radius.
7. Angle.
8. Distance between features.

12.3 Rules for dimensioning

1. Use clear and readable figures.
2. Use suitable dimension lines.
3. Avoid unnecessary repetition of dimensions.
4. Place dimensions where they can be read easily.
5. Avoid placing dimensions inside the object unless necessary.
6. Do not allow dimension lines to cross unnecessarily.
7. Use millimetres for many engineering and technical drawings unless another unit is specified.
8. Indicate the scale of the drawing.
9. Ensure dimensions agree across the different views.
10. Do not measure dimensions from an inaccurate or distorted view when actual measurements are provided.

12.4 Example of dimensioning a rectangular block

A rectangular block has:

- Length = 100 mm.
- Width = 60 mm.
- Height = 40 mm.

The front view is dimensioned using the length and height. The top view is dimensioned using the length and width. The side view is dimensioned using the width and height.

PRACTICAL APPLICATION OF ORTHOGRAPHIC PROJECTION IN BUILDING CONSTRUCTION

Orthographic projection is used in many areas of the construction industry.

13.1 Drawing building components

It is used to represent:

- Concrete blocks.
- Door frames.
- Window frames.
- Timber components.
- Staircase parts.
- Roof components.
- Foundation components.

13.2 Drawing building elevations

It is used to prepare:

- Front elevations.
- Rear elevations.
- Left-side elevations.
- Right-side elevations.

These drawings show the external appearance of a building from different directions.

13.3 Preparing floor plans

The plan view is an important orthographic representation in building drawing.

It shows:

- Arrangement of rooms.
- Wall positions.
- Door openings.
- Window positions.
- Corridors.
- Staircases.
- Other building features.

13.4 Drawing construction details

Orthographic projection is used to prepare detailed drawings of:

- Wall junctions.
- Foundation sections.
- Door and window details.
- Roof connections.
- Staircase construction.
- Reinforced concrete components.

13.5 Producing building components

Technicians and artisans use technical drawings to produce components accurately.

Examples include:

- Cutting timber to specified dimensions.
- Fabricating metal window frames.
- Producing concrete moulds.
- Preparing precast concrete elements.
- Fabricating steel roof trusses.

13.6 Using orthographic projection in CAD

Computer-aided design applications allow learners and professionals to prepare accurate orthographic drawings.

Examples of software include:

- AutoCAD.
- FreeCAD.
- LibreCAD.

- Autodesk Fusion.

The software used should be appropriate to the learner's level and available school resources.

14.0 COMMON ERRORS IN ORTHOGRAPHIC PROJECTION AND HOW TO AVOID THEM

Common error	How to avoid it
Placing the top view in the wrong position	First identify whether the drawing uses first-angle or third-angle projection.
Placing the side view on the wrong side	Follow the correct arrangement of views.
Drawing views that are not aligned	Use projection lines to transfer measurements accurately.
Using incorrect dimensions	Measure the object carefully and check all dimensions.
Drawing visible edges using dashed lines	Use continuous thick lines for visible edges.
Drawing hidden edges using continuous thick lines	Use thin dashed lines for hidden edges.
Selecting an unsuitable front view	Choose the side that reveals the most important features.
Using different scales for different views	Apply the same scale consistently unless otherwise specified.
Making construction lines too dark	Use a light pencil for construction lines.
Omitting the projection symbol	Include the correct projection symbol in the drawing information.

15.0 PRACTICAL LEARNING ACTIVITIES

Activity 1: Identifying the views of a shaped block

Materials required:

- A rectangular wooden block or concrete block.
- Drawing paper.
- Pencil.
- Ruler.
- Set square.
- Eraser.

Procedure:

1. Obtain a rectangular block.
2. Place it on a flat surface.
3. Observe it from the front.
4. Draw its front view.
5. Observe it from above.
6. Draw its top view.

7. Observe it from the right side.
8. Draw its right-side view.
9. Compare the three views.
10. Identify the dimensions represented in each view.

Expected learning outcome: The learner should be able to identify the front, top and side views of a simple three-dimensional object.

Activity 2: Drawing a block using first-angle projection

Materials required:

- Drawing board.
- Drawing paper.
- T-square.
- Set squares.
- Scale rule.
- Pencils.
- Eraser.
- Rectangular block.

Object dimensions:

- Length: 80 mm.
- Width: 50 mm.
- Height: 30 mm.

Procedure:

1. Observe the rectangular block.

2. Identify the front view.
3. Draw the front view as a rectangle measuring 80 mm by 30 mm.
4. Project the top view below the front view.
5. Draw the top view measuring 80 mm by 50 mm.
6. Develop the right-side view.
7. Place the right-side view to the left of the front view.
8. Check the alignment of the three views.
9. Add dimensions.
10. Insert the first-angle projection symbol.

Activity 3: Drawing a block using third-angle projection

Use the same rectangular block measuring 80 mm by 50 mm by 30 mm.

Procedure:

1. Draw the front view at the centre.
2. Draw the top view above the front view.
3. Draw the right-side view to the right of the front view.
4. Ensure that all corresponding dimensions are aligned.
5. Add dimensions.
6. Insert the third-angle projection symbol.

Expected learning outcome: The learner should be able to produce and compare first-angle and third-angle drawings of the same object.

Activity 4: Drawing a stepped block

1. Obtain or make a simple stepped block using cardboard, wood or modelling material.
2. Observe its shape from different directions.
3. Identify its length, width and height.
4. Draw the front view.

5. Develop the top view.
6. Develop the right-side view.
7. Arrange the views using first-angle projection.
8. Repeat the exercise using third-angle projection.
9. Compare the two drawings.
10. Present the completed work for assessment.

REVISION QUESTIONS

SECTION A: MULTIPLE-CHOICE QUESTIONS

INSTRUCTIONS: Choose the correct answer from the alternatives provided.

Question 1. Orthographic projection is a method of drawing used to represent:

A. Two-dimensional objects in three dimensions
B. Three-dimensional objects using two-dimensional views
C. Objects using only pictorial drawings
D. Objects using freehand sketches only

Question 2. Which of the following best describes orthographic projection?

A. Projectors meet the projection plane at an angle of 45°.
B. Projectors converge at a single point.
C. Parallel projectors meet the projection plane at right angles.
D. Objects are represented using perspective lines.

Question 3. The view obtained by looking directly at an object from above is called:

A. Front view
B. Rear view
C. Top view
D. Side view

Question 4. Which dimensions are mainly represented by the front view?

A. Length and height
B. Length and width
C. Width and depth
D. Width and height

Question 5. In first-angle projection, the top view is positioned:

A. Above the front view
B. Below the front view
C. To the right of the front view
D. To the left of the front view

Question 6. In third-angle projection, the top view is positioned:

A. Below the front view
B. To the left of the front view
C. Above the front view
D. Behind the front view

Question 7. In first-angle projection, the right-side view is placed:

A. To the right of the front view
B. To the left of the front view
C. Above the front view
D. Below the front view

Question 8. In third-angle projection, the right-side view is placed:

A. To the left of the front view
B. Above the front view
C. Below the front view
D. To the right of the front view

Question 9. Which of the following is a role of orthographic projection in building construction?

A. Decorating building walls
B. Communicating accurate construction dimensions
C. Mixing concrete
D. Transporting construction materials

Question 10. Which of the following represents the first-angle projection system?

A. The projection plane is between the observer and the object.
B. The object is between the observer and the projection plane.
C. The object is behind the observer.
D. The observer is positioned below the projection plane.

Question 11. The view obtained by looking directly at the right-hand side of an object is called:

A. Front view
B. Top view
C. Right-side view
D. Bottom view

Question 12. Which instrument is commonly used to draw horizontal lines?

A. Compass
B. T-square
C. Protractor
D. Divider

Question 13. A set square is mainly used for drawing:

A. Circles only
B. Horizontal dimensions only
C. Vertical and inclined lines
D. Curved outlines only

Question 14. Which type of line is used to represent visible outlines?

A. Dashed thin line
B. Continuous thick line
C. Chain thin line
D. Freehand thin line

Question 15. Hidden edges are normally represented using:

A. Continuous thick lines
B. Continuous thin lines
C. Dashed thin lines
D. Zigzag lines

Question 16. The front and top views of an object share the same:

A. Width
B. Height
C. Length
D. Depth only

Question 17. The front and side views of an object share the same:

A. Height
B. Length
C. Width
D. Area

Question 18. The top and side views of an object share the same:

A. Height
B. Width
C. Length
D. Front elevation

Question 19. The symbol for first-angle projection is based on the representation of:

A. A cylinder
B. A sphere
C. A truncated cone
D. A rectangular prism

Question 20. Which of the following is an example of CAD software used in technical drawing?

A. Microsoft Excel
B. AutoCAD
C. Microsoft Word
D. PowerPoint

Question 21. The right-side view of an object mainly shows:

A. Length and height
B. Width and height
C. Length and width
D. Length and depth

Question 22. A 45-degree mitre line is useful when:

A. Drawing circles
B. Transferring measurements between views
C. Erasing construction lines
D. Drawing dimension arrows

Question 23. Which of the following is a characteristic of third-angle projection?

A. The top view is below the front view.
B. The right-side view is to the left of the front view.
C. The top view is above the front view.
D. The left-side view is to the right of the front view.

Question 24. Which view of an object is obtained by looking directly from behind?

A. Rear view
B. Front view
C. Top view
D. Bottom view

Question 25. A rectangular block has a length of 80 mm, width of 50 mm and height of 30 mm. What will be the dimensions of its front view?

A. 80 mm by 50 mm
B. 50 mm by 30 mm
C. 80 mm by 30 mm
D. 30 mm by 50 mm

Question 26. Which of the following is a major reason for using orthographic projection?

A. To make objects appear larger
B. To show accurate shapes and dimensions
C. To decorate technical drawings
D. To avoid using drawing instruments

Question 27. In first-angle projection, the left-side view is positioned:

A. To the left of the front view
B. To the right of the front view
C. Above the front view
D. Below the front view

Question 28. In third-angle projection, the left-side view is positioned:

A. To the right of the front view
B. Below the front view
C. To the left of the front view
D. Above the front view

Question 29. Which instrument is used to measure and construct angles?

A. T-square
B. Protractor
C. Eraser
D. Drawing board

Question 30. A learner is drawing a building component and wants to show its front, top and side clearly. Which drawing method is most suitable?

A. Freehand pictorial drawing only
B. Perspective drawing only
C. Orthographic projection
D. Decorative drawing

SECTION B: STRUCTURED QUESTIONS

Question 1.

a) Define orthographic projection. (2 marks)

b) Explain four principles of orthographic projection. (8 marks)

c) State five roles of orthographic projection in building construction. (5 marks)

Question 2.

a) Name the two main types of orthographic projection. (2 marks)

b) Explain the meaning of first-angle projection. (3 marks)

c) Explain the meaning of third-angle projection. (3 marks)

d) State four differences between first-angle and third-angle projection. (8 marks)

Question 3.

a) Define the term direction of view. (2 marks)

b) Explain the following views of an object:

i. Front view. (2 marks)

ii. Top view. (2 marks)

iii. Right-side view. (2 marks)

iv. Rear view. (2 marks)

Question 4.

a) State the positions of the following views in first-angle projection:

i. Top view. (1 mark)

ii. Bottom view. (1 mark)

iii. Right-side view. (1 mark)

iv. Left-side view. (1 mark)

b) State the positions of the same views in third-angle projection. (4 marks)

Question 5.

Explain six roles of orthographic projection in the building construction industry. (12 marks)

Question 6.

a) What is a projection plane? (2 marks)

b) Name three principal projection planes. (3 marks)

c) Explain the function of projectors in orthographic projection. (3 marks)

Question 7.

State the dimensions represented by each of the following views:

a) Front view. (2 marks)

b) Top view. (2 marks)

c) Side view. (2 marks)

Question 8.

Identify six drawing instruments used in orthographic projection and explain one function of each. (12 marks)

Question 9.

a) What is a projection symbol? (2 marks)

b) Describe the symbol used to represent first-angle projection. (3 marks)

c) Describe the symbol used to represent third-angle projection. (3 marks)

Question 10.

State and explain five types of lines used in orthographic drawing. (10 marks)

Question 11.

Explain the procedure followed when developing the front, top and side views of a shaped block. (10 marks)

Question 12.

Explain five common errors made when drawing orthographic projections and state how each error can be avoided. (10 marks)

Question 13.

Explain the importance of correct alignment of views in orthographic projection. (6 marks)

Question 14.

Describe the use of a 45-degree mitre line when developing orthographic views. (4 marks)

Question 15.

Explain five ways in which orthographic projection supports quality control in building construction. (10 marks)

SECTION C: COMPETENCY-BASED APPLICATION QUESTIONS

Question 1: Drawing a Concrete Block

A construction learner is given a rectangular concrete block measuring 100 mm long, 60 mm wide and 40 mm high. The learner is required to prepare its orthographic drawing.

Tasks

a) Identify the three principal views required. (3 marks)

b) State the dimensions shown in each view. (3 marks)

c) Describe how the three views should be arranged using first-angle projection. (3 marks)

d) Explain how the views would be arranged using third-angle projection. (3 marks)

e) State four drawing instruments required for the task. (4 marks)

Question 2: Interpreting a Technical Drawing

A building technician receives a drawing of a shaped concrete component. The drawing has its top view above the front view and its right-side view to the right of the front view.

Tasks

a) Identify the projection system used. (1 mark)

b) Give a reason for your answer. (2 marks)

c) Explain how the views would be arranged if the drawing were changed to first-angle projection. (4 marks)

d) State three reasons why the technician should follow the correct projection arrangement. (3 marks)

Question 3: A School Workshop Activity

A Grade 11 learner makes a stepped block using pieces of timber. The learner is required to draw its orthographic views.

Tasks

a) State four observations the learner should make before drawing. (4 marks)

b) Describe the procedure for obtaining the front view. (3 marks)

c) Explain how the top view can be developed. (3 marks)

d) State three precautions the learner should observe when using drawing instruments. (3 marks)

Question 4: Application in a Building Project

A building contractor wants to manufacture a special concrete component for use in a construction project. The contractor provides the artisan with only a pictorial sketch.

Tasks

a) Explain why the pictorial sketch may not provide sufficient construction information. (3 marks)

b) Explain how orthographic projection can assist the artisan. (4 marks)

c) Identify four views that may be required to describe the component fully. (4 marks)

d) State four benefits of using accurate orthographic drawings during production. (4 marks)

PRACTICAL PROJECT AND ASSESSMENT

Project: Preparation of orthographic drawings of shaped blocks

Project objective: To develop the learner's ability to observe three-dimensional objects and represent them accurately using first-angle and third-angle orthographic projection.

Materials and equipment

- Rectangular wooden blocks.
- Cardboard.
- Modelling clay.
- Drawing paper.
- Drawing board.
- T-square.
- Set squares.
- Scale rule.
- Drawing pencils.
- Eraser.
- Ruler.

Project procedure

1. Make a rectangular block using cardboard or modelling material.
2. Make a second block with a stepped shape.
3. Observe each block from the front, top and right side.
4. Record the overall dimensions.
5. Draw the three principal views using first-angle projection.
6. Draw the same views using third-angle projection.
7. Insert the correct projection symbols.
8. Add dimensions to the drawings.
9. Label each view correctly.
10. Submit the completed drawings for assessment.

Suggested assessment rubric

Assessment area	**Marks**
Correct identification of views	10
Accuracy of dimensions	15
Correct first-angle arrangement	15
Correct third-angle arrangement	15
Appropriate use of drawing instruments	10
Correct line types and thickness	10
Correct projection symbols	10
Neatness and presentation	10
Labelling and completeness	5

Total	100

SUMMARY OF KEY POINTS

1. Orthographic projection represents three-dimensional objects using two-dimensional views.
2. The two main systems are first-angle and third-angle projection.
3. First-angle projection places the object between the observer and the projection plane.
4. Third-angle projection places the projection plane between the observer and the object.
5. In first-angle projection, the top view is below the front view.
6. In third-angle projection, the top view is above the front view.
7. In first-angle projection, the right-side view is placed to the left of the front view.
8. In third-angle projection, the right-side view is placed to the right of the front view.
9. The front view shows length and height.
10. The top view shows length and width.
11. The side view shows width and height.
12. Projection symbols identify the projection system used.
13. Correct alignment is essential when developing views.
14. Visible edges are represented using continuous thick lines.
15. Hidden edges are represented using dashed thin lines.

16. Orthographic projection supports accurate communication, construction, manufacturing and quality control.

STRAND 2.0: RELATED DRAWING

SUB-STRAND 2.2: COMPUTER-AIDED DRAWING (CAD)

Introduction

Computer-Aided Drawing (CAD) is an important technology in modern building construction. It enables construction professionals to prepare accurate technical drawings using computers and specialised software instead of relying entirely on manual drawing instruments.

In the construction industry, CAD is used to prepare building plans, elevations, sections, construction details, structural drawings and three-dimensional models. It helps architects, engineers, technicians, artisans and contractors communicate construction ideas accurately.

CAD also enables learners to develop three-dimensional representations of building components. For example, a learner can create a rectangular concrete block, modify it into a stepped block, and represent it using isometric or oblique projection.

In Kenya, CAD skills are useful in architectural design offices, construction companies, technical institutions, engineering workshops and building technology departments.

This sub-strand introduces learners to the CAD environment, setting up a drawing, drawing limits, units, scale, grid settings, three-dimensional drawing, isometric projection and oblique projection.

1.0 MEANING OF COMPUTER-AIDED DRAWING

1.1 Definition of Computer-Aided Drawing

Computer-Aided Drawing (CAD) is the use of computer hardware and specialised software to create, modify, store, display, manage and print technical drawings.



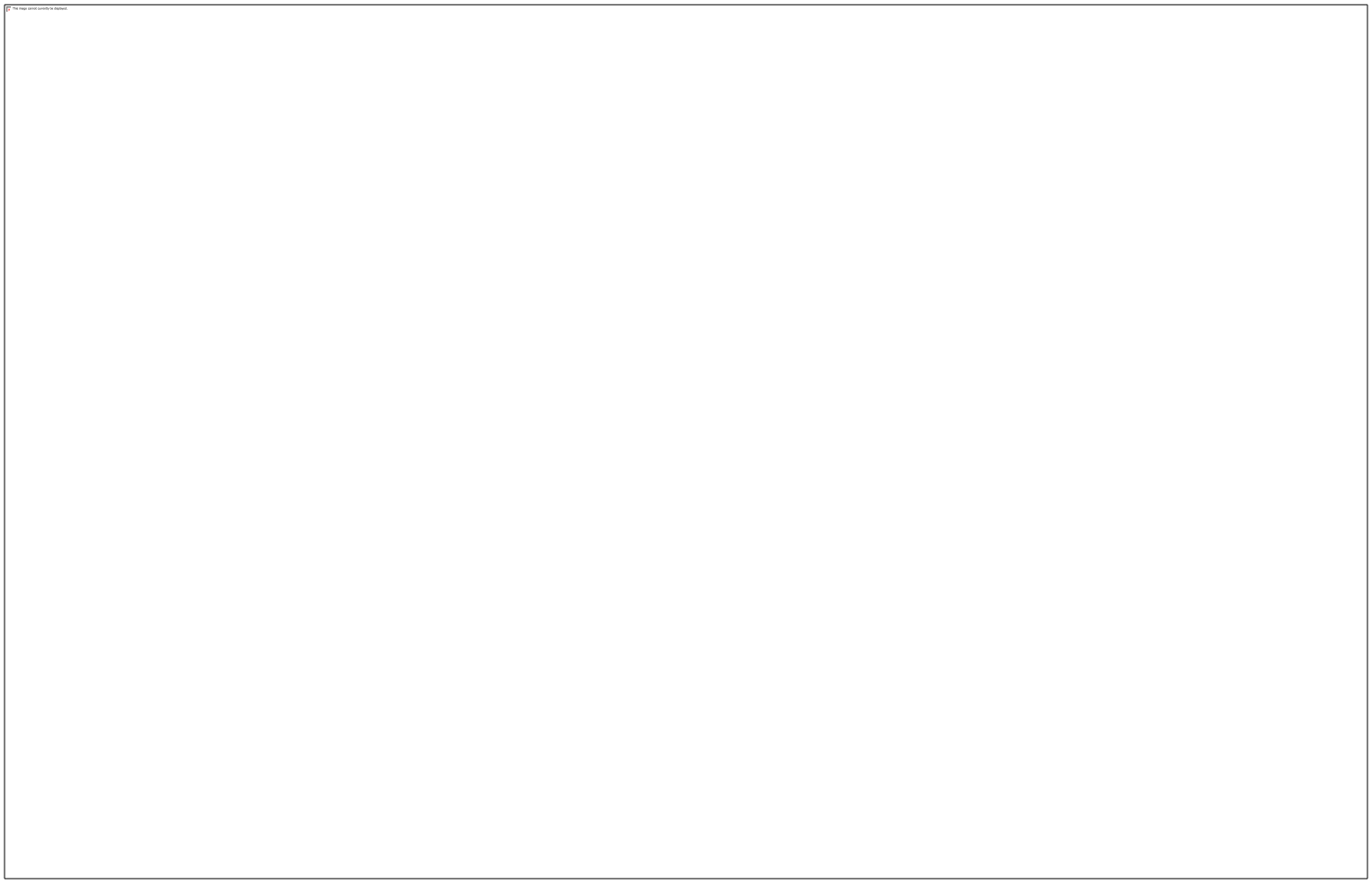
It enables a user to produce accurate two-dimensional (2D) drawings and three-dimensional (3D) models of objects and structures.

In simple terms, **CAD is the use of a computer and drawing software to prepare technical drawings digitally.**

Examples of objects that can be drawn using CAD include:

- Rectangular concrete blocks.
- Doors and window frames.
- Building floor plans.
- Roof structures.
- Staircases.
- Foundation details.
- Columns and beams.
- Furniture.
- Plumbing components.
- Electrical installation layouts.





1.2 Meaning of computer-aided design

Computer-Aided Design (also abbreviated CAD) refers to the use of computer technology to support the creation, development, modification and evaluation of designs.

Although the terms Computer-Aided Drawing and Computer-Aided Design are sometimes used interchangeably, they have slightly different emphasis:

- **Computer-Aided Drawing:** Focuses on producing technical drawings.
- **Computer-Aided Design:** Covers the wider process of developing, modifying, analysing and communicating designs.

In Building Construction, CAD can be used for both drawing and design activities.

1.3 Meaning of a CAD drawing

A CAD drawing is a technical drawing created and stored electronically using CAD software.

It may contain:

- Lines.
- Circles.
- Arcs.
- Polygons.
- Dimensions.
- Text.
- Hatching.
- Layers.
- Three-dimensional solids.
- Construction symbols.
- Building details.

A CAD drawing can be saved, edited, copied, shared and printed.

1.4 Meaning of 2D CAD

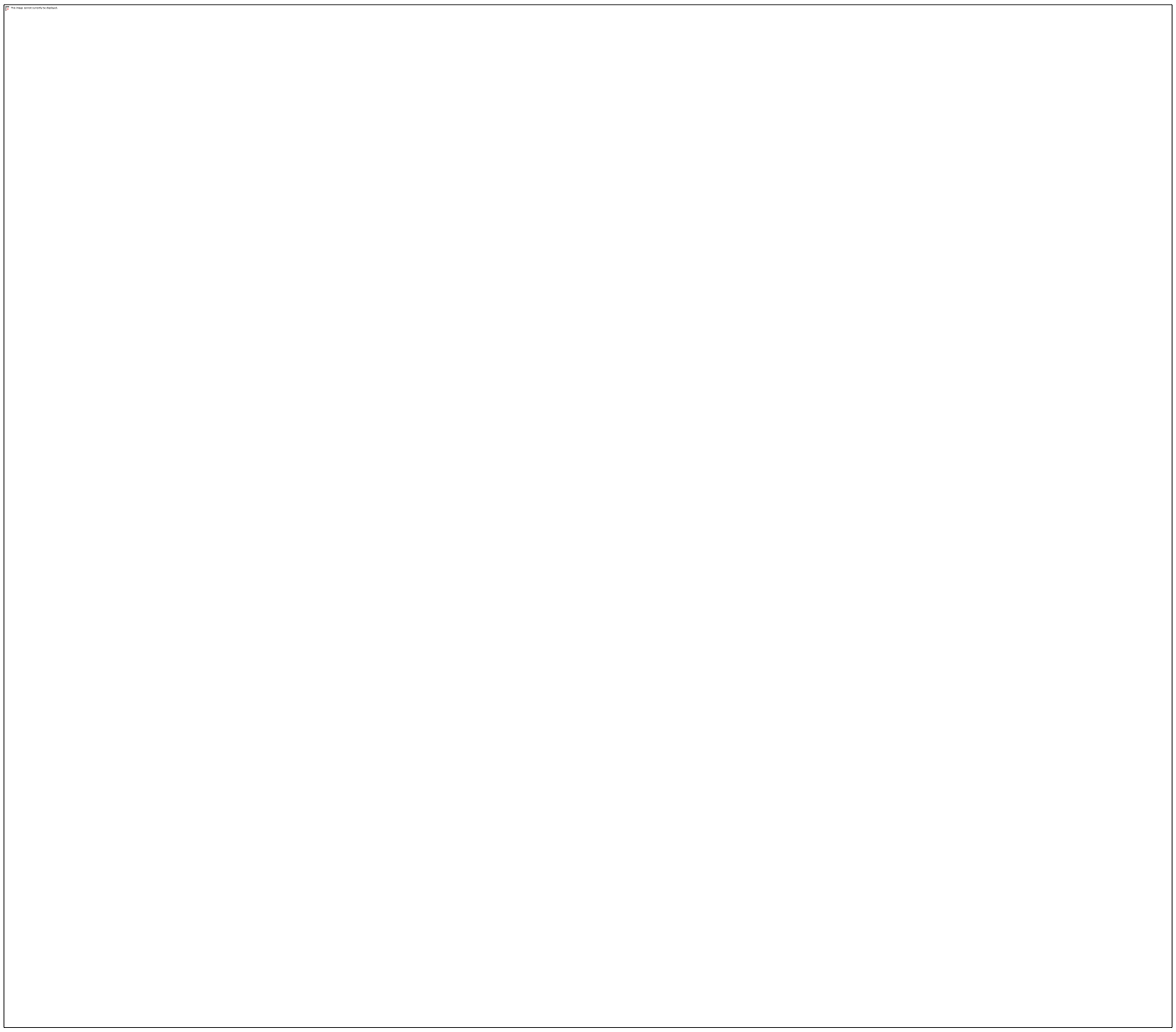
2D CAD refers to the preparation of drawings using two dimensions:

1. Length.
2. Width.

The drawing is produced on a flat plane.

Examples of 2D CAD drawings include:

- Floor plans.
- Front elevations.
- Side elevations.
- Sections.
- Site plans.
- Door and window details.
- Orthographic projections.



1.5 Meaning of 3D CAD

3D CAD refers to the creation of digital models using three dimensions:

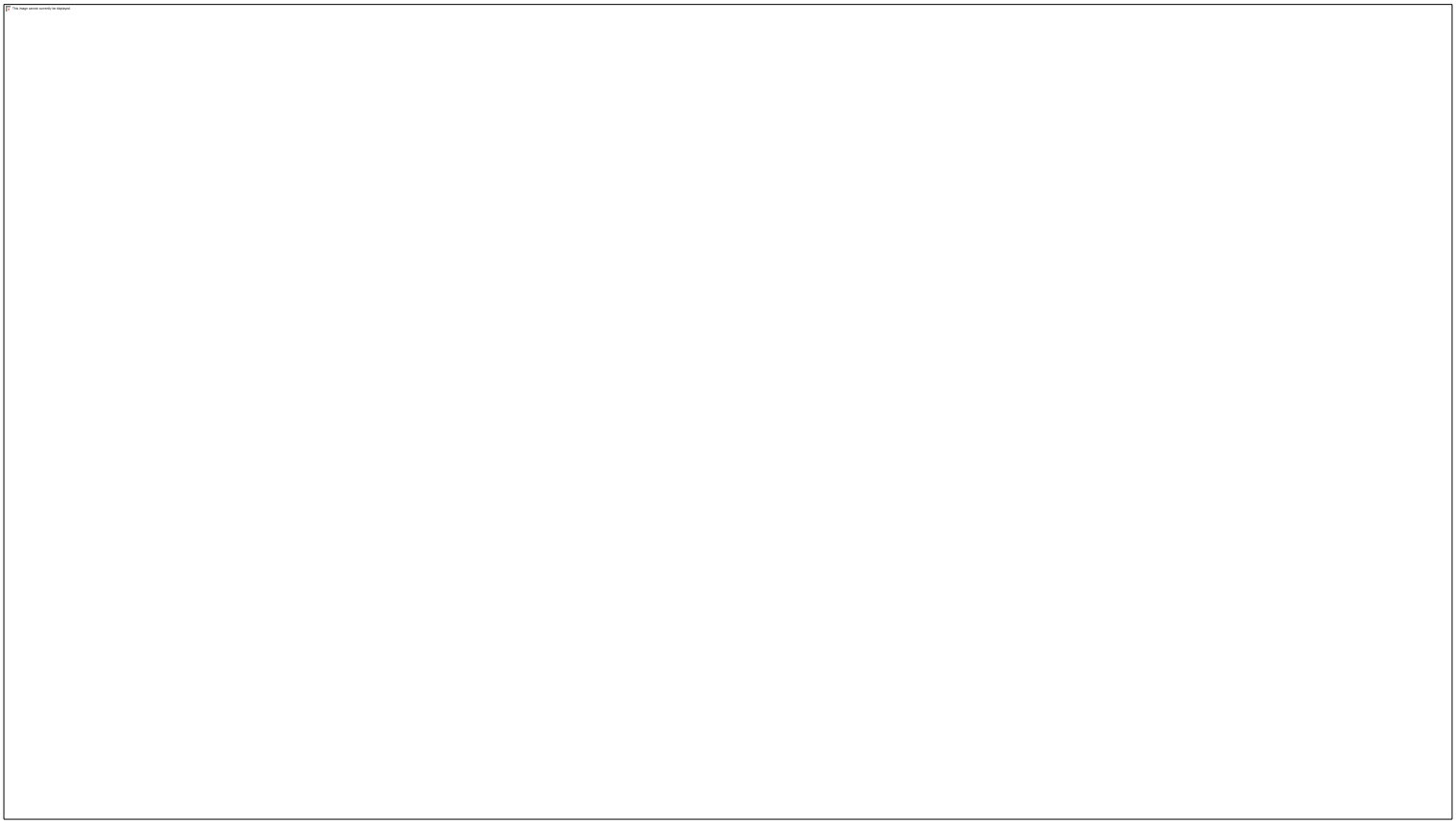
1. Length.
2. Width.
3. Height.

It enables the user to represent an object as a solid or surface model that can be viewed from different directions.

Examples include:

- A three-dimensional concrete block.
- A stepped block.
- A building model.
- A roof structure.

- A staircase.
- A window frame.
- A three-dimensional foundation model.



1.6 Differences between 2D CAD and 3D CAD

2D CAD	3D CAD
Uses two dimensions.	Uses three dimensions.
Represents objects on a flat plane.	Represents objects with length, width and height.
Commonly produces plans, elevations and sections.	Produces solid, surface or other 3D models.
Easier to use for simple technical layouts.	Useful for visualising complex shapes and forms.
Does not normally provide a complete three-dimensional model.	Allows the user to view an object from different directions.
Examples include floor plans and elevations.	Examples include 3D building and component models.

2.0 CAD SOFTWARE USED IN BUILDING CONSTRUCTION

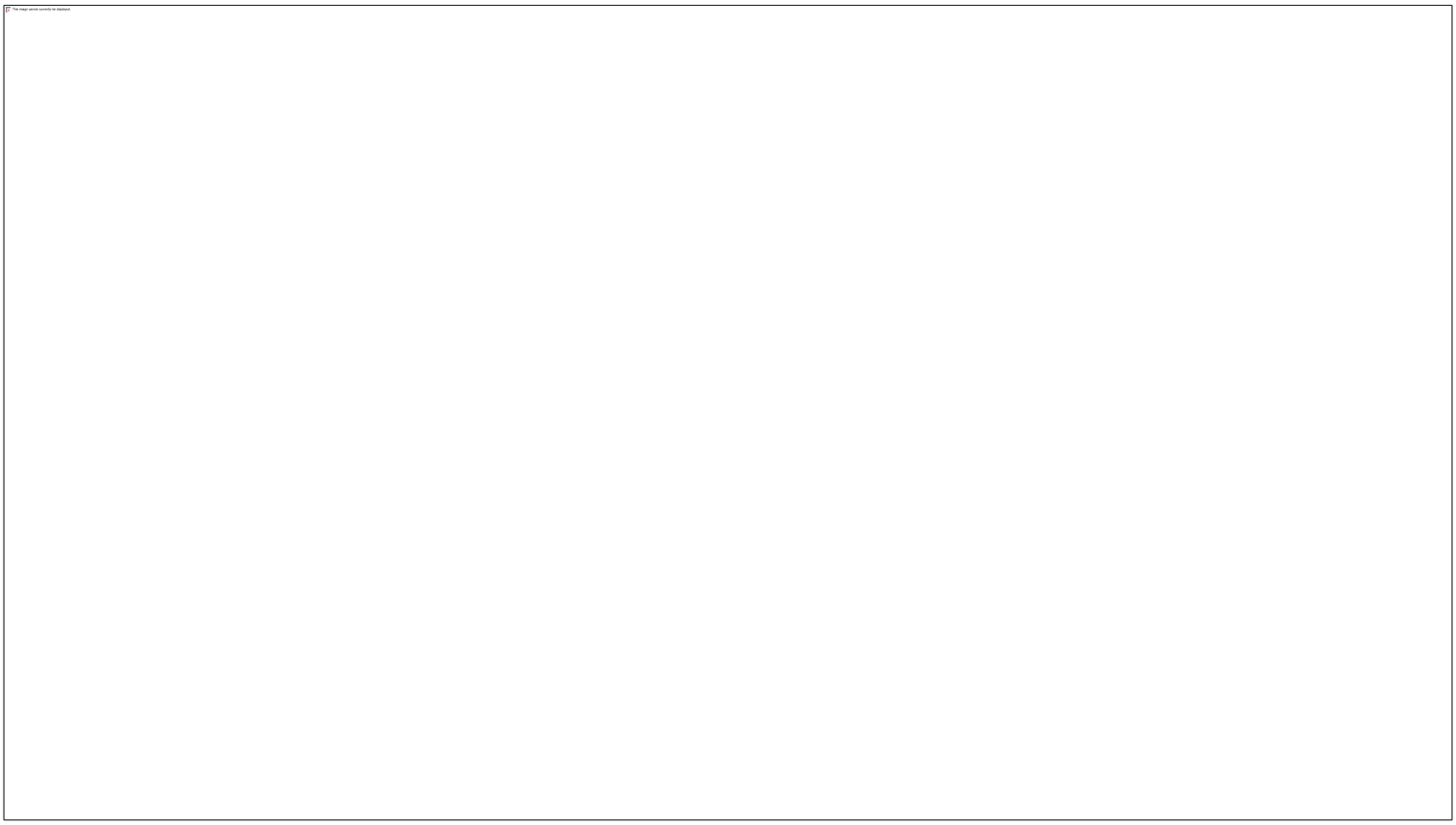
2.1 Meaning of CAD software

CAD software refers to computer programs designed to help users create, modify, display, organise and print technical drawings and models.

The software provides tools and commands for drawing geometric shapes, preparing building plans, creating three-dimensional objects and producing technical documentation.

2.2 Examples of CAD software

A. AutoCAD



AutoCAD

AutoCAD is a widely used CAD program developed by Autodesk.

Main uses:

- Preparing building floor plans.
- Drawing elevations and sections.
- Producing construction details.
- Preparing site layouts.
- Creating two-dimensional technical drawings.
- Creating three-dimensional models.
- Adding dimensions and annotations.

Examples of its application in Kenya:

- Preparing drawings for a residential house.
- Drawing a school classroom block.
- Preparing door and window details.
- Drawing a foundation layout.
- Producing a roof plan.

B. FreeCAD



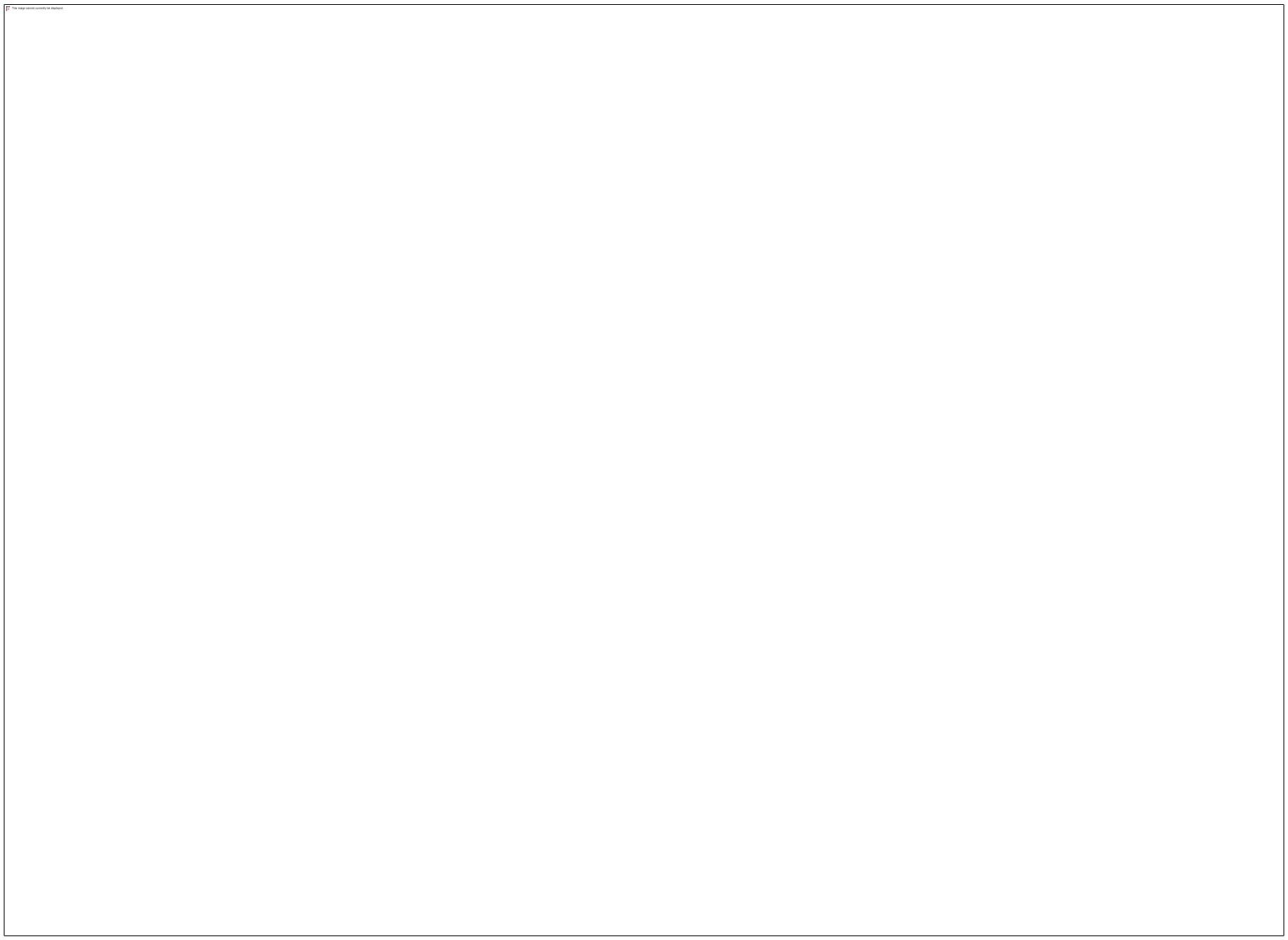
FreeCAD is an open-source parametric CAD application used to create and modify three-dimensional models.

Main uses:

- Creating solid models.
- Modelling building components.
- Developing three-dimensional objects.
- Modifying dimensions.
- Preparing technical drawings from models.

It can be useful in schools and training institutions where access to open-source software is preferred.

C. LibreCAD



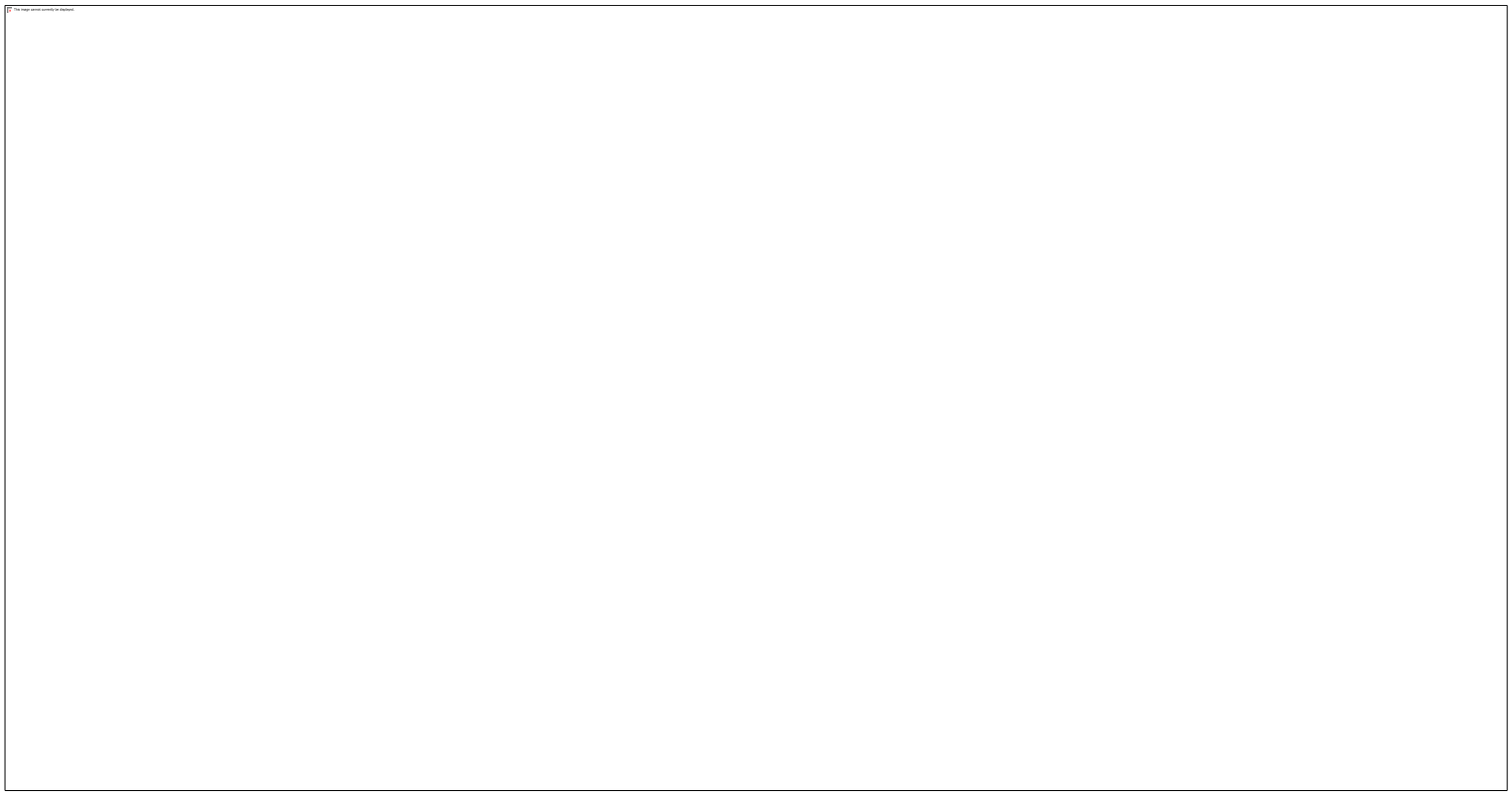
LibreCAD

LibreCAD is an open-source application mainly used for two-dimensional technical drawing.

Main uses:

- Drawing floor plans.
- Preparing elevations.
- Drawing geometric shapes.
- Preparing technical layouts.
- Adding dimensions and annotations.

D. SketchUp



SketchUp

SketchUp is a three-dimensional modelling application used in architecture, interior design and construction visualisation.

Main uses:

- Modelling buildings.
- Creating three-dimensional rooms.
- Modelling roofs.
- Visualising building components.
- Presenting design concepts.

E. Other CAD applications

Other applications used in technical drawing and construction-related work include:

- Revit.
- ArchiCAD.
- BricsCAD.
- Fusion.

Note: Different CAD programs have different interfaces, commands and tools. The specific procedure for drawing may therefore vary from one application to another. The examples in these notes use general CAD principles, with some common command examples from AutoCAD-style software.

2.3 Factors to consider when selecting CAD software

1. **Purpose of the drawing**
    - Select software that can perform the required drawing tasks.
    - For example, 2D drafting software may be sufficient for a simple floor plan.
2. **Cost and licensing**
    - Consider the purchase price, subscription fees and licensing conditions.
    - Open-source options may be suitable for some learning environments.
3. **Ease of use**
    - Choose software that learners and technicians can understand and operate.
4. **Computer specifications**
    - Consider the computer's processor, memory, graphics capability and available storage.
5. **Compatibility**
    - The software should support the file formats required for sharing and printing.
6. **Available training**
    - Consider whether learning materials, tutorials and technical support are available.
7. **Required features**
    - Consider whether the software supports layers, dimensions, 3D modelling, printing and exporting.

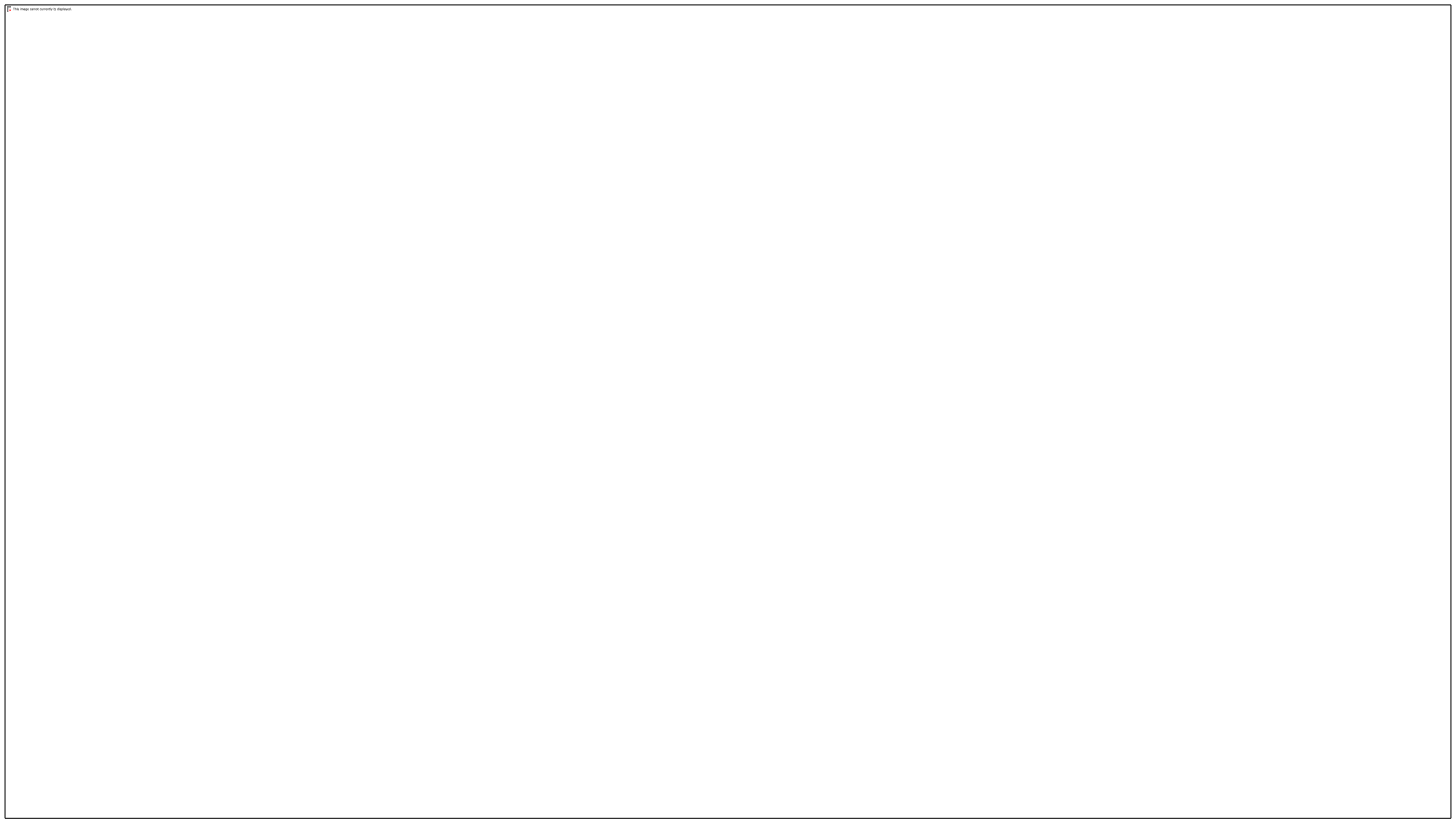
3.0 THE CAD ENVIRONMENT

3.1 Meaning of CAD environment

The CAD environment is the working interface displayed on a computer screen when CAD software is opened.

It contains different tools, menus, panels, commands and drawing areas that enable a user to create and manage technical drawings.

The CAD environment allows the user to interact with the software using a mouse, keyboard, touch screen or other input device.



3.2 Main components of the CAD environment

A. Application menu or file menu

The application menu provides access to file-related operations.

Functions:

- Creating a new drawing.
- Opening an existing drawing.
- Saving a drawing.
- Saving a drawing under a different name.
- Importing and exporting files.
- Printing or plotting drawings.
- Closing a drawing.

B. Title bar

The title bar is the area at the top of the CAD application window that displays the name of the software and, in many programs, the name of the current drawing.

Functions:

- Identifies the active CAD application.
- Displays the drawing file name.
- Helps the user identify the currently opened drawing.

C. Ribbon or toolbar

A ribbon or toolbar contains groups of drawing and editing tools.

Common tool groups include:

- Draw.
- Modify.
- Layers.
- Annotation.
- Dimensions.
- Properties.
- View.
- Solid modelling.

Functions:

- Provides quick access to commands.
- Reduces the need to type commands.
- Organises tools according to their functions.

D. Drawing area

The drawing area is the main working space where objects are created and edited.

Functions:

- Displays the current drawing.
- Allows the user to create geometric shapes.
- Provides space for 2D drawings and 3D models.
- Displays selected objects and construction elements.

E. Command line

The command line is an area where the user can type commands and enter instructions.

For example, in AutoCAD-style software:

- LINE – creates straight lines.
- CIRCLE – creates circles.

- RECTANG – creates rectangles.
- MOVE – moves selected objects.
- COPY – duplicates objects.
- ERASE – removes selected objects.
- EXTRUDE – extends a closed profile into a 3D solid where supported.
- BOX – creates a rectangular 3D solid where supported.

Functions:

- Allows commands to be entered using the keyboard.
- Displays prompts and instructions.
- Shows information about drawing operations.
- Helps users work accurately.

F. Status bar

The status bar is normally found at the lower part of the CAD window.

It contains settings that control the drawing process.

Common settings include:

- Grid display.
- Snap mode.
- Ortho mode.
- Polar tracking.
- Object snap.
- Dynamic input.
- Model space and layout controls.

G. Navigation tools

Navigation tools help the user move around the drawing and view objects from different directions.

Examples include:

- Zoom.
- Pan.
- Orbit.
- View cube.
- View controls.

Functions:

- Zoom enlarges or reduces the displayed drawing.
- Pan moves the displayed drawing across the screen.
- Orbit rotates the viewing direction around a 3D object.

- View cube helps select standard viewing directions such as front, top and right.

H. Properties panel

The properties panel displays information about selected objects.

It may show:

- Object type.
- Length.
- Width.
- Height.
- Position.
- Colour.
- Layer.
- Line type.
- Thickness.
- Solid properties.

I. Model space

Model space is the main environment in which objects are created at their intended real-world sizes.

For example, a rectangular block measuring 200 mm by 100 mm by 80 mm can be modelled using those dimensions when the drawing units are set to millimetres.

J. Layout or paper space

Paper space is used to arrange drawings for presentation and printing.

It may contain:

- Drawing sheets.
- Title blocks.
- Viewports.
- Drawing scales.
- Notes.
- Dimensions.
- Revision information.

3.3 Functions of the CAD environment

1. Provides a workspace for creating technical drawings.
2. Provides tools for modifying drawings.
3. Allows users to enter drawing commands.
4. Provides settings for controlling accuracy.
5. Allows the user to view objects from different directions.

6. Supports the creation of 2D and 3D drawings.
7. Enables the saving and retrieval of drawing files.
8. Supports printing and sharing of completed drawings.

4.0 SETTING UP A CAD DRAWING

4.1 Meaning of setting up a CAD drawing

Setting up a CAD drawing is the process of preparing the drawing environment before creating the actual objects.

It involves selecting the required drawing settings to ensure that the drawing is accurate, properly organised and suitable for its intended purpose.

The setup process may involve:

1. Creating a new drawing.
2. Selecting a suitable template.
3. Setting drawing units.
4. Setting drawing limits.
5. Selecting the drawing scale or output scale.
6. Configuring the drawing grid.
7. Setting snap and tracking options.
8. Creating drawing layers.
9. Selecting suitable line types and colours.
10. Saving the drawing file.



4.2 Procedure for setting up a new drawing

The following is a general procedure. Exact menu names may vary between CAD applications.

Step 1: Start the computer

- Switch on the computer.
- Allow the operating system to load.
- Check that the mouse and keyboard are functioning properly.

Step 2: Open CAD software

- Locate the CAD program.
- Open the application.
- Wait for the working environment to appear.

Step 3: Create a new drawing

- Select the New Drawing option.
- Choose an appropriate template if required.
- Open a blank drawing workspace.

Step 4: Set drawing units

- Select the units required for the project.
- For many building construction drawings in Kenya, millimetres or metres may be appropriate depending on the drawing purpose.
- Use the same unit system consistently.

Step 5: Set drawing limits

- Specify the intended drawing area.
- Ensure that the limits are large enough for the drawing.

Step 6: Set the drawing grid

- Select an appropriate grid spacing.
- Enable or disable the grid depending on the task.
- Set the snap spacing where appropriate.

Step 7: Set drawing layers

- Create layers for different drawing elements.
- Assign appropriate names and properties.
- For example, create separate layers for walls, dimensions, text and construction lines.

Step 8: Save the drawing

- Give the drawing a meaningful file name.
- Select an appropriate storage location.
- Save the drawing in the required file format.

Step 9: Begin drawing

- Select the required drawing tools.
- Create the object using the correct dimensions.

- Save changes regularly.

5.0 DRAWING UNITS IN CAD

5.1 Definition of drawing units

Drawing units are the measurement units used to represent the dimensions of objects in a CAD drawing.

They determine how numerical measurements entered into the CAD program are interpreted.

For example, when drawing a concrete block that is 200 mm long, the user should establish whether the drawing is using millimetres, centimetres, metres or another unit system.

5.2 Common drawing units

Unit	Symbol	Application
Millimetre	mm	Detailed building components and technical details
Centimetre	cm	Some classroom and general measurements
Metre	m	Building plans, site layouts and larger dimensions
Inch	in	Drawings using imperial measurements
Foot	ft	Some international construction drawings

5.3 Importance of selecting correct drawing units

1. **Accurate measurement**
   - Correct units help ensure that dimensions represent the intended physical sizes.
2. **Consistency**
   - They ensure that all parts of a drawing use a common measurement system.
3. **Ease of interpretation**
   - Other users can understand the intended dimensions.
4. **Accurate printing**
   - Correct units help establish appropriate drawing sizes and output scales.
5. **Avoiding construction errors**
   - Correct units reduce the risk of producing components that are too large or too small.
6. **Compatibility**
   - Correct unit settings help when sharing drawings with other professionals.

5.4 Example of selecting drawing units

A learner is required to draw a concrete block with the following dimensions:

- Length = 400 mm.
- Width = 200 mm.
- Height = 150 mm.

The learner selects millimetres as the drawing unit.

The block is then modelled using the numerical dimensions:

- X-direction = 400.
- Y-direction = 200.
- Z-direction = 150.

This creates a model representing a block measuring 400 mm × 200 mm × 150 mm, assuming the software uses the selected millimetre unit consistently.

5.5 Procedure for setting units in AutoCAD-style software

A common command-based approach is:

1. Open the drawing.
2. Type UNITS in the command line.
3. Press Enter.
4. Select the required length type and precision.
5. Select the appropriate insertion scale where available.
6. Confirm the settings.



Note: The UNITS command controls how units are displayed and interpreted in certain operations. It does not automatically resize geometry that has already been drawn.

6.0 DRAWING LIMITS IN CAD

6.1 Definition of drawing limits

Drawing limits refer to the defined rectangular working area within which a drawing is intended to be prepared.

They establish the lower-left and upper-right coordinate boundaries of the drawing area in CAD applications that support drawing-limit settings.

Drawing limits help organise the working space and may be used with grid and zoom settings.

6.2 Meaning of drawing coordinates

Coordinates are numerical values used to identify the position of a point in a drawing.

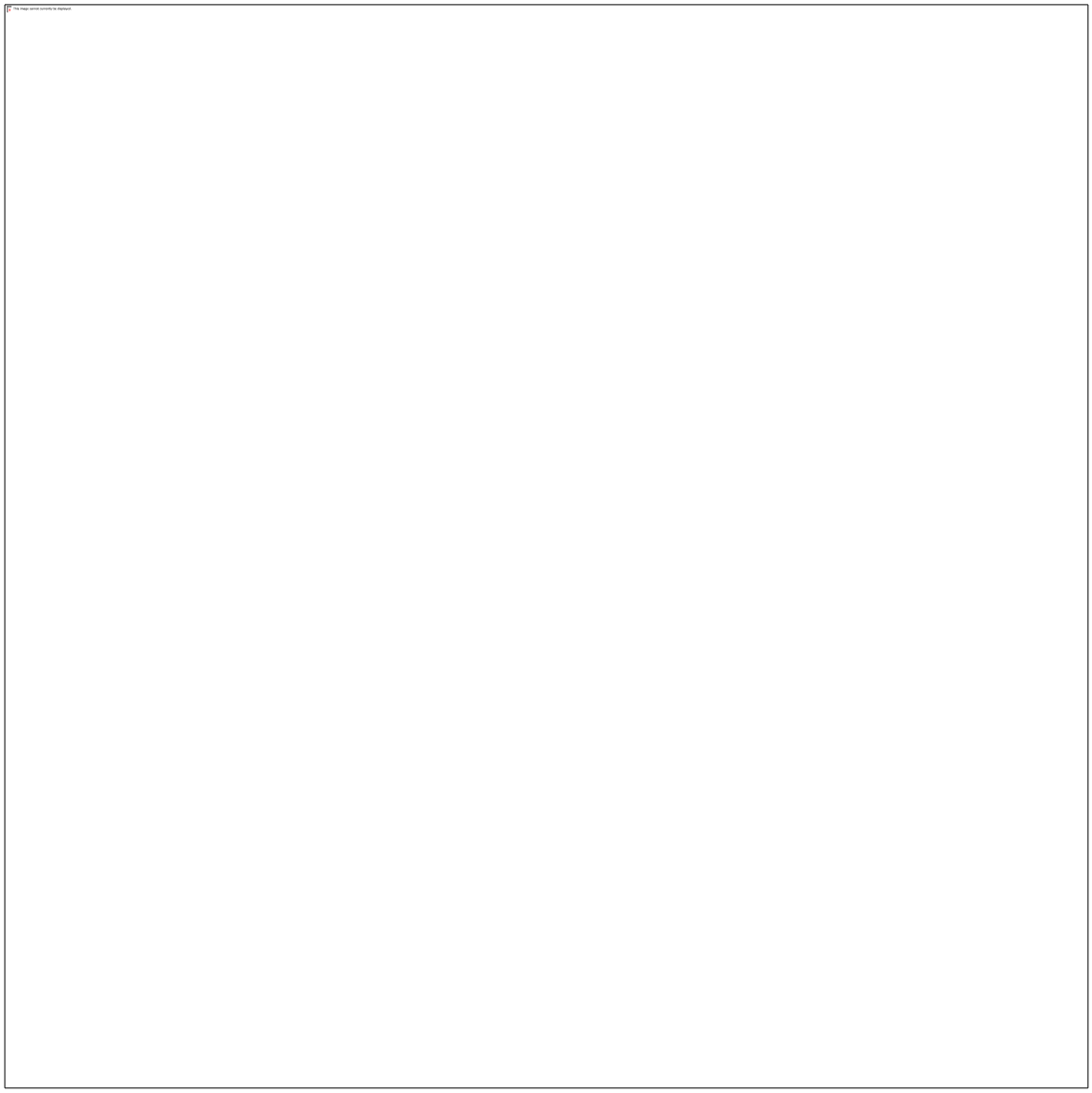
In a two-dimensional CAD drawing, a point is commonly represented using:

- X-coordinate: Horizontal position.
- Y-coordinate: Vertical position.

In a three-dimensional CAD model, an additional coordinate is used:

- Z-coordinate: Height or depth position, depending on the selected coordinate system.

For example, the coordinate (100, 50, 0) identifies a point 100 units along the X-axis, 50 units along the Y-axis and 0 units along the Z-axis from the coordinate origin.



6.3 Importance of drawing limits

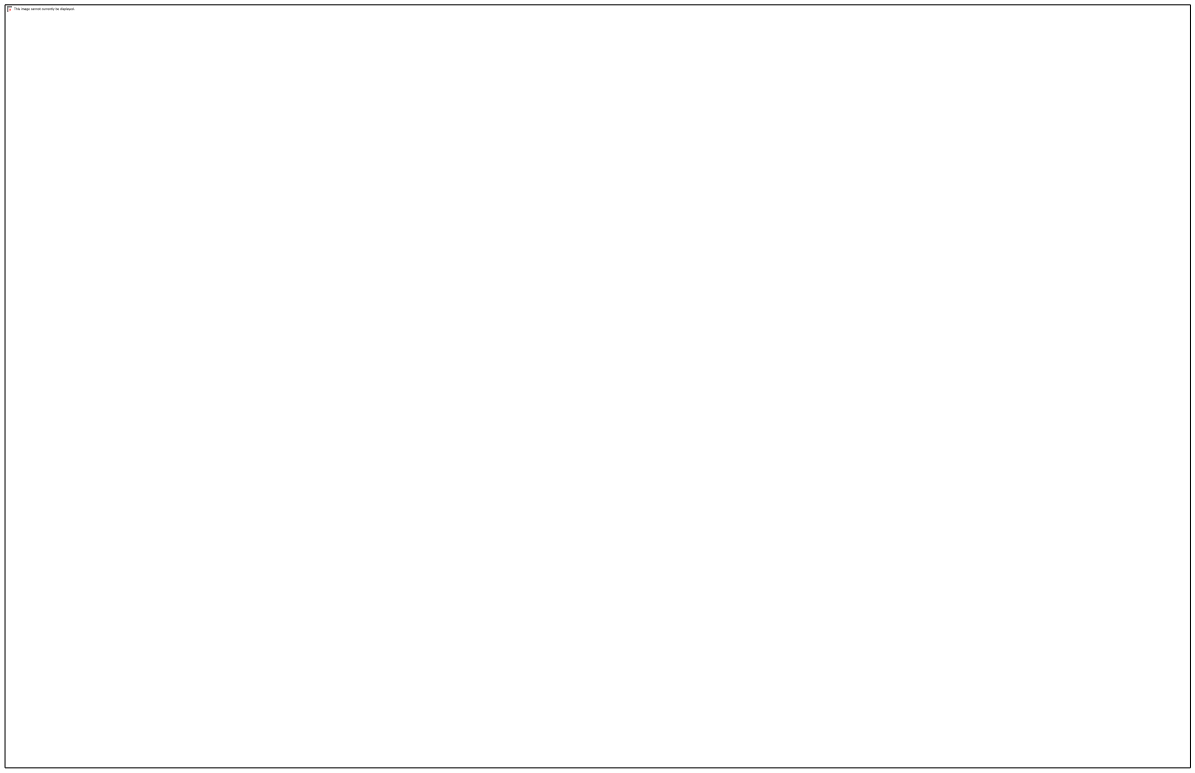
1. They help define the intended working area.
2. They assist in organising drawing space.

3. They help control the display of the grid in applications that use limits.
4. They can help the user focus on the intended drawing area.
5. They assist in preparing drawings with known working dimensions.
6. They help learners understand coordinate positions.

6.4 Procedure for setting drawing limits

In AutoCAD-style software, a common procedure is:

1. Open the CAD drawing.
2. Type LIMITS in the command line.
3. Press Enter.
4. Specify the lower-left corner, for example 0,0.
5. Specify the upper-right corner, for example 500,400.
6. Confirm the settings.
7. Use ZOOM and the ALL option if necessary to display the defined drawing area.



Example

A learner wants to prepare a drawing within an area measuring 500 mm by 400 mm.

The drawing limits may be set as:

- Lower-left corner: (0,0).
- Upper-right corner: (500,400).

This establishes a rectangular limit area of 500 mm horizontally and 400 mm vertically, assuming the drawing is set up in millimetres.

Important: Drawing limits do not necessarily prevent objects from being created outside the specified area. They mainly establish a working boundary and can influence grid and zoom behaviour. They are not the same as paper size or a printed sheet boundary.

7.0 DRAWING SCALE IN CAD

7.1 Definition of drawing scale

Drawing scale is the ratio between a measurement on a drawing and the corresponding actual measurement of the object represented.

It determines how an object is represented on a drawing sheet compared with its real-life size.

CAD allows objects to be drawn at their actual sizes in model space and then displayed at a suitable scale when preparing a drawing for printing.

For example, a building measuring 12 metres long can be modelled using its actual dimensions, then printed at a smaller scale such as 1:100.

7.2 Types of drawing scales

There are three main types of drawing scales.

A. Full-size scale

A full-size scale represents an object at its actual size.

It is written as:

1:11:1

Explanation:

- One unit on the drawing represents one unit on the actual object.
- It is suitable for objects that can fit conveniently on the drawing sheet.
- It is useful for drawing small construction components.

Example: A concrete block measuring 200 mm long is drawn as 200 mm long.

B. Reducing scale

A reducing scale represents an object smaller than its actual size.

Examples include:

- 1:2.
- 1:5.
- 1:10.
- 1:50.
- 1:100.
- 1:200.

Explanation:

- The drawing is smaller than the actual object.
- It is suitable for large objects and building layouts.

- It allows large structures to fit on standard drawing sheets.

Example: At a scale of 1:100, 1 mm on the drawing represents 100 mm on the actual object.

C. Enlarging scale

An enlarging scale represents an object larger than its actual size.

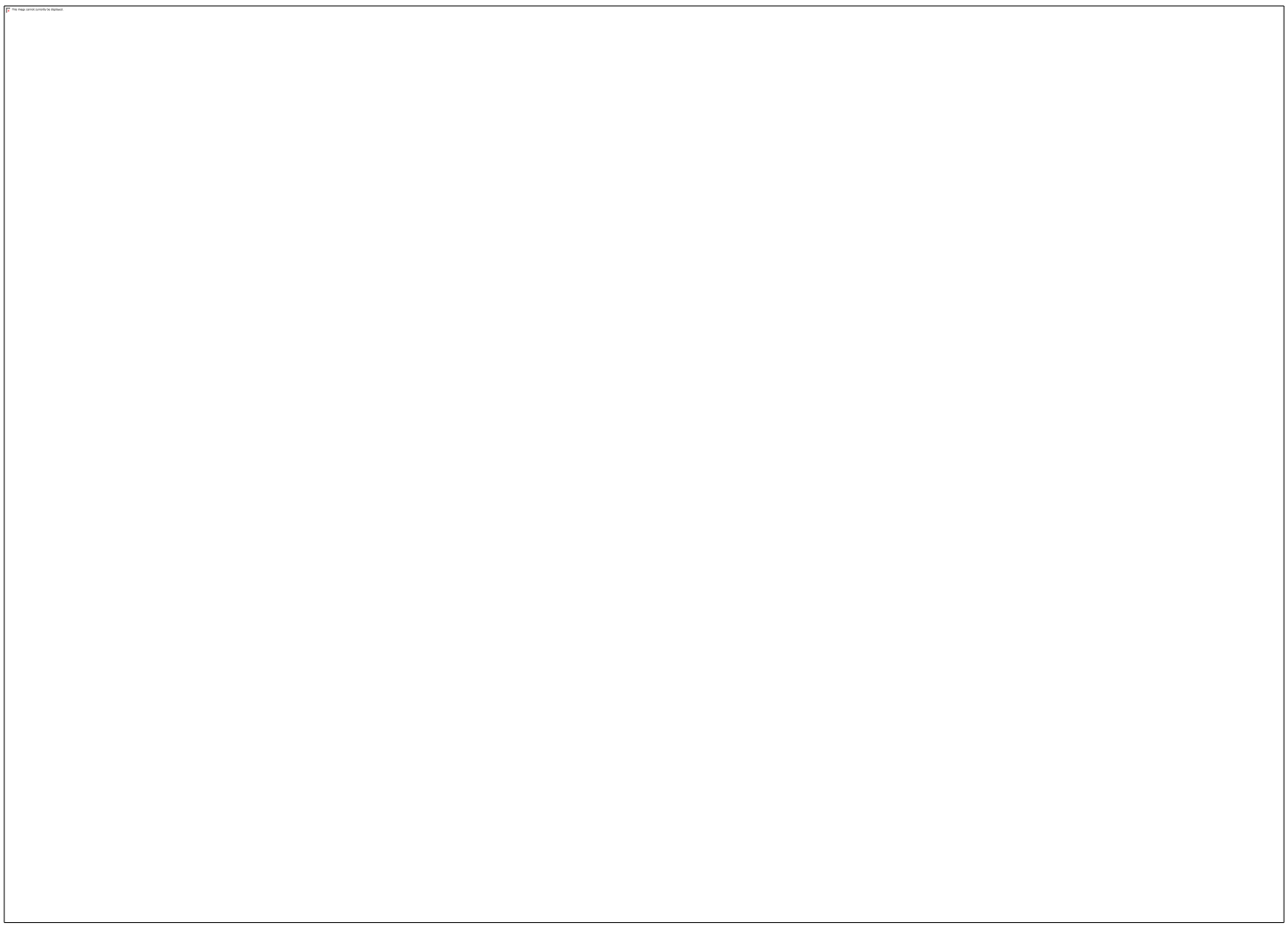
Examples include:

- 2:1.
- 5:1.
- 10:1.

Explanation:

- The drawing is larger than the actual object.
- It is useful when representing small details.
- It makes small features easier to observe and understand.

Example: A small door hinge may be drawn at a scale of 2:1 to show its details clearly.



7.3 Importance of drawing scale

1. **Fitting drawings onto paper**
   - Large building plans can be reduced to fit available drawing sheets.
2. **Representing small details**
   - Small components can be enlarged to show their features clearly.
3. **Maintaining proportions**
   - Scale ensures that the relative sizes of different parts are represented consistently.
4. **Accurate measurement**
   - It helps communicate the intended size of objects when dimensions and scale are correctly applied.
5. **Ease of interpretation**
   - It enables construction professionals to understand the relative sizes of components.
6. **Professional presentation**
   - It helps produce well-organised technical drawings.

7.4 Calculating drawing scale

The drawing scale is calculated using the following formula:

Scale=Drawing sizeActual sizeScale=Actual sizeDrawing size

Both measurements must be expressed in the same units.

Example 1: Reducing scale

A wall is 6 metres long. It is represented by a line measuring 60 mm on a drawing.

Calculate the scale.

Step 1: Convert actual length into millimetres.

6m=6000mm6*m*=6000*mm*

Step 2: Apply the formula.

Scale=606000Scale=600060

=1100=1001

Therefore, the scale is **1:100**.

Example 2: Full-size scale

A wooden component measures 150 mm in actual length. It is drawn as 150 mm.

Scale=150150=1Scale=150150=1

Therefore, the scale is **1:1**.

Example 3: Enlarging scale

A small construction detail measures 20 mm in actual length. It is drawn as 100 mm.

Scale=10020=5Scale=20100=5

Therefore, the scale is **5:1**.

7.5 Applying scale in CAD

In many CAD applications, the recommended practice is to:

1. Draw the object at its actual size in model space.
2. Set the required drawing units.
3. Prepare a layout or paper-space sheet.
4. Create a viewport to display the model.
5. Set the viewport scale, such as 1:50 or 1:100.
6. Arrange dimensions, annotations and the title block.
7. Check the plotted output to confirm the required scale.

Important: Do not confuse zooming with changing the actual size of an object. Zoom changes how large an object appears on the screen. It does not necessarily change the object's real dimensions.

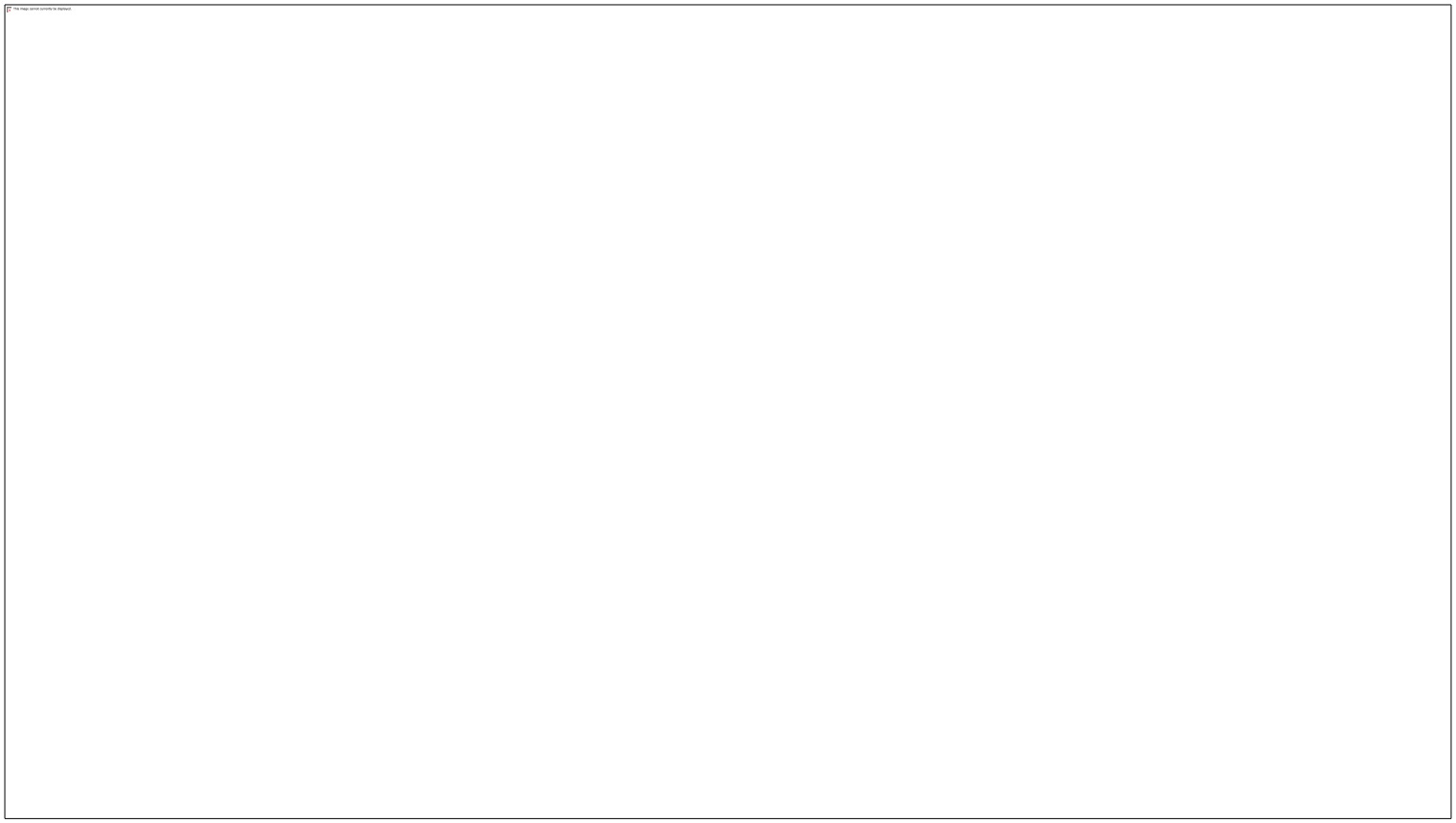
8.0 DRAWING GRID IN CAD

8.1 Definition of drawing grid

A drawing grid is a pattern of regularly spaced horizontal and vertical reference points or lines displayed in the CAD working area to assist in positioning and aligning objects.

It acts like the squares on graph paper.

The grid helps users estimate positions and maintain order when drawing geometric shapes.



8.2 Types of drawing grids

A. Rectangular grid

A rectangular grid consists of regularly spaced horizontal and vertical lines or points forming rectangular or square spaces.

Uses:

- Drawing rectangular blocks.
- Aligning walls.
- Positioning doors and windows.
- Preparing floor plans.
- Arranging construction components.

B. Isometric grid

An isometric grid consists of three sets of guide directions representing the three principal axes of an isometric drawing.

The directions are usually:

- Vertical.
- 30° to the right.
- 30° to the left.

Uses:

- Drawing isometric blocks.
- Constructing isometric boxes.
- Preparing pictorial representations.
- Aligning edges in isometric drawings.

C. Polar tracking guides

Polar tracking guides help the user draw lines at selected angles, such as 30°, 45°, 90° and 180°, depending on the software settings.

They are useful when drawing inclined and angular features.

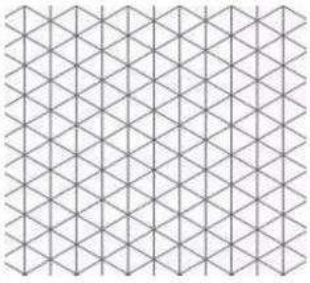
➢ Plain



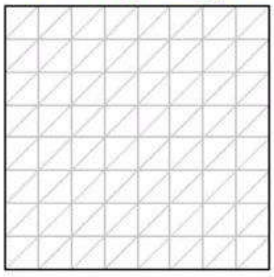
➢ Cartesian grid



➢ Isometric grid



➢ Oblique grid



8.3 Importance of the drawing grid

1. Helps align objects.
2. Assists in maintaining regular spacing.
3. Makes positioning easier.
4. Supports the drawing of rectangular and square shapes.
5. Helps learners maintain neatness.
6. Assists in creating isometric drawings.
7. Improves the organisation of the working area.
8. Helps users estimate the location of objects.

8.4 Difference between grid and snap

These two CAD settings are related but perform different functions.

Grid	Snap
Displays a visual reference pattern.	Restricts the cursor to specified movement intervals or positions, depending on the software.
Helps the user estimate alignment.	Helps the user position points accurately.
Can be displayed or hidden.	Can be enabled or disabled.
Does not necessarily restrict cursor movement.	Controls cursor positioning when active.

8.5 Setting the grid in CAD

A general procedure is:

1. Open the CAD program.
2. Locate the grid settings on the status bar or drafting settings.

3. Enable the grid display.
4. Open the drafting settings if required.
5. Select the grid spacing.
6. Select snap spacing where necessary.
7. Apply the settings.
8. Begin drawing.

In AutoCAD-style software, the grid can commonly be toggled using the F7 key, while snap mode is commonly toggled using F9. Keyboard shortcuts may vary depending on the application and configuration.

9.0 THREE-DIMENSIONAL DRAWING IN CAD

9.1 Meaning of three-dimensional drawing

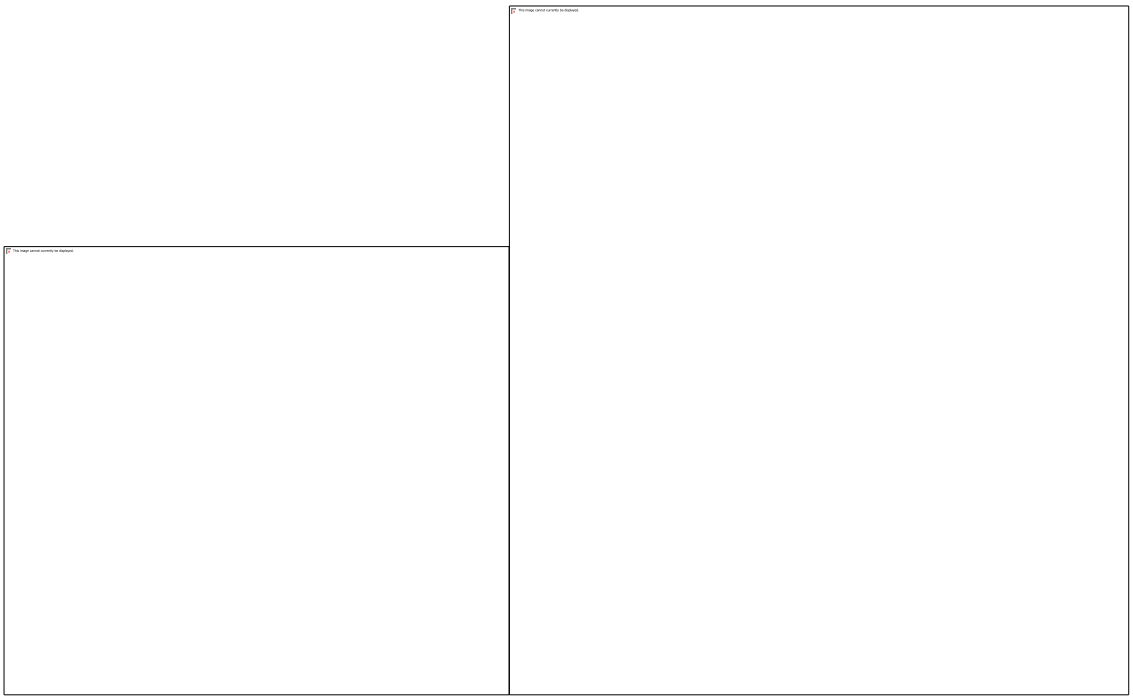
Three-dimensional drawing is the representation of an object using length, width and height.

It enables a user to create a digital model that has depth and volume.

In Building Construction, three-dimensional drawings are used to represent building components and structures more realistically.

Examples include:

- Concrete blocks.
- Foundation units.
- Columns.
- Beams.
- Roof structures.
- Staircases.
- Building models.
- Drainage components.





9.2 Three principal axes in 3D CAD

A three-dimensional model is developed using three principal coordinate axes.

A. X-axis

- Represents one horizontal direction.
- Commonly used to represent the length of an object in a selected model orientation.

B. Y-axis

- Represents the second horizontal direction.
- Commonly used to represent the width or depth of an object.

C. Z-axis

- Represents the vertical direction.
- Commonly used to represent the height of an object.



9.3 Types of 3D modelling

A. Wireframe modelling

Wireframe modelling represents an object using points, lines and curves.

Characteristics:

- Shows the edges and framework of an object.
- Does not necessarily show solid surfaces.

- Can be used to represent the basic structure of an object.
- May be difficult to interpret when the object has many overlapping edges.

B. Surface modelling

Surface modelling represents an object using its outer surfaces.

Characteristics:

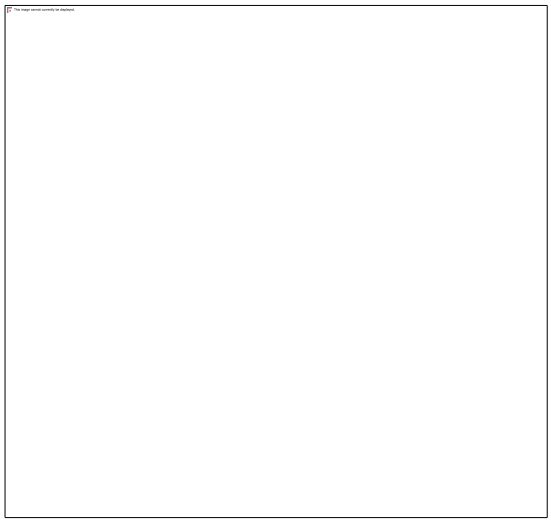
- Describes the visible surfaces of an object.
- Can represent complex curved shapes.
- Does not necessarily represent a solid volume.
- Is useful for objects with complex surface forms.

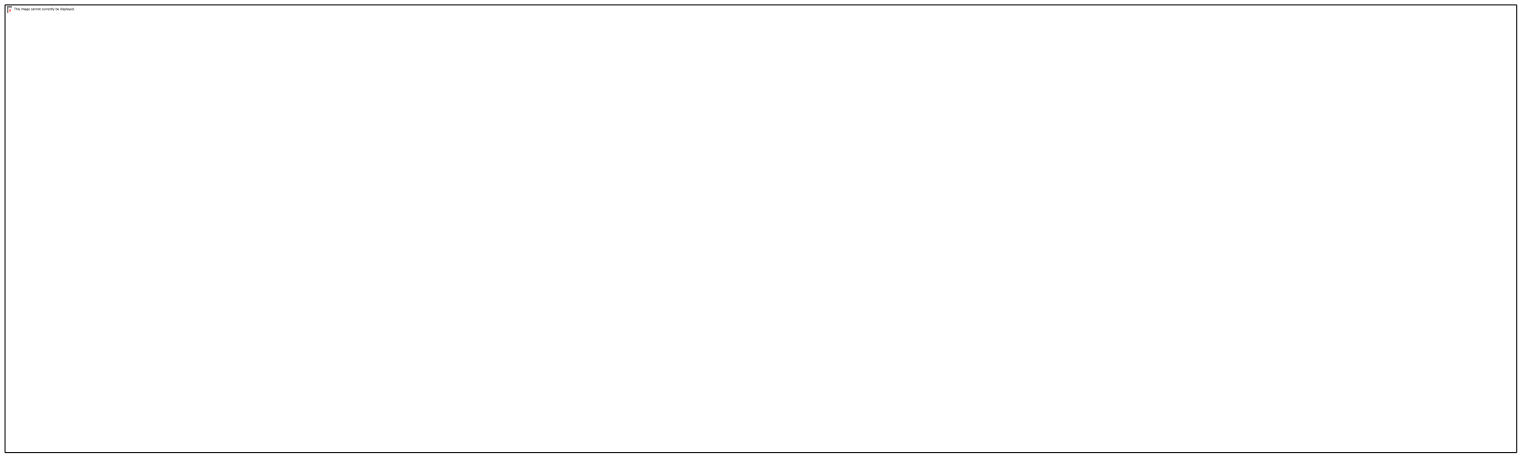
C. Solid modelling

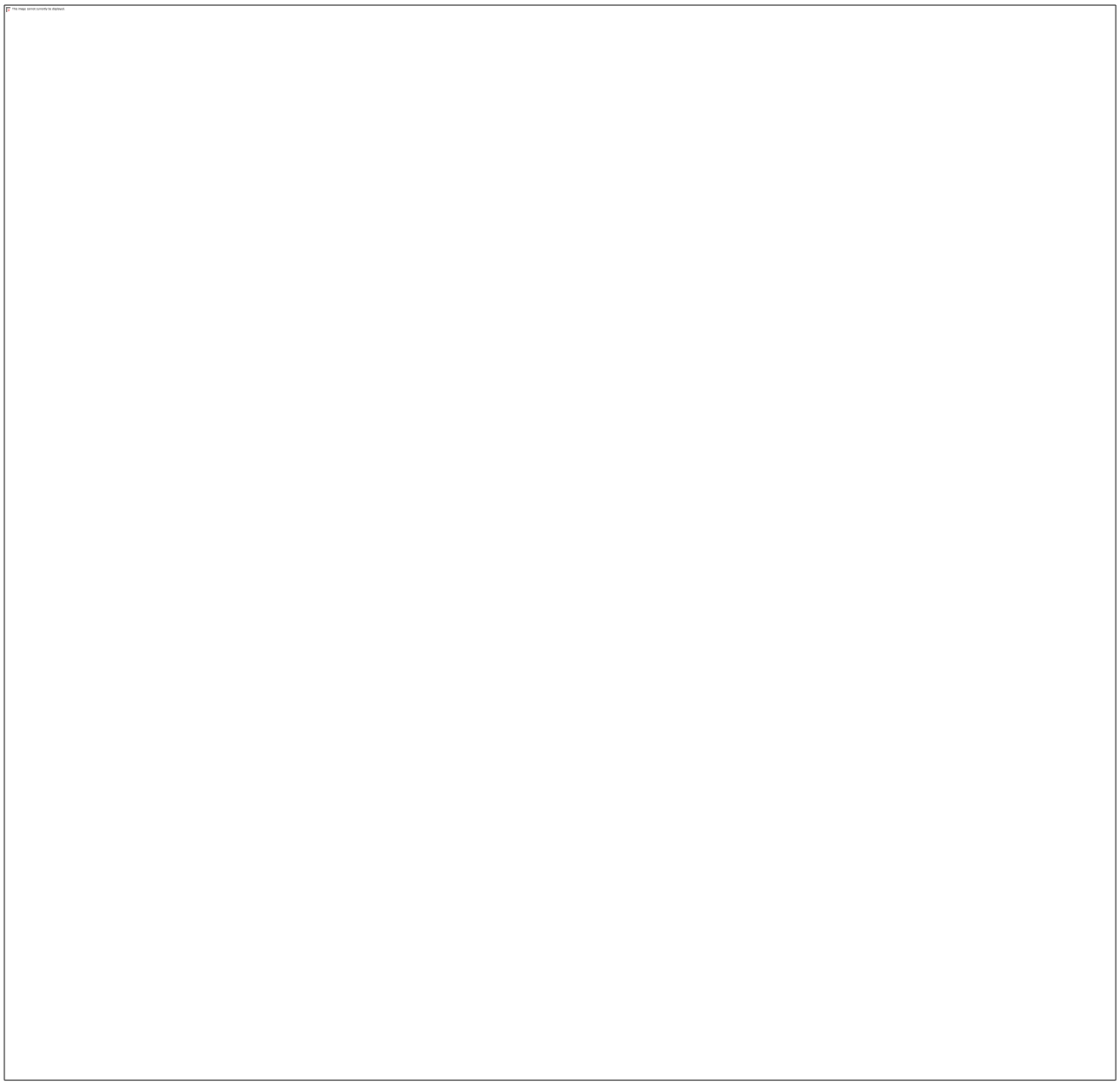
Solid modelling represents an object as a three-dimensional solid with volume.

Characteristics:

- Represents the object's length, width and height.
- Shows the complete solid form.
- Allows solid operations such as joining, subtracting and intersecting.
- Is useful for modelling building components.







9.4 Common 3D CAD commands and tools

The following commands are common in AutoCAD-style 3D modelling environments. Other programs may use different names.

Command or tool	Function
BOX	Creates a rectangular solid.
CYLINDER	Creates a cylindrical solid.
SPHERE	Creates a spherical solid.
EXTRUDE	Extends a closed 2D profile into a 3D form.
PRESSPULL	Pushes or pulls a bounded area to create or modify 3D geometry.

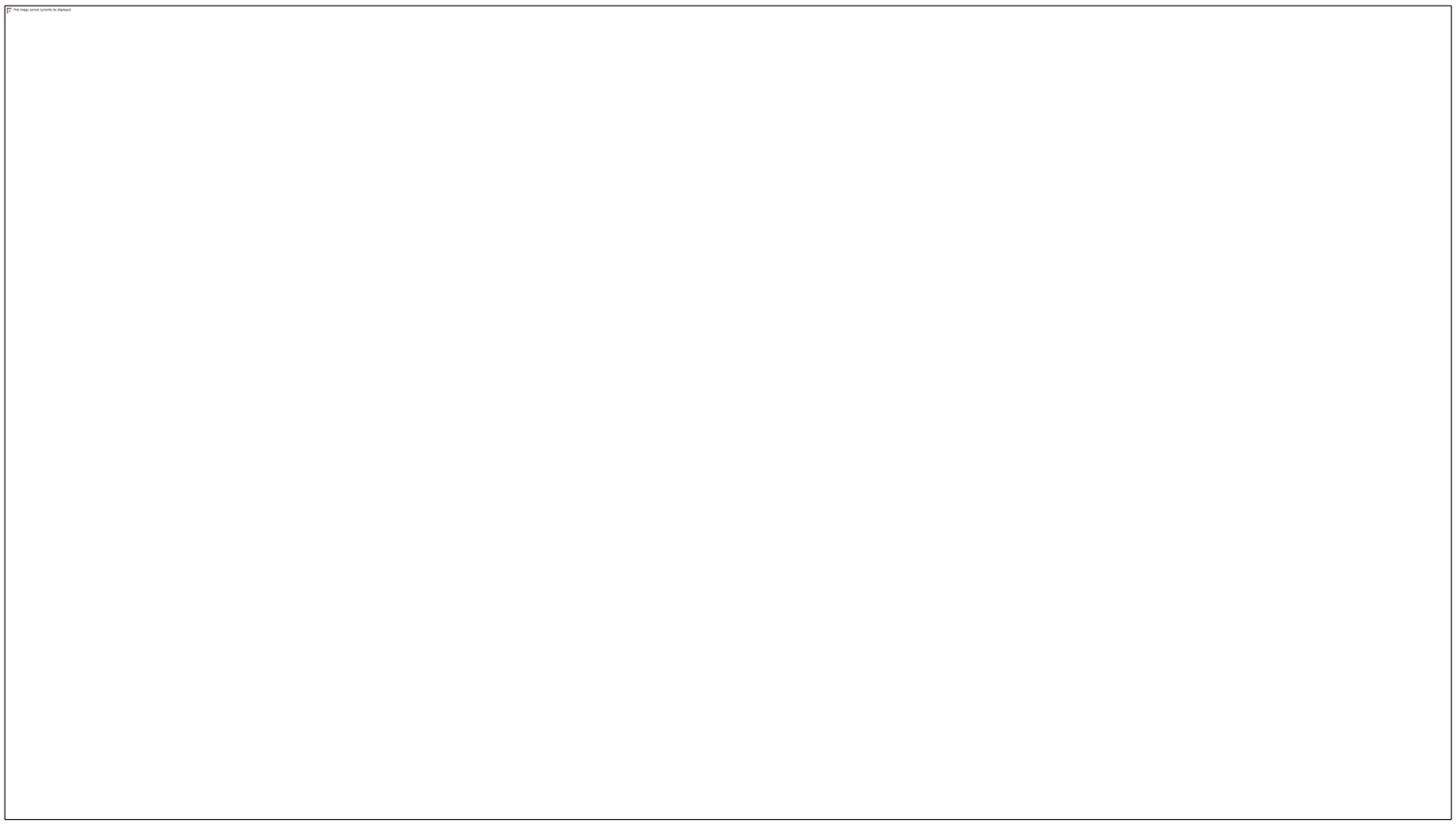
UNION	Combines two or more solids into one solid.
SUBTRACT	Removes one solid from another.
INTERSECT	Creates a solid from the common overlapping volume of selected solids.
MOVE	Changes the position of an object.
ROTATE3D	Rotates an object about a selected 3D axis.
3DORBIT	Allows the user to rotate the view around a model.
FILLETEDGE	Rounds selected edges of a solid where supported.

9.5 Setting up a 3D CAD workspace

A 3D CAD workspace is an environment configured to support three-dimensional modelling.

Procedure:

1. Open the CAD program.
2. Create a new drawing.
3. Select a 3D modelling workspace if available.
4. Set drawing units.
5. Establish the required working area.
6. Select a suitable visual style, such as shaded or conceptual.
7. Display the coordinate axes.
8. Select an appropriate 3D view.
9. Set the required grid and snap options.
10. Save the drawing before modelling.



9.6 Procedure for creating a simple 3D rectangular block

A rectangular block is one of the simplest objects that can be created in a 3D CAD program.

Example dimensions:

- Length = 400 mm.
- Width = 200 mm.
- Height = 150 mm.

Procedure using a BOX command in AutoCAD-style software:

1. Open the 3D modelling workspace.
2. Confirm that the drawing units are millimetres.
3. Type BOX in the command line.
4. Press Enter.
5. Specify the first corner of the base, for example 0,0,0.
6. Specify the opposite corner of the base, for example 400,200.
7. Enter the height as 150.
8. Press Enter to complete the solid.
9. Use the ViewCube or 3D Orbit to view the block from different directions.
10. Save the drawing.



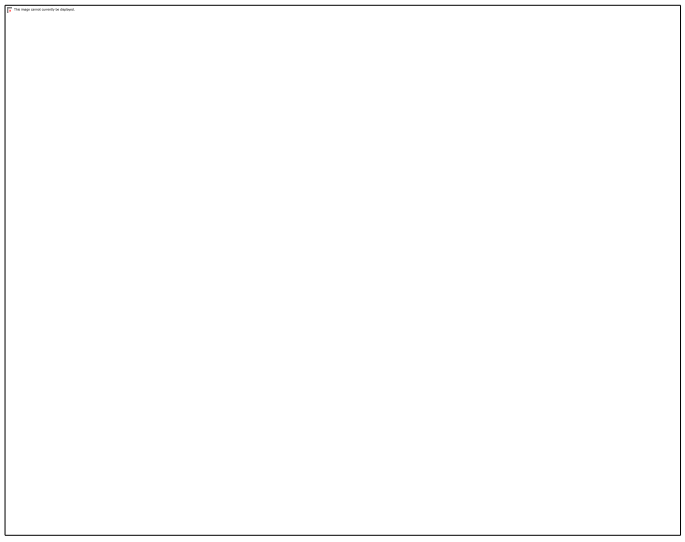
Expected result: A rectangular solid measuring 400 mm long, 200 mm wide and 150 mm high.

9.7 Procedure for creating a stepped block

A stepped block is a solid object made up of two or more levels.

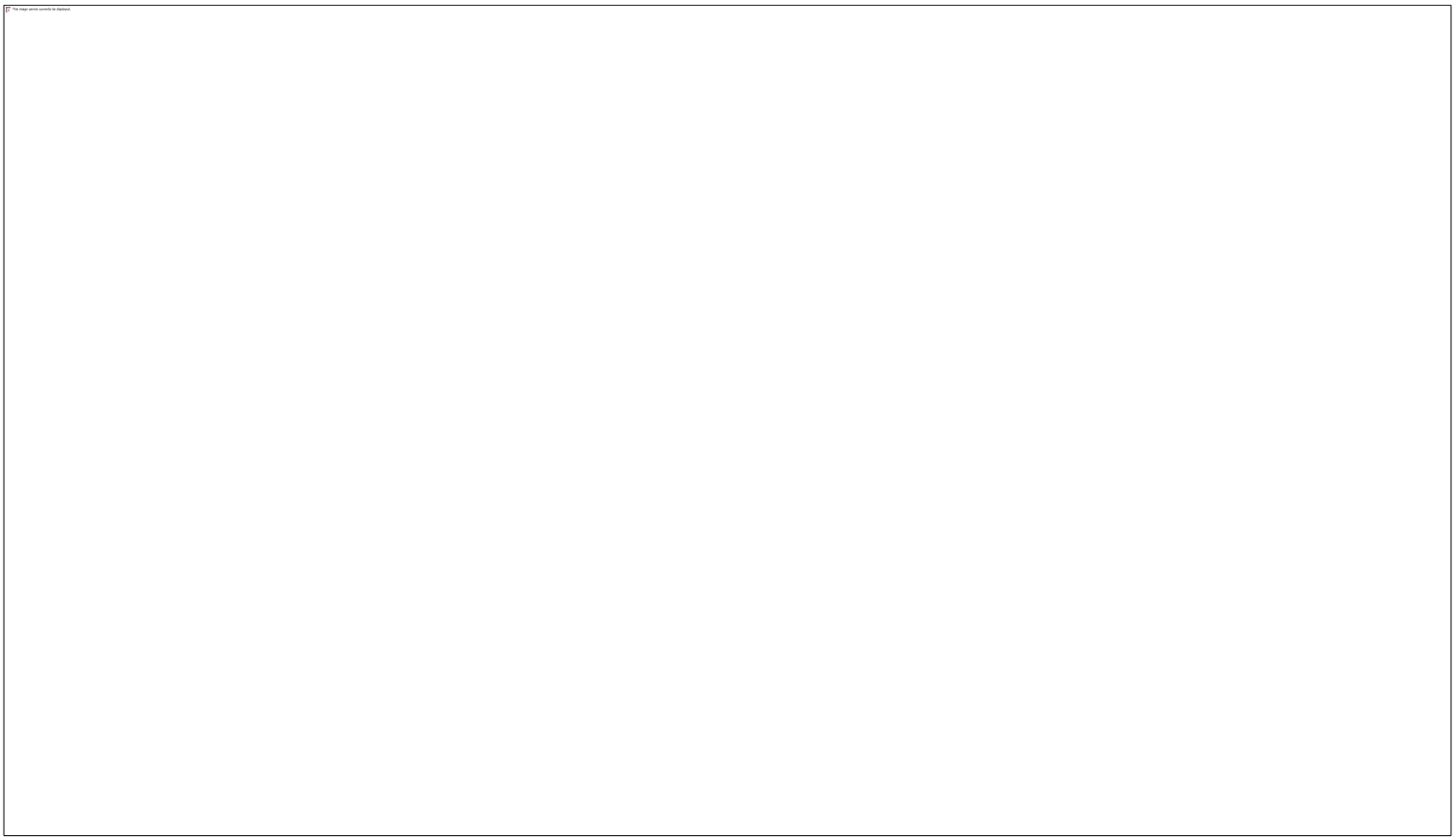
Procedure using solid modelling:

1. Create the first rectangular solid using the BOX command.
2. Create a second rectangular solid with the required dimensions.
3. Position the second solid on top of or beside the first solid.
4. Use MOVE to adjust its position.
5. Use UNION to combine the solids if a single solid is required.
6. Use the 3D Orbit tool to inspect the model.
7. Check the overall dimensions.
8. Save the drawing.



9.8 Procedure for creating a block with a rectangular recess

1. Create a rectangular solid using the BOX command.
2. Create a smaller rectangular solid to represent the material to be removed.
3. Position the smaller solid where the recess is required.
4. Ensure that the cutting solid overlaps the main block appropriately.
5. Use the SUBTRACT command.
6. Select the main block as the solid to retain.
7. Select the smaller solid as the cutting object.
8. Complete the operation.
9. Inspect the resulting recess.
10. Save the model.



10.0 ISOMETRIC PROJECTION USING CAD

10.1 Meaning of isometric projection

Isometric projection is a method of representing a three-dimensional object on a two-dimensional drawing surface in which the three principal axes are equally inclined to the plane of projection.

In a conventional isometric drawing:

- The vertical axis remains vertical.
- The two horizontal receding axes are drawn at 30° to the horizontal.
- The three principal axes are equally spaced at 120° to one another.

The three dimensions of an object can therefore be represented in one pictorial view.



10.2 Characteristics of isometric projection

1. It represents length, width and height in one drawing.
2. The vertical edges are drawn vertically.
3. The two receding directions are drawn at 30° to the horizontal.
4. The three principal axes are equally spaced at 120°.
5. Parallel edges remain parallel.
6. It gives a pictorial representation of an object.
7. It helps the viewer understand the shape of an object.
8. It is useful for representing building components.

10.3 Isometric projection and isometric drawing

These terms are related but have a technical difference.

- **Isometric projection:** Uses equal foreshortening along the three principal axes.
- **Isometric drawing:** Commonly uses the actual dimensions along the isometric axes without applying the isometric projection reduction.

For a standard mathematical isometric projection, the projected length along each principal axis is approximately 0.816 of the actual length.

In many practical CAD exercises, learners create isometric views using actual model dimensions or an isometric visual style. They should follow the drawing method specified in the task.

10.4 Isometric axes

The three principal axes are:

1. Vertical axis.
2. Left receding axis.
3. Right receding axis.

The left and right receding axes are each inclined at 30° to the horizontal.



10.5 Advantages of isometric projection

1. Shows three dimensions in one drawing.
2. Makes it easier to visualise a solid object.
3. Helps explain the shape of construction components.
4. Supports communication between designers and construction workers.
5. Makes it easier to present design concepts.
6. Can be used to represent blocks, beams, columns and other components.
7. Helps learners develop spatial awareness.
8. Supports the interpretation of three-dimensional models.

10.6 Limitations of isometric projection

1. It does not show every surface in its true shape.
2. Circular surfaces appear elliptical in a conventional isometric representation.
3. Some features may be hidden from the selected viewing direction.
4. It is not a substitute for fully dimensioned orthographic drawings.
5. Complex objects may be difficult to interpret using one isometric view alone.

10.7 Setting an isometric view in CAD

There are different ways of creating an isometric representation.

Method 1: Using a 3D solid model

1. Create a 3D solid object.
2. Select an isometric view using the ViewCube or view menu.
3. Choose a suitable visual style.

4. Adjust the zoom to display the complete object.
5. Save the drawing or export the view.

Method 2: Using 2D isometric drafting

Some CAD programs provide an isometric drafting mode.

In AutoCAD-style software, a traditional 2D isometric drafting setup may involve:

1. Switching to a 2D drafting environment.
2. Enabling isometric drafting or selecting an isometric snap style.
3. Choosing the required isoplane.
4. Drawing the required edges along the isometric directions.
5. Changing between left, right and top isoplanes where necessary.

Important: A 2D isometric drawing is a pictorial representation made from lines on a flat plane. It is not automatically a true 3D solid model.

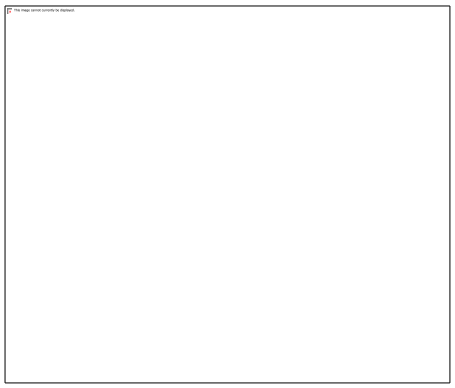
10.8 Drawing a rectangular block in isometric projection using CAD

Object dimensions:

- Length = 400 mm.
- Width = 200 mm.
- Height = 150 mm.

Procedure:

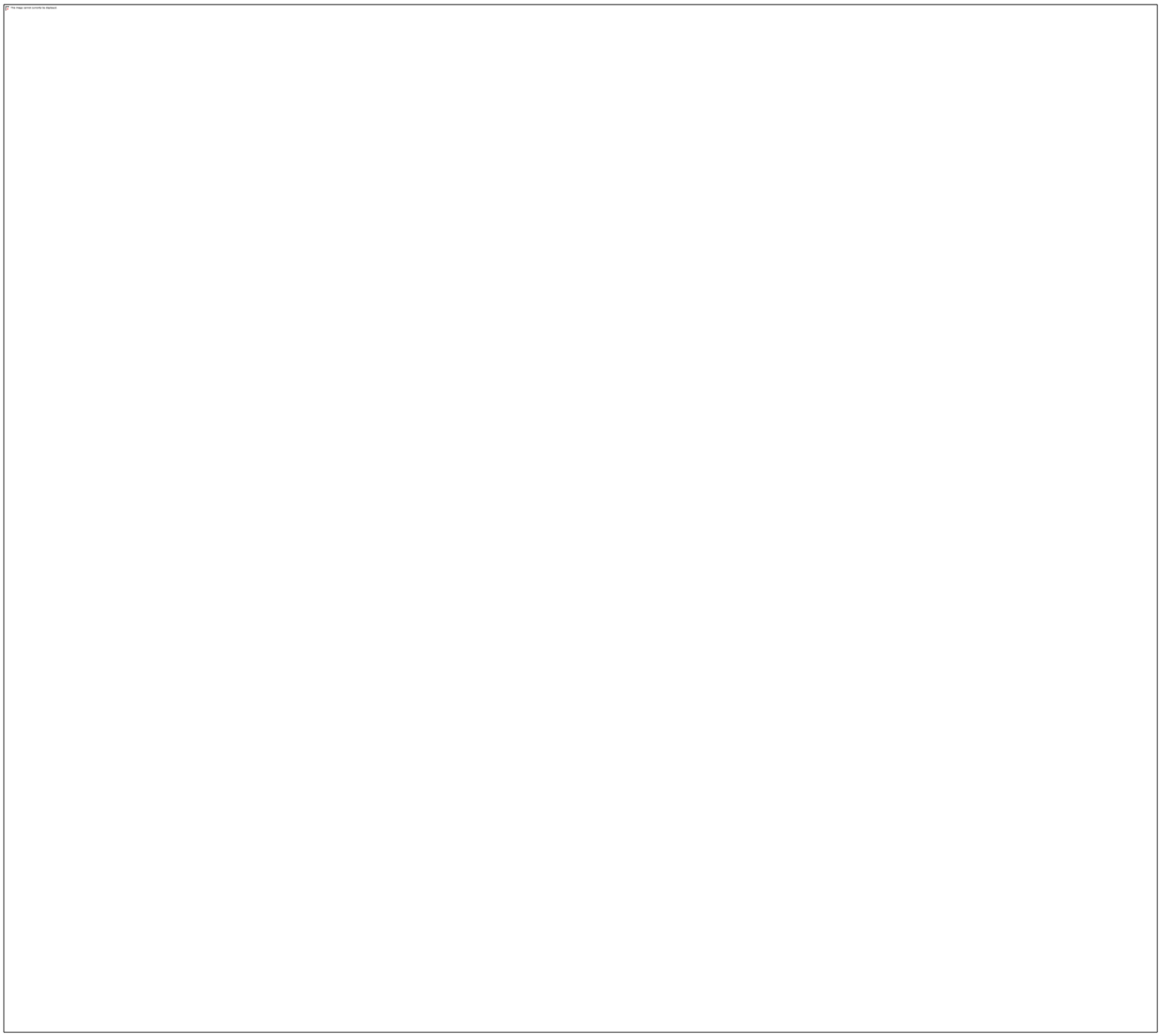
1. Open the CAD program.
2. Set the drawing units to millimetres.
3. Activate the required isometric drawing mode or create a 3D solid.
4. Establish the isometric axes.
5. Draw the vertical edges representing the height.
6. Draw the left receding edges representing one horizontal dimension.
7. Draw the right receding edges representing the other horizontal dimension.
8. Complete the top and side outlines.
9. Check that corresponding parallel edges remain parallel.
10. Add dimensions where required.
11. Save the drawing.



10.9 Drawing a stepped block in isometric projection using CAD

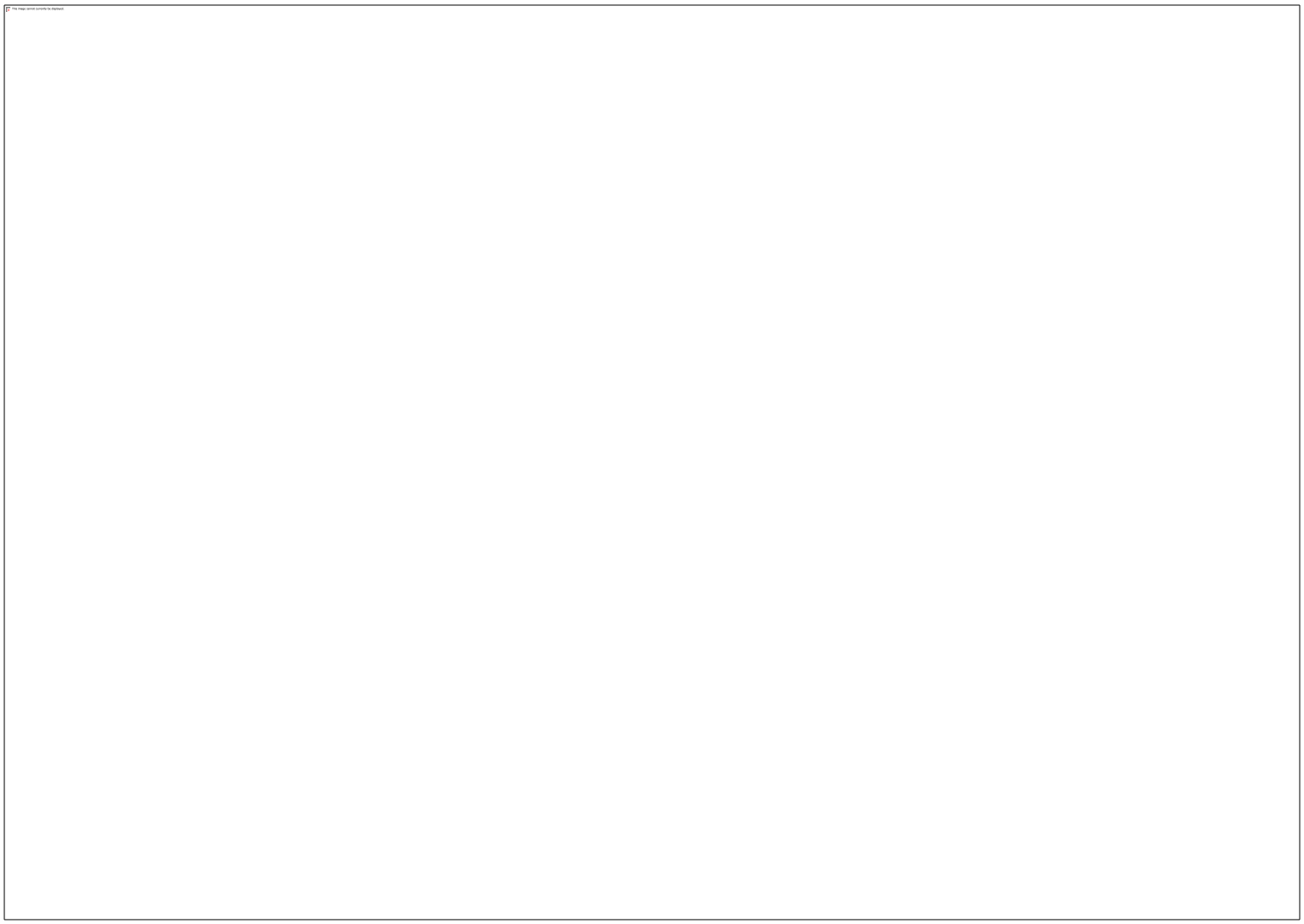
Procedure:

1. Create the base rectangular solid.
2. Create the upper rectangular portion.
3. Position the upper portion correctly.
4. Combine the two solids using UNION if appropriate.
5. Select an isometric view.
6. Adjust the viewing angle.
7. Apply a suitable visual style.
8. Add dimensions if required.
9. Save the drawing.



10.10 Drawing a block with a slot in isometric projection

1. Create the main rectangular solid.
2. Create a smaller cutting solid representing the slot.
3. Position the cutting solid correctly.
4. Use the SUBTRACT command to remove the material.
5. Select an isometric view.
6. Inspect the slot from the top and sides.
7. Apply a suitable visual style.
8. Save the model.



11.0 OBLIQUE PROJECTION USING CAD

11.1 Meaning of oblique projection

Oblique projection is a method of representing a three-dimensional object on a two-dimensional surface in which the front face is drawn in its true shape and size, while the receding edges are drawn at an angle to the horizontal.

It is used to represent the depth of an object while retaining the actual shape of the front face.



11.2 Characteristics of oblique projection

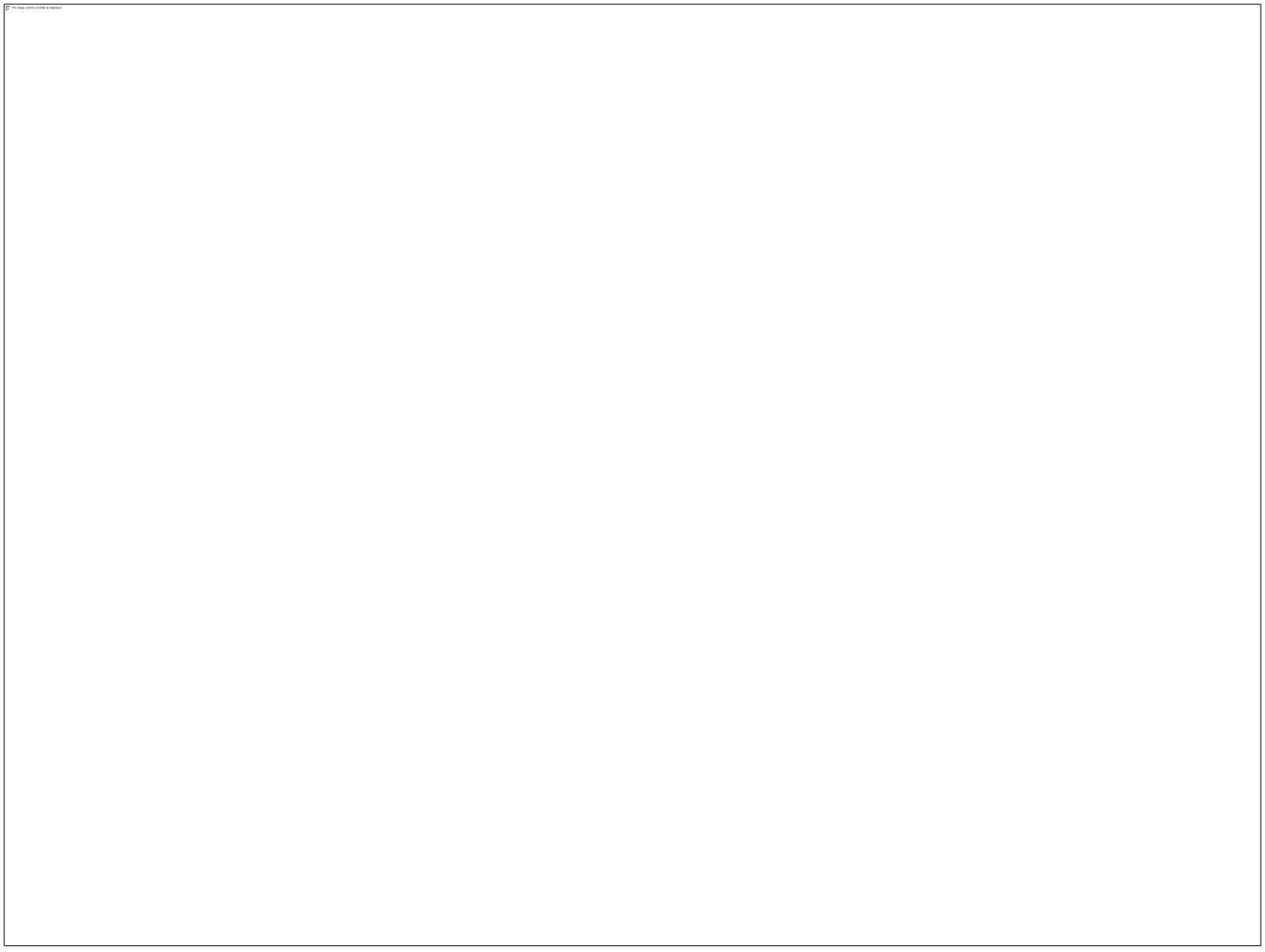
1. The front face is drawn in its true shape and size.
2. The front horizontal edges are drawn horizontally.
3. The front vertical edges are drawn vertically.
4. Receding edges are drawn at an angle, commonly 45°.
5. Depth is represented using receding lines.
6. It can show length, width and height in one pictorial drawing.
7. It is useful for simple shaped blocks and construction components.
8. It can be produced using CAD drawing and modelling tools.

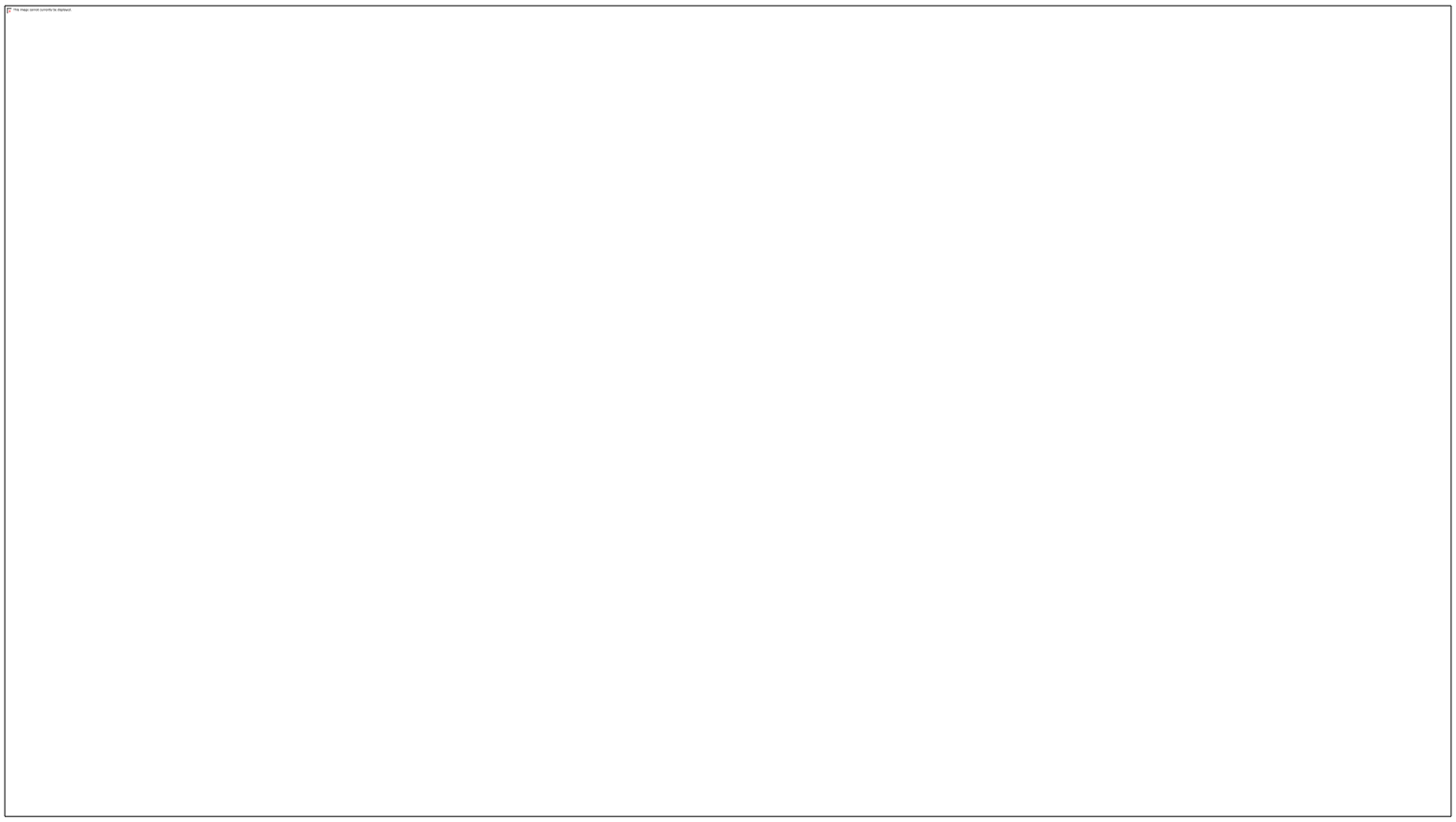
11.3 Main types of oblique projection

The two commonly taught forms of oblique projection are:

1. Cavalier projection.
2. Cabinet projection.







12.0 CAVALIER OBLIQUE PROJECTION

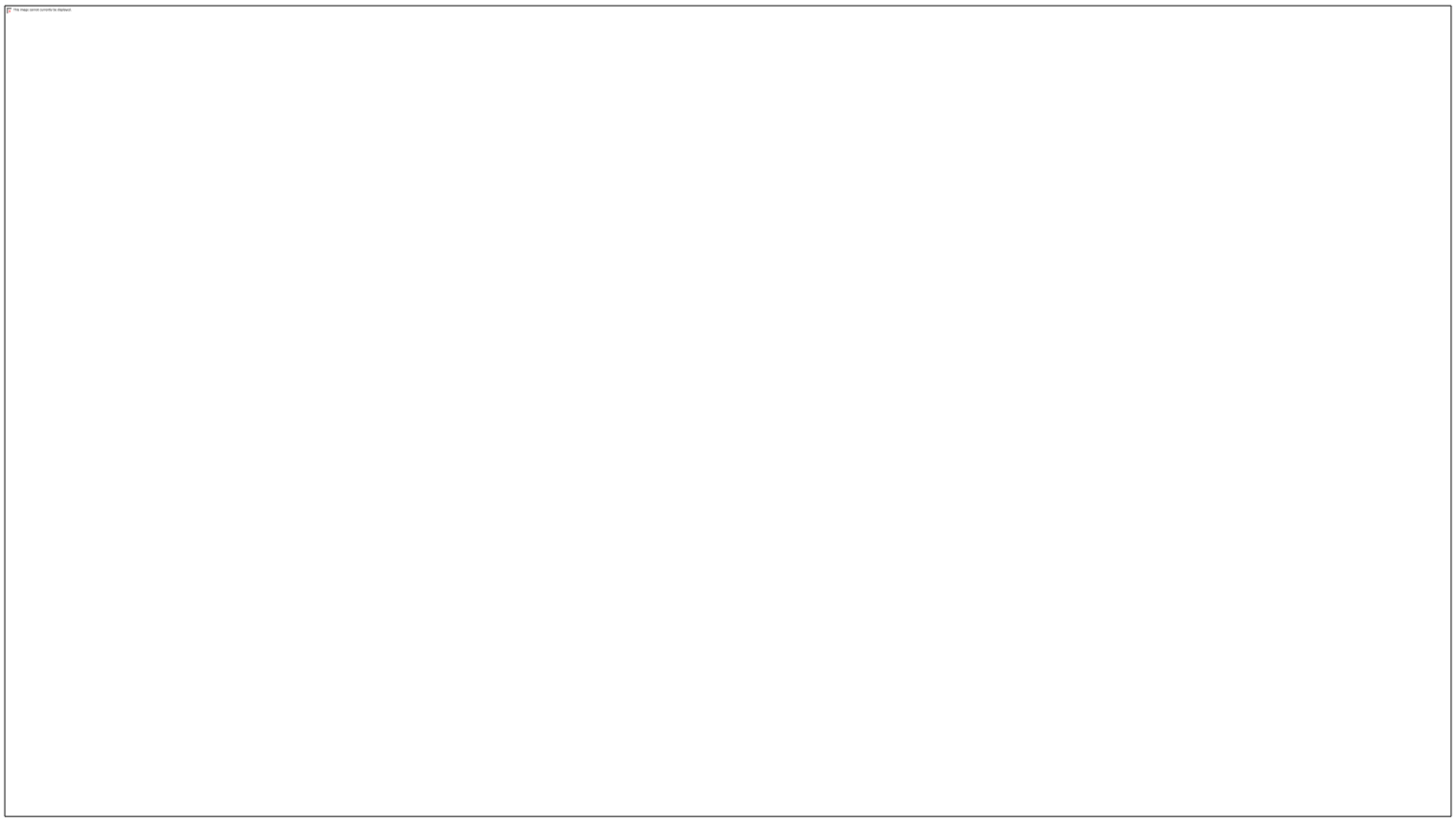
12.1 Definition of cavalier projection

Cavalier projection is a type of oblique projection in which the front face is drawn in its true shape and size, while the receding edges are drawn at an angle, commonly 45°, using the full actual depth of the object.

This means that the depth is not reduced in the drawing.

12.2 Characteristics of cavalier projection

1. The front face is drawn in its true shape and size.
2. The front horizontal edges remain horizontal.
3. The front vertical edges remain vertical.
4. Receding edges are commonly drawn at 45°.
5. The full depth is represented.
6. The receding dimensions are not shortened.
7. It may make objects appear elongated or distorted.
8. It is useful for demonstrating the principle of oblique projection.



12.3 Example of cavalier projection

A rectangular block has the following dimensions:

- Length = 100 mm.
- Height = 60 mm.
- Depth = 40 mm.

In cavalier projection:

- Draw the front face as a rectangle measuring 100 mm by 60 mm.
- Draw the receding edges at 45°.
- Draw each receding edge using the full depth of 40 mm.
- Complete the top and side faces.

12.4 Procedure for drawing a block in cavalier projection using CAD

1. Open the CAD program.
2. Set the units to millimetres.
3. Select the 2D drafting workspace or a suitable drawing plane.
4. Draw the front face using the required length and height.
5. From the appropriate front-face corners, draw receding lines at 45°.
6. Set the receding line length equal to the actual depth.
7. Join the corresponding endpoints.
8. Complete the visible outlines.

9. Apply suitable line thickness.
10. Add dimensions and a drawing title.
11. Save the drawing.

Example dimensions: Front face = 100 mm × 60 mm; depth = 40 mm.

13.0 CABINET OBLIQUE PROJECTION

13.1 Definition of cabinet projection

Cabinet projection is a type of oblique projection in which the front face is drawn in its true shape and size, while the receding edges are drawn at an angle, commonly 45°, using half the actual depth of the object.

It reduces the length of the receding edges to make the drawing appear more natural and less distorted than cavalier projection.

13.2 Characteristics of cabinet projection

1. The front face is drawn in its true shape and size.
2. The front horizontal edges remain horizontal.
3. The front vertical edges remain vertical.
4. Receding edges are commonly drawn at 45°.
5. The depth is reduced to half its actual size.
6. It generally gives a more balanced pictorial appearance than cavalier projection.
7. It is suitable for representing rectangular blocks and furniture-like objects.
8. It is used to communicate the shape of simple objects.

13.3 Example of cabinet projection

A rectangular block has:

- Length = 100 mm.
- Height = 60 mm.
- Actual depth = 40 mm.

In cabinet projection:

Drawing depth=Actual depth2Drawing depth=2Actual depth

=402=20mm=240=20*mm*

Therefore:

- Draw the front face as 100 mm by 60 mm.
- Draw the receding lines at 45°.
- Draw the receding lines 20 mm long.
- Complete the visible outline.

13.4 Procedure for drawing a block in cabinet projection using CAD

1. Open the CAD program.

2. Set the drawing units.
3. Select the 2D drafting environment.
4. Draw the front face in its true shape and size.
5. Calculate half the actual depth.
6. Draw receding lines at 45°.
7. Use the calculated half-depth measurement.
8. Join the endpoints to complete the object.
9. Check that the front face remains unchanged.
10. Add dimensions and a title.
11. Save the drawing.

14.0 DIFFERENCES BETWEEN CAVALIER AND CABINET PROJECTION

Cavalier projection	Cabinet projection
Front face is drawn in true shape and size.	Front face is drawn in true shape and size.
Receding edges are commonly drawn at 45°.	Receding edges are commonly drawn at 45°.
Full actual depth is used.	Half actual depth is used.
Receding lines are longer.	Receding lines are shorter.
Objects may appear elongated.	Objects usually appear less distorted.
Useful for demonstrating full-depth oblique representation.	Useful for producing more visually balanced oblique drawings.

14.1 Worked comparison

A shaped block has the following dimensions:

- Front length = 120 mm.
- Front height = 80 mm.
- Actual depth = 60 mm.

Cavalier projection:

Receding length=60mmReceding length=60*mm*

Cabinet projection:

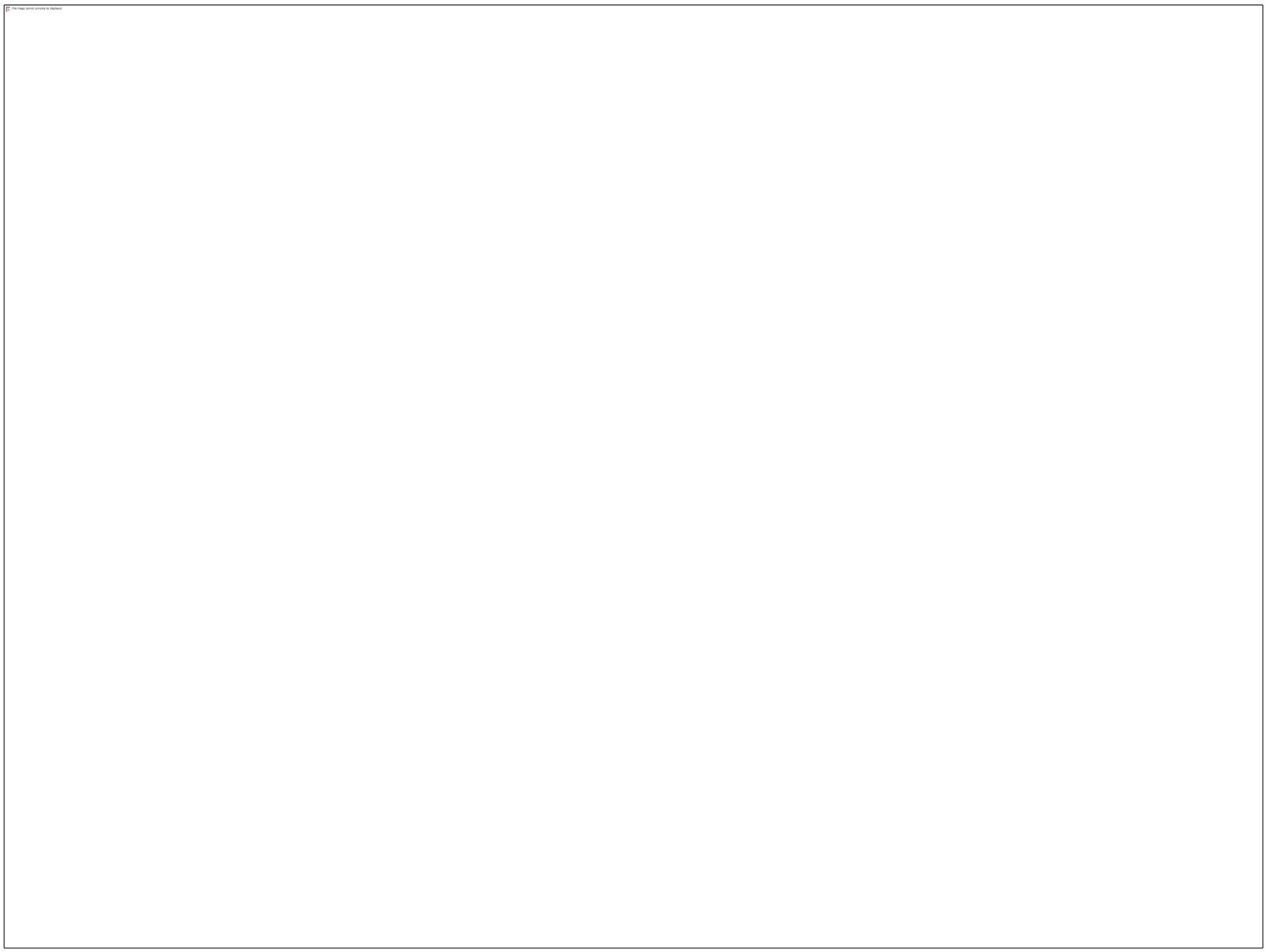
Receding length=602=30mmReceding length=260=30*mm*

Observation: The front face is identical in both drawings. The difference is the length of the receding edges.

15.0 COMPARISON BETWEEN ISOMETRIC AND OBLIQUE PROJECTION

Both isometric and oblique projection are methods of representing three-dimensional objects on two-dimensional drawing surfaces. However, they differ in the arrangement of their axes and the way dimensions are represented.

Isometric projection	**Oblique projection**
The three principal axes are equally inclined to one another.	The front face is drawn in its true shape and size.
Vertical edges are drawn vertically.	Vertical edges on the front face are drawn vertically.
Receding axes are commonly drawn at 30° to the horizontal.	Receding edges are commonly drawn at 45° to the horizontal.
The three principal dimensions are equally foreshortened in true isometric projection.	The front-face dimensions remain unchanged.
It does not show the front face in its true shape in the usual isometric representation.	It shows the front face in its true shape.
It provides a balanced pictorial representation.	Its appearance depends on the receding angle and depth reduction.
Useful for representing building components and three-dimensional models.	Useful for representing objects whose front-face details need to remain clear.





16.0 IMPORTANCE OF CAD IN BUILDING CONSTRUCTION

Computer-Aided Drawing has become an important tool in the construction industry because it improves the preparation, modification, presentation and management of technical drawings.

16.1 Improves drawing accuracy

- CAD allows users to enter exact dimensions.
- It reduces errors associated with manual measurement.
- It enables accurate positioning of objects.

- It helps maintain correct proportions.
- It supports the preparation of precise construction details.

Example: A technician can draw a concrete column measuring 300 mm by 300 mm using exact dimensions.

16.2 Saves time

- CAD provides ready-made drawing tools.
- Objects can be copied and reused.
- Repetitive drawing operations can be automated.
- Changes can be made without redrawing the entire drawing.
- Complex drawings can be prepared more efficiently.

16.3 Allows easy modification of drawings

- Dimensions can be changed when design requirements change.
- Objects can be moved, copied, rotated or deleted.
- Different design alternatives can be developed.
- Drawings can be updated without starting from the beginning.

Example: A classroom plan can be modified to change the position of doors and windows.

16.4 Improves drawing presentation

- CAD produces neat and clear drawings.
- Line thickness and colour can be controlled.
- Text and dimensions can be arranged professionally.
- Three-dimensional models can improve the presentation of design ideas.

16.5 Supports three-dimensional visualisation

- CAD allows users to view objects from different directions.
- It helps learners understand the shape of construction components.
- It enables designers to identify possible design problems.
- It makes it easier to explain building proposals to clients.

16.6 Reduces material wastage

- Accurate drawings help reduce measurement errors.
- Components can be planned before fabrication.
- Construction materials can be estimated more accurately.
- Incorrect cutting and unnecessary alterations can be reduced.

16.7 Facilitates storage and retrieval of drawings

- Digital drawings can be stored electronically.
- Files can be organised into folders.

- Old drawings can be retrieved when needed.
- Digital copies can be kept as construction records.

16.8 Promotes collaboration

- Drawings can be shared among architects, engineers, technicians and contractors.
- Different professionals can work on related project information.
- Design changes can be communicated more easily.
- It supports coordination between different construction activities.

16.9 Supports printing and reproduction

- Drawings can be printed in different sheet sizes.
- Multiple copies can be produced.
- Drawings can be exported into different file formats.
- Digital copies can be sent to other professionals.

16.10 Supports modern construction technologies

CAD is an important foundation for other digital construction processes.

It supports activities such as:

- Building Information Modelling (BIM).
- Digital building visualisation.
- Computer-aided manufacturing.
- Preparation of construction documentation.
- Digital coordination of building projects.

16.11 Improves safety planning

- Construction layouts can be prepared before work begins.
- Access routes and working spaces can be planned.
- Potential spatial conflicts can be identified.
- Safety-related construction details can be communicated clearly.

16.12 Provides opportunities for employment and entrepreneurship

CAD skills can help learners develop competencies useful in:

- Architectural drafting.
- Building design support.
- Technical drawing.
- Construction documentation.
- Digital modelling.
- CAD freelancing and related services, subject to relevant professional requirements.

17.0 LIMITATIONS AND CHALLENGES OF USING CAD

Although CAD has many advantages, it also has some challenges.

17.1 High initial costs

- Some CAD software requires paid licences.
- Computers with suitable specifications may be expensive.
- Schools and small construction businesses may find the costs challenging.

Possible solution: Use appropriate open-source software and shared computer facilities where suitable.

17.2 Need for specialised skills

- Users need training to operate CAD programs.
- Complex drawings require advanced skills.
- Beginners may take time to understand the interface and commands.

Possible solution: Provide regular practice, demonstrations and structured training.

17.3 Dependence on electricity

- Computers require electrical power.
- Power interruptions can disrupt drawing activities.
- Unsaved work may be lost when a computer shuts down unexpectedly.

Possible solution: Save work regularly and use suitable backup power where available.

17.4 Computer breakdowns

- Hardware failures may prevent access to drawings.
- Damaged storage devices may result in data loss.
- Software errors can interrupt work.

Possible solution: Maintain computers and keep backup copies of important drawings.

17.5 Software compatibility problems

- Different programs may use different file formats.
- Some features may not transfer correctly between applications.
- Users may experience problems when sharing drawings.

Possible solution: Agree on suitable exchange formats, such as DXF or PDF where appropriate, and verify exported files.

17.6 Cybersecurity and data loss

- Computer files may be affected by malware.
- Unauthorised persons may access drawings.
- Important project information may be lost.

Possible solution: Use appropriate security software, access controls and reliable backups.

17.7 Overdependence on technology

- Learners may struggle with manual drawing if they rely entirely on CAD.
- Technical understanding is still necessary.
- CAD cannot replace sound construction knowledge and professional judgement.

Possible solution: Combine manual drawing exercises with computer-based drawing activities.

18.0 PROCEDURES FOR SAVING, OPENING AND PRINTING CAD DRAWINGS

18.1 Saving a CAD drawing

Saving is the process of storing a drawing electronically so that it can be accessed and modified later.

Procedure:

1. Complete the drawing or the current stage of work.
2. Open the File menu.
3. Select Save As when saving for the first time.
4. Select the appropriate storage folder.
5. Enter a meaningful file name.
6. Select the required file format.
7. Click Save.
8. Save changes regularly as work continues.

Common file formats include:

File format	Main purpose
DWG	Native drawing format used by AutoCAD and supported by some other CAD programs
DXF	Drawing exchange format
PDF	Sharing and printing drawings
STL	Commonly used for 3D printing models
STEP	Exchange of 3D model geometry between supported CAD applications

18.2 Opening an existing CAD drawing

1. Start the CAD application.
2. Select Open.
3. Locate the folder containing the drawing.
4. Select the required file.
5. Click Open.
6. Allow the software to load the drawing.

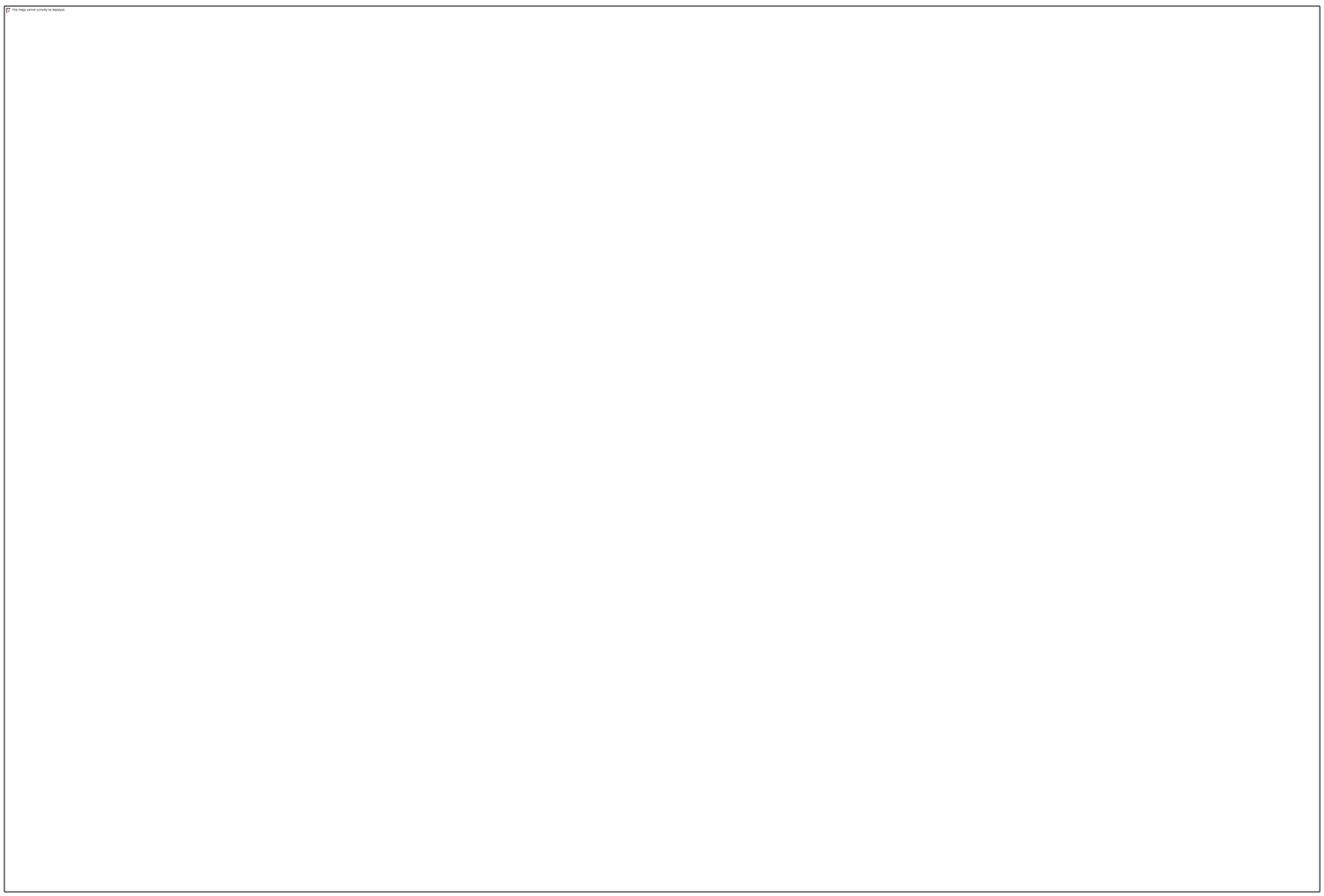
7. Check whether the drawing displays correctly.

18.3 Printing or plotting a CAD drawing

Printing or plotting is the process of producing a physical copy of a CAD drawing on paper.

Procedure:

1. Open the completed drawing.
2. Select the Print or Plot option.
3. Select the available printer or plotter.
4. Select the required paper size.
5. Select the drawing area or layout to be printed.
6. Set the appropriate print scale.
7. Select line weights and other print settings.
8. Preview the drawing.
9. Check the title block and dimensions.
10. Print the drawing.



19.0 PRACTICAL APPLICATIONS OF CAD IN THE KENYAN BUILDING CONSTRUCTION INDUSTRY

CAD can be applied in different construction activities in Kenya.

19.1 Residential building construction

CAD can be used to prepare:

- Bungalow floor plans.
- Maisonette plans.
- Building elevations.
- Roof plans.
- Foundation layouts.
- Staircase details.
- Door and window schedules.

19.2 School construction

In the construction of a school in areas such as Kilgoris, Narok, Nakuru or Nairobi, CAD can be used to prepare:

- Classroom layouts.
- Administration block drawings.
- Laboratory layouts.
- Sanitation block drawings.
- Dining hall layouts.
- Computer laboratory arrangements.
- Playground and site layouts.

19.3 Commercial building construction

CAD is useful when preparing drawings for:

- Shops.
- Offices.
- Warehouses.
- Hotels.
- Shopping centres.
- Workshops.

19.4 Road and drainage construction

CAD can assist in preparing:

- Road layouts.
- Drainage layouts.
- Culvert details.

- Access road drawings.
- Site grading plans.

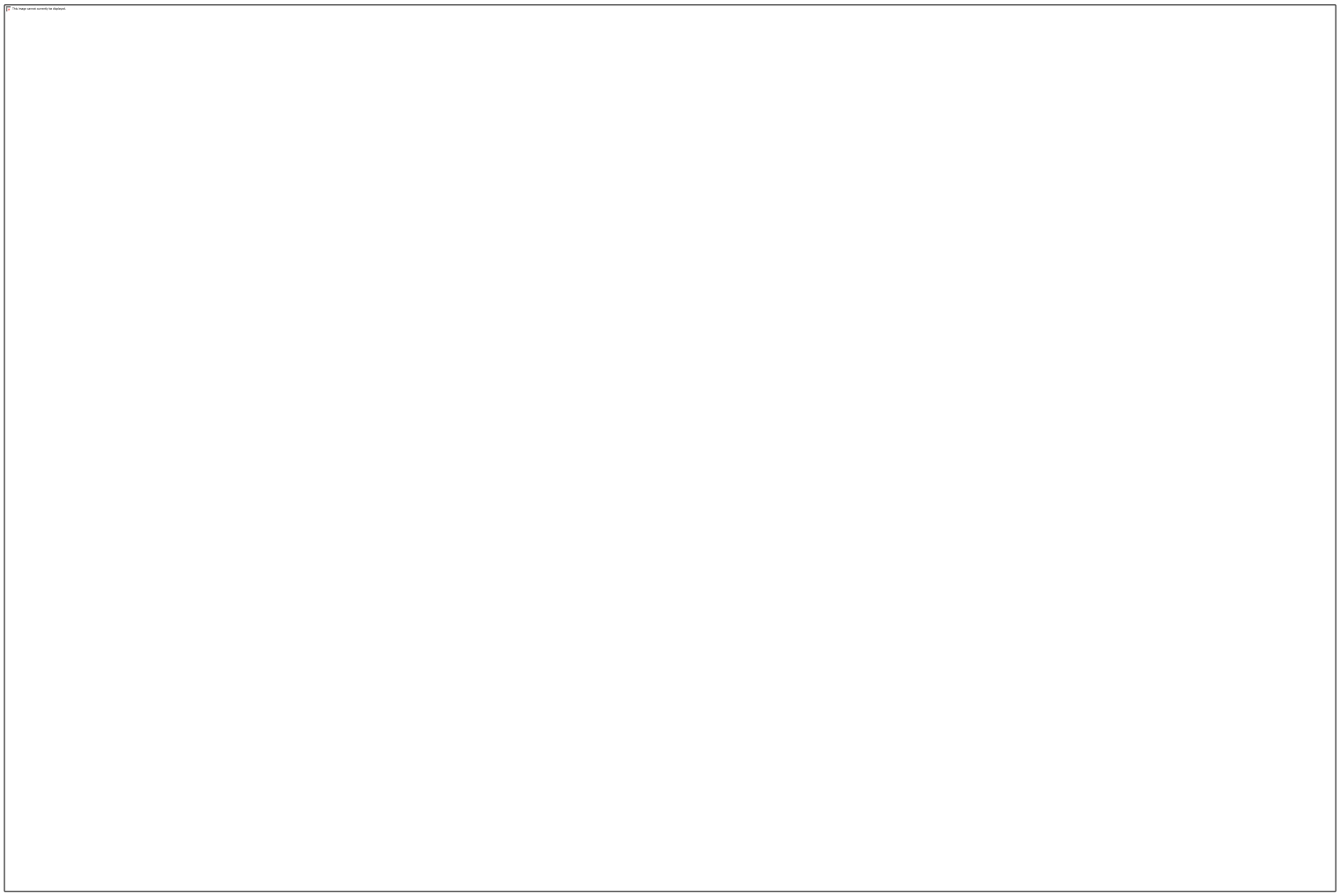
19.5 Construction of building components

CAD can be used to model and draw:

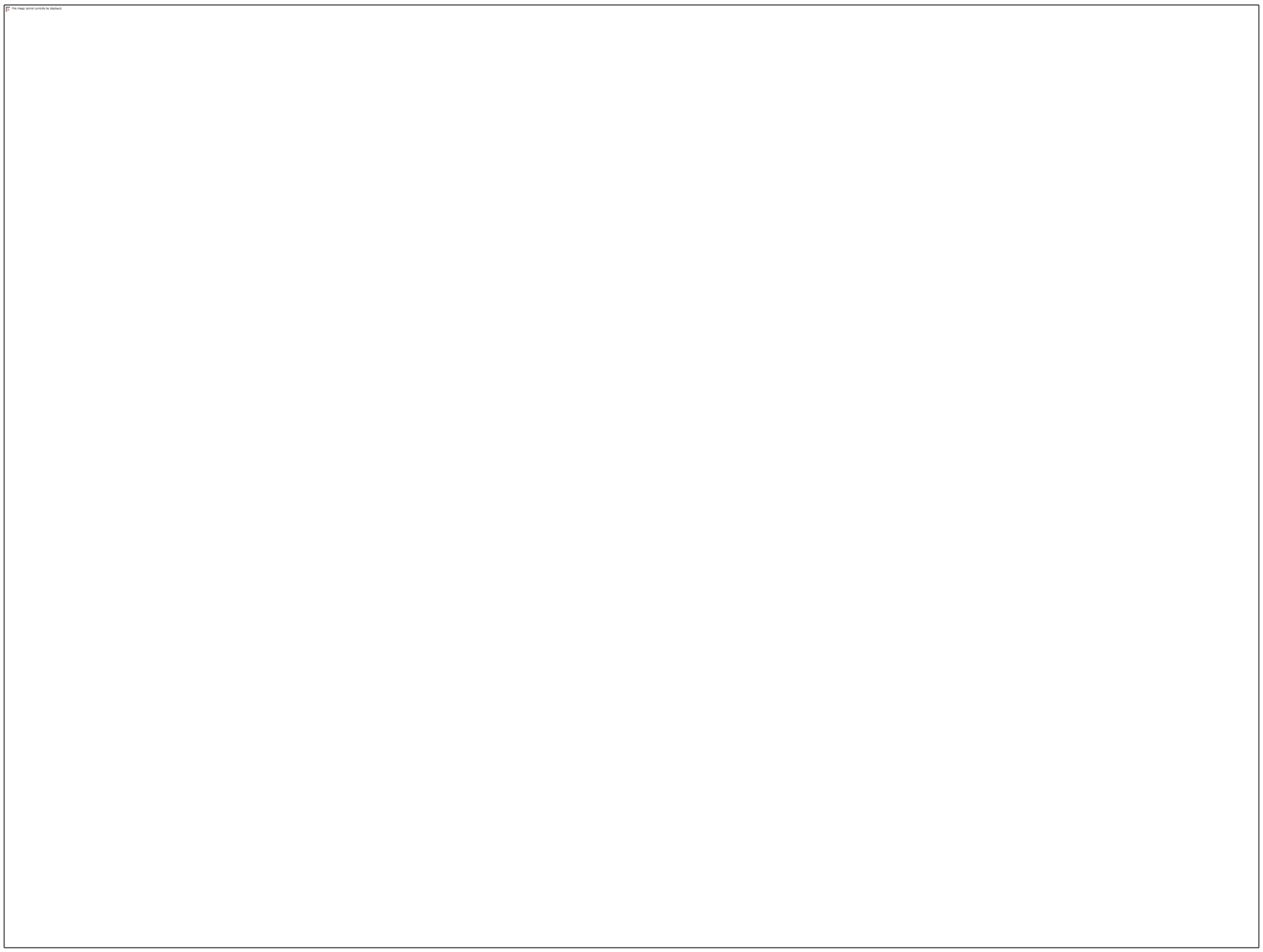
- Concrete blocks.
- Reinforced concrete columns.
- Beams.
- Timber roof components.
- Window frames.
- Door frames.
- Staircase components.

19.6 Visualisation of proposed buildings

Three-dimensional CAD models help clients and construction teams understand the proposed appearance of buildings before construction starts.



AMANI SENIOR SCHOOL



20.0 PRACTICAL LEARNING ACTIVITIES

Activity 1: Exploring the CAD environment

Learning task: Identify the main components of a CAD interface.

Requirements:

- A computer.
- CAD software.
- Projector where available.
- Notebook.

Procedure:

1. Switch on the computer.
2. Open the CAD application.
3. Observe the interface.
4. Identify the title bar.
5. Identify the ribbon or toolbar.
6. Identify the drawing area.
7. Identify the command line.
8. Identify the status bar.
9. Identify the navigation tools.
10. Record the functions of the identified components.

Expected outcome: The learner should be able to identify and explain the main parts of a CAD environment.

Activity 2: Setting up a CAD drawing

Learning task: Create a new drawing and configure the required settings.

Procedure:

1. Open the CAD program.
2. Create a new drawing.
3. Set the drawing units to millimetres.
4. Set suitable drawing limits.
5. Enable the drawing grid.
6. Set suitable snap spacing.
7. Create layers for object outlines and dimensions.
8. Save the drawing as GRADE11_BLOCK_EXERCISE.
9. Take note of the settings used.

Expected outcome: The learner should be able to prepare a CAD drawing environment correctly.

Activity 3: Creating a 3D rectangular block

Object dimensions:

- Length = 400 mm.
- Width = 200 mm.
- Height = 150 mm.

Procedure:

1. Open the 3D CAD workspace.
2. Set the drawing units.
3. Select the BOX tool.
4. Enter the required length and width.
5. Enter the required height.
6. Complete the model.
7. Use Orbit to inspect the block.
8. Display it in an isometric view.
9. Save the model.

Expected outcome: The learner should be able to create a 3D solid block with specified dimensions.

Activity 4: Creating a stepped block

Procedure:

1. Create a rectangular solid.
2. Create another smaller solid.
3. Position the second solid above the first.
4. Combine the solids using UNION if required.
5. View the model in isometric orientation.
6. Save the drawing.

Expected outcome: The learner should be able to create a stepped block using solid modelling tools.

Activity 5: Drawing a block in isometric projection

1. Create or select a rectangular block.
2. Establish the isometric axes.
3. Draw the vertical edges.
4. Draw the receding edges.
5. Complete the top and side faces.
6. Check the alignment of the edges.
7. Add dimensions.
8. Save the drawing.

Activity 6: Drawing a block in cavalier and cabinet projection

Use a block with the following dimensions:

- Length = 120 mm.
- Height = 80 mm.
- Actual depth = 60 mm.

Task A: Cavalier projection

1. Draw the front face.
2. Draw the receding edges at 45°.
3. Use the full depth of 60 mm.
4. Complete the object.

Task B: Cabinet projection

1. Draw the same front face.
2. Calculate half the actual depth.
3. Draw the receding edges at 45°.
4. Use a receding length of 30 mm.
5. Complete the object.

Expected outcome: The learner should be able to distinguish and draw the two types of oblique projection.

REVISION QUESTIONS

SECTION A: MULTIPLE-CHOICE QUESTIONS

Choose the correct answer from the alternatives provided.

SECTION A: MULTIPLE-CHOICE QUESTIONS

INSTRUCTIONS: Choose the correct answer from the alternatives provided.

1. Computer-Aided Drawing (CAD) refers to the use of:

A. Manual instruments only to prepare drawings.
B. Computers and specialised software to prepare technical drawings.
C. Cameras to capture construction photographs.
D. Printers to produce building materials.

2. Which of the following is an example of CAD software?

A. Microsoft Word
B. Microsoft Excel
C. AutoCAD
D. Microsoft PowerPoint

3. Which of the following is mainly used for two-dimensional CAD drafting?

A. LibreCAD
B. Media Player
C. Calculator
D. Web browser

4. The main working area where objects are created in CAD is called:

A. Title bar
B. Drawing area
C. Status bar
D. Application menu

5. Which part of the CAD environment is used to enter typed drawing commands?

A. Command line
B. Title bar
C. Navigation cube
D. Properties panel

6. The CAD component that displays drawing settings such as grid and snap is commonly called:

A. Title bar
B. Status bar
C. File menu
D. Drawing sheet

7. Which of the following is an example of a CAD command used to create a rectangular solid in AutoCAD-style software?

A. BOX
B. ERASE
C. COPY
D. PRINT

8. Drawing units refer to:

A. The colours used in a drawing.
B. The measurement system used to represent dimensions.
C. The number of lines in a drawing.
D. The size of the computer screen.

9. Which unit is commonly used for detailed building components and technical drawings?

A. Kilogram
B. Litre
C. Millimetre
D. Degree

10. Drawing limits are used to:

A. Define a working boundary for the drawing.
B. Change the colour of the computer screen.
C. Delete unwanted objects automatically.
D. Print drawings in colour.

11. Which of the following coordinates represents a point in a three-dimensional CAD system?

A. X and Y only
B. X and Z only
C. X, Y and Z
D. Length and width only

12. A drawing grid is mainly used to:

A. Colour drawing objects.
B. Assist in alignment and positioning.
C. Print drawings.
D. Delete unwanted lines.

13. Which of the following best describes snap mode?

A. It displays the drawing in different colours.
B. It restricts cursor positioning to specified intervals or positions.
C. It automatically prints the drawing.
D. It changes the drawing scale.

14. A scale of 1:100 means that:

A. 100 units on the drawing represent one unit in reality.
B. One unit on the drawing represents 100 units in reality.
C. The drawing is enlarged 100 times.
D. The drawing is full size.

15. A drawing scale of 2:1 is an example of:

A. Reducing scale
B. Full-size scale
C. Enlarging scale
D. Natural scale

16. Which of the following represents three-dimensional drawing?

A. Length and width only
B. Length, width and height
C. Height only
D. Length only

17. Which of the following is a characteristic of solid modelling?

A. It represents only lines.
B. It represents objects with volume.
C. It represents only surface outlines.
D. It cannot be modified.

18. Which command is commonly used to combine two or more solid objects?

A. SUBTRACT
B. UNION
C. ERASE
D. PAN

19. Which command is commonly used to remove one solid from another?

A. UNION
B. MOVE
C. SUBTRACT
D. ZOOM

20. Isometric projection represents an object using:

A. Length only
B. Length and width only
C. Length, width and height
D. Height and width only

21. In conventional isometric drawing, the receding axes are commonly drawn at:

A. 15° to the horizontal
B. 30° to the horizontal
C. 45° to the horizontal
D. 60° to the horizontal

22. In isometric projection, the three principal axes are equally spaced at:

A. 45°
B. 60°
C. 90°
D. 120°

23. Oblique projection is characterised by:

A. A front face drawn in its true shape and size.
B. All edges converging at a vanishing point.
C. A front face drawn as a circle only.
D. The absence of receding edges.

24. Which of the following is a type of oblique projection?

A. Cavalier projection
B. First-angle projection
C. Third-angle projection
D. Perspective projection

25. In cavalier projection, the receding edges are drawn using:

A. Half the actual depth
B. One-quarter of the actual depth
C. The full actual depth
D. Twice the actual depth

26. In cabinet projection, the receding edges are normally drawn using:

A. Full actual depth
B. Half actual depth
C. Double actual depth
D. Zero depth

27. A block has an actual depth of 80 mm. What receding length is used in cabinet projection?

A. 80 mm
B. 60 mm
C. 40 mm
D. 20 mm

28. A block has an actual depth of 50 mm. What receding length is used in cavalier projection?

A. 25 mm
B. 50 mm
C. 100 mm
D. 10 mm

29. Which of the following is an advantage of CAD?

A. It increases drawing errors.
B. It prevents all design changes.
C. It allows accurate modification of drawings.
D. It eliminates the need for technical knowledge.

30. Which of the following is a limitation of CAD?

A. It allows digital storage.
B. It requires computer equipment and appropriate skills.
C. It supports accurate measurements.
D. It enables easy modification.

SECTION B: STRUCTURED QUESTIONS

1.

a) Define Computer-Aided Drawing. (2 marks)

b) Differentiate between Computer-Aided Drawing and Computer-Aided Design. (4 marks)

c) Explain four uses of CAD in Building Construction. (8 marks)

2.

a) Define CAD software. (2 marks)

b) Name five CAD software applications used in technical drawing and construction. (5 marks)

c) Explain five factors to consider when selecting CAD software. (10 marks)

3.

a) Define the CAD environment. (2 marks)

b) Identify eight components of a CAD environment. (8 marks)

c) Explain the functions of the following:

i. Drawing area. (2 marks)

ii. Command line. (2 marks)

iii. Status bar. (2 marks)

iv. Navigation tools. (2 marks)

4.

a) Explain the meaning of drawing units. (2 marks)

b) State five drawing units that may be used in CAD. (5 marks)

c) Explain five reasons why selecting the correct drawing units is important. (10 marks)

5.

a) Define drawing limits. (2 marks)

b) Explain four importance of setting drawing limits. (8 marks)

c) Describe the procedure for setting drawing limits in AutoCAD-style software. (5 marks)

6.

a) Define drawing scale. (2 marks)

b) Name the three main types of drawing scale. (3 marks)

c) Differentiate between reducing and enlarging scales. (4 marks)

d) A wall is 8 metres long. It is represented by a line measuring 80 mm. Calculate the drawing scale. (4 marks)

7.

a) Define a drawing grid. (2 marks)

b) Explain three types of drawing grids or drawing guidance settings used in CAD. (6 marks)

c) Differentiate between grid and snap. (4 marks)

8.

a) Define three-dimensional drawing. (2 marks)

b) Identify the three principal axes used in 3D CAD. (3 marks)

c) Explain the differences between wireframe, surface and solid modelling. (9 marks)

9.

a) Define isometric projection. (2 marks)

b) State six characteristics of isometric projection. (6 marks)

c) Explain four advantages of isometric projection in Building Construction. (8 marks)

10.

a) Define oblique projection. (2 marks)

b) Identify the two main types of oblique projection. (2 marks)

c) Explain six characteristics of oblique projection. (6 marks)

11.

a) Define cavalier projection. (2 marks)

b) State five characteristics of cavalier projection. (5 marks)

c) A block has a depth of 70 mm. State the receding length used in cavalier projection. (2 marks)

12.

a) Define cabinet projection. (2 marks)

b) State five characteristics of cabinet projection. (5 marks)

c) A block has an actual depth of 100 mm. Calculate the receding length used in cabinet projection. (2 marks)

13. State and explain eight differences between cavalier and cabinet projection. (16 marks)

14. Explain ten importance of CAD in the Building Construction industry. (20 marks)

15. Describe the procedure for creating a rectangular solid measuring 400 mm long, 200 mm wide and 150 mm high using a 3D CAD program. (10 marks)

16. Explain five challenges associated with the use of CAD in construction and suggest one solution to each. (10 marks)

17. Setting up a drawing for a school project

A Grade 11 learner has been assigned the task of preparing a CAD drawing of a proposed classroom block for a school in Narok County.

Before beginning the drawing, the learner is required to prepare the CAD environment.

Tasks:

a) Explain five settings the learner should establish before drawing. (5 marks)

b) Identify five components of the CAD environment that the learner will use. (5 marks)

c) Explain why correct drawing units are important in this project. (3 marks)

d) State four ways the learner can protect the digital drawing from loss or damage. (4 marks)

18. Developing a three-dimensional concrete block

A construction workshop requires a three-dimensional model of a concrete block measuring 400 mm by 200 mm by 150 mm.

Tasks:

a) Identify the three dimensions of the block. (3 marks)

b) State the three coordinate axes used in 3D CAD. (3 marks)

c) Describe the procedure for creating the block using the BOX command. (5 marks)

d) Explain three benefits of creating a 3D model before producing the actual block. (3 marks)

19: Comparing isometric and oblique projection

A learner is required to represent a shaped block using isometric and oblique projection.

Tasks:

a) Define isometric projection. (2 marks)

b) Define oblique projection. (2 marks)

c) State four differences between the two methods. (4 marks)

d) Explain why a designer may choose oblique projection when the front face contains important details. (3 marks)

20: Cavalier and cabinet projection

A technician is preparing two drawings of the same concrete component.

The component has an actual depth of 80 mm.

Tasks:

a) Calculate the receding length for cavalier projection. (2 marks)

b) Calculate the receding length for cabinet projection. (2 marks)

c) State four differences between the two projections. (4 marks)

d) Explain why cabinet projection may give a more balanced pictorial appearance. (2 marks)

21: CAD in a Kenyan construction project

A construction company is planning to build a two-storey commercial building in Nakuru County. The company wants to use CAD to prepare and present the proposed design.

Tasks:

a) Explain six ways CAD can support the project. (6 marks)

b) Identify four types of drawings that can be prepared using CAD. (4 marks)

c) Explain three challenges the company may experience when using CAD. (3 marks)

d) Suggest three measures that can improve the use of CAD in the project. (3 marks)

22.0 PRACTICAL PROJECT AND ASSESSMENT

Project: Digital modelling and representation of shaped blocks

Practical CBE activity

Project objective

To enable the learner to use CAD software to set up a drawing, create three-dimensional shaped blocks and represent them using isometric, cavalier and cabinet projection.

Required materials and equipment

- Desktop or laptop computer.
- CAD software.
- Mouse.
- Keyboard.
- Drawing paper.
- Ruler.
- Calculator.
- Projector, where available.
- Sample wooden or concrete blocks.

Project activities

Task A: Setting up the CAD environment

1. Open the CAD software.
2. Create a new drawing.
3. Set drawing units to millimetres.
4. Set appropriate drawing limits.
5. Configure the drawing grid.
6. Save the drawing.

Task B: Creating a 3D rectangular block

Create a block with:

- Length = 400 mm.
- Width = 200 mm.
- Height = 150 mm.

Save the model.

Task C: Creating a stepped block

1. Create a base rectangular solid.
2. Create an upper rectangular solid.
3. Position the upper solid correctly.
4. Combine the solids where appropriate.
5. Display the result in isometric view.

Task D: Drawing an isometric representation

1. Select the appropriate isometric view.
2. Display the three visible faces.
3. Check the direction of the principal axes.
4. Add dimensions.
5. Save the drawing.

Task E: Drawing cavalier and cabinet projections

Use a front face measuring 120 mm by 80 mm and an actual depth of 60 mm.

- Draw the cavalier projection using a receding depth of 60 mm.
- Draw the cabinet projection using a receding depth of 30 mm.
- Compare the two drawings.

Suggested assessment rubric

Assessment area	**Marks**
Correct setup of CAD environment	10
Correct selection of drawing units	5
Appropriate drawing limits and grid	10
Accuracy of 3D rectangular block	15
Accuracy of stepped block	15
Correct isometric representation	15
Correct cavalier projection	10
Correct cabinet projection	10
Saving and presentation of drawings	5
Neatness and completeness	5
Total	100

23.0 KEY TERMS AND DEFINITIONS

Term	Meaning
CAD	Use of computers and specialised software to create and manage technical drawings and models.
CAD software	Computer program used to prepare and modify technical drawings.
CAD environment	The working interface of a CAD application.
Drawing area	The main workspace where objects are created.
Command line	Area used to enter commands and instructions.
Drawing units	Measurement units used in a drawing.
Drawing limits	Defined working boundaries of a drawing.
Drawing scale	Ratio between drawing measurements and actual measurements.
Drawing grid	Visual reference pattern used to guide positioning and alignment.
Snap	A setting that controls cursor positioning at specified intervals or locations.
2D drawing	Drawing represented using length and width.
3D drawing	Drawing or model represented using length, width and height.
Wireframe	Representation of an object using lines and curves.
Surface modelling	Representation of an object using its surfaces.
Solid modelling	Representation of an object as a three-dimensional solid with volume.
Isometric projection	Representation of an object using three equally inclined principal axes.
Oblique projection	Representation in which the front face is drawn in true shape and receding edges are drawn at an angle.
Cavalier projection	Oblique projection using full actual depth along the receding edges.
Cabinet	Oblique projection using half actual depth along the receding edges.

projection	
Extrude	Extending a 2D profile into a 3D form.
Union	Combining solids into one solid.
Subtract	Removing one solid from another.
Orbit	Rotating the view around a 3D model.
Viewport	A window used to display a model or drawing view, particularly in a layout.
Model space	The main area where CAD geometry is created.
Paper space	An environment used to arrange drawings for printing and presentation.

24.0 SUMMARY OF THE SUB-STRAND

1. CAD means Computer-Aided Drawing or Computer-Aided Design, depending on the context.
2. CAD uses computers and specialised software to prepare technical drawings.
3. CAD can produce both two-dimensional drawings and three-dimensional models.
4. Examples of CAD software include AutoCAD, FreeCAD, LibreCAD and SketchUp.
5. The CAD environment includes the drawing area, ribbon, command line, status bar and navigation tools.
6. Setting up a drawing involves configuring units, limits, scale, grid and other drawing settings.
7. Drawing units determine how measurements are represented.
8. Drawing limits establish a working boundary for the drawing.
9. Drawing scale determines the relationship between drawing size and actual size.
10. A drawing grid assists with positioning and alignment.
11. Three-dimensional CAD uses the X, Y and Z axes.
12. Wireframe, surface and solid modelling are different methods of representing 3D objects.
13. Isometric projection represents three dimensions in one pictorial drawing.
14. Oblique projection represents the front face in its true shape and size.
15. Cavalier projection uses the full actual depth.
16. Cabinet projection uses half the actual depth.
17. CAD improves accuracy, speed, presentation, modification, storage and communication.
18. CAD skills are useful in modern building construction and technical drawing.

STRAND 3.0: BUILDING CONSTRUCTION PROCESS

SUB-STRAND 3.1: MASONRY SUPERSTRUCTURE WALLING

Introduction

Masonry superstructure walling is an important activity in building construction. It involves constructing walls above the foundation level using individual building units such as stones, bricks, concrete blocks and other suitable masonry materials.

Walls form an essential part of buildings because they enclose spaces, provide privacy, support structural loads where designed to do so, protect occupants from weather and help create different rooms and functional spaces.

In Kenya, masonry walling is commonly used in the construction of residential houses, schools, hospitals, commercial buildings, churches, offices and other structures. Common walling materials include machine-cut stones, natural building stones, clay bricks and concrete blocks.

The quality of a masonry wall depends on proper setting out, selection of suitable walling materials, preparation of walling units, correct mortar mixing, accurate bonding, proper alignment, safe working practices and good workmanship.

This sub-strand introduces learners to the classes of walls, walling materials, types of masonry bonds, profile boards, setting out of superstructure walls and the procedures followed when constructing masonry walls.

1.0 MEANING OF MASONRY SUPERSTRUCTURE WALLING

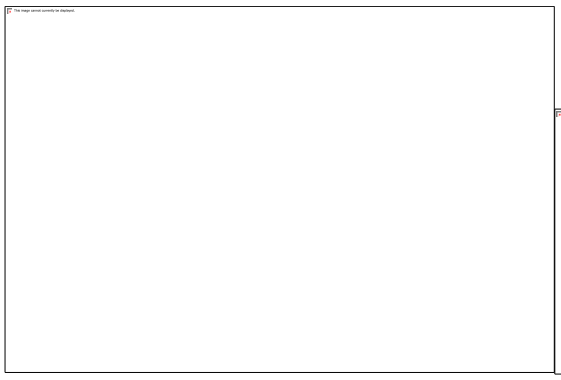
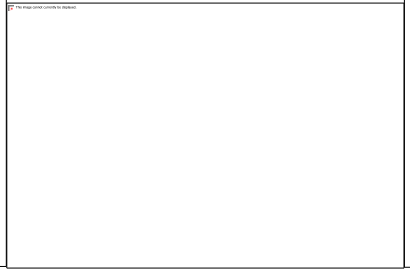
1.1 Definition of a wall

A wall is a vertical building component constructed to enclose, divide, protect or support parts of a building.

Walls may be constructed using stones, bricks, concrete blocks, reinforced concrete, timber or other suitable building materials.

Examples of walls in a building include:

- External walls enclosing a residential house.
- Internal partition walls separating bedrooms and living rooms.
- Load-bearing walls supporting floors and roof structures.
- Boundary walls surrounding a school or residential compound.
- Parapet walls constructed above roof edges.
- Ventilation walls that allow air to pass through a building.


1.2 Definition of masonry

Masonry is a method of construction in which individual building units such as stones, bricks or concrete blocks are arranged and joined together to form a structure.

The units may be joined using mortar or placed without mortar in suitable dry masonry applications.

Examples of masonry construction:

1. Construction of stone walls.
2. Construction of brick walls.
3. Construction of concrete block walls.
4. Construction of stone boundary walls.
5. Construction of masonry retaining walls, where properly designed.

1.3 Definition of superstructure

A superstructure is the part of a building constructed above the foundation or substructure.

It includes the building components that rise above the ground or foundation level and provide the required spaces, enclosure and structural support.

Examples of superstructure components include:

- Walls.
- Columns.
- Beams.
- Suspended floors.
- Staircases.
- Roof structures.
- Door and window openings.



1.4 Meaning of masonry superstructure walling

Masonry superstructure walling is the process of constructing walls above the foundation using masonry units such as stones, bricks and concrete blocks, usually joined together using mortar.

The process involves:

1. Establishing the wall outline.
2. Setting out the wall positions.
3. Preparing the walling units.
4. Preparing mortar.
5. Laying the walling units.
6. Maintaining the correct bond.
7. Checking alignment, level and plumb.
8. Cleaning the completed work area.

1.5 Importance of masonry superstructure walling

Walls perform several important functions in buildings.

A. Enclosing building spaces

- Walls form the outer boundaries of buildings.
- They protect the interior from external conditions.
- They help create secure and usable indoor spaces.

Example: External stone walls enclose a residential house in Nakuru County.

B. Providing privacy

- Walls separate private areas from public spaces.
- They prevent direct viewing into rooms.
- They help create privacy in bedrooms, offices and bathrooms.

C. Supporting structural loads

- Properly designed load-bearing walls support loads from floors, roofs and other building components.
- They transfer these loads to the foundation.
- They contribute to the stability of the building.

D. Dividing internal spaces

- Internal walls divide buildings into functional rooms.
- They help organise spaces according to their intended uses.

Examples:

- Dividing a school building into classrooms.
- Separating bedrooms from living rooms.
- Creating offices within commercial buildings.

E. Protecting occupants from weather

- External walls protect occupants from rain, wind and excessive sunlight.
- They help regulate indoor conditions.
- They contribute to the comfort of building users.

F. Providing security

- Strong external walls help protect buildings from unauthorised entry.
- Boundary walls help control access to properties.
- They provide a physical barrier around buildings.

G. Reducing noise transmission

- Some masonry walls reduce the transmission of sound between rooms and from outside.
- Their effectiveness depends on thickness, density, construction details and openings.

H. Improving the appearance of buildings

- Walls provide surfaces for architectural finishes.
- Different walling materials create different appearances.
- Wall finishes may include plaster, paint, stone facing or exposed brickwork.

I. Supporting building services

- Walls may accommodate electrical conduits, plumbing pipes and other service installations.
- Service routes must be properly planned to avoid weakening structural walls.

J. Improving fire separation

- Suitable masonry walls can provide fire resistance.
- They may be used to separate spaces and slow the spread of fire.
- Their performance depends on material type, thickness, construction and applicable fire-safety requirements.

2.0 CLASSIFICATION OF WALLS USED IN BUILDING CONSTRUCTION

Walls can be classified according to:

1. Their functions.
2. Their locations in a building.
3. The materials used to construct them.
4. Their methods of construction.

Understanding these classifications helps a builder select the correct type of wall for a particular construction purpose.

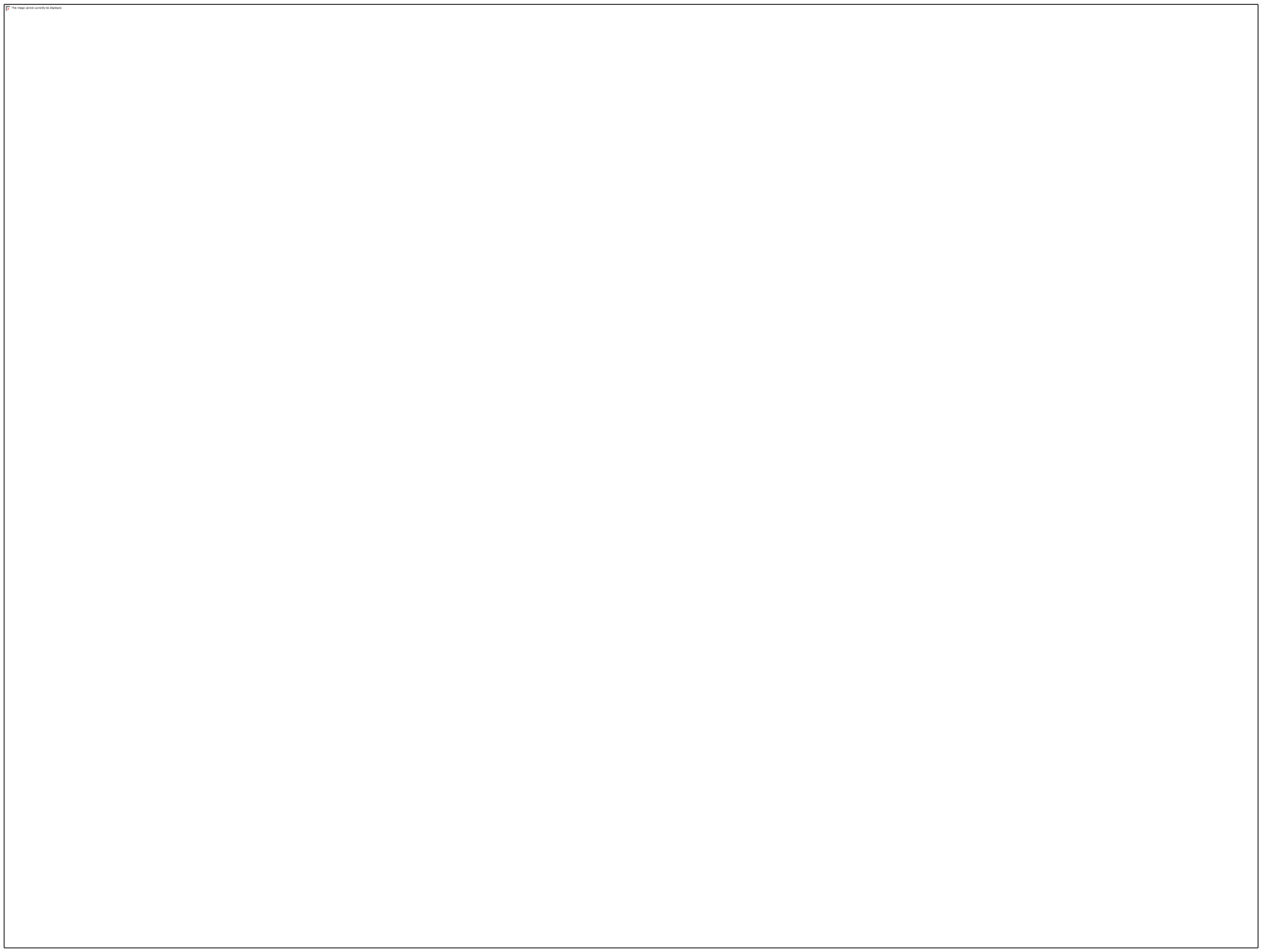
2.1 Classification of walls according to function

This classification considers the purpose performed by the wall.

The main categories include:

- Load-bearing walls.
- Non-load-bearing walls.
- Partition walls.
- Parapet walls.
- Ventilation walls.

A. Load-bearing walls



Definition: A load-bearing wall is a wall designed to carry loads from building components above it and transfer those loads safely to the foundation.

The loads may come from:

- Roof structures.
- Floor slabs.
- Beams.
- Upper floors.
- The weight of the wall itself.

Characteristics of load-bearing walls:

1. They are designed to support structural loads.
2. They transfer loads to the foundation.
3. They require suitable strength and stability.
4. Their thickness and material selection depend on structural design.
5. They must be properly connected to other structural components.
6. They should not be removed or altered without professional structural assessment.

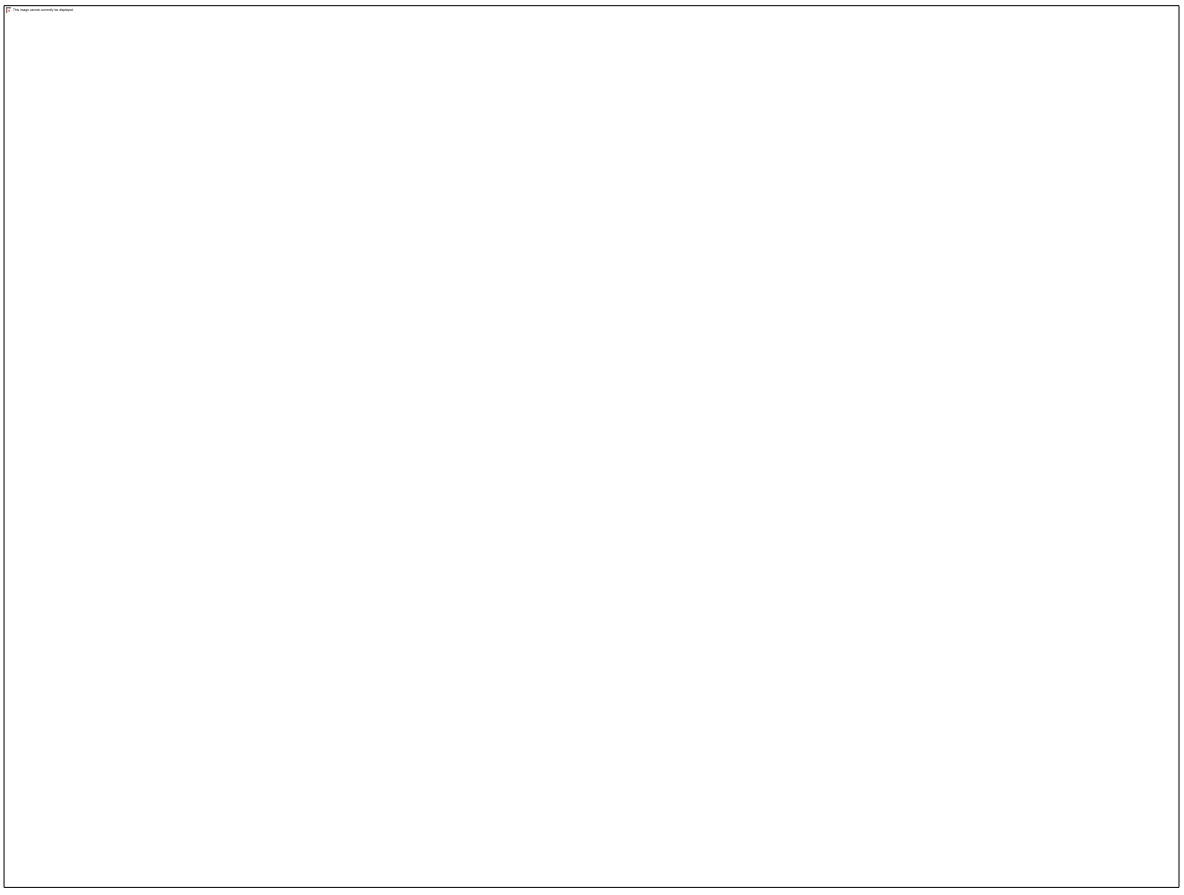
Examples:

- Masonry walls supporting a roof in a single-storey house.
- Walls supporting an upper floor in a properly designed masonry building.
- Structural masonry walls in some school and residential buildings.

Importance of load-bearing walls:

1. They support the weight of building components.
2. They help maintain structural stability.
3. They transfer loads to the foundation.
4. They reduce the need for some independent supporting elements, depending on the design.
5. They contribute to the overall strength of a building.

B. Non-load-bearing walls



Definition: A non-load-bearing wall is a wall that is not designed to support the loads of floors or roof structures above it, apart from its own weight and any loads specifically allowed by its design.

Characteristics:

1. It mainly provides enclosure or division of spaces.
2. It carries its own weight.
3. It is not intended to support major structural loads from upper building components.
4. It may be constructed using lightweight blocks, bricks or other suitable materials.
5. Its design must account for stability and lateral forces.
6. It may be easier to alter than a load-bearing wall, but alterations still require checks for services, stability and building requirements.

Examples:

- Internal masonry partitions.
- Some external infill walls in framed buildings.
- Walls dividing offices in a commercial building.

Importance of non-load-bearing walls:

1. They divide spaces into rooms.
2. They provide privacy.
3. They improve the organisation of buildings.
4. They provide surfaces for finishes.
5. They may help control sound transmission.

C. Partition walls



Definition: A partition wall is a wall used mainly to divide the internal space of a building into separate rooms or functional areas.

Partition walls are commonly non-load-bearing, although their actual structural role must always be confirmed from the building design.

Characteristics:

1. They are mainly constructed inside buildings.
2. They divide large spaces into smaller functional areas.
3. They provide privacy.
4. They may be constructed using bricks, blocks, timber or lightweight walling systems.
5. Their thickness depends on the materials and design requirements.
6. They may contain doorways and other openings.

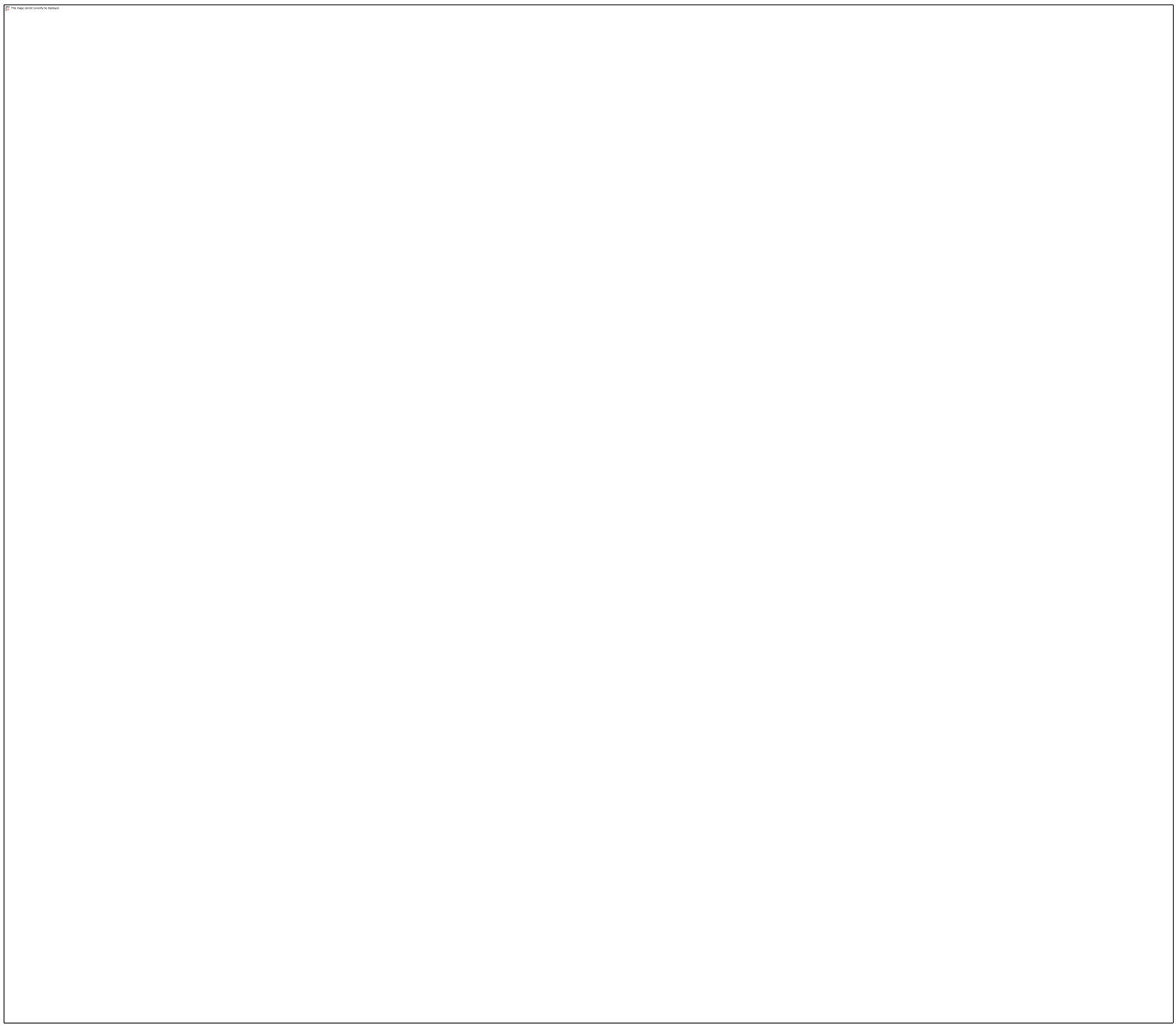
Examples in Kenyan buildings:

- A wall separating two classrooms.
- A wall dividing an office into separate working areas.
- A wall separating a bedroom from a living room.
- A wall separating a bathroom from a bedroom.

Importance of partition walls:

1. They organise internal spaces.
2. They improve privacy.
3. They provide sound separation.
4. They improve the functionality of buildings.
5. They create separate areas for different activities.

D. Parapet walls



Definition: A parapet wall is a low wall constructed along the edge of a roof, balcony, terrace or raised platform.

It extends above the roof or floor level and may provide protection and concealment.

Characteristics:

1. It is commonly constructed at roof edges.
2. It is generally lower than ordinary room walls.
3. It may be constructed using masonry or reinforced concrete.
4. It requires suitable weather protection and waterproofing details.
5. It must be properly designed and secured against wind and other forces.
6. Its height and construction details should meet applicable safety requirements.

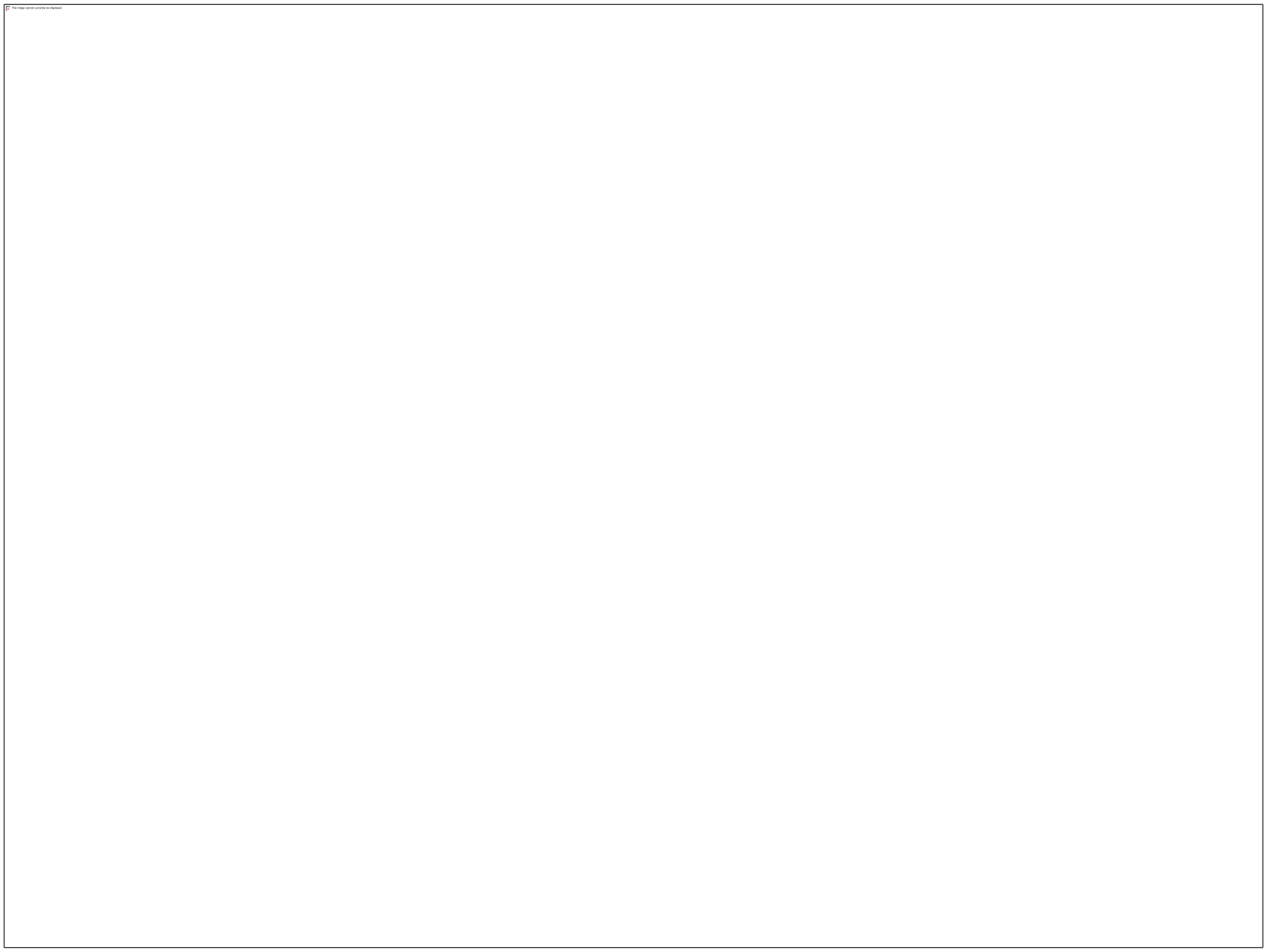
Uses of parapet walls:

- Protecting people from falling at roof edges where designed as a guard.

- Concealing roof edges and services.
- Improving the appearance of flat-roofed buildings.
- Providing an edge for roof waterproofing details.
- Screening rooftop equipment.

Example: A masonry parapet around the roof of a commercial building in Nairobi.

E. Ventilation walls



Definition: A ventilation wall is a wall designed with openings or specially arranged units to allow air to pass through a building or enclosed space.

Ventilation walls may be constructed using perforated bricks, ventilation blocks, lattice masonry or other suitable materials.

Characteristics:

1. They contain openings that permit air movement.
2. They allow natural ventilation.
3. They may admit natural light.
4. They provide partial screening and privacy.

5. They can improve indoor comfort.
6. They must be designed to maintain adequate strength and stability.

Examples:

- Perforated block walls in school corridors.
- Ventilation walls in bathrooms.
- Lattice masonry walls in kitchens.
- Ventilation screens in livestock structures.

Importance of ventilation walls:

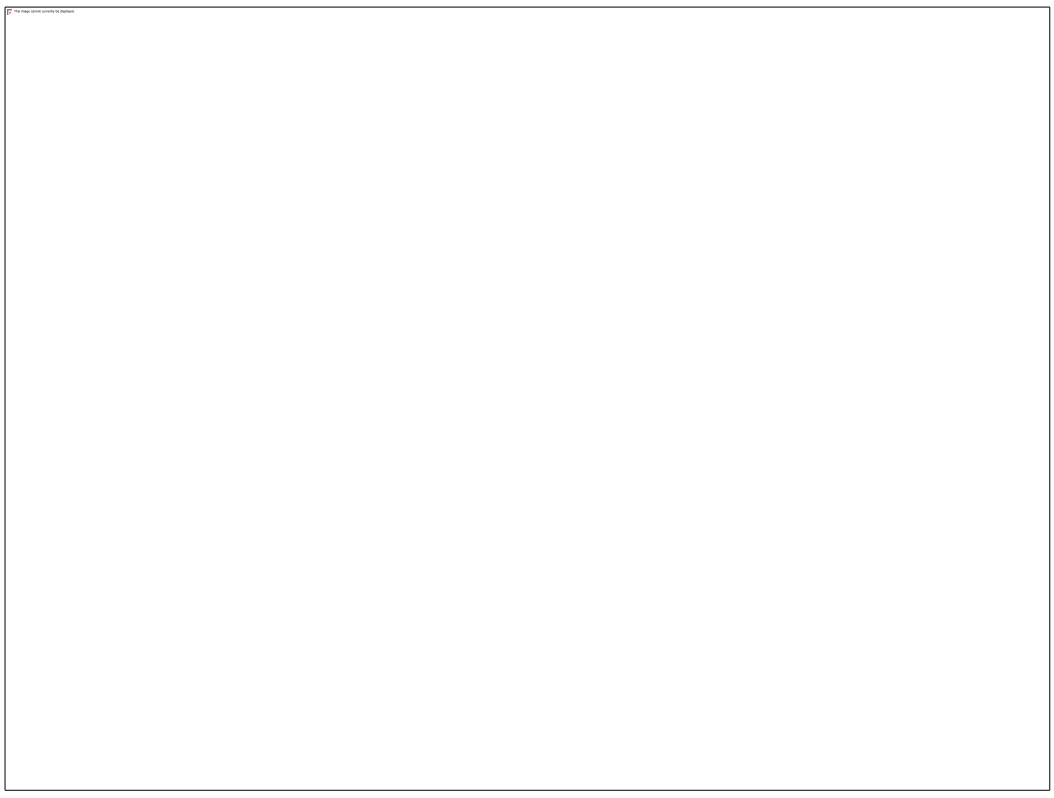
1. Improve circulation of fresh air.
2. Help remove hot air from enclosed spaces.
3. Reduce moisture build-up.
4. Improve indoor comfort.
5. Allow natural light into some spaces.
6. Reduce dependence on mechanical ventilation in suitable situations.

2.2 Classification of walls according to location

According to their position in a building, walls are classified into:

1. Interior walls.
2. Exterior walls.

A. Interior walls



Definition: Interior walls are walls constructed within a building to divide, enclose or organise internal spaces.

Characteristics:

1. They are located inside buildings.
2. They may be load-bearing or non-load-bearing.
3. They provide privacy between rooms.
4. They help organise internal spaces.
5. They may accommodate electrical and plumbing services.
6. They may receive finishes such as plaster, paint or tiles.

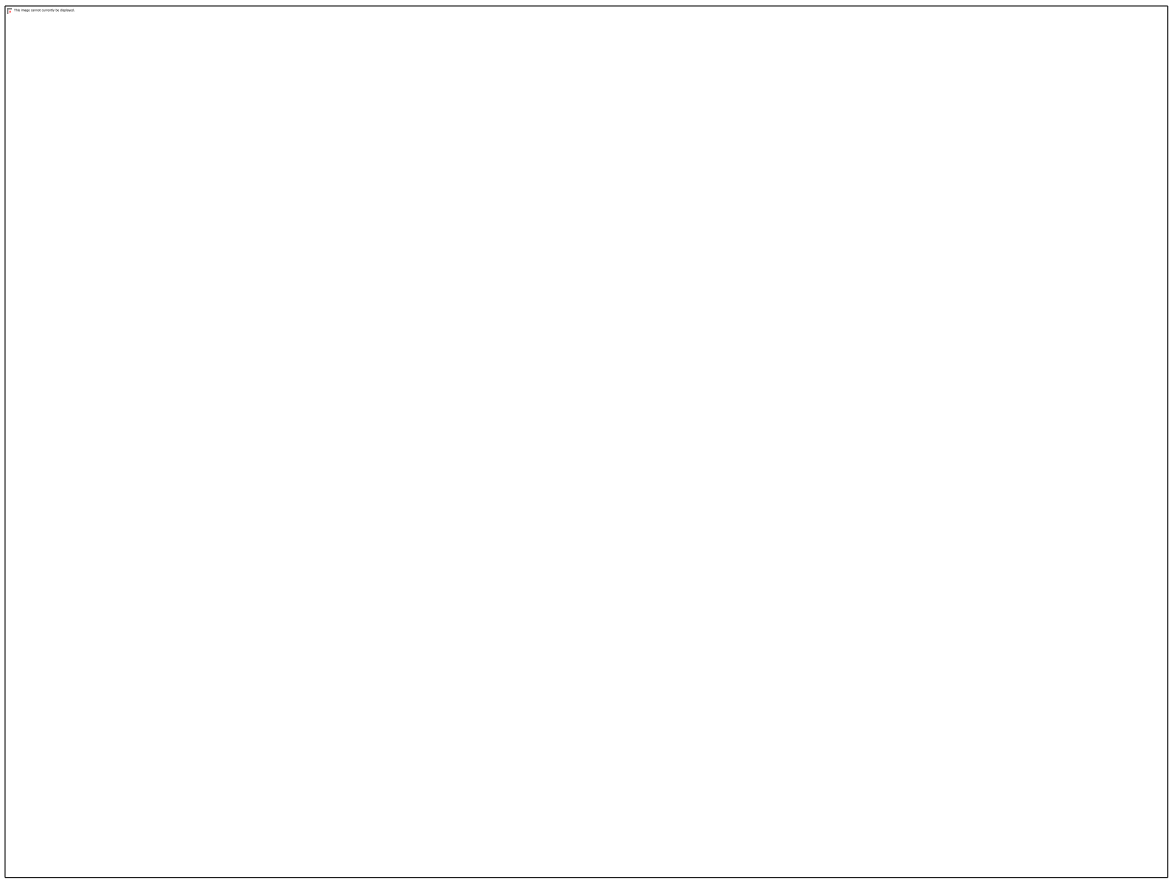
Examples:

- Walls separating classrooms.
- Walls separating bedrooms.
- Walls dividing offices.
- Walls enclosing internal staircases.

Functions of interior walls:

1. Dividing rooms.
2. Providing privacy.
3. Reducing noise transmission.
4. Supporting structural loads where designed to do so.
5. Providing surfaces for internal finishes.
6. Separating areas with different functions.

B. Exterior walls



Definition: Exterior walls are walls constructed around the outside of a building to enclose and protect the internal spaces from external conditions.

Characteristics:

1. They form the external enclosure of a building.
2. They are exposed to weather conditions.
3. They must resist rain, wind and other environmental effects.
4. They may be load-bearing or non-load-bearing.
5. They require appropriate weather-resistant finishes or detailing.
6. They may contain windows, doors and ventilation openings.

Functions of exterior walls:

1. Protecting occupants from rain and wind.
2. Providing security.
3. Enclosing internal spaces.
4. Reducing unwanted heat transfer.
5. Improving the appearance of a building.
6. Supporting structural loads where designed for that purpose.

Example: External machine-cut stone walls enclosing a residential house in Narok County.

2.3 Classification of walls according to materials used

Walls can also be classified according to the main material used in their construction.

The main masonry wall types include:

1. Brick walls.
2. Stone walls.
3. Concrete walls.

A. Brick walls



Definition: A brick wall is a wall constructed using individual brick units arranged in a systematic pattern and usually joined using mortar.

Bricks may be manufactured from clay, concrete or other suitable materials.

Types of bricks used in walling:

- Burnt clay bricks.
- Concrete bricks.
- Engineering bricks.
- Perforated bricks.
- Solid bricks.

Characteristics of brick walls:

1. They are constructed using relatively small masonry units.
2. They can be arranged in different bonding patterns.
3. They may have attractive exposed finishes.
4. They can be used for internal and external walls.
5. Their strength depends on the quality of the bricks, mortar and workmanship.
6. They require correct joint thickness and bonding.

Uses of brick walls:

- Residential buildings.
- Partition walls.

- Boundary walls.
- Decorative walling.
- Selected structural masonry applications.

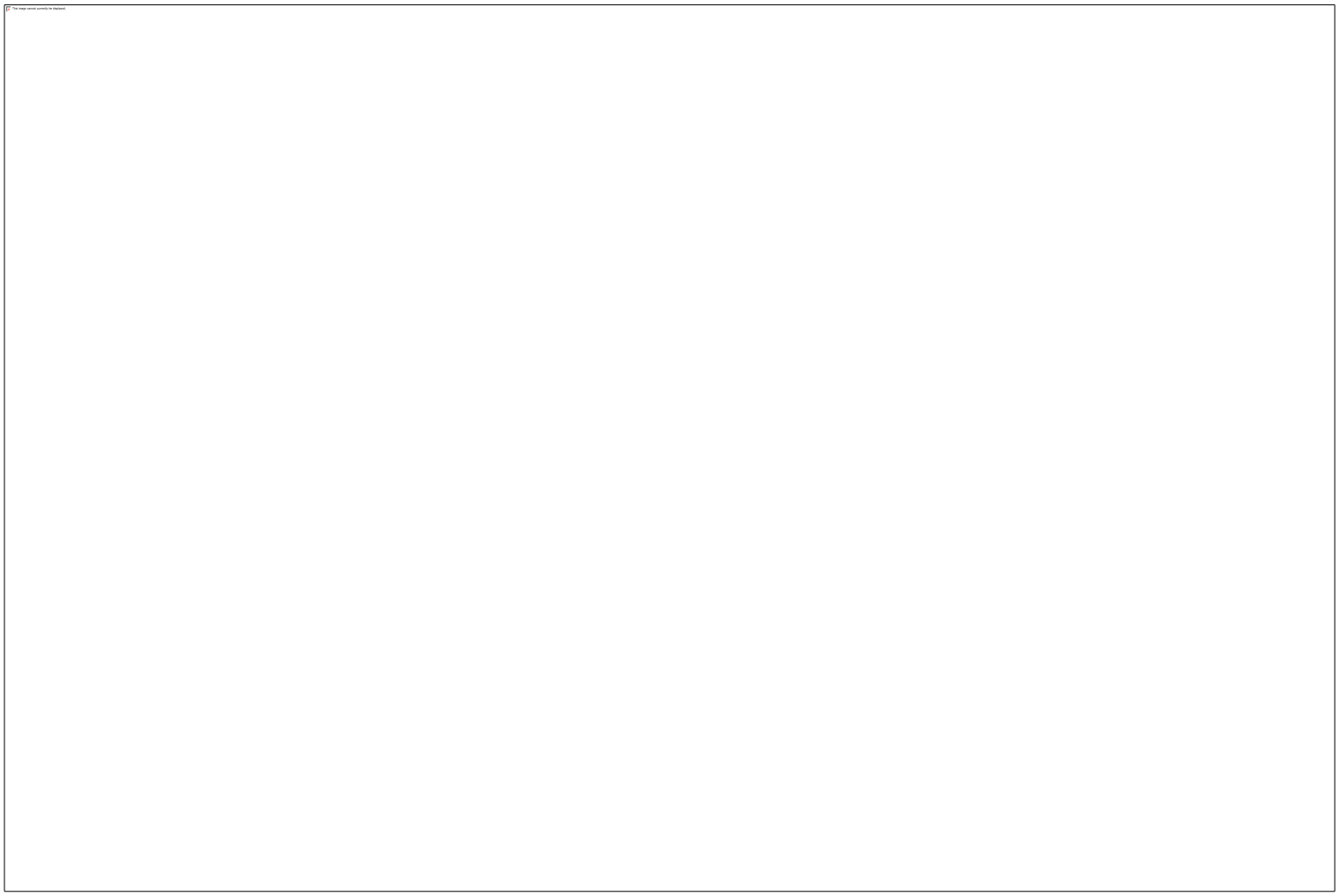
Advantages of brick walls:

1. Bricks are relatively easy to handle because of their manageable size.
2. They can produce attractive wall finishes.
3. They are suitable for different bonding patterns.
4. Individual damaged bricks can sometimes be replaced.
5. Suitable bricks can provide good durability.

Limitations of brick walls:

1. Construction may be slow because many units are required.
2. Poor-quality bricks may crack or absorb excessive water.
3. Large quantities of mortar may be required.
4. Skilled workmanship is needed to maintain proper bonding.
5. Transport costs may be high where bricks are produced far from the site.

B. Stone walls



Definition: A stone wall is a wall constructed using natural or processed stone units joined together using mortar or, in suitable applications, arranged without mortar.

Stone is widely used in Kenyan building construction because it is available in different regions and can provide strong and durable walls when properly selected and laid.

Types of stones used in wall construction:

1. Natural rubble stones.
2. Machine-cut stones.
3. Dressed stones.
4. Ashlar stones.
5. Quarry stones suitable for masonry.

Characteristics of stone walls:

1. They are made from natural stone or processed stone units.
2. They can provide durable walling.
3. They may have rough or smooth surfaces.
4. Their weight varies depending on the stone type and size.
5. They require appropriate foundations and structural design.
6. The units should be properly selected and arranged.

Uses of stone walls:

- External walls of residential houses.
- Internal masonry walls.
- Boundary walls.
- Retaining walls where properly designed.
- School and commercial buildings.

Advantages of stone walls:

1. Suitable stones can provide high durability.
2. They can resist weathering when appropriate stone is selected.
3. They provide good thermal mass.
4. They are available in many parts of Kenya.
5. They can provide an attractive natural appearance.
6. They may require relatively little maintenance when properly constructed and protected.

Limitations of stone walls:

1. Some stones are heavy and difficult to handle.
2. Transport may be expensive.
3. Irregular stones require skilled dressing and laying.

4. Poor-quality stones may crack or deteriorate.
5. Thick stone walls may occupy considerable floor space.

C. Concrete walls



Definition: A concrete wall is a wall constructed using concrete units or concrete placed in formwork to create a continuous wall.

In masonry walling, concrete blocks are commonly used as individual walling units.

Types of concrete masonry units:

1. Solid concrete blocks.
2. Hollow concrete blocks.
3. Cellular concrete blocks.
4. Interlocking concrete blocks.
5. Special-shaped concrete masonry units.

Characteristics of concrete block walls:

1. They are constructed using manufactured concrete units.
2. They may be solid or hollow.
3. Their dimensions are generally more uniform than irregular natural stones.
4. They can be laid using mortar or a specified block-laying system.
5. They are available in different strengths and sizes.
6. Their suitability depends on their quality and intended structural use.

Uses of concrete block walls:

- Residential buildings.

- Commercial buildings.
- Schools.
- Internal partitions.
- Boundary walls.
- Service and utility structures.

Advantages of concrete block walls:

1. Uniform blocks can make setting out easier.
2. Larger units may reduce the number of joints.
3. They can be manufactured to specified dimensions.
4. Hollow blocks can reduce self-weight compared with equivalent solid units.
5. They can provide durable walls when properly manufactured and installed.

Limitations of concrete block walls:

1. Poorly manufactured blocks may have inadequate strength.
2. Some blocks may absorb excessive water.
3. Heavy units may require careful handling.
4. Poor mortar and workmanship can weaken the wall.
5. Some hollow blocks require special detailing around openings and structural connections.

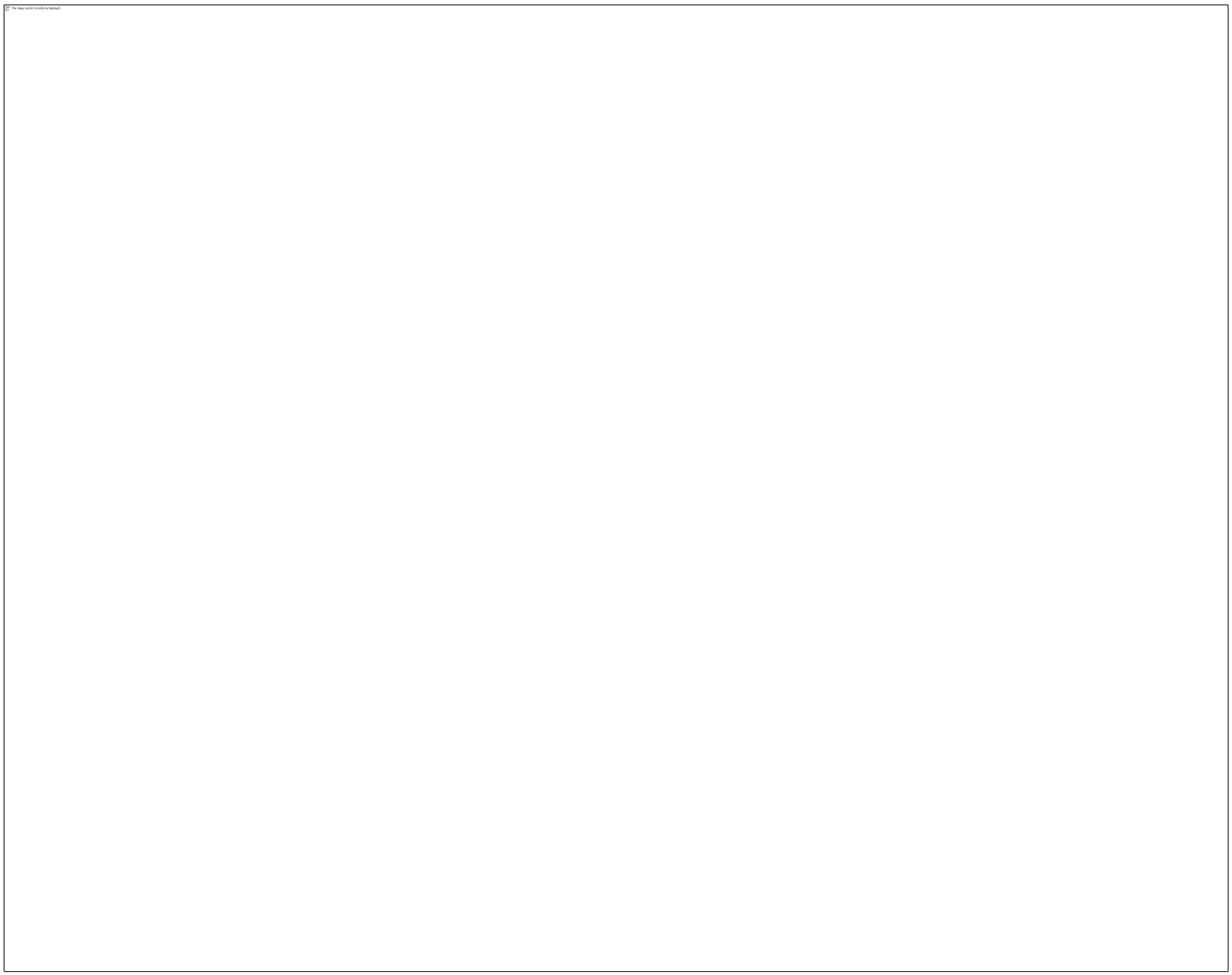
2.4 Classification of walls according to method of construction

This classification considers how the wall is formed or assembled.

The main categories include:

1. Solid walls.
2. Cavity walls.
3. Dry walls.

A. Solid walls



Definition: A solid wall is a wall constructed as one continuous thickness of masonry without a continuous cavity separating two leaves.

It may consist of one or more bonded masonry units across its thickness.

Characteristics:

1. It has no continuous air cavity through its thickness.
2. It may be constructed using bricks, stones or concrete blocks.
3. Its thickness depends on the design and walling material.
4. It may be load-bearing or non-load-bearing.
5. It requires proper bonding and suitable mortar.
6. It may need additional measures to control moisture and heat transfer.

Examples:

- A solid machine-cut stone wall.
- A single-leaf concrete block wall.
- A solid brick wall.

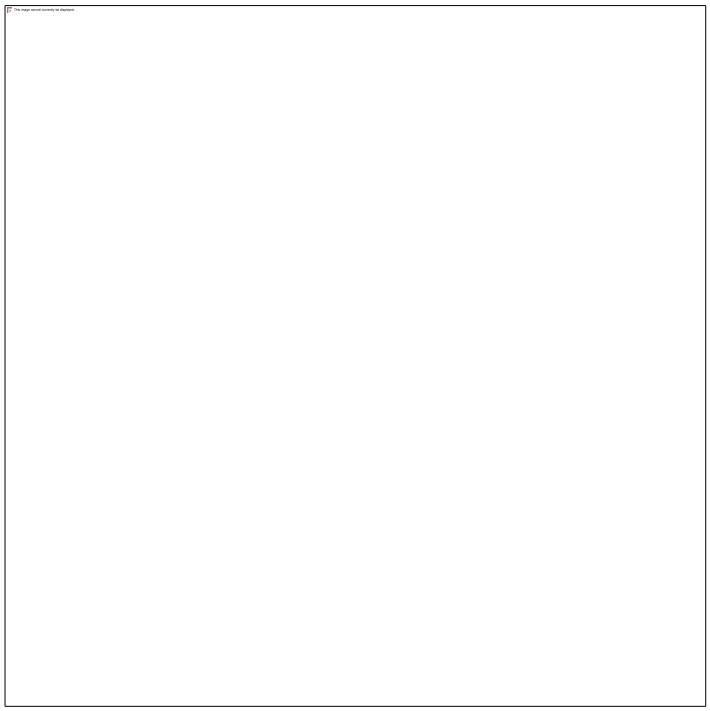
Advantages:

1. Relatively straightforward construction.
2. Fewer components than some cavity wall systems.
3. Can provide good durability.
4. Suitable for different masonry materials.
5. May provide useful thermal mass.

Limitations:

1. It may transfer moisture more readily than a properly designed cavity wall.
2. It may provide less thermal insulation than some cavity wall systems.
3. Thick solid walls may reduce usable floor space.
4. Large solid masonry walls may be heavy.

B. Cavity walls



Definition: A cavity wall is a wall constructed using two separate masonry leaves with a continuous or substantially continuous space called a cavity between them.

The two leaves are connected using suitable wall ties or other specified connectors.

Main components of a cavity wall:

1. **Outer leaf:** The external masonry layer exposed to weather.
2. **Inner leaf:** The internal masonry layer.
3. **Cavity:** The space between the two leaves.
4. **Wall ties:** Components that connect the two leaves.
5. **Insulation, where specified:** Material installed to improve thermal performance.
6. **Cavity trays and drainage details, where required:** Components used to manage moisture.

Characteristics:

1. It consists of two masonry leaves.
2. The leaves are separated by a cavity.
3. Wall ties connect the two leaves.
4. The cavity helps control the movement of moisture across the wall.
5. It may improve thermal performance.
6. It requires careful detailing around openings and wall intersections.

Advantages:

1. Helps reduce rainwater penetration into internal spaces when correctly detailed.
2. Can improve thermal insulation.
3. May reduce heat transfer through the wall.
4. Can improve indoor comfort.
5. Provides an opportunity to incorporate suitable insulation.

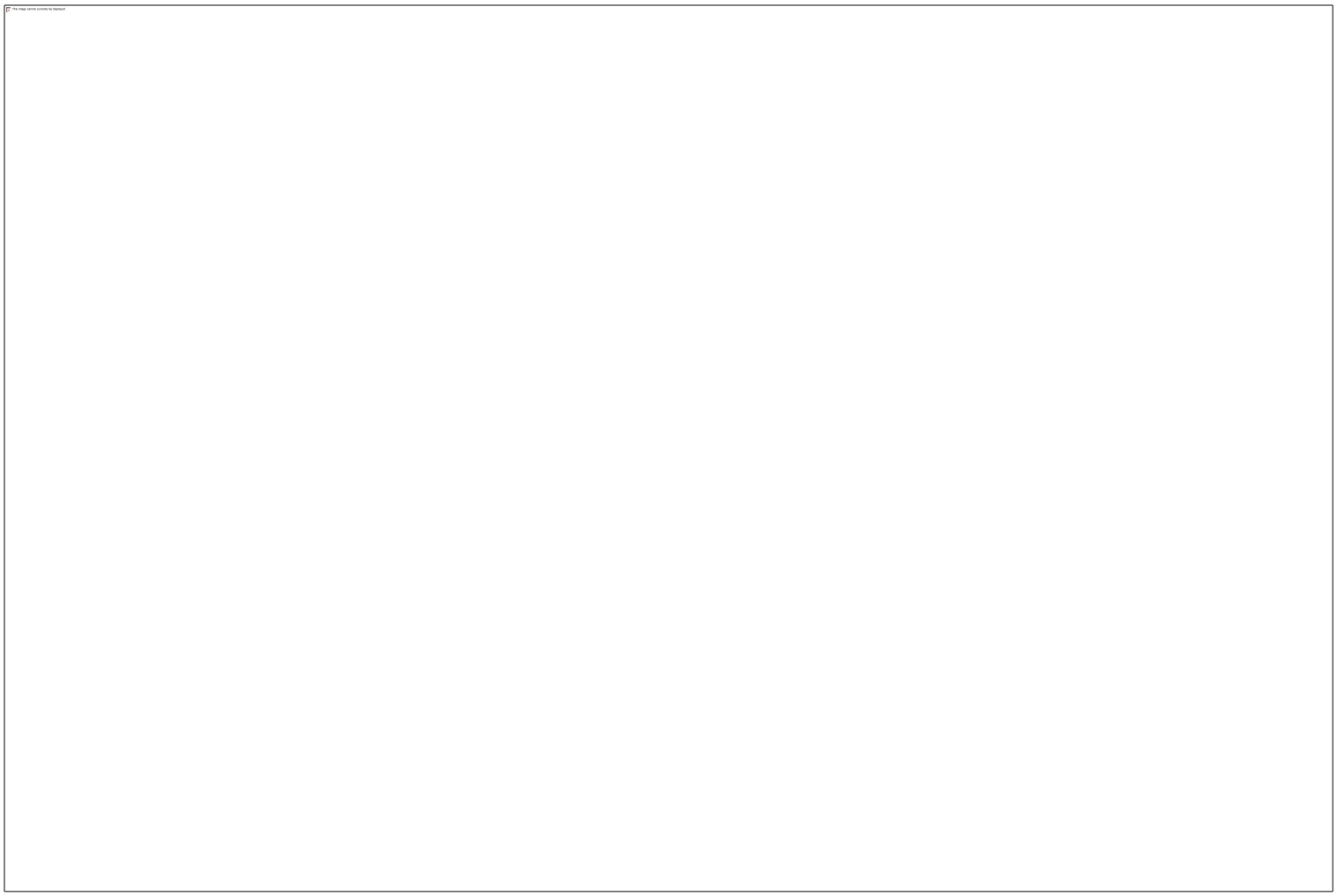
Limitations:

1. Construction is more complex than a simple solid wall.
2. It may require more materials.
3. Incorrectly installed wall ties may affect stability.
4. Mortar droppings can obstruct the cavity.
5. Poor cavity detailing can cause dampness problems.

Important construction precautions:

- Keep the cavity free from mortar droppings.
- Use the specified wall ties.
- Ensure correct spacing and fixing of ties according to the design.
- Provide suitable drainage and damp-proofing details.
- Protect the cavity during construction.

C. Dry walls



Definition: A dry wall is a wall constructed by assembling prefabricated sheets or panels onto a supporting framework without the conventional wet mortar-based walling process.

Dry walls are commonly constructed using gypsum boards, fibre-cement boards, timber panels or other suitable sheet materials.

Main components of a dry wall:

1. Supporting framework.
2. Vertical studs.
3. Horizontal tracks or members.
4. Wall panels or boards.
5. Screws and other fixings.
6. Jointing materials.
7. Insulation, where specified.

Characteristics:

1. They are usually lightweight compared with masonry walls.
2. They are assembled using panels and a supporting framework.
3. They require little or no masonry mortar.
4. They can be installed relatively quickly.

5. They are commonly used for internal partitions.
6. Their performance depends on the board type, framework and installation method.

Advantages:

1. Quick installation.
2. Reduced construction weight.
3. Less wet construction work.
4. Easier routing of some building services.
5. Can be dismantled or modified in suitable systems.
6. Useful for internal space division.

Limitations:

1. Some systems are vulnerable to impact damage.
2. Moisture-sensitive boards may deteriorate in wet areas.
3. Special boards and detailing may be required for fire resistance.
4. They may provide less security than suitable masonry walls.
5. Correct installation is necessary to achieve the required sound and structural performance.

Examples of dry wall applications:

- Office partitions.
- Interior divisions in commercial buildings.
- Hotel room partitions.
- Internal walls in suitable residential buildings.

Important distinction: A dry wall is not the same as dry stone masonry. Dry stone masonry uses stones placed without mortar, while a modern dry wall commonly uses boards fixed to a framework.

3.0 COMPARISON OF THE MAIN CLASSES OF WALLS

Classification basis	Type of wall	Main purpose or feature
Function	Load-bearing	Supports designed structural loads.
Function	Non-load-bearing	Carries its own weight and other specified loads but does not support major building loads.
Function	Partition	Divides internal spaces.
Function	Parapet	Provides an upstand at roof, balcony or terrace edges.
Function	Ventilation	Allows air to pass through openings.
Location	Interior	Located within the building.
Location	Exterior	Forms the external enclosure.
Material	Brick	Constructed using brick units.

Material	Stone	Constructed using natural or processed stone units.
Material	Concrete	Constructed using concrete masonry units or concrete.
Method	Solid	Has no continuous cavity between two leaves.
Method	Cavity	Has two leaves separated by a cavity.
Method	Dry wall	Uses panels or boards assembled onto a framework.

Important: These classifications can overlap. For example, a stone wall can be an exterior load-bearing solid wall, while a concrete block wall can be an interior non-load-bearing partition.

4.0 WALLING MATERIALS AND THEIR SELECTION

4.1 Meaning of walling materials

Walling materials are the building materials used to construct walls in a building.

They may be natural, manufactured or processed materials.

Examples:

- Natural stones.
- Burnt clay bricks.
- Concrete blocks.
- Cement.
- Sand.
- Water.
- Wall ties.
- Damp-proofing materials.
- Reinforcement where specified.

4.2 Factors to consider when selecting walling materials

A. Strength

- The material should have sufficient strength for its intended application.
- Load-bearing walls require materials that meet the specified structural requirements.
- Materials should be tested or certified where required.

B. Durability

- The material should resist deterioration during its expected service life.
- It should withstand the environmental conditions at the site.
- It should not easily disintegrate or crack under normal service conditions.

C. Availability

- Materials that are readily available near the construction site may reduce transportation costs.
- Locally available suitable stones, bricks and blocks may be considered.

Example: A contractor working in a stone-producing area may consider suitable locally available machine-cut stones.

D. Cost

- The purchase price should be considered.
- Transportation costs should be included.
- Labour and maintenance costs should also be considered.

E. Weight

- Heavy walling materials impose greater loads on foundations and supporting structures.
- Lightweight materials may be appropriate where reduced structural loading is required.

F. Water absorption

- Materials should have suitable water absorption characteristics.
- Excessive absorption may affect mortar bonding and wall durability.
- The manufacturer's or applicable specification should be followed when preparing masonry units.

G. Appearance

- The material should suit the architectural design.
- Some walls are left exposed while others receive plaster, paint or cladding.

H. Thermal performance

- Walling materials influence heat transfer through buildings.
- Suitable materials and wall designs help improve indoor comfort.

I. Fire resistance

- Materials should meet the fire-performance requirements of the building.
- Wall construction and finishing details also influence fire resistance.

J. Ease of construction

- The material should be suitable for the available labour skills and equipment.
- Uniform units may make wall setting out and laying easier.

K. Environmental considerations

- Consider the environmental impact of extracting, manufacturing and transporting the materials.
- Locally available materials may reduce transport-related impacts.
- Waste should be minimised during construction.

L. Compliance with standards

- Materials should comply with relevant Kenya Standards and project specifications.
- The suitability of masonry units should be verified before use.

5.0 TYPES OF MASONRY BONDS USED IN WALLING

5.1 Meaning of masonry bond

A masonry bond is the systematic arrangement of bricks, stones or other masonry units in a wall to ensure proper interlocking, strength, stability and an attractive appearance.

In brickwork, bonding involves arranging the units in successive courses so that vertical joints are appropriately staggered.

A good masonry bond helps distribute loads and reduces the formation of continuous vertical joints that may weaken the wall.



5.2 Importance of masonry bonds

1. **Improves wall strength**
    - Proper bonding helps distribute loads through the masonry wall.
    - It reduces weaknesses caused by continuous vertical joints.
2. **Improves stability**
    - The arrangement of units helps the wall act as a connected structure.
    - Appropriate bonding improves the interlocking of masonry units.
3. **Prevents continuous vertical joints**
    - Staggering vertical joints helps avoid continuous lines of weakness.
    - It improves the continuity of the masonry.
4. **Improves appearance**

- Different bonds create attractive wall patterns.
- They give walls a neat and organised appearance.

5. **Improves load distribution**
   - Properly bonded units help distribute loads across the wall.
   - This is particularly important in structural masonry.
6. **Improves durability**
   - Proper bonding and mortar joints reduce the likelihood of local instability and cracking associated with poor workmanship.
7. **Provides uniformity**
   - Bonding helps maintain consistent arrangements of units in successive courses.

5.3 Main types of masonry bonds

The main types of brick bonds covered in this sub-strand are:

1. Stretcher bond.
2. Header bond.
3. English bond.
4. Flemish bond.

5.4 Stretcher bond



Definition: Stretcher bond is a masonry bond in which all bricks are laid with their longer faces visible along the length of the wall.

A stretcher is the longer face of a brick exposed on the face of the wall.

Characteristics of stretcher bond:

1. Bricks are laid with their long faces visible.
2. Vertical joints in successive courses are staggered.
3. Each course commonly overlaps the one below by approximately half a brick length.
4. It produces a simple and regular pattern.
5. It is commonly used for half-brick-thick walls.
6. Additional bonding arrangements or wall ties may be needed where it is used in thicker wall construction.

Procedure for laying stretcher bond:

1. Prepare the wall base.
2. Spread a suitable mortar bed.
3. Place the first brick with its longer face along the wall.
4. Apply mortar to the appropriate joint.
5. Place the next brick beside it.
6. Continue laying the first course.
7. Start the next course with an appropriate half-bond arrangement.
8. Ensure that vertical joints are staggered.
9. Check the line, level and plumb.
10. Continue with successive courses.

Uses of stretcher bond:

- Half-brick partition walls.
- Cavity wall leaves.
- Decorative brickwork.
- Non-load-bearing brick walls where appropriate.

Advantages:

1. Easy to understand and construct.
2. Requires relatively simple setting out.
3. Produces a regular appearance.
4. Suitable for many simple brick wall applications.
5. Can be economical for suitable wall thicknesses.

Limitations:

1. It is not, by itself, a suitable bonding arrangement for every thick solid brick wall.
2. It may require additional wall ties or other bonding arrangements in some wall systems.
3. Poorly staggered joints may reduce wall integrity.

5.5 Header bond



Definition: Header bond is a masonry bond in which bricks are laid with their shorter ends visible on the face of the wall.

A header is the shorter face of a brick exposed on the wall surface.

Characteristics:

1. The short faces of bricks are visible.
2. Each brick extends across the wall thickness in the direction of its length.
3. Vertical joints are staggered in successive courses.
4. It can be used in suitable thick brick masonry construction.
5. It creates a pattern of short rectangular faces.
6. Proper bonding at corners is necessary.

Procedure for laying header bond:

1. Prepare the wall foundation or base.
2. Spread the mortar bed.
3. Position the first brick with its short face visible.
4. Place the next brick beside it.
5. Complete the first course.
6. Begin the second course with staggered joints.
7. Check the alignment of the headers.
8. Maintain uniform joint thickness.
9. Check the wall for level and plumb.

10. Continue with the required number of courses.

Uses:

- Suitable thick brick walls.
- Curved brickwork where appropriate.
- Certain traditional and decorative masonry applications.

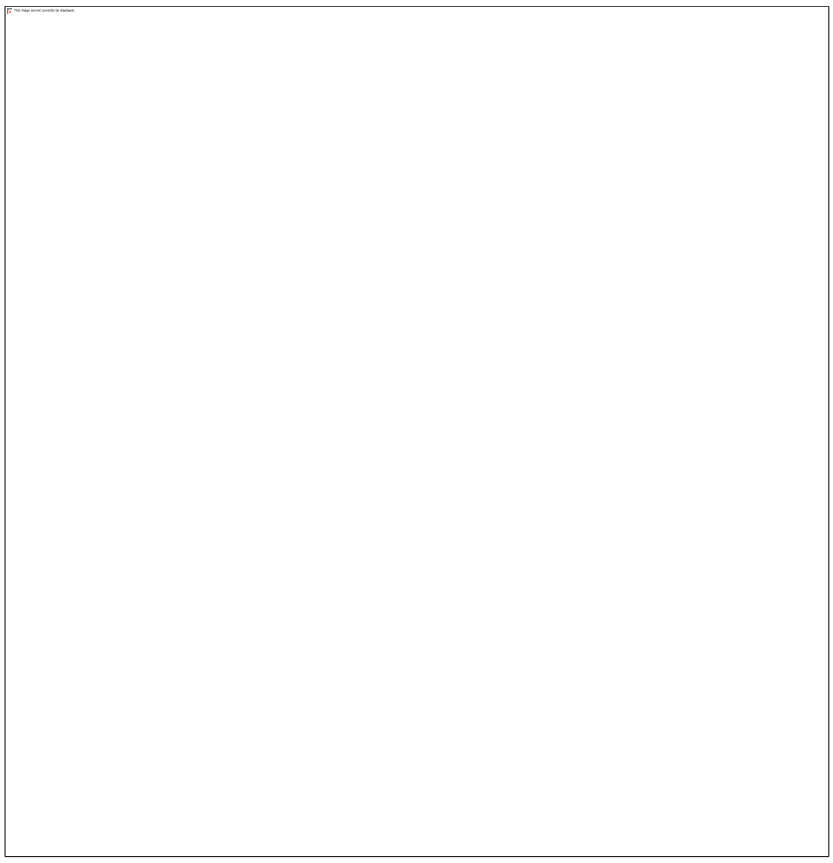
Advantages:

1. Provides bonding across the thickness of suitable brick walls.
2. Produces a distinctive appearance.
3. Can provide good interlocking when properly laid.
4. Suitable for some thick brick masonry arrangements.

Limitations:

1. Requires careful setting out.
2. May involve more cutting and special units at corners.
3. Its suitability depends on the wall design and brick dimensions.

5.6 English bond



Definition: English bond is a brick masonry bond in which alternate courses consist of headers and stretchers.

This means that one course is made up mainly of headers, while the next course is made up mainly of stretchers.

Characteristics:

1. It consists of alternating header and stretcher courses.
2. Header courses show the short faces of bricks.
3. Stretcher courses show the long faces of bricks.
4. Vertical joints are staggered between courses.
5. It is commonly used in suitable thick brick walls.
6. It produces a regular horizontal pattern.
7. Closers or specially cut bricks may be needed at corners to maintain the bond.

Procedure for laying English bond:

1. Prepare the wall base.
2. Set out the wall dimensions.
3. Lay the first course using the specified arrangement.
4. Arrange the bricks in a header course.
5. Apply mortar to the bed and vertical joints.
6. Check alignment and level.
7. Lay the next course using stretchers.
8. Ensure that the vertical joints are staggered.
9. Continue alternating header and stretcher courses.
10. Check the corners, line, level and plumb regularly.

Uses:

- Suitable thick brick walls.
- Structural brickwork where specified.
- Boundary walls.
- Certain traditional masonry buildings.

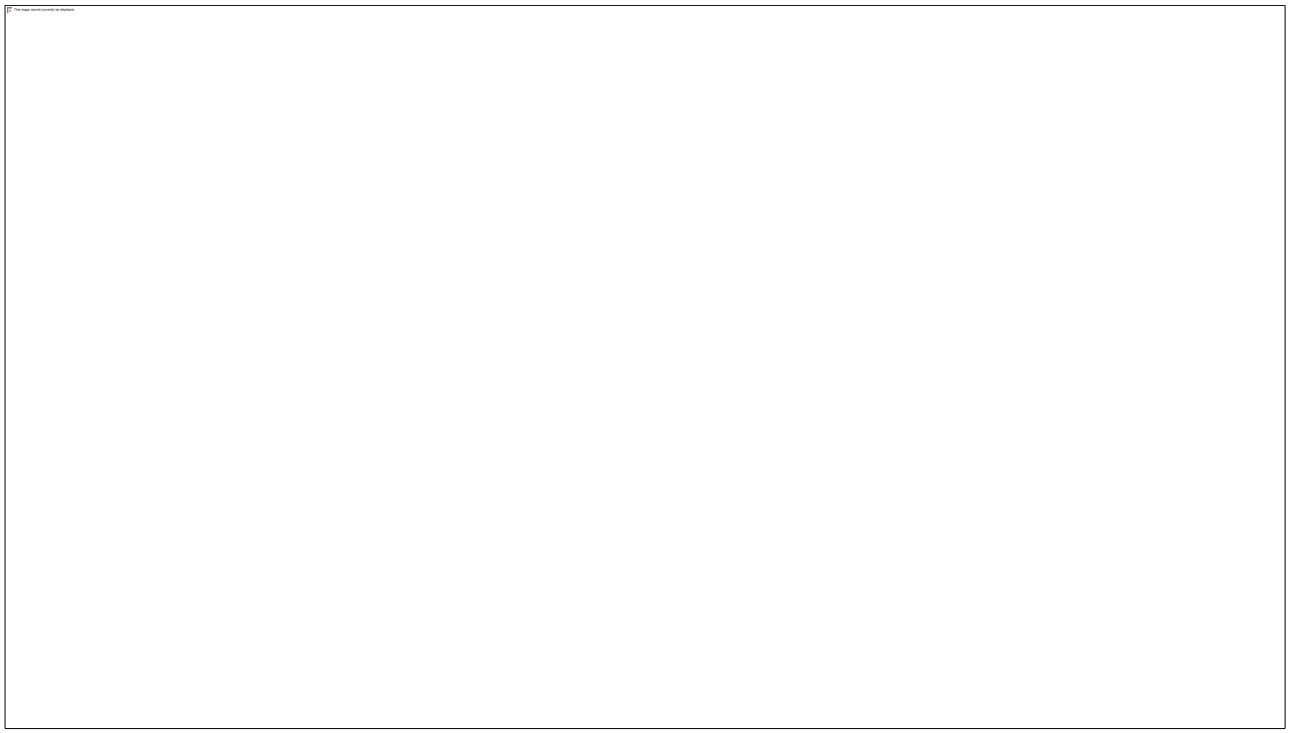
Advantages:

1. Provides effective bonding in suitable thick brickwork.
2. Produces a strong and regular arrangement when correctly constructed.
3. Provides a neat appearance.
4. Can be used in many traditional brick masonry applications.

Limitations:

1. Requires careful arrangement of alternating courses.
2. Corner details may require special cuts.
3. May take more time than simple stretcher bond.
4. Requires skilled workmanship.

5.7 Flemish bond



Definition: Flemish bond is a masonry bond in which headers and stretchers alternate within each course.

In a typical Flemish bond, each course has an alternating pattern of a header followed by a stretcher.

The header in one course is positioned approximately over the middle of a stretcher in the course below.

Characteristics:

1. Headers and stretchers alternate in each course.
2. It creates a decorative wall pattern.
3. Vertical joints are staggered.
4. It requires careful positioning of bricks.
5. Closers may be required at corners.
6. It is commonly used where appearance is important.

Procedure for laying Flemish bond:

1. Prepare the wall base.
2. Set out the wall dimensions.
3. Spread the mortar bed.
4. Position a header at the required starting point.
5. Place a stretcher next to it.
6. Continue alternating headers and stretchers.
7. Start the next course using the correct staggered arrangement.

8. Check the positions of the headers and stretchers.
9. Maintain uniform mortar joints.
10. Continue with the remaining courses.

Uses:

- Decorative brick walls.
- Residential buildings.
- Boundary walls.
- Selected thick brick masonry applications.

Advantages:

1. Produces an attractive appearance.
2. Provides a distinctive brick pattern.
3. Can provide effective bonding when properly constructed.
4. Allows the use of headers and stretchers in each course.

Limitations:

1. Requires skilled workmanship.
2. Needs careful setting out.
3. Corner arrangements can be complicated.
4. May involve more cutting and special brick units.

5.8 Comparison of the four masonry bonds

Feature	Stretcher bond	Header bond	English bond	Flemish bond
Arrangement	All visible faces are stretchers.	All visible faces are headers.	Alternate courses of headers and stretchers.	Headers and stretchers alternate in each course.
Visible face	Long face.	Short face.	Long and short faces in separate courses.	Long and short faces in the same course.
Appearance	Simple and regular.	Repeated short faces.	Regular alternating horizontal courses.	Decorative alternating pattern.
Common application	Half-brick walls and suitable cavity wall leaves.	Suitable thick brickwork.	Suitable thick brickwork.	Decorative and suitable thick brickwork.
Main consideration	Not sufficient alone for all thick walls.	Correct cross-wall bonding is important.	Alternate course arrangement must be maintained.	Careful arrangement in each course is required.

5.9 Important masonry bonding terms

A. Stretcher

A brick laid so that its longer face is visible on the wall surface.

B. Header

A brick laid so that its shorter face is visible on the wall surface.

C. Course

A horizontal layer of bricks, stones or blocks in a wall.

D. Bed joint

The horizontal mortar joint between successive courses of masonry units.

E. Perpend joint

The vertical mortar joint between adjacent masonry units.

F. Quoin

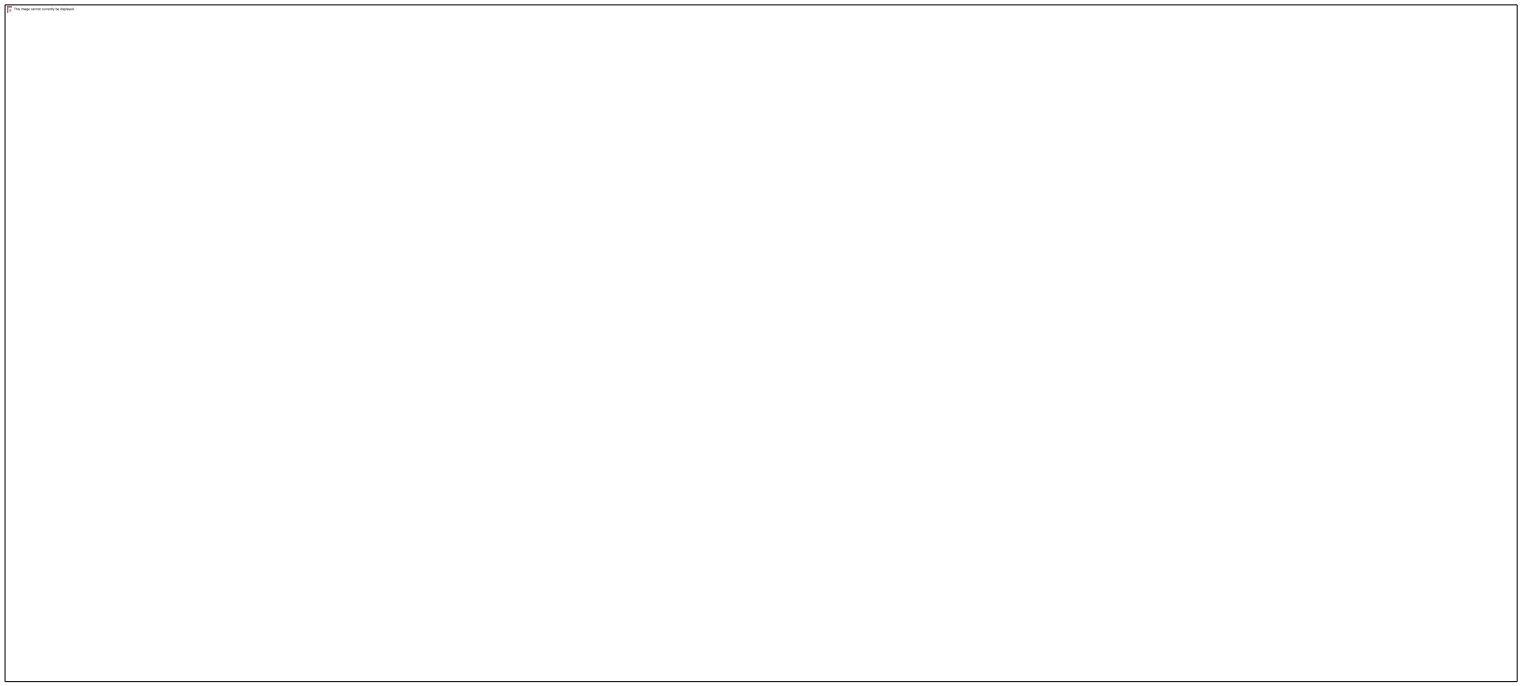
The external corner of a wall, especially where two walls meet.

G. Closer

A cut brick or part of a brick used to maintain the correct bond at a corner or other location.

H. Bonding

The arrangement of masonry units so that they interlock and form a stable wall.



Note for learners: The four bonds above are primarily traditional brickwork bonds. Stone and concrete block walls also require appropriate bonding, interlocking, wall ties or other specified connections depending on their construction system.

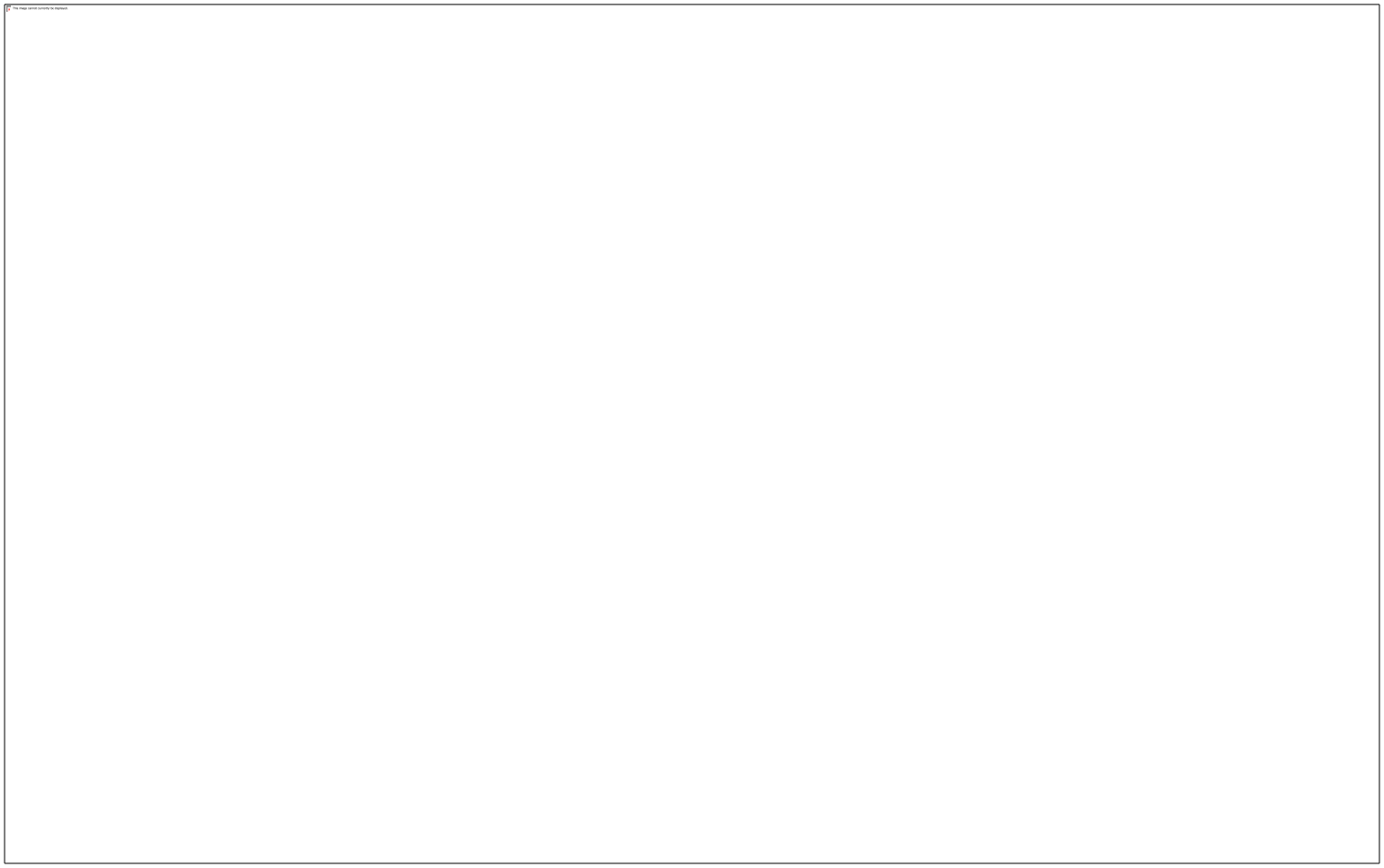
6.0 PROFILE BOARDS USED IN MASONRY SUPERSTRUCTURE WALLING

6.1 Definition of profile boards

Profile boards are temporary horizontal timber boards fixed to supports or stakes at selected positions around a building to help establish and maintain the alignment, position and dimensions of walls during setting out.

They provide reference points from which mason's lines can be stretched to indicate the position of wall faces and corners.

Profile boards may also be called *batter boards* in some construction settings.



6.2 Main components of profile boards

A. Horizontal timber boards

- These are timber pieces fixed horizontally to vertical supports.
- They provide surfaces for fixing nails or marking wall positions.
- They should be sufficiently straight and stable.

B. Vertical stakes or supports

- These are timber pegs or posts driven into the ground.
- They support the horizontal profile boards.
- They should be firmly fixed to prevent movement.

C. Nails

- Nails are fixed to the profile boards at marked positions.
- They provide reference points for mason's lines.
- They help maintain the correct wall dimensions.

D. Mason's line

- This is a strong string or cord stretched between marked positions.
- It indicates the intended alignment of the wall.
- It guides the mason when laying masonry units.

E. Reference marks

- These are marks made on the boards to indicate wall positions and important measurements.
- They help maintain the building layout during construction.

6.3 Functions of profile boards

1. **Maintaining wall alignment**
   - They help keep the wall in the correct straight line.
   - Mason's lines are stretched between the marked points.
2. **Establishing wall dimensions**
   - They help transfer the required wall lengths and widths to the site.
   - They assist in maintaining the correct building outline.
3. **Locating corners**
   - They help identify where external and internal walls meet.
   - They assist in setting out wall intersections.
4. **Maintaining squareness**
   - They help preserve the required right angles between walls.
   - They support accurate building layout.
5. **Providing reference points**
   - They provide stable reference positions during wall construction.
   - They help replace measurements that might otherwise be lost during excavation or site activities.
6. **Guiding masonry work**
   - They help masons position walls according to the building plan.
   - They reduce errors in wall placement.
7. **Maintaining consistent measurements**
   - They help transfer dimensions from the drawing to the construction site.
   - They assist in checking wall positions.
8. **Reducing setting-out errors**
   - They help identify incorrect wall positions before masonry work begins.

- They improve the accuracy of the construction process.

6.4 Characteristics of good profile boards

1. They should be made from suitable, reasonably straight timber.
2. They should be firmly supported.
3. They should be positioned outside the immediate construction area where practical.
4. They should be set at a convenient and consistent height.
5. Their markings should be clear and permanent enough for the duration of the work.
6. They should not be disturbed during construction.
7. They should be positioned so that mason's lines can be stretched accurately.

6.5 Procedure for erecting profile boards

Step 1: Select suitable positions

- Identify locations where the boards can be erected without interfering with construction activities.
- Place them outside the intended excavation and walling areas where practical.

Step 2: Drive the vertical supports

- Drive timber stakes firmly into the ground.
- Ensure that they are stable.
- Position them to support the horizontal boards.

Step 3: Fix horizontal boards

- Nail the horizontal boards to the vertical supports.
- Ensure that the boards are reasonably level and stable.

Step 4: Transfer measurements

- Use the building plan and setting-out measurements.
- Mark the wall positions on the boards.

Step 5: Fix nails at reference points

- Drive nails at the appropriate marked positions.
- These nails will hold the mason's lines.

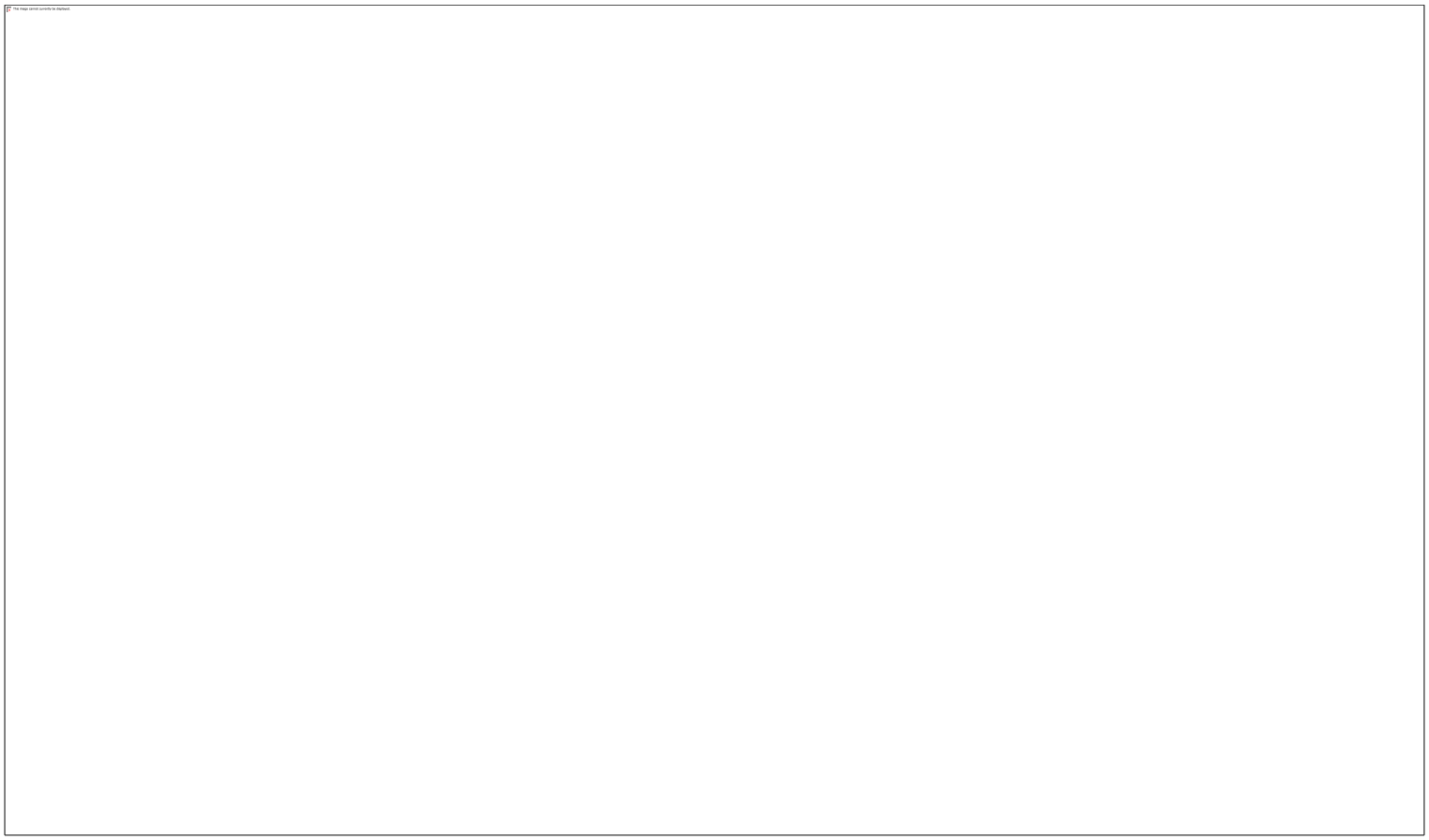
Step 6: Stretch the mason's lines

- Stretch lines between corresponding reference nails.
- Check that the lines represent the required wall faces.

Step 7: Check accuracy

- Check wall dimensions.
- Check squareness.
- Check the alignment of the lines.

- Correct any errors before walling begins.



6.6 Precautions when using profile boards

1. Use straight and suitable timber.
2. Fix the supports firmly into the ground.
3. Avoid placing boards where they may be struck by machinery or workers.
4. Do not disturb the reference nails after setting out.
5. Check the measurements before stretching the lines.
6. Ensure that mason's lines are sufficiently tight.
7. Recheck the dimensions if the boards are accidentally moved.
8. Keep the work area around the boards free from unnecessary obstruction.

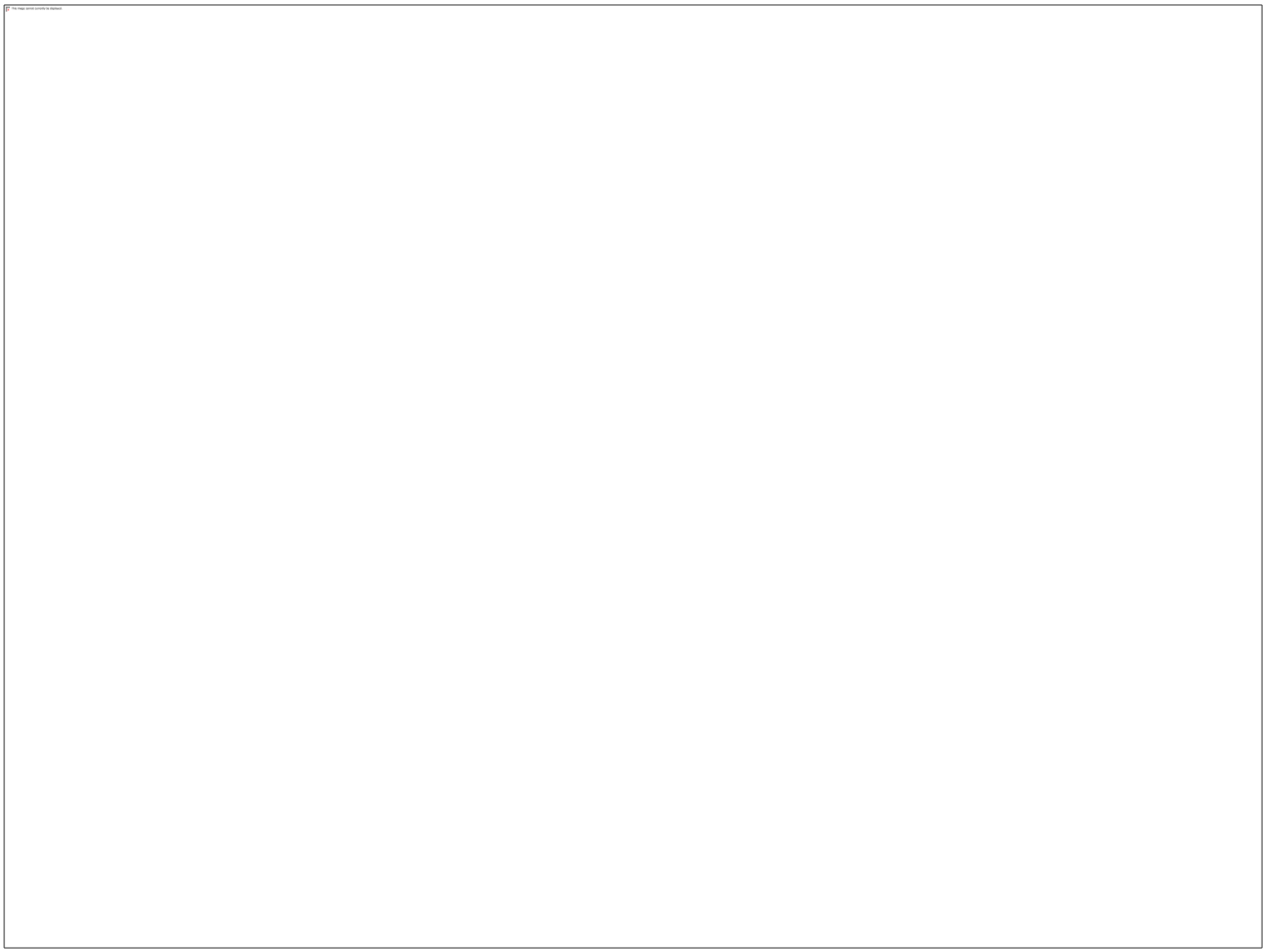
7.0 SETTING OUT A MASONRY SUPERSTRUCTURE WALL

7.1 Definition of setting out

Setting out is the process of transferring the dimensions, positions and layout of a building or its components from a drawing onto the actual construction site.

In masonry superstructure walling, setting out involves establishing the exact position, length, thickness, corners and alignment of walls before laying masonry units.

It helps ensure that the walls are constructed according to the approved building plan.

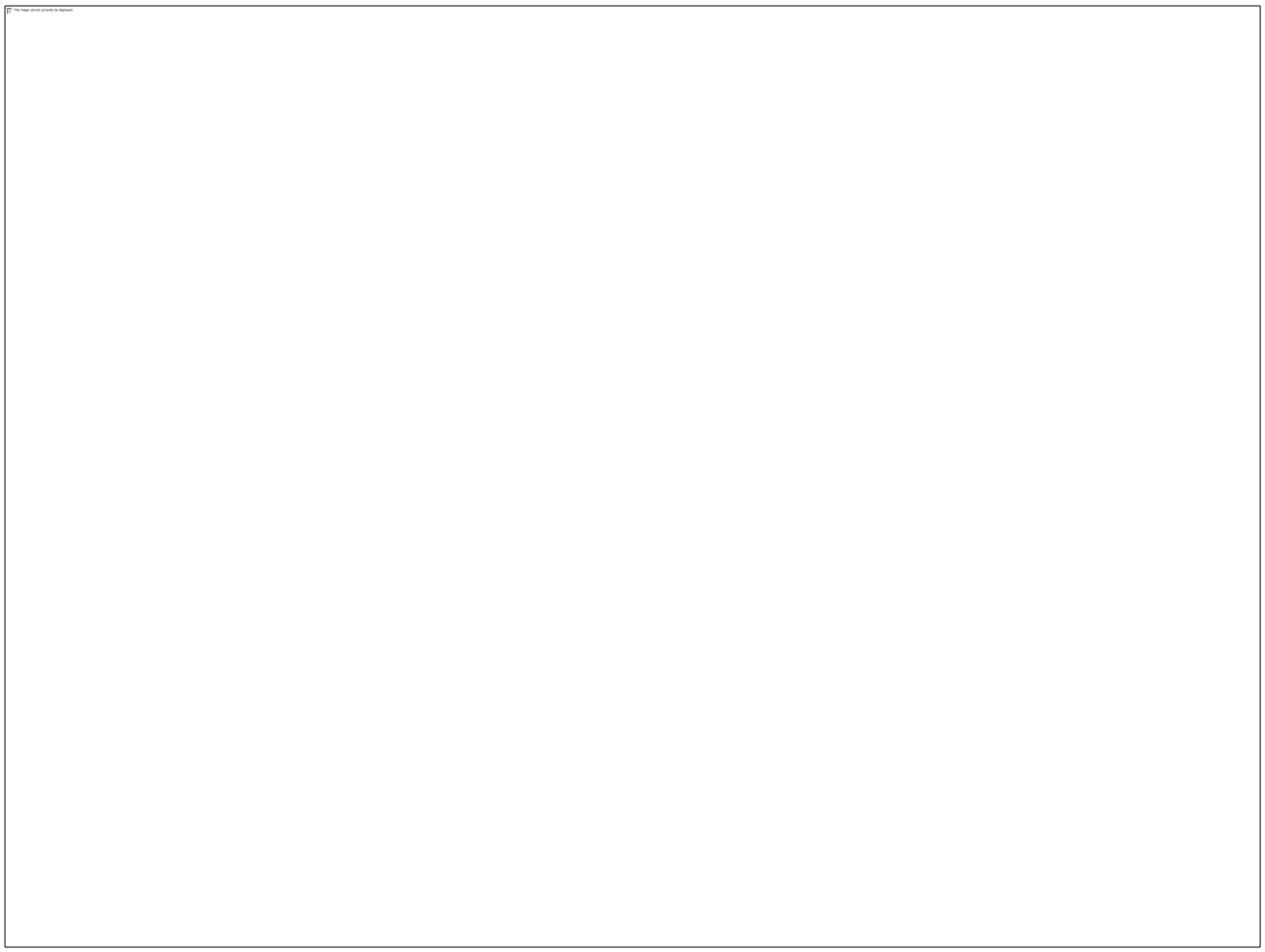


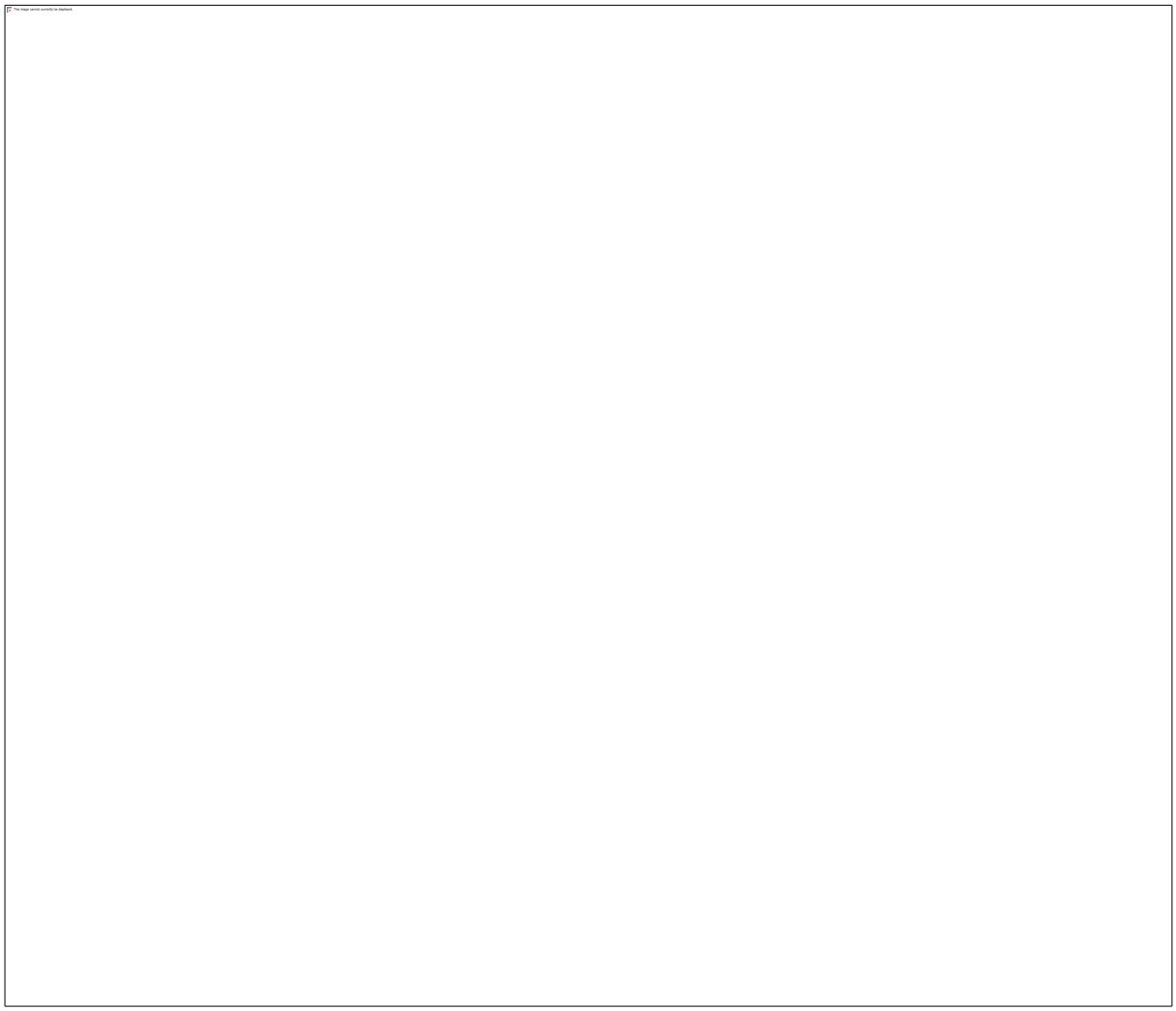
7.2 Importance of setting out masonry walls

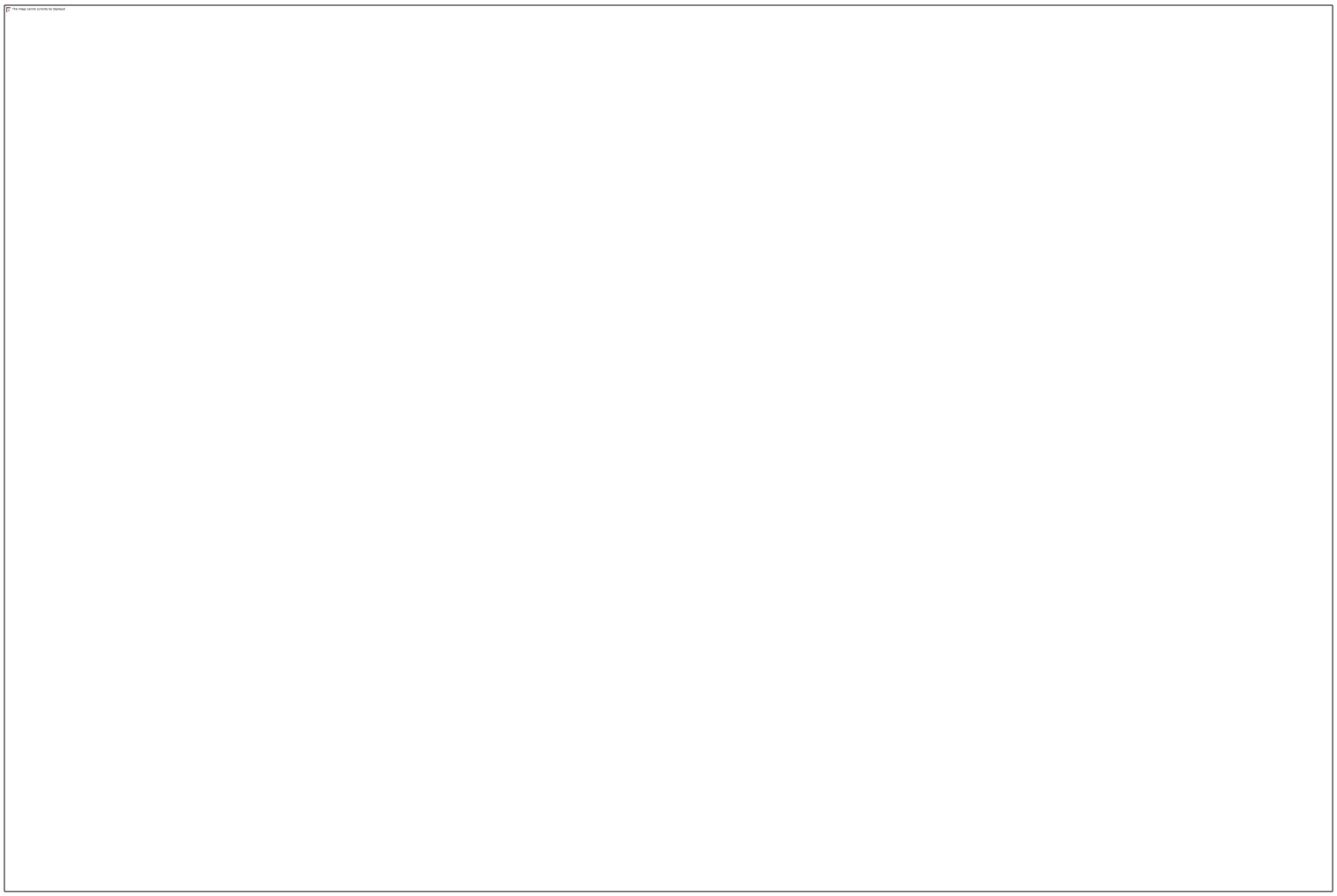
1. Ensures walls are constructed in the correct positions.
2. Helps maintain the correct building dimensions.
3. Ensures that corners are properly located.
4. Helps maintain right angles between walls.
5. Reduces errors during construction.
6. Prevents unnecessary demolition and rebuilding.
7. Helps position door and window openings correctly.
8. Ensures that wall thicknesses are maintained.
9. Helps align superstructure walls with the supporting foundation.
10. Reduces material wastage.
11. Improves the appearance of the completed building.
12. Supports coordination with other construction activities.

7.3 Tools and equipment used when setting out masonry walls

Tool or equipment	Function
Tape measure	Measures wall lengths, widths and distances.
Mason's line	Indicates wall alignment.
Spirit level	Checks horizontal levels.
Plumb bob	Checks vertical alignment.
Builder's square	Checks right angles.
Steel rule	Measures short distances.
Profile boards	Provide reference points for setting out.
Timber pegs	Support profile boards or mark positions.
Hammer	Drives nails and pegs.
Nails	Hold mason's lines on profile boards.
Chalk line	Marks straight reference lines.
String line	Transfers wall alignment.
Marker or pencil	Makes measurement marks.







7.4 Procedure for setting out a masonry superstructure wall

The main stages include:

1. Establishing the outline.
2. Marking out the outline.
3. Setting out the corner stones.

Stage 1: Establishing the outline

Meaning: Establishing the outline involves identifying the intended positions and dimensions of the walls using the building drawings and site references.

Procedure:

1. Obtain the approved building drawings.
2. Study the floor plan and relevant wall details.
3. Identify the external wall positions.
4. Identify the internal wall positions.
5. Identify the locations of corners and wall intersections.
6. Identify the positions of door and window openings.
7. Confirm the dimensions of the walls.
8. Confirm the position of the wall lines relative to the foundation or supporting structure.

9. Identify any service openings or other special wall details.
10. Prepare the site for marking out.

Importance:

- Helps the builder understand the wall layout.
- Ensures the correct dimensions are used.
- Reduces confusion during construction.
- Helps coordinate the wall positions with the building plan.

Stage 2: Marking out the outline

Meaning: Marking out the outline involves transferring the established wall positions onto the construction site using reference marks, profile boards, string lines or other suitable methods.

Procedure:

1. Establish suitable reference points.
2. Erect profile boards where required.
3. Transfer the wall dimensions onto the profile boards.
4. Fix nails at the marked positions.
5. Stretch mason's lines between corresponding nails.
6. Indicate the external wall faces.
7. Mark internal wall positions.
8. Check the lengths and widths.
9. Check the right angles at corners.
10. Verify that the marked wall layout agrees with the building drawings.

Importance:

- Provides clear wall alignment references.
- Helps maintain the required wall thickness.
- Helps locate wall intersections.
- Reduces the possibility of wrongly positioned walls.

Stage 3: Setting out the cornerstone

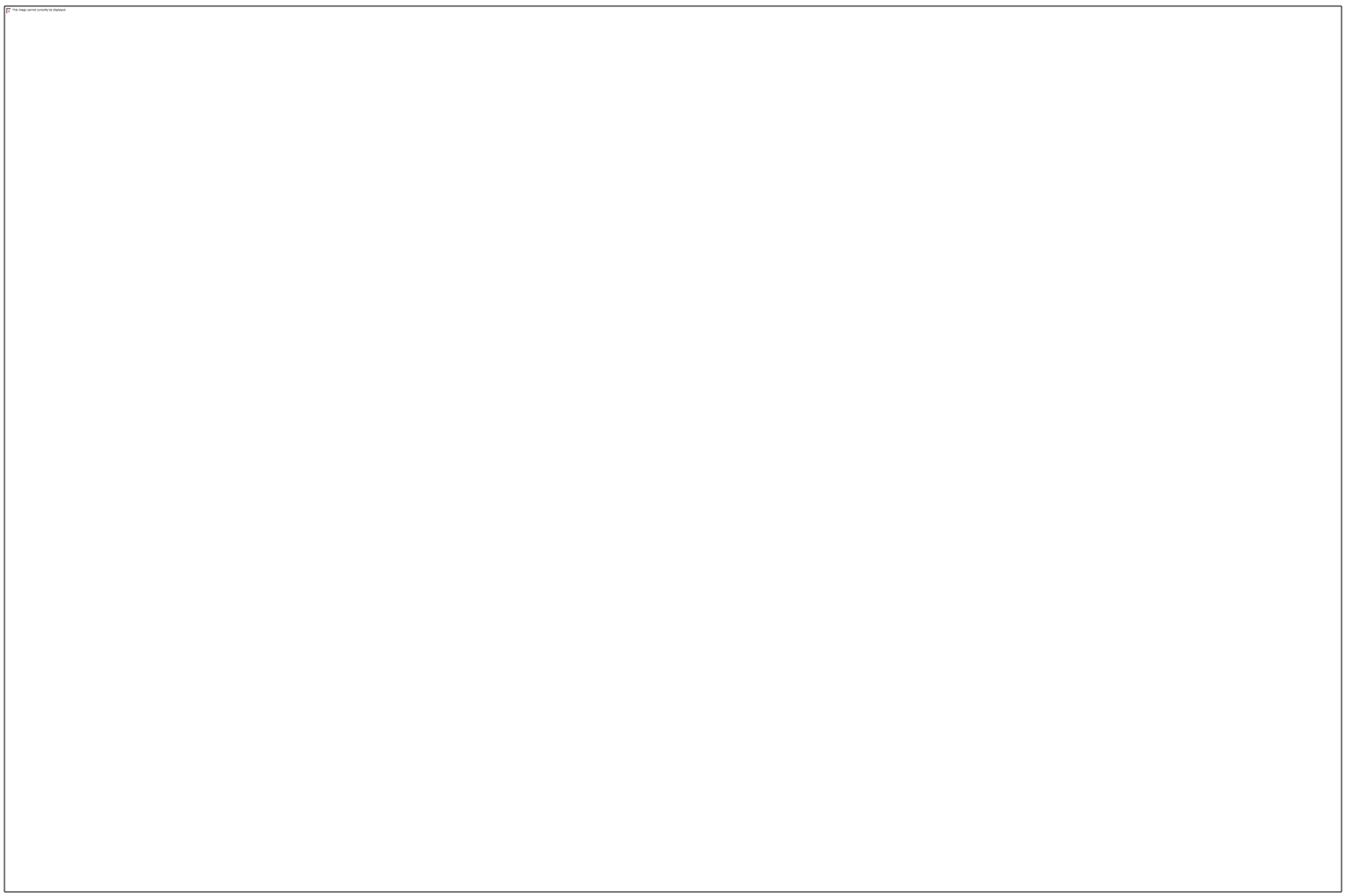
Meaning: Setting out the cornerstone involves accurately positioning the first masonry units at the corners of the wall layout to establish the wall's direction, level and alignment.

The cornerstones act as reference points for laying the intermediate masonry units.

Procedure:

1. Clean and prepare the wall base.
2. Confirm that the foundation or supporting base is ready and suitable.
3. Check the position of the corner.

4. Spread a suitable mortar bed where mortar bedding is specified.
5. Place the first corner masonry unit.
6. Adjust the unit to the required position.
7. Check its level using a spirit level.
8. Check its vertical alignment using a plumb bob or suitable level.
9. Place the corresponding corner unit at the other end.
10. Stretch a mason's line between the established corner references.
11. Repeat the process for other corners.
12. Recheck the dimensions, levels and alignment before laying intermediate units.



Importance of accurate corner setting out:

1. Establishes the direction of the wall.
2. Provides reference points for intermediate units.
3. Helps maintain straight walls.
4. Helps maintain right angles.
5. Reduces the possibility of uneven wall surfaces.
6. Improves the accuracy of masonry construction.

8.0 MASONRY SUPERSTRUCTURE WALL CONSTRUCTION PROCEDURE

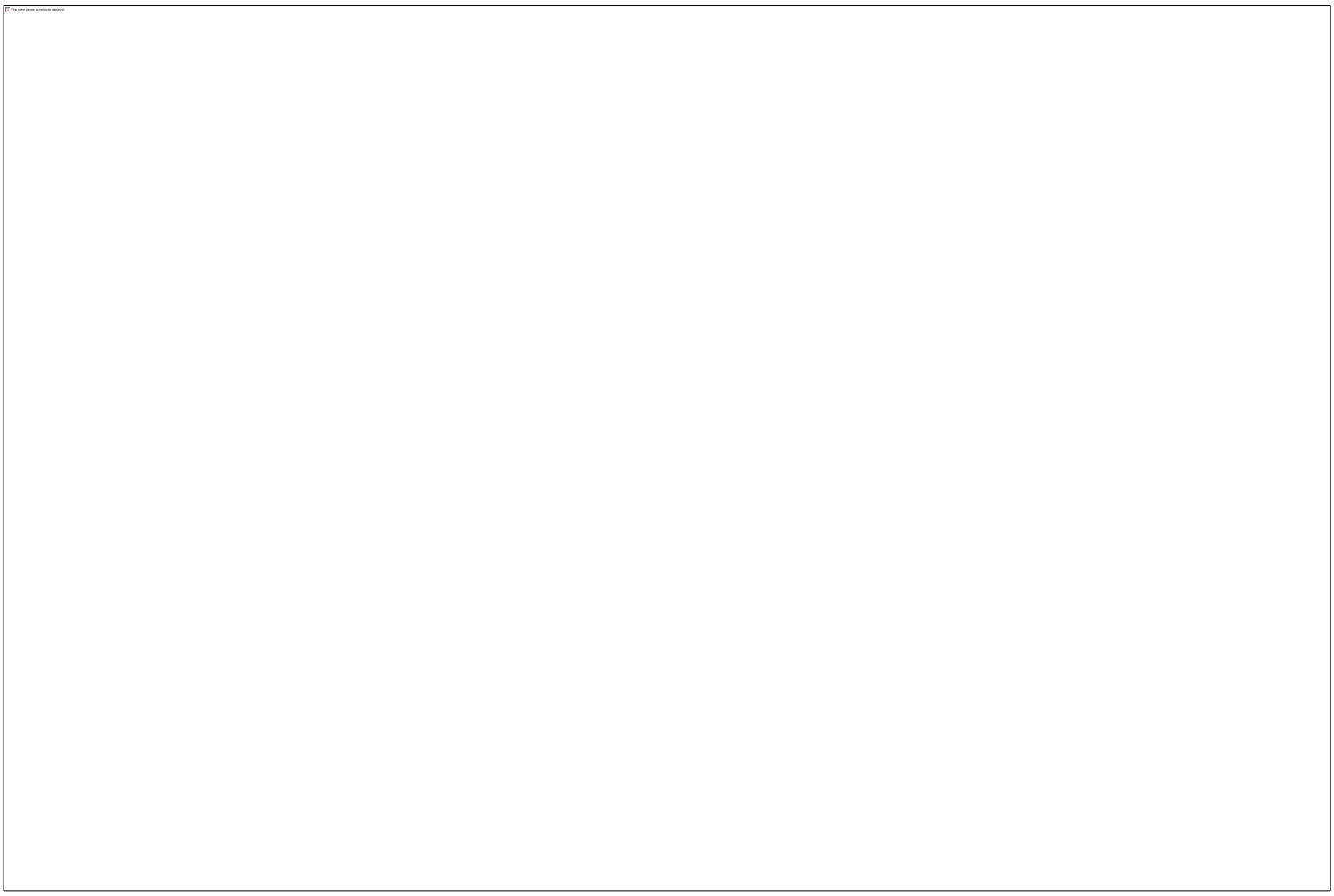
8.1 Meaning of masonry wall construction

Masonry wall construction is the process of assembling stones, bricks or concrete blocks in a planned arrangement to form a wall.

The process involves preparing the work area, selecting walling materials, preparing the units, mixing mortar, laying the units and checking the completed work.

The following are the main stages:

1. Prepare the working area.
2. Select suitable walling materials.
3. Prepare the walling units.
4. Mix mortar to the specified ratio.
5. Lay the corner and intermediate walling units.
6. Check alignment, level and plumb.
7. Finish the joints and wall surface as specified.
8. Clean up the working area.



8.2 Stage 1: Preparation of the working area

Meaning: Preparation of the working area involves organising the construction site and ensuring that the walling area is clean, safe and ready for construction.

Procedure:

1. Remove unnecessary materials from the working area.
2. Clear vegetation and loose debris.
3. Remove standing water where present.
4. Check that the foundation or supporting base is ready.
5. Confirm the wall positions.
6. Arrange walling materials near the work area without obstructing access.
7. Provide a suitable location for mortar mixing.
8. Arrange tools and equipment.
9. Establish safe access routes.
10. Provide appropriate personal protective equipment.

Importance:

- Improves working efficiency.
- Reduces accidents.
- Prevents contamination of mortar.
- Makes materials easier to access.
- Provides sufficient working space.

8.3 Stage 2: Selecting walling materials

Meaning: Selecting walling materials involves choosing suitable masonry units and associated materials according to the design, specifications and intended function of the wall.

Materials commonly selected include:

- Natural stones.
- Machine-cut stones.
- Burnt clay bricks.
- Concrete blocks.
- Cement.
- Building sand.
- Clean water.
- Wall ties where required.
- Reinforcement where specified.
- Damp-proof course materials where required.

Factors to consider when selecting masonry units:

1. Strength requirements.
2. Durability.

3. Uniformity of dimensions.
4. Appearance.
5. Water absorption.
6. Availability.
7. Cost.
8. Ease of handling.
9. Compatibility with mortar.
10. Compliance with the project specification.

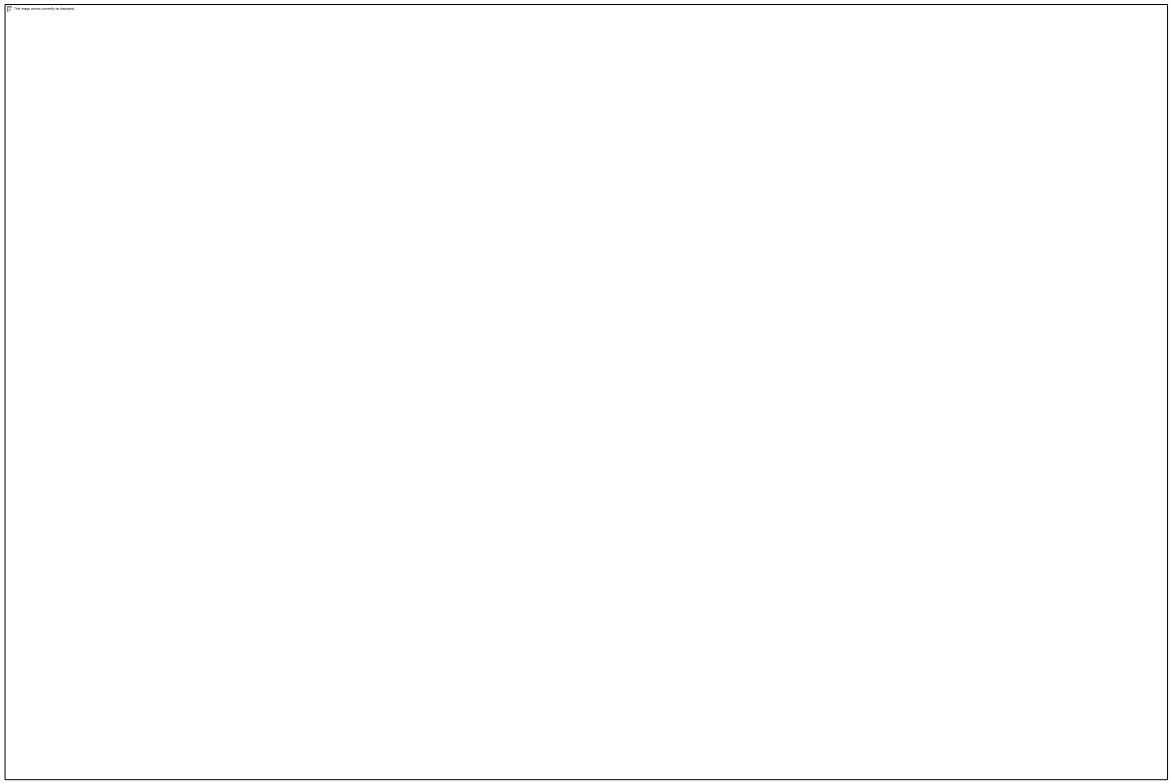
Characteristics of good masonry units:

- They should be sound and free from serious cracks.
- They should have suitable strength.
- They should be reasonably uniform in shape and size.
- They should be free from harmful contamination.
- They should be appropriate for the intended exposure conditions.
- They should comply with applicable specifications.

Example: When constructing a classroom block, a contractor may select tested concrete blocks or suitable machine-cut stones depending on the approved drawings, structural requirements and project specifications.

8.4 Stage 3: Preparing walling units

Meaning: Preparing walling units is the process of inspecting, cleaning, sorting, conditioning and, where necessary, cutting masonry units before they are laid.



Procedure:

1. Deliver the masonry units to the construction site.
2. Inspect them for cracks, damage and defects.
3. Separate defective units from acceptable units.
4. Sort the units according to size and type.
5. Remove loose dust and dirt.
6. Remove mud, oil and other contaminants.
7. Cut units where necessary using suitable tools and safe methods.
8. Prepare special units for corners and openings.
9. Condition the units according to the manufacturer's or project requirements.
10. Arrange the prepared units close to the working area.

Importance of preparing walling units

1. Ensures only suitable materials are used.
2. Reduces interruptions during wall construction.
3. Improves the appearance of the completed wall.
4. Helps maintain uniform courses.
5. Improves mortar bonding where correct conditioning is required.
6. Reduces material wastage.

Precautions when preparing masonry units

- Do not use severely cracked or damaged units.
- Avoid excessive soaking unless required by the material specification.
- Follow manufacturer instructions for moisture conditioning.
- Use suitable cutting equipment.
- Wear eye protection and respiratory protection where cutting produces dust.
- Store prepared units on stable ground.

8.5 Stage 4: Mixing mortar to a given ratio

Definition of mortar

Mortar is a workable mixture of a binding material, fine aggregate and water used to join masonry units and fill the joints between them.

Common masonry mortar may contain:

- Cement.
- Clean building sand.
- Clean water.
- Lime where specified.



Functions of mortar in walling

1. Joins masonry units together.
2. Fills spaces between masonry units.
3. Helps distribute loads between units.
4. Provides a reasonably uniform bedding surface.
5. Helps seal joints against air and water penetration.
6. Accommodates small variations in unit dimensions.
7. Contributes to the stability of the wall.

Meaning of mortar mix ratio

A mortar mix ratio is the specified proportion of the constituent materials used to prepare mortar.

For example, a nominal cement-sand ratio of 1:4 means:

- One measured part of cement.
- Four measured parts of sand.

The proportions should be measured consistently using the method specified for the project.

Common nominal cement-sand mortar proportions

Nominal mix ratio	Cement	Sand
1:3	1 part	3 parts
1:4	1 part	4 parts
1:5	1 part	5 parts
1:6	1 part	6 parts

Important: These are examples of nominal proportions for learning purposes, not universal instructions for every wall. The correct mortar mix must be specified according to the masonry units, wall function, exposure conditions, applicable standards and project design. Stronger mortar is not automatically better; mortar must be compatible with the masonry units.

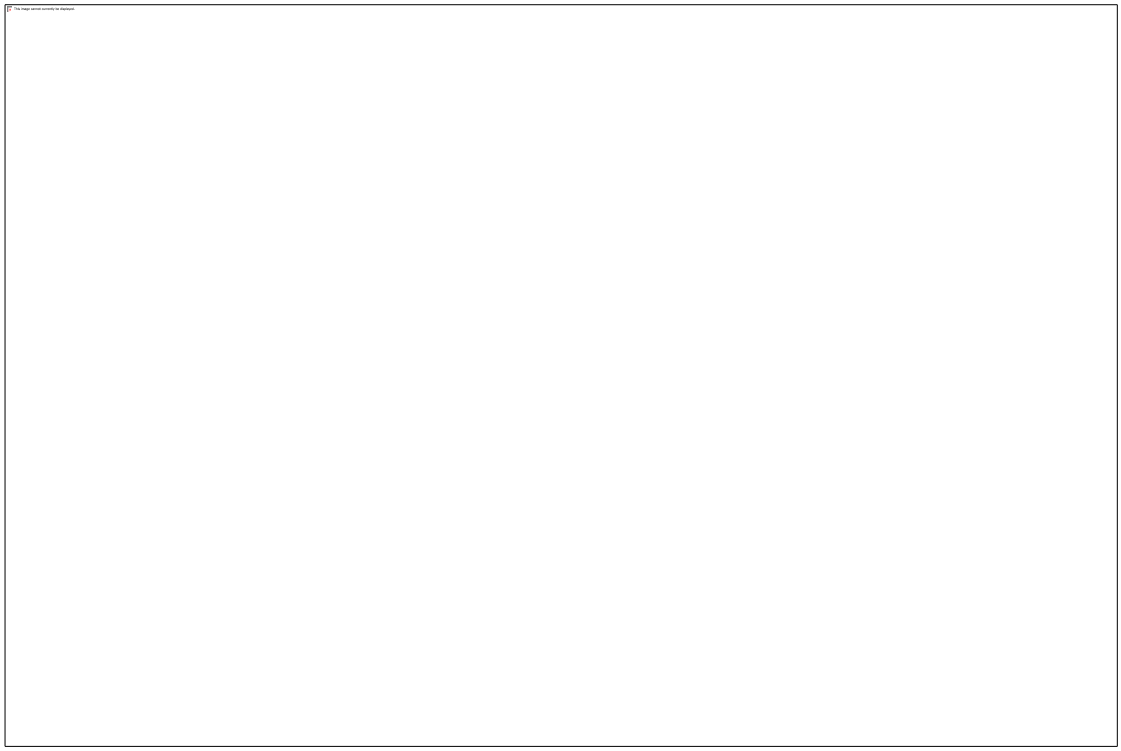
Characteristics of good mortar

1. It should have suitable workability.
2. It should be reasonably cohesive.
3. It should be free from harmful contamination.
4. It should have the specified strength.
5. It should retain sufficient water for proper placement.
6. It should bond effectively with the masonry units.
7. It should be mixed uniformly.

Materials required for mortar preparation

- Cement.
- Clean, well-graded building sand.
- Clean water.
- Measuring containers.
- Mixing board or clean mixing platform.
- Shovel or mechanical mixer.
- Wheelbarrow.
- Bucket.

Procedure for mixing mortar manually



Step 1: Prepare the mixing area

- Select a clean and firm mixing platform.
- Remove soil, leaves and other contaminants.
- Arrange the required materials.

Step 2: Measure the cement

- Measure the required quantity of cement.
- Use a consistent measuring method.
- Avoid estimating quantities without measurement.

Step 3: Measure the sand

- Measure the required quantity of clean sand.
- Use the specified mix ratio.
- Remove harmful impurities where necessary.

Step 4: Dry mixing

- Spread the sand on the mixing platform.
- Add the measured cement.
- Turn the mixture several times using a shovel.
- Continue until the colour is reasonably uniform.

Step 5: Add water

- Make a depression in the dry mixture.
- Add clean water gradually.
- Avoid pouring too much water at once.

Step 6: Wet mixing

- Turn the mixture repeatedly.
- Continue adding small quantities of water until the required workability is achieved.
- Ensure that the mixture is uniform.

Step 7: Check the consistency

Good mortar should:

- Be workable.
- Hold together when placed.
- Spread reasonably easily with a trowel.
- Not be excessively wet or too dry.

Step 8: Use the mortar

- Use the mortar within its specified working time.
- Do not use mortar that has started to set.

- Do not retemper mortar by adding water unless expressly permitted by the applicable specification and product instructions.

Example of mortar proportion calculation

A mason is instructed to prepare mortar using a nominal cement-sand ratio of 1:4.

If one measuring container of cement is used, how many equal containers of sand are required?

Solution:

1:41:4

Cement = 1 part.

Sand = 4 parts.

Therefore, the mason requires four equal measuring containers of sand for every one container of cement.

Precautions when mixing mortar

1. Use clean water.
2. Use suitable sand.
3. Measure the ingredients accurately.
4. Mix the dry ingredients thoroughly.
5. Add water gradually.
6. Avoid excessive water.
7. Use suitable personal protective equipment.
8. Avoid direct skin contact with wet cement.
9. Do not mix mortar on contaminated ground.
10. Clean mixing tools after use.

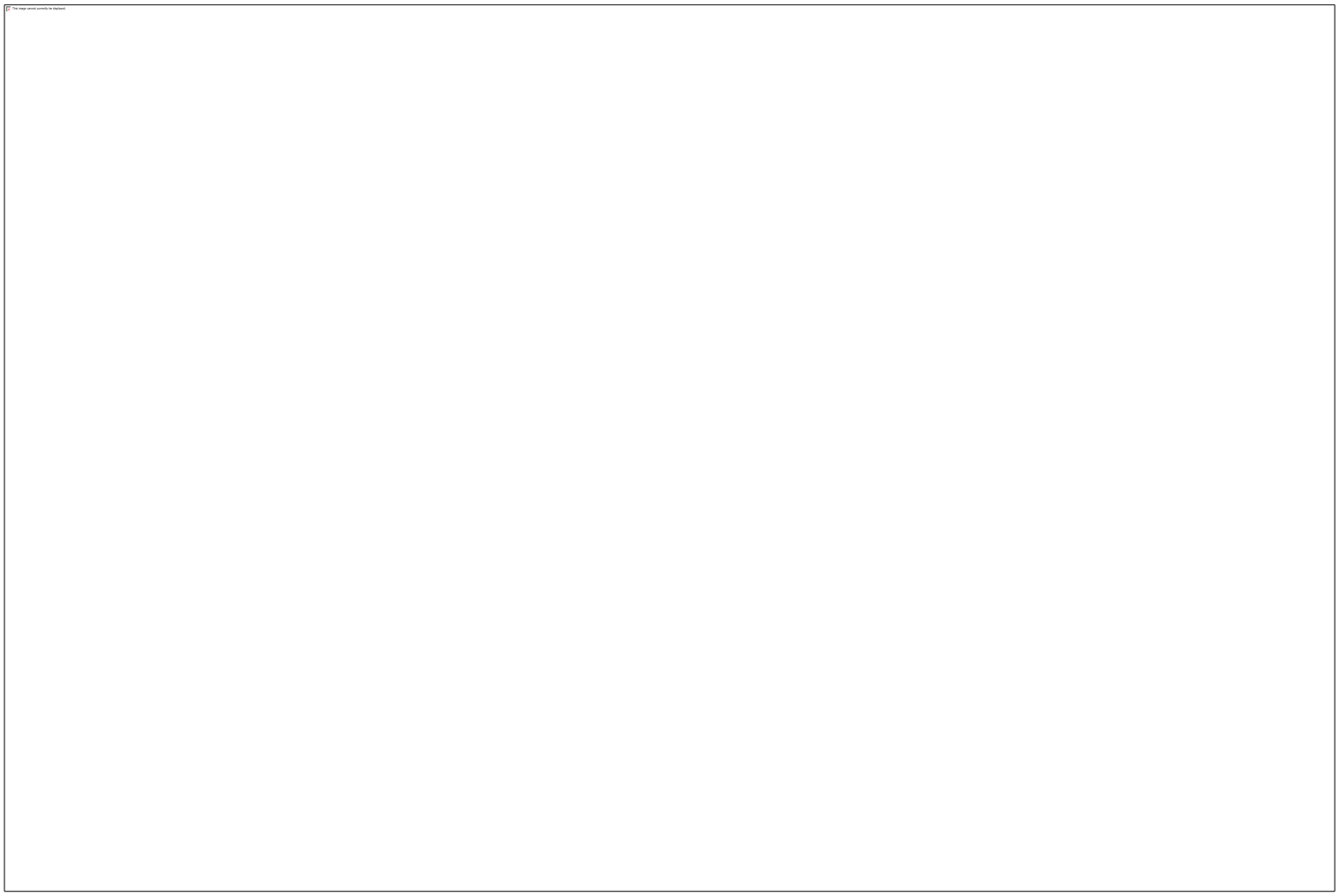
8.6 Stage 5: Laying corner walling units

Corner units are laid first because they establish the direction, height and alignment of the wall.

Procedure:

1. Confirm the wall setting-out lines.
2. Check the foundation or supporting base.
3. Spread the required mortar bed.
4. Place the first corner unit.
5. Adjust it to the correct position.
6. Check the level.
7. Check the vertical alignment.
8. Place the next corner unit according to the required bond.
9. Establish the height of the initial course.

10. Repeat for the other corners.
11. Stretch mason's lines between the corner references.

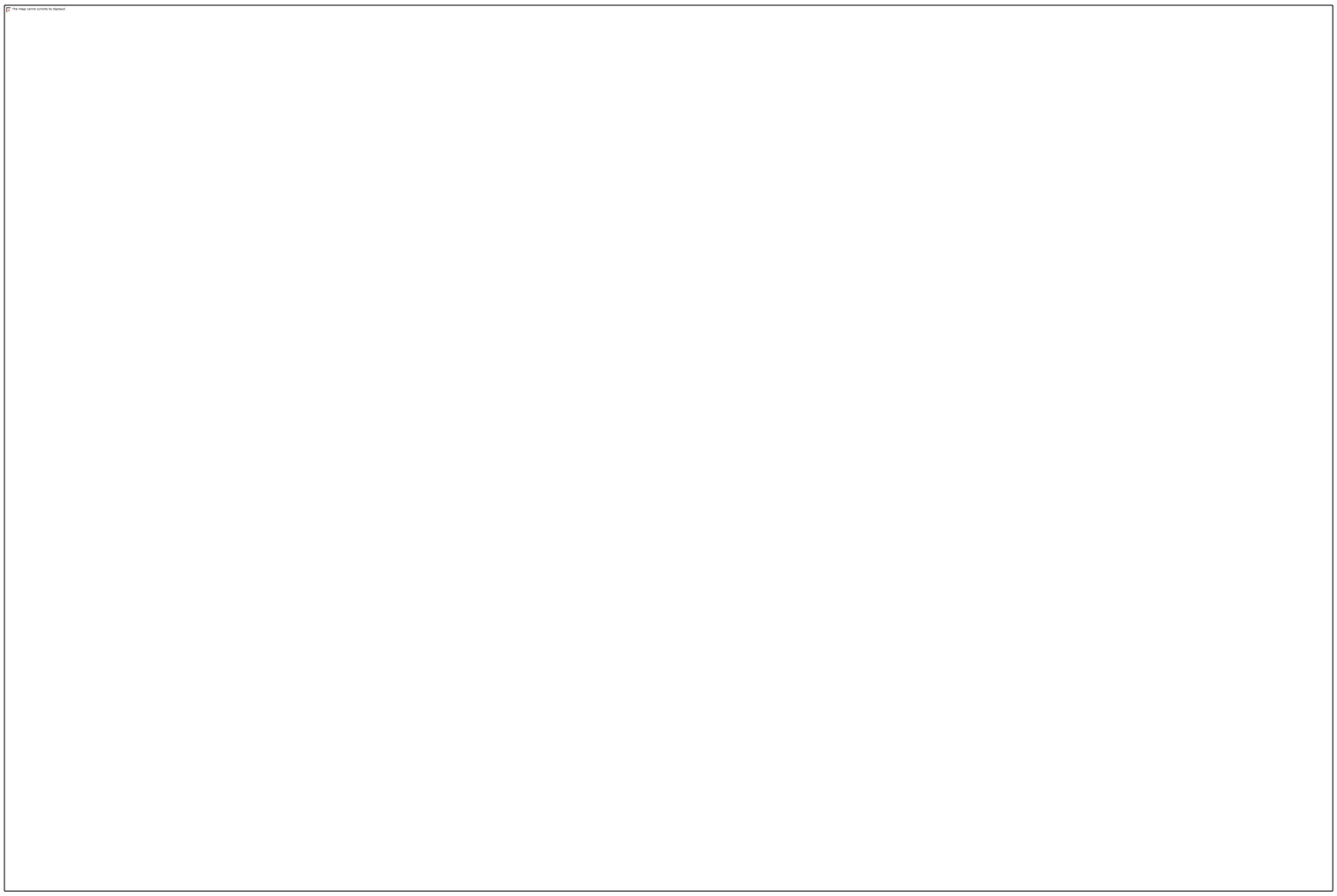


Importance of laying corner units first:

- Establishes the wall direction.
- Provides reference points for intermediate units.
- Helps maintain straightness.
- Helps maintain the required wall height.
- Reduces errors in subsequent courses.

8.7 Stage 6: Laying intermediate walling units

Definition: Intermediate walling units are the masonry units laid between established corner units to complete the length of a wall.



Procedure:

1. Stretch a mason's line between the established corner units.
2. Spread a suitable mortar bed along the wall.
3. Select the correct masonry unit.
4. Position the unit along the line.
5. Lower it carefully onto the mortar bed.
6. Adjust it gently to the required position.
7. Fill the vertical joint with mortar.
8. Remove excess mortar from the wall face.
9. Check the level of the unit.
10. Check its alignment against the mason's line.
11. Continue laying the remaining units.
12. Maintain the specified bond pattern.
13. Check the wall regularly for level and plumb.
14. Repeat the process for subsequent courses.

Important considerations when laying intermediate units

A. Maintaining line

- Use a stretched mason's line.
- Ensure that the faces of units follow the required alignment.
- Avoid pushing units beyond the reference line.

B. Maintaining level

- Use a spirit level.
- Check the horizontal position of each course.
- Correct minor deviations while the mortar is workable.

C. Maintaining plumb

- Use a plumb bob or suitable level.
- Check the vertical alignment of the wall.
- Avoid allowing the wall to lean.

D. Maintaining bond

- Follow the specified masonry bond.
- Stagger joints where required.
- Use appropriate cut or special units at corners and openings.

E. Maintaining mortar joints

- Keep joints reasonably uniform according to the specification.
- Fill joints adequately.
- Avoid leaving large gaps or voids.

F. Forming openings

- Set out door and window openings according to the drawings.
- Use the specified lintels and support details.
- Do not cut or remove structural masonry without approval.

Common defects in masonry walling

Defect	Possible cause	Prevention
Uneven wall surface	Poor alignment of masonry units	Use mason's line and regular checks.
Leaning wall	Failure to check plumb	Check vertical alignment regularly.
Cracked mortar joints	Poor mortar, movement or improper workmanship	Use specified mortar and follow construction details.

Weak bonding	Incorrect bond arrangement	Follow the specified bond pattern.
Excessive joint thickness	Poor control during laying	Maintain consistent bedding and joint thickness.
Dampness	Poor moisture protection or detailing	Provide appropriate damp-proofing and drainage details.
Uneven courses	Inaccurate setting out	Check levels regularly.
Loose units	Inadequate mortar bedding or poor workmanship	Ensure proper bedding and joint filling.

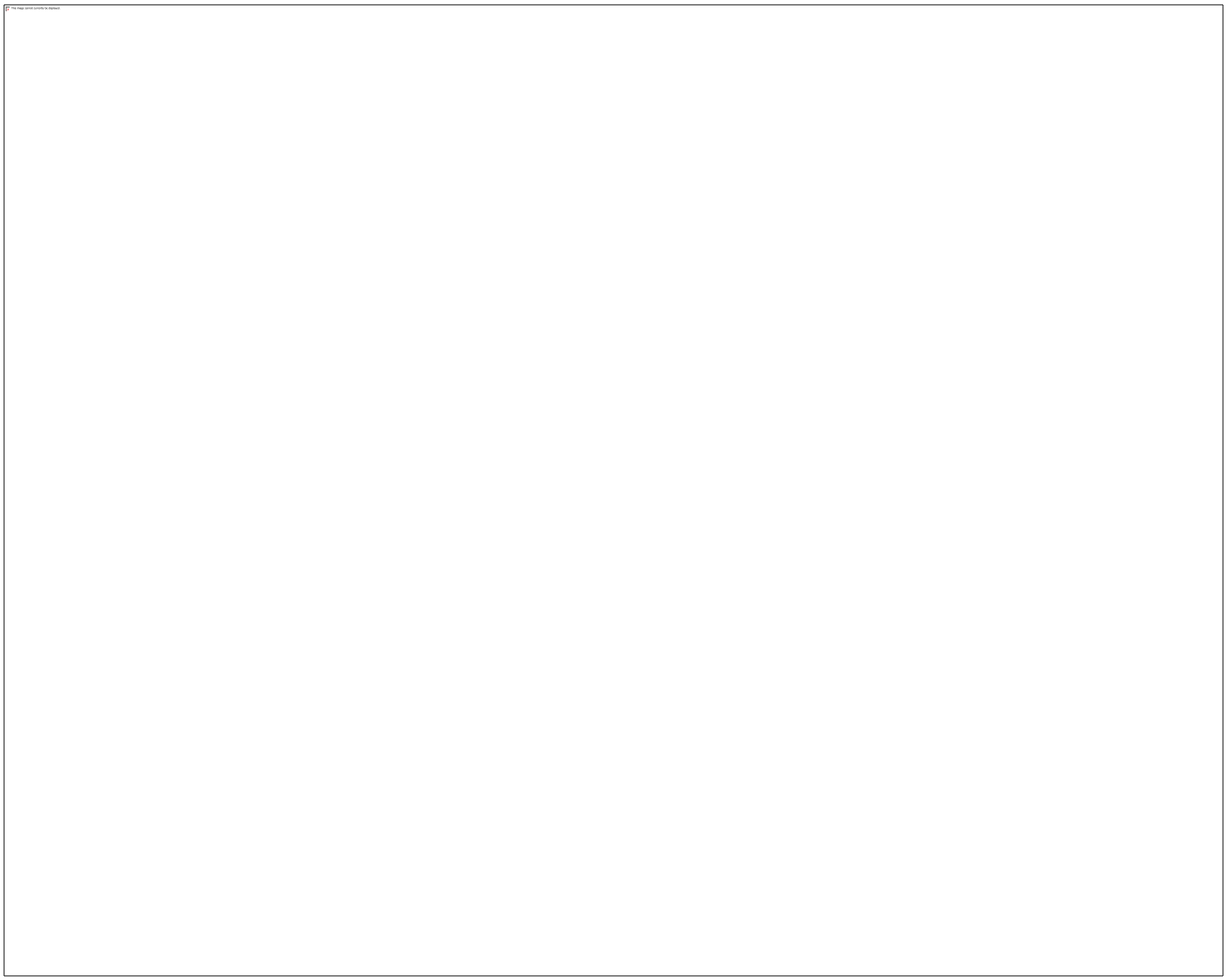
8.8 Stage 7: Finishing masonry joints

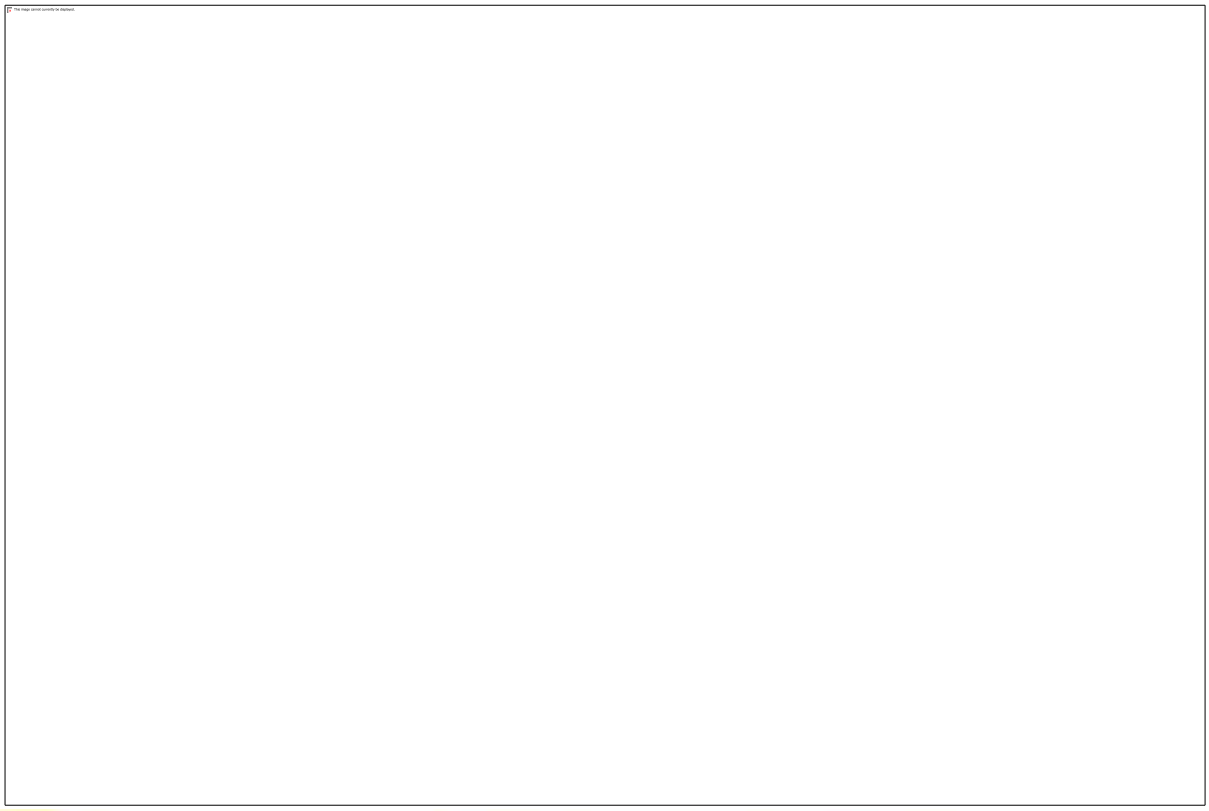
After masonry units have been laid, the joints may be finished according to the specified wall finish.

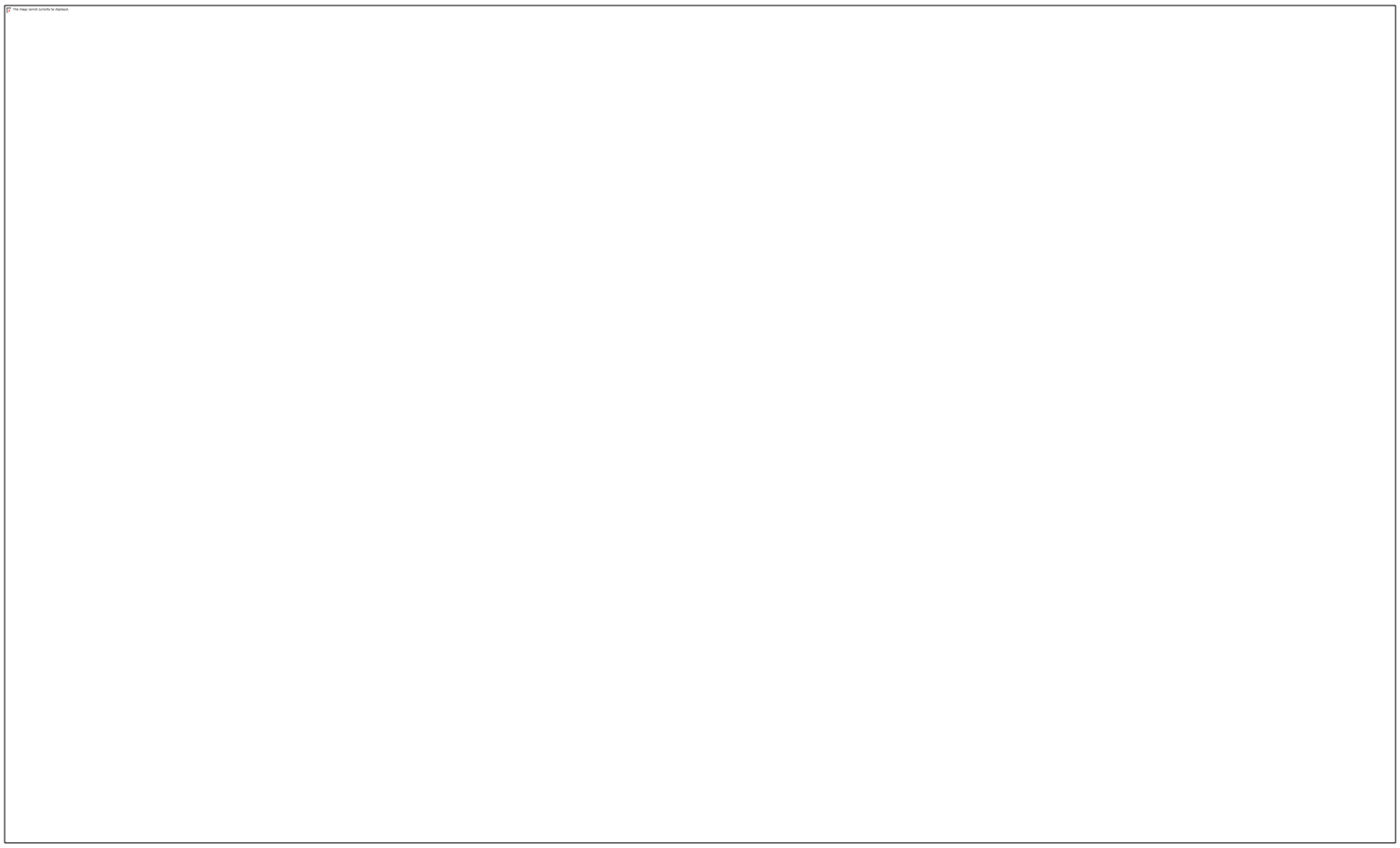
Meaning of joint finishing: Joint finishing is the process of shaping and compacting exposed mortar joints to produce the required appearance and performance.

Common types of mortar joint finishes:

1. Flush joint.
2. Recessed joint.
3. Weather-struck joint.
4. Concave joint.
5. Struck joint.







Importance of joint finishing:

- Improves the appearance of the wall.
- Produces a neat surface.
- Helps compact exposed mortar joints where appropriate.
- Improves resistance to weathering when the correct finish is used.
- Prepares the wall for further finishing or exposure.

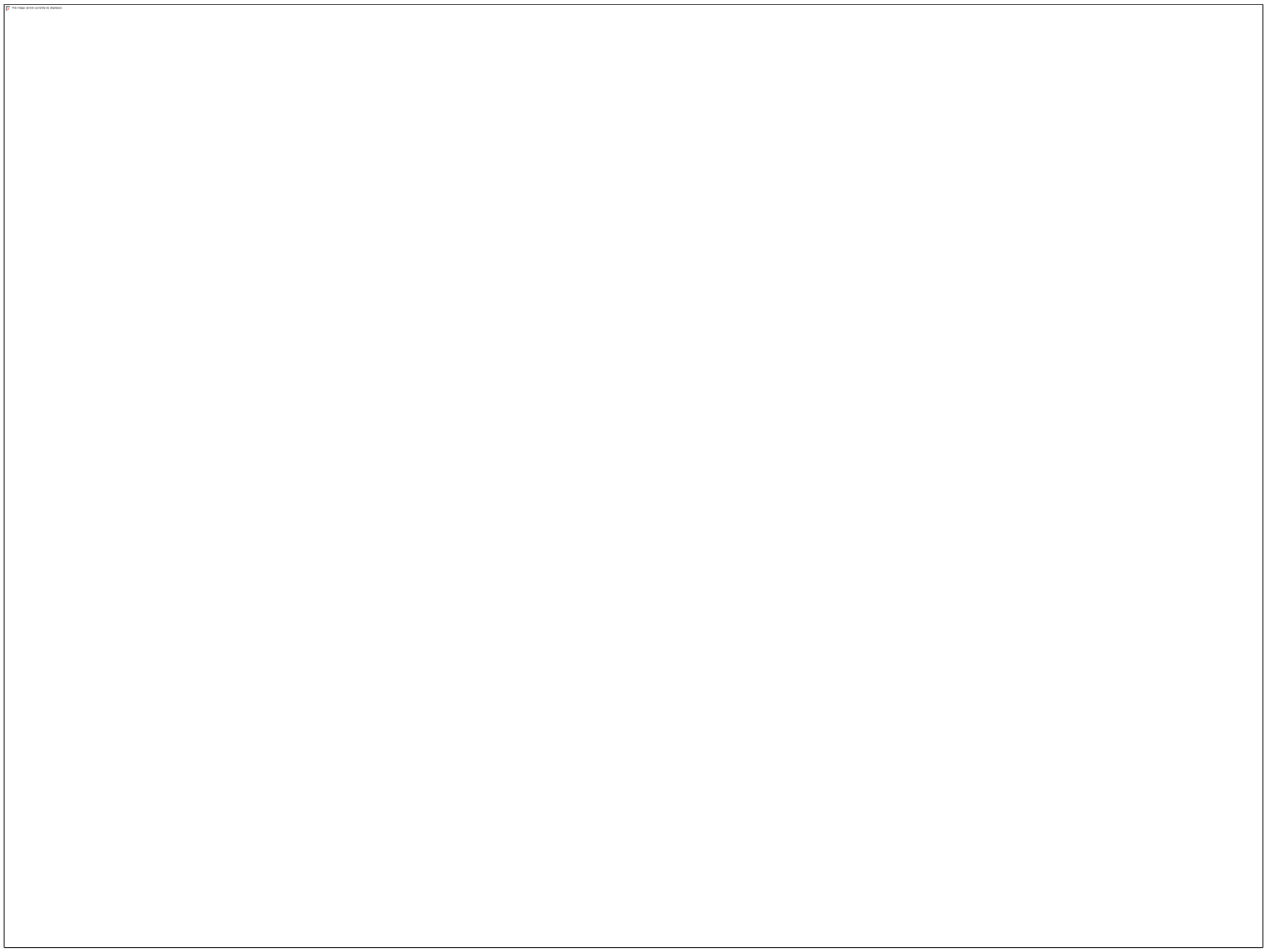
8.9 Stage 8: Cleaning up the working area

Meaning: Cleaning up is the process of removing unused materials, waste, mortar droppings and other debris after completing the masonry work.

Procedure:

1. Collect unused masonry units.
2. Separate reusable materials from waste.
3. Remove excess mortar from the working area.
4. Clean tools and equipment.
5. Store reusable materials appropriately.
6. Dispose of waste according to site procedures.
7. Clear access routes.
8. Remove trip hazards.
9. Stack remaining masonry units safely.

10. Leave the working area clean and organised.



Importance of cleaning up:

1. Prevents accidents.
2. Improves site organisation.
3. Prevents damage to tools.
4. Reduces material wastage.
5. Provides a clean working environment.
6. Makes the site ready for subsequent construction activities.
7. Helps maintain environmental cleanliness.

9.0 APPROPRIATE SAFETY MEASURES DURING MASONRY WALLING

Masonry work involves lifting heavy materials, handling cement, cutting stones and bricks, mixing mortar and working at different heights. These activities may expose workers to injuries if proper safety measures are not observed.

9.1 Personal protective equipment (PPE)



Workers should use appropriate personal protective equipment, including:

1. **Safety helmet**
    - Protects the head from falling objects and accidental impacts.
2. **Safety boots**
    - Protect the feet from falling masonry units and sharp objects.
    - Provide grip on construction surfaces.
3. **Protective gloves**
    - Reduce direct contact with wet cement and rough masonry materials.
    - Help protect hands from cuts and abrasions.
4. **Safety goggles**
    - Protect the eyes from dust and flying particles during cutting and dressing.
5. **Dust mask or suitable respirator**
    - Helps protect workers from inhaling dust.
    - The level of respiratory protection should match the exposure risk.
6. **Reflective vest**

- Improves visibility, especially in busy construction areas.

7. **Appropriate work clothing**

- Protects the body from abrasion, cement splashes and other hazards.

9.2 General safety measures

A. Safe handling of masonry materials

- Use correct lifting techniques.
- Avoid carrying excessive loads.
- Seek assistance when lifting heavy stones or blocks.
- Stack materials on firm and level ground.
- Avoid stacking masonry units too high.
- Keep materials away from unstable edges.

B. Safe mortar mixing

- Wear gloves and suitable eye protection.
- Avoid direct contact with wet cement.
- Do not inhale cement and sand dust.
- Use clean mixing areas.
- Keep water and cement away from electrical hazards.
- Wash cement from the skin immediately.

C. Safe use of tools and equipment

- Inspect tools before use.
- Use the correct tool for each task.
- Keep sharp tools in safe storage.
- Avoid leaving tools on walkways.
- Use suitable cutting equipment.
- Ensure equipment is operated by trained persons.

D. Safe working at heights

- Use properly constructed and stable scaffolding.
- Provide safe access to working platforms.
- Use suitable edge protection where required.
- Do not stand on loose masonry units or unstable supports.
- Avoid overreaching.
- Inspect scaffolding before use.

E. Maintaining a safe working area

- Keep access routes clear.

- Remove waste materials regularly.
- Provide suitable storage areas.
- Keep children and unauthorised persons away from the work area.
- Display safety warning signs where necessary.
- Provide adequate lighting.

F. Electrical safety

- Keep electrical equipment away from water.
- Inspect cables before use.
- Avoid damaged extension leads.
- Use suitable electrical protection.
- Ensure electrical equipment is operated by competent persons.

G. Dust control

- Use suitable dust suppression measures during cutting.
- Avoid dry cutting where it creates uncontrolled dust.
- Use suitable respiratory protection.
- Keep workers away from unnecessary dust exposure.

H. Emergency preparedness

- Provide a first-aid kit.
- Ensure workers know how to report accidents.
- Keep emergency access routes clear.
- Provide suitable fire-fighting equipment where required.
- Ensure emergency contact information is available.

9.3 Hazards associated with masonry walling and their control measures

Hazard	Possible injury or effect	Control measure
Falling stones or blocks	Head and foot injuries	Wear helmets and safety boots; stack materials safely.
Cement contact	Skin irritation or chemical burns	Wear gloves and wash exposed skin promptly.
Dust inhalation	Respiratory irritation and illness	Control dust and use suitable respiratory protection.
Sharp tools	Cuts and puncture wounds	Use tools correctly and store them safely.

Manual lifting	Back and muscle injuries	Use safe lifting techniques and mechanical assistance where appropriate.
Unstable scaffolding	Falls and serious injuries	Use inspected and properly constructed scaffolds.
Wet floors	Slips and falls	Remove spills and maintain clear walkways.
Flying particles	Eye injuries	Wear safety goggles and suitable face protection.
Electrical faults	Electric shock or burns	Inspect equipment and use appropriate electrical protection.
Poor site organisation	Trips and collisions	Keep the site clean and organised.

9.4 Importance of observing safety measures

1. Prevents accidents and injuries.
2. Protects workers and learners.
3. Reduces damage to tools and equipment.
4. Improves productivity.
5. Reduces work interruptions.
6. Promotes responsible construction practices.
7. Helps comply with occupational safety requirements.
8. Protects members of the public near construction sites.

10.0 QUALITY CONTROL DURING MASONRY WALLING

Quality control refers to the measures taken to ensure that masonry work meets the specified construction requirements.

10.1 Important quality checks

A. Checking wall position

- Confirm that the wall follows the approved setting-out lines.
- Check the wall thickness.
- Confirm the positions of corners and openings.

B. Checking level

- Use a spirit level to check the horizontal alignment of each course.
- Correct deviations while the mortar is workable.

C. Checking plumb

- Use a plumb bob or suitable level to check vertical alignment.

- Ensure that the wall does not lean.

D. Checking bond

- Confirm that the correct bonding pattern is followed.
- Check that joints are properly staggered where required.
- Ensure suitable arrangements at corners and intersections.

E. Checking mortar joints

- Ensure that joints are adequately filled.
- Maintain the specified joint thickness.
- Avoid excessive mortar and large gaps.

F. Checking masonry units

- Use sound units.
- Remove badly damaged units.
- Confirm that the units meet the required specification.

G. Checking openings

- Confirm the correct positions and dimensions of door and window openings.
- Check that lintels and other supports are installed according to the design.

H. Checking curing and protection

- Protect fresh masonry from excessive drying, heavy rain and physical damage.
- Follow the specified curing and protection procedures for the masonry system and mortar used.

10.2 Importance of quality control

1. Improves the durability of walls.
2. Reduces construction defects.
3. Improves the appearance of the building.
4. Helps ensure structural requirements are met.
5. Reduces repair and maintenance costs.
6. Improves safety.
7. Promotes client satisfaction.

11.0 PRACTICAL LEARNING ACTIVITIES

Activity 1: Identifying different classes of walls

Observation and classification activity

Learning task: Identify and classify different walls used in building construction.

Requirements:

- Photographs of different buildings.
- Sample bricks.

- Concrete blocks.
- Stone samples.
- Notebook.
- Measuring tape.

Procedure:

1. Observe different buildings within the school or community.
2. Identify external walls.
3. Identify internal walls.
4. Identify partition walls.
5. Identify load-bearing and non-load-bearing walls from available drawings or under teacher guidance.
6. Identify parapet walls.
7. Identify ventilation walls.
8. Classify the walls according to their materials.
9. Classify them according to their methods of construction.
10. Record your observations.

Expected learning outcome: The learner should be able to identify and classify walls according to their functions, locations, materials and methods of construction.

Activity 2: Identifying masonry bonds

Learning task: Construct models demonstrating different types of brick bonds.

Requirements:

- Small bricks or brick models.
- Modelling mortar or suitable reusable modelling material.
- Flat working surface.
- Ruler.
- Mason's line.

Procedure:

1. Obtain suitable brick units.
2. Arrange bricks to demonstrate stretcher bond.
3. Arrange another set to demonstrate header bond.
4. Construct a model of English bond.
5. Construct a model of Flemish bond.
6. Observe the arrangement of the bricks.
7. Identify the differences between the bonds.

8. Draw each bond pattern in your notebook.
9. Present your models to the class.

Expected learning outcome: The learner should be able to identify and demonstrate four common masonry bonds.

Activity 3: Erecting profile boards

Learning task: Erect profile boards for a sample masonry wall.

Requirements:

- Timber boards.
- Timber stakes.
- Nails.
- Hammer.
- Mason's line.
- Tape measure.
- Builder's square.
- Spirit level.

Procedure:

1. Identify the proposed wall position.
2. Select suitable locations for profile boards.
3. Drive the timber stakes into the ground.
4. Fix horizontal boards to the stakes.
5. Transfer the wall dimensions onto the boards.
6. Fix nails at the reference points.
7. Stretch mason's lines between the nails.
8. Check the wall alignment.
9. Check the right angles.
10. Present the completed setting-out arrangement.

Expected learning outcome: The learner should be able to erect profile boards and use them to establish wall alignment.

Activity 4: Preparing masonry mortar

Learning task: Prepare mortar using a specified cement-sand ratio.

Requirements:

- Cement.
- Clean sand.
- Clean water.

- Measuring containers.
- Shovel.
- Mixing platform.
- Wheelbarrow.
- Protective gloves.
- Safety boots.

Procedure:

1. Wear appropriate PPE.
2. Prepare a clean mixing platform.
3. Measure the cement.
4. Measure the sand according to the specified ratio.
5. Mix the dry ingredients.
6. Add water gradually.
7. Mix until the required consistency is achieved.
8. Check the workability.
9. Use the mortar as specified.
10. Clean the tools and working area.

Expected learning outcome: The learner should be able to prepare workable mortar using a specified mix proportion.

Activity 5: Constructing a sample masonry wall

Learning task: Construct a small masonry wall using suitable bricks, stones or concrete blocks.

Requirements:

- Masonry units.
- Cement.
- Sand.
- Water.
- Trowel.
- Spirit level.
- Plumb bob.
- Mason's line.
- Tape measure.
- Mortar board.
- Safety equipment.

Procedure:

1. Wear appropriate PPE.
2. Prepare the working area.
3. Select suitable walling materials.
4. Prepare the masonry units.
5. Set out the wall outline.
6. Establish the corner positions.
7. Mix mortar using the specified ratio.
8. Lay the corner units.
9. Stretch the mason's line.
10. Lay intermediate units.
11. Maintain the required bond.
12. Check line, level and plumb.
13. Finish the joints as specified.
14. Protect the completed work.
15. Clean the working area.

Expected learning outcome: The learner should be able to construct a simple masonry wall while observing appropriate safety and quality requirements.

REVISION QUESTIONS

SECTION A: MULTIPLE-CHOICE QUESTIONS

INSTRUCTIONS: Choose the correct answer from the alternatives provided.

1. A wall is best described as a building component constructed mainly to:

A. Produce electricity
B. Enclose, divide, protect or support building spaces
C. Transport building materials
D. Mix construction mortar

2. The part of a building constructed above the foundation is called:

A. Substructure
B. Superstructure
C. Excavation
D. Foundation bed

3. Which of the following is an example of a load-bearing wall?

A. A wall designed to support a roof structure
B. A lightweight decorative screen
C. A temporary timber partition
D. A movable office divider

4. A wall designed mainly to divide internal spaces is called:

A. Parapet wall
B. Retaining wall
C. Partition wall
D. Foundation wall

5. Which type of wall is commonly constructed along the edge of a flat roof?

A. Partition wall
B. Parapet wall
C. Cavity wall
D. Ventilation wall

6. A wall constructed with openings to allow air circulation is called:

A. Load-bearing wall
B. Ventilation wall
C. Solid wall
D. Retaining wall

7. Which of the following is an example of an exterior wall?

A. A wall separating two bedrooms
B. A wall dividing an office
C. A wall enclosing the outside of a house
D. A wall separating a bathroom from a kitchen

8. A wall constructed using burnt clay bricks is classified according to:

A. Location
B. Material
C. Height
D. Function only

9. Which of the following describes a cavity wall?

A. A wall made entirely of timber
B. A wall with two leaves separated by a cavity
C. A wall without any joints
D. A wall constructed only with concrete

10. Which of the following is commonly used in constructing a modern dry wall?

A. Gypsum boards
B. Natural rubble stones only
C. Wet concrete only
D. Clay soil only

11. A masonry bond refers to:

A. The colour of a wall
B. The arrangement of masonry units in a wall
C. The height of a building
D. The type of roof covering

12. A stretcher is a brick laid with its:

A. Short face visible
B. Long face visible
C. Bottom face visible
D. Upper face visible only

13. A header is a brick laid with its:

A. Long face visible
B. Short face visible
C. Side edge hidden
D. Bottom surface visible

14. Which masonry bond consists mainly of stretchers in each course?

A. English bond
B. Flemish bond
C. Stretcher bond
D. Header bond

15. Which masonry bond consists of alternate courses of headers and stretchers?

A. Flemish bond
B. English bond
C. Stretcher bond
D. Header bond

16. In Flemish bond, the headers and stretchers are arranged:

A. In separate alternate courses
B. Alternately in each course
C. Only at the corners
D. Without a regular pattern

17. Which bond is commonly associated with short faces of bricks appearing on the wall surface?

A. Header bond
B. Stretcher bond
C. Flemish bond only
D. Random bond

18. The horizontal mortar joint between successive courses is called:

A. Perpend joint
B. Bed joint
C. Expansion joint
D. Movement joint

19. The vertical mortar joint between adjacent masonry units is called:

A. Bed joint
B. Perpend joint
C. Roof joint
D. Foundation joint

20. Profile boards are mainly used to:

A. Mix mortar
B. Establish and maintain building and wall alignment
C. Cut bricks
D. Plaster walls

21. Which of the following is a component of profile boards?

A. Timber stake
B. Concrete mixer drum only
C. Roofing sheet
D. Door frame

22. A mason's line is used to:

A. Mix cement
B. Guide the alignment of masonry units
C. Cut concrete blocks
D. Measure the strength of mortar

23. Which tool is used to check the horizontal level of a masonry unit?

A. Hammer
B. Spirit level
C. Bolster
D. Trowel

24. Which instrument is commonly used to check vertical alignment?

A. Plumb bob
B. Wheelbarrow
C. Shovel
D. Measuring bucket

25. The first stage in setting out a masonry superstructure wall is:

A. Cleaning the site
B. Establishing the outline
C. Plastering the wall
D. Painting the wall

26. Cornerstones are laid first mainly because they:

A. Decorate the wall
B. Establish reference points for intermediate walling units
C. Replace the foundation
D. Reduce the need for mortar

27. A nominal mortar ratio of 1:4 means:

A. Four parts cement and one part sand
B. One part cement and four parts sand
C. One part cement and one part water
D. Four parts water and one part cement

28. Which of the following is an important function of mortar?

A. Joining masonry units
B. Producing roofing sheets
C. Cutting timber
D. Manufacturing nails

29. Which of the following should be done when mixing mortar?

A. Add all the water at once without checking
B. Use contaminated sand
C. Measure materials and add water gradually
D. Mix on muddy ground

30. Which of the following is an appropriate safety measure during masonry walling?

A. Working without protective footwear
B. Stacking blocks carelessly
C. Wearing safety boots and gloves
D. Leaving tools on access routes

SECTION B: STRUCTURED QUESTIONS

1.

a) Define a wall. (2 marks)

b) Explain the meaning of masonry superstructure walling. (3 marks)

c) State five functions of walls in a building. (5 marks)

2.

a) Define a superstructure. (2 marks)

b) Identify six components of a building superstructure. (6 marks)

c) Explain four reasons why masonry walling is important in building construction. (8 marks)

3.

a) Classify walls according to their functions. (5 marks)

b) Explain the difference between load-bearing and non-load-bearing walls. (4 marks)

c) State four functions of partition walls. (4 marks)

4.

a) Define a parapet wall. (2 marks)

b) Explain four functions of parapet walls. (8 marks)

c) State four characteristics of ventilation walls. (4 marks)

5.

a) Classify walls according to their location. (2 marks)

b) Differentiate between interior and exterior walls. (4 marks)

c) State four functions of exterior walls. (4 marks)

6.

a) Identify three types of walls based on the materials used. (3 marks)

b) Explain four characteristics of stone walls. (4 marks)

c) State four advantages of concrete block walls. (4 marks)

d) Explain three limitations of brick walls. (3 marks)

7.

a) Classify walls according to their methods of construction. (3 marks)

b) Define a cavity wall. (2 marks)

c) Explain five components of a cavity wall. (5 marks)

d) State four advantages of cavity walls. (4 marks)

8.

a) Define masonry bond. (2 marks)

b) Explain the importance of masonry bonds. (6 marks)

c) Name four common types of masonry bonds. (4 marks)

9.

a) Define stretcher bond. (2 marks)

b) Explain five characteristics of stretcher bond. (5 marks)

c) State four uses of stretcher bond. (4 marks)

10.

a) Define header bond. (2 marks)

b) State four characteristics of header bond. (4 marks)

c) Explain three advantages of header bond. (3 marks)

11.

a) Define English bond. (2 marks)

b) Explain the arrangement of bricks in English bond. (4 marks)

c) State four advantages of English bond. (4 marks)

12.

a) Define Flemish bond. (2 marks)

b) Explain the arrangement of bricks in Flemish bond. (4 marks)

c) State four characteristics of Flemish bond. (4 marks)

13. Differentiate between the following types of masonry bonds:

a) Stretcher bond and header bond. (4 marks)

b) English bond and Flemish bond. (4 marks)

14.

a) Define profile boards. (2 marks)

b) Identify five components of profile boards. (5 marks)

c) Explain six functions of profile boards in building construction. (12 marks)

15. Describe the procedure for erecting profile boards during building construction. (10 marks)

16.

a) Define setting out. (2 marks)

b) Explain five reasons why setting out is important in masonry superstructure walling. (10 marks)

17. Describe the three main stages followed when setting out a masonry superstructure wall:

a) Establishing the outline. (4 marks)

b) Marking out the outline. (4 marks)

c) Setting out the cornerstones. (4 marks)

18. Identify eight tools and equipment used when setting out masonry superstructure walls and explain one function of each. (16 marks)

19.

a) Define mortar. (2 marks)

b) State five functions of mortar in masonry walling. (5 marks)

c) Explain five characteristics of good mortar. (5 marks)

20. Describe the procedure for manually mixing cement-sand mortar. (10 marks)

21. A mason is instructed to prepare mortar using a nominal cement-sand ratio of 1:5.

a) Explain the meaning of the ratio. (2 marks)

b) If one container of cement is used, calculate the number of equal containers of sand required. (2 marks)

c) State four precautions to observe when mixing mortar. (4 marks)

22. Describe the procedure for laying intermediate walling units after establishing the corner units. (10 marks)

23. Explain six quality checks that should be carried out during masonry wall construction. (12 marks)

24. Identify ten safety measures that should be observed during masonry walling. (10 marks)

25. Explain five reasons why cleaning up the working area is important after masonry wall construction. (10 marks)

SECTION C:

Question 1: Selecting walls for a school building

A school in Narok County plans to construct additional classrooms, an administration office and a sanitation block. The contractor proposes using masonry walls for the project.

Tasks:

a) Recommend a suitable type of wall for dividing the classrooms internally. (2 marks)

b) Explain four factors to consider when selecting materials for the external walls. (4 marks)

c) State three functions of external walls in the school building. (3 marks)

d) Explain three reasons why ventilation walls may be suitable for selected areas of the school. (3 marks)

e) Identify three safety measures to observe during wall construction. (3 marks)

Question 2: Identifying masonry bonds

A learner visits a construction site and observes four brick walls. The first wall has only long brick faces visible. The second wall has short brick faces visible. The third wall has alternate courses of headers and stretchers. The fourth wall has alternating headers and stretchers within each course.

Tasks:

a) Identify the bond used in each wall. (4 marks)

b) Explain two differences between English bond and Flemish bond. (4 marks)

c) State three reasons why proper bonding is important. (3 marks)

d) Recommend a bond suitable for a decorative brick wall and give a reason. (2 marks)

Question 3: Setting out a classroom wall

A contractor is required to construct a masonry wall separating two classrooms. The wall must follow the approved building plan.

Tasks:

a) Explain why the wall must be set out before construction. (3 marks)

b) Identify four tools required for setting out the wall. (4 marks)

c) Describe the procedure for establishing the wall outline. (4 marks)

d) Explain the importance of laying corner units first. (3 marks)

e) State three checks that should be made before laying intermediate units. (3 marks)

Question 4: Preparation of mortar

A group of Grade 11 learners is instructed to prepare mortar using a nominal cement-sand ratio of 1:4.

Tasks:

a) Explain the meaning of the ratio 1:4. (2 marks)

b) Calculate the quantity of sand required if two equal measuring containers of cement are used. (2 marks)

c) Describe the procedure for mixing the mortar. (5 marks)

d) State four characteristics of good mortar. (4 marks)

e) Identify three safety measures to observe during mortar preparation. (3 marks)

Question 5: Constructing a masonry wall

A construction team is building a concrete block wall for a residential house in Nakuru County. The supervisor notices that some blocks are not aligned and some mortar joints are not completely filled.

Tasks:

a) Identify three defects that may result from poor masonry workmanship. (3 marks)

b) Explain four ways of maintaining proper alignment during walling. (4 marks)

c) State three reasons for filling mortar joints properly. (3 marks)

d) Explain three quality checks that should be performed before continuing with the next course. (3 marks)

e) Suggest three ways of improving the quality of the completed wall. (3 marks)

Question 6: Profile boards on a construction site

A contractor has erected profile boards to guide the construction of the external walls of a residential house. Some workers accidentally move one of the boards.

Tasks:

a) Explain the purpose of profile boards. (3 marks)

b) Identify four components of profile boards. (4 marks)

c) Explain three problems that may occur if a profile board is moved. (3 marks)

d) State four measures that can prevent the disturbance of profile boards. (4 marks)

Question 7: Safety during masonry walling

A masonry team is constructing the upper walls of a two-storey building. Workers are handling heavy blocks, mixing mortar and working on scaffolding.

Tasks:

a) Identify four hazards associated with the work. (4 marks)

b) State suitable personal protective equipment for the workers. (4 marks)

c) Explain four measures that can improve safety when working on scaffolding. (4 marks)

d) State three safe practices when handling masonry blocks. (3 marks)

Question 8: Selecting a wall construction method

A building owner wants to divide a large office space into smaller offices. The owner is considering a solid masonry wall, a cavity wall and a dry wall.

Tasks:

a) Explain the difference between the three wall construction methods. (6 marks)

b) Recommend a suitable wall type for an internal office partition and justify your choice. (3 marks)

c) State four factors to consider before selecting the walling method. (4 marks)

d) Explain two limitations of your recommended wall type. (2 marks)

PRACTICAL PROJECT AND ASSESSMENT

Project: Setting out and constructing a sample masonry superstructure wall

Competency-based practical project

Project objective

To enable the learner to demonstrate practical skills in classifying walls, identifying masonry bonds, erecting profile boards, setting out a wall, preparing mortar and constructing a small masonry wall safely.

Materials and equipment

- Suitable bricks, stones or concrete blocks.
- Cement.
- Clean building sand.
- Clean water.
- Timber boards.
- Timber stakes.
- Nails.
- Hammer.
- Mason's line.
- Tape measure.
- Spirit level.
- Plumb bob.
- Builder's square.
- Mason's trowel.
- Mortar board.
- Wheelbarrow.
- Shovel.
- PPE.

Project procedure

Task A: Wall classification

1. Identify five types of walls from drawings or photographs.
2. Classify them according to function.
3. Classify them according to location.
4. Classify them according to materials.
5. Classify them according to construction method.

Task B: Masonry bond models

1. Prepare sample brick units.
2. Demonstrate stretcher bond.

3. Demonstrate header bond.
4. Demonstrate English bond.
5. Demonstrate Flemish bond.
6. Label each arrangement.

Task C: Erecting profile boards

1. Select suitable positions.
2. Drive timber stakes into the ground.
3. Fix horizontal boards.
4. Transfer wall dimensions.
5. Fix nails at reference points.
6. Stretch mason's lines.
7. Check the wall alignment and dimensions.

Task D: Preparing mortar

1. Wear appropriate PPE.
2. Measure cement and sand according to the specified ratio.
3. Mix the dry materials.
4. Add water gradually.
5. Mix until suitable workability is achieved.
6. Present the mortar for inspection.

Task E: Constructing the wall

1. Prepare the wall base.
2. Lay the corner units.
3. Establish the mason's line.
4. Lay intermediate units.
5. Maintain the required bond.
6. Check level and plumb.
7. Finish the joints.
8. Protect the completed work.
9. Clean the working area.

Suggested assessment rubric

Assessment area	Marks
Identification and classification of walls	10
Identification of masonry bonds	10
Erection of profile boards	15
Accuracy of wall setting out	15
Selection and preparation of walling units	10
Correct preparation of mortar	10
Laying of corner and intermediate units	15
Alignment, level, plumb and bond	5
Observance of safety measures	5
Cleaning and organisation of working area	5
Total	100

14.0 KEY TERMS AND DEFINITIONS

Term	Meaning
Wall	A vertical building component used to enclose, divide, protect or support spaces.
Masonry	Construction using individual units such as stones, bricks or blocks.
Superstructure	The part of a building above the foundation or substructure.
Load-bearing wall	A wall designed to support structural loads and transfer them to the foundation.
Non-load-bearing wall	A wall that carries its own weight and other specified loads but is not designed to support major building loads.
Partition wall	A wall used mainly to divide internal spaces.
Parapet wall	A low wall constructed along a roof, balcony or terrace edge.

Ventilation wall	A wall designed with openings to allow air movement.
Interior wall	A wall located within a building.
Exterior wall	A wall forming part of the external enclosure of a building.
Brick wall	A wall constructed using brick units.
Stone wall	A wall constructed using natural or processed stones.
Concrete wall	A wall constructed using concrete or concrete masonry units.
Solid wall	A masonry wall without a continuous cavity separating two leaves.
Cavity wall	A wall consisting of two leaves separated by a cavity.
Dry wall	A wall assembled using boards or panels fixed to a framework.
Masonry bond	The systematic arrangement of masonry units in a wall.
Stretcher	A brick with its long face visible on the wall surface.
Header	A brick with its short face visible on the wall surface.
Stretcher bond	A bond in which the visible faces are mainly stretchers.
Header bond	A bond in which the visible faces are mainly headers.
English bond	A bond consisting of alternate courses of headers and stretchers.
Flemish bond	A bond in which headers and stretchers alternate within each course.
Course	A horizontal layer of masonry units.
Bed joint	The horizontal mortar joint between successive courses.
Perpend joint	The vertical mortar joint between adjacent masonry units.
Profile board	A temporary board used to establish and maintain setting-out references.
Mason's line	A string used to guide the alignment of masonry units.

Setting out	Transferring building dimensions and positions from drawings to the construction site.
Cornerstone	A masonry unit positioned at a wall corner to establish alignment and reference points.
Mortar	A workable mixture used to join masonry units and fill joints.
Mortar ratio	The specified proportion of mortar constituents.
Alignment	The correct positioning of masonry units along a required line.
Plumb	The condition of being vertically aligned.
Level	The condition of being horizontally aligned.
Lintel	A structural component spanning an opening to support the masonry above it.
Wall tie	A connector used to join two leaves of a cavity wall.
Dry stone masonry	Masonry constructed using stones without conventional mortar joints.

15.0 SUMMARY OF THE SUB-STRAND

1. Masonry superstructure walling involves constructing walls above foundation level using suitable masonry units.
2. Walls enclose, divide, protect and, where designed, support building spaces.
3. Walls can be classified according to function, location, materials and construction method.
4. Load-bearing walls support structural loads.
5. Non-load-bearing walls mainly carry their own weight and other specified loads.
6. Partition walls divide internal spaces.
7. Parapet walls are constructed along roof, balcony or terrace edges.
8. Ventilation walls allow air to pass through openings.
9. Interior walls are located inside buildings, while exterior walls form part of the external enclosure.
10. Brick, stone and concrete are common materials used in masonry wall construction.
11. Solid, cavity and dry walls are different wall construction methods.
12. Common brick bonds include stretcher, header, English and Flemish bonds.
13. Masonry bonds improve the arrangement, interlocking and appearance of masonry units.
14. Profile boards provide reference points for setting out walls.
15. Setting out involves establishing the outline, marking the outline and setting out the corner units.

16. Suitable walling materials must be selected according to the design and project requirements.
17. Masonry units should be inspected, cleaned and prepared before laying.
18. Mortar joins masonry units and fills the joints between them.
19. Corner units are established before intermediate units are laid.
20. Intermediate units should follow the mason's line and the specified bond.
21. Level, plumb, alignment and joint quality should be checked regularly.
22. Appropriate PPE and safe working practices must be observed throughout masonry work.
23. The working area should be cleaned and organised after construction.

STRAND 3.0: BUILDING CONSTRUCTION PROCESS

SUBSTRAND 3.2: TIMBER SUPERSTRUCTURE WALLING

INTRODUCTION

Timber superstructure walling is an important aspect of building construction that involves using timber and timber products to construct walls above the foundation level of a building.

Timber walls are commonly used in residential buildings, temporary structures, holiday cottages, site offices, partitions and other lightweight buildings. In Kenya, timber walling is particularly useful in areas where timber is readily available and where lightweight, economical and relatively quick construction methods are required.

Timber superstructure walls provide enclosure, privacy, security, support and separation of internal spaces. They can also contribute to the aesthetic appearance and thermal comfort of a building.

This sub-strand covers the types of timber walls, timber wall construction methods, timber joints, profile boards, model timber walls, setting out procedures, tools and equipment, and safety precautions.

1.0 LEARNING OUTCOMES

By the end of this sub-strand, the learner should be able to:

1. Identify different types of timber walls used in building construction.
2. Describe the characteristics and applications of timber-framed walls, panel timber walls and plank walls.
3. Identify and explain common timber joints used in wall construction.
4. Demonstrate methods of constructing timber superstructure walls.
5. Explain the procedure for setting out timber superstructure walls.
6. Use profile boards when setting out timber wall positions.
7. Identify tools and equipment used in timber wall construction.
8. Construct a simple model of a timber superstructure wall.
9. Observe safety precautions when working with timber and carpentry tools.
10. Appreciate the importance of timber walling in sustainable building construction.

2.0 MEANING OF TIMBER SUPERSTRUCTURE WALLING

Timber superstructure walling refers to the construction of walls above the foundation or floor level using timber members, timber boards or manufactured timber products.

A timber wall may consist of a framework of timber members covered with boards, plywood, fibre-cement boards or other suitable wall-cladding materials.

Important terms used in timber walling

1. Superstructure

- The part of a building constructed above the foundation.
- It includes walls, columns, beams, floors, roofs, doors and windows.
- It transfers building loads to the substructure through appropriate structural members.

2. Timber

- Timber is wood that has been processed and prepared for use in construction, carpentry and other applications.
- It is obtained from trees and converted into suitable sizes and shapes.
- Examples include cypress, pine, cedar, eucalyptus and suitable hardwoods.

3. Wall frame

- A structural arrangement of timber members forming the skeleton of a wall.
- It consists of vertical and horizontal members.
- It provides support for wall coverings and transfers loads to the supporting structure.

4. Stud

- A vertical timber member forming part of a timber wall frame.
- Studs are normally placed at regular intervals between the bottom and top plates.
- They provide support for wall coverings and help transfer loads.

5. Wall plate

- A horizontal timber member forming part of a wall frame.
- The bottom plate is fixed at the base of the wall.
- The top plate connects the upper ends of the studs.

6. Wall cladding

- The material fixed to the framework to form the wall surface.
- It may be made from timber boards, plywood or other suitable manufactured boards.

7. Nogging

- A short horizontal timber member fixed between adjacent vertical studs.
- It strengthens the wall frame.
- It helps prevent studs from twisting or buckling.
- It provides additional support for fixing wall coverings.

3.0 IMPORTANCE OF TIMBER SUPERSTRUCTURE WALLING

Timber walling has several applications and advantages in building construction.

3.1 Advantages of timber walling

1. **Lightweight construction**

- Timber is relatively light compared with materials such as stone, concrete and solid masonry.
- This reduces the dead load imposed on the foundation and supporting structure.

2. **Ease of construction**

- Timber members can be cut, shaped and assembled using ordinary carpentry tools.
- Construction can be completed relatively quickly by skilled carpenters.

3. **Thermal insulation**

- Timber has relatively low thermal conductivity.
- Properly designed timber walls can help reduce heat transfer between the inside and outside of a building.
- Insulation materials may be installed between studs to improve thermal performance.

4. **Aesthetic appearance**

- Timber provides a natural and attractive appearance.
- It can be stained, painted, polished or varnished to achieve different finishes.

5. **Flexibility in design**

- Timber walls can be designed in different shapes, sizes and arrangements.
- They can accommodate openings for doors and windows.

6. **Ease of modification**

- Non-load-bearing timber partitions can be modified or relocated more easily than many masonry walls.
- This makes them useful in offices, classrooms and residential buildings.

7. **Availability**

- Suitable timber species and timber products are available in the Kenyan construction market.
- Examples include cypress and treated pine.

8. **Renewable construction material**

- Timber can be renewed through responsible forest management and tree planting.
- It can contribute to sustainable construction when obtained from legally and responsibly managed sources.

9. **Ease of transportation**

- Timber members are relatively easy to transport and handle.
- They are useful in locations where transporting heavy construction materials is difficult.

10. **Reduced construction time**

- Timber wall components can be prepared in a workshop and assembled on site.
- This reduces the amount of work required at the construction site.

3.2 Limitations of timber walling

1. **Susceptibility to termites**

- Some timber species are attacked by termites.
- Appropriate timber treatment and regular inspection are necessary.

2. **Fire risk**

- Timber is combustible.
- Fire-resistant design, protective treatments and suitable construction details are important.

3. **Moisture damage**

- Excessive moisture may cause timber to swell, warp, decay or develop fungal growth.
- Proper ventilation, damp protection and weatherproofing are necessary.

4. **Shrinkage and expansion**

- Timber changes dimensions when its moisture content changes.
- This may cause cracks, gaps and distortion if the timber is not properly seasoned and installed.

5. **Maintenance requirements**

- Timber surfaces may require periodic painting, staining, sealing or treatment.

6. **Limited durability of untreated timber**

- Timber exposed to weather, insects and fungi may deteriorate quickly if not properly selected and protected.

4.0 TYPES OF TIMBER WALLS

Timber walls are classified according to their method of construction, arrangement of timber members and materials used to form the wall.

The three main types of timber walls are:

1. Timber-framed walls.
2. Panel timber walls.
3. Plank timber walls.

4.1 TIMBER-FRAMED WALLS

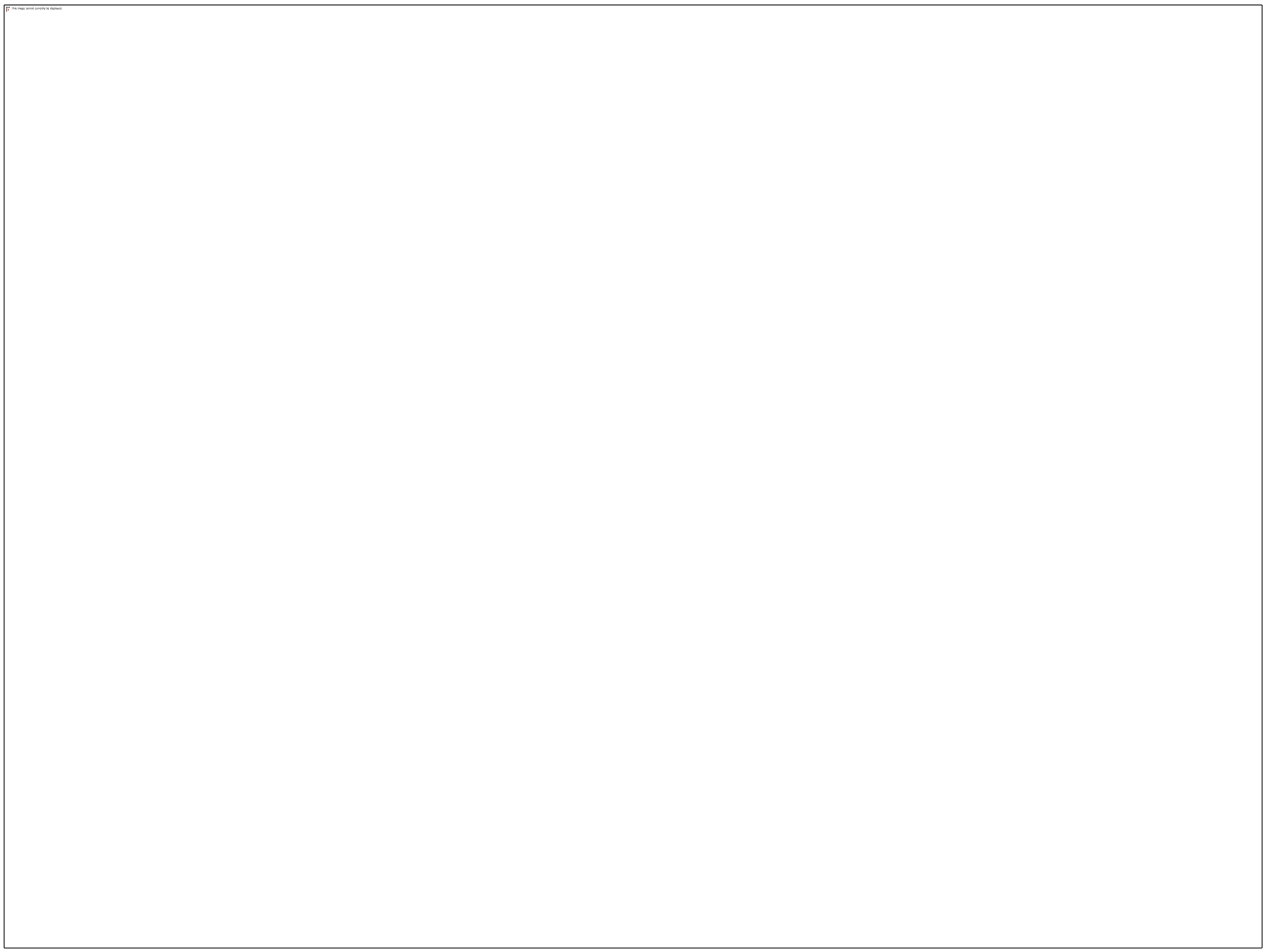
Definition

A timber-framed wall is a wall constructed using a framework of vertical and horizontal timber members, which is subsequently covered with suitable wall-cladding materials.

The timber framework provides structural support, while the cladding forms the internal and external wall surfaces.

Timber-framed walls are commonly used in residential buildings, cottages, site offices, timber houses and lightweight building structures.

Components of a timber-framed wall



1. Bottom plate (sole plate)

- It is a horizontal timber member fixed at the bottom of the wall frame.
- It provides a base for fixing the vertical studs.
- It distributes loads from the wall frame to the supporting floor or foundation.
- It is fixed to the floor using suitable anchors or bolts.
- It should be protected against moisture, especially where it is close to concrete.

2. Top plate

- It is a horizontal timber member fixed at the top of the wall frame.
- It connects the upper ends of the vertical studs.
- It provides support for roof structures, ceiling members or upper floor components, depending on the building design.
- It helps distribute loads along the wall.

3. Vertical studs

- These are vertical timber members fixed between the bottom and top plates.
- They form the main vertical framework of the wall.

- They support wall cladding materials.
- They transfer loads from the top plate to the bottom plate.
- They are normally spaced at regular centres according to the design and cladding requirements.

4. Noggings

- These are short horizontal timber members fixed between adjacent studs.
- They provide lateral stability to the wall.
- They help prevent studs from twisting.
- They provide additional fixing points for wall cladding.

5. Bracing

- Bracing consists of diagonal or sheet materials used to resist sideways movement of the wall.
- It prevents the wall from becoming distorted or leaning.
- It improves the stability of the timber frame.
- Examples include diagonal timber braces and structural plywood sheathing.

6. Wall cladding

- These are materials fixed onto the timber frame to form the wall surface.
- They provide enclosure and protect the internal parts of the wall.
- Examples include timber boards, plywood and suitable fibre-cement boards.

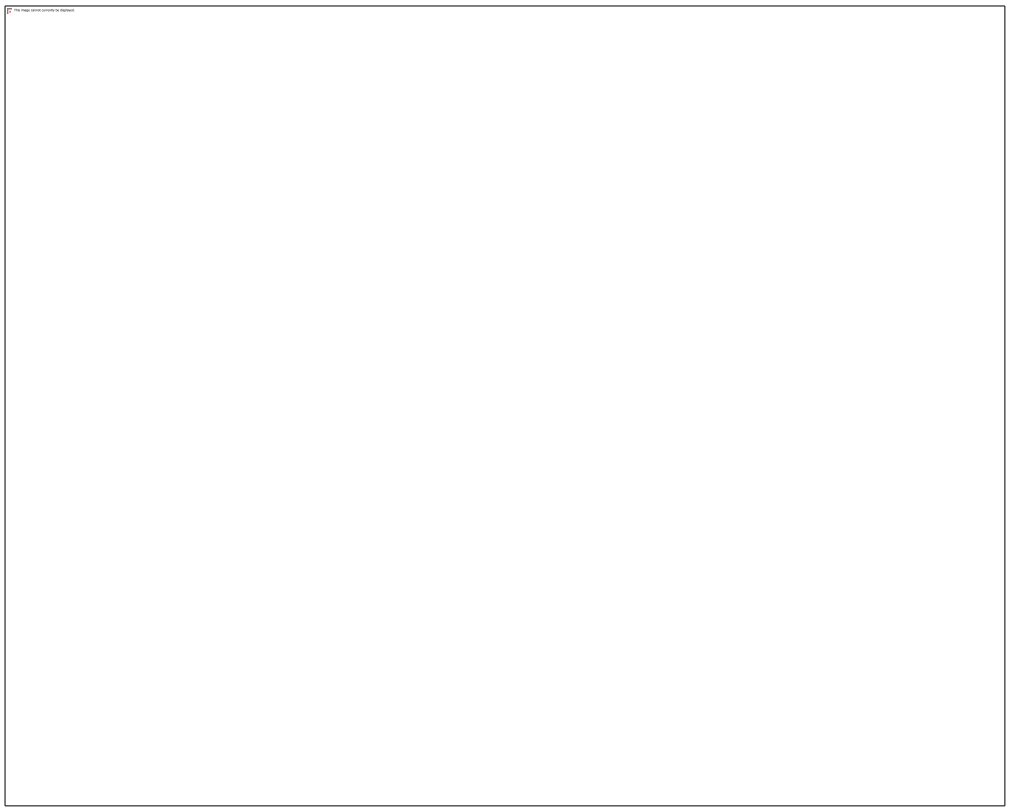
7. Lintels

- A lintel is a horizontal structural member placed above a door or window opening.
- It supports the loads above the opening and transfers them to the adjacent supporting members.
- It must be appropriately sized according to the structural design.

8. Trimmers and king studs

- Trimmer studs support the ends of lintels around openings.
- King studs are full-height studs positioned beside openings.
- They help transfer loads around doors and windows.

Simple sketch of a timber-framed wall



Advantages of timber-framed walls

1. They are relatively lightweight.
2. They are quick to construct.
3. They provide space for installing electrical cables and plumbing services.
4. Insulation materials can be installed between studs.
5. They are easy to modify where they are non-load-bearing.
6. They require relatively simple carpentry tools.
7. They can accommodate different wall finishes.
8. They can be prefabricated before transportation to the construction site.

Disadvantages of timber-framed walls

1. They require protection against termites.
2. They can be damaged by excessive moisture.
3. They require proper fire protection.
4. Poor workmanship may result in weak or unstable walls.
5. They require careful selection and seasoning of timber.
6. They may require regular maintenance.

Applications of timber-framed walls in Kenya

- Timber residential houses.
- Holiday cottages.
- Rural houses.

- Temporary site offices.
- Lightweight classrooms.
- Interior partition walls.
- Garden structures.

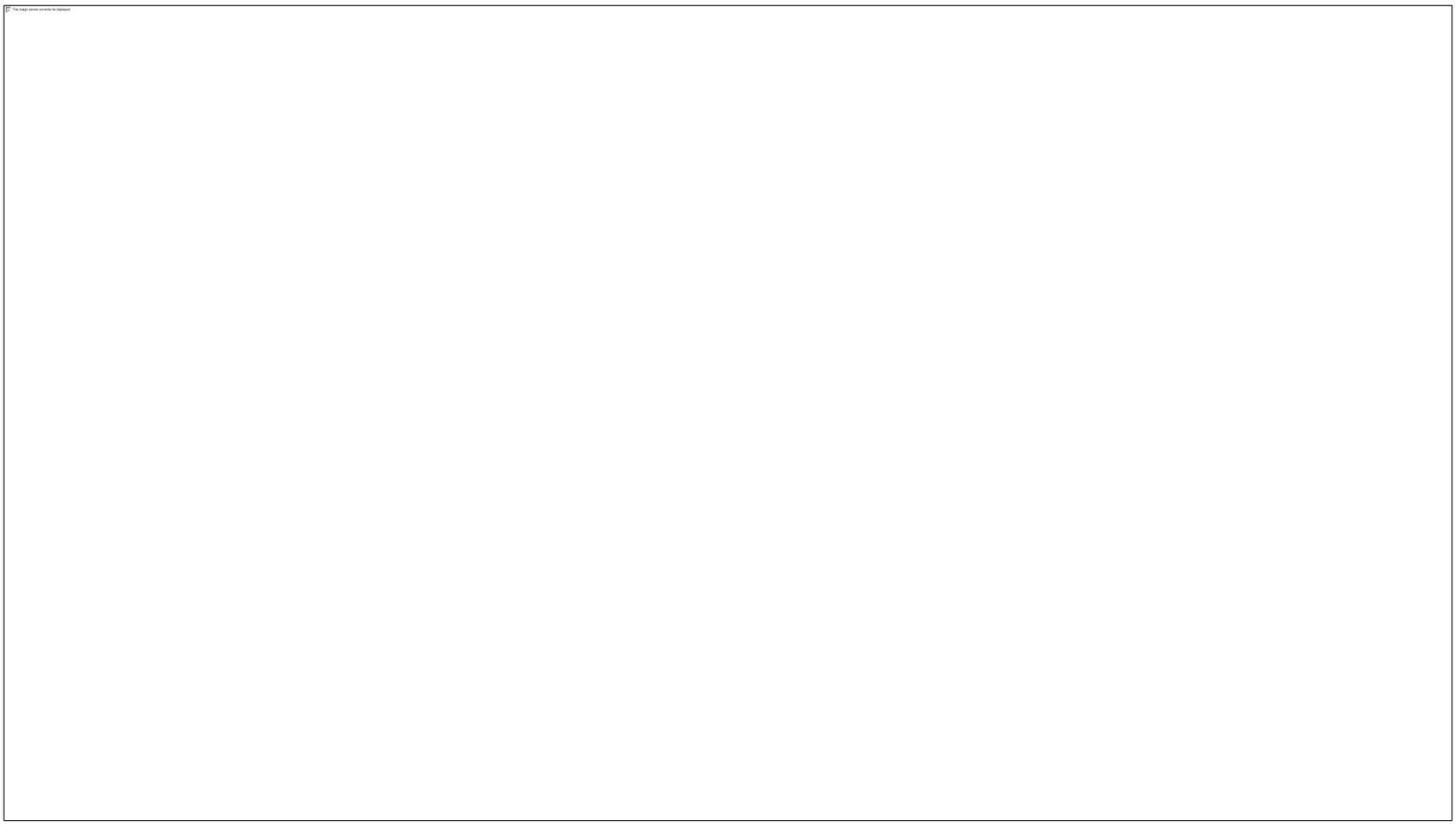
4.2 PANEL TIMBER WALLS

Definition

A panel timber wall is a wall constructed using prefabricated or assembled timber panels that are joined together to form a continuous wall.

A panel is a relatively large, flat section made from timber boards, plywood, engineered timber products or a combination of timber members and sheet materials.

Panel walls may be constructed in a workshop and transported to the construction site for installation.



Types of panel timber walls

1. Solid timber panel walls

- These are made from solid timber boards joined together.
- The boards may be arranged vertically or horizontally.
- The joints are designed to minimise gaps.
- They are suitable for lightweight buildings and partitions.

2. Framed timber panel walls

- These consist of a timber frame covered with sheet materials.
- The frame provides structural support.

- The covering may be plywood, oriented strand board (OSB) or other suitable board materials.
- They are relatively easy to manufacture and install.

3. Insulated timber panel walls

- These consist of timber panels containing insulation materials.
- Insulation is placed between or within the panel layers.
- They help reduce heat transfer and improve indoor comfort.
- They are useful in buildings requiring improved thermal performance.

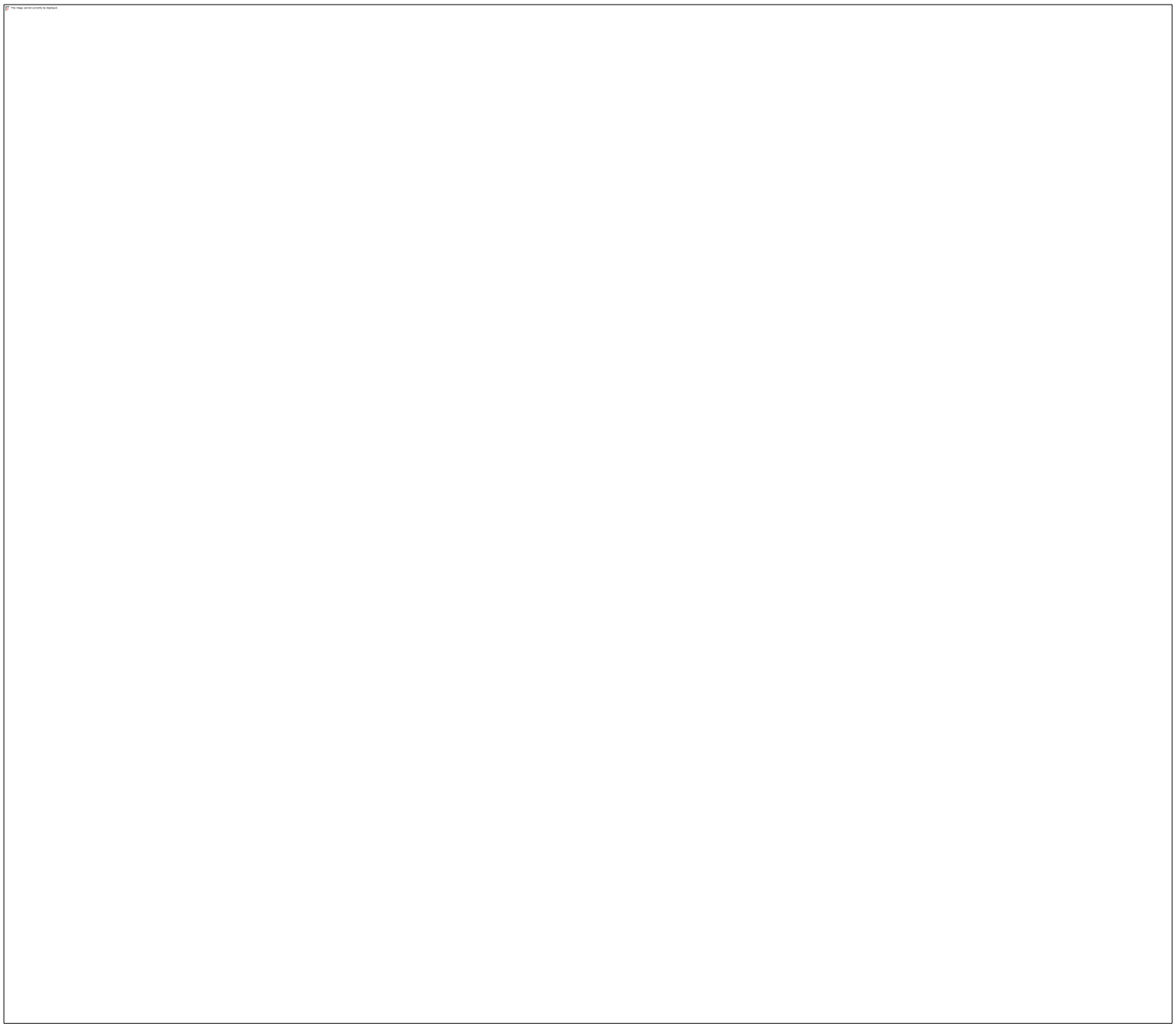
4. Structural insulated panels (SIPs)

- These are manufactured panels consisting of an insulating core sandwiched between structural facing boards.
- The core is commonly made from rigid insulation material.
- They provide structural and thermal performance when properly designed and installed.
- Their use requires appropriate engineering details and suitable connections.

Components of a framed timber panel

1. Timber perimeter frame.
2. Vertical supporting members.
3. Horizontal supporting members.
4. Internal bracing where required.
5. External sheathing.
6. Insulation materials where specified.
7. Internal lining.
8. Fixing materials such as screws and nails.

Construction of panel timber walls



The following procedure is commonly followed:

1. **Preparation of materials**
    - Select suitable, well-seasoned timber.
    - Obtain the required plywood, boards, insulation and fasteners.
    - Check that all materials meet the design requirements.
2. **Measuring and marking**
    - Study the wall drawings.
    - Establish the required panel dimensions.
    - Mark the cutting and assembly positions.
3. **Cutting timber members**
    - Cut the top and bottom members to the required lengths.

- Cut the vertical studs and intermediate supports.
- Ensure accurate measurements.

4. **Assembly of the frame**
   - Arrange the timber members on a level working surface.
   - Join the vertical members to the horizontal members.
   - Fix the joints using appropriate nails, screws or connectors.
5. **Checking the frame**
   - Measure the diagonals to confirm squareness.
   - Check the dimensions and alignment.
   - Correct any distortion before installing the covering.
6. **Fixing the sheathing**
   - Fix plywood, OSB or other specified sheet materials to the frame.
   - Use the correct fastener type and spacing.
   - Ensure that sheet edges are properly supported.
7. **Installing insulation**
   - Fit insulation between the framing members where required.
   - Avoid leaving unnecessary gaps.
   - Install suitable vapour and moisture-control layers according to the building design.
8. **Finishing**
   - Install the specified internal and external finishes.
   - Seal joints and openings appropriately.
   - Prepare the panel for transportation or installation.
9. **Erecting the panel**
   - Position the panel on the prepared base.
   - Align it correctly.
   - Secure it using suitable anchors and connections.

Advantages of panel timber walls

1. They reduce construction time.
2. They can be manufactured under controlled workshop conditions.
3. They provide accurate dimensions when properly manufactured.
4. They reduce material wastage.
5. They can accommodate thermal and acoustic insulation.
6. They are relatively easy to transport when designed in manageable sizes.
7. They provide a neat and uniform finish.

8. They allow standardisation of building components.

Disadvantages of panel timber walls

1. They require accurate measurements during fabrication.
2. Large panels may require lifting equipment.
3. Transportation can be difficult where access roads are poor.
4. They require suitable storage to prevent moisture damage.
5. Poorly connected panels may result in structural instability.
6. They may be expensive where specialised manufactured panels are used.

Applications

- Prefabricated residential houses.
- Timber classrooms.
- Office partitions.
- Holiday cottages.
- Temporary accommodation.
- Modular buildings.

4.3 PLANK TIMBER WALLS

Definition

A plank timber wall is a wall constructed by arranging long, relatively thick timber boards or planks horizontally or vertically and fixing them together to form a continuous wall surface.

Plank walls may be supported by timber posts, frames or other structural members.



Types of plank timber walls

1. Vertical plank walls

- Timber planks are fixed vertically from the lower supporting member towards the upper supporting member.
- They may be secured to horizontal rails or a supporting frame.
- The joints between the boards are designed to minimise water penetration.
- They are commonly used for lightweight structures and timber sheds.

2. Horizontal plank walls

- Timber planks are fixed horizontally.
- The planks may overlap or interlock.
- They are supported by vertical posts or framing members.
- They provide a traditional timber appearance.

3. Overlapping plank walls

- The edges of adjacent boards overlap.
- The overlap reduces direct entry of rainwater through the joints.
- The arrangement provides a protective external surface.
- It is useful in weather-exposed structures when properly detailed.

4. Tongue-and-groove plank walls

- One edge of the plank has a projecting tongue.
- The opposite edge has a matching groove.
- The tongue of one board fits into the groove of the next board.
- This produces a relatively tight and neat joint.

Methods of fixing plank walls

1. **Nailing**
   - Planks are fixed to supporting timber members using suitable nails.
   - Nails should be of appropriate length and corrosion resistance.
2. **Screwing**
   - Screws are used to secure planks to the supporting framework.
   - They provide firm connections and can be removed during repairs.
3. **Tongue-and-groove fixing**
   - Adjacent planks are fitted together through matching profiles.
   - The joint helps reduce gaps between boards.
4. **Lap fixing**
   - One board overlaps the edge of another.
   - It provides protection against direct rain penetration.
5. **Bolting**

- Bolts may be used where stronger connections are required.
- They are particularly useful for connecting substantial timber components.

Advantages of plank timber walls

1. They are relatively simple to construct.
2. They can be constructed using ordinary carpentry tools.
3. They provide a natural timber appearance.
4. They can be repaired by replacing damaged planks.
5. They are suitable for small buildings and temporary structures.
6. They may use locally available timber.
7. They can be constructed with relatively few specialised components.

Disadvantages of plank timber walls

1. Gaps may develop due to timber shrinkage.
2. They require protection against rain and moisture.
3. They may be attacked by termites.
4. They may have lower thermal and acoustic performance without additional insulation.
5. Poorly fixed planks may loosen over time.
6. Long planks may warp or twist if poorly seasoned.

Applications

- Timber cottages.
- Storage sheds.
- Animal shelters.
- Temporary site structures.
- Timber cabins.
- Boundary and garden structures.

5.0 COMPARISON OF THE THREE TYPES OF TIMBER WALLS

Feature	Timber-framed walls	Panel timber walls	Plank timber walls
Main construction	Timber framework	Prefabricated or assembled panels	Timber boards or planks
Main components	Studs, plates, noggings	Panels and connections	Planks and supports
Construction	Frame assembled and clad	Panels assembled and erected	Planks fixed together
Speed	Relatively fast	Very fast where prefabricated	Relatively fast
Flexibility	High	Depends on panel design	Moderate

Common use	Houses and partitions	Modular buildings	Sheds and cottages

6.0 TIMBER JOINTS USED IN TIMBER WALL CONSTRUCTION

6.1 Meaning of a timber joint

A timber joint is a connection formed by joining two or more pieces of timber together to create a strong and stable structure.

Timber joints are important in the construction of timber walls because they hold the various components together and help transfer forces between members.

The selection of a joint depends on:

- The type of timber members being connected.
- The direction of the applied forces.
- The strength required.
- The appearance of the finished work.
- The tools and skills available.
- The purpose of the structure.

6.2 IMPORTANCE OF TIMBER JOINTS

1. **Joining timber members**
   - Joints connect separate pieces of timber to form larger components.
2. **Increasing structural stability**
   - Properly constructed joints prevent unnecessary movement between members.
3. **Transferring loads**
   - Some joints help transfer forces from one timber member to another.
4. **Improving appearance**
   - Well-made joints provide neat and professional finishes.
5. **Reducing material wastage**
   - Proper jointing allows shorter timber pieces to be used effectively where appropriate.
6. **Allowing different arrangements**
   - Joints enable timber members to meet at different angles and positions.
7. **Facilitating repairs**
   - Certain mechanical joints can be dismantled and replaced during maintenance.

7.0 TYPES OF TIMBER JOINTS

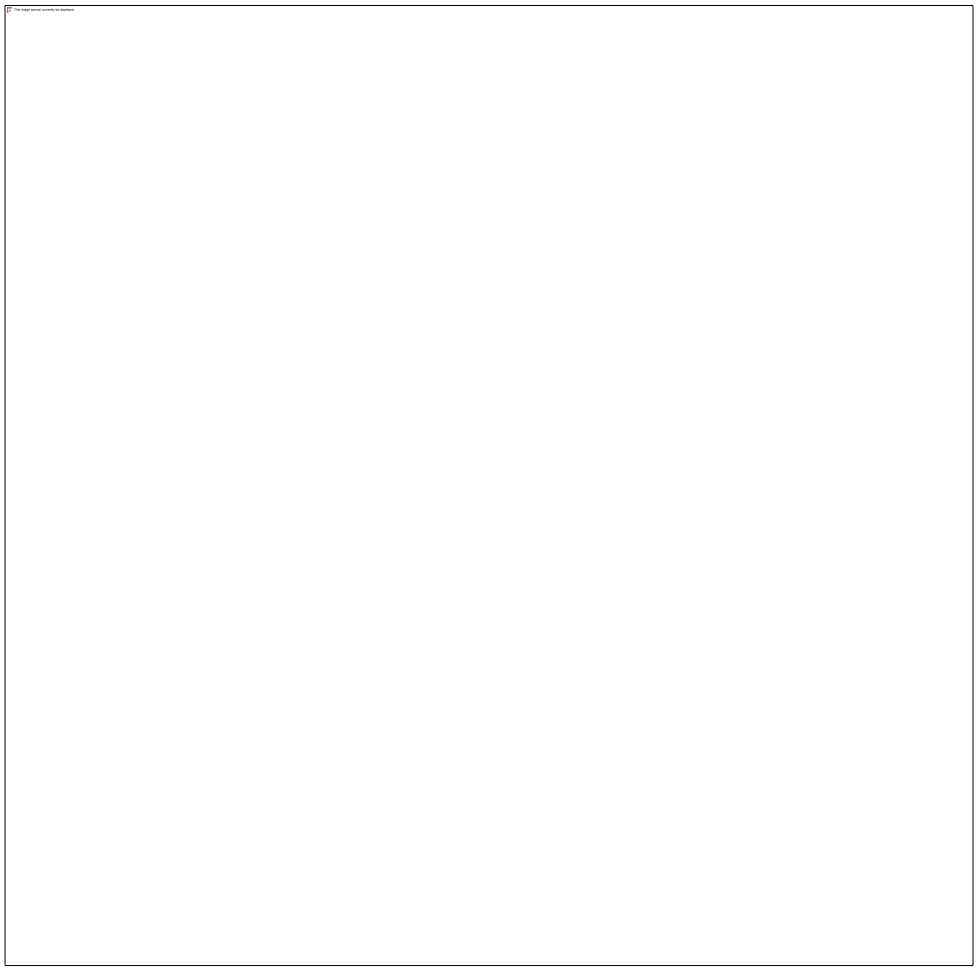
The following are important timber joints used in carpentry and timber wall construction.

7.1 BUTT JOINT

Definition

A butt joint is a simple timber joint formed by placing the end or edge of one timber member against the face or end of another timber member.

The two pieces are then secured using nails, screws, bolts, adhesive or suitable connectors.



Construction procedure

1. Measure the timber pieces to the required dimensions.
2. Cut the ends squarely using a suitable saw.
3. Position one timber member against the other.
4. Check that the members are correctly aligned.
5. Apply adhesive where specified.
6. Fix the members using nails or screws.
7. Check that the joint is firm and properly aligned.

Advantages

- Easy to construct.
- Requires simple tools.
- Saves time.
- Requires minimal timber cutting.
- Suitable for simple frame connections.

Disadvantages

- Relatively weak if used without reinforcement.
- Depends heavily on nails, screws or other fasteners.
- May separate under heavy loading if poorly constructed.

Applications

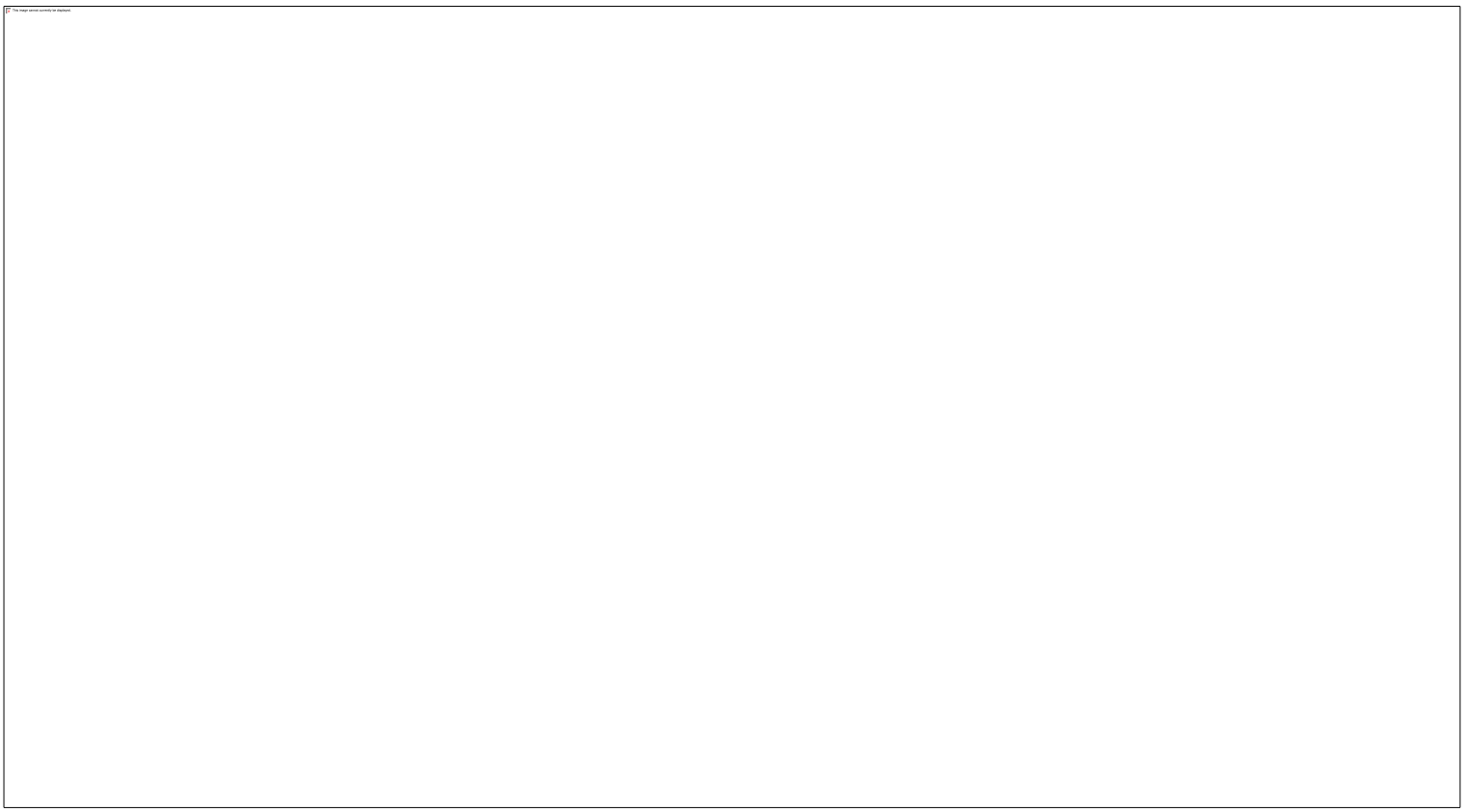
- Simple timber frames.
- Temporary structures.
- Light partition frames.
- Joining non-critical timber members.

7.2 LAP JOINT

Definition

A lap joint is a timber joint formed by allowing two timber members to overlap each other, either fully or partially.

In a half-lap joint, part of the thickness of each timber member is removed so that the two pieces fit together with their surfaces approximately flush.



Types of lap joints

1. Half-lap joint.
2. Cross-lap joint.
3. End-lap joint.
4. Corner-lap joint.

Construction procedure

1. Measure the timber members.
2. Mark the overlapping sections.
3. Mark the depth of the material to be removed.
4. Saw along the marked boundaries.
5. Remove the unwanted timber using a chisel.
6. Smooth the joint surfaces.
7. Fit the two pieces together.
8. Secure the joint using suitable adhesive or mechanical fasteners.

Advantages

- Provides a larger contact area than a simple butt joint.
- Relatively easy to construct.
- Can provide a neat finish.
- Useful for connecting intersecting timber members.

Disadvantages

- Reduces the cross-sectional area of the timber.
- Requires accurate cutting.
- May weaken the member if too much timber is removed.

Applications

- Timber wall frames.
- Cross-bracing arrangements.
- Timber framework intersections.
- Light structural assemblies.

7.3 MORTISE AND TENON JOINT

Definition

A mortise and tenon joint is a timber joint formed by cutting a rectangular or shaped projection (tenon) on one timber member and a matching recess (mortise) in another member.

The tenon is inserted into the mortise to form a firm connection.



Main parts

1. Mortise

- A rectangular or shaped hole cut into a timber member.
- It receives the tenon.

2. Tenon

- A projecting section formed at the end of another timber member.
- It fits into the mortise.

3. Shoulder

- The part of the tenon that meets the surface of the receiving member.
- It helps provide a neat fit and alignment.

Construction procedure

1. Select suitable timber pieces.
2. Measure and mark the mortise position.
3. Mark the size and depth of the mortise.
4. Cut the mortise using a chisel or suitable mortising machine.
5. Mark the tenon on the second timber member.
6. Saw the tenon to the required shape.
7. Trim the shoulders accurately.
8. Test the fit.

9. Apply suitable adhesive where specified.
10. Assemble the joint and clamp until secure.

Advantages

- Provides a strong connection when properly designed and made.
- Provides good alignment between members.
- Gives a neat appearance.
- Suitable for traditional timber framework construction.

Disadvantages

- Requires skilled workmanship.
- Takes more time to construct.
- Requires accurate measurements.
- May weaken the timber if the mortise is excessively large.

Applications

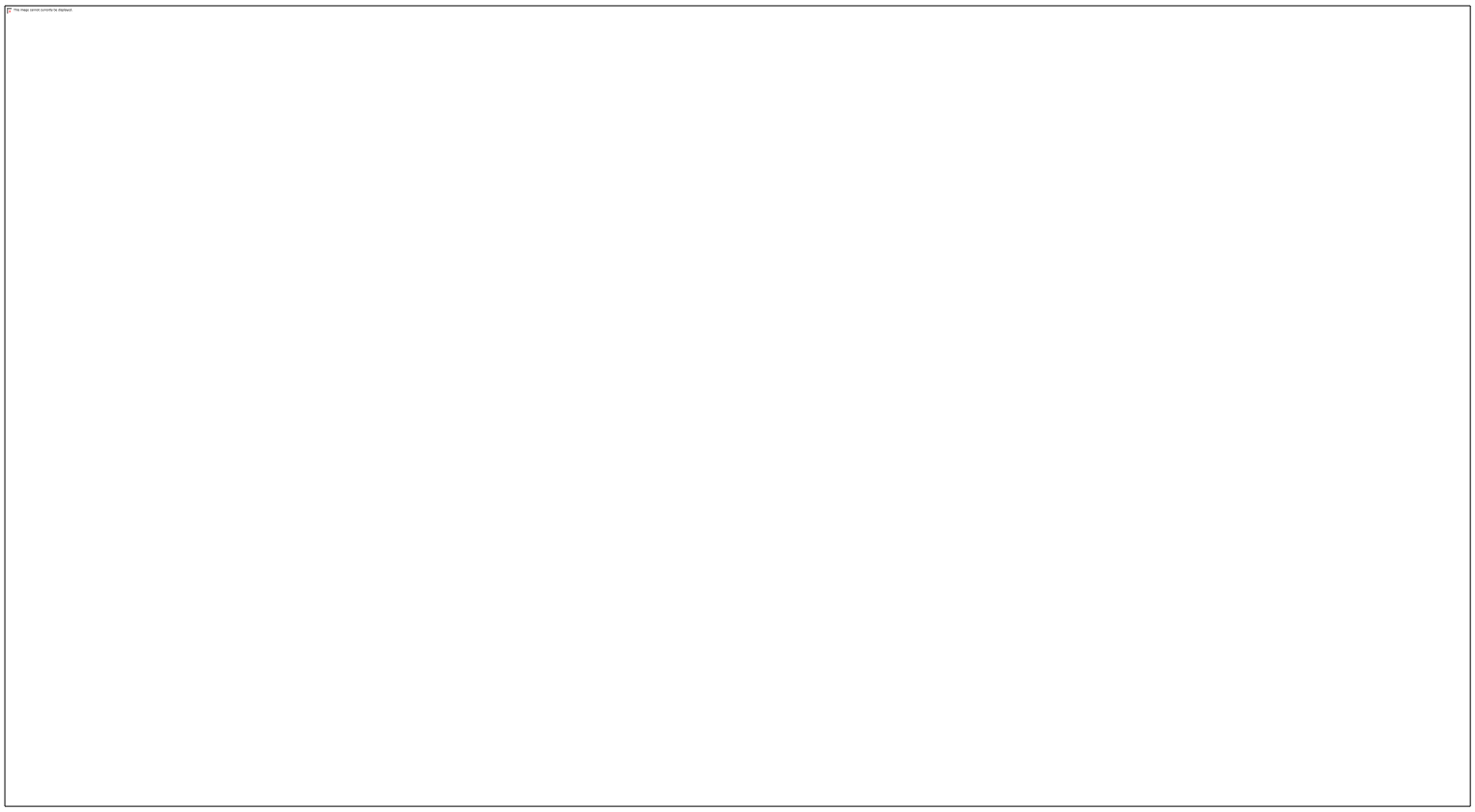
- Timber frames.
- Door frames.
- Window frames.
- Traditional carpentry.
- Timber structural assemblies.

7.4 TONGUE AND GROOVE JOINT

Definition

A tongue and groove joint is a timber joint in which one board has a projecting tongue along one edge while the adjacent board has a matching groove.

The tongue fits into the groove to connect the two boards.



Parts of the joint

1. Tongue – the projecting part of one board.
2. Groove – the channel cut into the adjacent board.
3. Face – the visible surface of the board.
4. Edge – the side along which the joint is formed.

Construction procedure

1. Select timber boards of uniform thickness.
2. Prepare the edges using a suitable plane or machine.
3. Cut a tongue along one edge.
4. Cut a matching groove along the opposite edge of the adjacent board.
5. Check that the tongue fits properly into the groove.
6. Align the boards.
7. Join them together.
8. Fix them to the supporting frame where required.

Advantages

- Produces a neat finish.
- Reduces visible gaps between boards.
- Helps maintain alignment.
- Provides a relatively continuous wall surface.
- Can improve resistance to direct air movement through joints.

Disadvantages

- Requires specialised cutting tools or machines.
- Poorly made joints may not fit properly.
- Timber movement may cause gaps or distortion.
- It does not automatically make a wall waterproof.

Applications

- Timber plank walls.
- Timber ceilings.
- Wooden flooring.
- Wall panelling.
- Interior decorative finishes.

7.5 HOUSING JOINT

Definition

A housing joint is a timber joint formed by cutting a groove or recess across the grain of one timber member to receive another timber member.

The inserted member fits into the housing, which helps position and support it.



Types of housing joints

1. **Through housing joint**

- The groove passes completely across the width of the receiving timber member.
- The inserted member rests inside the groove.

2. **Stopped housing joint**

- The groove stops before reaching the edge of the receiving timber member.
- It provides a neater appearance because the groove is not visible at the end.

3. **Dovetail housing joint**

- The housing has sloping sides.
- The inserted member is shaped to fit the sloping recess.
- It provides resistance to withdrawal.

Construction procedure

1. Measure the position of the joint.
2. Mark the width and depth of the housing.
3. Cut along the marked lines using a suitable saw.
4. Remove the unwanted timber using a chisel.
5. Clean and smooth the recess.
6. Prepare the inserted member.
7. Fit the member into the housing.
8. Secure it using suitable adhesive or fasteners where required.

Advantages

- Provides good support to the inserted timber member.
- Helps maintain accurate positioning.
- Can produce neat connections.
- Useful for supporting horizontal members.

Disadvantages

- Requires accurate marking and cutting.
- Removes some material from the receiving member.
- Poorly made housings may weaken the connection.

Applications

- Timber framing.
- Shelving.
- Supporting horizontal timber members.
- Timber partitions.
- Joinery work.

8.0 SUMMARY OF TIMBER JOINTS

Joint	Main feature	Common application
Butt joint	Two members meet directly	Simple frames
Lap joint	Members overlap	Wall frames
Mortise and tenon	Projection fits into recess	Timber frames
Tongue and groove	Tongue fits into groove	Plank walling

Housing joint	Member fits into a recess	Supporting horizontal members

9.0 METHODS OF CONSTRUCTING TIMBER WALLS

Timber walls can be constructed using different methods depending on the building design, available materials, intended use and required structural performance.

The major methods include:

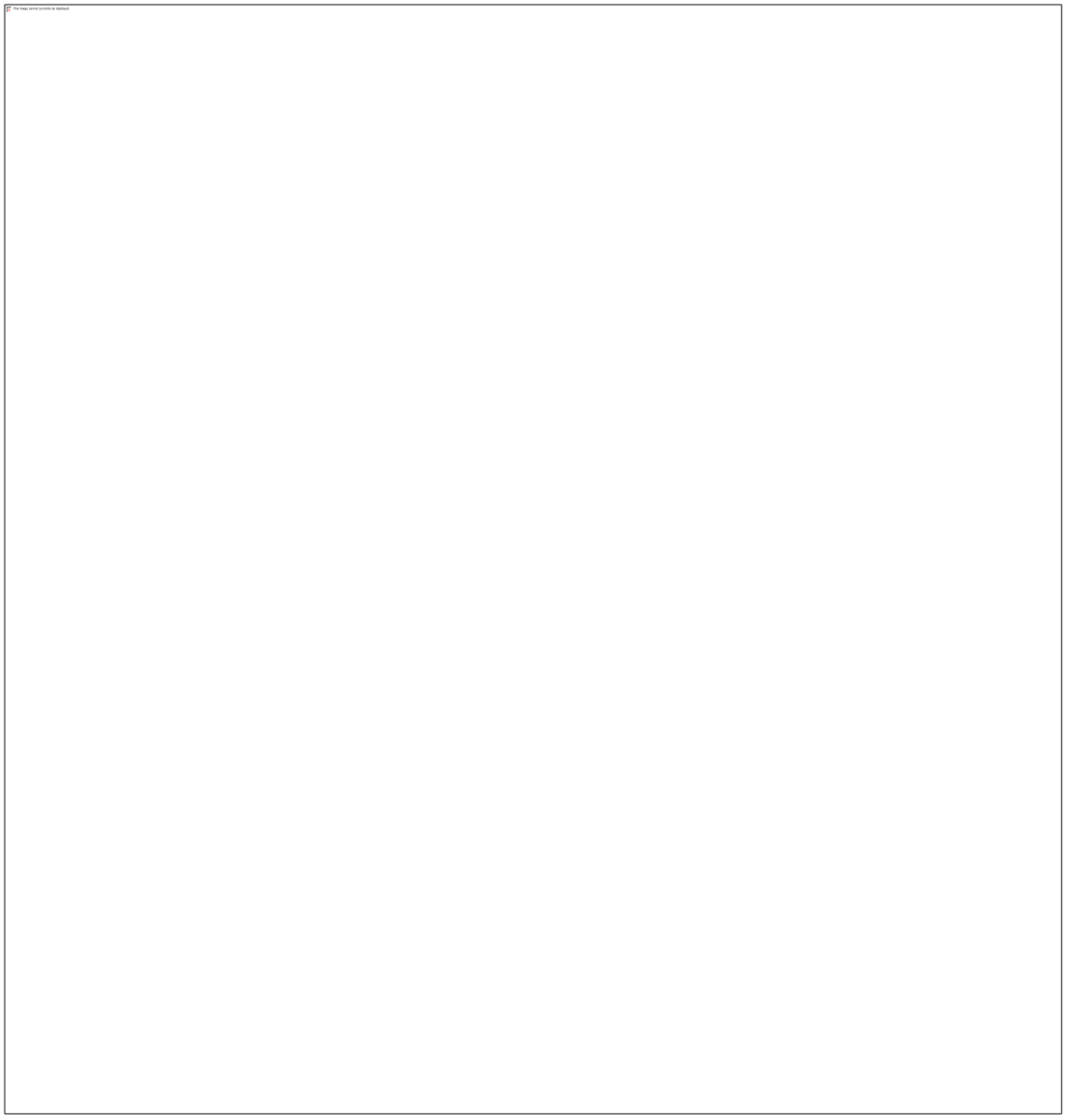
1. Stud construction.
2. Panel construction.
3. Plank construction.
4. Prefabricated timber wall construction.

9.1 STUD CONSTRUCTION METHOD

Definition

Stud construction is a method of constructing timber walls using vertical timber members called studs, which are connected by horizontal plates and strengthened with noggings and bracing.

The framework is covered with suitable wall-cladding materials to form a complete wall.



Main components used in stud construction

- Bottom plate.
- Top plate.
- Vertical studs.
- Noggings.
- Diagonal bracing or structural sheathing.
- Lintels.
- Trimmer studs.
- King studs.
- Wall cladding.
- Fixing materials.

Procedure for stud construction

Step 1: Preparation of the site

- Clear the working area.
- Remove unwanted materials and obstructions.
- Check that the supporting floor or foundation is ready.
- Confirm the required wall dimensions using the building drawings.

Step 2: Selection of timber

- Select straight, properly seasoned timber.
- Check for cracks, excessive knots, decay and insect damage.
- Ensure that the timber sizes comply with the construction drawings.
- Apply appropriate preservative treatment where required.

Step 3: Measuring and cutting

- Measure the required lengths of the top and bottom plates.
- Mark the positions of the vertical studs.
- Cut the timber members accurately.
- Prepare members for door and window openings.

Step 4: Positioning the bottom plate

- Place the bottom plate along the marked wall position.
- Check its alignment.
- Secure it to the supporting floor using appropriate anchors.

Step 5: Fixing the vertical studs

- Position the studs at the specified centres.
- Fix them to the bottom plate.

- Ensure that the studs are vertical.
- Check the spacing before final fixing.

Step 6: Fixing the top plate

- Position the top plate across the upper ends of the studs.
- Fix it securely.
- Check that the wall frame is straight and level.

Step 7: Installing noggings

- Measure the spaces between the studs.
- Cut noggings to the required lengths.
- Fix them horizontally between the studs.
- Stagger the joints where appropriate to facilitate fixing.

Step 8: Installing bracing

- Fix diagonal braces or structural sheathing as specified.
- Ensure that the frame can resist sideways movement.
- Check the alignment of the wall.

Step 9: Providing openings

- Form openings for doors and windows.
- Install lintels and supporting studs according to the design.
- Check the dimensions of the openings.

Step 10: Fixing wall cladding

- Fix the selected wall-covering material.
- Use appropriate screws, nails or other fasteners.
- Ensure that the cladding is properly aligned.

Step 11: Finishing

- Apply the required internal and external finishes.
- Seal joints and openings.
- Apply suitable protective coatings.
- Inspect the completed wall for defects.

9.2 PANEL CONSTRUCTION METHOD

This method involves preparing timber wall panels separately and assembling them on site.

Procedure

1. Study the wall drawings.
2. Measure the required panel dimensions.
3. Prepare the timber frame.

4. Cut and assemble the vertical and horizontal members.
5. Fix the required sheathing.
6. Check the panel for squareness.
7. Install insulation where specified.
8. Prepare the supporting floor or foundation.
9. Lift and position the panel.
10. Align and secure the panel.
11. Connect adjacent panels.
12. Complete the wall finishes.

9.3 PLANK CONSTRUCTION METHOD

This method involves joining timber planks together to form a continuous wall.

Procedure

1. Select suitable timber planks.
2. Check that the planks are straight and properly seasoned.
3. Measure the required wall dimensions.
4. Cut the planks to the required lengths.
5. Install the supporting posts or frame.
6. Position the first plank accurately.
7. Fix subsequent planks horizontally or vertically.
8. Form suitable joints between adjacent planks.
9. Check alignment and level.
10. Apply protective finishes.

9.4 PREFABRICATED TIMBER WALL CONSTRUCTION

Definition

Prefabricated timber wall construction involves manufacturing wall components or complete wall panels away from their final installation position, usually in a workshop or factory, and transporting them to the construction site for assembly.

Procedure

1. Prepare construction drawings.
2. Calculate the dimensions of each wall panel.
3. Select appropriate timber and board materials.
4. Cut and assemble the wall components.
5. Install openings and supporting members.
6. Fix the specified wall coverings.

7. Inspect the completed panels.
8. Transport the panels safely.
9. Position the panels at the construction site.
10. Connect and secure the panels.
11. Complete the joints and finishes.

Advantages of prefabrication

- Saves construction time.
- Improves quality control.
- Reduces on-site cutting.
- Minimises material wastage.
- Allows repeated production of standard panels.
- Reduces disruption at the construction site.

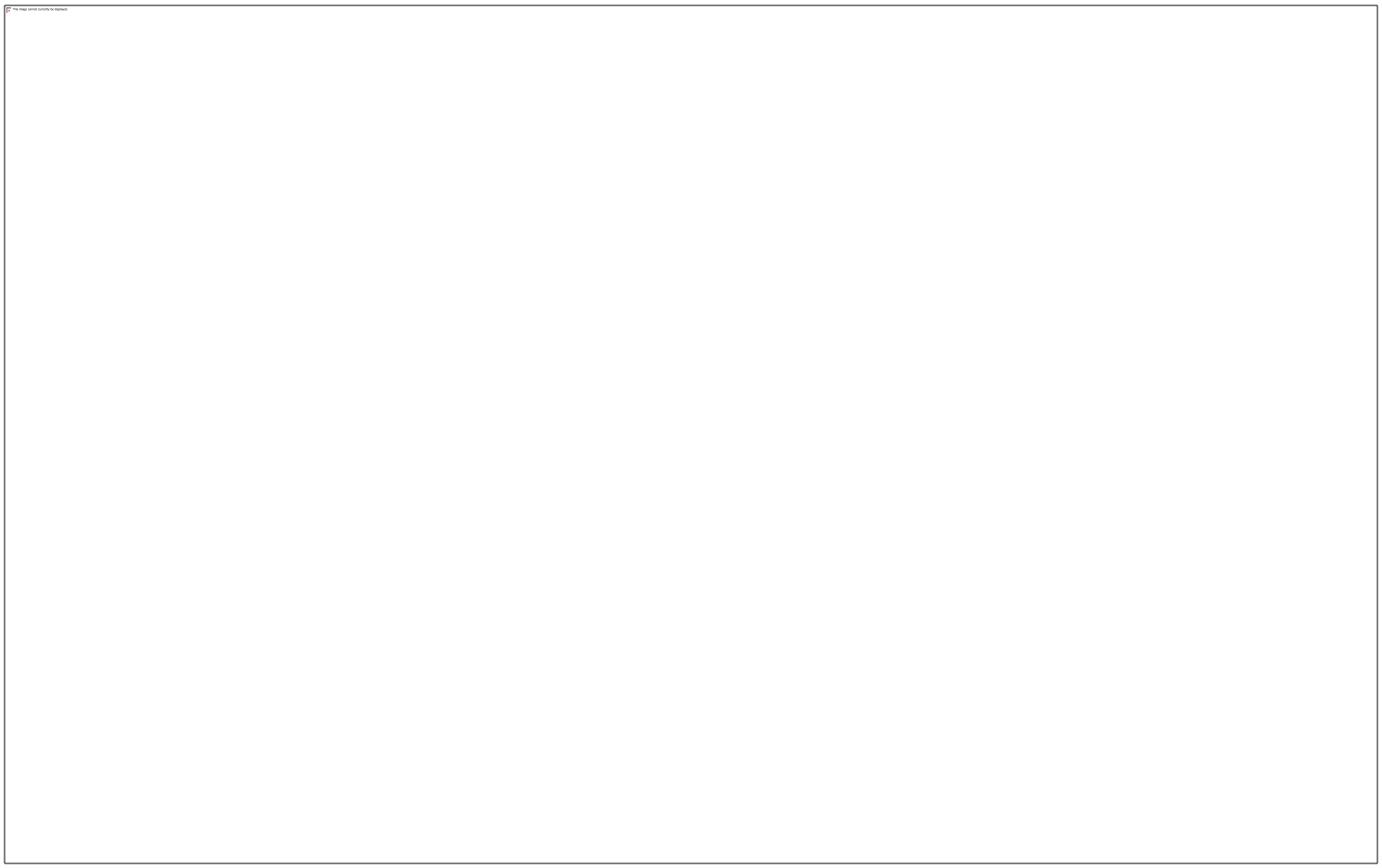
10.0 PROFILE BOARDS IN BUILDING CONSTRUCTION

10.1 Meaning of profile boards

Profile boards are temporary horizontal boards fixed to upright pegs or stakes around a building site to establish and preserve the positions, lines and levels of building components during setting out.

They are commonly used to maintain accurate building dimensions and wall positions before and during construction.

Profile boards are particularly useful when establishing the positions of timber superstructure walls in relation to the foundation and floor layout.



10.2 Components of profile boards

1. Profile boards

- These are horizontal timber boards fixed to upright stakes.
- They provide surfaces for marking building lines.
- They support nails used to hold string lines.

2. Profile pegs or stakes

- These are vertical timber pieces driven into the ground.
- They support the horizontal profile boards.
- They should be firm and stable.

3. Nails

- Nails are driven into the profile boards at accurately marked positions.
- They provide fixing points for string lines.

4. String lines

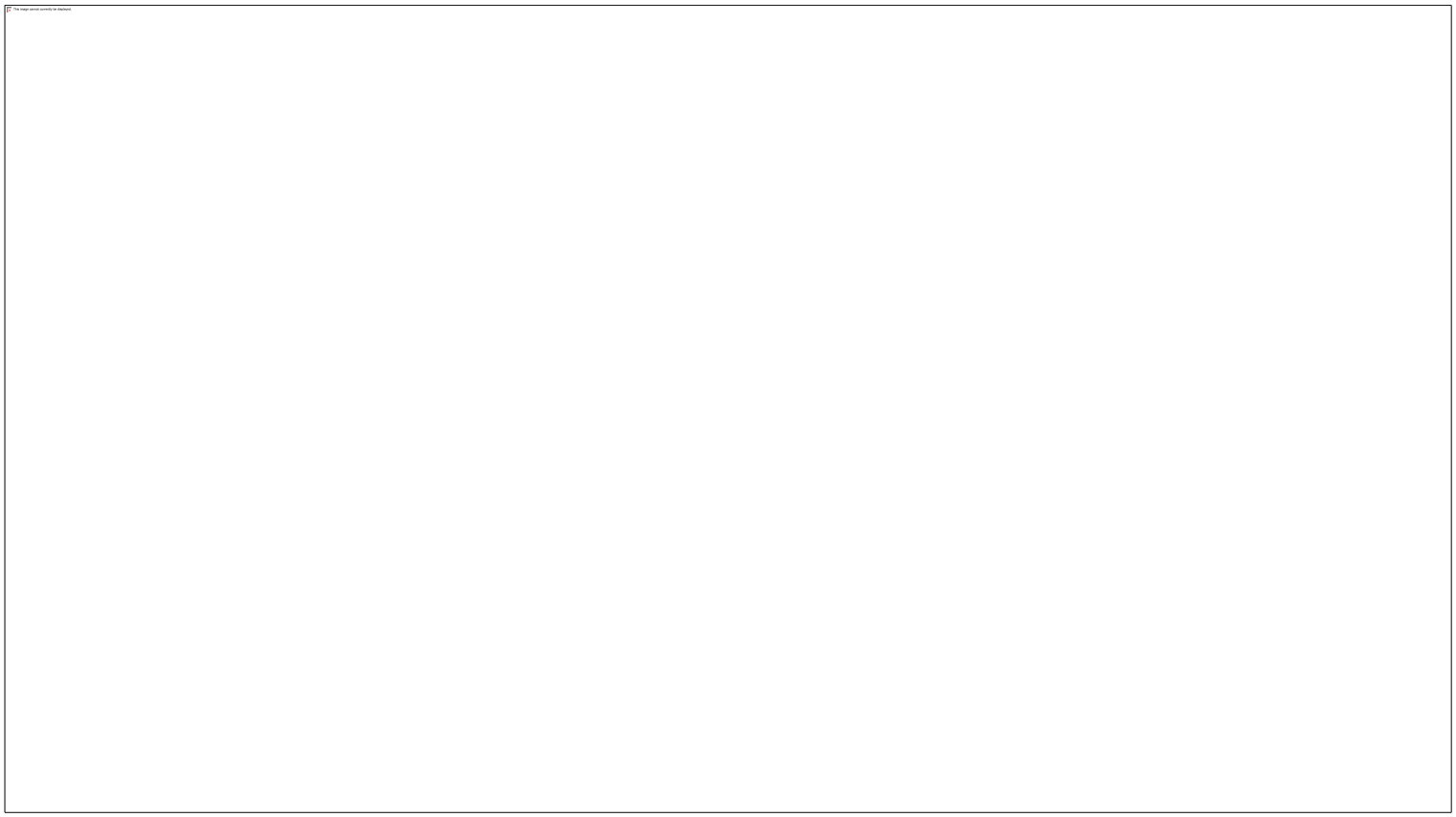
- These are strong cords stretched between nails on opposite profile boards.
- They represent the building lines, wall positions or foundation lines.
- They help transfer dimensions and alignment to the ground.

5. Braces

- These are supporting timber members used to strengthen the profile boards.

- They prevent movement during setting out.

10.3 Sketch of profile boards



The string lines are stretched between marked points on the profile boards to establish the required building lines.

10.4 Types of profile boards

1. Corner profile boards

- These are installed at or near the corners of the building layout.
- They help establish the positions of external wall lines.
- They are useful when checking the squareness of the building.

2. Intermediate profile boards

- These are installed between the corner profiles.
- They help maintain long building lines.
- They are useful where a wall is relatively long.

3. Batter boards

- These are horizontal boards supported by stakes.
- They are commonly used in setting out foundations.
- They hold string lines that define the positions of excavations and building lines.

10.5 Importance of profile boards

1. **Establishing building dimensions**

- They help transfer dimensions from the building drawings to the site.

2. **Maintaining alignment**
    - They help keep wall lines straight and correctly positioned.
3. **Checking squareness**
    - They assist in establishing right angles at building corners.
4. **Preserving setting-out marks**
    - The profile boards remain in position even when excavation or other site activities disturb ground markings.
5. **Establishing wall positions**
    - They indicate where the external and internal walls should be constructed.
6. **Reducing construction errors**
    - Accurate profile boards reduce mistakes associated with incorrect measurements.
7. **Maintaining levels**
    - They can be used as reference points when establishing specified levels.
8. **Supporting string lines**
    - They provide secure points for stretching setting-out strings.
9. **Improving construction efficiency**
    - They make it easier to transfer dimensions and re-establish building lines.

10.6 Procedure for setting up profile boards

1. Study the building drawings.
2. Clear the site of obstructions.
3. Identify the building corners.
4. Establish the main building lines.
5. Measure and mark the required positions.
6. Drive the profile pegs firmly into the ground.
7. Fix horizontal profile boards onto the pegs.
8. Check that the boards are stable.
9. Establish the required levels.
10. Drive nails into the profile boards at the marked positions.
11. Stretch string lines between corresponding nails.
12. Check dimensions, alignment and squareness.
13. Make corrections where necessary.
14. Preserve the profile boards until they are no longer required.

11.0 PROCEDURE FOR SETTING OUT TIMBER SUPERSTRUCTURE WALLS

11.1 Meaning of setting out

Setting out is the process of transferring the dimensions and positions of building components from construction drawings onto the actual building site or supporting floor.

In timber superstructure walling, setting out involves establishing the correct positions of the timber walls before installing the bottom plates and erecting the wall frames.

Accurate setting out ensures that the walls are correctly positioned, aligned, square and dimensionally accurate.

11.2 Importance of setting out timber walls

1. Ensures that walls are constructed in the correct positions.
2. Prevents dimensional errors.
3. Ensures that corners are square.
4. Provides correct positions for door and window openings.
5. Prevents unnecessary material wastage.
6. Ensures proper alignment with the foundation.
7. Facilitates accurate installation of the roof structure.
8. Improves the appearance and stability of the building.
9. Reduces the cost of correcting construction mistakes.

11.3 Steps involved in setting out timber superstructure walls

STEP 1: STUDY THE BUILDING DRAWINGS

- Obtain the approved building drawings.
- Identify the positions of all external and internal walls.
- Identify the wall thicknesses and lengths.
- Identify door and window openings.
- Check the dimensions of the building.
- Identify the required floor levels and reference points.

STEP 2: PREPARE THE WORKING AREA

- Clear the floor or supporting surface.
- Remove dust, loose materials and obstructions.
- Check that the foundation or floor is complete and suitable.
- Ensure that the surface is sufficiently level.
- Confirm that the damp-proofing arrangement is provided where required.

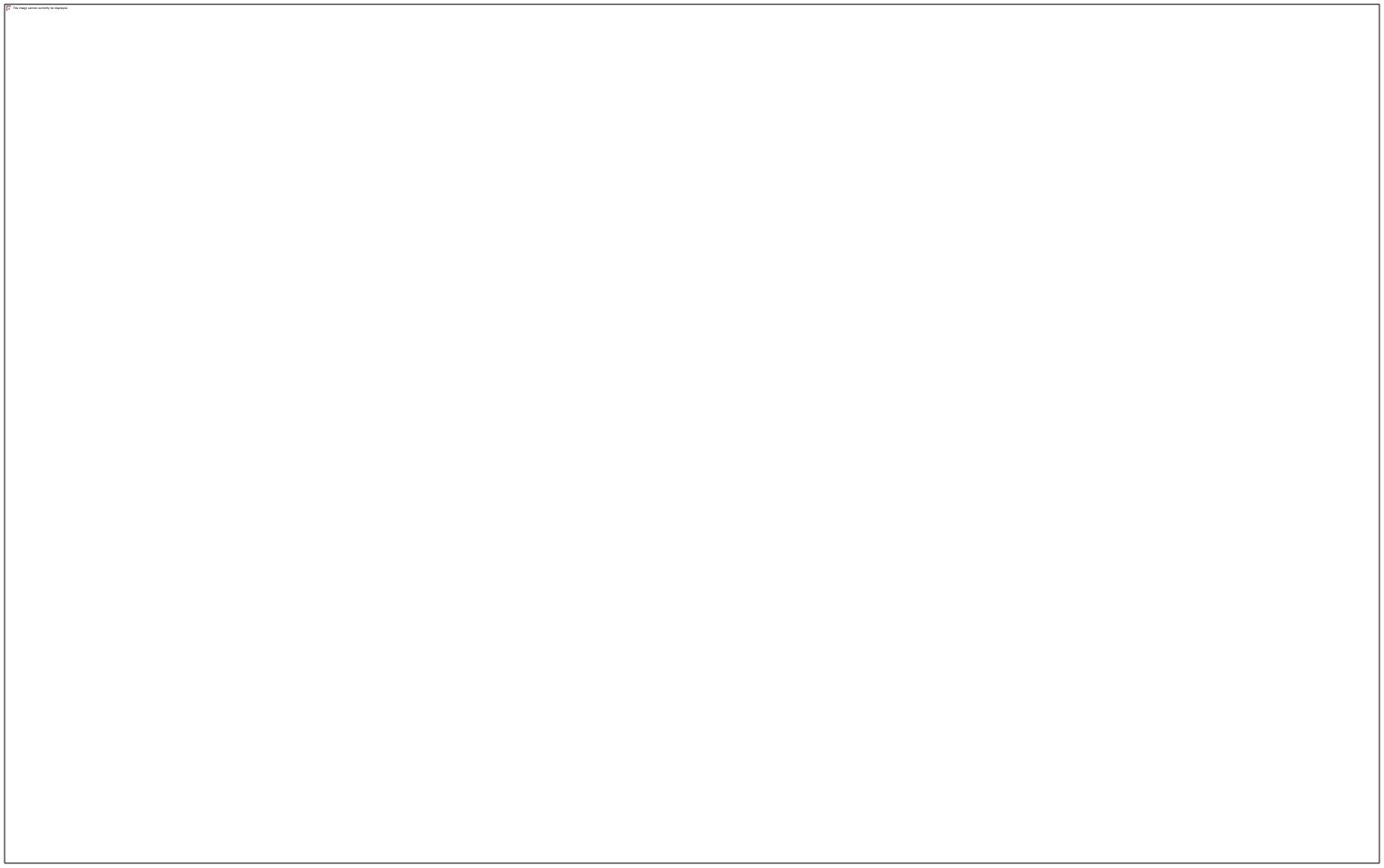
STEP 3: MEASURE AND MARK WALL POSITIONS

This involves transferring the wall dimensions from the drawings onto the floor or supporting surface.

Procedure

1. Identify the starting reference point.

2. Use a tape measure to establish the first wall position.
3. Measure the length of the wall.
4. Mark the wall position using a chalk line or pencil.
5. Mark the positions of internal partitions.
6. Mark the locations of doors and windows.
7. Measure the wall thickness.
8. Mark both edges of the wall plate where necessary.
9. Check all dimensions against the building drawings.



Important points to observe

- Use accurate measurements.
- Always work from a fixed reference point.
- Avoid measuring from several different starting points unnecessarily.
- Clearly mark wall positions.
- Confirm that internal and external wall positions correspond with the floor plan.

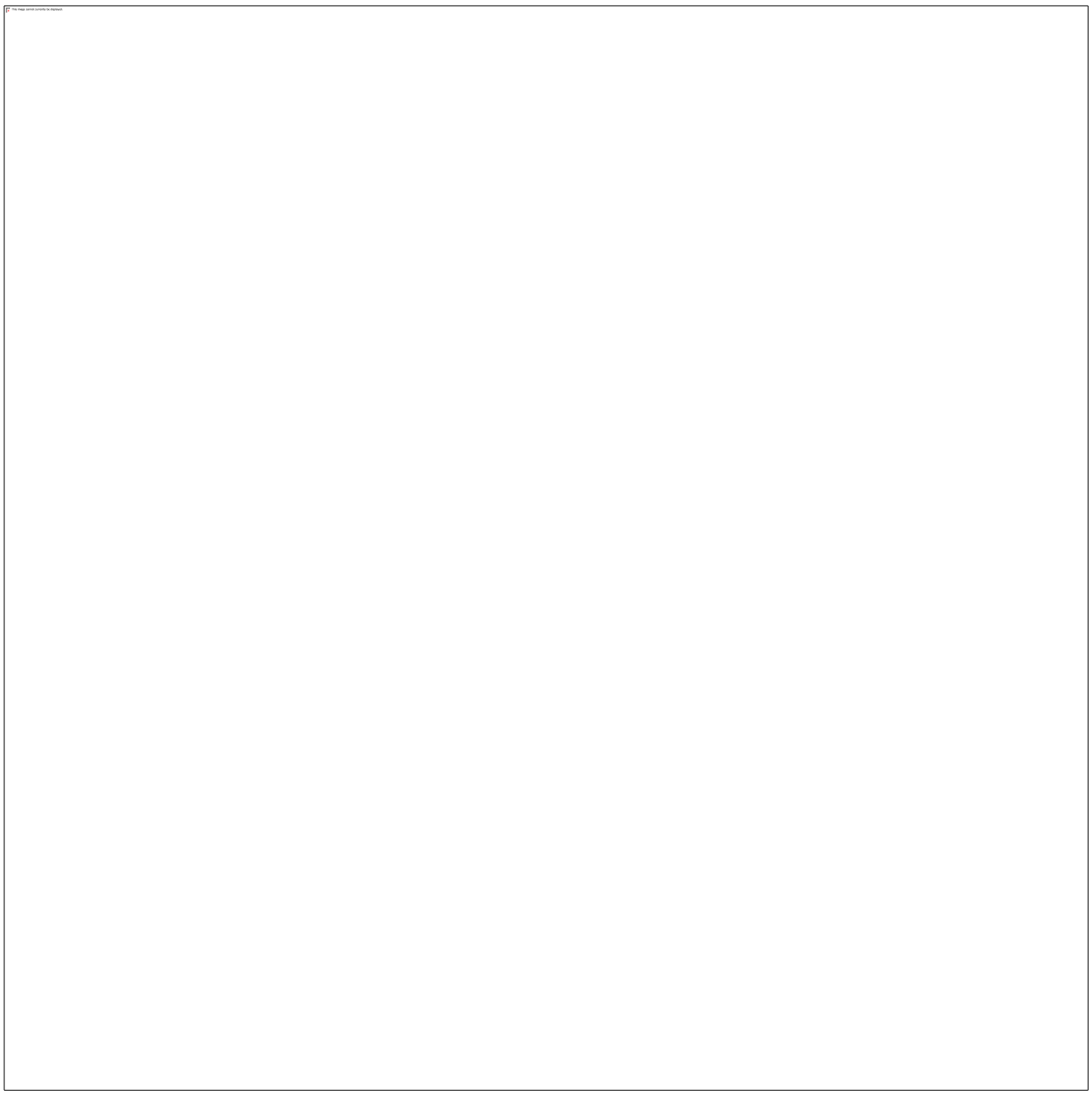
STEP 4: LOCATE THE BOTTOM PLATE POSITION

The bottom plate is the horizontal timber member that forms the base of the wall frame.

Procedure

1. Select the correct bottom plate timber.

2. Check that the timber is straight and properly seasoned.
3. Measure the required length.
4. Cut the bottom plate to the required size.
5. Position it along the marked wall line.
6. Check that it is correctly aligned.
7. Mark the positions of the vertical studs.
8. Mark the locations of door openings and other interruptions.
9. Check that the bottom plate is properly supported.
10. Secure it to the supporting floor or foundation using suitable anchors.



Important considerations

- Timber in contact with concrete should have appropriate moisture protection.
- Use suitable treated timber where required.

- Ensure that the bottom plate is straight.
- Use appropriate fixing materials.
- Do not fix the bottom plate before confirming the setting-out measurements.

STEP 5: CHECK THE SQUARENESS OF CORNERS

Squareness refers to the condition in which two adjoining walls meet at a right angle of 90 degrees.

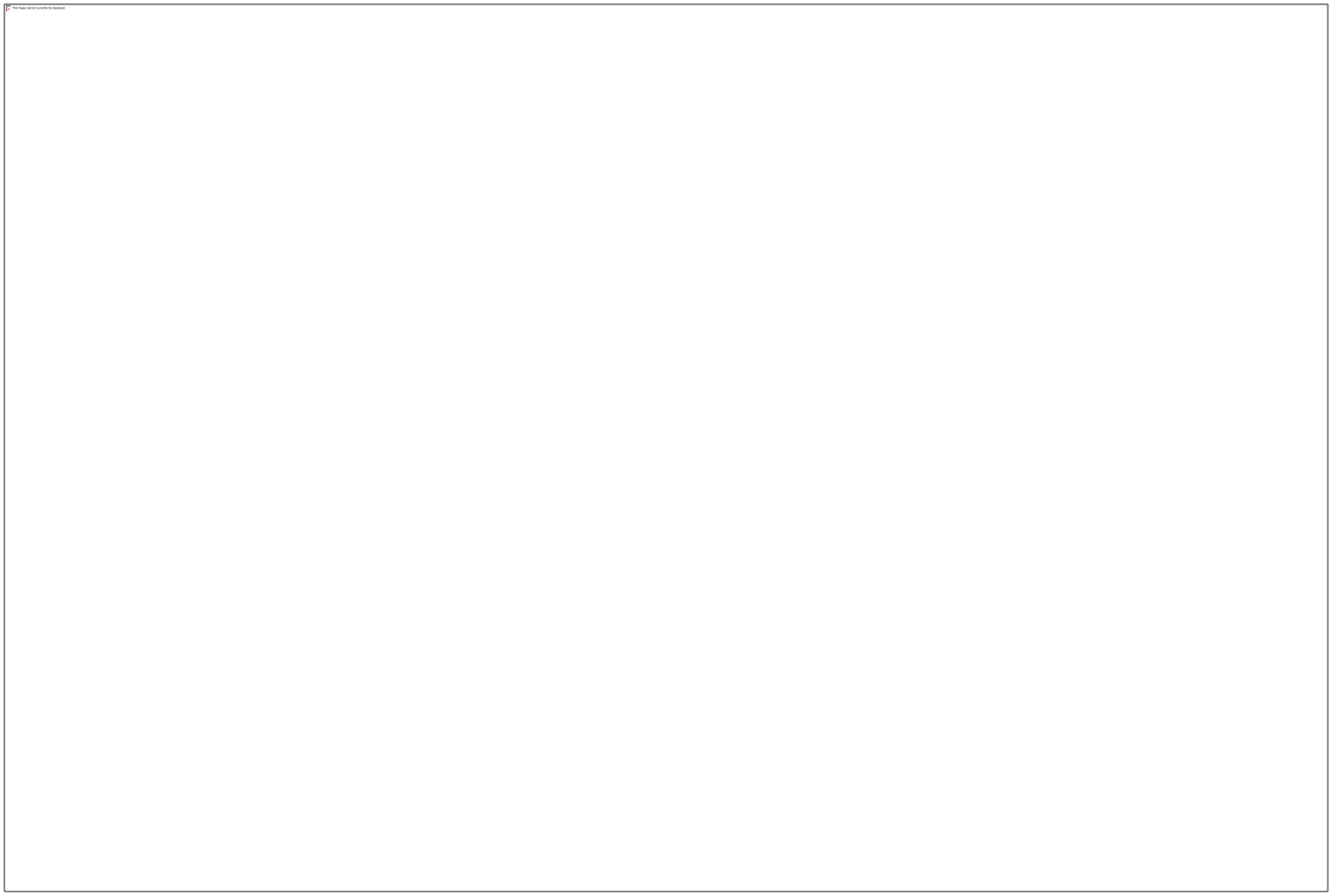
Correct squareness is important because it ensures that the building has accurate corners and properly aligned walls.

Methods of checking squareness

A. The 3-4-5 method

This is a setting-out method based on the Pythagorean relationship.

A triangle with sides measuring 3 units, 4 units and 5 units forms a right angle between the shorter sides.



Procedure

1. Identify the corner where the right angle is required.
2. Measure 3 metres along one wall line.
3. Measure 4 metres along the adjoining wall line.
4. Measure the diagonal distance between the two marked points.

5. The diagonal should measure 5 metres.
6. Adjust the wall line until the required measurements are achieved.
7. Recheck the dimensions before fixing the frame permanently.

Other multiples can be used, such as:

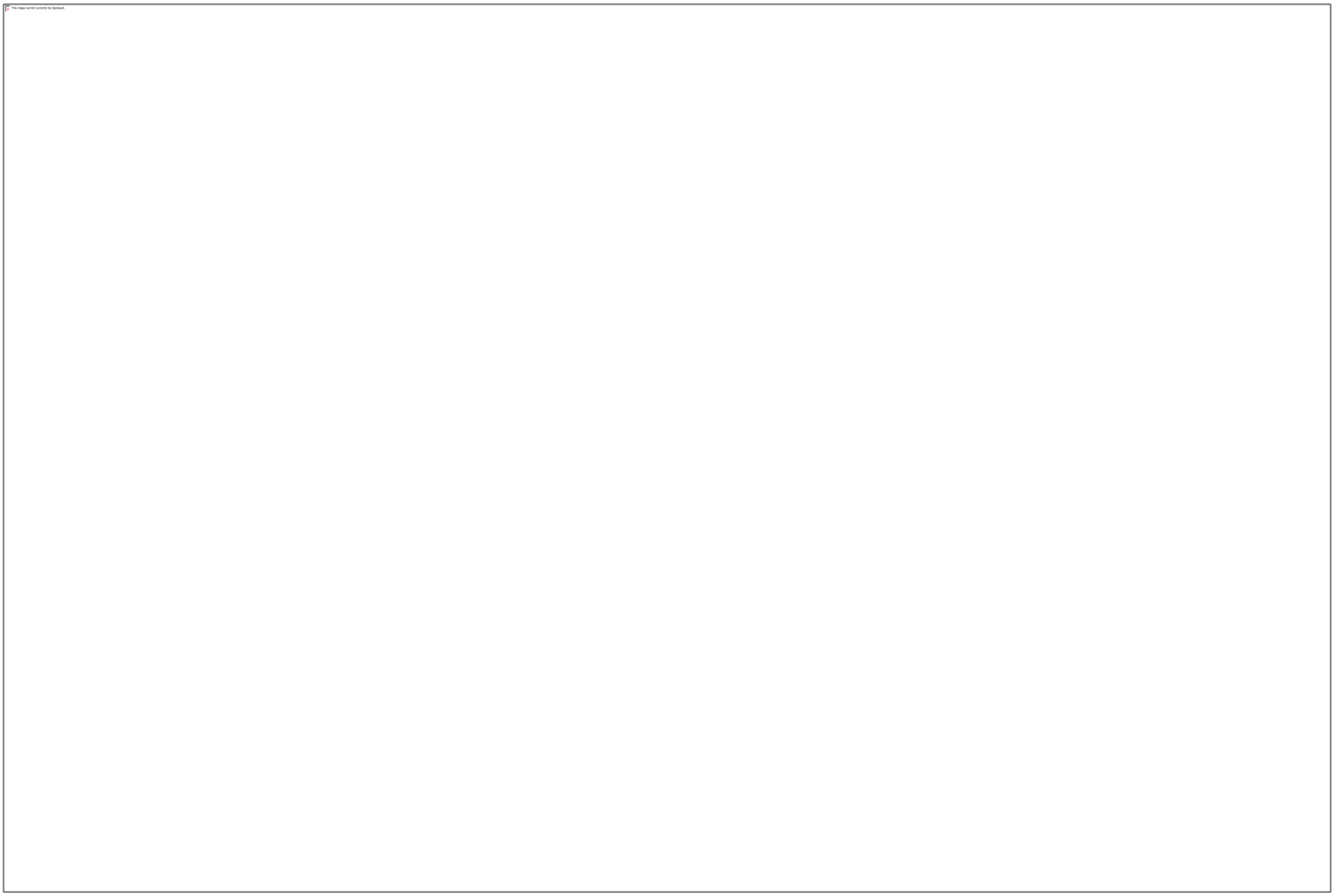
- 6 m, 8 m and 10 m.
- 9 m, 12 m and 15 m.

B. Diagonal measurement method

This method is used to check whether a rectangular building layout is square.

Procedure:

1. Measure from the first corner to the opposite corner.
2. Measure the second diagonal.
3. Compare the two measurements.
4. If the diagonals are equal, the rectangular layout is square, provided the side dimensions are also correct.
5. Adjust the layout if the diagonals are unequal.



Example

A rectangular timber building has the following dimensions:

- Length = 6 metres.
- Width = 8 metres.

Using the Pythagorean theorem:

D=L2+W2$D=L2+W2$

D=62+82$D=62+82$

D=36+64$D=36+64$

D=100=10m$D=100=10m$

Therefore, each diagonal should measure 10 metres.

STEP 6: CHECK ALIGNMENT AND LEVEL

- Use a spirit level to check the level of the bottom plate.
- Use a straight edge or string line to check alignment.
- Check that the plate is not twisted.
- Make necessary adjustments before fixing.

STEP 7: MARK STUD POSITIONS

- Refer to the construction drawings.
- Measure the required spacing between studs.
- Mark the positions on the bottom plate.
- Identify corner studs.
- Mark the positions of king studs and trimmer studs around openings.
- Confirm that the spacing suits the structural design and wall coverings.

STEP 8: VERIFY ALL DIMENSIONS

- Recheck the overall building dimensions.
- Check the positions of internal walls.
- Check door and window openings.
- Check the wall alignment.
- Confirm that the corners are square.
- Obtain approval before proceeding to erect the timber wall frame.

12.0 TOOLS AND EQUIPMENT USED IN TIMBER WALLING

Timber wall construction requires various tools and equipment for measuring, marking, cutting, shaping, joining, fixing and checking timber components.

12.1 Measuring tools



1. Tape measure

- Used to measure lengths, widths and heights of timber members.
- Used to establish wall dimensions.
- Available in different lengths.

2. Steel rule

- Used for taking short and accurate measurements.
- Useful when marking timber joints.

3. Folding rule

- Used for measuring timber components.
- It can be folded for convenient storage.

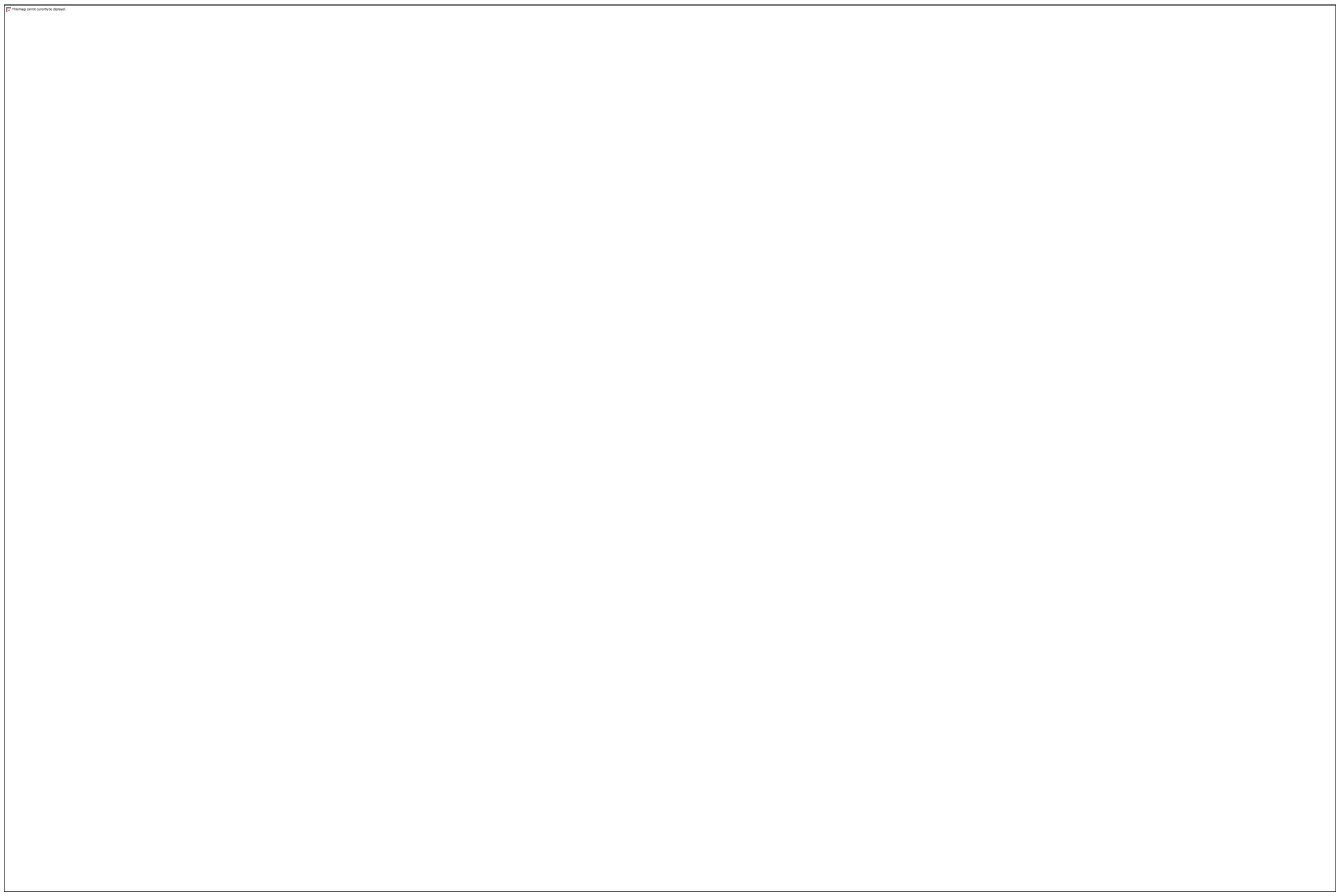
4. Try square

- Used to mark and check right angles on timber.
- Helps ensure that cut ends are square.

5. Framing square

- Used for marking and checking larger timber components.
- It is useful in setting out wall frames and checking angles.

12.2 Marking tools



1. Carpenter's pencil

- Used to mark cutting lines and measurements on timber.

2. Marking gauge

- Used to mark parallel lines along the surface or edge of timber.

3. Chalk line

- Used to mark long straight lines on floors and timber surfaces.

4. String line

- Used to establish straight wall positions and alignment.

5. Marking knife

- Used to make accurate marking lines when preparing timber joints.

12.3 Cutting tools



1. Hand saw

- Used for cutting timber to the required lengths.
- Suitable for general carpentry work.

2. Tenon saw

- Used for accurate cutting of timber joints.
- It has a reinforced back that helps maintain a straight cut.

3. Coping saw

- Used for cutting curved or irregular shapes.
- It is useful for detailed woodworking.

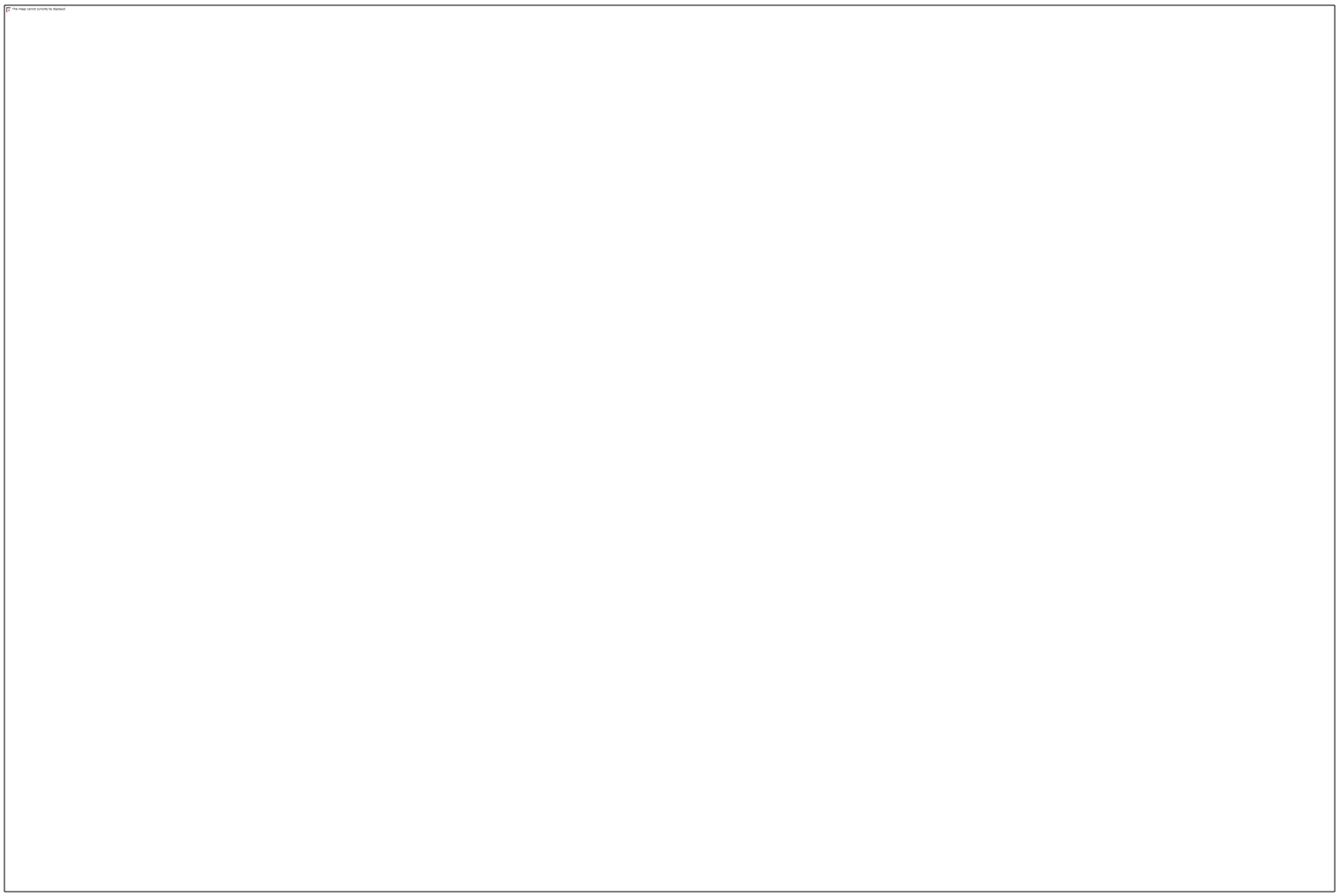
4. Circular saw

- A powered cutting tool used for straight cuts in timber and sheet materials.
- It is commonly used when many pieces require cutting.

5. Jigsaw

- Used for cutting curves and irregular shapes.
- It is useful when preparing openings or shaped timber components.

12.4 Shaping and finishing tools



1. Wood chisel

- Used for removing unwanted timber.
- Used when preparing mortise, tenon, lap and housing joints.

2. Hand plane

- Used to smooth and level timber surfaces.
- Helps produce accurate dimensions and neat finishes.

3. Wood rasp

- Used for shaping and smoothing timber.
- Useful for removing small amounts of material.

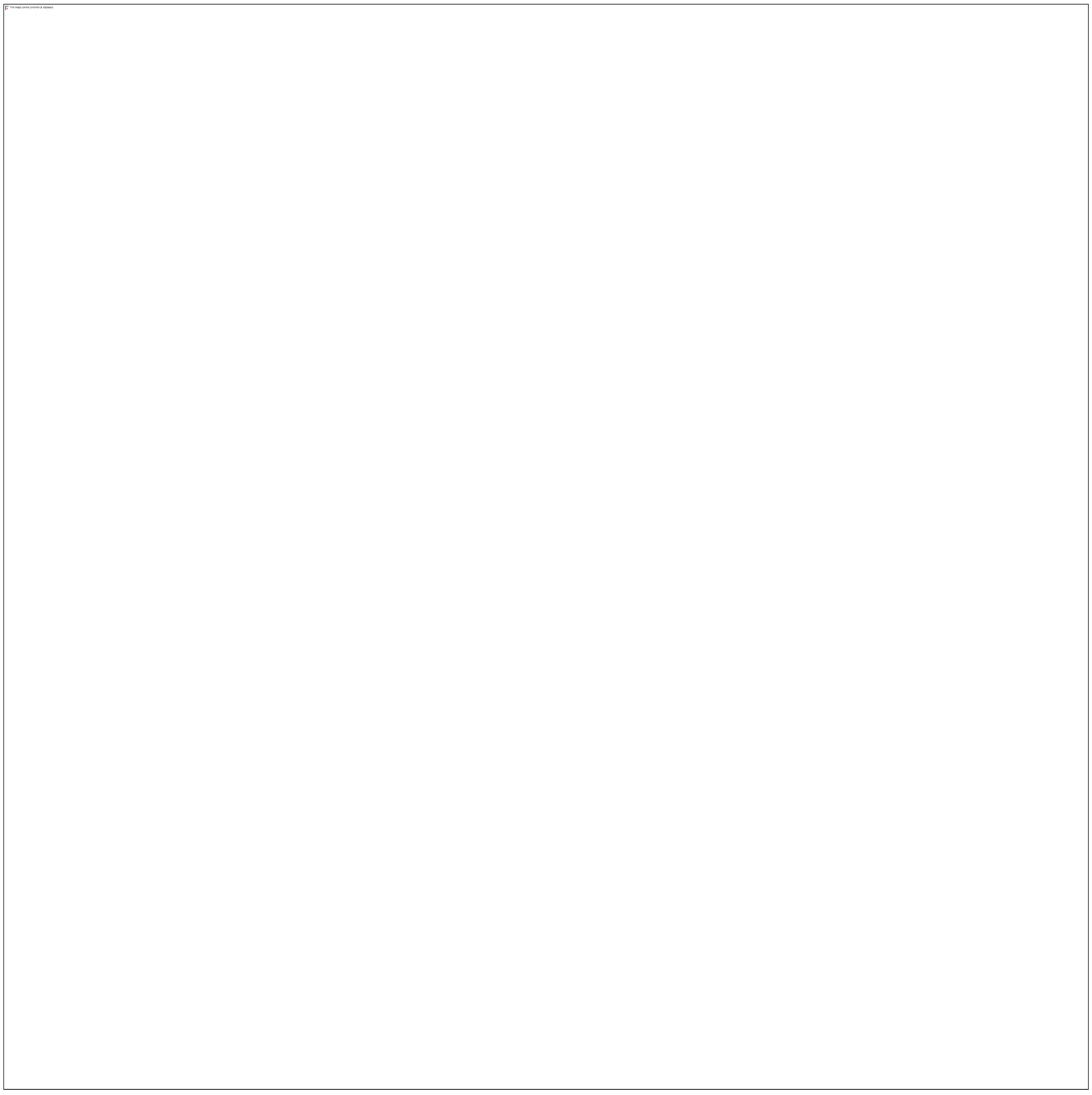
4. Mallet

- Used to strike chisels during timber joint preparation.
- It is generally made from wood or other suitable materials.

5. File

- Used for smoothing and refining timber edges and surfaces.

12.5 Fixing tools



1. Claw hammer

- Used for driving nails into timber.
- Its curved claw is used for removing nails.

2. Screwdriver

- Used for tightening and loosening screws.
- Available in different sizes and head types.

3. Power drill

- Used for drilling holes in timber.

- Can also be used for driving screws with suitable attachments.

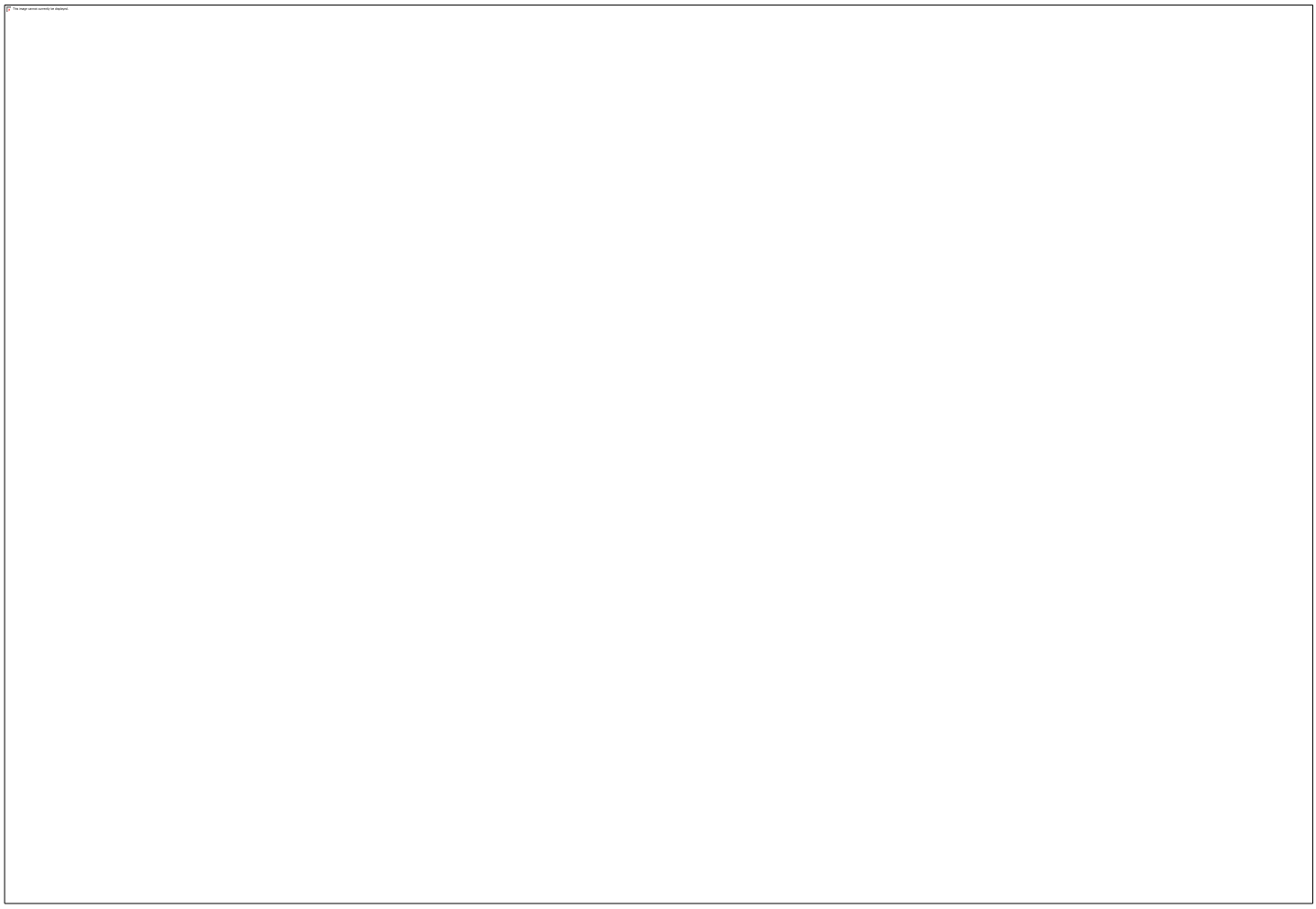
4. Clamps

- Used to hold timber members firmly during joining and assembly.
- They prevent movement while adhesive sets or fasteners are installed.

5. Nail punch

- Used to drive nail heads below the timber surface.

12.6 Checking and levelling equipment



1. Spirit level

- Used to check whether timber members are horizontal or vertical.
- Helps maintain accurate alignment.

2. Plumb bob

- Used to check vertical alignment.
- It works through gravity acting on a suspended weight.

3. Straight edge

- Used to check whether a timber surface or member is straight.

4. Laser level

- Used to establish accurate horizontal and vertical reference lines.

- It is particularly useful on larger construction projects.

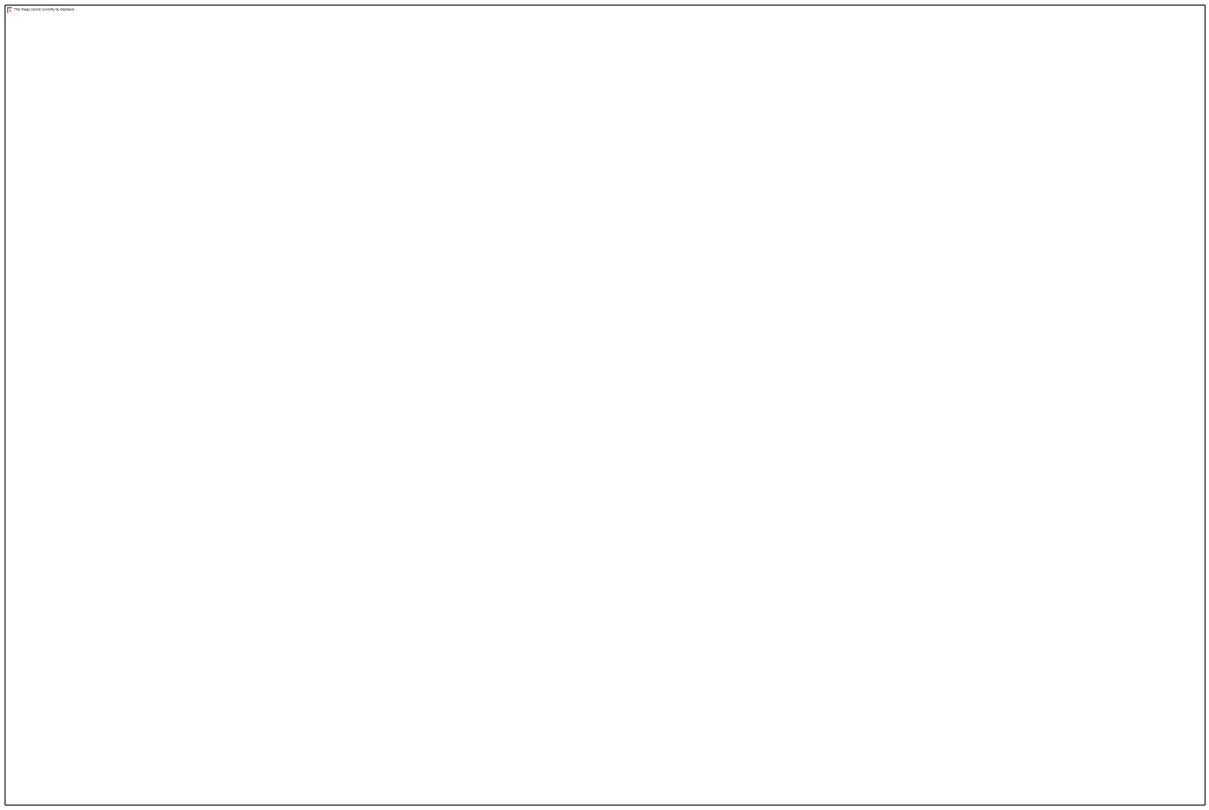
12.7 Other equipment and materials

- Workbench – provides a stable surface for cutting and assembling timber.
- Sawhorses – support timber during cutting and preparation.
- Ladders – provide access to elevated working areas.
- Safety goggles – protect the eyes.
- Dust masks – reduce inhalation of wood dust.
- Protective gloves – protect hands during suitable handling operations.
- Safety boots – protect feet against falling objects and sharp materials.
- Nails and screws – fasten timber components.
- Timber preservatives – protect timber against insects and fungi.
- Adhesives – strengthen suitable timber joints.

13.0 SAFETY PRECAUTIONS WHEN CONSTRUCTING TIMBER WALLS

Safety is essential during timber wall construction because carpentry involves sharp tools, powered machinery, heavy materials, wood dust and working at heights.

13.1 Personal protective equipment (PPE)



The following protective equipment should be used:

1. Safety goggles

- Protect the eyes against flying wood chips, dust and debris.

2. Dust masks or respirators

- Protect workers from inhaling harmful wood dust.
- They are particularly important when sanding, cutting and machining timber.

3. Safety boots

- Protect feet against falling timber, nails and other sharp objects.

4. Protective gloves

- Protect hands when handling rough timber and materials.
- Gloves should not be worn near rotating machinery where they could become entangled.

5. Hearing protection

- Protects the ears from excessive noise produced by power saws and other machinery.

6. Hard hats

- Protect the head from falling objects, especially on active construction sites.

7. Overalls

- Protect the body against dust, splinters and minor injuries.

13.2 General safety precautions

1. **Inspect tools before use**
   - Check that tools are in good working condition.
   - Replace damaged or defective tools.
2. **Use the correct tool**
   - Select tools appropriate for the particular operation.
   - Avoid using tools for purposes for which they were not designed.
3. **Maintain a clean working environment**
   - Remove wood offcuts, nails and other waste materials.
   - Keep pathways free from obstructions.
4. **Handle sharp tools carefully**
   - Carry chisels and saws with their sharp edges properly protected.
   - Store them safely after use.
5. **Observe electrical safety**
   - Check electrical cables before using powered equipment.
   - Avoid using electrical equipment in wet conditions unless it is specifically designed and protected for such use.
   - Use appropriate electrical protection.
6. **Secure timber before cutting**
   - Use clamps or suitable supports to prevent timber from moving.
   - Never hold small pieces too close to the cutting blade.

7. **Use machines correctly**
   - Follow manufacturers' instructions.
   - Keep hands away from moving blades.
   - Ensure guards are in place.
8. **Avoid loose clothing**
   - Wear properly fitting work clothing.
   - Tie back long hair to prevent entanglement.
9. **Store timber properly**
   - Stack timber safely.
   - Prevent materials from falling or rolling.
   - Keep timber away from sources of excessive moisture.
10. **Observe safe lifting procedures**
   - Bend the knees when lifting heavy timber.
   - Keep the load close to the body.
   - Seek assistance when lifting long or heavy members.
11. **Use ladders safely**
   - Place ladders on firm and level ground.
   - Do not overreach.
   - Maintain three points of contact when climbing.
12. **Control wood dust**
   - Use dust extraction where available.
   - Clean work areas using suitable methods rather than blowing dust into the air.
13. **Handle timber preservatives carefully**
   - Follow the manufacturer's safety instructions.
   - Wear suitable protective equipment.
   - Store chemicals safely.
14. **Maintain fire safety**
   - Keep timber offcuts and sawdust away from ignition sources.
   - Do not smoke near flammable materials or chemicals.
   - Provide suitable fire extinguishers.
15. **Report accidents immediately**
   - Inform the instructor or site supervisor about injuries and unsafe conditions.
   - Obtain first aid where necessary.

13.3 Safety when using specific tools

Tool	Safety precaution
Hand saw	Cut away from the body and keep the workpiece secure.
Chisel	Keep the cutting edge sharp and cut away from the body.
Hammer	Use a hammer with a firm handle and sound head.
Circular saw	Keep the blade guard in position and follow safe operating procedures.
Power drill	Secure the workpiece and use the correct drill bit.
Hand plane	Keep hands away from the cutting edge.
Ladder	Use on firm ground and avoid overreaching.
Clamps	Check that the workpiece is securely held.

14.0 CONSTRUCTION OF A MODEL TIMBER WALL

14.1 Meaning of a model timber wall

A model timber wall is a small-scale or full-scale demonstration structure constructed to represent the components, arrangement and construction methods of an actual timber wall.

It enables learners to develop practical skills in measuring, marking, cutting, joining and assembling timber members.



14.2 Importance of constructing a model timber wall

1. Helps learners understand the components of a timber wall.
2. Develops practical carpentry skills.

3. Demonstrates the arrangement of timber members.
4. Helps learners understand different timber joints.
5. Develops accuracy in measuring and marking.
6. Improves teamwork and collaboration.
7. Promotes creativity and problem-solving.
8. Provides an opportunity to practise safe tool handling.
9. Helps learners understand construction drawings.
10. Prepares learners for actual construction activities.

14.3 Materials required

- Small timber pieces.
- Plywood or suitable board materials.
- Nails.
- Screws.
- Wood adhesive.
- Sandpaper.
- Suitable timber preservative or finish.

14.4 Tools required

- Tape measure.
- Steel rule.
- Carpenter's pencil.
- Try square.
- Hand saw.
- Tenon saw.
- Hammer.
- Chisel.
- Screwdriver.
- Clamps.
- Sandpaper.

14.5 Procedure for constructing a model timber wall

Step 1: Study the model design

- Identify the type of timber wall to be constructed.

- Prepare a simple drawing.
- Identify the required dimensions and components.

Step 2: Prepare materials

- Select suitable timber pieces.
- Check that the timber is straight.
- Remove defective sections.
- Gather the required fasteners and adhesives.

Step 3: Measure and mark

- Measure the top and bottom plates.
- Mark the vertical studs.
- Mark the positions of the noggings.
- Use a try square to ensure accurate markings.

Step 4: Cut timber members

- Cut the timber pieces to the required sizes.
- Ensure that the ends are square.
- Smooth rough edges.

Step 5: Assemble the frame

- Position the bottom plate on a flat surface.
- Fix the vertical studs.
- Attach the top plate.
- Install the noggings.
- Check the frame for squareness.

Step 6: Install bracing

- Fit diagonal braces where required.
- Secure the bracing using suitable fasteners.

Step 7: Fix the cladding

- Attach the selected wall-covering material.
- Ensure that the cladding is correctly positioned.

Step 8: Finish the model

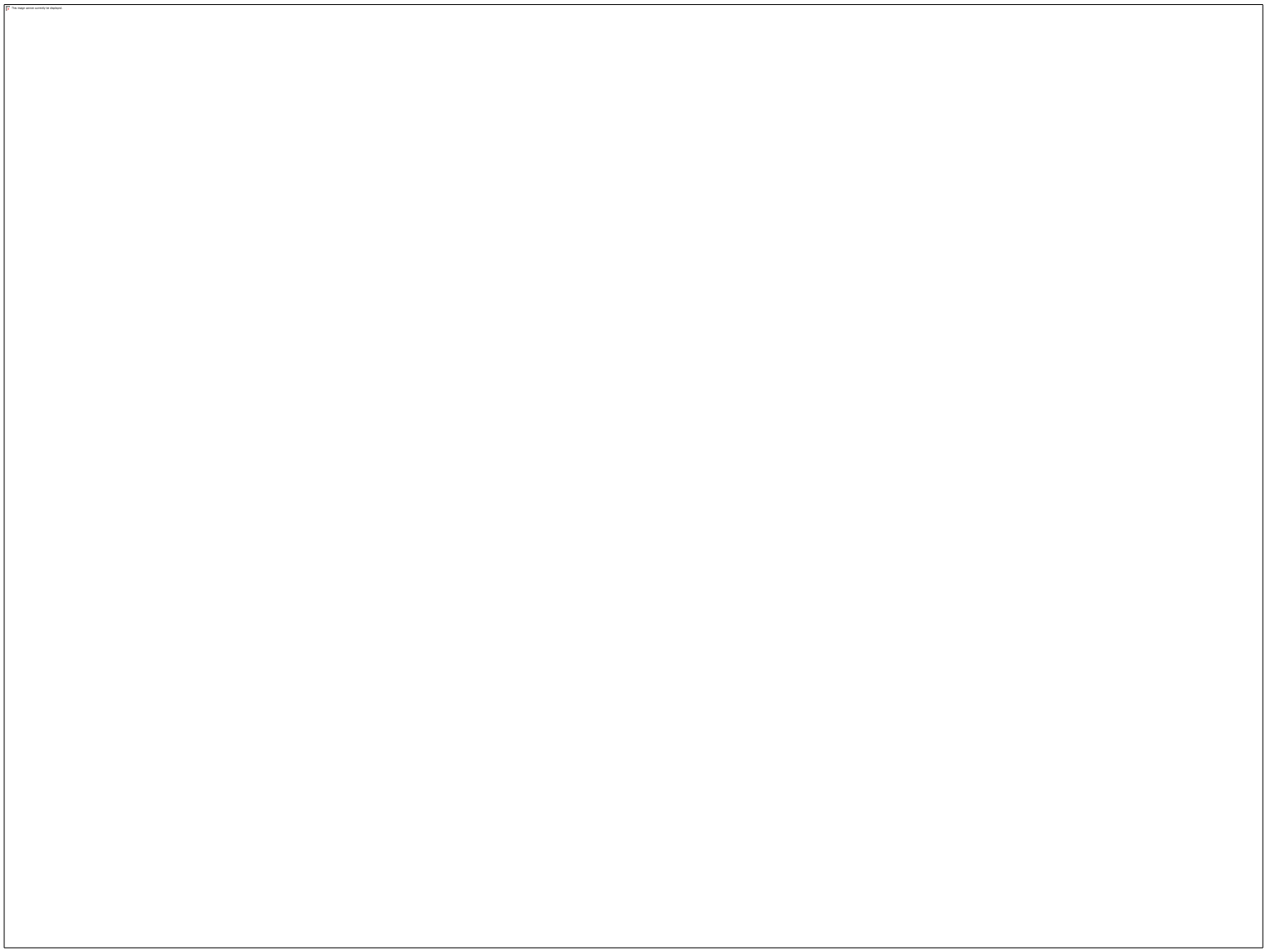
- Smooth rough surfaces.
- Remove projecting nails.
- Apply an appropriate finish.
- Label the different components.

Step 9: Evaluate the model

- Check the dimensions.
- Check the joints.
- Check the alignment.
- Assess the stability and appearance.
- Identify areas that require improvement.

14.6 Suggested model project

PROJECT: Construction of a simple timber-framed wall



Project requirements

- Construct a rectangular timber frame.
- Include top and bottom plates.
- Install at least four vertical studs.
- Include two rows of noggings.
- Provide one diagonal brace.
- Demonstrate at least two types of timber joints.
- Partially cover one side with plywood or suitable board material.

- Label all major components.

Expected learning evidence

- Accurate measurements.
- Correct cutting techniques.
- Properly formed joints.
- Neat assembly.
- Safe handling of tools.
- Ability to explain the function of each component.

15.0 ENVIRONMENTAL CONSIDERATIONS IN TIMBER WALL CONSTRUCTION

Timber is a valuable natural resource. Its use in building construction should be guided by environmental conservation and sustainable practices.

Important environmental practices

1. **Responsible sourcing**
   - Obtain timber from legally and sustainably managed sources.
   - Avoid illegally harvested timber.
2. **Tree planting**
   - Encourage reforestation and tree-planting programmes.
   - Replace trees harvested for construction purposes.
3. **Reducing wastage**
   - Measure timber accurately before cutting.
   - Reuse suitable offcuts for smaller components.
4. **Proper timber treatment**
   - Use suitable preservatives to increase timber durability.
   - Handle treatment chemicals responsibly.
5. **Recycling**
   - Reuse suitable timber from demolished structures.
   - Recycle timber products where appropriate.
6. **Efficient transportation**
   - Plan timber deliveries to reduce unnecessary transportation.
7. **Waste management**
   - Collect and dispose of sawdust, offcuts and packaging responsibly.

16.0 SUMMARY OF KEY CONCEPTS

Concept	Main point
Timber superstructure walling	Construction of walls above foundation level using timber
Timber-framed wall	Wall made using studs, plates, noggings and cladding
Panel timber wall	Wall made using assembled or prefabricated panels
Plank timber wall	Wall formed by joining timber planks
Butt joint	Two timber members meet directly
Lap joint	Two timber members overlap
Mortise and tenon	A tenon fits into a mortise
Tongue and groove	A tongue fits into a matching groove
Housing joint	One member fits into a recess in another
Stud construction	Uses vertical studs connected by horizontal plates
Profile boards	Temporary boards used to preserve setting-out lines
Setting out	Transferring building dimensions onto the construction site
Model timber wall	A demonstration structure representing an actual timber wall

REVISION QUESTIONS

SUBSTRAND 3.2

SECTION A: MULTIPLE-CHOICE QUESTIONS

Choose the correct answer from the alternatives A, B, C and D.

1. What is timber superstructure walling?

A. Construction of foundations using timber.

B. Construction of walls above foundation level using timber.

C. Construction of concrete floors using timber.

D. Construction of roofs using metal sheets.

2. Which of the following is a major component of a timber-framed wall?

A. Reinforcement bar.

B. Vertical stud.

C. Concrete block.

D. Foundation stone.

3. The main function of a bottom plate in timber wall construction is to:

A. Cover the roof.

B. Support the lower ends of the vertical studs.

C. Provide decoration to the wall.

D. Support the ceiling finish only.

4. Which timber member is fixed horizontally between adjacent vertical studs?

A. Lintel.

B. Rafter.

C. Nogging.

D. Purlin.

5. Which of the following materials can be used as timber wall cladding?

A. Plywood.

B. Reinforcement steel.

C. Ballast.

D. Roofing stone.

6. A wall constructed using large prefabricated timber sections is referred to as:

A. Stone wall.

B. Panel timber wall.

C. Concrete wall.

D. Brick wall.

7. Which of the following describes a plank timber wall?

A. A wall made from concrete blocks.

B. A wall made by joining timber boards or planks.

C. A wall made from steel sheets only.

D. A wall made from reinforced concrete.

8. The main function of bracing in a timber wall frame is to:

A. Increase the weight of the wall.

B. Prevent sideways movement and distortion.

C. Cover the floor.

D. Increase the size of the windows.

9. Which timber joint is formed by placing two timber members directly against each other?

A. Butt joint.

B. Mortise and tenon joint.

C. Housing joint.

D. Dovetail joint.

10. A joint formed by allowing two timber members to overlap is called:

A. Butt joint.

B. Lap joint.

C. Housing joint.

D. Tongue and groove joint.

11. Which part of a mortise and tenon joint is the projecting section?

A. Mortise.

B. Shoulder.

C. Tenon.

D. Groove.

12. Which timber joint is commonly used when joining adjacent timber boards to produce a continuous surface?

A. Butt joint.

B. Tongue and groove joint.

C. Housing joint.

D. Half-lap joint.

13. A housing joint is formed by:

A. Welding two timber members.

B. Cutting a recess to receive another timber member.

C. Placing two timber members end to end.

D. Bending timber into a circular shape.

14. Which tool is most suitable for checking a right angle on a timber member?

A. Hammer.

B. Try square.

C. Screwdriver.

D. Chisel.

15. Which equipment is used to check whether a timber member is vertically upright?

A. Plumb bob.

B. Hand saw.

C. Claw hammer.

D. Marking gauge.

16. What is the main purpose of profile boards?

A. To provide permanent wall coverings.

B. To establish and preserve building setting-out lines.

C. To support roof tiles.

D. To decorate the building.

17. Which material is stretched between nails fixed on profile boards?

A. Reinforcement wire.

B. String line.

C. Electrical cable.

D. Roofing felt.

18. Which method is commonly used to check the squareness of building corners?

A. 3-4-5 method.

B. Painting method.

C. Plastering method.

D. Polishing method.

19. In a 3-4-5 triangle, what is the length of the diagonal when the shorter sides measure 3 m and 4 m?

A. 6 m. B. 5 m.

C. 7 m. D. 8 m.

20. Which of the following is an appropriate safety measure when using a circular saw?

A. Removing the blade guard.

B. Holding timber loosely during cutting.

C. Keeping the blade guard in position.

D. Wearing loose clothing.

21. Which tool is mainly used to remove unwanted timber when preparing a mortise?

A. Chisel.

B. Tape measure.

C. Spirit level.

D. Screwdriver.

22. Which tool is used for driving nails into timber?

A. Claw hammer.

B. Try square.

C. Marking gauge.

D. Hand plane.

23. Which of the following is a major cause of timber deterioration?

A. Proper seasoning.

B. Excessive moisture.

C. Correct storage.

D. Appropriate treatment.

24. What is the main purpose of constructing a model timber wall?

A. To replace all actual buildings.

B. To develop practical construction skills.

C. To increase timber wastage.

D. To avoid learning construction procedures.

25. Which of the following is an advantage of prefabricated timber walls?

A. They always require more site labour.

B. They reduce construction time.

C. They cannot be transported.

D. They increase material wastage.

26. Which timber member is placed above a door or window opening to support loads above it?

A. Nogging. B. Lintel.

C. Bottom plate. D. Floor joist.

27. Which of the following is an appropriate method of protecting timber against termite attack?

A. Soaking timber in ordinary water.

B. Applying suitable timber preservatives.

C. Leaving timber exposed to soil.

D. Storing timber in damp conditions.

28. Which of the following is an example of a measuring tool used in timber wall construction?

A. Tape measure.

B. Claw hammer.

C. Wood chisel.

D. Hand plane.

29. Which of the following is an environmental practice in timber construction?

A. Using illegally harvested timber.

B. Burning all timber offcuts.

C. Reusing suitable timber offcuts.

D. Cutting down trees without replacement.

30. Which statement correctly describes the top plate?

A. It is a horizontal member connecting the upper ends of the studs.

B. It is a vertical member supporting the foundation.

C. It is a material used for roof covering.

D. It is a temporary profile peg.

SECTION B: STRUCTURED AND SHORT-ANSWER QUESTIONS

Question 1: Introduction to timber walling

a) Define timber superstructure walling. (2 marks)

b) State four advantages of timber walling. (4 marks)

c) Explain four limitations of using timber for wall construction. (4 marks)

Question 2: Types of timber walls

a) Identify three main types of timber walls. (3 marks)

b) Explain the construction of a timber-framed wall. (5 marks)

c) Differentiate between panel timber walls and plank timber walls. (4 marks)

Question 3: Components of timber-framed walls

a) Name six components of a timber-framed wall. (3 marks)

b) Explain the functions of the following components:

i. Bottom plate. (2 marks)

ii. Top plate. (2 marks)

iii. Vertical studs. (2 marks)

iv. Noggings. (2 marks)

v. Bracing. (2 marks)

Question 4: Timber joints

a) Define a timber joint. (2 marks)

b) Explain the construction of a butt joint. (3 marks)

c) Describe the procedure for making a half-lap joint. (4 marks)

d) State three applications of mortise and tenon joints. (3 marks)

Question 5: Timber joints

a) Differentiate between a mortise and a tenon. (2 marks)

b) Describe how a tongue and groove joint is formed. (4 marks)

c) Explain the construction of a housing joint. (4 marks)

d) State two advantages of using tongue and groove joints in timber walling. (2 marks)

Question 6: Methods of constructing timber walls

a) Define stud construction. (2 marks)

b) Describe eight steps involved in constructing a timber-framed wall. (8 marks)

c) State three advantages of prefabricated timber wall construction. (3 marks)

Question 7: Profile boards

a) Define profile boards. (2 marks)

b) Identify four components of profile boards. (4 marks)

c) Explain five importance of profile boards during building construction. (5 marks)

d) Describe the procedure for installing profile boards on a building site. (5 marks)

Question 8: Setting out timber superstructure walls

a) Explain the meaning of setting out. (2 marks)

b) Describe the procedure for measuring and marking wall positions. (4 marks)

c) Explain the procedure for locating and fixing the bottom plate. (4 marks)

d) State four reasons for checking the squareness of building corners. (4 marks)

Question 9: Squareness of corners

A rectangular timber building measures 6 metres by 8 metres.

a) Calculate the expected diagonal measurement using the Pythagorean theorem. (3 marks)

b) Explain how the 3-4-5 method can be used to establish a right angle during setting out. (4 marks)

c) State three consequences of inaccurate setting out. (3 marks)

Question 10: Tools and equipment

a) Identify five measuring and marking tools used in timber wall construction. (5 marks)

b) Explain the functions of the following tools:

i. Hand saw. (2 marks)

ii. Wood chisel. (2 marks)

iii. Spirit level. (2 marks)

iv. Claw hammer. (2 marks)

v. Clamps. (2 marks)

Question 11: Safety in timber wall construction

a) Define personal protective equipment (PPE). (2 marks)

b) Identify six types of PPE used during timber wall construction. (6 marks)

c) Explain six safety precautions that should be observed when using carpentry tools. (6 marks)

Question 12: Model timber wall construction

a) Define a model timber wall. (2 marks)

b) Identify six materials required when constructing a model timber wall. (3 marks)

c) Describe the procedure for constructing a simple timber-framed wall model. (7 marks)

d) State four benefits of constructing a model timber wall. (4 marks)

Question 13: Application and problem-solving

A school intends to construct a lightweight timber partition to separate two classrooms.

a) Recommend the most suitable type of timber wall and give two reasons for your choice. (3 marks)

b) Identify five materials required for the construction. (5 marks)

c) Explain four safety precautions that should be observed during the construction. (4 marks)

d) State three ways of protecting the timber wall against deterioration. (3 marks)

18.0 PRACTICAL LEARNING ACTIVITIES

The following activities can be undertaken in a school workshop or suitable construction training area.

Activity	Expected competency
Identify different types of timber walls from photographs and actual structures	Observation and classification
Prepare sketches of timber wall frames	Technical drawing
Make butt and lap joints	Carpentry skills
Demonstrate mortise and tenon joints	Jointing skills
Prepare a tongue and groove demonstration	Practical craftsmanship
Construct profile boards	Setting-out skills
Use the 3-4-5 method	Mathematical application
Set out a timber wall on a floor surface	Accuracy and measurement
Construct a model timber wall	Creativity and problem-solving
Demonstrate safe use of carpentry tools	Safety awareness

STRAND 3.0: BUILDING CONSTRUCTION PROCESS

SUBSTRAND 3.3: WALL OPENINGS

1.0 INTRODUCTION TO WALL OPENINGS

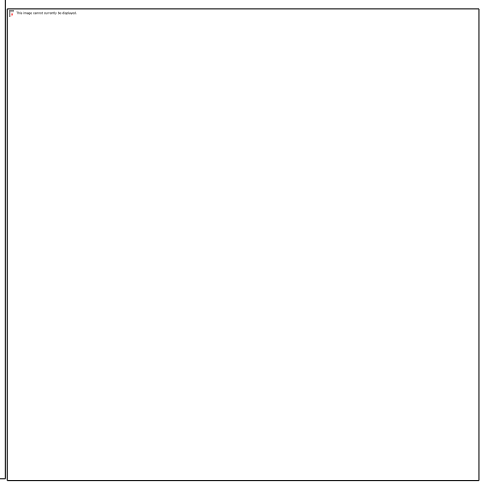
Buildings are constructed with walls to provide enclosure, privacy, security and protection against weather conditions. However, walls require openings to allow people to enter and leave buildings, provide natural lighting, improve ventilation and accommodate building services.

Wall openings are deliberately created spaces within walls during construction. They may be provided for doors, windows, ventilation systems and other building installations.

In building construction, openings must be properly designed and constructed to ensure that the wall remains stable. The masonry or other wall materials above an opening require adequate support to prevent collapse. This support is commonly provided by lintels or arches.

In Kenya, wall openings are commonly used in residential houses, schools, hospitals, commercial buildings, offices, factories and other structures.







1.2 MEANING OF WALL OPENINGS

Definition

A wall opening is a deliberately created gap or space within a wall to accommodate doors, windows, ventilation facilities or other building installations.

Wall openings are provided during the construction of superstructure walls or created later through carefully controlled alterations.

Examples include:

- Door openings.
- Window openings.
- Ventilation openings.
- Service openings.
- Access openings.

Important construction consideration

When an opening is created in a masonry wall, the wall material above the opening must be adequately supported. This is because masonry materials such as bricks, concrete blocks and stones cannot safely span large unsupported gaps.

The supporting structure above the opening is called a *bridging member*. Common bridging members include lintels and arches.

2.0 IMPORTANCE OF WALL OPENINGS IN BUILDINGS

Wall openings perform several important functions in buildings.

2.1 Provision of access

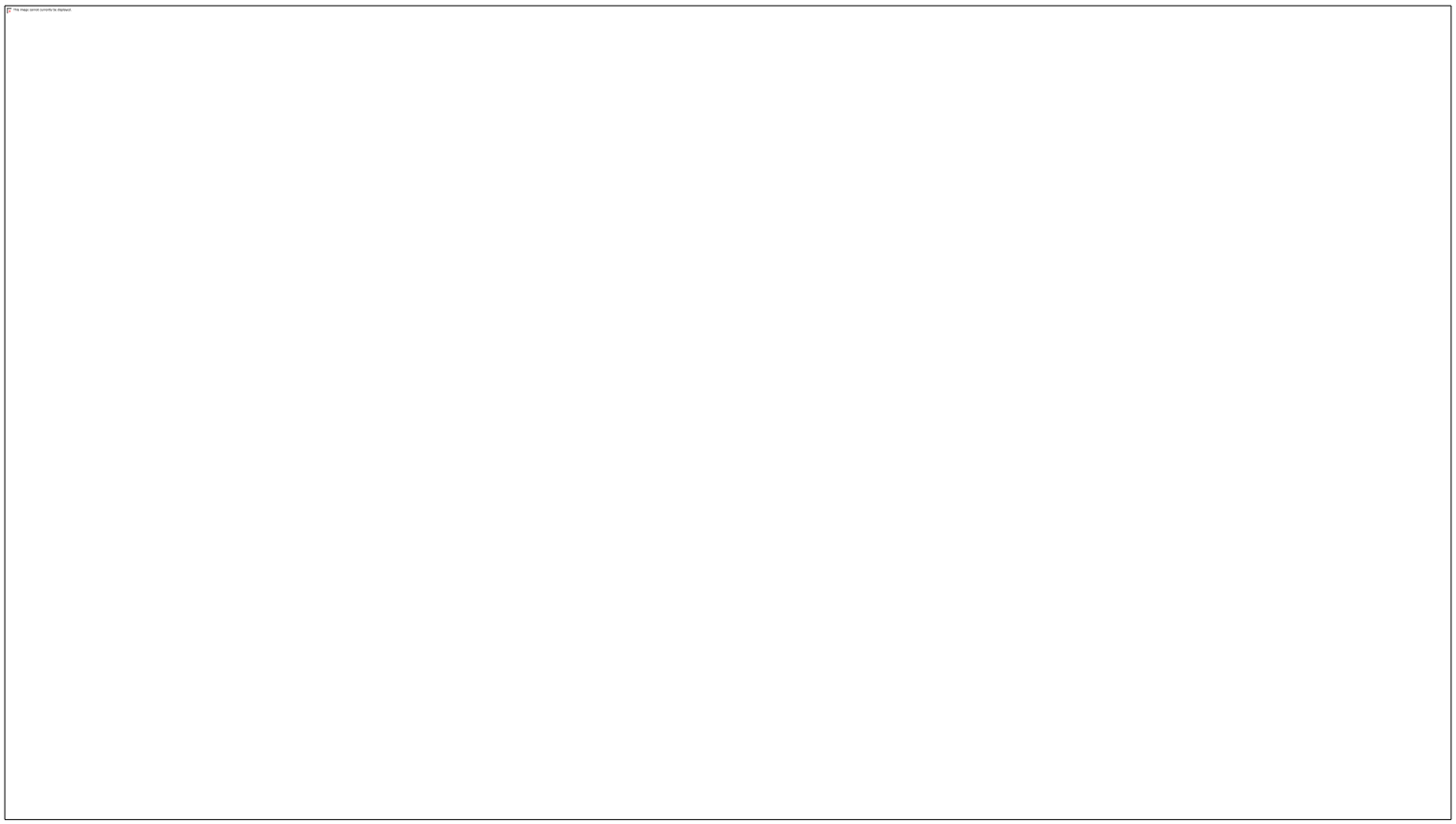
- Door openings provide entry into and exit from buildings.
- They allow movement between rooms and between internal and external spaces.
- They facilitate movement of furniture, equipment and other materials.
- They provide access for emergency evacuation.

Example: A school classroom requires a door opening to allow learners and teachers to enter and leave safely.

2.2 Provision of natural lighting

- Window openings allow natural daylight to enter buildings.
- They reduce dependence on artificial lighting during the day.
- Adequate natural lighting improves visibility during activities.
- It can contribute to energy conservation.

Example: Classroom windows provide daylight that enables learners to read and write comfortably.



2.3 Provision of ventilation

- Wall openings allow fresh air to enter buildings.
- They facilitate the removal of warm and stale air.
- They help regulate indoor temperature.
- They improve indoor air quality.
- They help reduce excessive moisture and unpleasant odours.

Example: Ventilation openings in a kitchen help remove smoke, heat and cooking odours.

2.4 Improvement of indoor comfort

- Openings allow air circulation.
- They help reduce excessive indoor heat.
- They provide access to natural light.
- They contribute to a comfortable indoor environment.

2.5 Provision of emergency exits

- Specially designed door openings provide escape routes.
- They enable occupants to leave buildings during emergencies.
- They facilitate access by rescue personnel.
- Their dimensions, operation and locations should comply with applicable building and fire-safety requirements.

2.6 Accommodation of building services

- Some wall openings accommodate electrical installations, plumbing pipes and ventilation ducts.

- They provide routes for communication and other building services.
- Properly designed service openings prevent unnecessary damage to structural walls.

2.7 Improvement of building appearance

- Windows and doors contribute to the architectural design of buildings.
- They create attractive elevations and balanced proportions.
- Different opening shapes and arrangements can improve the appearance of a building.

2.8 Provision of views

- Window openings allow occupants to see the surrounding environment.
- They connect internal spaces with the external environment.
- They improve the experience of occupants.

2.9 Facilitation of movement of materials

- Door openings allow furniture, construction materials and equipment to be moved into and out of buildings.
- Large openings may be provided for workshops, stores and industrial buildings.

2.10 Contribution to hygiene

- Ventilation openings allow fresh air circulation.
- Windows allow sunlight into rooms.
- Proper ventilation helps control moisture accumulation and indoor pollutants.

3.0 TYPES OF WALL OPENINGS IN BUILDINGS

Wall openings are classified according to their intended use, position, shape and design.

The main types covered in this sub-strand are:

1. Door openings.
2. Window openings.
3. Ventilation openings.

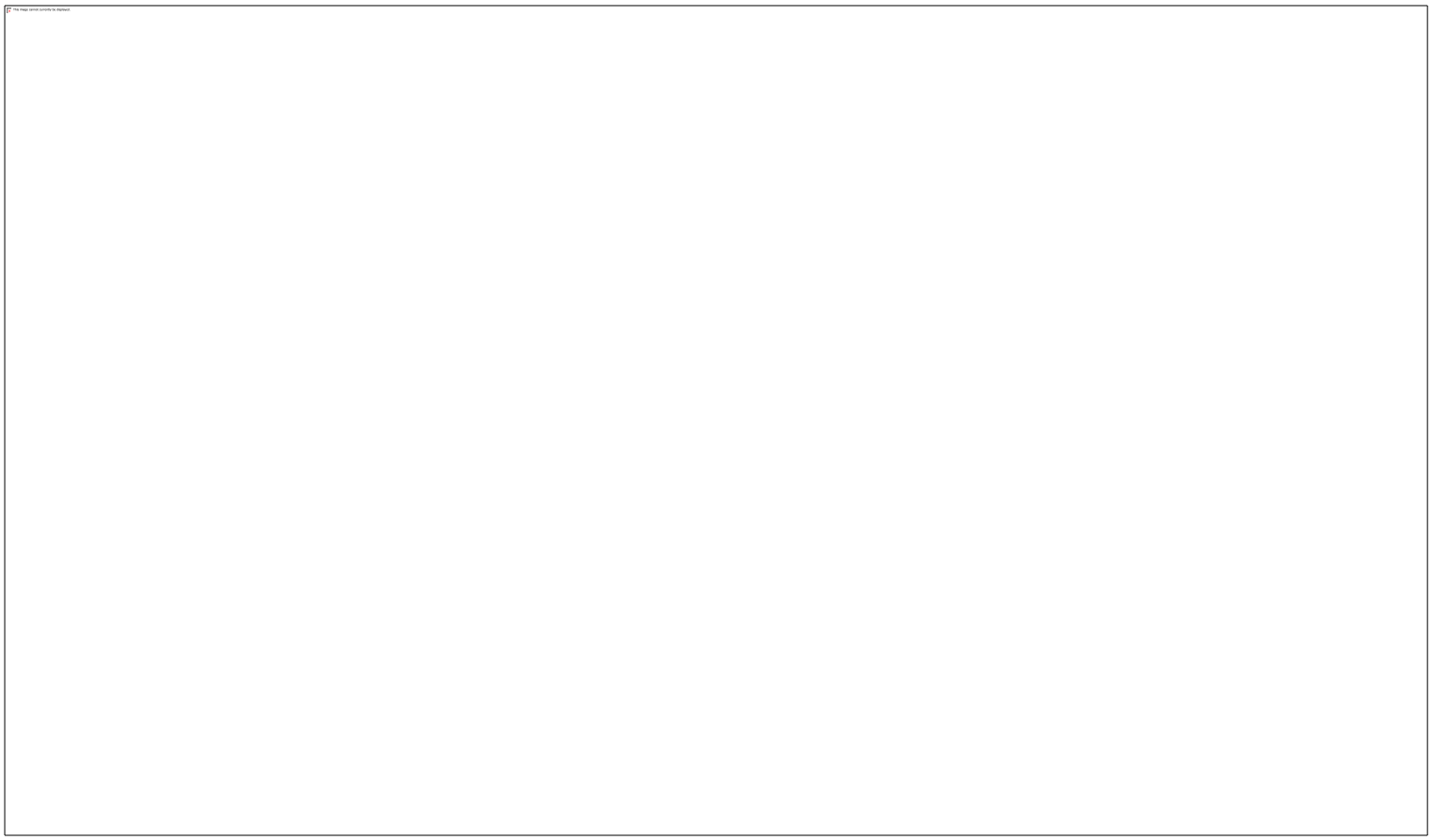
Other specialised openings include service openings and access openings.

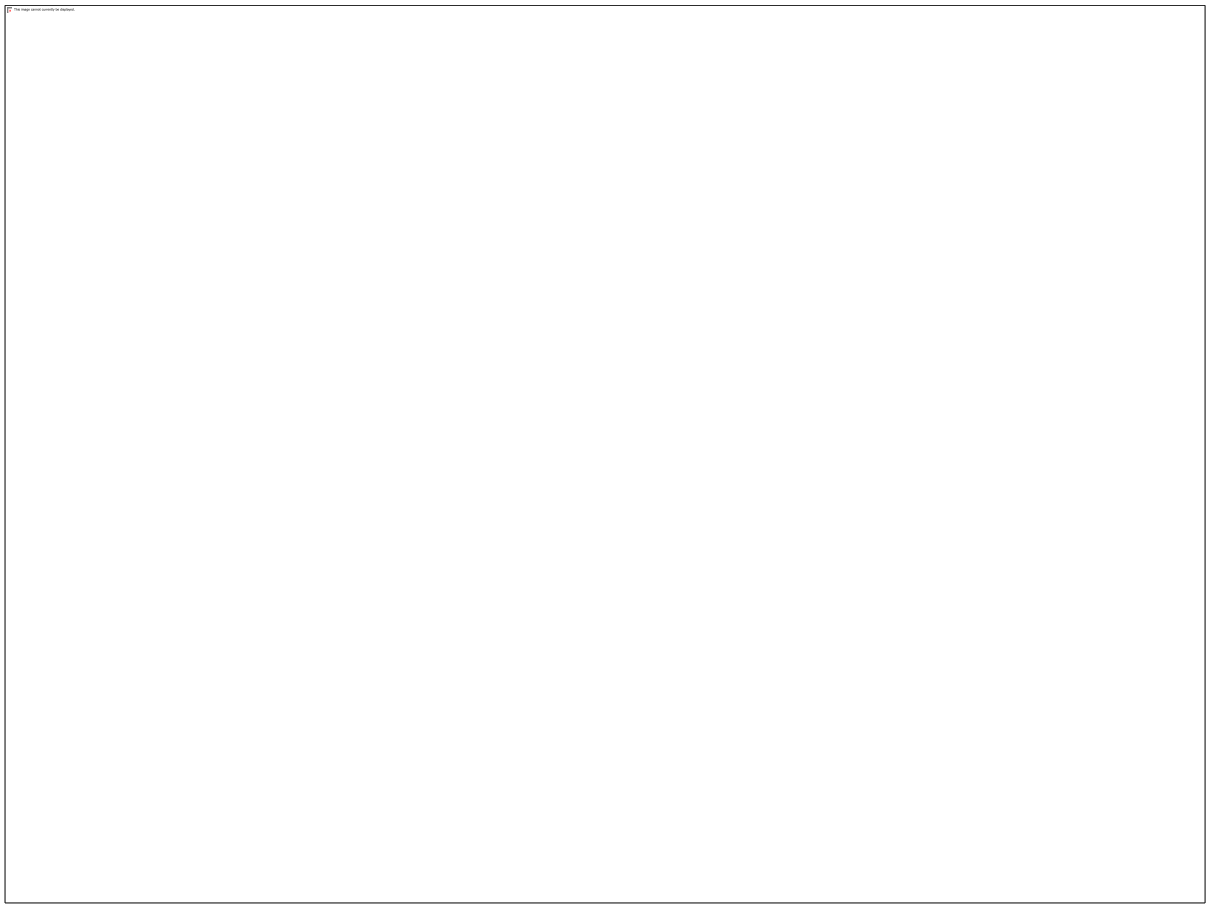
3.1 DOOR OPENINGS

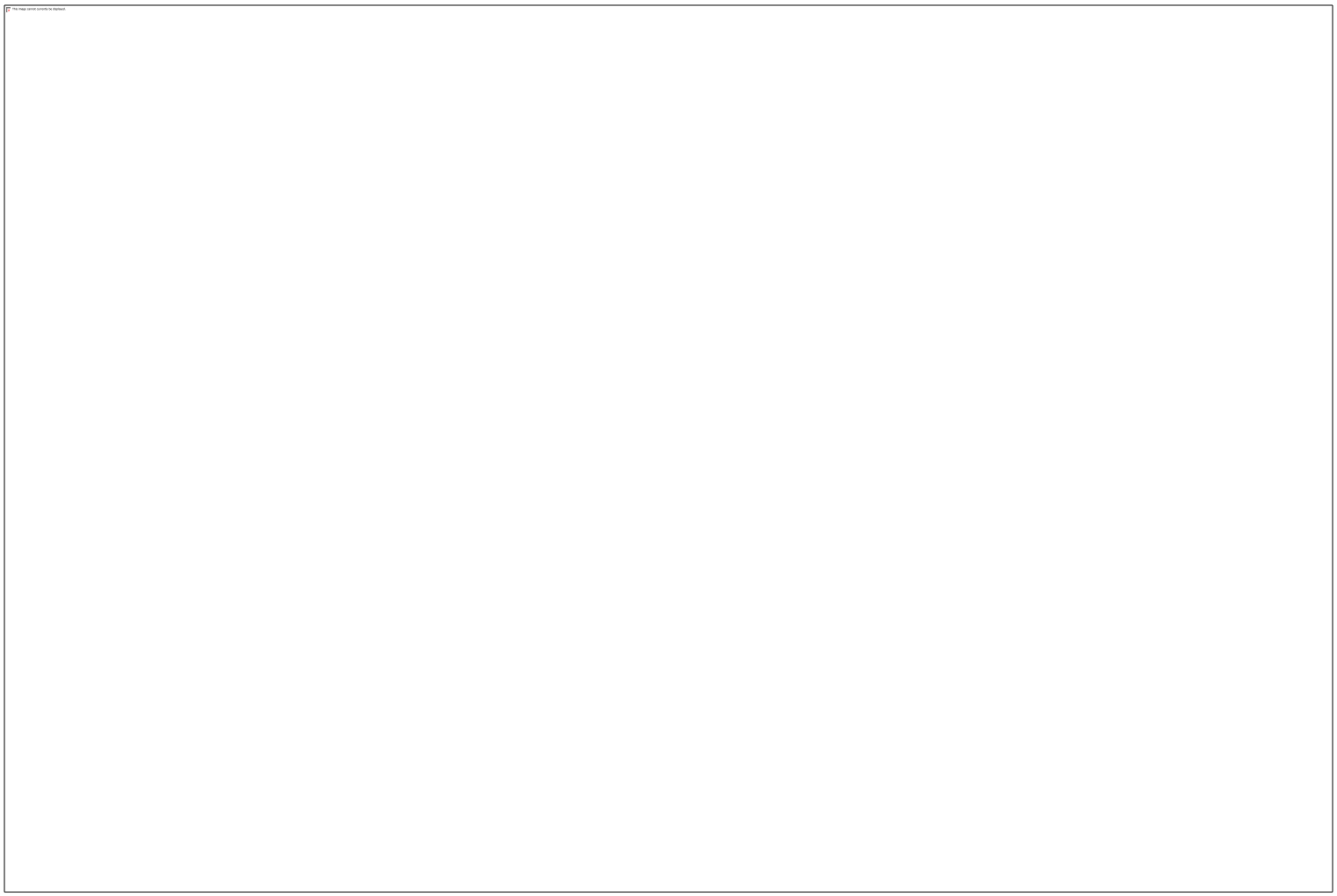
Definition

A door opening is a space provided in a wall to accommodate a door assembly, allowing people or materials to enter and leave a building or room.

Door openings are normally formed during wall construction and are fitted with door frames and door leaves.







Components of a door opening

1. Door jambs

- These are the vertical sides of a door opening.
- They support the door frame.
- They define the width of the opening.
- They provide fixing surfaces for the door assembly.

2. Head

- This is the horizontal upper part of the door opening.
- It is located directly below the lintel or arch.
- It defines the upper boundary of the opening.

3. Sill or threshold

- A threshold is the lower part of a doorway where one is provided.
- It may be constructed from concrete, stone, timber or another suitable material.
- It provides a transition between adjoining floor surfaces.
- It may help control water entry where properly detailed.

4. Door frame

- This is the supporting framework fitted within the wall opening.

- It consists of vertical jambs and a horizontal head.
- It provides support for the hinges and locking arrangements.

5. Lintel

- This is the structural member positioned above the door opening.
- It supports the masonry above the opening.
- It transfers the loads to the supporting wall sections on either side.

Types of door openings

A. Single-leaf door opening

- Designed to accommodate one door leaf.
- Commonly used in bedrooms, classrooms and offices.
- Requires less wall space than many double-leaf arrangements.

B. Double-leaf door opening

- Designed to accommodate two door leaves.
- Provides a wider access space.
- Commonly used in halls, large rooms, entrances and assembly spaces.

C. Sliding door opening

- Designed to accommodate a door that moves horizontally.
- The door may slide along a track or into a wall cavity.
- Useful where the swinging movement of a conventional door would occupy valuable space.

D. Folding door opening

- Designed for a door consisting of panels that fold together when opened.
- Useful for providing wider access.
- Commonly used in halls and spaces requiring flexible room arrangements.

E. Emergency exit door opening

- Designed to provide safe evacuation during emergencies.
- It should be appropriately positioned and sized.
- Its door fittings should comply with applicable fire-safety requirements.

Factors considered when designing door openings

1. Intended use of the room.
2. Number of expected occupants.
3. Movement of furniture and equipment.
4. Accessibility requirements.
5. Security requirements.
6. Door type and frame dimensions.

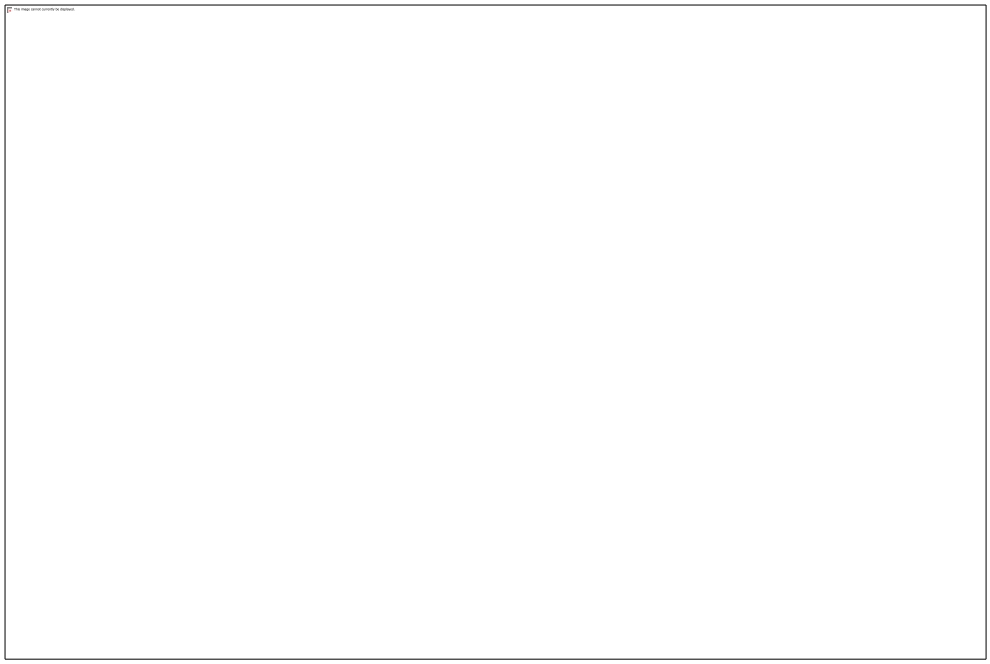
7. Structural requirements of the wall.
8. Fire safety and means of escape.

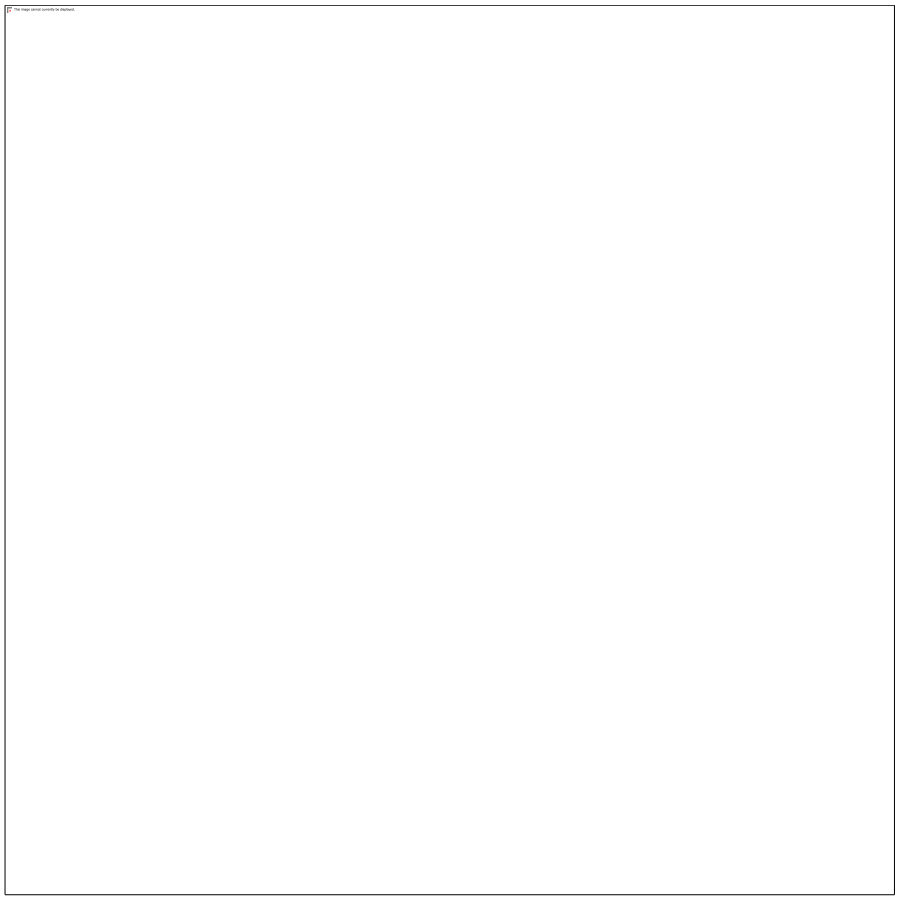
3.2 WINDOW OPENINGS

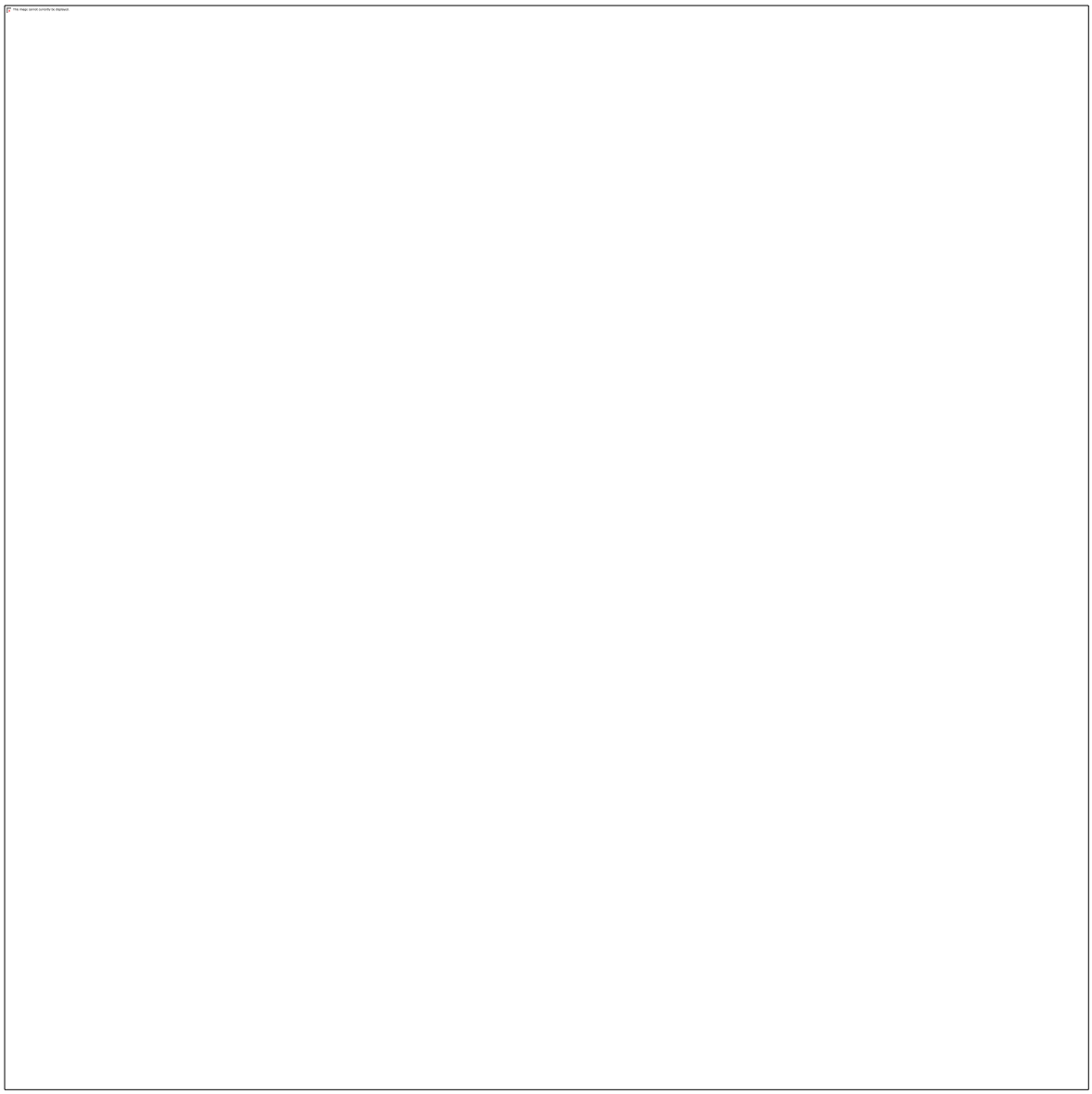
Definition

A window opening is a space provided in a wall to accommodate a window assembly for admitting natural light, providing ventilation and allowing occupants to view the outside environment.

Window openings are commonly positioned at suitable heights to provide adequate lighting, privacy and ventilation.







Components of a window opening

1. Window jambs

- These are the vertical sides of the window opening.
- They define the width of the opening.
- They provide support and fixing surfaces for the window frame.

2. Head

- This is the upper horizontal boundary of the window opening.
- It is positioned below the lintel or arch.

3. Sill

- This is the lower horizontal part of the window opening.
- It supports the bottom of the window frame.
- It may be constructed using concrete, stone, timber or other suitable materials.
- It is normally detailed to direct rainwater away from the wall.

4. Window frame

- This is the framework that holds the window components.
- It may be made from timber, steel, aluminium or uPVC.
- It provides support for glazing and opening mechanisms.

5. Lintel

- This is the structural member above the window opening.
- It supports the masonry above the opening.
- It transfers the load to the supporting wall sections.

6. Glazing

- Glazing refers to the glass or other transparent or translucent material fitted into the window frame.
- It allows daylight into the room.
- It may provide additional thermal and sound insulation depending on its specification.

Types of window openings

A. Fixed window opening

- Designed for a window that cannot be opened.
- Mainly provides natural lighting and external views.
- It does not provide natural ventilation through the window itself.

B. Casement window opening

- Designed for a window with one or more hinged sashes.
- The sash opens by swinging inwards or outwards.
- It provides natural ventilation.

C. Sliding window opening

- Designed for a window with movable panels that slide horizontally or vertically.
- It is useful where swinging windows would obstruct movement.

D. Louvered window opening

- Designed to accommodate adjustable glass or other suitable blades.
- The blades can be adjusted to control airflow.
- It is commonly used in areas requiring continuous ventilation.

E. Awning window opening

- Designed for a window hinged at the top.
- The lower section opens outwards.
- It can provide ventilation while offering some protection against light rain, depending on its design.

F. Clerestory window opening

- Located high on a wall, usually above normal eye level.
- It allows daylight to enter deep into a building.
- It is useful in halls, workshops and large rooms.

G. Bay window arrangement

- Projects outward from the main external wall.
- It increases the amount of daylight and external view.
- It may provide additional internal space.

Factors considered when positioning window openings

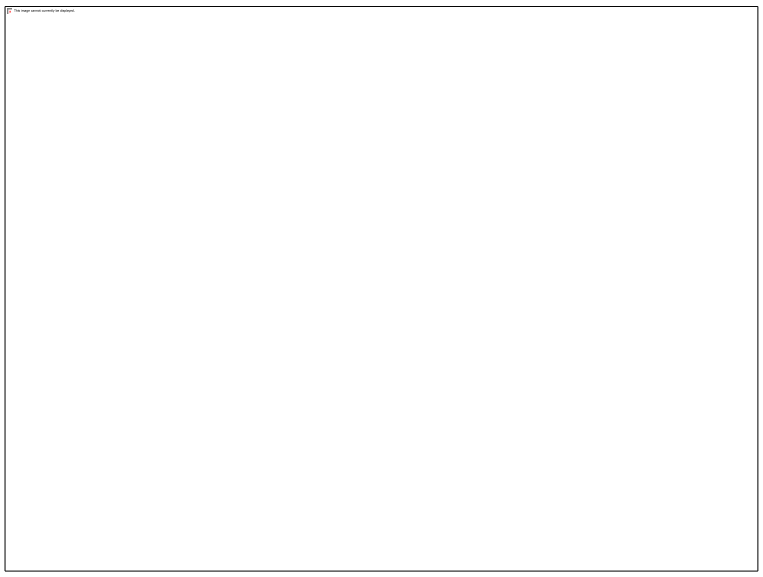
1. Direction of sunlight.
2. Prevailing wind direction.
3. Privacy requirements.
4. Room function.
5. Building orientation.
6. External appearance.
7. Security.
8. Structural stability.
9. Rainwater protection.

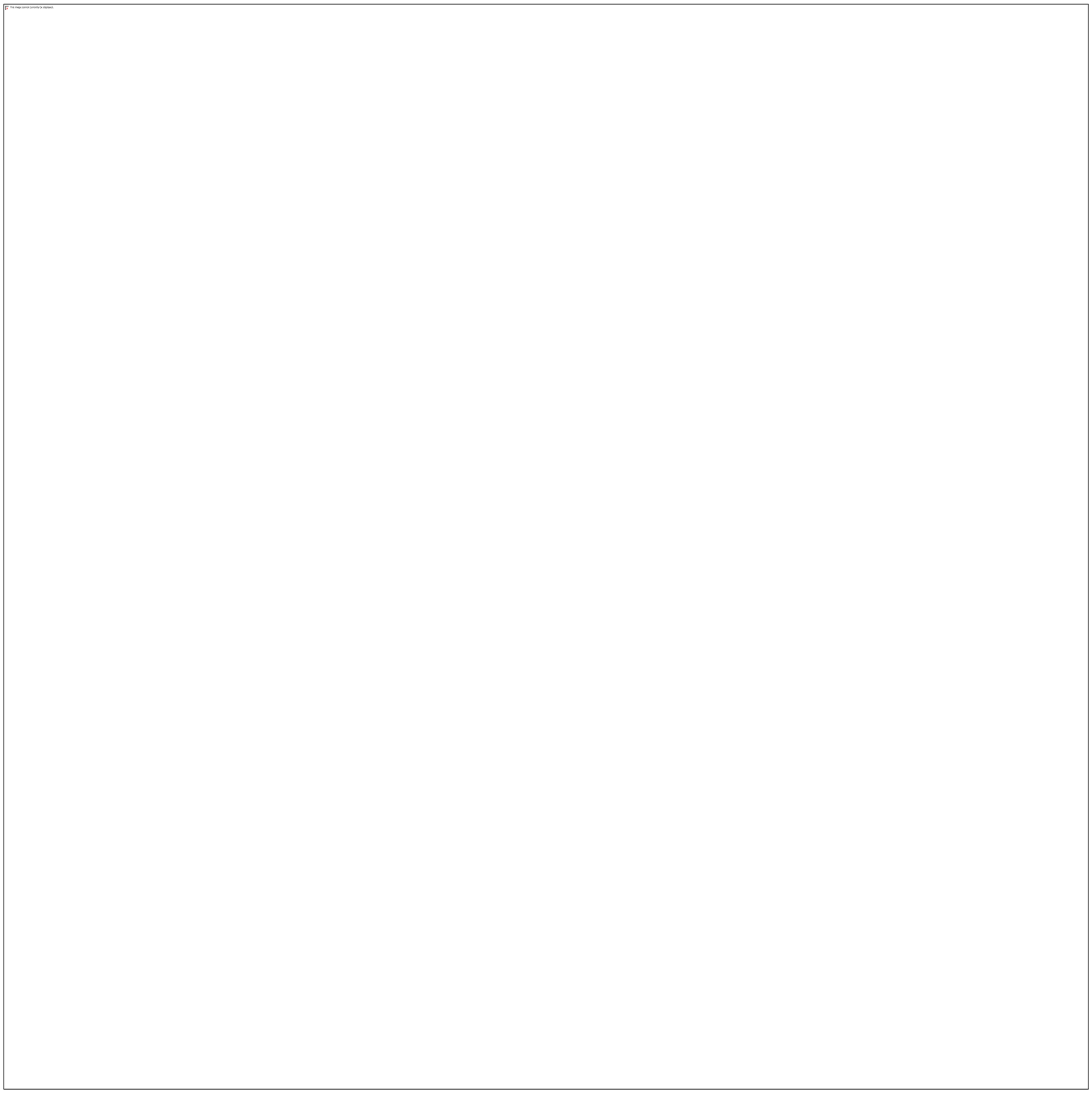
3.3 VENTILATION OPENINGS

Definition

A ventilation opening is a space provided in a wall to allow the movement of air into or out of a building.

Ventilation openings help maintain fresh indoor air and remove excess heat, moisture, smoke and unpleasant odours.







Types of ventilation openings

1. Permanent ventilation openings

- These are openings designed to remain open.
- They allow continuous movement of air.
- They may be fitted with ventilation grilles or mesh.
- They are useful in stores, kitchens and other spaces requiring continuous ventilation.

2. Adjustable ventilation openings

- These have devices that can be opened or closed.
- They allow occupants to regulate airflow.
- Examples include adjustable louvers and ventilation grilles.

3. High-level ventilation openings

- These are positioned near the upper part of a wall.
- They allow warm air to escape.
- They can be used together with lower-level openings to promote air circulation.

4. Low-level ventilation openings

- These are positioned near the lower part of a wall.
- They allow fresh air to enter.
- They may be combined with high-level openings to facilitate natural ventilation.

5. Air-brick openings

- These are openings fitted with specially designed perforated bricks or ventilation units.

- They allow air to pass through the wall.
- They may be used in ventilation and subfloor ventilation arrangements.

6. Louvered ventilation openings

- These contain inclined or adjustable blades.
- They allow air movement while helping to restrict direct rain entry.
- They may be made from metal, glass or suitable plastic materials.

Importance of ventilation openings

1. Provide fresh air.
2. Remove stale air.
3. Reduce indoor heat.
4. Help control moisture.
5. Remove cooking odours.
6. Improve indoor air quality.
7. Assist in reducing condensation.
8. Improve comfort in occupied rooms.

3.4 OTHER SPECIALISED WALL OPENINGS

A. Service openings

- These are openings provided for pipes, cables, ducts and other building services.
- They are planned to accommodate building installations.
- They should be properly sealed and protected where necessary.

B. Access openings

- These are openings provided to allow access to restricted spaces or building installations.
- Examples include access to service ducts and maintenance spaces.

C. Hatch openings

- These are relatively small openings fitted with a cover or hinged panel.
- They provide access to specific areas or installations.

D. Inspection openings

- These allow inspection and maintenance of building services.
- They may be fitted with removable covers.

4.0 BRIDGING OF WALL OPENINGS

4.1 Meaning of bridging

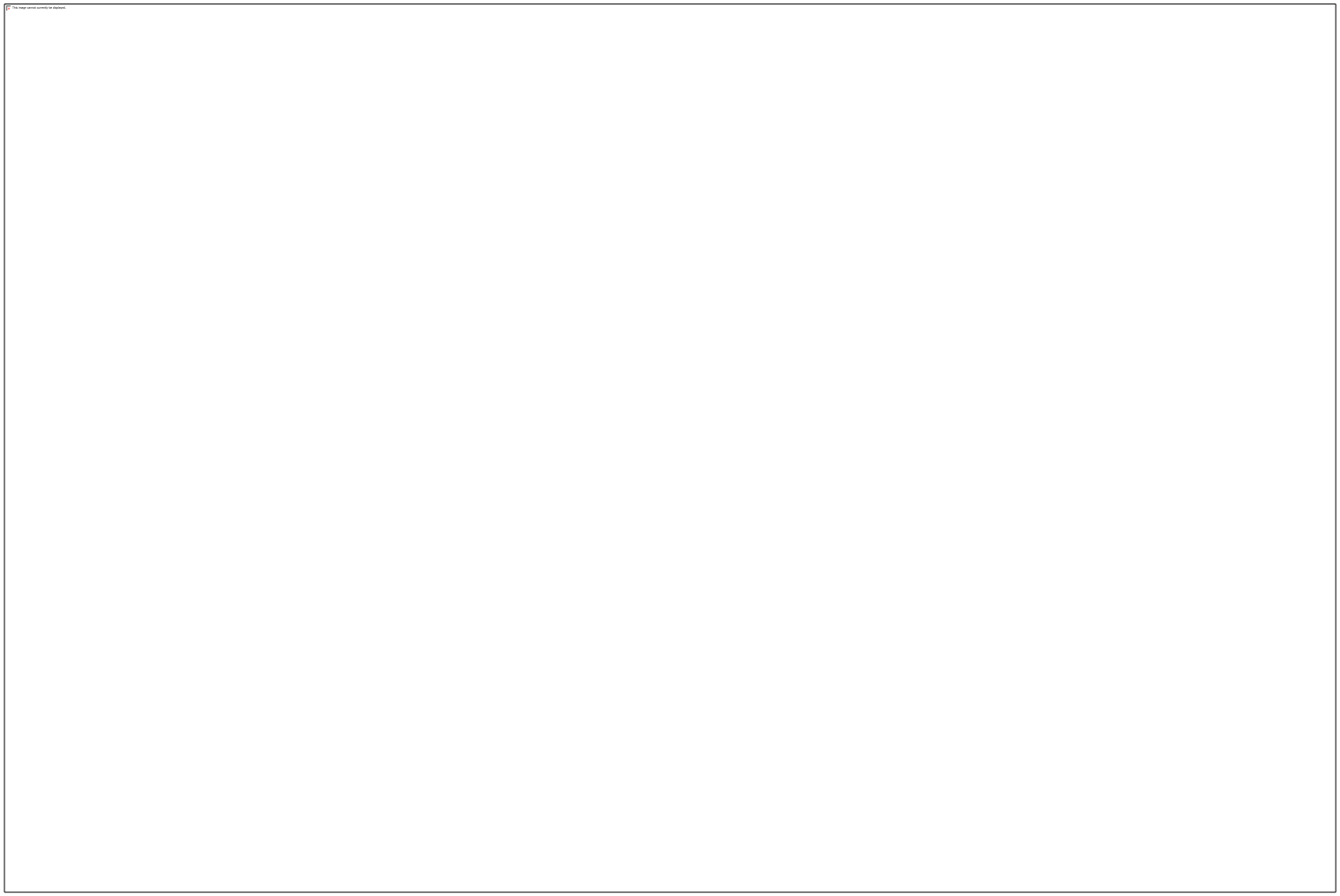
Definition

Bridging is the provision of a structural supporting member above a wall opening to carry the weight of the masonry or other building materials above the opening and transfer the loads safely to the supporting wall sections on either side.

When a door, window or other opening is formed in a masonry wall, the wall loses its continuity at that point. The masonry above the opening therefore requires support to prevent cracking, displacement or collapse.

The two main methods of bridging wall openings are:

1. Using lintels.
2. Using arches.



4.2 Importance of bridging wall openings

1. **Supporting masonry above openings**

- Bridging supports the weight of bricks, blocks or stones above a door or window opening.
- It prevents the unsupported masonry from falling.

2. **Transferring structural loads**

- It transfers loads from the masonry above the opening to the wall sections on either side.
- This helps maintain the stability of the building.

3. **Preventing cracks**

- Proper bridging reduces the likelihood of cracks developing above openings.

- It helps control structural movement caused by unsupported masonry.

4. **Maintaining wall stability**
   - It prevents the wall sections above openings from becoming unstable.
   - It helps maintain the integrity of the superstructure.
5. **Maintaining the shape of openings**
   - It helps preserve the intended width and height of doors and windows.
   - It prevents deformation of the opening.
6. **Supporting finishes**
   - It provides a stable base for plastering and other wall finishes.
   - It helps reduce cracking around the upper edges of openings.
7. **Improving building safety**
   - Properly designed bridging reduces the risk of masonry failure.
   - It protects building occupants from falling materials.
8. **Allowing larger openings**
   - Bridging makes it possible to provide wider door and window openings without leaving masonry unsupported.

5.0 TYPES OF BRIDGING USED ABOVE WALL OPENINGS

The two major types of bridging are:

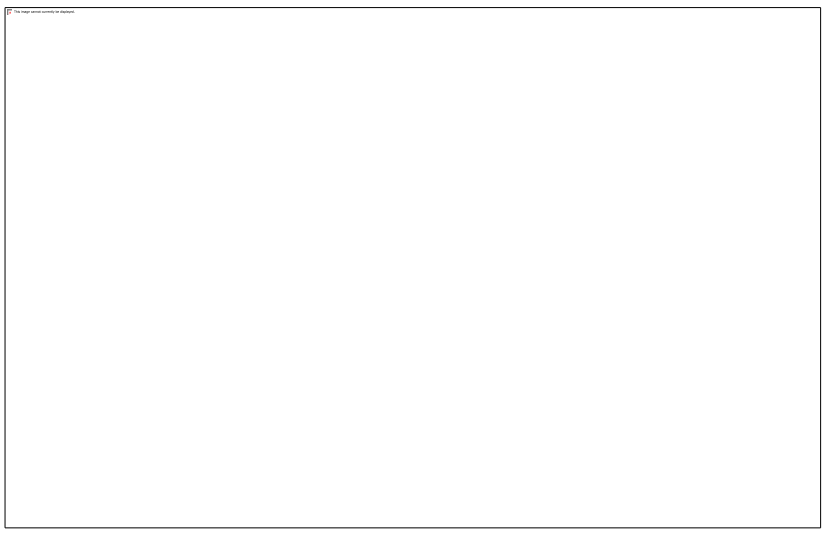
- Lintels.
- Arches.

5.1 LINTELS

Definition of a lintel

A lintel is a horizontal structural member placed across the top of a door, window or other wall opening to support the masonry or other loads above it and transfer them to the supporting wall sections on either side.

Lintels are widely used in Kenyan residential, commercial, institutional and industrial buildings.



5.1.1 Main parts of a lintel

1. Bearing ends

- These are the portions of the lintel that rest on the supporting masonry at either side of the opening.
- They transfer the loads carried by the lintel to the wall.
- The bearing length must be determined by the structural design.

2. Span

- This is the horizontal distance between the supporting points of the lintel.
- It generally corresponds to the clear opening plus the required bearing lengths.

3. Depth

- This is the vertical dimension of the lintel.
- It contributes to the structural capacity of the member.

4. Width

- This is the horizontal dimension measured across the wall thickness.
- It is normally selected to suit the wall construction and structural requirements.

5. Reinforcement

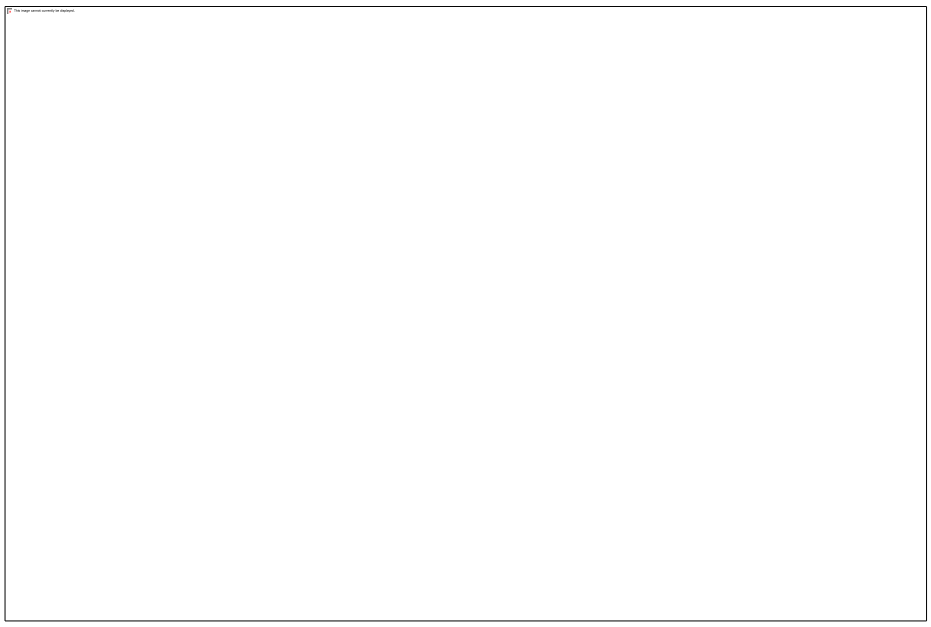
- In reinforced concrete lintels, steel bars are embedded in concrete.
- They provide tensile strength and help the lintel resist bending.
- The reinforcement arrangement must follow structural design specifications.

5.1.2 Types of lintels

Lintels are classified according to the materials used in their construction.

A. Timber lintels

Definition: A timber lintel is a horizontal timber member placed above a wall opening to support the materials above it.



Characteristics:

- Made from suitable structural timber.
- Relatively lightweight.
- Easy to cut and install.
- May be used in lightweight timber buildings.
- Requires protection against termites, moisture and fire.
- Must be designed to carry the intended loads.

Advantages:

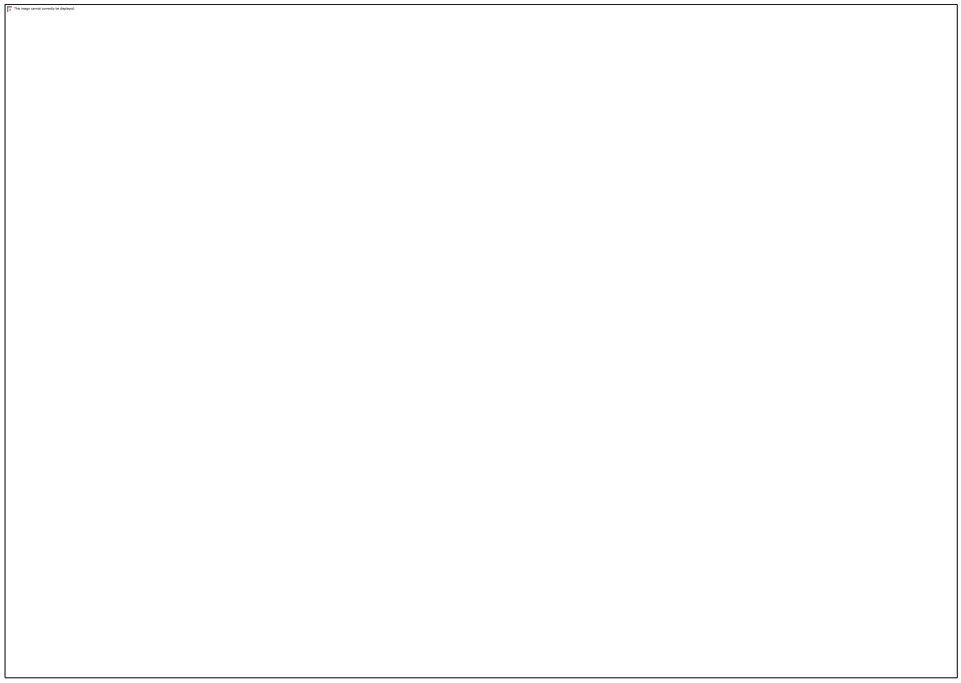
1. Easy to work with.
2. Relatively light in weight.
3. Can be installed quickly.
4. Requires simple carpentry tools.
5. Suitable for certain lightweight structures.

Disadvantages:

1. Susceptible to termite attack if untreated.
2. Can decay when exposed to excessive moisture.
3. Combustible.
4. May warp or shrink.
5. Has limitations in carrying heavy loads and spanning large openings.

B. Steel lintels

Definition: A steel lintel is a horizontal supporting member made from structural steel and installed above a wall opening.



Characteristics:

- Made from structural steel sections.
- May be manufactured using steel angles, channels or other suitable sections.
- Has high strength relative to its size.
- Can be used in buildings requiring slender supporting members.
- Requires protection against corrosion and fire as specified.

Advantages:

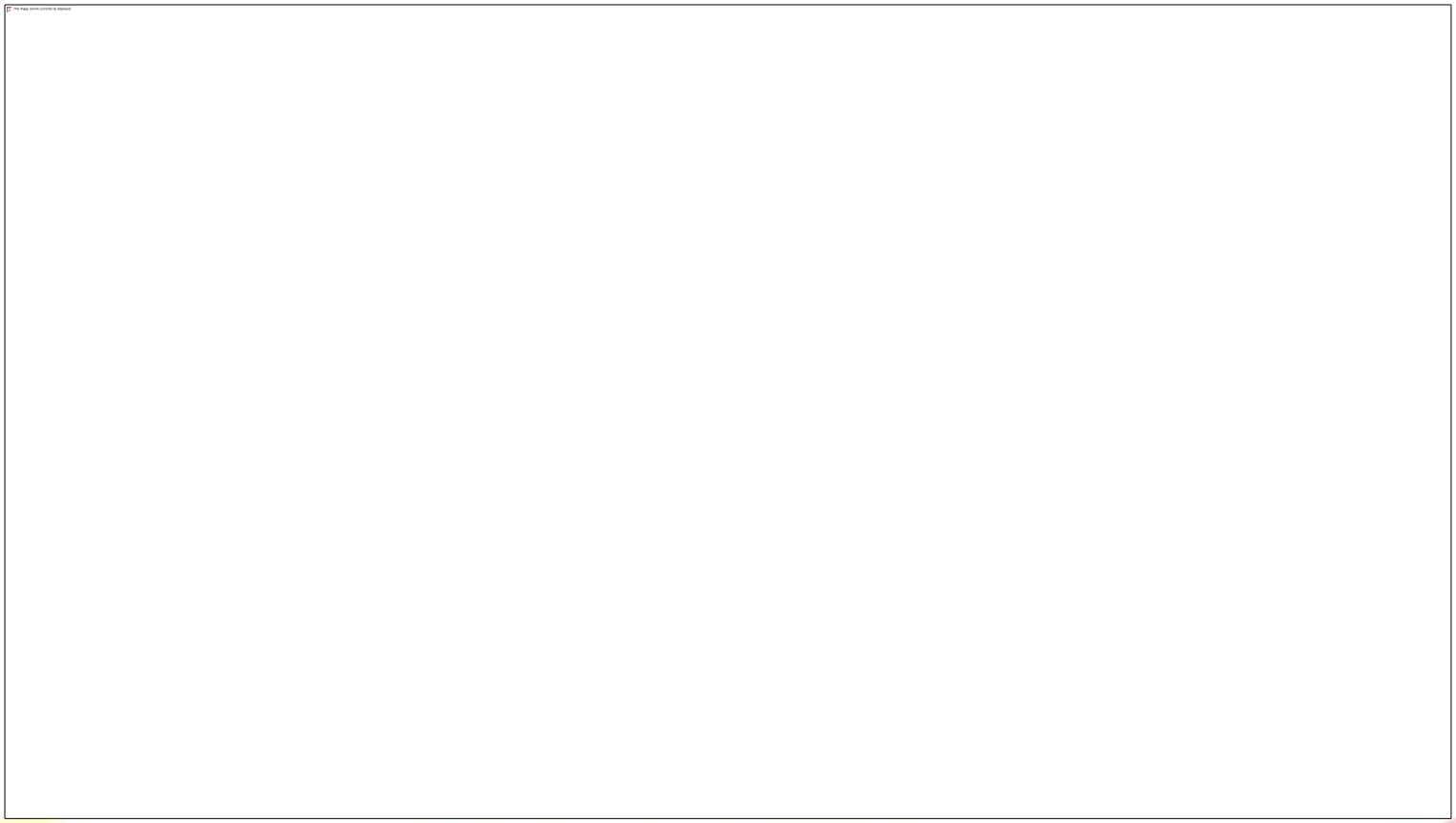
1. High strength.
2. Can support substantial loads when properly designed.
3. Suitable for different opening widths.
4. Can be fabricated to required dimensions.
5. Relatively quick to install.

Disadvantages:

1. May corrode when exposed to moisture.
2. May require fire protection.
3. Requires skilled fabrication and installation.
4. May be expensive.
5. Requires proper structural connections and bearing support.

C. Reinforced concrete lintels

Definition: A reinforced concrete lintel is a horizontal structural member made from concrete containing steel reinforcement bars, used to bridge wall openings.



Characteristics:

- Made using concrete and steel reinforcement.
- Can be cast in position or precast.
- Provides a durable supporting member when properly designed and constructed.
- Can be made to suit different wall thicknesses and opening dimensions.
- Requires suitable formwork when cast in position.

Advantages:

1. Strong and durable when properly constructed.
2. Resistant to weathering when adequately protected.
3. Can be integrated with reinforced concrete structural elements.
4. Suitable for many masonry buildings.
5. Can be constructed to different shapes and dimensions.

Disadvantages:

1. Requires formwork when cast in situ.
2. Needs adequate curing.
3. Requires skilled reinforcement fixing.
4. Can be relatively heavy.
5. Construction may take longer because concrete requires time to gain strength.

D. Stone lintels

Definition: A stone lintel is a horizontal piece of suitable natural stone placed above a wall opening to support the masonry above it.



Characteristics:

- Made from strong and suitable natural stone.
- May be used in traditional stone masonry.
- Can provide an attractive appearance.
- Requires careful selection and dressing of stone.
- Must be designed to resist bending and other structural forces.

Advantages:

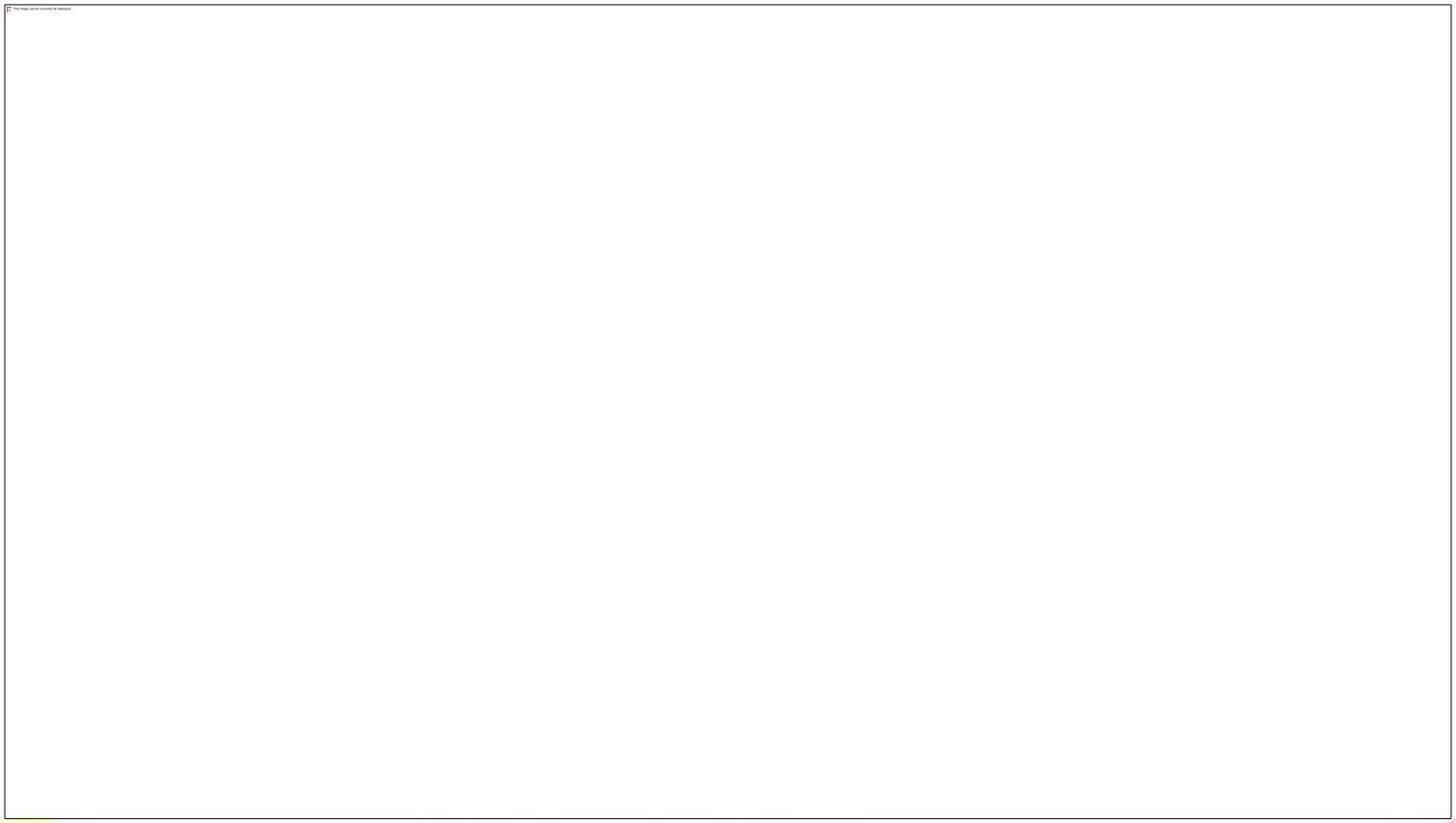
1. Durable when suitable stone is selected.
2. Resistant to many weather conditions.
3. Provides a natural architectural appearance.
4. Requires relatively little maintenance when properly installed.

Disadvantages:

1. Heavy to transport and install.
2. Difficult to cut and shape.
3. Some stones may crack under bending forces.
4. Requires careful structural design.
5. May be expensive due to dressing and installation.

E. Precast concrete lintels

Definition: A precast concrete lintel is a concrete supporting member manufactured and cured away from its final position before being transported to the site for installation.



Characteristics:

- Manufactured in a controlled environment.
- May contain steel reinforcement.
- Available in different dimensions.
- Transported to the site after adequate curing.
- Installed over prepared wall openings.

Advantages:

1. Reduces on-site formwork.
2. Speeds up construction.
3. Provides uniform dimensions.
4. Allows quality control during production.
5. Reduces the amount of concrete work carried out on site.

Disadvantages:

1. Requires transportation.
2. May need lifting equipment.
3. Can be damaged during handling.
4. Requires correct bearing and installation.
5. Must be selected according to the structural requirements.

5.1.3 General procedure for constructing a reinforced concrete lintel



Step 1: Study the construction drawings

- Identify the location of the opening.
- Establish the width and height of the opening.

- Check the lintel dimensions and reinforcement details.
- Confirm the required bearing length.

Step 2: Prepare the supporting masonry

- Construct the wall up to the required lintel level.
- Ensure that the masonry is stable.
- Check the bearing areas on both sides of the opening.
- Remove loose mortar and debris.

Step 3: Fabricate the formwork

- Measure the required lintel dimensions.
- Cut suitable timber boards or formwork panels.
- Prepare the bottom and side panels.
- Assemble the panels to form a mould.
- Provide supports to prevent the formwork from moving or collapsing.

Step 4: Fix the reinforcement

- Cut reinforcement bars according to the structural drawings.
- Bend and arrange the bars as specified.
- Tie the reinforcement using binding wire.
- Install suitable spacers to maintain the required concrete cover.
- Check the reinforcement before concreting.

Step 5: Prepare concrete

- Select the specified concrete materials.
- Measure and mix the materials according to the approved mix design.
- Ensure that the concrete is workable and suitable for placing.

Step 6: Place concrete

- Pour the concrete into the formwork.
- Distribute it evenly around the reinforcement.
- Compact the concrete properly using an appropriate method.
- Avoid leaving voids or honeycombing.

Step 7: Finish the concrete

- Level the upper surface where required.
- Check the shape and dimensions.
- Protect the fresh concrete from damage.

Step 8: Cure the lintel

- Keep the concrete adequately moist using an appropriate curing method.

- Protect it from premature drying.
- Allow sufficient time for strength development.

Step 9: Remove formwork

- Remove the formwork only when the concrete has gained sufficient strength.
- Follow the specified striking times and structural instructions.
- Avoid disturbing the lintel.

Step 10: Continue masonry construction

- Continue building the wall above the lintel when it is safe to do so.
- Ensure that construction loads do not exceed the lintel's capacity.

Important: Reinforcement size, concrete grade, lintel dimensions, bearing length, propping and striking times must be determined by the structural design and applicable construction requirements. They should not be guessed on site.

6.0 ARCHES USED IN BRIDGING WALL OPENINGS

6.1 Meaning of an arch

Definition

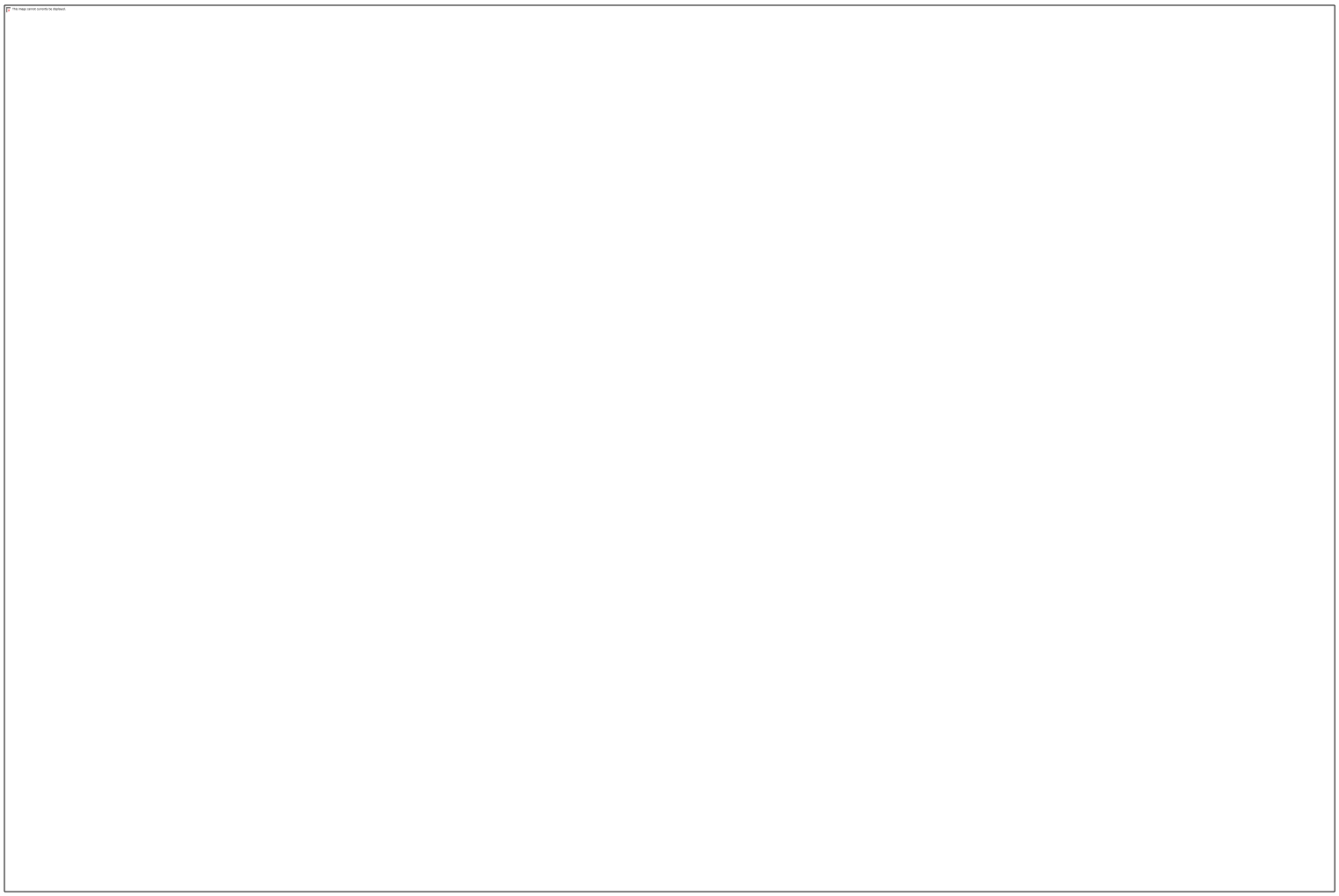
An arch is a curved structural arrangement constructed over a wall opening to support the masonry or other loads above it and transfer those loads to the supporting sections on either side.

Unlike a lintel, which generally acts as a horizontal beam, an arch carries loads mainly through compression along its curved shape.

Arches are commonly constructed using bricks, dressed stones, concrete or other suitable materials.



6.2 Main parts of an arch



1. Voussoirs

- These are wedge-shaped units forming the curved body of an arch.
- They may be made from specially shaped bricks or dressed stones.
- They are arranged so that their joints direct forces towards the supports.

2. Keystone

- This is the central voussoir placed at the crown of an arch.
- It is usually inserted near the end of arch construction.
- It helps lock the arch units together.

3. Crown

- This is the highest point of the arch.
- It is located at the centre of the arch span in a symmetrical arch.

4. Springing point

- This is the point from which the arch curve begins to rise.
- It marks the transition between the supporting structure and the curved arch.

5. Springing line

- This is the horizontal reference line passing through the springing points.

6. Intrados

- This is the inner curved surface of the arch.
- It faces the opening beneath the arch.

7. Extrados

- This is the outer curved surface of the arch.
- It forms the upper boundary of the arch.

8. Abutment

- An abutment is the supporting structure at either end of an arch.
- It resists the outward thrust generated by the arch.

9. Span

- This is the horizontal distance between the supports of an arch.

10. Rise

- This is the vertical distance from the springing line to the crown of the arch.

11. Haunch

- This is the curved portion of an arch between the crown and the springing area.

12. Impost

- This is the supporting or projecting member on which the arch begins to spring.

6.3 How an arch supports loads

An arch transfers loads through compression along its curved profile.

The loads are transmitted through the arch units towards the supporting ends. The abutments must be strong enough to resist the resulting vertical reactions and horizontal thrust.

The construction of an arch therefore requires:

- Properly shaped arch units.
- Accurate positioning of voussoirs.
- Correct joint arrangements.
- Adequately designed abutments.
- Properly fabricated and supported centring or formwork during construction.

7.0 TYPES OF ARCHES USED ABOVE WALL OPENINGS

The common types of arches studied in this sub-strand are:

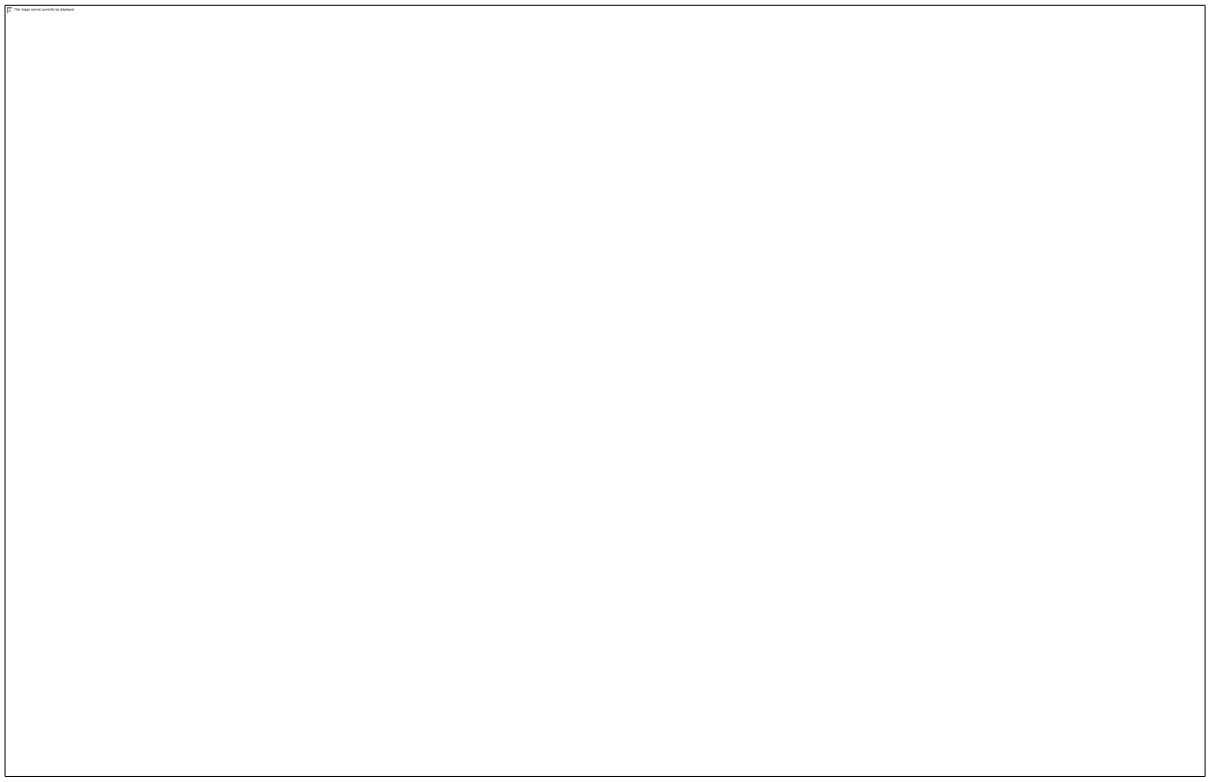
1. Flat arch.
2. Segmental arch.
3. Semi-circular arch.

7.1 FLAT ARCH

Definition

A flat arch is an arch that has a nearly horizontal appearance at the intrados, although its construction involves slightly inclined joints arranged to transfer forces towards the supports.

It is also commonly referred to as a jack arch.



Characteristics of a flat arch

1. It has a relatively flat appearance.
2. It is formed using bricks or stones arranged in a carefully designed pattern.
3. The joints are inclined towards a suitable centre of construction.
4. It has a relatively small rise compared with its span.
5. It requires accurate cutting and positioning of arch units.
6. It requires properly designed supporting masonry.

Construction procedure

Step 1: Prepare the opening

- Construct the wall to the required springing level.
- Check the width and position of the opening.
- Ensure that the supporting masonry is stable.

Step 2: Prepare the arch design

- Determine the arch shape and dimensions.
- Identify the number and arrangement of arch units.
- Prepare the required bricks or stones.

Step 3: Fabricate the formwork

- Prepare a suitable template or centring arrangement.

- Ensure that it supports the arch units in the correct positions.
- Provide adequate support during construction.

Step 4: Position the arch units

- Place the first units at the springing points.
- Continue laying the units towards the centre.
- Maintain the designed joint arrangement.

Step 5: Insert the central unit

- Position the central unit according to the design.
- Ensure that the arch arrangement is properly locked.

Step 6: Complete the arch

- Fill the joints with suitable mortar.
- Check alignment and appearance.
- Allow the mortar to gain sufficient strength.

Step 7: Remove the centring

- Remove the support only when the arch has gained adequate strength.
- Follow the approved construction procedure.

Advantages of flat arches

1. Provide a relatively flat upper profile.
2. Have a simple architectural appearance.
3. Can be used where headroom is limited.
4. Can be constructed using suitable masonry units.
5. Provide an attractive finish in traditional buildings.

Disadvantages

1. Require accurate cutting and positioning.
2. Develop horizontal thrust.
3. Require strong supporting abutments.
4. May be unsuitable for large spans without special design.
5. Poor workmanship can result in cracking or failure.

Applications

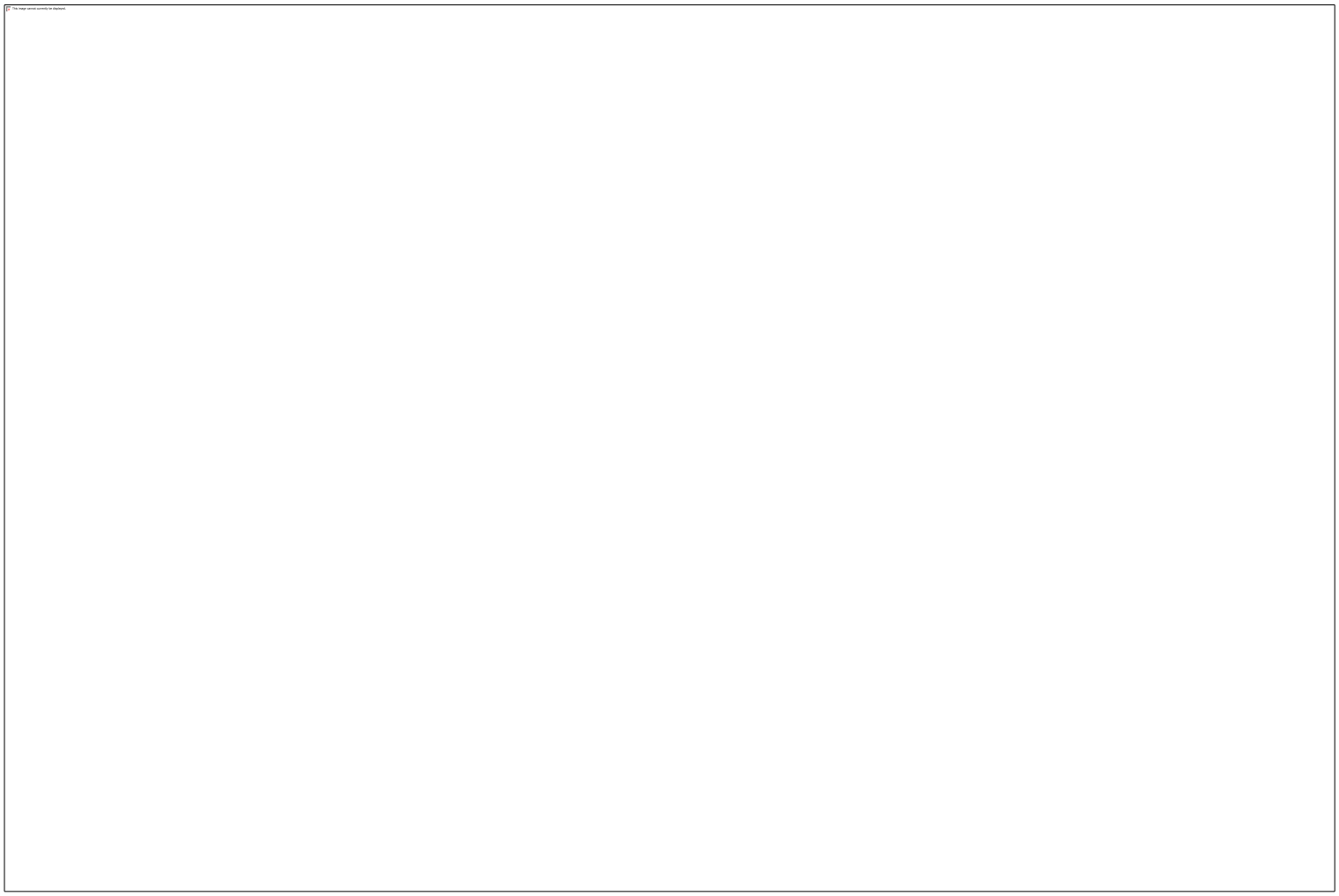
- Window openings.
- Door openings in traditional masonry buildings.
- Decorative brickwork.
- Small masonry openings where structurally suitable.

7.2 SEGMENTAL ARCH

Definition

A segmental arch is an arch formed from a segment of a circle, having a curved profile that is less than a semicircle.

It has a relatively shallow curve and is commonly used above door and window openings.



Characteristics

1. It has a curved profile.
2. Its curve forms part of a circle.
3. Its rise is less than half the span.
4. It is usually constructed using wedge-shaped bricks or stones.
5. It requires suitable centring during construction.
6. It transfers loads towards the supporting abutments.

Construction procedure

1. Prepare the wall up to the required springing level.
2. Determine the span and rise of the arch.
3. Prepare the arch units.
4. Fabricate a curved timber template or centring.
5. Position the centring over the opening.

6. Lay the arch units from both springing points towards the crown.
7. Maintain uniform and properly arranged joints.
8. Insert the central keystone or final central unit where the design requires one.
9. Fill the joints with mortar.
10. Allow the mortar to gain adequate strength.
11. Remove the centring carefully.
12. Inspect the finished arch.

Advantages

1. Provides an attractive curved appearance.
2. Can be used for different architectural designs.
3. Requires less rise than a semi-circular arch.
4. Can be constructed using bricks or stones.
5. Provides an effective compression-based load path when properly designed.

Disadvantages

1. Requires accurate setting out.
2. Needs suitable formwork or centring.
3. Produces horizontal thrust.
4. Requires strong supporting masonry.
5. Poorly constructed joints may lead to instability.

Applications

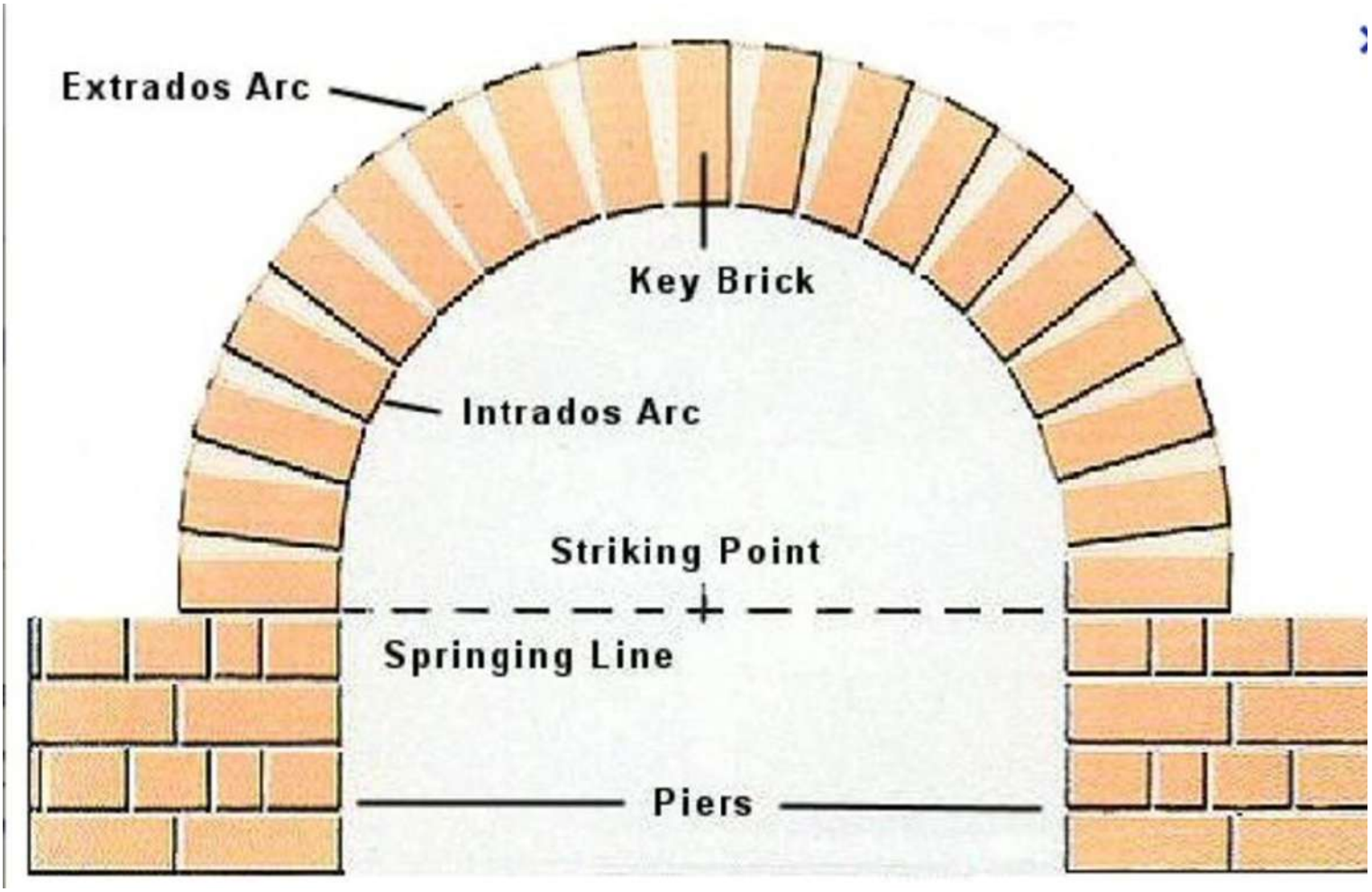
- Residential building windows.
- Door openings.
- Decorative masonry work.
- Traditional and modern architectural designs.

7.3 SEMI-CIRCULAR ARCH

Definition

A semi-circular arch is an arch whose curved profile forms exactly half of a circle.

Its rise is equal to half of its span.



Characteristics

1. It forms half of a circle.
2. Its rise is equal to half its span.
3. It has a symmetrical curved shape.
4. It is commonly constructed using wedge-shaped bricks or stones.
5. It requires a carefully prepared semi-circular centring.
6. It transfers loads towards the supporting abutments.

Construction procedure

Step 1: Prepare the opening

- Construct the supporting wall sections.
- Establish the required span.
- Check the positions of the springing points.

Step 2: Determine the arch dimensions

- Measure the span.
- Calculate the required rise.
- For a semi-circular arch, the rise is half the span.

Example

If the span is 2 metres:

Rise=Span2*Rise*=2*Span*

Rise=22=1m*Rise*=22=1*m*

Therefore, the rise of the semi-circular arch is 1 metre.

Step 3: Prepare the centring

- Mark a semi-circular profile on a suitable timber board.
- Cut the curved shape.
- Assemble the supporting framework.
- Ensure that the centring is stable and level.

Step 4: Position the centring

- Place the centring over the opening.
- Support it firmly.
- Check the curve and alignment.

Step 5: Lay the arch units

- Begin laying the units from both springing points.
- Work upwards towards the crown.
- Maintain the correct curvature and joint thickness.

Step 6: Complete the crown

- Place the final central unit as specified.
- Check the alignment of the arch.

Step 7: Finish the arch

- Fill joints with mortar.
- Remove excess mortar.
- Allow the arch to gain adequate strength.

Step 8: Remove centring

- Remove the supporting formwork gradually and carefully when authorised.
- Inspect the finished arch for cracks and movement.

Advantages

1. Has a symmetrical and attractive appearance.
2. Has a clearly defined geometric shape.
3. Can be constructed using standard arch units.
4. Provides a suitable compression-based structural form.
5. Can be used in traditional and decorative buildings.

Disadvantages

1. Requires more vertical space than a shallow segmental arch of the same span.
2. Requires accurate centring.
3. Produces horizontal thrust.
4. Needs properly designed abutments.
5. Requires skilled workmanship.

Applications

- Entrance doorways.
- Decorative windows.
- Churches and institutional buildings.
- Traditional masonry buildings.
- Architectural features in residential buildings.

8.0 COMPARISON OF LINTELS AND ARCHES

Lintels and arches are both used to bridge wall openings. However, they differ in their shapes, construction methods and load-transfer mechanisms.



Feature	Lintel	Arch
Shape	Generally horizontal	Curved or flat-appearing curved form
Main materials	Timber, steel, concrete or stone	Bricks, stones or concrete

Load transfer	Acts mainly through bending and shear	Acts mainly through compression
Construction	Relatively straightforward	Requires accurate shaping and centring
Support	Requires adequate bearing at both ends	Requires suitable abutments
Formwork	Required for cast-in-situ concrete lintels	Centring normally required during construction
Appearance	Usually straight	Usually curved
Main application	Door and window openings	Door and window openings

8.1 Advantages of lintels compared with arches

1. Generally easier to construct.
2. Can provide a straight upper boundary.
3. Suitable for different wall construction materials.
4. Can be prefabricated.
5. Often require less specialised masonry workmanship.
6. Can be integrated with reinforced concrete construction.

8.2 Advantages of arches compared with lintels

1. Provide an attractive architectural appearance.
2. Transfer loads mainly through compression.
3. Can be constructed using suitable masonry units.
4. Can provide distinctive traditional architectural features.
5. May reduce the need for a conventional horizontal beam where an appropriately designed arch is suitable.

8.3 Factors determining the choice between lintels and arches

1. Width of the opening.
2. Magnitude of the loads above the opening.
3. Type of wall construction.
4. Availability of construction materials.
5. Architectural requirements.
6. Cost of construction.
7. Availability of skilled labour.

8. Construction time.
9. Strength of supporting masonry.
10. Structural design requirements.

9.0 FORMWORK FOR BRIDGING WALL OPENINGS

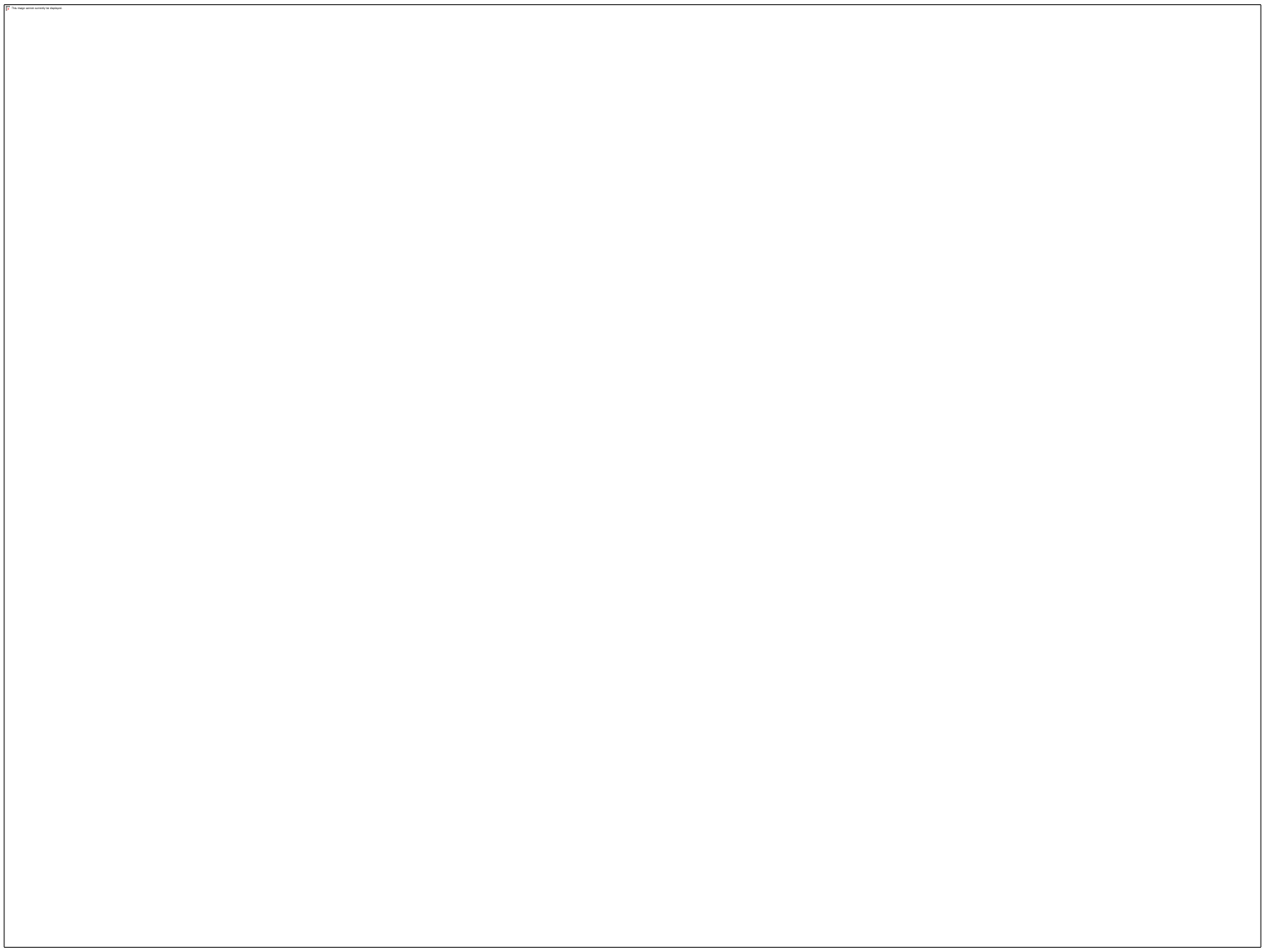
9.1 Meaning of formwork

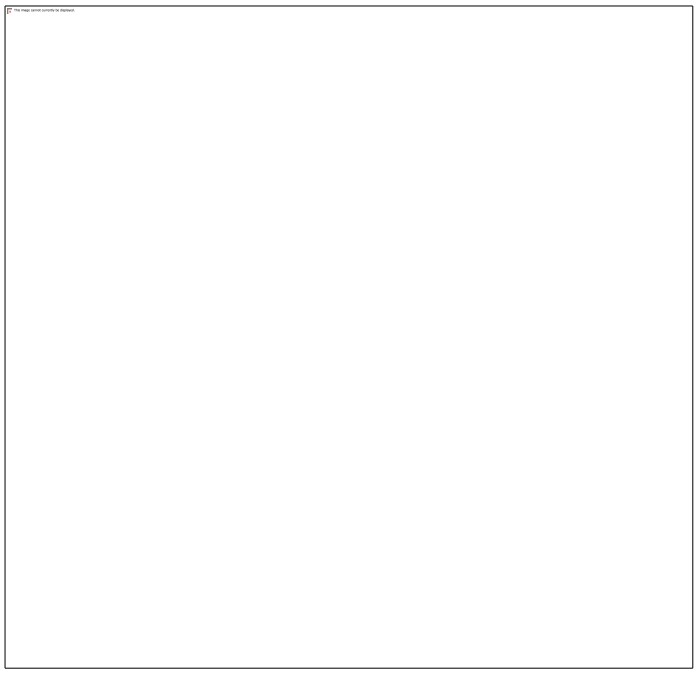
Definition

Formwork is a temporary or permanent mould into which fresh concrete is placed to give it the required shape, dimensions and position until it gains sufficient strength to support itself.

In wall opening construction, formwork is commonly used when casting reinforced concrete lintels.

For arches, a temporary supporting structure called *centring* is used to support the arch units during construction until the arch can safely carry its own weight and the imposed loads.







9.2 Importance of formwork

1. **Provides the required shape**
   - It gives fresh concrete the required lintel shape.
2. **Maintains dimensions**
   - It ensures that the concrete member has the specified width, depth and length.
3. **Supports fresh concrete**
   - It holds the weight of fresh concrete and reinforcement during casting.
4. **Prevents leakage**

- Properly fitted formwork prevents excessive loss of cement paste through gaps.

5. **Maintains alignment**
   - It ensures that the lintel is correctly positioned above the opening.
6. **Improves surface finish**
   - It provides a suitable surface to the concrete after formwork removal.
7. **Provides stability during construction**
   - It prevents fresh concrete from spreading or changing shape.
8. **Improves construction accuracy**
   - It helps achieve the dimensions shown in construction drawings.

9.3 Materials used in fabricating formwork

The following materials are commonly used:

1. Timber boards
- Used to make the sides and bottom of the formwork.
- They can be cut and assembled to the required dimensions.
- They should be sufficiently strong and reasonably straight.

2. Plywood
- Used to provide smooth formwork surfaces.
- It is suitable for making lintel moulds.
- Formwork-grade plywood is preferable for repeated use.

3. Timber battens
- Used to reinforce and stiffen formwork panels.
- They help prevent deformation under the weight of fresh concrete.

4. Nails
- Used to connect timber formwork components.
- They should be of suitable size and strength.

5. Screws
- Used to join formwork components.
- They allow easier dismantling where necessary.

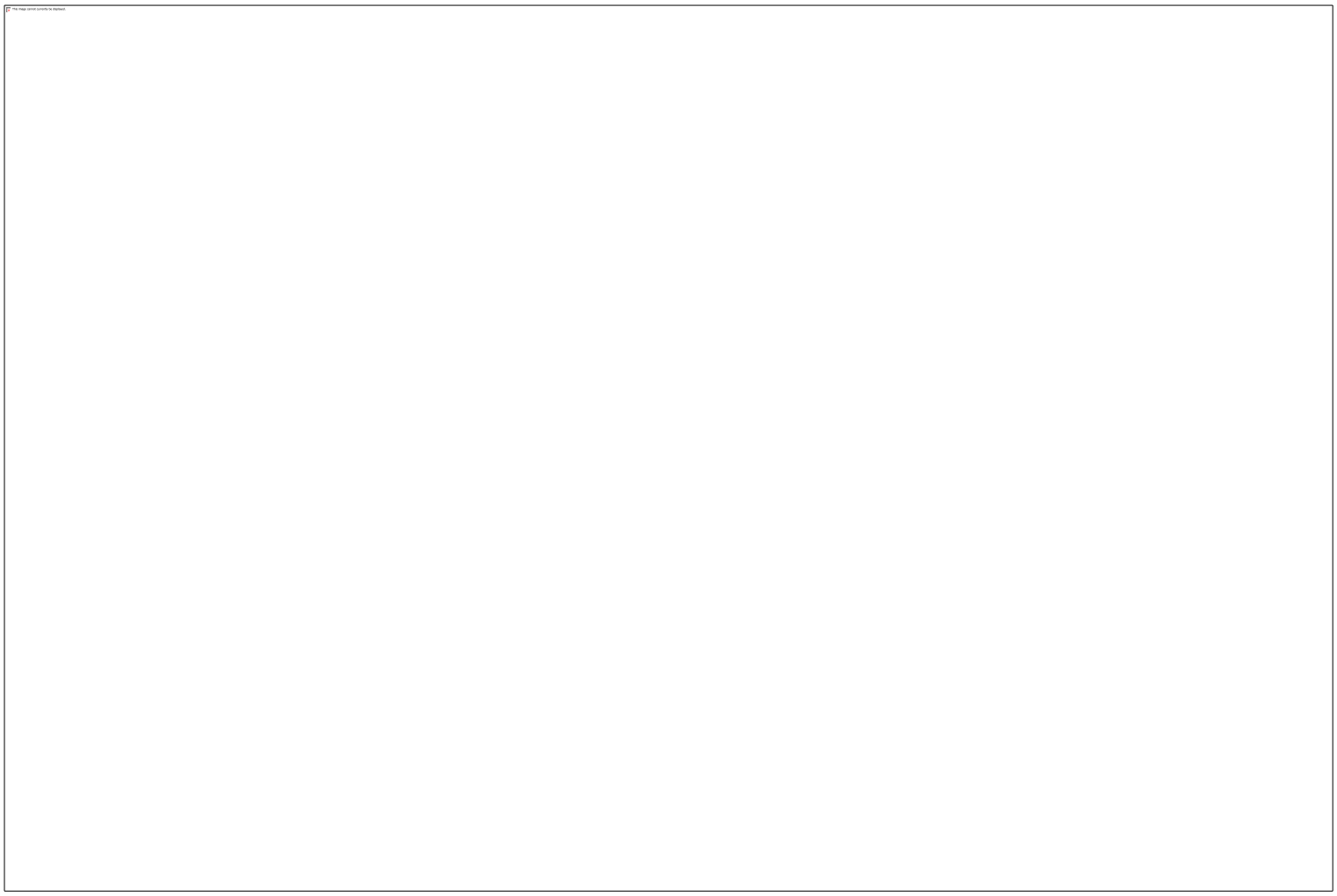
6. Props
- These are vertical supports used to carry the formwork and fresh concrete loads.
- They must be stable and properly positioned.

7. Braces
- Used to prevent movement and sideways displacement of the formwork.
- They improve stability.

8. Release agent

- Applied to the inside surface of suitable formwork.
- It helps prevent concrete from sticking to the formwork.
- It facilitates removal without damaging the concrete surface.

9.4 Tools used in fabricating formwork



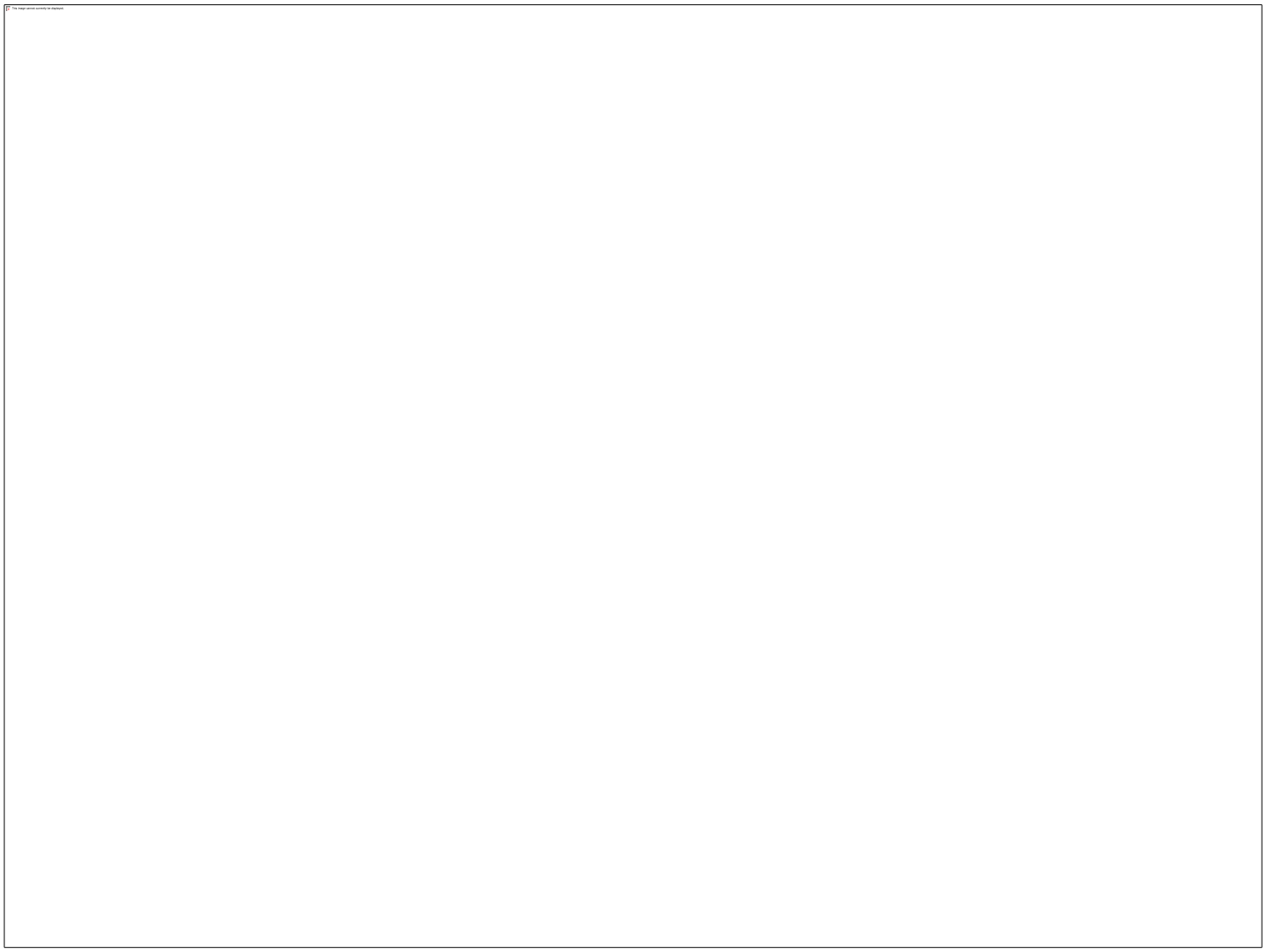
1. Tape measure – measuring timber boards and formwork dimensions.
2. Carpenter's pencil – marking cutting lines.
3. Try square – checking right angles.
4. Hand saw – cutting timber boards.
5. Circular saw – making straight cuts in formwork materials.
6. Claw hammer – driving and removing nails.
7. Screwdriver – fixing and removing screws.
8. Spirit level – checking horizontal and vertical alignment.
9. Drill – making holes and driving screws.
10. Clamps – holding components during assembly.

10.0 FABRICATION OF FORMWORK FOR A REINFORCED CONCRETE LINTEL

10.1 Meaning of fabrication

Fabrication is the process of measuring, cutting, shaping and assembling materials to produce a required construction component.

Fabrication of lintel formwork involves preparing and joining timber boards or plywood to create a mould of the required lintel dimensions.



10.2 Procedure for fabricating lintel formwork

Step 1: Study the structural drawings

- Obtain the approved construction drawings.
- Identify the location of the lintel.
- Determine the required length, width and depth.
- Establish the bearing arrangements.
- Confirm the reinforcement details.

Step 2: Select suitable materials

- Choose strong timber boards or formwork-grade plywood.
- Select suitable timber battens for stiffening.

- Obtain nails, screws and other fixing materials.
- Select appropriate supports and braces.

Step 3: Measure and mark the formwork materials

- Use a tape measure to establish the required dimensions.
- Mark the bottom board.
- Mark the two side boards.
- Mark the positions of supporting battens.
- Check the dimensions against the structural drawings.

Step 4: Cut the formwork materials

- Cut the bottom board to the required length and width.
- Cut the side boards to the required dimensions.
- Cut timber battens for reinforcement.
- Smooth rough edges where necessary.

Step 5: Assemble the bottom and side boards

- Place the bottom board on a suitable working surface.
- Position the side boards along its edges.
- Ensure that the side boards form the required lintel depth.
- Fix them using suitable nails or screws.

Step 6: Install supporting battens

- Fix battens along the external surfaces of the side boards.
- Provide additional supports where required.
- Ensure that the formwork can resist the pressure of fresh concrete.

Step 7: Provide props and bracing

- Position suitable props beneath the formwork.
- Ensure that the props stand on firm supports.
- Install braces to prevent sideways movement.
- Check that the complete arrangement is stable.

Step 8: Check dimensions and alignment

- Measure the internal width and depth.
- Check the length of the mould.
- Use a spirit level to check horizontal alignment.
- Check that the sides are straight and properly fixed.
- Correct any defects.

Step 9: Apply release agent

- Clean the inside surfaces.
- Apply a suitable formwork release agent.
- Avoid excessive application that could contaminate reinforcement or concrete.

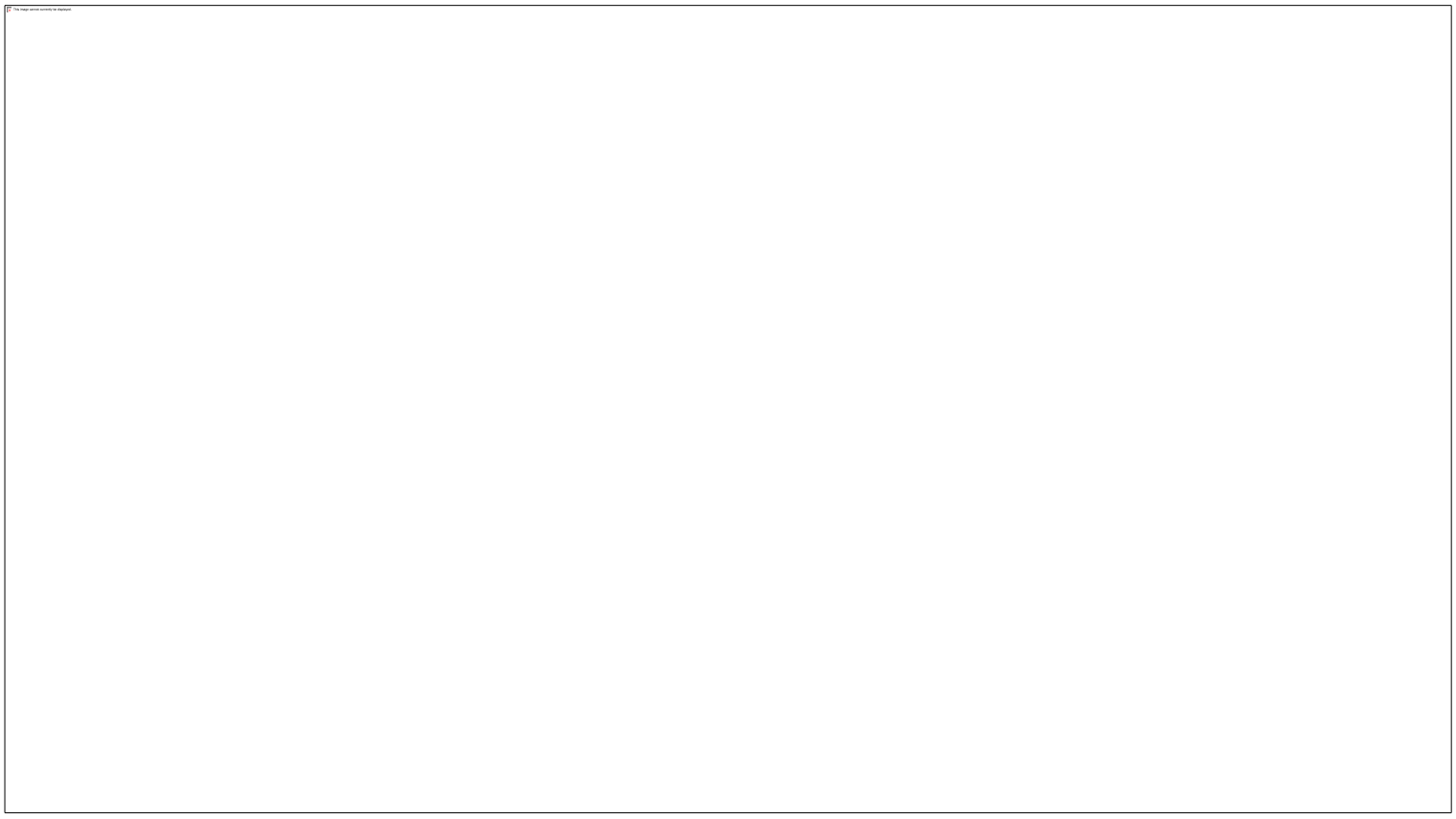
Step 10: Install reinforcement

- Position the reinforcement according to the structural drawings.
- Use suitable spacers to maintain concrete cover.
- Ensure that reinforcement does not touch the formwork.

Step 11: Inspect before concreting

- Check all joints for gaps.
- Confirm that supports and braces are secure.
- Check the reinforcement position.
- Obtain the required inspection or approval before concrete placement.

10.3 Sketch of lintel formwork



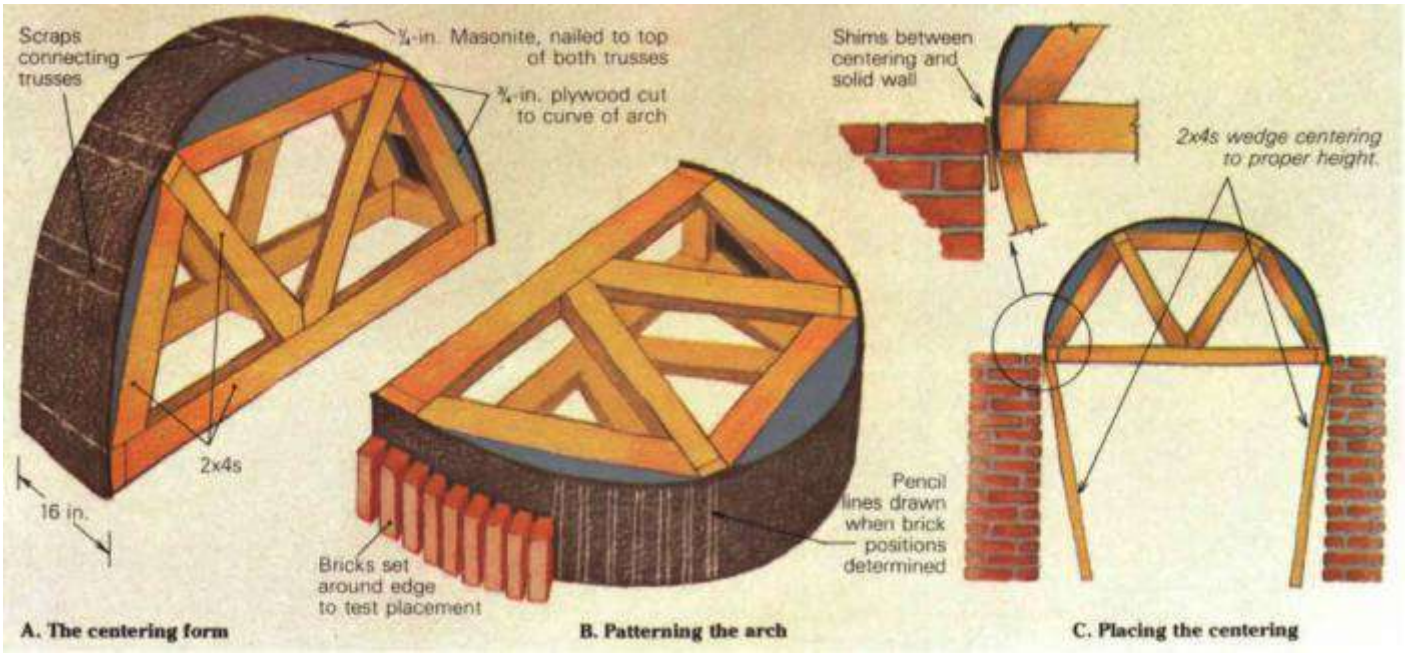
Note: The actual formwork must be designed to withstand the weight and pressure of fresh concrete without excessive movement or deformation.

11.0 CENTRING FOR ARCH CONSTRUCTION

11.1 Meaning of centring

Centring is a temporary curved supporting framework constructed to hold masonry arch units in their correct positions during the construction of an arch.

It supports the arch until the masonry units and mortar have developed sufficient strength to make the arch self-supporting.



11.2 Materials used in arch centring

1. Plywood – used to form the curved profile.
2. Timber boards – used to form the supporting framework.
3. Timber battens – used to stiffen the framework.
4. Nails and screws – used for fixing components.
5. Timber props – used to support the centring.
6. Braces – used to prevent movement.
7. Wedges – used to facilitate controlled removal where appropriate.

11.3 Procedure for fabricating arch centring

Step 1: Determine the arch dimensions

- Study the architectural and structural drawings.
- Establish the span of the arch.
- Determine the rise and shape.
- Identify the springing positions.

Step 2: Prepare a template

- Draw the required arch profile on plywood or another suitable material.
- Check the curvature and dimensions.

- Ensure that the two sides are symmetrical where required.

Step 3: Cut the curved profile

- Cut the marked profile using a suitable saw.
- Smooth the edges.
- Prepare matching curved members.

Step 4: Assemble the centring

- Join the curved members using timber battens.
- Provide sufficient stiffening.
- Ensure that the framework maintains the required shape.

Step 5: Install the supports

- Position props beneath the centring.
- Ensure that the props stand on firm ground or suitable support.
- Provide adequate bracing.

Step 6: Position the centring

- Place the centring over the wall opening.
- Align it with the springing points.
- Check the span and rise.
- Ensure that the framework is level across the width.

Step 7: Inspect the arrangement

- Check stability.
- Confirm that the framework cannot move sideways.
- Check that it can support the weight of the arch during construction.

Step 8: Construct the arch

- Lay the arch units in the correct sequence.
- Maintain the required curvature.
- Complete the central portion as specified.

Step 9: Remove centring

- Allow the arch to gain adequate strength.
- Remove the centring gradually and carefully.
- Inspect the completed arch for movement or cracking.

11.4 Difference between lintel formwork and arch centring

Lintel formwork	Arch centring
Usually forms a rectangular mould	Provides a curved supporting profile
Commonly used for cast-in-situ concrete lintels	Used when constructing masonry arches
Holds fresh concrete	Supports arch units and mortar
Has a bottom and side panels	Has a curved supporting surface
Removed after concrete gains adequate strength	Removed after the arch becomes self-supporting

12.0 MASONRY WORK ASSOCIATED WITH WALL OPENINGS

12.1 Meaning of masonry

Masonry is the construction of walls and other structures by laying individual building units such as bricks, blocks or stones and joining them using mortar or another suitable bonding material.

Masonry work is important when forming door and window openings because the wall sections surrounding the openings must remain stable and correctly aligned.



12.2 Materials used in masonry around openings

1. Bricks

- Small rectangular masonry units made from clay or other suitable materials.
- Used to construct walls and the sides of openings.

2. Concrete blocks

- Manufactured masonry units made from concrete.
- Commonly used in residential, commercial and institutional buildings.
- Available in different sizes and shapes.

3. Natural stones

- Used in stone masonry construction.
- They may be dressed or undressed depending on the type of masonry.
- Suitable stones provide durable wall construction.

4. Cement

- Used in preparing cement-based mortar.
- It acts as a binding material.

5. Sand

- Used as a fine aggregate in mortar.
- It contributes to the volume and workability of the mixture.

6. Water

- Used for mixing mortar and concrete.
- It should be clean and suitable for construction.

7. Mortar

- A workable mixture used to bind bricks, blocks or stones together.
- It fills joints and helps distribute loads between masonry units.

8. Reinforcement

- Steel bars or other specified reinforcing materials may be incorporated in lintels and other structural components.

12.3 Important considerations when constructing masonry around openings

1. **Correct dimensions**

- Openings should be constructed according to approved drawings.
- Incorrect dimensions may cause difficulties when installing door and window frames.

2. **Vertical jambs**

- The sides of the opening should be properly aligned.
- This ensures correct fitting of the frames.

3. **Horizontal head**

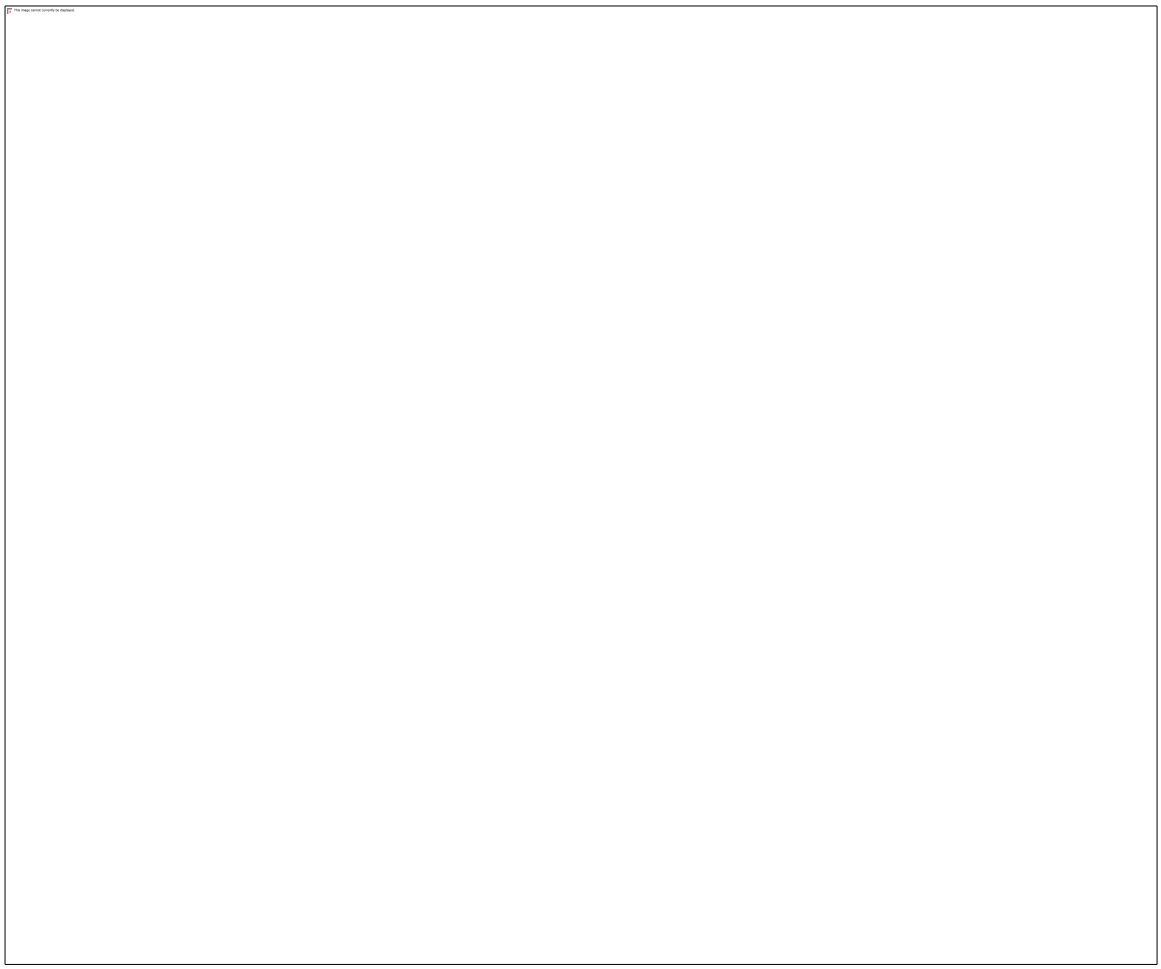
- The upper boundary should be accurately formed.
- It should accommodate the specified lintel or arch arrangement.

4. **Proper bonding**
   - Masonry units should be laid in the required bond.
   - Proper bonding helps improve wall stability.
5. **Mortar joint thickness**
   - Joints should be uniform and comply with the specified masonry requirements.
6. **Adequate bridging**
   - Lintels or arches should be provided according to the design.
   - Unsupported masonry above an opening can become unstable.
7. **Correct bearing**
   - Lintels and arches must have adequate support on both sides.
   - The bearing arrangement must comply with the structural design.
8. **Protection against moisture**
   - Window sills and external door thresholds should be detailed to control water entry.
9. **Proper curing**
   - Cement-based masonry and concrete components should be cured as specified.
10. **Quality inspection**
    - Check dimensions, alignment, joint quality and stability before proceeding.

13.0 TOOLS AND EQUIPMENT USED IN CONSTRUCTING WALL OPENINGS AND BRIDGING

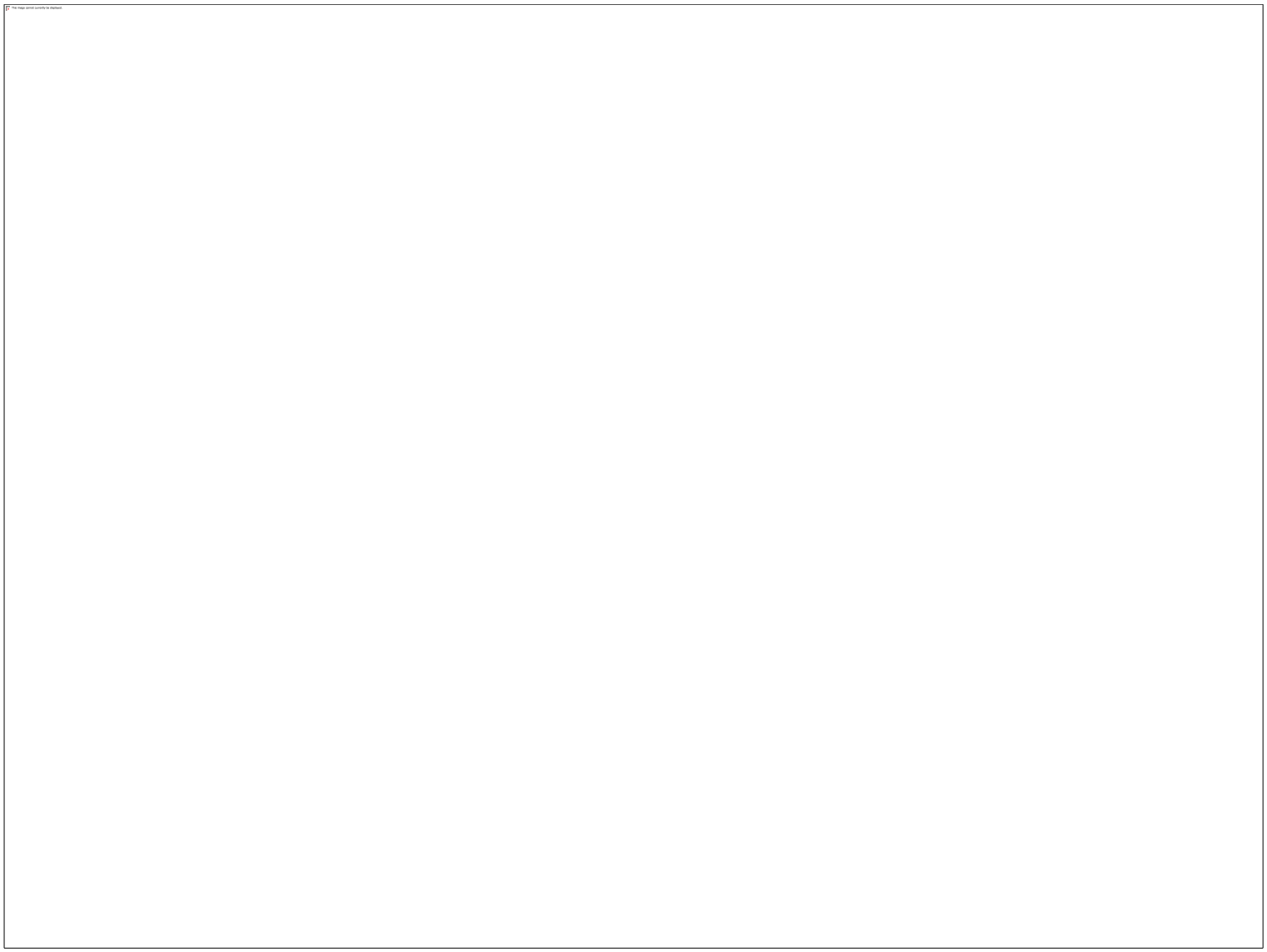
Different tools are required for measuring, marking, cutting, laying masonry units, mixing mortar, fabricating formwork and checking the completed work.

13.1 Measuring and setting-out tools



Tool	Function
Tape measure	Measures opening width, height and wall dimensions.
Steel rule	Measures short distances accurately.
Try square	Checks right angles.
Spirit level	Checks horizontal and vertical alignment.
Plumb bob	Checks verticality of jambs and walls.
Chalk line	Marks long straight lines.
String line	Maintains straight masonry courses and alignment.

13.2 Masonry tools



1. Brick trowel

- Used for spreading mortar.
- Used for placing and adjusting bricks.
- Helps remove excess mortar from joints.

2. Pointing trowel

- Used for filling and finishing mortar joints.
- Useful for detailed work around openings.

3. Club hammer

- Used for striking masonry chisels.
- May be used for suitable masonry preparation work.

4. Bolster chisel

- Used for cutting bricks and blocks.
- Helps produce suitable masonry shapes.

5. Masonry hammer

- Used for dressing and shaping certain masonry units.
- It should be used with appropriate protective equipment.

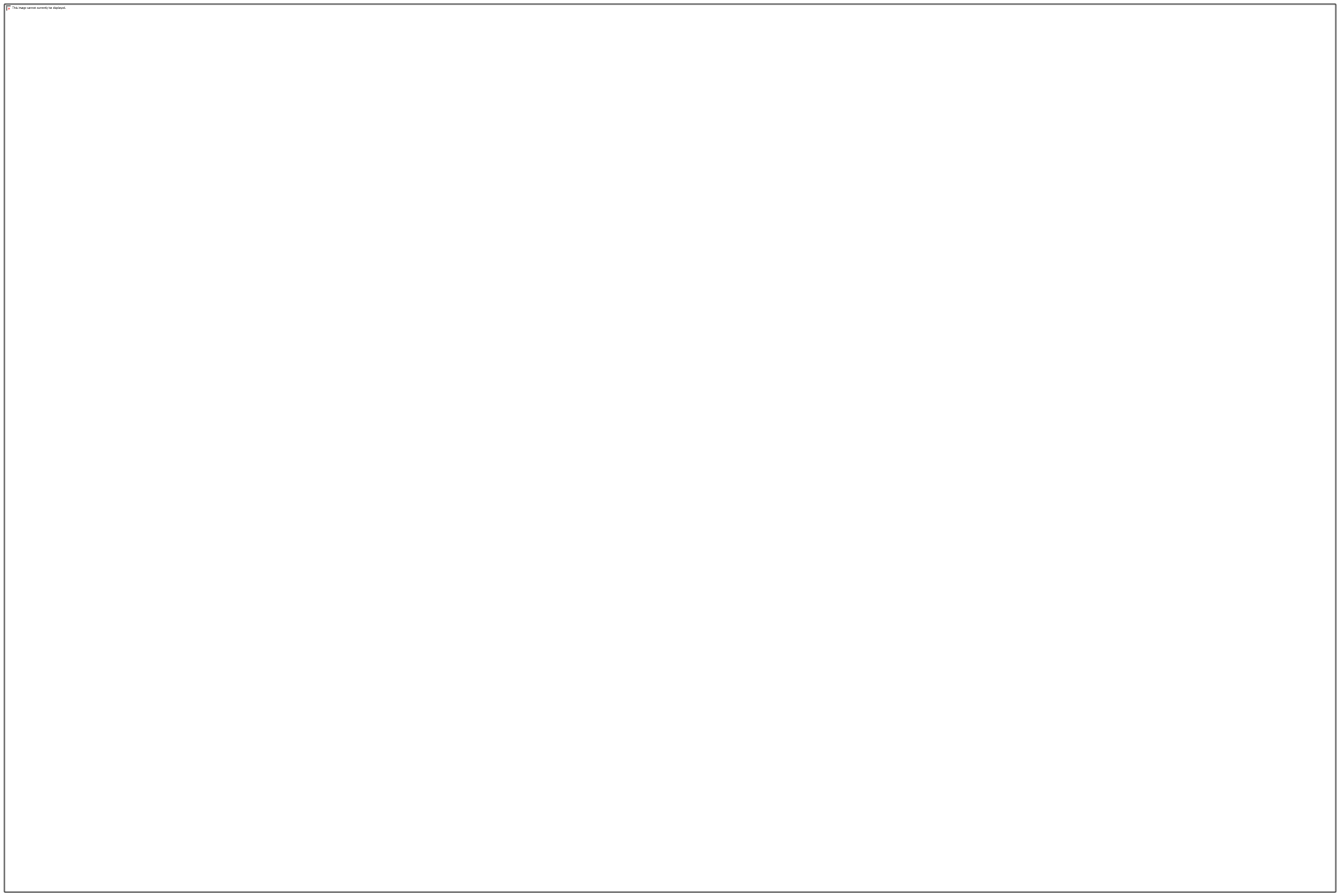
6. Jointing tool

- Used for shaping mortar joints.
- Produces a neat and consistent finish.

7. Mortar board

- Provides a surface for holding mortar during masonry work.

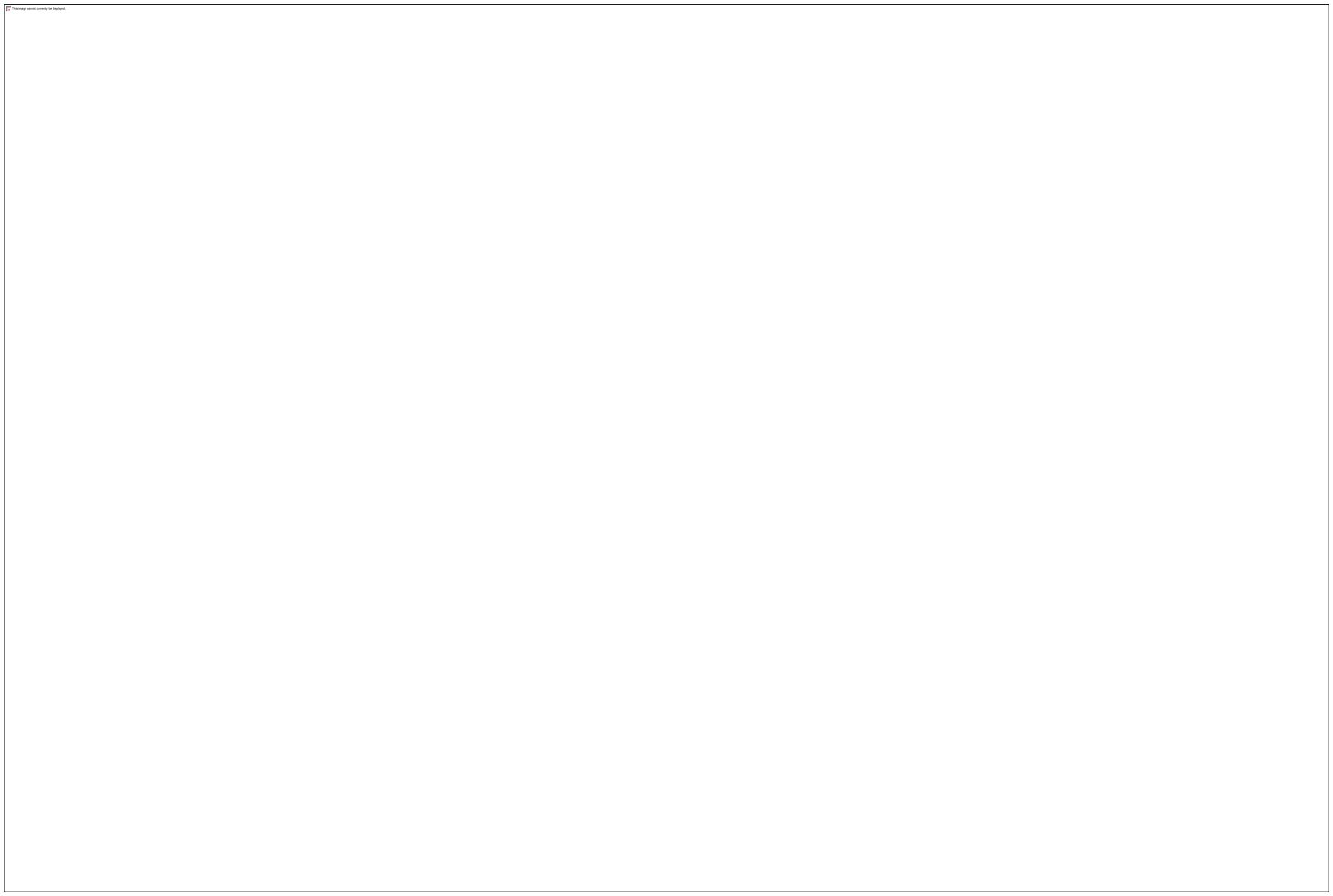
13.3 Concrete and formwork tools



1. Hand saw – cuts timber formwork.
2. Circular saw – makes accurate straight cuts.
3. Hammer – drives nails.
4. Screwdriver – fixes screws.
5. Power drill – drills holes and drives screws.
6. Tape measure – measures formwork dimensions.
7. Try square – checks corners.
8. Clamps – hold components during assembly.
9. Spirit level – checks formwork alignment.

10. Spanner – tightens suitable bolts and nuts.

13.4 Mixing and placing equipment



1. Shovel

- Used for handling and mixing sand, cement and aggregates.

2. Wheelbarrow

- Used for transporting mortar and concrete.

3. Mixing tray

- Provides a surface for mixing small quantities of mortar.

4. Concrete mixer

- Used for mechanically mixing concrete.

5. Bucket

- Used for measuring, carrying and placing construction materials.

6. Head pan

- Used for transporting sand, aggregates and other materials over short distances.

13.5 Safety equipment



- Safety helmet.
- Safety boots.
- Protective gloves.
- Safety goggles.
- Dust mask or respirator.
- Hearing protection.
- Reflective safety vest.
- Safety harness where appropriate.

14.0 SAFETY PRECAUTIONS WHEN CONSTRUCTING WALL OPENINGS

1. Wear appropriate personal protective equipment.
2. Use properly maintained tools and equipment.
3. Keep the working area clean and free from obstructions.
4. Handle bricks, blocks and stones carefully.
5. Use safe lifting techniques when handling heavy lintels.
6. Provide adequate temporary support before removing any load-bearing masonry.
7. Never remove supporting masonry without an approved method and suitable temporary propping.
8. Ensure that formwork is strong and stable.
9. Check that props are positioned on firm supports.

10. Do not stand beneath unsupported masonry or suspended loads.
11. Use ladders and working platforms safely.
12. Handle cement carefully because wet cement can cause skin irritation and burns.
13. Avoid inhaling cement and masonry dust.
14. Use eye protection when cutting bricks, blocks and concrete.
15. Keep hands away from moving blades when cutting timber.
16. Store reinforcement bars and sharp materials safely.
17. Do not remove lintel formwork before the concrete has gained adequate strength.
18. Do not remove arch centring before the arch is stable.
19. Follow the structural engineer's instructions.
20. Report unsafe conditions and accidents immediately.

15.0 PRACTICAL LEARNING ACTIVITIES

The following activities enable learners to develop practical competencies related to wall openings and bridging.

Practical activity	Expected learning outcome
Identify door, window and ventilation openings	Classification skills
Sketch different types of wall openings	Technical drawing skills
Identify different types of lintels	Material identification
Observe different types of arches	Observation skills
Construct a small model of a lintel	Practical construction skills
Prepare a flat arch model	Masonry and setting-out skills
Fabricate timber formwork for a lintel	Carpentry skills
Prepare centring for a segmental arch	Formwork skills
Construct a model wall with a window opening	Construction skills
Identify tools used in bridging openings	Tool identification
Demonstrate safety procedures	Occupational safety

16.0 REVISION SUMMARY

The following are the major concepts learners should remember.

Term	Meaning
Wall opening	A gap provided in a wall for a specific purpose
Door opening	Space provided for a door assembly
Window opening	Space provided for a window assembly
Ventilation opening	Space provided to allow air movement
Bridging	Structural support provided above a wall opening
Lintel	Horizontal structural member above an opening
Arch	Curved structural arrangement above an opening
Flat arch	Arch with a nearly horizontal intrados
Segmental arch	Arch forming part of a circle, less than a semicircle
Semi-circular arch	Arch forming half of a circle
Voussoir	Wedge-shaped unit forming an arch
Keystone	Central voussoir at the crown
Intrados	Inner curved surface of an arch
Extrados	Outer curved surface of an arch
Abutment	Supporting structure at an end of an arch
Formwork	Mould used to shape and support fresh concrete
Centring	Temporary support used during arch construction
Bearing	Length of support provided to a lintel at its ends
Span	Horizontal distance between the supports
Rise	Vertical distance from the springing line to the crown

REVISION QUESTIONS

SUBSTRAND 3.3

SECTION A: MULTIPLE-CHOICE QUESTIONS

Choose the correct answer from the alternatives A, B, C and D.

1. What is a wall opening in building construction?

A. A solid section of a foundation.

B. A space deliberately provided in a wall for a specific purpose.

C. A horizontal roof member.

D. A concrete floor surface.

2. Which of the following is a major function of window openings?

A. Supporting the foundation.

B. Providing natural lighting.

C. Carrying roof loads.

D. Supporting floor joists.

3. Which opening is specifically designed to accommodate a door?

A. Ventilation opening.

B. Service opening.

C. Door opening.

D. Inspection opening.

4. Which type of window is designed to remain permanently closed?

A. Casement window.

B. Fixed window.

C. Sliding window.

D. Louvered window.

5. Which of the following is mainly used to provide continuous air circulation?

A. Permanent ventilation opening.

B. Fixed door opening.

C. Solid wall section.

D. Concrete lintel.

6. What is the main purpose of bridging a wall opening?

A. To decorate the wall.

B. To support masonry above the opening.

C. To increase the floor area.

D. To provide a wall finish.

7. Which of the following is a horizontal structural member used above a wall opening?

A. Rafter.

B. Purlin.

C. Lintel.

D. Stud.

8. Which material is commonly used to construct reinforced concrete lintels?

A. Timber only.

B. Concrete and steel reinforcement.

C. Glass and aluminium.

D. Clay and sand only.

9. Which type of lintel is manufactured away from its final position before being transported to the construction site?

A. Timber lintel.

B. Stone lintel.

C. Precast concrete lintel.

D. Cast-in-situ lintel.

10. Which of the following is an advantage of steel lintels?

A. They are always resistant to corrosion.

B. They have high strength relative to their size.

C. They require no structural design.

D. They cannot be affected by fire.

11. What is an arch in building construction?

A. A vertical timber member.

B. A curved structural arrangement used to bridge an opening.

C. A horizontal floor covering.

D. A foundation trench.

12. Which of the following is the central wedge-shaped unit in an arch?

A. Abutment.

B. Intrados.

C. Keystone.

D. Extrados.

13. The inner curved surface of an arch is called the:

A. Extrados.

B. Intrados.

C. Abutment.

D. Springing line.

14. Which part of an arch resists the thrust transmitted towards its supports?

A. Keystone.

B. Abutment.

C. Crown.

D. Intrados.

15. Which type of arch forms exactly half of a circle?

A. Segmental arch.

B. Flat arch.

C. Semi-circular arch.

D. Elliptical arch.

16. Which type of arch has a rise that is less than half its span?

A. Semi-circular arch.

B. Segmental arch.

C. Circular arch.

D. Full-centred arch.

17. A flat arch is also commonly known as a:

A. Jack arch.

B. Gothic arch.

C. Pointed arch.

D. Horseshoe arch.

18. What is the main purpose of formwork when casting a reinforced concrete lintel?

A. To decorate the concrete.

B. To hold fresh concrete in the required shape.

C. To increase the wall height.

D. To replace reinforcement.

19. Which material is commonly used to fabricate timber formwork?

A. Glass. B. Plywood.

C. Ceramic tiles. D. Roofing sheets.

20. What is centring in arch construction?

A. A permanent wall covering.

B. Temporary support used to hold arch units during construction.

C. A concrete floor finish.

D. A type of reinforcement bar.

21. Which of the following tools is used to spread mortar when laying bricks?

A. Brick trowel.

B. Tape measure.

C. Spirit level.

D. Plumb bob.

22. Which tool is used to check the vertical alignment of a wall jamb?

A. Claw hammer.

B. Plumb bob.

C. Hand saw.

D. Shovel.

23. Which of the following tools is suitable for cutting bricks and blocks?

A. Bolster chisel.

B. Screwdriver.

C. Steel rule.

D. Marking gauge.

24. Which of the following is an important consideration when constructing masonry around a window opening?

A. Ignoring the wall dimensions.

B. Providing adequate support above the opening.

C. Removing all wall supports.

D. Using untreated timber in contact with wet masonry.

25. Which of the following is a major advantage of ventilation openings?

A. They support roof trusses.

B. They allow fresh air to enter buildings.

C. They replace all windows.

D. They increase foundation depth.

26. Which part of a window opening forms its lower horizontal boundary?

A. Head.

B. Jamb.

C. Sill.

D. Crown.

27. Which part of an arch represents the highest point?

A. Springing point.

B. Crown.

C. Abutment.

D. Intrados.

28. What is the horizontal distance between the supports of an arch called?

A. Rise.

B. Crown.

C. Span.

D. Haunch.

29. Which of the following is an appropriate safety measure during concrete lintel construction?

A. Removing props before the concrete gains sufficient strength.

B. Standing beneath unsupported formwork.

C. Ensuring that formwork is stable before placing concrete.

D. Ignoring reinforcement cover.

30. Why should arch centring be removed carefully?

A. To avoid disturbing the newly constructed arch.

B. To increase the opening width.

C. To remove the wall supports permanently.

D. To reduce the height of the wall.

SECTION B: STRUCTURED AND SHORT-ANSWER QUESTIONS

QUESTION 1: INTRODUCTION TO WALL OPENINGS

a) Define the term wall opening. (2 marks)

b) Identify four types of wall openings found in buildings. (4 marks)

c) Explain five reasons why wall openings are provided in buildings. (5 marks)

d) State four factors considered when positioning window openings. (4 marks)

QUESTION 2: DOOR OPENINGS

a) Define a door opening. (2 marks)

b) Identify four types of door openings. (4 marks)

c) Explain the functions of the following components of a door opening:

i. Door jambs. (2 marks)

ii. Head. (2 marks)

iii. Threshold. (2 marks)

iv. Door frame. (2 marks)

d) State four factors considered when designing door openings. (4 marks)

QUESTION 3: WINDOW AND VENTILATION OPENINGS

a) Define a window opening. (2 marks)

b) Identify five types of windows used in buildings. (5 marks)

c) Explain the functions of the following window components:

i. Window jambs. (2 marks)

ii. Window sill. (2 marks)

iii. Window head. (2 marks)

iv. Glazing. (2 marks)

d) State five importance of ventilation openings in buildings. (5 marks)

QUESTION 4: BRIDGING WALL OPENINGS

a) Define bridging in building construction. (2 marks)

b) Identify the two main methods of bridging wall openings. (2 marks)

c) Explain six reasons why wall openings require bridging. (6 marks)

d) State four factors considered when selecting a bridging method. (4 marks)

QUESTION 5: LINTELS

a) Define a lintel. (2 marks)

b) Identify five types of lintels according to the materials used. (5 marks)

c) Explain the functions of the following parts of a lintel:

i. Bearing ends. (2 marks)

ii. Span. (2 marks)

iii. Reinforcement. (2 marks)

d) Explain four advantages of reinforced concrete lintels. (4 marks)

e) State three disadvantages of timber lintels. (3 marks)

QUESTION 6: ARCHES

a) Define an arch. (2 marks)

b) Identify three types of arches used in bridging wall openings. (3 marks)

c) Explain the functions of the following parts of an arch:

i. Voussoir. (2 marks)

ii. Keystone. (2 marks)

iii. Crown. (2 marks)

iv. Intrados. (2 marks)

v. Extrados. (2 marks)

vi. Abutment. (2 marks)

QUESTION 7: TYPES OF ARCHES

a) Describe the characteristics of a flat arch. (4 marks)

b) Explain the construction procedure of a segmental arch. (6 marks)

c) Differentiate between a segmental arch and a semi-circular arch. (4 marks)

d) State four advantages of arches in building construction. (4 marks)

QUESTION 8: LINTELS AND ARCHES

a) Differentiate between a lintel and an arch. (4 marks)

b) Explain four advantages of using lintels instead of arches. (4 marks)

c) State four factors that influence the selection of lintels or arches. (4 marks)

d) Explain how an arch transfers loads to its supporting walls. (3 marks)

QUESTION 9: FORMWORK FABRICATION

a) Define formwork. (2 marks)

b) Identify six materials used in fabricating lintel formwork. (6 marks)

c) Explain the procedure for fabricating formwork for a reinforced concrete lintel. (8 marks)

d) State four functions of formwork during concrete construction. (4 marks)

QUESTION 10: ARCH CENTRING

a) Define centring. (2 marks)

b) State five materials used in making arch centring. (5 marks)

c) Describe the procedure for fabricating and installing centring for a segmental arch. (8 marks)

d) Explain three reasons why centring should not be removed prematurely. (3 marks)

QUESTION 11: MASONRY AND WALL OPENINGS

a) Define masonry. (2 marks)

b) Identify six materials used in masonry construction. (6 marks)

c) Explain five considerations when constructing masonry around wall openings. (5 marks)

d) State four tools used in masonry construction and explain their functions. (8 marks)

QUESTION 12: TOOLS AND EQUIPMENT

a) Identify five measuring and setting-out tools used when constructing wall openings. (5 marks)

b) Explain the functions of the following tools:

i. Brick trowel. (2 marks)

ii. Bolster chisel. (2 marks)

iii. Spirit level. (2 marks)

iv. Tape measure. (2 marks)

v. Plumb bob. (2 marks)

QUESTION 13: SAFETY IN CONSTRUCTION

a) Define personal protective equipment. (2 marks)

b) Identify six types of PPE used during wall opening construction. (6 marks)

c) Explain six safety precautions observed when constructing lintels and arches. (6 marks)

d) State four dangers associated with poorly supported wall openings. (4 marks)

QUESTION 14: APPLICATION AND PROBLEM-SOLVING

A construction company is building a classroom block in a Kenyan school. The building has several window and door openings. The contractor intends to use reinforced concrete lintels above the openings.

a) Give four reasons why the classroom requires wall openings. (4 marks)

b) Identify four materials required when constructing reinforced concrete lintels. (4 marks)

c) Explain the procedure for constructing a reinforced concrete lintel. (6 marks)

d) State four precautions that should be observed during lintel construction. (4 marks)

QUESTION 15: PRACTICAL APPLICATION

A learner is required to construct a model masonry wall with a window opening and a segmental arch above it.

a) Identify five materials required for the project. (5 marks)

b) Identify five tools required for the project. (5 marks)

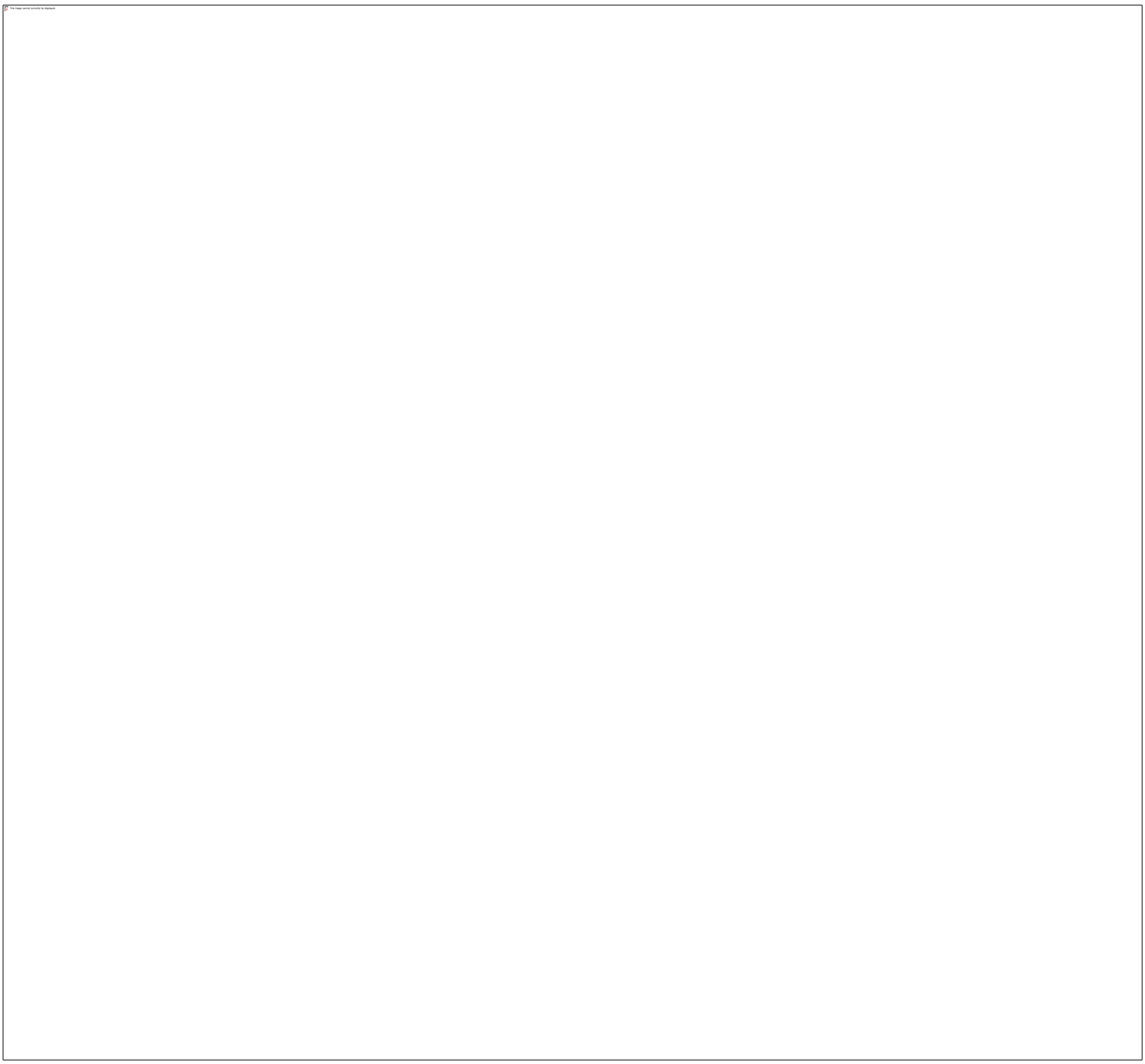
c) Describe the procedure for constructing the model wall and its segmental arch. (8 marks)

d) State two competencies developed through the activity. (2 marks)

SUGGESTED CBE PROJECT

PRACTICAL PROJECT

CONSTRUCTION OF A MODEL MASONRY WALL WITH A WINDOW OPENING AND LINTEL



Project objective

To enable learners to demonstrate practical skills in constructing wall openings and providing suitable bridging.

Materials

- Small bricks or concrete masonry units.
- Cement.
- Sand.

- Water.
- Small timber pieces.
- Plywood.
- Reinforcement wire or suitable demonstration reinforcement.
- Nails.

Tools

- Brick trowel.
- Tape measure.
- Spirit level.
- Try square.
- Hammer.
- Hand saw.
- Bucket.
- Mixing tray.

Project procedure

1. Prepare the construction drawing.
2. Measure and mark the wall dimensions.
3. Prepare the foundation or model base.
4. Lay the masonry units.
5. Form a suitable window opening.
6. Fabricate a model lintel mould.
7. Demonstrate reinforcement positioning.
8. Cast or prepare a model lintel.
9. Install the lintel above the opening using a safe demonstration arrangement.
10. Complete the masonry and finishing.
11. Label the components.
12. Present the completed model and explain its construction.

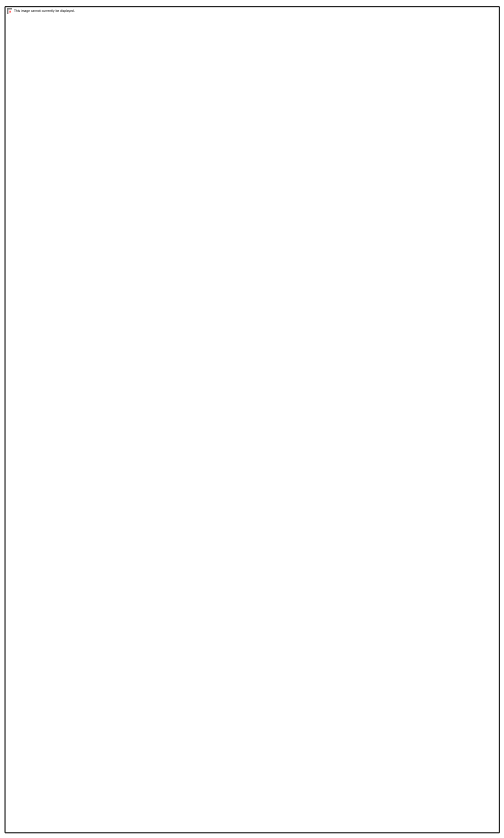
Expected assessment evidence

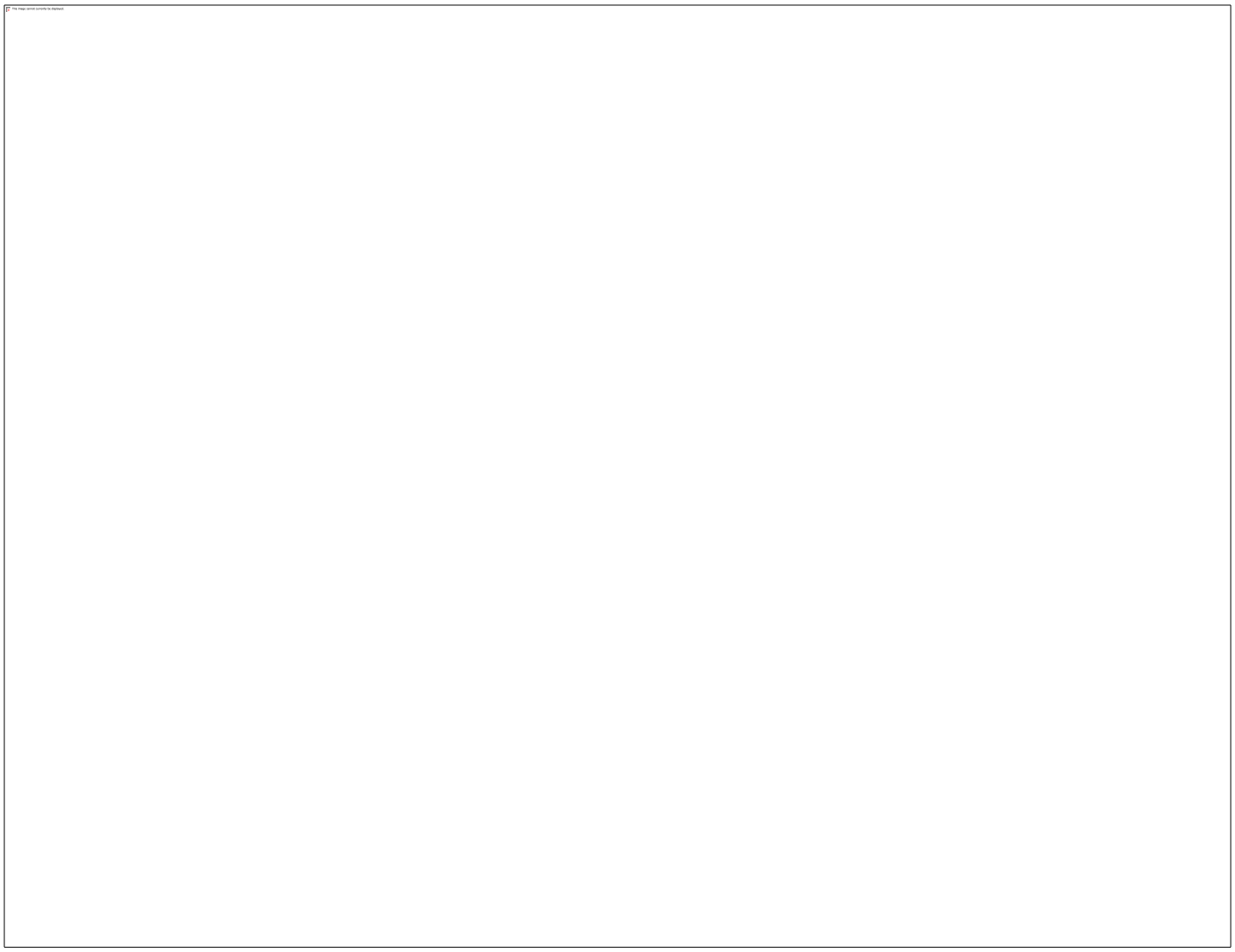
- Accuracy of measurements.
- Correct formation of the opening.
- Appropriate bridging arrangement.
- Quality of workmanship.
- Proper use of tools.
- Observation of safety procedures.

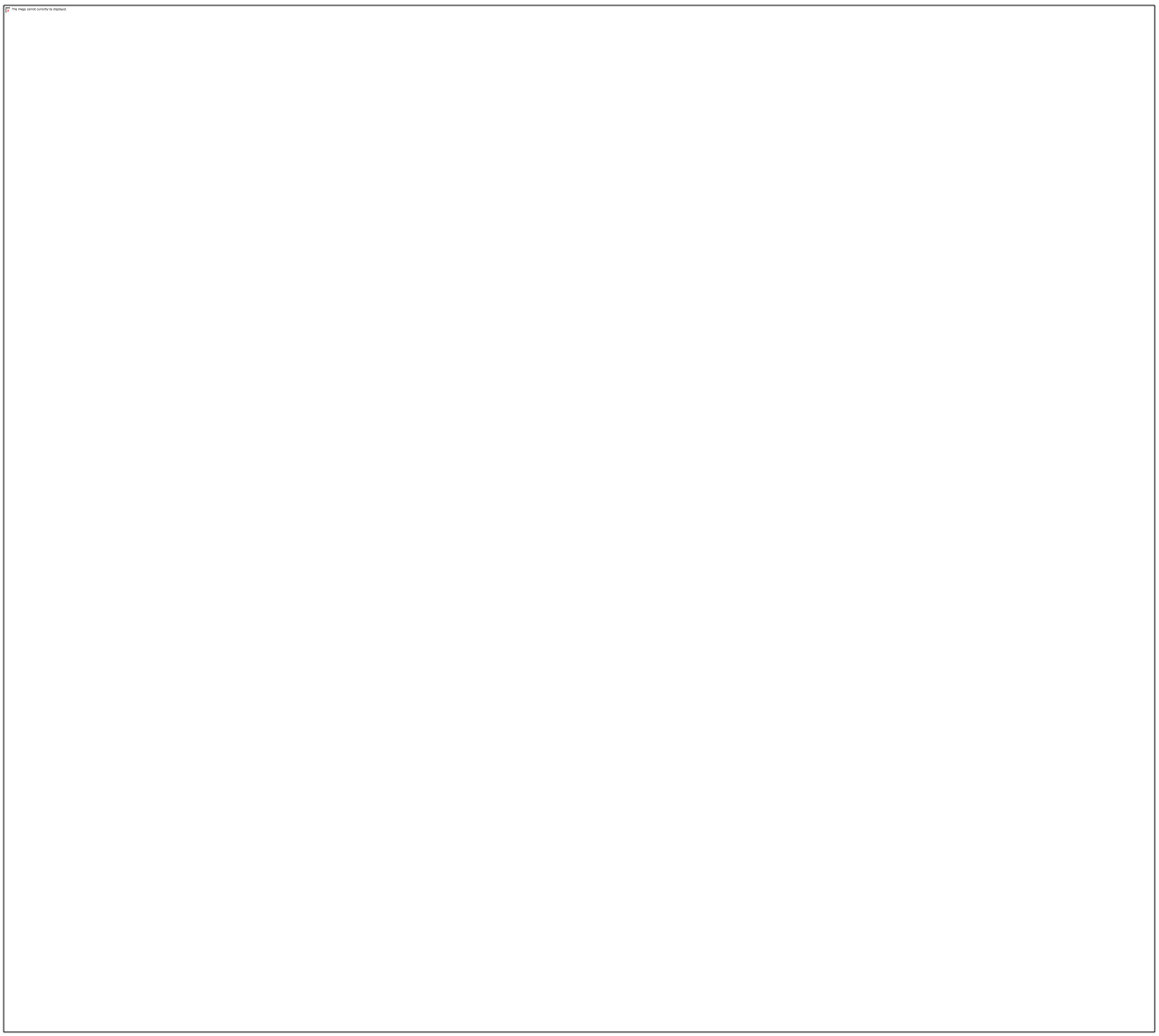
- Ability to explain the functions of components.

STRAND 3.0: BUILDING CONSTRUCTION PROCESS

SUB-STRAND 3.4: SCAFFOLDING







1.0 INTRODUCTION TO SCAFFOLDING

Scaffolding is an important temporary structure used in building construction, maintenance, renovation and repair works. It provides workers with safe and convenient access to elevated parts of a building.

In Kenya, scaffolding is commonly used during the construction of residential houses, schools, hospitals, commercial buildings, apartments and other structures.

Construction activities such as plastering, painting, masonry, installation of windows, roofing and external wall finishing may require scaffolding.

Scaffolding enables construction workers to perform tasks at different heights while providing a working platform for tools and materials.

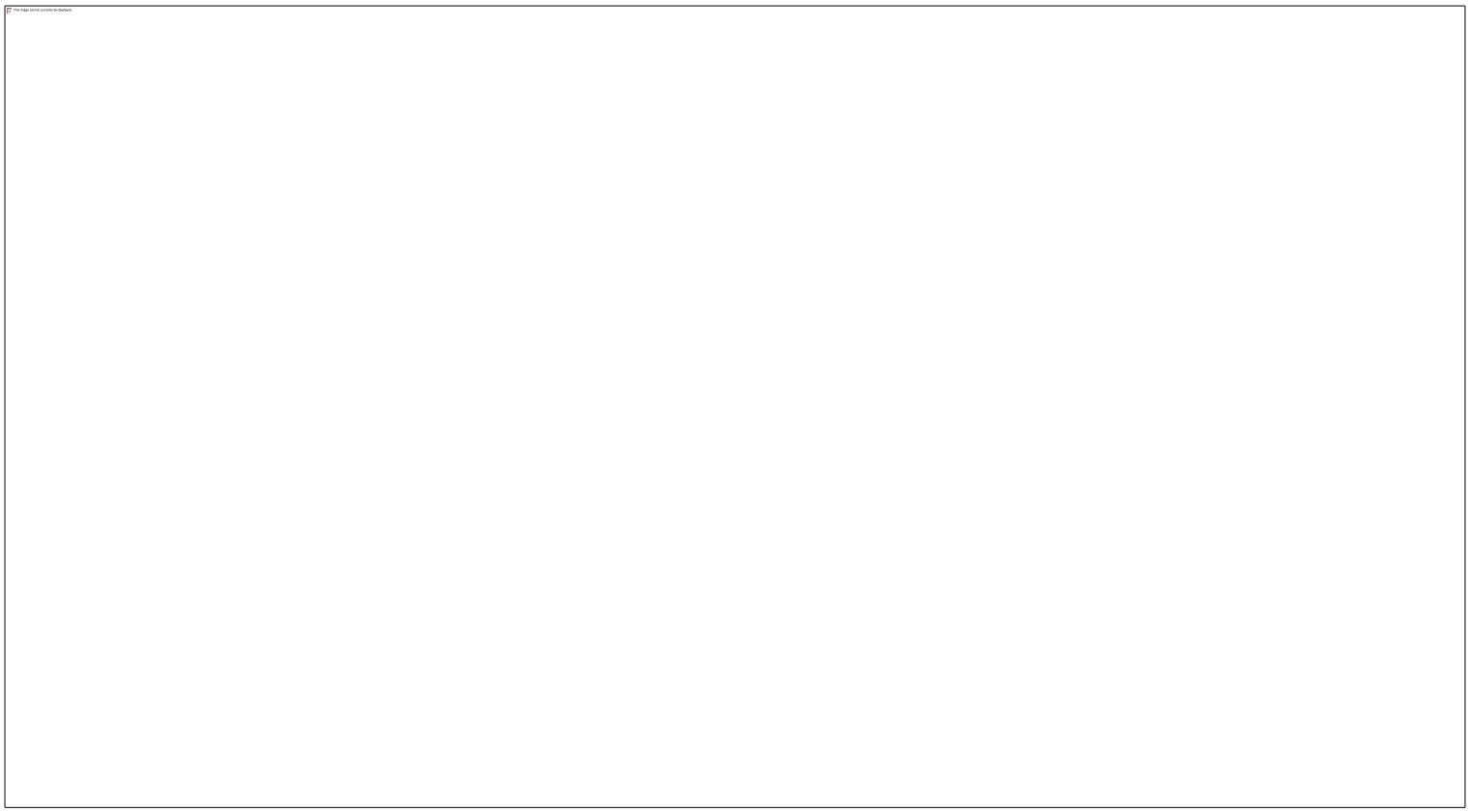
1.1 Meaning and definition of scaffolding

Definition

Scaffolding is a temporary elevated framework constructed from materials such as steel, aluminium, timber or bamboo to provide safe working platforms and access for workers carrying out construction, maintenance, repair and finishing activities at heights.

The framework is usually supported from the ground or an existing structure and consists of interconnected vertical, horizontal and diagonal members.

A properly erected scaffold should be stable, strong, adequately supported and fitted with suitable protective components.



1.2 Meaning of a scaffold

A scaffold is the actual temporary structure erected at a construction site to support workers, tools and materials during work at height.

Difference between scaffolding and a scaffold

- Scaffolding refers to the system, arrangement or process of providing temporary elevated access and working platforms.
- A scaffold refers to the assembled temporary structure itself.

1.3 Characteristics of good scaffolding

Good scaffolding should have the following characteristics:

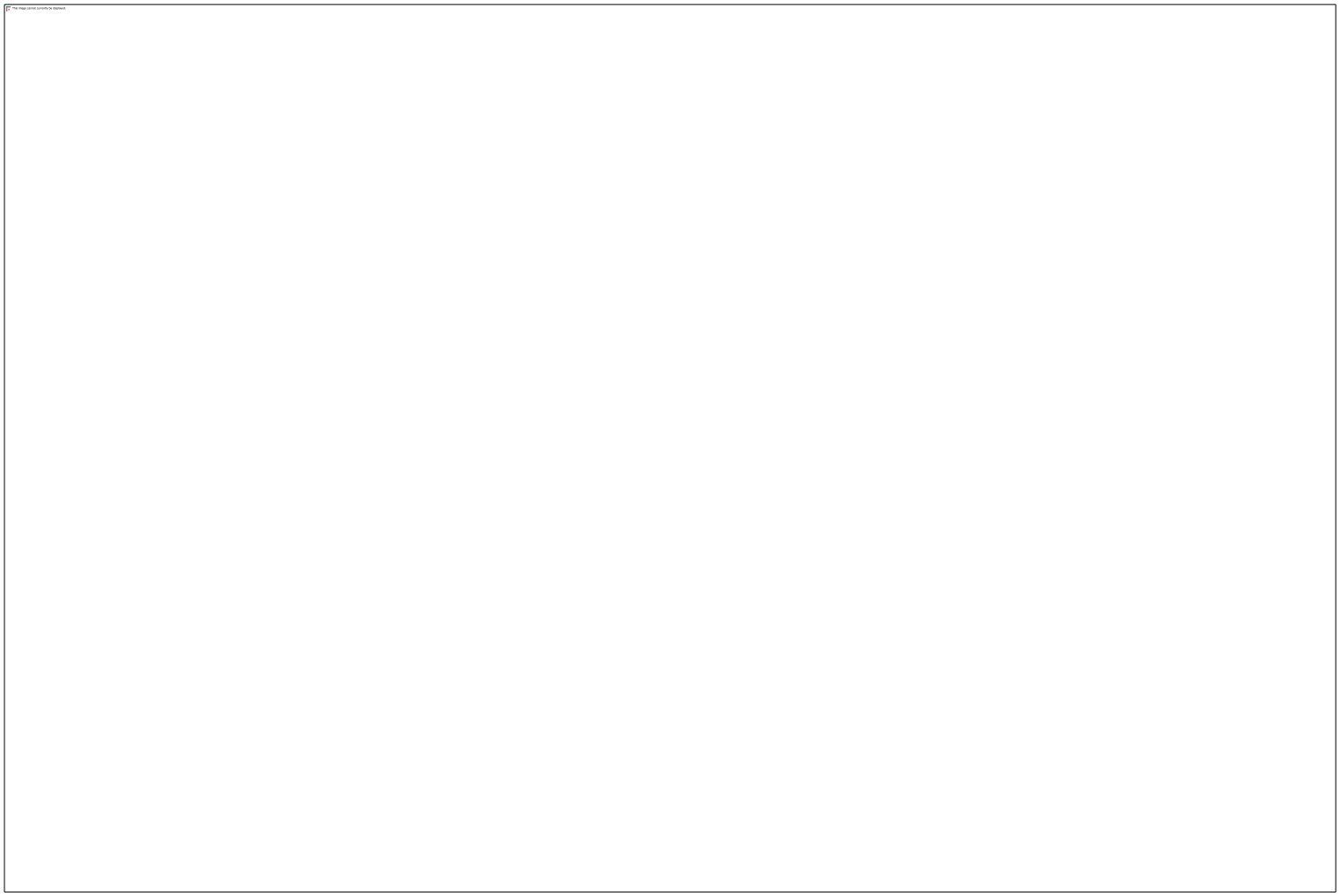
1. **Strength**
   - It should be strong enough to support workers, tools and construction materials.
   - Its components should withstand the expected loads without failure.
2. **Stability**
   - It should remain stable during construction activities.
   - It should be properly supported, tied or braced as required.
3. **Safety**
   - It should have appropriate guardrails, toe boards and safe access.
   - It should minimise the risk of workers and materials falling.
4. **Durability**

- Its materials should withstand the conditions under which they are used.
- Metal components should be protected against excessive corrosion.

5. **Accessibility**
   - It should provide safe access to the required working levels.
   - Suitable ladders, stairways or access towers should be provided.
6. **Proper working space**
   - Platforms should provide adequate space for workers to carry out their tasks.
   - Materials should be arranged without obstructing movement.
7. **Ease of erection and dismantling**
   - Its components should be capable of being assembled and dismantled using approved procedures.
8. **Proper alignment**
   - Vertical and horizontal members should be correctly positioned.
   - The scaffold should not lean or become distorted.

2.0 IMPORTANCE OF SCAFFOLDING IN BUILDING CONSTRUCTION

Scaffolding plays an important role in construction because many building activities are carried out above ground level.



2.1 Providing access to elevated areas

- Scaffolding enables workers to reach elevated sections of buildings.
- It provides access to walls, roofs, ceilings and other high-level construction components.
- For example, masons use scaffolding when constructing upper-floor walls.

2.2 Providing working platforms

- It provides a stable platform where workers can stand while carrying out construction activities.
- Workers can perform plastering, painting, pointing and masonry more conveniently.
- It reduces the need to work from unsafe positions.

2.3 Improving workers' safety

- Properly erected scaffolding provides guarded working platforms.
- It helps minimise falls from height.
- It can also reduce the risk of workers losing balance while performing construction activities.

2.4 Facilitating masonry construction

- Scaffolding enables masons to construct walls above normal ground level.
- It allows them to position bricks, blocks and stones conveniently.
- It is useful when constructing tall walls and multi-storey buildings.

2.5 Facilitating plastering and rendering

- It provides access to external and internal wall surfaces.
- Workers can apply plaster and render more conveniently.
- It helps improve the quality and uniformity of finishes.

2.6 Facilitating painting and decoration

- Painters use scaffolding to reach elevated wall surfaces.
- It allows them to apply paint, decorations and protective coatings.
- It is useful when painting high ceilings and external building elevations.

2.7 Supporting maintenance and repair works

- Scaffolding enables workers to inspect and repair building components.
- It is used when repairing cracks, replacing damaged materials and cleaning external walls.
- It provides access to parts of buildings that are difficult to reach from the ground.

2.8 Facilitating installation works

- It provides access when installing windows, ventilation systems, electrical fittings and external building components.
- It enables technicians to work at elevated positions.

2.9 Improving productivity

- It reduces unnecessary movement up and down ladders.
- It provides convenient access to tools and materials.

- It enables workers to carry out tasks more efficiently.

2.10 Facilitating roofing activities

- Scaffolding may provide access to roof edges and other elevated construction areas.
- It assists workers during installation, repair and maintenance of certain roofing components.
- Appropriate additional edge protection and fall-prevention systems may still be necessary.

2.11 Supporting construction of multi-storey buildings

- Scaffolding provides temporary access to different floors and external elevations.
- It supports masonry, finishing and maintenance operations.
- It is useful in the construction of apartments, office blocks and commercial buildings.

2.12 Reducing construction difficulties

- It provides a more convenient working position.
- It reduces dependence on improvised supports.
- It enables workers to perform tasks at different heights in a more organised manner.

3.0 MATERIALS USED IN SCAFFOLDING

Scaffolding can be constructed using different materials depending on the type of scaffold, building height, intended use, availability of materials and construction requirements.

The common materials include:

1. Steel.
2. Aluminium.
3. Timber.
4. Bamboo.
5. Fibre-reinforced materials.
6. Manufactured scaffold boards and metal platforms.

3.1 STEEL



Definition

Steel is a strong metallic construction material commonly used to manufacture scaffolding tubes, frames, couplers, braces and other scaffold components.

Characteristics of steel scaffolding

1. It has high strength.
2. It is suitable for heavy-duty applications when properly designed.
3. It is durable when adequately maintained.
4. It can be manufactured into standardised components.
5. It can withstand repeated assembly and dismantling when undamaged.
6. It is relatively heavy compared with aluminium.

Advantages of steel scaffolding

1. **High strength**
   - Steel can support substantial loads when the scaffold is properly designed.
   - It is suitable for many construction applications.
2. **Durability**
   - Good-quality steel components can be used repeatedly.
   - They can serve for many construction projects when properly maintained.
3. **Reusability**
   - Steel tubes, frames and fittings can be dismantled and reused.
   - This makes them economical for construction companies undertaking many projects.
4. **Availability of standard components**
   - Steel scaffold systems are manufactured in standardised sizes.
   - This facilitates assembly and replacement of damaged components.
5. **Resistance to physical damage**
   - Properly manufactured steel components can withstand considerable handling and site activities.

Disadvantages of steel scaffolding

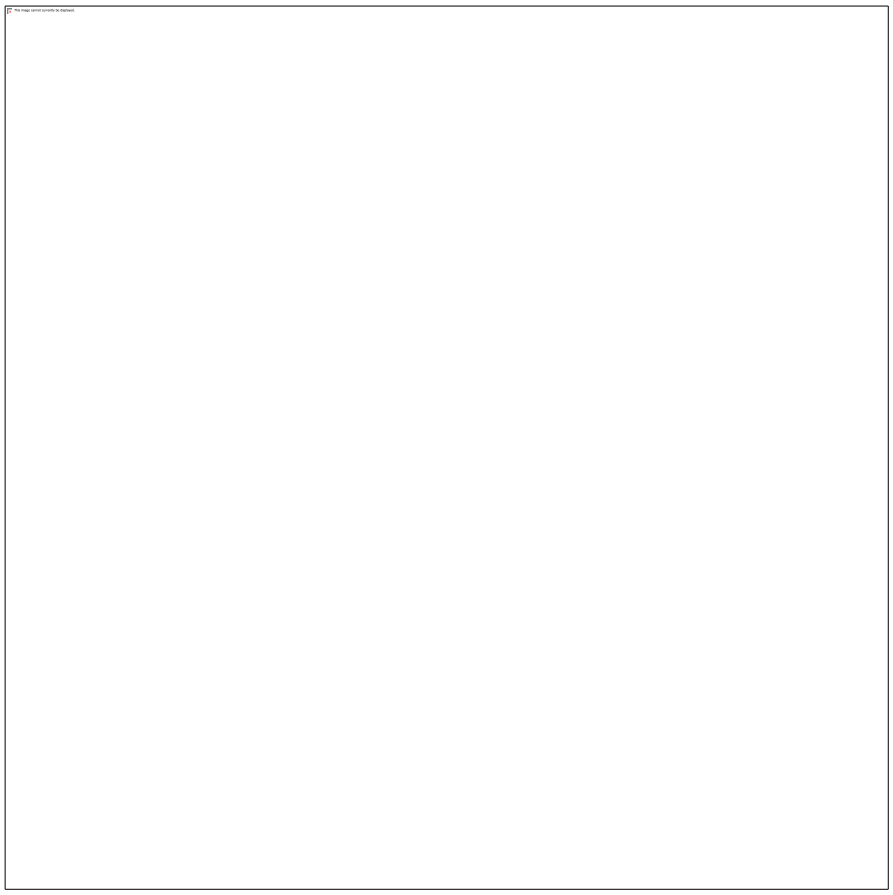
1. It is relatively heavy to transport and handle.
2. It can corrode when exposed to moisture.
3. It conducts electricity and therefore presents electrical hazards near overhead power lines.
4. It may require protective coatings to prevent rusting.
5. It requires appropriate lifting and handling procedures.

Applications of steel scaffolding

- Construction of multi-storey buildings.

- External wall plastering.
- Masonry construction.
- Industrial construction.
- Painting and maintenance of high buildings.

3.2 ALUMINIUM



Definition

Aluminium is a lightweight metallic material used in manufacturing scaffold frames, access towers, platforms and other scaffolding components.

Characteristics

1. It is lighter than steel.
2. It has good resistance to corrosion.
3. It is relatively easy to transport.
4. It can be manufactured into prefabricated scaffold components.
5. It requires careful handling to avoid damage and deformation.

Advantages of aluminium scaffolding

1. **Lightweight**

- It is easier to transport and handle than many steel systems.
- It reduces the effort required when moving scaffold components.

2. **Corrosion resistance**

- Aluminium forms a protective oxide layer that helps resist corrosion.

3. **Ease of assembly**
   - Prefabricated aluminium scaffold systems can be assembled relatively quickly by trained workers.
4. **Portability**
   - Aluminium is suitable for mobile scaffold towers.
5. **Reusability**
   - Its components can be used repeatedly when maintained properly.

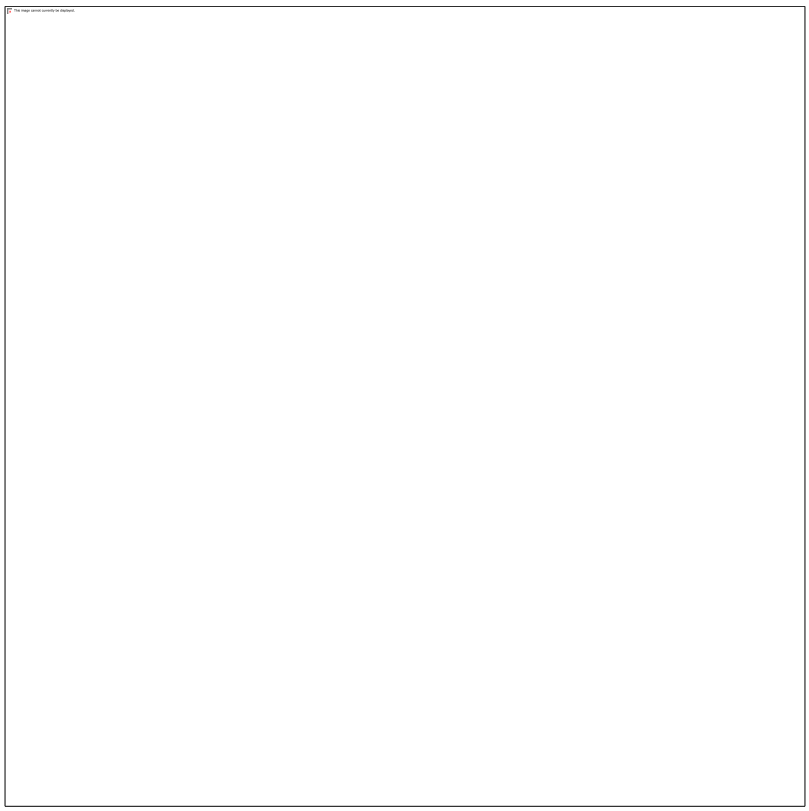
Disadvantages

1. It may be more expensive than some other materials.
2. It can deform if overloaded or mishandled.
3. It is electrically conductive.
4. Its strength and load capacity depend on the design and component dimensions.
5. It may be unsuitable for some heavy-duty applications unless specifically designed for them.

Applications

- Painting.
- Ceiling installation.
- Electrical installation away from electrical hazards.
- Indoor maintenance.
- Light construction and finishing activities.

3.3 TIMBER



Definition

Timber scaffolding is a temporary access and working platform system constructed using suitable wooden poles, boards, battens and other timber components.

Characteristics

1. It is obtained from trees.
2. It can be cut and shaped using carpentry tools.
3. It is available in different sizes and dimensions.
4. It is relatively easy to work with.
5. Its strength depends on the timber species, grade, condition and dimensions.
6. It can be affected by moisture, decay and termite attack.

Advantages of timber scaffolding

1. **Availability**
   - Timber may be readily available in many parts of Kenya.
   - It can be obtained from local timber suppliers.
2. **Ease of working**
   - Timber can be cut, shaped and joined using ordinary carpentry tools.
3. **Ease of handling**
   - Some timber components are relatively light compared with steel components of similar dimensions.
4. **Versatility**
   - Timber can be used to make platforms, temporary supports and other components when appropriately designed.
5. **Low initial cost in some locations**
   - Locally available timber may reduce initial material costs.

Disadvantages of timber scaffolding

1. It may decay when exposed to moisture.
2. It can be attacked by termites and other wood-destroying organisms.
3. It may split or crack.
4. Its strength can vary considerably.
5. It is combustible.
6. It may deteriorate after repeated use.

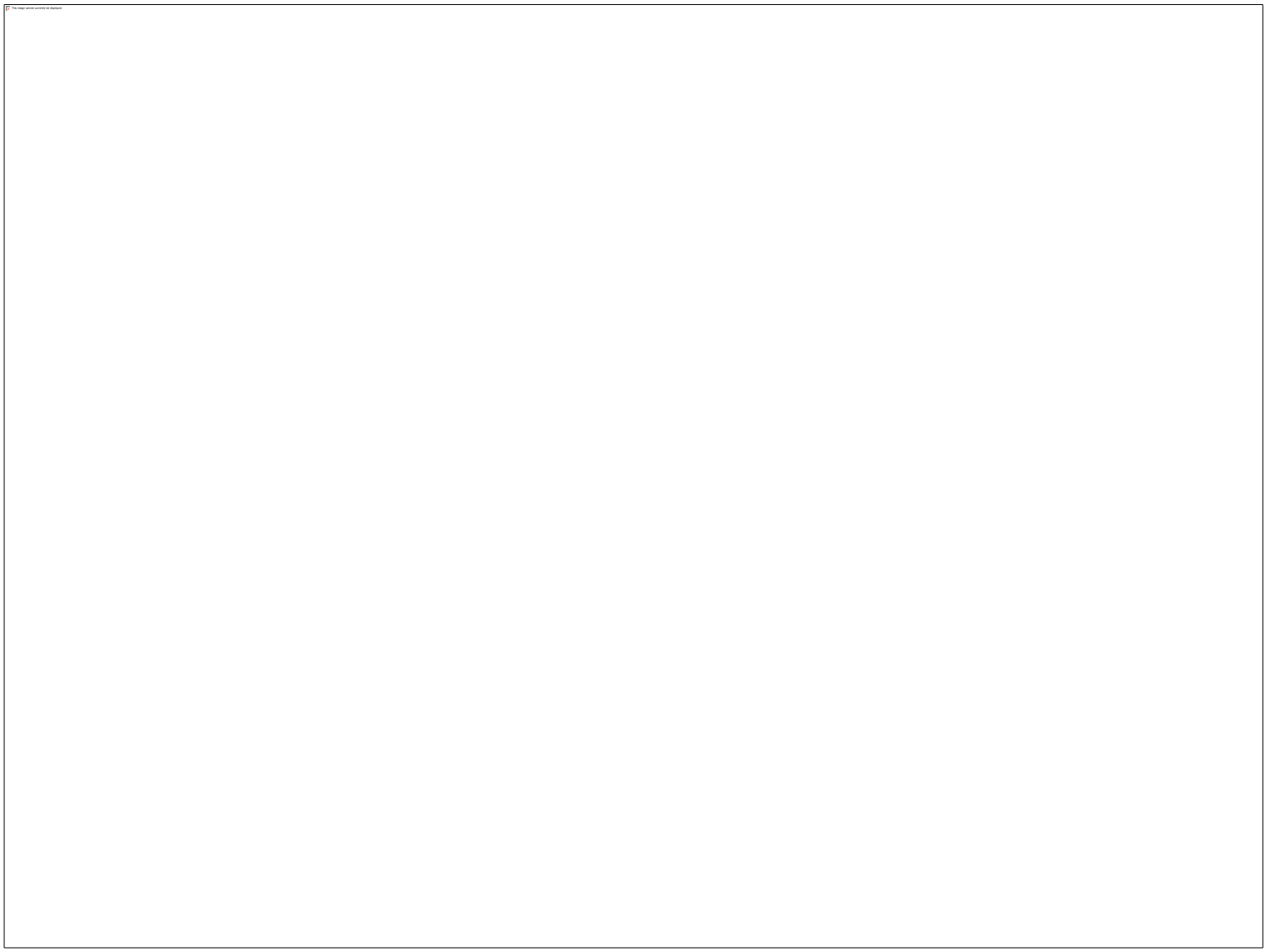
Applications

- Certain low-rise construction activities.
- Temporary access arrangements where properly designed.

- Construction activities involving suitable timber scaffold systems.

Safety note: Timber should never be assumed safe merely because it appears strong. Scaffold timber must be suitable, graded where required, inspected and designed for the intended loading.

3.4 BAMBOO



Definition

Bamboo scaffolding is a temporary scaffold system constructed using suitable bamboo poles joined together to provide access and working platforms.

Characteristics

1. Bamboo is a naturally occurring plant material.
2. It has a hollow stem structure.
3. It is relatively lightweight.
4. It has good strength in relation to its weight when suitable species and dimensions are used.
5. It can be assembled using appropriate connections.
6. Its performance depends on its condition, quality and construction method.

Advantages

1. It is relatively lightweight.
2. It can be flexible.
3. It may be readily available in regions where bamboo is cultivated.
4. It is a renewable material.
5. It can be used for certain temporary construction systems where recognised standards and competent erection procedures permit it.

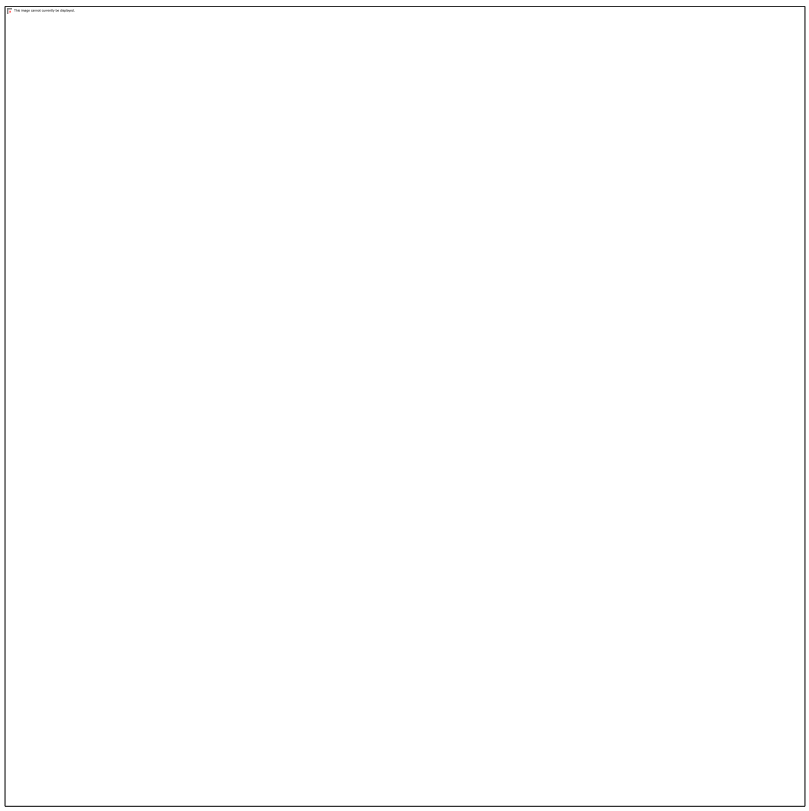
Disadvantages

1. It can deteriorate due to moisture.
2. It may be attacked by insects.
3. It can split or crack.
4. Its quality and strength may vary.
5. It requires skilled selection and connection.
6. It may not be suitable where approved construction regulations require a different system.

Applications

- Traditional scaffolding systems in regions where bamboo scaffolding is established.
- Certain temporary construction arrangements subject to applicable standards.

3.5 FIBRE-REINFORCED MATERIALS



Definition

Fibre-reinforced materials are manufactured materials in which strong fibres are embedded in a resin or another binding material to improve their mechanical properties.

Examples include fibre-reinforced polymer and fibreglass components.

Characteristics

1. They can be lightweight.
2. Some types have good corrosion resistance.
3. Certain specially designed systems have low electrical conductivity.
4. They can be manufactured into different shapes.
5. Their suitability depends on their design and certification.

Advantages

- Some types are suitable for environments where corrosion is a concern.
- Specially designed non-conductive systems may be useful for certain electrical maintenance operations.
- They can be lightweight.
- They require less protection against corrosion than ordinary steel.

Disadvantages

- They can be expensive.
- They may be damaged by impact.
- Their load capacity depends on the specific product.
- They require specialised inspection and maintenance.

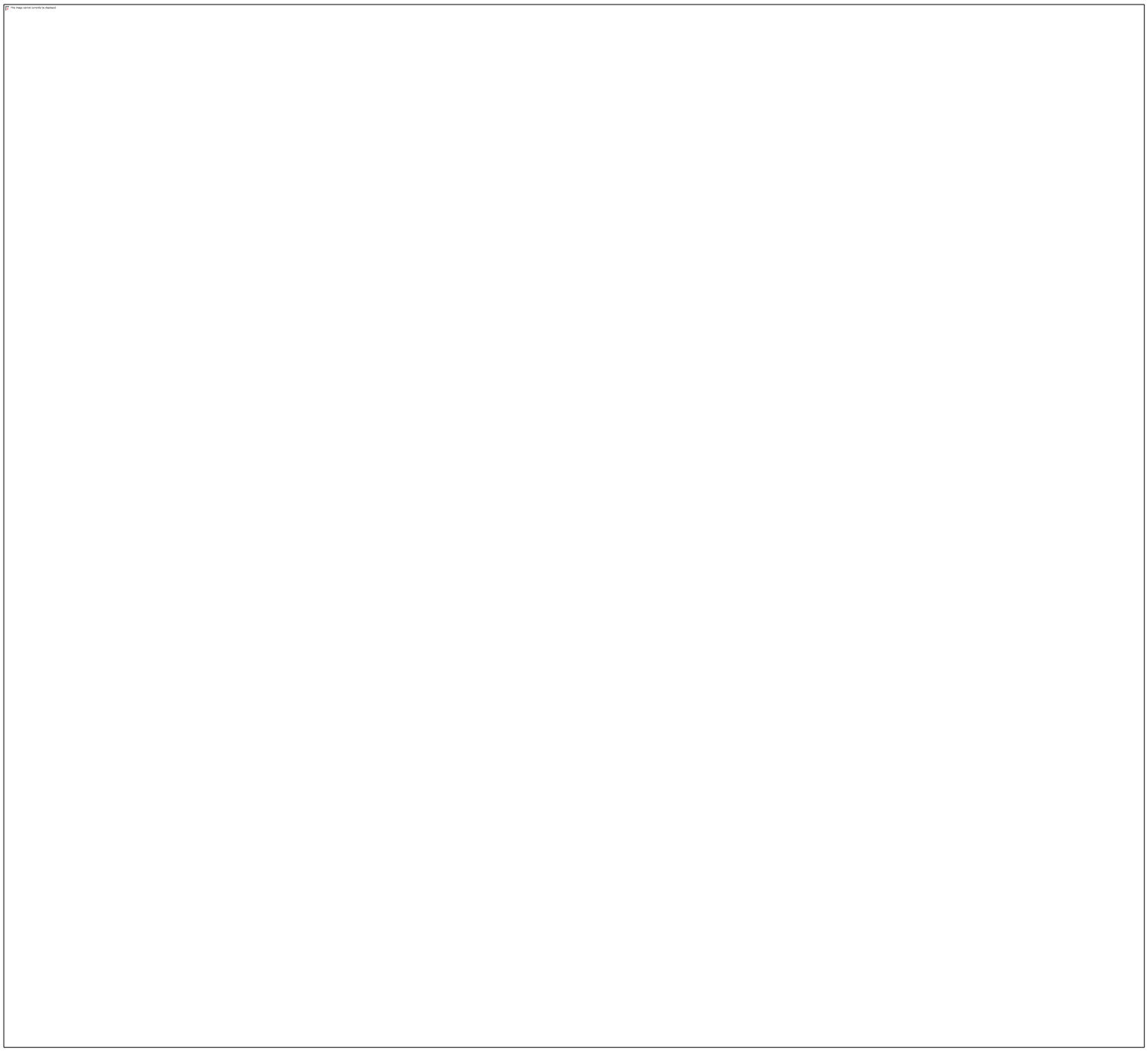
3.6 COMPARISON OF MATERIALS USED IN SCAFFOLDING

Material	Main advantage	Main disadvantage
Steel	High strength and durability	Heavy and may corrode
Aluminium	Lightweight and corrosion resistant	Can deform when overloaded
Timber	Easy to cut and work with	Can decay and split
Bamboo	Lightweight and renewable	Quality and strength vary
Fibre-reinforced material	Some types resist corrosion and conduct little electricity	Expensive and specialised

4.0 COMPONENTS OF SCAFFOLDING

A scaffold consists of several interconnected components that work together to provide a stable and safe working structure.

Understanding these components is important because each one performs a specific function.



4.1 Standards

Definition: Standards are the vertical members of a scaffold that transfer the loads from the working platforms and other scaffold components down to the ground or supporting structure.

Functions:

1. Support horizontal scaffold members.
2. Transfer loads to the base plates and ground.
3. Maintain the vertical framework.
4. Provide support for the working platforms.
5. Help maintain the overall stability of the scaffold.

4.2 Ledgers

Definition: Ledgers are horizontal scaffold members running parallel to the building or along the length of the scaffold. They connect the standards at different levels.

Functions:

1. Connect vertical standards.
2. Support transoms.
3. Maintain the horizontal arrangement of the scaffold.
4. Improve the stability of the scaffold framework.
5. Help distribute loads between the standards.

4.3 Transoms

Definition: Transoms are horizontal scaffold members placed at right angles to the ledgers. They extend across the width of the scaffold and support the working platform.

Functions:

1. Support scaffold boards.
2. Maintain the width of the scaffold.
3. Connect the two rows of standards in independent scaffolding.
4. Transfer platform loads to the scaffold framework.
5. Provide support for working platforms.

4.4 Braces

Definition: Braces are diagonal members fitted to a scaffold to prevent excessive movement, distortion and sideways instability.



Functions:

1. Improve the rigidity of the scaffold.
2. Prevent sideways movement.

3. Maintain the correct alignment of scaffold members.
4. Resist forces caused by wind and other horizontal actions.
5. Reduce the possibility of scaffold collapse.

4.5 Base plates

Definition: A base plate is a metal plate fitted at the bottom of a scaffold standard to distribute the load over a supporting surface.

Functions:

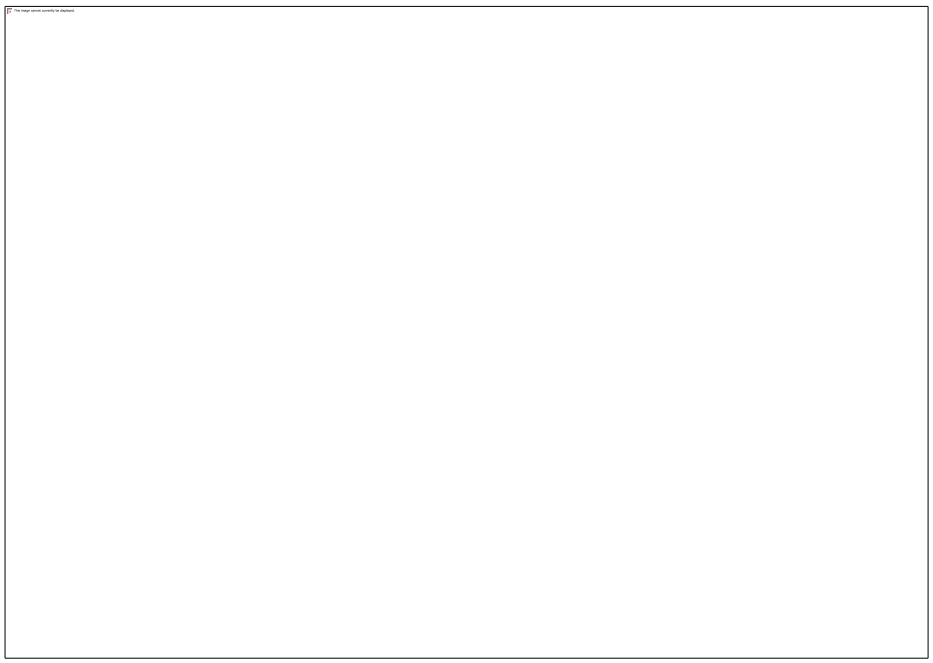
1. Distribute loads from the standards.
2. Provide a firm bearing surface.
3. Reduce concentrated pressure on the ground.
4. Provide a connection for adjustable base jacks where used.

4.6 Sole boards

Definition: A sole board is a suitable timber or engineered support placed beneath scaffold base plates or adjustable base jacks to distribute loads over a larger ground area.

Functions:

1. Distribute scaffold loads over a wider area.
2. Reduce settlement into soft ground.
3. Provide a more stable supporting surface.
4. Help prevent uneven sinking of scaffold standards.



4.7 Scaffold boards and working platforms

Definition: Scaffold boards are specially selected boards or manufactured platform units placed on scaffold supports to provide a working surface for construction workers.

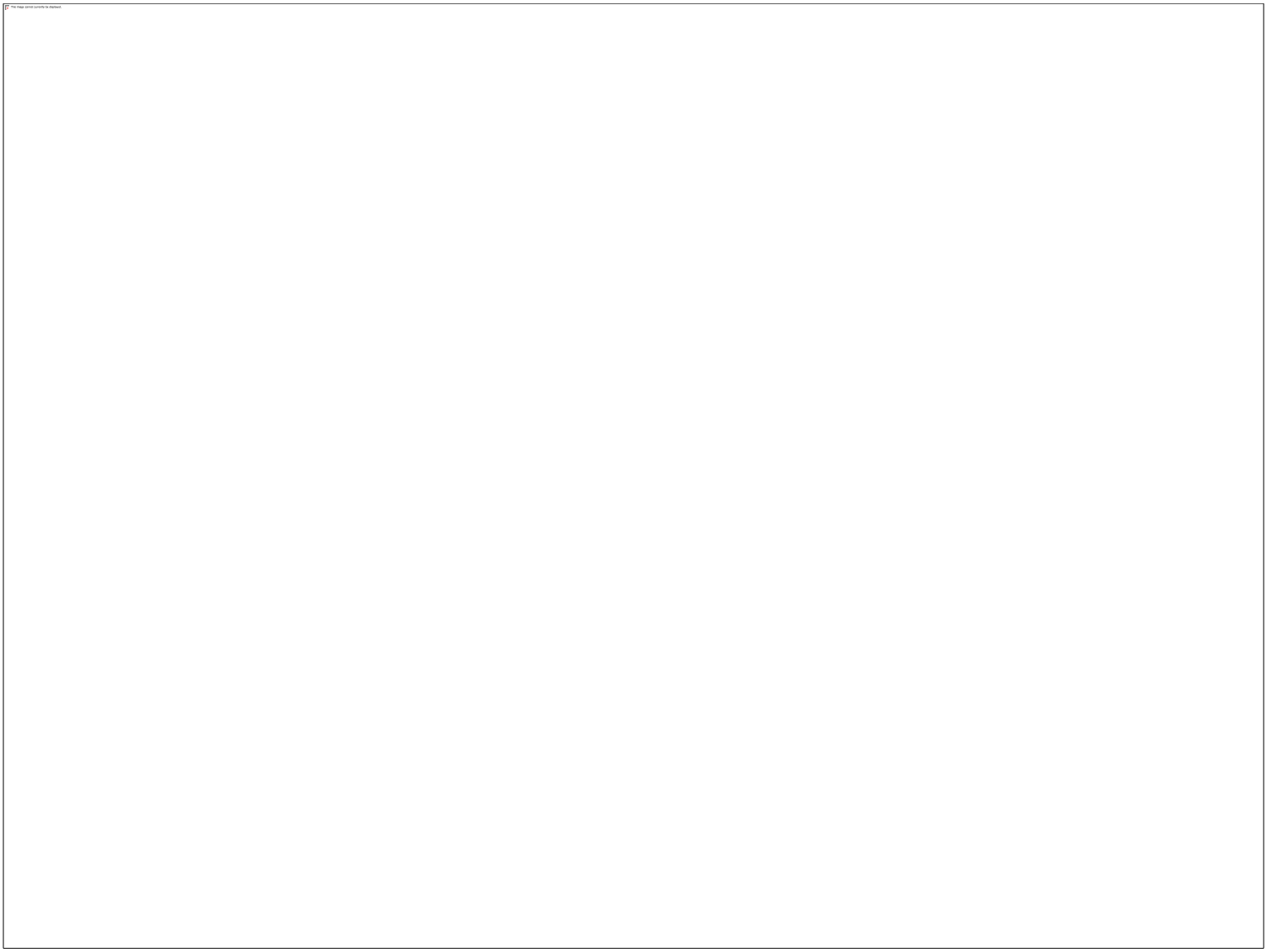
Functions:

1. Provide a surface on which workers stand.

2. Support suitable tools and materials.
3. Allow workers to move along the scaffold.
4. Provide a working area for construction activities.

Requirements:

- They must be suitable for scaffold use.
- They must be in good condition.
- They should be properly supported and secured.
- They should not be overloaded.
- They should provide an adequately wide working platform.
- Damaged or defective boards should be removed from service.



4.8 Guardrails

Definition: Guardrails are protective horizontal barriers fitted along the exposed edges of scaffold working platforms to prevent workers from falling.

Functions:

1. Protect workers from falling.

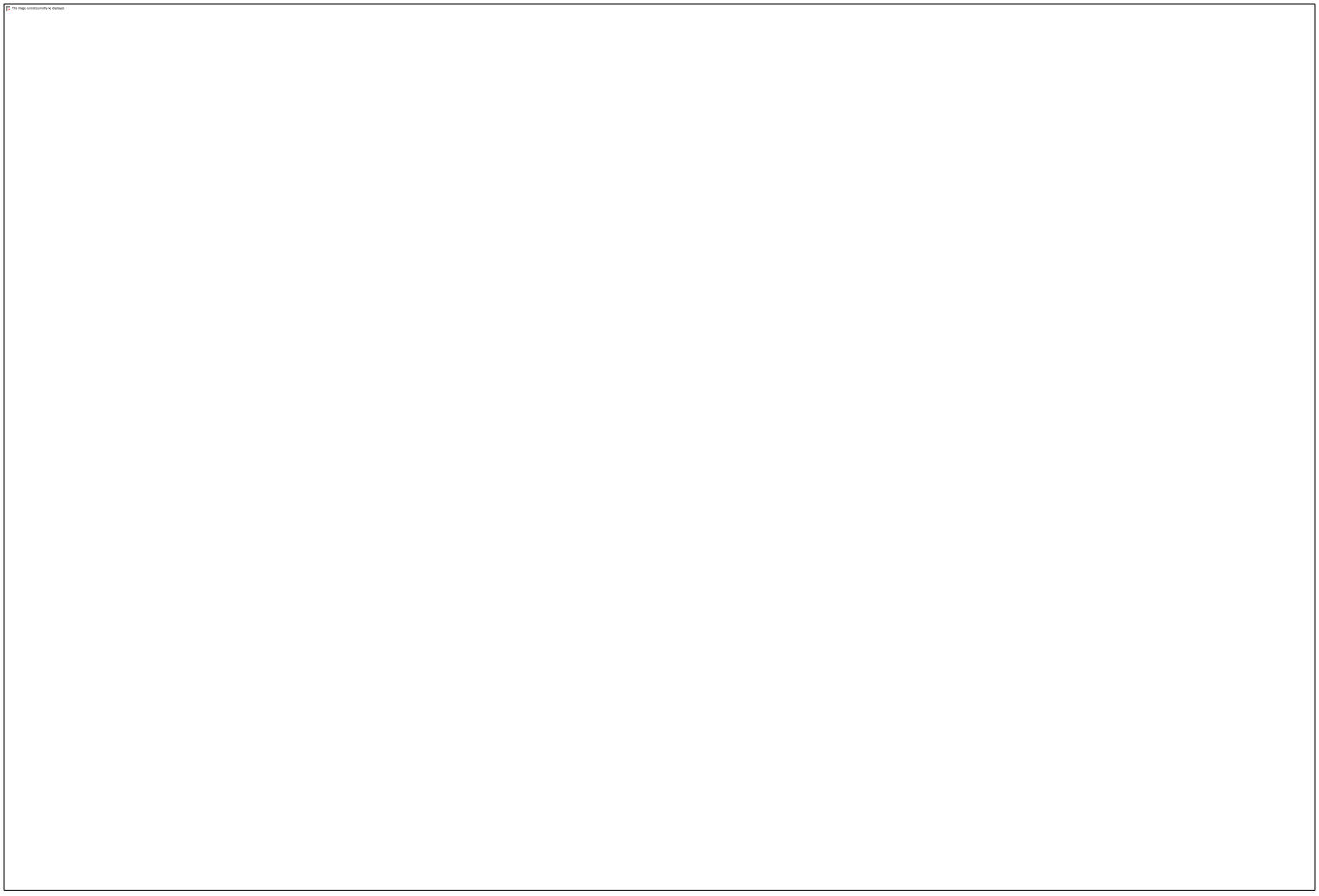
2. Provide a physical barrier at platform edges.
3. Improve safety during elevated construction activities.
4. Reduce accidental movement beyond platform boundaries.

4.9 Toe boards

Definition: Toe boards are protective barriers fitted along the lower edges of scaffold working platforms to prevent tools, materials and other objects from falling.

Functions:

1. Prevent materials from slipping off the platform.
2. Reduce the risk of injuries to people below.
3. Help keep small construction materials within the platform.
4. Improve housekeeping and working safety.



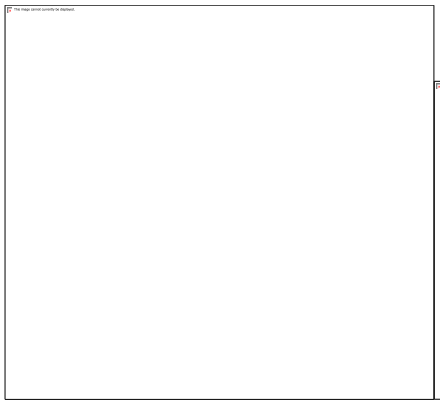
4.10 Couplers

Definition: Couplers are mechanical fittings used to connect scaffold tubes together.

Common types include:

1. Right-angle couplers – connect two tubes at right angles.
2. Swivel couplers – connect tubes at different angles.
3. Sleeve couplers – join two tubes end to end.

4. Putlog couplers – used in appropriate scaffold arrangements to connect putlogs to ledgers.





Functions:

- Connect scaffold tubes.
- Maintain the required arrangement of components.
- Provide mechanical connections.
- Help maintain scaffold stability when correctly selected and installed.

4.11 Ties and anchors

Definition: Scaffold ties are connections used to secure a scaffold to a building or another suitable supporting structure.

Functions:

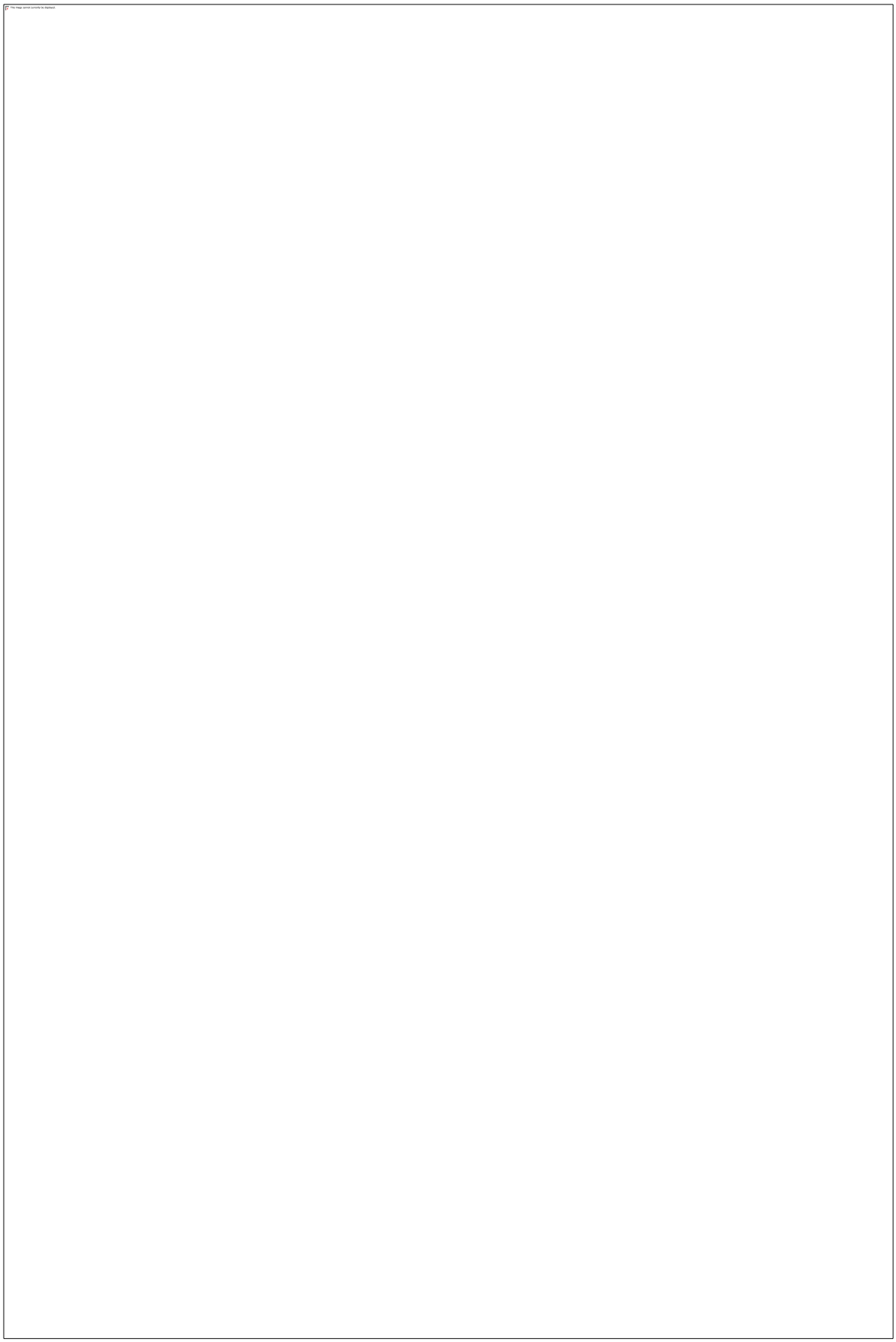
1. Prevent the scaffold from moving away from the building.
2. Improve resistance to overturning.
3. Improve overall stability.
4. Help resist wind forces and other horizontal loads.

4.12 Access ladders and stairways

Definition: These are components provided to allow workers to move safely between different scaffold levels.

Functions:

1. Provide safe access to working platforms.
2. Reduce the need to climb scaffold frames.
3. Allow movement between different working levels.
4. Improve accessibility during construction.



5.0 TYPES OF SCAFFOLDING

Scaffolding is classified according to its structural arrangement, method of support, intended use and construction system.

The main types include:

1. Single scaffolding.
2. Double scaffolding.
3. Cantilever scaffolding.
4. Suspended scaffolding.
5. Trestle scaffolding.
6. Steel or tube-and-coupler scaffolding.
7. Patented scaffolding.
8. Mobile scaffolding.
9. Birdcage scaffolding.
10. System scaffolding.

The two important structural arrangements under this sub-strand are:

- Dependent scaffolding.
- Independent scaffolding.

5.1 SINGLE SCAFFOLDING



Definition

Single scaffolding is a type of scaffolding commonly used in brick masonry construction. It consists of one row of standards positioned at a distance from the wall, with the building wall providing support for the putlogs through suitable openings or connections.

It is sometimes called bricklayer's scaffolding.

Main components

1. Standards.
2. Ledgers.
3. Putlogs.
4. Braces.
5. Working platforms.
6. Base plates.
7. Sole boards.

Characteristics

- It has one main row of standards.
- Putlogs extend from the standards towards the wall.
- The wall provides support for the inner ends of the putlogs.
- It is commonly associated with brick masonry work.

Advantages

1. Requires fewer standards than double scaffolding.
2. May use fewer scaffold tubes.
3. Can be economical for suitable brick masonry activities.
4. Provides access to external wall surfaces.

Disadvantages

1. It depends on suitable wall support.
2. It may not be suitable for completed walls where openings cannot be made.
3. It requires careful connection and support arrangements.
4. It is not suitable for every type of masonry or wall construction.

Applications

- Bricklaying.
- External wall finishing.
- Masonry construction where the wall can safely support the putlogs.

5.2 DOUBLE SCAFFOLDING



Definition

Double scaffolding is a type of scaffolding consisting of two rows of standards that provide support for the scaffold framework without relying on the wall to support the inner ends of putlogs.

It is commonly used in stone masonry construction and other activities where making holes in the wall is undesirable.

Characteristics

1. It has two rows of standards.
2. The inner row is positioned near the wall.
3. The outer row is positioned away from the wall.
4. Transoms connect the rows.
5. The scaffold is supported independently of the wall, although it may still require ties to the building for stability.

Advantages

1. Does not require holes to be made in the wall for putlog support.
2. Suitable for stone masonry.
3. Can be used for different wall construction activities.
4. Provides a stable working platform when properly designed.
5. Reduces dependence on the strength of the wall for platform support.

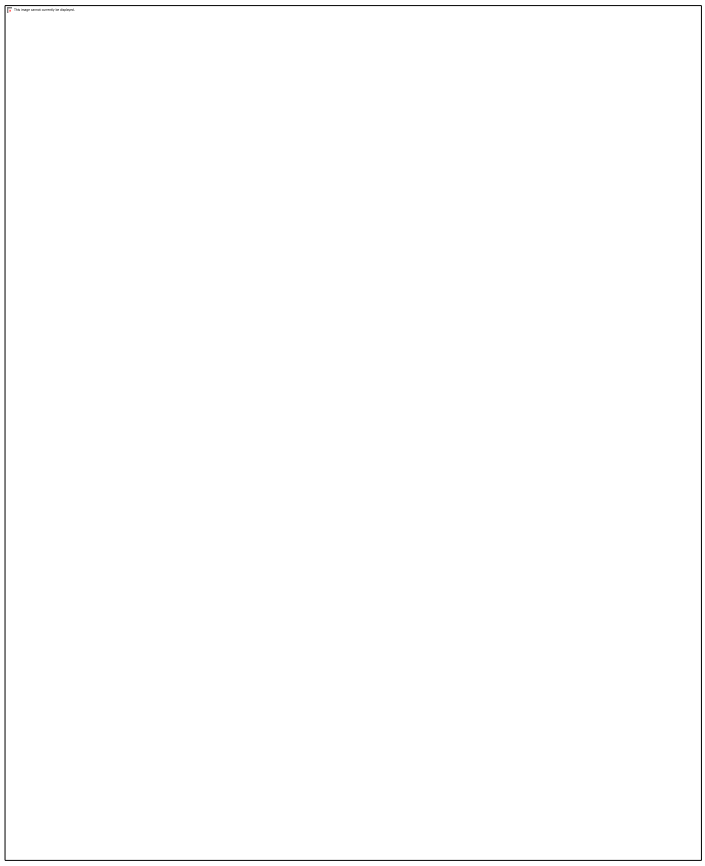
Disadvantages

1. Requires more materials than single scaffolding.
2. May occupy more ground space.
3. Requires more labour during erection.
4. Requires proper bracing and tying.

Applications

- Stone masonry.
- External plastering.
- Painting.
- Wall repairs.
- Construction of buildings with delicate or finished wall surfaces.

5.3 CANTILEVER SCAFFOLDING



Definition

Cantilever scaffolding is a type of scaffold in which the working platform is supported by projecting structural members known as needles, which are securely supported by the building or another designed structure.

Characteristics

1. It is supported by projecting members.
2. It may be used where ground-level support is obstructed.
3. It requires careful structural design.

4. It must have secure connections.
5. It is suitable for specialised construction situations.

Advantages

1. Allows work where the ground cannot accommodate standards.
2. Provides access above obstacles.
3. Can be useful in busy urban construction areas.
4. Reduces obstruction at ground level.

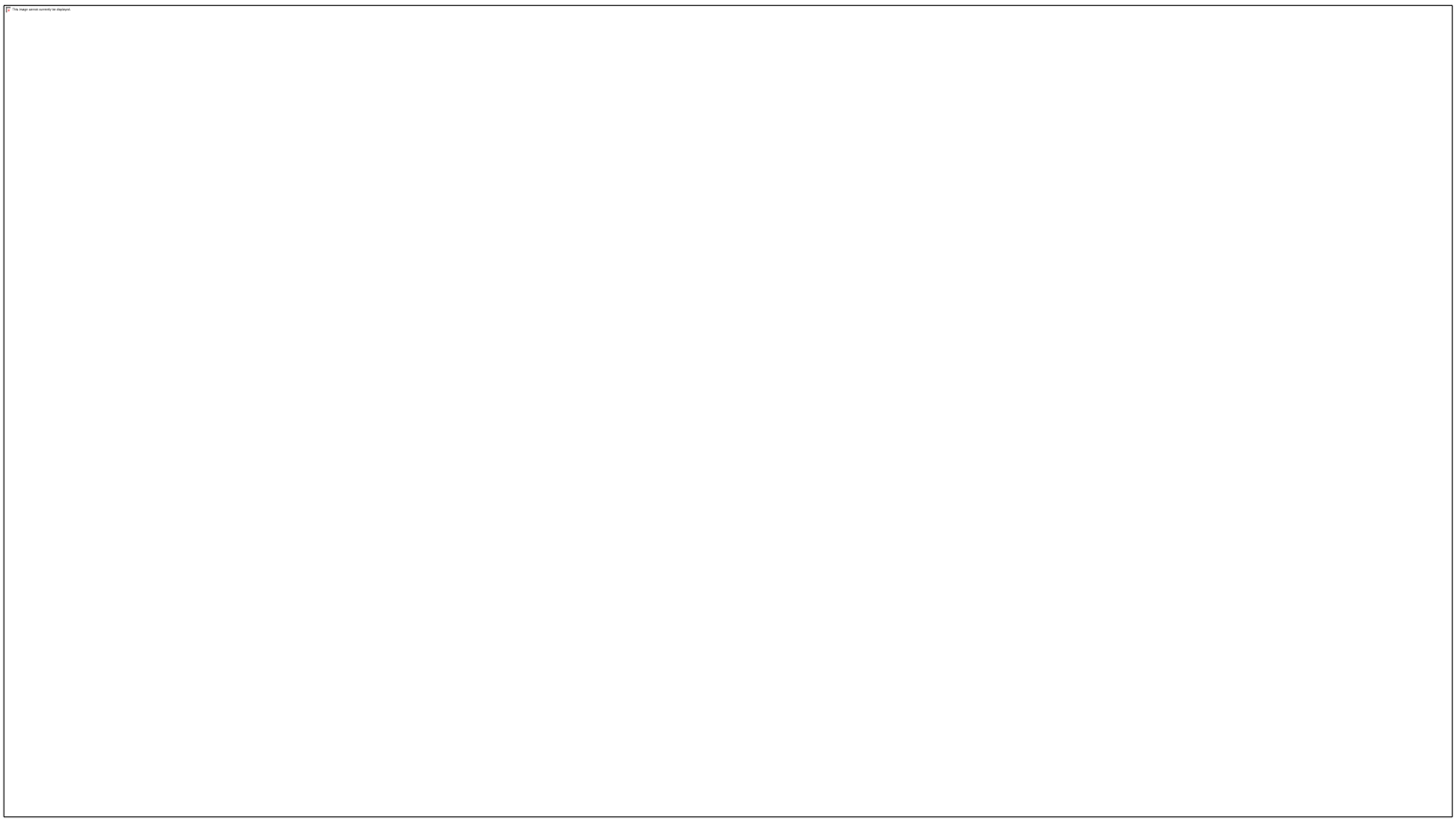
Disadvantages

1. Requires skilled design and installation.
2. Can be expensive.
3. Needs strong supporting structures.
4. Failure of the supporting arrangement can cause serious accidents.

Applications

- Construction above busy pedestrian areas.
- Building work above obstacles.
- Repair work where ground support is unavailable.

5.4 SUSPENDED SCAFFOLDING



Definition

Suspended scaffolding is a type of scaffold in which a working platform is suspended from an overhead supporting structure using ropes, cables or other approved suspension arrangements.

The platform may be raised or lowered using suitable mechanical equipment.

Characteristics

1. The platform is suspended above ground level.
2. It is supported by an overhead structure.
3. It may be adjustable in height.
4. It requires suitable suspension and safety systems.
5. It is commonly used for external building maintenance.

Advantages

1. Provides access to high building elevations.
2. Can be raised or lowered to the required level.
3. Occupies less ground space.
4. Suitable for certain high-rise maintenance activities.

Disadvantages

1. Requires specialised equipment.
2. Requires trained operators.
3. Failure of suspension components can cause serious accidents.
4. It may be affected by strong winds.
5. Requires strict inspection and maintenance.

Applications

- Painting tall buildings.
- Cleaning external windows.
- Repairing external walls.
- Inspecting building facades.

5.5 TRESTLE SCAFFOLDING



Definition

Trestle scaffolding is a type of scaffold in which a working platform is supported by movable or fixed trestles.

A trestle is a supporting frame designed to carry a platform.

Characteristics

1. It is commonly used for low-level work.
2. It consists of trestle supports and a platform.
3. It is relatively simple to assemble.
4. Some types are adjustable in height.
5. It is generally used indoors or in suitable controlled areas.

Advantages

1. Easy to assemble.
2. Relatively economical for suitable low-level tasks.
3. Portable.
4. Suitable for indoor finishing activities.

Disadvantages

1. Has limitations in working height.
2. May be unstable if incorrectly positioned.
3. Not suitable for heavy-duty high-level construction.
4. Requires a firm and level supporting surface.

Applications

- Indoor plastering.
- Painting.
- Ceiling work at suitable heights.
- Installation of interior fittings.

5.6 MOBILE SCAFFOLDING



Definition

Mobile scaffolding is a type of scaffold fitted with wheels or castors to allow it to be moved from one location to another.

Characteristics

1. It is fitted with wheels.
2. It can be moved along suitable firm surfaces.
3. It may be manufactured from steel or aluminium.
4. It has a working platform.
5. It should have suitable wheel-locking mechanisms.

Advantages

1. Easy to move between working locations.
2. Saves time when carrying out repetitive tasks.
3. Suitable for indoor finishing activities.
4. Reduces the need to dismantle and re-erect the scaffold for every nearby task.

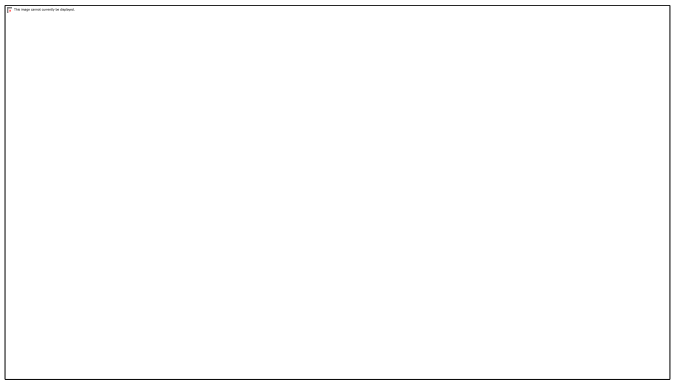
Disadvantages

1. It requires a firm, level supporting surface.
2. Unlocked wheels can cause movement.
3. It may overturn if improperly used.
4. Its movement is restricted by obstacles.
5. Workers must not ride on it while it is being moved unless a specifically approved system and procedure permit this.

Applications

- Painting large halls.
- Ceiling installation.
- Electrical and mechanical installation.
- Indoor maintenance.

5.7 BIRDCAGE SCAFFOLDING



Definition

Birdcage scaffolding is a scaffold consisting of several rows of standards connected by ledgers and transoms to form a grid-like structure supporting a large working platform.

Characteristics

1. It has several rows of standards.
2. Standards are arranged in a grid.
3. Ledgers and transoms connect the standards.
4. It provides a large working platform.
5. It is commonly used for work beneath ceilings.

Advantages

1. Provides a large working area.
2. Supports several workers where designed for the required loading.
3. Provides access to extensive ceiling surfaces.
4. Suitable for installation and maintenance activities.

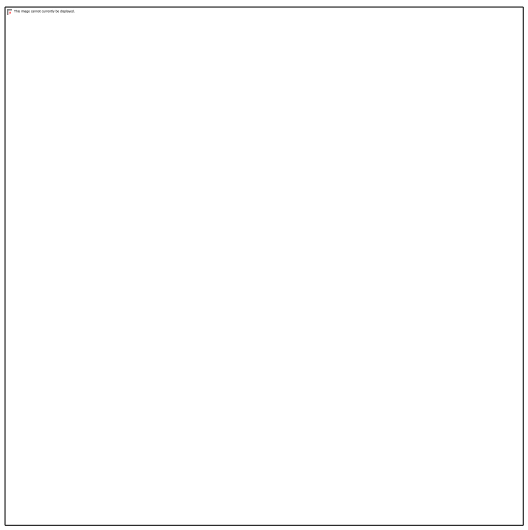
Disadvantages

1. Requires many materials.
2. Takes time to erect.
3. Occupies considerable floor space.
4. Requires careful design and inspection.

Applications

- Ceiling construction.
- Auditorium maintenance.
- Large hall plastering.
- Installation of overhead services.

5.8 PATENTED SCAFFOLDING



Definition

Patented scaffolding is a manufactured scaffold system consisting of specially designed components and connection mechanisms intended to simplify assembly and provide a standardised arrangement.

Characteristics

1. Components are manufactured to specified dimensions.
2. Connections may use special locking devices.
3. It can be assembled relatively quickly.
4. It may be designed for repeated use.
5. Its components should be used according to the manufacturer's instructions.

Advantages

- Quick assembly and dismantling.
- Standardised components.
- Reduced need for improvised connections.
- Reusable components.
- Can provide reliable performance when correctly installed.

Disadvantages

- May have a high initial purchase cost.
- Replacement components may need to come from the manufacturer.
- Requires training in the specific system.
- Components from different systems may not be interchangeable.

5.9 SYSTEM SCAFFOLDING



Definition

System scaffolding is a modular scaffold system made from prefabricated components that connect through specially designed node points, rosettes, locking devices or other approved connections.

Characteristics

1. Uses prefabricated standards.
2. Has standardised connection points.
3. Uses compatible ledgers and braces.
4. Can be adapted to different building shapes.
5. Requires proper installation according to the manufacturer's design.

Applications

- Large commercial buildings.
- Industrial structures.
- Complex building elevations.
- Construction and maintenance projects.

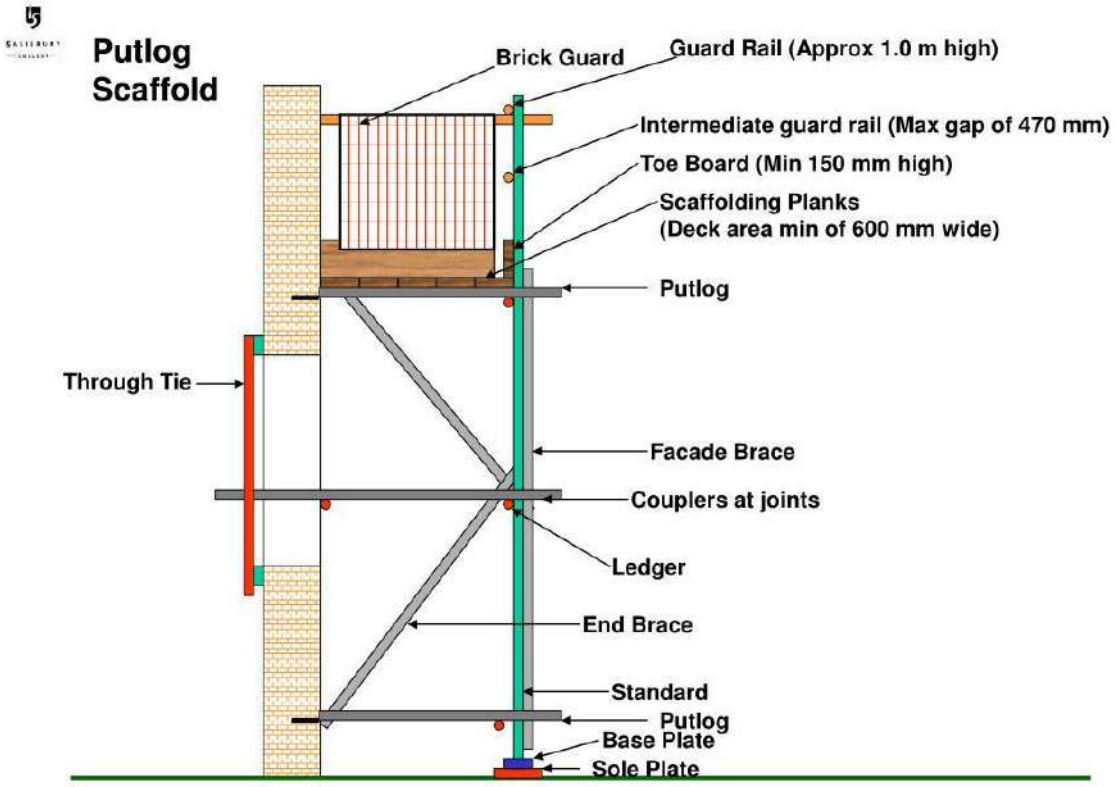
6.0 DEPENDENT AND INDEPENDENT SCAFFOLDING

Scaffolding can be classified according to how its supporting structure relates to the building being constructed.

The two main arrangements are:

1. Dependent scaffolding.
2. Independent scaffolding.

6.1 DEPENDENT SCAFFOLDING



Definition

Dependent scaffolding is a scaffold arrangement in which part of the scaffold's support is obtained from the building or structure against which the scaffold is erected.

The scaffold may use putlogs or other supporting members that rest on or are connected to the building.

Characteristics of dependent scaffolding

1. It relies partly on the building for support.
2. It may have a single row of standards.
3. Supporting members extend towards the wall.
4. Some components may be supported by the wall.
5. Its stability depends on the supporting arrangement and the condition of the building.
6. It requires proper connections and support.

Advantages of dependent scaffolding

1. **Economical use of materials**
   - It may require fewer standards and other supporting members.
   - This can reduce the quantity of materials needed.
2. **Less ground space**
   - Its arrangement may occupy less ground space than some independent systems.
3. **Convenient for suitable masonry work**
   - It provides access to walls during construction.
4. **Relatively simple arrangement**
   - Traditional putlog scaffolding can be straightforward to assemble where the wall and construction method permit it.

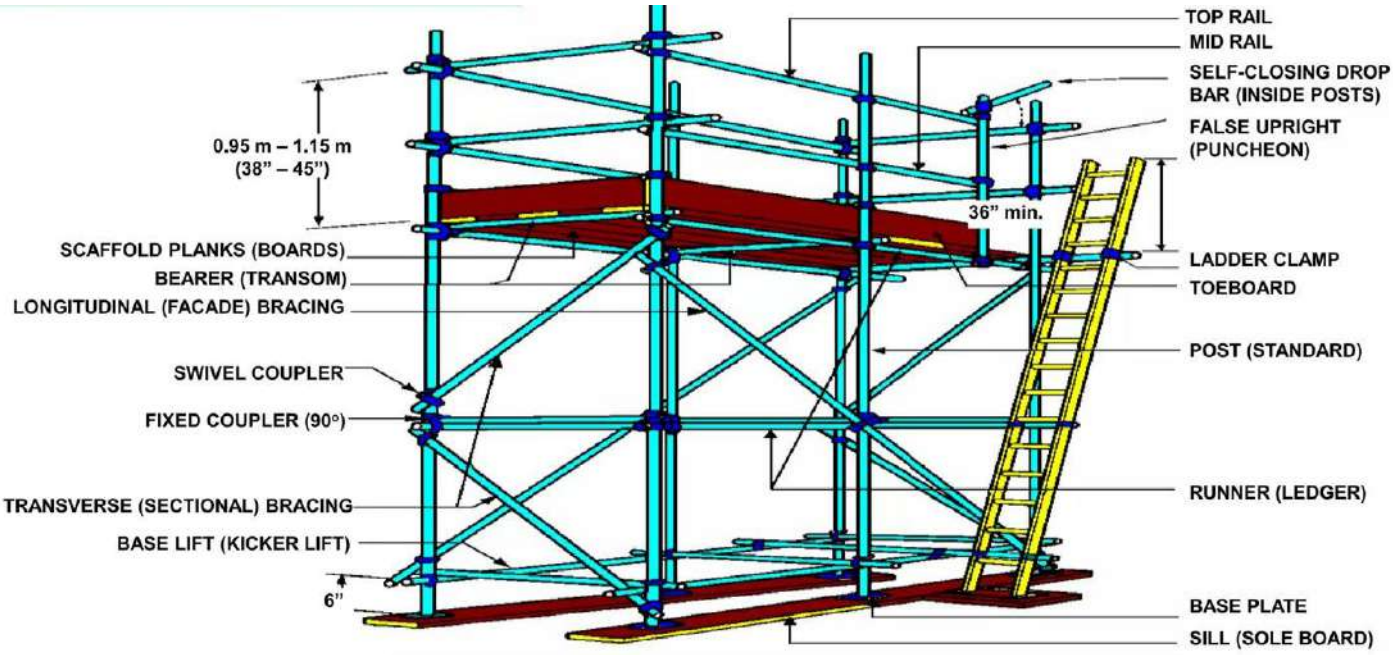
Disadvantages

1. It depends on the strength and condition of the supporting wall.
2. It may require openings or suitable connections in the wall.
3. It may be unsuitable for delicate or finished wall surfaces.
4. Its use is restricted where the wall cannot safely support scaffold components.
5. Alterations to the wall may affect the scaffold support arrangement.

Applications

- Suitable brick masonry construction.
- Certain external wall construction activities.
- Work where the building can safely provide the required scaffold support.

6.2 INDEPENDENT SCAFFOLDING



Definition

Independent scaffolding is a scaffold arrangement in which the scaffold has its own supporting framework, usually consisting of two rows of standards connected by ledgers and transoms.

It does not rely on the wall to support the working platform, although it is normally tied to the building or otherwise stabilised as required by its design.

Characteristics of independent scaffolding

1. It has two rows of standards.
2. One row is positioned close to the building.
3. The second row is positioned away from the building.
4. Transoms connect the two rows.
5. The working platform is supported by the scaffold framework.
6. It may be tied to the building to provide stability.
7. It can be used for different masonry and finishing operations.

Advantages of independent scaffolding

1. **Does not depend on wall support for the working platform**
   - It has its own supporting framework.
   - This reduces dependence on the strength of the wall.
2. **Suitable for different wall materials**
   - It can be used for stone, brick and block walls.
3. **Protects finished wall surfaces**
   - It does not require the wall to be pierced to support the inner ends of putlogs.

4. **Provides a convenient working platform**

- Workers can perform masonry, painting and plastering activities.

5. **Can be adapted**

- Its arrangement can be adjusted to suit different building elevations.

Disadvantages

1. Requires more materials.
2. Occupies more ground space.
3. Requires additional labour during erection.
4. Needs proper bracing and tying.
5. May be more expensive than suitable dependent scaffolding arrangements.

Applications

- External plastering.
- Stone masonry.
- Painting high walls.
- Construction of multi-storey buildings.
- Repair and maintenance of external walls.

6.3 DIFFERENCES BETWEEN DEPENDENT AND INDEPENDENT SCAFFOLDING

Dependent scaffolding	**Independent scaffolding**
Relies partly on the building for support	Has its own supporting framework
May have one row of standards	Usually has two rows of standards
May use putlogs supported by the wall	Uses transoms connecting the two rows
Requires suitable wall support	Working platform does not rely on wall support
May require fewer materials	Generally requires more materials
May occupy less ground space	Usually occupies more ground space
Suitable for certain brick masonry operations	Suitable for different masonry and finishing operations
Wall condition affects its support arrangement	Wall condition does not determine platform support, although building ties may be required

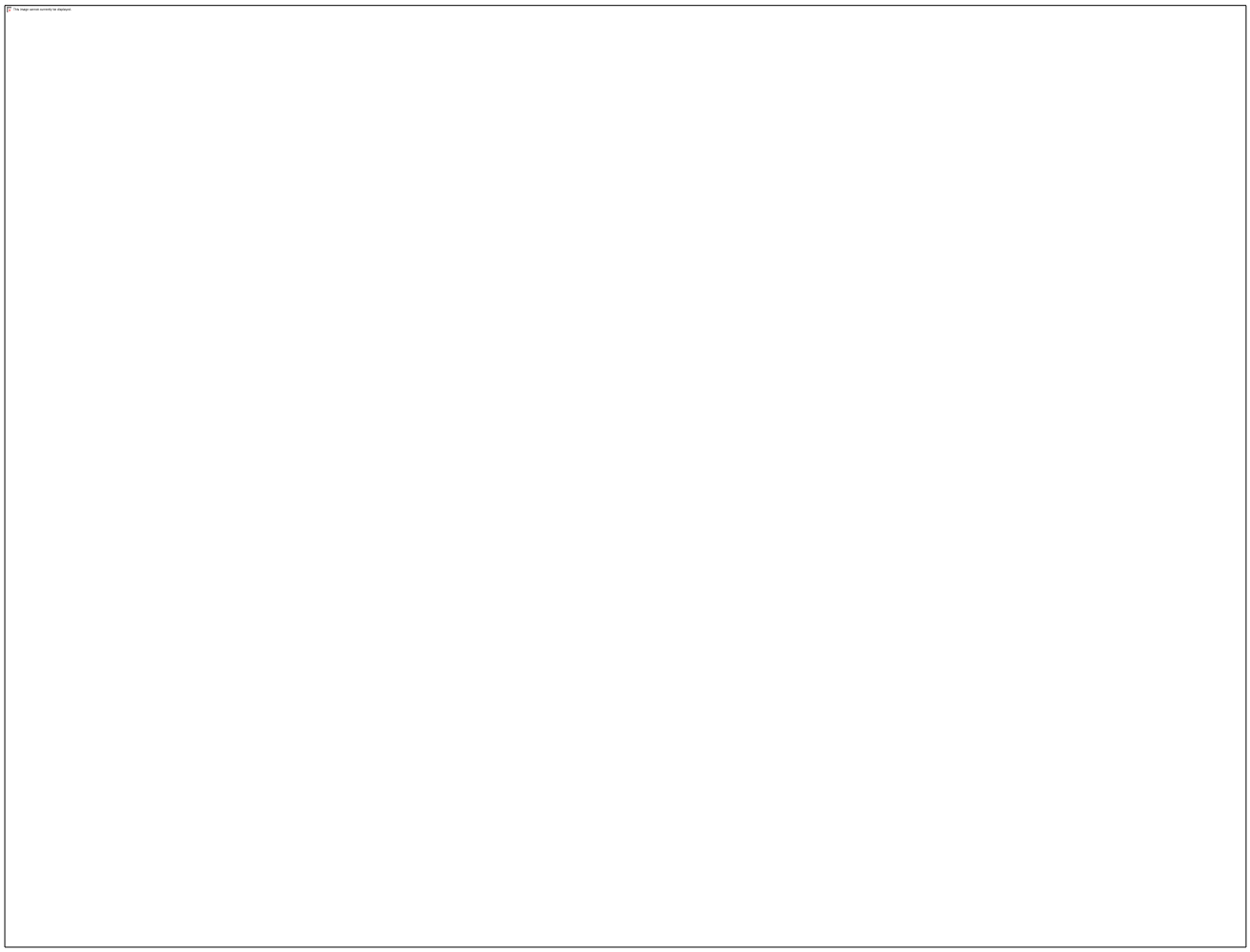
Important: Independent scaffolding does not mean that the scaffold must be completely free-standing. It may still require ties, anchors, braces or other stabilising arrangements to prevent overturning.

7.0 REQUIREMENTS OF GOOD SCAFFOLDING

7.1 Meaning of scaffold requirements

Scaffold requirements are the technical, structural and safety conditions that a scaffold must satisfy to provide a safe working environment for construction workers.

A scaffold must be properly designed, constructed, inspected, maintained and used according to the intended purpose.



7.2 Main requirements of scaffolding

1. Adequate strength

- The scaffold must be strong enough to support workers, tools and materials.
- Its members must be capable of carrying the expected loads.
- Weak or damaged components should not be used.

2. Firm foundation

- The scaffold should be erected on firm and stable ground.
- The supporting ground must be capable of carrying the scaffold loads.
- Base plates and suitable sole boards should be provided where required.
- Soft or uneven ground should be properly assessed and prepared.

3. Proper vertical alignment

- Standards should be positioned vertically.
- Incorrect alignment can create instability.
- A spirit level or other suitable equipment should be used during erection.

4. Proper horizontal alignment

- Ledgers and transoms should be correctly positioned.
- The working platform should be level.
- Incorrect positioning may affect scaffold stability.

5. Adequate bracing

- Diagonal braces should be installed as required by the scaffold design.
- Bracing helps prevent sideways movement.
- It increases the rigidity of the framework.

6. Proper tying and anchorage

- Scaffolding should be securely tied to a suitable permanent structure where required.
- Ties should be installed at the specified positions.
- The supporting building structure must be capable of resisting the forces transferred to it.

7. Adequate working platforms

- Platforms should be sufficiently wide for the intended activities.
- They should be properly supported.
- They should be free from unnecessary gaps and defects.
- They should not be overloaded.

8. Guardrails

- Suitable guardrails should be provided along exposed platform edges.
- They help prevent workers from falling.
- Intermediate rails or equivalent protection should be provided where necessary.

9. Toe boards

- Toe boards should be fitted where necessary to prevent tools and materials from falling.
- They help protect people working below the scaffold.

10. Safe access

- Suitable ladders or stairways should be provided.
- Workers should not climb scaffold braces or standards.
- Access routes should be maintained in a safe condition.

11. Suitable materials

- Scaffold materials should be strong and suitable for their intended use.

- Timber should be free from serious defects.
- Metal components should be free from corrosion or damage that could affect their strength.

12. Proper inspection

- Scaffolding should be inspected by competent persons.
- Defects should be identified and corrected.
- The scaffold should not be used when it is unsafe.

13. Protection against falling materials

- Suitable toe boards, brick guards, screens or debris protection should be provided where required.
- Materials should be securely arranged.
- Tools should not be left close to unprotected platform edges.

14. Suitable working height

- The scaffold should reach the working level required.
- Its height and arrangement should comply with the approved design.
- Workers should not improvise by placing boxes, blocks or drums on the platform to gain extra height.

15. Resistance to weather conditions

- The scaffold should be suitable for expected wind and weather conditions.
- Additional precautions may be necessary during strong winds or heavy rain.
- Temporary sheeting and netting should only be installed where the scaffold design allows for the additional wind loading.

16. Proper maintenance

- Components should be maintained in good condition.
- Damaged parts should be repaired or replaced by competent persons.
- Components should be stored properly when not in use.

8.0 BUILDING CODES AND REGULATIONS RELATING TO SCAFFOLDING IN KENYA

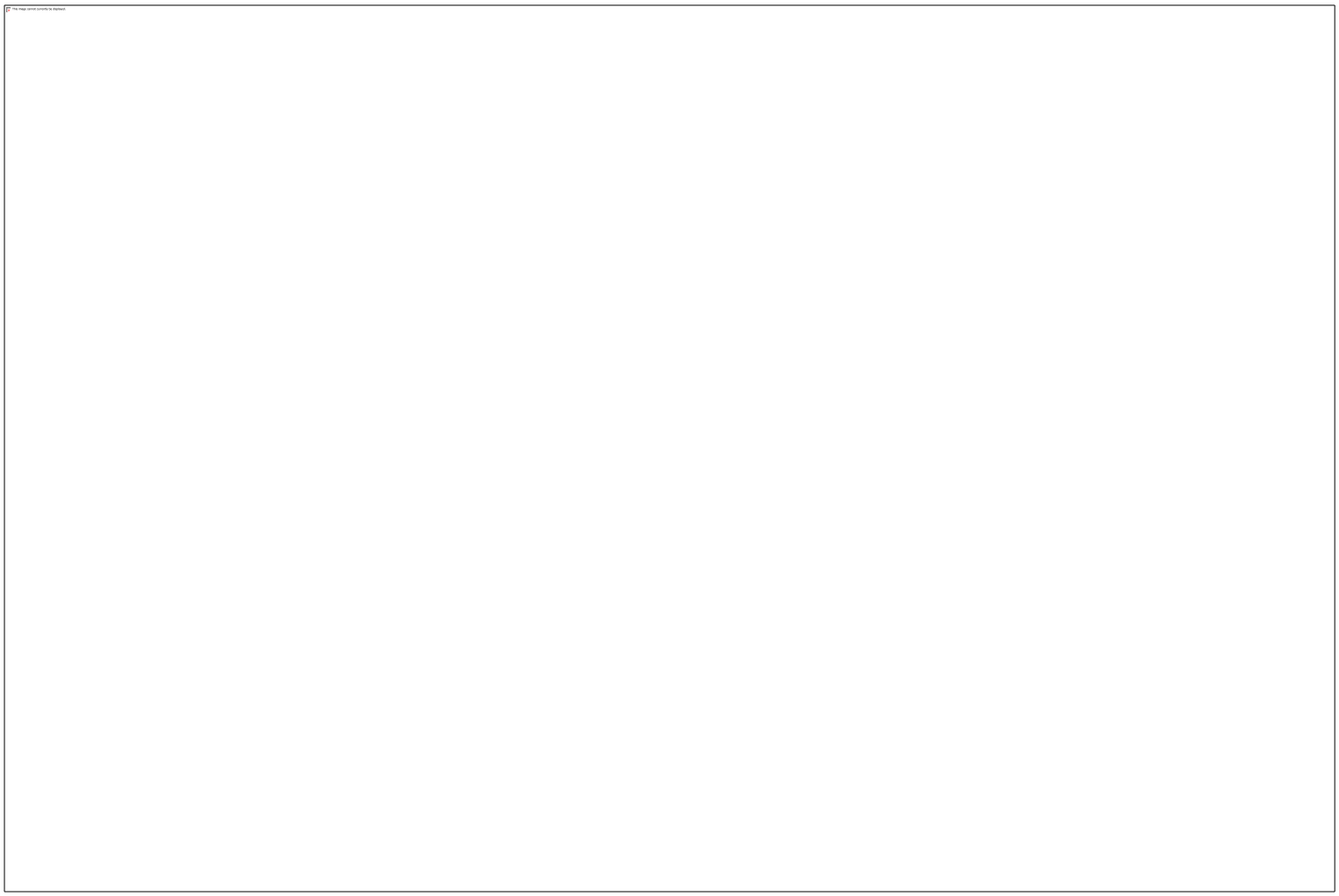
8.1 Meaning of a building code

Definition

A building code is a set of legally recognised rules, standards and requirements that regulate the planning, design, construction, alteration, maintenance and safety of buildings and construction activities.

Building codes are established to ensure that buildings and construction operations meet acceptable standards of safety, health, quality and performance.

In Kenya, construction activities must comply with applicable building laws, occupational safety and health requirements and relevant technical standards.



8.2 The National Building Code, 2024

The principal building regulation to study in the Kenyan context is the **National Building Code, 2024**, published under Legal Notice No. 47 of 2024.

It replaced the former Local Government (Adoptive By-Laws) (Building) Order of 1968 and came into operation on 1 March 2025.

The Code provides requirements relating to:

1. Design and construction of buildings.
2. Structural safety.
3. Construction site safety.
4. Building materials.
5. Inspection and maintenance.
6. Health and safety of construction workers.
7. Disaster risk management.
8. Safe construction operations.

8.3 Specific National Building Code provisions relating to scaffolding

Part XXIII of the National Building Code, 2024 deals with disaster risk management on construction sites.

The following paragraphs are particularly relevant:

Code paragraph	Subject
466	Duties of contractor
467	Health and safety file
468	Safe place of work
469	Good order and construction site security
470	Stability of structure
471	Scaffold
472	Working platform
473	Guarding
474	Preventing falling
475	Suitable plank
476	Ladder
477	Position of material

A. Paragraph 471: Scaffold

The Code provides important requirements concerning scaffold construction and inspection.

The main provisions include:

1. A scaffold should not be erected, added to, altered or dismantled except under the supervision of a contractor.
2. An engineer should inspect scaffolds before they are used.
3. A scaffold should be constructed according to an engineer's design.
4. Sufficient suitable materials should be provided for scaffold construction.
5. Timber used for scaffolding should not be painted or treated in a manner that conceals defects.
6. Metal scaffold components should be free from corrosion and other obvious defects that could materially affect their strength.

B. Paragraph 472: Working platforms

The Code provides minimum working-platform widths for certain work platforms above 2 metres in height.

The specified widths include:

Intended use	Minimum width
Footing only, without depositing materials	635 mm
Depositing materials	865 mm
Supporting a higher platform	1,065 mm
Dressing or roughly shaping stone	1,295 mm
Supporting a higher platform used for stone dressing	1,500 mm

The Code also requires adequate clear passageways in the circumstances specified.

These are legal minimum requirements for the stated uses, not universal scaffold design dimensions. The actual platform must be designed to provide adequate working space and safely carry the intended loads.

C. Paragraph 473: Guarding

This provision addresses the guarding of working platforms and the protection of workers against falls.

Learners should understand that exposed platform edges require suitable protective barriers.

D. Paragraph 474: Preventing falling

This provision addresses measures for preventing workers and materials from falling during construction operations.

E. Paragraph 475: Suitable plank

Scaffold planks must be suitable for their intended purpose and capable of providing safe working surfaces.

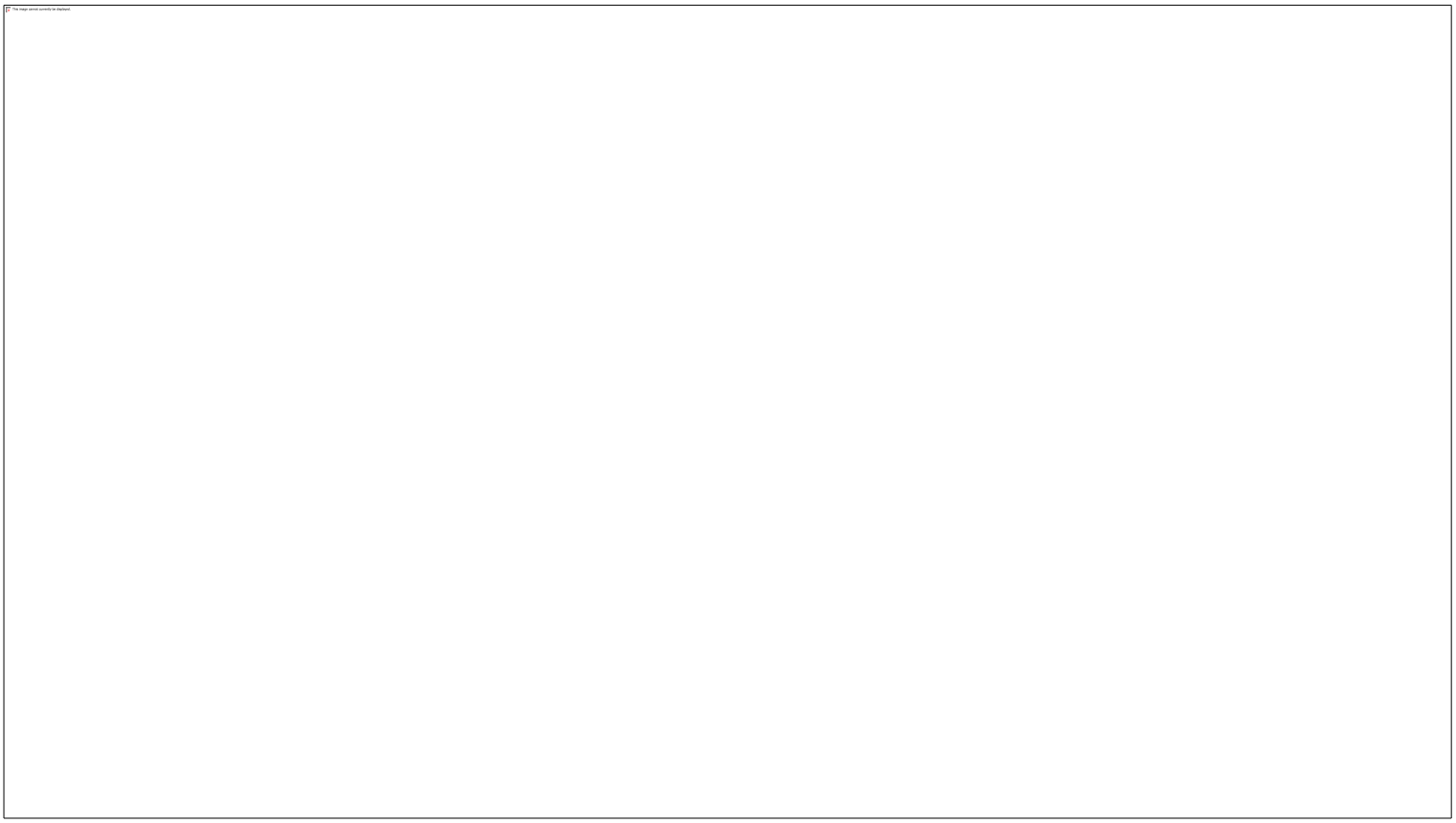
F. Paragraph 476: Ladder

This provision addresses ladders used to provide access during construction activities.

G. Paragraph 477: Position of material

Materials must be positioned appropriately to avoid creating hazards or interfering with safe construction activities.

8.4 Occupational Safety and Health Act, 2007



The Occupational Safety and Health Act, 2007 provides a legal framework for protecting workers and other persons present at workplaces.

It places responsibilities on workplace occupiers and employers to provide and maintain safe working systems.

Important areas relevant to scaffolding include:

1. Provision of safe working conditions.
2. Safe use of construction equipment.
3. Provision of appropriate protective equipment.
4. Information, instruction and training.
5. Supervision of construction activities.
6. Prevention of workplace accidents.
7. Maintenance of safe working systems.

The Directorate of Occupational Safety and Health Services (DOSHS) is responsible for enforcing the Act.

8.5 Importance of complying with building codes

1. **Protection of workers**
   - Helps reduce accidents during construction activities.
2. **Prevention of scaffold collapse**
   - Ensures scaffolds are properly designed and constructed.
3. **Improved construction quality**
   - Promotes acceptable workmanship and use of suitable materials.
4. **Legal compliance**
   - Helps contractors and building owners meet their legal obligations.
5. **Protection of the public**
   - Reduces risks to pedestrians, visitors and neighbouring property owners.
6. **Professional accountability**
   - Encourages proper supervision and inspection by qualified personnel.
7. **Improved site management**
   - Promotes organised and safe construction activities.
8. **Reduction of financial losses**
   - Helps prevent damage, accidents, delays and costly repairs.

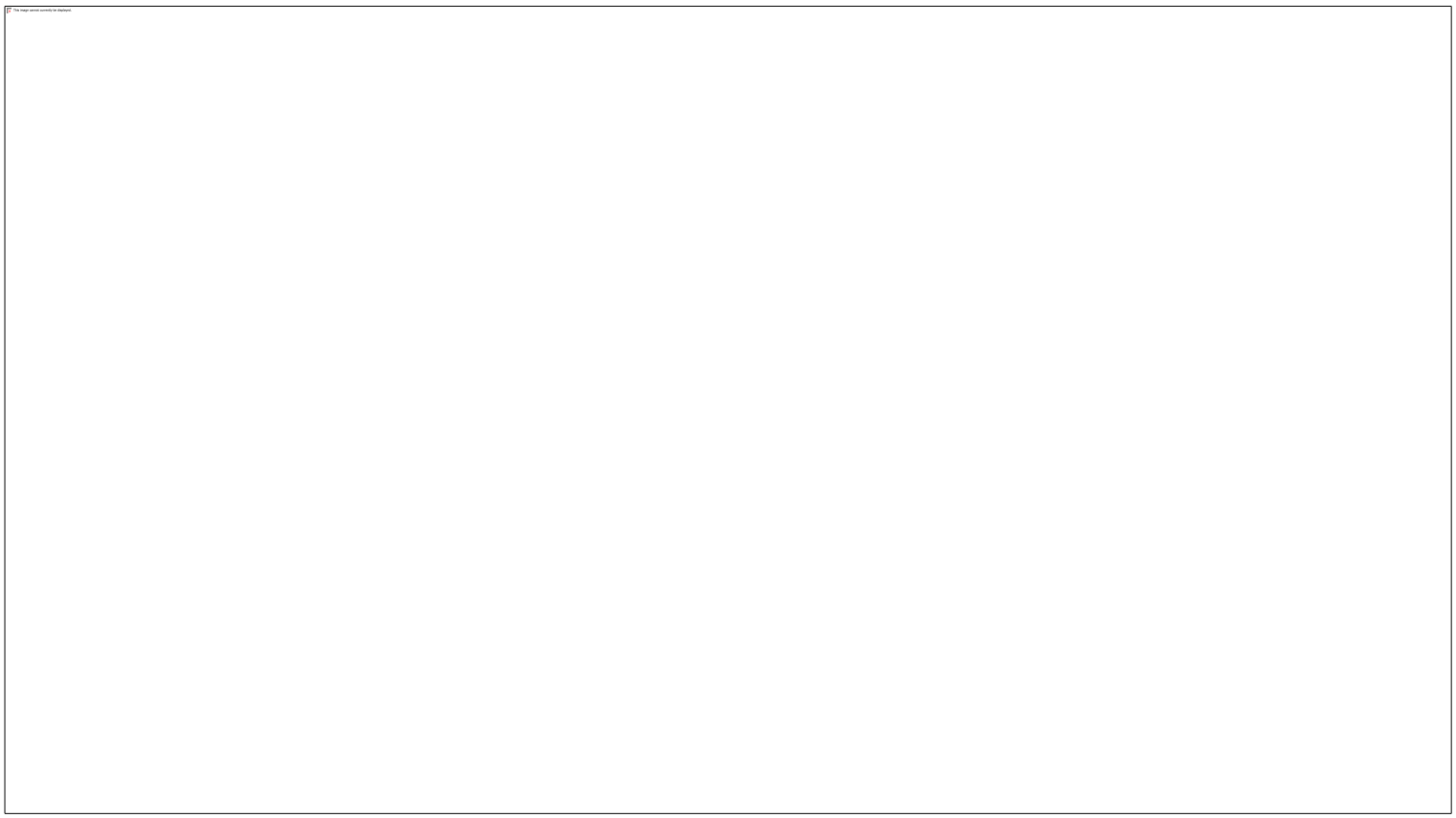
Textbook reference: National Building Code, 2024, Legal Notice No. 47, particularly paragraphs 466–477. Learners should consult the official published Code for complete legal wording and project-specific requirements.

9.0 SAFETY MEASURES TO OBSERVE WHEN USING SCAFFOLDING

9.1 Meaning of scaffolding safety

Scaffolding safety refers to the precautions, procedures and protective measures adopted during the erection, use, alteration and dismantling of scaffolds to prevent accidents, injuries and damage to property.

Scaffolding accidents can result in serious injuries or death. Therefore, safety must be considered at every stage of scaffold construction and use.



9.2 General safety precautions

1. Use competent and trained workers

- Scaffolding should be erected, altered and dismantled by competent workers.
- Workers should understand scaffold components and safe assembly procedures.
- Complex scaffolds should be erected under appropriate technical supervision.

2. Inspect scaffold materials

- Examine scaffold tubes, boards, couplers and fittings before use.
- Remove damaged components.
- Do not use cracked, rotten or excessively worn timber boards.
- Do not use corroded or bent metal components where their strength may be affected.

3. Provide a firm foundation

- Erect scaffolding on stable and level ground.
- Use appropriate base plates and sole boards.

- Avoid placing scaffold standards on loose soil, loose bricks or unstable surfaces.
- Provide suitable support where the ground is weak.

4. Install adequate bracing

- Fit diagonal braces according to the scaffold design.
- Ensure that connections are secure.
- Do not remove braces without authorisation.

5. Provide guardrails

- Install suitable guardrails on exposed working-platform edges.
- Provide intermediate rails or equivalent protection as required.
- Check that the protective barriers are secure.

6. Provide toe boards

- Fit toe boards where necessary.
- They help prevent tools and materials from falling.
- Use additional protection where there is a risk of falling objects.

7. Provide safe access

- Provide suitable ladders or stairways.
- Secure ladders properly.
- Do not climb scaffold braces or standards.
- Keep access points free from obstructions.

8. Avoid overloading

- Do not place more materials on the scaffold than it is designed to carry.
- Distribute loads evenly.
- Remove unnecessary materials.
- Observe the scaffold's specified safe working load.

9. Maintain good housekeeping

- Keep working platforms clean.
- Remove waste materials.
- Avoid leaving loose tools on platforms.
- Keep access routes clear.

10. Wear personal protective equipment

- Wear safety helmets.
- Wear safety boots.
- Use protective gloves.
- Wear safety harnesses where required by the risk assessment and work system.

- Use appropriate eye and respiratory protection.

11. Protect against falling objects

- Secure tools and materials.
- Use suitable toe boards and brick guards.
- Provide protective netting or covered walkways where required.
- Restrict access beneath scaffold work areas where falling objects may cause injury.

12. Inspect regularly

- Have scaffolding inspected by competent persons.
- Inspect before first use.
- Reinspect after alteration or damage.
- Inspect following events such as strong winds that may affect stability.
- Maintain inspection records as required.

13. Avoid working during dangerous weather

- Stop scaffold work when wind, lightning, heavy rain or other weather conditions make it unsafe.
- Reassess the scaffold before use after severe weather.
- Do not allow water and mud to create slippery working conditions.

14. Maintain a safe distance from electrical cables

- Avoid erecting scaffolding near overhead power lines without the necessary electrical safety arrangements.
- Consult the relevant electricity authority where necessary.
- Use suitable isolation, diversion or exclusion arrangements.
- Remember that steel and aluminium scaffolding conduct electricity.

15. Prevent unauthorised access

- Restrict access to scaffolds by unauthorised persons.
- Display warning signs where necessary.
- Secure access ladders when scaffolding is not in use.

16. Avoid unsafe modifications

- Workers should not remove scaffold ties, braces, guardrails or other structural components without authorisation.
- Any alterations should be undertaken by competent persons under appropriate supervision.

17. Use appropriate lifting methods

- Use suitable lifting equipment for heavy scaffold components.
- Do not throw materials between scaffold levels.
- Ensure that materials are secured during lifting.

18. Do not use incomplete scaffolding

- Incomplete or unsafe scaffolds should be clearly marked and access restricted.
- Do not use platforms with missing boards, guardrails or essential supports.

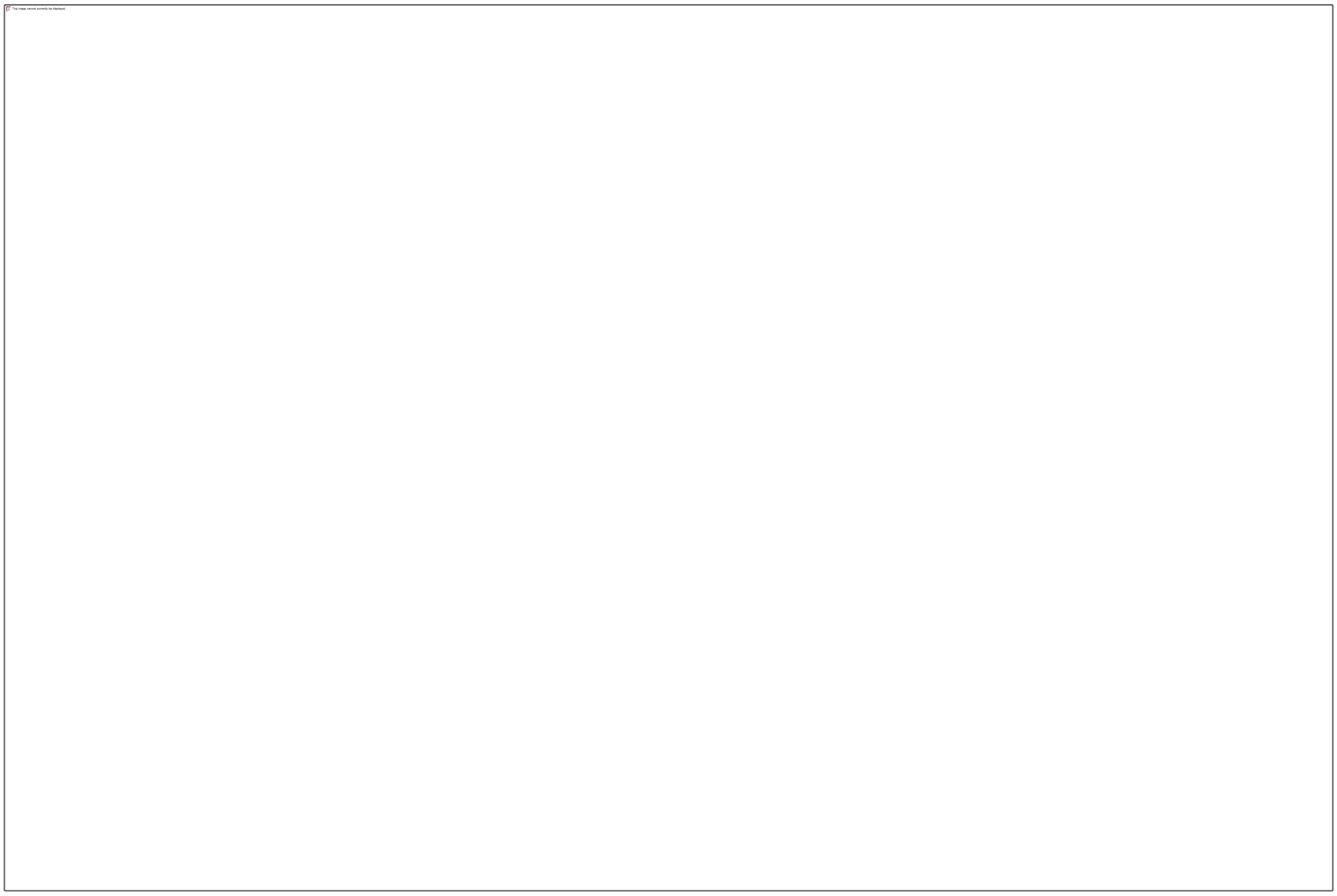
19. Do not move an occupied mobile scaffold

- Workers should leave the tower before it is moved unless the specific system and approved procedure expressly permit otherwise.
- Lock the castors before using the scaffold.
- Ensure the ground is firm and level.

20. Prepare for emergencies

- Provide emergency arrangements.
- Ensure workers know how to report accidents.
- Make suitable first-aid arrangements available.
- Plan for the rescue of workers who may fall or become suspended in safety harnesses.

9.3 Personal protective equipment used during scaffolding



PPE	Function
Safety helmet	Protects the head against falling objects and impact
Safety boots	Protect the feet against injuries and slipping

Protective gloves	Protect the hands against cuts and abrasion
Safety goggles	Protect the eyes against dust and flying particles
Reflective vest	Improves visibility of workers
Dust mask or respirator	Protects against harmful construction dust
Safety harness	Forms part of an appropriate personal fall-protection system
Hearing protection	Protects against excessive noise

10.0 PROCEDURE FOR ERECTING SCAFFOLDING

10.1 Meaning of scaffold erection

Scaffold erection is the process of assembling scaffold components in their correct positions to form a stable temporary structure for construction activities.

The process should be undertaken by competent workers under appropriate supervision and according to the approved scaffold design and manufacturer's instructions.



10.2 Steps followed when erecting scaffolding

Step 1: Study the construction requirements

- Determine the purpose of the scaffold.
- Establish the required working height.
- Identify the type of scaffold to be used.
- Determine the expected loads.
- Obtain the approved scaffold design where required.

Step 2: Inspect the construction site

- Examine the ground conditions.

- Identify underground services and drainage channels.
- Identify overhead electrical cables.
- Check for obstructions.
- Establish safe access and working areas.

Step 3: Prepare the ground

- Clear vegetation, debris and loose materials.
- Prepare a firm and level supporting surface.
- Provide suitable foundations or sole boards where necessary.
- Ensure that the ground can support the intended loads.

Step 4: Inspect scaffold components

- Examine standards, ledgers, transoms and braces.
- Check scaffold boards.
- Inspect couplers and fittings.
- Remove defective components from service.

Step 5: Position the base plates

- Mark the scaffold positions.
- Place base plates at the required locations.
- Provide suitable sole boards where necessary.
- Ensure that the bases are properly supported.

Step 6: Install the standards

- Position the vertical standards.
- Check their alignment.
- Connect the necessary horizontal members.
- Ensure that the supporting arrangement follows the design.

Step 7: Fix the ledgers and transoms

- Connect the standards using ledgers.
- Install transoms at the specified positions.
- Check the horizontal alignment.
- Tighten or secure all appropriate connections.

Step 8: Install diagonal braces

- Fix diagonal braces.
- Ensure that the scaffold is adequately stabilised.
- Check the connections.

Step 9: Install scaffold ties

- Connect the scaffold to the building at the designed positions.
- Ensure that the supporting structure can resist the imposed forces.
- Maintain the specified tie arrangement as erection progresses.

Step 10: Install working platforms

- Position suitable scaffold boards or manufactured platform units.
- Ensure that they are adequately supported and secured.
- Check the platform width and condition.

Step 11: Install protective components

- Fit guardrails.
- Install intermediate rails.
- Fit toe boards.
- Provide additional protection where necessary.

Step 12: Provide safe access

- Install suitable access ladders or stairways.
- Secure the access arrangements.
- Ensure that workers can move safely between levels.

Step 13: Conduct inspection

- Check the entire scaffold.
- Inspect connections, braces and ties.
- Check working platforms and protective barriers.
- Ensure compliance with the approved design.

Step 14: Authorise use

- The required competent persons should inspect and approve the scaffold before use.
- Defects should be corrected before workers are allowed onto the platform.

11.0 PROCEDURE FOR DISMANTLING SCAFFOLDING

11.1 Meaning of dismantling

Dismantling is the process of carefully taking apart a scaffold after the construction or maintenance activity has been completed.



11.2 Steps followed when dismantling scaffolding

1. **Plan the dismantling operation**
    - Establish the sequence of dismantling.
    - Ensure that competent workers are available.
    - Identify possible hazards.
2. **Clear the working platforms**
    - Remove tools and unused materials.
    - Ensure that no unnecessary loads remain.
3. **Restrict access**
    - Place barriers around the working area.
    - Prevent unauthorised people from entering.
4. **Wear protective equipment**
    - Workers should wear suitable PPE.
    - Use fall-protection systems where required.
5. **Remove upper-level components**
    - Start dismantling from the uppermost level.
    - Follow the approved dismantling sequence.
6. **Remove platform boards**
    - Remove scaffold boards carefully.
    - Lower them using appropriate methods.
7. **Remove guardrails and toe boards**
    - Remove protective components in the sequence specified by the dismantling plan.
    - Maintain suitable fall protection for workers.
8. **Remove transoms and ledgers**
    - Disconnect the horizontal members in the approved sequence.
    - Avoid destabilising the remaining scaffold.

9. **Remove braces**

- Remove diagonal braces only when authorised and when the remaining structure is stable.

10. **Remove standards**

- Dismantle the vertical members progressively.

11. **Remove base plates and sole boards**

- Remove the remaining supporting components.

12. **Inspect and store materials**

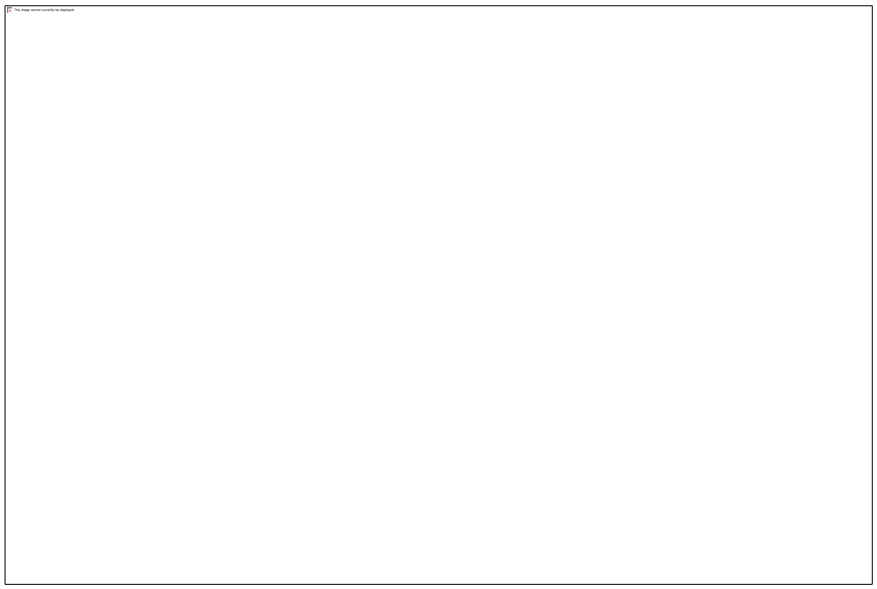
- Check components for damage.
- Separate defective materials.
- Store reusable components properly.

Important: Scaffold ties and braces must not be removed prematurely. Dismantling should proceed in a sequence that maintains stability throughout the operation.

12.0 INSPECTION AND MAINTENANCE OF SCAFFOLDING

12.1 Meaning of scaffold inspection

Scaffold inspection is the systematic examination of a scaffold to establish whether its components and supporting arrangements are safe and suitable for use.



Importance of scaffold inspection

1. Identifies damaged components.
2. Detects loose connections.
3. Identifies missing braces and ties.
4. Detects unstable foundations.
5. Checks the condition of working platforms.
6. Identifies unsafe access arrangements.
7. Helps prevent scaffold collapse.

8. Protects workers and the public.

12.2 Components to inspect

Component	What to check
Standards	Vertical alignment, damage and support
Ledgers	Correct positioning and secure connections
Transoms	Proper support and connections
Braces	Correct installation and secure fixing
Base plates	Proper positioning and bearing
Sole boards	Stability and condition
Couplers	Tightness, damage and corrosion
Scaffold boards	Cracks, splits and secure support
Guardrails	Correct installation and rigidity
Toe boards	Proper fitting and condition
Ties	Secure connections and correct positioning
Access ladders	Condition and secure installation

12.3 Maintenance practices

1. Clean scaffold components after use.
2. Remove mud, mortar and other materials.
3. Protect steel components against corrosion.
4. Store timber components in dry conditions.
5. Replace damaged scaffold boards.
6. Replace defective couplers and fittings.
7. Lubricate suitable mechanical components according to manufacturer instructions.
8. Store components in an organised manner.
9. Keep different scaffold components properly classified.
10. Arrange repairs and inspections by competent personnel.

13.0 HAZARDS ASSOCIATED WITH SCAFFOLDING

13.1 Meaning of a hazard

A hazard is anything with the potential to cause injury, illness, damage to property or harm to the environment.

13.2 Common scaffolding hazards and their control measures

Hazard	Possible consequence	Control measure
Falling from height	Serious injury or death	Guardrails, safe platforms and appropriate fall protection
Scaffold collapse	Crushing injuries	Proper design, erection and inspection
Falling materials	Injuries to workers below	Toe boards, brick guards and exclusion zones
Electrical contact	Electric shock or electrocution	Safe clearance and electrical isolation arrangements
Slippery platforms	Slips and falls	Housekeeping and suitable working surfaces
Overloading	Structural failure	Observe the specified safe working load
Unstable ground	Scaffold settlement or overturning	Firm foundation and suitable base support
Strong winds	Loss of scaffold stability	Stop unsafe work and inspect after severe weather
Defective components	Structural failure	Inspection and replacement
Improper access	Falls and injuries	Suitable ladders and stairways

Unauthorised alterations	Scaffold instability	Competent supervision and controlled modifications



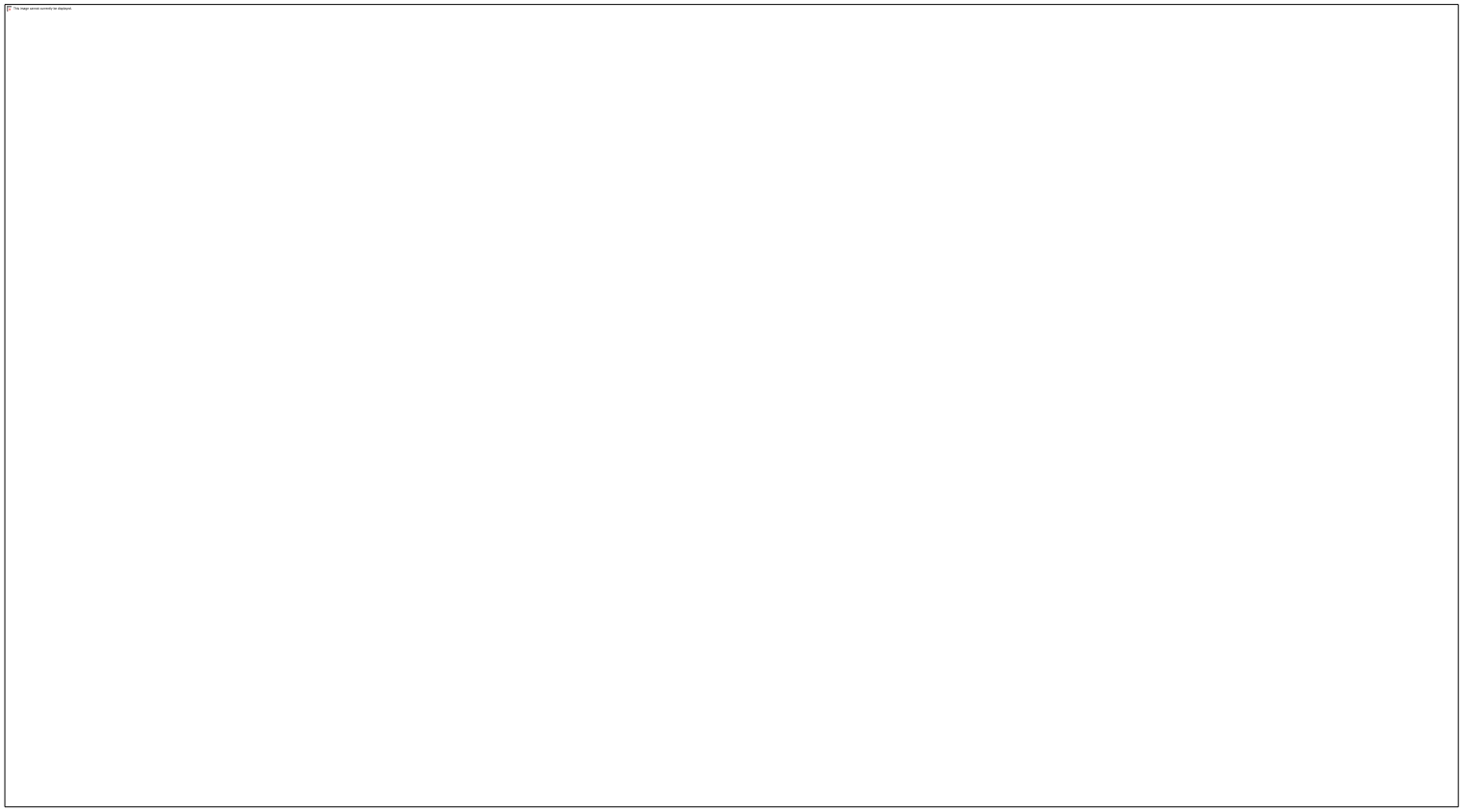
14.0 FACTORS TO CONSIDER WHEN SELECTING A TYPE OF SCAFFOLDING

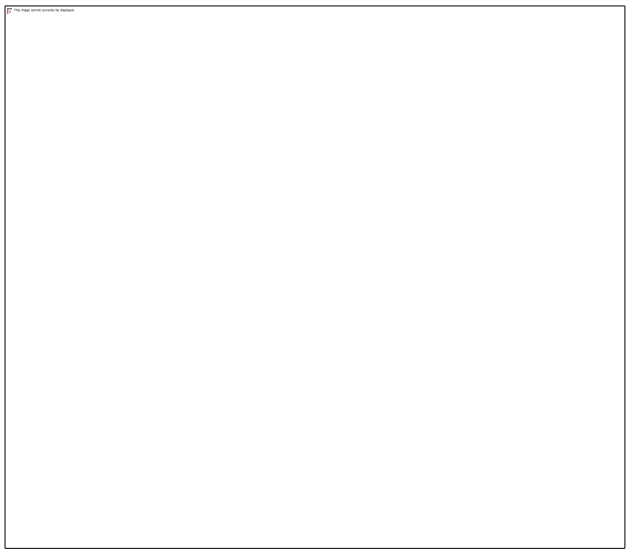
The selection of scaffolding depends on several factors.

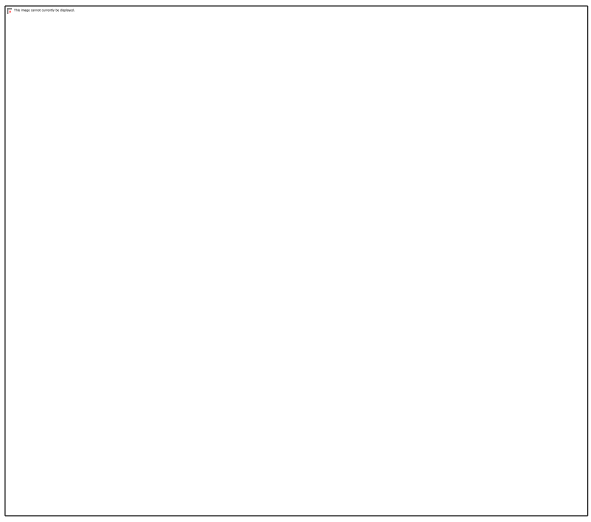
1. **Height of the building**
   - The scaffold should reach the required working height safely.
   - High buildings may require specially designed scaffold systems.
2. **Nature of construction work**
   - Masonry, painting, plastering and maintenance may require different scaffold arrangements.
3. **Type of building**
   - Residential houses, schools, hospitals and commercial buildings may require different scaffolding systems.
4. **Ground conditions**
   - The supporting ground should be capable of carrying the scaffold loads.
5. **Availability of materials**
   - The selected scaffold should use suitable materials available for the project.
6. **Cost**
   - The cost of purchasing, hiring, transporting and erecting scaffolding should be considered.
7. **Safety requirements**
   - The scaffold must provide suitable protection for workers and the public.
8. **Duration of work**
   - Long-term projects may require durable and reusable scaffold systems.
9. **Working space**
   - The available space around the building may influence scaffold selection.
10. **Nature of the supporting structure**
    - The strength and condition of the building should be considered when selecting dependent scaffolding.
11. **Weather conditions**
    - Wind and rain exposure may influence scaffold design and use.
12. **Availability of skilled labour**
    - Some specialised systems require trained scaffold erectors.

15.0 PRACTICAL LEARNING ACTIVITIES

These activities help learners acquire practical skills in scaffolding.







Activity	Expected learning outcome
Identify scaffold materials	Material identification skills
Identify scaffold components	Knowledge of scaffold structure
Observe different scaffold types	Classification skills
Sketch dependent scaffolding	Technical drawing skills
Sketch independent scaffolding	Technical drawing skills
Assemble a miniature scaffold model	Practical construction skills
Inspect scaffold components	Inspection skills
Demonstrate PPE use	Occupational safety skills
Prepare a scaffold safety checklist	Problem-solving skills
Compare steel and timber scaffolding	Analytical skills

15.1 Suggested practical project

PROJECT: CONSTRUCTION OF A MINIATURE INDEPENDENT SCAFFOLD MODEL



Project objective

To enable learners to demonstrate their understanding of independent scaffolding through the construction of a miniature scaffold model.

Materials required

1. Small timber pieces or suitable model tubes.
2. Small wooden boards.
3. Binding wire or suitable model connectors.
4. Glue.
5. Cardboard for the building model.
6. Marking materials.
7. Paint for identification.

Tools required

1. Tape measure.
2. Ruler.
3. Pencil.
4. Small hand saw.
5. Try square.
6. Pliers.
7. Cutting tools appropriate to the model materials.

Procedure

1. Draw the design of the proposed scaffold.
2. Prepare the model building.
3. Measure and cut the vertical standards.
4. Assemble the two rows of standards.
5. Connect the standards using ledgers.
6. Install transoms.
7. Add diagonal braces.
8. Prepare and install the working platform.
9. Add model guardrails and toe boards.
10. Label the scaffold components.
11. Present the model and explain the function of each component.

Expected learning outcomes

- Identification of scaffold components.
- Understanding independent scaffolding.
- Development of measuring and marking skills.
- Development of practical construction skills.
- Application of safety principles.
- Creativity and teamwork.

16.0 REVISION SUMMARY

Term	Meaning
Scaffolding	Temporary framework providing elevated access and working platforms
Scaffold	The assembled temporary structure
Standard	Vertical scaffold member
Ledger	Horizontal member running along the length of a scaffold
Transom	Horizontal member running across the width of a scaffold
Brace	Diagonal member that strengthens a scaffold
Base plate	Plate fitted beneath a standard
Sole board	Support placed beneath a base plate to distribute loads
Scaffold board	Board used to form a working platform
Guardrail	Barrier protecting workers against falls
Toe board	Barrier preventing materials from falling from a platform
Coupler	Fitting used to connect scaffold tubes
Tie	Connection securing a scaffold to a building
Dependent scaffold	Scaffold that relies partly on the building for support
Independent scaffold	Scaffold with its own supporting framework
Single scaffold	Scaffold having one main row of standards
Double scaffold	Scaffold having two rows of standards
Cantilever scaffold	Scaffold supported by projecting structural members
Suspended scaffold	Scaffold suspended from an overhead support
Trestle scaffold	Scaffold supported by trestles

Mobile scaffold	Scaffold fitted with wheels
Birdcage scaffold	Scaffold consisting of several rows of standards forming a grid
Formwork	Temporary mould used to shape and support fresh concrete

REVISION QUESTIONS

SUB-STRAND 3.4

SECTION A: MULTIPLE-CHOICE QUESTIONS

Choose the correct answer from the alternatives A, B, C and D.

1. What is scaffolding in building construction?

A. A permanent foundation structure.

B. A temporary framework used to provide elevated working platforms.

C. A type of roofing material.

D. A permanent wall support.

2. Which of the following is the main purpose of scaffolding?

A. To support the foundation.

B. To provide access and working platforms at elevated positions.

C. To replace building walls.

D. To support underground drainage pipes.

3. Which material is commonly used in manufacturing scaffold tubes?

A. Glass.

B. Steel.

C. Ceramic.

D. Gypsum.

4. Which of the following is a major advantage of aluminium scaffolding?

A. It is extremely heavy.

B. It is lightweight.

C. It is always electrically insulating.

D. It cannot be damaged.

5. Which scaffolding material is susceptible to termite attack?

A. Steel.

B. Aluminium.

C. Timber.

D. Stainless steel.

6. Which of the following is a vertical member of a scaffold?

A. Ledger.

B. Transom.

C. Standard.

D. Toe board.

7. Which scaffold component runs horizontally along the length of the scaffold?

A. Standard.

B. Ledger.

C. Base plate.

D. Sole board.

8. Which scaffold component supports the working platform across its width?

A. Transom.

B. Standard.

C. Coupler.

D. Guardrail.

9. What is the main function of diagonal braces?

A. To decorate the scaffold.

B. To improve scaffold stability.

C. To support the foundation.

D. To increase the wall thickness.

10. Which component is placed beneath a scaffold base plate to distribute loads over a larger area?

A. Guardrail.

B. Toe board.

C. Sole board.

D. Ledger.

11. Which component prevents tools and materials from falling from the edges of a working platform?

A. Standard.

B. Toe board.

C. Ledger.

D. Coupler.

12. Which fitting is used to connect scaffold tubes?

A. Coupler. B. Sole board.

C. Scaffold plank. D. Base plate.

13. Which type of scaffolding uses one main row of standards and putlogs supported by the wall?

A. Double scaffolding.

B. Single scaffolding.

C. Birdcage scaffolding.

D. Suspended scaffolding.

14. Which type of scaffolding consists of two rows of standards?

A. Single scaffolding.

B. Trestle scaffolding.

C. Double scaffolding.

D. Suspended scaffolding.

15. Which type of scaffolding is commonly used where ground-level support is obstructed?

A. Cantilever scaffolding.

B. Trestle scaffolding.

C. Single scaffolding.

D. Mobile scaffolding.

16. Which type of scaffolding is suspended from an overhead structure?

A. Double scaffolding. B. Suspended scaffolding.

C. Birdcage scaffolding. D. Trestle scaffolding.

17. Which type of scaffolding is fitted with wheels to facilitate movement?

A. Cantilever scaffolding.

B. Independent scaffolding.

C. Mobile scaffolding.

D. Single scaffolding.

18. Which scaffolding is particularly suitable for providing a large working platform beneath a ceiling?

A. Birdcage scaffolding.

B. Single scaffolding.

C. Suspended scaffolding.

D. Cantilever scaffolding.

19. What is dependent scaffolding?

A. A scaffold that has no supporting members.

B. A scaffold that relies partly on the building for support.

C. A scaffold supported only by wheels.

D. A scaffold suspended from a crane.

20. Which of the following describes independent scaffolding?

A. It depends entirely on the wall for platform support.

B. It has its own supporting framework.

C. It has no standards.

D. It is supported by ladders only.

21. Which component is used to secure scaffolding to a building?

A. Tie.

B. Toe board.

C. Scaffold plank.

D. Ladder.

22. Which of the following is an important requirement of good scaffolding?

A. Weak foundation.

B. Loose couplers.

C. Adequate bracing.

D. Overloaded platforms.

23. What is the main function of a base plate?

A. To provide a working surface.

B. To distribute the load from a standard.

C. To connect two ledgers.

D. To protect workers against falling.

24. Which organisation is responsible for enforcing the Occupational Safety and Health Act in Kenya?

A. KICD. B. DOSHS. C. KNEC. D. KRA.

25. Which Kenyan legal instrument contains specific provisions on scaffolds under paragraph 471?

A. National Building Code, 2024.

B. Basic Education Act.

C. Employment Act only.

D. Traffic Act.

26. Which of the following should be done before erecting scaffolding?

A. Load the scaffold with materials.

B. Inspect and prepare the supporting ground.

C. Remove all braces.

D. Install working platforms first without supports.

27. Why should scaffolding be inspected before use?

A. To increase its height.

B. To identify defects and ensure safety.

C. To reduce the number of workers.

D. To change the building design.

28. Which PPE protects workers' heads against falling objects?

A. Safety boots.

B. Safety helmet.

C. Gloves.

D. Reflective vest.

29. What should be done when scaffold components are found to be defective?

A. Continue using them.

B. Hide the defects.

C. Remove them from service.

D. Paint over the defects.

30. Which of the following is an unsafe practice when using mobile scaffolding?

A. Locking the wheels during work.

B. Using it on firm and level ground.

C. Moving it while workers remain on the platform without an approved safe procedure.

D. Providing suitable guardrails.

SECTION B: STRUCTURED AND SHORT-ANSWER QUESTIONS

QUESTION 1: INTRODUCTION TO SCAFFOLDING

a) Define scaffolding. (2 marks)

b) Differentiate between a scaffold and scaffolding. (2 marks)

c) State six characteristics of good scaffolding. (6 marks)

d) Explain six reasons why scaffolding is important in building construction. (6 marks)

QUESTION 2: MATERIALS USED IN SCAFFOLDING

a) Identify five materials used in constructing scaffolding. (5 marks)

b) Explain four advantages of steel scaffolding. (4 marks)

c) State four disadvantages of timber scaffolding. (4 marks)

d) Explain three advantages of aluminium scaffolding. (3 marks)

e) State four factors considered when selecting scaffold materials. (4 marks)

QUESTION 3: COMPONENTS OF SCAFFOLDING

a) Define a scaffold standard. (2 marks)

b) Identify eight components of scaffolding. (8 marks)

c) Explain the functions of the following components:

i. Standards. (2 marks)

ii. Ledgers. (2 marks)

iii. Transoms. (2 marks)

iv. Braces. (2 marks)

v. Base plates. (2 marks)

vi. Sole boards. (2 marks)

QUESTION 4: TYPES OF SCAFFOLDING

a) Identify six types of scaffolding used in building construction. (6 marks)

b) Explain the construction and arrangement of single scaffolding. (4 marks)

c) Describe the characteristics of double scaffolding. (4 marks)

d) State four advantages of mobile scaffolding. (4 marks)

e) Explain three applications of suspended scaffolding. (3 marks)

QUESTION 5: DEPENDENT AND INDEPENDENT SCAFFOLDING

a) Define dependent scaffolding. (2 marks)

b) Define independent scaffolding. (2 marks)

c) State five differences between dependent and independent scaffolding. (5 marks)

d) Explain four advantages of independent scaffolding. (4 marks)

e) State three limitations of dependent scaffolding. (3 marks)

QUESTION 6: IMPORTANCE OF SCAFFOLDING

a) Explain eight importance of scaffolding in building construction. (8 marks)

b) Identify four construction activities that require scaffolding. (4 marks)

c) Explain four ways scaffolding improves workers' productivity. (4 marks)

QUESTION 7: REQUIREMENTS OF GOOD SCAFFOLDING

a) Explain the meaning of scaffold requirements. (2 marks)

b) State eight requirements of good scaffolding. (8 marks)

c) Explain the importance of the following:

i. Firm foundation. (2 marks)

ii. Proper bracing. (2 marks)

iii. Guardrails. (2 marks)

iv. Toe boards. (2 marks)

v. Safe access. (2 marks)

QUESTION 8: BUILDING CODES

a) Define a building code. (2 marks)

b) Name the National Building Code applicable in Kenya. (2 marks)

c) State five objectives of the National Building Code, 2024. (5 marks)

d) Identify five provisions of the National Building Code relating to scaffolding. (5 marks)

e) State four reasons why construction workers should comply with building regulations. (4 marks)

QUESTION 9: SAFETY IN SCAFFOLDING

a) Define scaffolding safety. (2 marks)

b) Identify six types of PPE used during scaffolding operations. (6 marks)

c) Explain eight safety precautions observed when using scaffolding. (8 marks)

d) State four hazards associated with scaffolding. (4 marks)

QUESTION 10: SCAFFOLD ERECTION AND DISMANTLING

a) Define scaffold erection. (2 marks)

b) Describe the procedure for erecting independent scaffolding. (8 marks)

c) Explain the procedure for dismantling scaffolding. (6 marks)

d) State four precautions observed during scaffold dismantling. (4 marks)

QUESTION 11: INSPECTION AND MAINTENANCE

a) Define scaffold inspection. (2 marks)

b) State six components that should be inspected before using scaffolding. (6 marks)

c) Explain six importance of scaffold inspection. (6 marks)

d) State six maintenance practices for scaffolding materials. (6 marks)

QUESTION 12: APPLICATION AND PROBLEM-SOLVING

A contractor is constructing a three-storey classroom block in Nakuru County. The external walls require masonry, plastering and painting. The contractor intends to use steel scaffolding.

a) Explain four reasons why scaffolding is required for this project. (4 marks)

b) Identify six materials or components required for erecting steel scaffolding. (6 marks)

c) Explain the procedure for erecting the scaffolding. (6 marks)

d) State four safety precautions that should be observed during its use. (4 marks)

QUESTION 13: PRACTICAL APPLICATION

A group of Grade 11 learners is required to construct a miniature independent scaffold model.

a) Identify five materials required for the activity. (5 marks)

b) Identify five tools required for the activity. (5 marks)

c) Describe the procedure for constructing the model. (6 marks)

d) State four competencies developed through the activity. (4 marks)

STRAND 3.0: BUILDING CONSTRUCTION PROCESS

SUB-STRAND 3.5: ROOF CONSTRUCTION

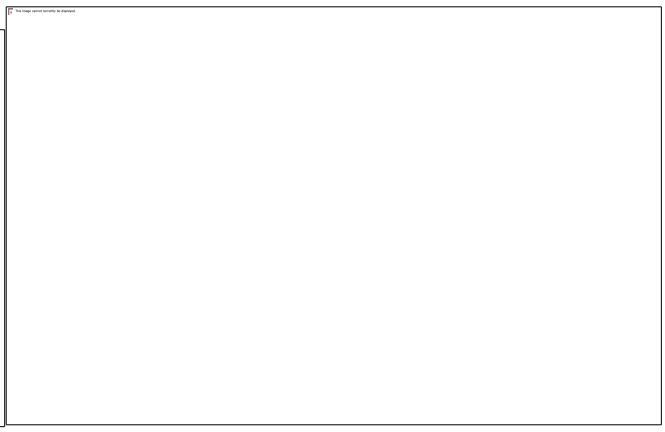
1.0 Introduction to roof construction

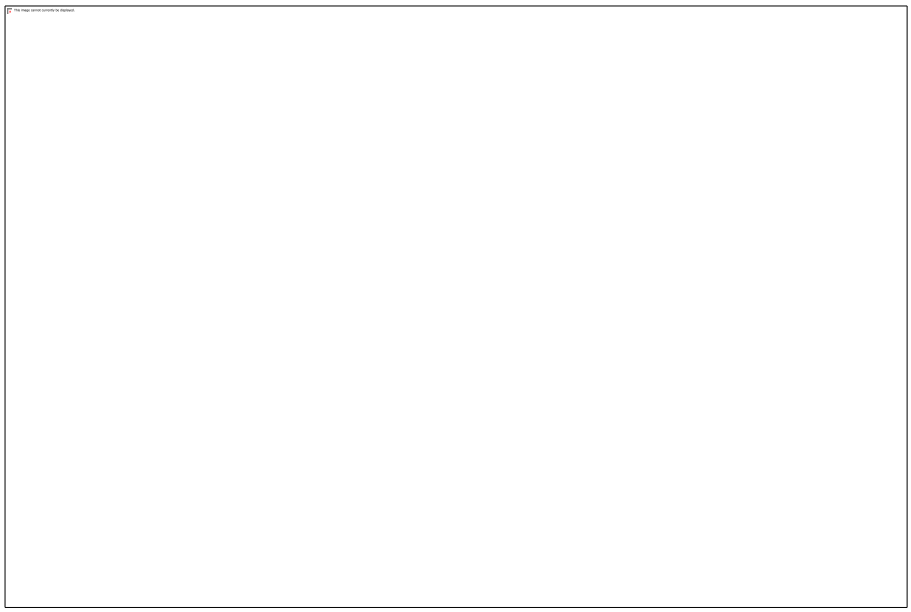
A roof is one of the most important parts of a building. It forms the uppermost covering of a building and protects the occupants, building materials, furniture and other contents from weather conditions such as rain, strong winds, sunlight and dust.

Roof construction involves designing, selecting materials, assembling structural members and fixing roof coverings to provide a strong, stable, durable and weather-resistant structure.

In Kenya, roofs are commonly constructed using timber, steel, reinforced concrete and other suitable materials. The choice depends on the building design, climate, cost, availability of materials and intended use of the building.







2.0 Meaning of a roof

A **roof** is the upper covering of a building, supported by a structural framework or other suitable support system, which protects the building from weather and provides shelter to its occupants.

Main functions of a roof

1. **Protection against rain**

Prevents rainwater from entering the building.

Directs rainwater towards gutters, downpipes or suitable drainage points.

Helps protect walls, ceilings, floors and furniture from water damage.

2. **Protection against sunlight**

Provides shade and reduces direct exposure to strong sunlight.

Helps maintain comfortable indoor temperatures.

Protects building materials from excessive heat and ultraviolet radiation.

3. **Protection against wind**

Provides a barrier against wind and wind-driven rain.

A properly designed and anchored roof resists wind forces.

4. **Protection against dust and other external elements**

Prevents dust, leaves and debris from entering the building.

Helps maintain cleanliness and hygiene indoors.

5. **Improvement of building appearance**

Contributes to the beauty and architectural character of a building.

Different roof shapes and coverings give buildings different appearances.

6. **Provision of thermal comfort**

Helps control heat transfer between the outside and inside of a building.

Insulation and ventilation beneath the roof improve indoor comfort.

7. **Provision of space**

Some pitched roofs provide attic or roof-space storage.

Flat roofs may be designed as usable terraces or recreational spaces where structurally and legally appropriate.

8. **Support for building services**

Roofs may support appropriately designed solar panels, aerials, satellite dishes and other installations.

Such installations must not compromise the structural strength or waterproofing of the roof.

9. **Protection of the building structure**

Prevents prolonged exposure of walls and internal finishes to rain and sunlight.

Helps increase the durability of the building.

3.0 Types of roofs used in buildings

Roofs are classified according to their shape, slope, construction method and structural arrangement.

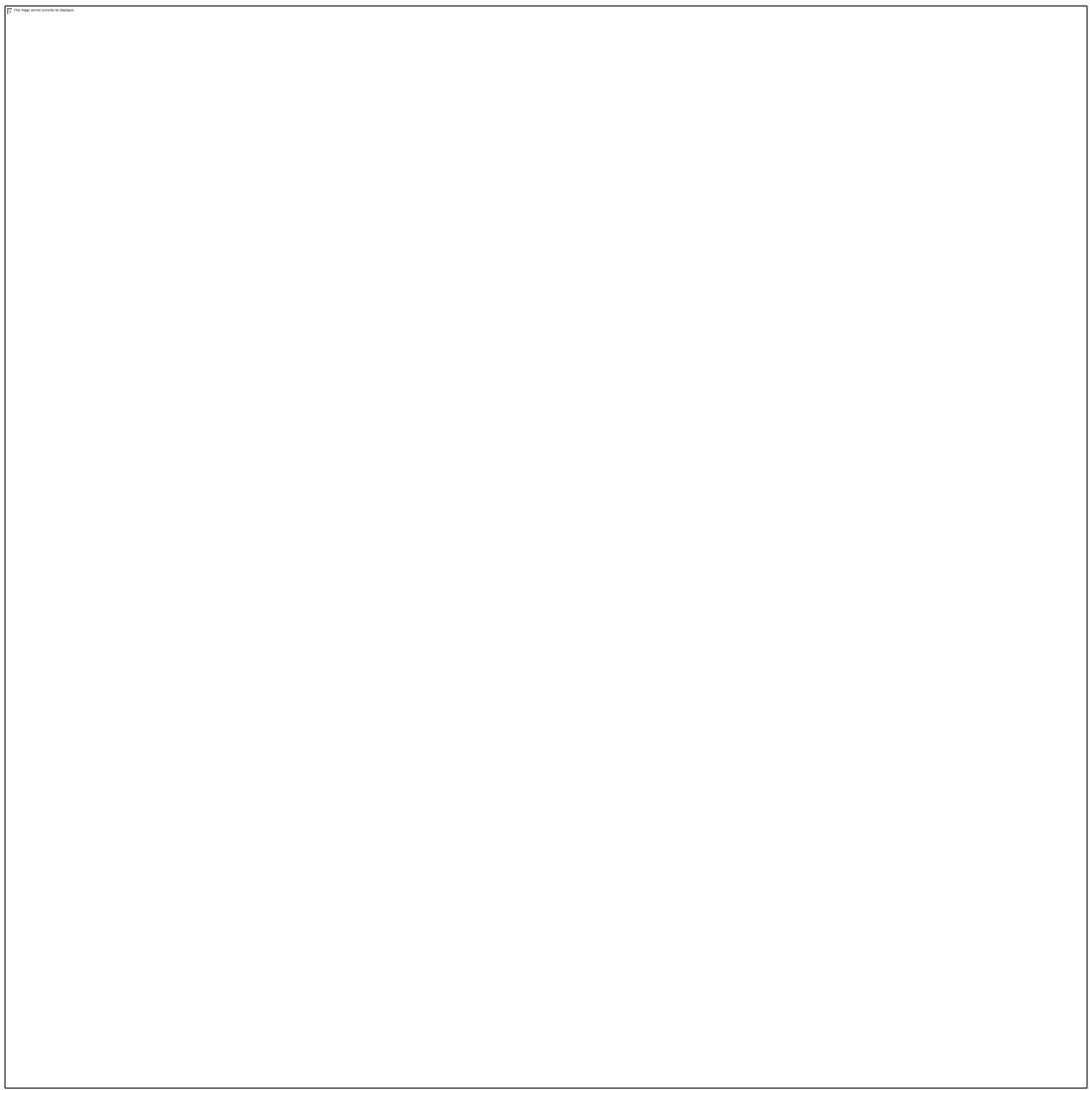
The two broad categories commonly studied are:

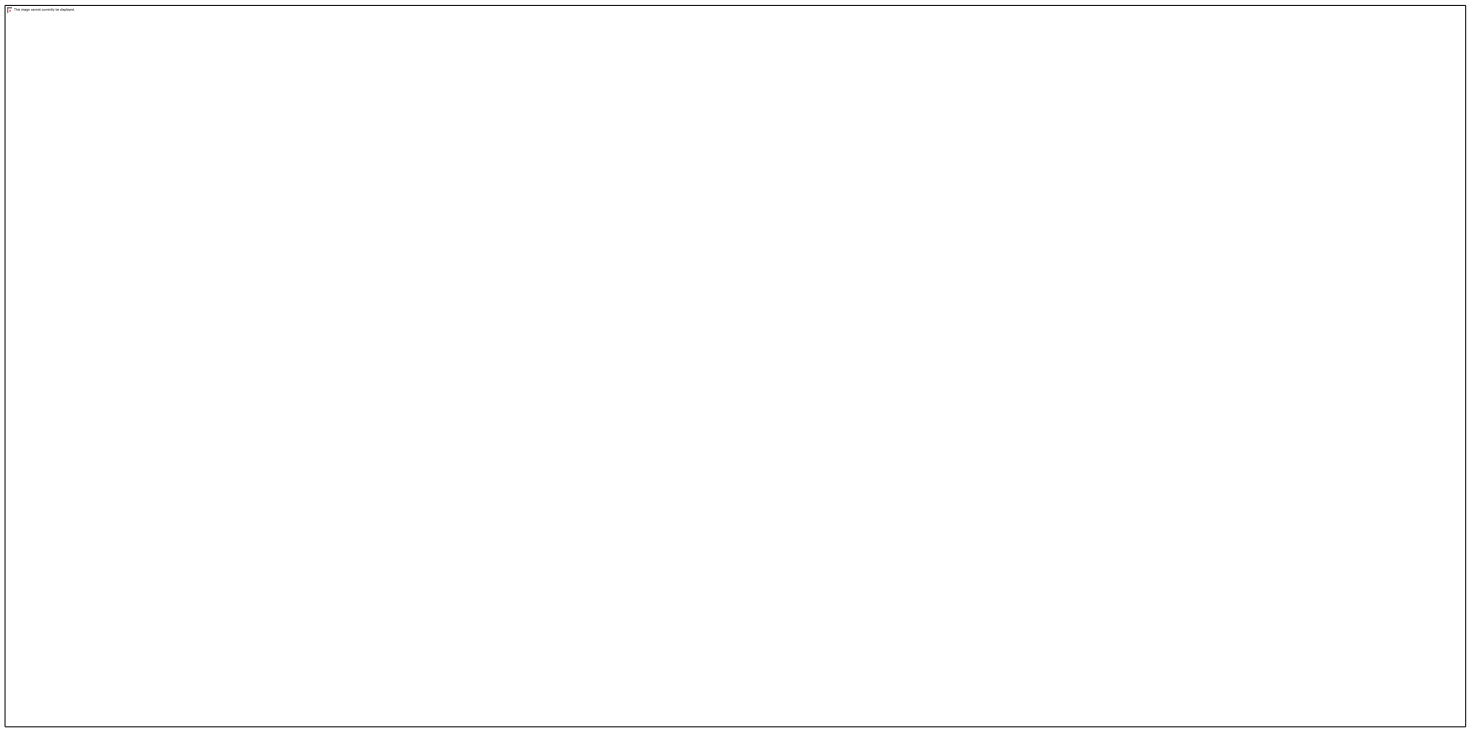
Flat roofs.

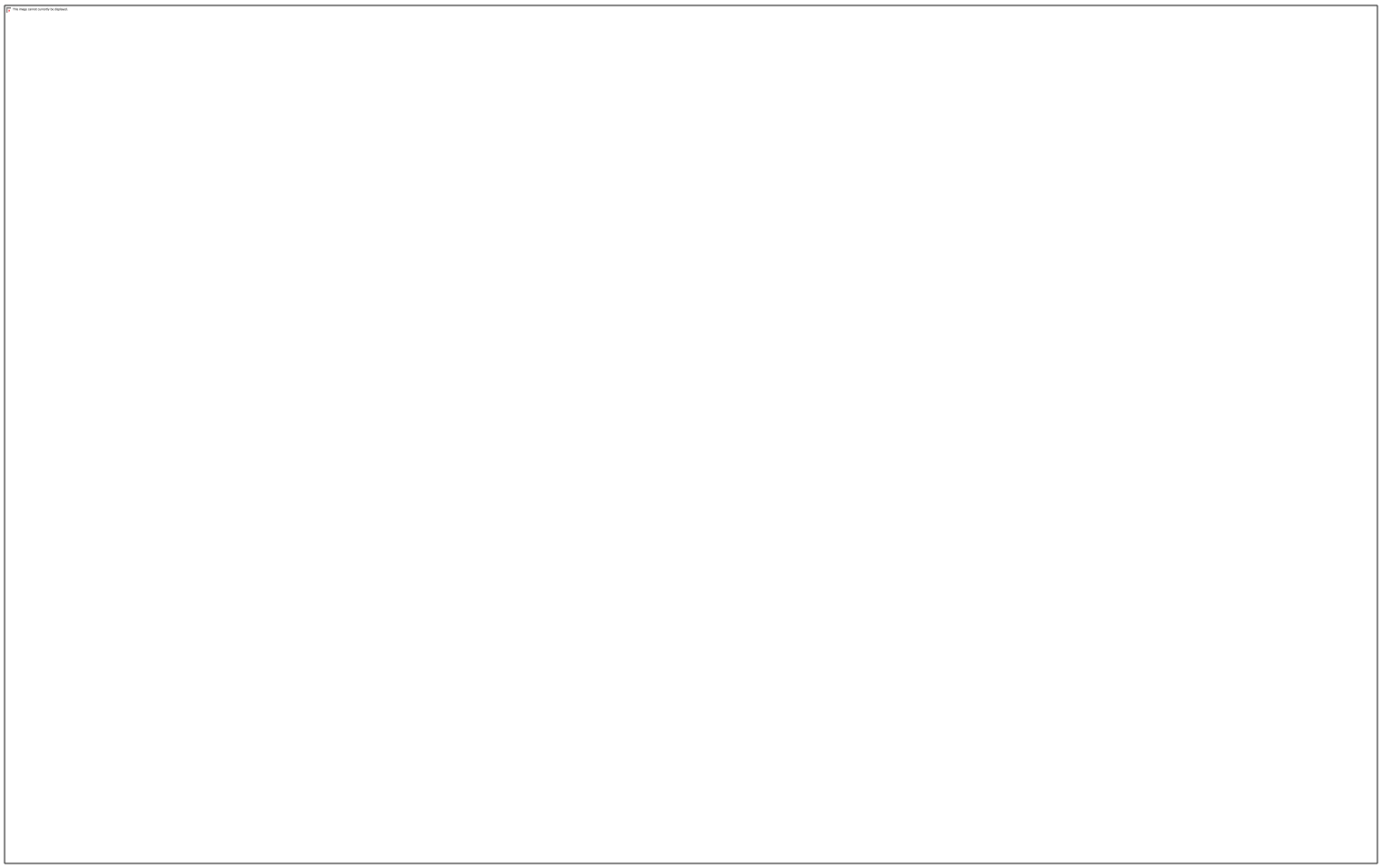
Pitched roofs.

Other roof forms include curved roofs, domed roofs and shell roofs.

3.1 Flat roofs







Definition of a flat roof

A **flat roof** is a roof constructed with a very small slope or gradient to allow rainwater to drain away. Despite its name, a properly constructed flat roof is not perfectly horizontal.

Flat roofs are commonly constructed using reinforced concrete slabs, steel structures or other engineered roof systems.

Characteristics of flat roofs

Have a low slope or gradient.

Require proper waterproofing to prevent water penetration.

Have drainage outlets, gutters or other systems to remove rainwater.

May be used as terraces or outdoor spaces if designed for such use.

Often require careful maintenance to prevent water accumulation.

May have parapet walls around their edges.

Can be constructed using reinforced concrete or suitable lightweight systems.

Common components of a flat roof

Roof slab: The structural surface supporting the roof system.

Waterproofing membrane: Prevents water from penetrating the roof.

Insulation layer: Reduces heat transfer where required.

Screed: Provides the required slope and a suitable surface for finishing.

Drainage outlets: Allow rainwater to leave the roof.

Protective finish: Protects waterproofing materials from damage where required.

Parapet wall: A low protective wall along the edge of the roof, where provided.

Advantages of flat roofs

Can provide additional usable outdoor space.

May be easier to access for inspection and maintenance, if safe access is provided.

Can accommodate solar panels and other services when properly designed.

May have a simple external appearance.

Can be suitable for buildings where additional upper-floor space is required.

May be constructed without a complex pitched roof framework.

Can be used in modern architectural designs.

Disadvantages of flat roofs

Require effective waterproofing.

Poor drainage can cause water to accumulate.

Waterproofing failure may lead to leakage.

May require regular inspection and maintenance.

Reinforced concrete flat roofs can be expensive and heavy.

Water accumulation can increase structural loading.

Some flat roof systems may absorb considerable heat if not properly insulated.

Suitable uses of flat roofs

Modern residential buildings.

Commercial buildings.

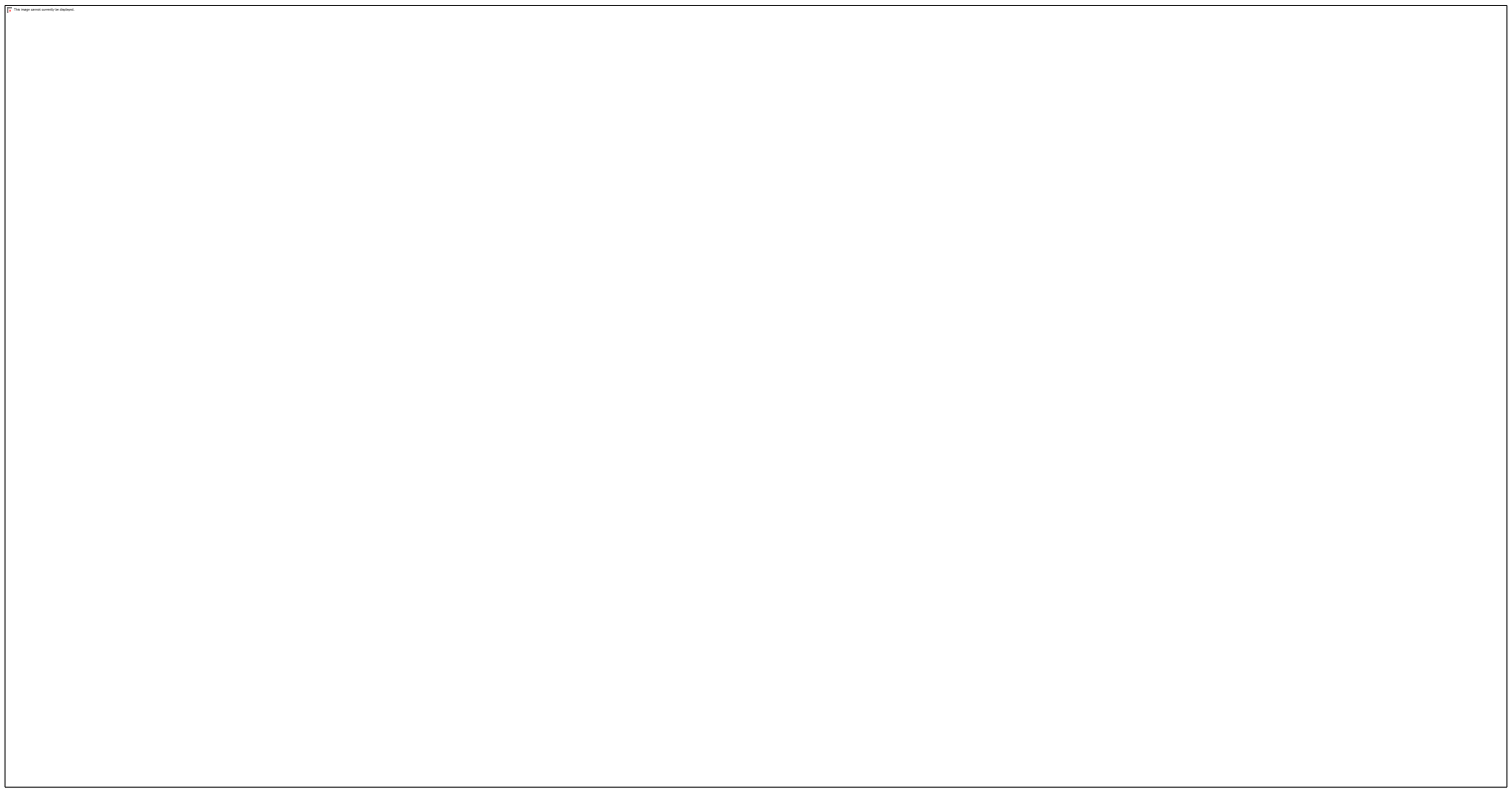
Apartment blocks.

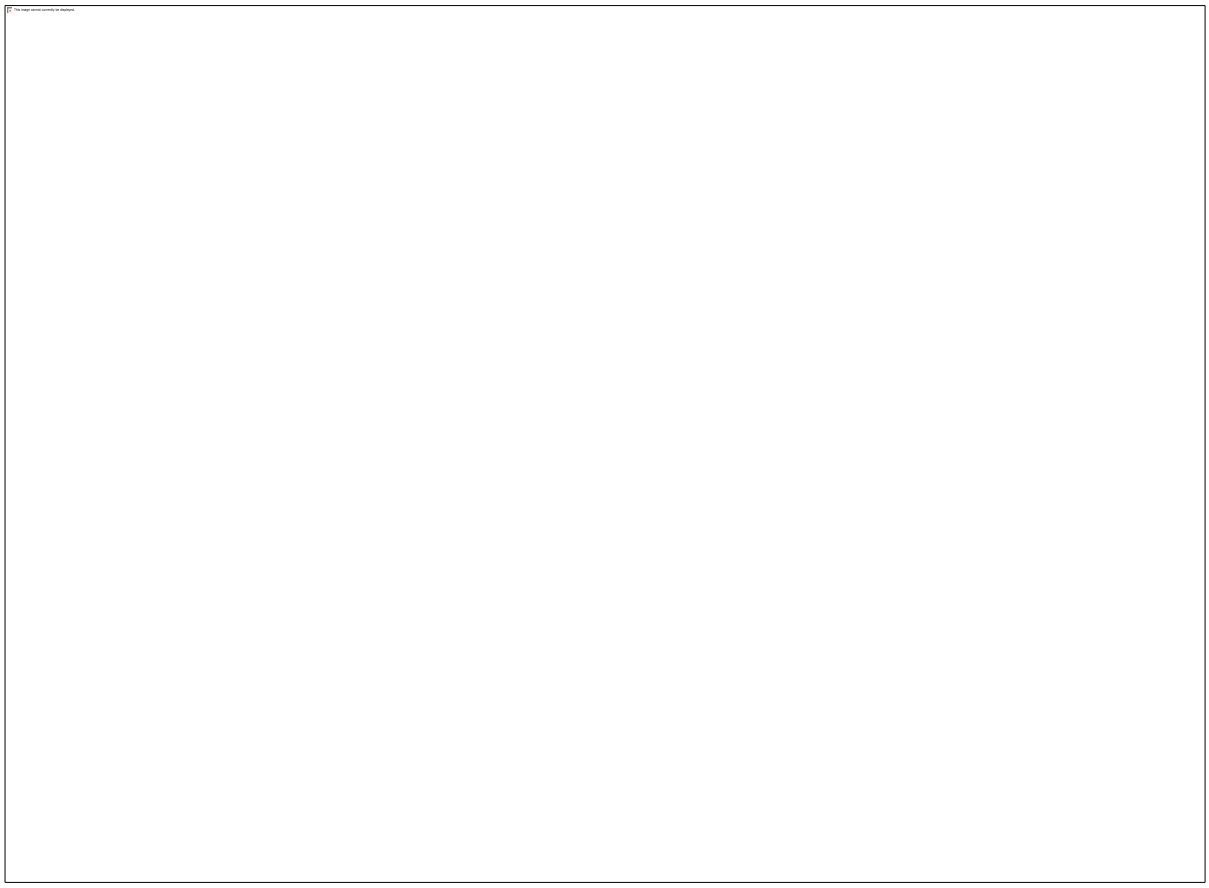
Office buildings.

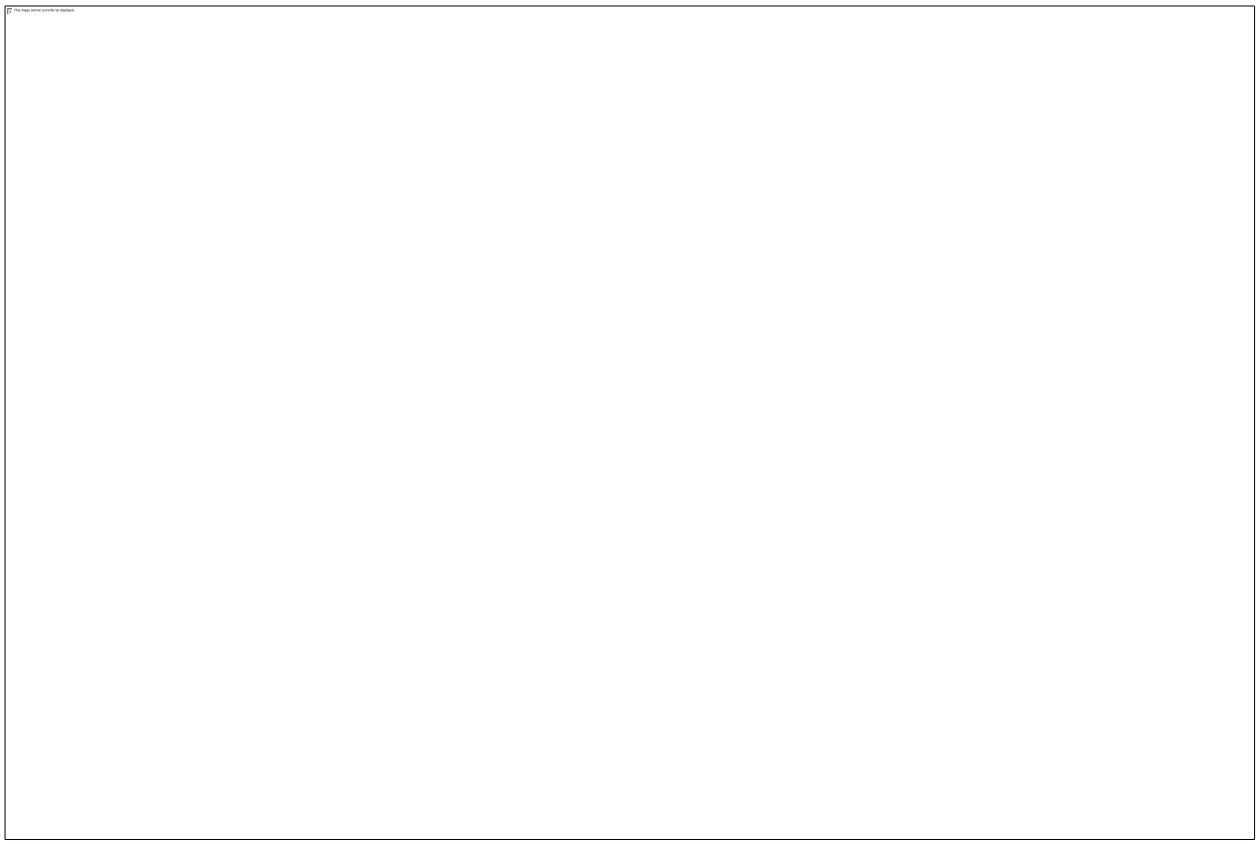
Buildings designed with roof terraces.

Buildings requiring rooftop service installations.

3.2 Pitched roofs







Definition of a pitched roof

A **pitched roof** is a roof constructed with one or more sloping surfaces designed to allow rainwater to flow down towards the eaves and into gutters or drainage channels.

Pitched roofs are widely used in Kenyan residential houses, schools, churches, stores and other buildings.

Characteristics of pitched roofs

Have one or more sloping surfaces.

Allow rainwater to drain by gravity.

Can be covered using corrugated iron sheets, tiles, shingles or other suitable materials.

Usually require a structural framework made of timber, steel or reinforced concrete.

Can provide roof space for ventilation and storage.

Their slope is selected according to the covering material, climate and design requirements.

Can be designed in different shapes and forms.

Advantages of pitched roofs

Drain rainwater effectively when properly designed.

Reduce the likelihood of prolonged water accumulation on the roof surface.

Can provide space for ventilation beneath the roof covering.

Offer a wide range of architectural designs.

Can provide attic or roof-space accommodation.

Are suitable for many regions in Kenya that experience seasonal heavy rainfall.

Can be covered using a variety of locally available roofing materials.

Disadvantages of pitched roofs

Require more complicated structural framing than some flat roofs.

Construction may require skilled carpenters and roof installers.

Steep roofs may be difficult and dangerous to access during maintenance.

Some designs require more roofing materials.

Strong winds can damage poorly secured roof coverings.

Complex roof shapes may increase construction costs.

Suitable uses of pitched roofs

Residential houses.

Schools and classrooms.

Churches.

Agricultural stores.

Workshops.

Commercial buildings.

Institutional buildings.

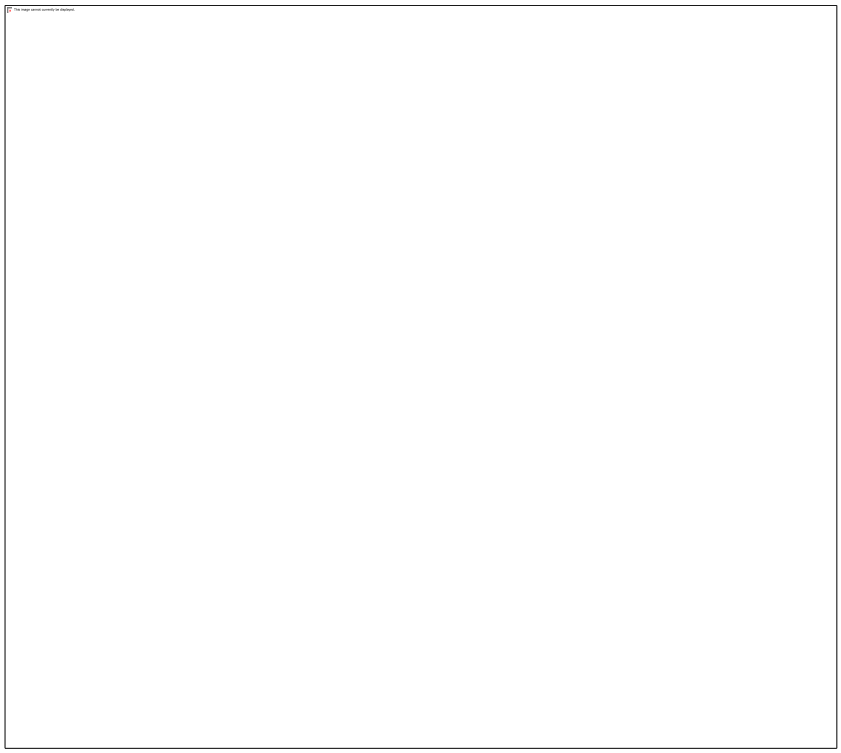
3.3 Comparison between flat and pitched roofs

Feature	**Flat roof**	**Pitched roof**
Slope	Very low slope	Noticeable slope
Drainage	Requires carefully designed outlets	Rainwater flows down sloping surfaces
Common materials	Reinforced concrete, steel systems	Timber, steel, tiles, iron sheets
Roof space	Usually limited unless designed otherwise	Can provide attic or roof space
Waterproofing	Particularly important	Roof covering and joints provide weather protection
Maintenance	Requires inspection of drainage and waterproofing	Requires inspection of sheets, tiles, ridges and fixings
Common uses	Apartments and modern commercial buildings	Houses, schools and churches

4.0 Other types of roof shapes

Apart from flat and pitched roofs, buildings may have the following roof forms.

4.1 Lean-to roof



Definition: A lean-to roof is a roof with a single sloping surface, usually supported by walls of different heights.

Characteristics:

Has one sloping surface.

Is simple to construct.

Directs rainwater towards one side.

Can be attached to an existing building.

Requires proper flashing where it joins a wall.

Examples of use:

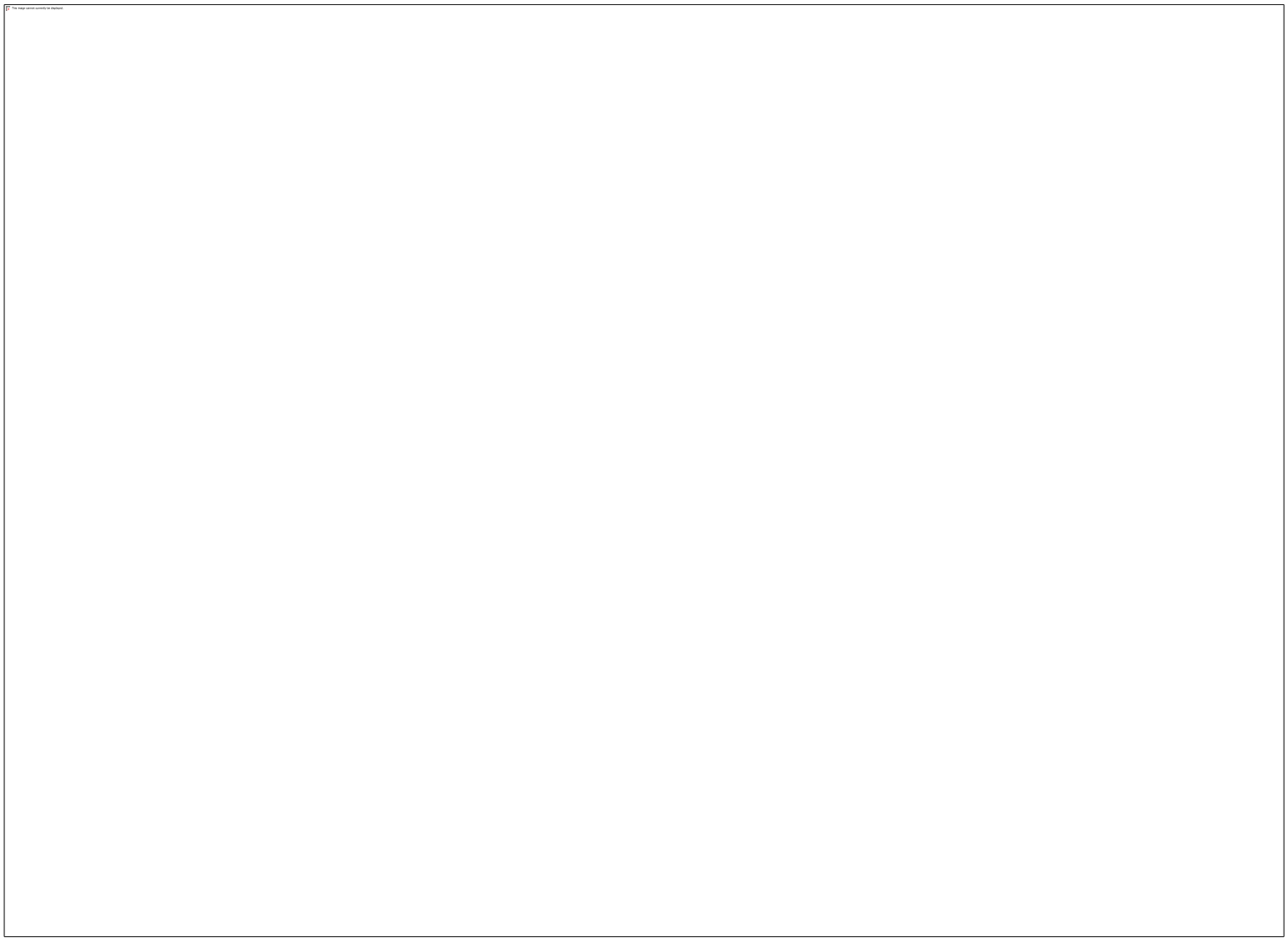
Kitchen extensions.

Sheds.

Verandas.

Small stores.

4.2 Gable roof



Definition: A gable roof consists of two sloping roof surfaces that meet at a ridge, forming triangular gable walls at the ends of the building.

Characteristics:

Has two sloping sides.

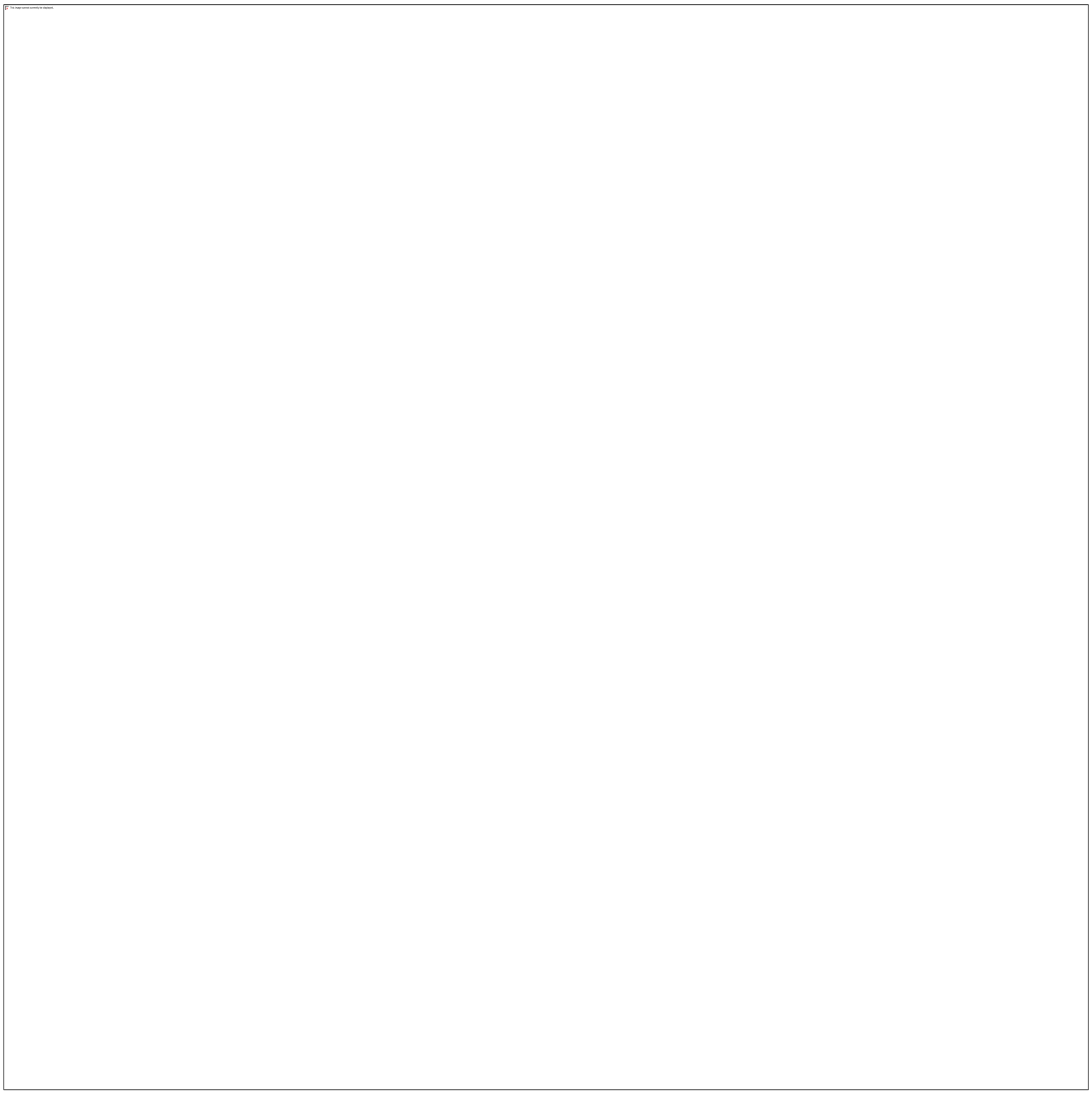
Has a horizontal ridge at the top.

Forms triangular gable ends.

Provides effective rainwater drainage.

Is common in Kenyan residential buildings.

4.3 Hipped roof



Definition: A hipped roof is a roof with sloping surfaces on all four sides of a rectangular building, which meet at ridges or hips.

Characteristics:

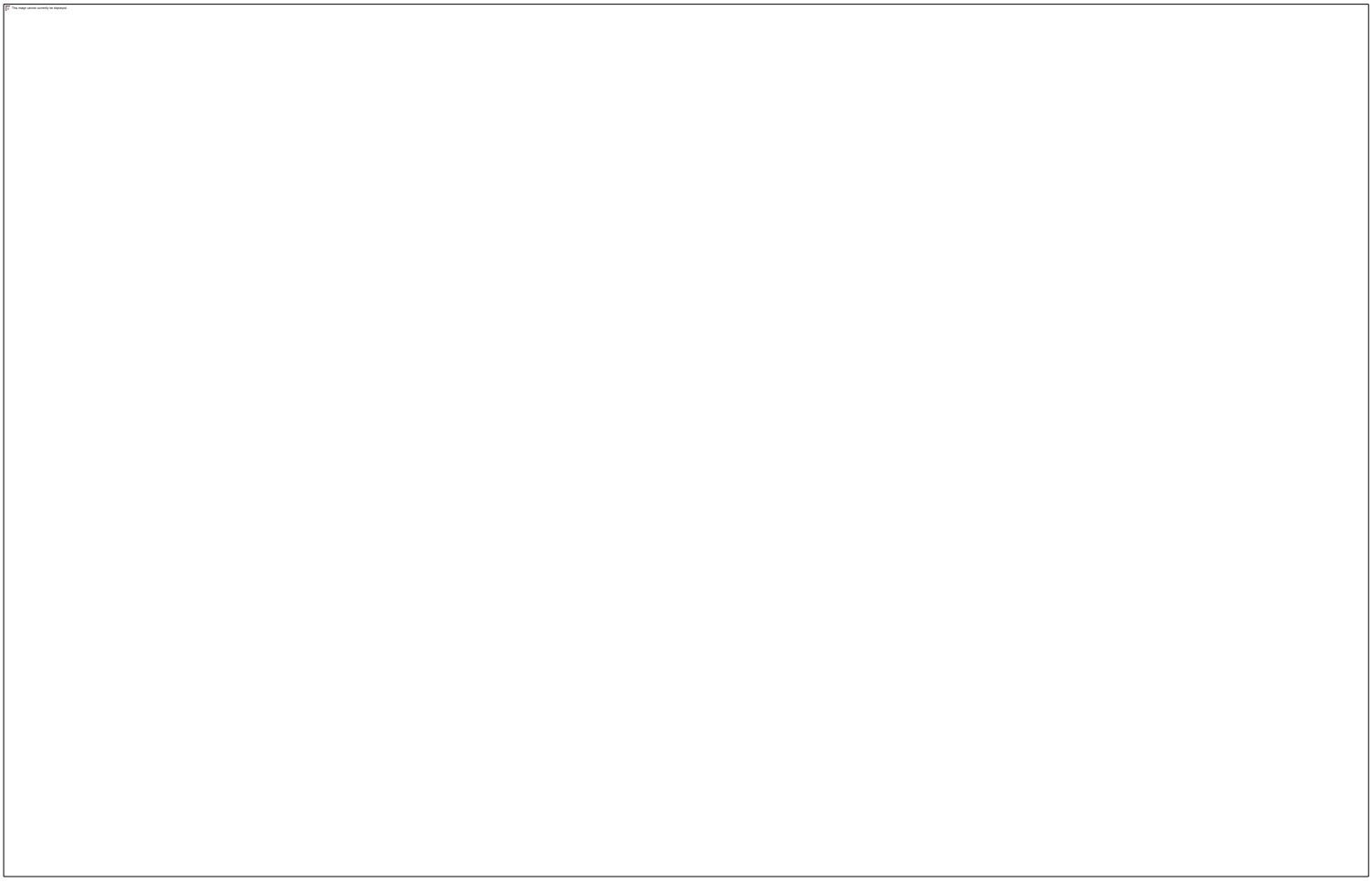
Has no vertical gable ends in a typical rectangular design.

Has sloping surfaces on all sides.

Provides good resistance to wind when properly designed and anchored.

Requires more complicated framing than a simple gable roof.

4.4 Mansard roof



Definition: A mansard roof is a roof with two slopes on each of its four sides, with the lower slope being steeper than the upper slope.

Characteristics:

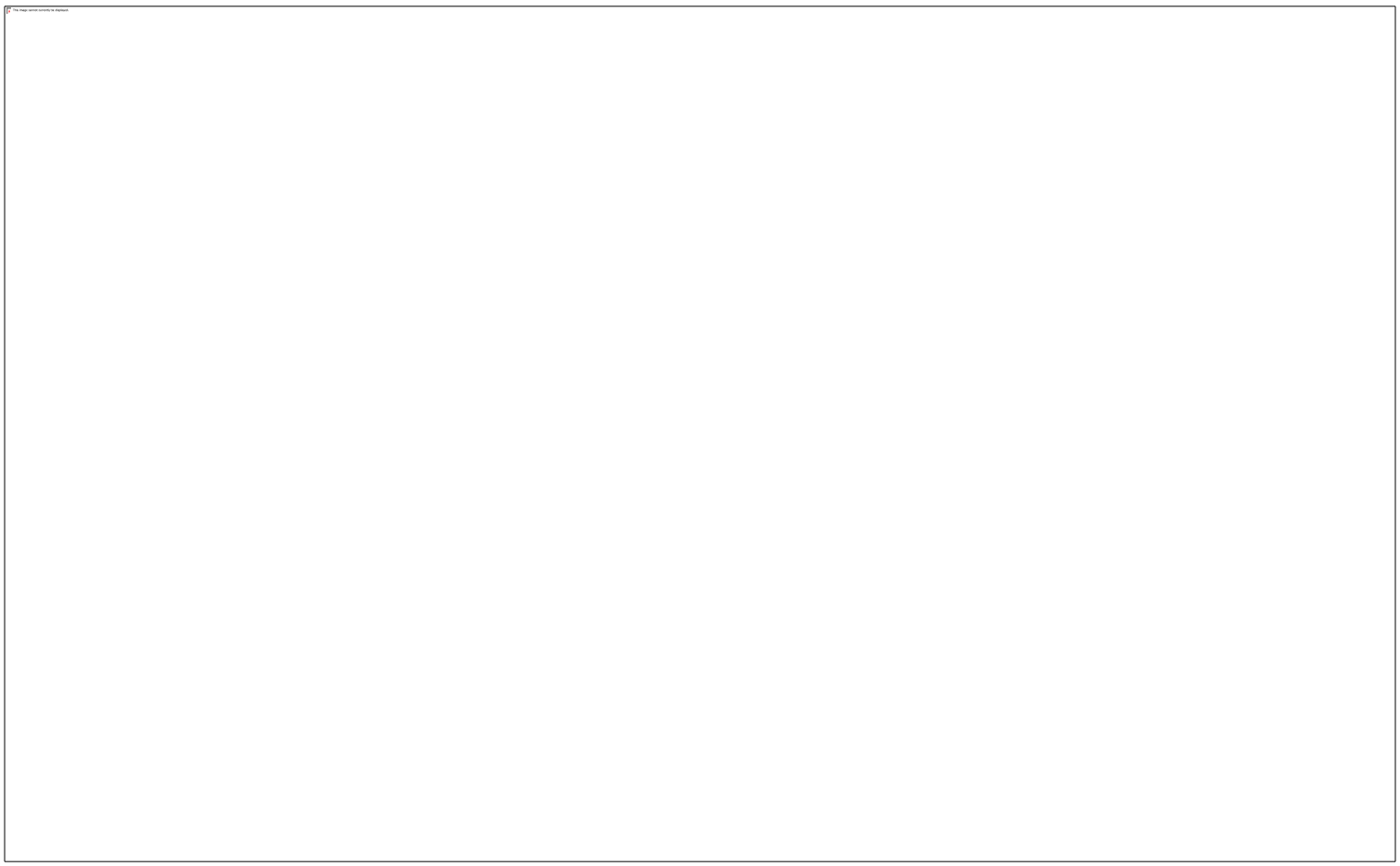
Has a steep lower slope.

Has a flatter upper slope.

Can provide additional usable roof-space accommodation.

Requires careful structural design.

4.5 Gambrel roof



Definition: A gambrel roof is a roof with two slopes on each side, commonly used in barns and some traditional building designs.

Characteristics:

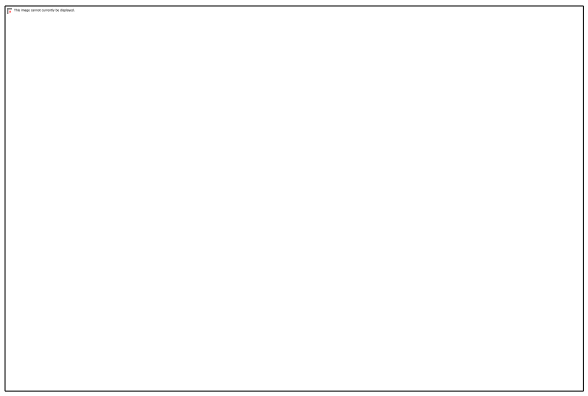
Has two slopes on each side.

The lower slope is steeper than the upper slope.

Can provide additional space beneath the roof.

Is commonly associated with barn-like structures.

4.6 Curved or barrel-vault roof



Definition: A curved roof is a roof with a curved surface instead of straight sloping surfaces.

Uses:

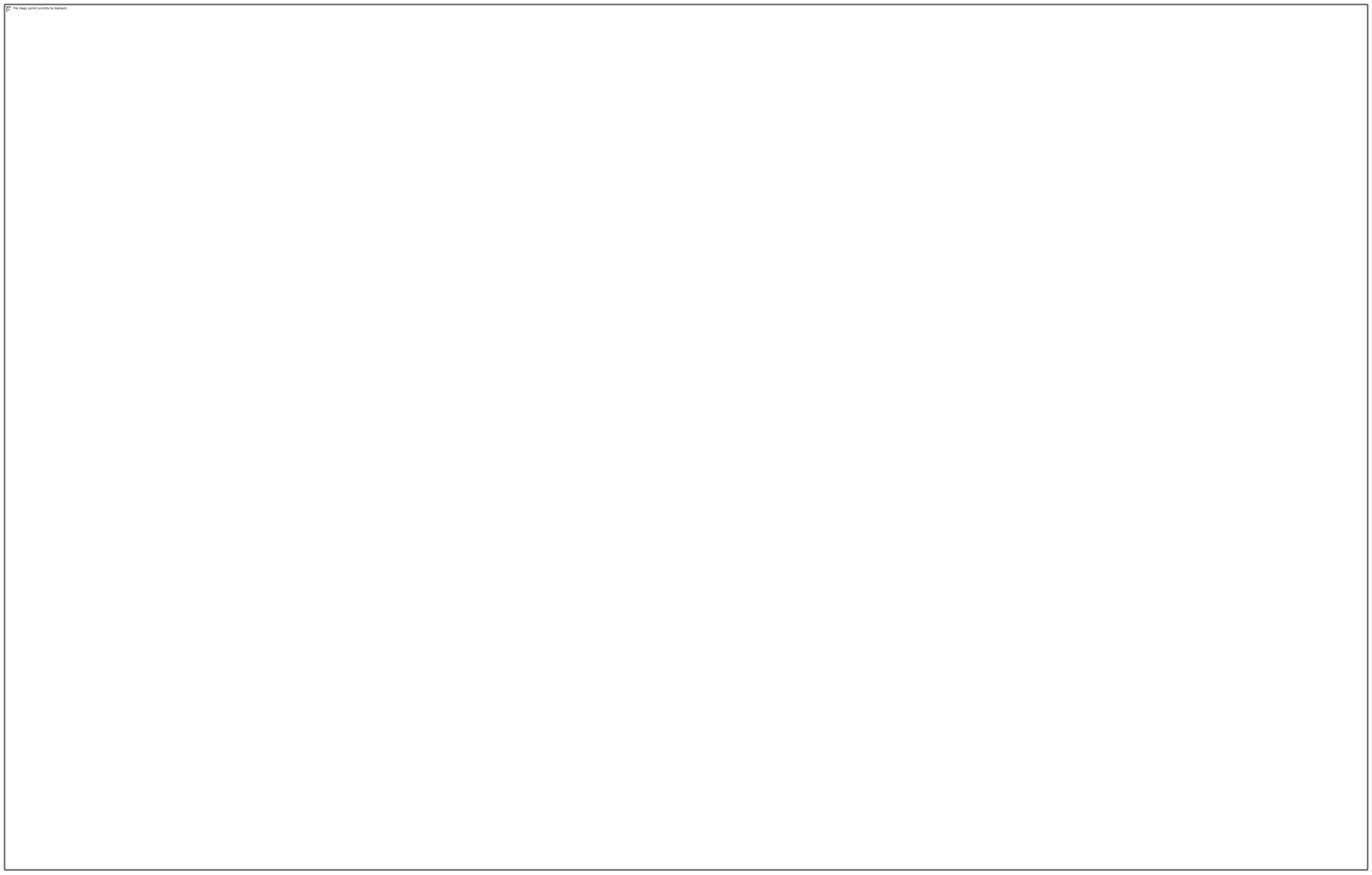
Large halls.

Sports facilities.

Auditoriums.

Special architectural structures.

4.7 Domed roof



Definition: A domed roof is a roof with a rounded, dome-shaped form.

Uses:

Religious buildings.

Museums.

Public buildings.

Special architectural structures.

5.0 Components of a roof

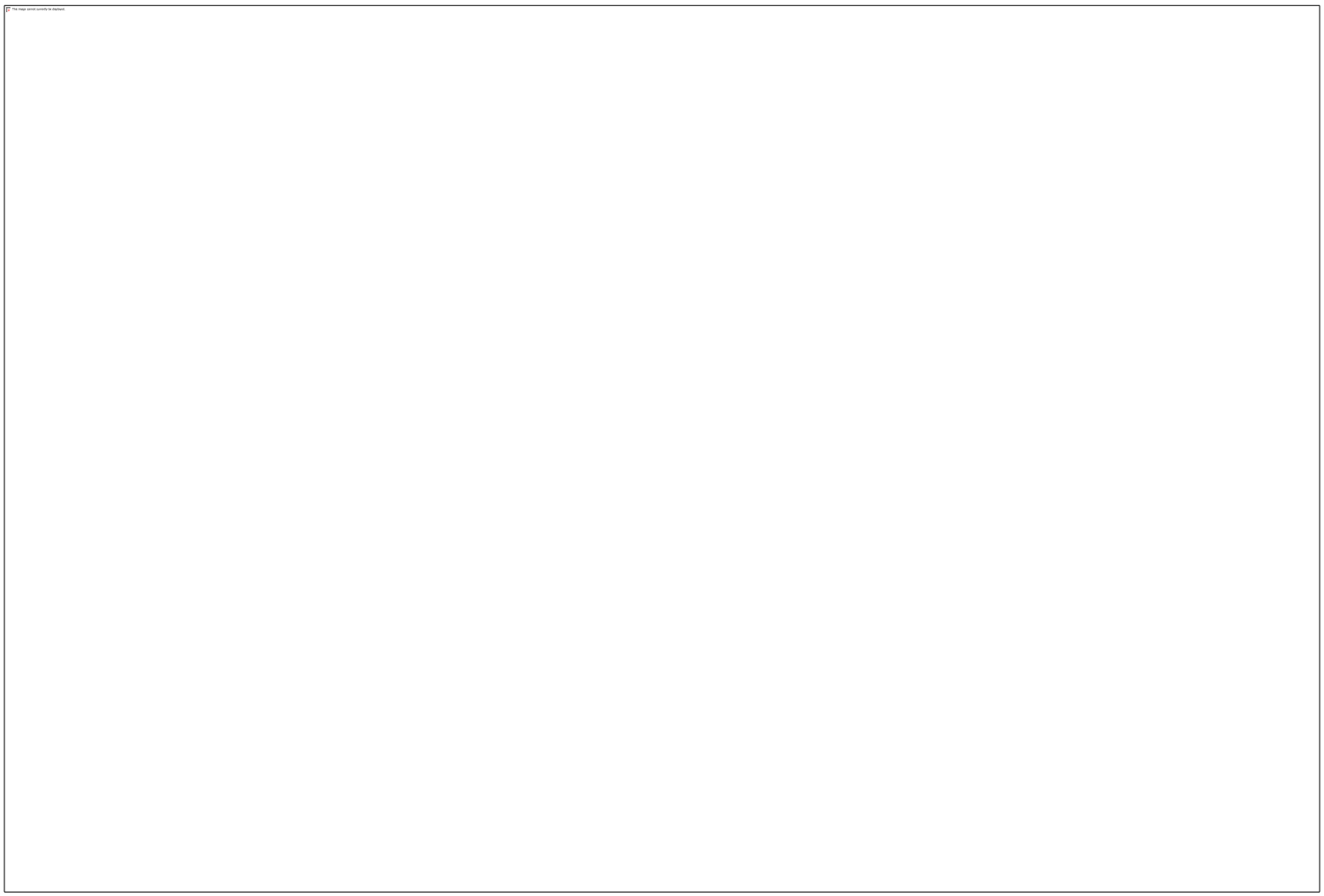
A roof is made up of different structural and finishing components. Each component performs a specific function in supporting the roof covering, transferring loads safely to the walls or other supports, and protecting the building from weather.

The components used depend on the roof design, materials and construction method.

5.1 Main components of a pitched roof







5.1.1 Rafter

Definition: A rafter is an inclined structural member that extends from the ridge or upper part of a roof towards the eaves and supports the roof covering, directly or through purlins and battens.

Functions of rafters

Support the roof covering directly or indirectly.

Transfer roof loads to the supporting walls, beams or trusses.

Determine the slope and shape of the roof.

Provide support for battens or other secondary roof members.

Help maintain the required alignment of the roof.

Materials used to make rafters

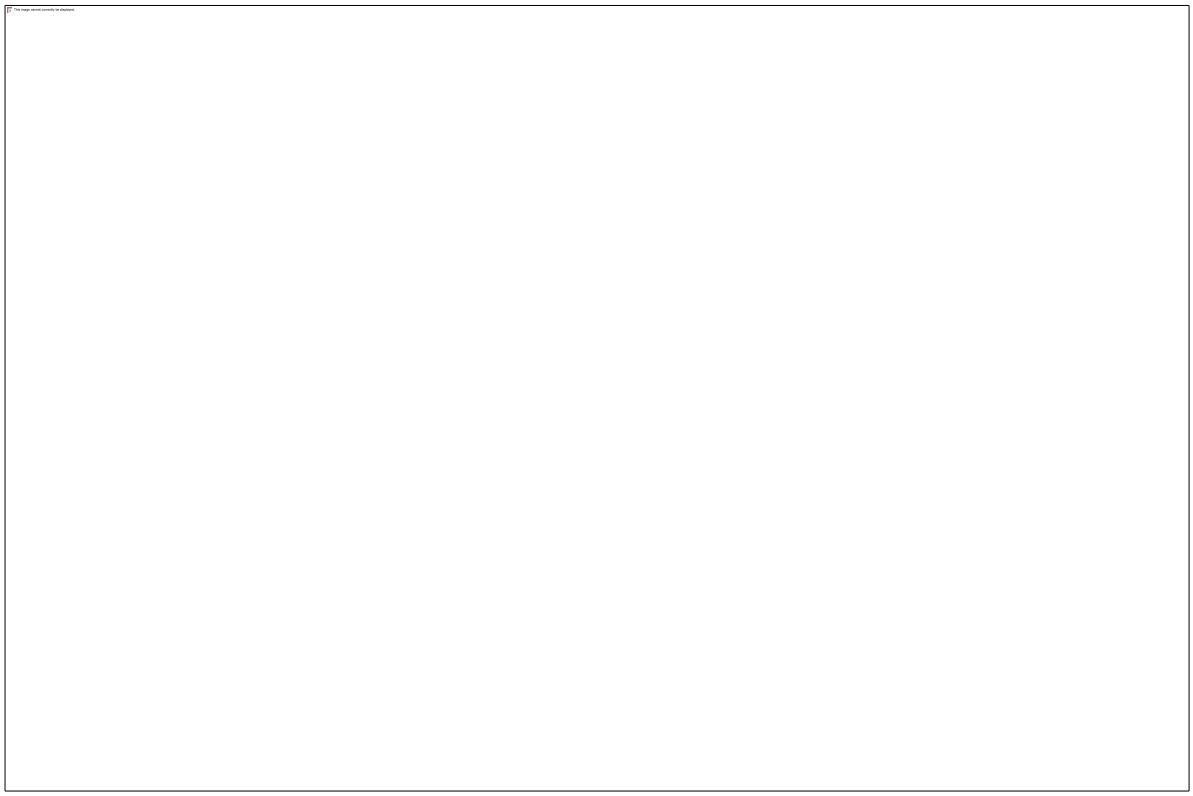
Timber.

Steel sections.

Engineered timber products.

Reinforced concrete in some roof systems.

Examples: Timber rafters are commonly used in residential houses with corrugated galvanised iron sheets or roofing tiles.



5.1.2 Purlins

Definition: Purlins are horizontal or nearly horizontal structural members fixed across rafters or roof trusses to support roof covering or the secondary members carrying the covering.

Functions of purlins

Support roof sheets, tiles or other roofing elements, either directly or through battens.

Transfer roof loads to rafters or trusses.

Reduce the unsupported span of roof coverings.

Help maintain the alignment and stability of the roof.

Provide fixing points for roofing materials.

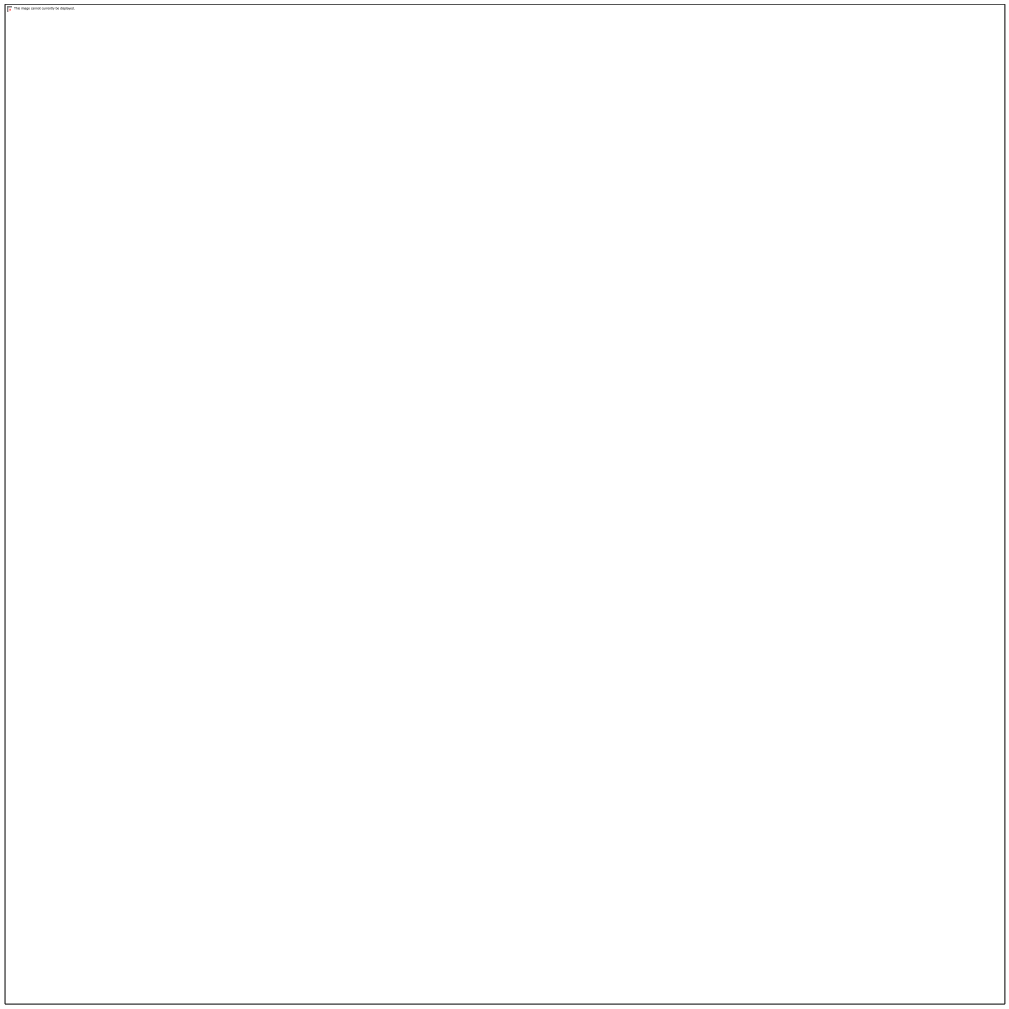
Materials used

Timber.

Steel.

Reinforced concrete in certain roof systems.

Examples: Timber or steel purlins may be used in a school classroom roof covered with corrugated iron sheets.



5.1.3 Fascia board

Definition: A fascia board is a board fixed along the lower ends of the roof rafters at the eaves, forming a finishing edge to the roof.

Functions of a fascia board

Covers the exposed ends of rafters.

Provides a neat and finished appearance to the roof edge.

Provides support for gutter brackets where gutters are fitted.

Protects the ends of roof members from direct exposure to weather.

Helps form the external edge of the roof.

Materials used

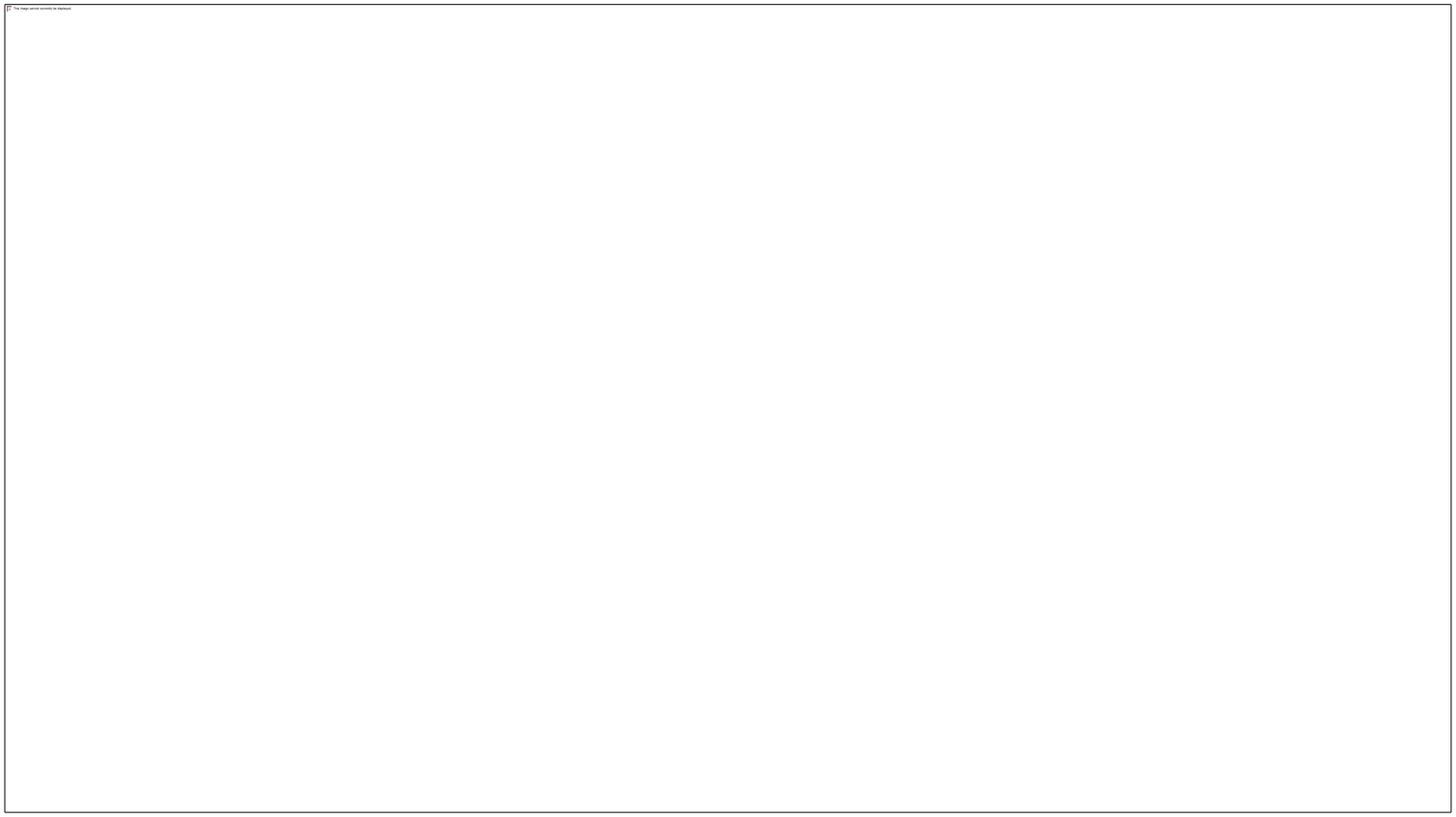
Timber.

uPVC.

Fibre-cement boards.

Metal fascia sections.

Example: A timber fascia board may be fixed along the eaves of a residential house to support rainwater gutter brackets.



5.1.4 Joist

Definition: A joist is a horizontal structural member used to support a floor, ceiling or other building surface.

In roof construction, the term may refer to members supporting a ceiling or forming part of a roof-floor structure.

Functions of joists

Support ceiling boards or other ceiling finishes.

Transfer loads to supporting walls or beams.

Provide a framework for fixing ceiling materials.

Help maintain the required level and alignment of the ceiling.

In suitable structural designs, support floor or roof-space loads.

Materials used

Timber.

Steel.

Reinforced concrete.

Engineered timber.

Important distinction: A joist is a general term for a horizontal supporting member. A ceiling joist is specifically used to support a ceiling and may also help tie opposing roof members together in certain roof designs.

5.1.5 Roof truss

Definition: A roof truss is a structural framework made up of interconnected members arranged in triangular forms to support a roof and transfer its loads to supporting walls or columns.

A truss is commonly made from timber or steel.

Main parts of a typical timber roof truss

Top chords: Inclined members forming the upper slopes of the truss.

Bottom chord: The lower horizontal member connecting the ends of the truss.

Web members: Internal members connecting the top and bottom chords.

Joints or nodes: Points where truss members meet.

Connectors: Plates, bolts, nails or other approved fittings used to connect members.

Functions of roof trusses

Support the roof covering and other roof loads.

Transfer loads to walls, beams or columns.

Provide a stable framework for the roof.

Cover relatively wide spaces without requiring many internal supporting walls.

Help maintain the roof shape and slope.

Provide support for purlins or other roof members, depending on the design.

Common types of roof trusses

King-post truss.

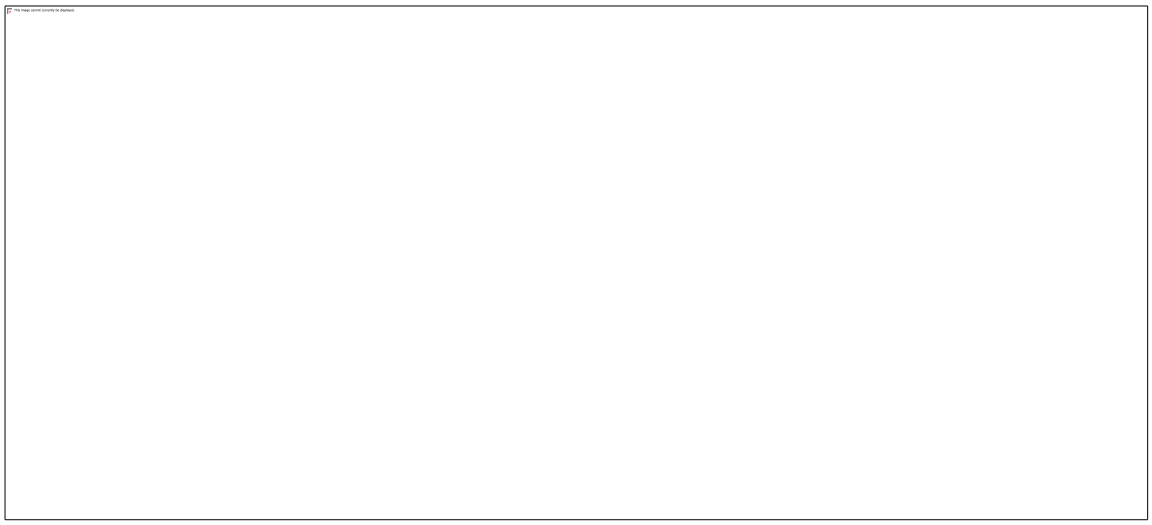
Queen-post truss.

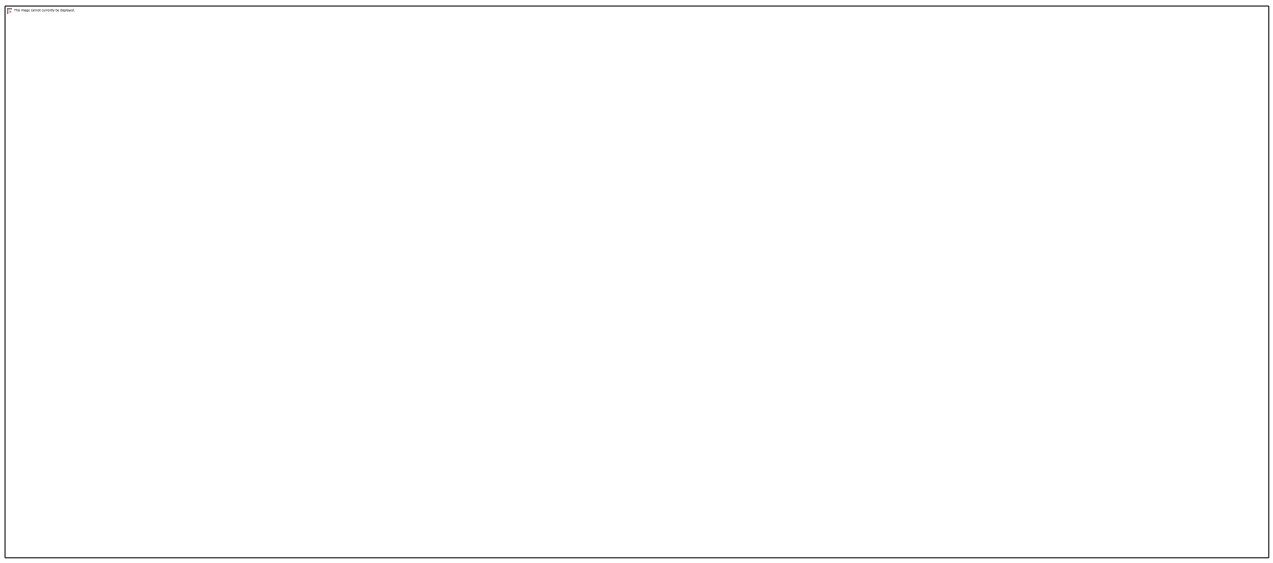
Fink truss.

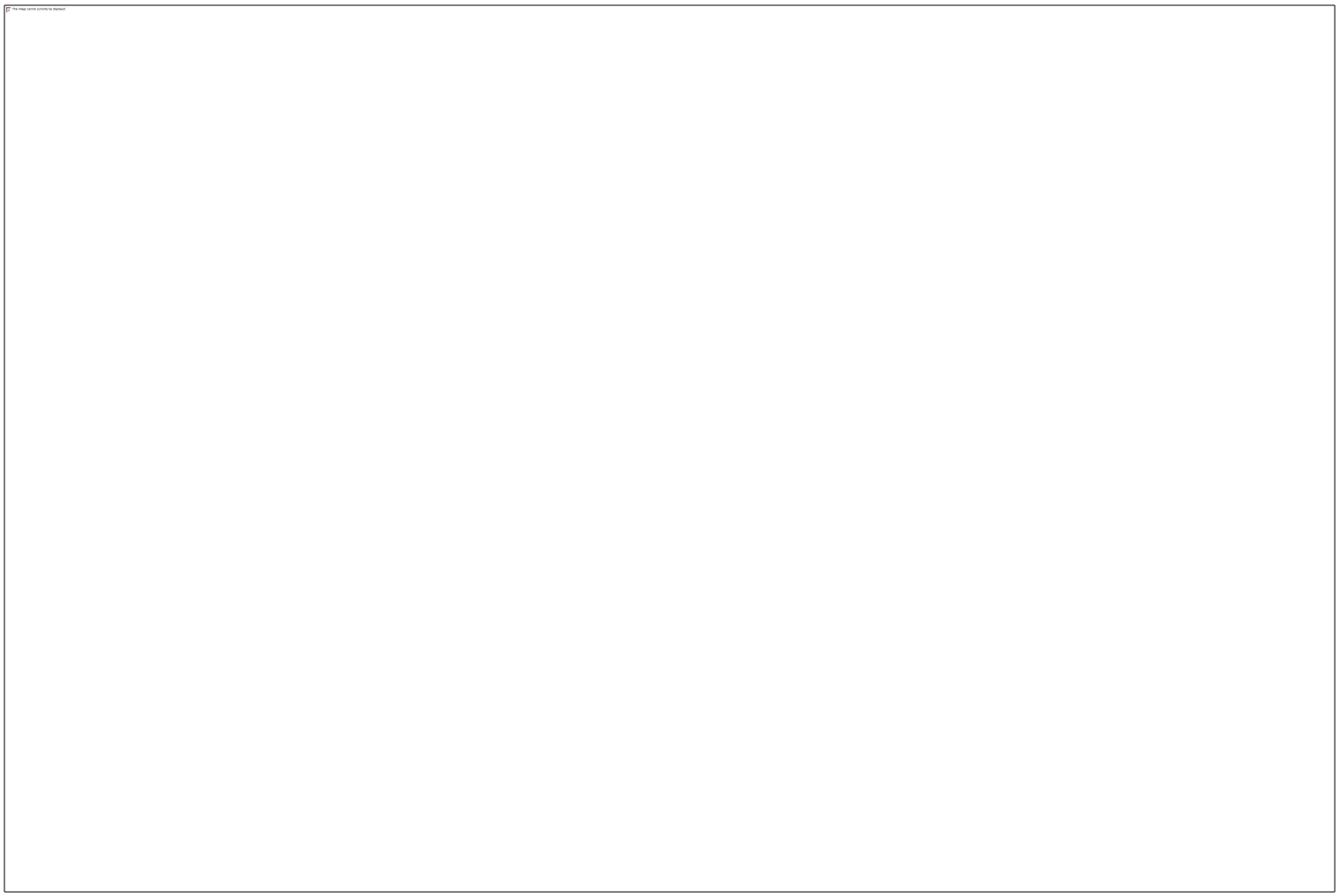
Howe truss.

Pratt truss.

Scissors truss.







Examples of roof truss applications in Kenya

Timber trusses in residential houses.

Steel trusses in school halls.

Steel trusses in churches.

Engineered trusses in commercial buildings and warehouses.

Important construction note: Roof trusses should be designed, fabricated, installed and braced according to approved structural drawings. Members should not be cut, drilled or altered without appropriate professional approval.

5.1.6 Wall plate

Definition: A wall plate is a horizontal timber or other suitable structural member placed on top of a supporting wall to provide a bearing and fixing surface for roof members.

Functions of wall plates

Provide a level bearing surface for rafters or roof trusses.

Distribute roof loads along the supporting wall.

Provide a fixing point for roof members.

Help secure the roof structure to the building.

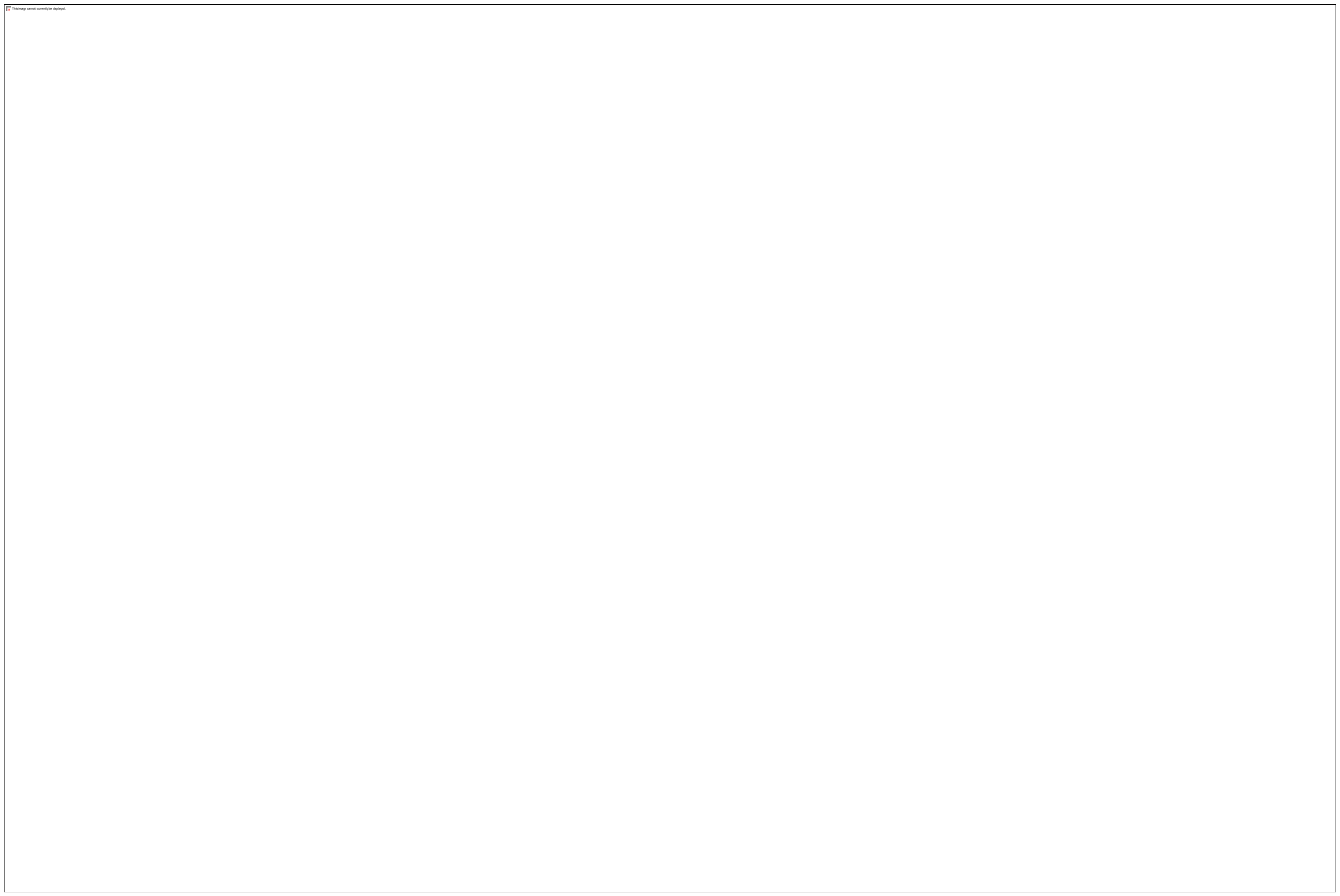
Reduce direct local pressure from individual roof members on the masonry.

Materials used

Treated timber.

Steel sections or other engineered support systems, where specified.

Example: A treated timber wall plate may be anchored to the top of a masonry wall before timber roof trusses are installed.



5.1.7 Ceiling joists

Definition: Ceiling joists are horizontal structural members that support the ceiling finish and may connect opposing rafters in certain roof structures.

Functions of ceiling joists

Support ceiling boards or other ceiling finishes.

Provide a framework for fixing ceiling materials.

Help maintain the shape of the ceiling.

In suitable roof designs, act as ties that resist the outward thrust of opposing rafters.

Provide support for light ceiling services and fittings where appropriately designed.

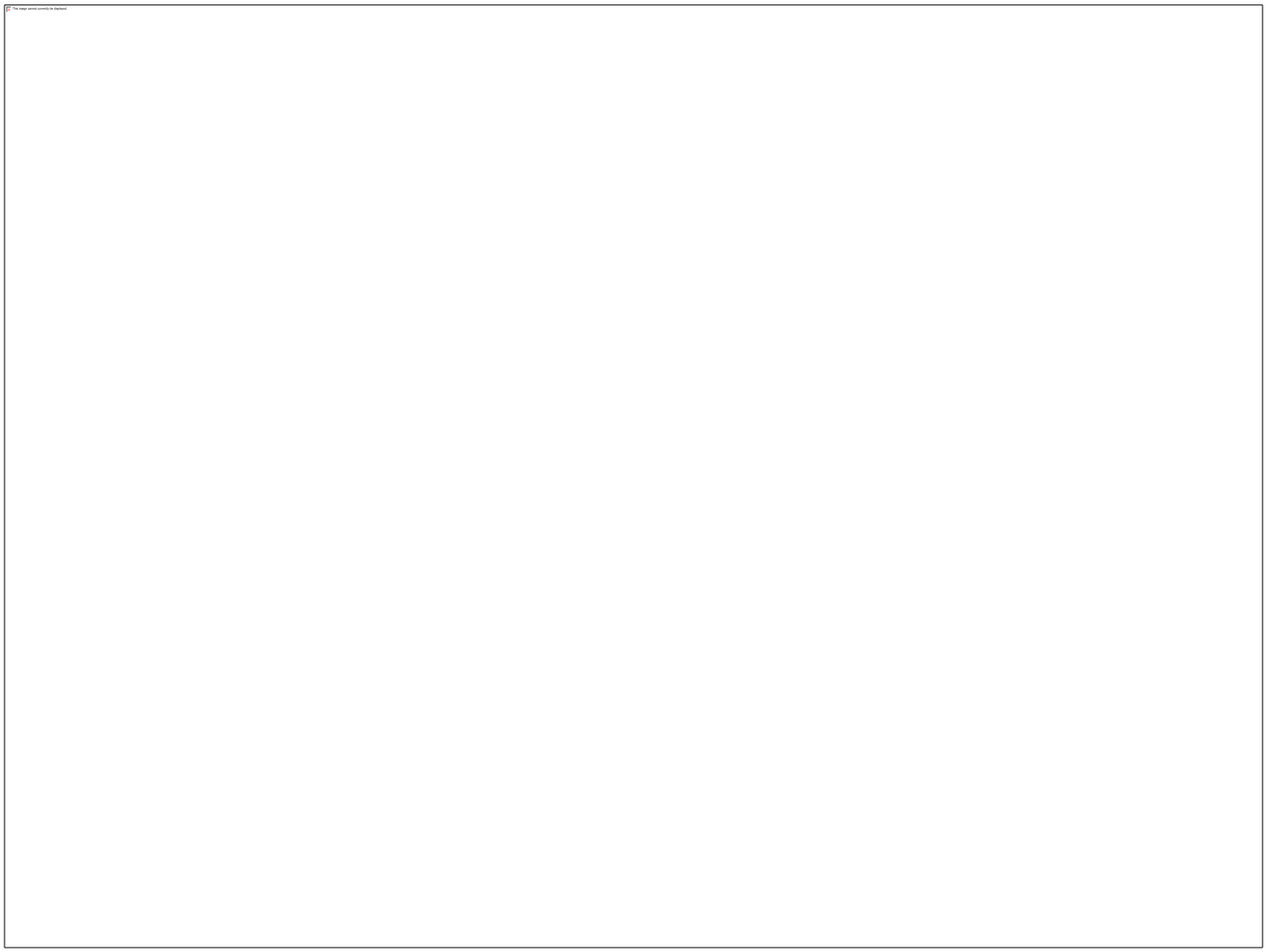
Materials used

Timber.

Light-gauge steel.

Engineered timber products.

Example: Timber ceiling joists may be used to support gypsum boards in a residential house.



5.1.8 Ridge board

Definition: A ridge board is a horizontal board fixed along the highest line of a pitched roof, where opposing common rafters meet.

Functions of a ridge board

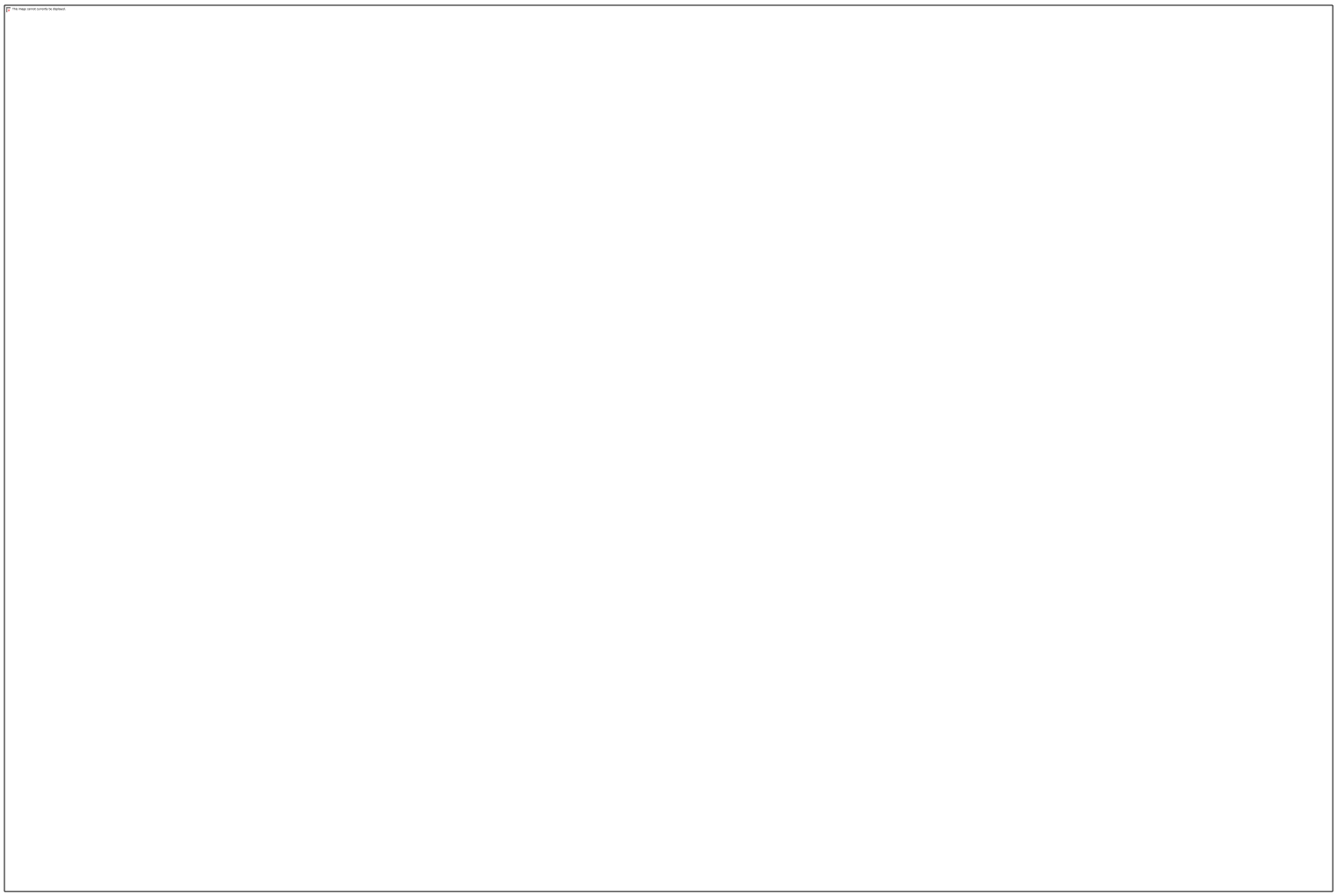
Provides a fixing surface for opposing rafters.

Helps align rafters at the ridge.

Maintains the position of rafters during roof construction.

Provides a continuous line for joining roof slopes.

Important distinction: A ridge board is not necessarily a load-bearing ridge beam. A ridge beam is a structural member designed to carry loads and transfer them to supports. A ridge board mainly provides a joining and alignment surface for rafters in conventional roof framing.



5.1.9 Barge board (gable board)

Definition: A barge board is a finishing board fixed along the sloping edge of a pitched roof at a gable end.

It is sometimes incorrectly referred to as a badge board. The correct construction term is **barge board**.

Functions of a barge board

Covers exposed ends of roof members at the gable.

Provides a neat finish to the sloping roof edge.

Protects roof edges from weather exposure.

Improves the appearance of the gable end.

Provides a suitable finishing surface for decorative roof details.

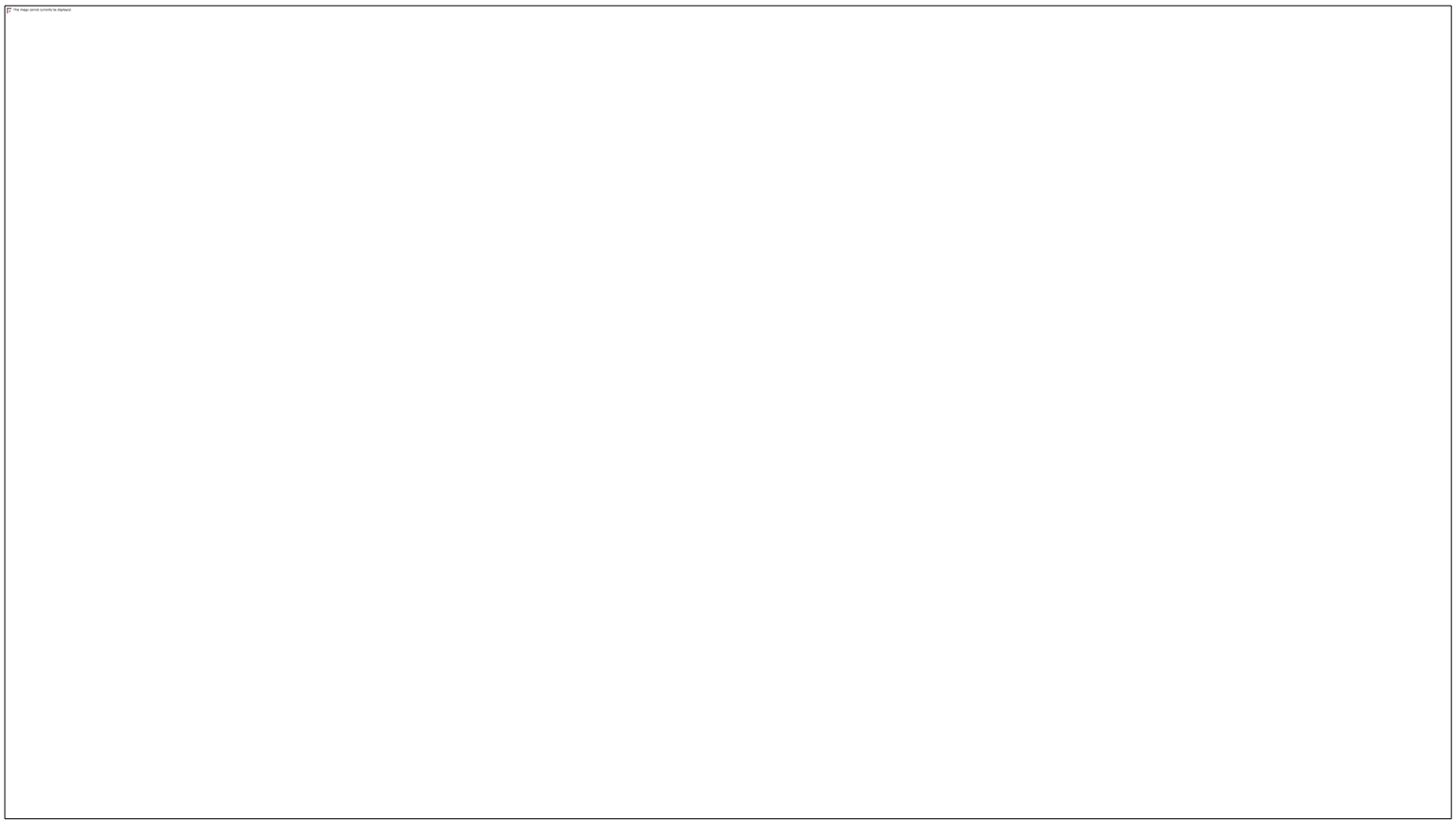
Materials used

Timber.

uPVC.

Fibre-cement boards.

Metal finishing sections.



5.1.10 Soffit board

Definition: A soffit board is a finishing board fixed to the underside of the projecting roof eaves, between the wall and the fascia board.

Functions of a soffit board

Covers the underside of the roof overhang.

Gives the roof edge a neat and finished appearance.

Helps prevent birds, insects and debris from entering the roof space.

Protects exposed roof edges from weather.

May incorporate ventilation openings to allow air circulation into the roof space.

Materials used

Timber.

uPVC.

Fibre-cement boards.

Aluminium or other suitable metal sheets.



5.1.11 Other important roof components

a) Ridge cap

A ridge cap is a specially shaped covering fixed along the ridge of a pitched roof.

Functions:

Covers the joint where two roof slopes meet.

Prevents rainwater from entering through the ridge.

Improves the appearance of the roof.

Helps protect the ridge area against wind-driven rain.

b) Battens

Battens are small horizontal members fixed across rafters or other supports to provide fixing points for roof tiles or other coverings.

Functions:

Support roof tiles and certain other coverings.

Provide fixing points for roofing materials.

Maintain the spacing and alignment of roof coverings.

Transfer loads to rafters or other supporting members.

c) Eaves

The eaves are the lower edges of a pitched roof that project beyond the external walls.

Functions:

Direct rainwater away from external walls.

Provide shade to walls and windows.

Protect parts of the building from direct rainfall.

Provide a location for gutters where installed.

d) Gutter

A gutter is a channel fixed along the eaves or roof edge to collect rainwater flowing from the roof.

Functions:

Collects rainwater.

Directs water towards downpipes.

Reduces uncontrolled water discharge around the building.

Helps protect the foundation and external walls from water damage.

e) Downpipe

A downpipe is a vertical pipe connected to a gutter to carry rainwater down to a suitable drainage or harvesting system.

Functions:

Carries water from gutters to ground-level drainage.

Helps prevent water from splashing against walls.

Can direct rainwater into storage tanks.

Helps control stormwater around the building.

f) Flashing

Flashing is a thin waterproof material fitted at roof junctions and openings to prevent water from entering through joints.

Common locations include:

Around chimneys.

At roof-to-wall junctions.

Around roof windows.

At valleys and other vulnerable joints.

g) Roof valley

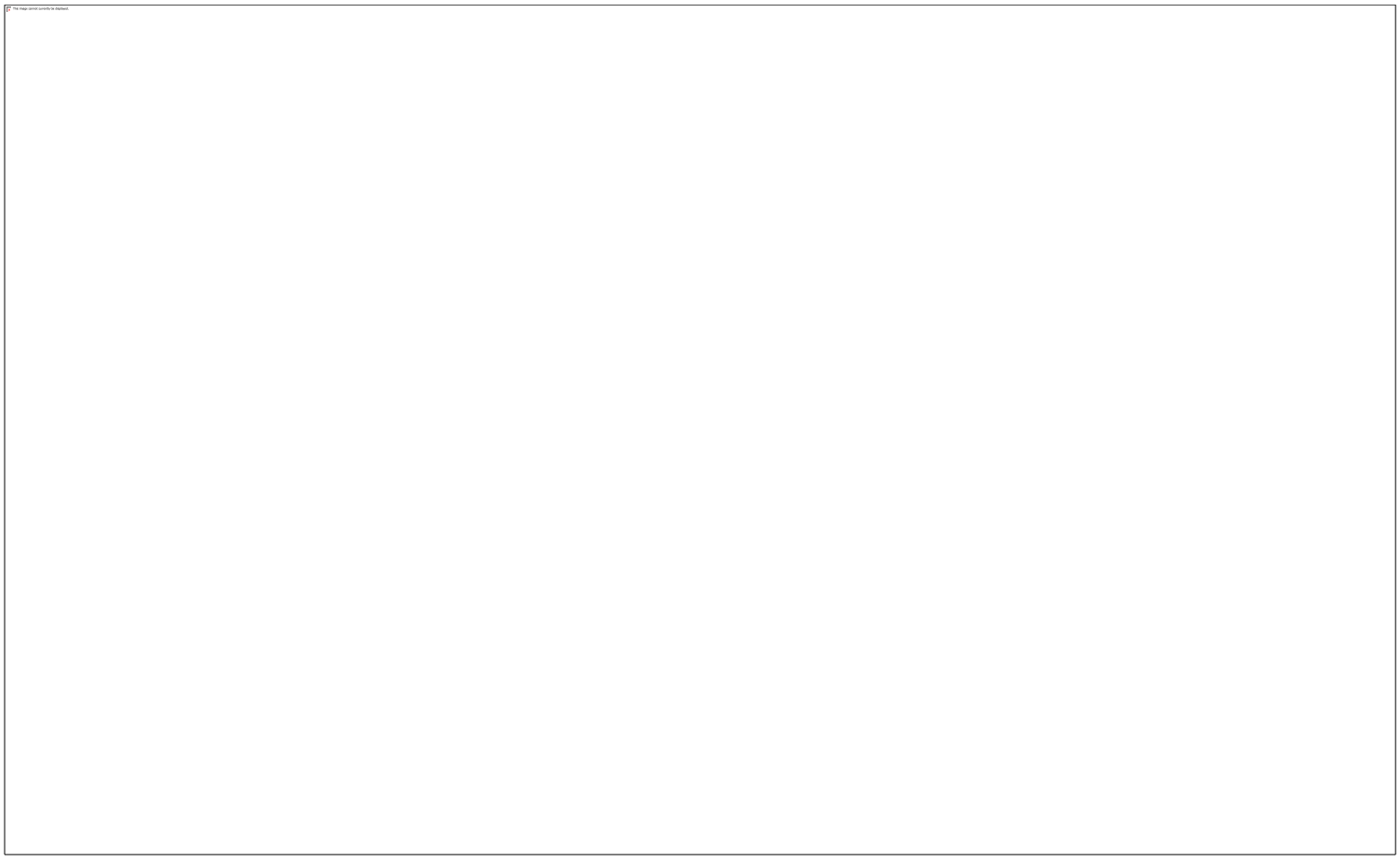
A valley is the internal angle formed where two sloping roof surfaces meet and direct rainwater towards a lower point.

It requires proper waterproofing and drainage because it carries water from adjoining roof surfaces.

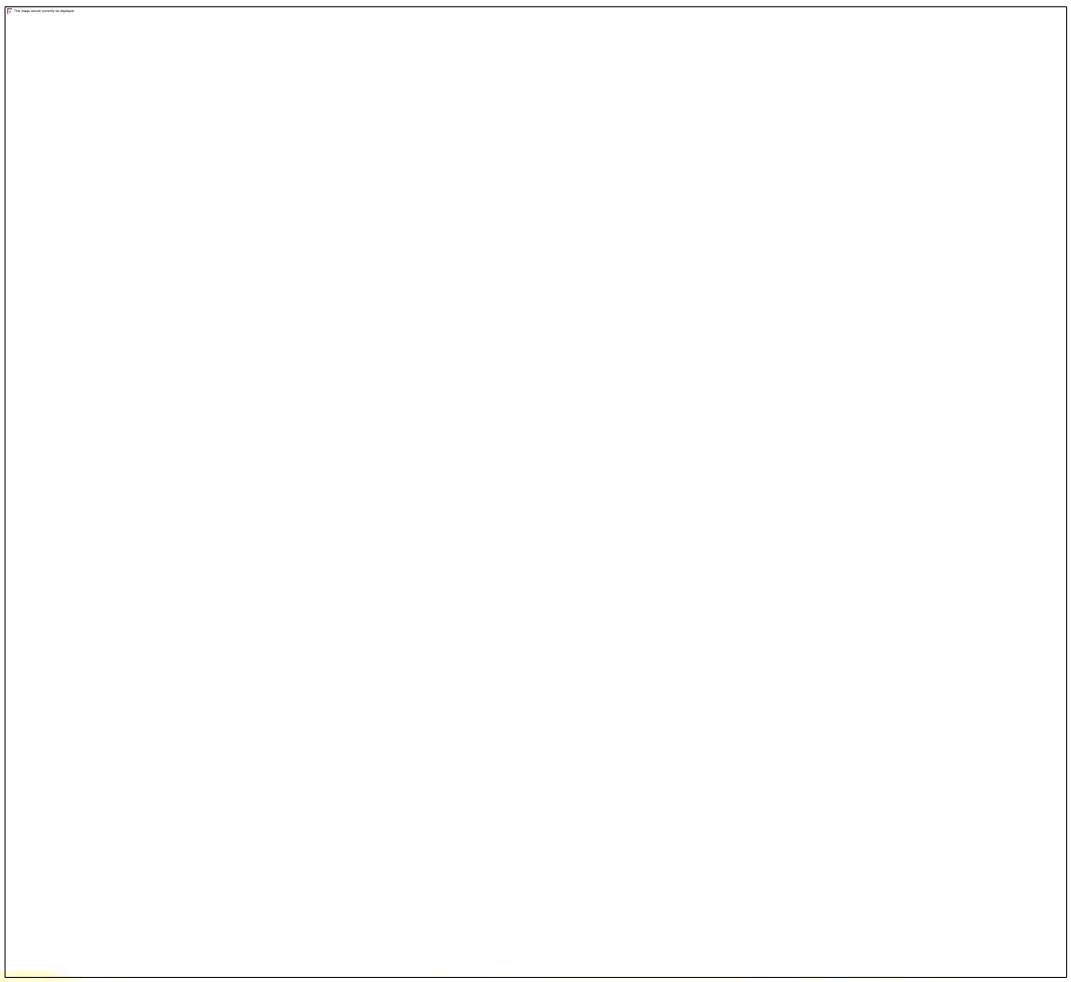
6.0 Sketches of roof components

The following simplified sketches help learners understand the position and arrangement of roof members. They are learning diagrams and not construction drawings to scale.

6.1 Sketch of a simple pitched roof



Simplified text sketch



Explanation of the sketch

The ridge is the highest line of the roof.

Rafters slope downwards from the ridge towards the eaves.

Purlins provide intermediate support to rafters or roof coverings, depending on the design.

Wall plates rest on the supporting walls.

Ceiling joists support the ceiling and may tie opposing rafters.

Fascia boards finish the roof edges at the eaves.

6.2 Sketch of a typical roof truss





Explanation

Principal rafters form the two sloping sides.

The king post is the central vertical member.

The tie beam connects the lower ends of the principal rafters.

The members work together to form a stable triangular framework.

6.3 Sketch of roof eaves showing fascia and soffit



Explanation

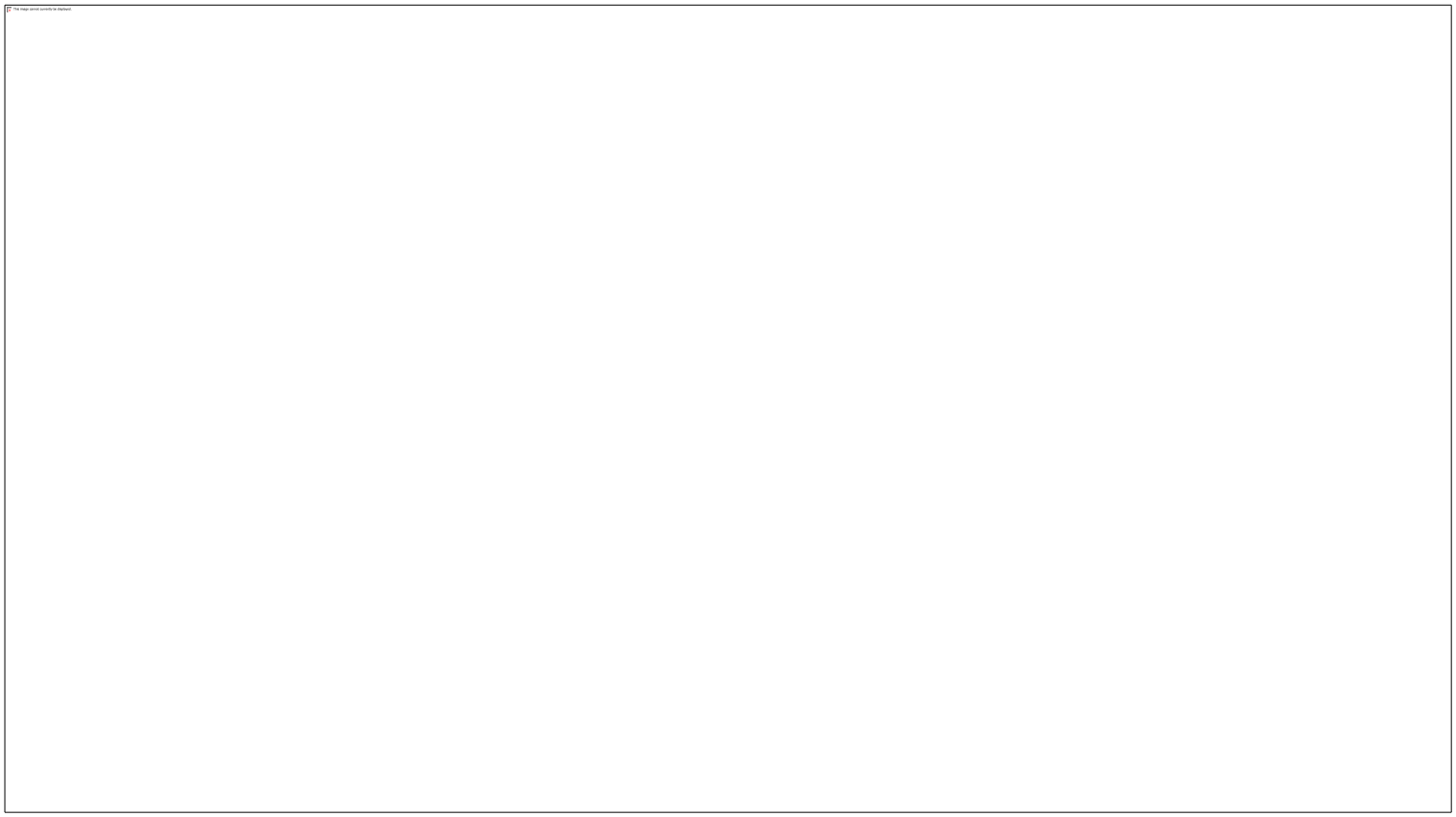
The fascia board covers the exposed ends of the rafters.

The soffit board covers the underside of the eaves.

The gutter collects rainwater from the roof.

The external wall supports the roof structure through the designed bearing arrangement.

6.4 Sketch showing a flat roof



Explanation

The parapet wall forms a protective edge where provided.

The protective finish protects the waterproofing system.

The waterproofing layer prevents water penetration.

The sloping screed directs water towards the drainage outlet.

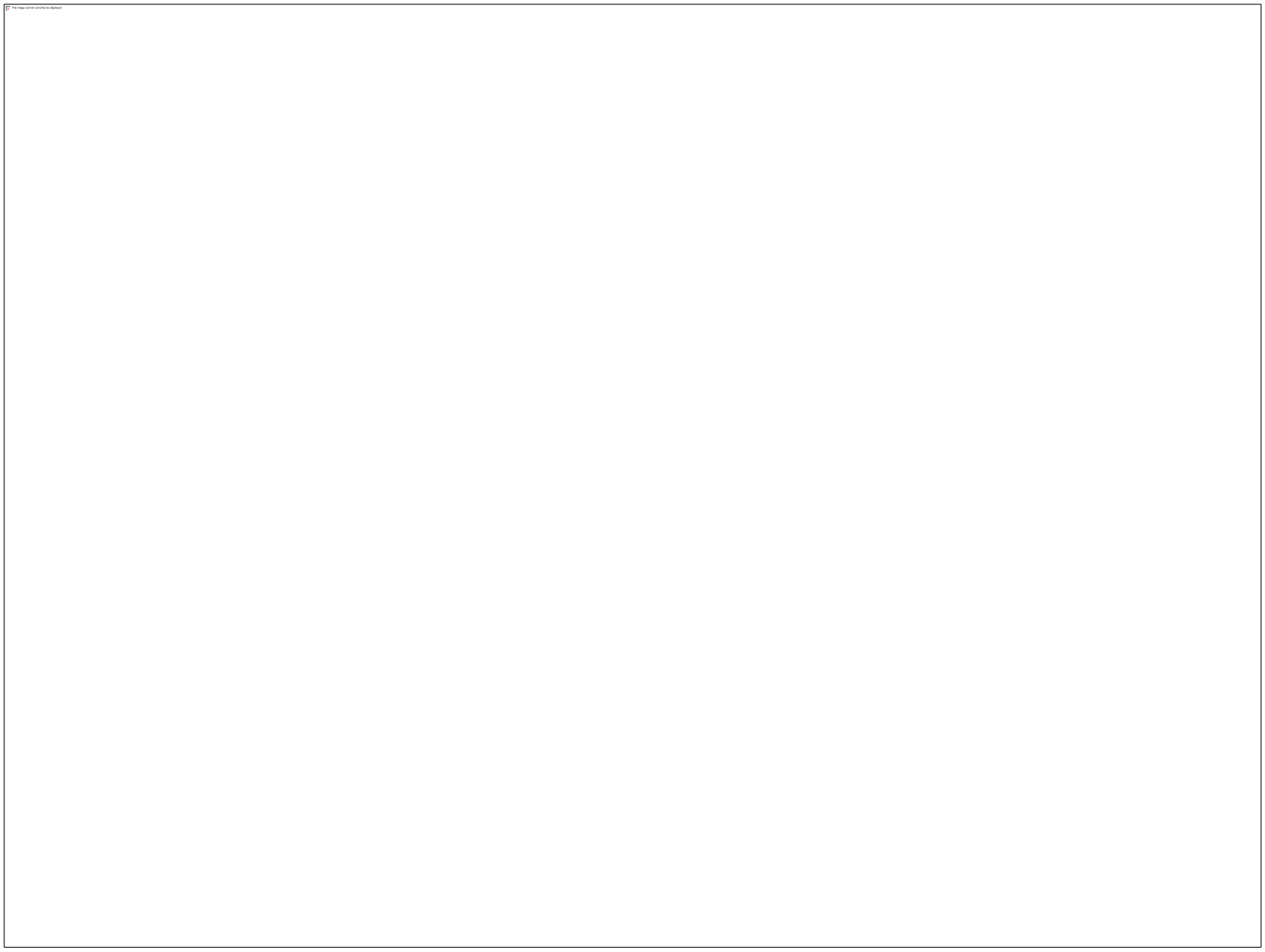
The reinforced concrete slab carries the designed roof loads.

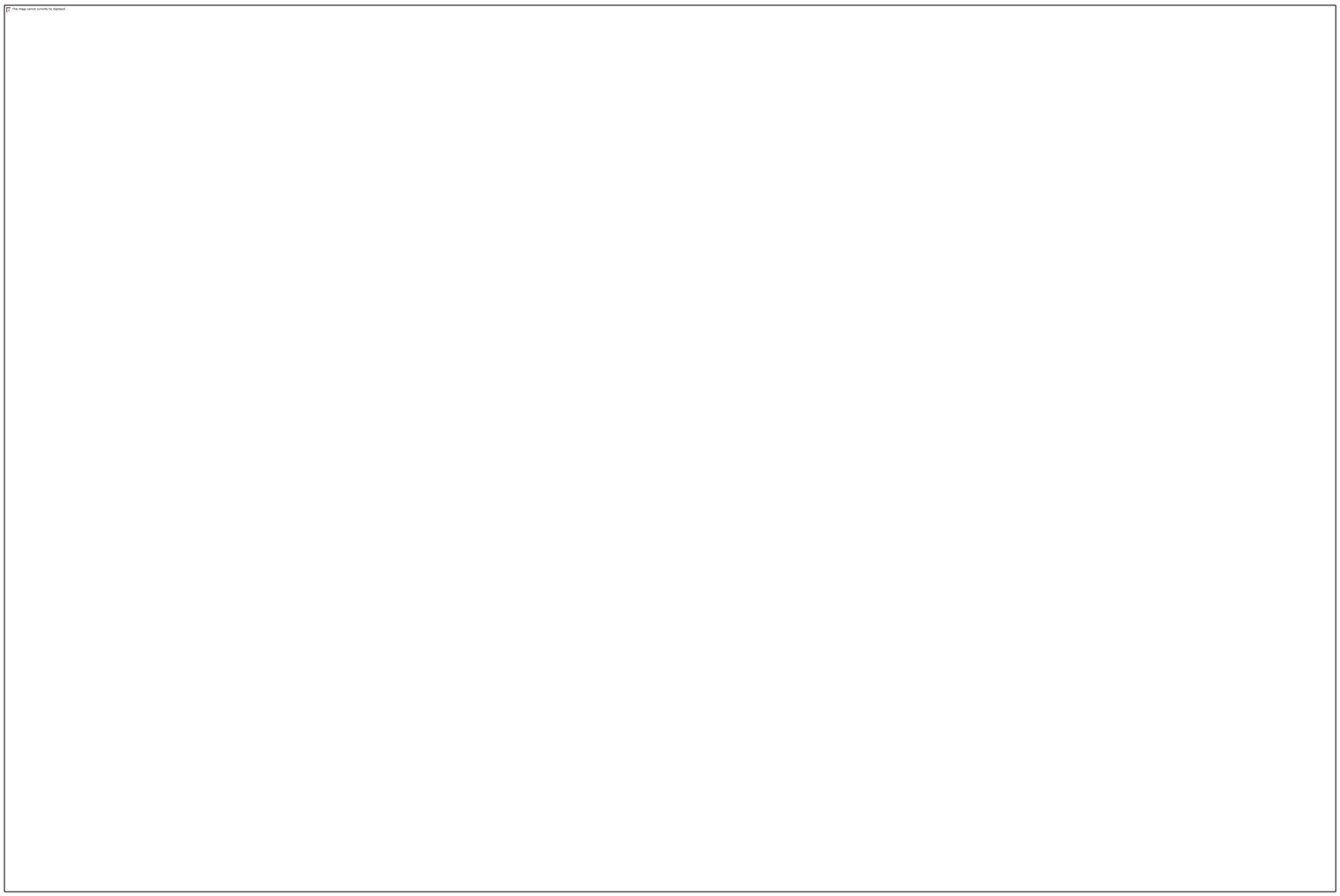
7.0 Materials used for roof covering

7.1 Meaning of roof covering

Roof covering refers to the outermost material or system fixed over a roof structure to protect the building against rain, sunlight, wind and other weather conditions.

Roof coverings should be durable, weather-resistant, properly fixed and suitable for the roof's slope and structural design.







7.2 Common materials used for roof covering

7.2.1 Corrugated galvanised iron sheets

Definition: Corrugated galvanised iron sheets are metal roofing sheets coated with zinc to reduce corrosion and improve durability.

Characteristics

Have a corrugated profile.

Are relatively light in weight.

Are available in different thicknesses and lengths.

Are fixed using suitable roofing screws or approved fasteners.

Require proper laps and sealing to prevent leakage.

Advantages

Readily available in many Kenyan hardware shops.

Relatively affordable compared with some other coverings.

Easy to transport.

Quick to install.

Suitable for many residential and institutional buildings.

Available in different colours and profiles.

Disadvantages

Can become hot under direct sunlight.

Can be noisy during heavy rainfall.

May corrode if the protective coating is damaged or if unsuitable conditions are ignored.

Can be damaged or lifted by strong winds if poorly fixed.

Thin sheets may dent easily.

Examples of use: Rural houses, urban houses, classrooms, stores, workshops and farm buildings.

7.2.2 Pre-painted coated steel roofing sheets

These are steel roofing sheets coated with protective and decorative paint finishes.

Advantages

Offer a variety of colours.

Provide an attractive roof finish.

Have protective coatings that help resist corrosion.

Are relatively light.

Can be installed quickly using suitable fasteners.

Disadvantages

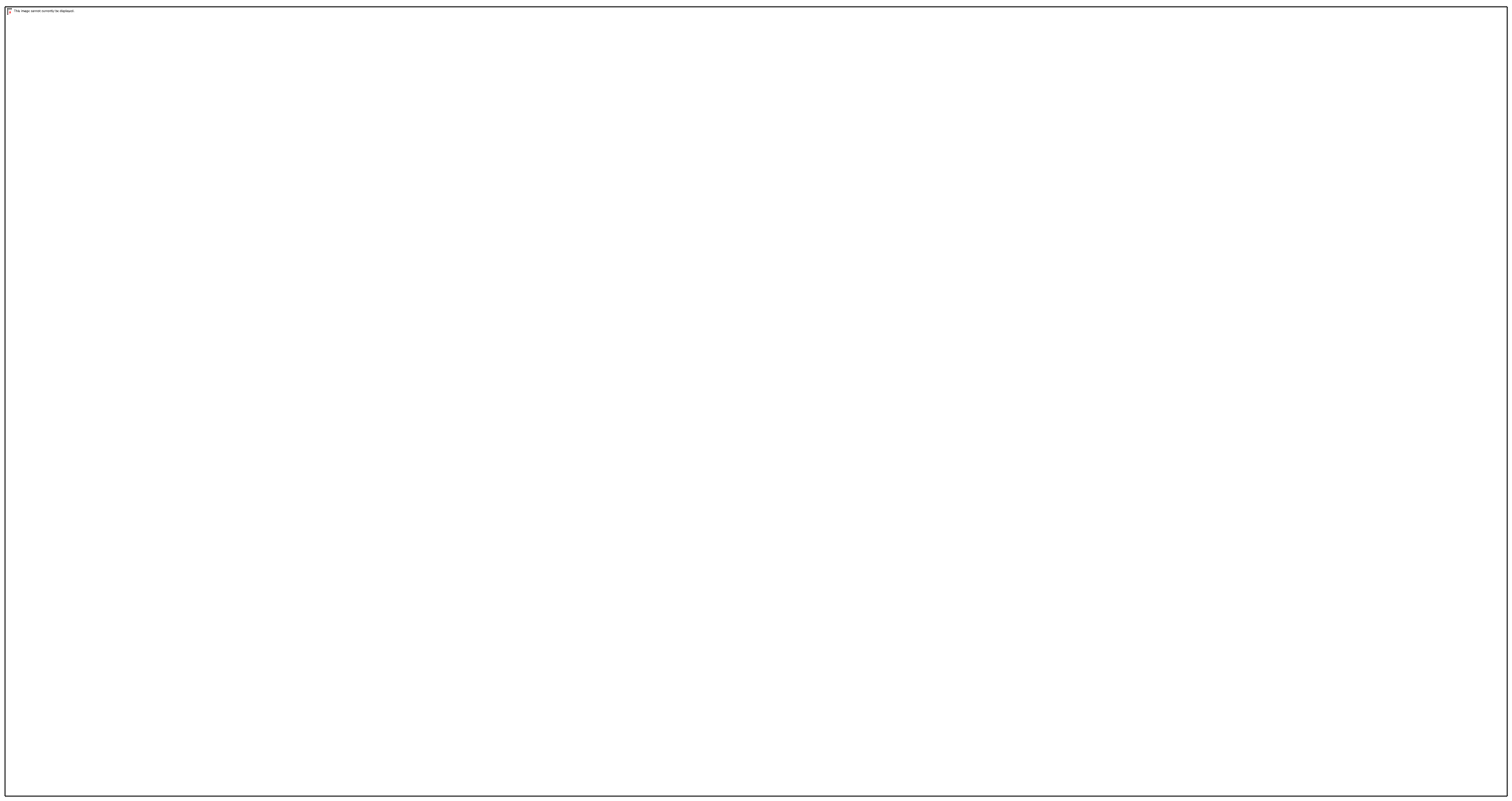
Scratches and damaged coatings may expose the steel to corrosion.

Some products may be more expensive than ordinary galvanised sheets.

Poor-quality products may fade or deteriorate faster.

Require correct installation and maintenance.

7.2.3 Concrete roof tiles



Definition: Concrete roof tiles are roofing units manufactured from cement, sand, water and other suitable additives, shaped and cured to form durable roofing elements.

Advantages

Are durable when properly manufactured and installed.

Provide an attractive appearance.

Offer good resistance to weather.

Are available in different shapes and colours.

Can provide good sound insulation compared with thin metal sheets.

Disadvantages

Are heavier than metal sheets.

Require a roof structure designed to carry their weight.

May break during careless handling.

Installation may take more time.

May cost more than basic metal sheet coverings.

Examples of use: Residential houses, villas and selected institutional buildings.

7.2.4 Clay roof tiles



Definition: Clay roof tiles are roofing units made by shaping natural clay and firing it in a kiln to produce hard, weather-resistant tiles.

Advantages

Have an attractive natural appearance.

Are durable when properly manufactured and installed.

Resist deterioration from sunlight.

Provide good thermal performance.

Are available in different shapes and colours.

Disadvantages

Are relatively heavy.

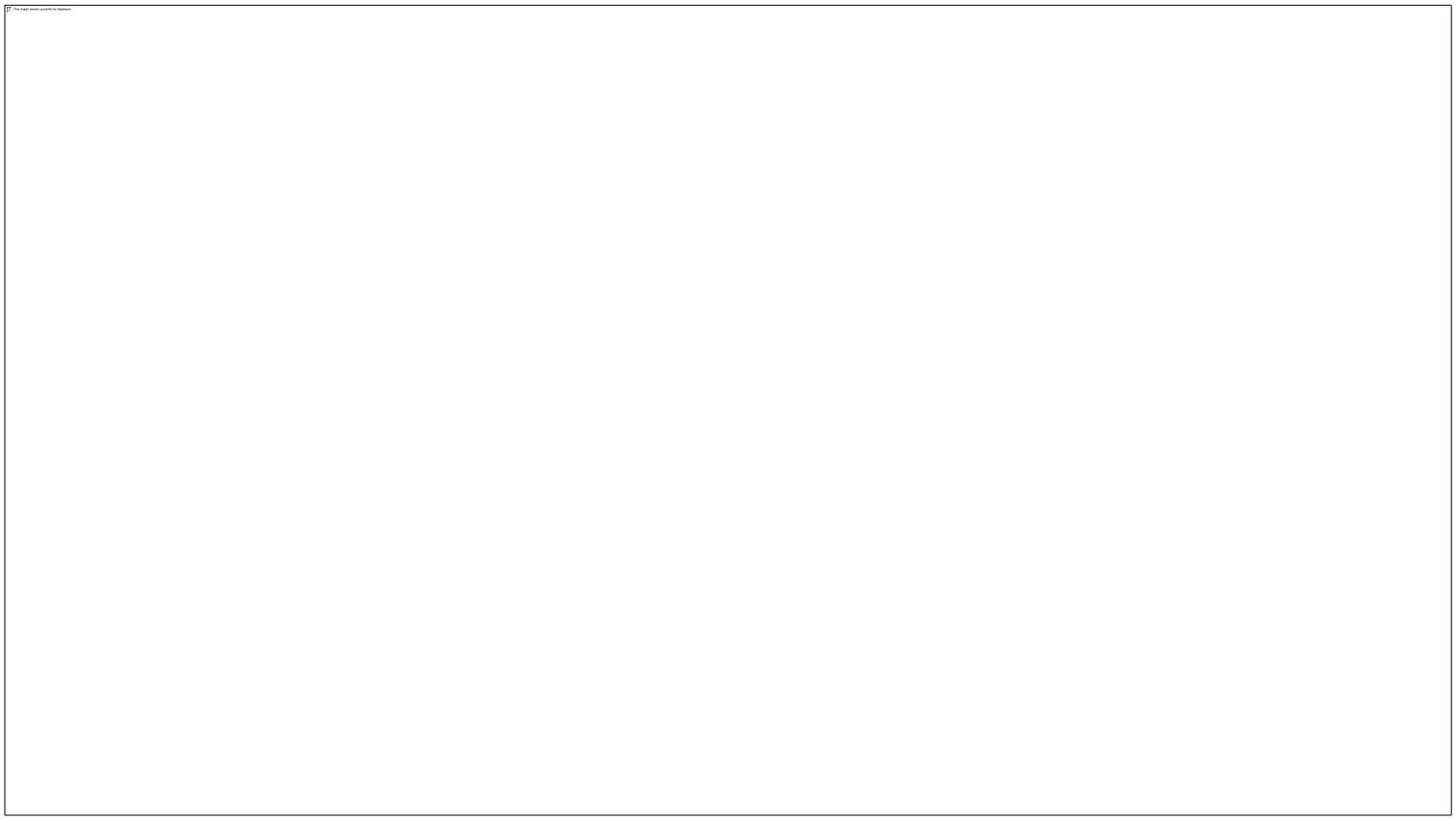
May break if dropped or handled carelessly.

Require a strong roof structure.

May be expensive or less readily available in some locations.

Require careful installation to prevent leakage.

7.2.5 Stone-coated steel roofing tiles



Definition: Stone-coated steel roofing tiles are metal roofing units coated with protective layers and a layer of stone granules to provide an attractive finish.

Advantages

Are lighter than many concrete and clay tile systems.

Provide an attractive tiled appearance.

Can resist weather when correctly manufactured and installed.

Are available in different profiles and colours.

Can be suitable for a variety of residential roof designs.

Disadvantages

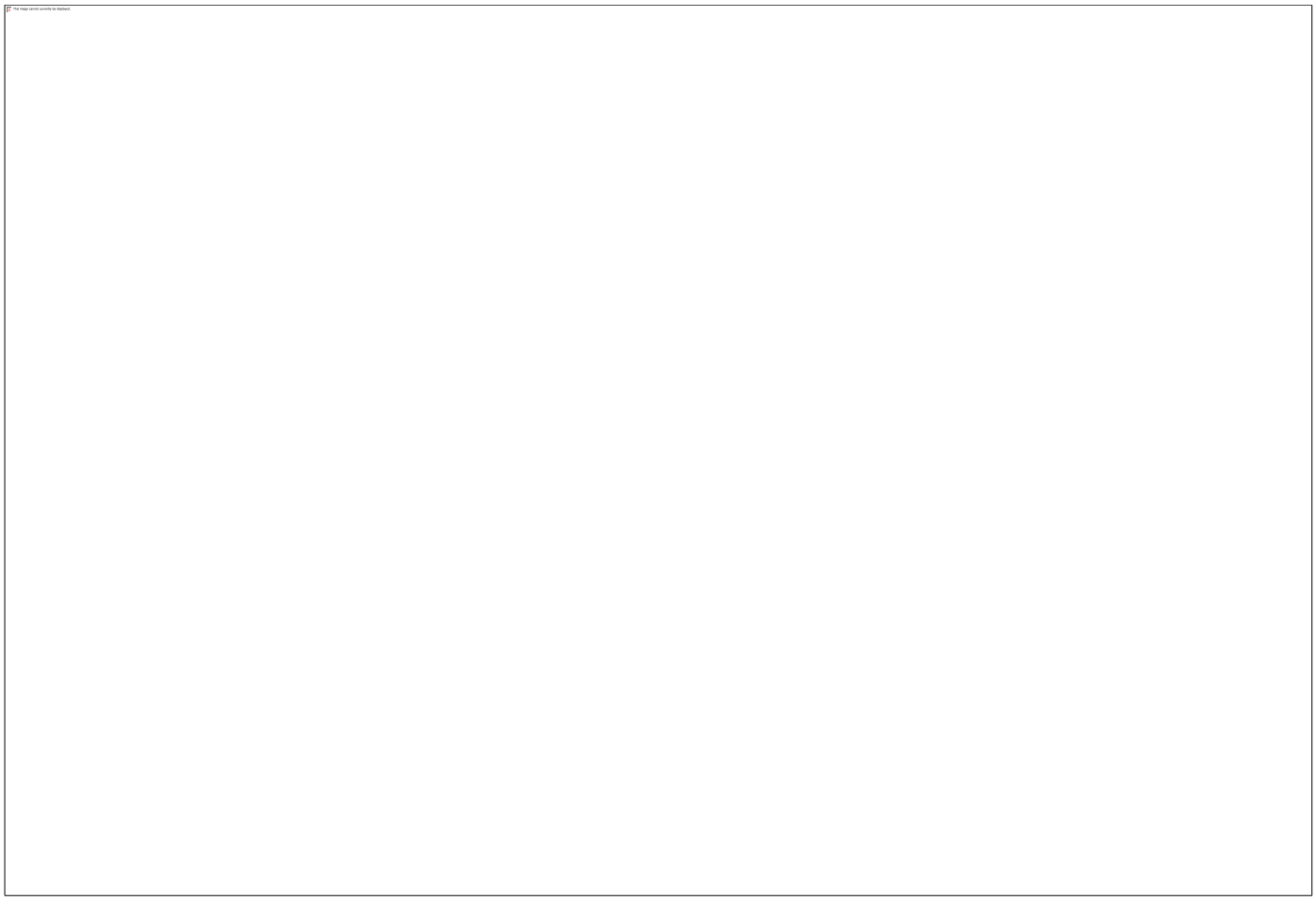
May be more expensive than ordinary roofing sheets.

Require compatible accessories and correct fixing methods.

Damaged coatings may require repair.

Poor installation can cause leakage or wind damage.

7.2.6 Slate roofing



Definition: Slate roofing consists of thin pieces of natural slate stone fixed to a roof structure as overlapping units.

Advantages

Is durable when good-quality slate is used.

Has an attractive natural appearance.

Is resistant to fire.

Can withstand different weather conditions.

Has a long service life when correctly installed.

Disadvantages

Can be expensive.

Requires specialised installation skills.

Is relatively heavy.

May be difficult to source in some Kenyan locations.

7.2.7 Thatch



Definition: Thatch is a traditional roofing covering made from dry plant materials such as grass, reeds, straw or palm leaves.

Advantages

Can be made from locally available natural materials.

Provides good thermal insulation when properly constructed.

Gives buildings a traditional appearance.

Can be relatively affordable where suitable materials are available.

Is renewable when materials are harvested sustainably.

Disadvantages

Can be highly vulnerable to fire.

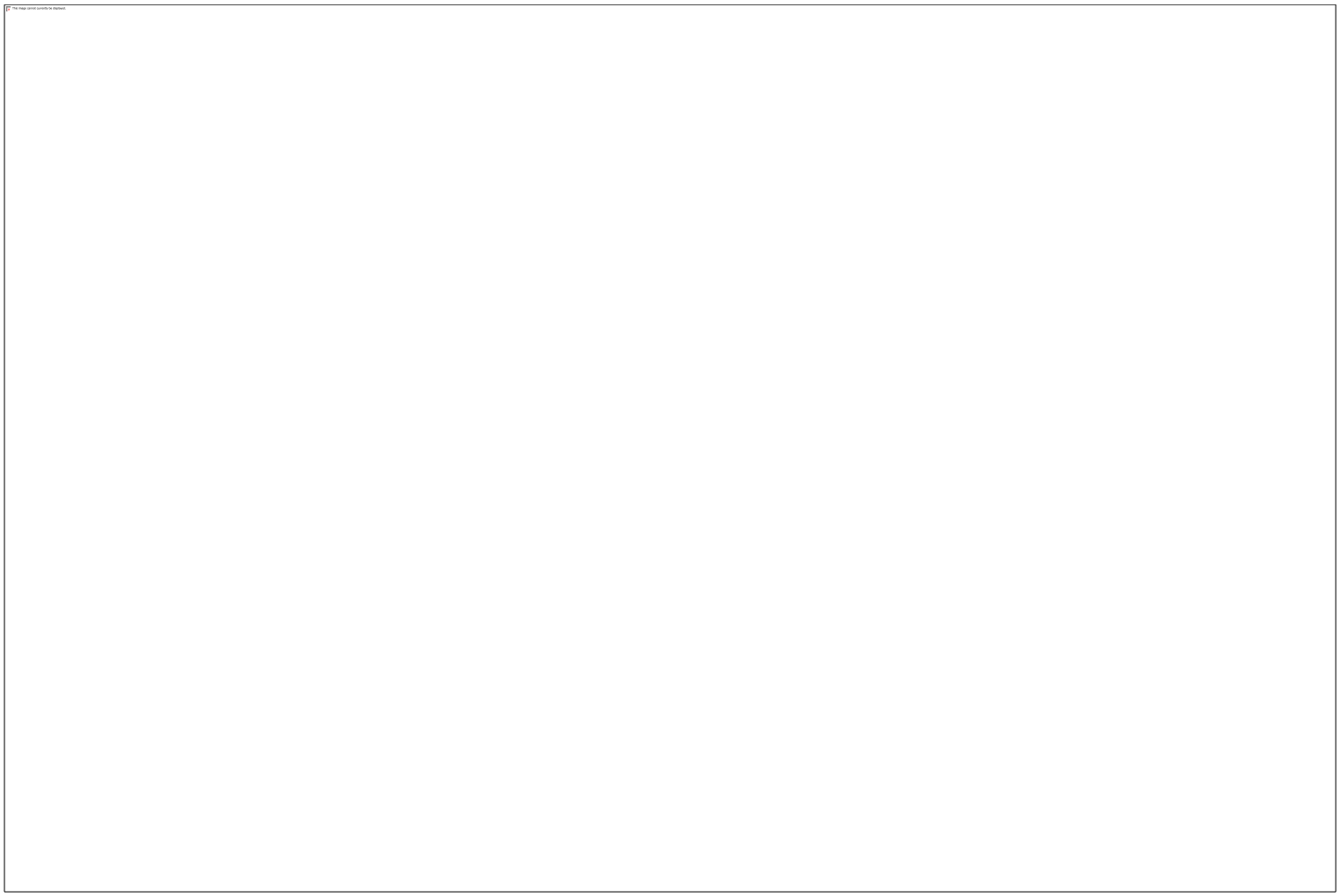
May deteriorate due to moisture, pests and biological attack.

Requires regular maintenance.

May have a shorter service life than many modern coverings.

Requires suitable construction techniques to prevent leakage.

7.2.8 Timber shingles



Definition: Timber shingles are small, thin pieces of treated or naturally durable wood fixed in overlapping rows to cover a roof.

Advantages

Provide a natural and attractive appearance.

Are relatively light compared with many tile systems.

Can provide good thermal insulation.

Can be made from suitable renewable timber sources.

Disadvantages

May be vulnerable to fire.

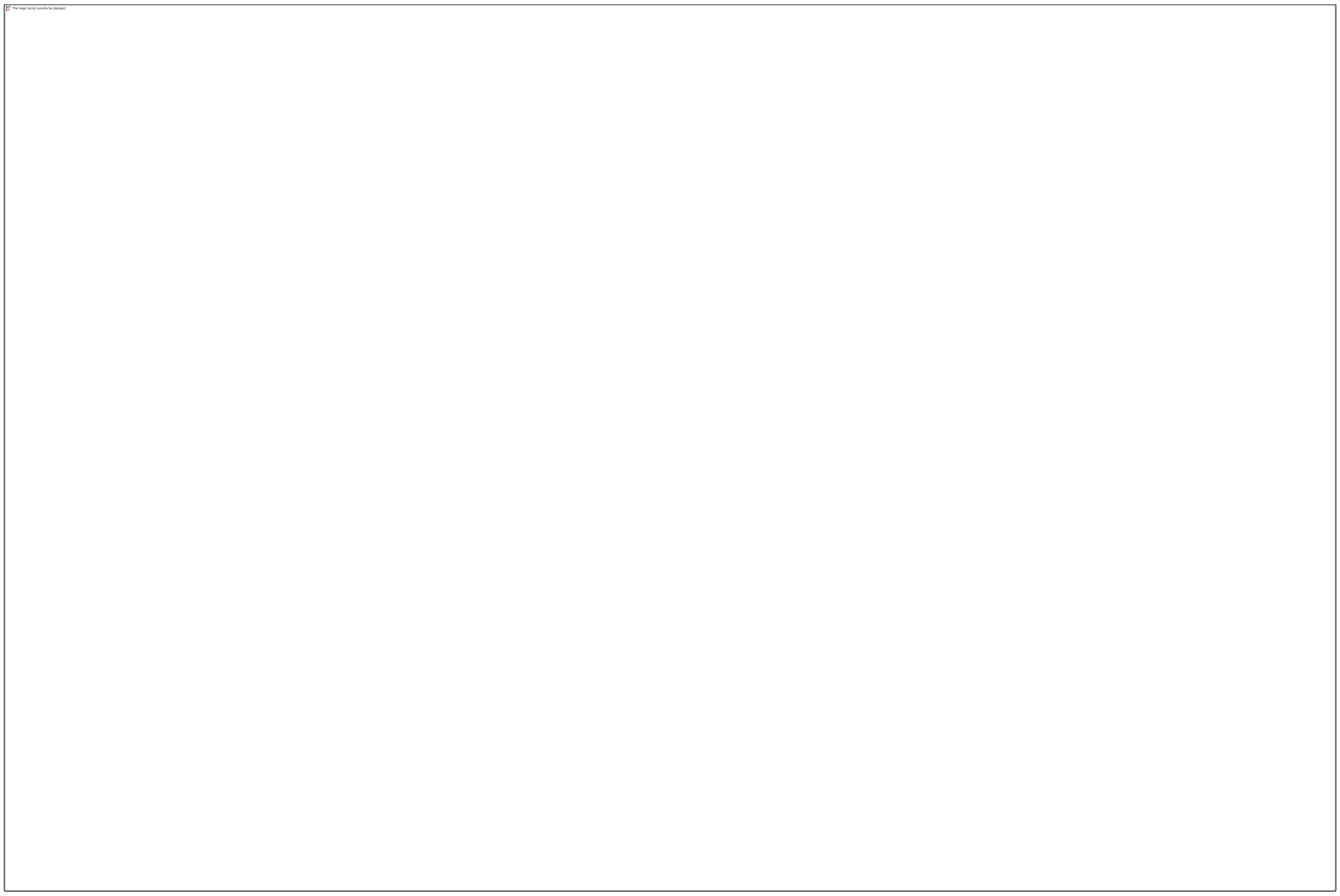
Can decay if not properly selected and maintained.

May be attacked by termites and other wood-boring insects.

Require proper treatment and installation.

May be expensive where suitable timber is scarce.

7.2.9 Bituminous shingles



Definition: Bituminous shingles are roofing units made using bitumen and reinforcing materials, usually finished with mineral granules.

Advantages

Are relatively light.

Are available in different colours and shapes.

Can provide an attractive roof finish.

Are suitable for appropriately designed sloping roofs.

Can be relatively easy to install with the correct system.

Disadvantages

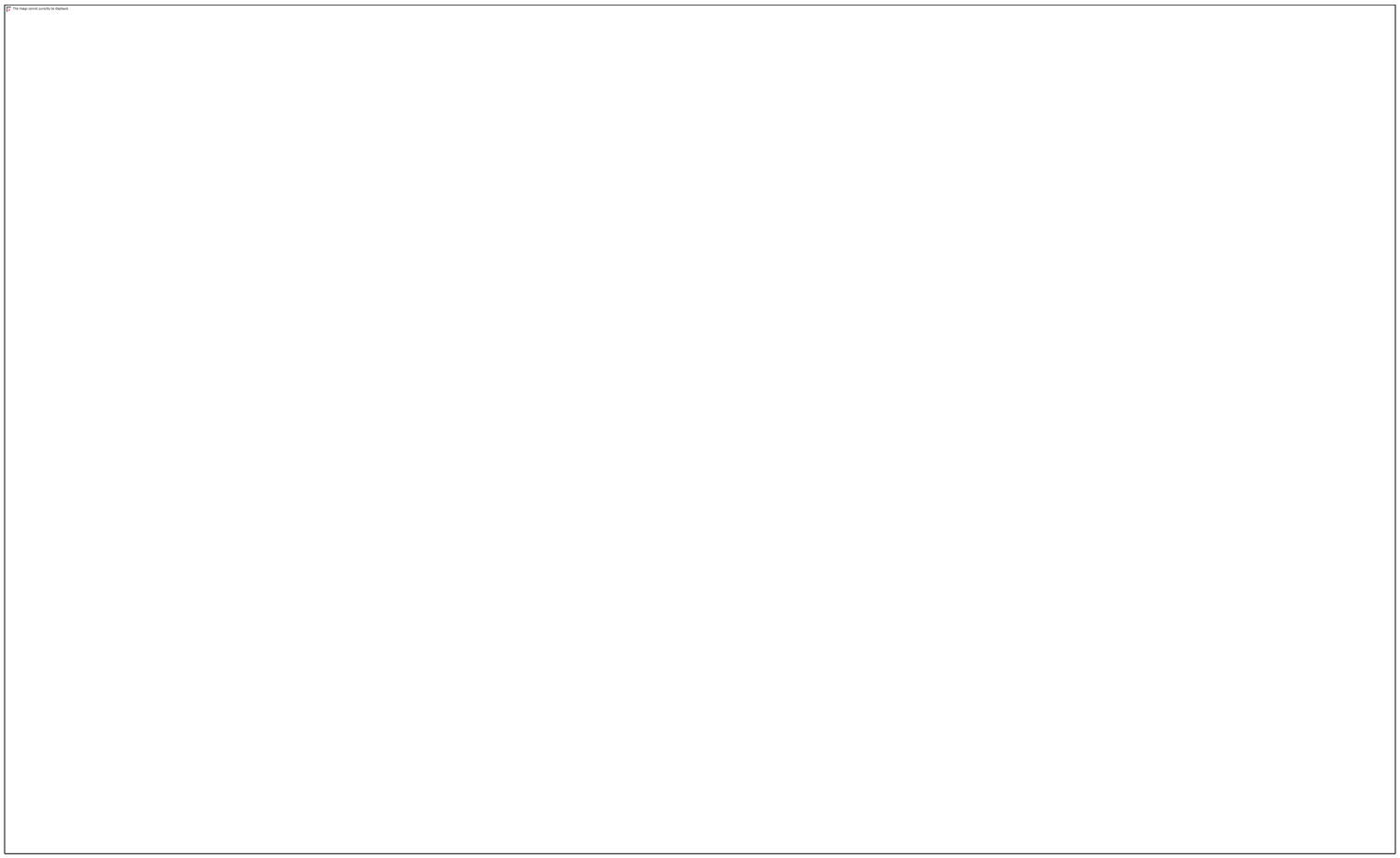
May deteriorate under prolonged exposure to harsh conditions.

Require a suitable roof deck.

May be damaged by poor installation.

Can be affected by excessive heat depending on product quality.

7.2.10 Polycarbonate sheets



Definition: Polycarbonate sheets are strong plastic roofing sheets that may be transparent, translucent or opaque.

Advantages

Allow natural light into buildings.

Are relatively light.

Are available in different colours and profiles.

Can be used for verandas, canopies and covered walkways.

Are easy to cut and install using suitable methods.

Disadvantages

Some types may scratch easily.

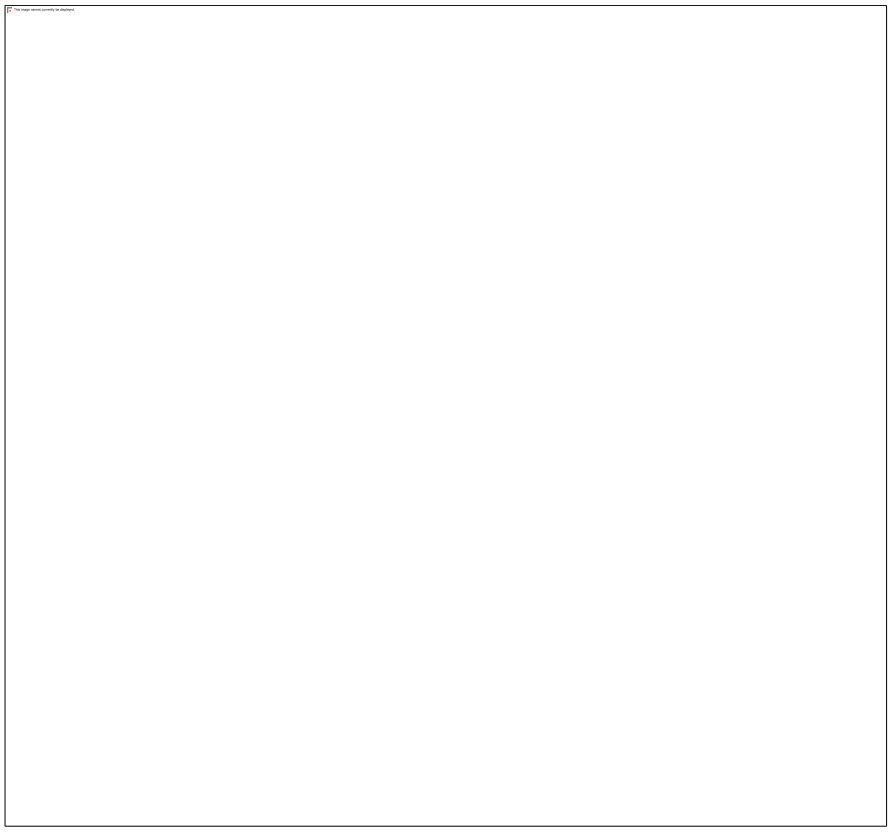
Can expand and contract with temperature changes.

May deteriorate under ultraviolet radiation if not adequately protected.

May become noisy during rainfall.

Require suitable fixing systems and allowances for thermal movement.

7.2.11 Fibre-cement roofing sheets



Definition: Fibre-cement roofing sheets are manufactured from cement and reinforcing fibres to form rigid roofing products.

Advantages

Can provide a durable roof covering when correctly manufactured and installed.

Are generally non-combustible.

Can provide good resistance to weather.

May offer better sound performance than thin metal sheets.

Disadvantages

Can be brittle and may crack if mishandled.

Are heavier than some metal sheets.

Cutting and handling require suitable dust controls.

Older fibre-cement products may contain asbestos and should not be cut, drilled or disturbed without specialist assessment and appropriate controls.

Safety note: Learners should never assume that an old fibre-cement roof is asbestos-free. Suspected asbestos-containing material should be assessed and handled by appropriately qualified specialists.

7.3 Comparison of common roof-covering materials

Material	Main advantage	Main limitation
Galvanised iron sheets	Relatively affordable and light	Can be noisy and hot
Pre-painted steel sheets	Attractive finish and variety of colours	Coating can be damaged
Concrete tiles	Durable and attractive	Heavy
Clay tiles	Attractive and good thermal performance	Heavy and may break
Stone-coated steel tiles	Tiled appearance with lower weight than many concrete tiles	Relatively costly
Slate	Durable and fire-resistant	Expensive and specialised
Thatch	Natural and locally available	Fire and moisture risks
Timber shingles	Natural appearance	Requires treatment and maintenance
Bituminous shingles	Light and available in different designs	May deteriorate in harsh conditions
Polycarbonate	Allows natural light	Can scratch and expand with heat
Fibre-cement sheets	Durable and non-combustible	Brittle; older products may contain asbestos

8.0 Factors to consider when selecting roof-covering materials

The selection of roof-covering materials is an important decision in building construction. The material selected should be suitable for the building's design, location, purpose, budget and environmental conditions.

The following factors should be considered.

8.1 Cost of materials

The cost of the roofing material should be within the available construction budget.

The cost of accessories, fasteners, transport and installation should also be considered.

Cheap materials may have a short service life and require frequent replacement.

Expensive materials may provide better durability or appearance but should offer value for money.

Example: A homeowner constructing a modest rural house in Narok County may select galvanised iron sheets because they are relatively affordable and readily available.

8.2 Durability

The roofing material should withstand weather conditions for a reasonable period.

It should resist corrosion, decay, cracking and other forms of deterioration.

Durable materials reduce the frequency of repairs and replacement.

The expected lifespan should be compared with the initial cost.

Example: Properly manufactured concrete tiles can provide a durable roof covering when supported by an appropriately designed roof structure.

8.3 Weight of the material

The weight of the roofing material determines the structural strength required of the roof framework.

Heavy coverings require stronger rafters, trusses, purlins and supporting walls.

Lightweight coverings may reduce the loads transferred to the supporting structure.

The roof structure must be designed to carry the total dead load and imposed loads safely.

Example: Concrete roof tiles are heavier than ordinary metal roofing sheets. Therefore, a building designed for concrete tiles may require a stronger roof framework.

8.4 Climate and weather conditions

The material should be suitable for the local climate.

Areas receiving heavy rainfall require coverings and roof details that drain water effectively.

Areas experiencing strong winds require securely fixed and appropriately designed roofing systems.

Hot areas may require materials and roof assemblies that reduce heat gain.

Materials exposed to high humidity or corrosive environments should have suitable corrosion protection.

Kenyan examples:

Buildings in areas experiencing heavy rainfall, such as parts of the Lake Victoria basin and the Kenyan highlands, require effective roof drainage.

Buildings in hot and dry areas may require suitable insulation and ventilation to improve indoor comfort.

Buildings in windy locations require suitable roof anchorage and fastening systems.

8.5 Availability of materials

Materials should be readily available in the local market.

Locally available materials reduce transportation costs.

Availability of replacement materials makes future maintenance easier.

The builder should consider the availability of skilled installers.

Example: Galvanised iron sheets are widely available in many Kenyan towns, making them convenient for many building projects.

8.6 Ease of installation

The material should be easy to install using available tools and skills.

Complicated materials may require specialised labour.

The installation method should be compatible with the roof design.

Incorrect installation can lead to leakage, damage and structural problems.

Example: Corrugated roofing sheets are generally quicker to install than individual clay tiles on a comparable roof.

8.7 Maintenance requirements

The material should be easy to inspect and maintain.

The frequency and cost of maintenance should be considered.

Materials that require frequent treatment or replacement may increase long-term costs.

The availability of spare parts and accessories should be considered.

Example: Timber shingles may require treatment and regular inspection to protect them against decay and insect attack.

8.8 Appearance and architectural design

The roofing material should complement the design of the building.

Colour, shape, texture and finish should be considered.

The material should match the intended appearance of the building.

Some buildings require traditional roofing materials, while others may use modern finishes.

Example: Clay tiles may be selected for a house where a traditional or decorative appearance is desired.

8.9 Fire resistance

Roofing materials should provide suitable fire performance for the building.

Non-combustible materials may be preferred where fire risk is a major concern.

Combustible materials may require additional fire precautions.

The complete roof assembly, including insulation and supporting materials, should be considered.

Example: Metal sheets and concrete tiles are generally non-combustible, while thatch and untreated timber are combustible.

8.10 Thermal insulation

The roof should help maintain comfortable indoor temperatures.

Materials with suitable thermal properties can reduce heat entering or escaping through the roof.

Additional insulation may be installed beneath the roof covering.

Adequate ventilation can reduce heat build-up in the roof space.

Example: A house in a hot area may require reflective roofing, insulation and adequate roof-space ventilation.

8.11 Sound insulation

Some roofing materials produce considerable noise during rainfall.

The builder should consider the intended use of the building.

Insulation and ceiling systems can help reduce noise transmission.

Schools, hospitals and residential buildings may require suitable acoustic performance.

Example: A classroom roof covered with thin metal sheets may require a suitable ceiling and insulation to reduce rainfall noise.

8.12 Slope or pitch of the roof

Different roofing materials have different minimum recommended roof slopes.

Some materials require steeper slopes to drain rainwater effectively.

The manufacturer's installation instructions should be followed.

The roof slope must also be suitable for the building's climate and design.

Example: A roof covering designed for steep slopes should not be installed on a low-slope roof unless the manufacturer approves the arrangement.

8.13 Environmental sustainability

The builder should consider the environmental impact of producing, transporting, installing and disposing of the material.

Materials from responsibly managed sources should be preferred.

Reusable and recyclable materials can reduce waste.

Locally available materials may reduce transport-related environmental impacts.

Roofing materials should be selected with consideration for their service life and maintenance needs.

Example: Properly sourced timber can be a sustainable roofing material when it comes from responsibly managed forests.

8.14 Security and resistance to damage

The roofing material should resist likely physical damage.

It should be properly secured against removal or lifting by strong winds.

Buildings in areas exposed to vandalism or accidental impact may require more robust materials.

The roof design should consider the security needs of the occupants.

8.15 Building regulations and standards

Roofing materials should comply with applicable Kenyan building requirements and relevant product standards.

The roof should be structurally sound and safely constructed.

The design should meet requirements relating to fire safety, drainage, structural stability and weather protection.

Approved drawings and professional specifications should guide material selection.

8.16 Summary of factors affecting selection of roof coverings

Factor	Explanation
Cost	Must fit the construction budget
Durability	Should withstand weather and ageing
Weight	Determines the strength required of the roof structure
Climate	Must suit rainfall, wind, heat and humidity
Availability	Should be accessible in the local market
Installation	Should suit available skills and equipment
Maintenance	Should have manageable repair and maintenance costs
Appearance	Should complement the building design
Fire resistance	Should provide suitable protection against fire
Thermal insulation	Should contribute to indoor comfort
Sound insulation	Should reduce unwanted noise
Roof pitch	Must be compatible with the covering's requirements
Sustainability	Should minimise environmental impact
Standards	Should meet relevant building and product requirements

9.0 Roof construction materials other than roof coverings

It is important to distinguish between materials used to construct the roof framework and materials used to cover the roof.

9.1 Materials used for roof framework

A. Timber

Timber is commonly used in roof construction to make rafters, purlins, trusses, wall plates, ceiling joists and other members.

Properties of suitable roofing timber

Should be adequately seasoned.

Should be strong enough for its intended structural use.

Should be free from serious defects that may weaken it.

Should be treated against termites and fungal attack where necessary.

Should have suitable dimensions as specified in the design.

Should be stored in a dry and protected place before installation.

Examples: Suitable structural timber species available in Kenya may be used according to their graded strength and design specifications.

B. Steel

Steel is used to manufacture roof trusses, purlins, rafters, connectors and other structural members.

Advantages of steel in roof construction

Has a high strength-to-weight ratio.

Can cover relatively large spans when properly designed.

Can be fabricated into different shapes.

Is suitable for industrial and commercial buildings.

Can be prefabricated to improve construction efficiency.

Limitations

May corrode if not adequately protected.

Requires suitable connections and skilled installation.

May lose strength at high temperatures during a fire.

Requires careful handling and lifting.

C. Reinforced concrete

Reinforced concrete may be used in flat roofs and in selected structural roof systems.

Advantages

Can provide a strong and rigid roof structure.

Can be formed into different shapes.

Provides good fire resistance compared with many combustible materials.

Can support appropriately designed roof installations.

Limitations

Is relatively heavy.

Requires formwork and reinforcement.

Needs adequate curing.

May require waterproofing to prevent leakage.

D. Aluminium

Aluminium may be used for roofing sheets, roof trims, gutters and other roof components.

Advantages

Is relatively lightweight.

Has good corrosion resistance in many environments.

Is easy to shape.

Can be used for modern roofing systems.

Limitations

May be more expensive than some alternative materials.

Can be dented by impact.

Requires compatible fasteners and detailing.

10.0 Basic stages in roof construction

Roof construction should follow approved drawings, specifications and safe construction procedures.

The following are common stages for a simple pitched roof.

Stage 1: Studying the roof design

Examine the approved building drawings.

Identify the roof type and pitch.

Determine the dimensions and structural arrangement.

Identify the specified materials.

Confirm the positions of supporting walls, columns and beams.

Stage 2: Preparing the supporting structure

Ensure the supporting walls and beams have attained the required strength.

Check that the top of the walls is level and properly prepared.

Confirm the positions of wall plates and anchorage points.

Prepare the required tools, equipment and materials.

Stage 3: Fixing wall plates

Position the wall plates on the supporting walls.

Check their alignment and level.

Secure them using the specified anchors and connections.

Ensure the plates provide adequate bearing for the roof members.

Stage 4: Fabricating and erecting roof trusses

Measure and prepare the truss members according to the approved design.

Cut and assemble the members accurately.

Use the specified connectors and fasteners.

Lift and position the trusses safely.

Secure them temporarily and then permanently as specified.

Install the required bracing.

Stage 5: Fixing rafters and purlins

Position rafters according to the design.

Ensure that they have the correct slope and spacing.

Fix purlins where required.

Check alignment and connections.

Ensure that the roof framework is adequately braced.

Stage 6: Fixing battens where required

Mark the required spacing.

Position battens across the supporting members.

Secure them using suitable fasteners.

Check that they provide the correct support for the selected covering.

Stage 7: Installing roof coverings

Begin installation according to the manufacturer's instructions.

Position the roofing material correctly.

Provide the required side and end laps.

Fix the covering using approved fasteners.

Install ridge caps, flashings and other accessories.

Check that joints are properly sealed where required.

Stage 8: Fixing fascia and soffit boards

Fix fascia boards along the eaves.

Install soffit boards beneath the roof overhang.

Provide ventilation openings where required.

Ensure that all finishing members are securely fixed.

Stage 9: Installing rainwater goods

Fix gutters along the required roof edges.

Connect downpipes.

Direct rainwater to an approved drainage system or storage tank.

Check that water flows without obstruction.

Stage 10: Inspection and completion

Check the roof covering for correct alignment.

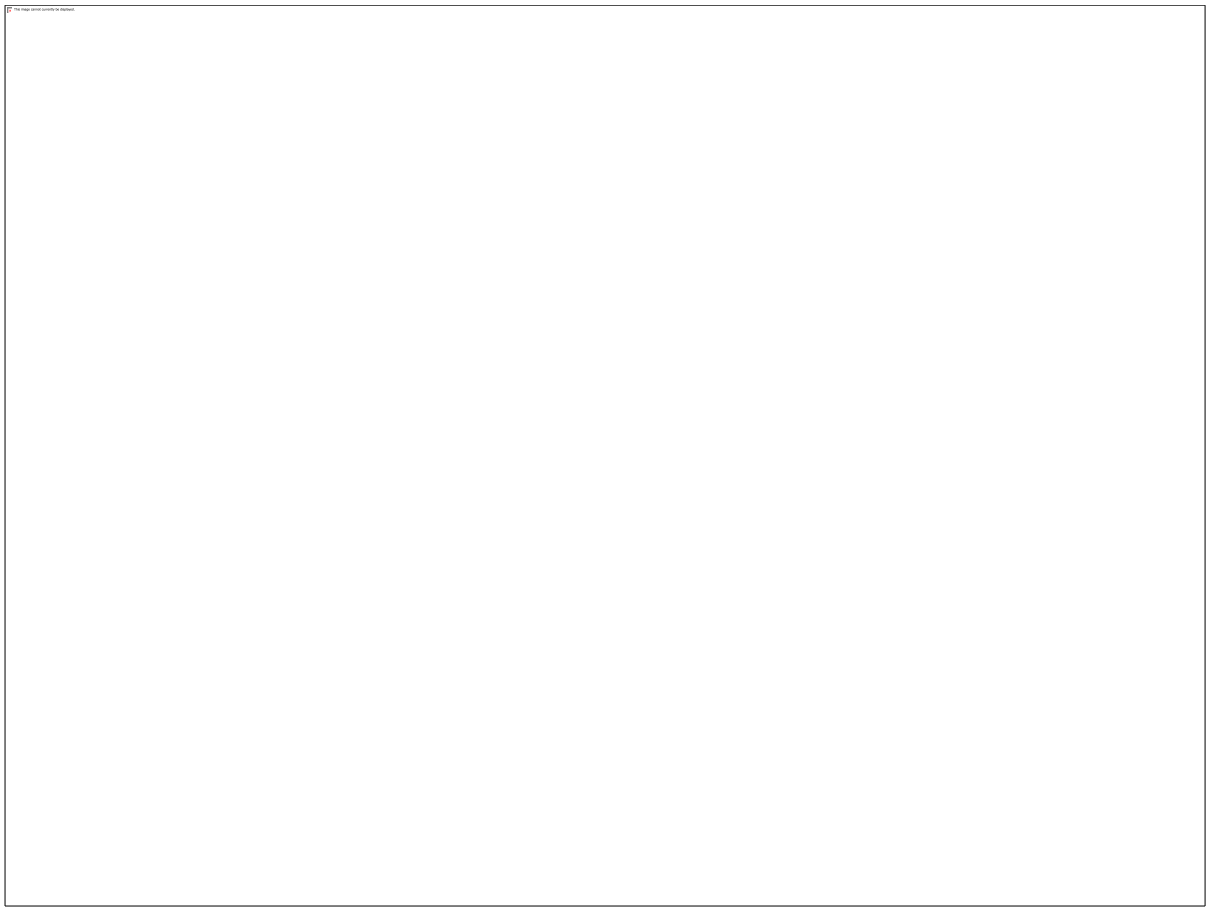
Inspect fasteners and connections.

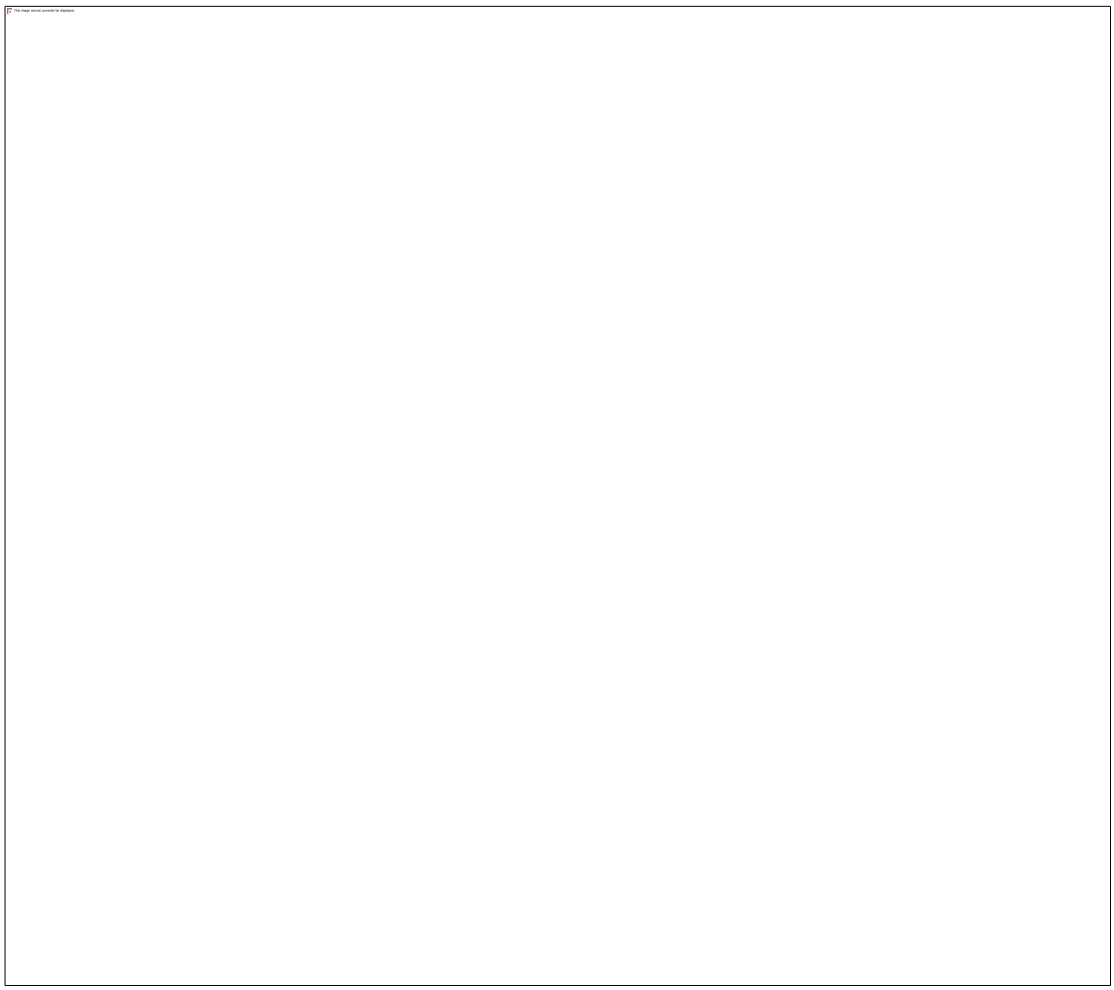
Check the ridge and other roof junctions.

Check drainage arrangements.

Remove construction waste safely.

Carry out any required corrections before handover.







11.0 Common roof defects and their causes

Roof defects may arise from poor design, unsuitable materials, poor workmanship, inadequate maintenance or severe weather.

Roof defect	Possible causes	Preventive measures
Roof leakage	Damaged sheets, poor laps, faulty flashing	Use suitable materials and correct installation
Corrosion	Damaged protective coating or unsuitable exposure conditions	Use corrosion-resistant materials and maintain coatings
Broken tiles	Poor handling, impact or inadequate support	Handle carefully and provide suitable support
Roof sagging	Inadequate structural design or overloading	Use properly designed structural members
Loose roofing sheets	Poor fixing or strong wind forces	Use approved fasteners and adequate anchorage
Timber decay	Moisture penetration and poor timber treatment	Use suitable treated timber and control moisture
Blocked gutters	Accumulation of leaves and debris	Clean gutters regularly
Damaged soffit	Moisture, insects or poor fixing	Use suitable materials and inspect regularly
Water ponding on flat roofs	Poor drainage or incorrect roof falls	Provide properly designed slopes and outlets
Cracked	Ageing, movement or poor installation	Use suitable waterproofing systems

waterproofing		and maintain them

12.0 Safety precautions during roof construction

Roof construction involves working at height and handling heavy or sharp materials. Workers and learners must observe appropriate safety precautions.

1. **Use appropriate personal protective equipment (PPE).**

Wear safety helmets, safety boots, gloves and suitable work clothing.

Use appropriate eye protection when cutting or drilling materials.

2. **Provide safe access.**

Use suitable ladders, access platforms or scaffolding.

Ensure that access equipment is stable and properly secured.

3. **Use fall-protection systems.**

Provide suitable edge protection and fall-arrest systems where required.

Workers should receive training in the use of such systems.

4. **Inspect roof structures.**

Check the stability of roof members before loading or covering them.

Do not work on an unstable roof framework.

5. **Avoid working during dangerous weather.**

Stop roof work during thunderstorms, lightning, strong winds or heavy rain.

Wet roof surfaces can be slippery.

6. **Handle roofing sheets carefully.**

Roofing sheets may have sharp edges.

Use gloves and safe lifting methods.

7. **Use appropriate tools.**

Ensure that cutting and drilling equipment is in good working condition.

Use tools according to their manufacturer's instructions.

8. **Avoid overloading the roof.**

Do not place excessive roofing materials on rafters, trusses or incomplete roof structures.

Distribute materials according to the approved loading arrangements.

9. **Keep the working area organised.**

Remove loose materials and unnecessary tools.

Prevent objects from falling onto people below.

10. **Observe electrical safety.**

Keep ladders, long metal sheets and other conductive materials away from overhead power lines.

Use appropriate isolation and safe working distances.

11. **Use safe lifting procedures.**

Use suitable lifting equipment for heavy trusses and roofing materials.

Do not stand beneath suspended loads.

12. **Follow approved drawings and instructions.**

Do not cut or remove structural roof members without professional approval.

Do not make unauthorised alterations to trusses or rafters.

13.0 Practical learning activities

Activity 1: Identifying roof types in the community

Instructions

Learners work in groups.

Visit the school compound or observe nearby buildings.

Identify different roof shapes.

Record whether each roof is flat, gable, hipped, lean-to or another form.

Identify the roof-covering materials used.

Discuss why the materials may have been selected.

Expected outcome: Learners should be able to identify roof types and relate them to their uses.

Activity 2: Identifying roof components

Materials required

Roof model or roof photograph.

Labels.

Notebook.

Pencil.

Instructions

Observe a roof model or a safe, accessible roof structure.

Identify the rafters, purlins, ridge, wall plates and trusses.

Identify the fascia, soffit and barge boards.

Discuss the function of each component.

Draw and label the components in a notebook.

Expected outcome: Learners should be able to identify roof components and explain their functions.

Activity 3: Making a simple roof model

Materials required

Cardboard.

Suitable lightweight timber strips.

Glue.

Ruler.

Pencil.

Scissors.

Labels.

Instructions

Draw a simple gable roof design.

Construct a small model of the roof framework.

Include rafters, ridge, purlins and trusses where appropriate.

Attach a lightweight covering to represent roofing sheets or tiles.

Label the components.

Present the model to the class and explain how the parts work together.

Safety: Use scissors and cutting tools under appropriate supervision.

Activity 4: Selecting a roof covering for a Kenyan building

Scenario

A community is planning to construct a classroom in a location that experiences seasonal heavy rainfall and strong sunshine. The available roofing materials include galvanised iron sheets, concrete tiles and clay tiles.

Tasks

Identify three factors that should guide the selection of the roofing material.

Compare the three materials.

Recommend one suitable option based on the project requirements.

Explain the importance of roof drainage.

State two safety precautions to observe during roof installation.

Expected outcome: Learners should demonstrate decision-making, problem-solving and communication skills.

14.0 Summary of key terms

Term	Meaning
Roof	Upper covering of a building
Flat roof	Roof with a very small slope for drainage
Pitched roof	Roof with one or more sloping surfaces
Rafter	Inclined member supporting the roof structure or covering
Purlin	Member supporting roof coverings or secondary roof members
Fascia board	Finishing board fixed along the lower ends of rafters

Joist	Horizontal member supporting a floor or ceiling
Ceiling joist	Member supporting the ceiling and sometimes tying opposing rafters
Roof truss	Framework of connected structural members supporting a roof
Wall plate	Member placed on top of a wall to provide bearing for roof members
Ridge board	Board joining and aligning opposing rafters at the ridge
Barge board	Finishing board along a sloping gable roof edge
Soffit board	Board covering the underside of the roof eaves
Batten	Small member providing fixing support for roof coverings
Ridge cap	Covering fitted over the ridge of a pitched roof
Gutter	Channel collecting rainwater from the roof
Downpipe	Pipe carrying rainwater from the gutter
Flashing	Waterproof material used at roof joints and junctions
Eaves	Lower projecting edge of a roof
Roof pitch	The degree of slope of a roof

Revision questions

SECTION A: MULTIPLE-CHOICE QUESTIONS

INSTRUCTIONS: Choose the correct answer from the alternatives provided.

1. Which of the following best defines a roof?

A. A horizontal member supporting a floor.
B. The upper covering of a building that protects it from weather.
C. A vertical member supporting a wall.
D. A foundation component supporting the building.

2. A roof constructed with a very small slope to allow water drainage is known as a:

A. Pitched roof
B. Gable roof
C. Flat roof
D. Mansard roof

3. Which of the following is a common characteristic of a pitched roof?

A. It has no slope.
B. It has one or more sloping surfaces.
C. It is always made of concrete.
D. It does not require structural support.

4. The inclined structural members extending from the ridge towards the eaves are known as:

A. Rafters
B. Joists
C. Wall plates
D. Fascia boards

5. Which component provides support for roof coverings or secondary roof members across rafters or trusses?

A. Soffit board
B. Purlin
C. Barge board
D. Downpipe

6. The horizontal member placed on top of a supporting wall to provide bearing for roof members is called a:

A. Ridge board
B. Wall plate
C. Fascia board
D. Batten

7. Which of the following is the main function of a fascia board?

A. To support the foundation.
B. To cover the exposed ends of rafters at the eaves.
C. To form the internal wall finish.
D. To support floor slabs.

8. A board fixed along the sloping edge of a roof at the gable end is known as a:

A. Soffit board
B. Ceiling board
C. Barge board
D. Wall plate

9. Which roof component covers the underside of the projecting roof eaves?

A. Soffit board
B. Ridge board
C. Purlin
D. Rafter

10. The highest horizontal line where two sloping roof surfaces meet is called the:

A. Eaves
B. Ridge
C. Valley
D. Fascia

11. Which of the following is a major function of ceiling joists?

A. Collecting rainwater.
B. Supporting ceiling finishes.
C. Covering the ridge.
D. Protecting roof edges.

12. A roof truss is mainly constructed to:

A. Collect rainwater.
B. Provide a structural framework for supporting a roof.
C. Cover the ends of rafters.
D. Form the external wall finish.

13. Which of the following is a common roof-covering material in Kenya?

A. Gypsum powder
B. Galvanised iron sheets
C. Ordinary wall paint
D. Floor tiles

14. Which roof-covering material is manufactured from clay that is shaped and fired?

A. Concrete tiles
B. Clay tiles
C. Polycarbonate sheets
D. Galvanised iron sheets

15. Which of the following is a major disadvantage of concrete roof tiles?

A. They are always transparent.
B. They are relatively heavy.
C. They cannot resist weather.
D. They cannot be used on pitched roofs.

16. Which roofing material allows natural light to enter a building?

A. Slate
B. Polycarbonate sheets
C. Concrete tiles
D. Thatch

17. Which of the following is a traditional roof-covering material made from dry plant materials?

A. Thatch
B. Steel
C. Concrete
D. Polycarbonate

18. The main purpose of a gutter is to:

A. Support rafters.
B. Collect rainwater from the roof.
C. Support ceiling boards.
D. Cover the roof ridge.

19. A vertical pipe that carries rainwater from a gutter to the drainage system is called a:

A. Purlin
B. Downpipe
C. Ridge board
D. Rafter

20. Which factor is particularly important when selecting roofing materials for an area experiencing heavy rainfall?

A. Colour of the internal walls.
B. Water resistance and effective drainage.
C. Number of internal doors.
D. Type of floor finish.

21. Which of the following is a disadvantage of thin metal roofing sheets?

A. They cannot be transported.
B. They may produce noise during heavy rainfall.
C. They are always heavier than concrete tiles.
D. They cannot be fixed to a roof structure.

22. A roof with two sloping surfaces meeting at a ridge and forming triangular gable ends is known as a:

A. Gable roof
B. Flat roof
C. Domed roof
D. Curved roof

23. A roof with sloping surfaces on all four sides of a rectangular building is called a:

A. Lean-to roof
B. Hipped roof
C. Flat roof
D. Barrel-vault roof

24. Which of the following is a function of roof covering?

A. Supporting the foundation.
B. Protecting the building against rain and sunlight.
C. Increasing the height of doors.
D. Supporting underground drainage.

25. Which material is commonly used to make roof trusses?

A. Timber and steel
B. Glass and paper
C. Clay and paint
D. Sand and plastic only

26. Which of the following should be considered when selecting roof-covering materials?

A. Durability
B. Availability
C. Cost
D. All of the above

27. Which component covers the joint where two sloping roof surfaces meet at the top?

A. Ridge cap
B. Soffit board
C. Wall plate
D. Ceiling joist

28. What is the main function of roof flashing?

A. To provide support for ceiling boards.
B. To prevent water entering through roof joints and junctions.
C. To increase the thickness of walls.
D. To support the building foundation.

29. Which of the following is an important safety precaution during roof construction?

A. Working on a wet roof without protection.
B. Removing structural bracing without approval.
C. Using appropriate fall-protection systems.
D. Standing beneath suspended roof trusses.

30. Why should the weight of roofing materials be considered during roof design?

A. It determines the colour of the roof.
B. It affects the structural loads carried by the roof framework.
C. It determines the number of windows.
D. It changes the building's floor area.

SECTION B: STRUCTURED QUESTIONS

1. a) Define the term roof. (2 marks)

b) State six functions of a roof in a building. (6 marks)

c) Explain four characteristics of a good roof. (4 marks)

2. a) Differentiate between a flat roof and a pitched roof. (4 marks)

b) State four advantages of pitched roofs. (4 marks)

c) State two disadvantages of flat roofs. (2 marks)

3. a) Define the following terms as used in roof construction:

i. Rafter. (2 marks)

ii. Purlin. (2 marks)

iii. Wall plate. (2 marks)

iv. Ridge board. (2 marks)

v. Fascia board. (2 marks)

4. Explain the functions of the following roof components:

a) Roof truss. (2 marks)

b) Ceiling joists. (2 marks)

c) Barge board. (2 marks)

d) Soffit board. (2 marks)

e) Gutter. (2 marks)

5. Draw a well-labelled sketch of a simple pitched roof showing the following components:

Ridge.

Rafters.

Purlins.

Wall plates.

Ceiling joists.

Fascia boards.

(6 marks)

6. a) Name six materials used for roof covering. (6 marks)

b) State four advantages of galvanised iron roofing sheets. (4 marks)

7. a) Explain five factors to consider when selecting roof-covering materials. (10 marks)

b) State two reasons why the weight of roofing materials should be considered during roof construction. (2 marks)

8. a) Differentiate between a fascia board and a barge board. (4 marks)

b) Explain three functions of a soffit board. (3 marks)

9. A family in a rural area of Kenya intends to construct a house using concrete roof tiles.

a) State four advantages of concrete roof tiles. (4 marks)

b) Explain three factors the family should consider before selecting the tiles. (6 marks)

10. a) Identify four types of pitched roofs. (4 marks)

b) Explain the characteristics of a hipped roof. (3 marks)

c) State three uses of lean-to roofs. (3 marks)

11. Explain five safety precautions that should be observed during roof construction. (10 marks)

12. Describe the main stages followed when constructing a simple pitched roof, from preparing the supporting walls to completing the roof covering. (10 marks)

13. A school intends to construct a classroom in an area that experiences heavy rainfall and strong sunshine.

a) Identify four factors the school should consider when selecting roof-covering materials. (4 marks)

b) Recommend a suitable roof-covering system and explain your choice. (4 marks)

c) State two measures that can improve thermal comfort inside the classroom. (2 marks)

16.0 CBE assessment and learner reflection

Suggested project

Design and construct a model of a simple pitched roof using locally available materials.

Project requirements

The model should demonstrate:

Correct identification of the roof type.

Proper arrangement of rafters.

Correct positioning of the ridge.

Appropriate placement of purlins.

Identification of wall plates.

Proper representation of roof covering.

Labelling of fascia and soffit boards.

Neat workmanship and safe handling of materials.

Suggested assessment criteria

Assessment area	What the teacher should observe
Understanding	Correct explanation of the selected roof type
Identification	Correct identification of roof components
Design	Suitable arrangement of roof members
Practical skills	Proper measuring, cutting and joining
Creativity	Appropriate use of locally available materials
Communication	Clear presentation and explanation
Safety	Safe use of tools and materials
Collaboration	Effective participation in group work

GRADE 11 BUILDING CONSTRUCTION

STRAND 3.0: BUILDING CONSTRUCTION PROCESS

SUB-STRAND 3.6: DOORS

1.0 Introduction to doors

Doors are important components of buildings. They provide access into and out of rooms and buildings, control movement, provide privacy and contribute to security. They also influence the appearance, comfort and functionality of a building.

In building construction, doors are fitted into openings left in walls during construction. They are supported by door frames, which are fixed securely to the surrounding wall structure.

In Kenya, different types of doors are used in residential houses, schools, hospitals, offices, commercial buildings, workshops, stores and industrial buildings. The choice of a door depends on its intended use, location, material, design, cost, security requirements and environmental conditions.

1.1 Definition of a door

A **door** is a movable or operable barrier fitted into an opening in a wall or partition to allow or control access between two spaces.

A door may be opened, closed, locked or secured depending on its design and intended purpose.

1.2 Meaning of door construction

Door construction refers to the process of designing, selecting materials, manufacturing, assembling, fitting and finishing doors for use in buildings.

It involves:

- Selecting suitable door materials.
- Choosing an appropriate door design.
- Preparing the door frame.
- Manufacturing or obtaining the door leaf.
- Fixing hinges, locks, handles and other fittings.
- Hanging or installing the door.
- Adjusting and testing its operation.
- Applying suitable finishes where required.

1.3 Learning outcomes

By the end of this sub-strand, the learner should be able to:

- Explain the meaning and importance of doors in buildings.
- Identify materials used in door construction.
- Classify doors according to their materials, construction, operation, location and function.
- Identify and describe the components of a door.
- Differentiate between different classes of doors.
- Sketch and label flush doors and panel doors.
- Select suitable doors for different buildings and situations.
- Appreciate the importance of proper door installation and maintenance.

1.4 Key competencies developed

Communication and collaboration: Discussing door types and their applications.

Critical thinking and problem-solving: Selecting appropriate doors for different building requirements.

Creativity and imagination: Designing door patterns and preparing door models.

Digital literacy: Using digital drawings and images to identify door components.

Learning to learn: Researching different door materials and construction methods.

Self-efficacy: Participating in practical door-making and installation activities.

2.0 Importance of doors in buildings

Doors serve several important functions in buildings.

2.1 Provision of access and exit

Doors provide openings through which people enter and leave buildings.

They connect different rooms and spaces.

They make movement between indoor and outdoor spaces possible.

Properly positioned doors improve accessibility within buildings.

Example: The main entrance door of a house allows occupants and visitors to enter and leave.

2.2 Security

Doors help protect buildings against unauthorised entry.

Strong doors fitted with suitable locks and security fittings improve building security.

Security doors may be used in banks, offices, stores and residential buildings.

External doors should be selected according to the security risks of the location.

Example: A steel security door may be installed at the main entrance of a shop to discourage unauthorised access.

2.3 Provision of privacy

Doors separate rooms and provide privacy to occupants.

They prevent unnecessary observation of activities taking place inside rooms.

They are important in bedrooms, bathrooms, offices and consultation rooms.

Example: A bedroom door provides privacy to a person using the room.

2.4 Control of noise

Properly constructed and fitted doors can reduce the movement of sound between rooms.

Solid-core doors and doors with suitable seals generally provide better sound insulation than thin hollow doors.

Acoustic doors are used where noise control is particularly important.

Example: An acoustic door may be installed in a music room or recording studio.

2.5 Fire protection

Specially designed fire-resistant doors help restrict the spread of fire and smoke.

They are used in buildings where fire compartmentation and safe escape are important.

Fire doors must be installed with compatible frames, seals and approved hardware.

They should not be wedged open or altered in ways that compromise their performance.

Example: Fire doors may be installed along protected escape routes in commercial buildings.

2.6 Improvement of ventilation

Some doors are designed to allow air movement when closed or partially opened.

Louvered doors contain angled slats that permit airflow while maintaining some visual screening.

Such doors may be used in stores, utility rooms and other suitable spaces.

Example: A louvered door may be fitted to a store requiring ventilation.

2.7 Control of light

Glass doors allow natural light to enter rooms.

Glazed sections in doors help illuminate internal spaces.

Frosted or patterned glass may allow light to pass through while providing privacy.

Example: A glazed door may be used between a living room and a veranda.

2.8 Improvement of appearance

Doors contribute to the architectural appearance of a building.

Their materials, colours, shapes and finishes can improve the interior and exterior design.

Decorative doors can make entrances more attractive.

Example: A well-finished timber panel door can improve the appearance of a residential entrance.

2.9 Separation of spaces

Doors divide a building into different rooms and functional areas.

They allow different activities to take place without unnecessary interference.

They help control access to restricted areas.

Example: Doors separate classrooms, offices, laboratories and stores in a school.

2.10 Protection against weather

External doors protect buildings from rain, wind, dust and excessive sunlight.

Properly fitted doors with suitable weather seals reduce water and air infiltration.

They help maintain comfortable indoor conditions.

2.11 Safety and emergency escape

Properly designed exit doors allow occupants to leave a building during emergencies.

Emergency exit doors should be appropriately positioned and fitted.

Where required, exit doors should open in the direction of escape and must not be obstructed or locked in a way that prevents safe evacuation.

Example: An assembly hall should have suitably designed exit doors to support safe evacuation.

2.12 Control of access

Doors can restrict entry to selected rooms and areas.

Access-control systems can be installed on suitable doors.

Special locks, keypads, card readers and biometric systems can regulate entry.

Example: A school administration office may have a lockable door to protect confidential records.

3.0 Materials used for door construction

Doors are manufactured using different materials depending on their purpose, location, expected performance and cost.

The common materials used in door construction include:

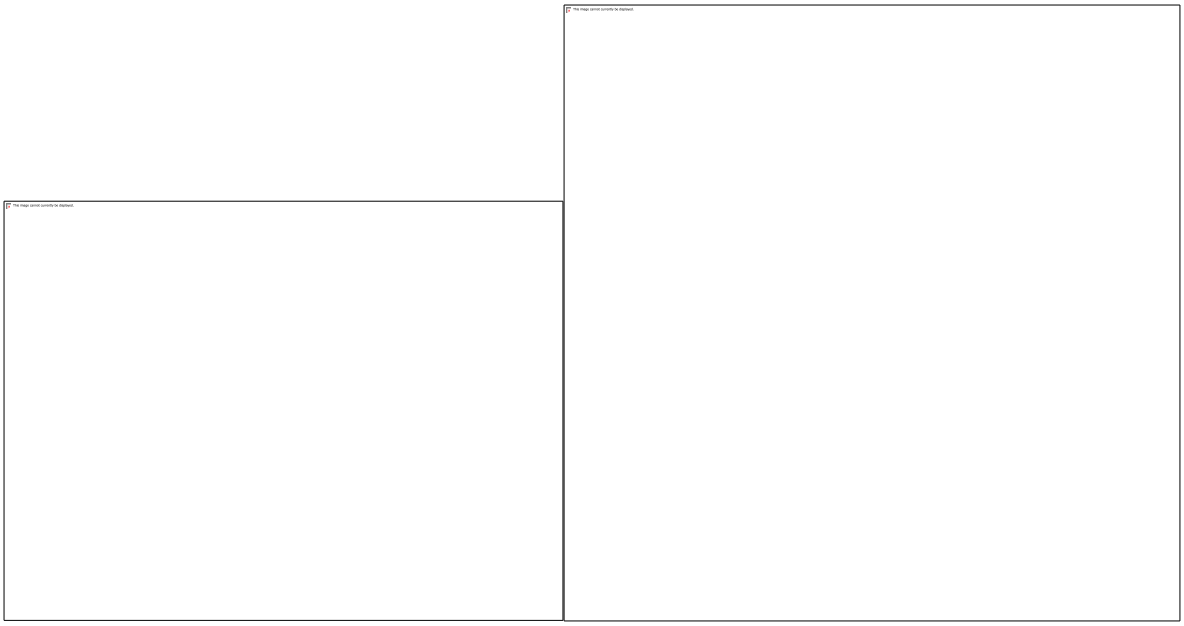
Timber.

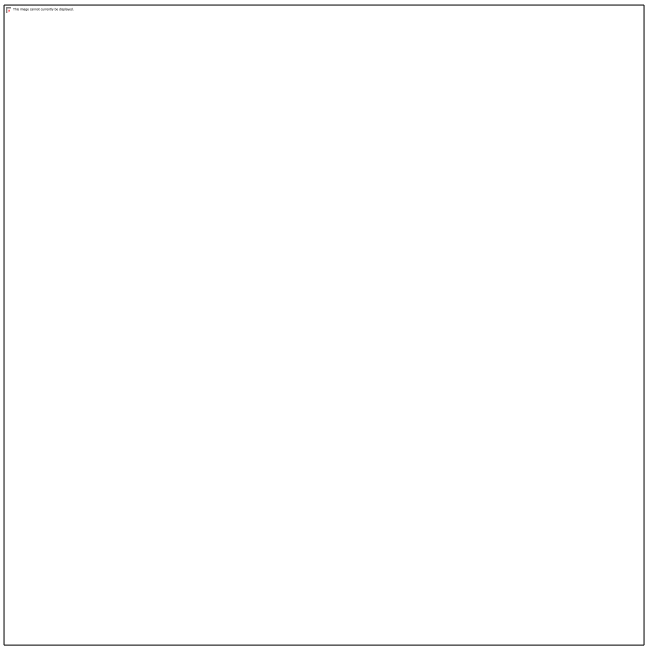
Metal.

Glass.

Polyvinyl chloride (PVC).

Composite materials.





3.1 Timber

Definition

Timber is wood that has been processed and prepared for use in construction and other manufacturing activities.

Timber is widely used in the manufacture of doors because it is relatively easy to work with and can be shaped into different designs.

Types of timber used in door construction

A. Hardwood

Hardwood is obtained from broad-leaved trees. Some hardwoods are strong and durable and are used for high-quality doors.

Examples of hardwoods available in Kenya include:

- Meru oak.
- Mahogany.
- Mvule.
- Camphor.
- Other suitable hardwood species.

B. Softwood

Softwood is obtained mainly from coniferous trees. It is commonly used for door frames, door leaves and other building components.

Examples include:

- Cypress.
- Pine.
- Cedar.
- Other suitable softwood species.

The suitability of timber depends on its grade, strength, moisture content, durability and intended application rather than simply whether it is hardwood or softwood.

Characteristics of timber doors

- Can be manufactured in different shapes and designs.
- Are relatively easy to cut, plane, shape and join.
- Can be painted, stained, polished or varnished.
- Provide a natural and attractive appearance.
- Can provide good thermal and sound insulation when appropriately constructed.
- May be made using solid timber or engineered timber products.
- Require protection against moisture, termites and fungal attack where necessary.

Advantages of timber doors

1. **Attractive appearance**

   Timber has a natural grain and texture.

It can improve the appearance of buildings.

2. **Ease of working**

Timber can be cut, shaped, drilled and joined using common woodworking tools.

3. **Variety of designs**

Timber can be used to manufacture flush, panel, framed and battened doors.

4. **Good insulation**

Timber generally has lower thermal conductivity than many metals.

Solid timber doors can also reduce sound transmission.

5. **Ease of repair**

Minor scratches, dents and surface defects can often be repaired.

6. **Availability**

Suitable timber and timber products are available through Kenyan timber suppliers.

7. **Finishing possibilities**

Timber doors can be painted, stained, polished or varnished.

Disadvantages of timber doors

May absorb moisture and swell.

May shrink when they lose moisture.

Can be attacked by termites and other wood-boring insects.

May decay due to fungal attack.

Can burn when exposed to fire.

May warp or twist if poorly seasoned or improperly stored.

Some high-quality timber species are expensive.

Uses of timber doors

Residential houses.

Bedrooms.

Offices.

Classrooms.

Hotels.

Internal partitions.

Selected external entrances.



3.2 Metal

Definition

Metal doors are doors manufactured using metals such as steel, aluminium or other suitable metal alloys.

They are commonly used where strength, security, durability or resistance to weather is required.

Types of metals used

A. Steel

Steel is widely used in manufacturing security doors, industrial doors, fire-rated door assemblies and other strong doors.

B. Aluminium

Aluminium is used in manufacturing lightweight doors, sliding doors, glazed doors and commercial entrance doors.

Characteristics of metal doors

- Can provide high strength.
- Are available in different designs.
- Can be manufactured as hinged, sliding or rolling doors.
- May require protective coatings to resist corrosion.
- Can be combined with glass panels.
- Require suitable hinges, tracks and locking mechanisms.

Advantages of metal doors

1. **Strength**

   Steel doors can provide strong resistance to forced entry when properly designed and installed.

2. **Durability**

Suitable metal doors can last for many years with proper maintenance.

3. **Security**

Steel doors can be fitted with strong locks and security fittings.

4. **Resistance to insects**

Metal is not attacked by termites.

5. **Variety**

Metal can be formed into different shapes and designs.

6. **Fire performance**

Certain tested metal door assemblies can provide fire resistance when installed as complete approved systems.

7. **Low maintenance**

Some metal doors require relatively little maintenance when their finishes are properly protected.

Disadvantages of metal doors

Steel may rust when protective coatings are damaged.

Some metal doors can be heavy.

Metal can conduct heat and sound.

Poor-quality metal doors may dent or deform.

Some metal doors may be expensive.

Aluminium doors may be damaged by severe impact.

Thermal expansion may affect operation if the door is poorly designed.

Uses of metal doors

Banks.

Shops.

Workshops.

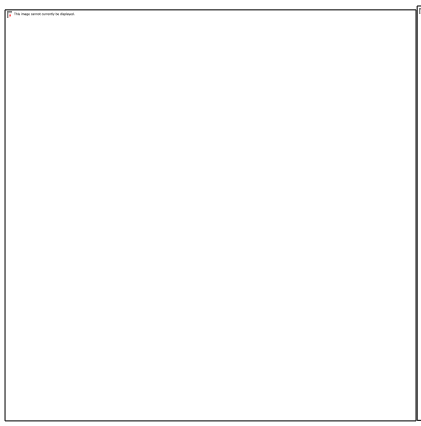
Factories.

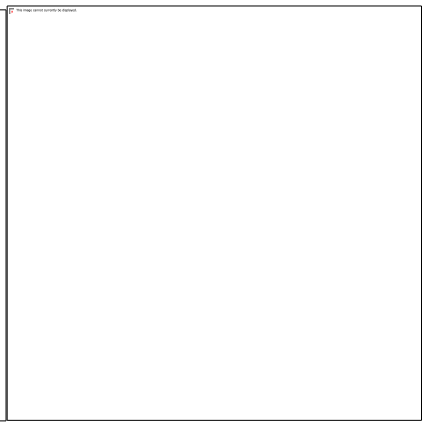
Stores.

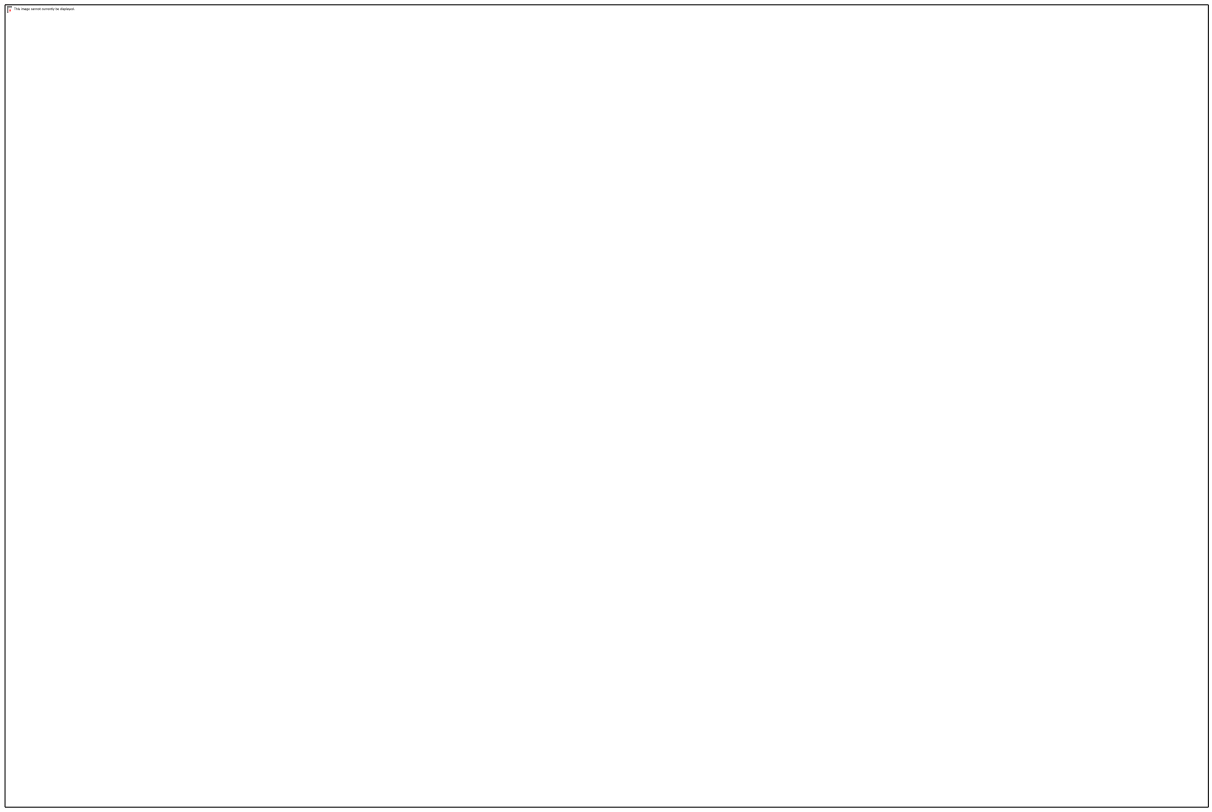
Residential entrances.

Garages.

Commercial buildings.







3.3 Glass

Definition

Glass doors are doors manufactured wholly or partly from glass, usually supported by suitable frames, fittings or structural hardware.

They are commonly used in offices, commercial buildings, hotels, shops and modern residential buildings.

Types of glass used in doors

Tempered glass: Glass that has been heat-treated to improve its strength and safety characteristics.

Laminated glass: Glass made by bonding layers together with an interlayer that helps hold fragments together if the glass breaks.

Frosted glass: Glass with a translucent finish that reduces clear visibility through it.

Patterned glass: Glass with decorative patterns on its surface.

Insulating glass units: Two or more glass panes separated by a sealed space to improve thermal performance.

Characteristics of glass doors

Allow natural light to pass through.

Can make rooms appear more spacious.

May be transparent, translucent or patterned.

Require suitable frames and fittings.

Need careful handling and installation.

Should use safety glazing appropriate to their location and risk of impact.

Advantages of glass doors

Allow natural light into buildings.

Improve the appearance of modern buildings.

Can create an impression of spaciousness.

Allow visual connection between spaces.

Are available in different colours and designs.

Can be combined with aluminium, timber or steel frames.

Disadvantages of glass doors

Ordinary glass may break when subjected to impact.

Transparent glass may provide limited privacy.

Fingerprints and dirt are easily visible.

Special safety glass can be expensive.

Some glass doors require regular cleaning.

Installation requires specialised fittings and skills.

Uses of glass doors

Office entrances.

Shops.

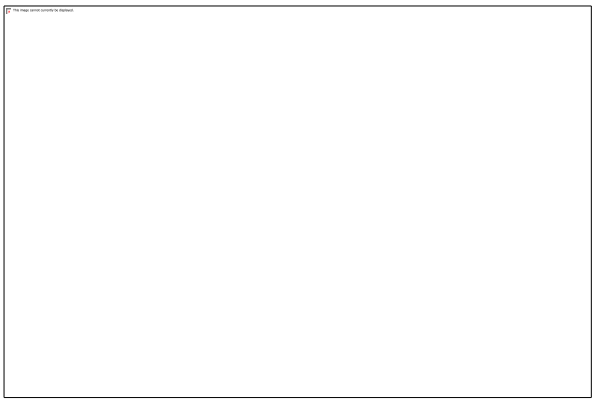
Hotels.

Restaurants.

Verandas.

Conference rooms.

Commercial buildings.



3.4 Polyvinyl chloride (PVC)

Definition

PVC is a synthetic plastic material used in manufacturing building products, including doors and window frames.

PVC doors are commonly used in bathrooms, utility rooms and selected residential and commercial applications.

Characteristics of PVC doors

Are generally lightweight.

Are resistant to moisture.

Do not rust.

Are available in different colours and finishes.

Can be manufactured in different designs.

Require suitable reinforcement in some applications.

May be made from rigid PVC or unplasticised PVC (uPVC), depending on the product.

Advantages of PVC doors

1. **Moisture resistance**

PVC does not absorb water in the same way as untreated timber.

It is suitable for many damp environments.

2. **Resistance to corrosion**

PVC does not rust.

3. **Ease of maintenance**

It can be cleaned using suitable cleaning materials.

4. **Light weight**

Many PVC doors are relatively easy to handle and operate.

5. **Resistance to termites**

PVC is not attacked by termites.

6. **Variety of designs**

It is available in different colours and finishes.

7. **Cost**

Some PVC door products are relatively affordable.

Disadvantages of PVC doors

Some products may become brittle after prolonged exposure to ultraviolet radiation.

May deform under excessive heat.

Some low-quality products may have limited strength.

May not be suitable for heavy-duty security applications.

Can be difficult to repair if badly damaged.

Some products may have limited fire performance.

Uses of PVC doors

Bathrooms.

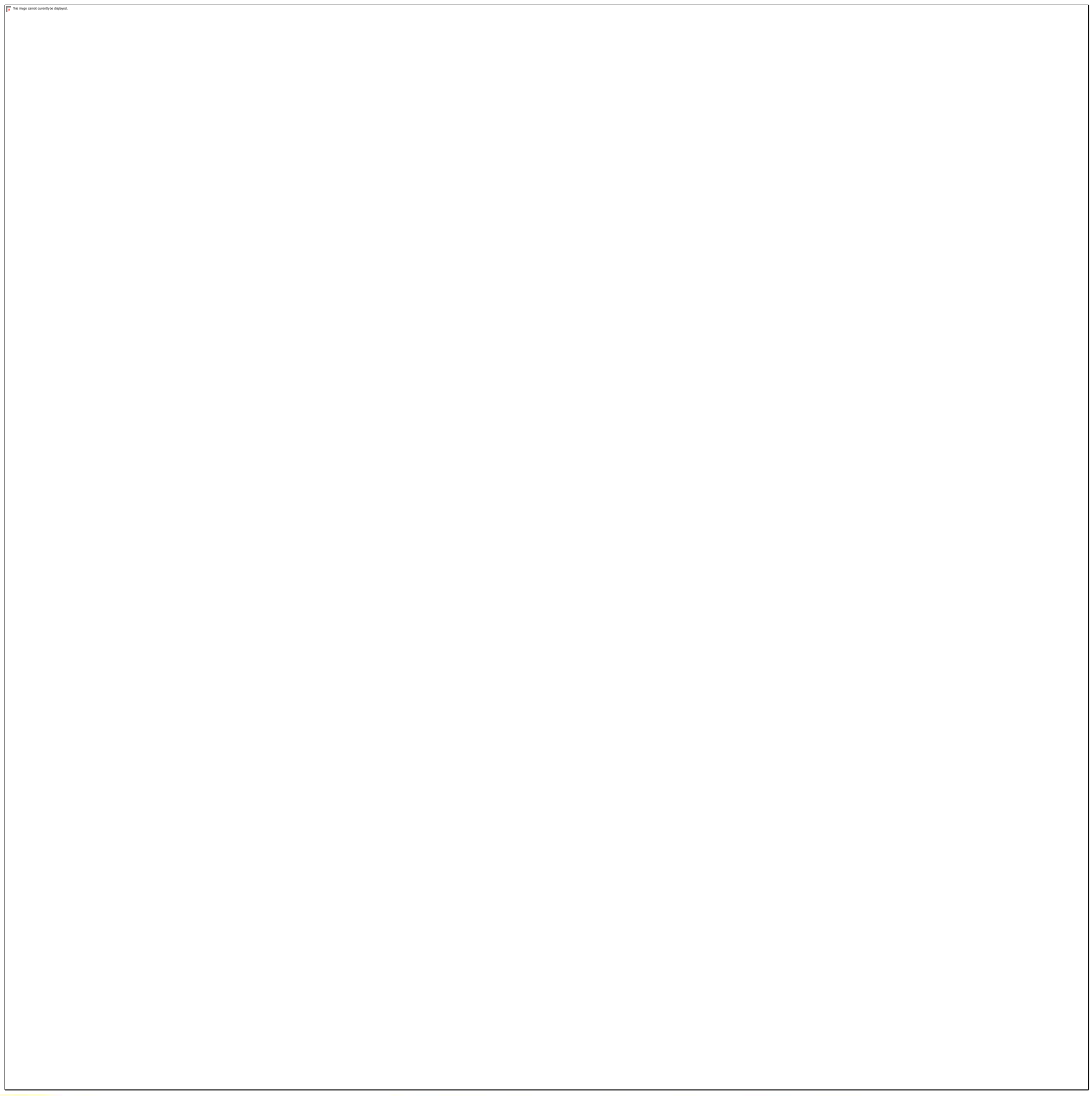
Toilets.

Laundry rooms.

Utility rooms.

Selected internal spaces.

Certain residential and commercial applications.



3.5 Composite materials

Definition

Composite doors are doors manufactured using two or more different materials combined to achieve desired properties such as strength, durability, insulation and appearance.

Examples include doors made using combinations of timber, engineered wood, plastic, glass fibres, metal reinforcement and insulating cores.

Characteristics of composite doors

Combine the properties of different materials.

May have decorative external finishes.

Can be manufactured with solid or insulated cores.

Are available in different designs.

May provide improved resistance to moisture compared with some untreated timber products.

Their performance depends on the materials and manufacturing quality.

Advantages of composite doors

Can provide good durability.

May resist moisture and warping better than some solid timber products.

Can provide good thermal insulation.

Are available in different finishes.

Can combine strength with attractive appearance.

Some designs require relatively little maintenance.

Disadvantages of composite doors

Some products are expensive.

Poor-quality products may delaminate or deteriorate.

Repairing severe damage may be difficult.

Some designs require specialised installation.

Quality varies depending on the manufacturing process.

Uses of composite doors

Residential entrances.

Modern apartments.

Offices.

Hotels.

Commercial buildings.

Selected internal spaces.



3.6 Comparison of materials used for door construction

Material	Main advantages	Main limitations	Common uses
Timber	Attractive, easy to work and finish	Can swell, shrink or decay	Bedrooms, offices, entrances
Steel	Strong and suitable for security	Can corrode and may be heavy	Security doors, stores, factories
Aluminium	Lightweight and corrosion-resistant	Can dent and may be costly	Sliding and glazed doors
Glass	Allows natural light and improves appearance	Requires safety glazing and careful handling	Offices, shops, verandas
PVC	Moisture-resistant and easy to clean	Some products have limited strength	Bathrooms, utility rooms
Composite	Combines different useful properties	Quality and cost vary	Modern entrances and offices

4.0 Classification of doors

Doors can be classified according to different characteristics, including:

Mode of operation.

Material used in construction.

Method of construction.

Location in a building.

Function or purpose.

Understanding these classifications helps a builder, architect, technician or client select a suitable door for a particular building.

4.1 Classification according to mode of operation

This classification is based on how a door opens and closes.

The main types include:

Hinged doors.

Sliding doors.

Folding doors.

Revolving doors.

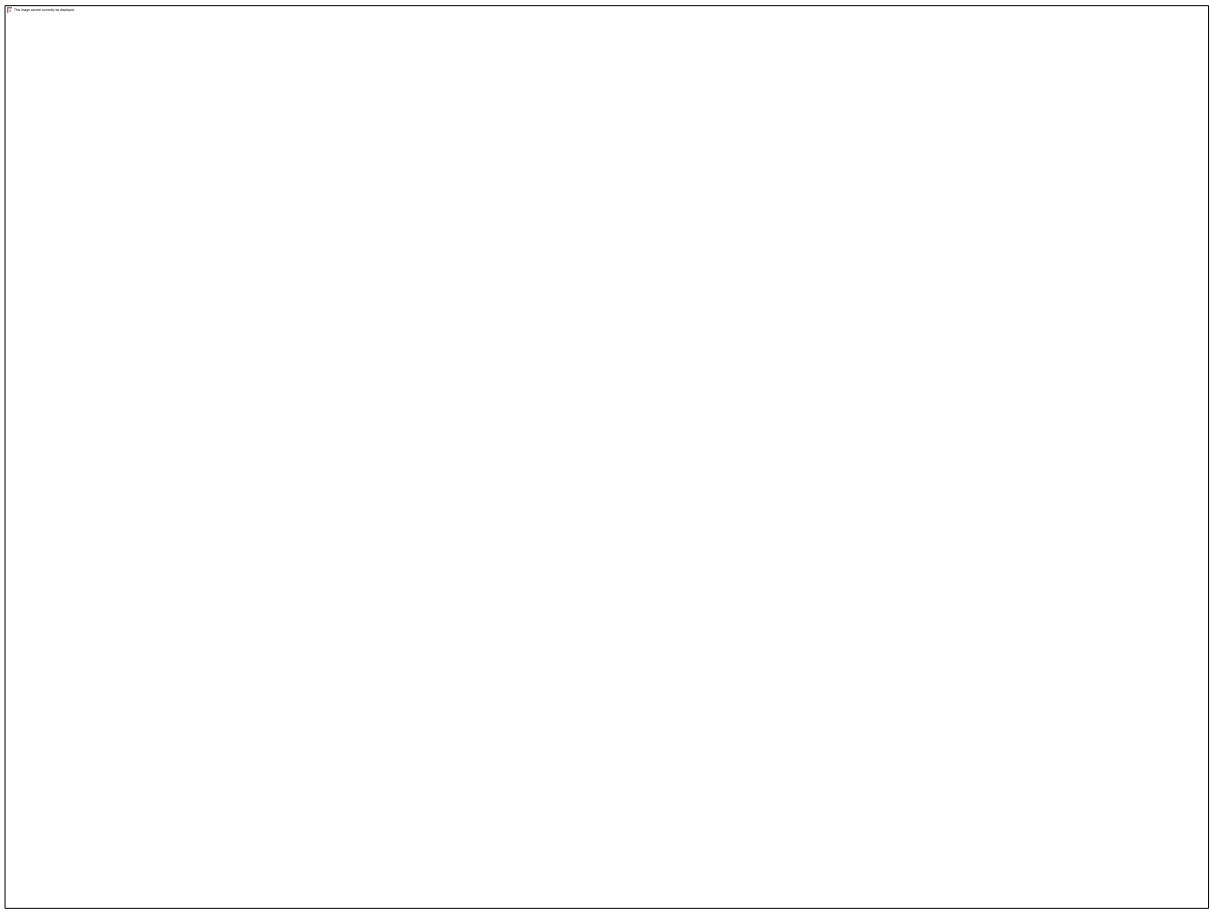
Rolling doors.

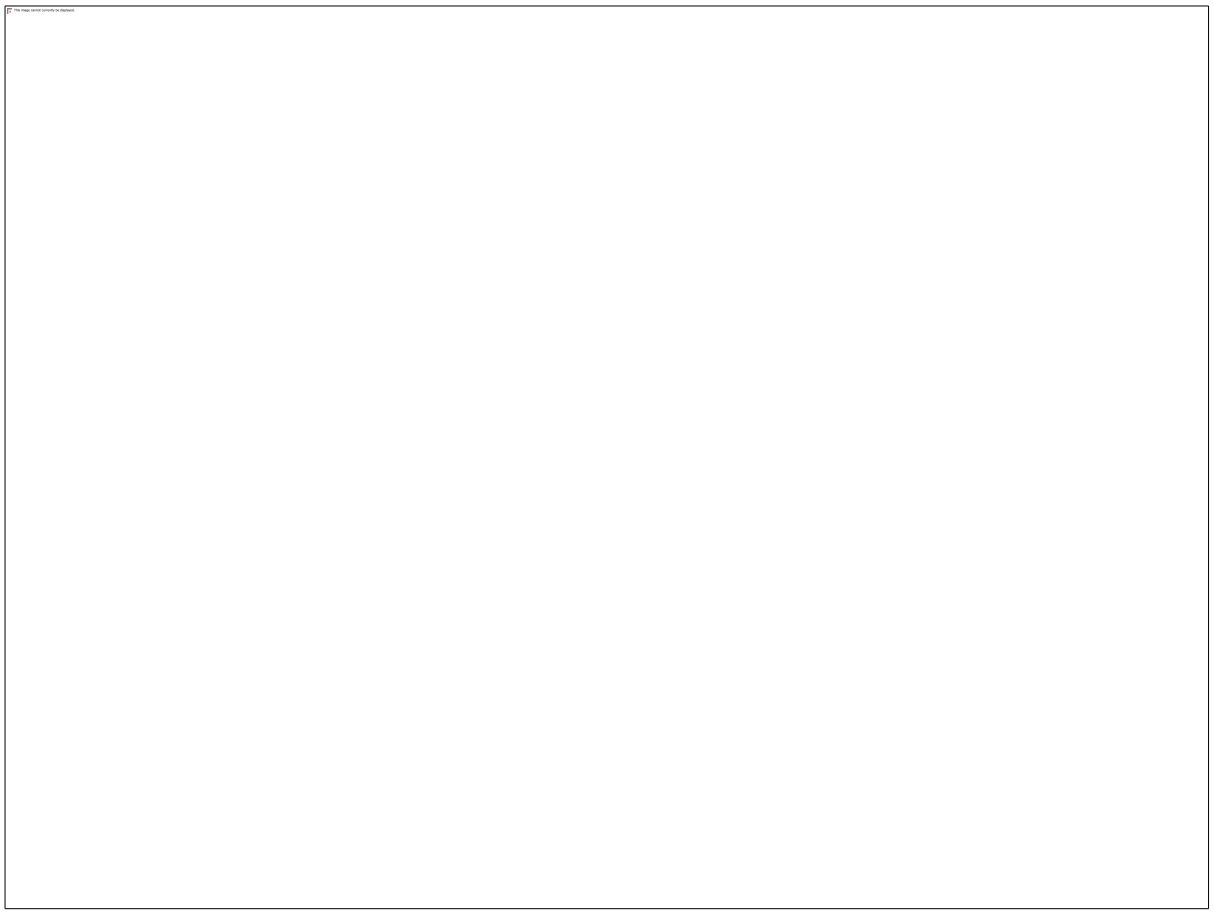
Shutter doors.

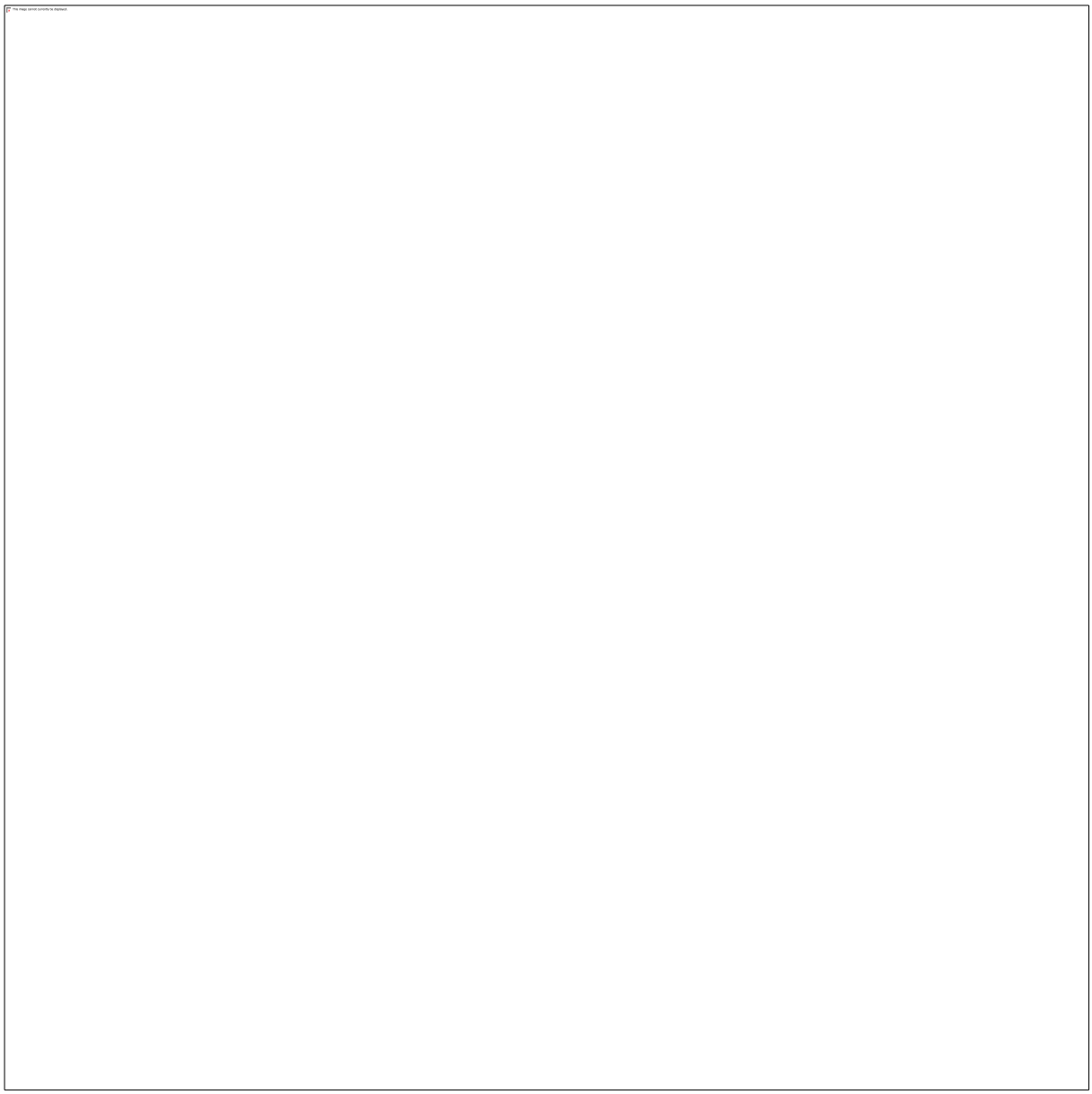
Swing doors.

Pivot doors.

4.1.1 Hinged doors







Definition: A hinged door is a door attached to a door frame using hinges, allowing it to rotate around one vertical edge when opened or closed.

Hinged doors are among the most commonly used doors in Kenyan residential and institutional buildings.

Characteristics

Have hinges fixed along one vertical edge.

Open by rotating around the hinge pins.

May open inwards or outwards.

May have one leaf or two leaves.

Require sufficient clearance for the door leaf to swing.

Can be made from timber, steel, aluminium or other suitable materials.

Types of hinged doors

Single-leaf hinged door: Has one movable door leaf.

Double-leaf hinged door: Has two movable door leaves.

Unequal double-leaf door: Has two leaves of different widths.

Advantages

Simple to operate.

Easy to install and maintain.

Available in many designs.

Can provide good security when fitted with suitable locks.

Suitable for many rooms and building types.

Can be fitted with automatic closers where required.

Disadvantages

Require space for the door leaf to swing.

Hinges may become loose with prolonged use.

Poor installation can cause the door to sag.

May obstruct movement in narrow corridors if poorly positioned.

Uses

Bedrooms.

Offices.

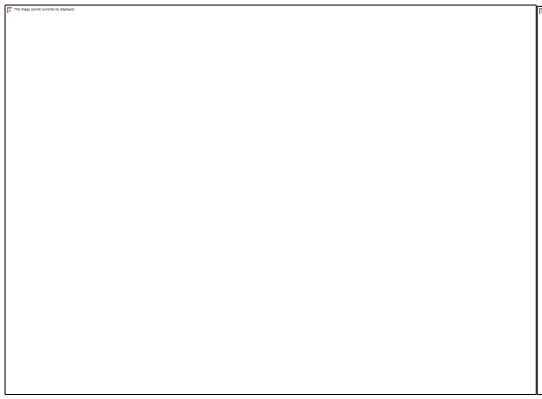
Classrooms.

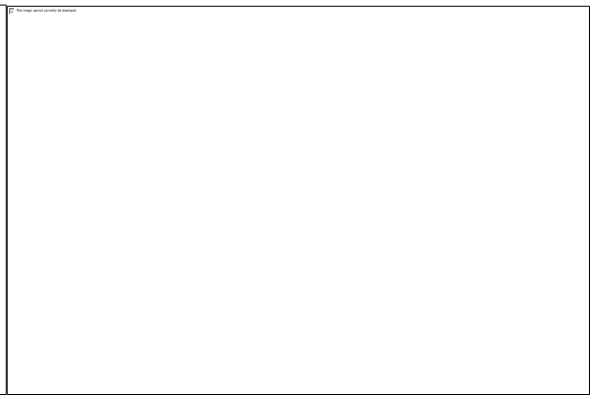
Kitchens.

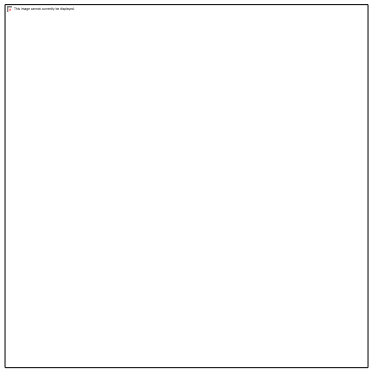
Main entrances.

Stores.

4.1.2 Sliding doors







Definition: A sliding door is a door that opens and closes by moving horizontally along tracks or guides rather than swinging on hinges.

Characteristics

Move horizontally along tracks.

May have one or more movable leaves.

Usually use rollers or sliding mechanisms.

Can be made from glass, timber, aluminium or composite materials.

May slide within a wall cavity or along the wall surface.

Advantages

Save floor space because they do not swing outwards or inwards.

Can provide wide openings.

Are suitable for modern building designs.

Glass sliding doors allow natural light into rooms.

Can connect indoor spaces to verandas and patios.

May be convenient in areas with limited swing clearance.

Disadvantages

Tracks may accumulate dust and debris.

Rollers may wear out and require replacement.

Some sliding doors provide less security if poorly designed.

They may not seal as effectively as some hinged doors.

They require accurate installation and alignment.

Uses

Verandas.

Patios.

Shops.

Offices.

Hotels.

Residential living rooms.

Commercial entrances.

4.1.3 Folding doors



Definition: A folding door is a door made up of two or more connected leaves or panels that fold together when opened.

It is also commonly called a bi-fold or concertina door, depending on its arrangement.

Characteristics

Consists of several connected panels.

Panels fold against one another during opening.

May operate using hinges, tracks and rollers.

Can be made from timber, aluminium, glass or PVC.

Can provide a wide opening when fully folded.

Advantages

Save space compared with some conventional swinging doors.

Provide wide access openings.

Can divide or combine large spaces.

Are available in different designs.

Suitable for areas where flexible space arrangement is required.

Disadvantages

Have more joints and fittings that may require maintenance.

May be expensive to manufacture and install.

Require accurate alignment of tracks and hinges.

Some designs may provide limited sound insulation.

Poorly maintained folding mechanisms may become difficult to operate.

Uses

Conference rooms.

Restaurants.

Large residential openings.

Hotels.

Room partitions.

Commercial premises.

4.1.4 Revolving doors



Definition: A revolving door is a door consisting of several leaves fixed around a central vertical axis, allowing people to pass through as the leaves rotate.

Characteristics

Have a central vertical rotating shaft.

Contain two or more door leaves.

Rotate within a circular enclosure.

Are commonly made using glass and metal frames.

Are often used in buildings with high pedestrian traffic.

Advantages

Allow continuous movement of people.

Can help reduce uncontrolled exchange of indoor and outdoor air.

Can reduce draughts in certain building entrances.

Provide an attractive modern appearance.

Can manage pedestrian movement at busy entrances.

Disadvantages

Are relatively expensive.

Require specialised installation and maintenance.

May be difficult for some people to use without suitable accessibility provisions.

Can create safety risks if not properly designed and maintained.

May not provide a suitable emergency exit on their own.

Uses

Hotels.

Airports.

Large shopping centres.

Office towers.

Commercial buildings.

4.1.5 Rolling doors



Definition: A rolling door is a door made of interconnected horizontal slats or sections that move vertically and roll around a drum or shaft when opened.

Characteristics

Move vertically.

Roll around a drum or shaft above the opening.

Are commonly manufactured using steel or aluminium.

May be operated manually or electrically.

Usually require guides on both sides of the opening.

Advantages

Save space because they do not swing into the building.

Can cover wide openings.

Provide security when properly designed.

Can be operated using mechanical or electric systems.

Are suitable for commercial and industrial buildings.

Disadvantages

May be noisy during operation.

Require maintenance of rollers, guides and drums.

Can be expensive when electrically operated.

Poor installation may cause jamming.

Some types provide limited thermal and sound insulation.

Uses

Shops.

Garages.

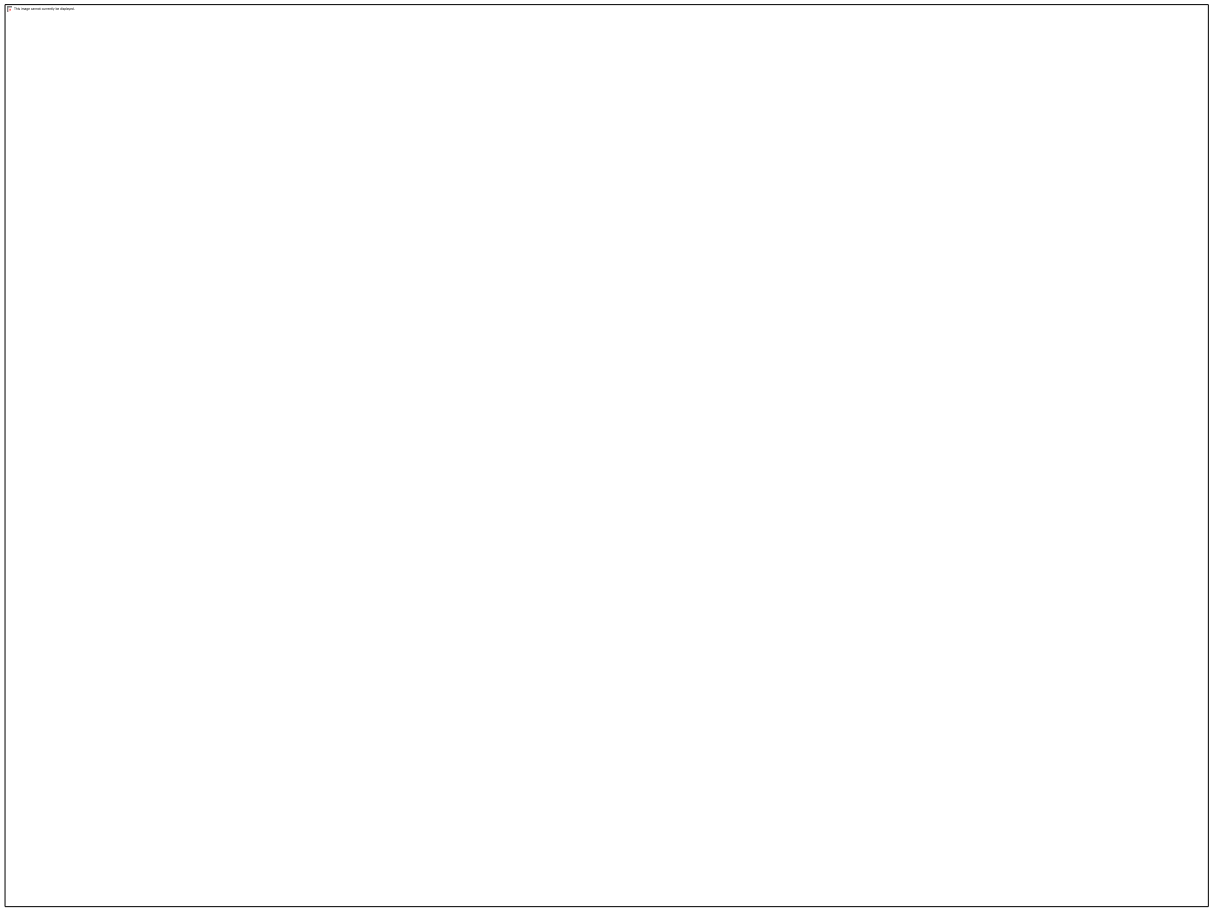
Warehouses.

Workshops.

Industrial premises.

Storage facilities.

4.1.6 Shutter doors



Definition: A shutter door is a door made of connected slats, panels or sections that can be moved to close or secure an opening. Many common shutter doors operate by rolling vertically, although the term can also describe other shutter arrangements.

Characteristics

May be made of steel, aluminium or timber.

May be manually or mechanically operated.

Can be designed to cover large openings.

Often provide security and protection.

May be fitted externally or internally.

Advantages

Provide security for shops and stores.

Can protect openings against unauthorised access.

Are suitable for large entrances.

Can be operated using manual or motorised mechanisms.

Some designs protect against dust and weather.

Disadvantages

May require regular maintenance.

Can be noisy.

May be difficult to operate if damaged.

Some designs require considerable installation space above the opening.

Uses

Shop fronts.

Warehouses.

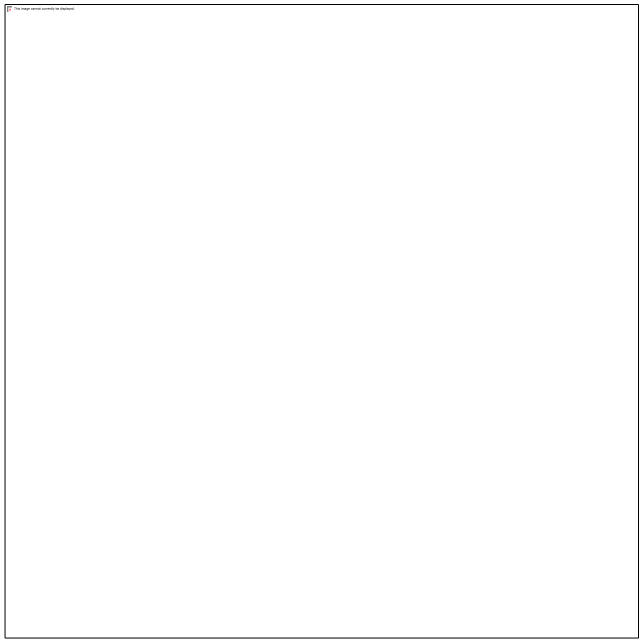
Garages.

Stores.

Industrial buildings.

Important distinction: A rolling door is a particular type of shutter door in which the door curtain rolls around a drum. The terms are sometimes used interchangeably in everyday construction practice.

4.1.7 Swing doors



Definition: A swing door is a door designed to swing open around hinges or a special pivot mechanism. Some swing doors can open in both directions.

Characteristics

Can be single-action or double-action.

May open inwards, outwards or in both directions, depending on the fittings.

May be fitted with spring hinges or door closers.

Can be made from timber, metal, glass or composite materials.

May have push plates instead of conventional handles.

Advantages

Allow convenient movement between spaces.

Double-action designs allow movement in both directions.

Can be useful in busy working environments.

Can be fitted with self-closing mechanisms.

Are suitable for service areas.

Disadvantages

Require space for swinging.

May cause injury if they swing into people unexpectedly.

Special fittings may require adjustment and maintenance.

Some designs may not provide adequate privacy.

Uses

Hotel kitchens.

Restaurants.

Hospitals.

Workshops.

Commercial kitchens.

Service corridors.

4.1.8 Pivot doors



Definition: A pivot door is a door supported by pivot fittings fixed at points near its top and bottom, allowing it to rotate around a vertical pivot axis rather than conventional side hinges.

Characteristics

Rotate around a vertical axis.

Use top and bottom pivot fittings.

May be large and heavy.

Can be made from timber, metal, glass or composite materials.

May be used as decorative entrance doors.

Advantages

Can accommodate large door leaves.

Provide a modern architectural appearance.

Can allow smooth movement when properly installed.

May distribute loads through the pivot fittings.

Can be designed for wide entrances.

Disadvantages

Require accurate positioning of pivot fittings.

May be expensive.

Heavy doors require suitable structural support.

May need specialised maintenance.

Some designs may have gaps that require careful weather and security detailing.

Uses

Modern residential entrances.

Hotels.

Commercial buildings.

Large offices.

Architectural entrance features.

4.2 Comparison of doors according to mode of operation

Door type	How it operates	Common application
Hinged	Rotates on side hinges	Bedrooms and offices
Sliding	Moves horizontally on tracks	Verandas and shops
Folding	Panels fold together	Partitions and large openings
Revolving	Leaves rotate around a central axis	Hotels and airports
Rolling	Slats roll around a drum	Shops and garages
Shutter	Connected sections move to cover an opening	Stores and warehouses
Swing	Swings on hinges or pivots, sometimes both directions	Kitchens and hospitals
Pivot	Rotates around top and bottom pivot points	Modern entrances

5.0 Classification of doors according to materials

Doors may also be classified according to the material from which they are manufactured.

5.1 Timber doors

Manufactured using natural timber or engineered timber products.

Can be solid, panelled, flush, framed and battened or glazed.

Can be painted, stained or varnished.

Commonly used in residential and institutional buildings.

Examples: Solid timber entrance doors, timber bedroom doors and timber panel doors.

5.2 Metal doors

Manufactured using steel, aluminium or other suitable metal alloys.

May be solid, perforated, glazed or louvered.

Are used where strength, security and durability are required.

Require suitable protective finishes depending on the metal and environment.

Examples: Steel security doors, aluminium sliding doors and metal garage doors.

5.3 Glass doors

Manufactured using safety glass or other suitable glazing systems.

May be frameless or supported by metal frames.

Allow natural light into buildings.

Are common in commercial and modern residential buildings.

Examples: Frameless glass office doors and aluminium-framed glazed entrance doors.

5.4 PVC doors

Manufactured using PVC or uPVC.

Are suitable for many internal applications.

Resist moisture and do not rust.

Are commonly used in bathrooms and utility spaces.

Examples: PVC bathroom doors and uPVC utility-room doors.

6.0 Classification of doors according to method of construction

This classification is based on how the door leaf is made and the arrangement of its materials and components.

The main types include:

Panel doors.

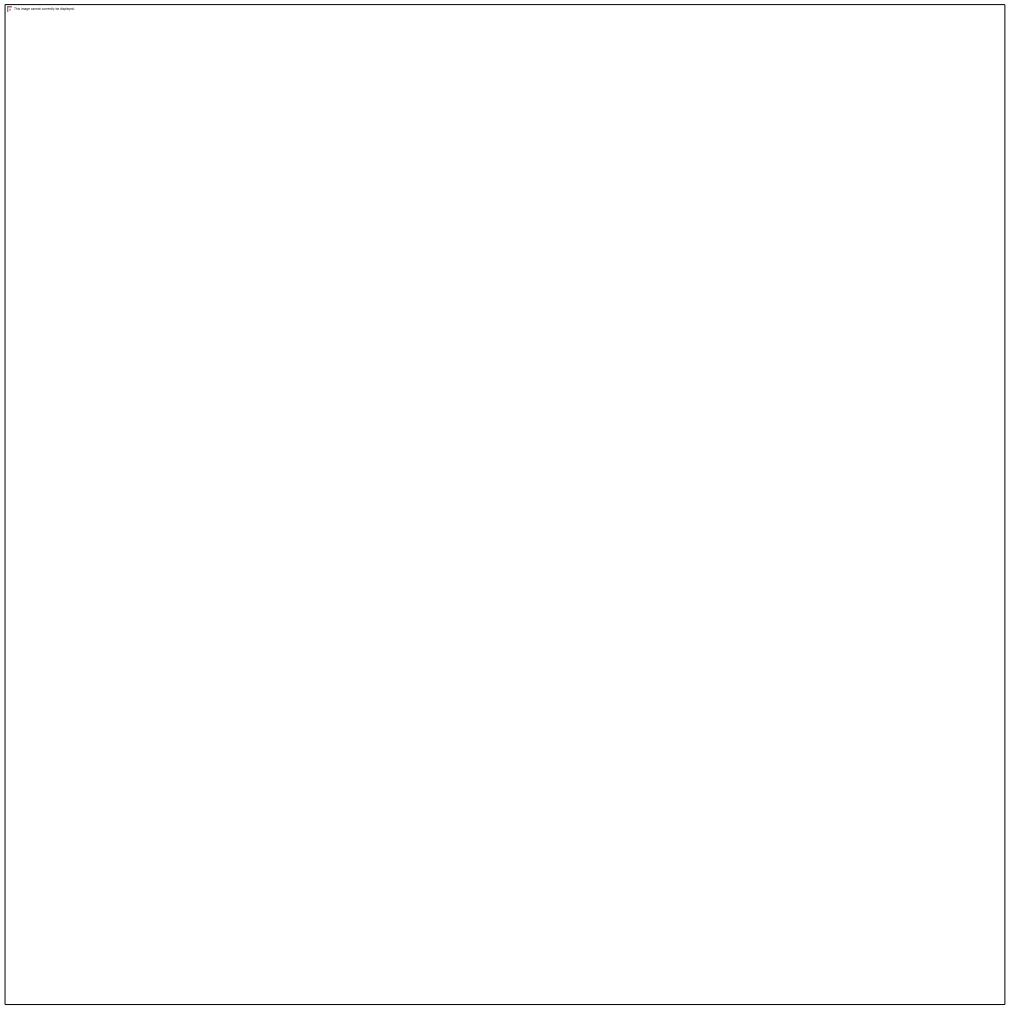
Flush doors.

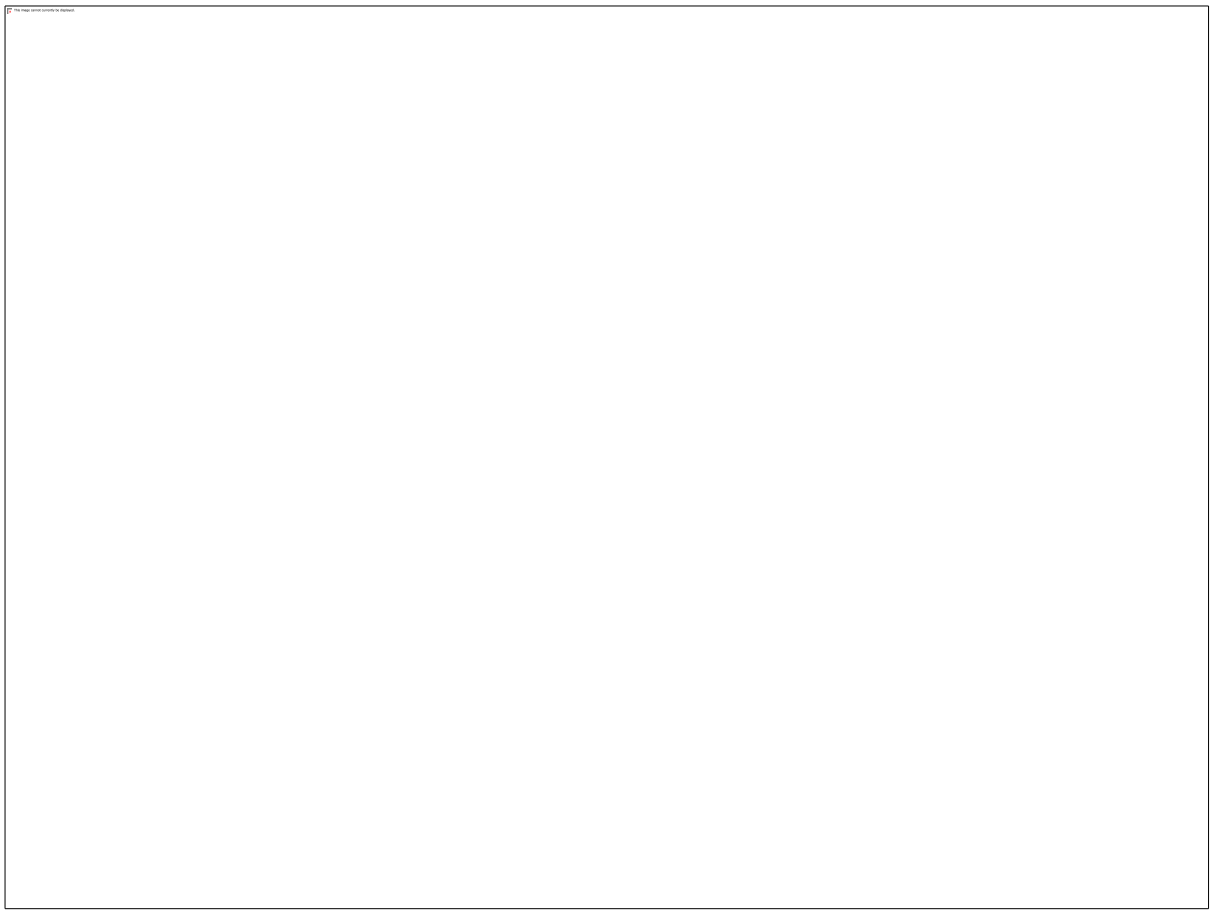
Glazed doors.

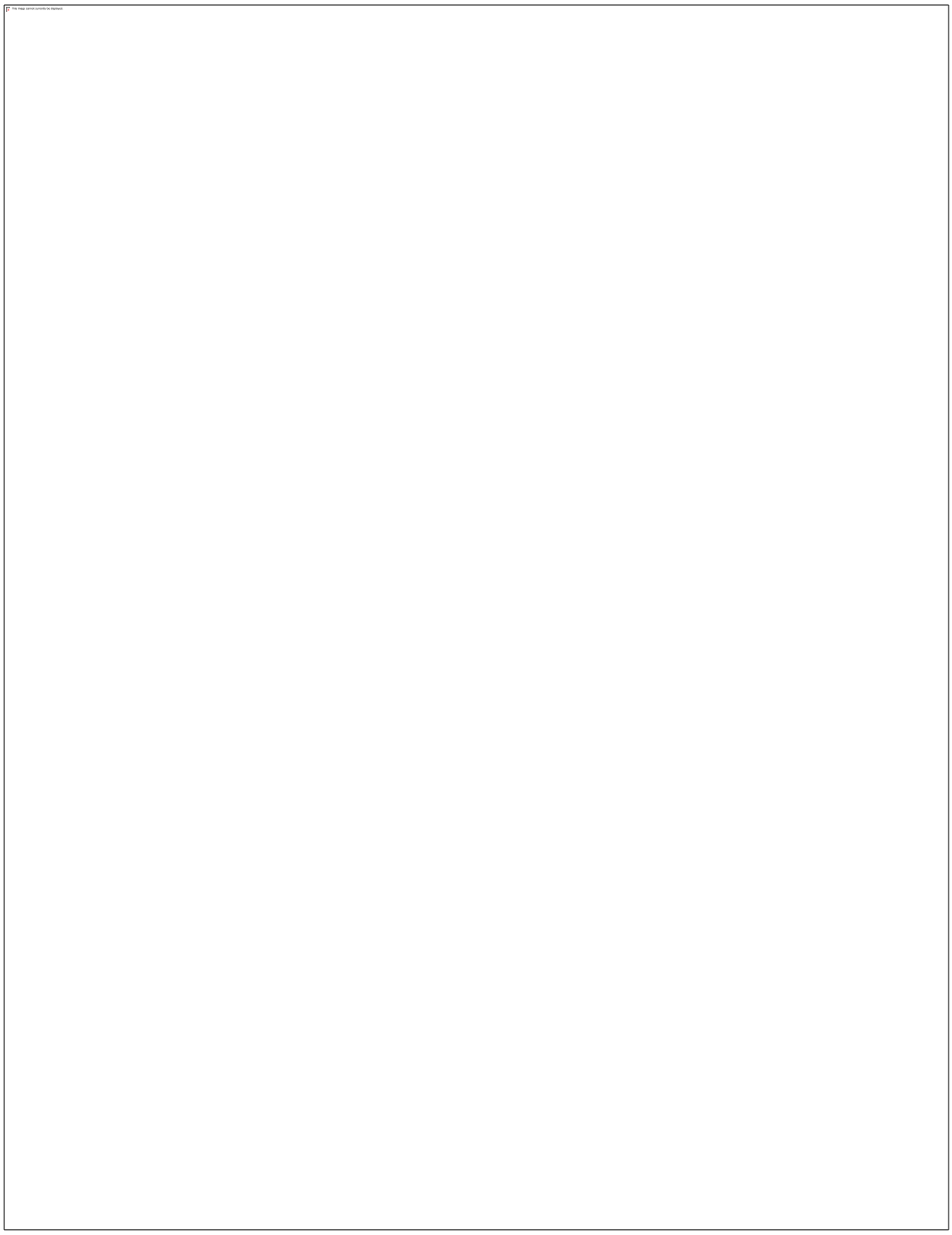
Louvered doors.

Framed and battened doors.

6.1 Panel doors







Definition

A **panel door** is a door constructed using a framework of stiles and rails with one or more panels fitted into the spaces formed by the framework.

The panels may be made from solid timber, plywood, glass or other suitable materials.

Main components of a panel door

Stiles.

Top rail.

Bottom rail.

Lock rail.

Intermediate rails.

Panels.

Mouldings, where provided.

Explanation of components

A. Stiles

Stiles are the vertical members forming the sides of a panel door.

They provide the main vertical framework.

They provide fixing points for hinges and other fittings.

B. Top rail

The top rail is the horizontal member at the upper part of the door.

It connects the two stiles.

It helps form the upper part of the door framework.

C. Bottom rail

The bottom rail is the horizontal member at the lower part of the door.

It connects the two stiles.

It provides strength and stability to the lower part of the door.

D. Lock rail

The lock rail is a horizontal member positioned around the lock or handle area.

It provides additional strength where the door lock is fitted.

It may also be referred to as a middle rail in some door designs.

E. Panels

Panels are the sections fitted into the framework between the stiles and rails.

They may be raised, recessed, flat or glazed.

They contribute to the appearance and construction of the door.

F. Mouldings

Mouldings are decorative or finishing profiles fitted around panels.

They improve the appearance of the door.

They may also help retain panels in certain traditional constructions.

Advantages of panel doors

Attractive appearance.

Can be made in different designs.

Can accommodate timber or glass panels.

Can be repaired by replacing damaged panels in suitable designs.

Provide a strong framework when properly constructed.

Suitable for many residential and institutional buildings.

Disadvantages of panel doors

May be expensive to manufacture.

Require skilled workmanship.

Have several joints that may loosen if poorly constructed.

May require regular maintenance and refinishing.

Some solid timber designs may be heavy.

Uses of panel doors

Main entrances.

Bedrooms.

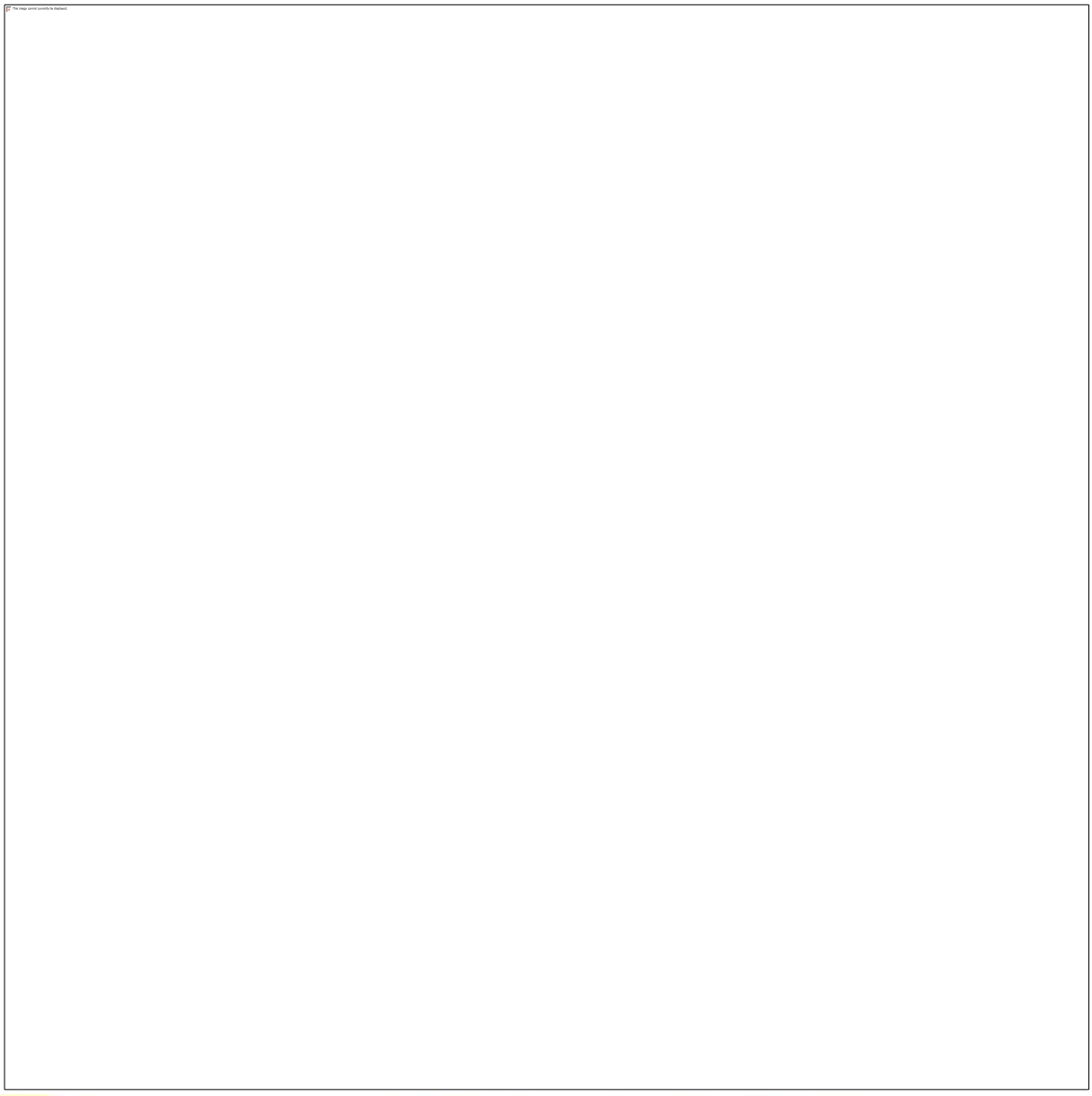
Offices.

Living rooms.

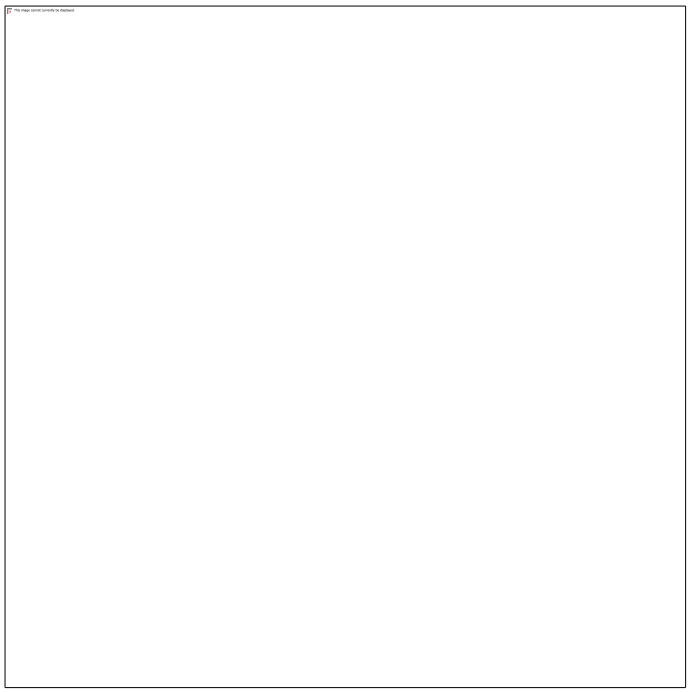
Hotels.

Institutional buildings.

6.2 Flush doors







Definition

A **flush door** is a door with smooth, flat surfaces on both faces, usually constructed using a timber or engineered frame, a core and face coverings such as plywood or other approved boards.

Main components of a flush door

Core.

Face panels or facings.

Stiles or edge members.

Top and bottom rails.

Lipping.

Adhesive and other joining materials.

Types of flush doors

A. Solid-core flush door

Has a solid or dense core made from suitable timber, engineered wood or other approved core materials.

Is generally heavier than a hollow-core flush door.

Can provide better sound reduction and a more substantial feel, depending on its construction.

May be suitable for areas requiring greater strength.

B. Hollow-core flush door

Has a lightweight internal core, often formed using a honeycomb structure or spaced internal members.

Has face coverings fixed to the core.

Is lighter than a solid-core door.

Is commonly used for internal doors where heavy-duty performance is not required.

Advantages of flush doors

Have a simple and neat appearance.

Are available in different finishes.

Can be relatively economical.

Have smooth surfaces that are easy to clean.

Are suitable for modern interior designs.

Hollow-core types are relatively lightweight.

Can be manufactured in standard sizes.

Disadvantages of flush doors

Some hollow-core doors have limited resistance to impact.

Damaged face coverings may be difficult to repair neatly.

Some types may have limited sound insulation.

Moisture can damage unsuitable core or face materials.

Their internal construction may make alterations difficult.

Uses of flush doors

Bedrooms.

Offices.

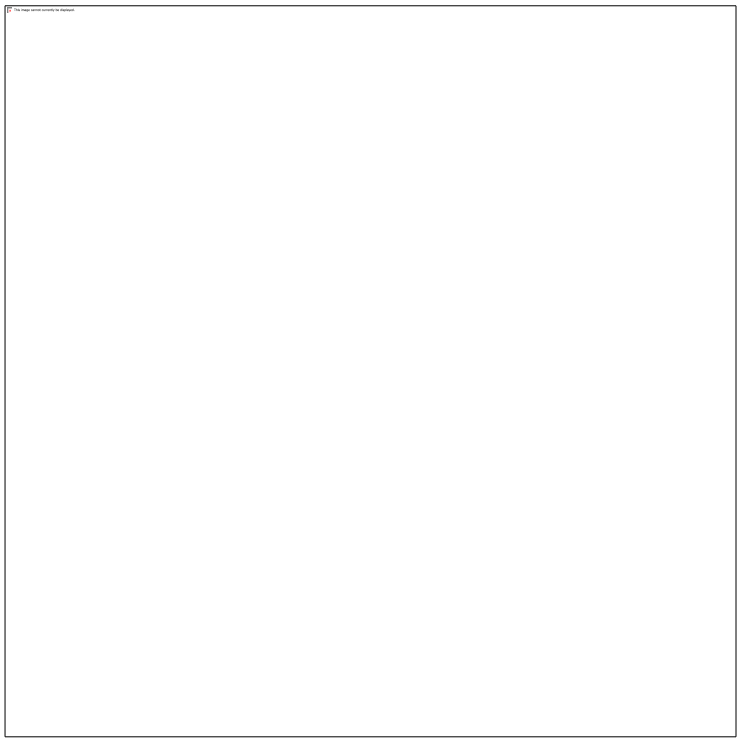
Classrooms.

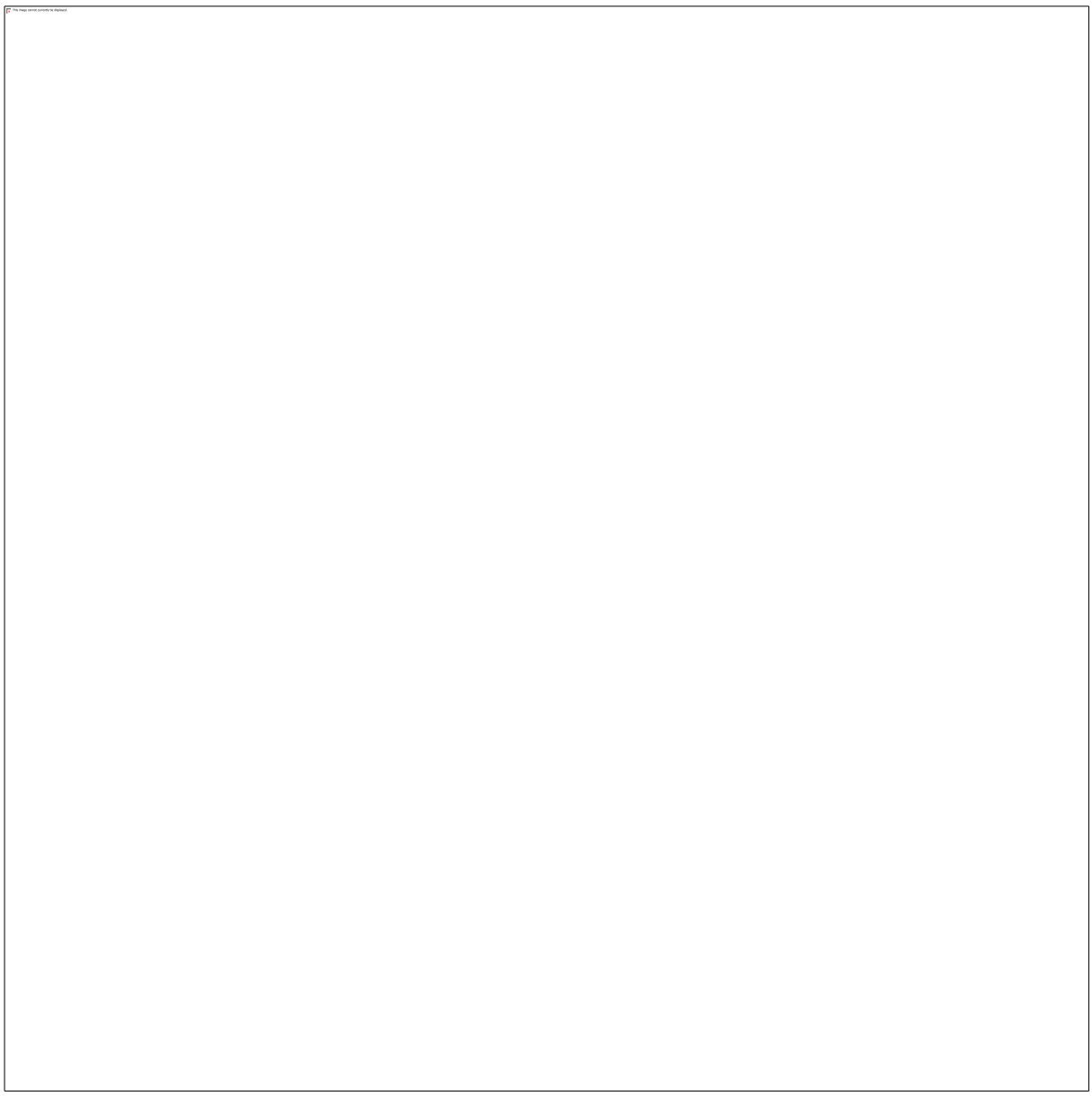
Internal corridors.

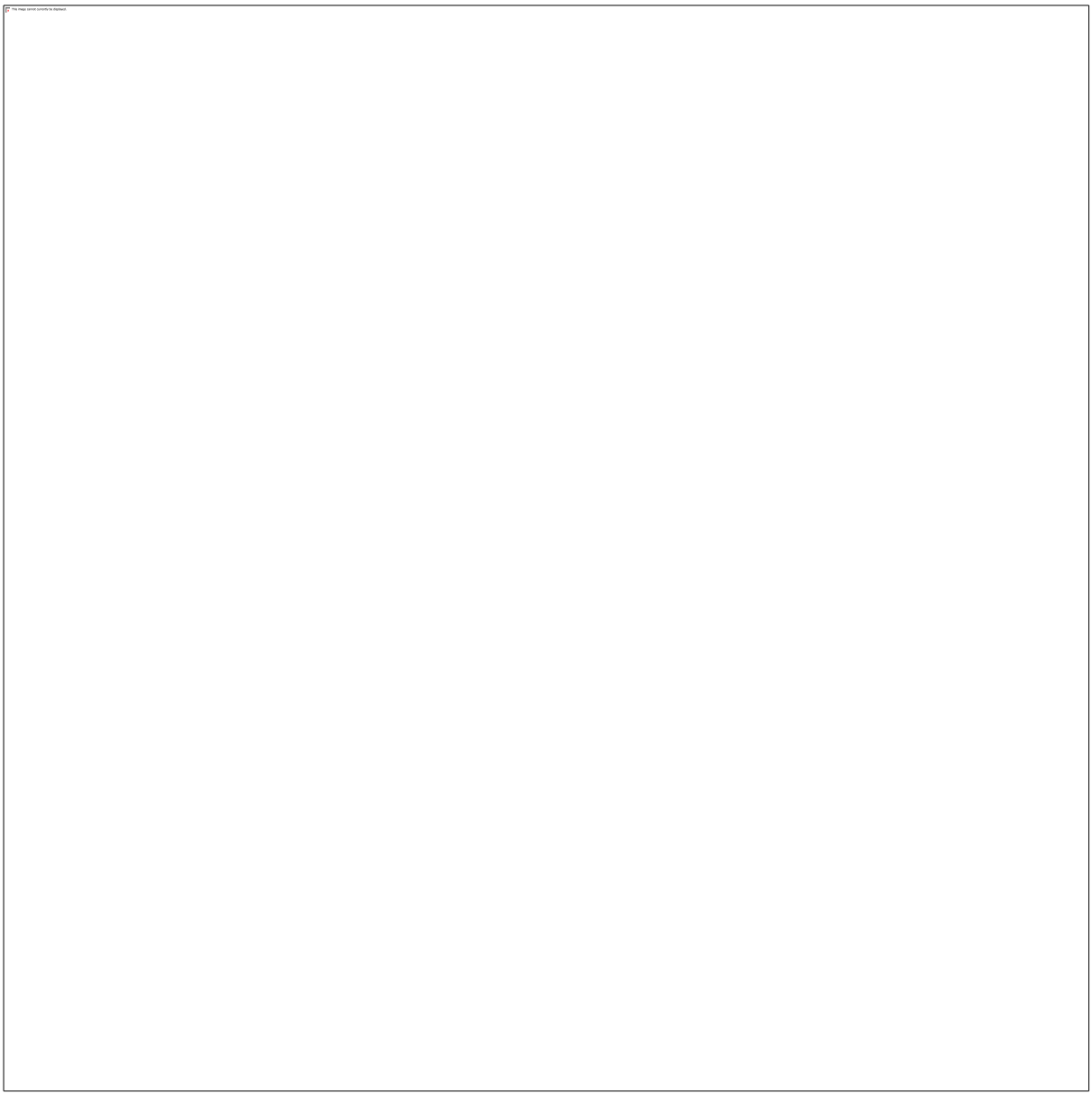
Residential buildings.

Commercial buildings.

6.3 Glazed doors







Definition

A **glazed door** is a door that contains one or more glass panels fitted into its leaf.

The glass may occupy the entire door leaf or only selected sections.

Characteristics

Have glass panels fitted into the door.

May be made using timber, steel or aluminium frames.

Allow light to pass through.

Can be fitted with clear, frosted, patterned or laminated glass.

Require suitable glazing beads, seals and safety glazing.

Advantages

Allow natural light into rooms.

Improve the appearance of buildings.

Provide visibility between spaces.

Can make rooms appear brighter.

Are available in different designs.

Disadvantages

Require suitable safety glazing.

Transparent glass may reduce privacy.

Glass can break if unsuitable or poorly installed.

Require regular cleaning.

Some glazing systems are expensive.

Uses

Office entrances.

Shops.

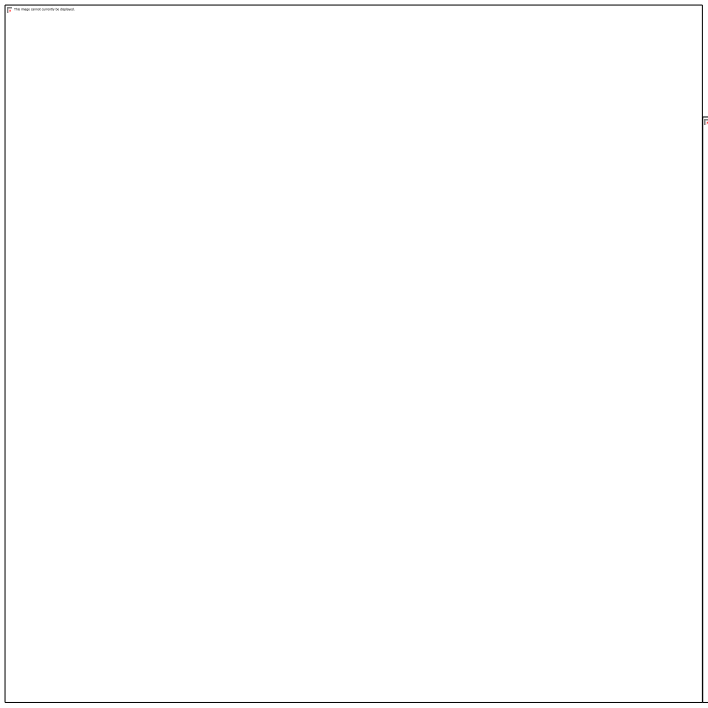
Hotels.

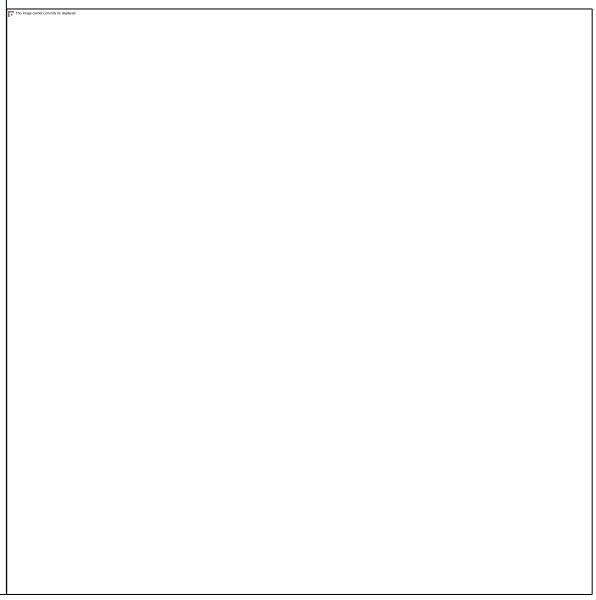
Verandas.

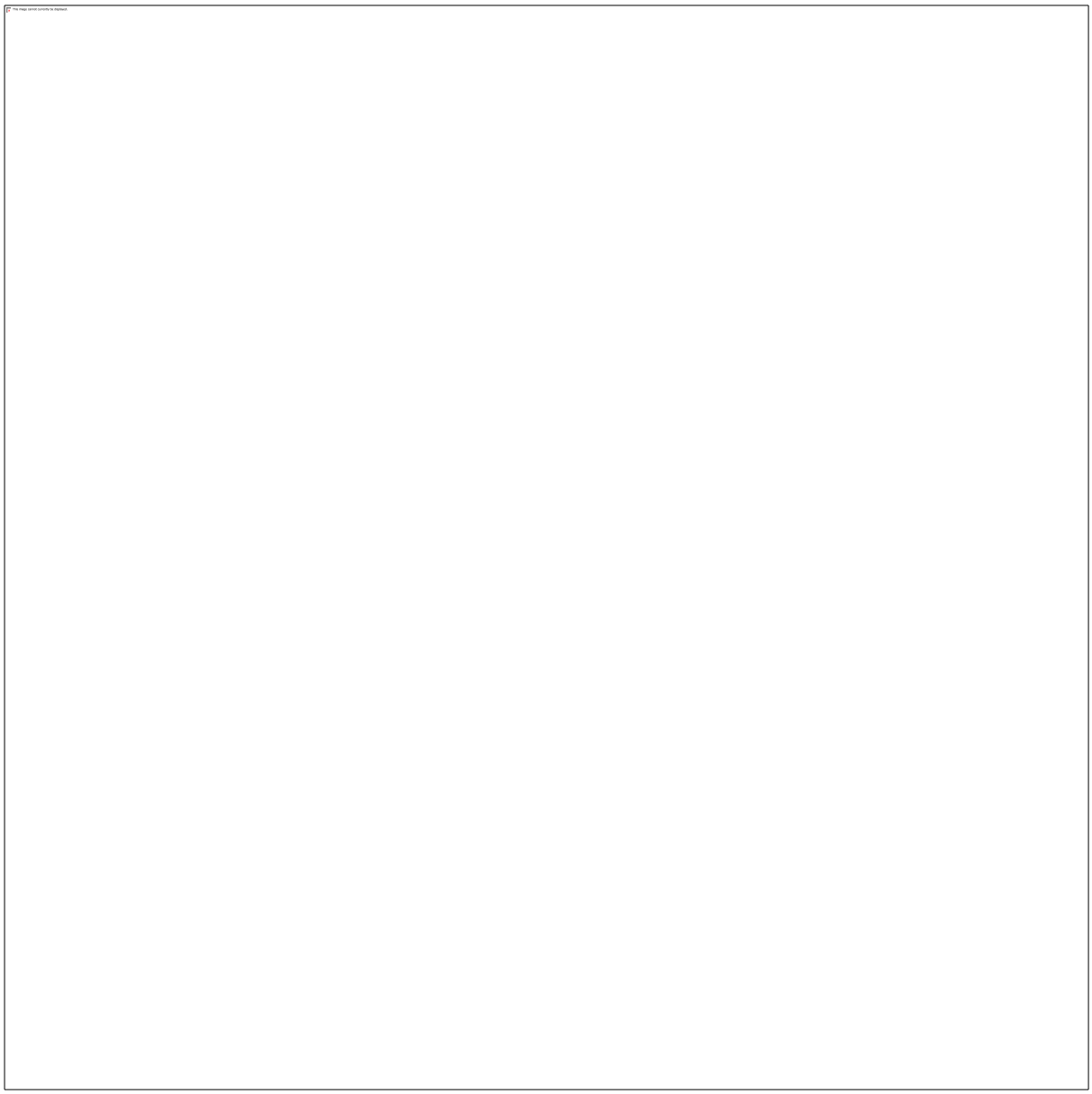
Commercial buildings.

Internal partitions.

6.4 Louvered doors







Definition

A **louvered door** is a door constructed with a series of inclined horizontal or vertical slats known as louvers, which allow air to pass through while reducing direct visibility.

Characteristics

Have angled slats.

Allow air circulation.

May be made from timber, metal or PVC.

May have fixed or adjustable louvers.

Provide partial visual screening.

Advantages

Allow ventilation when the door is closed.

Help reduce the accumulation of heat in enclosed spaces.

Can improve air circulation.

Provide some visual screening.

Are useful in utility spaces.

Disadvantages

Provide limited sound insulation.

May provide limited security compared with solid doors.

Dust may accumulate between the slats.

May allow some rain or moisture to enter depending on their location and design.

Can be difficult to clean thoroughly.

Uses

Bathrooms.

Laundry rooms.

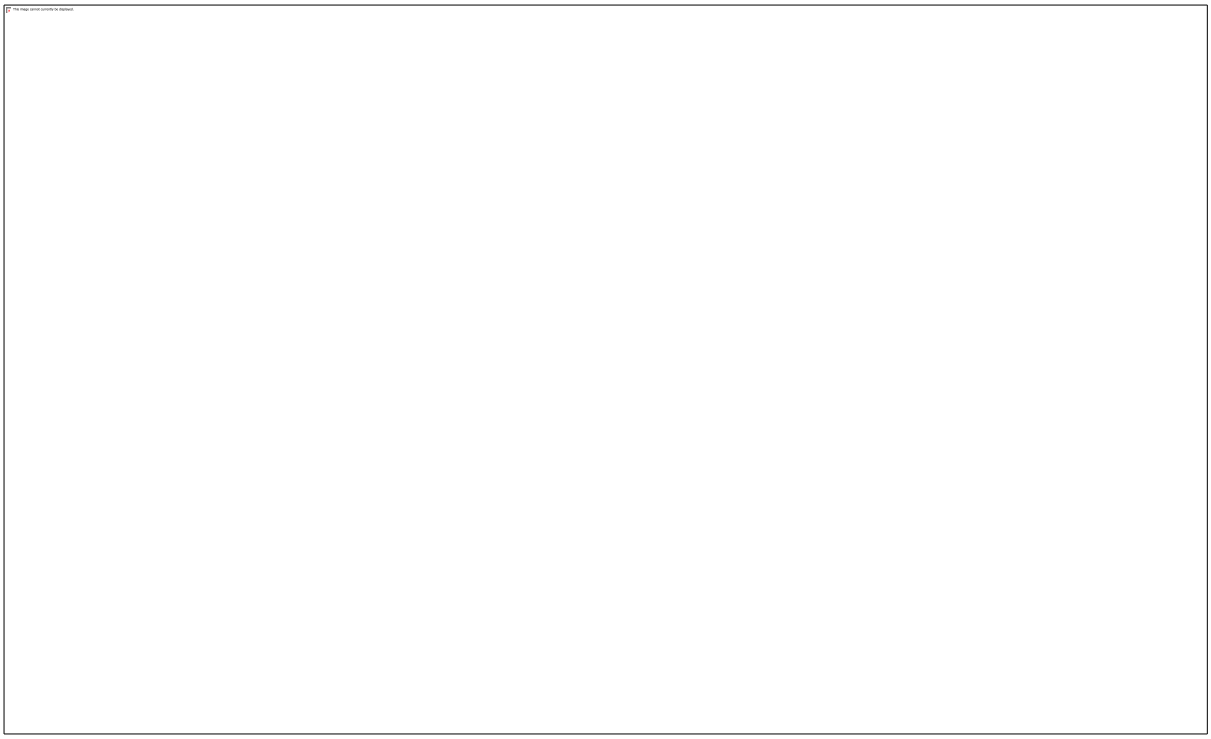
Plant rooms.

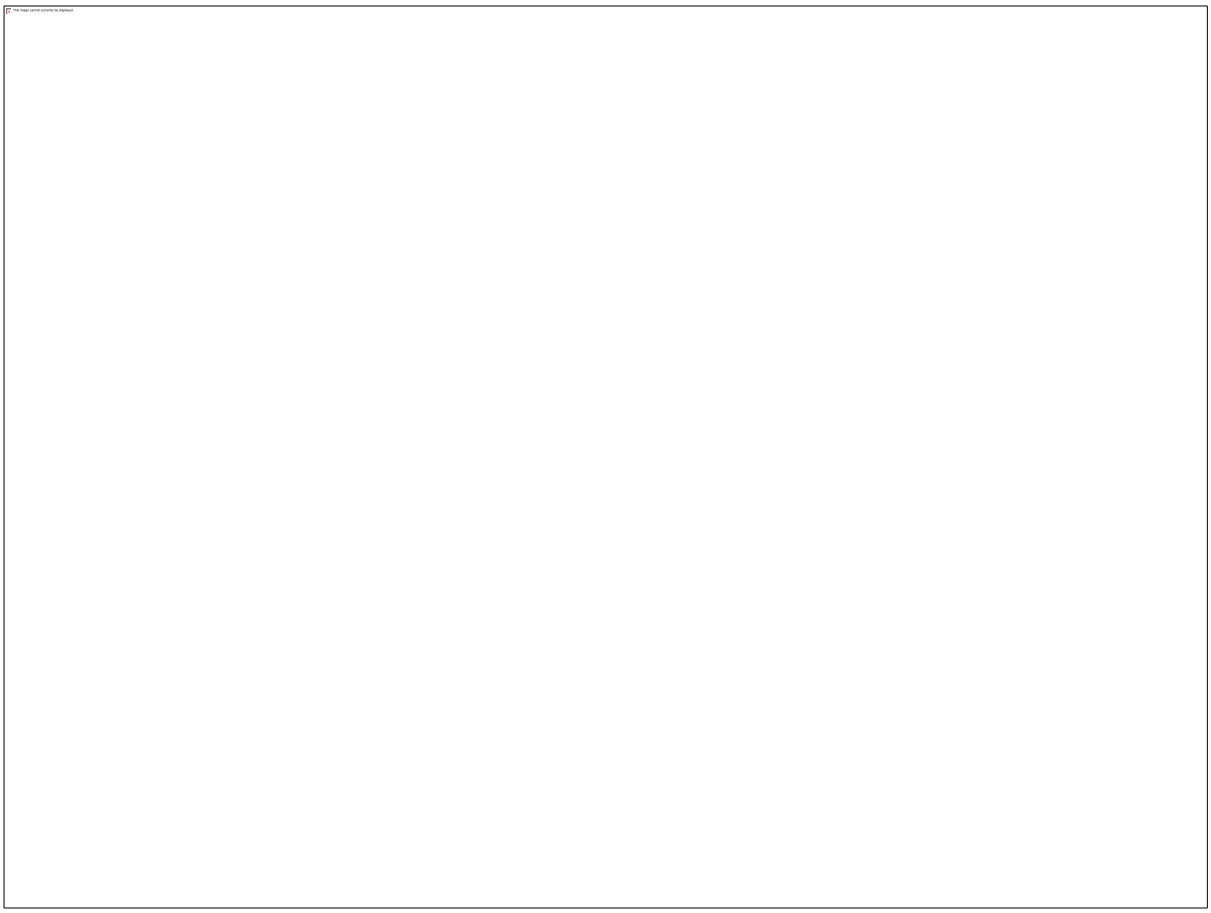
Storage rooms requiring ventilation.

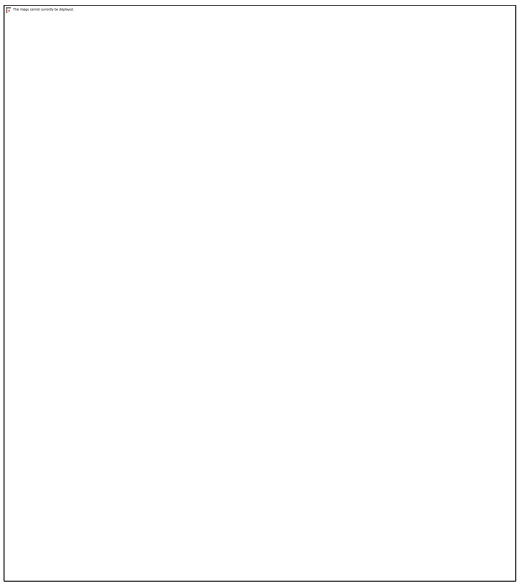
Wardrobes.

Utility rooms.

6.5 Framed and battened doors







Definition

A **framed and battened door** is a door constructed using vertical timber boards or battens supported by horizontal framing members and, in some designs, diagonal braces.

The horizontal members are commonly called ledges.

Main components

Vertical battens.

Top ledge.

Middle ledge.

Bottom ledge.

Diagonal braces, where provided.

Nails, screws or other approved fasteners.

Hinges and other fittings.

Explanation of components

A. Battens

These are vertical timber boards joined side by side.

They form the main door surface.

They are usually fixed to the horizontal ledges.

B. Ledges

These are horizontal timber members fixed across the back of the battens.

They hold the battens together.

They help maintain the shape of the door.

C. Braces

These are diagonal members fixed across the door framework.

They help reduce sagging and distortion.

They improve the stability of the door.

Advantages

Simple to construct.

Can be made using locally available timber.

Require relatively simple woodworking tools.

Can be economical for basic applications.

Are suitable for stores and utility buildings.

Disadvantages

May warp if timber is poorly seasoned.

May be less secure than properly constructed solid or reinforced doors.

May have a rougher appearance.

Require protection against moisture and insect attack.

Exposed joints and fasteners may loosen over time.

Uses

Stores.

Sheds.

Workshops.

Farm buildings.

Utility rooms.

Some traditional residential buildings.

7.0 Classification of doors according to location in a building

Doors may be classified according to where they are installed and the environment in which they operate.

The main categories are:

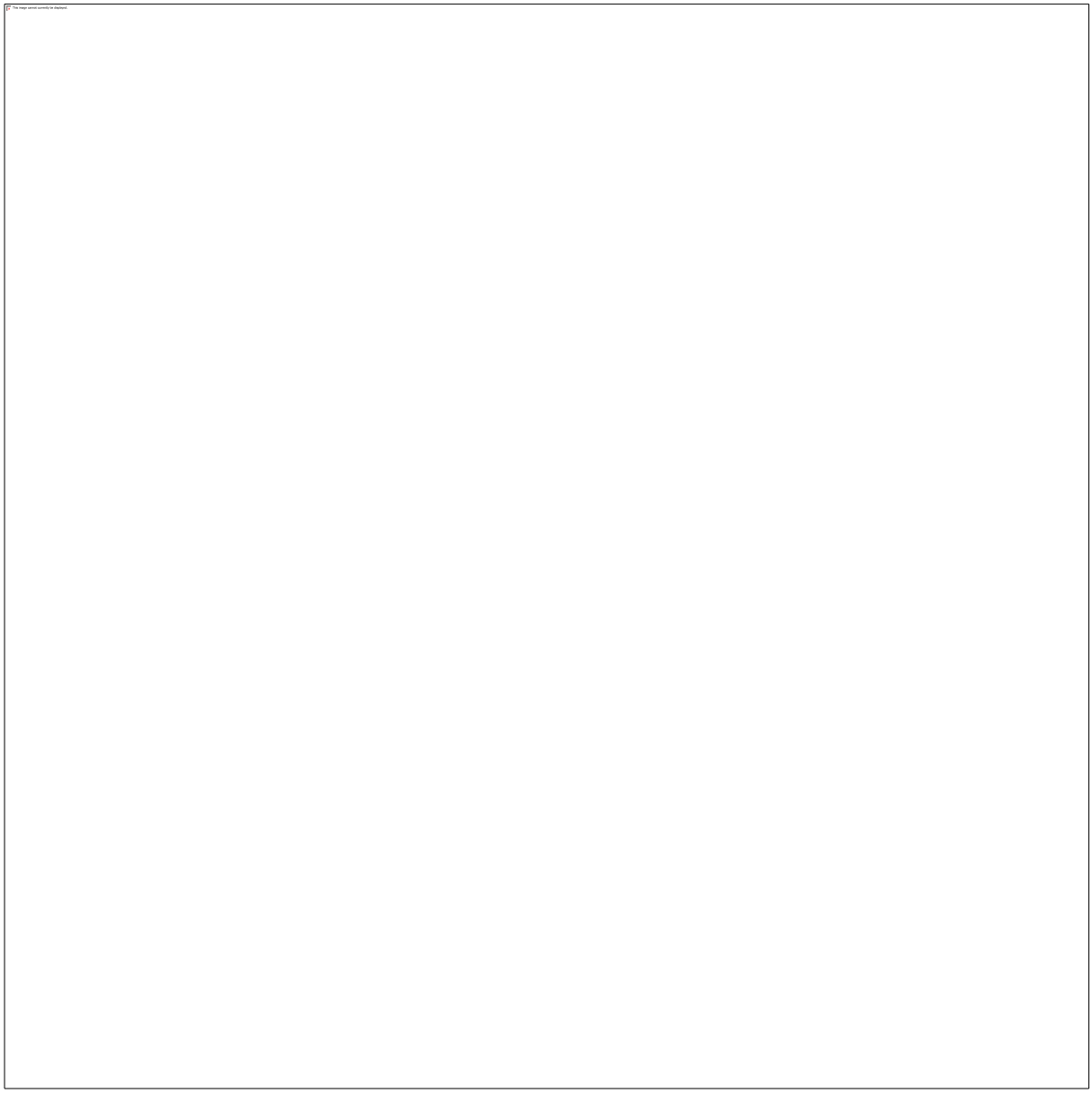
External doors.

Internal doors.

Garage doors.

Fire doors.

7.1 External doors



Definition

An **external door** is a door installed in an external wall of a building to provide access between the inside and outside environments.

Characteristics

Are exposed to weather conditions.

Should provide suitable security.

Should resist moisture and weather penetration.

May be made from timber, steel, aluminium, glass or composite materials.

Should have suitable locks, hinges and other fittings.

Should be properly sealed around the frame to reduce air and water penetration.

Advantages

Provide access into and out of buildings.

Improve building security.

Protect occupants against weather.

Can improve the external appearance of a building.

May provide thermal and sound insulation.

Uses

Main entrances.

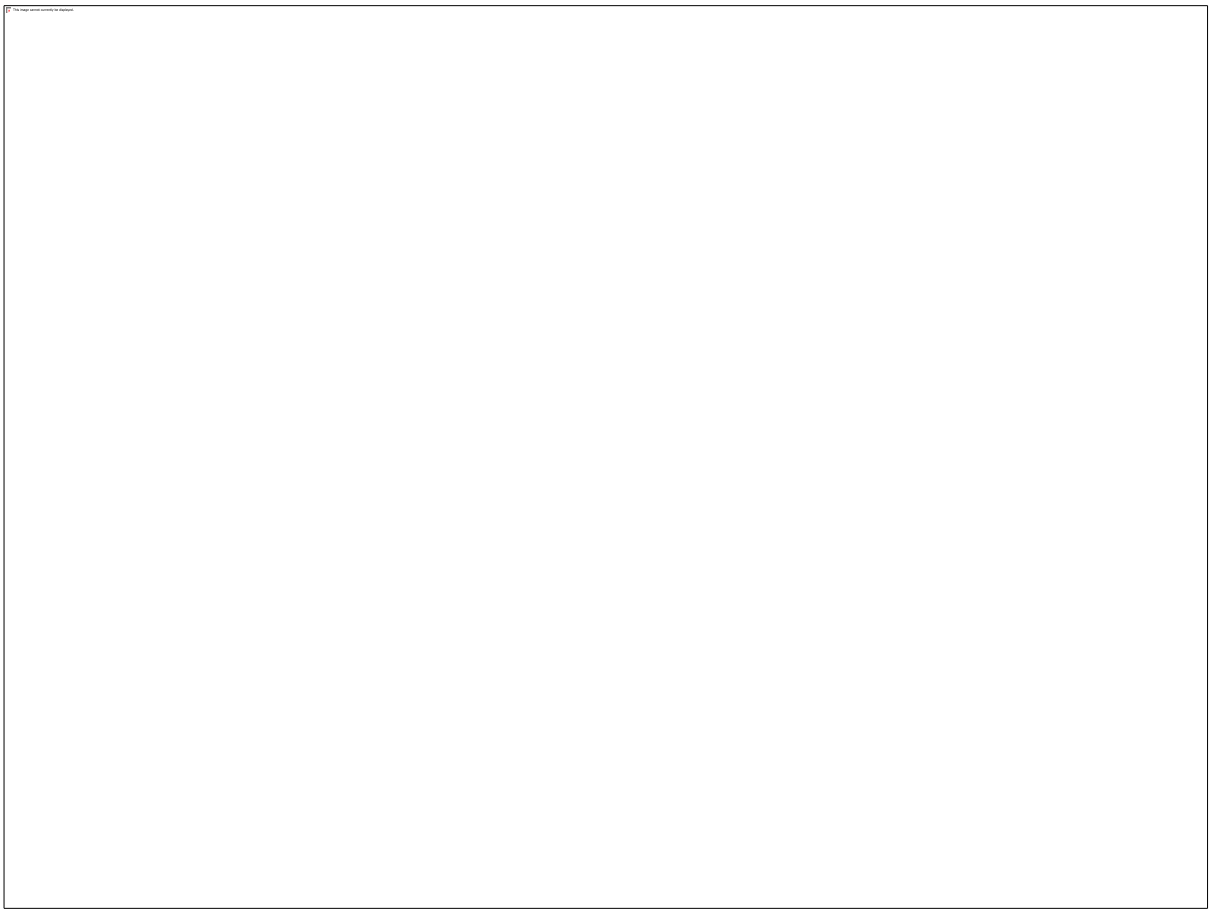
Back doors.

Side entrances.

Balcony and patio access.

School and office entrances.

7.2 Internal doors



Definition

An **internal door** is a door installed within a building to separate rooms, corridors or other internal spaces.

Characteristics

Are generally protected from direct exposure to outdoor weather.

May be lighter than external doors.

Are commonly made from timber, engineered wood, glass or PVC.

Provide privacy and separation.

May have simple locks or privacy fittings.

Their design depends on the function of the room.

Advantages

Separate rooms and activities.

Provide privacy.

Help control noise.

Improve the organisation of internal spaces.

Can improve interior appearance.

Uses

Bedrooms.

Bathrooms.

Offices.

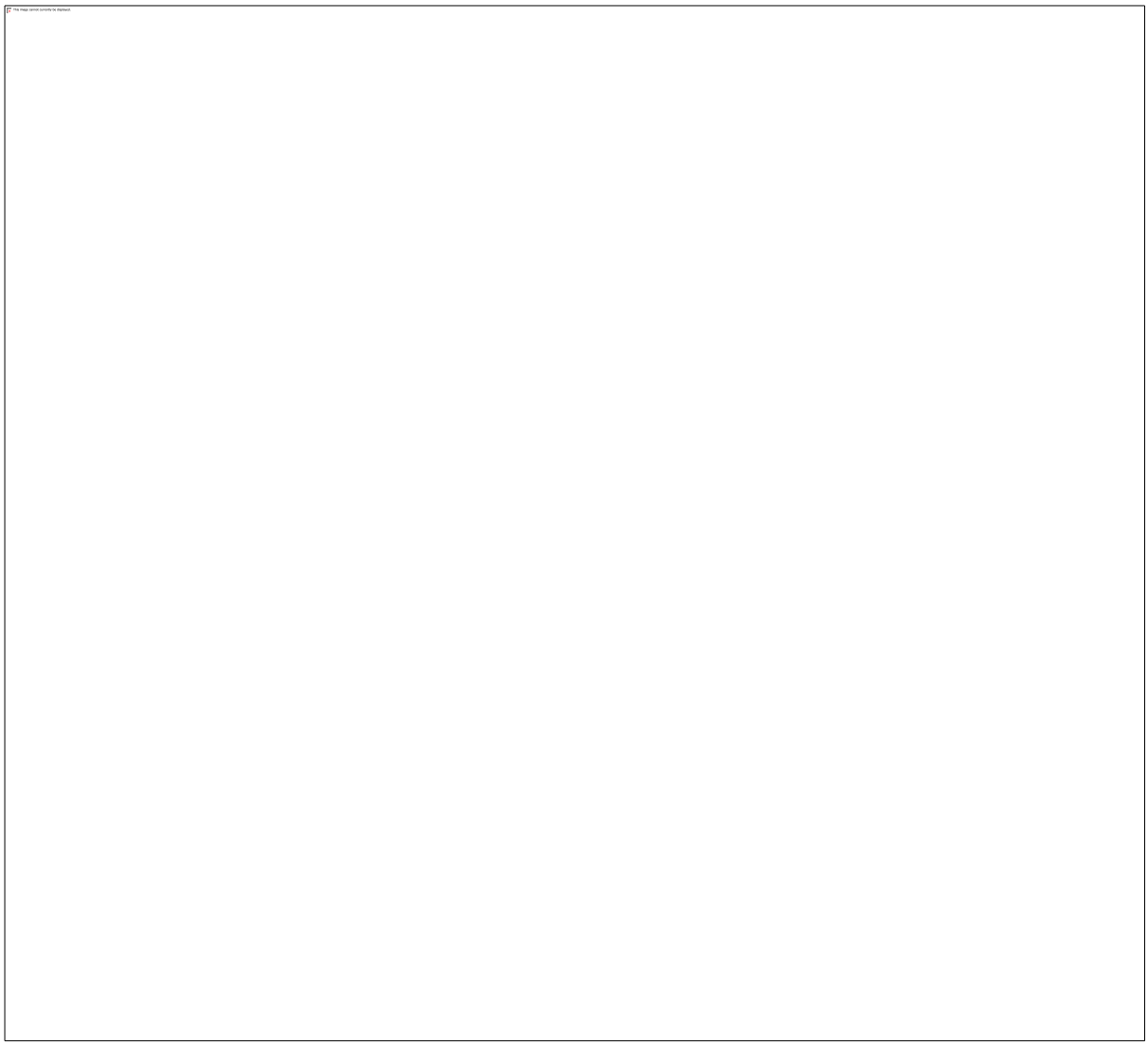
Classrooms.

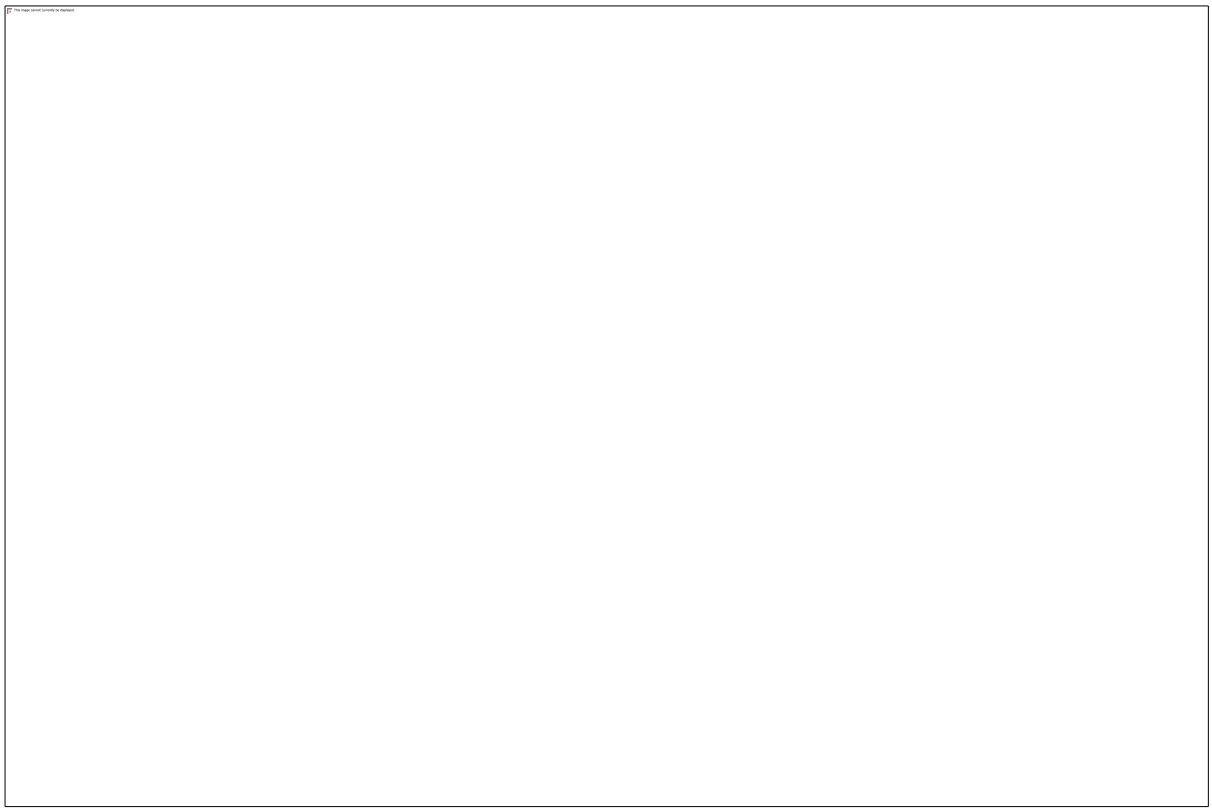
Kitchens.

Stores.

7.3 Garage doors







Definition

A **garage door** is a large door designed to provide access to a garage or vehicle storage space.

Characteristics

Are usually larger than ordinary room doors.

May operate by rolling, sliding, folding or sectional movement.

Are commonly made from steel, aluminium, timber or composite materials.

May be manually or electrically operated.

Require suitable locking and security arrangements.

Must be designed to operate safely.

Types of garage doors

Rolling garage doors.

Sectional garage doors.

Up-and-over doors.

Sliding garage doors.

Side-hinged garage doors.

Advantages

Allow vehicles to enter and leave a garage.

Protect vehicles from theft and weather.

Provide security for stored equipment.

Can improve the appearance of a building.

Motorised types provide convenient operation.

Disadvantages

Some types are expensive.

Motorised doors require electricity and maintenance.

Mechanical components may wear out.

Poorly maintained doors can create safety risks.

Large doors require adequate structural support and installation space.

Uses

Residential garages.

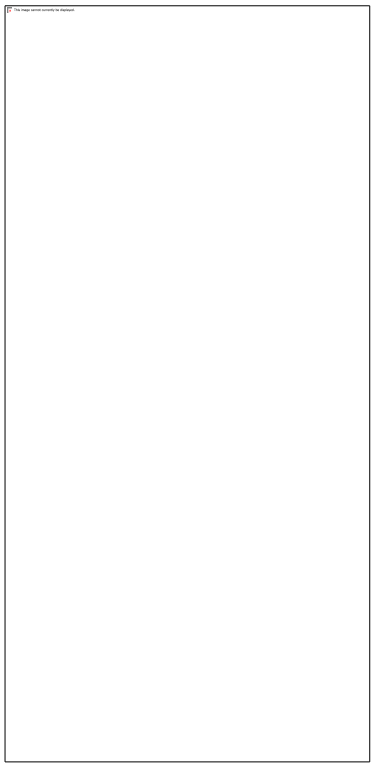
Commercial vehicle parking.

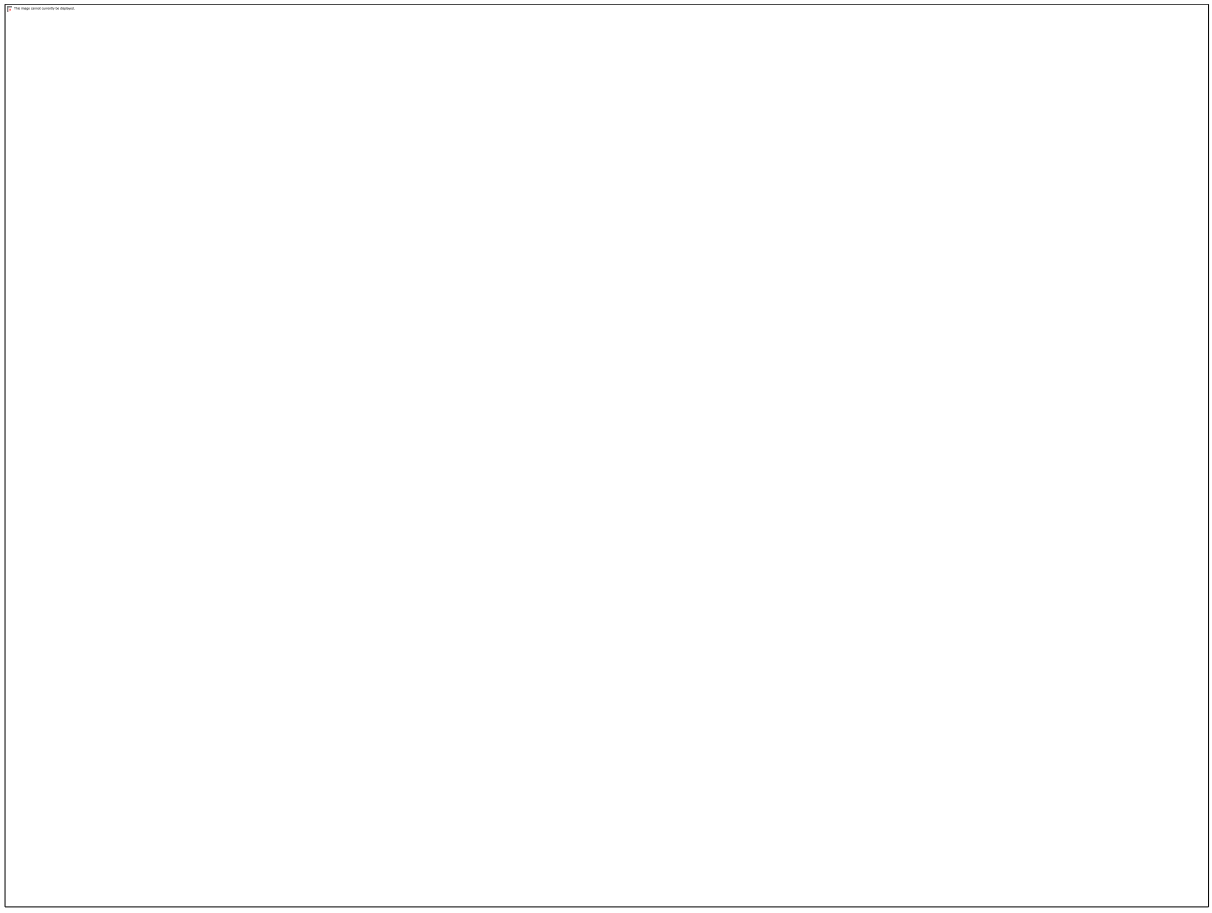
Workshops.

Vehicle service centres.

Industrial premises.

7.4 Fire doors







Definition

A **fire door** is a specially designed and tested door assembly intended to resist the passage of fire and, where specified, smoke for a stated period under defined test conditions.

A fire door is not simply an ordinary door made from metal or thick timber. Its performance depends on the complete door assembly, including the leaf, frame, seals, glazing where present, hinges, closer, locks and installation.

Main characteristics

- Manufactured using tested fire-resisting materials and construction methods.
- May be made from specially constructed timber, steel or other approved materials.
- May contain intumescent seals that expand when exposed to heat.
- May have smoke seals to reduce smoke leakage where required.
- Usually has compatible fire-rated hinges and other hardware.
- May be fitted with an automatic self-closing device.
- Must be installed according to the manufacturer's approved instructions.

Functions of fire doors

- Help restrict the spread of fire.
- Help protect escape routes.
- Provide additional time for occupants to evacuate.

Help protect property and building compartments.

Reduce the movement of smoke where the assembly is designed and tested for smoke control.

Advantages

Improve fire safety.

Help protect escape routes.

Reduce fire spread between building compartments.

Can protect occupants and property.

Support the overall fire-safety strategy of a building.

Limitations

Are generally more expensive than ordinary doors.

Require correct installation.

Require regular inspection and maintenance.

Must not be modified without approval.

Must not be held open using unauthorised wedges or objects.

Common locations of fire doors

Protected staircases.

Corridors.

Plant rooms.

Electrical rooms.

Certain store rooms.

Compartments separating different building uses.

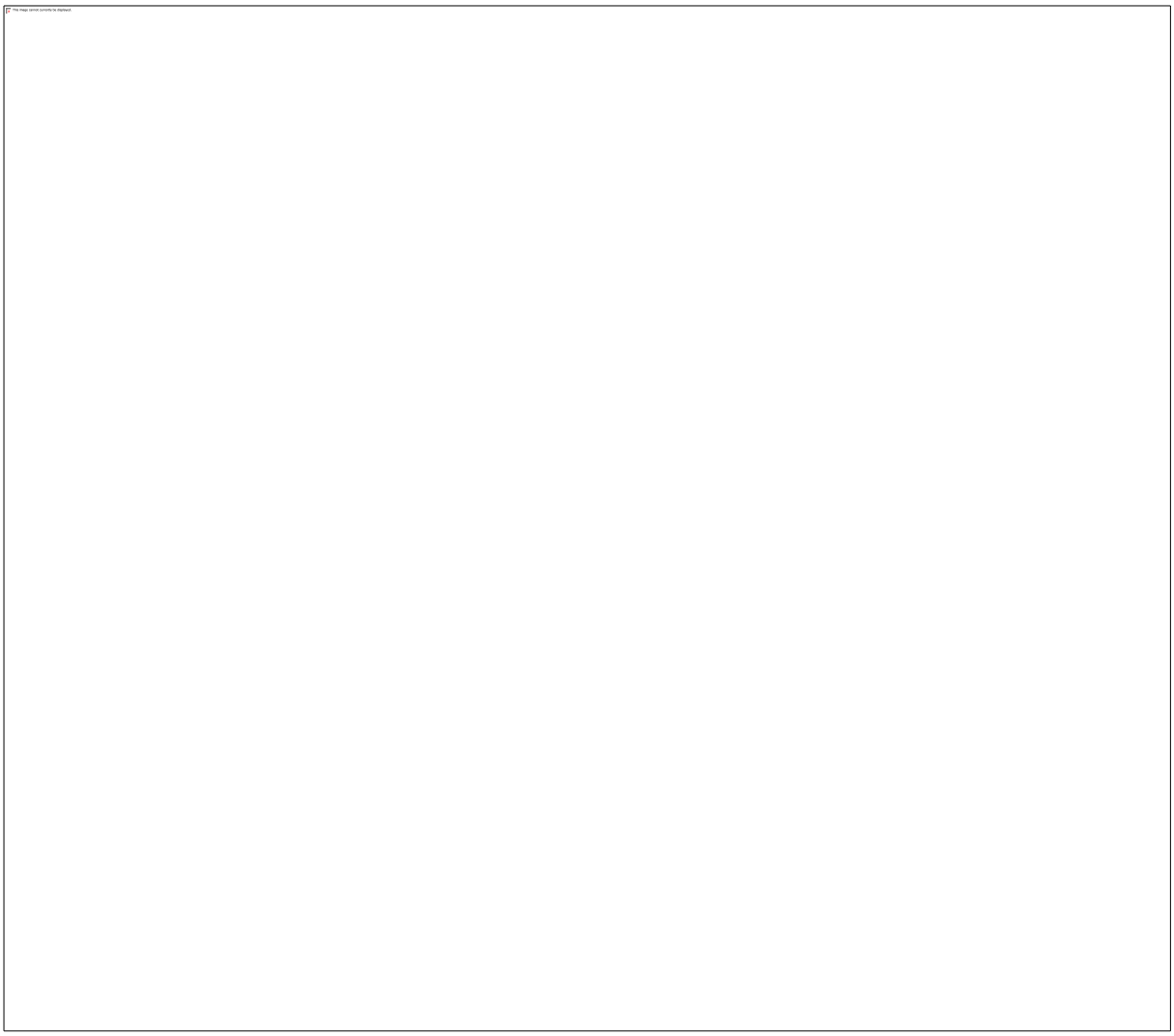
Other locations identified in the building fire-safety design.

Important: Fire doors must be selected according to the fire-safety design and applicable building requirements. A fire door should not be assumed to provide a particular fire-resistance period unless it has appropriate test evidence and certification.

8.0 Classification of doors according to function

This classification considers the main purpose a door is designed to perform.

8.1 Security doors



Definition: A security door is a door designed to provide increased resistance to unauthorised entry and forced access.

Characteristics

May be made from reinforced steel, aluminium or other strong materials.

May have reinforced frames.

May use multiple locking points.

May have security hinges and anti-tamper fittings.

May include security grilles or reinforced panels.

Advantages

Improve protection against forced entry.

Protect valuable property.

Provide peace of mind to occupants.

Can be combined with electronic access-control systems.

Uses

Banks.

Shops.

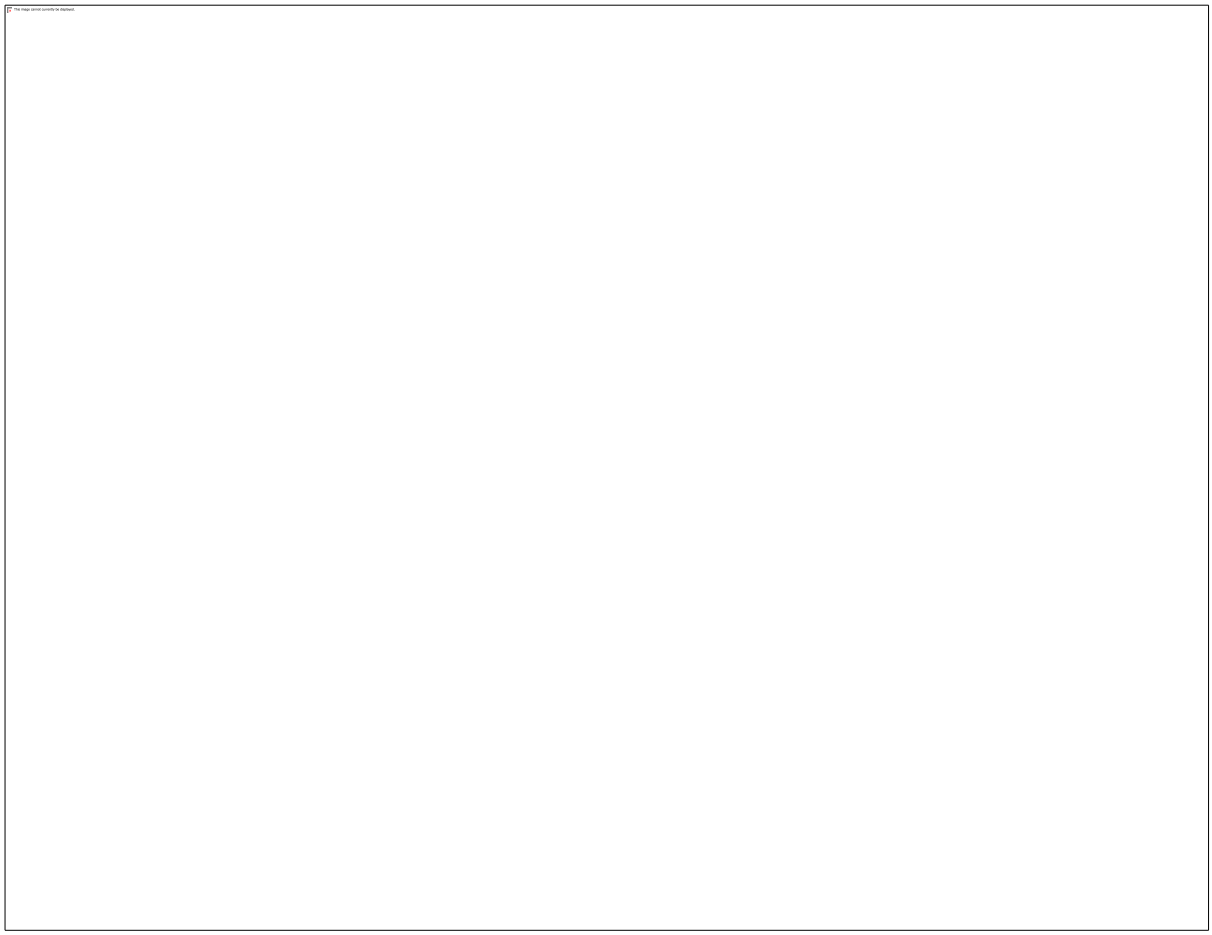
Residential entrances.

Stores.

Offices.

Warehouses.

8.2 Acoustic doors



Definition: An acoustic door is a specially designed door assembly intended to reduce the transmission of sound between spaces.

Characteristics

May have solid or specially constructed cores.

May contain sound-absorbing or sound-insulating materials.

May have perimeter seals.

May include automatic drop seals at the bottom.

Requires proper installation to reduce sound leakage.

Advantages

Reduces noise transmission.

Improves privacy.

Creates a quieter working environment.

Improves the performance of rooms used for sound-sensitive activities.

Uses

Recording studios.

Music rooms.

Hospitals.

Conference rooms.

Offices.

Laboratories.

Libraries.

8.3 Fire-resistant doors

These are doors designed and tested to resist fire for a specified period.

Important distinction: A fire-resistant door is also called a fire door in normal construction practice. It is classified by its fire-protection function, while its location may also determine the requirements for its use.

Functions

Restrict fire spread.

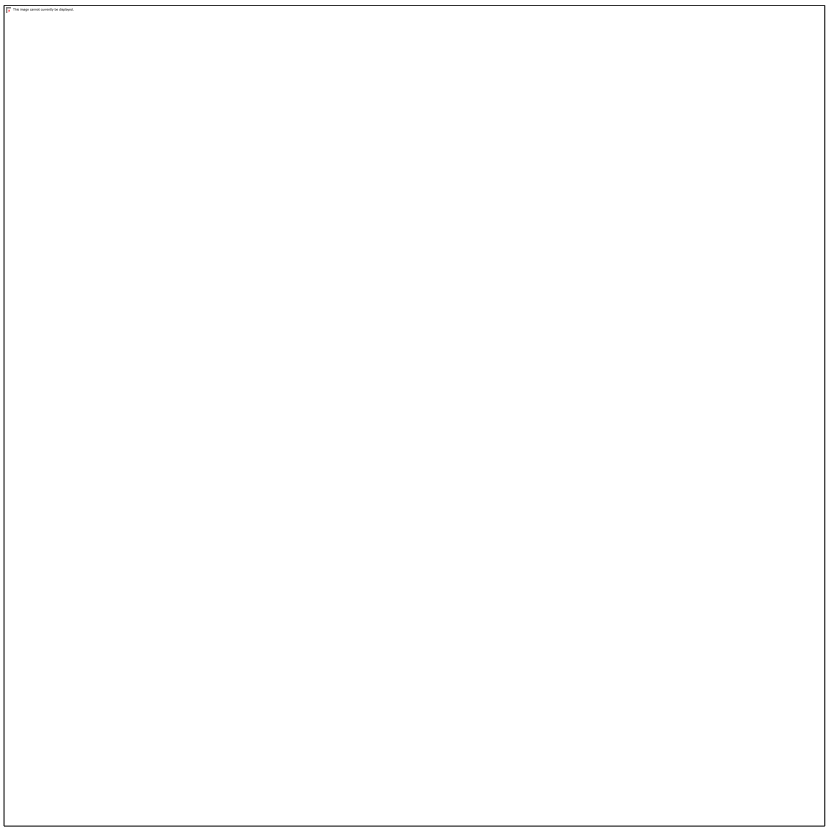
Protect escape routes.

Separate fire compartments.

Reduce the risk of fire moving between rooms.

Support safe evacuation.

8.4 Emergency exit doors



Definition: An emergency exit door is a door provided to allow occupants to leave a building quickly and safely during emergencies.

Characteristics

Are located along designated escape routes.

May be fitted with panic bars or approved emergency-release devices.

Should be clearly identifiable using suitable exit signs.

Should provide adequate clear opening width for the intended occupancy.

Must not be obstructed.

Must be fitted and operated in accordance with the building's evacuation and fire-safety arrangements.

Advantages

Support rapid evacuation.

Help reduce congestion during emergencies.

Provide a safe route out of a building.

Improve the overall safety of occupants.

Uses

Schools.

Hospitals.

Shopping centres.

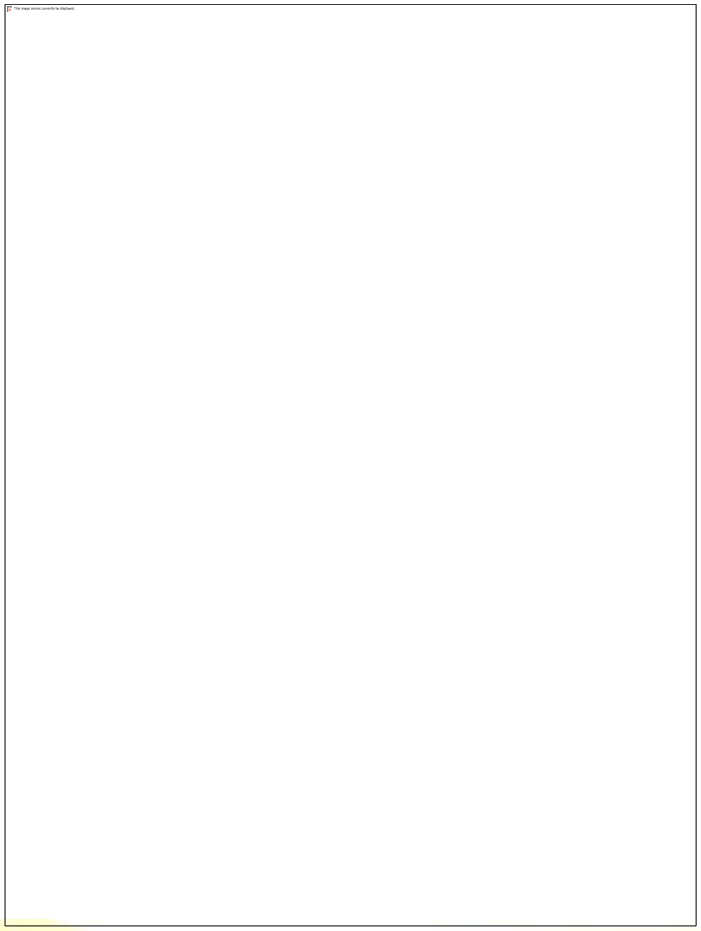
Hotels.

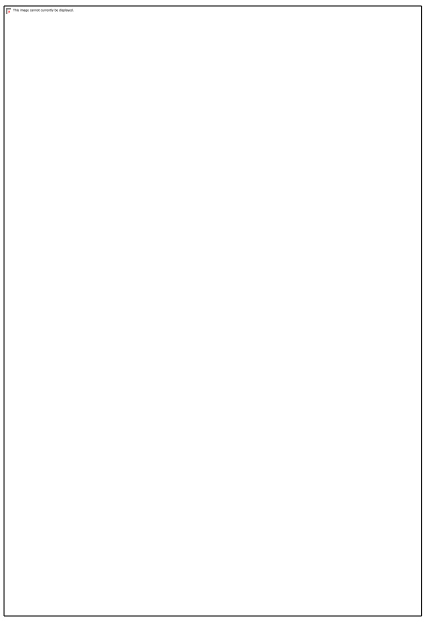
Offices.

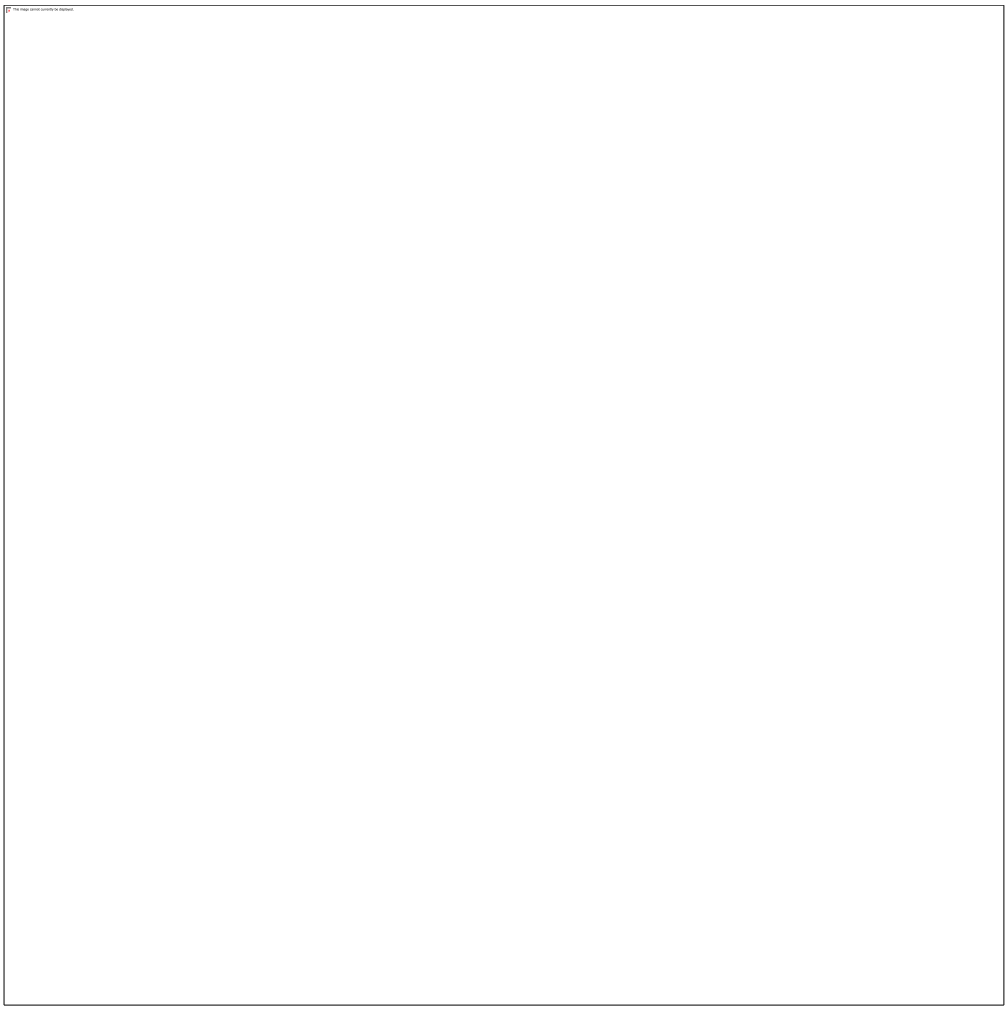
Assembly halls.

Factories.

8.5 Decorative doors







Definition: A decorative door is a door designed mainly to improve the appearance and architectural character of a building, while still performing its normal door functions.

Characteristics

May have carvings, patterns or ornamental features.

Can be made from timber, metal, glass or composite materials.

May have special finishes.

Can be designed to match the building's architectural style.

May include decorative glass or metalwork.

Advantages

Improves building appearance.

Creates an attractive entrance.

Can express cultural or architectural identity.

Adds value to the overall interior or exterior design.

Uses

Main entrances.

Hotels.

Residential houses.

Offices.

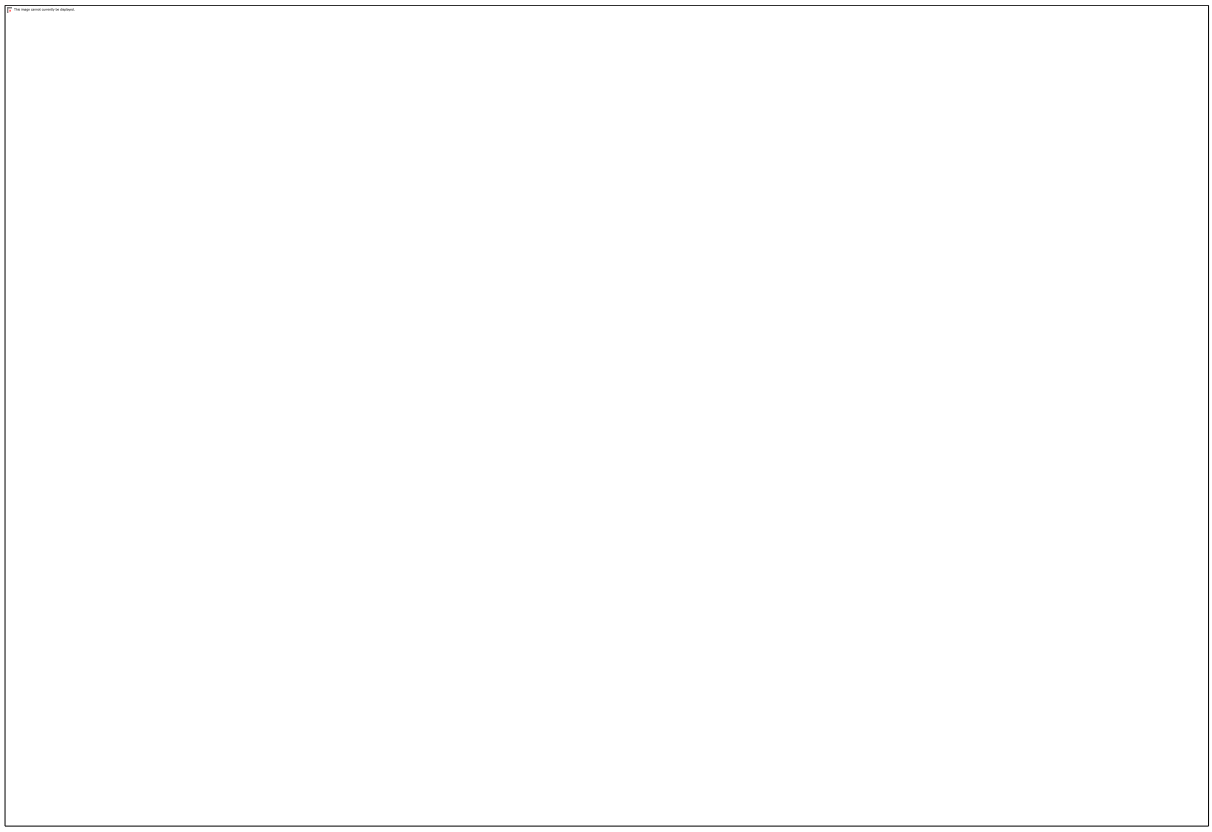
Religious buildings.

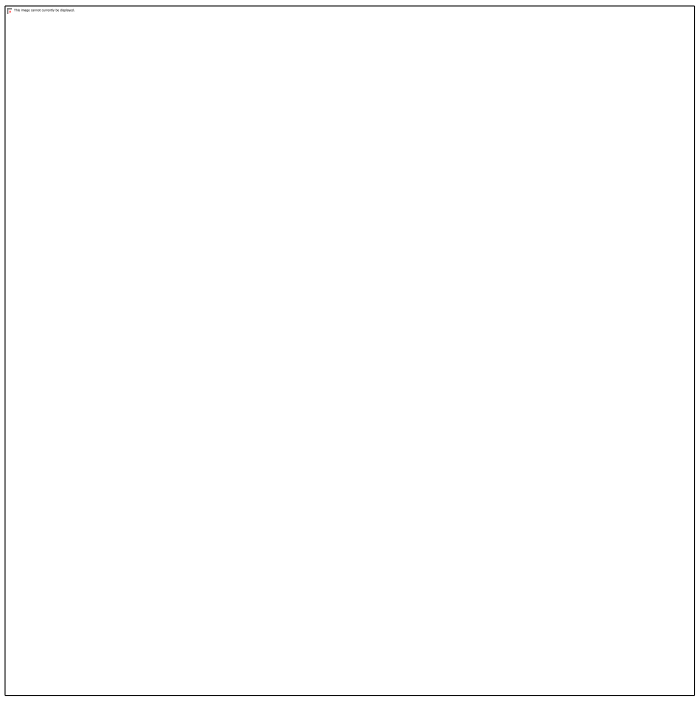
Commercial premises.

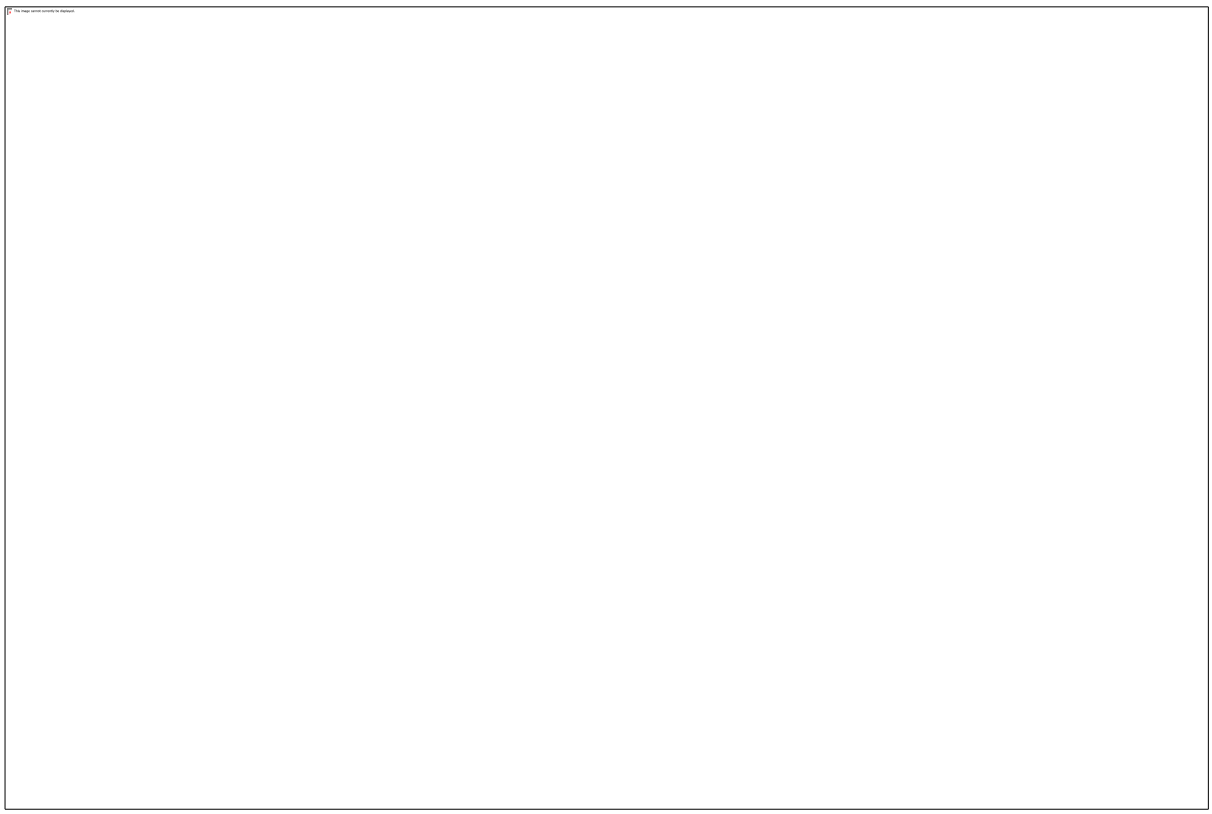
9.0 Components of a door

A complete door installation consists of several components. These include the door leaf, frame, hinges, locks, handles, hinges and other fittings.

The exact components depend on the type and design of the door.







9.1 Door leaf

Definition: A door leaf is the movable part of a door that opens and closes to control access through an opening.

Functions

Covers the doorway when closed.

Provides privacy and security.

Controls movement between spaces.

Protects the building against weather when used externally.

Supports fittings such as locks and handles.

Examples

A timber panel door leaf.

A steel security door leaf.

A glass sliding door leaf.

9.2 Door frame

Definition: A door frame is the fixed structural surround fitted into a wall opening to support the door leaf and its fittings.

A typical door frame consists of:

Head.

Two jambs.

Threshold or sill, where provided.

Stops or rebates, where provided.

Functions of a door frame

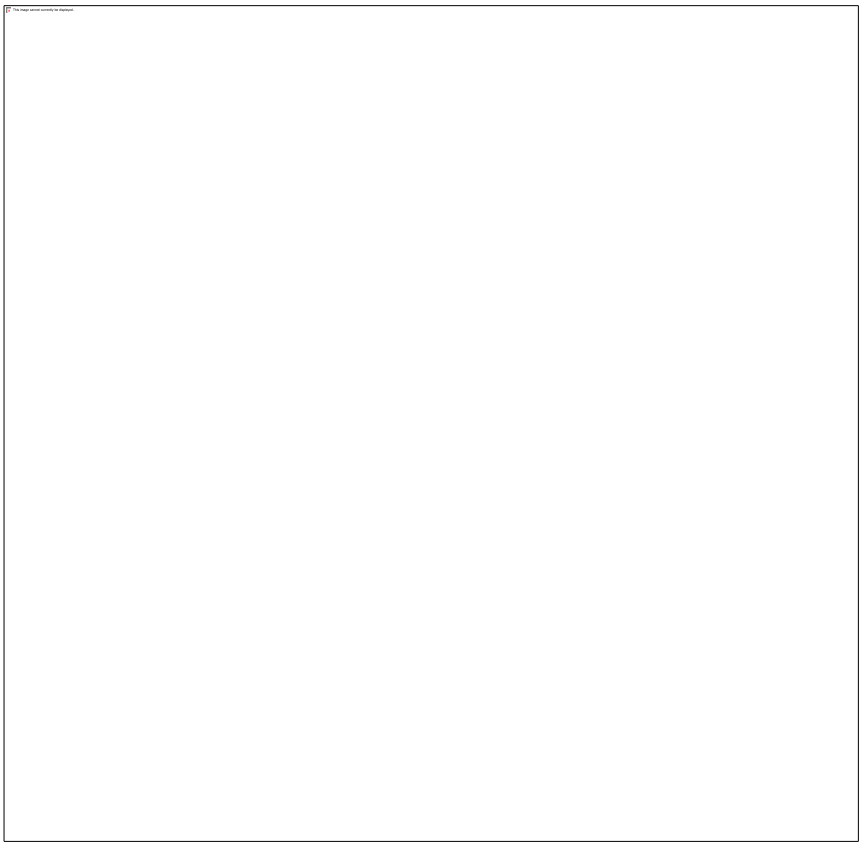
Supports the door leaf.

Provides fixing points for hinges.

Supports the locking and closing arrangements.

Maintains the shape and position of the doorway.

Provides a neat finish around the door opening.



9.3 Head

Definition: The head is the horizontal upper member of a door frame.

Functions

Connects the two jambs at the top.

Helps maintain the shape of the frame.

Provides a finishing edge at the top of the doorway.

Supports the upper part of the frame assembly.

9.4 Jambs

Definition: Jambs are the vertical members forming the two sides of a door frame.

Functions

Support the door leaf through the hinges and other fittings.

Provide fixing points for locks and strike plates.

Connect the head to the lower part of the frame.

Maintain the vertical alignment of the doorway.

9.5 Threshold

Definition: A threshold is a member or finishing strip placed across the bottom of a doorway, particularly at external entrances.

Functions

Provides a transition between floor surfaces.

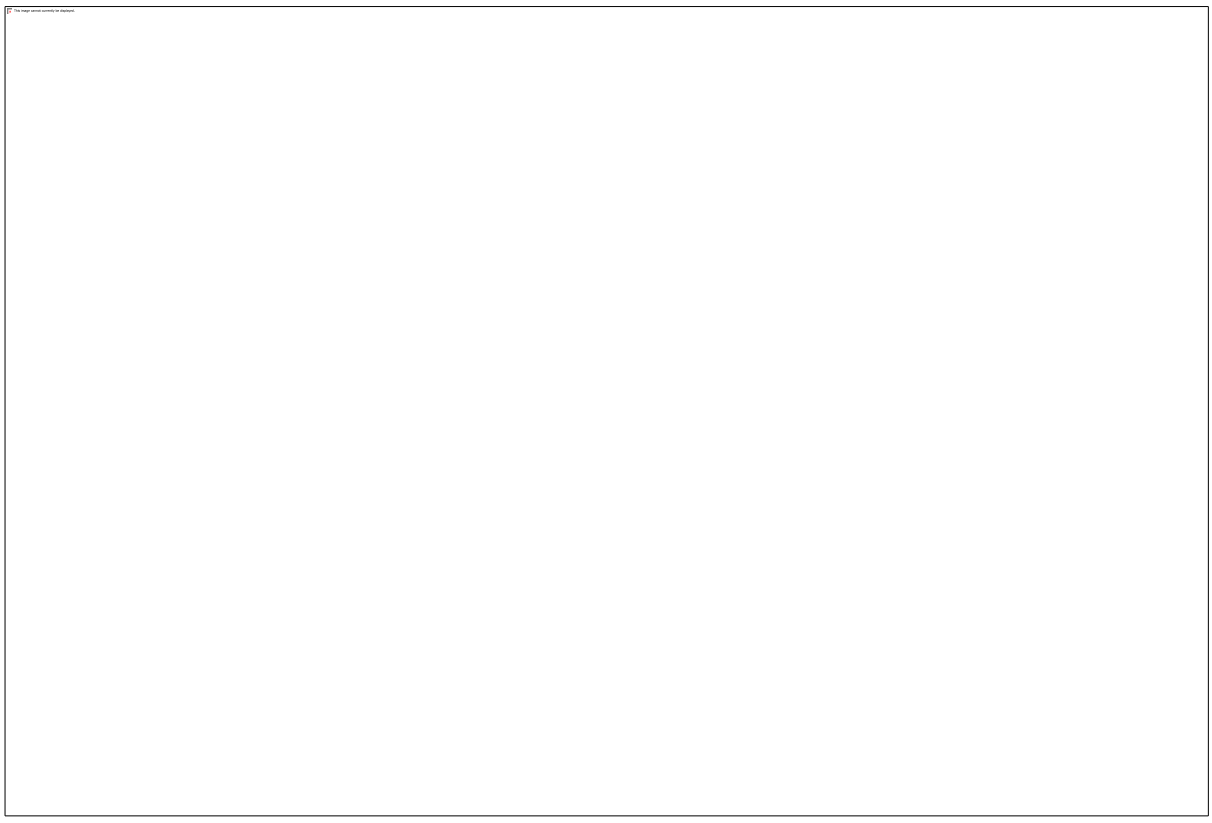
May help reduce the entry of rainwater and dust.

Can improve the finishing of a doorway.

May help support weather sealing.

Note: Not all doors have a raised threshold. Accessible doorways may require low or flush thresholds to reduce tripping hazards and allow easier movement.

9.6 Hinges



Definition: Hinges are mechanical fittings that connect a hinged door leaf to its frame and allow it to rotate during opening and closing.

Functions

Support the door leaf.

Allow the door to swing.

Maintain the connection between the leaf and frame.

Help control the movement of the door.

Transfer the weight of the door to the frame.

Common types of door hinges

Butt hinges.

Parliament hinges.

Pivot hinges.

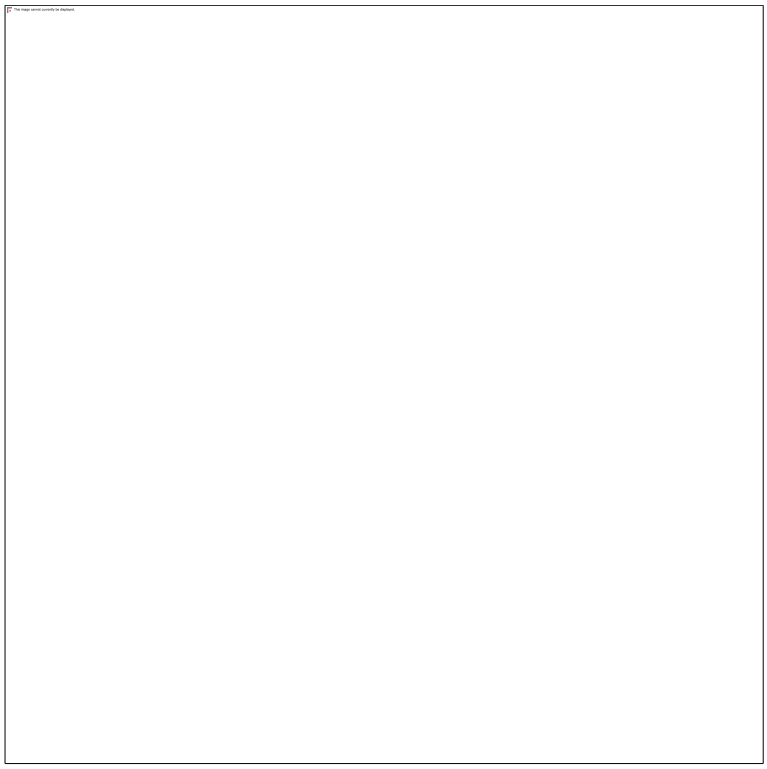
Ball-bearing hinges.

Concealed hinges.

Continuous or piano hinges.

Spring hinges.

9.7 Lock



Definition: A lock is a mechanical or electronic device used to secure a door and restrict unauthorised opening.

Functions

Provides security.

Controls access to rooms and buildings.

Protects property and occupants.

May allow controlled entry using a key, code, card or other approved method.

Types of door locks

Mortice lock.

Cylinder lock.

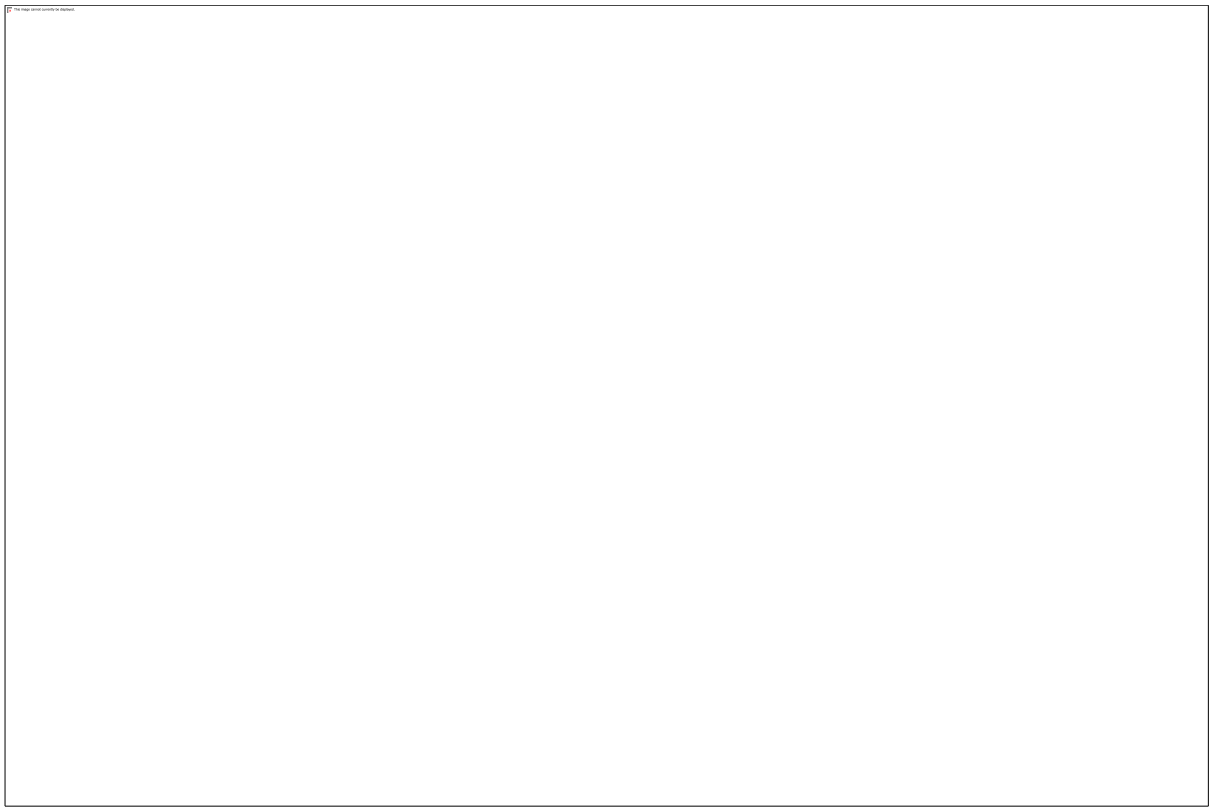
Deadbolt lock.

Padlock arrangement.

Electronic lock.

Smart lock.

9.8 Handle



Definition: A door handle is a fitting used to grip, pull, push or operate a door.

Functions

Enables users to open and close the door.

Provides a convenient gripping point.

May operate a latch mechanism.

Contributes to the appearance of the door.

Types

Lever handles.

Knob handles.

Pull handles.

Flush handles.

Push plates.

9.9 Latch

Definition: A latch is a mechanical fitting that holds a door closed by engaging with a receiver or strike plate.

Functions

Keeps a door in the closed position.

Prevents the door from swinging open unintentionally.

Allows convenient opening and closing.

May work together with a lock.

9.10 Strike plate

Definition: A strike plate is a metal plate fixed to the door frame into which the latch or lock bolt enters when the door is closed.

Functions

Receives the latch or bolt.

Protects the frame around the locking point.

Helps secure the door in the closed position.

Improves the durability of the locking area.

9.11 Door stop

Definition: A door stop is a fitting or fixed component used to limit the movement of a door or prevent the door leaf from hitting a wall or other object.

Functions

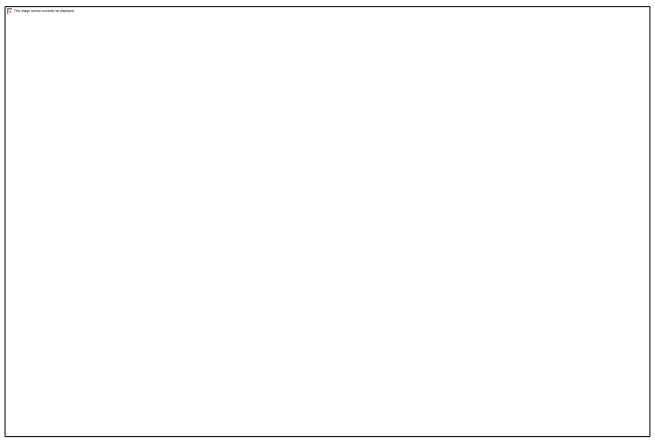
Prevents damage to walls.

Protects door handles and fittings.

Controls the maximum opening position.

Helps maintain the condition of the door and surrounding finishes.

9.12 Door closer



Definition: A door closer is a mechanical device fitted to a door to control and automatically return the door to its closed position after it has been opened.

Functions

Closes the door automatically.

Controls the speed of closing.

Helps prevent doors from remaining open unintentionally.

Supports the operation of some fire doors.

Can reduce slamming when correctly adjusted.

9.13 Weather strip

Definition: A weather strip is a flexible sealing material fitted around a door to reduce the entry of air, water, dust and insects through gaps.

Functions

Reduces air leakage.

Helps prevent rainwater entry.

Reduces dust entry.

Improves thermal comfort.

May improve sound insulation.

9.14 Glazing beads

Definition: Glazing beads are narrow strips used to hold glass panels in position within a glazed door frame or leaf.

Functions

Secure glass panels.

Provide a neat finish around glazing.

Help retain the glass within the frame.

Can allow replacement of glass where the design permits.

9.15 Door panel

Definition: A door panel is a section fitted within the framework of a panel door.

Functions

Forms part of the door surface.

Improves the appearance of the door.

May provide additional strength depending on its construction.

Can be made from timber, glass or other suitable materials.

9.16 Door stile

Definition: A stile is a vertical structural member forming the side of a framed door leaf.

Functions

Forms the vertical sides of the door.

Connects the horizontal rails.

Provides fixing points for hinges and locks.

Helps maintain the shape of the door.

9.17 Door rail

Definition: A rail is a horizontal structural member connecting the vertical stiles of a framed door.

Types

Top rail.

Bottom rail.

Lock rail.

Intermediate rail.

Functions

Connects the stiles.

Strengthens the door framework.

Supports or separates panels.

Provides a fixing area for certain fittings.

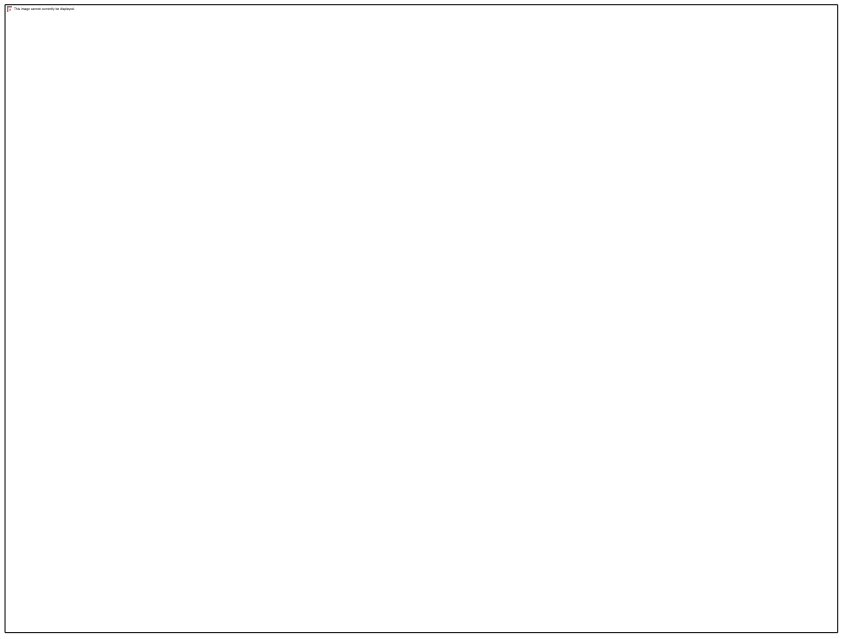
10.0 Sketches of flush and panel doors

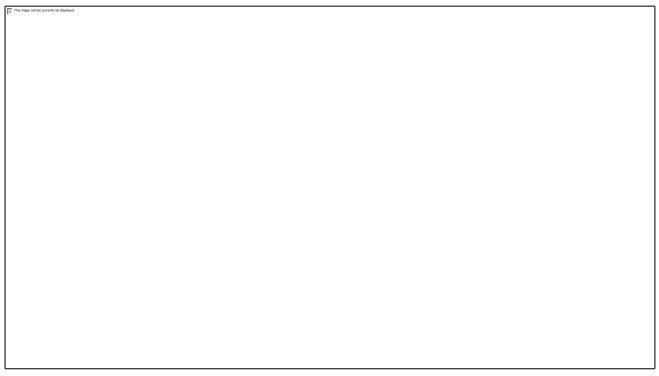
Learners should be able to draw, identify and label the main components of flush and panel doors.

10.1 Sketch of a flush door









Simplified sketch: Front elevation of a flush door

Simplified sketch: Cross-section of a flush door

Explanation of the sketch

Face covering: The outer material forming the smooth surface of the door.

Core: The internal material providing support and determining much of the door's weight and performance.

Edge members: Members along the sides that strengthen the door and provide suitable fixing areas.

Top and bottom rails: Members at the upper and lower edges in designs that use them.

Lipping: Material fixed along the edges to protect and finish the door leaf.

Important features of a flush door

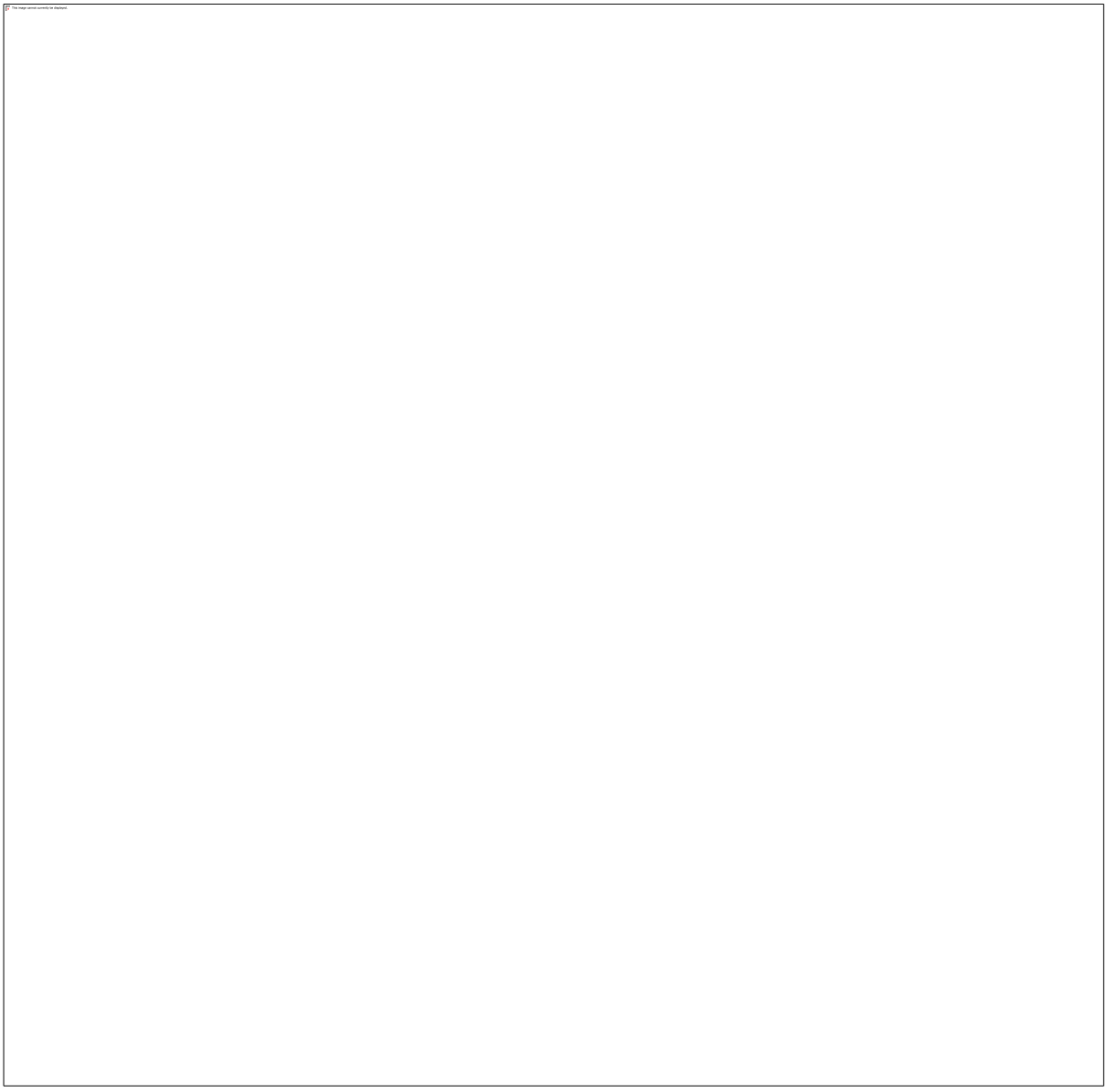
Has smooth surfaces on both sides.

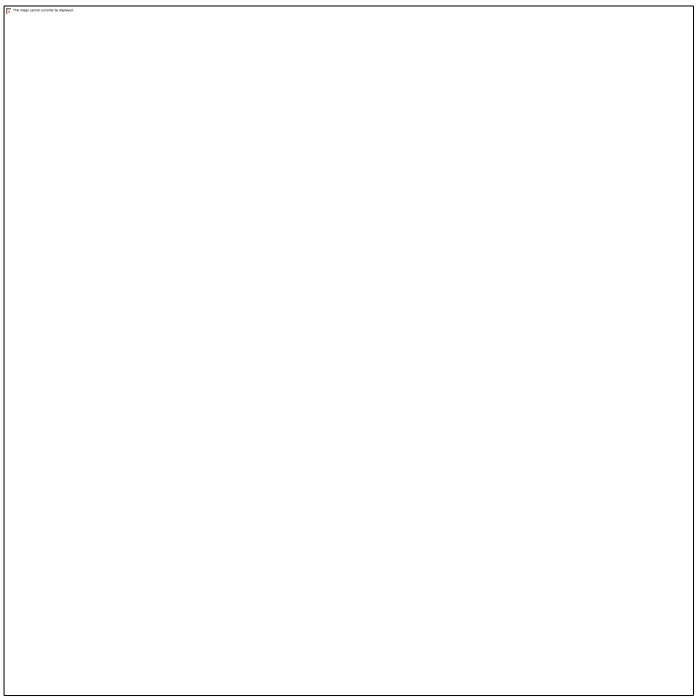
May have a hollow or solid core.

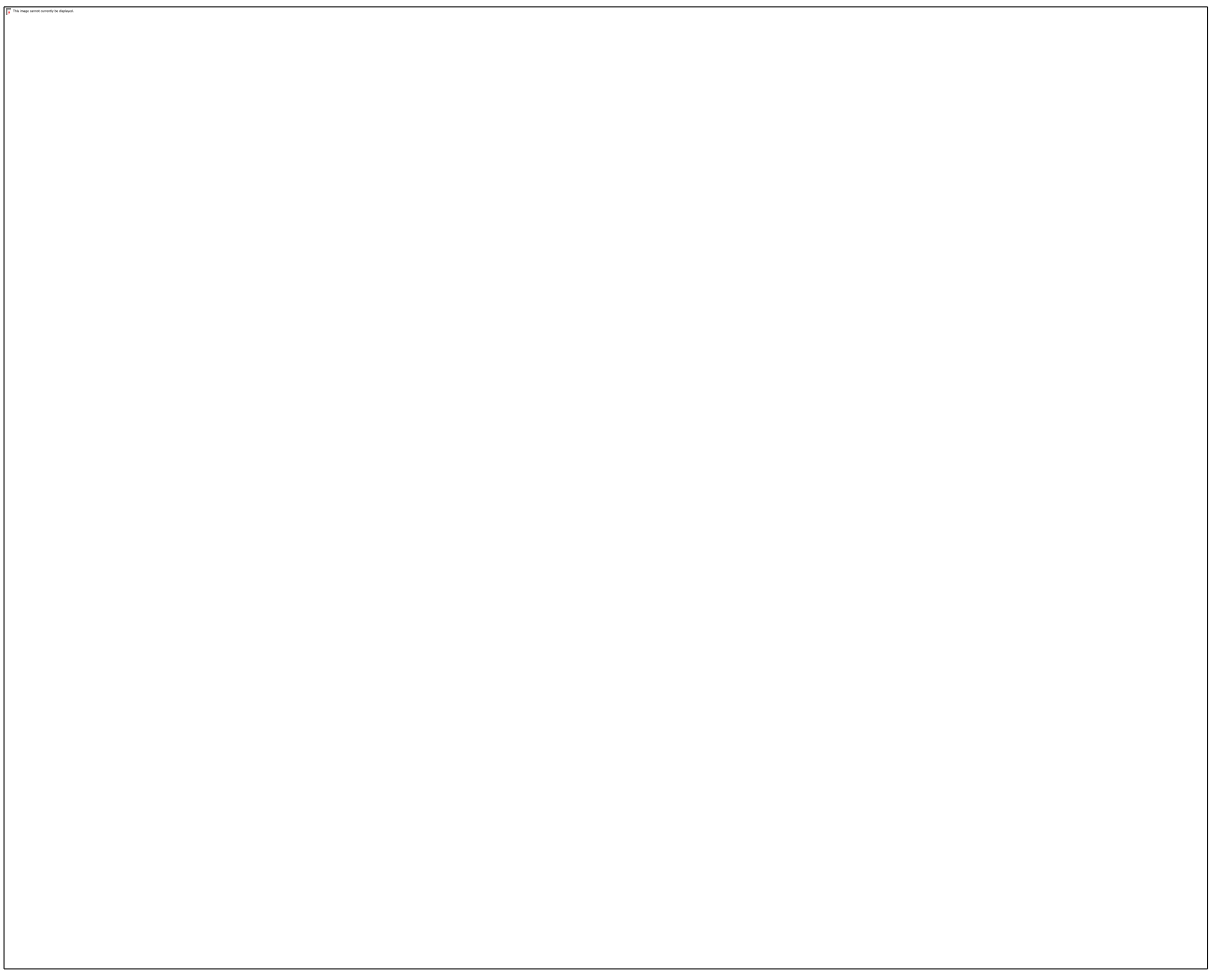
Can be finished with paint, laminate, veneer or other suitable finishes.

Is commonly used for internal doors.

10.2 Sketch of a panel door







Simplified sketch: Front elevation of a panel door



Explanation of the sketch

Top rail: Horizontal member at the top of the door.

Bottom rail: Horizontal member at the bottom.

Lock rail: Horizontal member near the lock or handle.

Stiles: Vertical members forming the sides of the door.

Panels: Sections fitted between the stiles and rails.

10.3 Differences between flush doors and panel doors

Flush door	**Panel door**
Has smooth, flat surfaces	Has separate panels within a framework
Usually has a core covered by face materials	Has stiles, rails and panels
Has a simple appearance	May have a decorative appearance
Can be manufactured with a hollow or solid core	Panels may be solid timber, engineered board or glass
Commonly used for internal doors	Used for internal and external doors
May be relatively economical	May require more skilled workmanship

11.0 Factors to consider when selecting doors for a building

The selection of doors should be based on the building's purpose, location, security needs, accessibility requirements, environmental conditions and available budget.

11.1 Purpose of the door

The intended function determines the type of door required.

A door for a bedroom may have different requirements from a door for a garage.

A fire escape door requires different features from an ordinary internal door.

Example: A school laboratory may require a durable door suitable for the activities carried out inside it.

11.2 Security requirements

External doors should provide suitable protection against unauthorised entry.

Security requirements depend on the location and value of property being protected.

Strong frames, locks, hinges and suitable door materials should be considered.

Example: A shop may require a reinforced steel security door.

11.3 Cost

The purchase price should fit the construction budget.

Installation, transport and hardware costs should also be considered.

Long-term maintenance costs should not be ignored.

11.4 Durability

The door should withstand repeated opening and closing.

Materials should resist wear, impact and environmental damage.

Doors in busy areas require suitable strength and hardware.

11.5 Location

External doors should withstand rain, wind and sunlight.

Internal doors may be selected according to privacy and room use.

Bathroom doors should have suitable moisture resistance.

Garage doors should be suitable for large openings and frequent operation.

11.6 Material availability

Materials should be readily available.

Locally available materials can reduce transportation costs.

Availability of replacement parts should be considered.

11.7 Appearance

The door should complement the building's architectural design.

Colour, texture, shape and finish should be considered.

Decorative doors may be used where appearance is important.

11.8 Weight of the door

Heavy doors require suitable frames, hinges and structural support.

The supporting wall and frame should be strong enough to carry the door.

Door weight also affects ease of operation.

11.9 Maintenance requirements

Some materials require frequent painting or treatment.

Door hardware should be easy to inspect and replace.

The cost and availability of maintenance materials should be considered.

11.10 Fire safety

Doors in designated fire compartments and escape routes should meet the required fire-performance specifications.

Fire doors should be complete compatible assemblies.

Their installation and maintenance should follow approved requirements.

11.11 Sound insulation

Doors in offices, bedrooms and hospitals may require sound-reducing properties.

Solid-core doors and suitable seals can reduce noise transmission.

Special acoustic doors may be necessary in sound-sensitive spaces.

11.12 Privacy

Bedrooms, bathrooms and consultation rooms require suitable privacy.

Clear glass may not be appropriate in some private spaces.

Frosted or patterned glazing may be considered where light transmission is desired.

11.13 Ventilation

Some rooms require additional air circulation.

Louvered doors may be suitable in certain utility spaces.

The ventilation design must also consider security, privacy and fire safety.

11.14 Ease of operation

Doors should be easy to open and close.

The operating mechanism should suit the expected users.

Sliding doors may be appropriate where there is insufficient swing space.

Door closers should be adjusted to avoid excessive opening forces.

11.15 Accessibility

Doors should allow appropriate access for all intended users.

Consider clear opening width, threshold height, handle position and operating force.

Accessible routes should not have unnecessary obstacles.

The door design should accommodate users with mobility limitations.

11.16 Environmental conditions

Moisture, heat, dust and exposure to sunlight can affect door performance.

Timber doors require suitable protection against moisture and insect attack.

Metal doors require suitable corrosion protection.

PVC and composite doors should be suitable for the expected temperatures and exposure conditions.

11.17 Building regulations and standards

Door selection and installation should comply with applicable Kenyan building requirements.

Fire doors and emergency exits should follow the approved fire-safety design.

Safety glazing should be used where required.

Structural fixing, accessibility and safe operation should be considered.

12.0 Door installation

Door installation is the process of fixing a door frame and door leaf into a prepared wall opening so that the door operates correctly.

12.1 Basic steps in installing a hinged door

Step 1: Preparation of the opening

Check the dimensions of the wall opening.

Ensure that the opening is correctly positioned.

Remove loose materials and obstructions.

Check that the surrounding wall is stable.

Confirm the door size and frame dimensions.

Step 2: Preparing the door frame

Measure the required frame dimensions.

Cut the head and jambs to the required sizes.

Join the frame members accurately.

Check that the frame is square.

Prepare suitable fixing points.

Step 3: Positioning the frame

Place the frame into the wall opening.

Use suitable temporary supports or wedges.

Check the vertical alignment of the jambs.

Check that the head is level.

Confirm that the frame is square and correctly positioned.

Step 4: Fixing the frame

Secure the frame using suitable anchors or approved fixing methods.

Ensure that the frame is firmly attached to the wall.

Fill and finish gaps using appropriate materials.

Avoid distorting the frame during fixing.

Step 5: Fixing the hinges

Mark the hinge positions on the door leaf.

Mark corresponding positions on the frame.

Prepare suitable recesses where required.

Fix the hinges using appropriate screws.

Check that the hinge pins are correctly aligned.

Step 6: Hanging the door leaf

Position the door leaf against the frame.

Connect the hinges.

Check the gaps around the door.

Ensure that the leaf swings freely.

Make necessary adjustments.

Step 7: Fixing locks and handles

Mark the position of the lock.

Prepare the required recesses or holes.

Install the lock mechanism.

Fit the handle.

Fix the strike plate to the frame.

Test the locking mechanism.

Step 8: Finishing

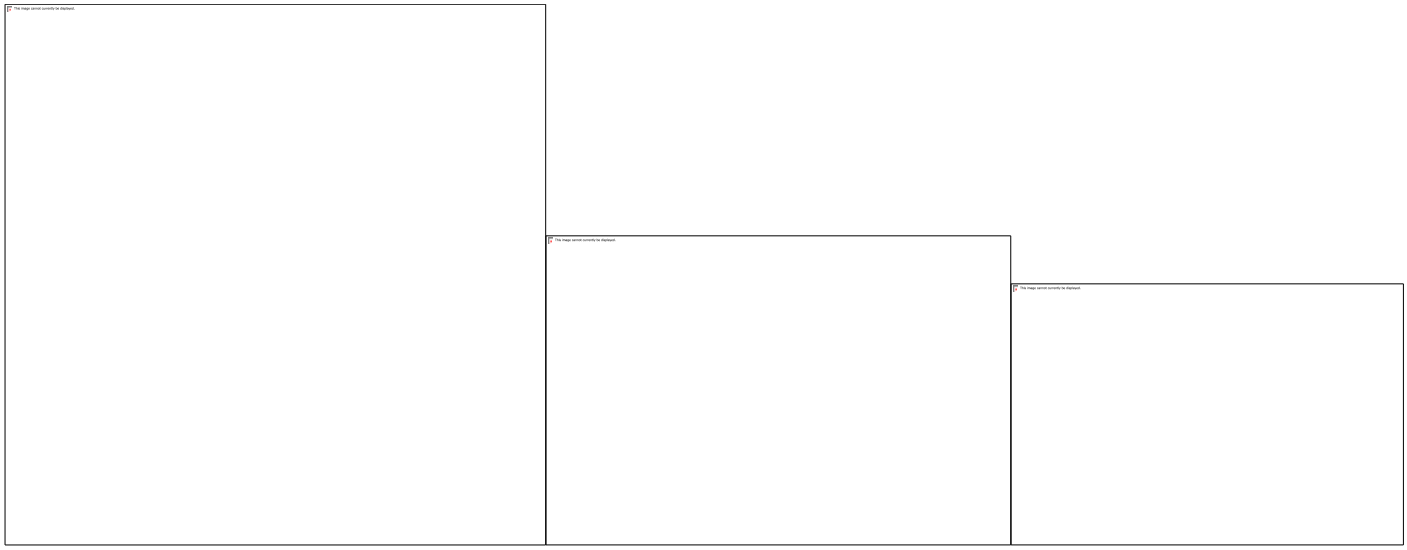
Sand timber surfaces where necessary.

Apply suitable paint, stain, varnish or other finish.

Install weather strips where required.

Clean the door and surrounding area.

Test the complete installation.



13.0 Maintenance of doors

Door maintenance involves inspecting, cleaning, adjusting and repairing doors to ensure safe and effective operation.

13.1 Timber doors

Apply suitable protective finishes.

Inspect for termite damage.

Repair scratches and damaged surfaces.

Prevent prolonged exposure to moisture.

Check for warping and loose joints.

Replace badly damaged sections where necessary.

13.2 Metal doors

Inspect for rust and corrosion.

Repair damaged protective coatings.

Lubricate hinges and moving parts where appropriate.

Tighten loose screws and fittings.

Check locks and handles.

Repair dents and damaged sections.

13.3 Glass doors

Clean glass surfaces regularly.

Inspect for cracks and chips.

Check glazing seals.

Tighten or adjust suitable fittings.

Check sliding tracks and rollers.

Replace damaged safety glazing using an appropriate system.

13.4 PVC doors

Clean using suitable cleaning materials.

Avoid excessive heat exposure.

Inspect hinges and locks.

Check for cracks and deformation.

Replace damaged fittings.

Avoid harsh chemicals that may damage the surface.

13.5 Composite doors

Clean according to the manufacturer's instructions.

Inspect joints and edges.

Check locks and hinges.

Repair damaged finishes using approved methods.

Prevent water from entering damaged joints.

Inspect the door for warping or delamination.

13.6 Common door defects and their remedies

Defect	Possible cause	Remedy
Door sticking	Swelling, poor alignment or loose hinges	Adjust hinges and correct the cause
Door sagging	Loose or inadequate hinges	Tighten or replace suitable hinges
Broken lock	Wear, damage or poor installation	Repair or replace the lock
Rusting	Damaged protective coating	Remove corrosion and apply suitable protection
Cracked timber	Drying, impact or poor timber quality	Repair or replace the affected part
Broken glass	Impact or unsuitable glazing	Replace with appropriate safety glazing
Loose handle	Loose screws or worn fittings	Tighten or replace fittings
Noisy hinges	Lack of lubrication or wear	Lubricate or replace hinges
Warped door	Moisture or poor seasoning	Control moisture and repair or replace the door
Sliding door jamming	Dirty tracks or damaged rollers	Clean tracks and repair rollers

14.0 Safety precautions during door construction and installation

Wear appropriate PPE, including safety boots, gloves and eye protection.

Use sharp tools and cutting equipment carefully.

Ensure that electrical tools are in good working condition.

Support heavy doors during installation to prevent them from falling.

Use suitable lifting techniques when handling heavy doors.

Avoid leaving sharp metal edges exposed.

Use appropriate safety glazing in doors containing glass.

Store glass panels upright in suitable racks and handle them carefully.

Ensure that door frames are securely fixed before hanging heavy leaves.

Keep the working area clean and free from obstructions.

Use appropriate dust controls when cutting or sanding materials.

Follow the manufacturer's instructions when installing mechanical or motorised door systems.

Do not obstruct emergency exit doors.

Do not disable or interfere with fire-door closers and seals.

Ensure that installed doors open and close safely without trapping fingers or causing injury.

15.0 Practical learning activities

Activity 1: Identifying doors in the school compound

Requirements

Notebook.

Pencil.

Camera or mobile device, where permitted.

Door classification table.

Procedure

Walk around the school compound under the teacher's guidance.

Identify different doors used in classrooms, offices, stores and toilets.

Record the material used to manufacture each door.

Identify the method of operation.

Identify the purpose of each door.

Discuss why each door is suitable for its location.

Expected learning outcome: Learners should be able to classify doors according to materials, operation, construction and location.

Activity 2: Identifying door components

Requirements

An existing door.

Labels.

Notebook.

Pencil.

Procedure

Observe a hinged timber door.

Identify the door leaf.

Identify the head and jambs.

Locate the hinges.

Identify the lock and handle.

Identify the door stop and threshold where provided.

Draw and label the components.

Activity 3: Making a model of a panel door

Materials

Cardboard.

Thin timber strips.

Glue.

Ruler.

Pencil.

Cutting tools under supervision.

Procedure

Draw a simple panel door design.

Prepare two vertical stiles.

Prepare the top, bottom and lock rails.

Fit lightweight panels between the frame members.

Assemble the parts carefully.

Label the different components.

Present the model to the class.

Activity 4: Selecting doors for different rooms

Scenario

A contractor is constructing a school containing classrooms, a laboratory, an administration office, toilets and a main entrance.

Tasks

Recommend a suitable door for each area.

State the material you would select.

Explain the purpose of each selected door.

Identify the fittings required.

Explain the safety requirements for emergency exits.

16.0 Summary of key terms

Term	**Meaning**
Door	Movable or operable barrier fitted in an opening
Door leaf	Movable part of a door
Door frame	Fixed structure supporting the door leaf

Head	Horizontal upper member of a door frame
Jamb	Vertical side member of a door frame
Threshold	Member or finishing strip at the bottom of a doorway
Hinge	Fitting allowing a door to rotate
Lock	Device used to secure a door
Handle	Fitting used to operate a door
Latch	Fitting that holds a door closed
Strike plate	Plate receiving the lock bolt or latch
Door closer	Device that automatically closes a door
Flush door	Door with smooth, flat faces
Panel door	Door with panels fitted into a framework
Glazed door	Door containing glass panels
Louvered door	Door containing angled slats for ventilation
Framed and battened door	Door made using battens supported by framing members
Hinged door	Door that rotates on side hinges
Sliding door	Door that moves horizontally along tracks
Folding door	Door made of panels that fold together
Revolving door	Door with leaves rotating around a central axis
Rolling door	Door that rolls around a drum
Pivot door	Door rotating around top and bottom pivot points
Fire door	Tested door assembly designed to resist fire for a specified period

Acoustic door	Door designed to reduce sound transmission
Security door	Door designed to resist unauthorised entry

REVISION QUESTIONS

SECTION A: MULTIPLE-CHOICE QUESTIONS

INSTRUCTIONS: Choose the correct answer from the alternatives provided.

1. Which of the following best defines a door?

A. A permanent horizontal member supporting a roof.
B. A movable barrier fitted into an opening to control access.
C. A vertical member supporting a foundation.
D. A material used for floor finishing.

2. Which of the following is an important function of a door?

A. Supporting the foundation.
B. Providing access and security.
C. Increasing the thickness of a wall.
D. Supporting roof trusses.

3. Which material is commonly used in the manufacture of traditional panel doors?

A. Timber
B. Sand
C. Concrete blocks
D. Roofing felt

4. A door attached to a frame using hinges and rotating around one vertical edge is called a:

A. Sliding door
B. Revolving door
C. Hinged door
D. Rolling door

5. Which type of door moves horizontally along tracks?

A. Folding door
B. Sliding door
C. Pivot door
D. Revolving door

6. A door made up of several connected panels that fold together is known as a:

A. Folding door
B. Hinged door
C. Flush door
D. Security door

7. Which type of door has leaves that rotate around a central vertical axis?

A. Sliding door
B. Revolving door
C. Rolling door
D. Panel door

8. A door made of interconnected slats that roll around a drum is called a:

A. Glazed door
B. Rolling door
C. Pivot door
D. Louvered door

9. Which material is particularly suitable for doors used in many damp environments?

A. Untreated timber
B. PVC
C. Unprotected steel
D. Ordinary cardboard

10. Which of the following is a major advantage of glass doors?

A. They cannot break.
B. They allow natural light into buildings.
C. They are always cheaper than timber doors.
D. They provide complete privacy in all conditions.

11. Which metal is commonly used to manufacture security doors?

A. Steel
B. Lead pencil graphite
C. Copper wire only
D. Tin foil

12. A door constructed using stiles, rails and panels is known as a:

A. Flush door
B. Panel door
C. Rolling door
D. Revolving door

13. Which of the following best describes a flush door?

A. A door with smooth, flat faces.
B. A door made entirely of glass.
C. A door with horizontal louvers only.
D. A door that rotates around a central axis.

14. The vertical members forming the sides of a panel door are known as:

A. Rails
B. Stiles
C. Hinges
D. Stops

15. The horizontal member at the top of a framed panel door is known as the:

A. Top rail
B. Bottom rail
C. Stile
D. Threshold

16. Which component connects the door leaf to the frame and allows it to rotate?

A. Lock
B. Hinge

C. Handle
D. Threshold

17. Which component is fitted to the door frame to receive the latch or lock bolt?

A. Strike plate
B. Door closer
C. Door stop
D. Soffit board

18. Which type of door allows ventilation through angled slats?

A. Flush door
B. Louvered door
C. Solid-core door
D. Fire door

19. A door fitted at the entrance of a garage is known as a:

A. Garage door
B. Panel door
C. Acoustic door
D. Internal door

20. Which of the following doors is specially designed to resist the spread of fire?

A. Decorative door
B. Fire door
C. Louvered door
D. Ordinary hollow-core door

21. Which type of door is designed mainly to reduce the transmission of sound?

A. Acoustic door
B. Revolving door
C. Rolling door
D. Decorative door

22. Which door is designed to provide a safe route out of a building during an emergency?

A. Decorative door
B. Emergency exit door
C. Louvered door
D. Sliding wardrobe door

23. Which of the following is a disadvantage of timber doors?

A. They cannot be painted.
B. They may swell when exposed to moisture.
C. They cannot be shaped.
D. They are always transparent.

24. Which of the following is an advantage of metal doors?

A. They are always lightweight.
B. They can provide high strength and security.

C. They cannot corrode.
D. They do not require suitable installation.

25. The horizontal upper member of a door frame is known as the:

A. Jamb
B. Head
C. Stile
D. Panel

26. The vertical side members of a door frame are known as:

A. Rails
B. Jambs
C. Panels
D. Thresholds

27. Which component automatically returns a door to its closed position?

A. Door closer
B. Door handle
C. Strike plate
D. Door panel

28. Which factor is particularly important when selecting an external door?

A. Its suitability for weather exposure and security.
B. Its ability to support a roof.
C. Its colour only.
D. Its ability to replace a window.

29. Why should safety glazing be considered when selecting glass doors?

A. To make the door heavier.
B. To reduce the risk of injury from glass breakage.
C. To prevent the door from opening.
D. To remove the need for a frame.

30. Which of the following is a major function of a door frame?

A. To support the door leaf and its fittings.
B. To support roof coverings.
C. To carry foundation loads.
D. To collect rainwater.

SECTION B: STRUCTURED QUESTIONS

1. a) Define the term door. (2 marks)

b) Explain six importance of doors in buildings. (6 marks)

c) State four factors that determine the selection of doors for a building. (4 marks)

2. a) Identify five materials used in door construction. (5 marks)

b) Explain four advantages of timber doors. (4 marks)

c) State three disadvantages of metal doors. (3 marks)

3. a) Classify doors according to their mode of operation. (8 marks)

b) Explain the operation of a sliding door. (2 marks)

4. a) Define a panel door. (2 marks)

b) Name five components of a panel door. (5 marks)

c) Explain the functions of stiles and rails in a panel door. (4 marks)

5. a) Define a flush door. (2 marks)

b) Differentiate between solid-core and hollow-core flush doors. (4 marks)

c) State four advantages of flush doors. (4 marks)

6. a) Differentiate between a glazed door and a louvered door. (4 marks)

b) State four advantages of glazed doors. (4 marks)

c) Give two uses of louvered doors. (2 marks)

7. Explain the functions of the following door components:

a) Door leaf. (2 marks)

b) Door frame. (2 marks)

c) Hinges. (2 marks)

d) Lock. (2 marks)

e) Door closer. (2 marks)

8. a) Classify doors according to their location in a building. (4 marks)

b) Explain four characteristics of an external door. (4 marks)

c) State two uses of internal doors. (2 marks)

9. a) Define a fire door. (2 marks)

b) Explain four functions of fire doors. (4 marks)

c) State four precautions to observe when installing fire doors. (4 marks)

10. Draw and label a well-proportioned sketch of a panel door showing:

Top rail.

Bottom rail.

Lock rail.

Stiles.

Panels.

(8 marks)

11. Draw a simple sketch of a flush door and explain its main construction features. (6 marks)

12. A contractor is constructing a modern residential house in Kenya. The building has bedrooms, bathrooms, a main entrance, a garage and a veranda.

a) Recommend a suitable type of door for each of the five locations. (5 marks)

b) Explain five factors the contractor should consider when selecting the doors. (5 marks)

13. a) Differentiate between a hinged door and a pivot door. (4 marks)

b) Explain three advantages of sliding doors. (3 marks)

c) State three disadvantages of folding doors. (3 marks)

14. Describe the main stages followed when installing a hinged timber door into a prepared wall opening. (10 marks)

15. Explain five maintenance practices that should be carried out on doors to ensure durability and efficient operation. (10 marks)

Suggested practical project: Design and make a model door

Project: Construct a miniature panel door or flush door using locally available materials.

Materials

Cardboard or thin plywood.

Thin timber strips.

Glue.

Ruler.

Pencil.

Small hinges or suitable model fittings.

Paint or finishing materials.

Project procedure

Select the type of door to construct.

Draw a simple design.

Measure and mark the required dimensions.

Prepare the frame or core.

Assemble the door components.

Fix the panels or face coverings.

Add model hinges and a handle.

Apply a suitable finish.

Label the components.

Present the model and explain how it works.

Suggested assessment criteria

Assessment area	Evidence of achievement
Knowledge	Correctly explains the selected door type
Identification	Identifies door components accurately
Design	Produces a suitable door drawing
Practical skills	Measures, cuts and joins materials accurately

Creativity	Produces an attractive and functional model
Communication	Explains the construction process clearly
Collaboration	Works effectively with other learners
Safety	Uses tools and materials safely

STRAND 3.0: BUILDING CONSTRUCTION PROCESS

SUB-STRAND 3.7: WINDOWS



1.0 Introduction to windows

A window is an opening provided in the wall or roof of a building and fitted with a glazed or other suitable panel, usually within a frame, to allow natural light and ventilation into the building.

Windows are important building components because they improve the comfort, health, safety, appearance and functionality of buildings.

In residential, commercial, institutional and industrial buildings in Kenya, windows are installed in places such as classrooms, offices, bedrooms, kitchens, hospitals, workshops and living rooms.

Examples of common windows found in Kenyan buildings include:

Aluminium sliding windows in modern houses and offices.

Steel casement windows in workshops and older buildings.

Timber-framed windows in traditional and residential buildings.

uPVC windows in buildings requiring good thermal and sound insulation.

Fixed glass windows in shops, offices and commercial buildings.

1.1 Characteristics of a good window

A good window should:

Allow sufficient natural light into the building.

Provide adequate ventilation where it is designed to open.

Be strong enough to withstand wind pressure and normal use.

Provide security against unauthorised entry.

Prevent excessive entry of rainwater and dust.

Be easy to open, close, clean and maintain.

Have a suitable appearance that complements the building.

Be durable and resistant to weather conditions.

Provide privacy where necessary.

Be properly fitted to prevent air and water leakage.

2.0 Importance of windows in buildings

Windows perform several important functions in buildings.

2.1 Providing natural lighting

Windows allow sunlight to enter rooms during the day.

Natural lighting reduces the need for artificial lighting.

It helps learners and workers see clearly when reading, writing and performing tasks.

Proper daylighting can reduce electricity consumption.

Example: Large windows in classrooms allow learners to read books and write without depending entirely on electric lights during daylight hours.

2.2 Providing ventilation

Opening windows allow fresh air to enter a room.

They allow warm, stale or polluted indoor air to escape.

Good ventilation helps maintain comfortable indoor conditions.

It helps reduce unpleasant smells, moisture and condensation.

It can improve indoor air quality when windows are properly positioned.

Example: Casement and louvred windows are commonly used in kitchens and classrooms to improve air circulation.

2.3 Improving the appearance of buildings

Windows contribute to the architectural design of a building.

They create attractive patterns and visual balance on external walls.

Different window shapes and sizes can give a building a modern or traditional appearance.

2.4 Providing an emergency escape route

Some appropriately designed and approved windows can serve as emergency escape openings.

They may provide an alternative exit during a fire or another emergency.

Their size, location, opening mechanism and accessibility must comply with applicable building and fire-safety requirements.

Not every window can be used as an emergency exit.

2.5 Providing views of the surroundings

Windows allow occupants to see outside the building.

They connect indoor spaces with the outdoor environment.

They can improve the sense of openness in a room.

2.6 Supporting natural lighting and ventilation in energy-efficient buildings

Properly positioned windows can reduce dependence on electric lighting.

Natural ventilation may reduce the need for mechanical cooling in suitable climates.

Shading devices and appropriate glazing help control excessive heat and glare.

2.7 Providing security

Strong window frames, suitable glazing, locks and restrictors help protect buildings.

Security grilles may be installed where appropriate.

Security features should not obstruct required emergency escape.

2.8 Providing privacy

Frosted, tinted or patterned glass can reduce visibility into rooms.

Blinds, curtains and other window coverings can provide additional privacy.

Privacy glazing is useful in bathrooms, clinics, offices and other sensitive spaces.

2.9 Controlling weather conditions

Properly designed windows help keep out rain, wind and dust.

Seals, weather strips, drainage channels and suitable frames improve weather resistance.

2.10 Supporting health and comfort

Natural light and ventilation contribute to comfortable indoor environments.

Adequate ventilation can help control moisture and indoor pollutants.

Proper daylighting can improve the usability of learning and working spaces.

3.0 Materials used for window construction

Windows are manufactured using different materials depending on their purpose, cost, appearance, strength, durability and environmental conditions.

The main materials include:

Timber.

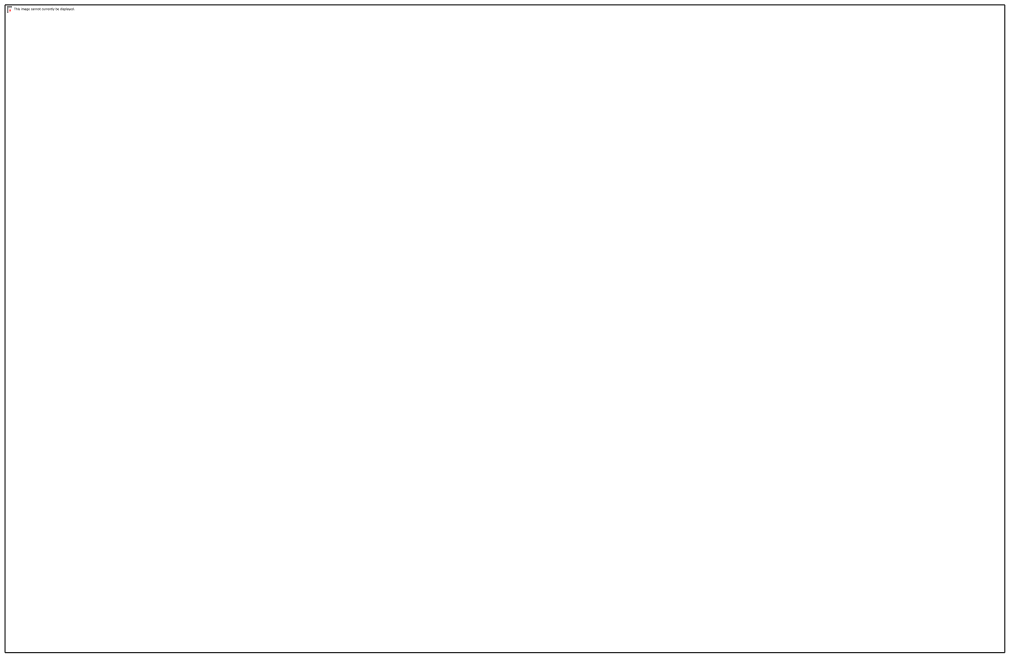
Metal.

Glass.

Unplasticised polyvinyl chloride (uPVC).

Composite materials.

3.1 Timber



Timber is a natural building material obtained from trees. It is used to manufacture window frames, sashes and other window components.

Examples of timber used:

Cypress.

Cedar.

Meru oak.

Mvule.

Other suitable seasoned hardwoods and softwoods.

Characteristics of timber windows

Timber is relatively easy to cut, shape and join.

It has a natural attractive appearance.

It is a relatively good thermal insulator.

It can be painted, stained or varnished.

Its strength depends on the species, quality and condition of the timber.

It requires protection against moisture, fungi and insect attack.

Advantages of timber windows

They have a warm and attractive natural appearance.

They can be manufactured into different shapes and sizes.

They are relatively easy to repair and modify.

They provide good thermal insulation.

Timber is renewable when sourced from responsibly managed forests.

Disadvantages of timber windows

They may absorb moisture and swell.

They may shrink, warp or crack if poorly seasoned.

They can be attacked by termites and wood-boring insects.

They require regular painting, sealing or varnishing.

Poor-quality timber may decay when exposed to moisture.

Uses of timber windows

Residential houses.

Traditional buildings.

Schools and offices.

Buildings designed with natural timber finishes.

3.2 Metal



Metal is used to manufacture strong and durable window frames and opening sections.

Common metals used include:

Aluminium.

Steel.

Galvanised steel.

Other suitable corrosion-resistant metal alloys.

Characteristics of metal windows

They are generally strong and durable.

They can be manufactured into slim frame sections.

They can support large glazed areas when properly designed.

Some metals conduct heat readily.

Steel requires suitable corrosion protection.

Aluminium naturally forms a protective oxide layer but may still require suitable finishes and detailing.

Advantages of metal windows

They are strong and can provide good security when properly designed.

They are suitable for modern architectural designs.

Aluminium frames are relatively light.

They can have a long service life when properly installed and maintained.

They can accommodate large glass panels.

They are generally resistant to termite attack.

Disadvantages of metal windows

Steel may rust when its protective coating is damaged.

Metal frames may transfer heat into or out of a building.

Some metal sections may bend or dent under impact.

Metal windows may be more expensive than some basic timber alternatives.

Poorly maintained joints and finishes may deteriorate.

Uses of metal windows

Commercial buildings.

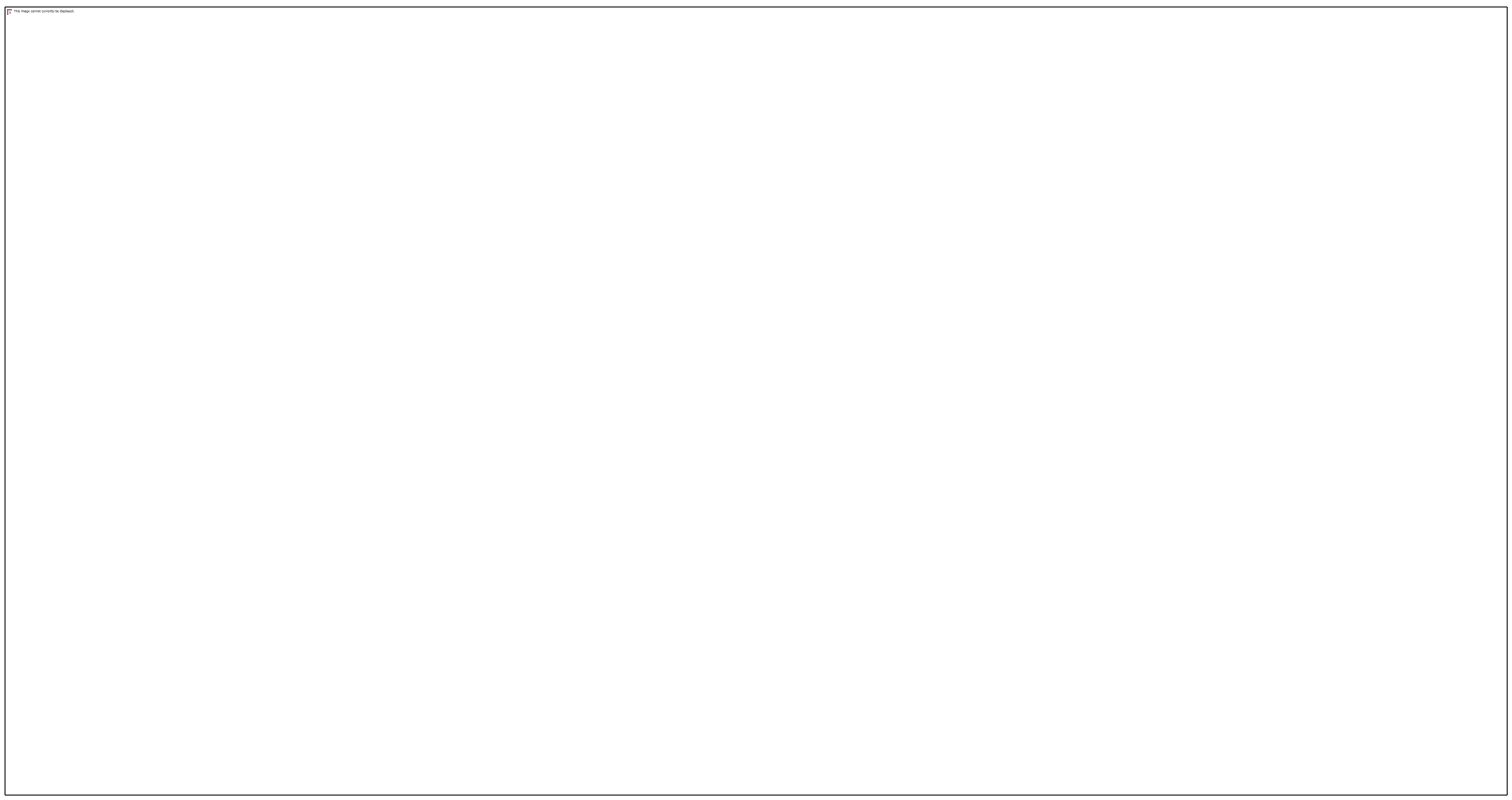
Schools and hospitals.

Industrial buildings.

Residential houses.

Shops and office blocks.

3.3 Glass



Glass is a transparent or translucent material used mainly to fill the openings in window frames.

Types of glass used in windows

Clear glass – allows a high level of visibility and daylight.

Tinted glass – reduces glare and may reduce solar heat gain, depending on its properties.

Frosted glass – provides privacy while allowing light to pass through.

Laminated safety glass – consists of glass layers bonded together using an interlayer.

Toughened or tempered glass – specially heat-treated to improve its strength and safety characteristics.

Patterned glass – has a decorative surface that distorts visibility.

Insulating glass units – use two or more panes separated by a sealed space to improve thermal performance.

Advantages of glass

It allows natural light into buildings.

It provides views of the surroundings.

It is available in different colours, finishes and thicknesses.

It can create an attractive modern appearance.

Special glass products can improve safety, privacy and thermal performance.

Disadvantages of glass

Ordinary glass can break when struck.

Some glass types may allow excessive solar heat and glare.

Large glass panels can be costly.

Glass requires careful handling during transportation and installation.

Glass can create safety risks if unsuitable products are installed in vulnerable locations.

Uses of glass in windows

Residential windows.

Office buildings.

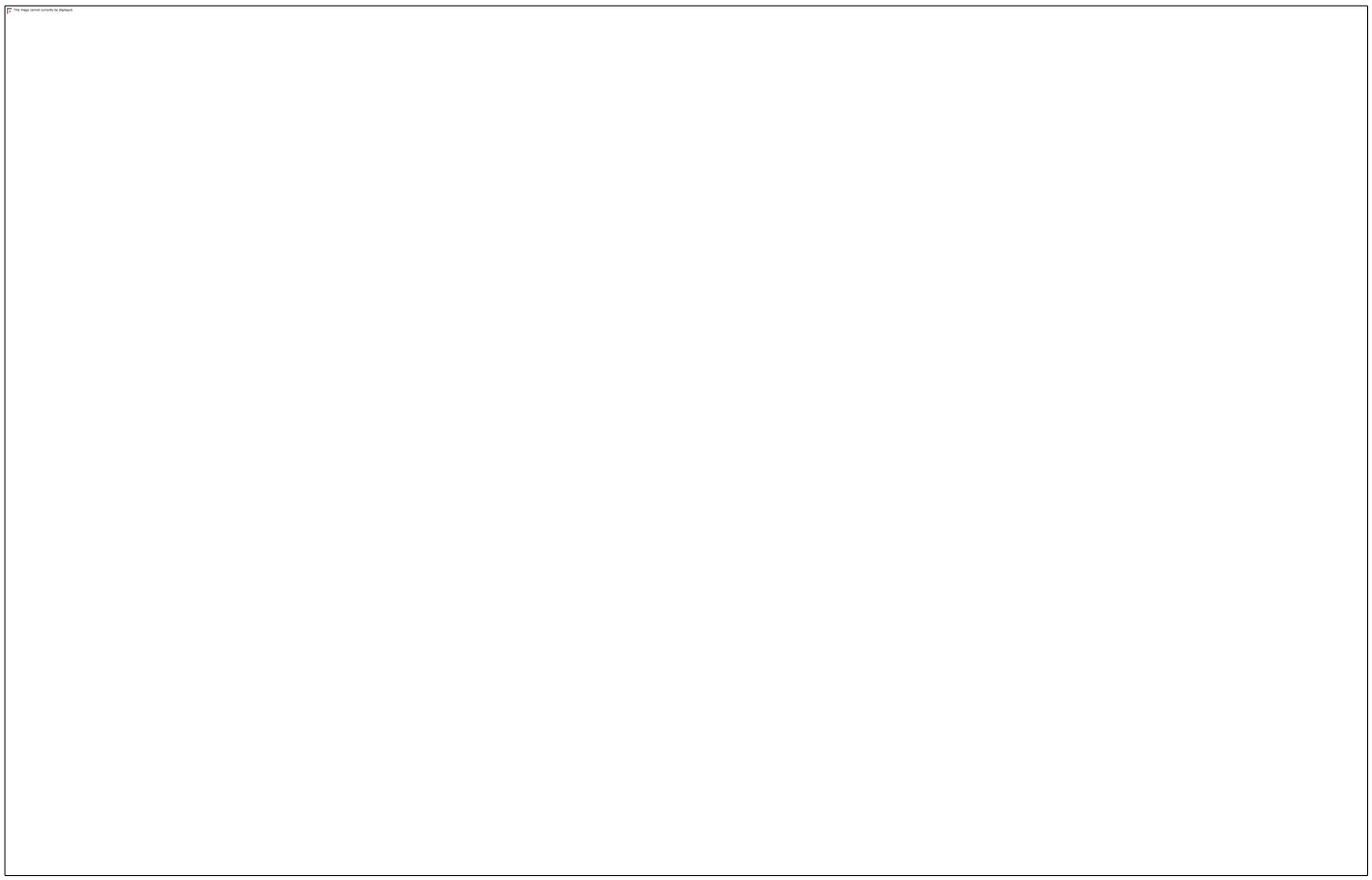
Shopfronts.

Hospitals and schools.

Skylights and roof windows.

Safety note: Appropriate safety glazing, such as toughened or laminated glass, should be used where required by the building design and applicable safety standards. Ordinary glass should not automatically be assumed suitable for doors, low-level glazing or other impact-prone locations.

3.4 Unplasticised polyvinyl chloride (uPVC)



uPVC is a rigid plastic material used to manufacture window frames and opening sections. It does not contain the plasticisers used to make flexible PVC.

Characteristics of uPVC windows

They are resistant to moisture.

They do not rust.

They are generally resistant to termite attack.

They can be manufactured in different colours and finishes.

They usually require relatively little routine maintenance.

Their performance depends on profile quality, reinforcement, hardware and installation.

Advantages of uPVC windows

They do not corrode like steel.

They are resistant to moisture.

They are easy to clean.

They generally require little painting.

Multi-chamber profiles can improve thermal insulation.

They can provide good sound insulation when correctly designed and sealed.

Disadvantages of uPVC windows

Low-quality profiles may become brittle or discolour with prolonged exposure to sunlight.

Some designs require internal metal reinforcement.

Damaged profiles may be difficult to repair.

They may be less suitable for some very large openings without appropriate structural reinforcement.

Disposal and recycling require proper environmental management.

Uses of uPVC windows

Residential buildings.

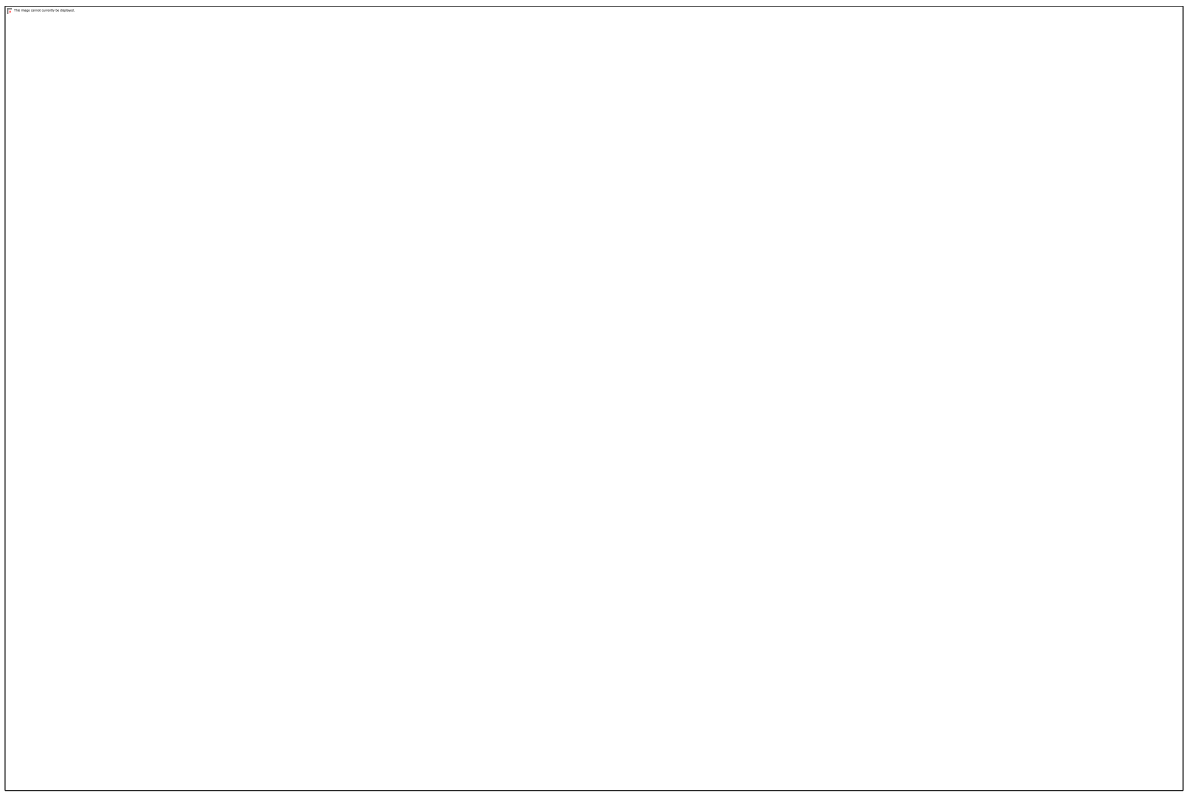
Offices.

Hospitals.

Hotels.

Buildings where low maintenance is required.

3.5 Composite materials



Composite window materials are made by combining two or more materials to obtain improved performance.

Examples include:

Timber-aluminium composite frames.

Fibreglass-reinforced polymer frames.

Engineered composite profiles.

Polymer frames with reinforcing materials.

Characteristics of composite windows

They combine the properties of different materials.

They can offer good strength and durability.

They may provide improved resistance to weathering.

They can be designed to provide good thermal performance.

Their performance depends on the materials and manufacturing process.

Advantages

They can combine the attractive appearance of timber with the weather resistance of metal.

Some types require relatively little maintenance.

They can provide good thermal and structural performance.

They are available in different designs and finishes.

Disadvantages

They may have a higher initial purchase cost.

Some damaged components may be difficult to repair.

Quality differs between manufacturers.

Replacement parts may not be readily available in some areas.

3.6 Comparison of materials used for windows

Material	Main advantages	Main limitations
Timber	Attractive, easy to shape, good insulation	Requires treatment and maintenance
Aluminium	Lightweight, durable, slim profiles	Conducts heat, can be costly
Steel	Strong and suitable for robust frames	Can rust if not protected
Glass	Allows light and views	Can break and requires careful selection
uPVC	Moisture-resistant, low maintenance	Quality and reinforcement are important
Composite	Combines properties of materials	May be expensive and difficult to repair

4.0 Classification of windows

Windows can be classified according to:

Mode of operation.

Material used in construction.

Purpose or function.

Location in the building.

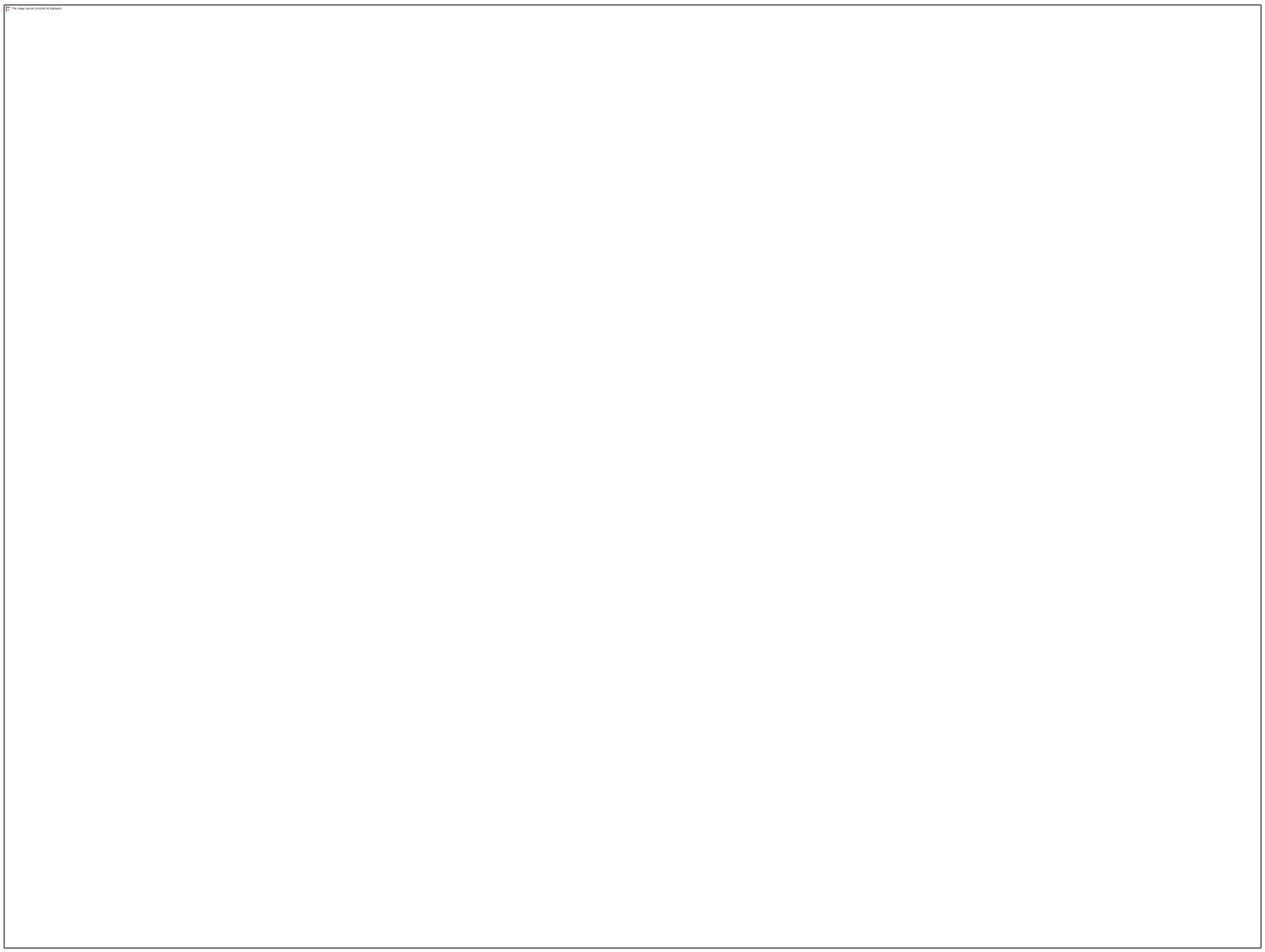
Shape and design.

A single window may belong to several categories. For example, an aluminium sliding window may be classified by its material, operation, location and purpose.

5.0 Classification according to mode of operation

This classification is based on how a window opens, closes or remains in position.

5.1 Fixed windows



A fixed window is a window that is permanently secured within its frame and cannot be opened.

Characteristics

It has no opening sash.

The glass is fixed directly into the frame or a fixed glazed section.

It is designed mainly to admit natural light and provide views.

It may use large glass panels.

Advantages

It allows natural light into a room.

It can provide wide and clear views.

It has fewer moving parts.

It is generally easy to maintain.

It can provide good weather resistance when properly sealed.

Disadvantages

It does not provide natural ventilation.

It cannot serve as an opening emergency escape window.

Cleaning the external surface may be difficult where access is limited.

It may cause overheating if poorly designed or shaded.

Uses

Staircases.

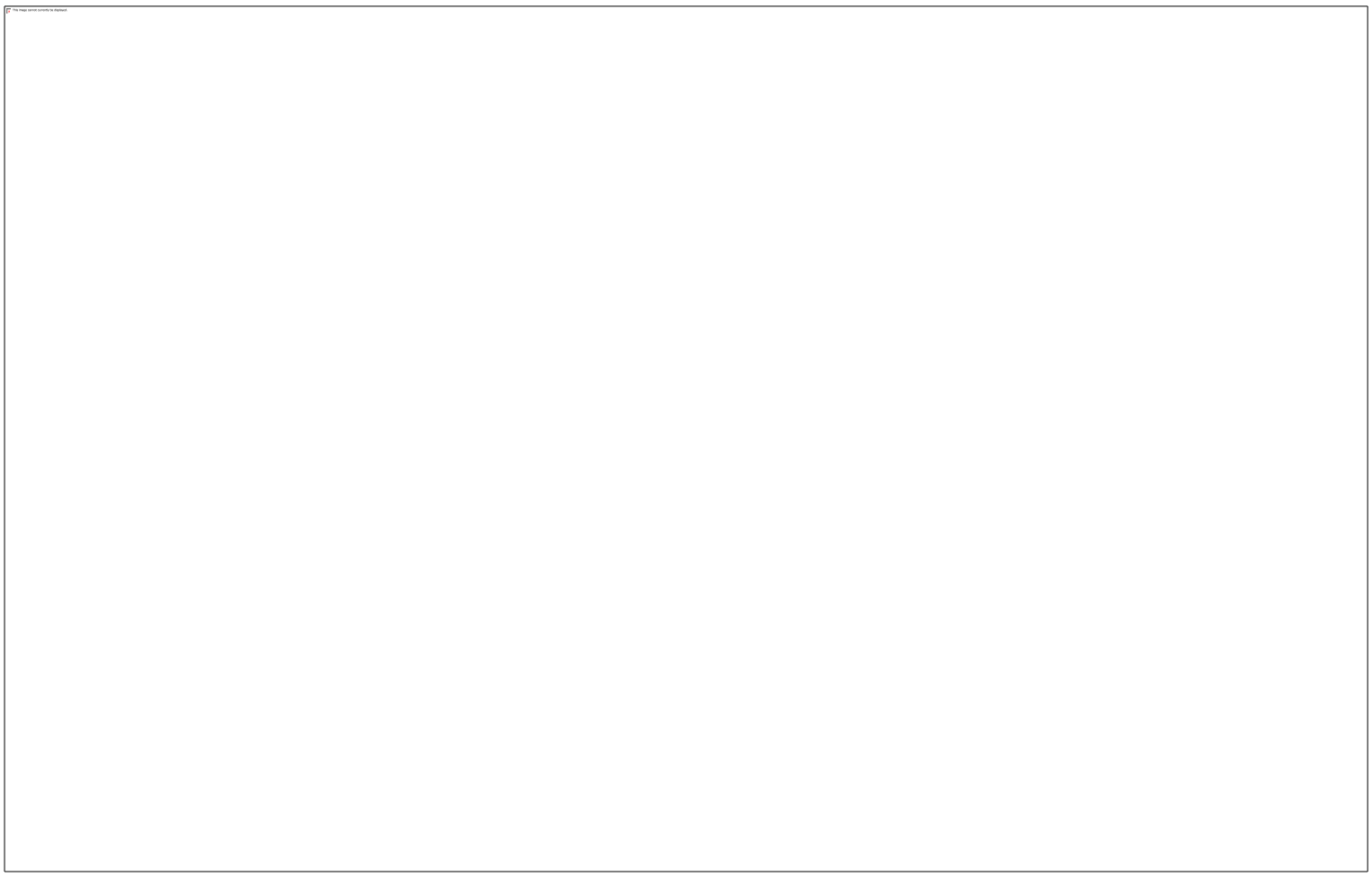
Corridors.

Shopfronts.

Office buildings.

Areas where ventilation is provided by other openings or mechanical systems.

5.2 Casement windows



A casement window is a window whose opening sash is attached to the frame using hinges, allowing it to swing open.

It may open inwards or outwards, depending on its design.

Main characteristics

It has a frame and one or more opening sashes.

Hinges are fixed along one side of the sash.

It may be operated using a handle or locking mechanism.

It can provide good ventilation when fully opened.

It may be fitted with security locks and restrictors.

Advantages

It allows good ventilation.

It is relatively easy to operate.

It can provide good weather sealing when properly fitted.

It is available in different materials.

It can be designed in single- or double-sash arrangements.

Disadvantages

The opening sash requires space when opened.

Strong winds may affect outward-opening sashes.

Hinges and locking mechanisms require maintenance.

Poorly fitted casement windows may allow air or water leakage.

Uses

Bedrooms.

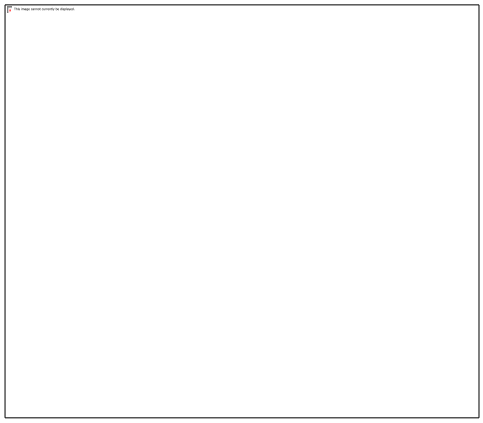
Kitchens.

Classrooms.

Offices.

Residential houses.

5.3 Sliding windows



A sliding window is a window whose sash moves horizontally or vertically along tracks instead of swinging on hinges.

Characteristics

It consists of a frame and one or more sliding sashes.

Rollers or sliding fittings help the sash move along tracks.

It may have two or more glazed sections.

Some designs have one fixed panel and one movable panel.

It does not require outward or inward swinging space.

Advantages

It saves space.

It is convenient in areas with limited clearance.

It can provide wide openings.

It is suitable for modern building designs.

It is relatively easy to operate when rollers and tracks are maintained.

Disadvantages

Usually, only part of the total window area can be opened at a time.

Tracks may collect dust and dirt.

Rollers can wear out.

Poorly sealed sliding windows may allow air or water leakage.

Uses

Residential houses.

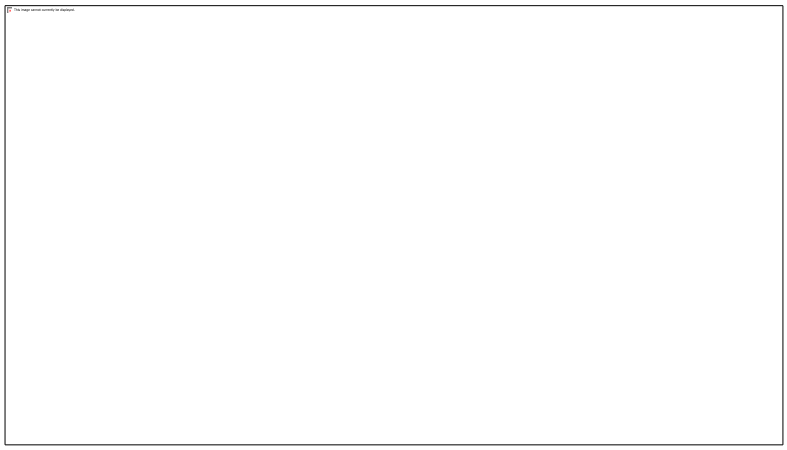
Offices.

Apartments.

Commercial buildings.

Balconies and living rooms.

5.4 Pivot windows



A pivot window is a window whose sash rotates around a central or near-central pivot point.

The pivot may be located horizontally or vertically.

Characteristics

It rotates around pivot fittings.

It can open inwards and outwards depending on the design.

It may be designed to rotate through a limited angle.

It requires suitable pivot hardware.

Advantages

It provides controlled ventilation.

It can have an attractive modern appearance.

Some designs are easy to clean from inside.

It can be used for large architectural openings when properly engineered.

Disadvantages

It may require specialised hardware.

It can be more expensive than simple casement windows.

Poorly positioned pivots may interfere with furniture or internal space.

It requires correct installation and adjustment.

Uses

Modern houses.

Offices.

Commercial buildings.

Architectural feature windows.

5.5 Hopper windows



A hopper window is a window hinged at the bottom, with the upper part opening inwards.

Characteristics

The hinges are fitted along the bottom edge.

The top of the sash tilts inwards.

It is commonly used for small openings.

It can be operated using a handle or stay.

Advantages

It provides controlled ventilation.

It can be suitable for small spaces.

It may offer some protection from light rain when properly designed.

It can be fitted high on a wall for privacy.

Disadvantages

It may obstruct internal space when opened.

It may not provide a large ventilation opening.

It requires suitable fittings to hold the sash safely.

Uses

Bathrooms.

Toilets.

Basements.

Utility rooms.

Small service spaces.

5.6 Awning windows



An awning window is a window hinged at the top, with the bottom part opening outwards.

Characteristics

The hinges are fixed along the top edge.

The lower edge swings outwards.

It may be operated using a handle, chain winder or other mechanism.

It is often installed above or below fixed glazing.

Advantages

It can allow ventilation during light rain, depending on the design and weather conditions.

It provides controlled ventilation.

It can be installed at high level.

It can be combined with fixed windows.

Disadvantages

It may be affected by strong winds.

It requires adequate external clearance.

It may not provide a wide opening for emergency escape.

The opening sash can obstruct external walkways if poorly positioned.

Uses

Kitchens.

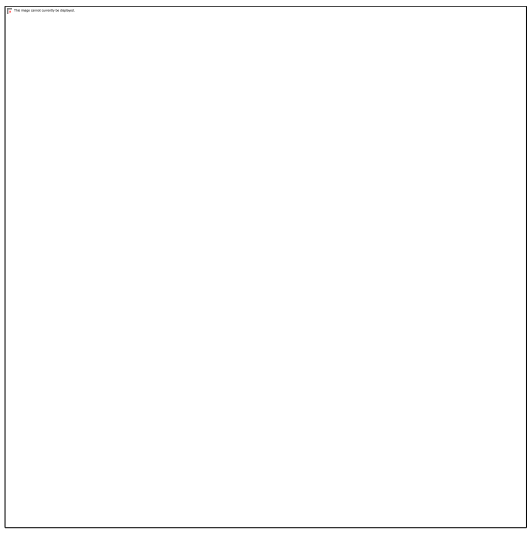
Bathrooms.

Offices.

Residential buildings.

High-level wall openings.

5.7 Louvered windows



A louvered window consists of a series of narrow horizontal or inclined blades fitted within a frame. The blades can be adjusted to control airflow and light.

The blades may be made of glass, metal, timber or other suitable materials.

Characteristics

It contains several narrow blades.

The blades are supported by special fittings.

A control mechanism adjusts the angle of the blades.

It allows air to pass through when open.

It can provide adjustable ventilation.

Advantages

It provides good ventilation.

Airflow can be controlled by adjusting the blades.

It can be suitable for warm environments.

It may provide privacy depending on the blade arrangement.

It is useful for high-level ventilation openings.

Disadvantages

Some designs may provide less security than other window types.

Dust may collect between the blades.

Poorly sealed blades may allow rainwater into the room.

Individual blades can break or become damaged.

It may not provide the same weather-tightness as well-sealed casement windows.

Uses

Kitchens.

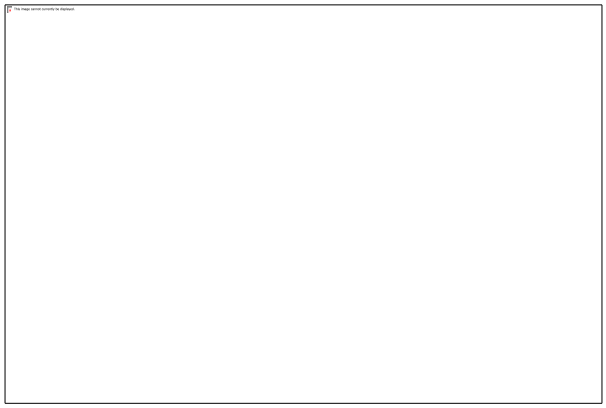
Bathrooms.

Workshops.

Stores.

Buildings requiring adjustable ventilation.

5.8 Sash windows



A sash window is a window in which one or more glazed sashes slide vertically or horizontally within a frame.

The common traditional type is the vertically sliding sash window.

Characteristics

It has movable glazed sections called sashes.

The sashes move within tracks or channels.

Some designs use counterweights or spring balances.

A double-hung sash window has two movable sashes.

Some designs have only one movable sash.

Advantages

It does not require swinging space.

It can provide controlled ventilation.

It can suit traditional architectural designs.

Some types allow ventilation through both the upper and lower sections.

Disadvantages

Tracks and balancing mechanisms require maintenance.

Older designs may be difficult to seal against air leakage.

Some types are difficult to clean.

Poorly maintained sashes may become difficult to operate.

Uses

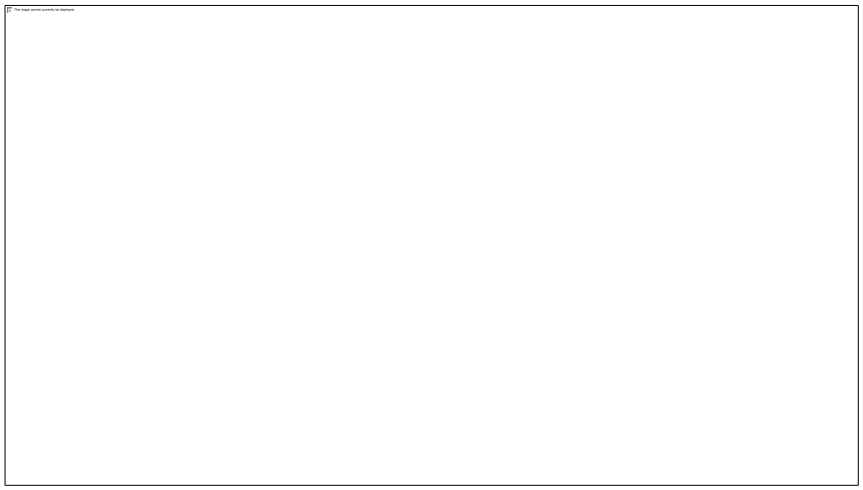
Traditional houses.

Heritage buildings.

Residential buildings.

Some commercial buildings.

5.9 Skylight windows



A skylight is a glazed opening installed in a roof or ceiling to admit natural light from above.

Some skylights are fixed, while others can open to provide ventilation.

Characteristics

It is installed on a roof or sloping ceiling.

It uses suitable glazing and weatherproofing materials.

It may be fixed or operable.

It requires careful flashing and waterproof detailing.

It may be designed to provide daylight to areas with limited wall openings.

Advantages

It allows natural light into the building.

It can improve daylight distribution.

It can reduce the need for artificial lighting during the day.

An operable skylight may assist in releasing warm air.

Disadvantages

Poor installation can cause roof leakage.

Direct sunlight may cause excessive heat and glare.

It may be difficult to clean and maintain.

It requires suitable safety glazing and weatherproofing.

Uses

Corridors.

Roof spaces.

Living rooms.

Staircases.

Large halls and commercial buildings.

5.10 Comparison of windows according to mode of operation

Window type	How it operates	Main feature
Fixed	Does not open	Provides light and views
Casement	Swings on side hinges	Good ventilation
Sliding	Moves along tracks	Saves space
Pivot	Rotates around a pivot	Special opening movement
Hopper	Hinged at the bottom	Top tilts inwards
Awning	Hinged at the top	Bottom opens outwards
Louvered	Blades tilt	Adjustable airflow
Sash	Glazed sections slide	Often moves vertically
Skylight	Fixed or opens in a roof	Provides overhead daylight

6.0 Classification according to materials

This classification is based on the main material used to manufacture the window frame and its opening sections.

6.1 Timber windows

Manufactured using seasoned timber.

May be constructed as casement, sliding or fixed windows.

Require suitable treatment and finishing.

Common in traditional and residential buildings.

6.2 Metal windows

Manufactured using aluminium, steel or other suitable metals.

Aluminium is commonly used for modern sliding windows.

Steel may be used where strong, robust frames are required.

Metal frames can accommodate different types of glazing.

6.3 uPVC windows

Manufactured from rigid PVC profiles.

Often fitted with metal reinforcement where required.

Resistant to moisture and termite attack.

Common in residential and commercial buildings.

6.4 Glass windows

The term glass window describes a window in which glass forms the main visible infill or glazed area. Glass is normally held in a frame made of timber, metal, uPVC or composite material.

Glass windows may use:

Clear glass.

Tinted glass.

Frosted glass.

Patterned glass.

Laminated safety glass.

Toughened safety glass.

6.5 Composite windows

Manufactured by combining two or more materials.

Examples include timber-aluminium and reinforced polymer systems.

They are designed to combine useful properties such as strength, appearance, insulation and weather resistance.

7.0 Classification according to purpose

Windows may also be classified according to the function they are designed to perform.

7.1 Ventilation windows



These are windows designed mainly to allow fresh air to enter and stale air to leave a building.

Characteristics

They are usually openable.

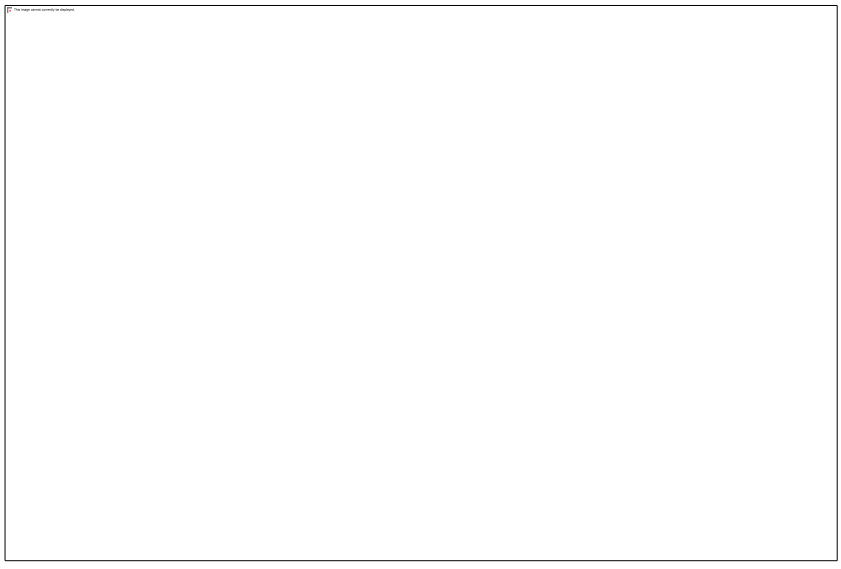
They may be casement, louvered, awning or sliding windows.

They are positioned to encourage air movement.

They should be designed to provide adequate ventilation without compromising safety.

Examples: Windows in kitchens, classrooms, bathrooms and workshops.

7.2 Lighting windows



These are windows designed mainly to admit natural light.

Characteristics

They may be fixed or openable.

They may contain large glazed areas.

They are positioned to distribute daylight effectively.

They may be fitted with shading devices to control glare and excessive heat.

Examples: Fixed windows in corridors, offices and staircases.

7.3 Emergency escape windows

These are windows designed and approved to provide an alternative escape opening during emergencies.

Characteristics

They must have suitable clear opening dimensions.

They should be accessible to the intended occupants.

Their opening mechanism should be easy to operate.

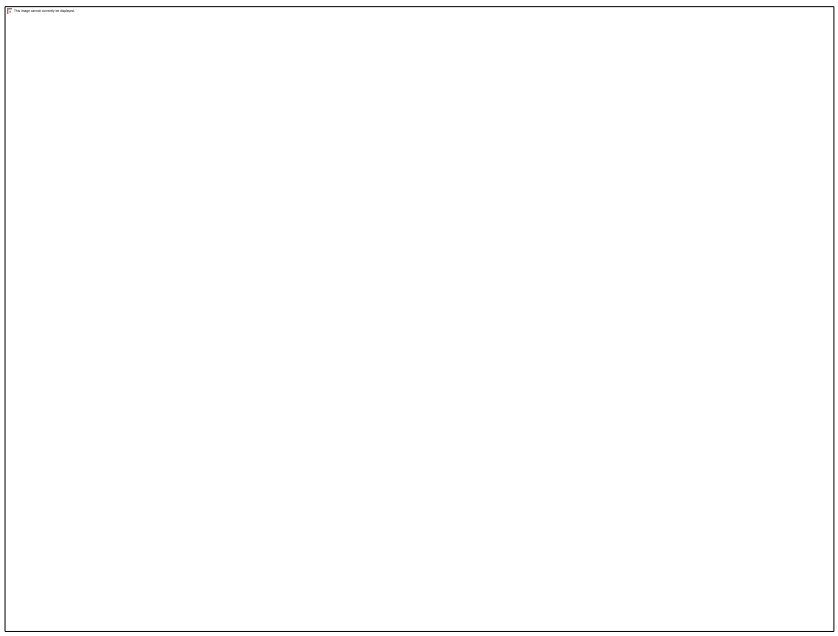
They should not be obstructed by furniture, grilles or other fittings.

Their design must comply with the applicable fire-safety and building requirements.

Uses: Certain bedrooms and other spaces where an approved emergency escape opening is required.

Important: A normal window should not automatically be considered an emergency escape window. Its suitability depends on the building design, applicable regulations, opening size, height above ground and accessibility.

7.4 Decorative windows



These are windows installed mainly to improve the appearance and architectural character of a building.

Characteristics

They may have unusual shapes and patterns.

They may use coloured, patterned or stained glass.

They may be fixed or openable.

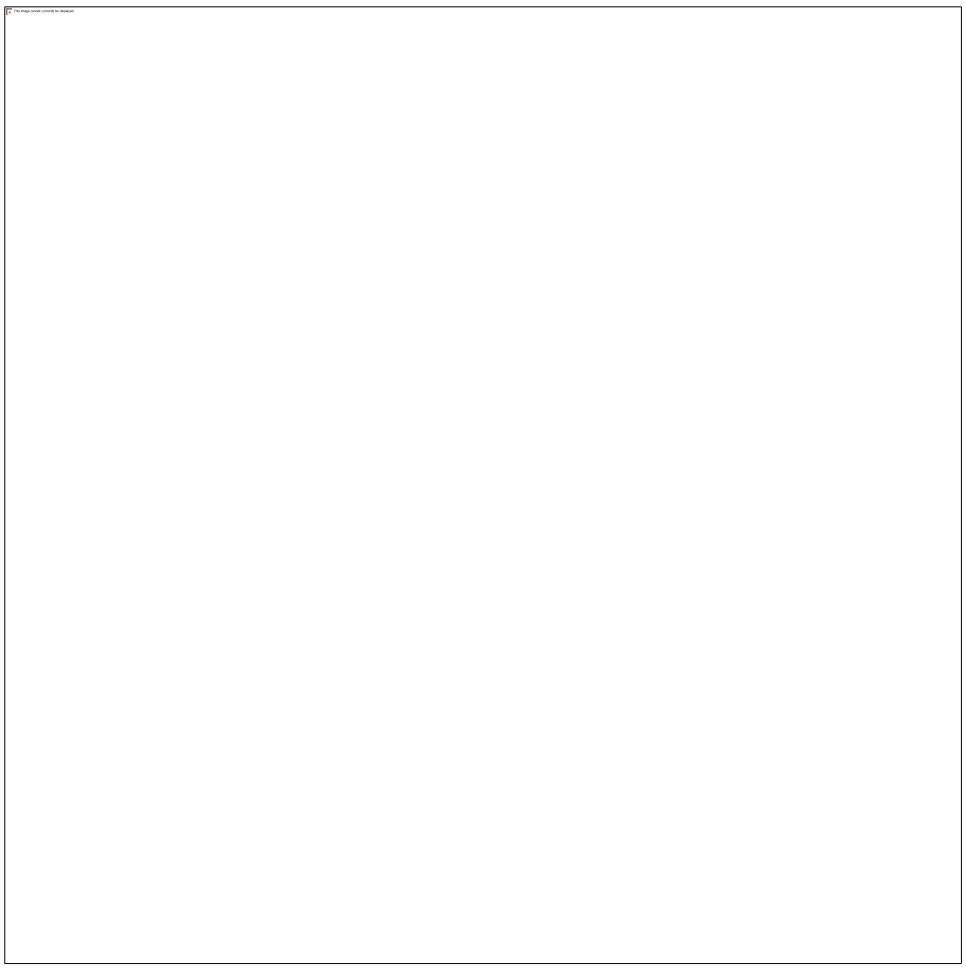
They may be designed to match the architectural style of a building.

Examples: Decorative windows in churches, hotels, reception areas and luxury houses.

8.0 Classification according to location

Windows can be classified according to the part of the building where they are installed.

8.1 External windows



External windows are fitted in external walls and separate the indoor environment from the outside environment.

Characteristics

They are exposed to rain, wind, sunlight and dust.

They require good weather resistance.

They should provide suitable security.

Their frames and seals should resist water and air leakage.

They may be fitted with insect screens, shading devices and security features.

Examples: Windows in bedrooms, living rooms, offices and classrooms.

8.2 Internal windows

Internal windows are installed between rooms or spaces within a building.

Characteristics

They may allow borrowed light to pass from one room to another.

They can improve visibility between spaces.

They may be used in glazed partitions.

They can improve supervision and communication.

They may be fixed or openable.

Examples: Windows between offices, reception areas and internal corridors.

8.3 Roof windows



Roof windows are installed in sloping or flat roof structures to provide natural lighting and, in some cases, ventilation.

Characteristics

They are exposed to direct rainfall and sunlight.

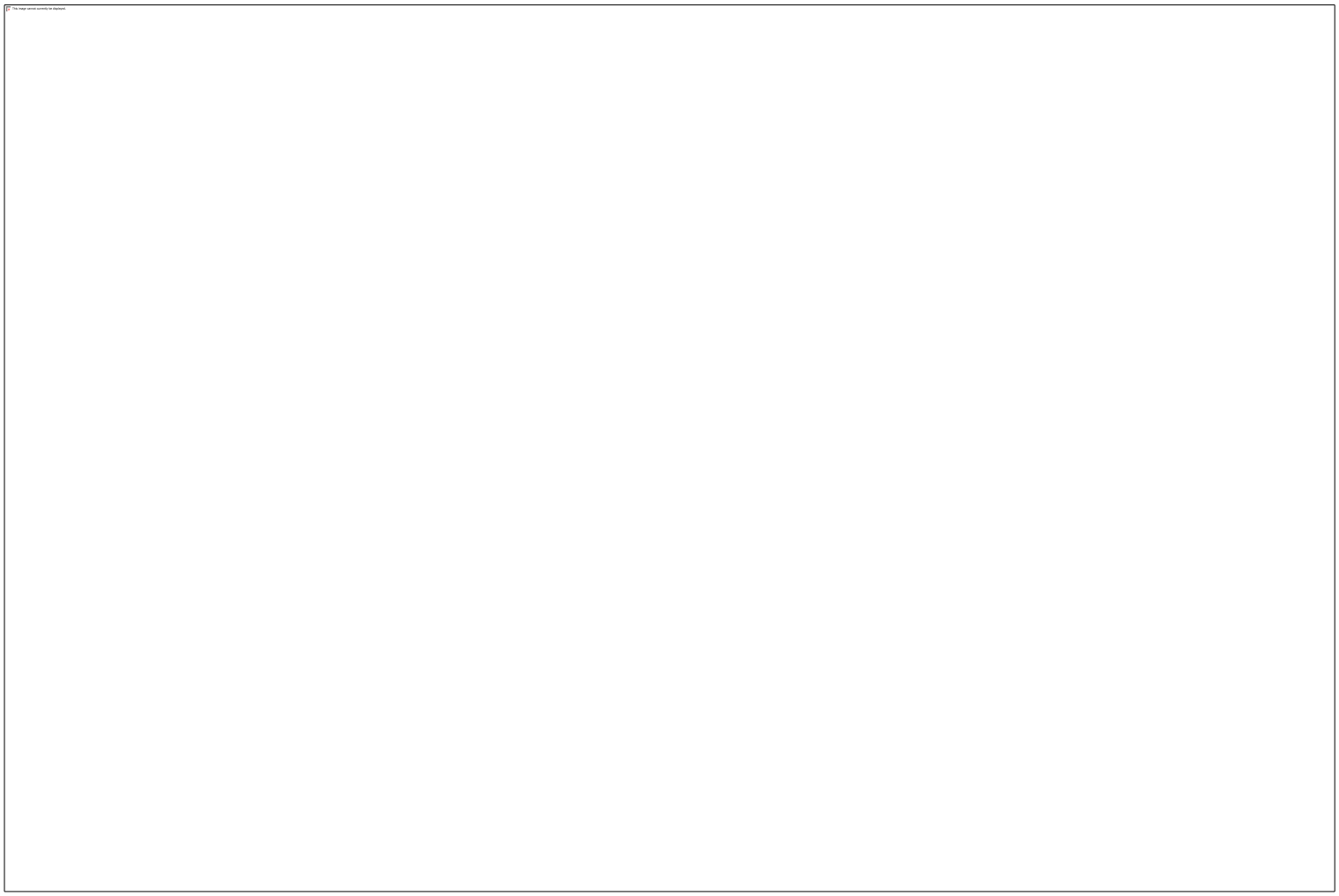
They require appropriate waterproofing and flashing.

They need suitable glazing and secure fixing.

They may be fixed or openable.

Examples: Roof windows in attic rooms, roof spaces and buildings with limited external wall openings.

8.4 Corner windows



A corner window is installed at the meeting point of two adjoining external walls.

Characteristics

It may extend around a building corner.

It can provide views in two directions.

It allows daylight to enter from different orientations.

It requires carefully designed structural support and weatherproof joints.

It may use special glazing and corner connections.

Advantages

It provides attractive architectural appearance.

It can improve natural lighting.

It provides wider views of the surroundings.

It creates a feeling of openness.

Limitations

It may be expensive to construct.

It requires careful structural design.

Corner joints require good weatherproofing.

It may increase solar heat gain if poorly designed.

9.0 Classification according to shape and design

Windows are manufactured in different shapes to meet architectural, functional and aesthetic requirements.

9.1 Rectangular windows



A rectangular window has four sides, with opposite sides parallel and all internal angles measuring 90 degrees.

Characteristics

It is the most common window shape.

It is relatively easy to manufacture and install.

It can be fixed, casement, sliding or louvered.

It is suitable for many building designs.

Uses: Houses, schools, offices, shops and hospitals.

9.2 Arched windows



An arched window has a curved upper section, usually forming part of a semicircle or another curved shape.

Characteristics

It has a curved head.

It can have a fixed or openable section.

It may be constructed using special frames and glazing.

It adds decorative value to a building.

Uses: Churches, hotels, traditional-style houses and decorative building facades.

9.3 Circular windows



A circular window is a window designed in the shape of a circle.

Characteristics

It has a curved frame.

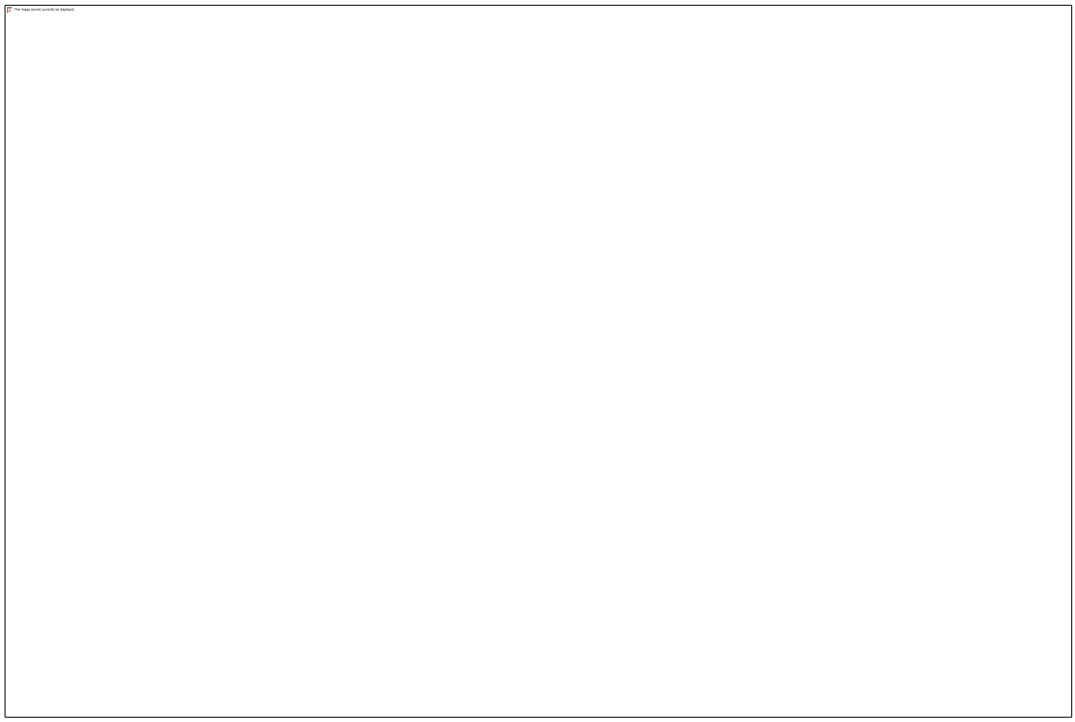
It may be fixed or specially designed to open.

It is commonly used for decorative purposes.

It may require specialised manufacturing.

Uses: Feature walls, staircases, roof spaces and decorative buildings.

9.4 Trapezoidal windows



A trapezoidal window has four sides, with one pair of opposite sides parallel.

Characteristics

It may have sloping sides.

It is often designed to fit unusual roof or wall shapes.

It may be fixed or specially designed to open.

It requires accurate measurement and fabrication.

Uses: Gable ends, modern houses and buildings with sloping roof profiles.

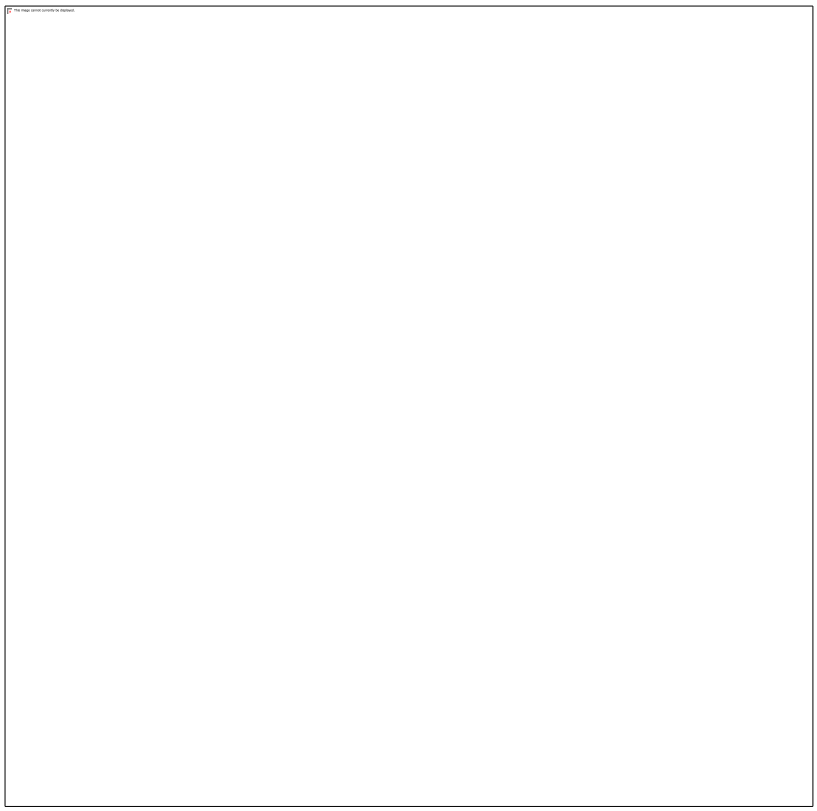
9.5 Summary of window shapes

Shape	Main feature	Common application
Rectangular	Four right-angled corners	Houses and offices
Arched	Curved upper section	Churches and decorative facades
Circular	Round shape	Feature walls and staircases
Trapezoidal	Four sides with one pair parallel	Gable ends and modern designs

10.0 Components of a window

A window is made up of several components that work together to provide support, operation, security, weather protection and appearance.

The components differ depending on the type of window. For example, a casement window has hinges, while a sliding window has tracks and rollers.







10.1 Window frame

The window frame is the fixed outer structure that holds the window in the wall opening and supports the opening sashes or glazing.

Functions

Supports the window assembly.

Provides a fixing point for the window.

Holds the sash or fixed glazing.

Transfers loads to the surrounding wall structure.

Provides a surface for attaching hinges, tracks and other fittings.

Frames may be made from timber, aluminium, steel, uPVC or composite materials.

10.2 Head

The head is the horizontal upper member of the window frame.

Functions

Connects the two vertical sides of the frame.

Provides support to the upper part of the window assembly.

Helps maintain the shape and alignment of the frame.

Forms part of the boundary around the glazed opening.

10.3 Jambs

Jambs are the vertical side members of the window frame.

Functions

Support and locate the window sash.

Connect the head and sill.

Provide fixing points for hinges and other hardware.

Help maintain the alignment of the window.

10.4 Sill

The sill is the lower horizontal part of a window opening or frame.

Functions

Supports the lower part of the window.

Helps direct rainwater away from the wall when properly shaped.

Provides a finished lower edge to the opening.

May provide a surface for internal finishing.

An external sill is often sloped outwards and may have a drip groove to reduce water running down the wall.

10.5 Sash

A sash is the movable or fixed framed section of a window that holds the glazing.

Functions

Holds the glass securely.

Moves when the window is designed to open.

Fits within the main frame.

Supports the glazing beads and associated fittings.

10.6 Glazing

Glazing refers to the glass or other transparent or translucent material fitted into the window sash or frame.

Functions

Allows natural light into the room.

Provides views of the surroundings.

Can provide weather protection.

May improve sound and thermal performance depending on the type selected.

10.7 Glazing beads

Glazing beads are narrow strips used to hold and secure the glass within the frame or sash.

Functions

Hold the glass in position.

Help prevent the glass from moving.

Provide a neat finish around the glazing.

May assist in securing glazing seals.

10.8 Mullion

A mullion is a vertical member that divides a window into separate sections.

Functions

Divides large window openings into smaller sections.

Provides support to adjoining window units.

Helps improve the rigidity of the window assembly.

Creates decorative patterns.

10.9 Transom

A transom is a horizontal member that divides a window into upper and lower sections.

Functions

Separates different glazed sections.

Supports adjoining window units where designed to do so.

Provides a decorative division.

May separate an upper fixed light from a lower opening sash.

10.10 Hinges

Hinges are mechanical fittings that connect a casement sash to the window frame and allow it to swing open or closed.

Functions

Support the opening sash.

Allow rotational movement.

Keep the sash connected to the frame.

Help control the opening movement.

10.11 Handles

Handles are fittings used to operate a window.

Functions

Provide a grip for opening and closing.

May operate the locking mechanism.

Help secure the window when closed.

10.12 Locks and fasteners

These are fittings used to secure the window in a closed or restricted position.

Functions

Improve security.

Prevent unwanted opening.

Keep the sash in position.

Help maintain proper contact between seals and frame.

10.13 Weather strips and seals

These are flexible materials fitted around parts of the window to reduce the passage of air, water, dust and noise.

Functions

Reduce air leakage.

Limit water penetration.

Improve thermal performance.

Reduce rattling between moving sections.

10.14 Drainage holes or weep holes

These are small openings provided in suitable window frame sections to allow accumulated water to drain out.

Functions

Remove water that enters the frame drainage chamber.

Reduce water accumulation.

Help protect the frame and surrounding wall from moisture damage.

10.15 Window stays and restrictors

These fittings help control the movement or maximum opening of a window sash.

Functions

Hold the sash at a selected opening position.

Limit excessive movement.

Improve safety where restricted opening is necessary.

10.16 Window sill board

In some window designs, a sill board is the finished horizontal surface at the lower edge of the window on the inside of a room.

Functions

Provides a neat internal finish.

Covers the lower edge of the opening.

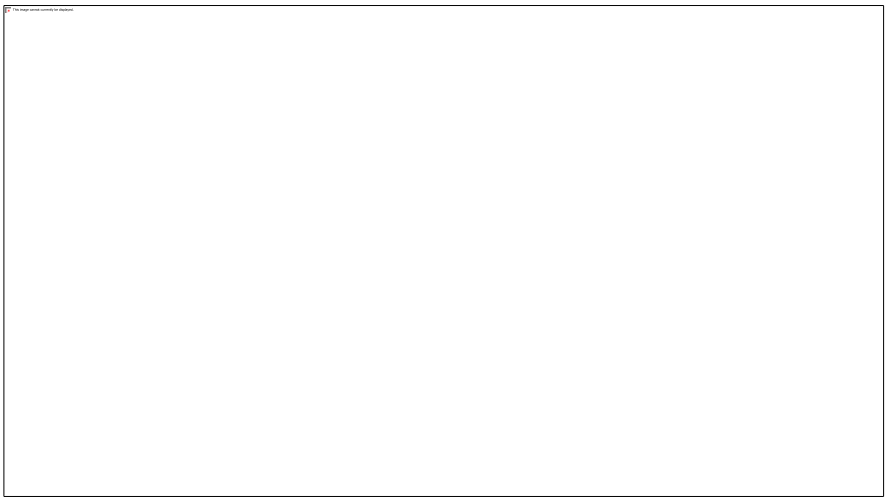
May provide a surface for placing light decorative objects, provided this does not create a safety hazard.

11.0 Sketches of window types and components

The following sketches are simplified teaching diagrams. Actual window profiles and hardware vary by manufacturer and design.

11.1 Sketch of a casement window

Simplified front elevation



SASH: The framed opening section

HINGES: Fitted along one side

HANDLE: Used to operate the sash

Explanation of the sketch

The head forms the upper horizontal part of the frame.

The jambs form the two vertical sides.

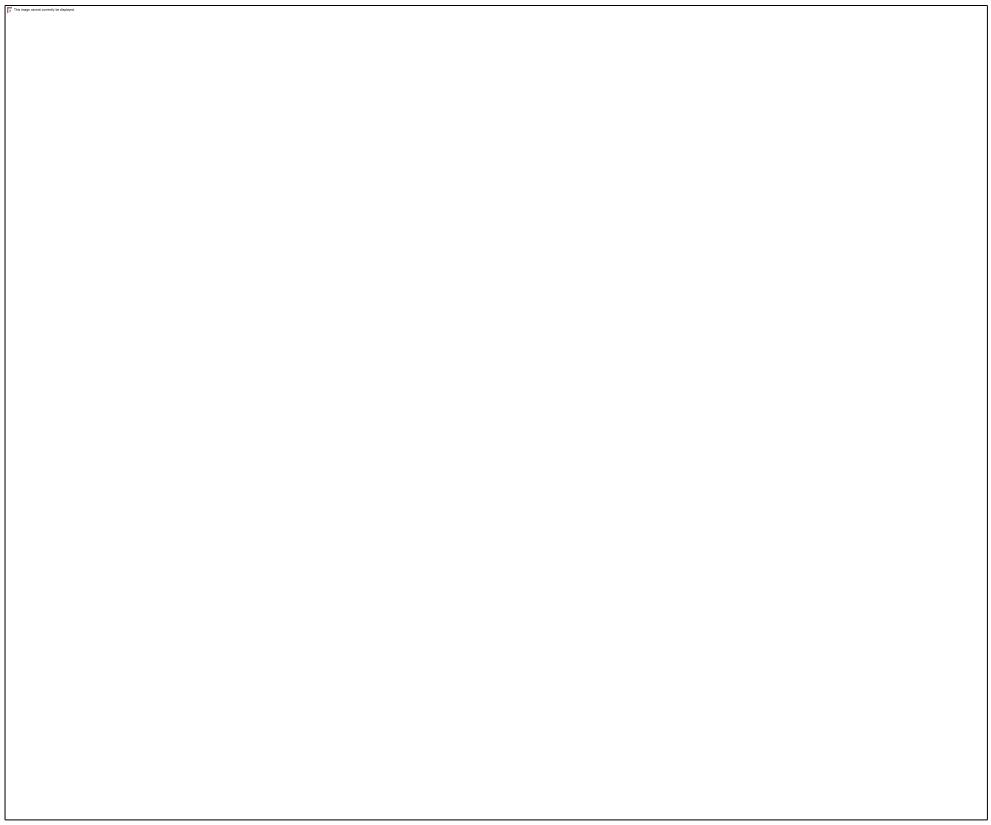
The sill forms the lower part of the frame.

The sash holds the glass.

Hinges connect the sash to the frame.

The handle is used to open and close the window.

11.2 Sketch of a sliding window



12.0 Main differences between casement and sliding windows

Feature	Casement window	Sliding window
Method of operation	Sash swings on hinges	Sash moves along tracks
Main fittings	Hinges, handle, stays and locks	Tracks, rollers, handles and locks
Space requirement	Needs swinging clearance	Does not need swinging clearance
Ventilation	May open widely	Usually only part of the total area opens
Maintenance	Hinges and stays need attention	Tracks and rollers need cleaning and maintenance
Common materials	Timber, aluminium, steel and uPVC	Commonly aluminium and uPVC
Typical use	Bedrooms, kitchens and offices	Living rooms, apartments and balconies

13.0 Factors to consider when selecting windows

The selection of windows should be based on the building's intended use, environmental conditions, safety requirements, budget and architectural design.

13.1 Purpose of the window

Determine whether the window is intended for ventilation, lighting, views, decoration or emergency escape.

Select a window type that performs the required function.

For example, a fixed window may be suitable for lighting, while a casement window may be suitable where good ventilation is needed.

13.2 Cost

Consider the purchase price of the window.

Include installation costs.

Consider the cost of glazing, fittings and finishing.

Consider future maintenance and replacement costs.

13.3 Durability

Select materials that can withstand expected weather conditions.

Consider resistance to moisture, corrosion, sunlight and physical damage.

Ensure that the window can provide the required service life.

13.4 Security

Consider the strength of the frame and glazing.

Select suitable locks and fasteners.

Consider security screens or grilles where appropriate.

Ensure security provisions do not prevent required emergency escape.

13.5 Natural lighting

Consider the size and position of the window.

Consider the direction the window faces.

Consider nearby buildings and trees that may block daylight.

Select glazing that provides suitable light transmission.

13.6 Ventilation requirements

Consider the amount of fresh air needed in the room.

Select suitable opening arrangements.

Consider the direction of prevailing winds.

Consider cross-ventilation where appropriate.

13.7 Climate and weather conditions

Consider rainfall, wind, temperature and solar exposure.

Use suitable weather-resistant materials.

Consider shading to reduce excessive solar heat.

Provide proper sealing and drainage.

13.8 Maintenance requirements

Consider how often the window needs cleaning, painting or repair.

Select materials that can be maintained using locally available skills and materials.

Consider the availability of replacement parts.

13.9 Appearance and architectural design

Select a window that complements the building.

Consider its shape, colour, size and proportions.

Ensure it fits the overall architectural style.

13.10 Privacy

Consider the activities carried out in the room.

Use suitable glazing, curtains or blinds.

Frosted glass may be suitable for bathrooms and other private spaces.

13.11 Sound insulation

Consider the level of noise around the building.

Suitable glazing, frame construction and weather seals can reduce sound transmission.

This is particularly important near busy roads, markets and industrial areas.

13.12 Availability of materials

Consider whether the selected material is readily available.

Consider the availability of skilled installers.

Ensure replacement fittings can be obtained locally.

13.13 Size and position of the opening

The size should suit the purpose of the room.

The window should be positioned to provide suitable lighting and ventilation.

Structural members above and around the opening should be properly designed.

13.14 Safety requirements

Consider safe glazing in areas where impact is likely.

Consider safe opening mechanisms and restrictors.

Ensure that windows intended for emergency escape meet the applicable requirements.

13.15 Energy efficiency

Consider the thermal performance of the frame and glazing.

Use suitable shading and orientation.

Consider double glazing or other suitable products where justified by the building's design and budget.

14.0 Installation of windows

Window installation involves fixing a prepared window unit into a building opening to ensure that it is secure, properly aligned, weather-resistant and functional.

14.1 Tools and equipment used

Examples include:

Tape measure.

Spirit level.

Plumb bob.

Hammer.

Screwdriver.

Drill.

Masonry drill bits.

Spanners.

Sealant gun.

Hacksaw, where appropriate.

Safety gloves.

Safety goggles.

Suitable access equipment.

14.2 Materials used

Window frame and sash.

Fixing screws or anchors.

Packers or shims.

Suitable sealant.

Weather strips.

Glazing materials.

Appropriate flashing where required.

Protective finishing materials.

14.3 General procedure for installing a window

Inspect the opening: Check that the opening is correctly positioned and suitable for the window dimensions.

Measure the opening: Measure the width, height and diagonals to establish whether the opening is square.

Prepare the frame: Check that the frame is complete and free from damage.

Position the frame: Place the window frame in the opening using suitable packers.

Check alignment: Use a spirit level and plumb bob to check that the frame is level, plumb and square.

Fix the frame: Secure the frame using appropriate fixings without distorting it.

Fit the sash: Install the opening sections where they are supplied separately.

Fit the glazing: Install the glass using the correct glazing method, seals and beads. Follow the manufacturer's instructions.

Seal the joints: Apply suitable sealant and weatherproofing materials at the required locations.

Test operation: Open and close the window to confirm smooth movement and proper locking.

Inspect drainage: Ensure that drainage holes and channels are not blocked.

Clean the window: Remove dirt, excess sealant and protective materials as appropriate.

Installation should follow the window manufacturer's instructions and the approved building details. Heavy glazing and work at height require suitable equipment and trained personnel.

15.0 Maintenance of windows

Window maintenance involves keeping windows in good working condition through regular inspection, cleaning, adjustment and repair.

15.1 Maintenance of timber windows

Inspect for termite attack and decay.

Replace damaged timber sections.

Apply suitable preservatives where necessary.

Repaint or varnish exposed surfaces.

Check hinges, handles and locks.

Repair cracks and joints to prevent water penetration.

15.2 Maintenance of metal windows

Inspect steel sections for rust.

Remove loose rust and apply suitable protective coatings.

Check aluminium frames for loose joints and damaged finishes.

Lubricate moving parts where recommended.

Replace damaged locks and handles.

15.3 Maintenance of glass windows

Clean glass using suitable cleaning materials.

Inspect for cracks and chips.

Replace damaged glazing using suitable safety glass where required.

Check glazing beads and seals.

Avoid using excessive force when cleaning or operating the window.

15.4 Maintenance of uPVC windows

Clean frames using suitable non-abrasive materials.

Clean drainage channels and weep holes.

Inspect weather seals.

Check locks and handles.

Lubricate moving hardware according to manufacturer instructions.

Replace damaged components.

15.5 Maintenance of sliding windows

Clean tracks regularly.

Remove dirt and debris from rollers.

Inspect rollers for wear.

Check that the sash moves smoothly.

Inspect locks and interlocking sections.

Ensure drainage openings remain clear.

15.6 Maintenance of casement windows

Check hinges for looseness.

Tighten suitable fixings.

Lubricate hinges where recommended.

Inspect handles and locking points.

Check weather seals.

Ensure that the sash opens and closes without obstruction.

16.0 Common window defects and their remedies

Defect	Possible cause	Remedy
Rusting of steel frame	Moisture and damaged protective coating	Remove rust and apply suitable protective coating
Rotting of timber	Prolonged moisture exposure	Replace affected timber and improve protection
Broken glass	Impact or unsuitable glazing	Replace with appropriate glazing
Difficult sliding movement	Dirty tracks or worn rollers	Clean tracks and repair or replace rollers
Loose hinges	Worn or loose fixings	Tighten or replace suitable fixings
Water leakage	Poor sealing or drainage	Repair seals and drainage details
Air leakage	Worn weather strips or poor fitting	Replace seals and adjust the window
Window difficult to lock	Misalignment or damaged hardware	Adjust sash and repair the locking mechanism
Condensation	High indoor humidity or cold surfaces	Improve ventilation and address thermal performance
Discoloured uPVC	Weathering or unsuitable cleaning chemicals	Clean using recommended products and replace badly damaged parts if necessary

17.0 Safety precautions when working with windows

Wear appropriate personal protective equipment, including gloves and safety goggles.

Handle glass carefully to prevent cuts and breakages.

Use suitable lifting equipment when handling large or heavy glazed units.

Do not lean out of open windows when working at height.

Use properly secured ladders or approved access platforms.

Keep the working area free from unnecessary materials and obstructions.

Store glass upright in suitable racks with appropriate support.

Use the correct tools for cutting, drilling and fixing window components.

Do not install damaged or cracked glass.

Protect completed windows from damage during construction.

Keep emergency escape openings unobstructed.

Follow the manufacturer's installation and safety instructions.

18.0 Practical learning activities

Activity 1: Identification of window types

Instructions

Learners observe different windows in the school or nearby buildings.

Identify each window according to its mode of operation.

Record the material used to construct each window.

State the purpose of each window.

Discuss the advantages and disadvantages of the identified windows.

Expected learning outcome: Learners should be able to identify and classify different types of windows.

Activity 2: Identification of window components

Resources

A casement window.

A sliding window.

Tape measure.

Drawing paper.

Pencil.

Procedure

Observe the casement window.

Identify the head, jambs, sill, frame, sash and glazing.

Identify hinges, handles and locks.

Observe the sliding window.

Identify the tracks, rollers, frame and sliding sash.

Draw and label the components.

Activity 3: Making a window model

Project: Construct a simple model of a casement or sliding window.

Materials

Suitable timber strips or cardboard.

Transparent plastic sheet.

Glue.

Small hinges or suitable model fittings.

Ruler.

Pencil.

Cutting tools.

Procedure

Draw the proposed window design.

Measure and mark the materials.

Cut the frame members to the required dimensions.

Assemble the frame.

Fit the transparent sheet to represent glazing.

Attach suitable model hinges or sliding guides.

Test the operation of the model.

Label all major components.

Expected outcome: A correctly assembled and labelled window model demonstrating the basic construction and operation of a window.

Activity 4: Selecting windows for different rooms

Learners should recommend suitable windows for:

A classroom.

A bathroom.

A kitchen.

A shopfront.

A bedroom.

A staircase.

For each room, explain the choice based on ventilation, lighting, privacy, safety, cost and maintenance.

REVISION QUESTIONS

SECTION A: MULTIPLE-CHOICE QUESTIONS

Choose the correct answer from the alternatives provided.

1. Which of the following best describes a window?

A. A horizontal structure used to support a roof.

B. An opening in a wall or roof fitted with a suitable frame and glazing.

C. A vertical structure used to divide rooms.

D. A component used to support floor finishes.

2. Which of the following is a major function of windows in buildings?

A. Supporting the foundation.

B. Carrying roof loads.

C. Providing natural lighting and ventilation.

D. Supporting ceiling finishes.

3. Which material is obtained from trees and commonly used to manufacture window frames?

A. Aluminium.

B. Timber.

C. Glass.

D. PVC.

4. Which of the following is a major disadvantage of timber windows?

A. They cannot be shaped.

B. They do not provide natural beauty.

C. They may be attacked by termites and fungi.

D. They cannot be painted.

5. Which metal is commonly used to manufacture modern sliding windows?

A. Copper.

B. Aluminium.

C. Lead.

D. Tin.

6. Which type of window is permanently fixed and cannot be opened?

A. Casement window.

B. Sliding window.

C. Fixed window.

D. Hopper window.

7. A window whose sash swings on hinges fitted along one side is known as a:

A. Sliding window.

B. Casement window.

C. Fixed window.

D. Louvered window.

8. Which window operates by moving its sash along tracks?

A. Pivot window.

B. Awning window.

C. Sliding window.

D. Hopper window.

9. A window that rotates around a central or near-central point is called a:

A. Pivot window.

B. Fixed window.

C. Sash window.

D. Louvered window.

10. Which type of window is hinged at the bottom and opens inwards at the top?

A. Awning window.

B. Hopper window.

C. Casement window.

D. Sliding window.

11. A window hinged at the top and opening outwards at the bottom is known as a:

A. Hopper window.

B. Pivot window.

C. Awning window.

D. Fixed window.

12. Which window consists of a series of adjustable horizontal blades?

A. Sash window.

B. Louvered window.

C. Fixed window.

D. Pivot window.

13. Which type of window is commonly installed in a roof to allow natural light into a building?

A. Casement window.

B. Skylight.

C. Hopper window.

D. Sliding window.

14. Which of the following materials is resistant to moisture and does not rust?

A. Ordinary steel.

B. Untreated timber.

C. uPVC.

D. Cast iron.

15. Which of the following is a composite window material?

A. Pure timber.

B. Pure aluminium.

C. Timber-aluminium combination.

D. Ordinary glass.

16. The horizontal upper member of a window frame is known as the:

A. Sill.

B. Jamb.

C. Head.

D. Mullion.

17. The vertical side members of a window frame are called:

A. Jambs.

B. Sills.

C. Heads.

D. Transoms.

18. The lower horizontal part of a window frame is called the:

A. Head.

B. Sill.

C. Mullion.

D. Transom.

19. Which component holds the glazing in a movable window section?

A. Sash.

B. Jamb.

C. Sill.

D. Wall plate.

20. A vertical member that divides a window into separate sections is called a:

A. Transom.

B. Mullion.

C. Sill.

D. Head.

21. Which component is used to secure glass within a window frame?

A. Glazing bead.

B. Door stop.

C. Wall plate.

D. Rafter.

22. Which fitting allows a casement window to swing open and closed?

A. Roller.

B. Hinge.

C. Track.

D. Drainage hole.

23. Which components assist the movement of a sliding window?

A. Hinges and stays.

B. Rollers and tracks.

C. Rafters and purlins.

D. Locks and transoms only.

24. Which type of glass consists of layers bonded together using an interlayer?

A. Frosted glass.

B. Laminated glass.

C. Patterned glass.

D. Ordinary clear glass.

25. Which of the following is the most suitable window type where swinging space is limited?

A. Sliding window.

B. Casement window.

C. Awning window.

D. Hopper window.

26. Which of the following is a major disadvantage of sliding windows?

A. They always require external swinging space.

B. They cannot be fitted with glass.

C. Tracks may accumulate dust and dirt.

D. They cannot be used in residential buildings.

27. Which window shape has a curved upper section?

A. Rectangular.

B. Circular.

C. Arched.

D. Trapezoidal.

28. Which of the following windows is installed between two rooms within a building?

A. External window.

B. Internal window.

C. Roof window.

D. Corner window.

29. Which factor should be considered when selecting windows for a building near a busy road?

A. Sound insulation.

B. Roof pitch only.

C. Foundation depth only.

D. Floor finish colour only.

30. Which of the following maintenance practices is most suitable for a sliding window?

A. Painting the glass.

B. Cleaning the tracks and checking the rollers.

C. Removing the window sill.

D. Applying timber preservative to the glass.

SECTION B: STRUCTURED QUESTIONS

1.

a) Define the term window.

b) State six functions of windows in buildings.

c) Explain four characteristics of a good window.

2.

a) Identify five materials used in window construction.

b) Explain four advantages of timber windows.

c) State four disadvantages of timber windows.

3.

a) Explain the characteristics of aluminium windows.

b) State four advantages of aluminium windows.

c) Give three limitations of metal windows.

4.

a) Name five types of glass used in window construction.

b) Explain the difference between laminated glass and toughened glass.

c) State four advantages of using glass in windows.

5.

a) What is uPVC?

b) State five characteristics of uPVC windows.

c) Explain three reasons why uPVC windows are used in modern buildings.

6.

a) Classify windows according to their mode of operation.

b) Explain the operation of a casement window.

c) Give four advantages of casement windows.

7.

a) Describe how a sliding window operates.

b) Identify four components of a sliding window.

c) State four advantages of sliding windows.

8. Differentiate between the following pairs of windows:

a) Hopper window and awning window.

b) Fixed window and casement window.

c) Sliding window and sash window.

d) Casement window and pivot window.

9.

a) Explain the meaning of a louvered window.

b) Describe how a louvered window operates.

c) State four advantages and three disadvantages of louvered windows.

10.

a) Explain the meaning of a skylight.

b) State four advantages of skylights.

c) Explain four precautions that should be considered when installing skylights.

11.

a) Classify windows according to their location in a building.

b) Explain the characteristics of external windows.

c) State four uses of internal windows.

12.

a) Identify five window shapes used in building construction.

b) Describe the characteristics of an arched window.

c) Explain three applications of trapezoidal windows.

13.

a) Name eight components of a window.

b) Explain the functions of the following components:

i. Head.

ii. Jamb.

iii. Sill.

iv. Sash.

v. Mullion.

vi. Transom.

14.

a) Draw a well-labelled sketch of a casement window.

b) Show and label the following components:

i. Frame.

ii. Head.

iii. Jambs.

iv. Sill.

v. Sash.

vi. Glazing.

vii. Hinges.

viii. Handle.

15.

a) Draw a well-labelled sketch of a sliding window.

b) Identify six components of the sliding window.

c) Explain the functions of tracks and rollers.

16. A contractor is constructing a new classroom block in a school in Kenya.

a) Recommend a suitable window type for the classrooms.

b) Give five reasons for your choice.

c) Explain five factors that should be considered when selecting windows for the classroom block.

17.

a) Explain five factors that influence the selection of windows in a building.

b) State four safety precautions to observe when handling glass during window installation.

18.

a) Outline the procedure followed when installing a window.

b) Identify five tools used during window installation.

c) Explain four maintenance practices for sliding windows.

19. Explain how the following window defects can be corrected:

a) Rusting of steel frames.

b) Rotting of timber frames.

c) Difficult sliding movement.

d) Water leakage around the frame.

e) Broken window glass.

20. A homeowner in Nakuru intends to install windows in a new residential building.

a) Recommend three suitable window materials.

b) Explain four considerations when choosing the materials.

c) Recommend suitable window types for the kitchen, bathroom, living room and staircase, giving reasons for each choice.

Project assessment

The following activities can be used to assess the learner's acquisition of knowledge, practical skills and competencies.

Assessment area	**Expected evidence**
Knowledge and understanding	Correctly explains window types, materials and components
Practical skills	Identifies and labels components of actual windows
Drawing skills	Produces neat, correctly labelled window sketches

Creativity	Designs a suitable window for a given building
Problem-solving	Recommends appropriate windows for different rooms
Communication	Explains window selection and construction procedures
Safety awareness	Demonstrates safe handling of glass and tools
Collaboration	Participates effectively in group window-model construction

Suggested learner project

Project title: Design and construct a model window

Design and construct a model of either a casement window or a sliding window using locally available materials.

The model should demonstrate:

Correct arrangement of the main frame components.

Proper positioning of the glazing.

A functional opening mechanism.

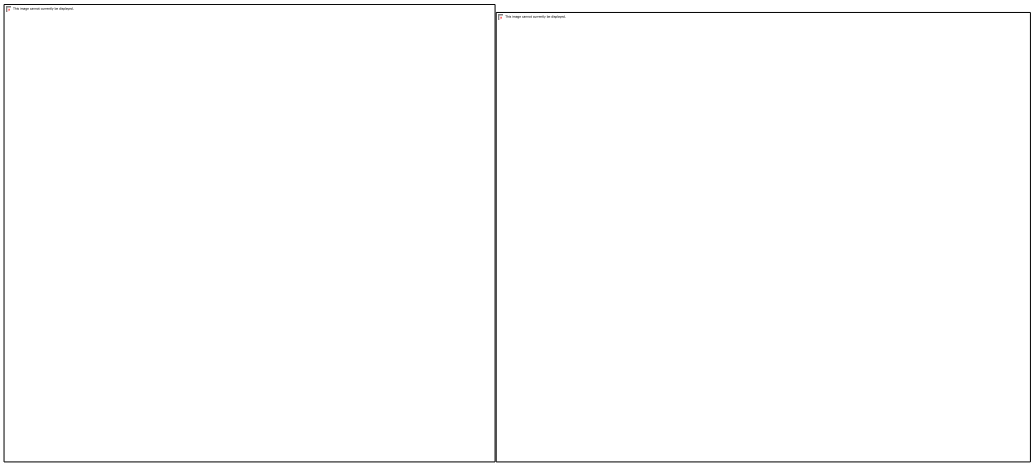
Neat workmanship.

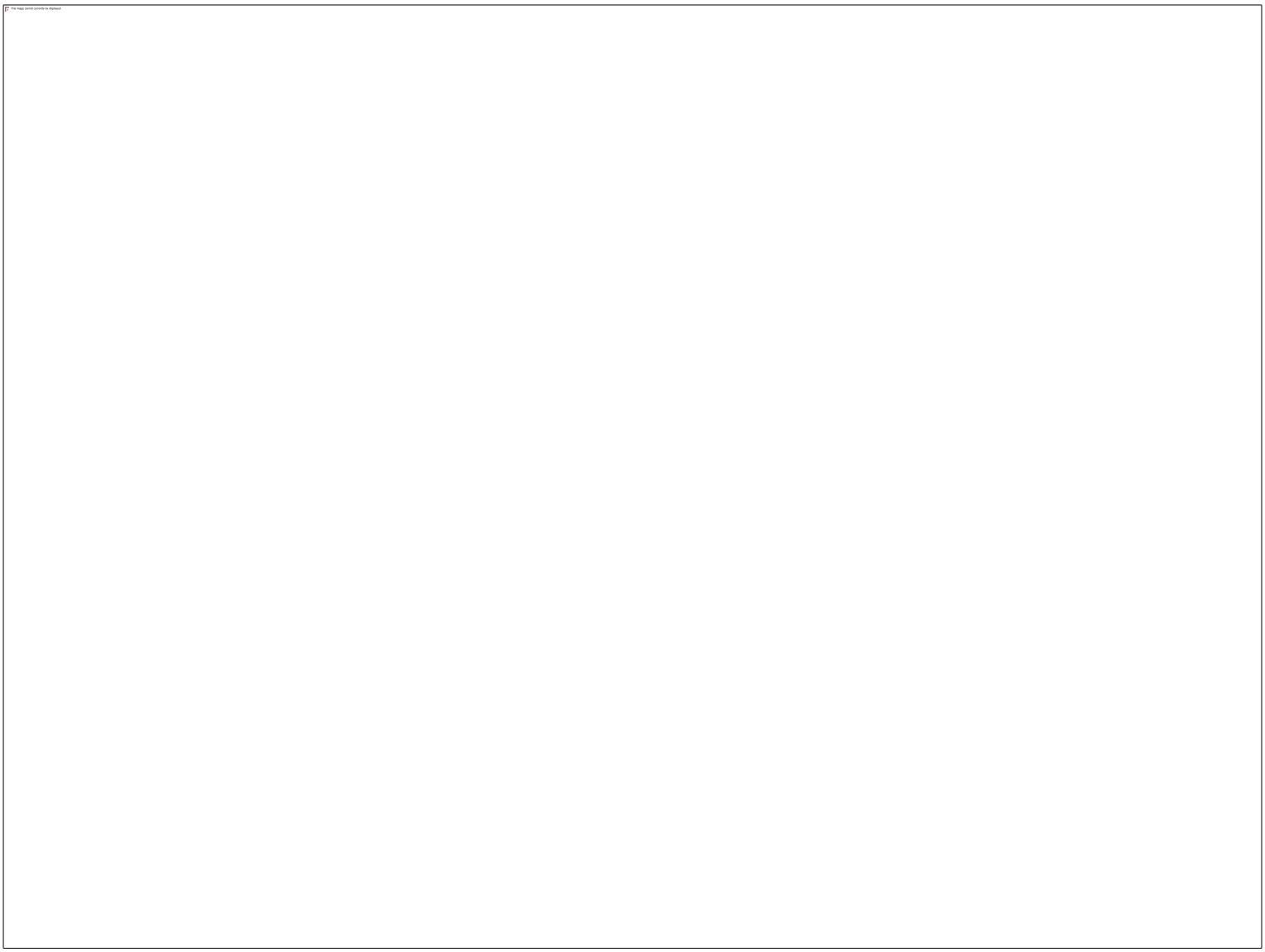
Correct labelling of the components.

Safe use of tools and materials.

STRAND 4.0: BUILDING SERVICES

SUB-STRAND 4.1: DOMESTIC WATER SUPPLY





1.0 Introduction to domestic water supply

Water is an essential requirement in every building. It is needed for drinking, cooking, cleaning, bathing, washing, sanitation, gardening and other domestic activities.

Domestic water supply refers to the provision and distribution of water to a residential building or other premises for household and related uses through an organised system of pipes, fittings, storage facilities and control devices.

A domestic water supply system consists of various components that work together to obtain water from a source, convey it to the building, store it where necessary and distribute it to points of use.

Examples of buildings that require domestic water supply include:

Residential houses.

Apartments and flats.

Schools and boarding institutions.

Hospitals and health centres.

Hotels and guest houses.

Offices and commercial buildings.

1.1 Meaning of important terms

1. Water source

A water source is a natural or developed place from which water is obtained for domestic use.

Examples include rivers, lakes, springs, wells, boreholes and rainwater.

2. Potable water

Potable water is water that is safe for human consumption because it meets the required drinking-water quality standards.

It should be free from harmful levels of disease-causing microorganisms, chemicals and other contaminants.

3. Non-potable water

Non-potable water is water that is not considered safe for drinking without suitable treatment.

It may sometimes be used for activities such as irrigation, toilet flushing or cleaning, provided it is suitable for that purpose and the system is safely designed.

4. Water distribution

Water distribution is the process of conveying water from a source or storage facility through pipes to the different points where it is needed in a building.

5. Water storage

Water storage is the process of keeping water in a suitable container or tank for use when required.

6. Water pressure

Water pressure is the force exerted by water within a pipe or plumbing system. It enables water to flow from one point to another and to reach taps, showers and other outlets.

7. Water demand

Water demand is the quantity of water required by the occupants of a building for their daily activities.

8. Plumbing

Plumbing is the installation and maintenance of pipes, fittings, valves, tanks and appliances used to convey water into, through and out of a building.

2.0 Importance of domestic water supply

A reliable water supply is necessary for the proper functioning of residential and institutional buildings.

2.1 Drinking

Water is required for human survival.

It helps maintain normal body functions.

It is used for drinking by occupants and visitors.

A reliable supply of safe drinking water helps prevent waterborne diseases.

2.2 Cooking and food preparation

Water is used to wash food ingredients.

It is used in preparing meals and beverages.

It is needed for cleaning cooking utensils.

Safe water helps prevent contamination of food.

2.3 Personal hygiene

Water is used for bathing and showering.

It is required for washing hands and face.

It is used for brushing teeth.

It helps maintain personal cleanliness and health.

2.4 Cleaning and sanitation

Water is used to clean floors, walls and other surfaces.

It is needed for washing toilets and bathrooms.

It is used to clean utensils, clothes and household equipment.

It helps maintain hygienic conditions in buildings.

2.5 Toilet flushing

Water is used in flushing water closets.

It helps remove human waste from sanitary appliances.

It supports proper sanitation and cleanliness.

Adequate water supply helps maintain the operation of sanitation facilities.

2.6 Laundry

Water is used for washing clothes, beddings and other fabrics.

It is needed for rinsing clothes after washing.

It supports cleaning activities in homes, schools and hotels.

2.7 Gardening and landscaping

Water is used to irrigate flowers, lawns and vegetable gardens.

It supports the growth of plants around residential buildings.

It helps maintain attractive outdoor spaces.

2.8 Fire safety

Water may be used to extinguish certain types of fires.

Some buildings have dedicated fire-fighting water storage and distribution systems.

The fire-water supply may require separate tanks, pumps and pipework.

Domestic plumbing should not automatically be assumed to provide adequate fire-fighting water.

2.9 Comfort and convenience

A reliable supply allows occupants to use showers, sinks and other appliances conveniently.

It reduces the need to fetch water manually.

It improves the quality of life in residential buildings.

2.10 Supporting institutional and commercial activities

Water is needed in:

Schools for drinking, cooking, cleaning and sanitation.

Hospitals for hygiene, cleaning and patient care.

Hotels for guest services, laundry and food preparation.

Offices for drinking, cleaning and sanitary facilities.

Workshops for suitable cleaning and operational activities.

3.0 Sources of water for domestic use

A source of water is the place from which water is collected or obtained before being supplied to a building.

The main sources of water for domestic use are:

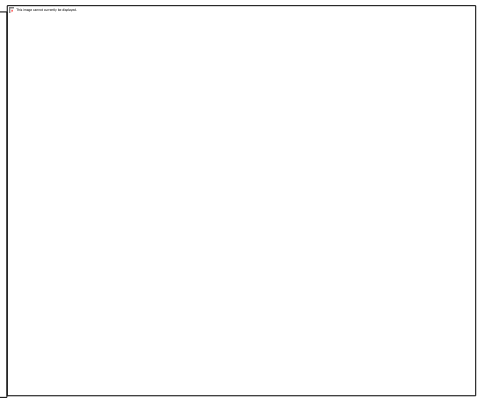
Surface water.

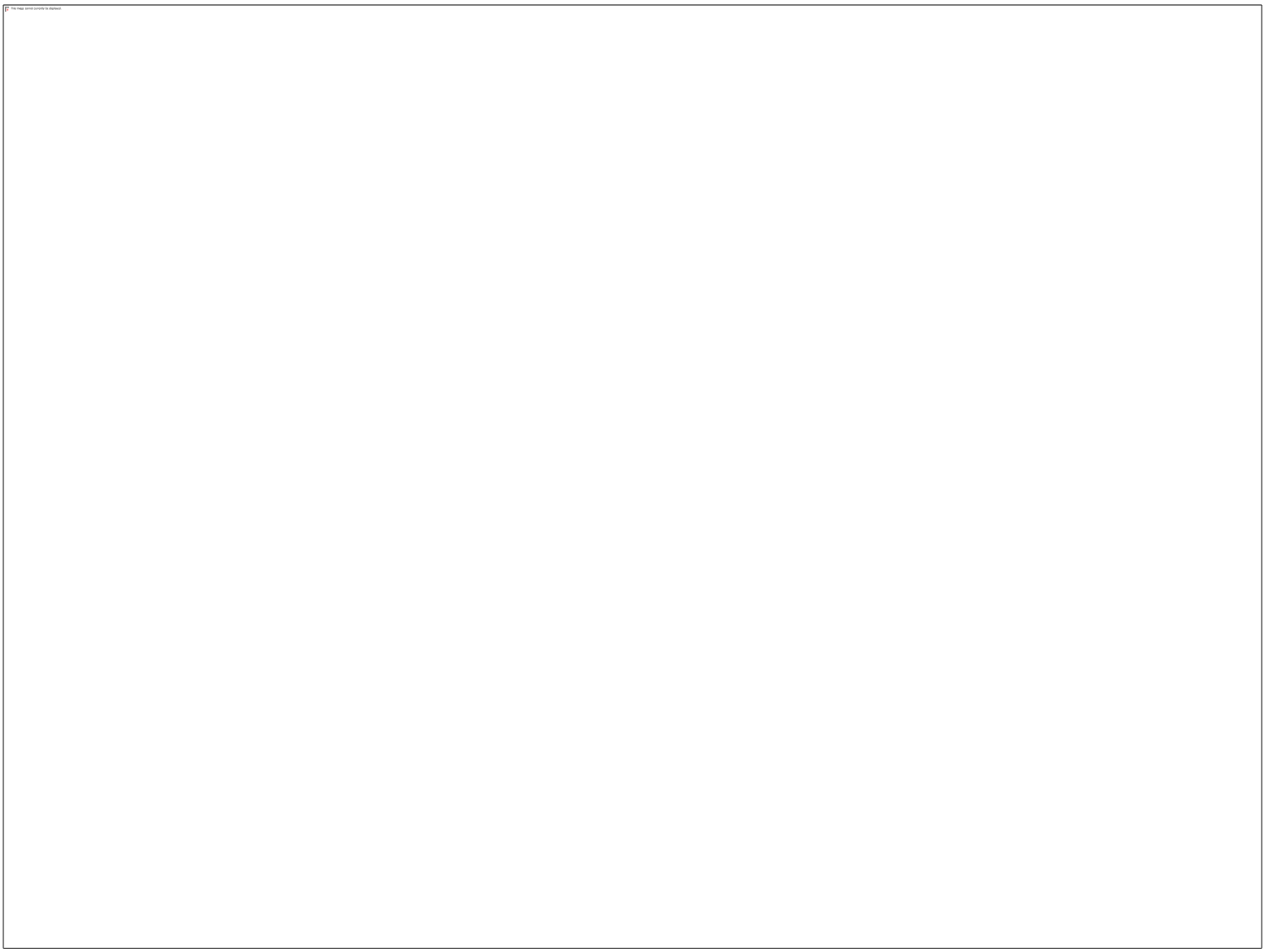
Underground water.

Rainwater.

Supplied or treated municipal water.







3.1 Surface water

Surface water is water found on the earth's surface. It collects in rivers, lakes, dams, reservoirs, ponds and streams.

Examples of surface water sources

Rivers.

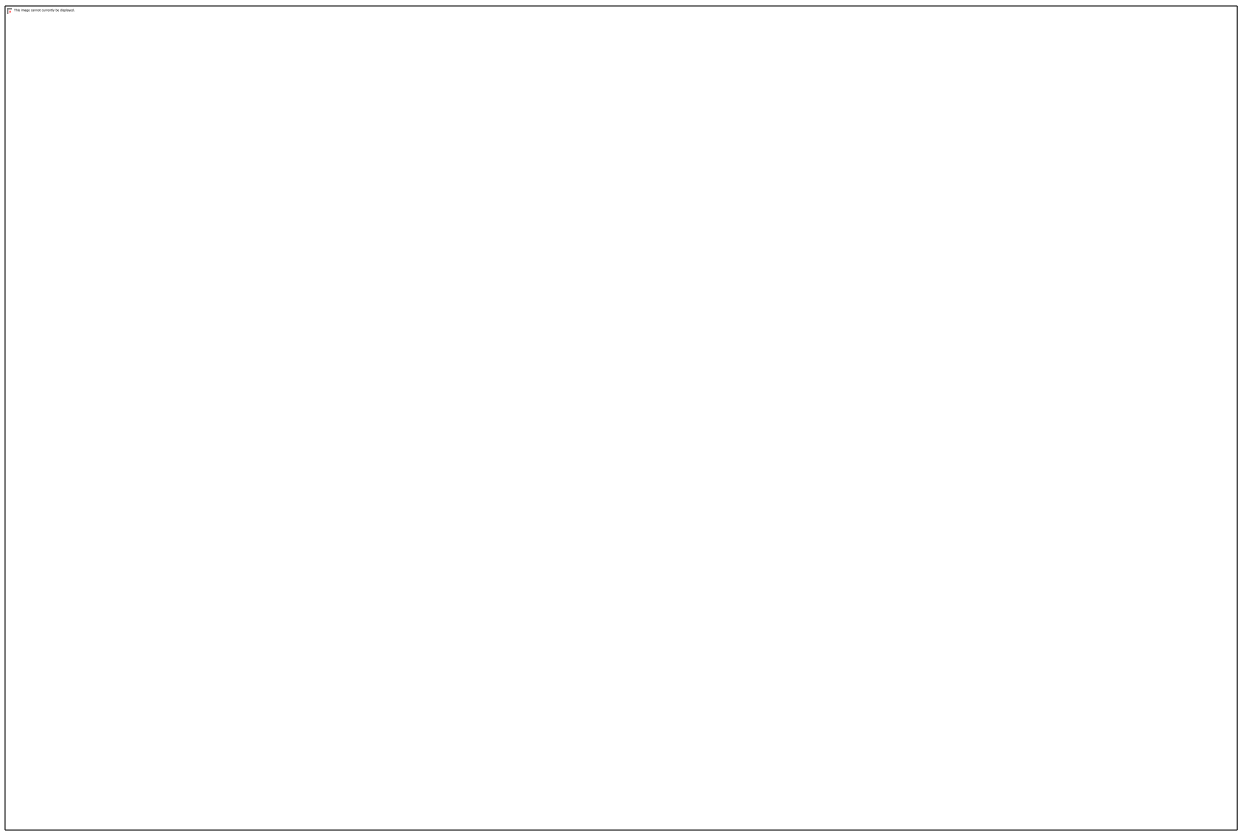
Lakes.

Dams.

Ponds.

Streams.

Reservoirs.



Characteristics of surface water

It is found above the ground.

It may be collected through intake structures.

It is often exposed to environmental contamination.

It may contain suspended soil particles, organic matter and microorganisms.

Its quantity may change depending on rainfall and seasons.

It may require treatment before being used for drinking.

Advantages of surface water

It can provide large quantities of water.

It can supply many households and communities.

It can be stored in dams and reservoirs.

It can be relatively accessible in areas near rivers and lakes.

It can support irrigation and other uses in addition to domestic supply.

Disadvantages of surface water

It may be contaminated by human and animal waste.

It may contain soil, silt and other suspended materials.

It may be affected by agricultural chemicals and industrial pollution.

Its availability may reduce during prolonged dry periods.

It usually requires treatment before drinking.

Examples in Kenya

Water abstracted from Lake Victoria for treatment and distribution.

Water obtained from rivers and dams supplying towns and communities.

Water stored in reservoirs for domestic supply.

Treatment of surface water

Before surface water is supplied as drinking water, it may undergo processes such as:

Screening: Removal of large materials such as leaves, sticks and rubbish.

Coagulation: Addition of suitable chemicals to help fine particles combine.

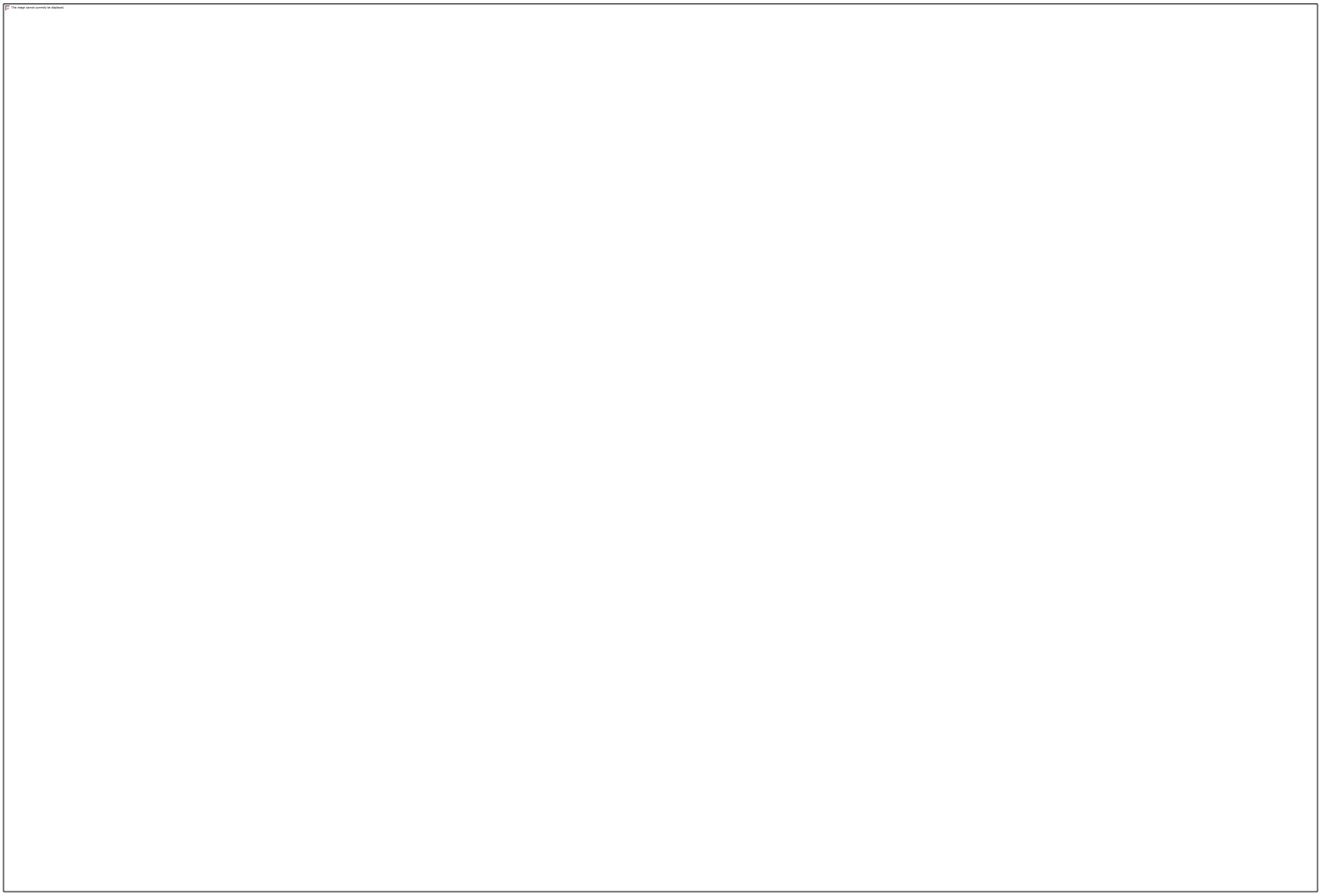
Flocculation: Gentle mixing to form larger particles called flocs.

Sedimentation: Allowing the heavier flocs to settle.

Filtration: Passing water through suitable filter materials to remove remaining particles.

Disinfection: Using an approved process, such as chlorination or ultraviolet treatment, to reduce harmful microorganisms.

Storage and distribution: Keeping treated water in suitable reservoirs before supplying it to consumers.



3.2 Underground water

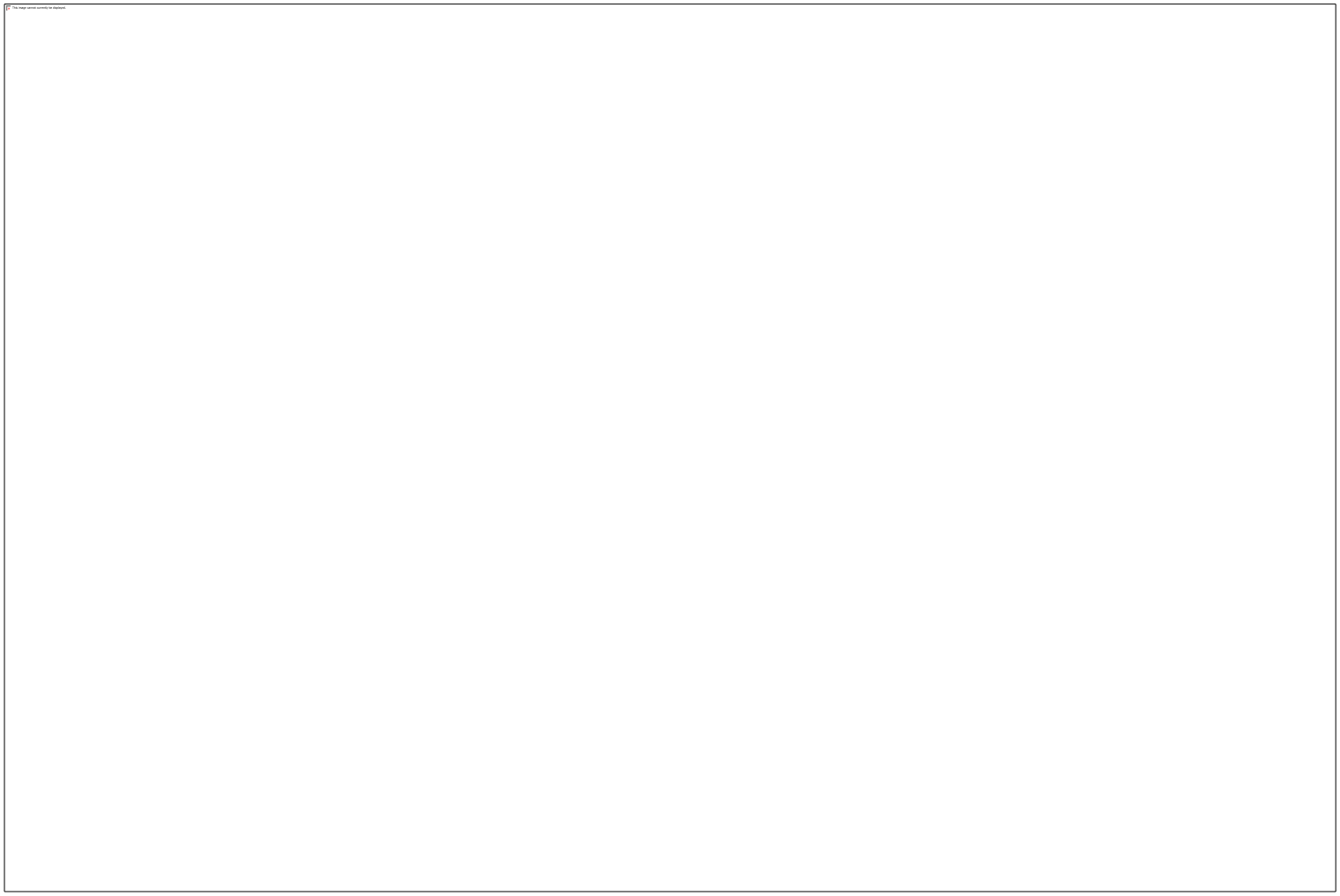
Underground water is water found beneath the earth's surface in soil pores, cracks and spaces within rocks.

It is commonly obtained from wells, boreholes and natural springs.

Main sources of underground water

A. Wells

A well is a hole or shaft dug into the ground to reach underground water.



Characteristics

It may be dug manually or mechanically.

It may reach shallow underground water.

It may be lined with concrete rings, masonry or other suitable materials.

Water may be drawn using buckets, hand pumps or motorised pumps.

It should be protected against surface contamination.

Advantages

It can provide water to individual households.

It may be relatively inexpensive to construct where groundwater is shallow.

It can be useful in rural areas without piped water.

It may provide water throughout the year where the aquifer is reliable.

Disadvantages

Shallow wells may easily become contaminated.

Water levels may fall during dry seasons.

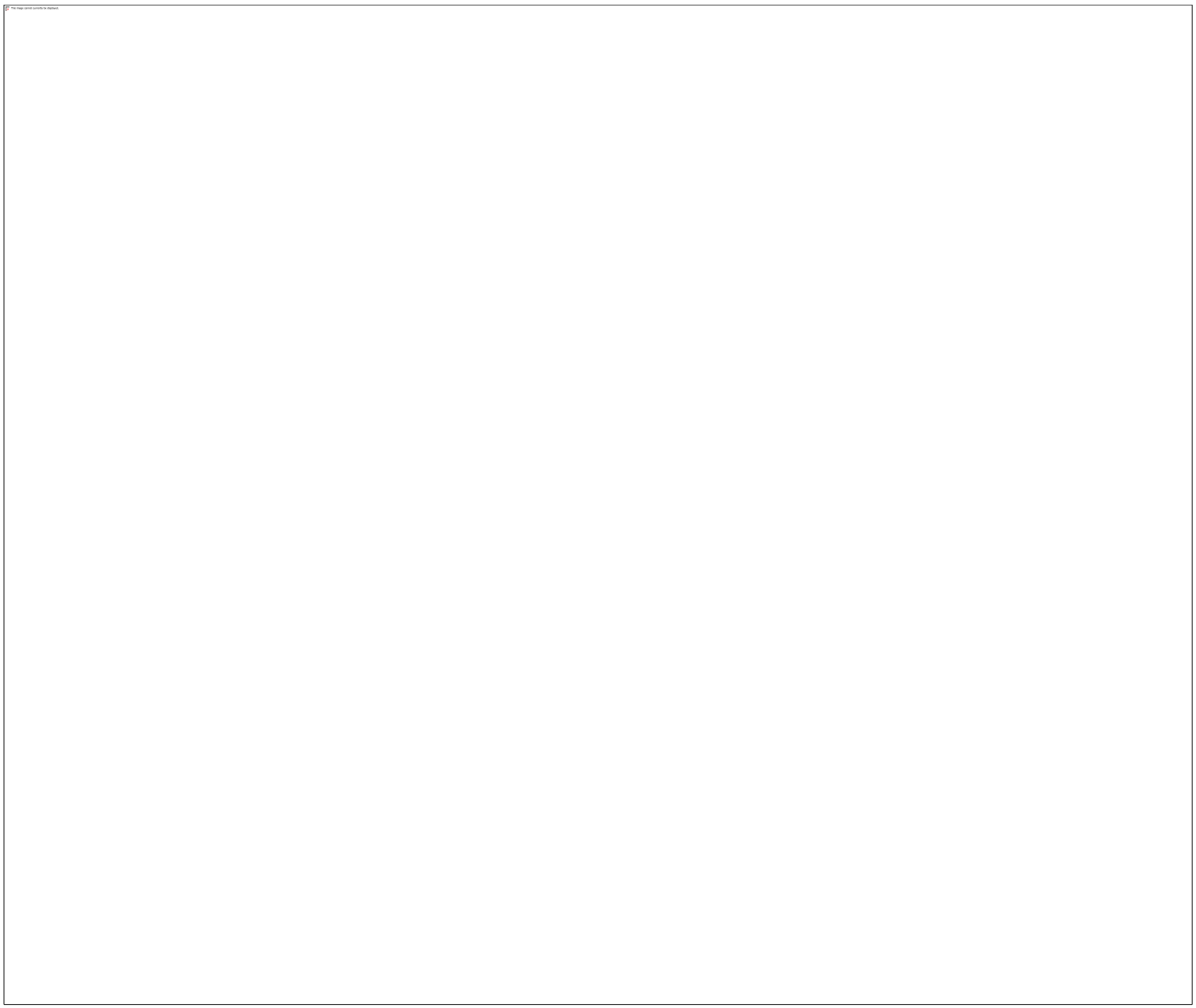
Manual drawing of water may be difficult.

Poorly constructed wells may collapse or become unsafe.

Water quality must be tested before drinking.

B. Boreholes

A borehole is a narrow, deep hole drilled into the ground to access underground water-bearing rock formations called aquifers.



Characteristics

It is drilled using specialised equipment.

It may reach deeper aquifers than ordinary wells.

It is usually fitted with a casing to support the sides.

Water is commonly lifted using a submersible pump.

It may supply individual buildings, institutions or communities.

Advantages

It can access water from deeper underground formations.

It may provide a reliable supply where the aquifer is productive.

It occupies relatively little surface space.

It can be used in areas without nearby rivers or municipal supply.

It may supply large institutions when properly designed.

Disadvantages

Drilling may be expensive.

Pumps require electricity, solar power or another energy source.

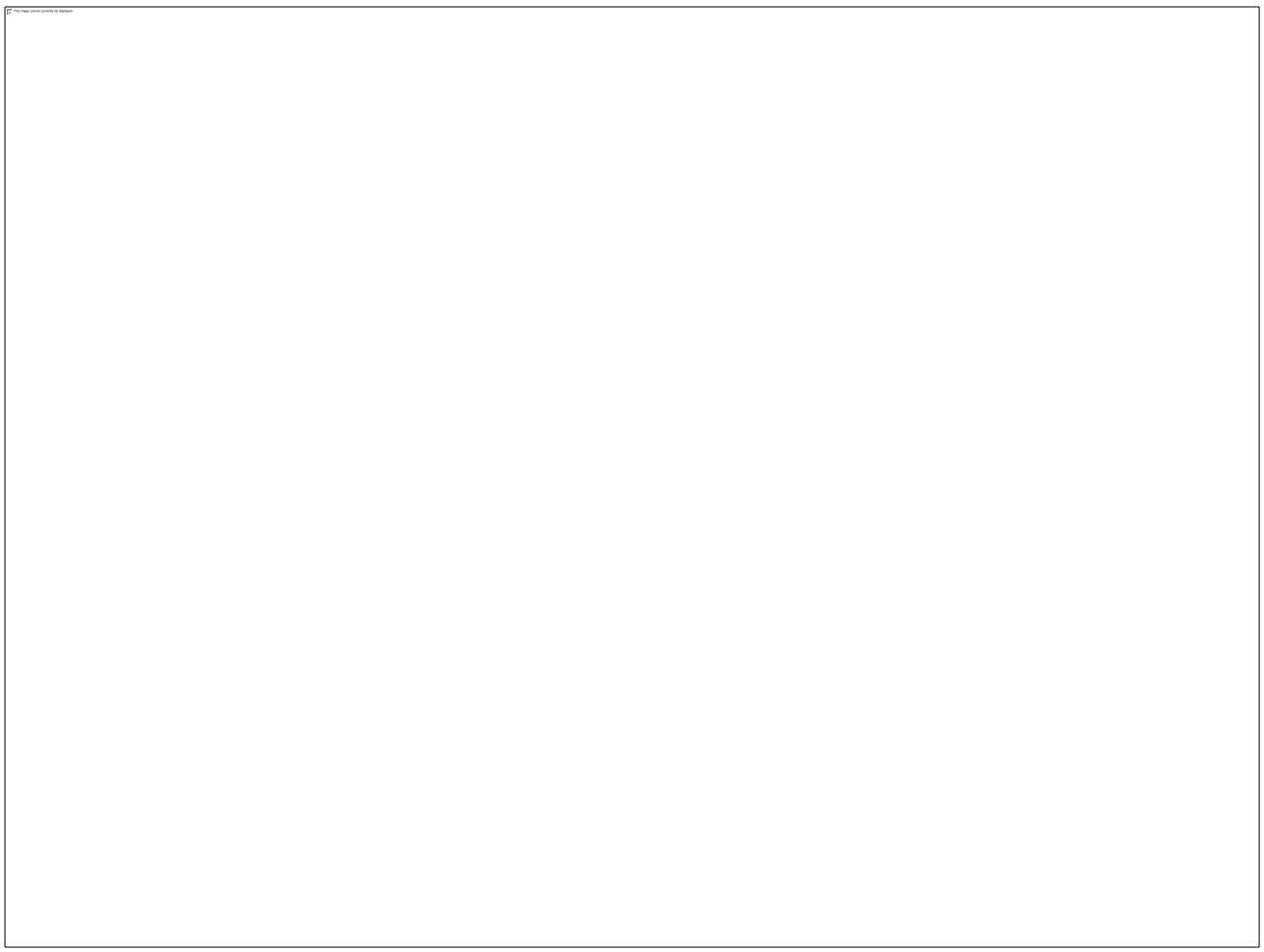
Boreholes may produce water containing unwanted dissolved minerals.

The water yield may be insufficient if the aquifer is poorly productive.

Pump and borehole maintenance may require specialised skills.

C. Springs

A spring is a natural point where underground water flows or emerges onto the earth's surface.



Characteristics

Water emerges naturally from the ground.

It may flow continuously or seasonally.

It may be collected using a protected spring structure.

Its quality depends on the surrounding geology and environmental conditions.

Advantages

It may provide water without mechanical pumping.

It can be relatively easy to collect where accessible.

It may supply water continuously where the underground source is reliable.

It can be useful for rural domestic water schemes.

Disadvantages

Some springs dry up during dry seasons.

They may be contaminated by surface runoff.

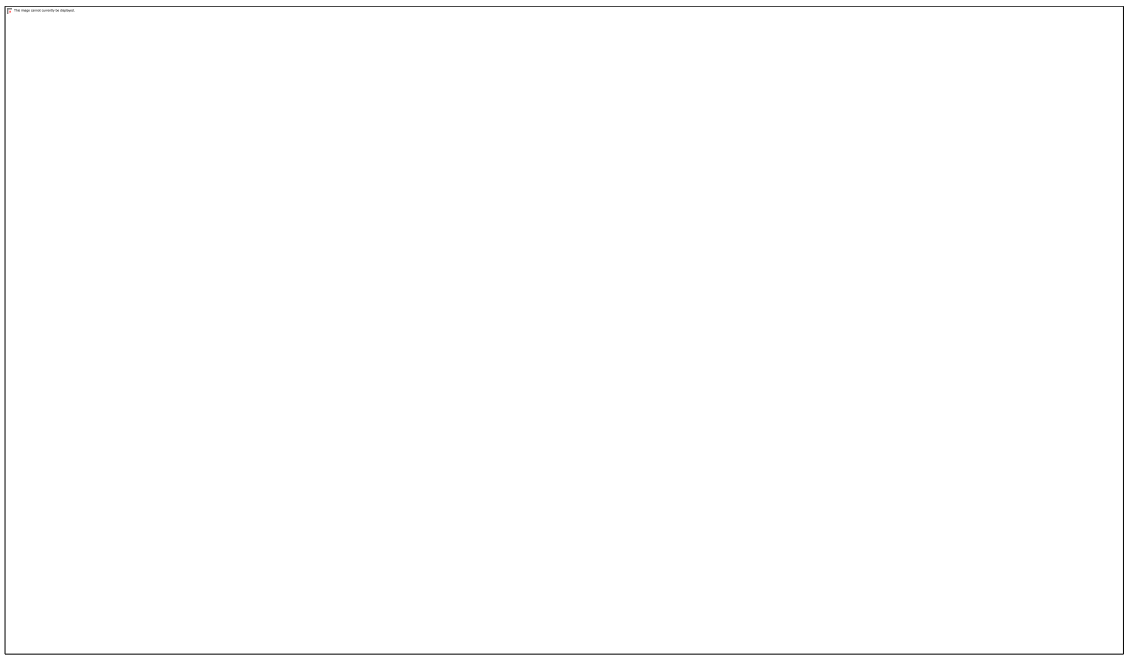
Their flow rate may be insufficient for large populations.

They require protection against human and animal interference.

3.3 Rainwater harvesting

Rainwater harvesting is the process of collecting and storing rainwater for later use.

Rainwater is commonly collected from roofs using gutters and downpipes.



Main components of a roof rainwater harvesting system

Catchment surface: The roof on which rainwater falls.

Gutters: Channels fixed along roof edges to collect rainwater.

Downpipes: Pipes that carry water from gutters to the storage tank.

Leaf screens: Devices that prevent leaves and large debris from entering the system.

First-flush diverter: A device that directs the initial roof runoff away from the storage tank.

Storage tank: A container used to store collected rainwater.

Inlet screen: Prevents insects and debris from entering the tank.

Overflow pipe: Allows excess water to leave the tank safely.

Tap or outlet pipe: Allows stored water to be drawn for use.

Advantages of rainwater harvesting

It provides an additional source of water.

It reduces dependence on municipal or other supplies.

It can reduce surface runoff around buildings.

It is useful in rural and urban areas.

It can reduce water costs where rainfall is adequate.

It can provide water during temporary supply interruptions.

Disadvantages of rainwater harvesting

Supply depends on rainfall.

Storage tanks may be expensive.

Roofs and gutters require regular cleaning.

Collected water may contain dust, bird droppings and other contaminants.

Additional treatment may be necessary before drinking.

Important safety considerations

Keep the roof catchment and gutters clean.

Use a first-flush arrangement where appropriate.

Cover tanks to prevent mosquito breeding and contamination.

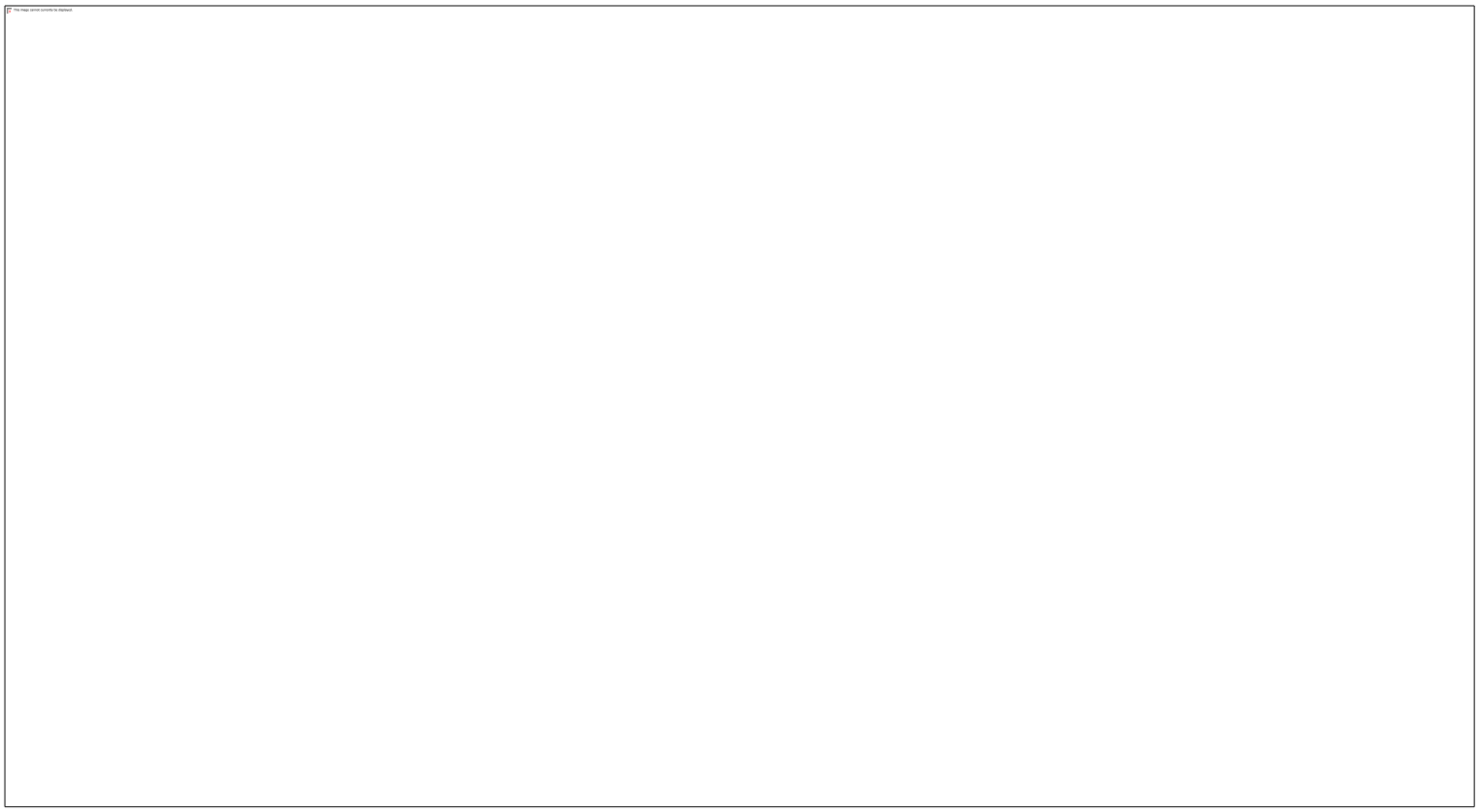
Test and treat water intended for drinking.

Keep rainwater pipework separate from potable water pipework unless an approved arrangement prevents cross-connection.

3.4 Municipal or public water supply

Municipal water supply refers to water provided through a public or licensed water service provider.

The water is normally abstracted from an approved source, treated where necessary, stored and distributed through a network of pipes.



Characteristics

Water is conveyed through a public distribution network.

It is supplied to buildings through service connections.

A water meter may be installed to measure consumption.

The supply may be controlled by valves.

The pressure and reliability depend on the distribution system.

Advantages

It can provide convenient piped water.

Water treatment and quality monitoring are generally managed by the responsible supplier.

It reduces the need for individual households to develop their own source.

It can supply many buildings through a shared network.

Disadvantages

Supply may be interrupted.

Pressure may fluctuate.

Consumers pay for water according to the applicable tariff and billing arrangement.

Some areas may not be connected to a public network.

Additional household storage may be needed where supply is unreliable.

3.5 Comparison of domestic water sources

Source	How water is obtained	Main advantage	Main limitation
River	Collected from a river intake	Can provide large quantities	Requires treatment
Lake	Abstracted from a lake	Can support large schemes	May be affected by pollution
Dam/reservoir	Collected from stored surface water	Water can be stored for later use	Depends on inflow and storage capacity
Well	Drawn from an excavated shaft	Useful for household supply	Can be contaminated
Borehole	Pumped from an underground aquifer	Can reach deep water sources	Drilling and pumping can be costly
Spring	Collected where groundwater emerges	May flow naturally	May have seasonal variation
Rainwater	Collected from roofs	Reduces dependence on other sources	Depends on rainfall
Municipal supply	Delivered through public pipes	Convenient piped supply	May experience interruptions

4.0 Types of water storage tanks used for domestic purposes

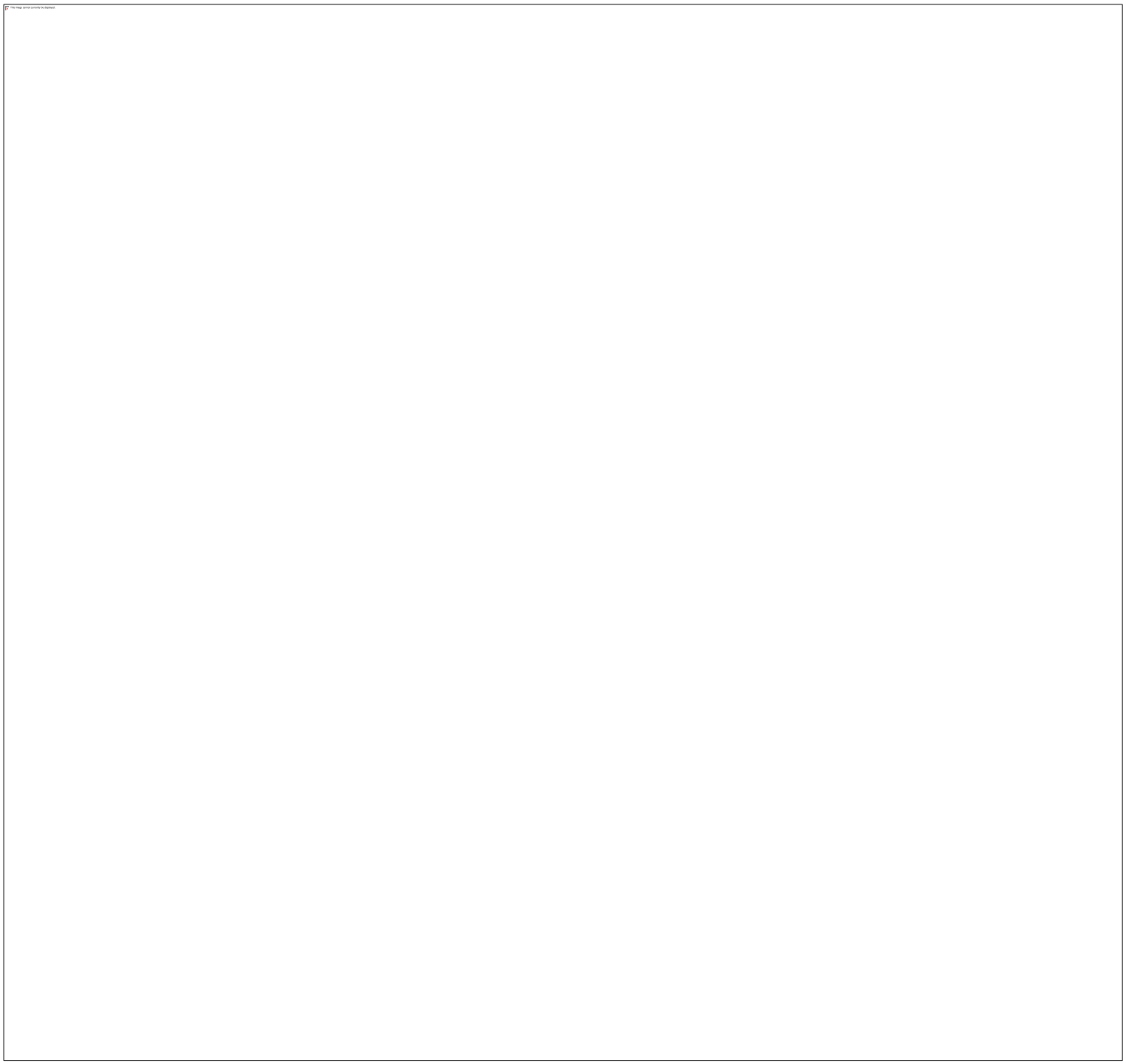
4.1 Meaning of a water storage tank

A water storage tank is a container designed to collect and hold water for use when required.

Water storage tanks are important in buildings because they ensure that water is available even when the main supply is interrupted or when demand is higher than the immediate supply.







4.2 Importance of domestic water storage tanks

Ensuring continuous water availability: Stored water can be used when the public supply is interrupted.

Meeting peak demand: Stored water supplements the incoming supply when many people use water at the same time.

Providing water during emergencies: Water can be reserved for use during temporary supply failures.

Maintaining water pressure: Elevated tanks can provide pressure through gravity.

Reducing dependence on direct pumping: Water can be pumped into a tank when electricity is available and supplied later by gravity.

Supporting rainwater harvesting: Tanks collect and store rainwater for later use.

Supplying remote buildings: Storage tanks can help supply buildings that are not connected to reliable piped networks.

Supporting institutional activities: Schools, hospitals and hotels may require large storage capacities.

4.3 Classification of water storage tanks according to location

Water storage tanks can be classified according to where they are installed.

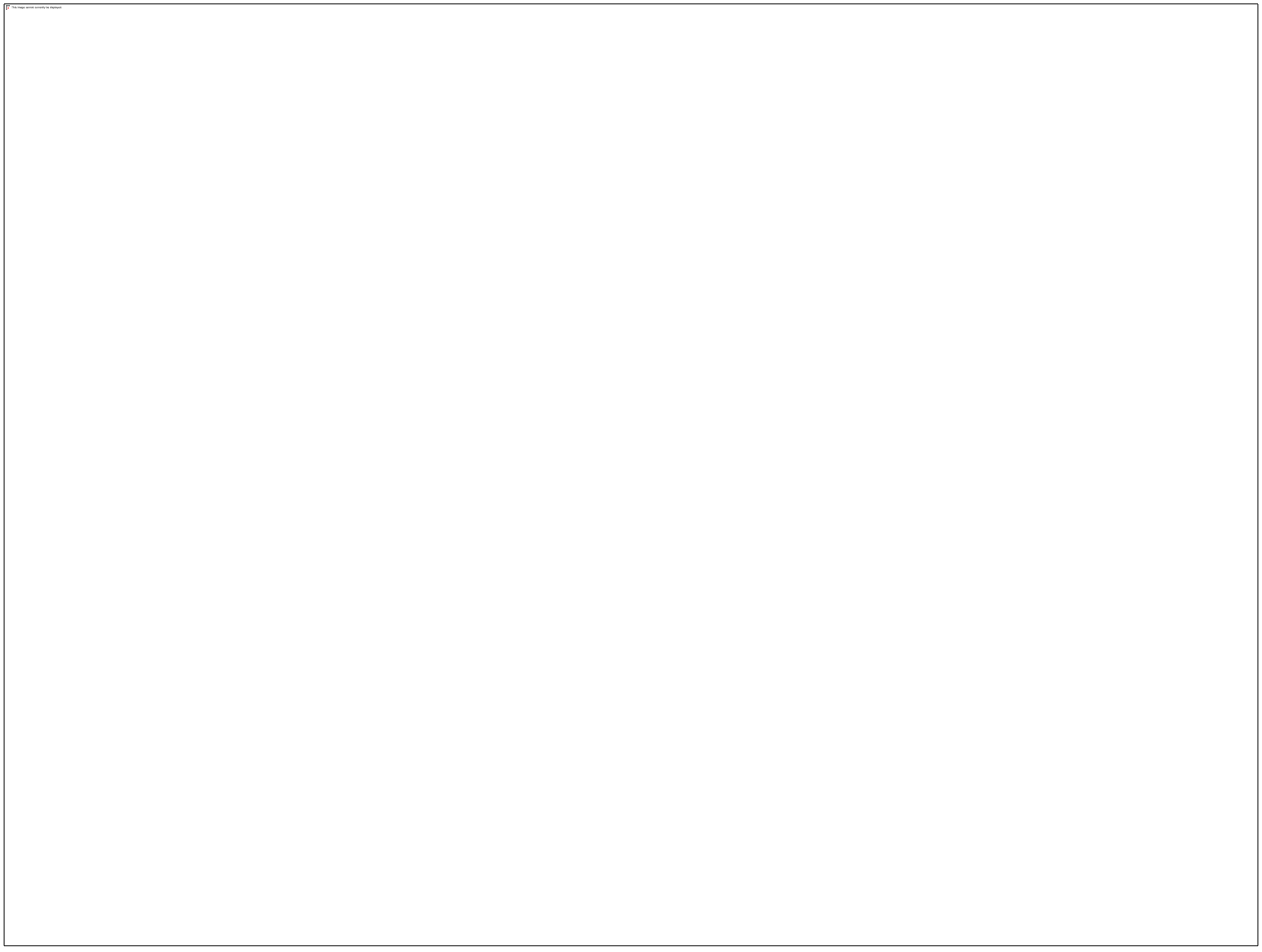
The main types are:

Underground water storage tanks.

Ground-level water storage tanks.

Elevated or overhead water storage tanks.

4.3.1 Underground water storage tanks



An underground water storage tank is a tank constructed or installed below ground level for storing water.

It may be constructed using reinforced concrete or installed as a suitable prefabricated tank designed for underground use.

Characteristics

It is located below the surrounding ground surface.

It may be constructed from reinforced concrete.

It may also be manufactured from specially designed underground-rated plastic or other materials.

It has an access opening for inspection and cleaning.

It requires suitable waterproofing and structural protection.

Water is commonly pumped from it to an elevated tank or directly into the distribution system.

Its design must consider groundwater pressure and soil conditions.

Advantages of underground water tanks

They save space above the ground.

They do not interfere significantly with the appearance of the building.

They can store large quantities of water.

They are protected from direct sunlight.

They may help maintain relatively stable water temperatures.

They are suitable where surface space is limited.

Disadvantages of underground water tanks

Construction and installation can be expensive.

Excavation may be difficult in rocky or waterlogged areas.

Inspection and cleaning may be more difficult.

Leakage may be difficult to detect.

Groundwater may enter through defective joints if the tank is poorly constructed.

They may be damaged by external soil pressure if not properly designed.

Contamination may occur if surface runoff enters through an inadequately sealed cover.

Uses

Residential estates.

Apartments.

Schools.

Hospitals.

Commercial buildings.

Large institutional buildings.

Important construction requirements

The tank should be structurally designed to withstand soil and groundwater pressures.

The base should be stable and properly prepared.

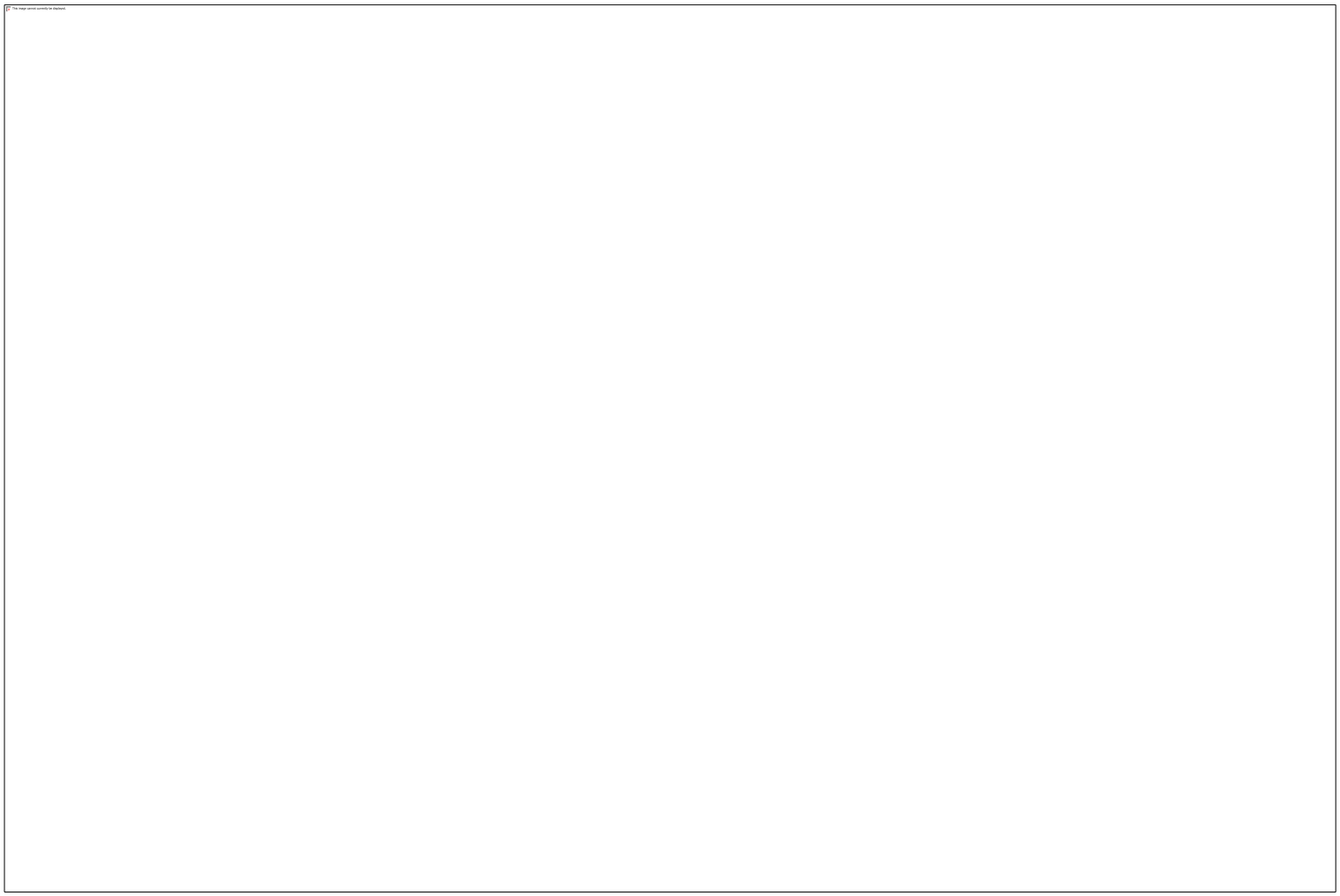
The walls and floor should be watertight.

The cover should prevent dirt, insects and runoff from entering.

Access should be provided for inspection and cleaning.

Inlet, outlet, overflow and washout arrangements should be properly provided.

4.3.2 Ground-level water storage tanks



A ground-level water storage tank is a tank installed on the ground or on a properly prepared foundation at approximately ground level.

It is commonly manufactured from plastic, steel, concrete or other suitable materials.

Characteristics

It is placed directly on a firm and level base.

It is easily accessible for inspection.

It can be connected to a pump or gravity-fed system where the outlet arrangement allows.

It is available in different shapes and capacities.

It may be cylindrical, rectangular or square.

Advantages

It is easier to install than many underground tanks.

It is relatively easy to inspect and clean.

It can be connected to a pump for transferring water to an overhead tank.

It is available in different sizes.

It is generally easier to detect external leakage.

Disadvantages

It occupies useful ground space.

It may interfere with the appearance of the compound.

It may be exposed to sunlight and weather.

Water pressure from a ground-level tank alone is limited unless the outlets are below the water level or a pump is used.

It may be vulnerable to accidental damage or unauthorised access.

Uses

Residential compounds.

Small commercial premises.

Schools.

Rural homes.

Construction sites.

4.3.3 Elevated or overhead water storage tanks



An elevated water storage tank is a tank installed above ground level on a supporting structure, such as a steel tower, reinforced concrete platform or suitably designed building structure.

It supplies water to lower-level outlets mainly through gravity.

Characteristics

It is positioned above the points of water use.

It may be installed on a tower or building roof.

It requires a strong supporting structure.

It usually has an inlet, outlet, overflow and washout connection.

It may be filled by a pump or another suitable supply arrangement.

Water flows to the building's outlets due to gravity.

Advantages

It provides water pressure without continuous pumping.

It can supply water during temporary electricity interruptions.

It can serve several outlets at the same time, depending on the design.

It can provide a reserve of water.

It can reduce the need for pumps to operate continuously.

Disadvantages

The supporting structure may be expensive.

The tank and support structure require regular inspection.

A full tank imposes a significant load on the support.

Water pressure may be inadequate if the tank is not sufficiently high.

High-level installation may be difficult and risky.

The tank may be exposed to sunlight and temperature changes.

Uses

Multi-storey residential buildings.

Schools.

Hospitals.

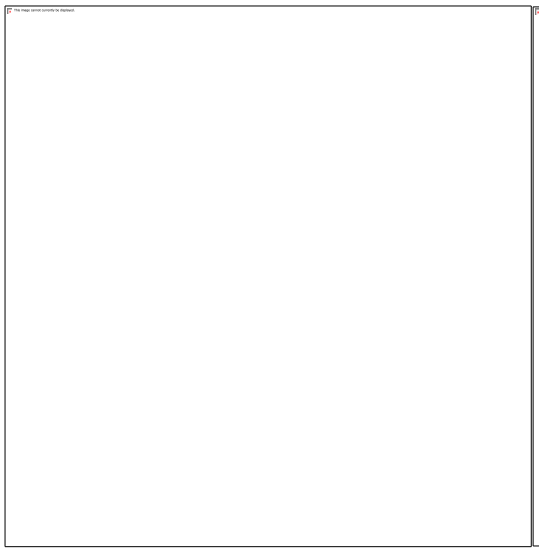
Commercial buildings.

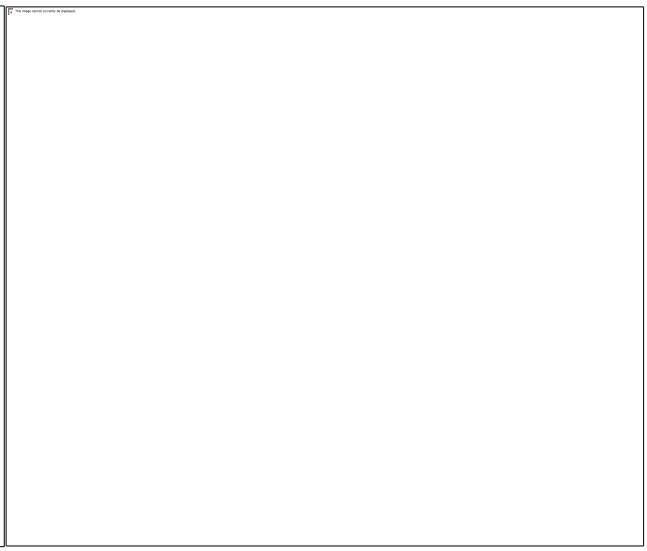
Residential houses with unreliable mains supply.

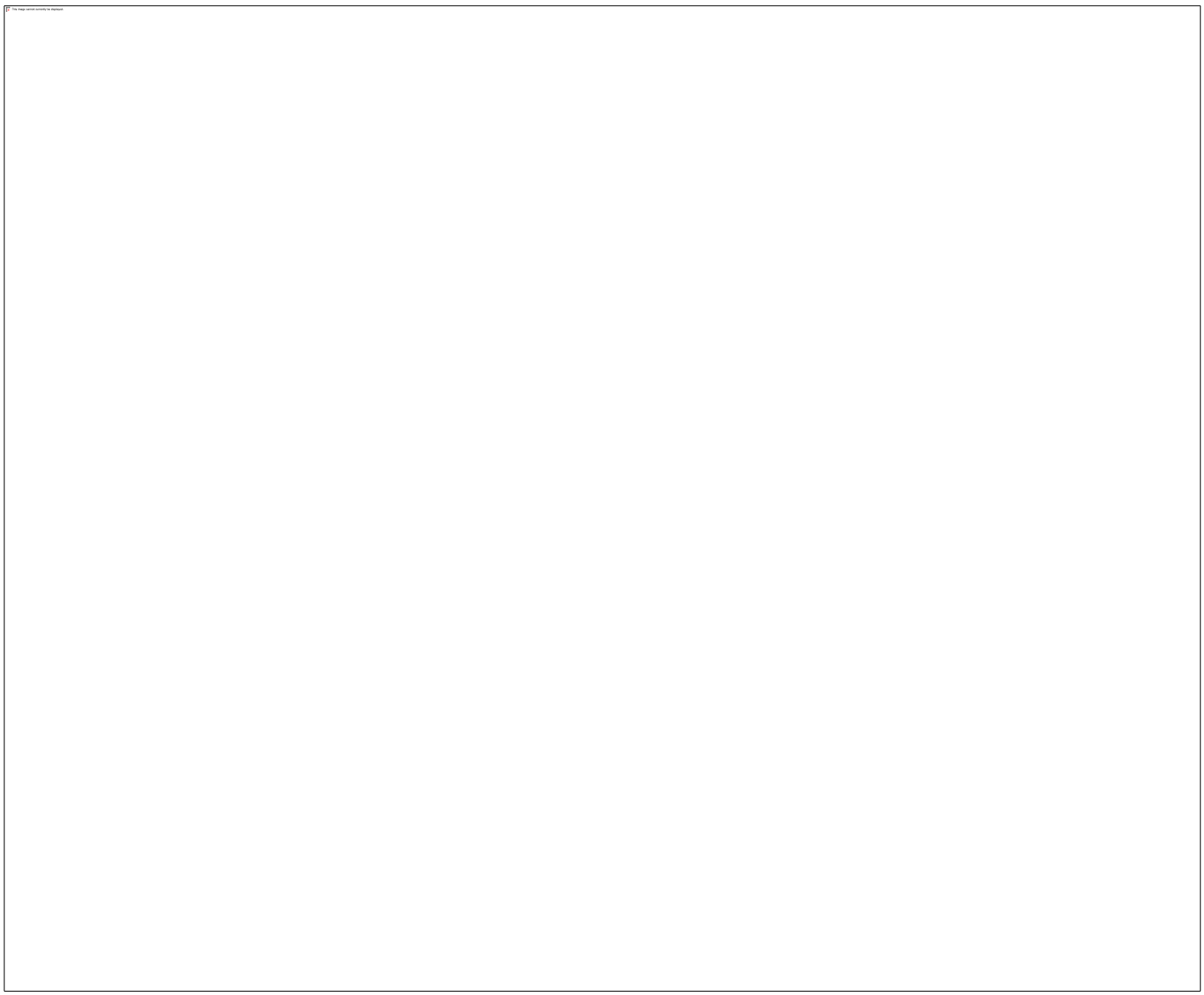
4.4 Comparison of the three main types of tanks

Feature	Underground tank	Ground-level tank	Elevated tank
Position	Below ground	At ground level	Above ground
Space use	Saves surface space	Uses ground space	Uses elevated space
Water delivery	Usually pumped	Often pumped or gravity-assisted	Mainly gravity-fed
Inspection	Relatively difficult	Relatively easy	Requires safe access
Initial installation	May be expensive	Usually simpler	Requires support structure
Main advantage	Large storage without occupying surface space	Easy installation and access	Provides gravity pressure
Main limitation	Difficult to inspect and repair	Does not normally provide strong pressure by itself	Requires a strong support structure

4.5 Common materials used to manufacture water tanks







A. Plastic tanks

Commonly manufactured from polyethylene.

They are relatively light.

They are available in many sizes.

They are resistant to corrosion.

They are easy to transport and install.

They should be made from materials suitable for the intended water use.

B. Concrete tanks

Constructed using concrete, usually reinforced where required.

They can store large quantities of water.

They can be constructed underground or above ground.

They are durable when properly designed and waterproofed.

Poor workmanship may cause cracking and leakage.

C. Steel tanks

Manufactured from suitable steel plates or sections.

They can be used for large storage capacities.

They require suitable corrosion protection.

They may be installed at ground level or on elevated supports.

Their joints and protective coatings require inspection.

D. Stainless-steel tanks

Manufactured from corrosion-resistant stainless steel.

They are strong and durable.

They are relatively easy to clean.

They may be costly compared with some alternatives.

Their suitability depends on the grade of stainless steel and the water conditions.

4.6 Factors to consider when selecting a domestic water storage tank

Storage capacity: The tank should hold enough water for the expected demand and storage period.

Number of occupants: A building with many occupants generally requires more storage than a small household.

Available space: Consider the area available for installation.

Cost: Include purchase, transportation, installation and maintenance expenses.

Material: Select a durable, safe and suitable material.

Location: Determine whether the tank will be underground, ground-level or elevated.

Water quality: The tank should be suitable for storing water for its intended use.

Structural strength: The base and supporting structure must safely carry the full tank weight.

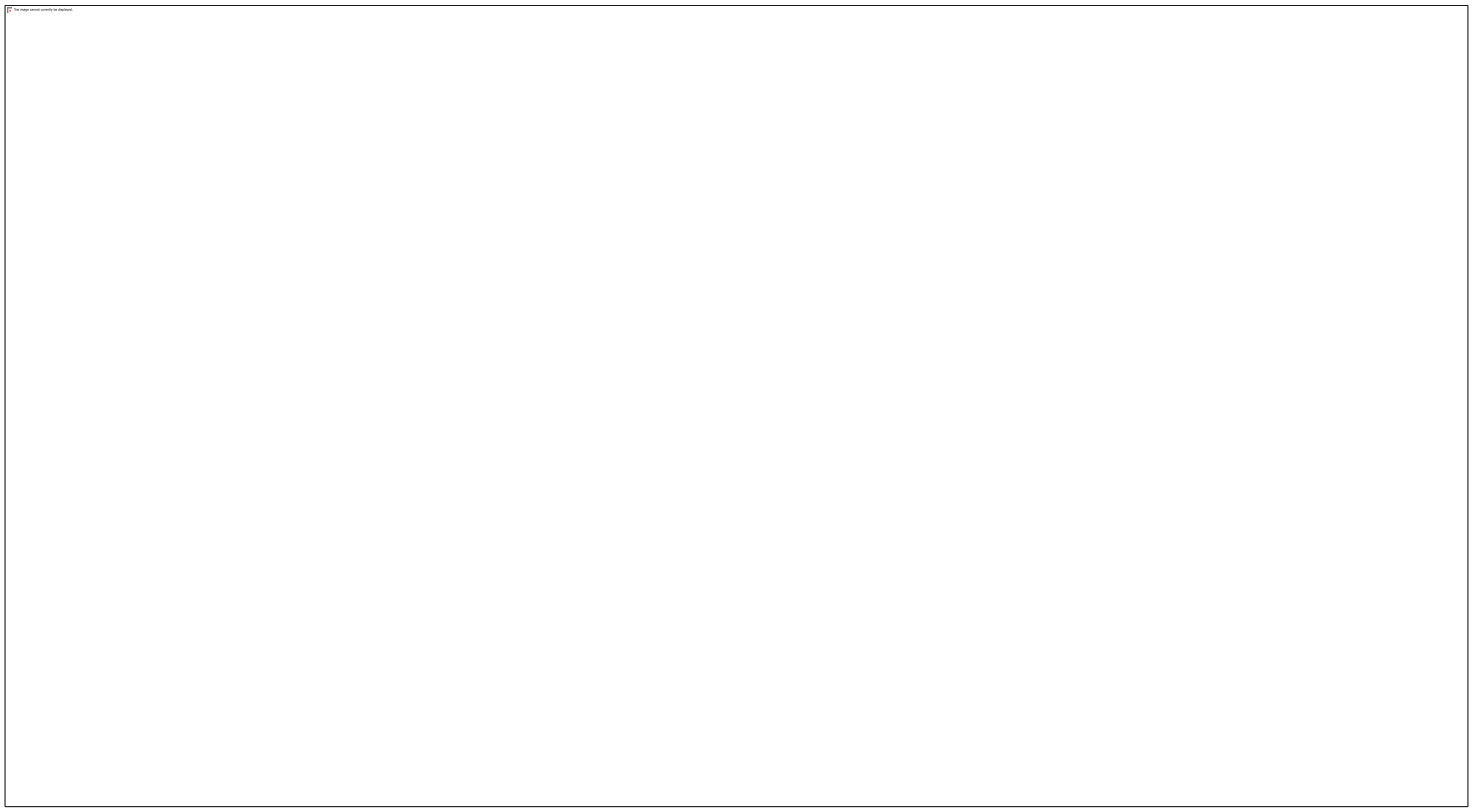
Maintenance: Consider ease of inspection, cleaning and repair.

Climate: Consider sunlight, temperature and weather exposure.

Water pressure: Consider whether the system needs a pump or gravity supply.

Future demand: Allow for reasonable changes in occupancy and water use.

4.7 Important fittings provided on a water storage tank



A properly designed water storage tank normally has the following fittings:

1. Inlet pipe

Carries water into the tank.

It may be connected to a public supply, borehole pump or rainwater harvesting system.

2. Outlet pipe

Carries stored water from the tank to the building or distribution system.

It should be positioned to allow adequate water withdrawal.

3. Overflow pipe

Allows excess water to escape when the tank becomes full.

It helps prevent flooding and damage.

It should discharge at a suitable location where leakage can be noticed.

4. Washout or scour pipe

Allows water and accumulated sediment to be drained during cleaning.

It is usually positioned near the bottom of the tank.

5. Float valve

Controls the entry of water into a tank.

It closes the inlet when the water reaches a predetermined level.

It helps prevent overflowing.

6. Vent pipe

Allows air to enter or leave the tank as the water level changes.

It should be protected against insects and debris.

7. Access cover or manhole

Provides access for inspection and cleaning.

It should be securely covered to prevent contamination.

8. Level indicator

Shows the amount of water stored in the tank.

It helps occupants monitor the available water.

9. Strainer or inlet screen

- Prevents large particles and debris from entering the tank.

10. Ball valve or isolation valve

- Allows water flow to be stopped when maintenance or repair is required.

4.8 Water storage tank maintenance

Inspect the tank regularly for cracks and leakage.

Clean the tank at suitable intervals.

Keep the access cover securely closed.

Prevent insects, rodents and other animals from entering.

Check the float valve to ensure it operates correctly.

Inspect the inlet and outlet pipes for leakage.

Ensure that the overflow pipe is not blocked.

Remove accumulated sediment during cleaning.

Check the tank foundation and supports for movement or damage.

Ensure that tanks used for drinking water are kept hygienic.

Safety note: A person should not enter a water tank without appropriate confined-space procedures, supervision and safety equipment. Tank cleaning should be carried out by suitably trained personnel.

5.0 Types of domestic cold-water supply systems to a building

5.1 Meaning of a cold-water supply system

A cold-water supply system is the arrangement of pipes, valves, tanks and fittings used to convey water at normal supply temperature to various outlets and appliances within a building.

The system supplies water to fittings such as:

Kitchen sinks.

Wash-hand basins.

Showers.

Baths.

Water closets.

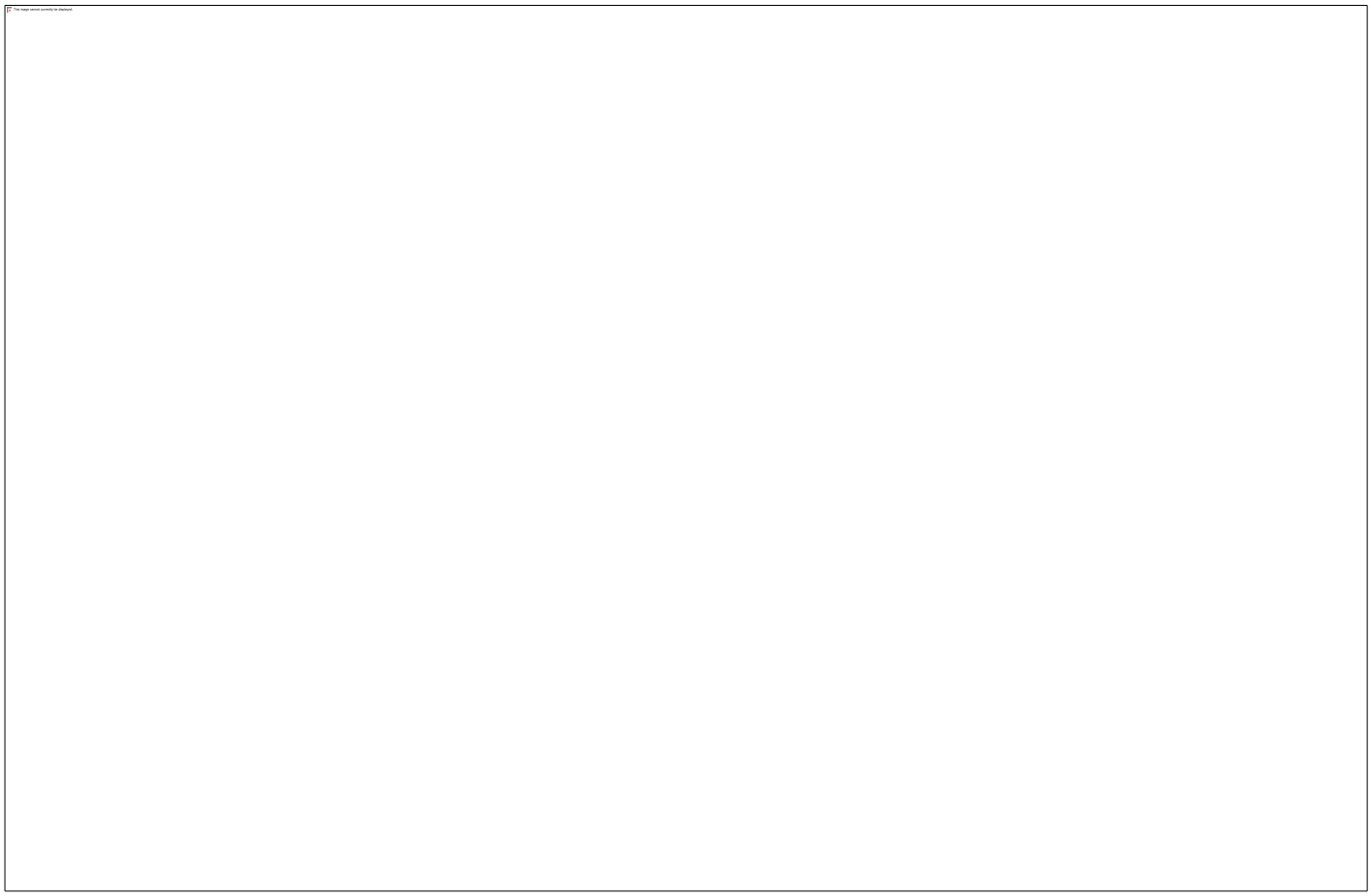
Washing machines.

External taps.

The two main traditional cold-water supply systems are:

Direct cold-water supply system.

Indirect cold-water supply system.



5.2 Direct cold-water supply system

A direct cold-water supply system is a plumbing arrangement in which water is supplied directly from the public water mains to the cold-water outlets and appliances in a building.

In this arrangement, the connected cold-water outlets receive water directly from the incoming supply, subject to the available pressure and the supplier's connection requirements.

How a direct cold-water system operates

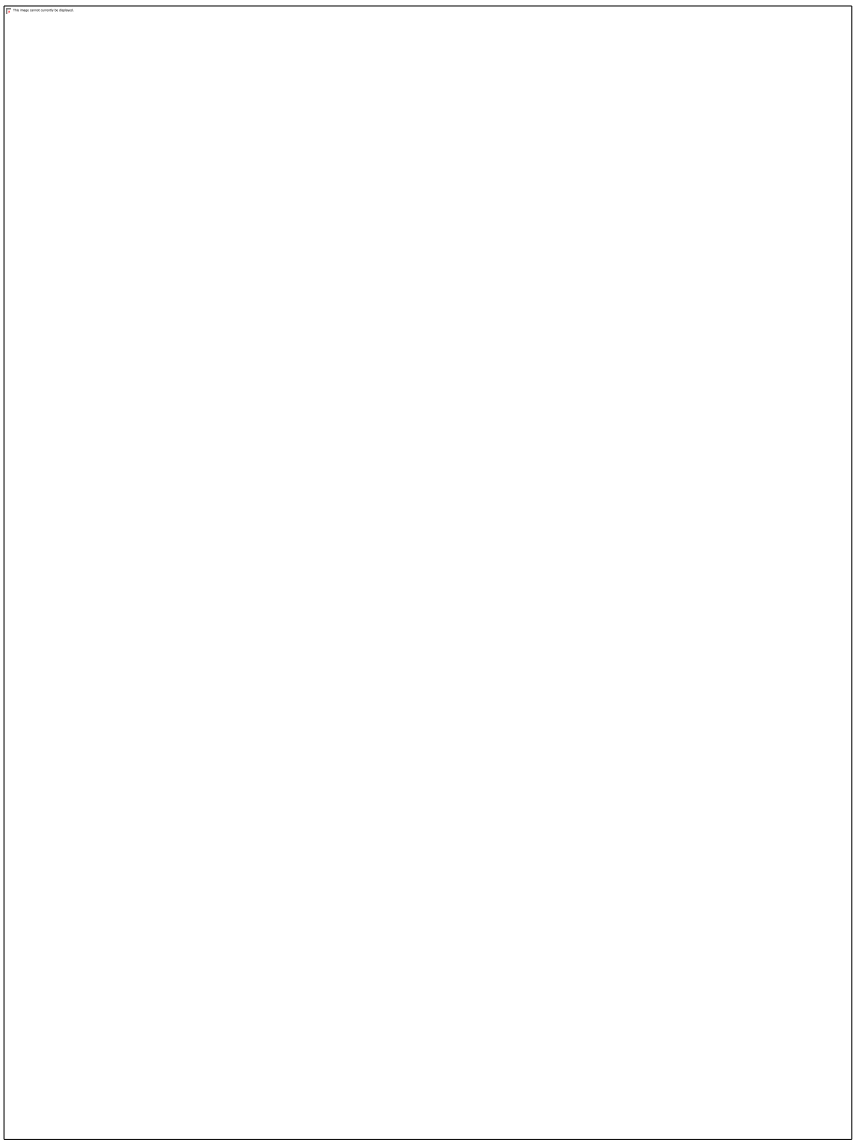
Water enters the building through a service connection from the public water main.

The incoming pipe passes through the necessary control fittings and water meter where provided.

The water is distributed through branch pipes to the cold-water outlets.

When a tap is opened, water flows directly from the mains through the pipework to the outlet.

The pressure depends mainly on the pressure available in the public supply system.



Simplified diagram of a direct cold-water supply system

Characteristics of a direct cold-water system

Cold-water outlets are connected directly to the incoming mains supply.

It does not normally depend on a domestic storage cistern for the outlets it serves.

It requires adequate and reasonably reliable mains pressure.

It uses a network of distribution pipes and fittings.

Water availability depends on the public supply.

Advantages of a direct cold-water supply system

Fresh supply: Water is delivered directly from the mains without first being stored in a domestic cistern.

Reduced storage requirements: It may eliminate the need for a domestic cold-water storage tank for the outlets served.

Less space required: There is no need to allocate space for a domestic storage cistern.

Reduced stagnation risk: It avoids the additional storage period associated with a cistern, although water can still stagnate in poorly designed pipework.

Simpler arrangement: The system may have fewer components than an indirect system.

Lower initial cost in suitable buildings: It may reduce tank and supporting-structure costs.

Disadvantages of a direct cold-water supply system

Dependence on mains supply: If the public supply is interrupted, the connected outlets may stop receiving water.

Pressure fluctuations: Low or fluctuating mains pressure may affect the performance of outlets.

Limited supply during peak demand: Many users drawing water at once may reduce available pressure.

No reserve from a domestic cistern: Water may not be available during a supply interruption unless another storage arrangement exists.

Restrictions on connections: Direct connections must comply with the water supplier's and applicable plumbing requirements.

Possible backflow risk: Poorly designed connections may allow contaminated water to flow back towards the public supply.

Suitable applications

Buildings with reliable mains water supply.

Small residential buildings.

Buildings where mains pressure is adequate.

Buildings where the water supplier permits the arrangement.

5.3 Indirect cold-water supply system

An indirect cold-water supply system is a plumbing arrangement in which water from the mains is first conveyed to a storage cistern or tank, and water is then distributed from the storage facility to some or most of the cold-water outlets in the building.

In a typical arrangement, certain outlets may receive a direct mains supply while other outlets receive water from a storage cistern. The exact arrangement depends on the design and applicable plumbing requirements.

How an indirect cold-water system operates

Water enters the building through the service pipe from the public water main.

The incoming water passes through the required control fittings.

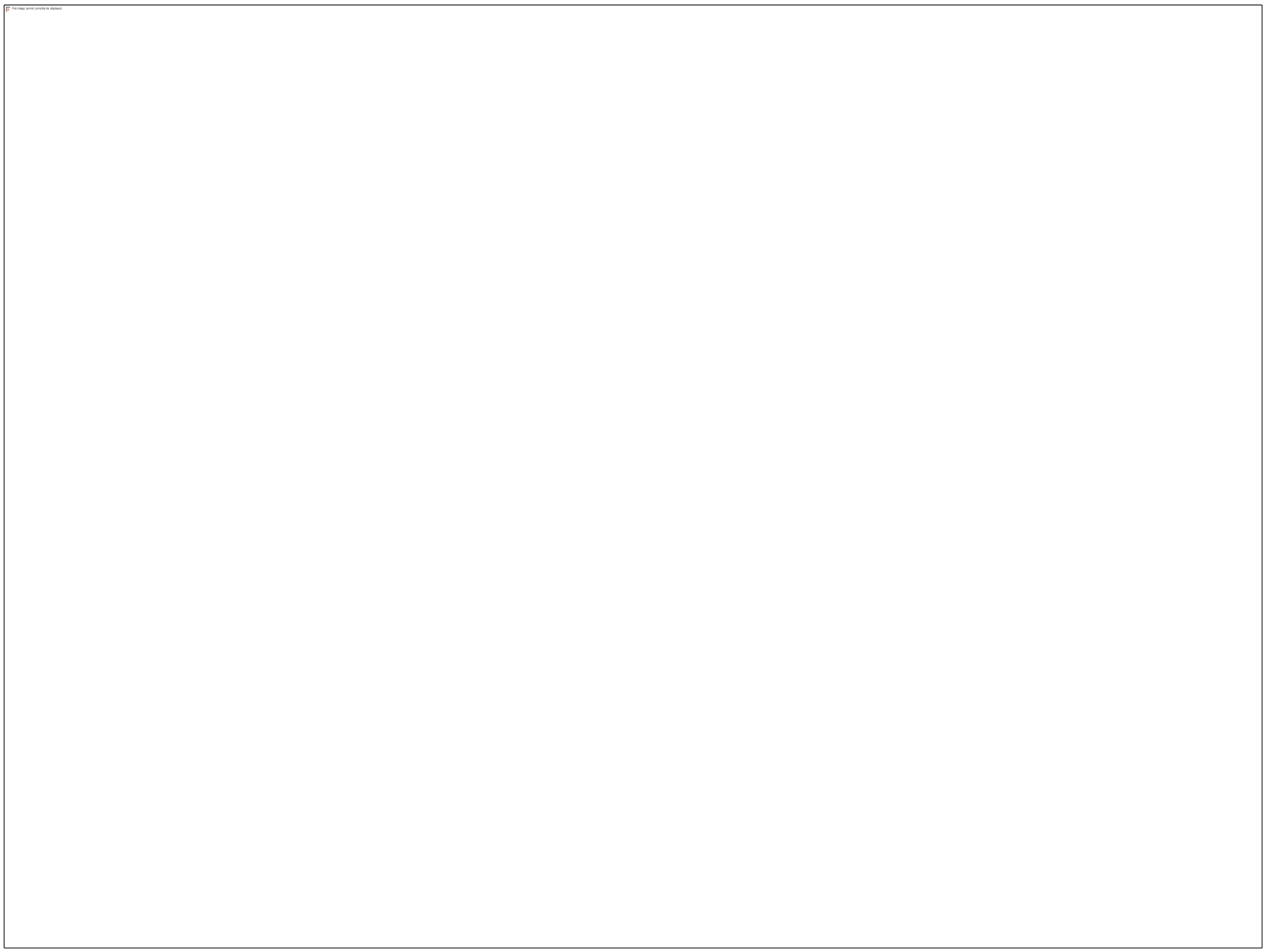
Water flows into a storage cistern or tank.

A float valve controls the amount of water entering the tank.

Water is stored until required.

Water flows from the storage tank through distribution pipes to the connected outlets.

Where the storage tank is elevated, gravity provides the pressure needed to supply lower-level outlets.



Characteristics of an indirect cold-water supply system

It includes a water storage cistern or tank.

The mains supply fills the storage tank.

A float valve may control the filling process.

Water is distributed from the tank to connected outlets.

An elevated tank can provide gravity-fed water pressure.

The system provides stored water for use when the mains supply is interrupted, provided the tank contains water.

Advantages of an indirect cold-water supply system

Water reserve: Stored water can be used during temporary mains interruptions.

Reduced dependence on continuous mains pressure: Water can continue flowing from an elevated tank even when mains pressure falls, as long as water remains stored.

Useful for unreliable supplies: It is suitable for buildings experiencing intermittent public water supply.

Peak demand support: Stored water can supplement the incoming supply during periods of high demand.

Gravity distribution: An elevated tank can supply lower-level outlets without continuous pumping.

Supply flexibility: It can be integrated with rainwater harvesting or other approved sources where systems are properly separated and designed.

Disadvantages of an indirect cold-water supply system

Higher installation cost: The system requires a tank, supporting arrangements and additional pipework.

Space requirement: A suitable location must be provided for the storage tank.

Maintenance: Tanks, float valves and distribution pipes require regular inspection and cleaning.

Contamination risk: Poorly maintained or uncovered tanks may become contaminated.

Water stagnation: Stored water may remain in the tank for long periods if demand is low.

Pressure limitations: Gravity pressure may be inadequate if the tank is not sufficiently elevated.

Structural loading: Elevated tanks impose significant loads on their supporting structures.

Suitable applications

Houses with unreliable public water supply.

Multi-storey residential buildings.

Schools and boarding institutions.

Hotels and guest houses.

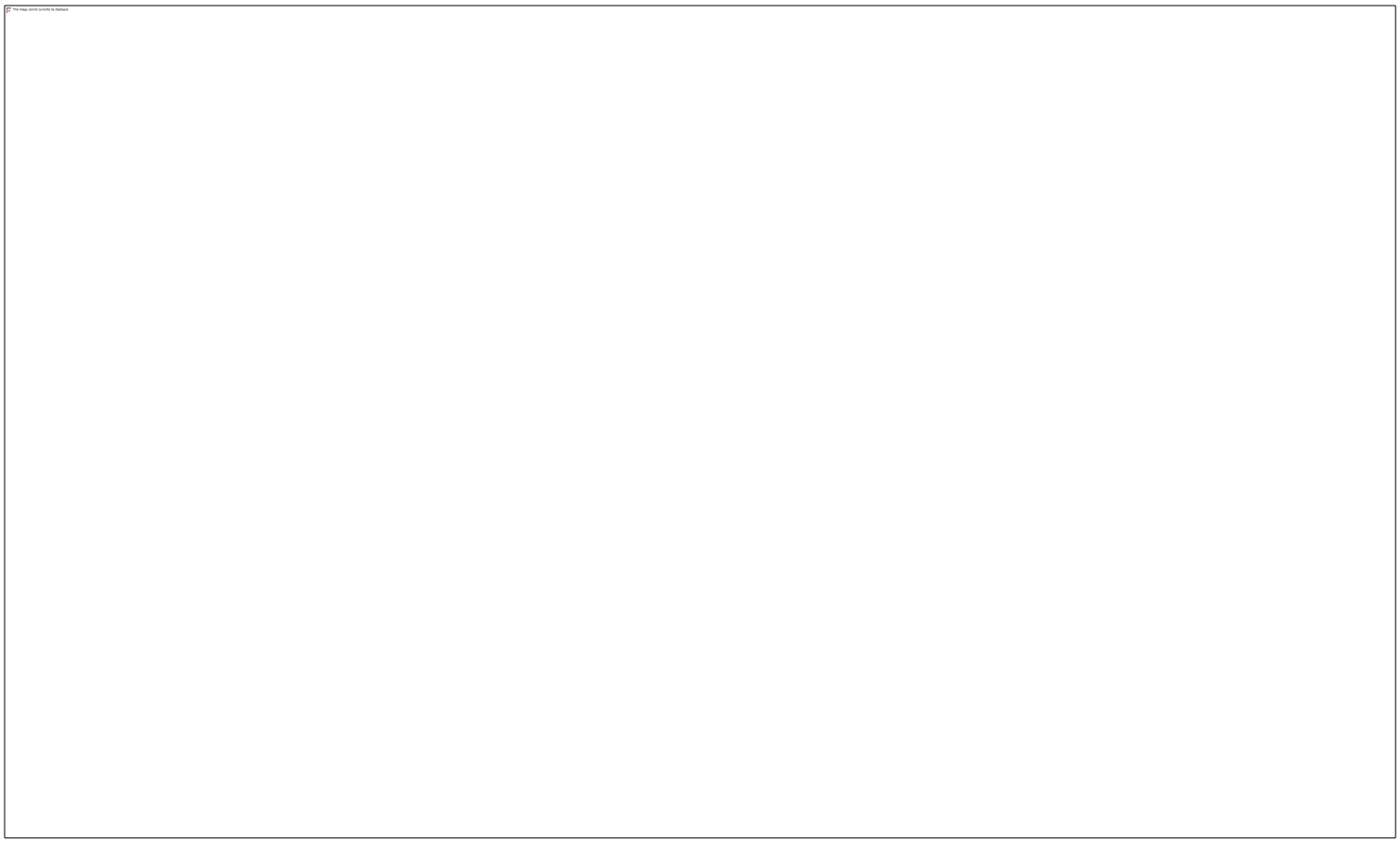
Buildings requiring a reserve of stored water.

5.4 Comparison between direct and indirect cold-water supply systems

Feature	Direct system	Indirect system
Water supply	Direct from mains to connected outlets	Mains water first enters a storage cistern or tank
Storage tank	Not normally required for the outlets served	Required
Water pressure	Depends mainly on mains pressure	May be provided by gravity or pumping
Supply interruption	Connected outlets may stop receiving water	Stored water may remain available
Installation cost	Often lower where mains conditions are suitable	Usually higher due to storage facilities
Space requirement	Less space needed	Space needed for tank
Maintenance	Mainly pipes, valves and fittings	Pipes, valves, tank and float valve
Water quality	Avoids domestic cistern storage	Tank hygiene must be maintained
Suitable location	Buildings with reliable mains supply	Buildings needing a reserve supply

6.0 Components of a domestic cold-water supply system

A domestic cold-water supply system consists of different components that work together to convey, control, store and distribute water.



6.1 Water service pipe

A service pipe is the pipe that conveys water from the public water distribution main to a building.

Functions

Connects the building to the public water supply.

Carries water into the premises.

Provides the main entry point for the building's water supply.

6.2 Water meter

A water meter is a device used to measure the volume of water supplied to a building.

Functions

Measures water consumption.

Provides information for water billing.

Helps identify unusual water usage.

Assists in monitoring water conservation.

6.3 Stop valve

A stop valve is a fitting used to control or stop the flow of water through a pipe.

Functions

Allows the water supply to be isolated during repairs.

Helps control the flow of water.

Enables maintenance of plumbing installations.

Can help limit water loss during emergencies.

6.4 Distribution pipes

Distribution pipes are pipes that convey water from the main supply or storage tank to different outlets within the building.

Functions

Carry water to taps and appliances.

Connect different sections of the plumbing system.

Distribute water to individual rooms.

Maintain the required flow when properly sized and installed.

6.5 Branch pipes

Branch pipes are smaller pipes connected to the main distribution pipes to supply individual outlets or groups of outlets.

Examples

Pipe supplying a kitchen sink.

Pipe supplying a wash-hand basin.

Pipe supplying a shower.

6.6 Float valve

A float valve is a device used to control the amount of water entering a storage tank.

How it operates

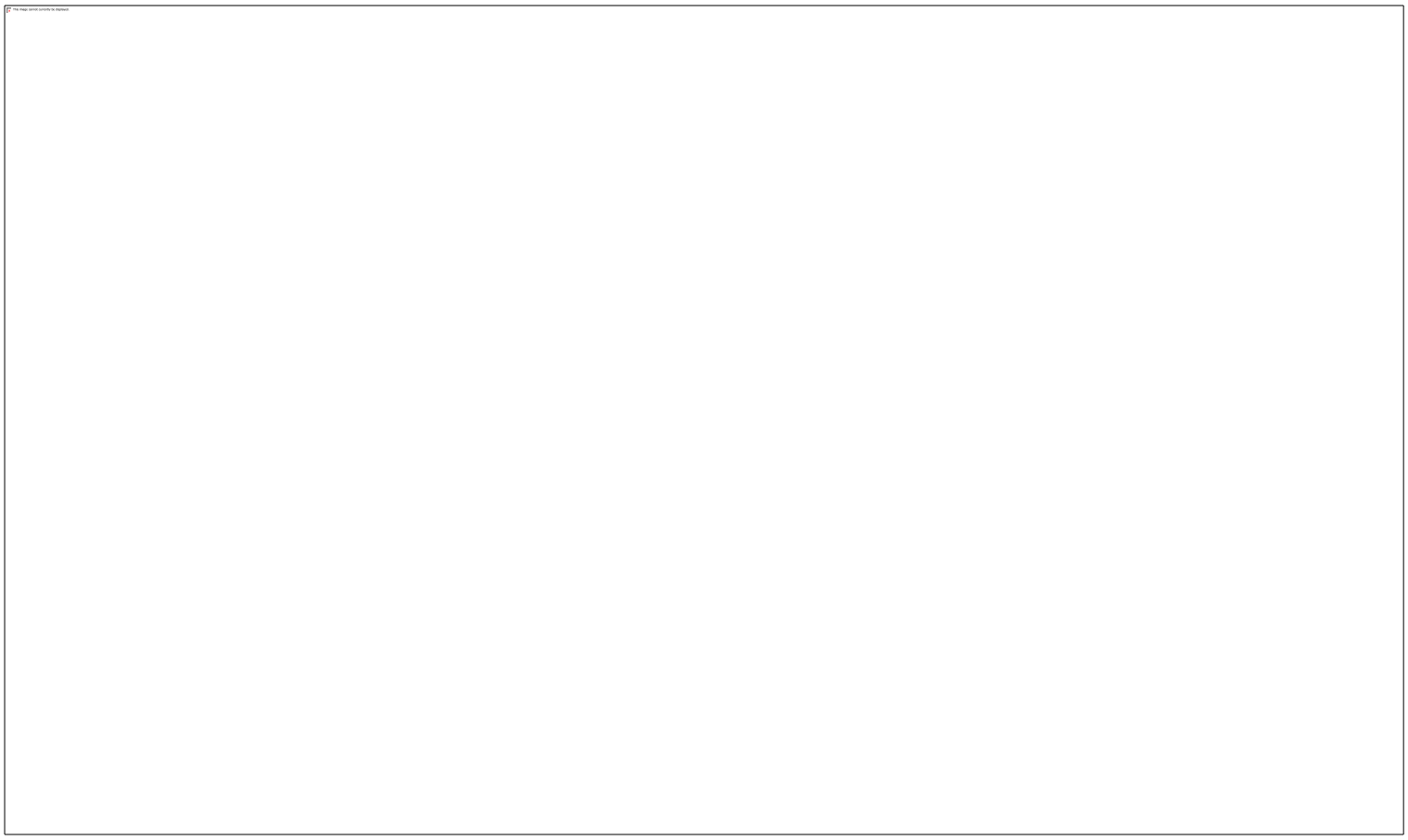
When the water level falls, the float moves downwards.

The valve opens and allows water into the tank.

As the tank fills, the float rises.

At the selected water level, the valve closes.

This prevents continuous filling and unnecessary overflow.



6.7 Taps or faucets

A tap is a fitting used to control the flow of water from a pipe.

Functions

Opens and closes the water outlet.

Controls the flow of water.

Allows users to draw water when needed.

Examples

Pillar taps.

Bib taps.

Mixer taps.

Stop taps.

6.8 Valves

A valve is a device fitted in a pipe to regulate, direct or stop water flow.

Common examples include:

Gate valves.

Ball valves.

Check valves.

Float valves.

Pressure-reducing valves.

Isolation valves.

Functions

Control the movement of water.

Isolate parts of the system during maintenance.

Prevent unwanted reverse flow where check valves are installed.

Control excessive pressure where pressure-reducing valves are required.

6.9 Pipe fittings

Pipe fittings are components used to connect pipes, change the direction of flow, reduce or increase pipe sizes, or provide branch connections.

Examples include:

Fitting	Function
Elbow	Changes the direction of a pipe
Tee	Provides a branch connection
Reducer	Connects pipes of different diameters
Coupling	Joins two pipe lengths
Union	Allows a pipe connection to be disconnected for maintenance
Socket	Joins two compatible pipe ends
Cap	Closes the end of a pipe
Plug	Closes a suitable threaded opening



6.10 Pumps

A pump is a mechanical device used to move water from a lower level or low-pressure location to a higher level or higher-pressure distribution system.

Functions

Lifts water from wells and boreholes.

Transfers water from underground tanks to overhead tanks.

Boosts pressure where required by the design.

Moves water through a distribution system.

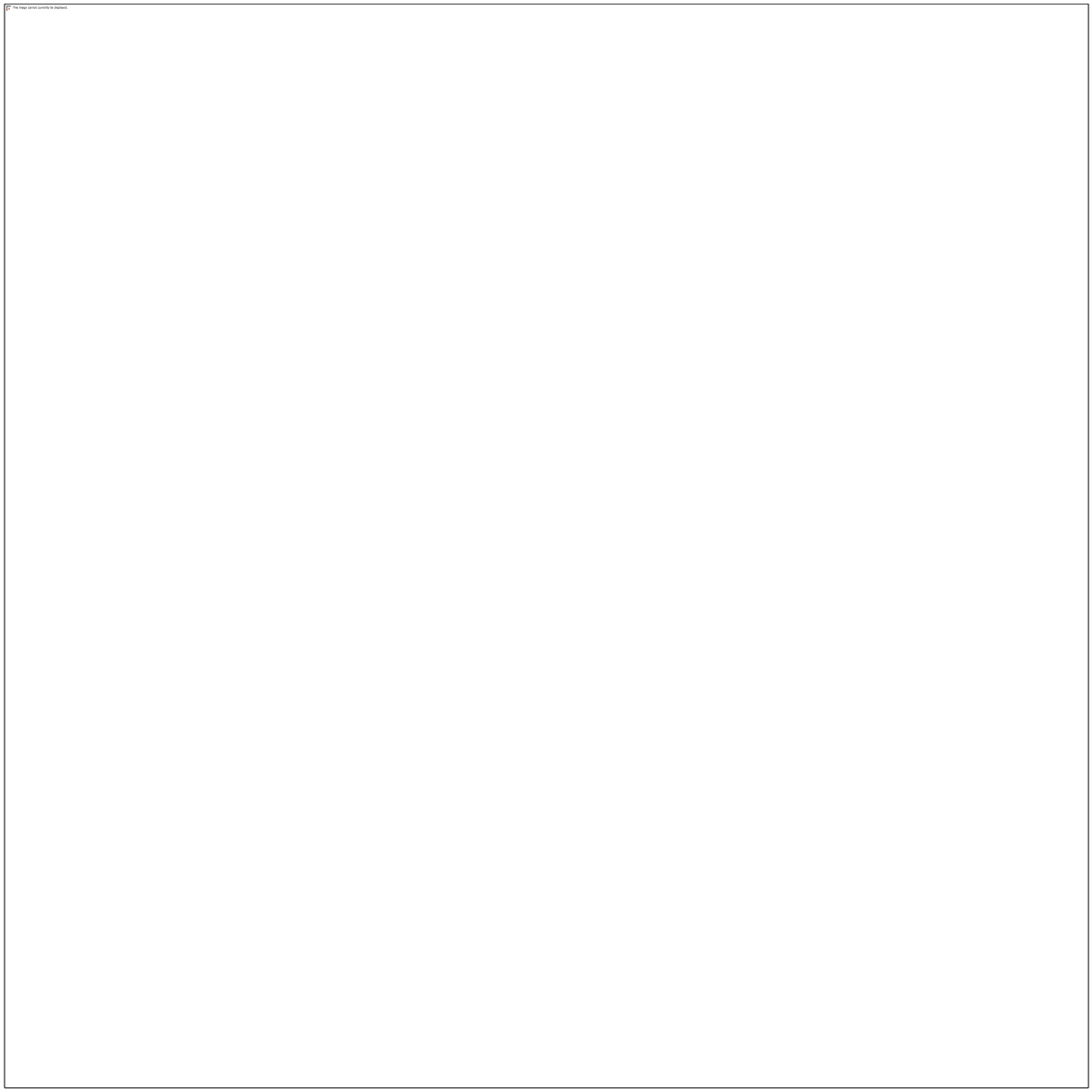
Common types of pumps used in domestic water supply

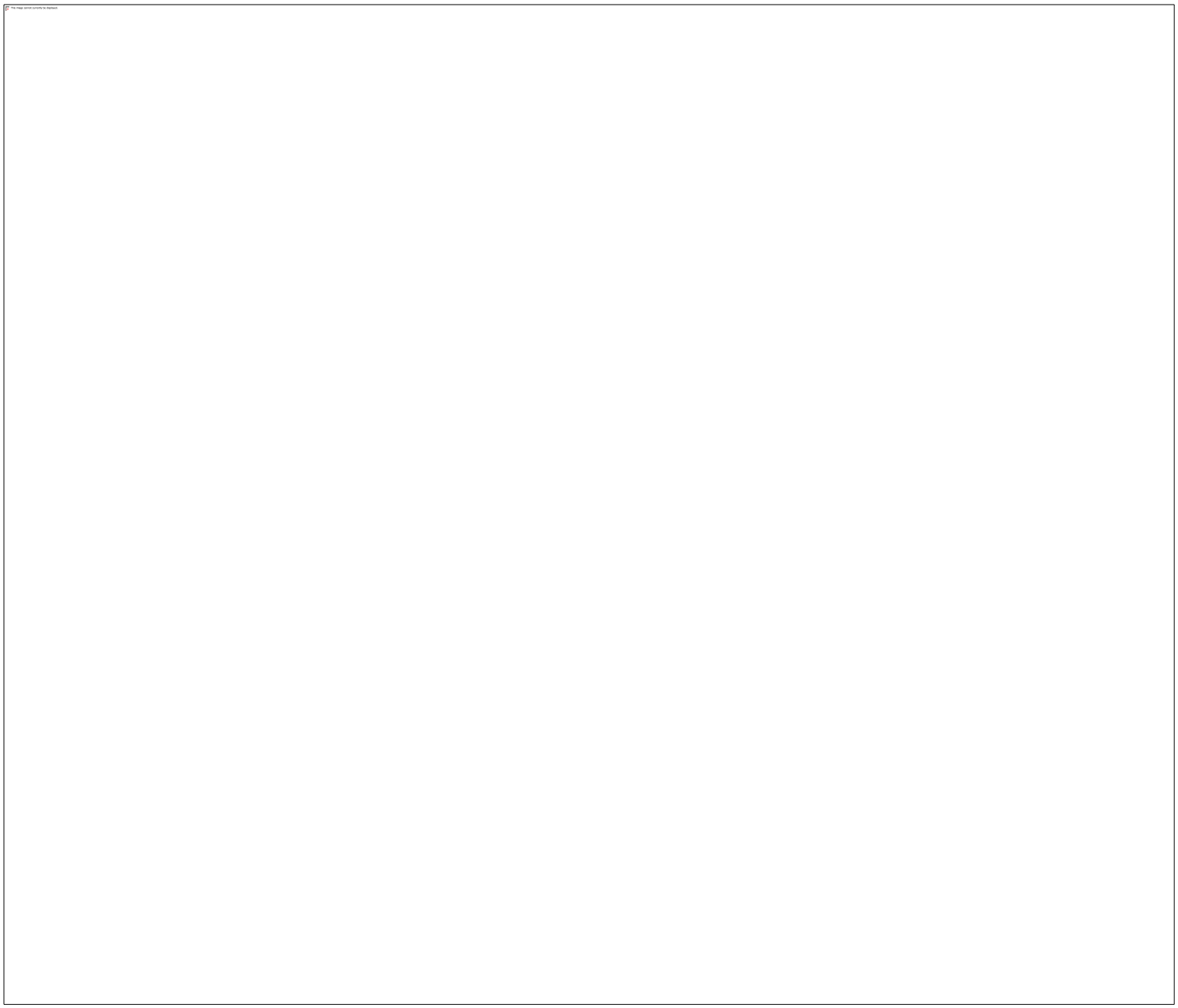
Centrifugal pumps.

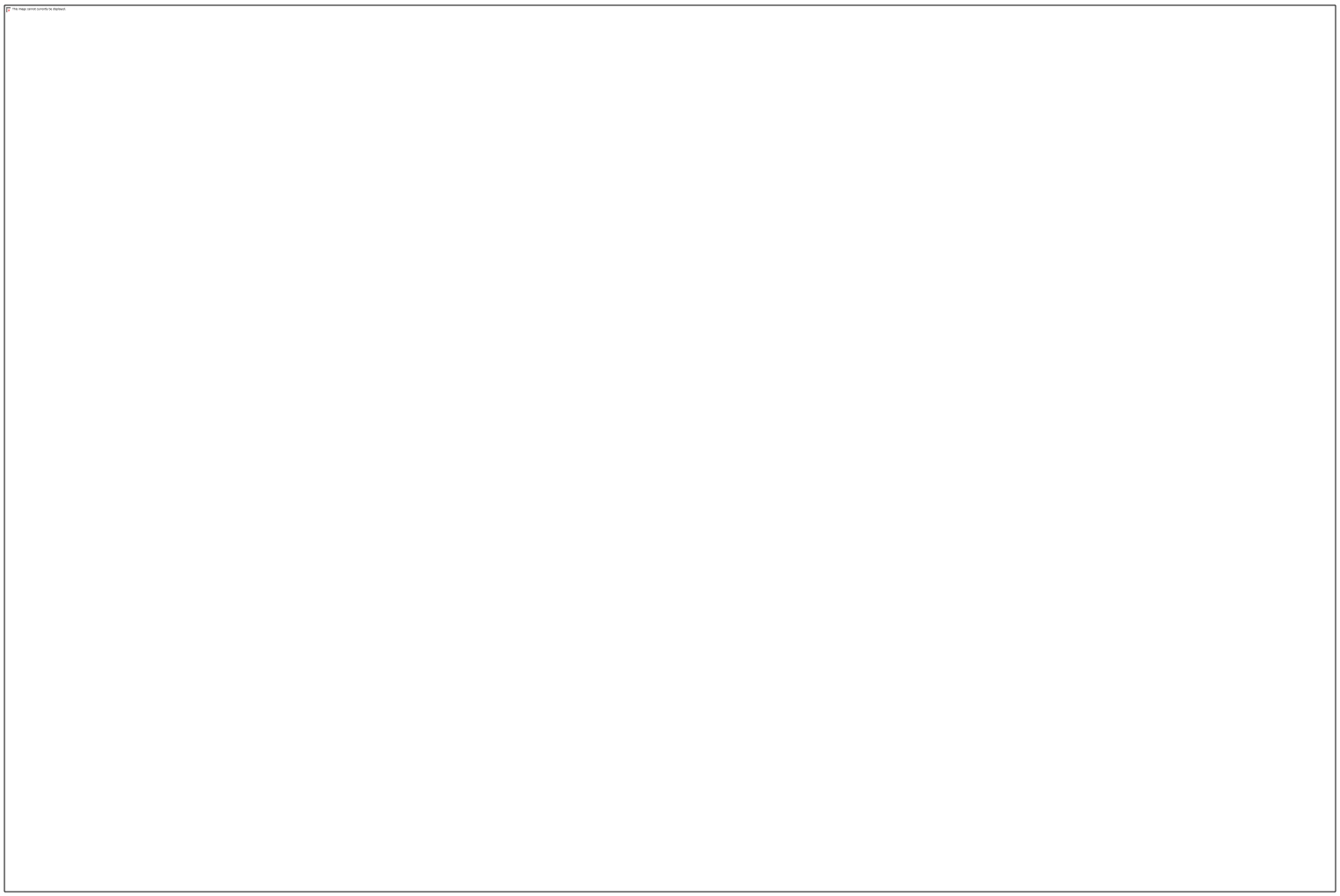
Submersible pumps.

Booster pumps.

Hand pumps.







6.11 Water outlets

Water outlets are the points where water is delivered for use.

Examples include:

Kitchen sink taps.

Wash-hand basin taps.

Shower outlets.

Bath taps.

External garden taps.

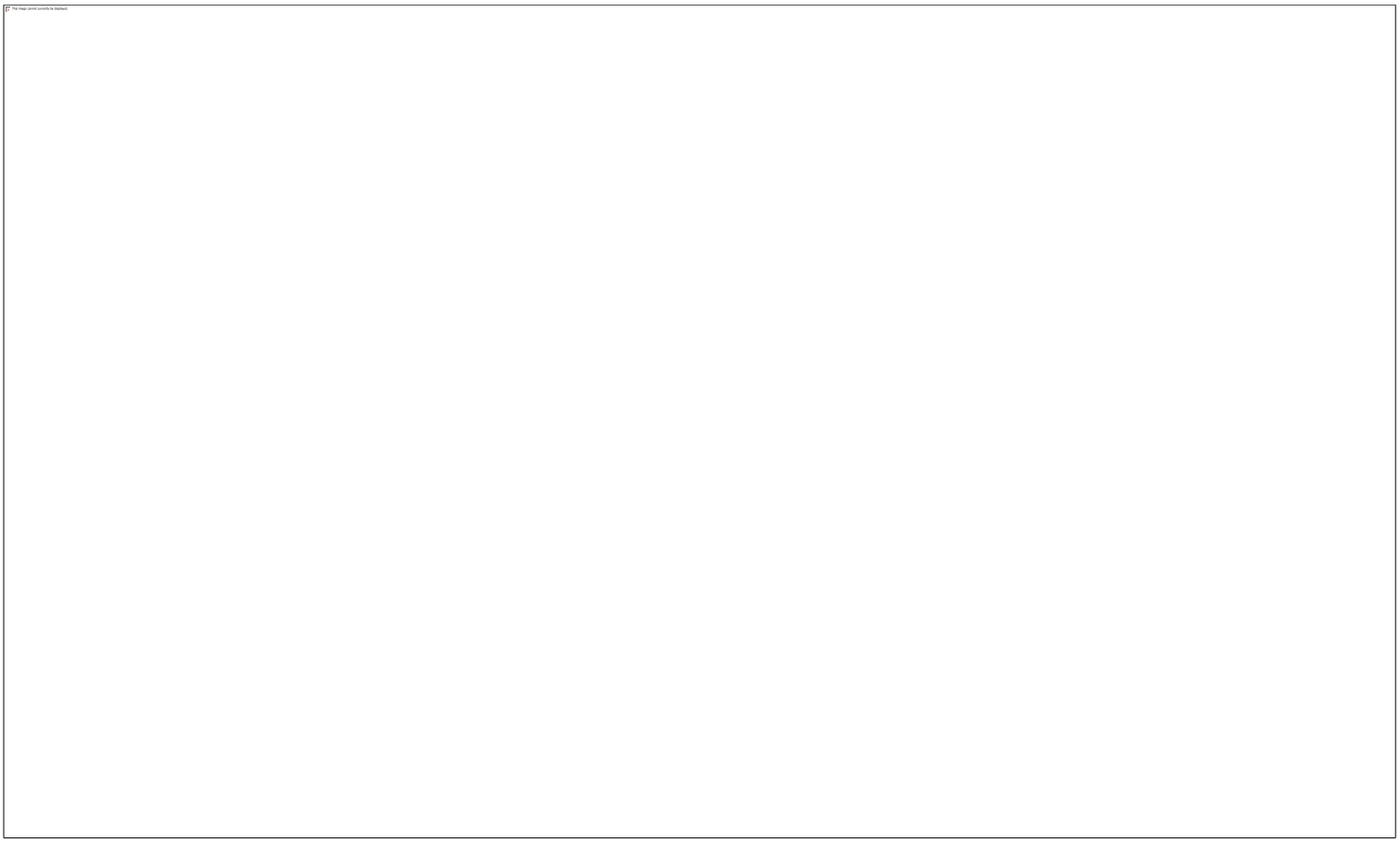
Washing machine connections.

Water closet cistern connections.

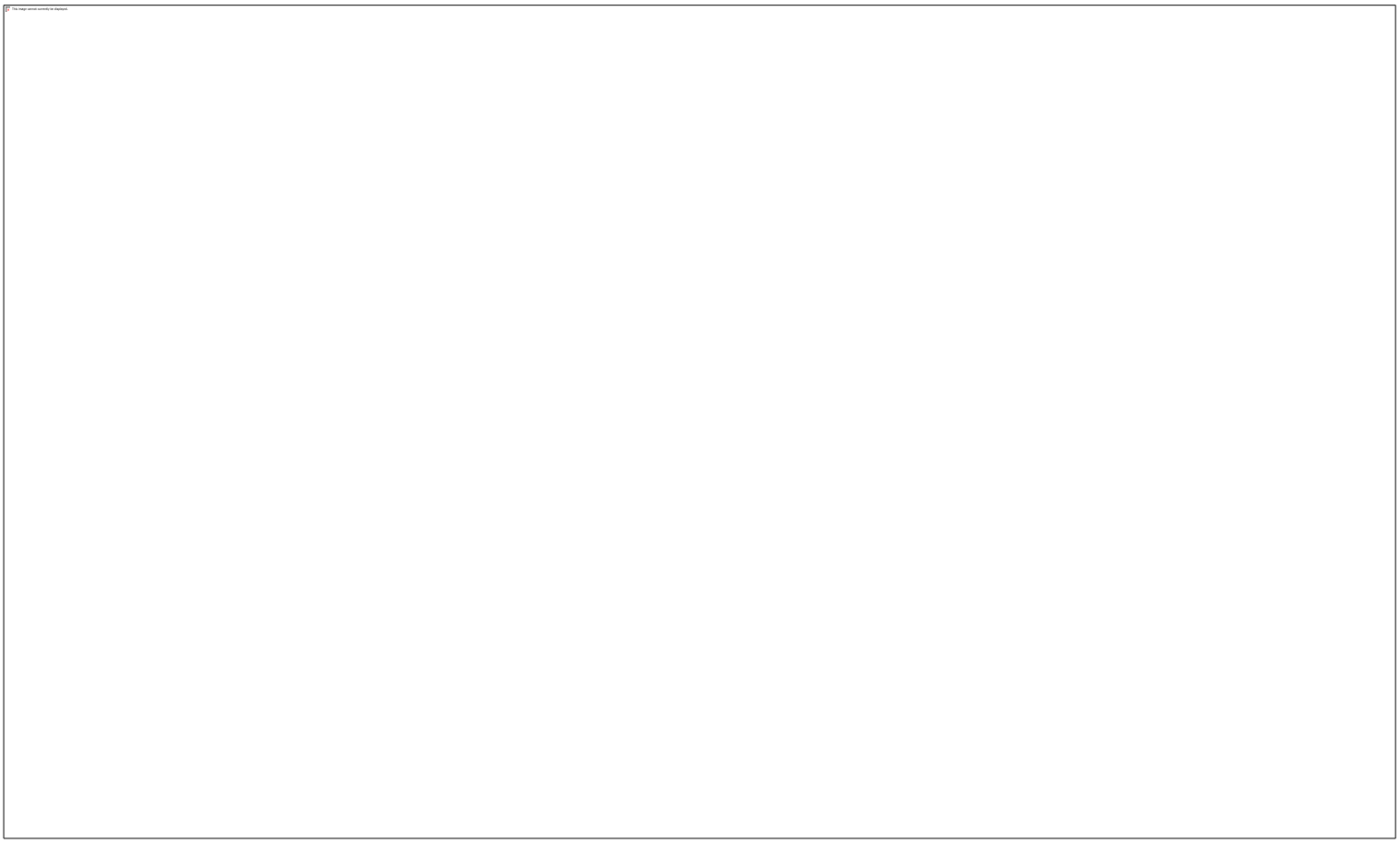
7.0 Basic layout of a domestic water supply system

The following diagrams illustrate how water can move from different sources to a building.

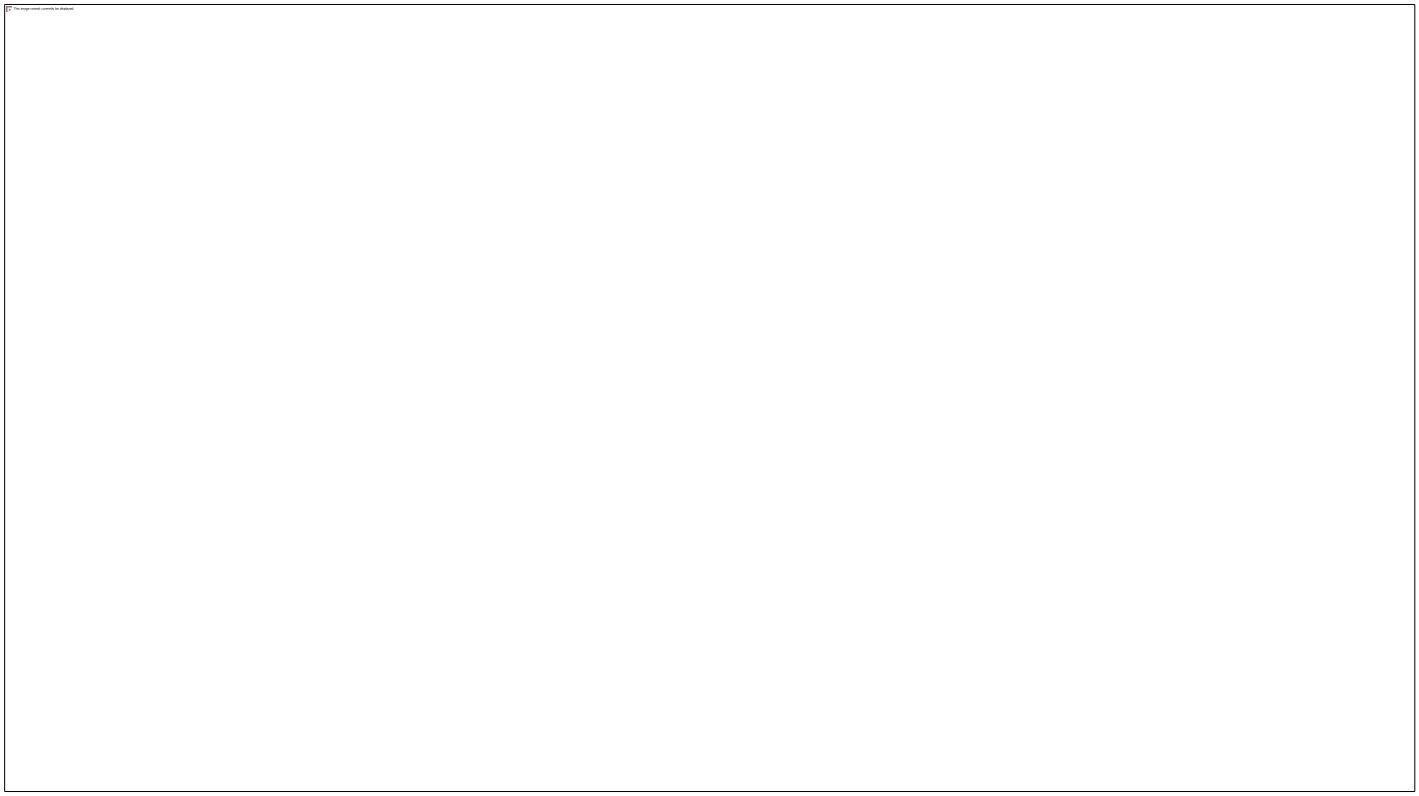
7.1 Supply from a public water main



7.2 Supply from a borehole through an elevated tank



7.3 Supply from an underground tank through a pump



8.0 Factors affecting the design of a domestic water supply system

Before installing a water supply system, the designer or plumber should consider several factors.

8.1 Number of occupants

The number of people using the building determines the likely water demand.

A house occupied by a large family requires more water than a small household.

Schools, hospitals and hotels require systems designed for their larger populations.

8.2 Purpose of the building

Different buildings have different water requirements.

A residential house mainly requires water for domestic activities.

A hospital may require additional water for hygiene and specialised operations.

A school requires water for drinking, sanitation, cooking and cleaning.

8.3 Availability of the water source

Determine whether the building receives municipal water.

Establish whether a borehole, well, spring or rainwater harvesting system is available.

Consider the reliability and seasonal availability of the source.

8.4 Water quality

The source should provide water suitable for its intended use.

Drinking water should meet the applicable drinking-water quality requirements.

Treatment should be provided where necessary.

8.5 Water pressure

The available pressure should be sufficient to serve the required outlets.

Low pressure may require storage tanks or pumping.

Excessive pressure may require pressure-reducing devices.

8.6 Height of the building

Multi-storey buildings may require special arrangements to deliver water to upper floors.

Elevated tanks, booster pumps or pressure zones may be necessary.

The system should provide suitable pressure without exceeding the pressure rating of pipes and fittings.

8.7 Cost

Consider:

Cost of pipes and fittings.

Cost of storage tanks.

Cost of pumps.

Installation charges.

Electricity or other energy costs.

Maintenance and replacement expenses.

8.8 Availability of space

Consider where tanks and pumps will be installed.

Provide sufficient access for inspection and repairs.

Avoid locating tanks where they interfere with building activities or create structural risks.

8.9 Reliability of electricity

Pumping systems depend on a suitable energy supply.

Solar-powered pumping may be considered where appropriate.

Backup arrangements may be necessary where water supply is critical.

8.10 Maintenance requirements

Select systems that can be inspected and maintained.

Ensure spare parts and skilled personnel are available.

Provide accessible valves and inspection points.

8.11 Future expansion

Consider possible increases in building occupancy.

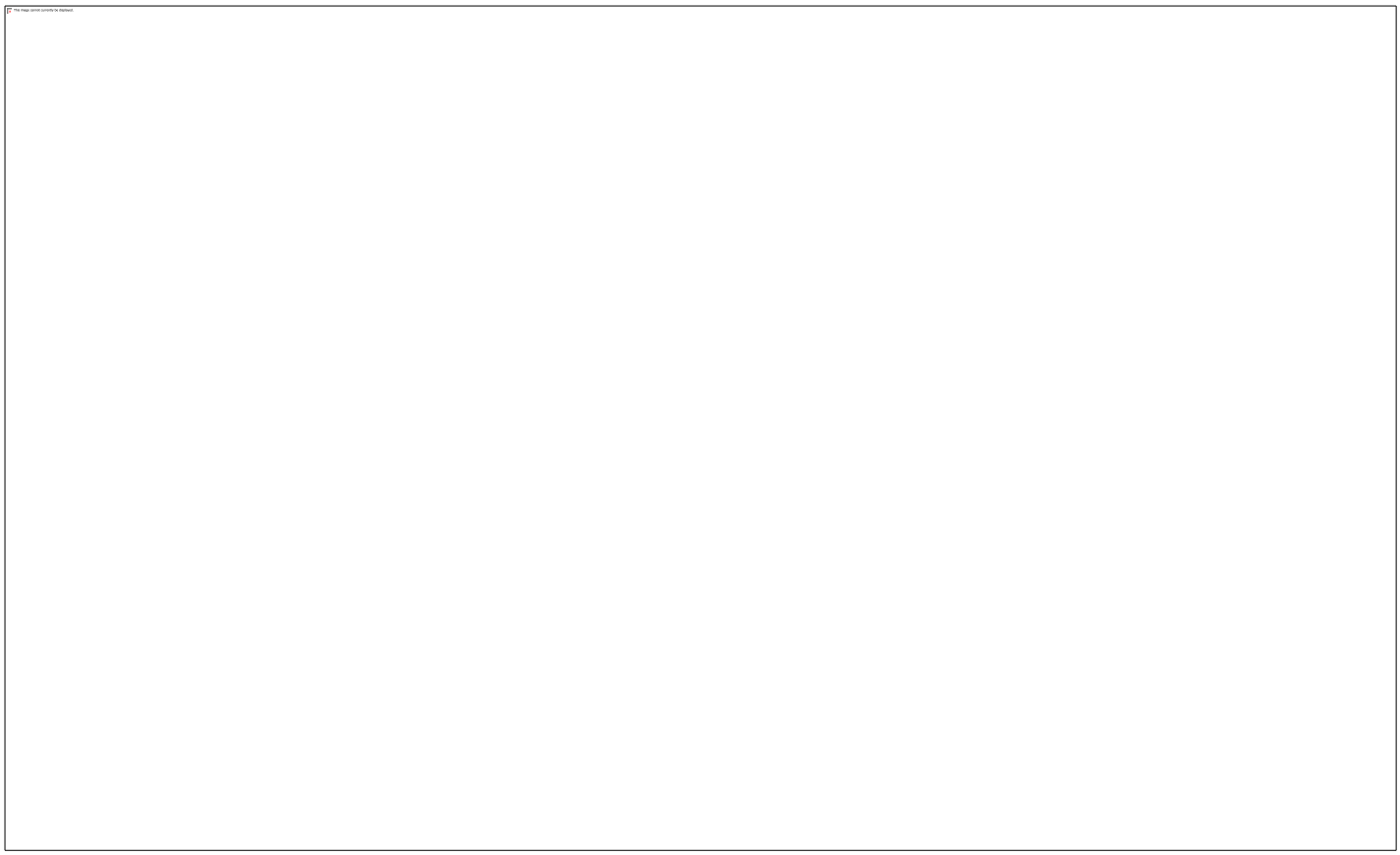
Allow for future extensions where practical.

Avoid designing a system that cannot meet reasonable future demand.

9.0 Water conservation in domestic buildings

Water conservation refers to the careful and efficient use of water to reduce wastage and protect available water resources.

Water conservation is important in Kenya because some areas experience water shortages, seasonal droughts and unreliable water supply.



9.1 Methods of conserving water

Repairing leaking taps: Damaged washers and fittings should be repaired promptly.

Repairing leaking pipes: Leaking pipes should be identified and replaced or repaired.

Installing water-efficient fittings: Suitable low-flow taps and showerheads reduce water consumption.

Using dual-flush toilets: These allow users to select an appropriate flushing volume.

Harvesting rainwater: Rainwater can be collected and stored for suitable uses.

Reusing suitable greywater: Properly treated or safely managed greywater may be used for selected non-drinking purposes where permitted.

Turning off taps: Taps should be closed when water is not needed.

Monitoring water meters: Regular monitoring can help identify unusual consumption and leakage.

Using drip irrigation: It delivers water near plant roots and can reduce wastage in gardens.

Educating occupants: Household members should be encouraged to use water responsibly.

9.2 Benefits of water conservation

Reduces water bills.

Reduces pressure on public water sources.

Helps maintain water availability during dry seasons.

Reduces energy used in pumping and treating water.

Minimises water wastage.

Supports environmental sustainability.

10.0 Water supply safety and hygiene

A domestic water supply system should be designed, installed and maintained to protect the quality of water.

10.1 Measures for maintaining safe water

Use tanks suitable for the intended water use.

Keep tank covers properly secured.

Clean and disinfect tanks when required.

Prevent sewage and wastewater from contaminating water sources.

Protect wells and boreholes against surface runoff.

Maintain gutters and roof catchment surfaces used for rainwater harvesting.

Use suitable materials for water supply pipes.

Repair leaking pipes and damaged fittings.

Avoid cross-connections between potable and non-potable water systems.

Install suitable backflow prevention devices where required.

Test water quality where there is a risk of contamination.

Follow the instructions of the water supplier and applicable plumbing requirements.

10.2 Common problems in domestic water supply systems

Problem	Possible cause	Remedy
Low water pressure	Low mains pressure, blocked pipe or inadequate tank height	Inspect the system and correct the pressure or obstruction problem
No water at outlets	Supply interruption, closed valve or pump failure	Check the supply, valves and pump
Tank overflowing	Faulty float valve	Repair or replace the float valve
Water leakage	Damaged pipe or loose joint	Repair or replace the affected section
Dirty water	Contaminated source or storage tank	Investigate, clean and treat the system appropriately
Pump failing to operate	Electrical fault or mechanical damage	Inspect and repair the pump safely
Air in pipes	Poor filling or air accumulation	Check the pipe layout and remove air using suitable arrangements
Water wastage	Leaking taps or faulty cisterns	Repair the defective fittings

11.0 Practical learning activities

Activity 1: Identifying sources of domestic water

Resources

Pictures of rivers, lakes, wells, boreholes, springs and rainwater harvesting systems.

Drawing paper.

Pens and pencils.

Procedure

Observe the pictures provided.

Identify each source of water.

Classify the sources into surface water and underground water.

State the advantages and disadvantages of each source.

Discuss which sources are commonly used in your local community.

Expected learning outcome: Learners should be able to identify and classify different sources of domestic water.

Activity 2: Identifying water storage tanks

Procedure

Observe different water storage tanks within the school or community.

Identify underground, ground-level and elevated tanks.

Determine the materials used to manufacture them.

Identify their capacities where the information is available.

Explain the advantages and limitations of each type.

Draw and label the different tanks.

Activity 3: Drawing a domestic water supply system

Resources

Drawing paper.

Pencils.

Rulers.

Pictures of plumbing installations.

Procedure

Draw a simple residential building.

Show the source of water.

Draw the service pipe.

Indicate the water meter and stop valve.

Show the storage tank where required.

Draw the distribution pipes.

Indicate the kitchen, bathroom and external water outlets.

Label all the components correctly.

Activity 4: Comparing direct and indirect cold-water systems

Learners should work in groups to:

Draw a direct cold-water supply system.

Draw an indirect cold-water supply system.

Identify the differences between the two systems.

Explain the advantages and disadvantages of each.

Recommend a suitable system for a residential building experiencing frequent water interruptions.

Activity 5: Constructing a miniature water supply model

Project title: Design and construct a simple domestic water supply model.

Materials

Small transparent plastic container.

Flexible plastic pipes.

Small water tank or bottle.

Small tap.

Suitable connectors.

Cardboard or plywood base.

Water.

Labels.

Procedure

Design a simple water supply layout.

Position the storage tank on the model.

Connect the outlet pipe to the distribution pipe.

Install a small tap to represent a water outlet.

Secure all pipe connections.

Introduce water into the tank.

Open the tap and observe the flow.

Explain how water moves through the system.

Label the main components.

Expected outcome: Learners should demonstrate how water is stored and distributed to outlets in a building.

REVISION QUESTIONS

SECTION A: MULTIPLE-CHOICE QUESTIONS

Choose the correct answer from the alternatives provided.

1. What is meant by domestic water supply?

A. The removal of wastewater from a building.

B. The provision and distribution of water for household use.

C. The construction of underground drainage channels.

D. The collection of solid waste from buildings.

2. Which of the following is a surface water source?

A. Borehole.

B. Well.

C. River.

D. Underground spring.

3. Water found beneath the earth's surface in soil pores and rock formations is known as:

A. Surface water.

B. Underground water.

C. Rainwater.

D. Runoff water.

4. Which of the following is an example of underground water?

A. Lake water.

B. River water.

C. Borehole water.

D. Dam water.

5. A narrow, deep hole drilled into the ground to obtain underground water is called a:

A. Reservoir.

B. Borehole.

C. Dam.

D. Canal.

6. Which of the following is a natural point where underground water emerges onto the earth's surface?

A. Reservoir.

B. Spring.

C. Canal.

D. Dam.

7. Which process involves collecting rainwater from roof surfaces and storing it for later use?

A. Water filtration.

B. Rainwater harvesting.

C. Sedimentation.

D. Water chlorination.

8. Which of the following is a major disadvantage of surface water?

A. It is always available in unlimited quantities.

B. It cannot be stored.

C. It may be contaminated by human activities.

D. It never requires treatment.

9. Which process is used to remove suspended particles by passing water through a suitable filtering material?

A. Filtration.

B. Evaporation.

C. Condensation.

D. Irrigation.

10. What is potable water?

A. Water used only for washing clothes.

B. Water that is safe for human consumption.

C. Water that contains visible soil particles.

D. Water used only for irrigation.

11. Which of the following is a major function of a domestic water storage tank?

A. To remove all impurities from water.

B. To store water for use when required.

C. To increase the size of the building.

D. To remove wastewater from the building.

12. Which water storage tank is installed below ground level?

A. Elevated tank.

B. Ground-level tank.

C. Underground tank.

D. Overhead tank.

13. Which type of water tank provides water pressure mainly through gravity?

A. Underground tank.

B. Elevated tank.

C. Ground-level tank.

D. Portable container.

14. A water storage tank installed directly on a properly prepared ground foundation is called a:

A. Ground-level tank.

B. Elevated tank.

C. Underground tank.

D. Suspended tank.

15. Which material is commonly used in manufacturing domestic water storage tanks?

A. Paper.

B. Polyethylene.

C. Cardboard.

D. Untreated fabric.

16. Which fitting controls the entry of water into a storage tank according to the water level?

A. Elbow.

B. Float valve.

C. Coupling.

D. Reducer.

17. Which pipe allows excess water to escape from a full storage tank?

A. Inlet pipe.

B. Outlet pipe.

C. Overflow pipe.

D. Washout pipe.

18. Which fitting is provided to allow accumulated water and sediment to be drained from a tank during cleaning?

A. Washout pipe.

B. Vent pipe.

C. Inlet pipe.

D. Distribution pipe.

19. Which of the following is a disadvantage of underground water storage tanks?

A. They occupy a large amount of surface space.

B. They are difficult to inspect and maintain.

C. They cannot store large quantities of water.

D. They are always exposed to direct sunlight.

20. What is the main function of a water meter?

A. To increase water pressure.

B. To measure water consumption.

C. To remove impurities from water.

D. To store water.

21. In a direct cold-water supply system, water is supplied to connected cold-water outlets:

A. Through a storage cistern only.

B. Directly from the mains supply.

C. Through a septic tank.

D. Through a wastewater pipe.

22. Which of the following is a major advantage of a direct cold-water supply system?

A. It always provides water during mains interruptions.

B. It does not normally require a domestic storage cistern for the outlets served.

C. It requires a large underground tank.

D. It always provides higher pressure than every indirect system.

23. An indirect cold-water supply system normally includes:

A. A storage cistern or tank.

B. A septic tank.

C. A soak pit.

D. A rainwater drainage channel only.

24. Which of the following is an advantage of an indirect cold-water supply system?

A. It does not require maintenance.

B. It provides stored water during temporary mains interruptions.

C. It cannot become contaminated.

D. It always uses less space than a direct system.

25. Which of the following systems depends mainly on available mains pressure to supply connected outlets?

A. Direct cold-water supply system.

B. Indirect cold-water supply system.

C. Wastewater drainage system.

D. Rainwater drainage system.

26. Which device is used to stop water flow during plumbing repairs?

A. Water meter.

B. Stop valve.

C. Elbow.

D. Strainer.

27. Which of the following pipe fittings is used to change the direction of a pipe?

A. Tee.

B. Elbow.

C. Coupling.

D. Reducer.

28. Which of the following devices is used to lift water from a borehole?

A. Float valve.

B. Submersible pump.

C. Water meter.

D. Stop valve.

29. Which practice helps conserve domestic water?

A. Leaving leaking taps unrepaired.

B. Allowing water to overflow from tanks.

C. Repairing leaking pipes promptly.

D. Leaving taps running unnecessarily.

30. Which of the following is the most appropriate way of protecting stored drinking water?

A. Leaving the tank uncovered.

B. Allowing animals to access the tank.

C. Keeping the tank covered and clean.

D. Connecting wastewater pipes to the tank.

SECTION B: STRUCTURED QUESTIONS

1.

a) Define domestic water supply.

b) Explain six reasons why water is important in residential buildings.

c) State five characteristics of potable water.

2.
a) Identify four main sources of domestic water.

b) Differentiate between surface water and underground water.

c) Give five examples of surface water sources.

3.
a) Explain the meaning of underground water.

b) Describe three methods of obtaining underground water.

c) State four advantages and four disadvantages of borehole water.

4.
a) Explain the meaning of rainwater harvesting.

b) Identify six components of a roof rainwater harvesting system.

c) Explain five advantages of rainwater harvesting in Kenyan homes.

5.
a) Describe how surface water is treated before being supplied for drinking.

b) Explain the importance of filtration in water treatment.

c) State four possible causes of contamination of surface water.

6.
a) Define a water storage tank.

b) State six reasons why water storage tanks are installed in buildings.

c) Identify four materials used in the manufacture of water storage tanks.

7.
a) Classify domestic water storage tanks according to their location.

b) Explain the construction characteristics of underground water storage tanks.

c) State four advantages and four disadvantages of underground tanks.

8.
a) Explain the meaning of a ground-level water storage tank.

b) State five advantages of ground-level tanks.

c) Explain four factors to consider when installing a ground-level tank.

9.
a) Define an elevated water storage tank.

b) Explain how an elevated tank supplies water to a building.

c) State five advantages and four disadvantages of elevated water tanks.

10.
a) Draw a well-labelled sketch of an elevated domestic water storage tank.

b) Show the following components:

i. Inlet pipe.

ii. Outlet pipe.

iii. Overflow pipe.

iv. Washout pipe.

v. Float valve.

vi. Access cover.

vii. Supporting structure.

11.
a) Identify eight fittings provided on a domestic water storage tank.

b) Explain the functions of the following fittings:

i. Inlet pipe.

ii. Outlet pipe.

iii. Overflow pipe.

iv. Washout pipe.

v. Float valve.

vi. Vent pipe.

12.
a) Define a direct cold-water supply system.

b) Explain how a direct cold-water supply system operates.

c) State five advantages and five disadvantages of a direct cold-water supply system.

13.
a) Define an indirect cold-water supply system.

b) Explain how an indirect cold-water supply system operates.

c) State five advantages and five disadvantages of an indirect cold-water supply system.

14.
a) Differentiate between direct and indirect cold-water supply systems.

b) Draw a well-labelled diagram of each system.

c) Recommend a suitable system for a residential building experiencing frequent interruptions of municipal water supply. Give reasons for your answer.

15.
a) Identify ten components of a domestic water supply system.

b) Explain the functions of the following:

i. Water meter.

ii. Stop valve.

iii. Float valve.

iv. Water pump.

v. Distribution pipe.

vi. Water outlet.

16.
a) Explain five factors that influence the design of a domestic water supply system.

b) State five factors to consider when selecting a water storage tank for a residential building.

17. A school in a rural area of Kenya experiences frequent interruptions of public water supply.

a) Recommend a suitable water source that the school can consider.

b) Suggest a suitable water storage arrangement.

c) Explain six reasons for your recommendations.

d) State five measures the school should take to maintain safe stored water.

18.
a) Explain the meaning of water conservation.

b) Identify eight methods of conserving water in domestic buildings.

c) State five benefits of water conservation.

19.
a) Explain five safety and hygiene measures that should be observed when storing domestic water.

b) State four possible causes of contamination of stored water.

c) Explain how contamination of domestic water can be prevented.

20. A contractor is designing a domestic water supply system for a multi-storey residential building in Nakuru.

a) Identify five factors that should be considered when designing the system.

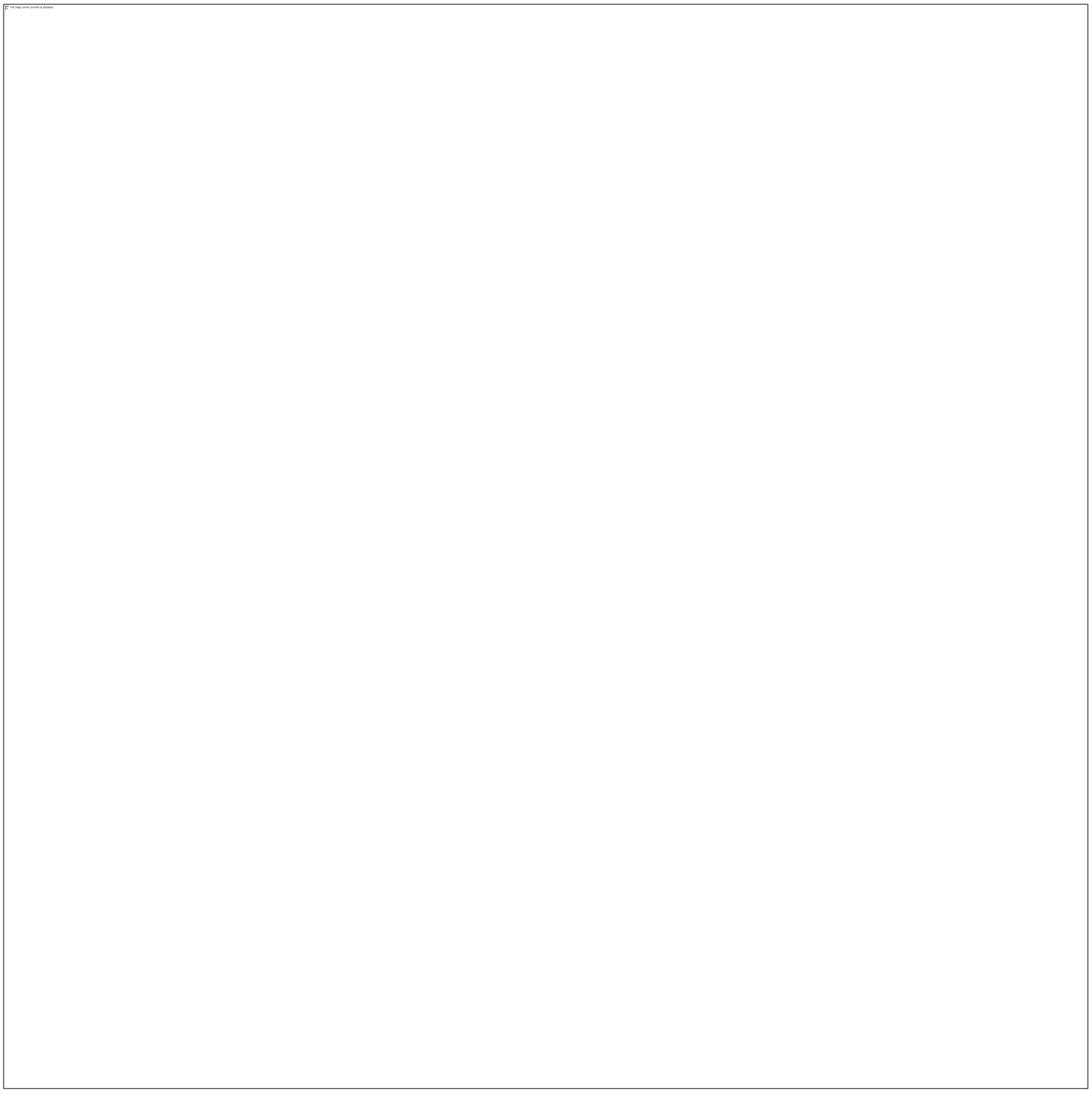
b) Explain why water storage may be necessary.

c) Recommend a suitable water distribution arrangement.

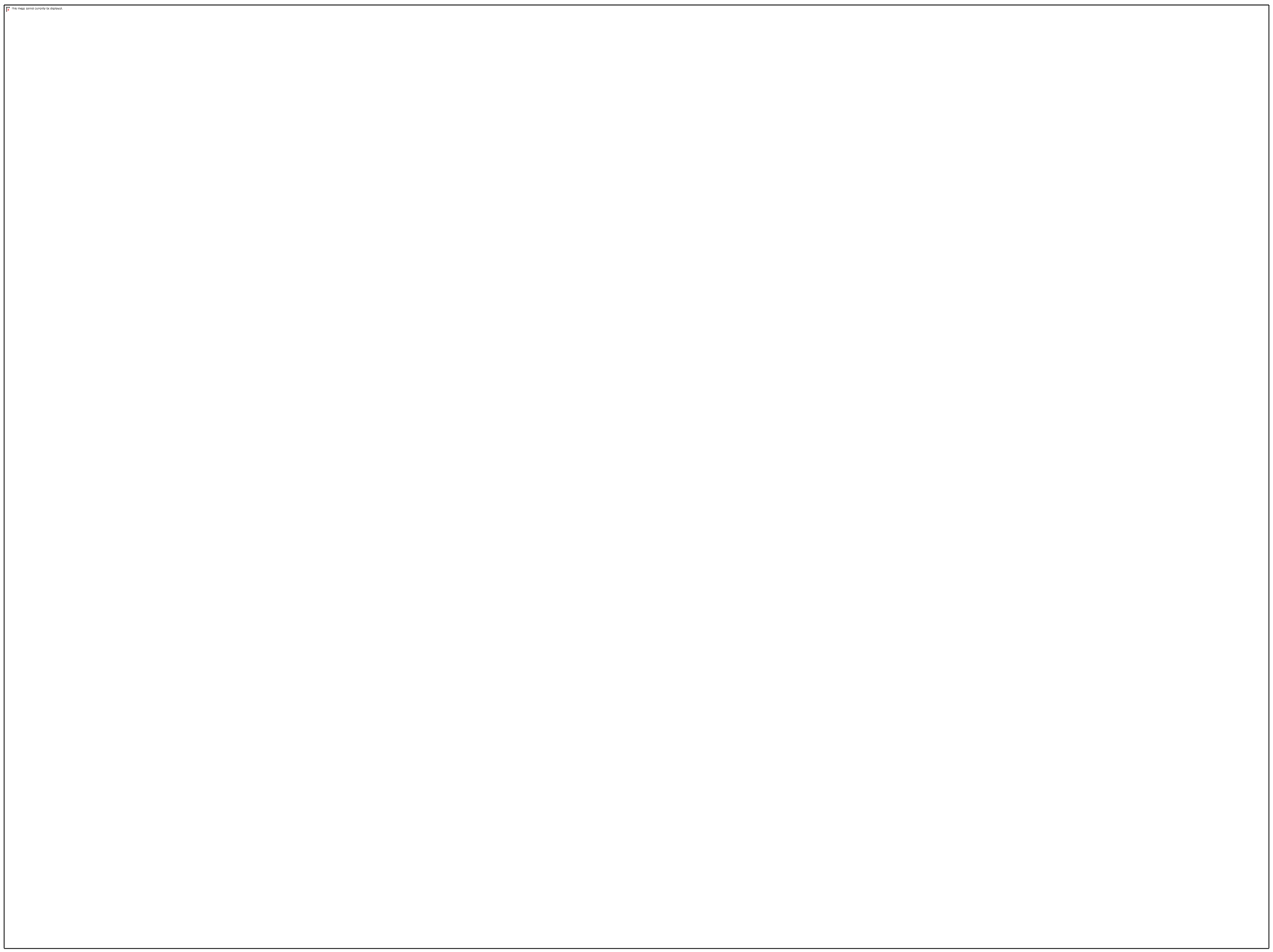
d) Explain the role of pumps and elevated tanks in the proposed system.

STRAND 4.0: BUILDING SERVICES

SUB-STRAND 4.2: SANITARY APPLIANCES







1.0 Introduction to sanitary appliances

Buildings require suitable facilities for personal hygiene, washing, bathing, cleaning and the safe disposal of wastewater. These facilities are provided through sanitary appliances connected to a plumbing and drainage system.

Sanitary appliances are commonly installed in residential houses, schools, hospitals, hotels, offices, shopping centres, factories and other public buildings.

In Kenya, sanitary appliances are found in different forms depending on the purpose of the building, the number of users, available water supply, construction cost, available space and sanitation requirements.

1.1 Meaning of sanitary appliances

Sanitary appliances are specially designed fixtures installed in buildings to receive water, enable washing, bathing and other hygienic activities, and discharge wastewater into an appropriate drainage system.

Examples include:

Water closets (toilets).

Wash hand basins.

Kitchen sinks.

Urinals.

Bathtubs.

Showers.

Bidets.

Washing machines.

Laundry sinks.

Note: Some appliances, such as washing machines, are commonly connected to plumbing and wastewater drainage systems. They are often described as plumbing appliances or equipment rather than traditional sanitary ware.

1.2 Meaning of plumbing works

Plumbing works refer to the installation, maintenance and repair of pipes, fittings, valves, sanitary appliances and other equipment used to supply water and remove wastewater from a building.

Examples of plumbing works include:

Installing water supply pipes.

Connecting a water closet to a soil pipe.

Installing a kitchen sink and its waste pipe.

Fixing taps and shower fittings.

Installing water storage tanks.

Repairing leaking pipes and taps.

Connecting sanitary appliances to drainage systems.

1.3 Importance of sanitary appliances in a building

Sanitary appliances play an important role in ensuring that buildings are clean, safe and comfortable for occupation.

1. **Promote personal hygiene**

Wash hand basins provide facilities for washing hands and faces.

Showers and bathtubs enable people to clean their bodies.

Bidets provide facilities for personal cleaning.

2. **Support proper sanitation**

Water closets and urinals provide facilities for the hygienic disposal of human excreta.

They reduce indiscriminate disposal of human waste.

3. **Prevent the spread of diseases**

Properly installed and maintained sanitary appliances help reduce contact with human waste.

Handwashing facilities help prevent the spread of disease-causing microorganisms.

4. **Improve cleanliness in buildings**

Kitchen sinks provide facilities for washing utensils and food items.

Laundry sinks and washing machines support cleaning of clothes.

5. **Provide comfort and convenience**

Bathtubs, showers and wash hand basins make buildings more comfortable for occupants.

They reduce the need to fetch water from distant sources for everyday activities.

6. **Improve the value of a building**

Well-designed sanitary facilities improve the appearance, usability and market value of a building.

7. **Support different building functions**

Schools require washrooms and toilets for learners and staff.

Hospitals require suitable sanitary facilities for patients and healthcare workers.

Hotels require bathrooms and other washing facilities for guests.

8. **Facilitate efficient wastewater management**

Properly connected appliances discharge wastewater into suitable drainage systems.

This helps prevent wastewater from accumulating inside buildings.

9. **Promote dignity and privacy**

Properly designed toilets and bathrooms provide privacy and dignity to users.

Accessible sanitary facilities support people with disabilities and those with limited mobility.

10. **Support environmental health**

Correct wastewater disposal helps protect the surrounding environment from contamination.

2.0 Classification of sanitary appliances used in buildings

Sanitary appliances can be classified according to the type of wastewater they receive and discharge.

The two main groups are:

Soil appliances.

Wastewater appliances.

2.1 Soil appliances

Soil appliances are sanitary fixtures designed to receive human excreta, particularly faeces and urine, and discharge it into a soil drainage system.

They are connected to soil pipes that convey sewage to an appropriate treatment or disposal system.

Examples of soil appliances include:

Water closets.

Urinals.

Bidets, where connected to the soil drainage system as designed.

Characteristics of soil appliances

They receive human excreta or wastewater associated with toilet use.

They are connected to an appropriate soil drainage arrangement.

They require suitable traps or water seals to prevent foul gases from entering the building.

They should be made from durable, smooth and easy-to-clean materials.

They must be installed in a manner that prevents leakage and contamination.

2.2 Wastewater appliances

Wastewater appliances are fixtures designed to receive used water from activities such as washing, bathing, cooking and cleaning, excluding discharge from toilets.

The wastewater they discharge is commonly referred to as *greywater*, although the exact classification depends on the source and the drainage system design.

Examples include:

Wash hand basins.

Kitchen sinks.

Bathtubs.

Showers.

Laundry sinks.

Washing machines.

Characteristics of wastewater appliances

They receive water used for washing, bathing and cleaning.

They are generally connected to waste pipes.

They require traps to prevent foul smells from entering rooms.

They should be easy to clean and maintain.

They should be properly connected to prevent water leakage.

They should discharge into an approved wastewater drainage system.

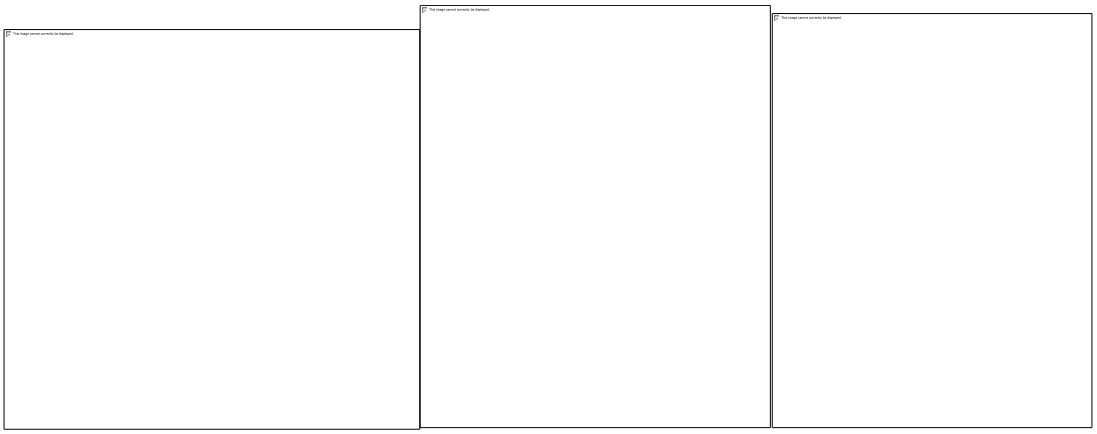
2.3 Differences between soil appliances and wastewater appliances

Soil appliances	Wastewater appliances
Receive human excreta, especially faeces and urine.	Receive used water from washing, bathing and cleaning.
Discharge into a soil drainage system.	Discharge into a waste drainage system.
Examples include water closets and urinals.	Examples include sinks, basins, showers and bathtubs.
Their discharge is sewage containing human excreta.	Their discharge is generally greywater, depending on the source.
Require suitable soil drainage connections.	Require suitable waste pipe connections.
Must be installed to prevent contamination and foul odours.	Must be installed to prevent leakage, blockages and foul odours.

Important distinction: A bidet is used for personal washing. Its drainage classification depends on the appliance design and plumbing arrangement. In many installations it is connected to the soil drainage system, but the actual connection must follow the approved plumbing design. Do not classify every bidet automatically as a soil appliance without considering its discharge arrangement.

3.0 Types of sanitary appliances used in buildings

3.1 Wash hand basins



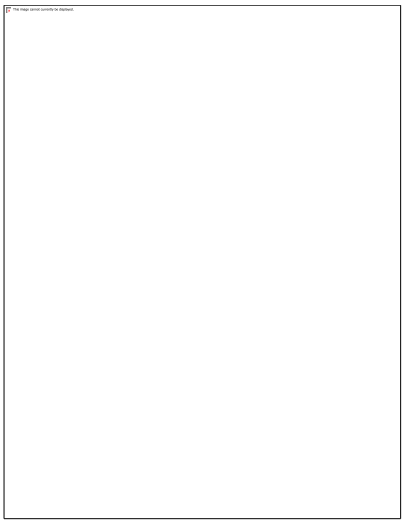
Definition

A wash hand basin is a sanitary appliance used for washing hands, face and other small personal cleaning activities.

It is commonly installed in bathrooms, toilets, washrooms, hospitals, schools, offices and other public buildings.

Types of wash hand basins

1. Pedestal wash hand basin



It consists of a basin supported by a pedestal.

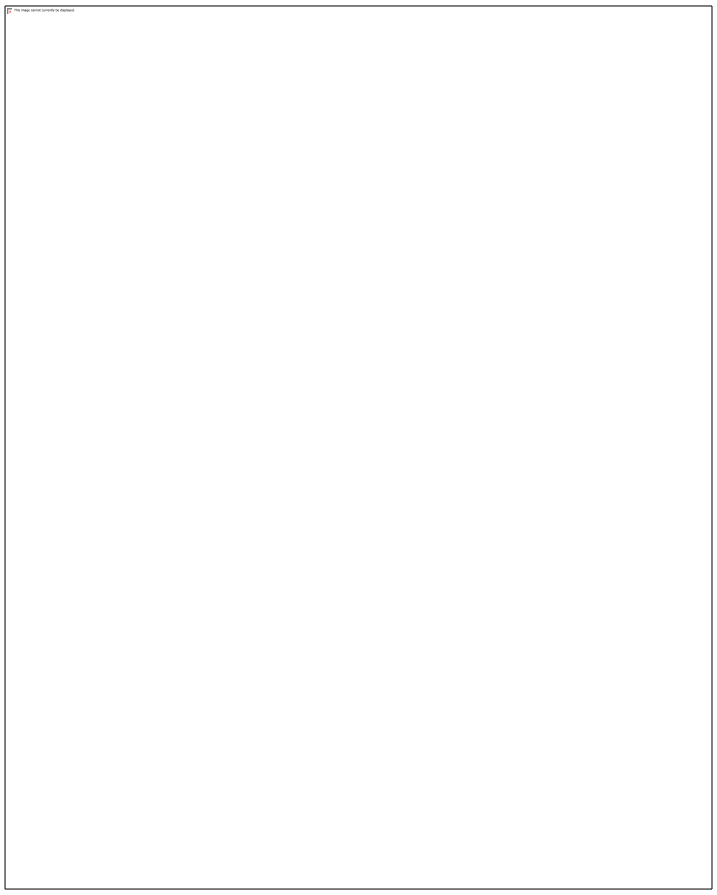
The pedestal may conceal some of the water supply and waste pipe connections.

It is commonly installed in domestic bathrooms.

It provides a neat and attractive appearance.

It occupies floor space.

2. Wall-mounted wash hand basin



It is fixed directly to a wall using suitable brackets or supports.

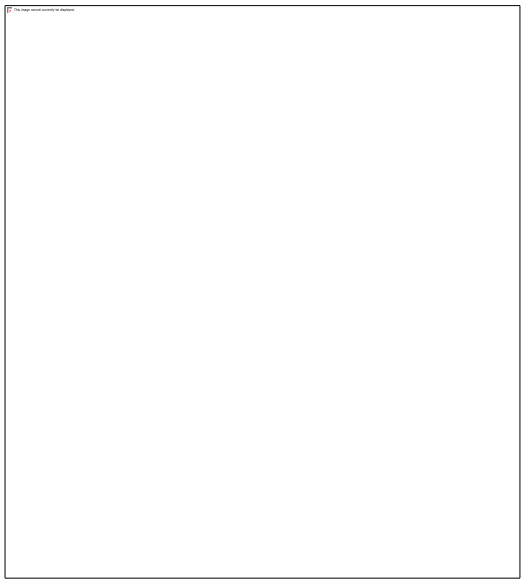
It does not require a floor pedestal.

It makes floor cleaning easier.

It is suitable for small bathrooms and public washrooms.

The wall must be strong enough to support the basin and the loads imposed on it.

3. Countertop wash hand basin



It is installed on top of a counter or vanity unit.

It may be circular, oval, rectangular or square.

It provides an attractive modern appearance.

It requires suitable counter support and properly sealed connections.

4. Semi-recessed wash hand basin

It is partly fitted into a counter or cabinet.

Part of the basin projects beyond the front edge of the counter.

It is useful where counter depth is limited.

It requires accurate cutting and fitting.

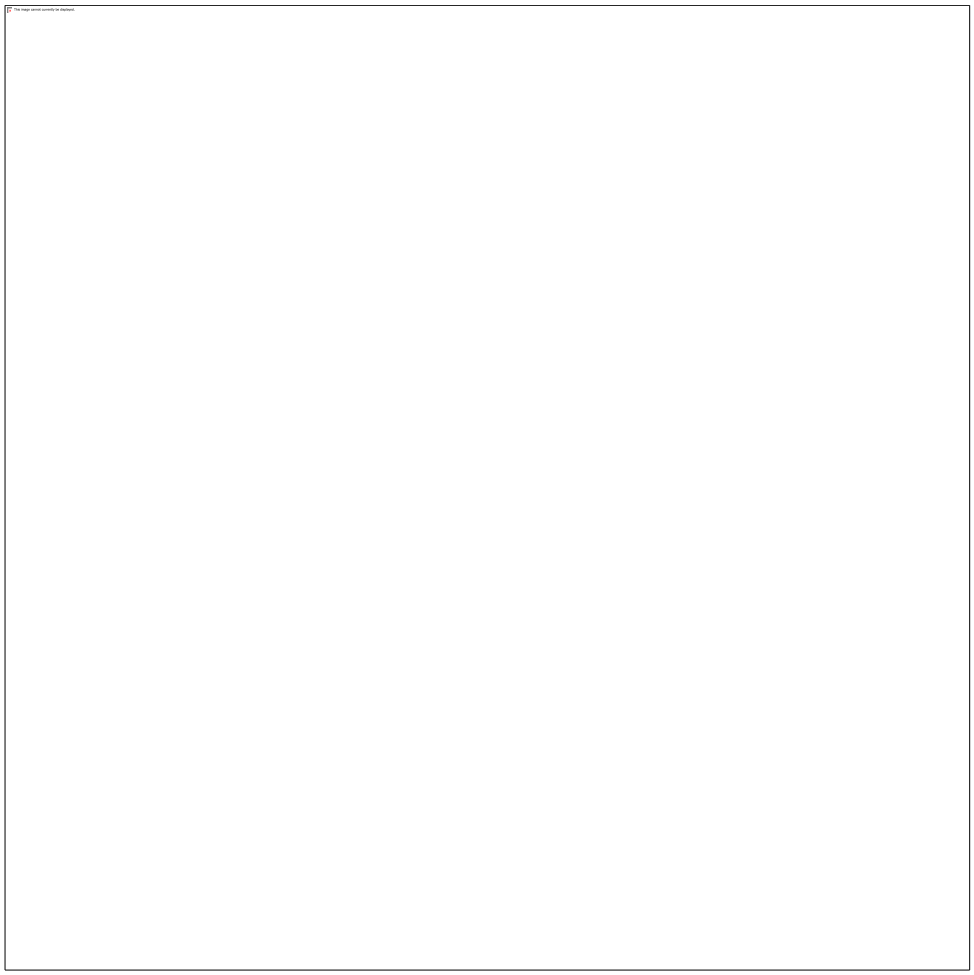
5. Corner wash hand basin

It is designed to fit into the corner of a room.

It saves space in small toilets and bathrooms.

It is commonly used where the available floor area is limited.

Main components of a wash hand basin



1. **Basin bowl**

The main part that holds water during washing.

It is usually made from glazed ceramic, although other materials are available.

2. **Tap or faucet**

Controls the flow of water into the basin.

It may supply cold water only or both hot and cold water.

3. **Waste outlet**

The opening through which used water leaves the basin.

4. **Plug or waste stopper**

Used to close the waste outlet when water needs to be retained in the basin.

5. **Overflow**

Provides an additional opening through which excess water can escape if the basin is overfilled.

Not all basin designs have an overflow.

6. **Trap**

Retains a water seal that prevents foul drainage gases from entering the building.

7. **Pedestal or support brackets**

Support the basin, depending on its design.

8. **Water supply pipes**

Convey water from the supply system to the tap.

9. **Waste pipe**

Carries used water from the trap to the drainage system.

Importance of wash hand basins

Promote handwashing and personal hygiene.

Help prevent the spread of infectious diseases.

Provide facilities for face washing and other personal cleaning.

Improve convenience in homes, schools and workplaces.

Support hygiene in healthcare facilities.

Provide a designated place for washing small personal items.

Materials used in making wash hand basins

Vitreous china.

Porcelain.

Stainless steel.

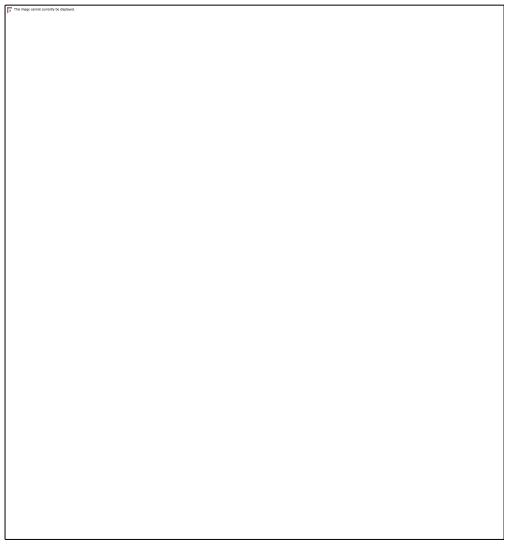
Glass.

Natural stone.

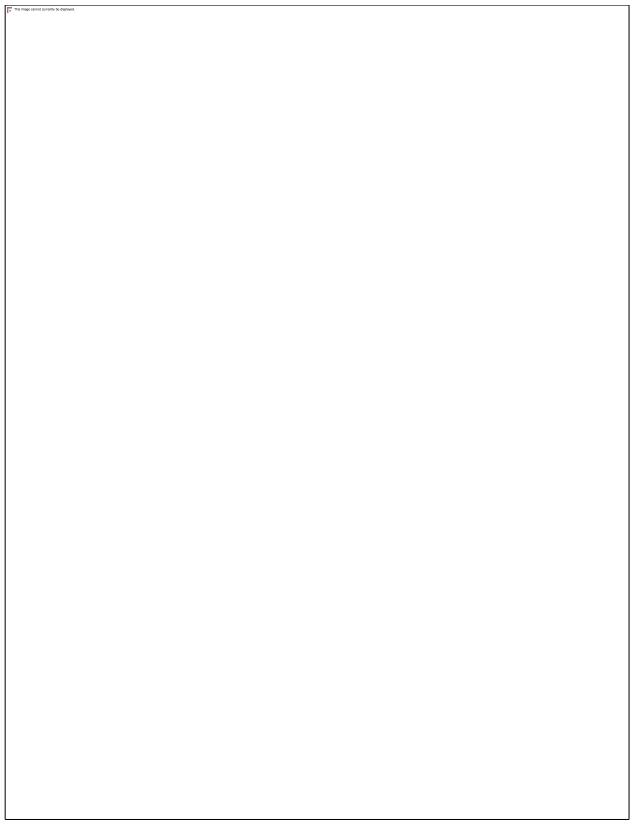
Solid-surface materials.

Ceramic basins are common because they are smooth, durable, non-porous when properly glazed and easy to clean.

3.2 Kitchen sinks







Definition

A kitchen sink is a plumbing appliance installed in a kitchen for washing utensils, food items and other kitchen equipment.

It receives water from the water supply system and discharges used water through a waste outlet and trap into the drainage system.

Types of kitchen sinks

1. Single-bowl sink

It has one main washing compartment.

It is suitable for small kitchens.

It occupies less counter space.

It is relatively simple to install.

2. Double-bowl sink

It has two separate compartments.

One bowl can be used for washing while the other is used for rinsing.

It is suitable for larger kitchens.

It requires adequate counter space.

3. Sink with a drainboard

It has a washing bowl and a sloping surface called a drainboard.

The drainboard provides space for draining wet utensils.

It helps keep water from spreading across the kitchen counter.

4. Undermount sink

It is fixed beneath a suitable countertop.

The countertop edge is exposed around the sink opening.

It provides a smooth, modern appearance.

Installation requires a compatible and adequately supported countertop.

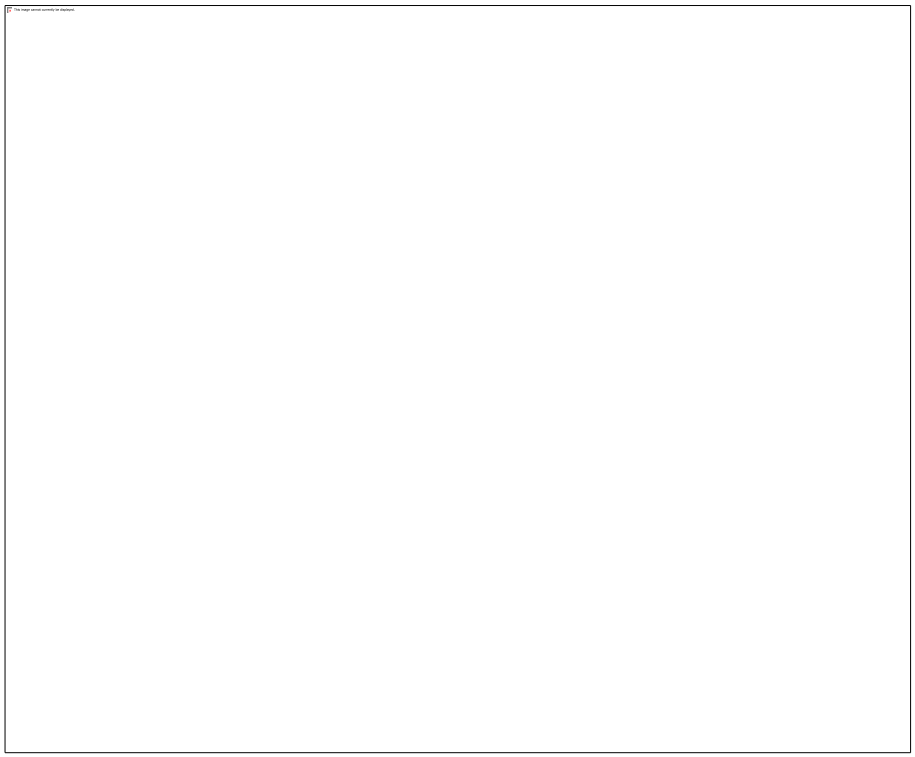
5. Top-mount or drop-in sink

It is fitted into an opening cut in the countertop.

Its rim rests on the counter surface.

It is relatively straightforward to install and replace.

Components of a kitchen sink



Sink bowl – holds water and utensils during washing.

Tap – controls the supply of water.

Spout – directs water into the sink.

Waste outlet – allows used water to drain away.

Strainer – traps food particles and other solid materials.

Plug – closes the waste outlet when necessary.

Overflow – prevents accidental overfilling in designs fitted with an overflow.

Trap – retains water to prevent foul gases from entering the kitchen.

Waste pipe – carries used water into the drainage system.

Drainboard – provides a surface for draining washed utensils.

Mounting clips or supports – secure the sink in position.

Materials used in making kitchen sinks

Stainless steel.

Ceramic or fireclay.

Granite composite.

Cast iron with enamel coating.

Solid-surface materials.

Importance of kitchen sinks

Provide facilities for washing dishes and cooking utensils.

Support food preparation and cleaning.

Promote kitchen hygiene.

Provide a convenient place for washing fruits and vegetables.

Help remove wastewater from the kitchen.

Improve the functionality of a kitchen.

Maintenance of kitchen sinks

Clean the sink regularly.

Remove food particles from the strainer.

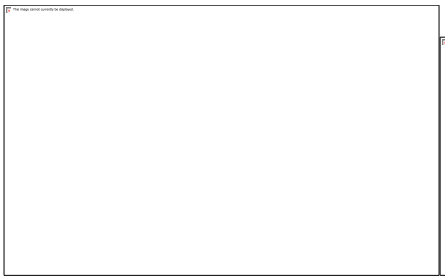
Avoid pouring cooking oil and grease into the drain.

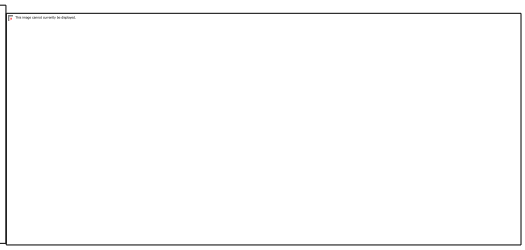
Repair leaking taps.

Clear blockages using appropriate methods.

Avoid harsh cleaning materials that may damage the sink's surface.

3.3 Bathtubs





Definition

A bathtub is a sanitary appliance designed to hold water in which a person can bathe or soak their body.

It is commonly installed in residential bathrooms, hotels, hospitals and other buildings where bathing facilities are required.

Types of bathtubs

1. Built-in bathtub

It is installed within a prepared enclosure.

The surrounding structure may be finished with tiles or other waterproof materials.

It is commonly used in residential buildings.

It can be fitted against a wall or between walls.

2. Freestanding bathtub

It stands independently on the bathroom floor.

It may be positioned away from walls.

It is often selected for its decorative appearance.

It requires suitable water supply and drainage connections.

3. Corner bathtub

It is designed to fit into a bathroom corner.

It may have a triangular or curved shape.

It can make effective use of available space, depending on its design.

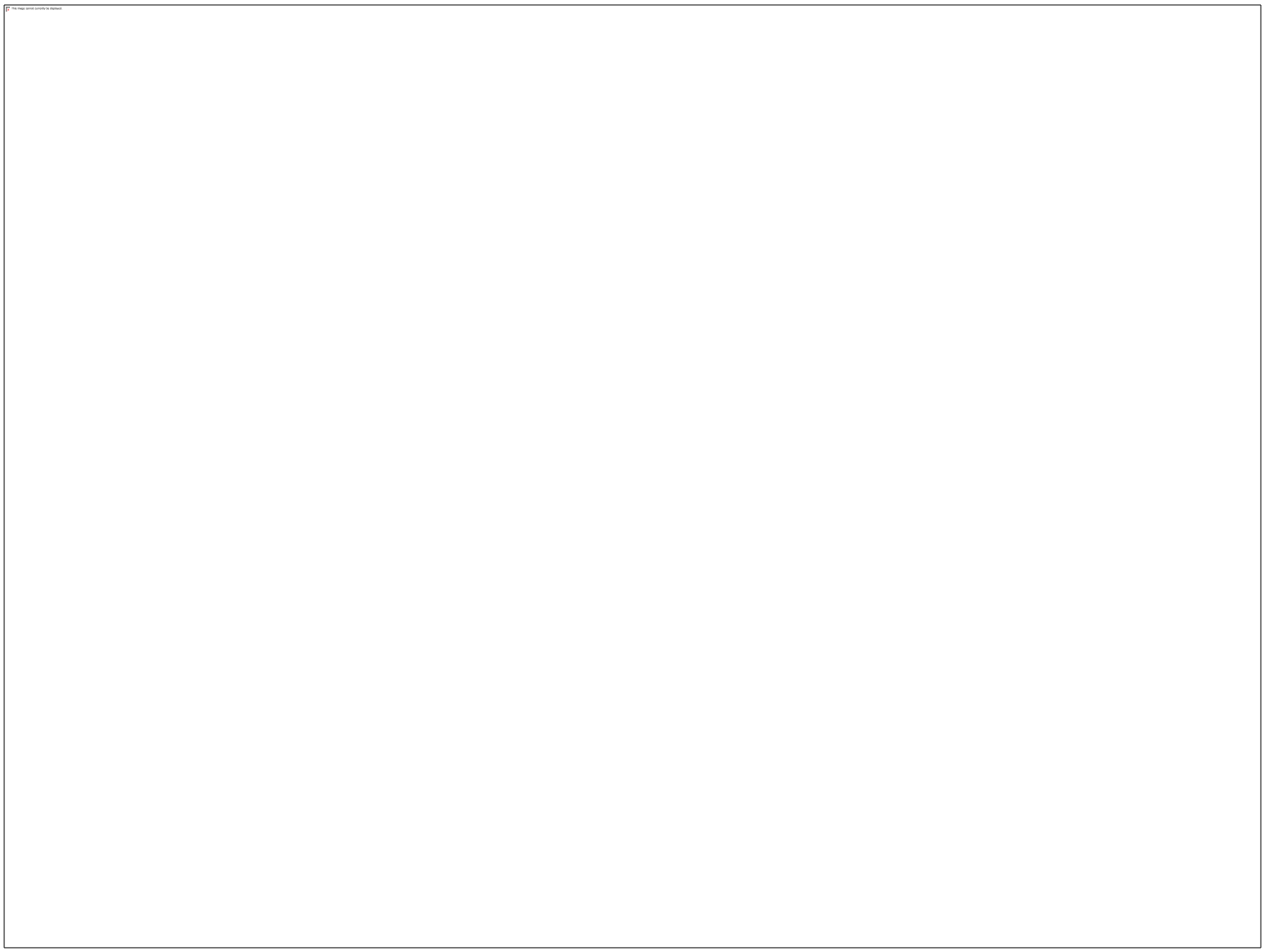
4. Whirlpool bathtub

It is fitted with a system that circulates water through jets.

The jets create a massaging effect.

It requires additional equipment, electrical safety measures and maintenance.

Components of a bathtub



Bathing bowl – holds water for bathing.

Tap or mixer – controls the supply of water.

Spout – directs water into the bathtub.

Waste outlet – allows water to drain from the bathtub.

Plug – closes the waste outlet.

Overflow – provides a route for excess water to drain.

Trap – prevents foul gases from entering the bathroom.

Supporting frame or legs – supports the weight of the bathtub and its contents.

Sealing material – prevents water from entering gaps around the bathtub.

Waste pipe – conveys used water to the drainage system.

Materials used in making bathtubs

Acrylic.

Fibreglass-reinforced plastic.

Enamelled steel.

Cast iron.

Solid-surface materials.

Importance of bathtubs

Provide facilities for full-body bathing.

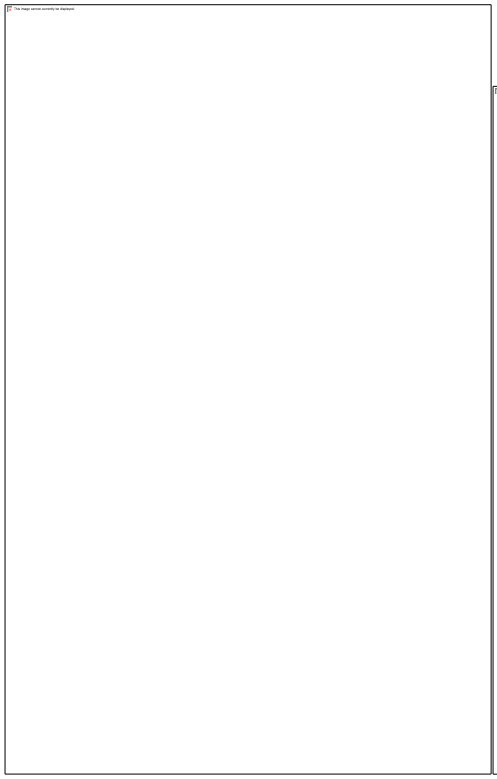
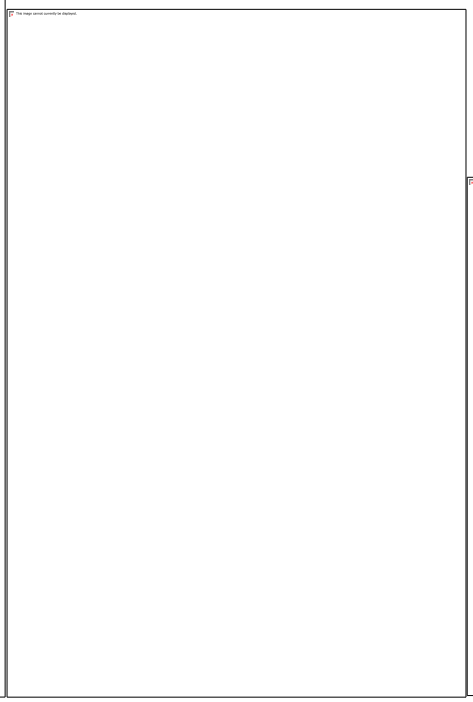
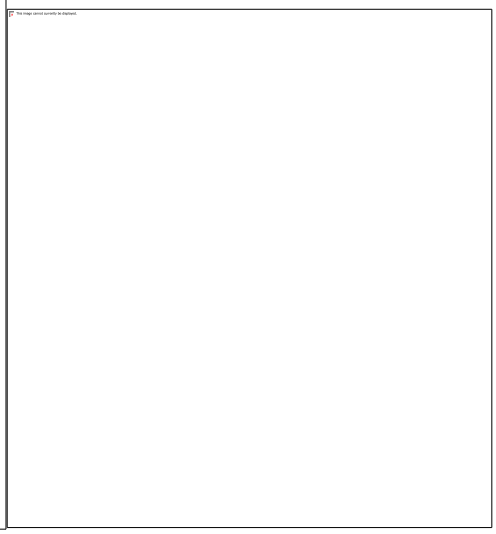
Promote personal hygiene.

Provide comfort and relaxation.

Improve the facilities available in hotels and residential buildings.

May support bathing needs of some users when designed with suitable access and safety features.

3.4 Showers

Definition

A shower is a sanitary appliance or bathing installation that delivers water through a showerhead onto the body for washing.

It is commonly installed in residential bathrooms, schools, hotels, hospitals and other buildings.

Types of showers

1. Fixed shower

It has a showerhead permanently attached to a wall or ceiling.

Water flows through the showerhead onto the user.

It is commonly used in domestic bathrooms.

2. Hand-held shower

It consists of a showerhead connected to a flexible hose.

It can be lifted and directed to different parts of the body.

It is useful for cleaning the shower area and assisting people with limited mobility.

3. Electric shower

It heats water using an electrical heating element within the unit.

It may operate independently of a central hot-water storage system.

It must be installed with suitable electrical protection and by a qualified person.

4. Mixer shower

It combines hot and cold water to provide the required water temperature.

It may use a manual or thermostatic mixing valve.

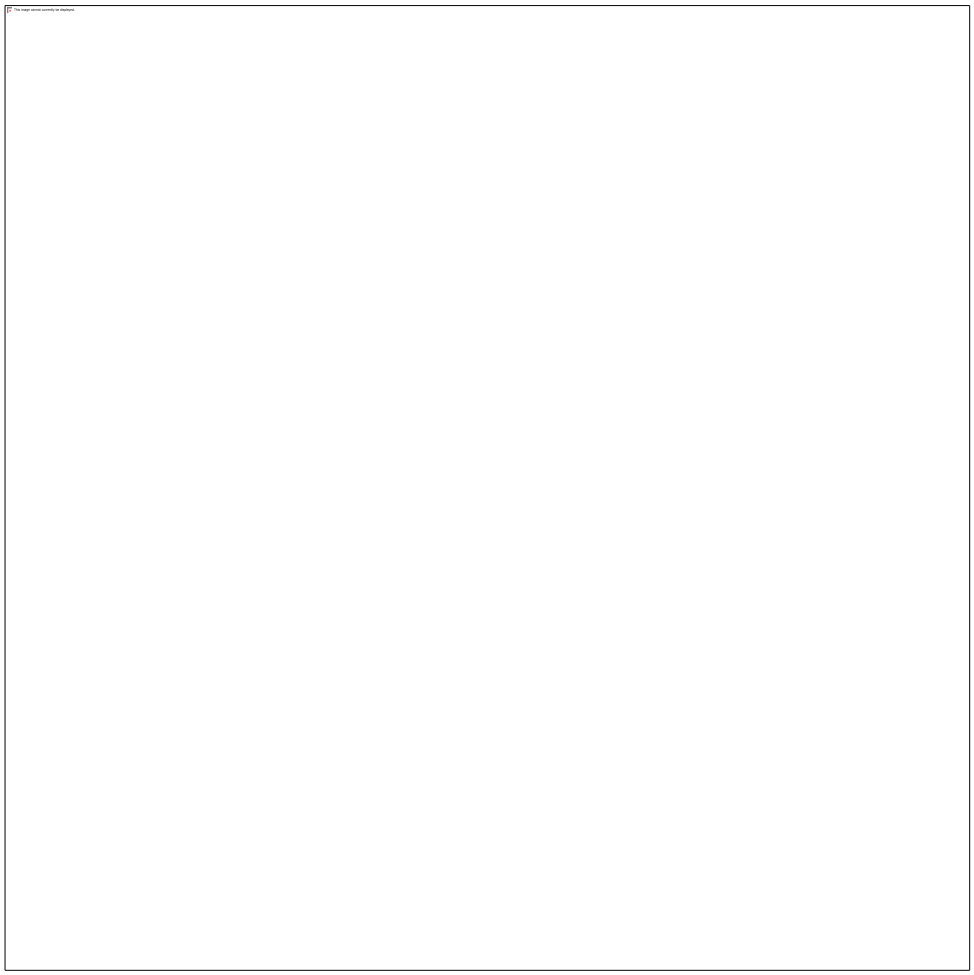
It requires suitable hot and cold water supplies.

5. Rain shower

It uses a relatively large showerhead to distribute water over a wider area.

It is commonly installed in modern bathrooms.

Main components of a shower



Showerhead – distributes water.

Shower arm – connects the showerhead to the water outlet.

Mixer valve – regulates the mixture of hot and cold water.

Control handle – adjusts water flow and temperature.

Riser rail – supports an adjustable hand-held shower.

Flexible hose – conveys water to the hand-held showerhead.

Shower tray or floor – collects water and directs it towards the drain.

Waste outlet – allows wastewater to leave the shower area.

Trap – prevents foul drainage gases from entering the bathroom.

Shower screen or curtain – helps prevent water from splashing outside the shower area.

Importance of showers

Provide convenient bathing facilities.

Promote personal cleanliness.

Use water efficiently when properly designed and managed.

Save space compared with some bathtub installations.

Provide accessible bathing options when fitted with suitable controls, seating and support rails.

Safety precautions when using and installing showers

Use non-slip flooring.

Ensure proper drainage to prevent water accumulation.

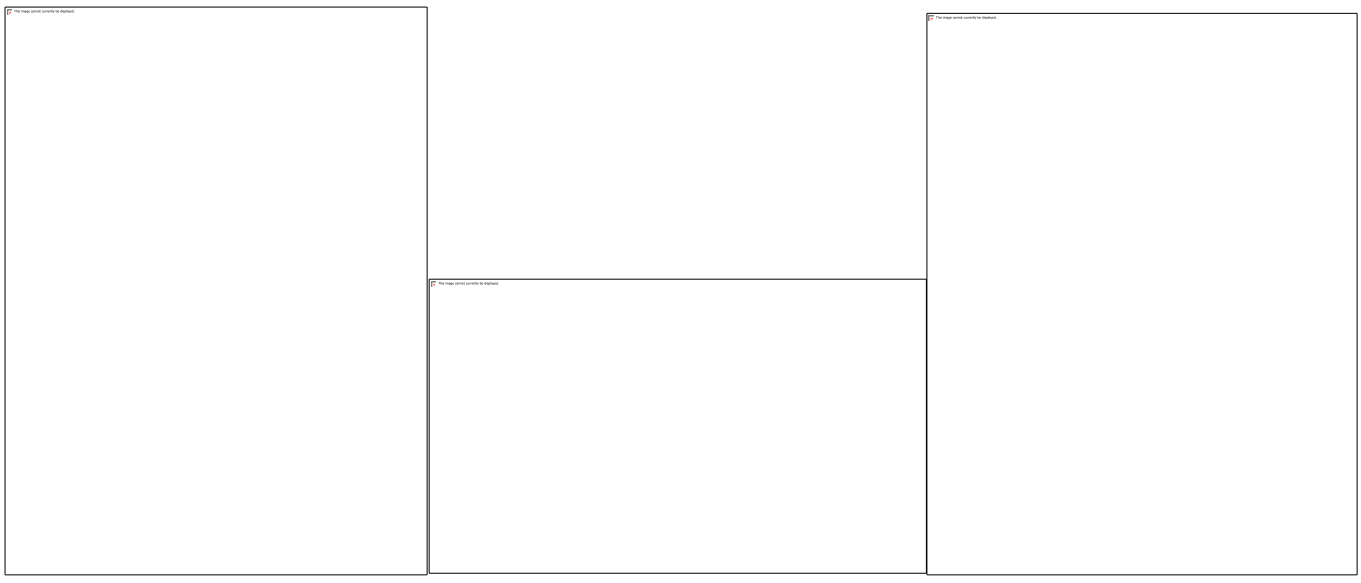
Provide suitable ventilation.

Protect electrical shower installations using appropriate electrical safety devices.

Avoid exposing electrical connections to water.

Fit suitable temperature controls to reduce scalding risks.

3.5 Water closets (WCs)



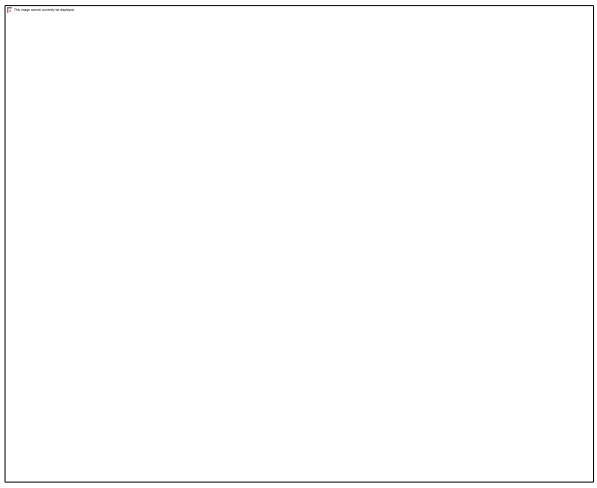
Definition

A water closet (WC) is a sanitary appliance designed to receive human excreta and flush it away using water into a soil drainage system.

It is commonly called a toilet. It is one of the most important sanitary appliances in residential, commercial and institutional buildings.

Main types of water closets

1. Close-coupled water closet



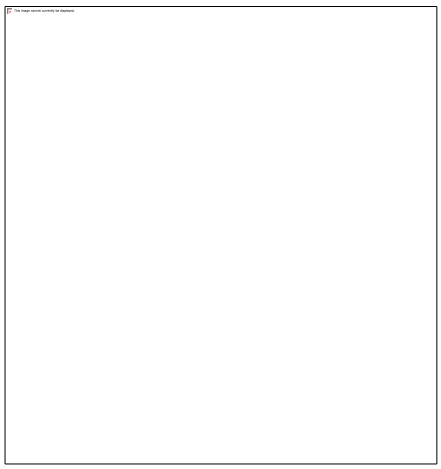
The cistern is attached directly to the toilet pan.

The cistern stores water for flushing.

It is commonly used in residential houses and institutions.

It is relatively easy to install and maintain.

2. One-piece water closet



The cistern and toilet pan are manufactured as one integrated unit.

It has fewer visible joints.

It provides a neat appearance.

It may be more expensive to purchase than some two-piece models.

3. Wall-hung water closet



It is fixed to a strong supporting wall frame.

The cistern is usually concealed behind the wall or within a service enclosure.

The floor below the toilet is easier to clean.

It requires a suitable support frame and careful installation.

4. S-trap water closet

The outlet passes through the bottom of the toilet pan.

It connects to a soil pipe entering through the floor.

It is suitable for drainage layouts designed for a floor connection.

5. P-trap water closet

The outlet passes horizontally or towards the rear of the pan.

It connects to a soil pipe through the wall or a suitable rear connection.

It is selected where the drainage layout allows a horizontal outlet.

6. Squatting water closet



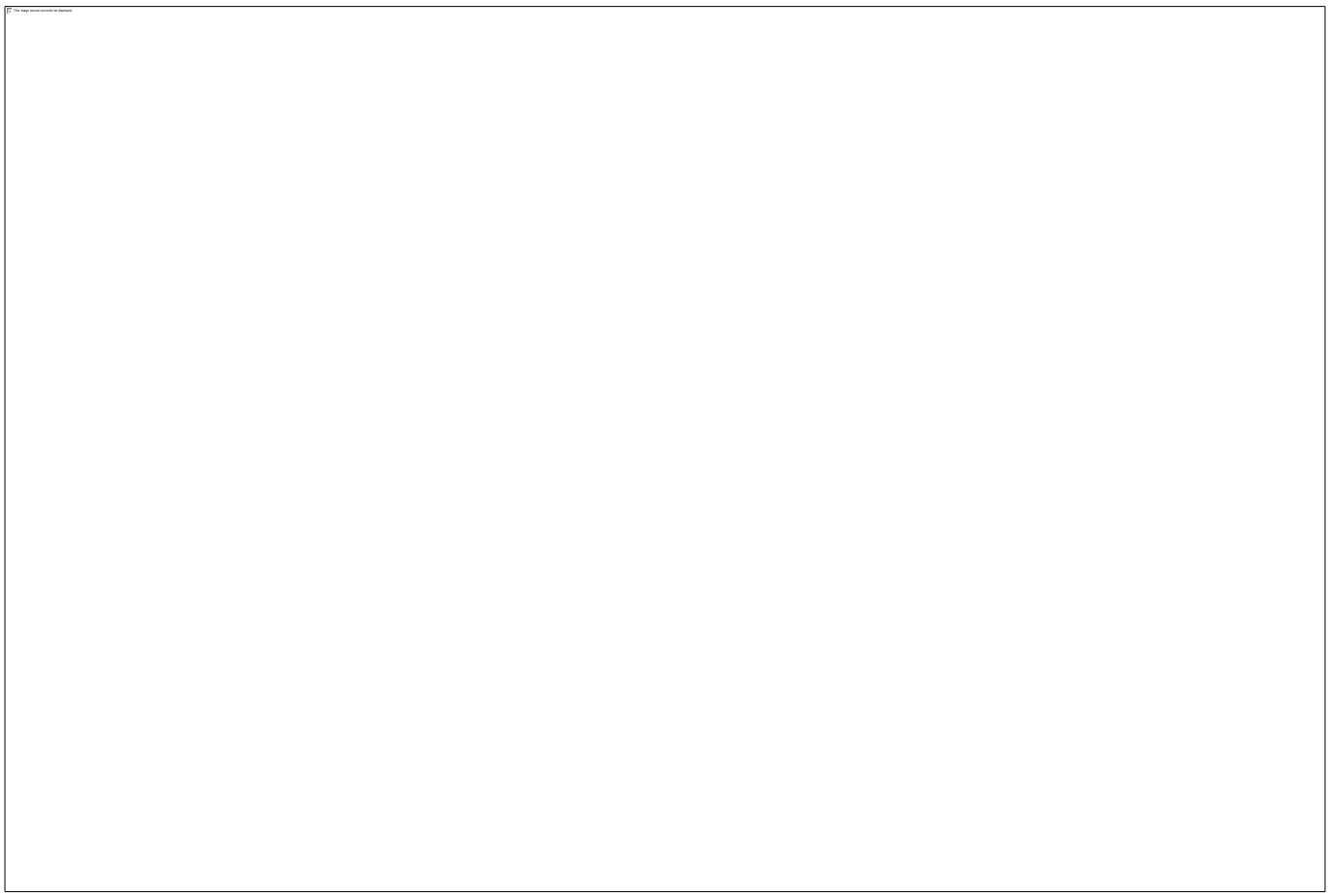
It is designed for use in a squatting position.

It is commonly found in some public toilets and older building designs.

It requires a properly constructed floor and drainage arrangement.

It should be installed with suitable cleaning and water supply facilities.

Main components of a water closet



1. **Toilet pan**

The bowl-shaped part that receives human excreta.

It is usually manufactured from glazed ceramic.

Its smooth surface makes cleaning easier.

2. **Cistern**

A container that stores water for flushing.

It may be fixed above, behind or directly onto the toilet pan.

3. **Flush mechanism**

Releases water from the cistern into the toilet pan.

It may be operated by a handle, push button or other approved mechanism.

4. **Flush pipe or flush passage**

Carries water from the cistern into the toilet pan in designs that use a separate flush pipe.

5. **Float valve**

Controls the refilling of the cistern.

It stops or reduces water inflow when the cistern reaches its designed water level.

6. **Overflow arrangement**

Provides a safe route for excess water in case the cistern filling mechanism fails.

Its design varies between cistern models.

7. **Toilet seat**

Provides a sitting surface for the user.

It is commonly made from plastic or other suitable materials.

8. **Toilet cover**

Covers the toilet seat and pan when not in use.

9. **Trap**

Retains a water seal that prevents foul gases from entering the toilet room.

It is commonly incorporated into the design of the toilet pan.

10. **Soil outlet**

Connects the toilet pan to the soil drainage pipe.

11. **Inlet valve**

Allows water to enter the cistern.

12. **Isolation valve**

Allows the water supply to the toilet to be shut off during repairs and maintenance.

Working principle of a water closet

Water enters the cistern through the inlet valve.

The float mechanism controls the filling of the cistern.

When the user operates the flush mechanism, stored water is released.

Water flows into the toilet pan and washes its contents towards the trap.

The flushing action carries waste into the soil pipe.

The cistern refills with water for the next use.

Water remains in the trap to form a seal against foul gases.

Importance of water closets

Provide hygienic facilities for the disposal of human excreta.

Promote sanitation in buildings.

Help reduce environmental contamination when connected to a properly designed disposal system.

Improve privacy and dignity.

Support public health in homes, schools, hospitals and workplaces.

Maintenance of water closets

Clean the toilet pan regularly using suitable cleaning products.

Repair leaking cisterns and flush valves.

Check that the toilet is firmly fixed.

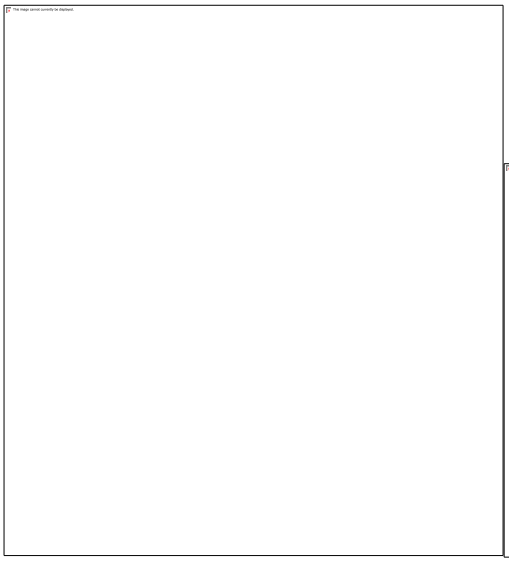
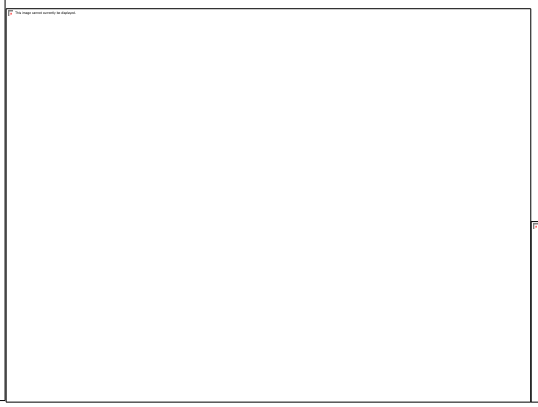
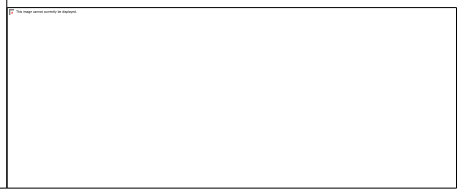
Avoid flushing sanitary towels, plastics and other unsuitable materials.

Clear blockages using appropriate plumbing equipment.

Check that the trap maintains its water seal.

Ensure that the soil pipe and ventilation arrangements remain functional.

3.6 Urinals

Definition

A urinal is a sanitary appliance mainly designed for receiving and disposing of urine.

Urinals are commonly installed in male washrooms in schools, hospitals, offices, shopping centres, hotels, factories and other public buildings.

Types of urinals

1. Wall-mounted urinal

It is fixed to a wall using suitable supports.

It is commonly made from glazed ceramic.

It occupies relatively little floor space.

It is easy to clean beneath when properly installed.

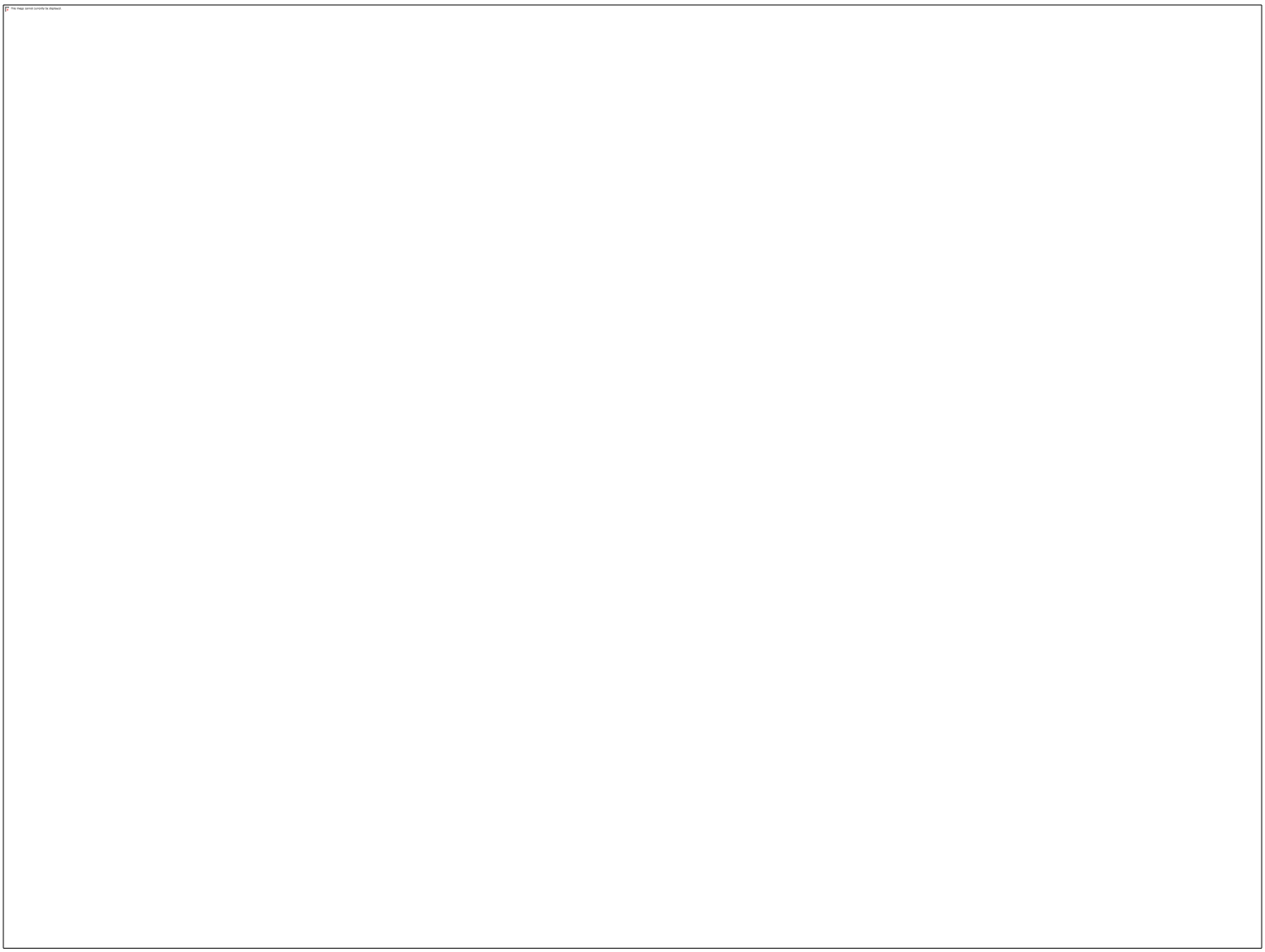
2. Stall urinal

It is designed as an individual urinal unit.

It may be fitted with partitions to provide privacy.

It is commonly used in public washrooms.

3. Trough urinal



It consists of a long trough-shaped fixture.

Several users can use it at the same time.

It is suitable for high-traffic public facilities.

It requires suitable flushing and drainage arrangements.

4. Waterless urinal

It is designed to operate without conventional flushing water.

It uses a specially designed cartridge, seal or barrier system to control odours.

It can reduce water consumption.

It requires maintenance according to the manufacturer's instructions.

5. Sensor-operated urinal

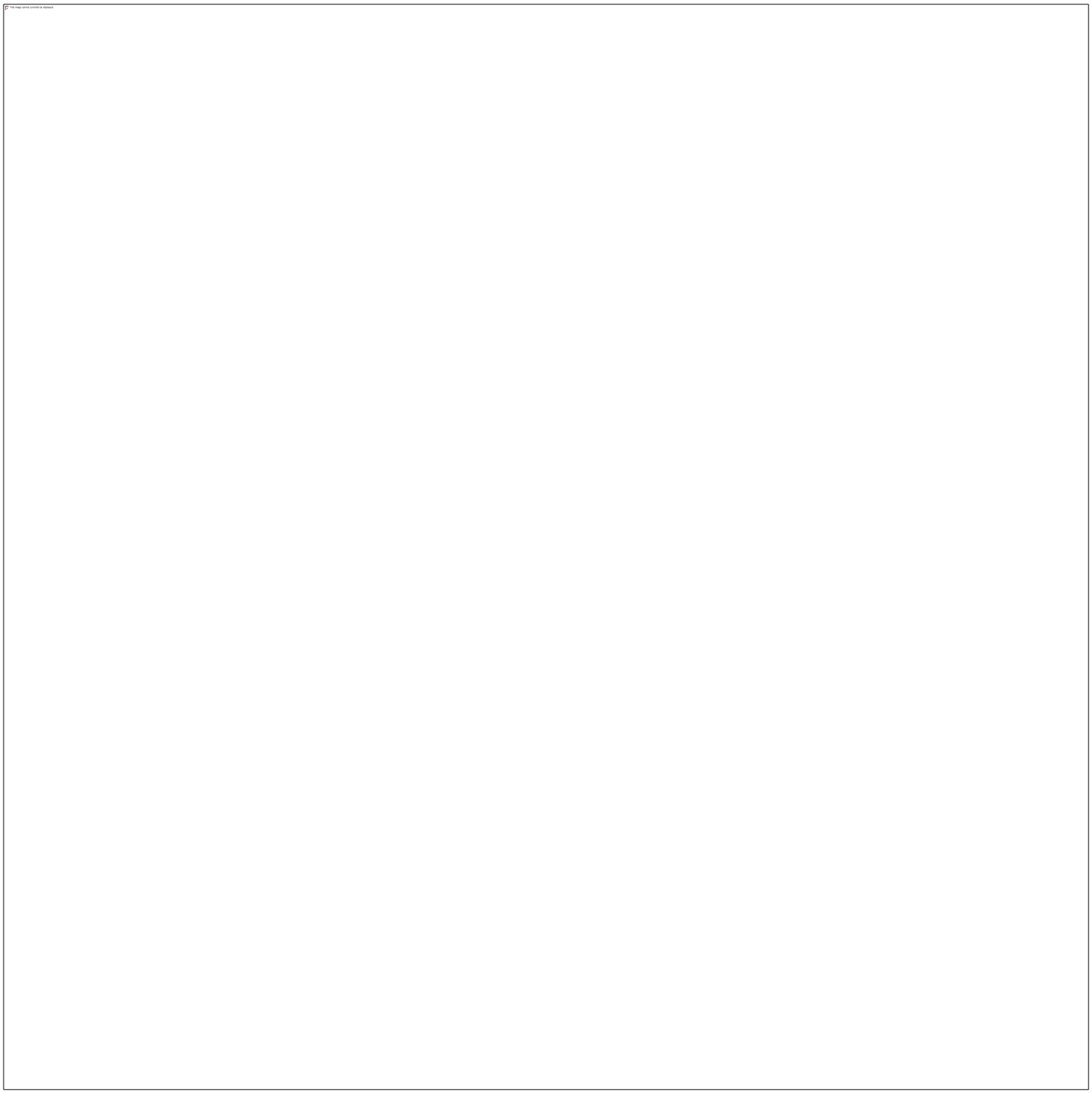
It uses an electronic sensor to activate flushing.

Flushing may take place automatically after use.

It reduces the need for users to touch flush controls.

It requires suitable water and, depending on the model, electrical or battery power.

Components of a urinal



Urinal bowl – receives urine.

Flush inlet – supplies flushing water.

Spreader – distributes flushing water over the urinal surface in designs fitted with one.

Flush valve – controls the release of flushing water.

Sensor or flush control – activates flushing in automatic or manual systems.

Waste outlet – allows urine and flushing water to drain away.

Trap – retains a water seal to prevent foul gases from entering the room.

Waste pipe – conveys discharge to the drainage system.

Partition – provides privacy between individual urinals where installed.

Fixing brackets – support the urinal on the wall.

Importance of urinals

Provide convenient facilities for urination.

Reduce queues in busy public washrooms.

Support sanitation in institutions and public buildings.

Can save space compared with providing only water closets.

Some designs reduce water consumption.

Improve the efficiency of washroom facilities.

Maintenance of urinals

Clean the urinal bowl frequently.

Check that the flushing system operates correctly.

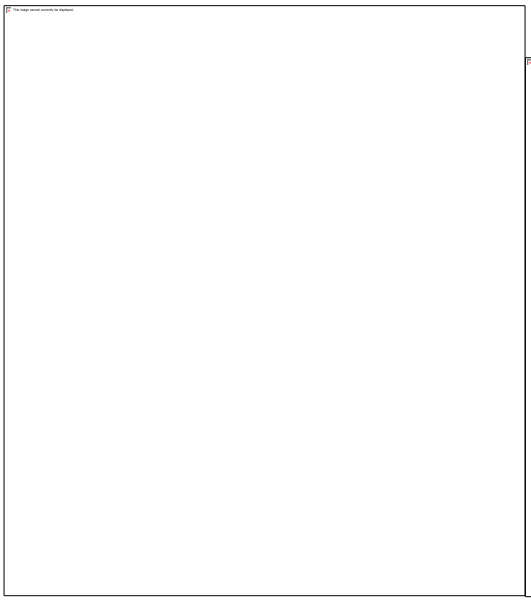
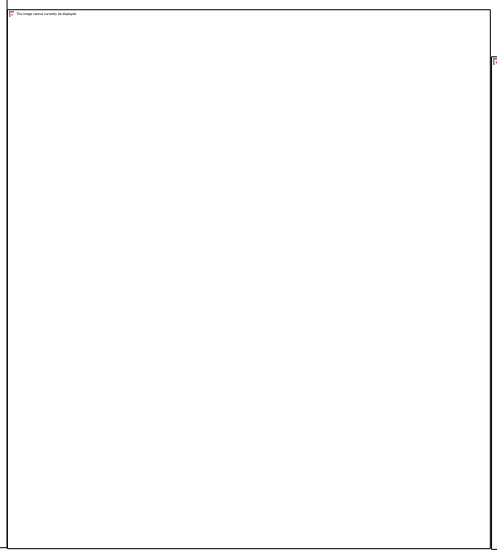
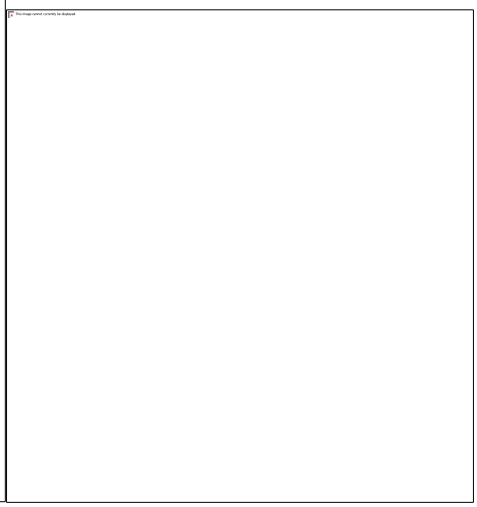
Remove deposits that may block the waste outlet.

Inspect traps and waste pipes for leakage.

Maintain automatic sensors according to the manufacturer's instructions.

Ensure that the water seal is maintained in water-seal trap systems.

3.7 Bidets

Definition

A bidet is a sanitary appliance designed to provide water for washing the external genital and anal areas after using the toilet.

A conventional bidet resembles a small basin and is normally installed near a water closet. Some modern toilets have integrated bidet functions, while bidet sprays are separate handheld fittings.

Types of bidets

1. Conventional floor-mounted bidet

It is fixed to the bathroom floor.

It has a bowl designed for personal washing.

It is supplied with water through a suitable tap or mixer.

It is connected to a waste outlet and trap.

2. Wall-mounted bidet

It is fixed to a supporting wall.

It leaves the floor beneath it clear.

It requires a strong fixing system and suitable concealed or exposed plumbing connections.

3. Bidet toilet seat

It is fitted onto a water closet.

It provides a washing function through integrated water jets.

Some models have additional temperature and control features.

It requires a suitable water connection and, for electrically powered models, safe electrical installation.

4. Handheld bidet spray

It consists of a spray head connected to a flexible hose and water supply.

It is commonly installed near a water closet.

It requires a suitable control valve and secure mounting arrangement.

The installation must prevent backflow contamination of the water supply.

Components of a conventional bidet

Bidet bowl – holds water during personal washing.

Tap or mixer – controls water supply.

Spray outlet or water jet – directs water for washing.

Waste outlet – allows used water to drain away.

Plug or stopper – closes the outlet where provided.

Trap – prevents foul drainage gases from entering the bathroom.

Water supply pipes – supply water to the bidet.

Waste pipe – conveys used water into the drainage system.

Fixing brackets or base – support the appliance.

Importance of bidets

Provide facilities for personal hygiene.

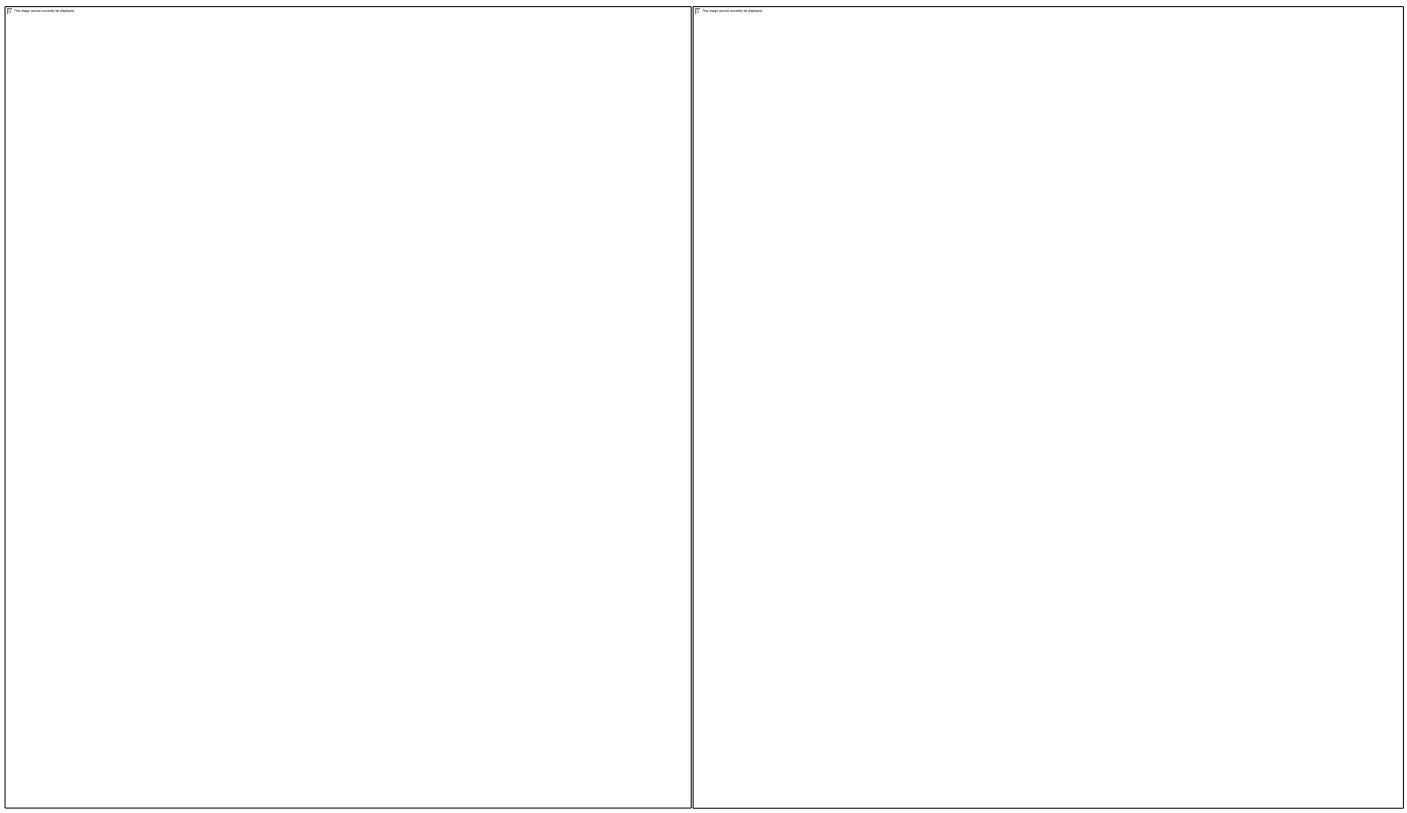
Support cleaning after toilet use.

Improve comfort and convenience.

May assist people who find conventional washing methods difficult.

Reduce dependence on other washing facilities.

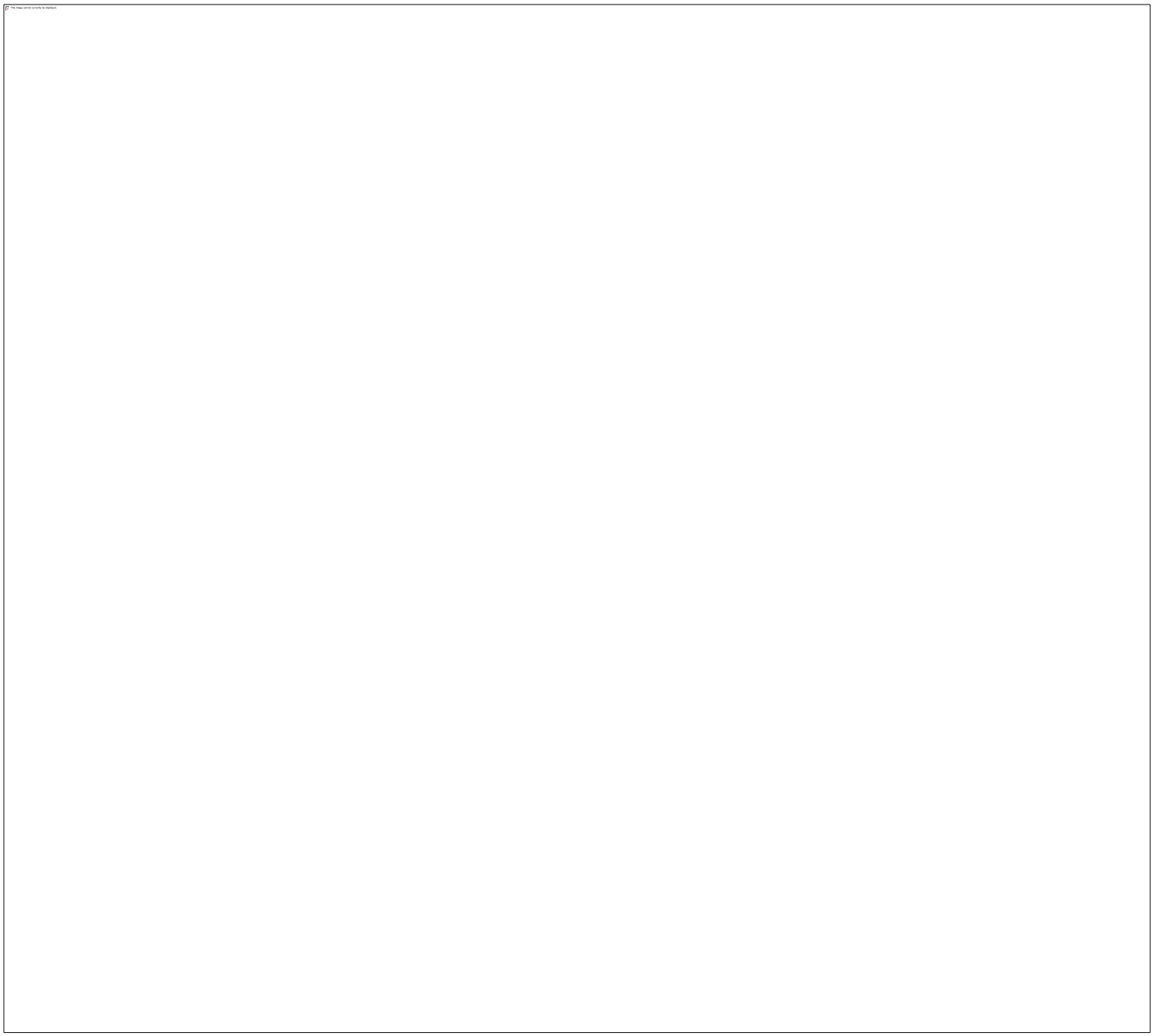
3.8 Washing machines



Definition

A washing machine is a plumbing-connected household or commercial appliance used for washing clothes and other suitable fabrics using water and detergent.

Although it is not traditionally classified as a sanitary ware fixture, it is an important appliance connected to the building's water supply and wastewater drainage systems.



Types of washing machines

1. Front-loading washing machine

Clothes are loaded through a door at the front.

It uses a rotating drum to wash clothes.

It commonly uses less water than many traditional top-loading models, depending on the model and cycle.

It requires a suitable water supply and drainage connection.

2. Top-loading washing machine

Clothes are loaded through an opening at the top.

It may use an agitator or impeller washing mechanism.

It is convenient for loading clothes without bending as much.

Water consumption varies depending on the design.

3. Semi-automatic washing machine

It requires some manual operations, such as transferring clothes between washing and spinning compartments in some models.

It may have separate washing and spinning tubs.

It requires water supply and suitable wastewater discharge arrangements.

Main components related to plumbing

Water inlet valve – controls water entering the machine.

Inlet hose – conveys water from the supply point.

Drum or tub – holds clothes and wash water.

Drain pump – removes used water from the machine.

Drain hose – conveys wastewater to an approved drainage connection.

Filter – collects lint and other particles in designs fitted with one.

Isolation tap – allows the water supply to be shut off during maintenance.

Importance of washing machines

Make washing clothes easier and faster.

Reduce manual labour.

Support cleanliness and hygiene.

Are useful in homes, hotels, hospitals and commercial laundries.

Help improve efficiency in buildings with large laundry requirements.

Installation and maintenance considerations

Provide a suitable water supply connection.

Install an accessible isolation valve.

Secure the inlet and drain hoses.

Connect wastewater to an approved drainage point.

Avoid allowing the drain hose to discharge onto the floor.

Clean filters according to the manufacturer's instructions.

Check hoses regularly for leaks and deterioration.

4.0 Materials used in manufacturing sanitary appliances

Sanitary appliances are manufactured from different materials depending on their function, cost, strength, appearance, hygiene requirements and durability.

4.1 Vitreous china

Meaning: Vitreous china is a ceramic material coated with a smooth, glass-like glaze and fired at high temperatures.

Uses

Water closets.

Wash hand basins.

Urinals.

Bidets.

Advantages

It has a smooth and hygienic surface.

It is easy to clean.

It resists many household cleaning chemicals.

It does not readily absorb water when properly manufactured and glazed.

It is durable under normal use.

It is available in different shapes and colours.

Disadvantages

It can crack or break when subjected to strong impact.

It is relatively heavy.

Transport and installation require care.

Repairs to major cracks are usually impractical.

4.2 Stainless steel

Uses

Kitchen sinks.

Commercial wash basins.

Trough urinals.

Some institutional sanitary fixtures.

Advantages

It is strong and durable.

It is relatively light compared with some ceramic fixtures.

It is easy to clean.

It is resistant to corrosion when the correct grade is selected and maintained.

It is suitable for commercial and institutional buildings.

Disadvantages

It may become scratched.

It can produce noise when water or utensils strike it.

It may show water spots and fingerprints.

Some grades may corrode in unsuitable environments.

4.3 Acrylic

Uses

Bathtubs.

Shower trays.

Some wash basins.

Advantages

It is lightweight.

It retains heat relatively well.

It is available in different shapes and designs.

It is easy to install compared with heavier materials.

It has a smooth surface.

Disadvantages

It can be scratched.

Some products may discolour with age.

It may require a supporting frame.

It can be damaged by unsuitable cleaning chemicals.

4.4 Fibreglass-reinforced plastic

Uses

Bathtubs.

Shower trays.

Some washroom fixtures.

Advantages

It is lightweight.

It can be moulded into different shapes.

It is relatively easy to transport.

It can be less expensive than some alternative materials.

Disadvantages

It may scratch or crack.

Its surface may deteriorate if poorly maintained.

It may require specialist repair in case of significant damage.

4.5 Cast iron with enamel coating

Uses

Bathtubs.

Some traditional sinks.

Advantages

It is strong.

It is durable.

It retains heat well.

Its enamelled surface is smooth and easy to clean.

Disadvantages

It is very heavy.

It requires strong floor support.

The enamel may chip when struck.

It is difficult to transport and install.

4.6 Glass

Uses

Decorative wash basins.

Some shower screens and enclosures.

Advantages

It provides an attractive appearance.

It is smooth and easy to clean when properly designed.

It is available in different colours and finishes.

Disadvantages

It may break if unsuitable glass is used or it is subjected to impact.

It requires careful installation.

Safety glass must be selected where required by the design and applicable standards.

4.7 PVC and other plastics

Uses

Some cisterns.

Waste fittings and pipework.

Certain lightweight sanitary fixtures.

Advantages

They are lightweight.

They are generally resistant to corrosion.

They are easy to transport.

They can be economical.

Disadvantages

Some plastics may deform under high temperatures.

They may be scratched or damaged.

Their strength and durability vary with the material and quality.

5.0 Soil pipes and waste pipes

A sanitary appliance must be connected to a suitable drainage pipe to remove its discharge safely.

5.1 Soil pipe

Definition: A soil pipe is a drainage pipe designed to convey discharge containing human excreta from soil appliances, such as water closets, to a suitable drainage system.

Functions of a soil pipe

Carries sewage from water closets.

Conveys discharge from connected soil appliances.

Provides a route for sewage to reach the building drain.

Forms part of the building's sanitary drainage system.

Works with suitable traps and ventilation arrangements to control foul gases and pressure changes.

5.2 Waste pipe

Definition: A waste pipe is a drainage pipe designed to convey used water from appliances such as sinks, wash hand basins, showers and bathtubs.

Functions of a waste pipe

Removes water from washing and bathing activities.

Carries wastewater from kitchen sinks.

Carries wastewater from wash hand basins.

Conveys water from showers and bathtubs.

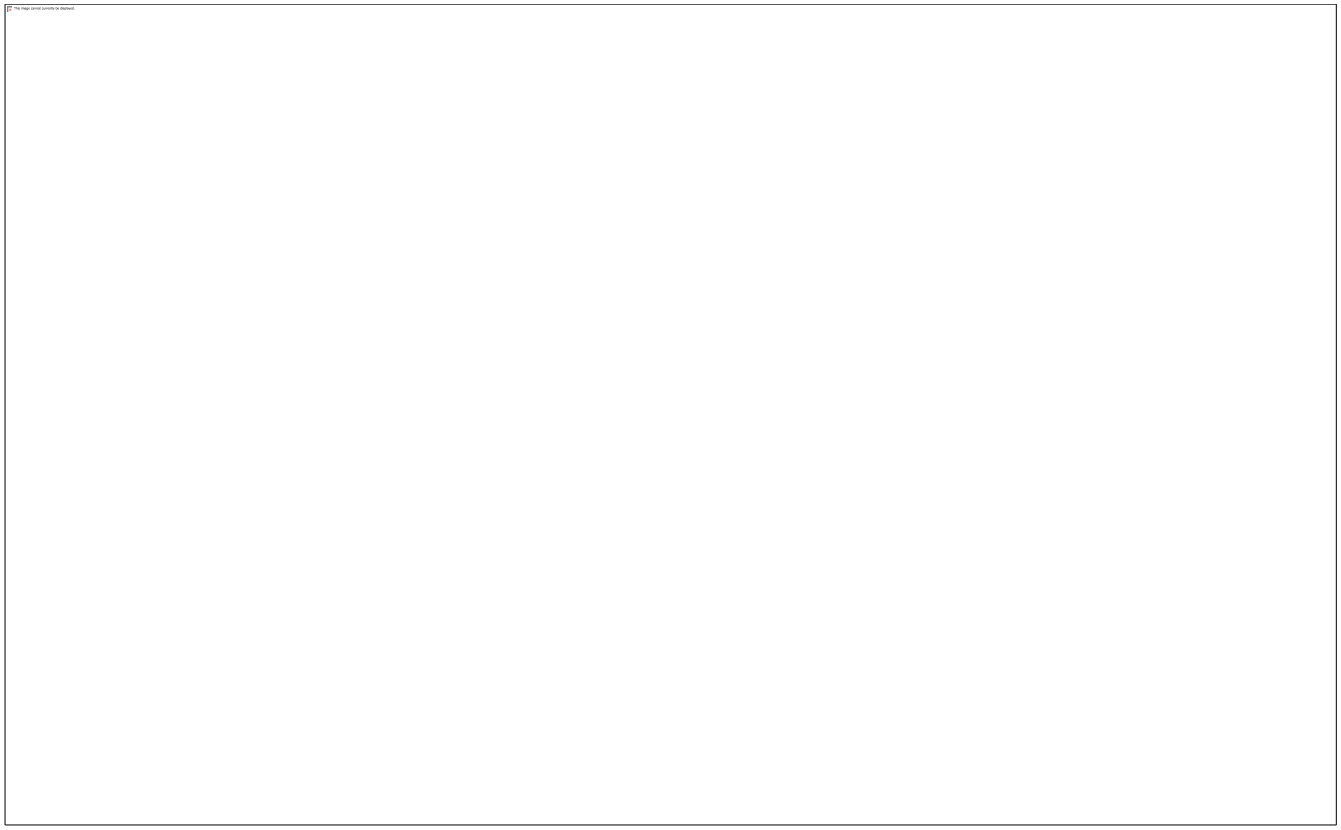
Connects wastewater appliances to the appropriate drainage system.

5.3 Differences between soil pipes and waste pipes

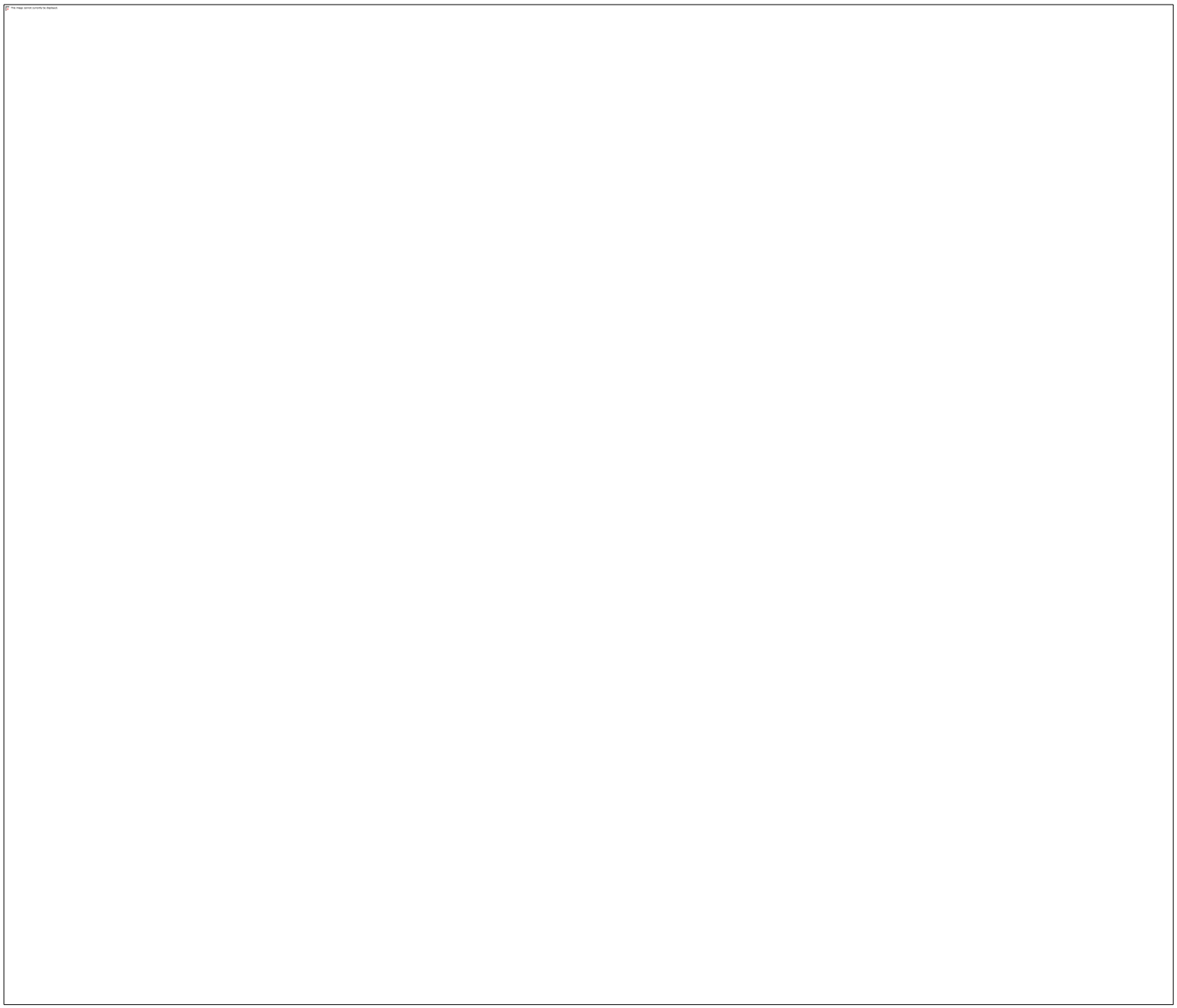
Soil pipe	Waste pipe
Carries discharge containing human excreta.	Carries wastewater from washing, bathing and cleaning.
Commonly receives discharge from WCs and other soil appliances.	Commonly receives discharge from sinks, basins, showers and bathtubs.
Conveys sewage.	Conveys wastewater, often classified as greywater depending on its source.
Requires a suitable connection to the soil drainage system.	Requires a suitable connection to the waste drainage system.
Must be designed to convey soil discharge safely.	Must be designed to convey wastewater without leakage or blockage.
Requires appropriate trap and ventilation arrangements within the drainage design.	Also requires appropriate traps and ventilation arrangements.

Important: Soil and waste systems may be arranged as separate systems or combined in parts of a building drainage layout, depending on the approved design. Never assume that all wastewater can be discharged into an open drain or onto the ground.

6.0 Traps used in sanitary appliance installations







6.1 Meaning of a trap

A **trap** is a plumbing fitting designed to retain a quantity of water, known as a water seal, which prevents foul gases from drainage pipes from entering a building.

Traps are fitted to sanitary appliances such as wash hand basins, kitchen sinks, showers, bathtubs and water closets.

6.2 Importance of traps

Prevent foul smells from entering rooms.

Prevent sewer gases from entering occupied spaces.

Improve hygiene in bathrooms and kitchens.

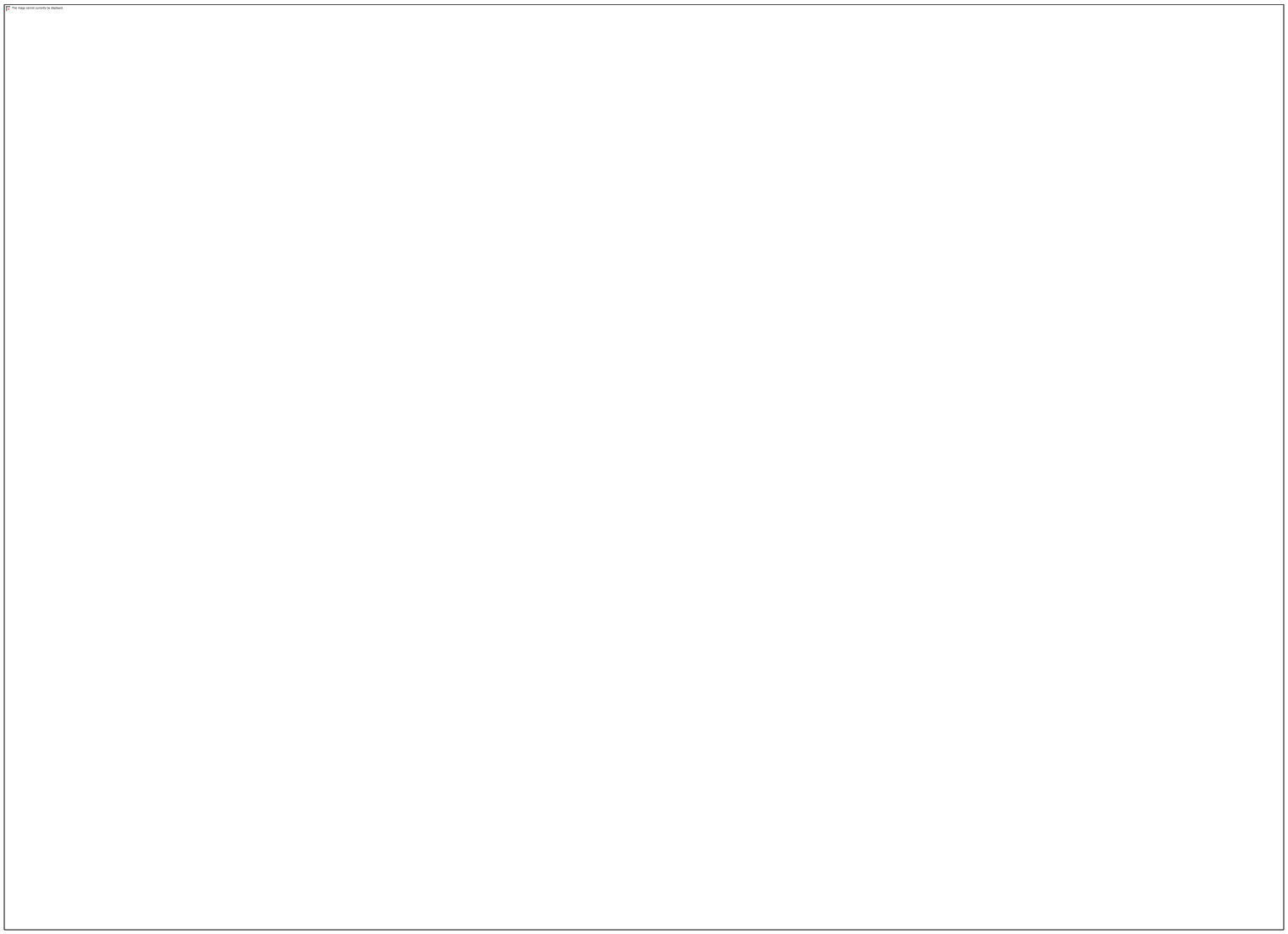
Help maintain a sanitary indoor environment.

Reduce the movement of insects and pests through drainage openings when properly maintained.

Provide a barrier between the building and the drainage system.

6.3 Types of traps

1. P-trap



It has a shape resembling the letter P when viewed from the side.

It is commonly used where the waste pipe passes horizontally through a wall.

It is commonly installed beneath wash hand basins and sinks.

It retains water to prevent foul gases from entering the room.

2. S-trap

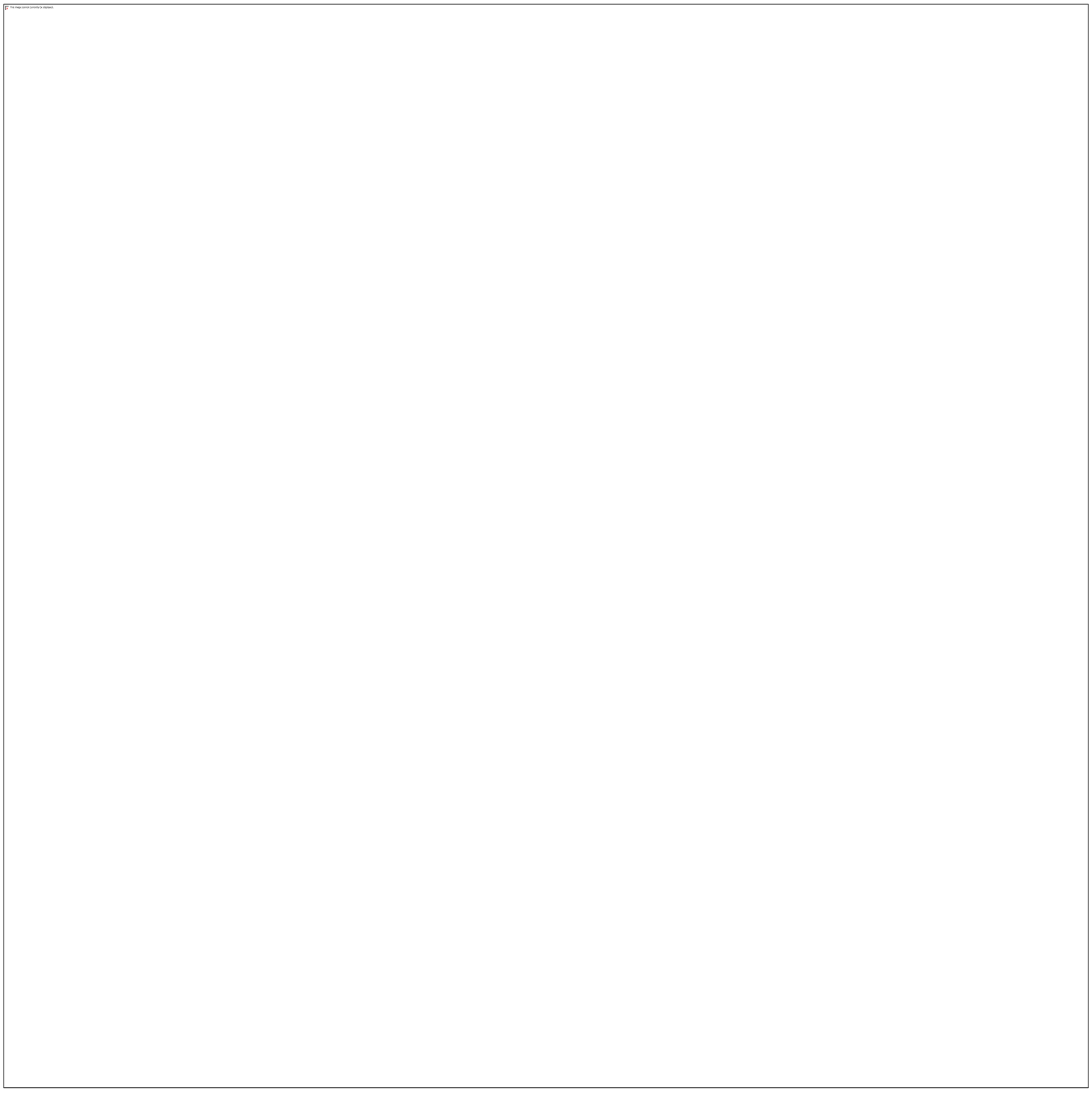
It has a shape resembling the letter S.

It is commonly associated with floor-outlet arrangements.

It is used where the drainage connection passes through the floor.

It provides a water seal when correctly installed and maintained.

3. Bottle trap



It has a compact bottle-shaped chamber.

It is commonly installed beneath wash hand basins.

It has a neat appearance where the plumbing is exposed.

It can be opened for cleaning, depending on the model.

4. Floor trap



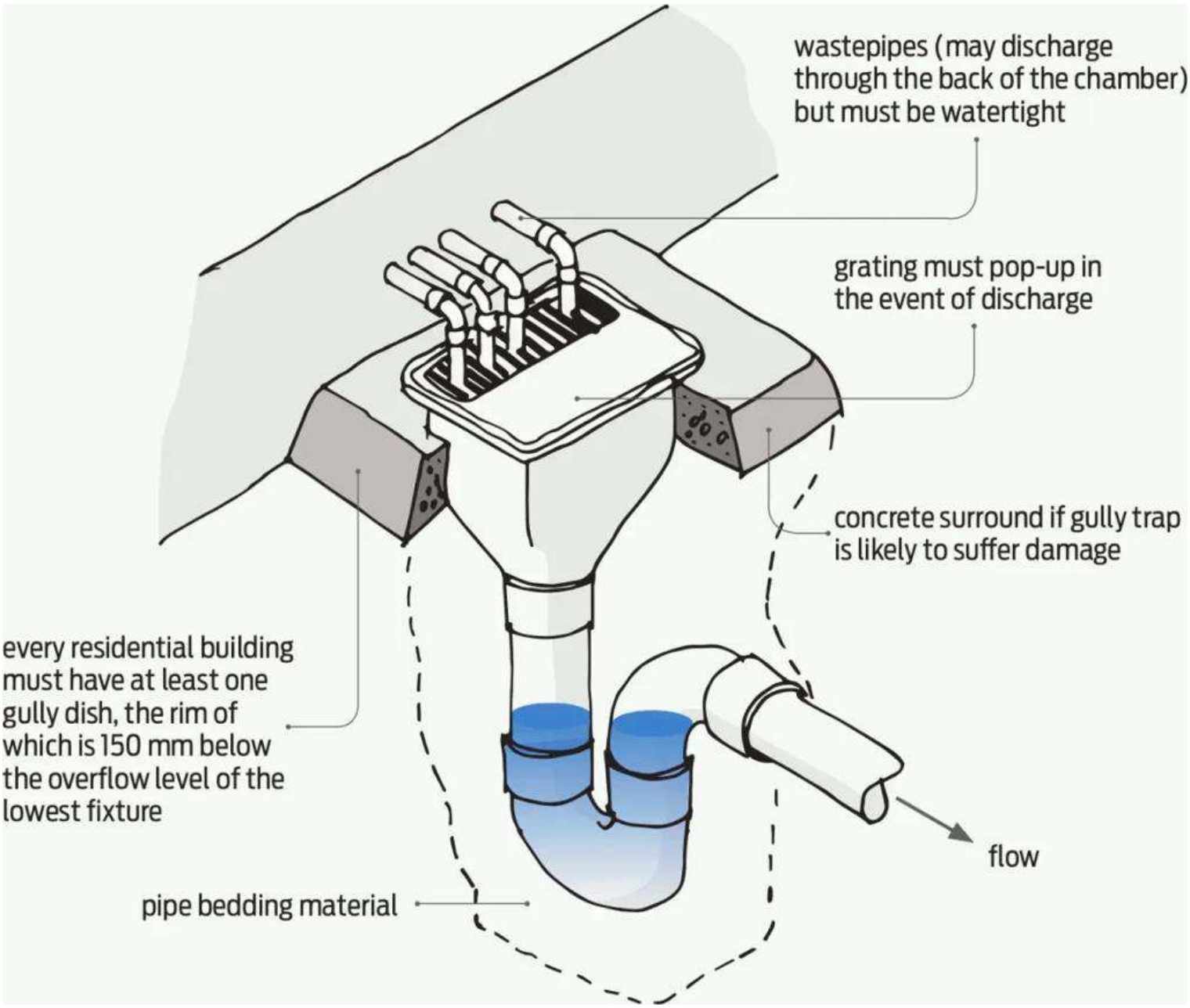
It is installed at floor level in areas such as bathrooms and shower rooms.

It collects water flowing across the floor.

It directs water into the drainage system.

It helps prevent foul gases from entering through the floor drain when fitted with a suitable water seal.

5. Gully trap



It is normally installed outside a building.

It receives wastewater from suitable waste pipes.

It provides a water seal between the building drainage system and the external drainage arrangement.

It allows wastewater to discharge into the drainage system.

6.4 Water seal in a trap

A water seal is the quantity of water retained inside a trap to prevent foul gases from passing into a building.

How it works:

Wastewater flows through the trap.

A portion of water remains in the curved section of the trap.

The retained water forms a barrier.

Foul gases from the drainage pipe are prevented from entering the room through the appliance outlet.

Causes of loss of water seal

Evaporation when an appliance is not used for a long time.

Siphonage due to unsuitable drainage design.

Excessive pressure fluctuations in drainage pipes.

Leakage or damage to the trap.

Poor installation.

Ways of maintaining a water seal

Install the correct trap for the appliance.

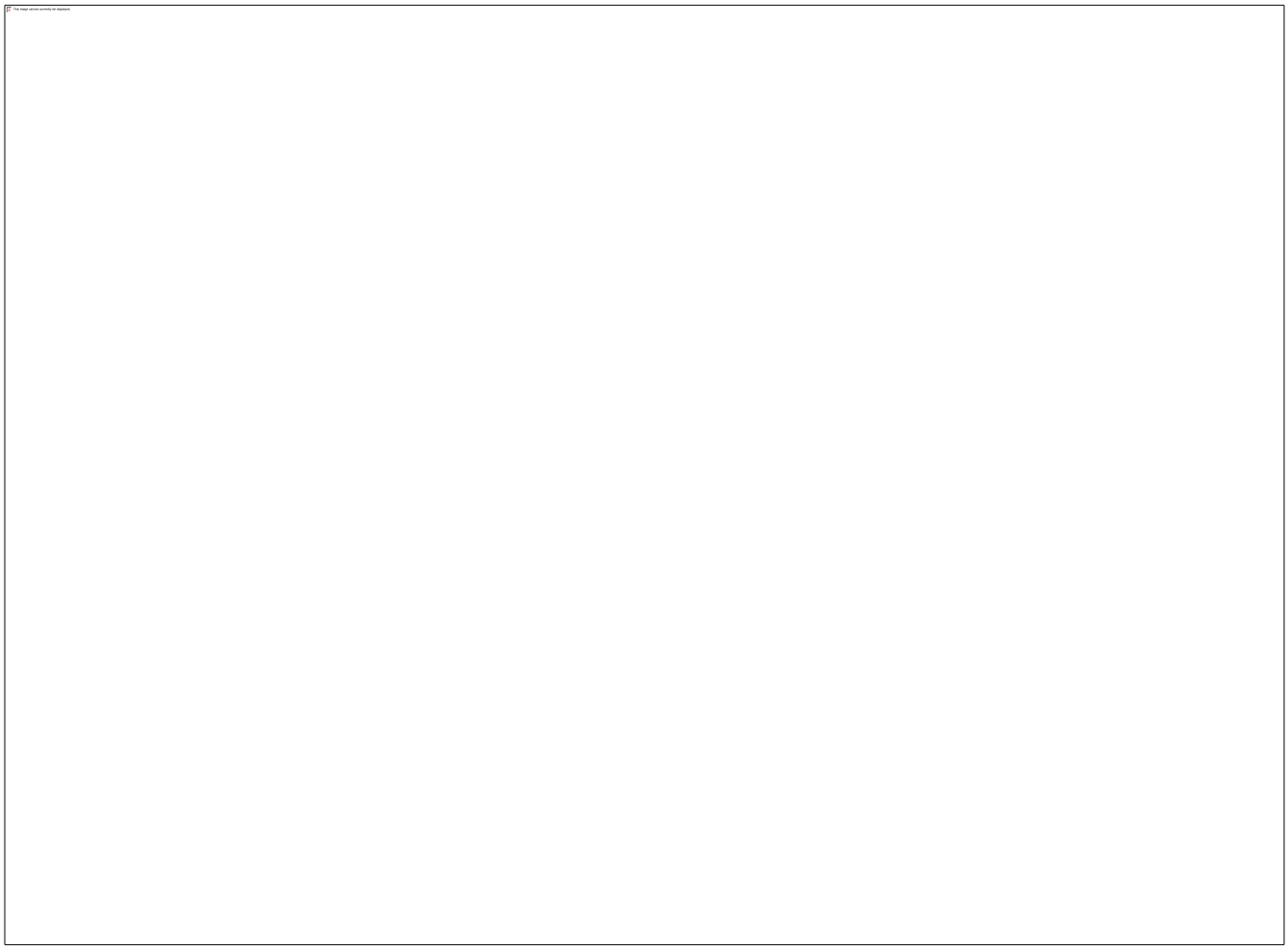
Ensure that drainage pipes are properly designed and ventilated.

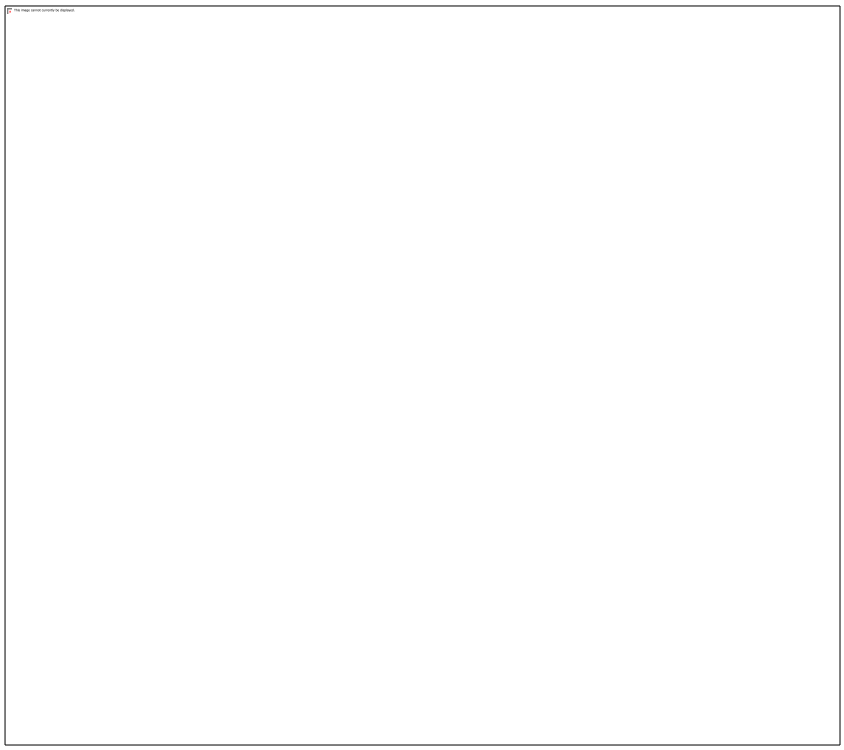
Repair leaking traps.

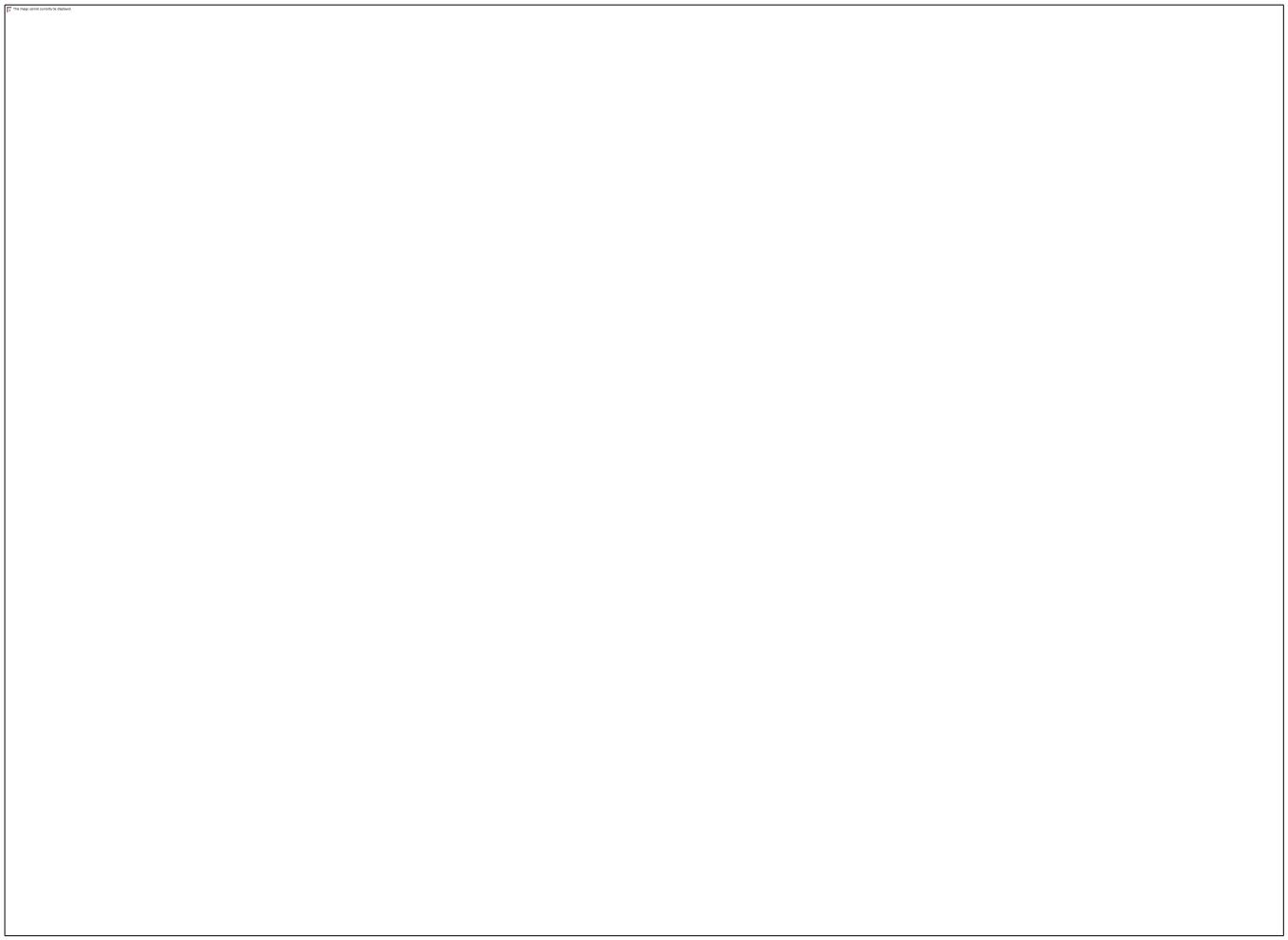
Refill traps that have dried out.

Clean traps regularly without damaging their fittings.

7.0 Components and fittings used when installing sanitary appliances







7.1 Water supply pipes

These convey water from the building's water distribution system to sanitary appliances.

Examples of materials include:

Copper.

Polypropylene.

Cross-linked polyethylene (PEX).

Suitable plastic water pipes.

Galvanised steel in some existing installations.

7.2 Waste pipes

Carry wastewater from appliances to the drainage system.

They are normally installed with suitable gradients to allow gravity flow.

They must be properly supported to prevent sagging.

Common materials include suitable uPVC and other approved drainage materials.

7.3 Soil pipes

Carry sewage containing human excreta.

They connect soil appliances to the soil drainage system.

They must be properly supported and connected.

They may be installed internally or externally depending on the building design.

7.4 Taps



Taps are fittings used to control the flow of water from a supply pipe.

Common types include:

Pillar taps.

Mixer taps.

Bib taps.

Wall-mounted taps.

Sensor-operated taps.

Shower mixer controls.

7.5 Valves

Valves regulate, control or stop the flow of water.

Examples include:

Isolation valves.

Stop valves.

Float valves.

Non-return valves.

Pressure-reducing valves.

Flush valves.

7.6 Pipe fittings

Pipe fittings connect pipes, change their direction, divide flow or change pipe diameter.

Examples include:

Elbows: Change the direction of a pipe.

Tees: Provide a branch connection.

Couplings: Join two pipe sections.

Reducers: Connect pipes of different diameters.

Unions: Allow pipe sections to be disconnected for maintenance.

Adaptors: Connect different types of pipe or fittings.

Bends: Change the direction of a pipe smoothly.

7.7 Fixing and supporting materials

These include:

Bolts and nuts.

Screws.

Wall plugs.

Brackets.

Pipe clips.

Supporting frames.

Sealing washers.

Suitable sanitary silicone sealant.

They secure appliances and pipework in their correct positions.

8.0 Installation of sanitary appliances

8.1 Meaning of installation of sanitary appliances

Installation of sanitary appliances is the process of positioning, fixing and connecting plumbing fixtures to the water supply and drainage systems of a building so that they operate safely and effectively.

Proper installation ensures that appliances are stable, watertight, hygienic, accessible and easy to maintain.

8.2 Factors to consider before installing sanitary appliances

1. **Purpose of the appliance**

Select an appliance suitable for its intended use.

For example, a kitchen sink should be suitable for washing utensils and food items.

2. **Location**

Install appliances in appropriate rooms.

Toilets should be positioned to provide privacy and convenient access.

3. **Availability of water supply**

Confirm that adequate water supply is available.

Consider water pressure and whether hot water is required.

4. **Drainage arrangement**

Ensure that suitable waste or soil drainage connections are available.

Check the position of drainage outlets before fixing the appliance.

5. **Available space**

Provide enough space for users to operate the appliance comfortably.

Allow room for cleaning and maintenance.

6. **Floor and wall strength**

Ensure that walls and floors can support the appliance and its contents.

Provide suitable additional supports where necessary.

7. **Cost**

Consider purchase, transport, installation and maintenance costs.

Select appliances that meet the project budget without compromising safety and quality.

8. **Durability**

Select materials that can withstand regular use.

Consider resistance to corrosion, cracking, scratching and chemical damage.

9. **Ease of cleaning**

Choose appliances with smooth surfaces and accessible areas.

Avoid designs that create difficult-to-clean spaces.

10. **Accessibility**

Consider the needs of children, older persons and persons with disabilities.

Provide suitable clearances, supports and accessible fittings.

11. **Appearance**

Select appliances that complement the design of the building.

Consider colour, shape and finish.

12. **Maintenance requirements**

Choose appliances whose parts can be inspected, cleaned and replaced.

Ensure that valves and service connections are accessible.

13. **Water conservation**

Consider water-efficient WCs, taps and shower fittings.

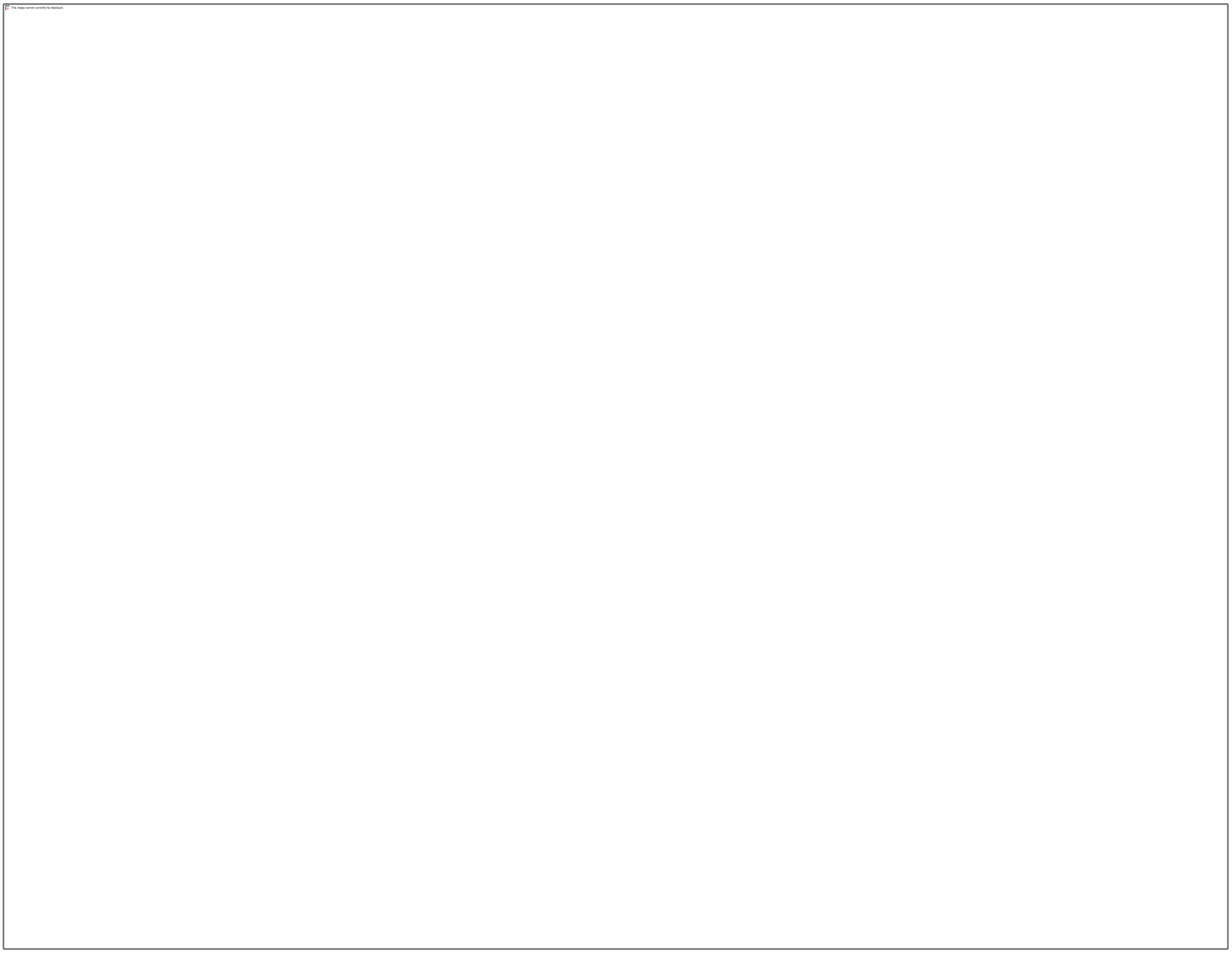
Avoid appliances that waste water unnecessarily.

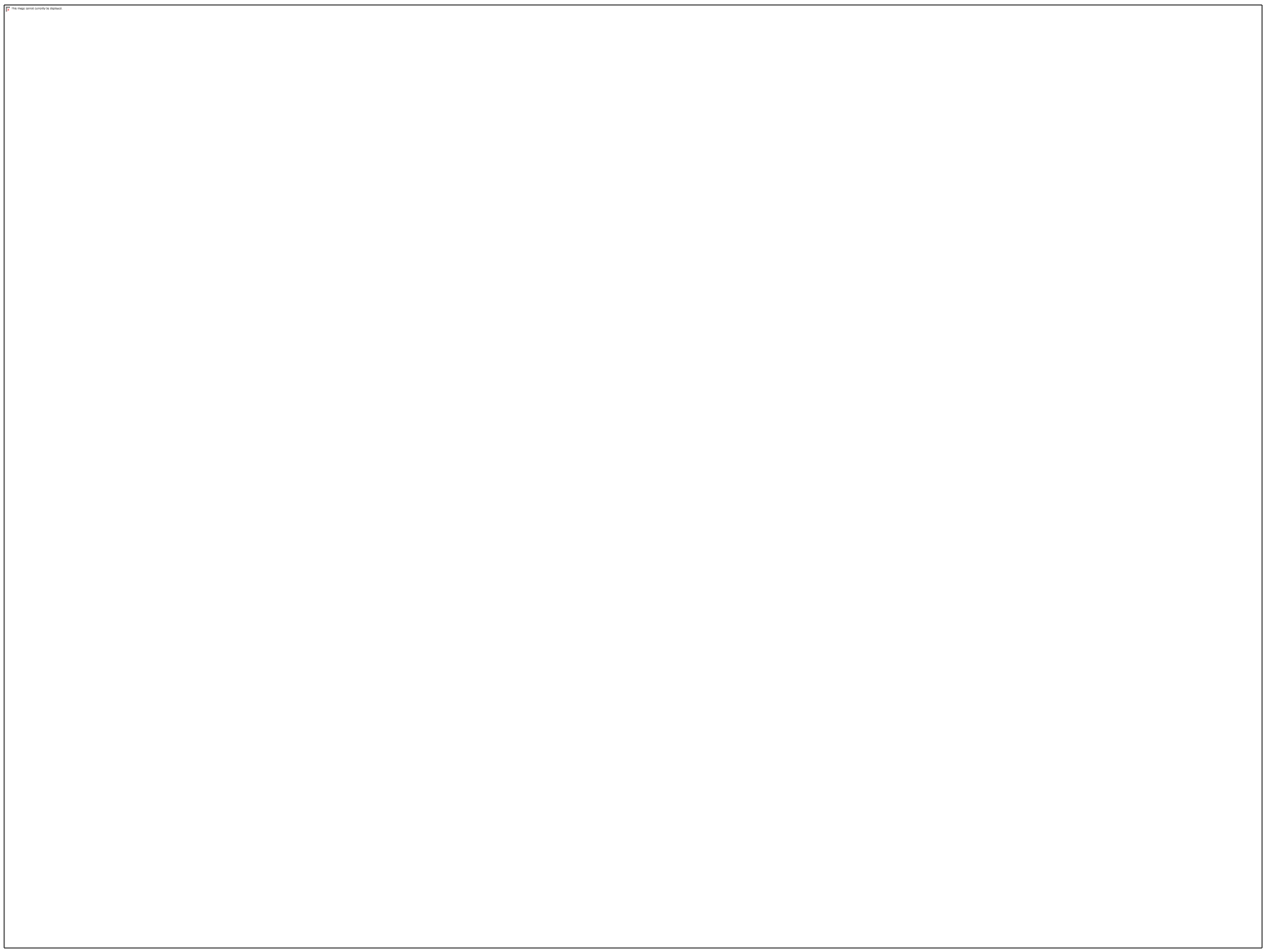
14. **Applicable regulations and standards**

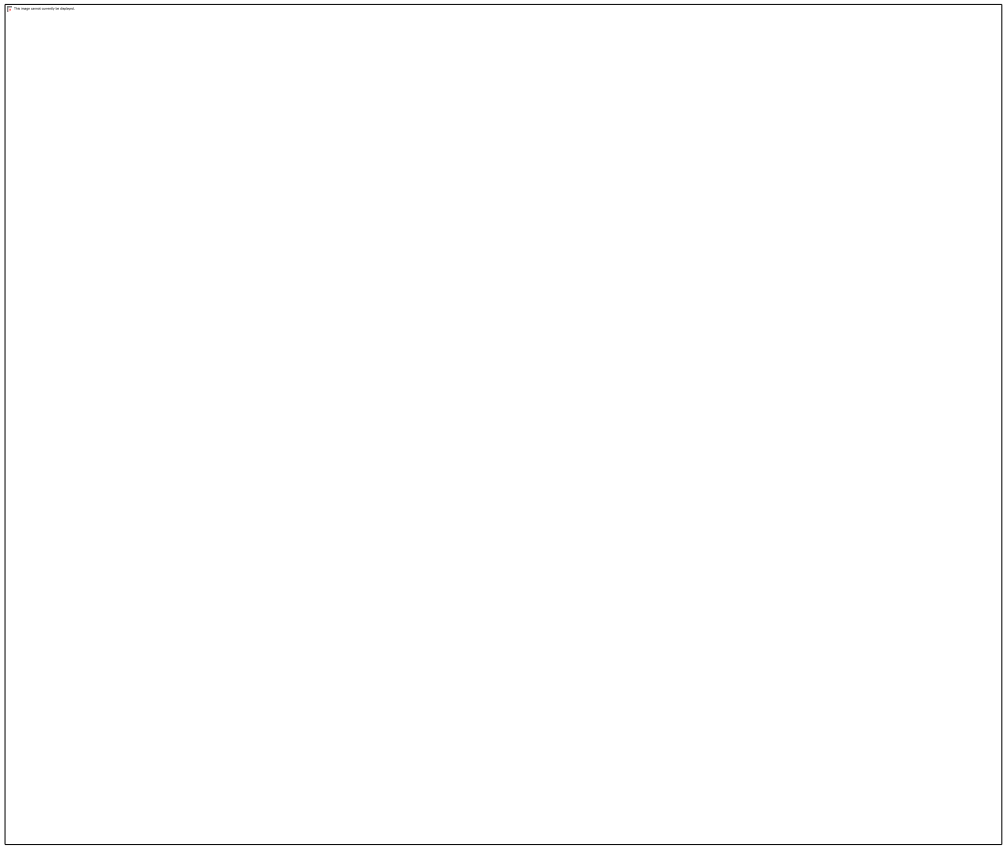
Ensure that the installation follows relevant Kenyan building, plumbing, public health and safety requirements.

Use suitable approved materials and competent installers.

8.3 Tools and equipment used in installing sanitary appliances

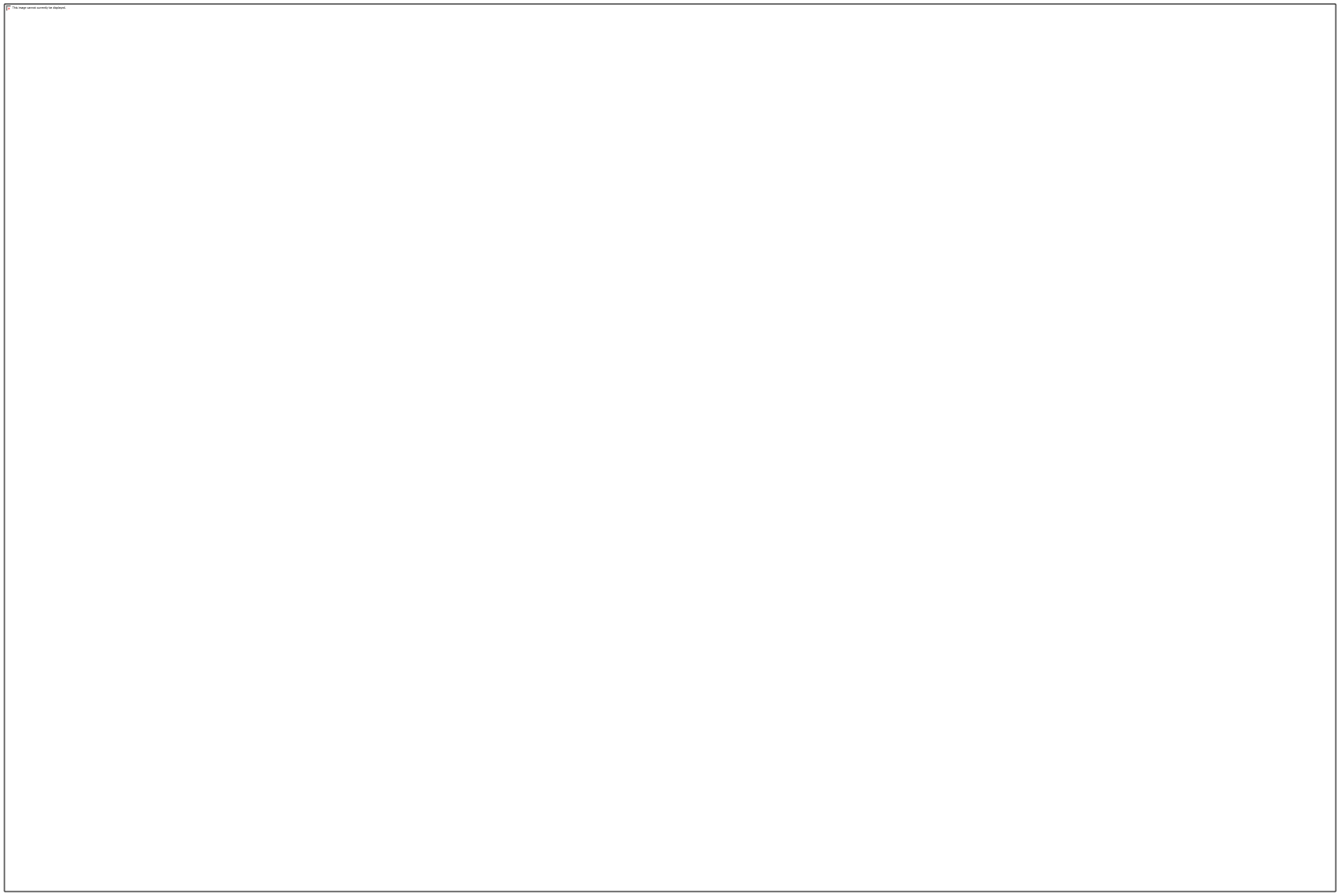






Tool/equipment	Use
Adjustable spanner	Tightening and loosening nuts and fittings.
Pipe wrench	Holding and turning suitable pipes and fittings.
Screwdriver	Tightening and loosening screws.
Pliers	Holding and gripping small components.
Spirit level	Checking that appliances are level.
Tape measure	Taking dimensions and setting out positions.
Drill	Making holes for fixing brackets and supports.
Hacksaw or suitable pipe cutter	Cutting pipes to the required length.
Hammer	Driving suitable fixings and performing light fitting work.
Sealant gun	Applying sanitary sealant.
Bucket	Collecting water during testing or repair.
Plunger	Clearing suitable minor drainage blockages.
PPE	Protecting workers during installation.

8.4 Personal protective equipment used during installation



Safety boots – protect feet from falling objects and sharp materials.

Gloves – protect hands from sharp edges, dirt and chemicals.

Safety goggles – protect eyes from dust and splashes.

Overalls – protect clothing and the body.

Dust mask or suitable respirator – protects against harmful dust where necessary.

Knee pads – protect knees when working at floor level.

Hard hat – protects the head where there is a risk of falling objects.

8.5 General procedure for installing sanitary appliances

The exact procedure varies according to the type and manufacturer's instructions. However, the following general steps apply to many installations.

Step 1: Study the building plumbing drawings

Examine the building plans.

Identify the position of the water supply pipes.

Identify the waste or soil pipe connections.

Confirm the location and dimensions of the appliance.

Step 2: Gather tools and materials

Collect the required appliance.

Assemble pipes, fittings, valves and fixing materials.

Check that all components are suitable and undamaged.

Step 3: Prepare the installation area

Clean the working area.

Remove obstructions.

Check the condition of the wall and floor.

Confirm that the installation area is suitable.

Step 4: Mark the appliance position

Measure the required position.

Mark fixing points.

Check the alignment and available clearance.

Use a spirit level where necessary.

Step 5: Prepare water supply connections

Identify the correct water supply point.

Install suitable pipework and valves.

Provide accessible isolation valves where required.

Ensure that pipe connections are secure.

Step 6: Prepare drainage connections

Identify the correct waste or soil outlet.

Install the suitable trap and waste connection.

Ensure that pipes are correctly aligned.

Provide the necessary gradient in gravity drainage pipes.

Step 7: Position and fix the appliance

Place the appliance in the marked position.

Secure it using suitable brackets, bolts or other approved fixing systems.

Ensure that it is level and stable.

Avoid overtightening fixings that may crack ceramic appliances.

Step 8: Connect the water supply

Connect the supply pipe to the tap, cistern or appliance inlet.

Fit suitable washers and seals.

Tighten connections appropriately.

Open the supply gradually and check for leaks.

Step 9: Connect the waste or soil outlet

Connect the appliance outlet to its suitable trap and drainage pipe.

Ensure that the connection is watertight.

Check that the pipework is properly supported.

Avoid unnecessary bends and poorly aligned connections.

Step 10: Seal and finish the installation

Apply suitable sanitary sealant where required.

Fit covers, seats, handles and other accessories.

Clean the appliance and the surrounding area.

Step 11: Test the installation

Run water through the appliance.

Check for leakage at all joints.

Test the flushing mechanism where applicable.

Confirm that wastewater drains away correctly.

Check that the appliance is firmly fixed and operates properly.

Step 12: Clean and hand over

Remove waste materials.

Clean the installation area.

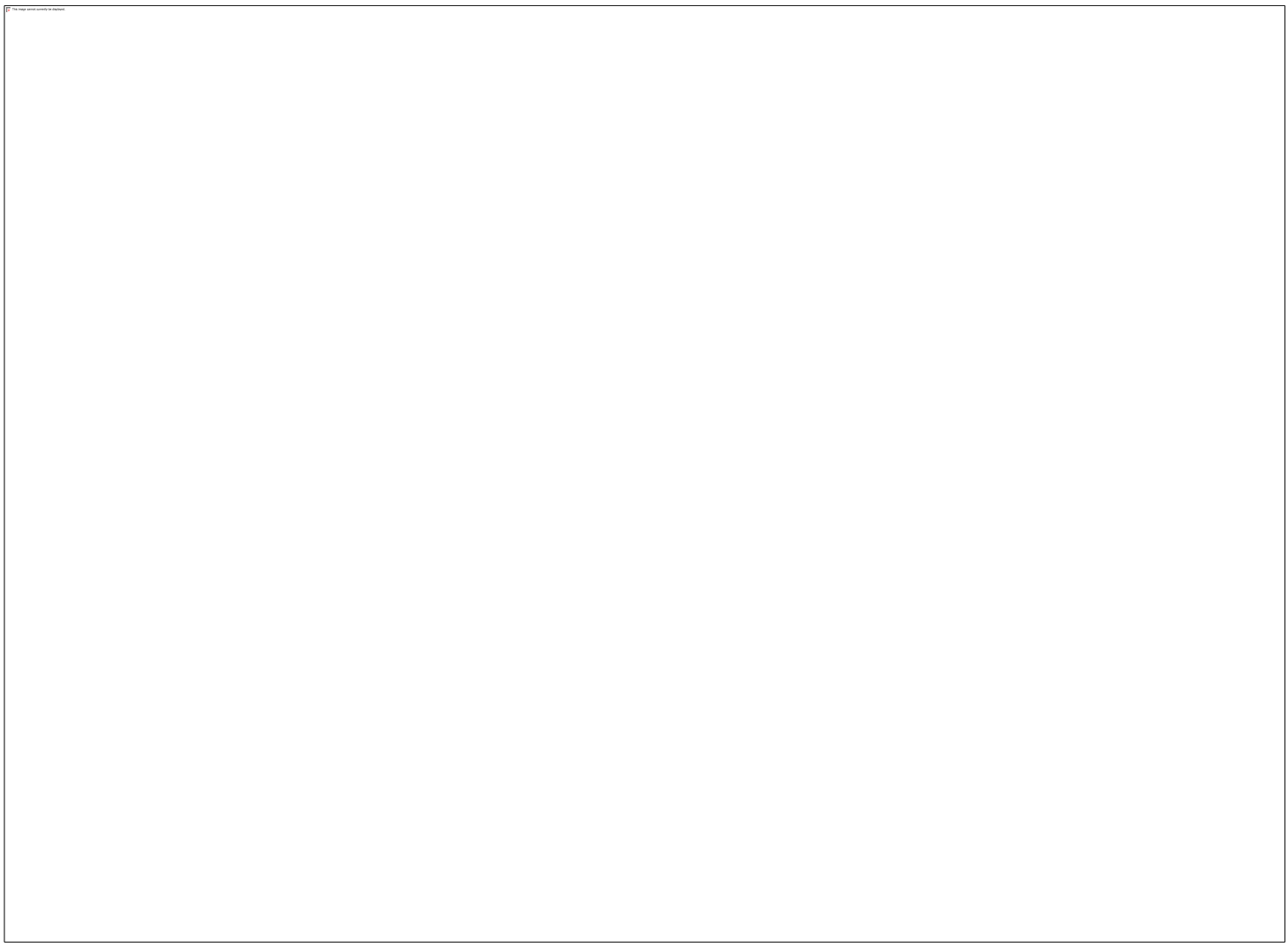
Report defects.

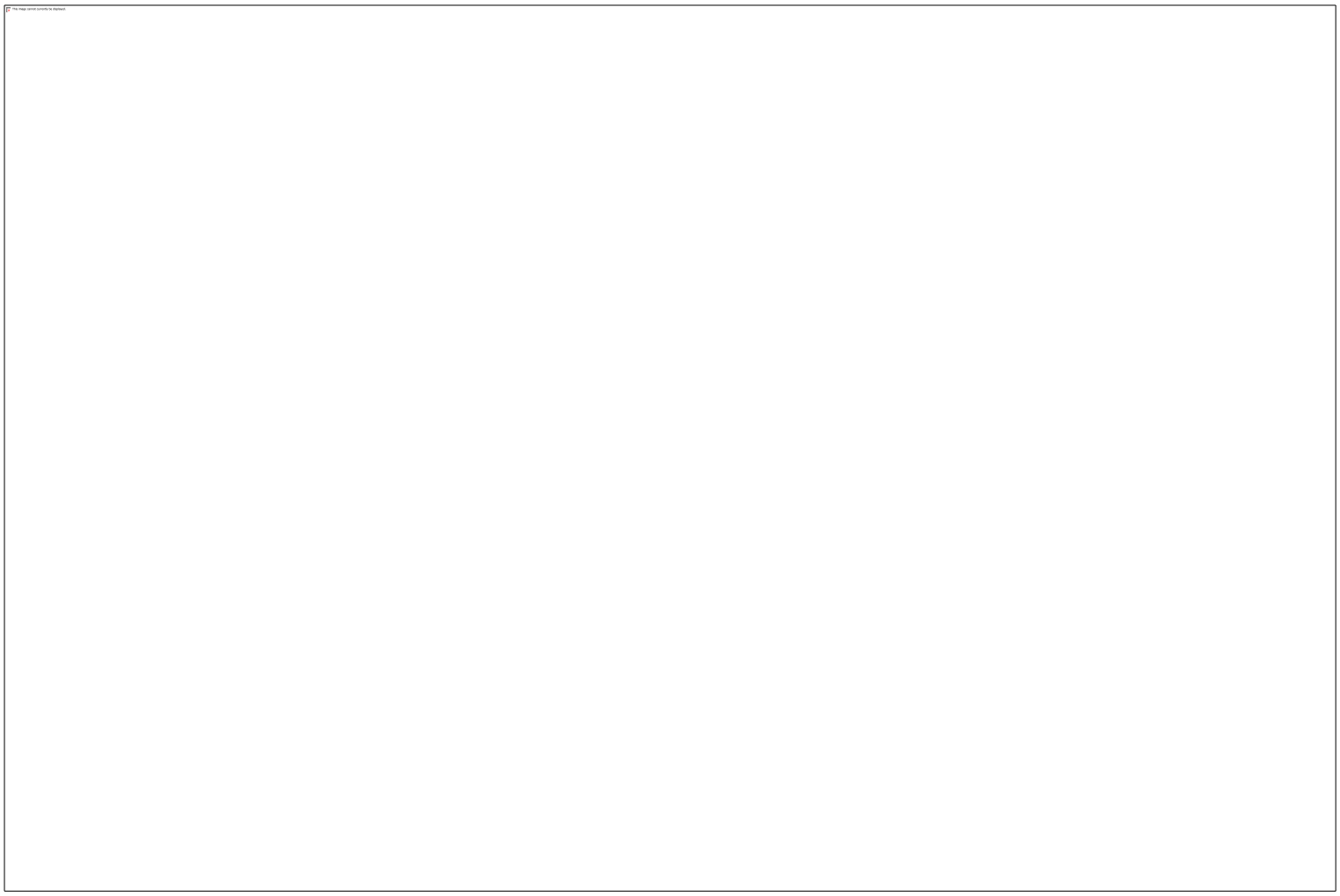
Explain basic operation and maintenance to the user.

9.0 Installation procedures for specific sanitary appliances

9.1 Installation of a wash hand basin







Procedure

Identify the correct basin position.

Check the height and available space against the design requirements.

Mark the fixing points on the wall or supporting structure.

Install suitable brackets or supports.

Fix the basin securely.

Fit the tap or mixer.

Connect the hot and cold water supply pipes where provided.

Fit the waste outlet and trap.

Connect the waste pipe to the drainage system.

Apply suitable sealant where necessary.

Open the water supply and test the tap.

Fill the basin and release the water to check drainage.

Inspect all joints for leakage.

Clean the basin and surrounding area.

Precautions

Do not overtighten bolts on ceramic basins.

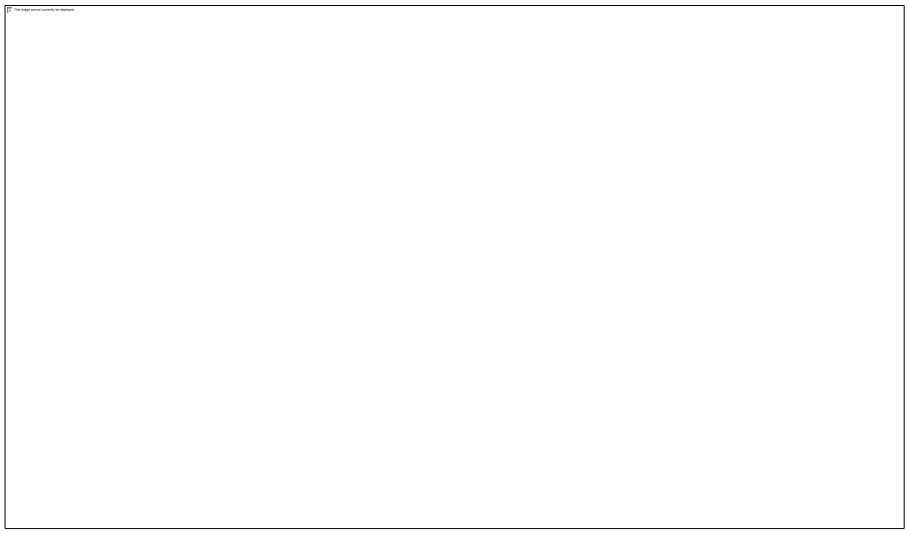
Ensure that the basin is level.

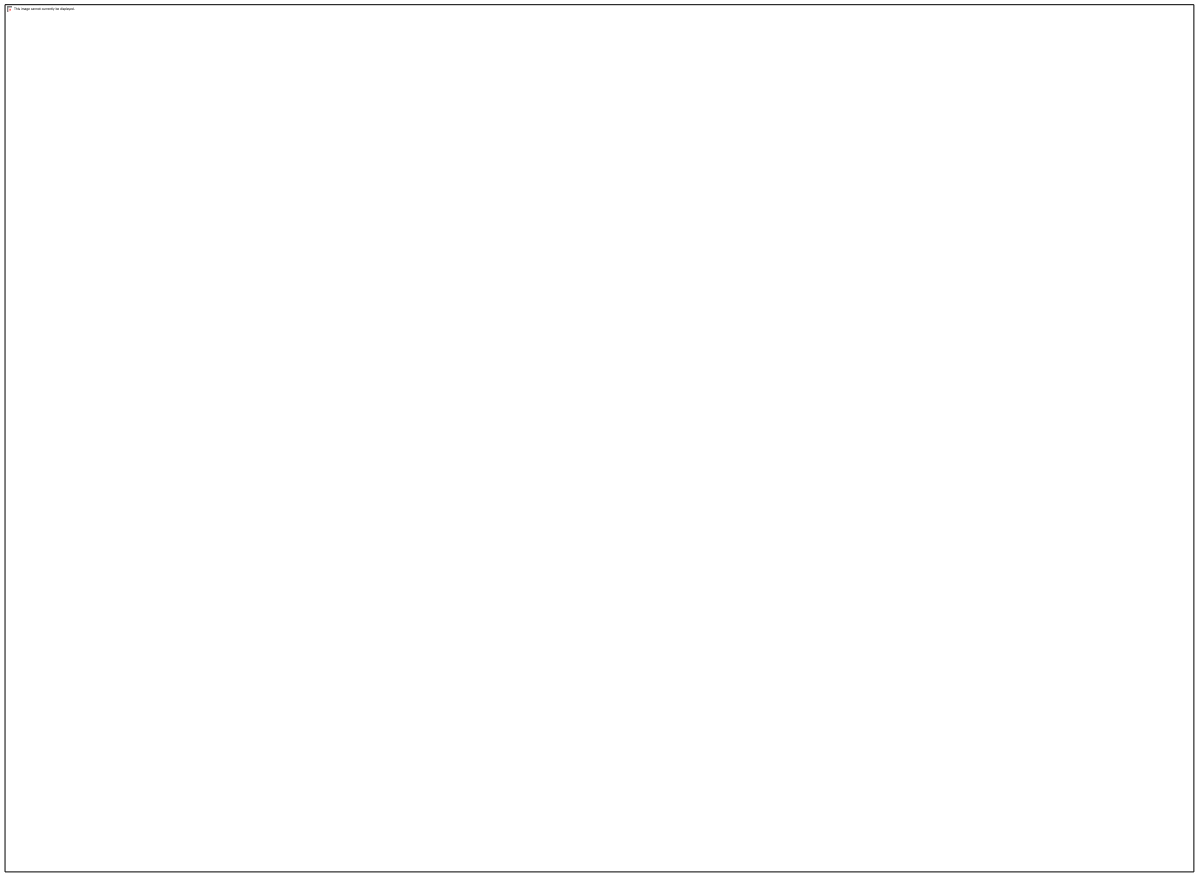
Use suitable wall supports.

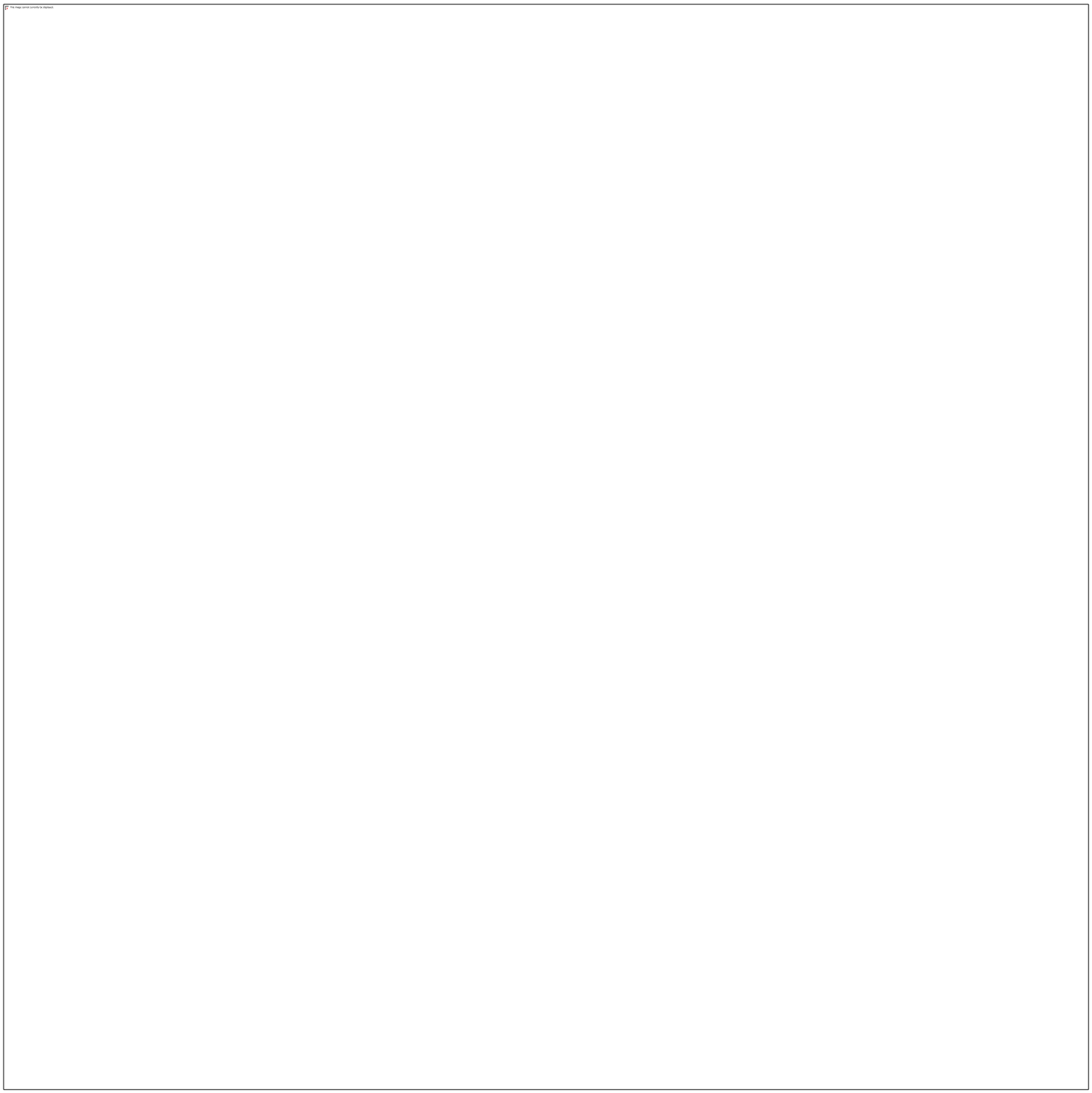
Ensure that the trap is accessible for maintenance.

Prevent water from entering gaps between the basin and wall.

9.2 Installation of a kitchen sink







Procedure

Measure the counter opening.

Confirm that the sink fits the opening.

Prepare the countertop according to the sink manufacturer's instructions.

Fit the tap and waste outlet to the sink.

Place the sink in position.

Secure it using the correct mounting clips or supports.

Apply suitable waterproof sealant around the rim where required.

Connect the water supply pipes.

Fit the trap below the sink.

Connect the waste pipe to the drainage system.

Open the water supply and test the tap.

Fill the sink and release the water.

Check for leakage and proper drainage.

Precautions

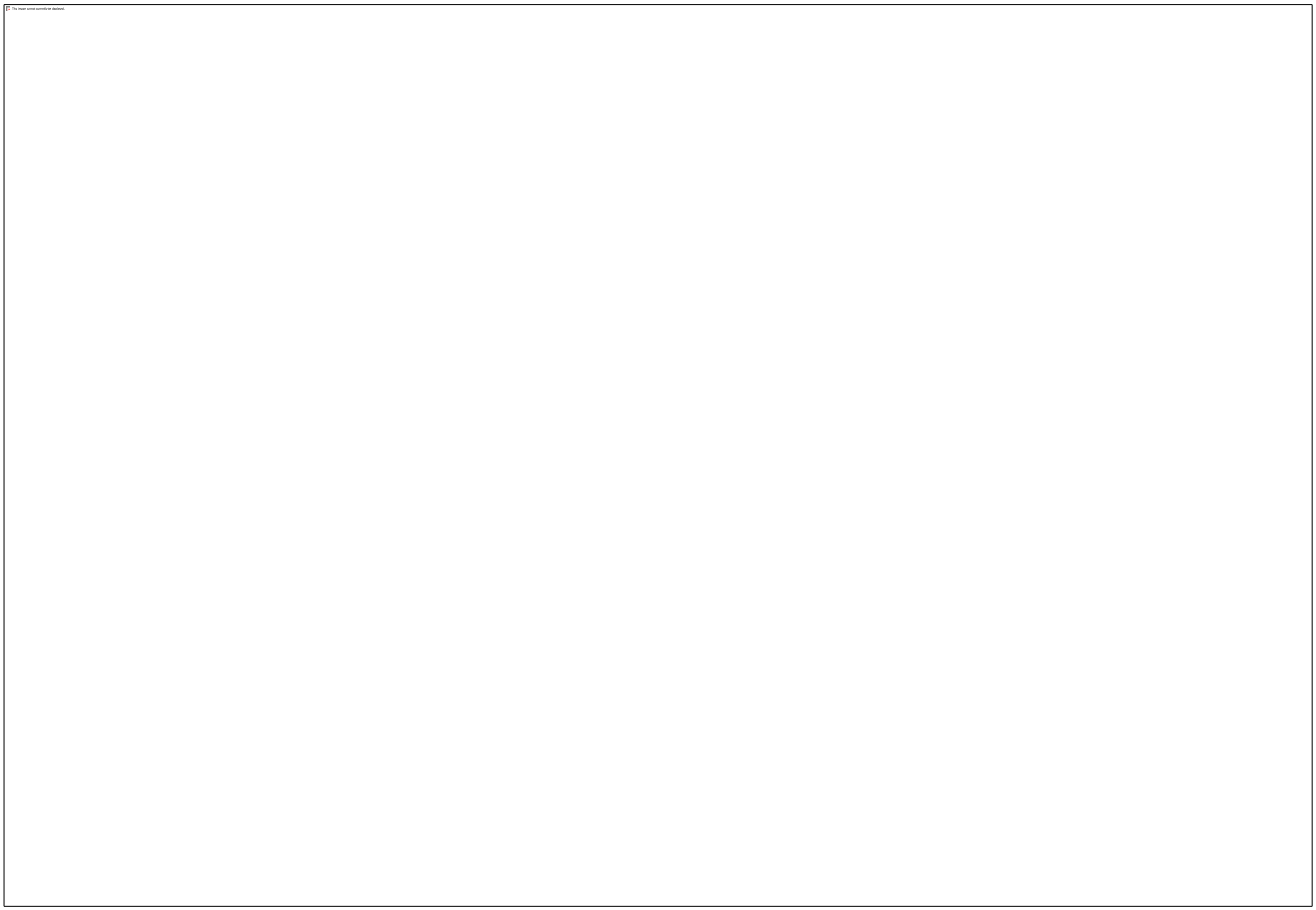
Provide adequate support for the sink.

Ensure that the countertop is suitable for the sink material.

Prevent food particles from entering the drainage system.

Ensure that the waste trap remains accessible.

9.3 Installation of a bathtub



Procedure

Inspect the bathroom floor and supporting structure.

Confirm the bathtub dimensions and position.

Prepare the floor and supporting frame.

Install the tap or mixer fittings.

Fit the waste outlet and overflow assembly.

Position the bathtub carefully.

Level the bathtub using its designed supports.

Connect the water supply pipes.

Connect the waste pipe and trap.

Secure the bathtub according to the manufacturer's instructions.

Seal the joints between the bathtub and surrounding surfaces.

Fill the bathtub and test the waste outlet and overflow.

Check for leaks.

Clean and finish the installation.

Precautions

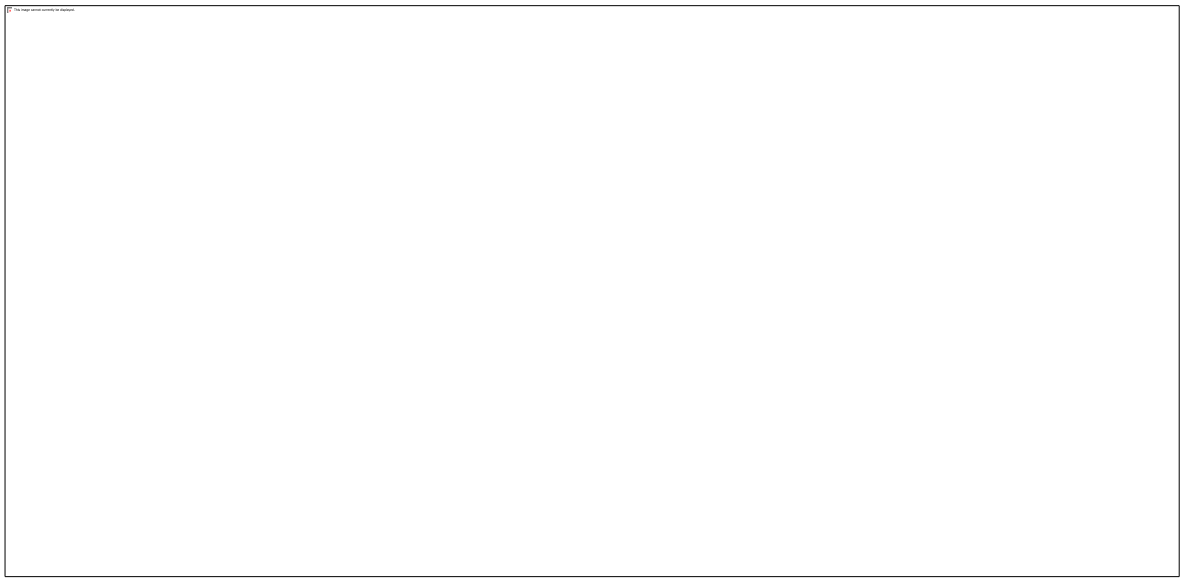
Ensure that the floor can support the filled bathtub and user.

Protect the bathtub surface during installation.

Ensure that the waste connection is accessible.

Do not rely on sealant alone to support the bathtub.

9.4 Installation of a shower



Procedure

Identify the shower location.

Prepare the water supply pipework.

Install the shower mixer or control valve.

Fit the shower arm and showerhead.

Install the shower tray or prepare the shower floor.

Provide suitable waterproofing to the shower area.

Install the waste outlet and trap.

Connect the waste pipe.

Fit the shower screen or curtain arrangement.

Test the water flow and temperature control.

Check the drainage system for leaks and blockage.

Clean the shower area.

Precautions

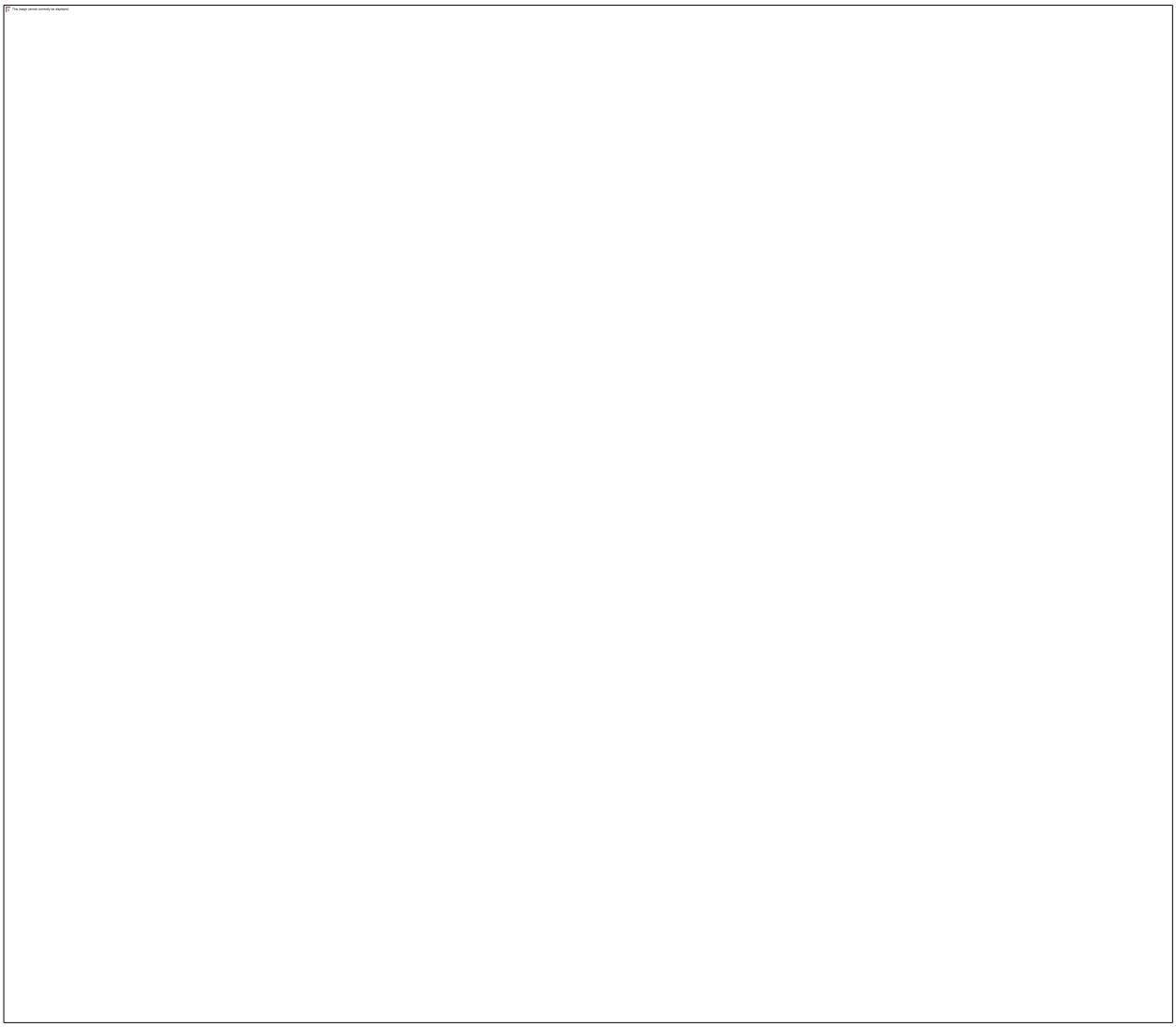
Waterproof the floor and walls appropriately.

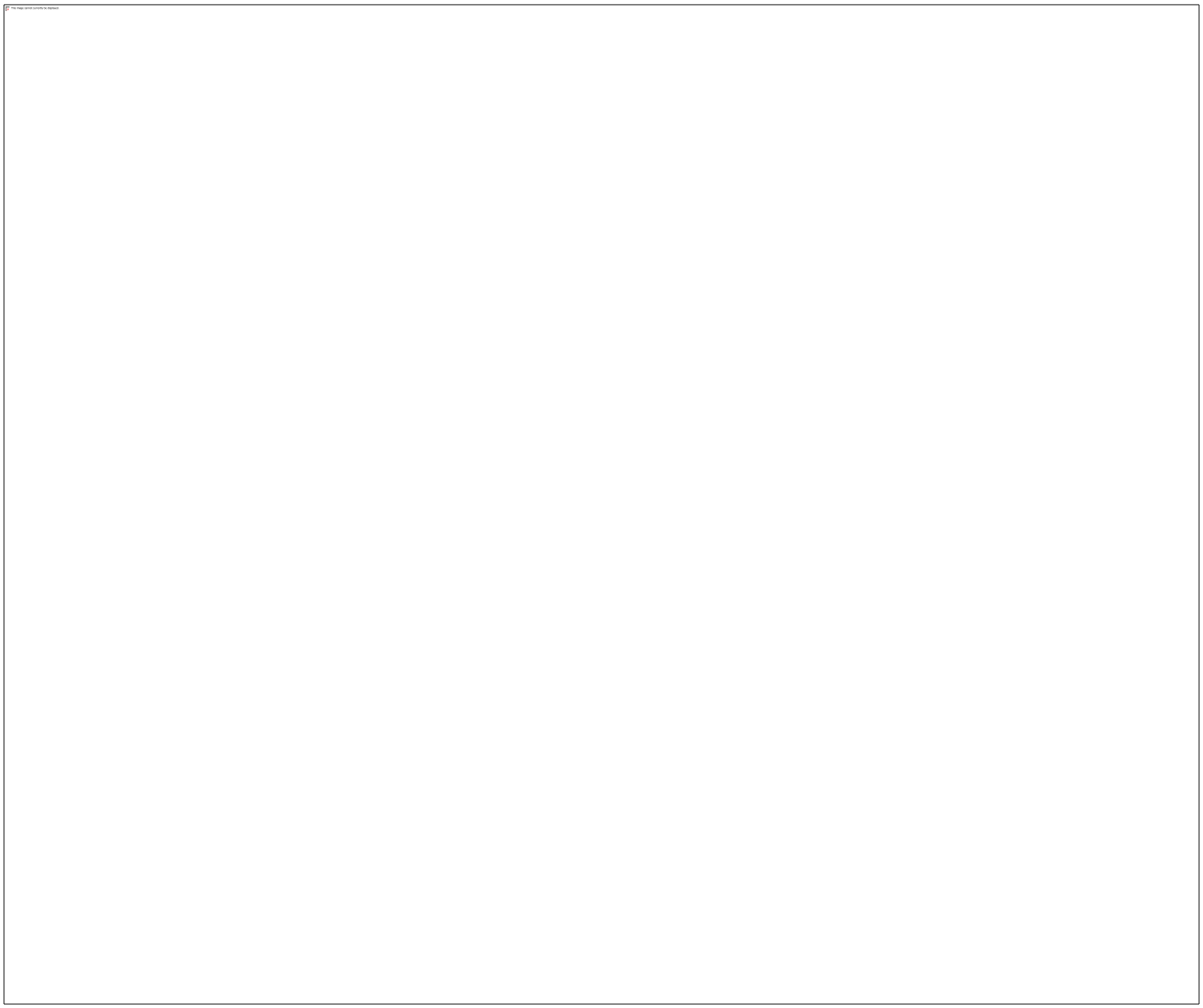
Provide a suitable floor gradient towards the drain.

Use safe electrical installation practices for electric showers.

Ensure that the shower floor is not slippery.

9.5 Installation of a water closet







Procedure

Check the position of the soil pipe outlet.

Confirm whether the WC requires an S-trap or P-trap connection.

Prepare the floor and drainage connection.

Position the WC pan over the outlet.

Fit the appropriate connector or sealing arrangement.

Secure the pan using suitable fixings.

Install the cistern if it is supplied separately.

Connect the water supply to the cistern.

Fit the flush mechanism and toilet seat.

Open the water supply.

Allow the cistern to fill.

Flush the toilet and check its operation.

Inspect the base and pipe connections for leaks.

Clean the installation area.

Precautions

Ensure that the WC is firmly fixed.

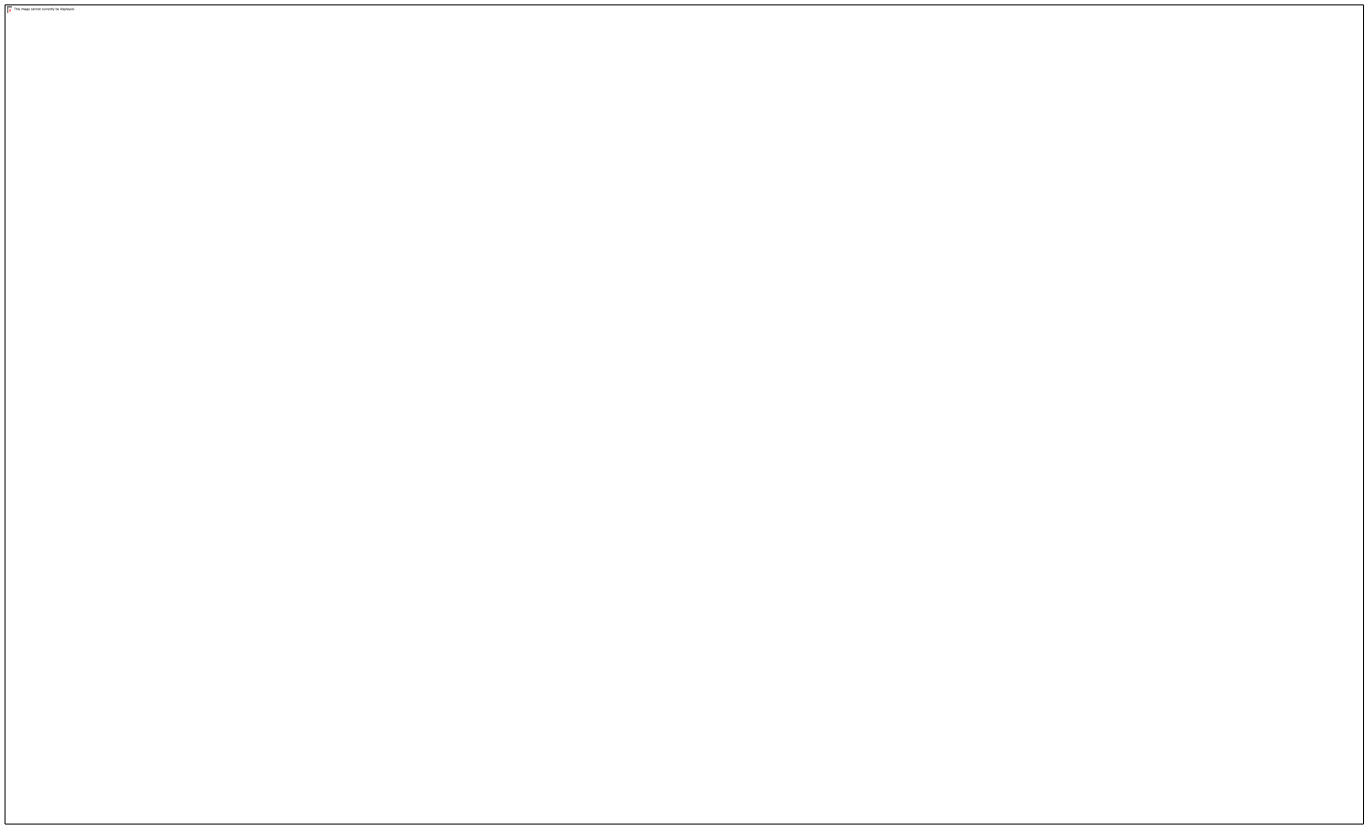
Use the correct connector for the outlet arrangement.

Avoid overtightening fixing bolts.

Ensure that the cistern fills and stops correctly.

Do not allow sewage to leak from the soil connection.

9.6 Installation of a urinal



Procedure

Identify the position of the urinal.

Mark the fixing points.

Confirm the position of the water supply and soil drainage connection.

Install suitable supporting brackets.

Fix the urinal firmly to the wall.

Fit the flush inlet or flushing system.

Install the waste outlet and trap.

Connect the drainage pipe.

Open the water supply where applicable.

Test the flushing system.

Check the waste connection for leakage.

Clean the appliance.

Precautions

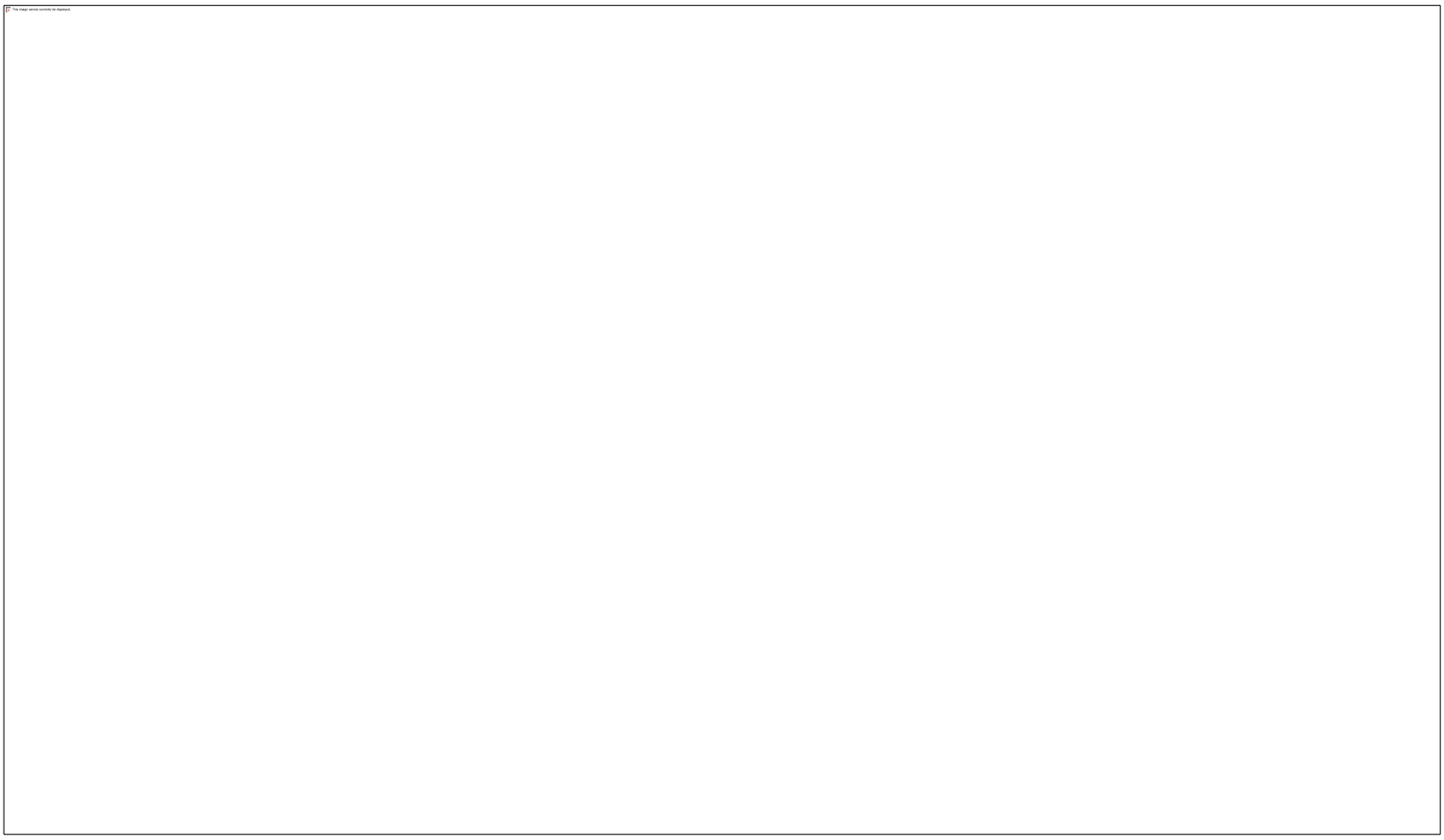
Ensure that the wall is strong enough to support the appliance.

Check that the flushing water covers the required bowl surface.

Ensure that the waste outlet is not blocked.

Maintain the trap water seal where a water-seal trap is used.

9.7 Installation of a bidet



Procedure

Select a suitable position near the water closet.

Confirm the water supply and drainage connections.

Mark the fixing points.

Install the tap or mixer.

Fit the waste outlet and trap.

Position and secure the bidet.

Connect the water supply pipes.

Connect the waste pipe to the designed drainage system.

Test the water controls.

Test the drainage system.

Inspect for leaks.

Clean the appliance and surrounding area.

Precautions

Provide suitable privacy and space.

Ensure that water connections are secure.

Provide appropriate backflow protection.

Use a suitable drainage connection according to the approved plumbing design.

9.8 Installation of a washing machine



Procedure

Select a suitable location with adequate space.

Ensure that the floor is firm and level.

Provide a suitable water supply point.

Install an accessible isolation tap.

Connect the inlet hose.

Connect the drain hose to an approved drainage arrangement.

Secure the hoses to prevent accidental disconnection.

Connect the machine to a suitable electrical outlet.

Level the machine using its adjustable feet.

Run a test cycle.

Inspect water supply and drainage connections for leaks.

Ensure that the machine operates without excessive vibration.

Precautions

Do not use damaged hoses.

Avoid kinking the inlet or drain hose.

Keep electrical connections away from water.

Do not discharge wastewater onto the floor.

Follow the manufacturer's installation instructions.

10.0 Common defects in sanitary appliances and their remedies

Defect	Possible cause	Remedy
Leaking tap	Worn washer or damaged cartridge	Replace the washer or cartridge.
Blocked wash basin	Accumulation of hair, soap or dirt	Clean the waste outlet and trap.
Leaking basin trap	Loose connection or damaged seal	Tighten the joint or replace the seal.
Cracked ceramic basin	Impact or excessive tightening	Replace the damaged basin.
Slow-draining bathtub	Blocked waste outlet or trap	Remove the blockage and clean the trap.
Leaking WC cistern	Faulty inlet or flush valve	Repair or replace the faulty component.
WC fails to flush properly	Inadequate water level or faulty flush mechanism	Adjust or repair the flushing mechanism.
WC leaks at its base	Damaged seal or poor connection	Remove and correctly reseal the WC connection.
Bad smell from a drain	Dry trap, damaged seal or drainage defect	Restore the water seal and inspect the drainage system.
Urinal does not flush	Blocked inlet or faulty flush valve	Clean the inlet or repair the valve.
Leaking washing machine hose	Damaged hose or loose connection	Replace the hose or tighten the connection.
Water collecting on bathroom floor	Blocked floor drain or poor floor gradient	Clear the drain and correct the drainage defect.

10.1 General maintenance of sanitary appliances

Clean appliances regularly.

Inspect water supply connections for leakage.

Check waste outlets and traps for blockages.

Repair damaged taps and valves.

Replace worn seals and washers.

Avoid using unsuitable chemicals that may damage appliance surfaces.

Keep drainage openings free from solid waste.

Ensure that cisterns and flushing systems work properly.

Inspect wall fixings and supports.

Replace cracked or badly damaged appliances.

Keep floor drains clean.

Maintain proper ventilation in bathrooms and toilets.

11.0 Safety precautions when installing and maintaining sanitary appliances

Wear appropriate personal protective equipment.

Shut off the water supply before carrying out plumbing repairs.

Use the correct tools for each operation.

Handle ceramic appliances carefully because they can break.

Use safe lifting techniques when moving heavy bathtubs and sanitary fixtures.

Ensure that ladders and working platforms are stable when working at height.

Keep the work area clean and free from obstacles.

Avoid contact with untreated sewage and contaminated wastewater.

Wash hands thoroughly after plumbing and sanitation work.

Use suitable ventilation when applying sealants and cleaning chemicals.

Never mix incompatible cleaning chemicals.

Ensure that electrical equipment is isolated before working on electric shower or washing machine connections.

Electrical installations should be carried out by qualified persons.

Dispose of damaged materials and wastewater safely.

Test all connections before handing over the installation.

12.0 Factors to consider when selecting sanitary appliances for a building

The selection of sanitary appliances should be guided by the needs of the building and its occupants.

Factor	Explanation
Building purpose	A school, hospital, hotel and house have different sanitary requirements.
Number of users	The number of occupants determines the quantity and capacity of appliances required.
Cost	Consider purchase, transportation, installation and maintenance costs.
Durability	Select appliances that can withstand the expected level of use.
Water availability	Consider the reliability and quantity of water available.
Space	Select appliances that fit the available room dimensions.
Drainage system	Ensure that suitable soil and waste connections are available.
Ease of cleaning	Smooth and accessible surfaces support hygiene.
Accessibility	Consider users with disabilities, children and older persons.
Maintenance	Choose appliances with readily available replacement parts.
Appearance	Consider colour, shape and design.
Water efficiency	Select fittings that minimise unnecessary water consumption.
Safety	Consider stability, non-slip surfaces and safe temperatures.
Material	Select suitable materials based on strength, corrosion resistance and hygiene.
Regulations	Follow relevant building, public health and plumbing requirements.

13.0 Sketching and drawing sanitary appliances

Technical drawing is an important skill in building construction. It enables learners to communicate the appearance, shape, position and components of sanitary appliances.

A learner should be able to produce neat, proportionate and well-labelled sketches of sanitary appliances.

13.1 Guidelines for sketching sanitary appliances

Study the appliance carefully before drawing.

Identify the main parts and their functions.

Choose a suitable drawing view.

Use light construction lines before drawing the final outline.

Maintain correct proportions.

Use appropriate drawing instruments where necessary.

Show important components clearly.

Use straight, neat labelling lines.

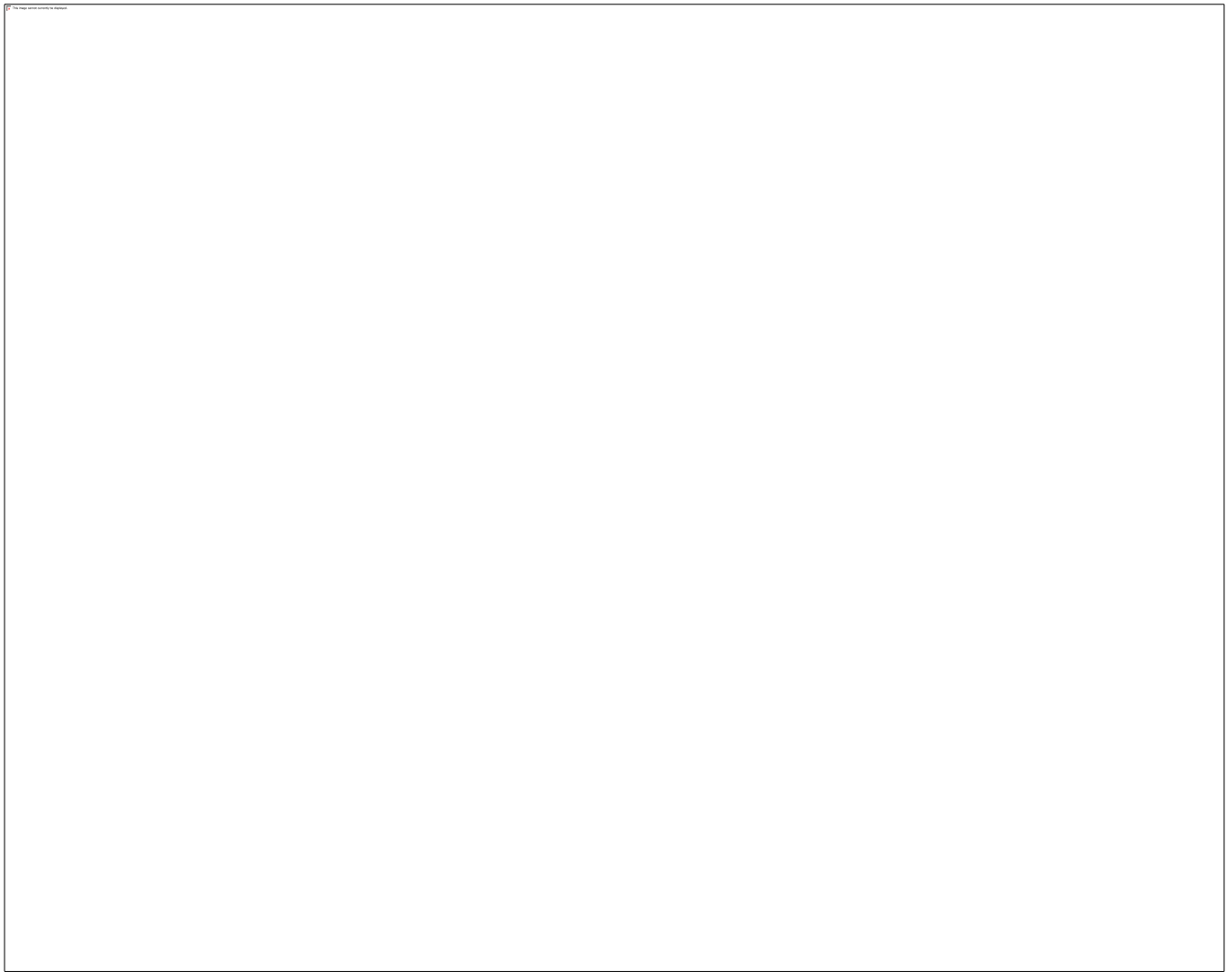
Avoid crossing labelling lines.

Give the drawing a suitable title.

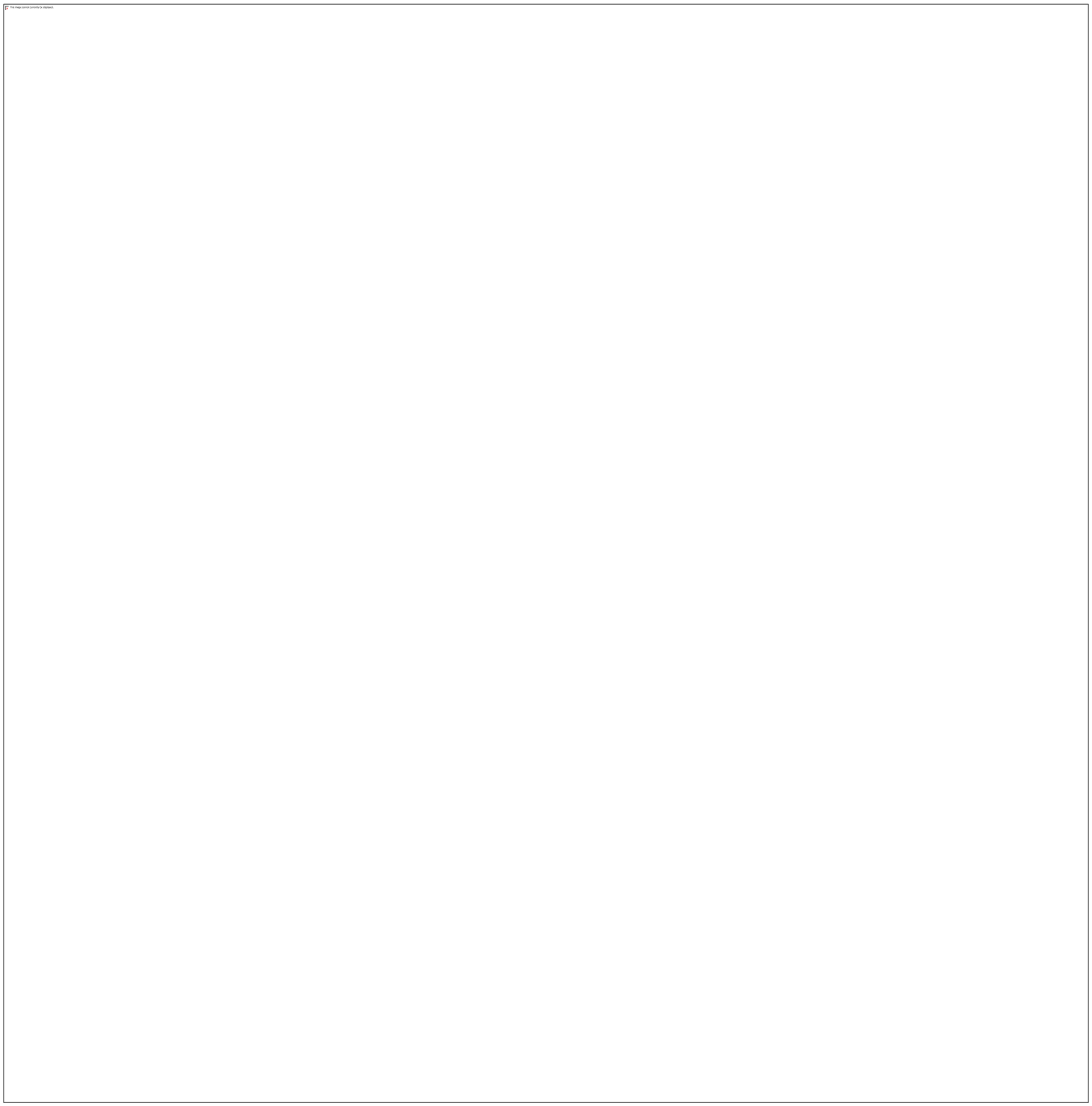
Include dimensions where required.

Use clear lines to distinguish visible parts.

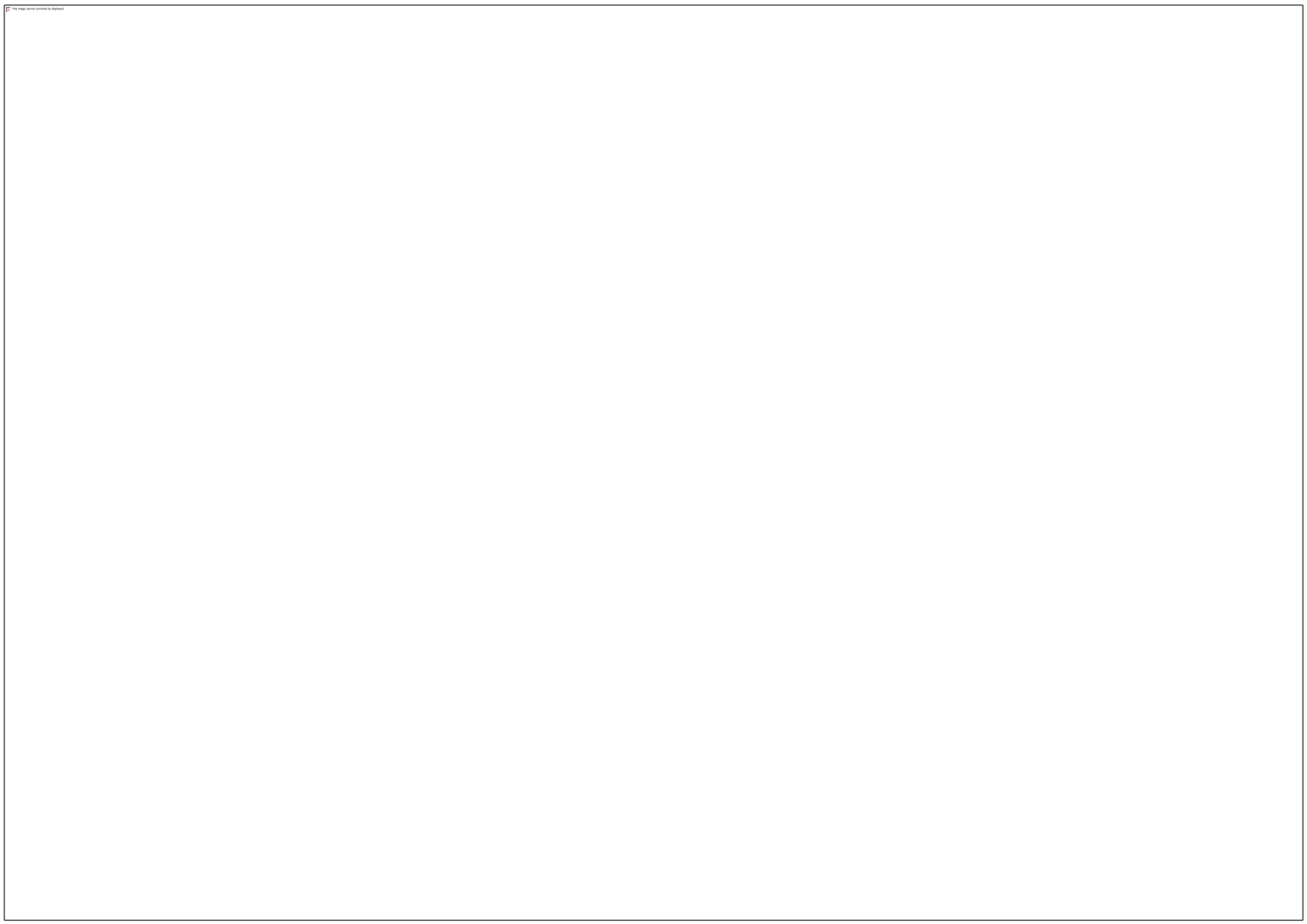
13.2 Sketch of a wash hand basin



13.3 Sketch of a kitchen sink



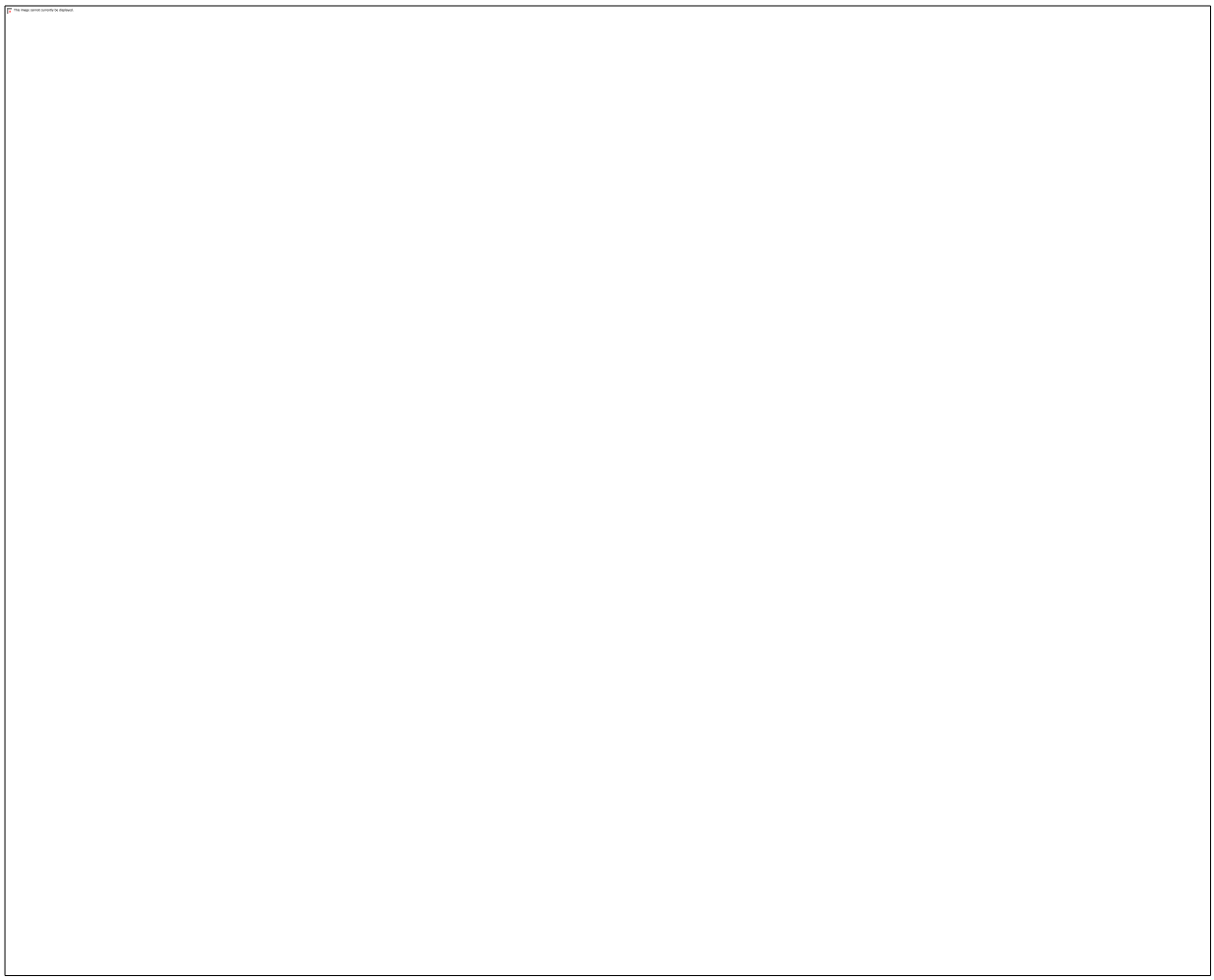
13.4 Sketch of a bathtub



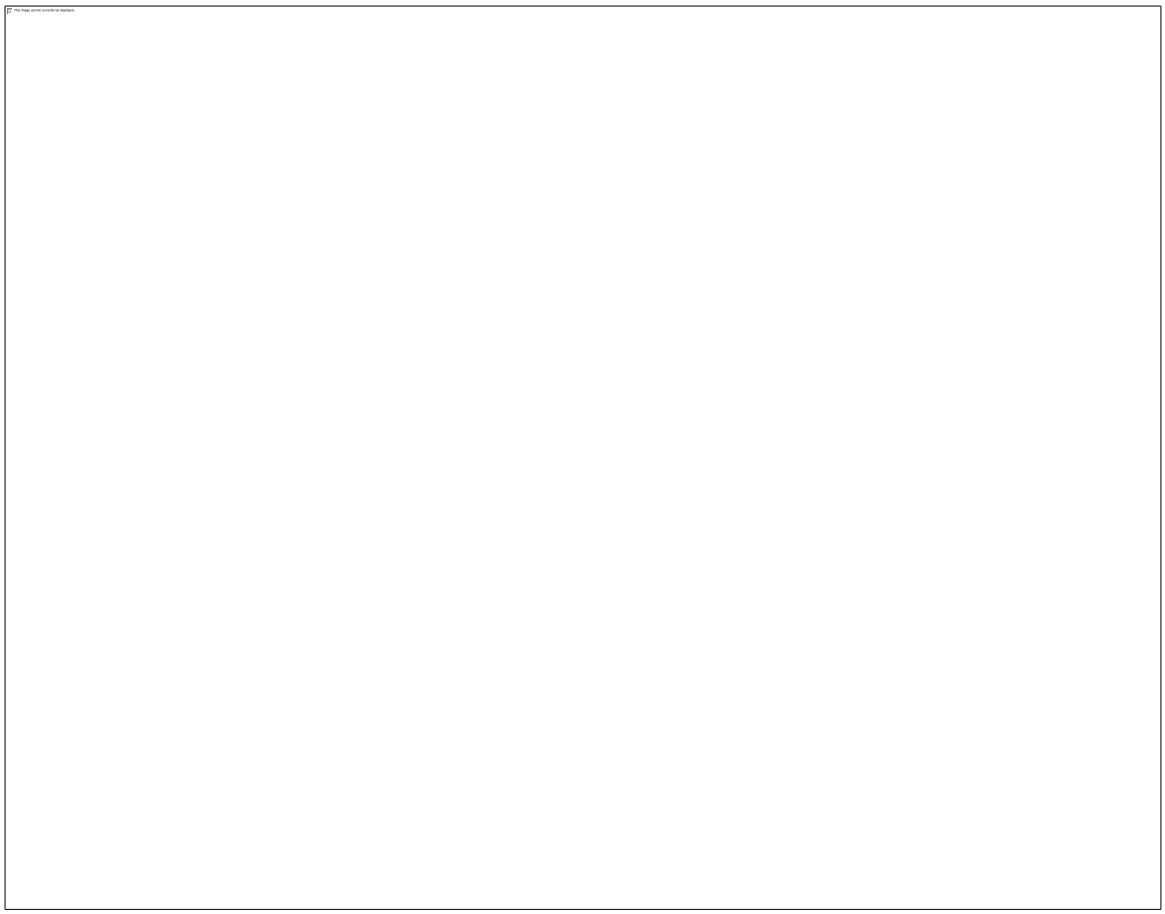
13.5 Sketch of a water closet



13.6 Sketch of a urinal



13.7 Sketch of a bidet



Drawing practice: The sketches above are simplified learning diagrams. In technical examinations and construction drawings, learners should draw the actual shape of each appliance more accurately, show the appropriate components and use neat, correctly positioned labels.

14.0 Water conservation in sanitary appliances

Water is an important resource in buildings. Sanitary appliances should be selected and used in ways that reduce unnecessary water wastage.

14.1 Ways of conserving water

Install water-efficient water closets.

Repair leaking taps immediately.

Install suitable water-saving showerheads.

Turn off taps when water is not required.

Use appropriate flow-control fittings.

Install dual-flush cisterns where suitable.

Use washing machines with efficient water-use cycles.

Avoid allowing water to run continuously during cleaning.

Monitor water consumption using a water meter.

Maintain pipes, valves and fittings to prevent leakage.

Educate building occupants on responsible water use.

Harvest rainwater for suitable non-potable uses where properly designed.

14.2 Examples of water-efficient sanitary appliances

Dual-flush water closets.

Low-flow showerheads.

Sensor-operated taps.

Water-efficient mixer taps.

Water-efficient washing machines.

Water-saving urinal flushing systems.

Note: Water-saving appliances should still provide effective cleaning, flushing and hygiene performance. Water conservation should not compromise sanitation.

Project and practical experiences

The following activities enable learners to develop practical skills, creativity, communication, problem-solving and environmental responsibility.

Activity 1: Identification of sanitary appliances

Task: Visit the school washrooms, kitchen and other approved areas.

Instructions

Identify the sanitary appliances installed in each area.

Record their names.

State their functions.

Identify their materials.

Determine whether they are soil or wastewater appliances.

Present your findings to the class.

Expected learning outcome: Learners identify sanitary appliances and explain their functions.

Activity 2: Classification of sanitary appliances

Task: Classify different sanitary appliances.

Prepare a table showing:

Appliance	Main function	Classification
Water closet	Disposal of human excreta	Soil appliance
Urinal	Disposal of urine	Soil appliance
Wash hand basin	Handwashing	Wastewater appliance
Kitchen sink	Washing utensils	Wastewater appliance
Bathtub	Bathing	Wastewater appliance
Shower	Bathing	Wastewater appliance
Washing machine	Washing clothes	Wastewater-producing appliance
Bidet	Personal washing	Depends on drainage design

Activity 3: Drawing sanitary appliances

Task: Draw and label the following appliances:

Wash hand basin.

Kitchen sink.

Bathtub.

Water closet.

Urinal.

Bidet.

Requirements

Use a suitable drawing sheet.

Draw each appliance neatly.

Label at least five components where applicable.

Use appropriate drawing instruments.

Present your work for assessment.

Activity 4: Demonstration of sanitary appliance installation

Under the guidance of a qualified instructor, learners may observe or practise installing a simple wash hand basin on a training board.

Requirements

Wash hand basin.

Suitable brackets.

Tap.

Water supply fittings.

Waste outlet.

Trap.

Waste pipe.

Appropriate tools.

PPE.

Procedure

Identify the components.

Measure and mark the installation position.

Fit the supporting brackets.

Position the basin.

Install the tap.

Connect the supply and waste fittings.

Test the installation.

Identify any leakage.

Activity 5: Water conservation investigation

Task: Investigate how sanitary appliances contribute to water consumption in the school.

Learners should:

Identify appliances that use water.

Observe possible leaks.

Identify water-saving fittings.

Suggest ways of reducing water wastage.

Present recommendations to the school administration.

Activity 6: Group project – sanitary appliance model

Task: In groups, construct a model bathroom showing the positions of sanitary appliances.

The model should include:

Water closet.

Wash hand basin.

Shower.

Bathtub, where appropriate.

Water supply pipes.

Waste pipes.

Soil pipe.

Door and ventilation openings.

Assessment criteria

Correct identification of appliances.

Correct positioning.

Neatness and accuracy.

Correct representation of pipe connections.

Creativity and use of locally available materials.

Teamwork and communication.

17.0 REVISION QUESTIONS

SECTION A: MULTIPLE-CHOICE QUESTIONS

Instructions: Answer all questions. Choose the correct answer from the alternatives provided.

1. Which of the following best describes a sanitary appliance?

A. A machine used for mixing concrete.

B. A fixture used for washing, bathing and hygienic disposal of waste.

C. A tool used for cutting pipes.

D. A material used for constructing walls.

2. Which one of the following is a soil appliance?

A. Kitchen sink.

B. Bathtub.

C. Water closet.

D. Wash hand basin.

3. The main function of a wash hand basin is to:

A. Store drinking water.

B. Wash hands and face.

C. Dispose of solid waste.

D. Store hot water.

4. Which sanitary appliance is mainly used for washing cooking utensils?

A. Bidet.

B. Urinal.

C. Kitchen sink.

D. Water closet.

5. The main purpose of a trap in a plumbing system is to:

A. Increase water pressure.

B. Prevent foul gases from entering a building.

C. Heat water.

D. Increase the size of drainage pipes.

6. Which of the following appliances is commonly manufactured from vitreous china?

A. Water closet.

B. Timber door.

C. Steel roof truss.

D. Concrete column.

7. A pipe that conveys discharge containing human excreta is known as a:

A. Supply pipe.

B. Soil pipe.

C. Overflow pipe.

D. Ventilation duct.

8. Which appliance is designed mainly for receiving and disposing of urine?

A. Bathtub.

B. Kitchen sink.

C. Urinal.

D. Bidet.

9. Which of the following is a wastewater appliance?

A. Water closet.

B. Urinal.

C. Wash hand basin.

D. Soil stack.

10. The component of a water closet that stores water for flushing is called a:

A. Trap.

B. Cistern.

C. Pan.

D. Waste outlet.

11. Which of the following materials is commonly used to manufacture kitchen sinks?

A. Stainless steel.

B. Untreated timber.

C. Plasterboard.

D. Softwood.

12. The main function of a cistern float valve is to:

A. Heat water in the cistern.

B. Control the filling of the cistern.

C. Remove waste from the toilet pan.

D. Prevent the toilet from moving.

13. Which type of wash hand basin is supported by a vertical pedestal?

A. Wall-mounted basin.

B. Countertop basin.

C. Pedestal basin.

D. Semi-recessed basin.

14. A double-bowl kitchen sink has:

A. Two taps only.

B. Two washing compartments.

C. Two drainage systems in every installation.

D. Two separate kitchens.

15. Which of the following is a function of a waste pipe?

A. Conveying drinking water to taps.

B. Carrying wastewater from sanitary appliances.

C. Supporting the roof.

D. Supplying electricity to a washing machine.

16. Which appliance is designed to deliver water through a showerhead for bathing?

A. Urinal.

B. Shower.

C. Bidet.

D. Kitchen sink.

17. A P-trap is commonly used where the drainage pipe connects:

A. Through the wall.

B. Through the roof.

C. Through the ceiling only.

D. To the electrical system.

18. Which sanitary appliance is commonly used for personal washing after toilet use?

A. Kitchen sink.

B. Bidet.

C. Urinal.

D. Laundry sink.

19. The waste outlet of a sanitary appliance is used to:

A. Supply water to the appliance.

B. Allow used water to drain away.

C. Support the appliance.

D. Control electrical power.

20. Which of the following is a water-conservation measure?

A. Leaving taps running.

B. Ignoring leaking pipes.

C. Installing water-efficient fittings.

D. Flushing solid waste through sinks.

21. Which tool is most suitable for checking whether a wash hand basin is level?

A. Pipe wrench.

B. Spirit level.

C. Hacksaw.

D. Pliers.

22. Before installing a water closet, the plumber should first confirm:

A. The colour of the bathroom walls.

B. The position and type of soil pipe connection.

C. The type of roof covering.

D. The height of the ceiling only.

23. Which of the following is a major advantage of a wall-mounted wash hand basin?

A. It always requires a pedestal.

B. It makes cleaning the floor beneath it easier.

C. It cannot be connected to a waste pipe.

D. It does not require wall support.

24. Which appliance commonly uses a flexible inlet hose and a drain hose?

A. Washing machine.

B. Urinal.

C. Bidet.

D. Bathtub.

25. A water seal is retained in a plumbing fitting known as a:

A. Tap.

B. Trap.

C. Cistern.

D. Coupling.

26. Which of the following is a possible cause of a foul smell from a wash hand basin?

A. A properly maintained trap.

B. A dry or defective trap.

C. A correctly installed tap.

D. A clean waste outlet.

27. Which material is lightweight and commonly used in the manufacture of bathtubs?

A. Acrylic.

B. Cast iron only.

C. Concrete.

D. Solid timber.

28. Which of the following should be done when installing a ceramic water closet?

A. Overtighten all fixing bolts.

B. Leave the appliance unsupported.

C. Fix it securely without excessive tightening.

D. Block the soil pipe outlet.

29. Which of the following appliances may use an electronic sensor to activate flushing?

A. Sensor-operated urinal.

B. Conventional bathtub.

C. Pedestal basin without a sensor.

D. Traditional kitchen sink.

30. One important reason for installing sanitary appliances in schools is to:

A. Increase the weight of the building.

B. Promote hygiene and proper sanitation among learners.

C. Reduce the number of classrooms.

D. Increase the amount of construction waste.

SECTION B: STRUCTURED QUESTIONS

Instructions: Answer all questions. Give clear explanations and relevant examples where necessary.

1. Introduction to sanitary appliances

a) Define the term sanitary appliances. (2 marks)

b) State six examples of sanitary appliances used in buildings. (6 marks)

c) Explain six reasons why sanitary appliances are important in buildings. (12 marks)

2. Classification of sanitary appliances

a) What is meant by a soil appliance? (2 marks)

b) State four examples of soil appliances or fixtures used in soil drainage arrangements. (4 marks)

c) Explain the meaning of wastewater appliances. (2 marks)

d) State six examples of wastewater appliances. (6 marks)

3. Soil appliances and wastewater appliances

a) Differentiate between soil appliances and wastewater appliances. (6 marks)

b) Give three examples of buildings where sanitary appliances are required. (3 marks)

c) Explain three consequences of poor installation of sanitary appliances. (6 marks)

4. Wash hand basins

a) Define a wash hand basin. (2 marks)

b) Name four types of wash hand basins. (4 marks)

c) State six components of a wash hand basin. (6 marks)

d) Explain four factors to consider when selecting a wash hand basin for a school. (8 marks)

5. Kitchen sinks

a) Define a kitchen sink. (2 marks)

b) State four types of kitchen sinks. (4 marks)

c) Explain five functions of a kitchen sink in a residential building. (10 marks)

d) State four materials used in manufacturing kitchen sinks. (4 marks)

6. Bathtubs and showers

a) Define a bathtub. (2 marks)

b) Identify four types of bathtubs. (4 marks)

c) State six components of a bathtub. (6 marks)

d) Explain five advantages of installing showers in residential buildings. (10 marks)

7. Water closets

a) Define a water closet. (2 marks)

b) State four types of water closets. (4 marks)

c) Name eight components of a water closet. (8 marks)

d) Explain the working principle of a water closet. (6 marks)

8. Urinals

a) Define a urinal. (2 marks)

b) State four types of urinals. (4 marks)

c) Explain five advantages of installing urinals in public buildings. (10 marks)

d) State four maintenance practices carried out on urinals. (4 marks)

9. Bidets and washing machines

a) Define a bidet. (2 marks)

b) State three types of bidets. (3 marks)

c) Explain four functions of a washing machine in a building. (8 marks)

d) State five plumbing-related components of a washing machine. (5 marks)

10. Materials used in sanitary appliances

a) State six materials used in manufacturing sanitary appliances. (6 marks)

b) Explain four advantages of vitreous china. (8 marks)

c) State four disadvantages of stainless steel as a material for sanitary appliances. (4 marks)

d) Explain two reasons why acrylic is commonly used in making bathtubs. (4 marks)

11. Soil pipes and waste pipes

a) Define a soil pipe. (2 marks)

b) Define a waste pipe. (2 marks)

c) State five differences between soil pipes and waste pipes. (10 marks)

d) Explain why drainage pipes should be properly supported. (4 marks)

12. Traps

a) Define a plumbing trap. (2 marks)

b) State four types of traps used in plumbing installations. (4 marks)

c) Explain five functions of traps in a building drainage system. (10 marks)

d) State four causes of loss of water seal in a trap. (4 marks)

13. Components and fittings

a) State six types of pipe fittings used in plumbing works. (6 marks)

b) Explain the functions of the following:

i. Elbow. (2 marks)

ii. Tee. (2 marks)

iii. Coupling. (2 marks)

iv. Reducer. (2 marks)

v. Isolation valve. (2 marks)

14. Installation of sanitary appliances

a) Define installation of sanitary appliances. (2 marks)

b) State eight factors to consider before installing sanitary appliances. (8 marks)

c) Describe the general procedure followed when installing a wash hand basin. (10 marks)

15. Installation of a water closet

a) Name six tools used when installing a water closet. (6 marks)

b) Describe the procedure followed when installing a water closet. (10 marks)

c) State four precautions to observe when installing a water closet. (4 marks)

16. Installation of kitchen sinks

a) State five materials and fittings required when installing a kitchen sink. (5 marks)

b) Explain the procedure for installing a kitchen sink. (10 marks)

c) State five maintenance practices for kitchen sinks. (5 marks)

17. Safety during plumbing installation

a) State six personal protective equipment used during plumbing works. (6 marks)

b) Explain six safety precautions to observe when installing sanitary appliances. (12 marks)

18. Defects and maintenance

a) State five common defects found in sanitary appliances. (5 marks)

b) Explain the possible causes and remedies of the following:

i. Leaking taps. (4 marks)

ii. Blocked wash hand basins. (4 marks)

iii. Foul smells from drainage outlets. (4 marks)

iv. Leaking water closet cisterns. (4 marks)

19. Water conservation

a) Explain six ways of conserving water when using sanitary appliances. (12 marks)

b) State four examples of water-efficient sanitary appliances or fittings. (4 marks)

c) Explain two benefits of conserving water in a building. (4 marks)

20. Drawing and sketching

a) Draw and label a wash hand basin showing at least five components. (5 marks)

b) Draw and label a kitchen sink showing at least five components. (5 marks)

c) Draw and label a water closet showing at least five components. (5 marks)

d) Draw and label a urinal showing at least four components. (5 marks)

STRAND 4.0: BUILDING SERVICES

SUB-STRAND 4.2: DRAINAGE SYSTEMS

1.0 Introduction to drainage systems

Every building and construction site requires an effective drainage system to remove excess water and wastewater safely. Water may originate from rainfall, washing activities, bathing, cooking, plumbing appliances, underground seepage and other sources.

When water is not properly drained away, it may accumulate around buildings, weaken foundations, cause dampness, damage roads and paths, encourage mosquito breeding and create unhealthy conditions.

Drainage systems are therefore important in building construction because they protect buildings, occupants, construction materials and the surrounding environment.

In Kenya, drainage systems are particularly important because buildings experience different rainfall patterns. Some areas receive heavy rainfall, while others experience seasonal rainfall, flash floods or prolonged dry periods. Drainage designs must therefore consider the local terrain, soil type, rainfall intensity, groundwater conditions and the intended use of the building.

1.1 Definition of drainage

Drainage is the process of collecting, conveying and disposing of excess water or wastewater from a building or piece of land to a suitable receiving point through natural or constructed channels, pipes and other drainage structures.

1.2 Definition of a drainage system

A **drainage system** is an arrangement of channels, pipes, drains, gutters, inspection chambers, manholes and other structures designed to collect and remove unwanted water from a building or site.

1.3 Meaning of a construction site drainage system

A construction site drainage system refers to the arrangement of temporary or permanent drainage facilities provided on a construction site to control surface water, stormwater, groundwater and wastewater.

Examples include:

Open surface drains.

Stormwater channels.

Underground drainage pipes.

Subsurface perforated pipes.

French drains.

Catch pits.

Inspection chambers.

Manholes.

Gutters and downpipes.

Soakaways, where suitable and permitted.

1.4 Main purposes of drainage systems

To remove excess water from buildings and construction sites.

To prevent flooding around buildings.

To protect building foundations from water damage.

To prevent waterlogging of the ground.

To protect roads, footpaths and paved areas.

To reduce soil erosion.

To prevent dampness in walls and floors.

To provide safe disposal of wastewater.

To improve sanitation and public health.

To protect the surrounding environment from uncontrolled wastewater discharge.

2.0 Classification of drainage systems used on construction sites

Drainage systems can be classified according to the source of water, the position of the drainage arrangement and the method used to collect and convey water.

The main types include:

Surface drainage systems.

Stormwater drainage systems.

Subsurface drainage systems.

Building wastewater and foul drainage systems.

Combined drainage systems.

2.1 Surface drainage systems

Definition: Surface drainage is the removal of excess water flowing or collecting on the ground surface through natural or constructed channels and drains.

Surface drainage is used to control rainwater and other water that collects on the ground.

It is commonly used around:

Residential buildings.

Schools.

Hospitals.

Roads.

Car parks.

Construction sites.

Sports grounds.

Industrial buildings.

Features of surface drainage systems

They are located on or close to the ground surface.

They collect water from roofs, paved areas, roads and open ground.

They may use open channels, gutters, kerbs and surface inlets.

They generally depend on suitable ground gradients to move water.

They should discharge into an appropriate receiving system.

They require regular cleaning to prevent blockage by soil, leaves and rubbish.

Types of surface drainage systems

A. Open surface drains



An open surface drain is a channel constructed on the ground surface to collect and convey excess water.

Characteristics

It is usually open at the top.

It may be constructed from concrete, masonry, stone or other suitable materials.

It is commonly built along roads, building boundaries and paved areas.

It may be rectangular, trapezoidal or V-shaped in cross-section.

Advantages

It is relatively easy to inspect.

It can be cleaned without specialised equipment.

It can carry substantial quantities of surface water when properly designed.

It may be economical for large open areas.

It can be constructed using locally available materials.

Disadvantages

It may create a safety hazard if left uncovered.

It can collect rubbish and sediment.

It occupies space on the site.

It may encourage mosquito breeding if water is allowed to stagnate.

It may require protective covers or barriers in pedestrian areas.

Applications

Along roads and footpaths.

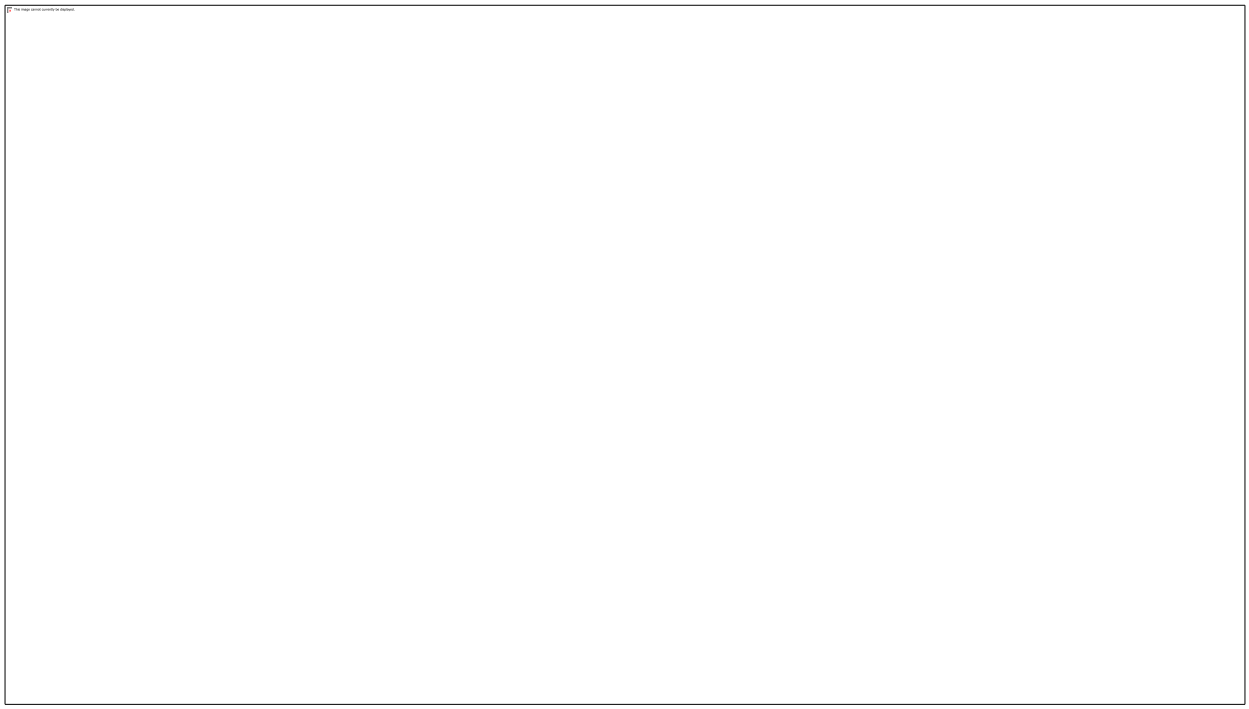
Around school compounds.

At the edges of parking areas.

Along building boundaries.

On construction sites to divert runoff.

B. Covered surface drains



A covered surface drain is a drainage channel provided with a cover or grating to allow water to enter while protecting the channel.

Characteristics

It is covered with concrete slabs, metal gratings or other suitable covers.

It may be installed along footpaths, driveways and paved compounds.

It allows water to flow below the walking or driving surface.

Advantages

It improves pedestrian safety when correctly designed.

It reduces direct contact with wastewater.

It provides a neater appearance.

It allows the surface above to be used for movement.

Disadvantages

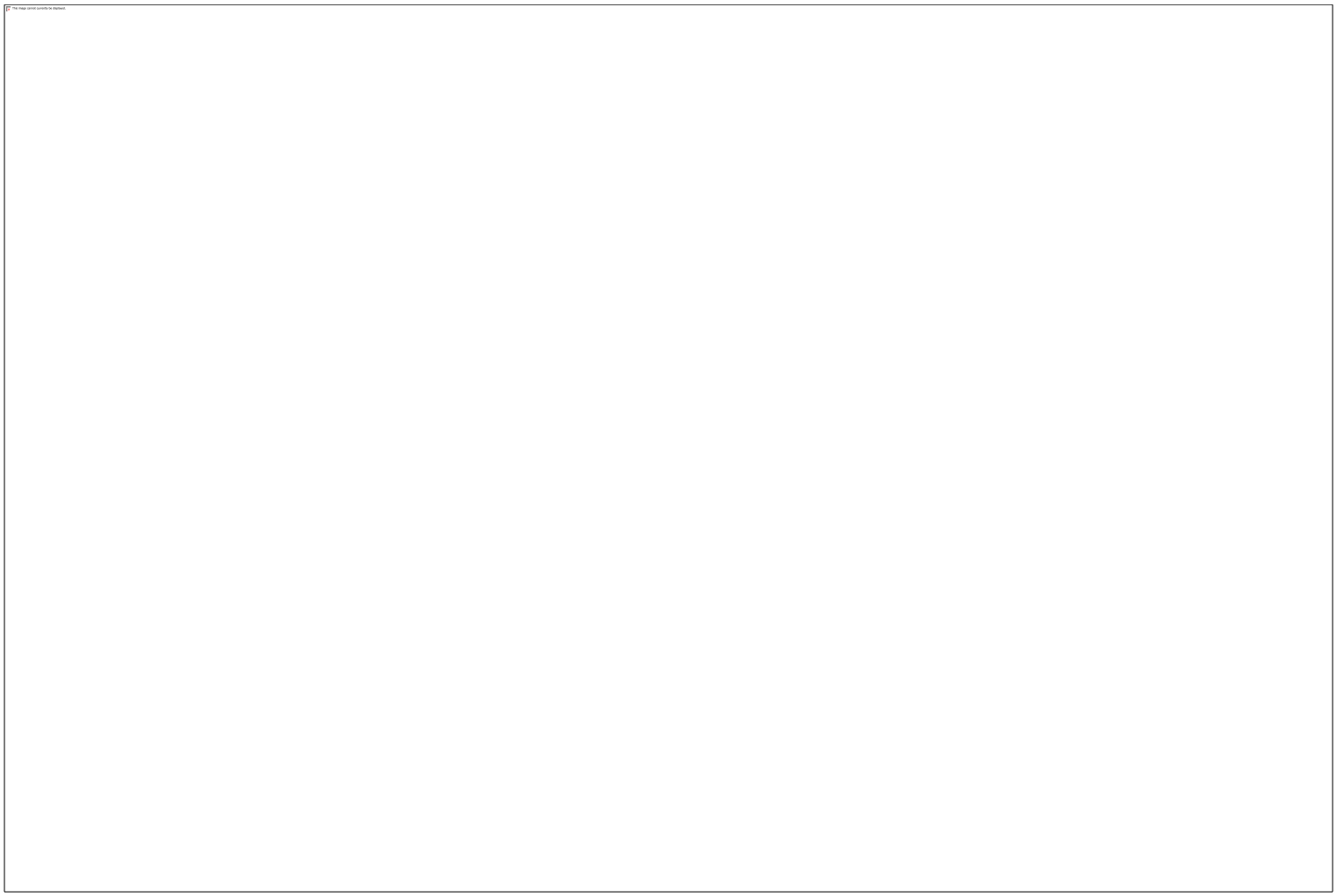
It may be difficult to inspect if covers cannot be removed easily.

It may become blocked by rubbish.

It can be expensive to construct.

Damaged covers may create serious hazards.

C. Surface channels and gutters



These are shaped channels that guide surface water towards a drain or collection point.

They may be constructed using concrete, masonry or precast units.

They are commonly installed beside buildings, roads and paved areas.

D. Kerb and channel drainage

It is commonly used along roads and paved areas.

Kerbs guide runoff towards drainage inlets.

Channels convey the collected water along the road edge.

Gullies or catch pits collect water and direct it into underground stormwater pipes.

2.2 Stormwater drainage systems



Definition: A stormwater drainage system is an arrangement of gutters, downpipes, channels, inlets, pipes and other structures used to collect and convey rainwater runoff from roofs, roads, paved areas and open ground to a suitable discharge or storage point.

Stormwater is rainwater that flows over surfaces instead of soaking into the ground.

Sources of stormwater

Rain falling on building roofs.

Rain falling on roads.

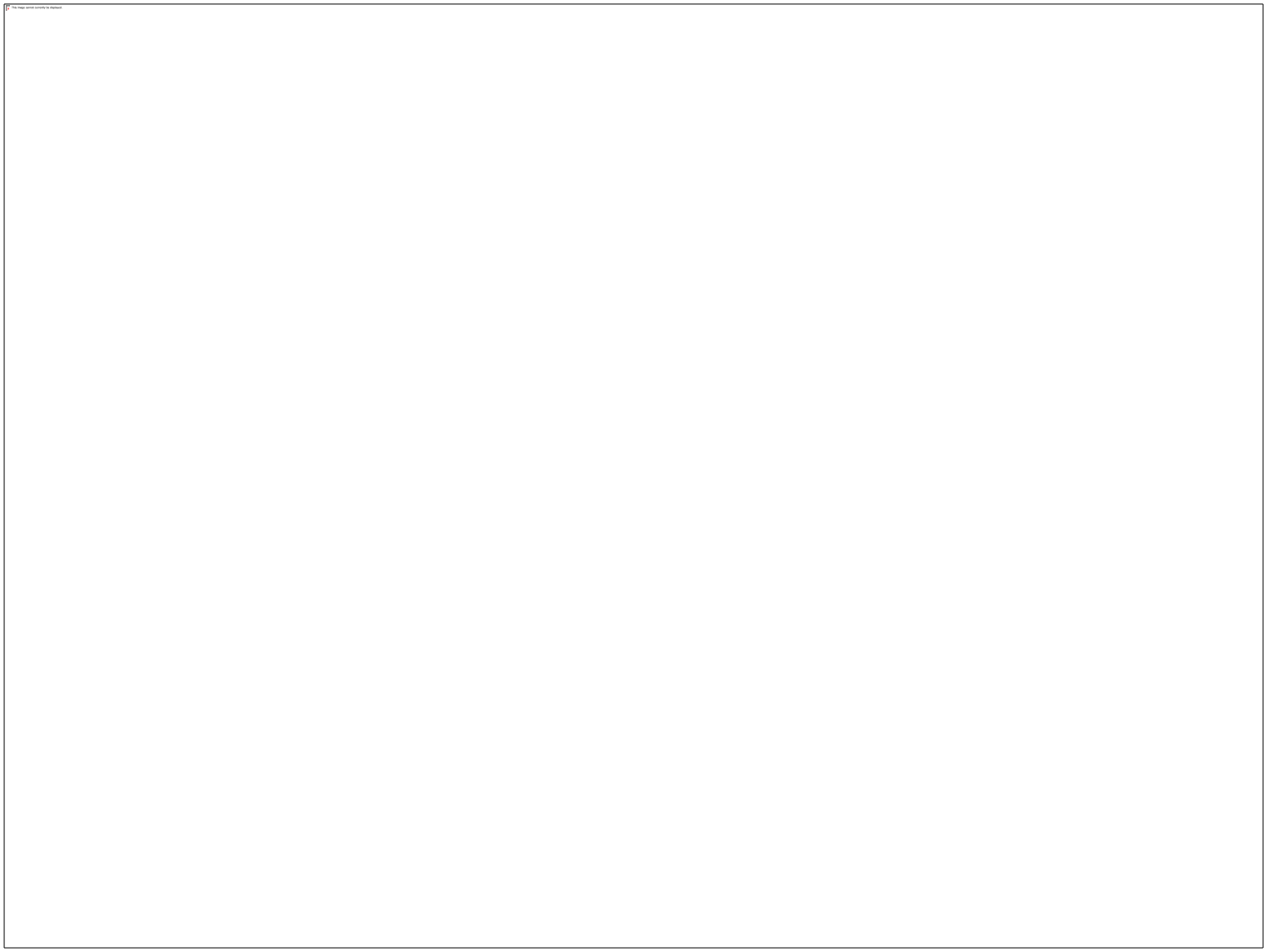
Runoff from parking areas.

Water flowing over paved compounds.

Runoff from compacted construction areas.

Rainwater flowing from neighbouring higher ground.

Components of a stormwater drainage system



1. Roof gutters

These are channels fixed along the edges of roofs.

They collect rainwater flowing down the roof.

They direct water towards downpipes.

They may be made from uPVC, aluminium, steel or other suitable materials.

2. Downpipes

These are vertical pipes that convey rainwater from roof gutters to ground-level drainage arrangements.

They may be made from plastic or metal.

They should be securely fixed to walls.

They should discharge into suitable drains, rainwater storage systems or other approved receiving points.

3. Surface channels

They collect runoff from paved areas and open ground.

They guide water towards drainage inlets or discharge points.

4. Catch pits or catch basins

These are chambers that collect stormwater entering the drainage system.

They may trap some sediment and debris.

They should be accessible for inspection and cleaning.

5. Stormwater pipes

These convey collected rainwater underground.

They may be made from uPVC, concrete or other suitable drainage materials.

They are installed with appropriate gradients and supports.

6. Inspection chambers

These provide access for inspecting and maintaining underground drainage pipes.

They may be positioned at changes in direction, junctions or other locations required by the design.

7. Manholes

These are larger access chambers that allow inspection and maintenance of drainage systems.

They are provided at suitable intervals and locations.

8. Outfalls

An outfall is the point where collected stormwater is discharged into an approved receiving system.

Examples include a designated stormwater channel, approved watercourse or properly designed infiltration facility.

9. Soakaways

These are underground structures designed to allow suitable stormwater to infiltrate into the surrounding soil.

They should only be used where ground conditions, groundwater level, site constraints and applicable requirements permit.

They must not be used as a substitute for safe disposal of sewage.

Advantages of stormwater drainage systems

Reduce flooding around buildings.

Protect building foundations from uncontrolled runoff.

Reduce soil erosion.

Protect roads and paved areas.

Help prevent waterlogging.

Direct rainwater away from entrances and pathways.

Support rainwater harvesting where storage systems are incorporated.

Protect landscaping and planted areas.

Reduce damage to construction materials.

Improve safety and movement around buildings.

Disadvantages of poorly designed stormwater systems

They may cause flooding if undersized.

Blocked inlets can prevent water from entering the drainage network.

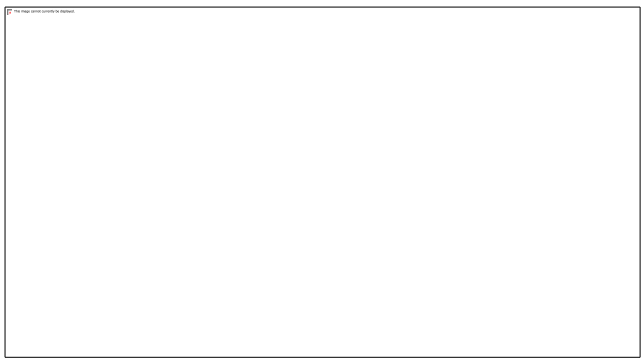
Poorly positioned outlets may cause erosion.

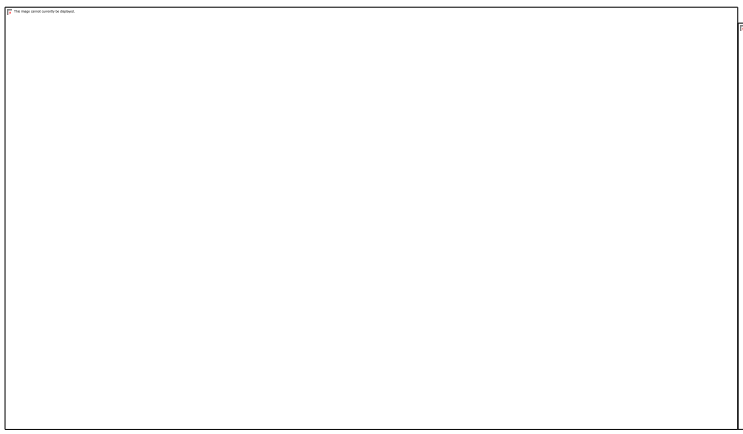
Uncontrolled discharge may flood neighbouring properties.

Poorly maintained drains may become breeding places for mosquitoes.

Excessively fast runoff may damage downstream channels.

2.3 Subsurface drainage systems







Definition: Subsurface drainage is the removal of excess water from below the ground surface through buried pipes, drainage layers, trenches or other underground drainage structures.

It is used where water accumulates within the soil and needs to be removed to improve ground conditions.

Subsurface drainage is particularly useful where:

The groundwater level is high.

Soil remains waterlogged for long periods.

Water seeps into basements.

Foundations are exposed to excessive groundwater.

Retaining walls experience water pressure.

Sports grounds or landscaped areas require improved drainage.

Main components of a subsurface drainage system

1. Perforated drainage pipes

These are pipes with small openings or perforations along their length.

The openings allow groundwater to enter the pipe.

They are commonly made from suitable plastic materials.

They convey collected water towards an outlet or collector drain.

2. Gravel or coarse aggregate

It is placed around the perforated pipe.

It creates spaces through which groundwater can move.

It helps protect the pipe from direct contact with fine soil particles.

3. Geotextile filter fabric

It is a permeable fabric used to separate soil from the drainage aggregate.

It reduces the movement of fine soil particles into the drainage material.

It helps reduce clogging when correctly selected and installed.

4. Drainage trench

This is an excavated channel in which the drainage pipe and filter materials are installed.

Its depth and width depend on the drainage design and site conditions.

5. Collector drain

It receives water from smaller drainage lines.

It conveys the collected water towards an appropriate outlet.

6. Inspection chambers

They provide access for inspecting and maintaining the drainage system.

They may be installed at suitable junctions and changes in direction.

7. Outlet

It provides a safe discharge point for the collected groundwater.

The outlet must be positioned to prevent erosion, flooding or damage to neighbouring property.

Advantages of subsurface drainage

Removes excess groundwater.

Reduces waterlogging in soil.

Helps protect foundations and underground structures.

Reduces hydrostatic pressure behind suitable retaining structures when correctly designed.

Improves ground conditions for construction.

Reduces dampness caused by groundwater.

Helps improve the performance of landscaped areas and sports grounds.

Can be installed underground without occupying much surface space.

Reduces prolonged saturation of soil around buildings.

Supports stability of suitably designed paved and landscaped areas.

Disadvantages of subsurface drainage

It may be expensive to install.

Excavation may disturb existing structures and services.

Pipes may become blocked by sediment and roots.

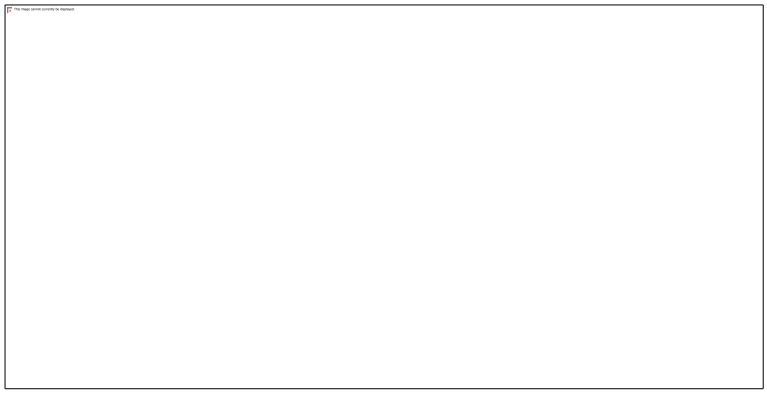
Faults may be difficult to locate.

It requires suitable gradients and an appropriate outlet.

Poor design may cause water to be transferred to another part of the site.

It may require specialist investigation where groundwater conditions are complex.

2.4 Building wastewater and foul drainage systems



Definition: A building wastewater and foul drainage system is an arrangement of pipes and drainage fittings that collects and conveys wastewater from sanitary appliances to an appropriate treatment or disposal system.

It receives discharge from appliances such as:

Water closets.

Urinals.

Wash hand basins.

Kitchen sinks.

Showers.

Bathtubs.

Washing machines.

Main categories of building drainage

A. Soil drainage

Conveys discharge containing human excreta from water closets and other designated soil appliances.

Uses soil pipes and appropriate drainage connections.

Must be designed to prevent leakage and the entry of foul gases into occupied spaces.

B. Wastewater drainage

Conveys used water from sinks, basins, showers and bathing appliances.

Uses waste pipes and suitable traps.

May be arranged separately or connected to a combined drainage arrangement as allowed by the design.

C. Foul drainage

Conveys sewage and wastewater requiring treatment before safe discharge.

It may carry toilet discharge and other wastewater, depending on the drainage arrangement.

Note: Building wastewater drainage is different from stormwater drainage. Stormwater should not be connected to foul drainage unless a specifically approved combined system is being used.

2.5 Combined drainage system



Definition: A combined drainage system is a drainage arrangement in which stormwater and foul sewage are conveyed through the same drainage network.

Characteristics

It uses a common drainage network for stormwater and sewage.

It may be found in some older urban drainage systems.

It requires careful design to manage flows during heavy rainfall.

It conveys both rainwater runoff and wastewater towards a treatment or receiving facility.

Advantages

It may require fewer separate drainage networks.

It can be convenient where an existing combined sewer system is available.

It may reduce duplication of some underground pipe routes.

Disadvantages

Heavy rainfall can overload the system.

Large volumes of stormwater may increase the burden on wastewater treatment facilities.

Overflow events can cause environmental pollution.

Maintenance and capacity management may be more complicated.

Important: Separate stormwater and foul drainage systems are commonly preferred in modern building and site planning where required by the design and local drainage arrangements. Never connect a building's drainage to a public sewer or watercourse without the necessary approval.

3.0 Layouts or patterns of subsurface drainage systems

3.1 Meaning of a subsurface drainage layout

A **subsurface drainage layout** is the planned arrangement of underground drainage pipes or channels within a site to collect excess groundwater and convey it towards a suitable outlet.

The layout determines:

The direction in which water flows.

The position of the drainage pipes.

The spacing between drainage lines.

The position of collector drains.

The location of inspection chambers.

The position of the final discharge point.

The choice of layout depends on the shape of the site, ground slope, soil conditions, groundwater movement, location of buildings and the amount of water to be removed.

3.2 Main layouts of subsurface drainage systems

The main layouts include:

Radial drainage layout.

Herringbone drainage layout.

Fan drainage layout.

Grid drainage layout.

Parallel drainage layout.

Branching drainage layout.

3.3 Radial drainage layout



Definition: A radial drainage layout is an arrangement in which drainage pipes extend outwards from a central collection point or collector pipe, resembling the spokes of a wheel.

In this layout, water is collected from different directions and conveyed towards a central point or a designed collection system.

Characteristics

Drainage lines extend in different directions from a central point.

The layout resembles the spokes of a wheel.

It may be suitable for sites with a central collection point.

The drainage lines are arranged to collect groundwater from surrounding areas.

The central collector must have sufficient capacity to convey the collected water.

Advantages

Collects water from different directions.

Can be effective around a central low-lying collection point.

May reduce the need for several separate discharge outlets.

Can be adapted to circular or irregularly shaped sites.

Disadvantages

Requires careful planning of pipe gradients.

The central collection point may receive a large volume of water.

Maintenance can be difficult where several pipes meet.

It may not be suitable for every site shape or ground condition.

Applications

Circular or radial site arrangements.

Landscaped areas with a central collection point.

Some recreational grounds.

Sites where groundwater flows towards a central low area.

3.4 Herringbone drainage layout



Definition: A herringbone drainage layout is an arrangement in which smaller lateral drainage pipes enter a main collector pipe from both sides at an angle, forming a pattern similar to the bones of a fish.

Characteristics

It consists of one main collector drain.

Smaller lateral drains connect to the collector.

The lateral pipes enter the main drain at an angle.

The arrangement resembles a fish skeleton.

Water from the lateral pipes flows into the main collector.

Advantages

Collects groundwater from a relatively wide area.

Provides an organised drainage arrangement.

Allows several lateral pipes to feed one collector.

Can be suitable for long and relatively narrow sites.

Disadvantages

The main collector must be correctly sized.

Installation requires careful setting out.

Junctions may require inspection and maintenance.

Poorly arranged connections may cause flow problems.

Applications

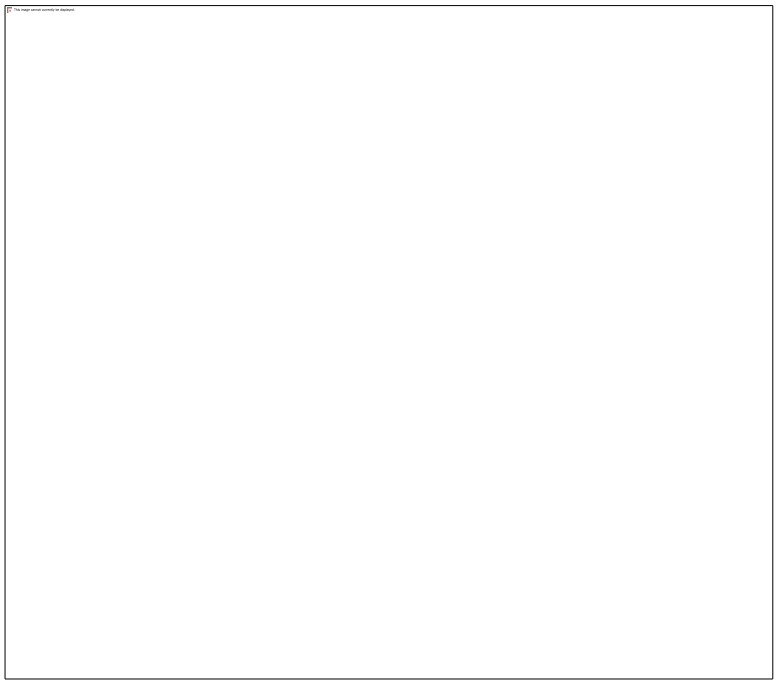
Large landscaped compounds.

Sports grounds.

Waterlogged areas.

Some agricultural and open-site drainage projects.

3.5 Fan drainage layout



Definition: A fan drainage layout is an arrangement in which several drainage lines spread out from a common collection point or collector arrangement, forming a fan-like pattern.

The pipes are arranged to collect groundwater from a wider area and guide it towards a suitable collection or discharge point.

Characteristics

Drainage lines spread out like the blades of a fan.

The pipes cover a broad area.

The lines may converge towards a common collector or outlet.

The layout is suitable for certain wedge-shaped or fan-shaped sites.

Pipe gradients must be planned to maintain effective flow.

Advantages

Covers a broad area.

Can collect water from irregularly shaped sites.

May direct water towards one collection area.

Can be adapted to sites with varying boundaries.

Disadvantages

Pipe lengths and gradients may differ.

The arrangement can be difficult to set out accurately.

The main collection area may receive high flows.

It may be costly where many drainage lines are required.

Applications

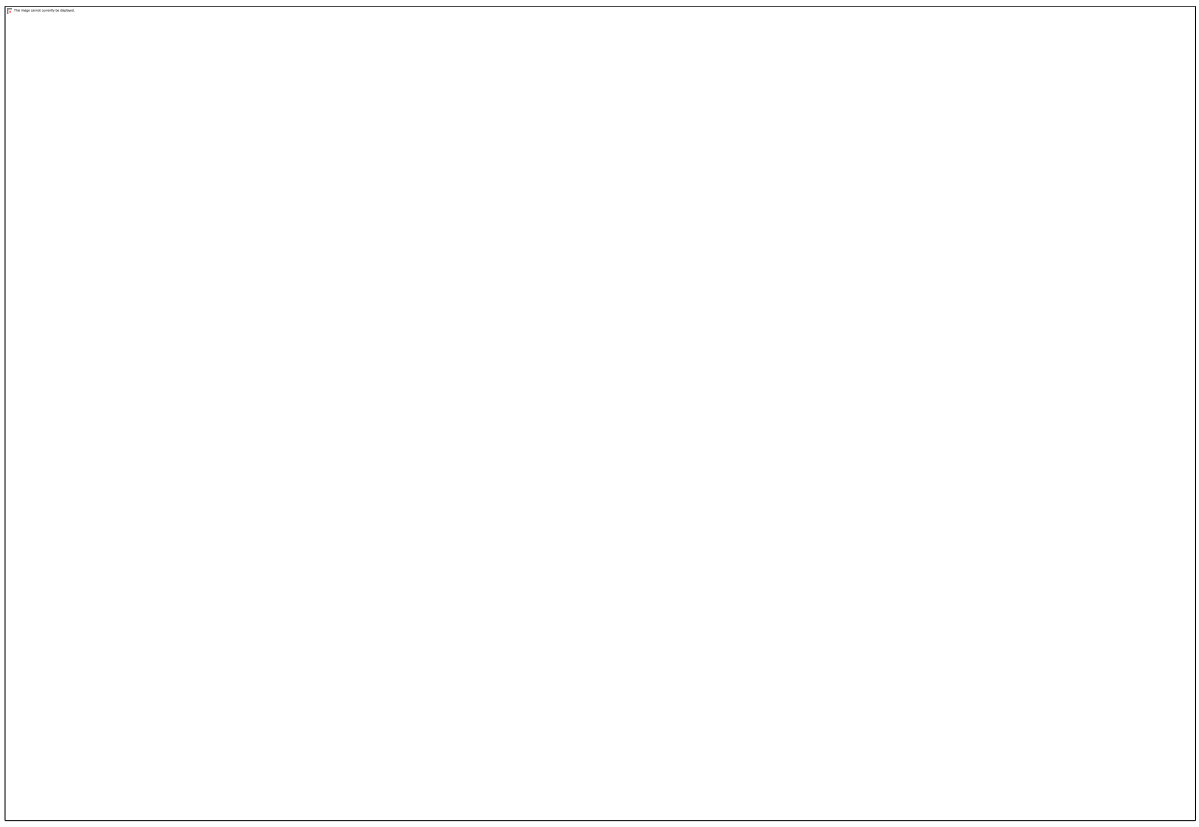
Irregularly shaped grounds.

Landscaped sites.

Some sloping or wedge-shaped areas.

Sites where drainage lines need to spread towards a common collection point.

3.6 Grid drainage layout



Definition: A grid drainage layout is an arrangement of drainage pipes laid in two or more intersecting directions to form a network resembling a grid.

Characteristics

Pipes are laid in an organised network.

Drainage lines may run in different directions.

The arrangement forms rectangular or square sections.

Junctions connect different drainage lines.

The network collects groundwater from several parts of the site.

Advantages

Covers a large area.

Provides several drainage routes.

Can be suitable for regularly shaped sites.

Allows groundwater to be collected from different sections.

Disadvantages

Requires more pipework than some simpler layouts.

It may be expensive to construct.

It has several junctions that require careful installation.

Poor design may cause uneven flow or unnecessary pipe intersections.

Applications

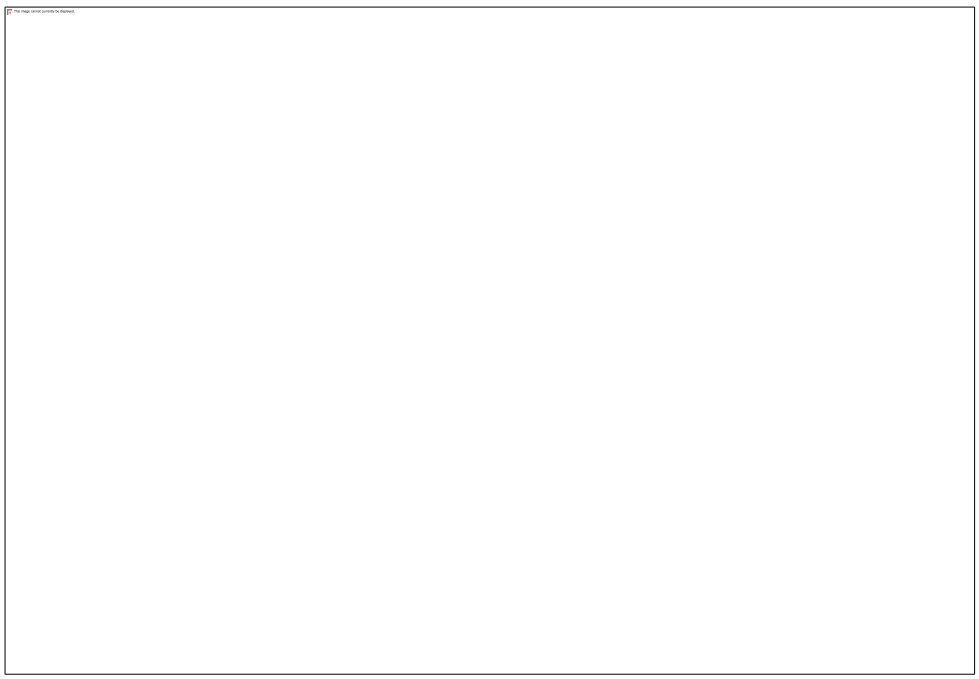
Large institutional compounds.

Some sports facilities.

Large landscaped areas.

Sites requiring drainage coverage in more than one direction.

3.7 Parallel drainage layout



Definition: A parallel drainage layout is an arrangement in which several drainage pipes are laid parallel to one another, usually at fairly regular spacing, to collect groundwater from an area.

The parallel lines may discharge into a collector drain positioned along one side or at the lower end of the site.

Characteristics

The drainage pipes run in the same general direction.

The lines are usually arranged at regular intervals.

They may connect to a main collector drain.

The layout is commonly suitable for rectangular or elongated areas.

The spacing depends on soil permeability, groundwater conditions and the required drainage performance.

Advantages

Simple to set out.

Easy to understand and plan.

Can provide relatively uniform drainage over an area.

Makes it easier to estimate pipe lengths and materials.

Suitable for regularly shaped sites.

Disadvantages

It may require a long collector drain.

It may not suit highly irregular sites.

Incorrect spacing may leave some areas waterlogged.

It requires a suitable outlet and carefully planned gradients.

Applications

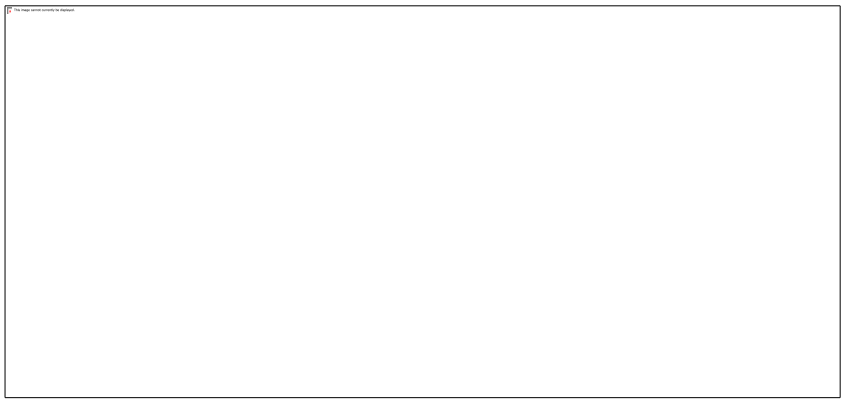
Sports grounds.

Agricultural fields.

Large open grounds.

Rectangular landscaped areas.

3.8 Branching drainage layout



Definition: A branching drainage layout is an arrangement in which smaller drainage pipes join larger collector pipes through a series of branches, resembling the branches of a tree.

Characteristics

It consists of a main drainage line.

Smaller branches connect to the main line.

The branches collect water from different sections of the site.

The main line conveys the collected water towards an outlet.

The network can be adapted to irregular site shapes.

Advantages

Can cover irregularly shaped sites.

Allows several drainage areas to connect to one main collector.

Can be expanded by adding suitable branches.

May reduce the need for separate outlets.

Disadvantages

Junctions require careful design.

Blockages in the main line may affect several branches.

The main collector must accommodate the combined flow.

Inspection and maintenance require proper access points.

Applications

Large building compounds.

Sites with irregular boundaries.

Landscaped grounds.

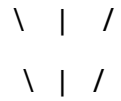
Areas where several smaller drainage zones feed one main outlet.

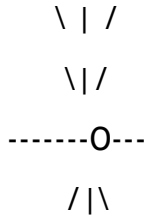
3.9 Comparison of subsurface drainage layouts

Layout	Arrangement	Main characteristic	Suitable site conditions
Radial	Pipes extend from a central collection area.	Spoke-like arrangement.	Sites with a central collection point.
Herringbone	Lateral pipes enter a main collector from both sides.	Fishbone-like arrangement.	Long sites requiring collection from both sides.
Fan	Pipes spread out in a fan-like pattern.	Broad coverage from a common collection arrangement.	Wedge-shaped or irregular sites.
Grid	Pipes form an intersecting network.	Square or rectangular pattern.	Large areas requiring drainage in several directions.
Parallel	Pipes run alongside one another.	Regularly spaced drainage lines.	Rectangular or elongated sites.
Branching	Smaller pipes connect to larger collector lines.	Tree-like arrangement.	Irregular sites with several drainage zones.

3.10 Simplified plan sketches of drainage layouts

A. Radial layout

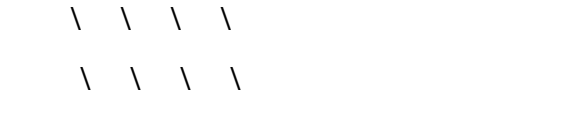




O = Central collection point

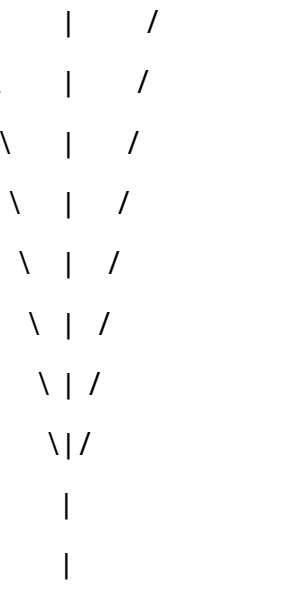
Lines = Drainage pipes

B. Herringbone layout



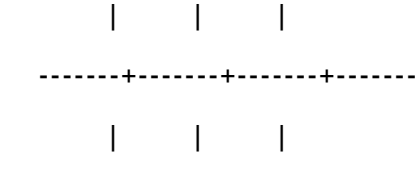
Main collector with angled laterals

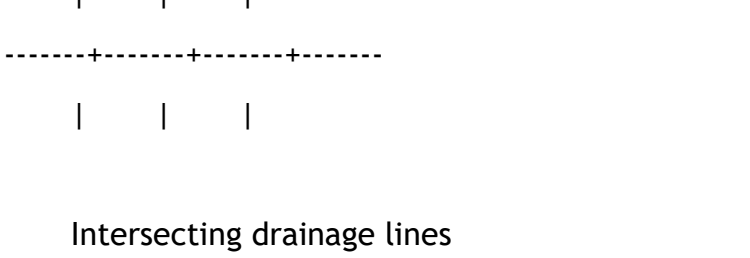
C. Fan layout



Outlet Drainage lines spread in a fan pattern

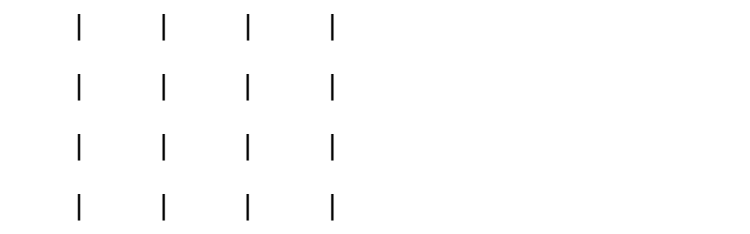
D. Grid layout





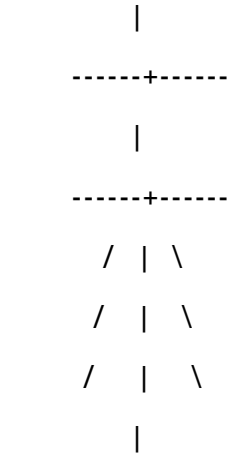
Intersecting drainage lines

E. Parallel layout



Collector

F. Branching layout



Outlet

Main drain with smaller branches

Important drawing note: In actual drainage plans, the arrows showing the direction of flow should be included. The lines must also be connected in a way that ensures gravity flow or another approved means of conveyance.

4.0 Factors considered when selecting a subsurface drainage layout

The choice of a drainage pattern depends on the physical and environmental characteristics of the construction site.

Shape of the site

Regular rectangular sites may be suitable for parallel or grid layouts.

Irregular sites may require branching, fan or radial arrangements.

Ground slope

The natural slope influences the direction of water movement.

Drainage pipes should be arranged to convey water towards a suitable outlet.

Soil type

Sandy soils generally allow water to move more easily than heavy clay soils.

Fine soils may require suitable filter materials to reduce blockage.

Groundwater level

The depth of groundwater affects the required depth of drainage pipes.

A high groundwater level may require a more extensive drainage arrangement.

Rainfall conditions

Areas receiving heavy rainfall may experience greater groundwater recharge and runoff.

The drainage system should be suitable for the expected water conditions.

Position of buildings

Drainage lines should be positioned to protect foundations.

Excavation should not undermine existing structures.

Existing underground services

Water pipes, electrical cables, communication lines and sewer pipes must be identified before excavation.

Availability of an outlet

The site must have a suitable point for discharging collected groundwater.

Discharge must not cause flooding or damage to neighbouring land.

Construction cost

Consider excavation, pipes, gravel, filter materials, chambers and labour.

Select a practical layout that meets the drainage requirements.

Maintenance requirements

Provide access points where inspection and cleaning may be necessary.

Avoid unnecessary bends and inaccessible junctions.

Environmental considerations

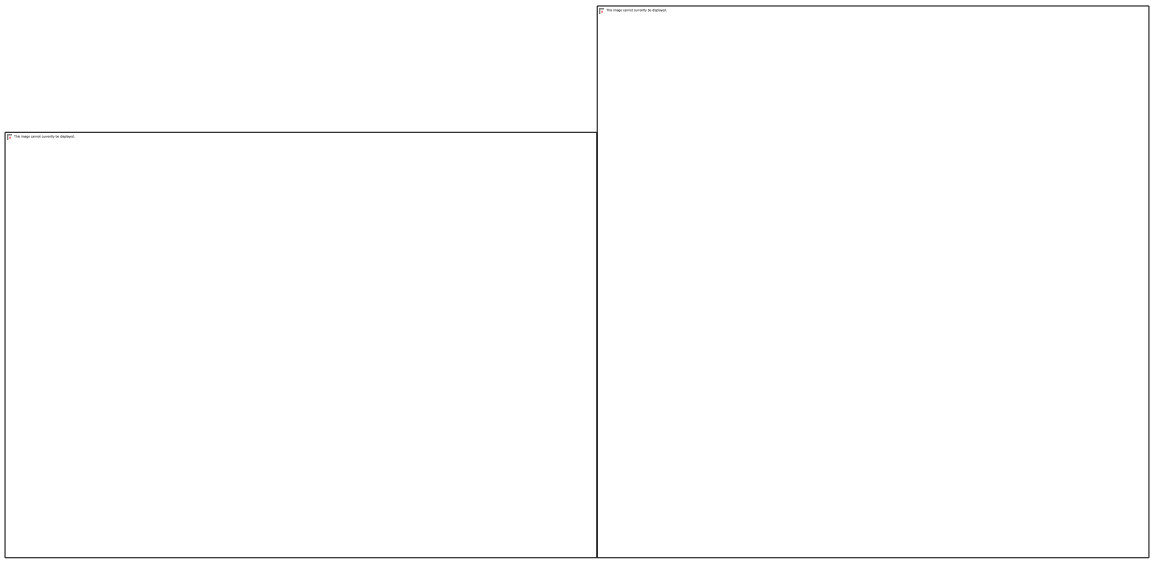
Prevent erosion, pollution and uncontrolled discharge.

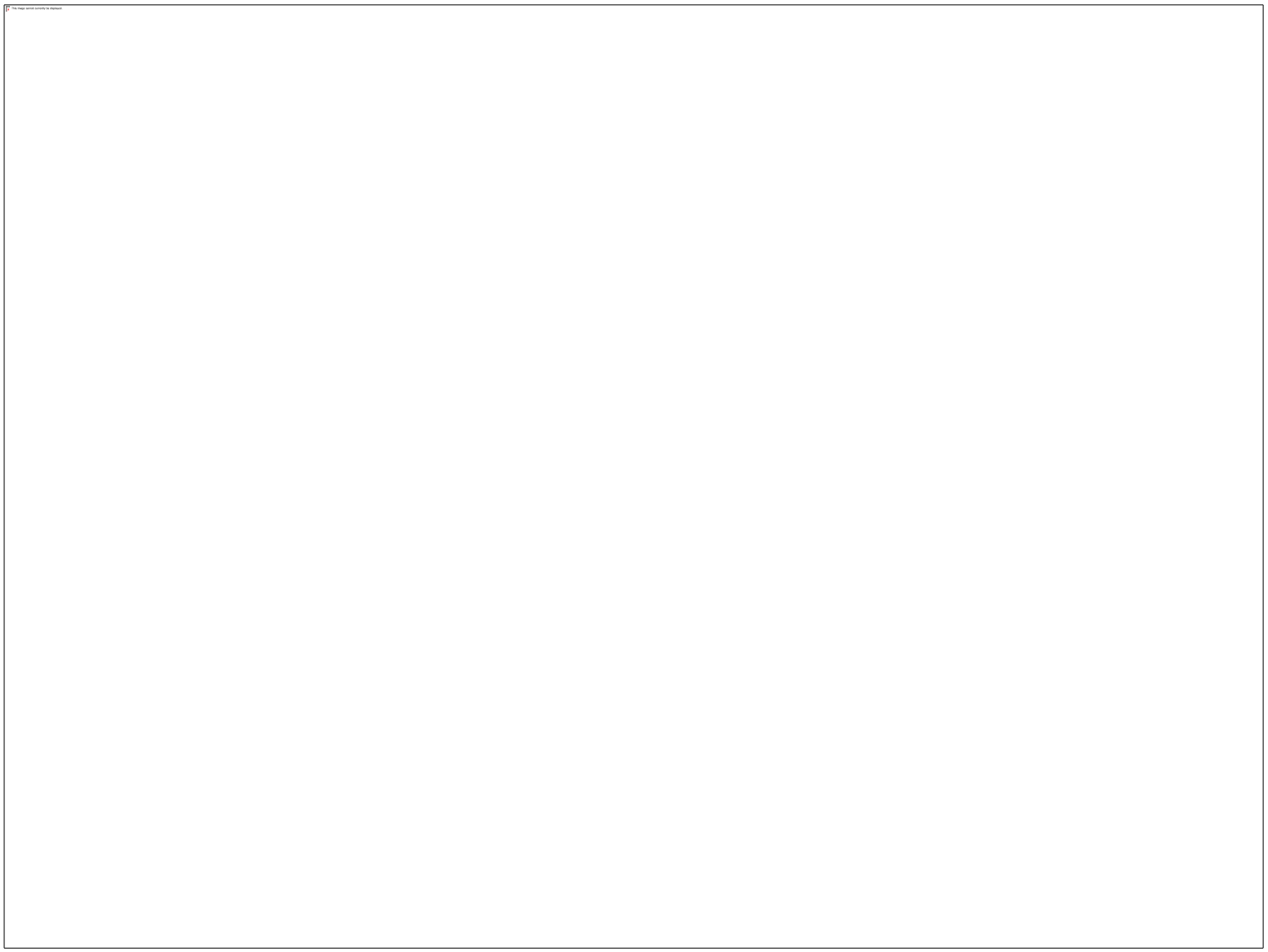
Protect natural watercourses and neighbouring properties.

Intended use of the site

Residential compounds, sports grounds, industrial sites and agricultural areas have different drainage needs.

5.0 Importance of an efficient drainage system in a building





An efficient drainage system is essential for the durability, safety, hygiene and functionality of a building.

5.1 Protects building foundations

Excess water around foundations can soften certain soils.

Changes in soil moisture may cause movement in some ground conditions.

Poor drainage may contribute to settlement, cracking and structural damage.

Effective drainage directs water away from foundation areas.

5.2 Prevents flooding

Drains remove excess rainwater from the building compound.

They prevent water from accumulating in low-lying areas.

They reduce the likelihood of water entering rooms, stores and basements.

5.3 Prevents dampness in buildings

Water accumulating near walls may enter the building through porous materials or defective joints.

Dampness can damage plaster, paint, timber and floor finishes.

Proper drainage reduces prolonged contact between water and building elements.

5.4 Prevents soil erosion

Uncontrolled runoff can wash away topsoil.

It may expose foundations and underground services.

Proper channels control the movement of surface water and reduce erosion.

5.5 Protects roads and footpaths

Standing water can weaken road and pavement layers.

Water may damage paving blocks and concrete surfaces.

Drainage channels direct runoff away from movement areas.

5.6 Promotes public health

Stagnant water can provide breeding places for mosquitoes.

Poorly managed wastewater can spread disease-causing microorganisms.

Effective drainage reduces stagnant water and supports a clean environment.

5.7 Improves safety

It reduces slippery surfaces caused by standing water.

It reduces flooding on access routes.

It helps prevent erosion and undermining around paths and structures.

5.8 Protects construction materials

Excess moisture may damage cement-based materials, timber and stored construction materials.

Wet storage conditions may cause corrosion of metal components.

Good drainage helps keep construction areas and storage facilities dry.

5.9 Improves the appearance of a site

Proper drainage prevents muddy and waterlogged areas.

It supports neat landscaping and usable outdoor spaces.

It improves the general appearance of residential and institutional compounds.

5.10 Improves the usability of the building

Well-drained compounds remain accessible during rainy periods.

Parking areas, walkways and playgrounds can be used more safely.

Water does not accumulate unnecessarily around entrances.

5.11 Reduces maintenance costs

Proper drainage reduces water-related damage.

It lowers the need for frequent repairs to foundations, pavements and finishes.

It extends the service life of some building components.

5.12 Protects neighbouring properties and the environment

Properly directed runoff reduces the risk of flooding neighbouring plots.

Controlled discharge reduces erosion.

Suitable wastewater treatment and disposal protect soil and water resources.

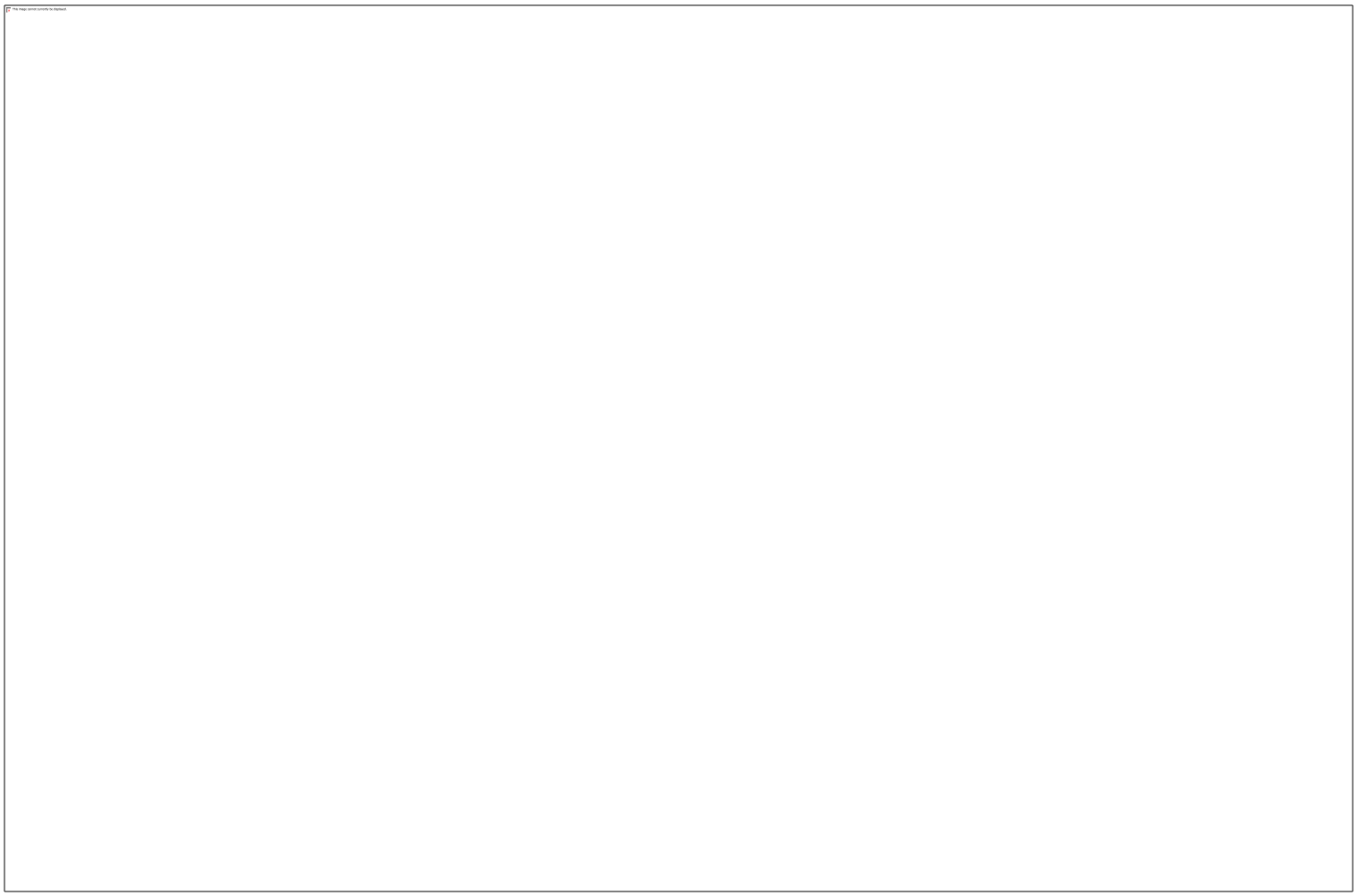
6.0 Layout of a subsurface drainage system on a construction site

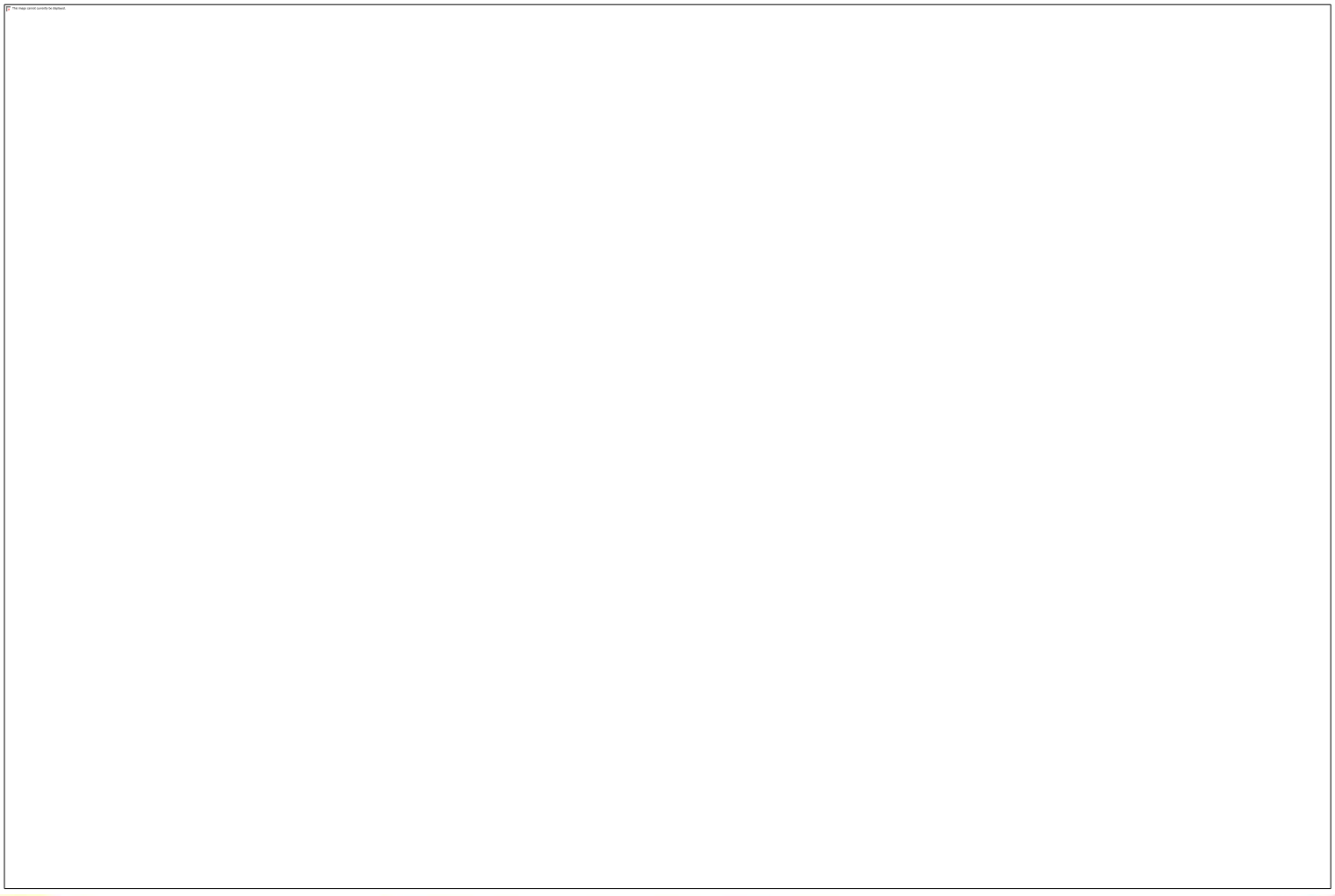
6.1 Meaning of a site drainage layout

A site drainage layout is a drawing or plan showing the positions, routes, connections and discharge points of drainage facilities within a construction site.

A subsurface drainage layout specifically shows the arrangement of buried drainage pipes and related structures used to remove groundwater from the site.







6.2 Information shown on a subsurface drainage layout plan

A properly prepared drainage layout plan may show the following:

1. **Site boundaries**

Indicate the limits of the construction site.

Help establish where drainage facilities can be installed.

2. **Building positions**

Show the location of existing and proposed buildings.

Help prevent drainage pipes from interfering with foundations.

3. **Ground contours**

Indicate changes in ground elevation.

Help the designer determine the direction of natural water movement.

4. **Drainage trenches**

Show the routes where underground drainage pipes will be installed.

Indicate the areas from which groundwater will be collected.

5. **Lateral drainage pipes**

Show smaller drainage lines that collect water from different sections of the site.

6. **Main collector drain**

Show the main pipe that receives water from lateral drains.

It conveys collected water towards an appropriate outlet.

7. **Inspection chambers**

Show access points for inspecting and maintaining the drainage system.

8. **Manholes**

Show larger access structures where required by the design.

9. **Outfall or discharge point**

Indicate where collected water leaves the drainage system.

10. **Pipe gradients and flow directions**

Indicate the direction in which water is expected to flow.

Show the designed falls or levels needed for effective drainage.

11. **Pipe sizes and materials**

Indicate the specified pipe diameters and materials.

12. **Existing underground services**

Show the position of water supply pipes, sewer lines, electrical cables and other buried services where known.

13. **Legend and symbols**

Explain the symbols used to represent pipes, chambers, outlets and other drainage structures.

6.3 Factors considered when preparing a site drainage layout

1. **Site survey**

Carry out a survey to establish the boundaries, levels and physical features of the site.

Identify low-lying areas where water may collect.

2. **Soil investigation**

Determine the soil type and its drainage characteristics.

Establish whether the soil allows water to infiltrate or retains moisture.

3. **Groundwater investigation**

Establish the groundwater level and whether it changes seasonally.

Identify areas where groundwater may affect foundations or underground structures.

4. **Topography**

Study the natural slope of the site.

Plan drainage routes that take advantage of suitable natural falls.

5. **Position of buildings**

Keep drainage routes appropriately separated from foundations.

Avoid excavation that may weaken building support.

6. **Existing drainage facilities**

Identify nearby drains, sewers and approved discharge points.

Confirm whether they have sufficient capacity to receive additional water.

7. **Underground services**

Locate existing buried services before excavation.

Coordinate the drainage route with other service installations.

8. **Type of drainage layout**

Select an appropriate pattern, such as parallel, herringbone, radial, fan, grid or branching.

9. **Pipe material and diameter**

Select suitable pipes based on the expected flow, soil conditions, loading and design requirements.

10. **Drainage gradient**

Provide suitable levels to enable water to flow towards the outlet.

Avoid reverse gradients and areas where water may stagnate.

11. **Maintenance access**

Provide suitable inspection chambers and access points.

Ensure that the drainage system can be inspected and cleaned.

12. **Environmental protection**

Prevent discharge from causing erosion, pollution or flooding.

Consider the protection of nearby watercourses and neighbouring properties.

6.4 Procedure for preparing a subsurface drainage layout

Step 1: Carry out a site inspection

Visit the site and observe its physical conditions.

Identify areas where water collects.

Examine existing drains and possible discharge points.

Identify buildings, roads, paths and other obstructions.

Step 2: Conduct a site survey

Measure the site boundaries.

Establish ground levels and contours.

Identify the natural direction of surface and groundwater movement.

Record the location of existing structures.

Step 3: Investigate soil and groundwater conditions

Examine the type of soil.

Establish whether the soil is permeable or poorly drained.

Investigate the groundwater level.

Identify possible seepage zones.

Step 4: Identify the drainage requirements

Determine the areas that require groundwater removal.

Establish the expected amount of water to be collected.

Consider the building foundations, basements and other structures that need protection.

Step 5: Select the appropriate drainage pattern

Choose a drainage layout that suits the site shape and ground conditions.

For example, parallel drains may be suitable for a regularly shaped open area.

A branching arrangement may suit a site with several drainage zones.

Step 6: Identify the main collector and outlet

Establish the route of the main collector drain.

Identify a suitable receiving point.

Confirm that the outlet can safely receive the collected water.

Step 7: Position the lateral drains

Arrange the lateral drainage pipes to collect water from the required areas.

Determine their spacing and direction from the drainage design.

Connect them appropriately to the collector.

Step 8: Locate inspection chambers

Position inspection chambers at appropriate junctions and changes in direction.

Provide access for future inspection and maintenance.

Step 9: Prepare the drainage drawing

Draw the site boundary and building positions.

Show the drainage lines and collector.

Mark inspection chambers and the outlet.

Indicate flow directions, pipe sizes, levels and other design information.

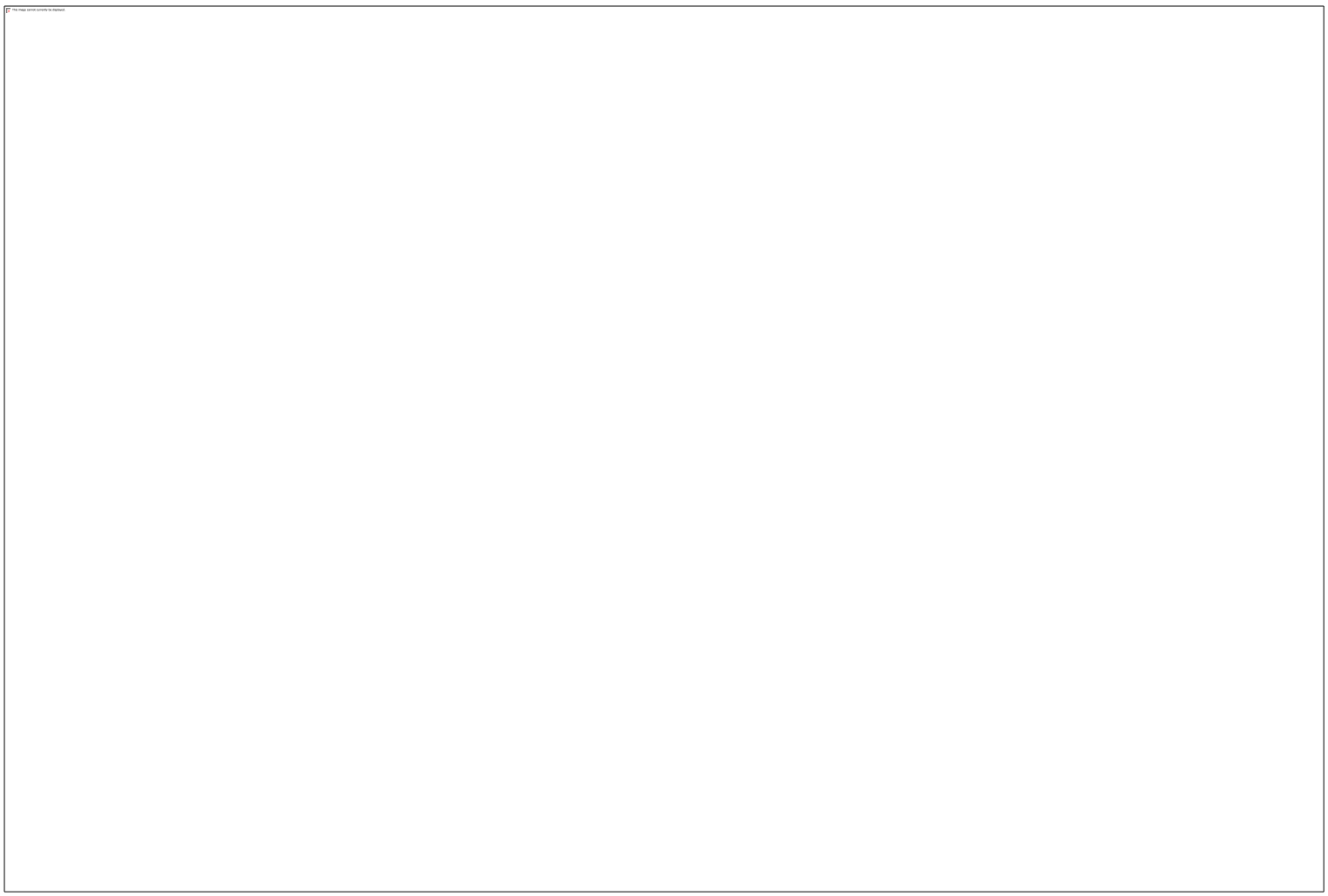
Step 10: Check the layout

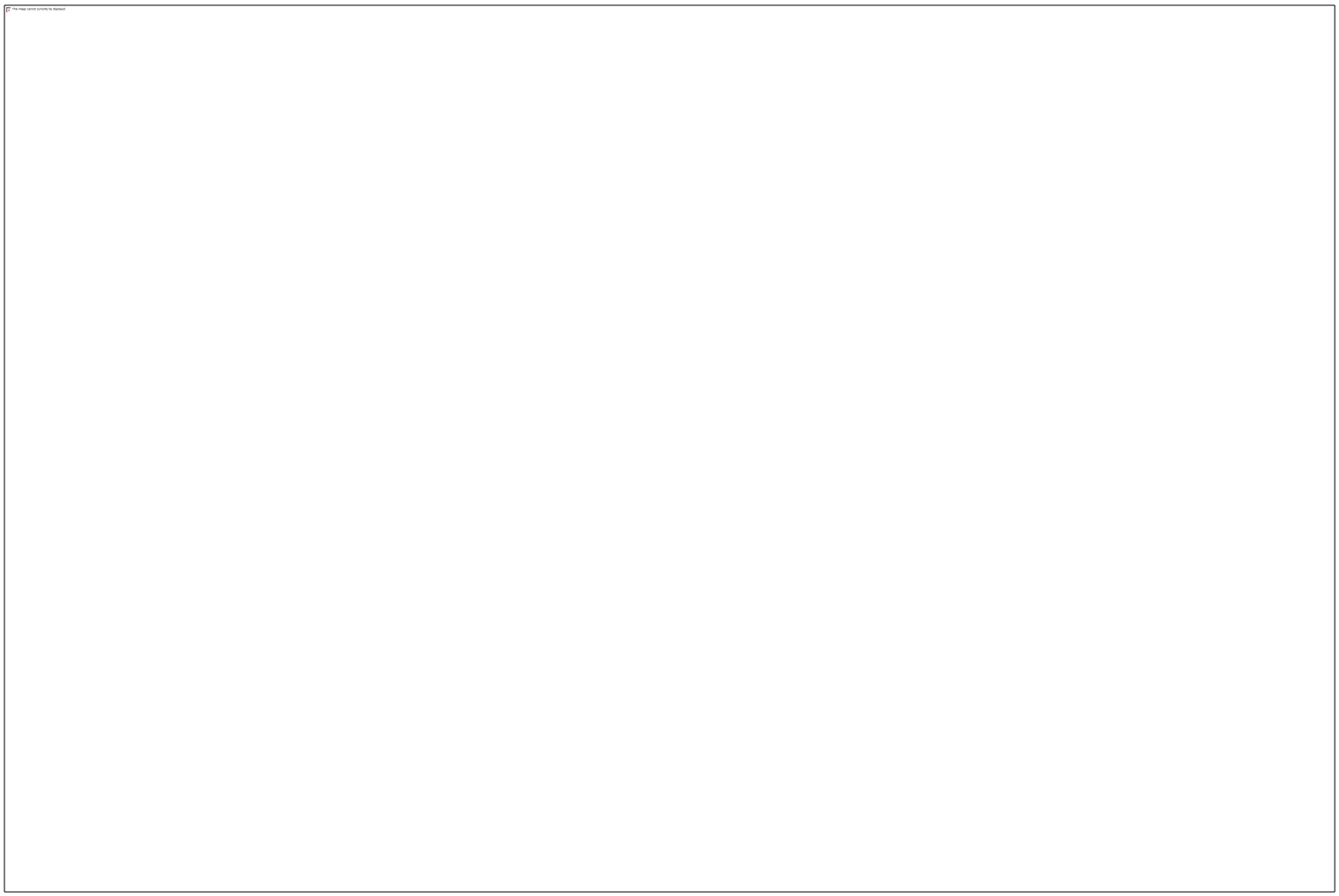
Confirm that the drainage arrangement is practical.

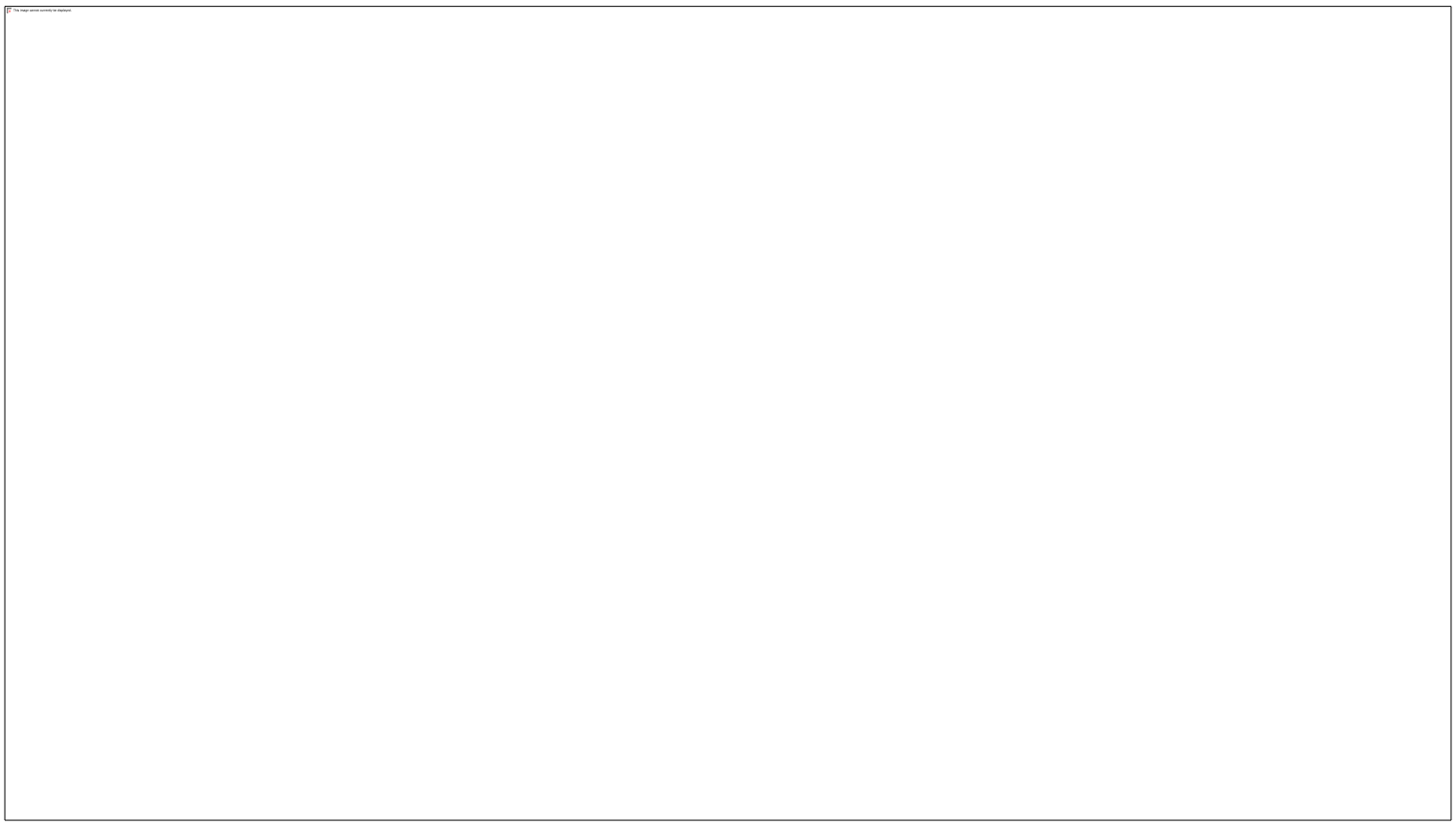
Check that the proposed routes do not interfere with foundations or underground services.

Ensure that collected water has a suitable discharge route.

6.5 Installation of a subsurface drainage system







After the drainage layout has been prepared and approved, the installation work can begin.

Step 1: Set out the drainage lines

Transfer the drainage routes from the plan onto the ground.

Mark the positions of the trenches and inspection chambers.

Identify and protect underground services.

Step 2: Excavate the trenches

Excavate trenches along the marked drainage routes.

Provide the required depth and width according to the design.

Ensure that excavation does not undermine nearby foundations.

Provide suitable protection against trench collapse.

Step 3: Prepare the trench base

Remove unsuitable material.

Prepare a stable and properly graded base.

Ensure that the trench follows the designed levels.

Step 4: Place filter material

Install suitable geotextile filter fabric where specified.

Provide an appropriate layer of clean gravel or coarse aggregate.

The filter materials should be selected to suit the surrounding soil.

Step 5: Lay the perforated drainage pipes

Place the perforated pipes along the prepared trench.

Follow the designed gradient and alignment.

Connect the pipes using appropriate fittings.

Ensure that joints are secure.

Step 6: Connect lateral drains to the collector

Connect smaller drainage lines to the main collector.

Use suitable junction fittings.

Ensure that the connections permit smooth flow.

Step 7: Provide inspection chambers

Install inspection chambers at the locations shown on the plan.

Ensure that they are accessible for maintenance.

Provide suitable covers.

Step 8: Surround the pipes with filter aggregate

Place the specified gravel or coarse aggregate around the pipes.

Avoid using contaminated material that may block the perforations.

Step 9: Wrap the filter fabric where specified

Fold the geotextile over the filter aggregate.

This helps separate the drainage material from surrounding soil.

Ensure that the arrangement follows the design details.

Step 10: Backfill the trench

Place suitable backfill material.

Compact it carefully where appropriate.

Avoid damaging the pipes during backfilling.

Step 11: Connect the outlet

Connect the collector to the approved discharge point.

Provide erosion protection where necessary.

Ensure that water does not discharge onto neighbouring property or create flooding.

Step 12: Inspect and test the system

Check the alignment and connections.

Confirm that water can flow through the drainage pipes.

Check inspection chambers and the outlet.

Correct defects before completing the work.

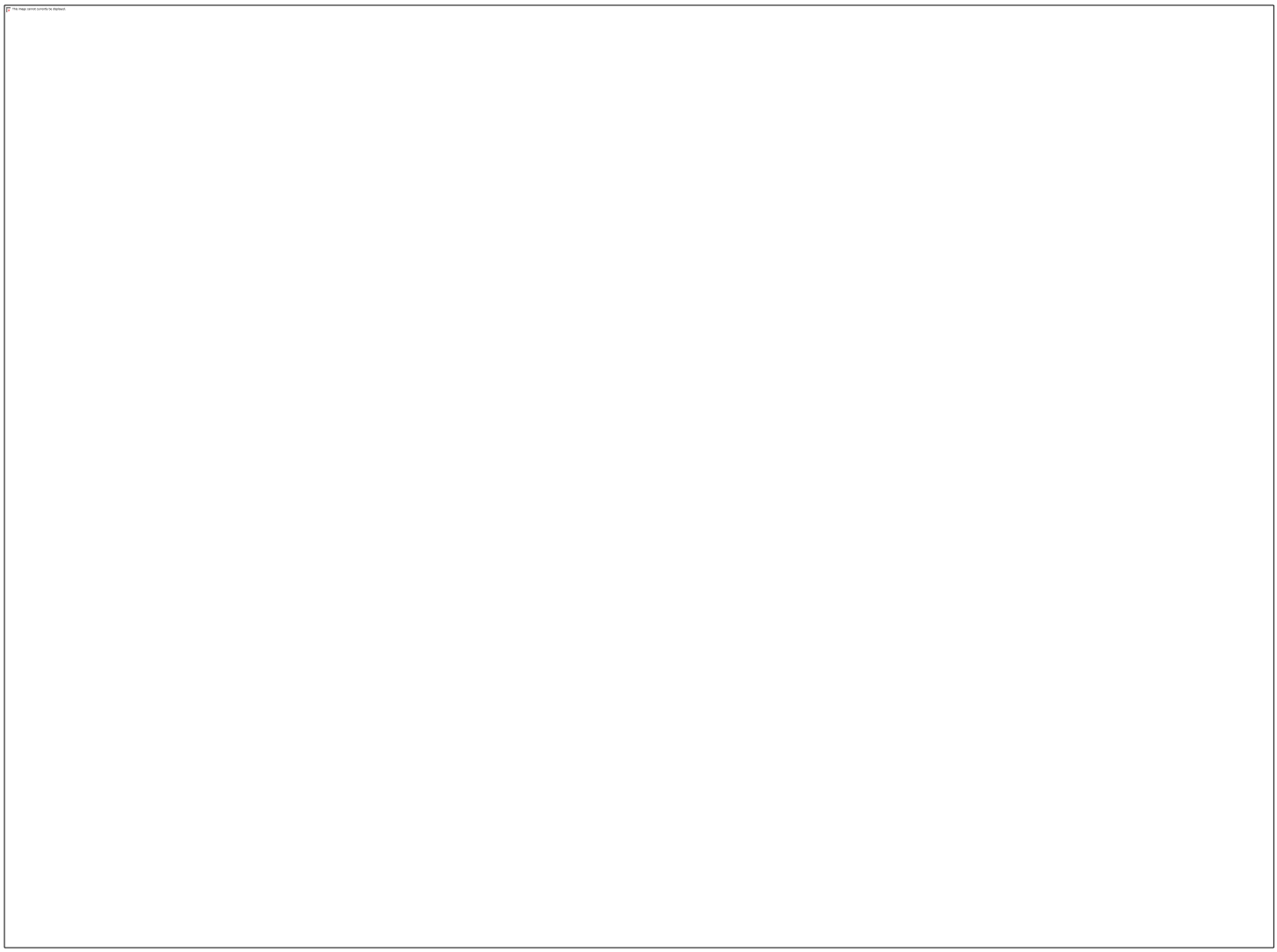
Safety note: Trenches must be protected against collapse. Workers should not enter unsafe excavations. Underground services must be identified before digging, and appropriate PPE and safe excavation procedures must be used.

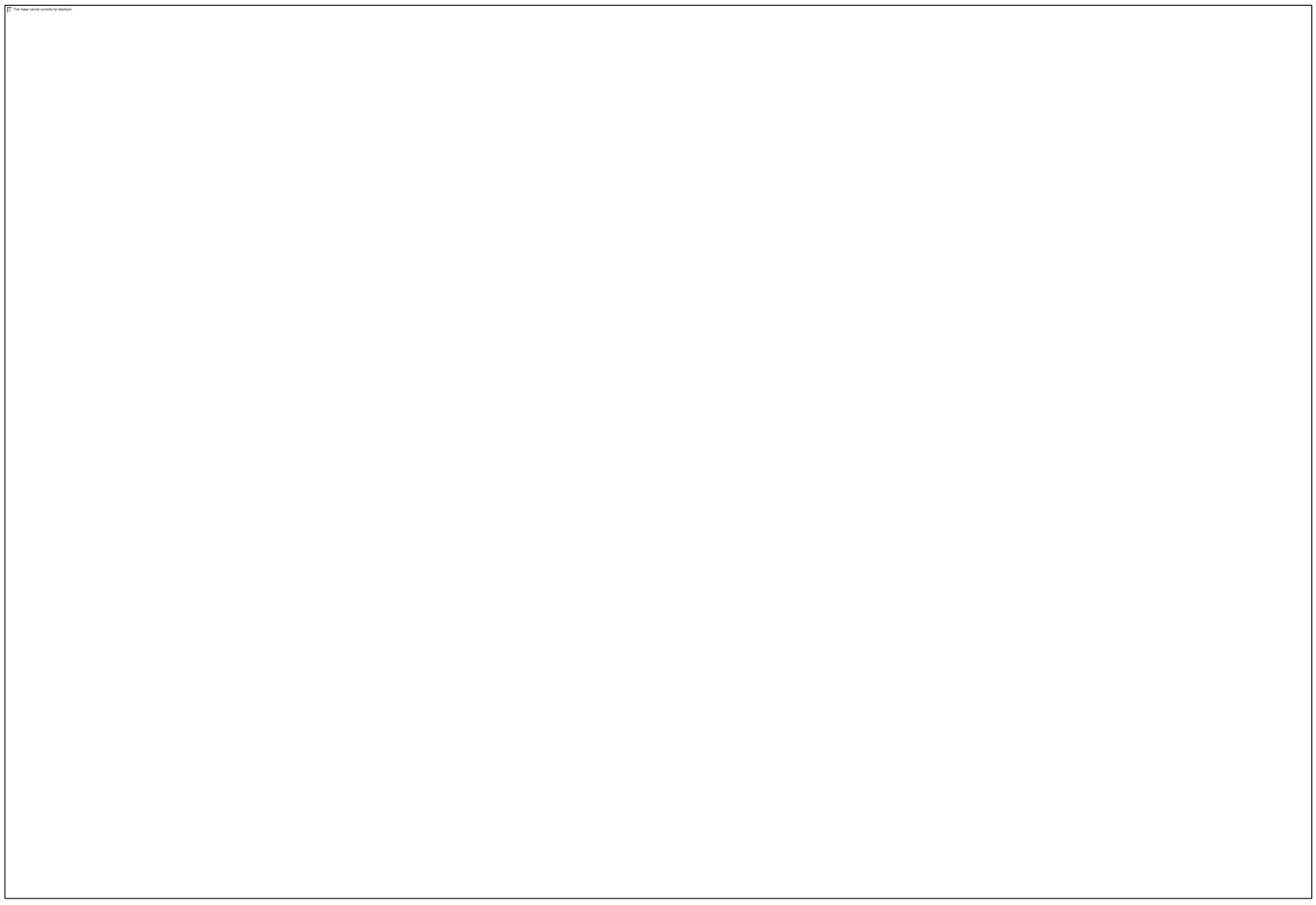
7.0 Drainage systems provided during construction work

During construction, temporary drainage facilities may be required before the permanent drainage system is completed.

Temporary drainage helps to keep the site workable and protects excavations, foundations, materials and workers.







7.1 Temporary surface drainage channels

Meaning: These are temporary channels constructed on a site to collect and divert rainwater away from active construction areas.

Uses

Divert rainwater away from foundation trenches.

Prevent flooding of working areas.

Protect stored construction materials.

Direct runoff towards suitable temporary collection points.

Reduce erosion around excavations.

7.2 Diversion drains

Meaning: Diversion drains are temporary or permanent channels constructed to redirect water away from a particular area.

Uses

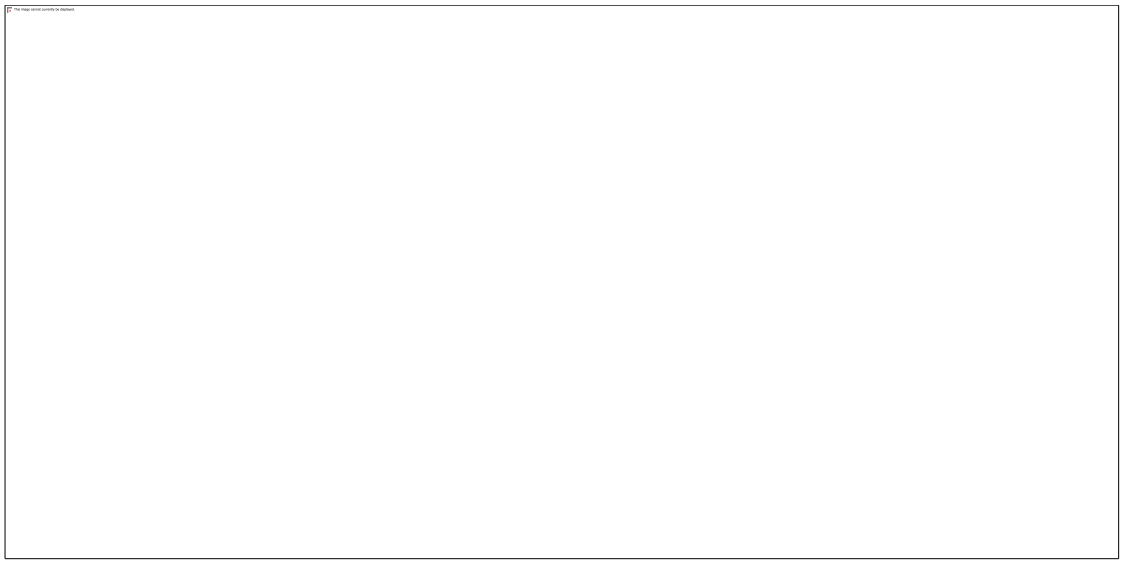
Divert runoff from higher ground around the construction site.

Prevent water from entering excavations.

Protect foundations and construction platforms.

Control the direction of surface water movement.

7.3 Sump drainage



Definition: Sump drainage is a method of collecting water in a small pit or low point from which it is removed using a pump or other suitable equipment.

Procedure

Identify the low point where water is likely to collect.

Prepare a suitable sump pit.

Direct water towards the sump.

Install a suitable pump where required.

Pump the collected water to an approved discharge point.

Monitor the sump to prevent overflow.

Advantages

Helps remove water from excavations.

Can be used during foundation construction.

Allows construction activities to continue in suitably dewatered areas.

Precautions

Do not discharge pumped water in a way that causes erosion or flooding.

Provide suitable sediment control where necessary.

Ensure that pumps and electrical connections are safely installed.

Monitor water levels and pump operation.

7.4 Dewatering systems

Definition: Dewatering is the process of lowering or controlling groundwater or removing accumulated water from an excavation or construction area.

Methods include:

Sump pumping.

Wellpoint systems.

Deep wells.

Ejector systems in suitable specialist applications.

Importance of dewatering

Keeps excavations relatively dry.

Helps provide suitable conditions for foundation construction.

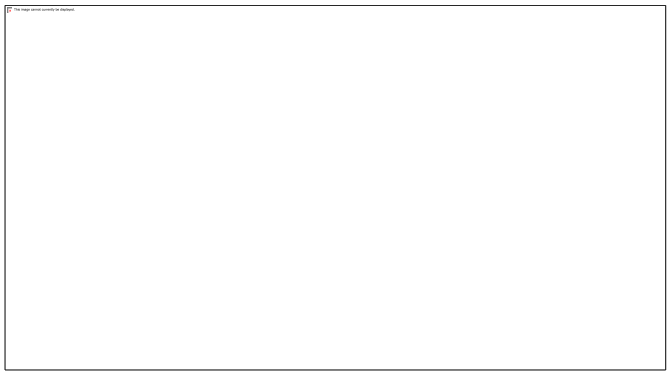
Reduces water-related instability in excavations.

Makes some construction activities easier.

Helps protect workers and materials.

Dewatering methods should be selected by competent professionals because excessive or poorly controlled groundwater removal can cause settlement or affect neighbouring structures.

7.5 Sediment and erosion control



Construction activities expose soil, which can be washed away by rainfall.

Sediment and erosion control measures include:

Silt fences.

Sediment traps.

Stabilised construction entrances.

Temporary vegetation cover.

Check dams in suitable channels.

Properly protected stockpiles.

Sediment settlement basins.

These measures help prevent soil particles from being carried into drainage systems and watercourses.

8.0 Difference between surface drainage, stormwater drainage and subsurface drainage

These terms are related, but they do not mean exactly the same thing.

Surface drainage	Stormwater drainage	Subsurface drainage
Removes excess water flowing or collecting on the ground surface.	Collects and conveys runoff resulting mainly from rainfall.	Removes excess water from below the ground surface.
May handle rainwater and other surface water.	Specifically deals with rainwater runoff.	Deals mainly with groundwater and water within the soil.
Uses open drains, channels and surface inlets.	Uses gutters, downpipes, channels, gullies and stormwater pipes.	Uses perforated pipes, gravel trenches and collector drains.
Usually visible at ground level.	May be visible or underground.	Mainly installed underground.
Helps prevent surface ponding and flooding.	Helps control runoff from roofs, roads and paved areas.	Helps reduce waterlogging and groundwater-related problems.
Example: an open concrete channel around a school compound.	Example: roof gutters connected to stormwater pipes.	Example: a French drain installed around a basement.

Remember:

Surface drainage describes the removal of water from the ground surface.

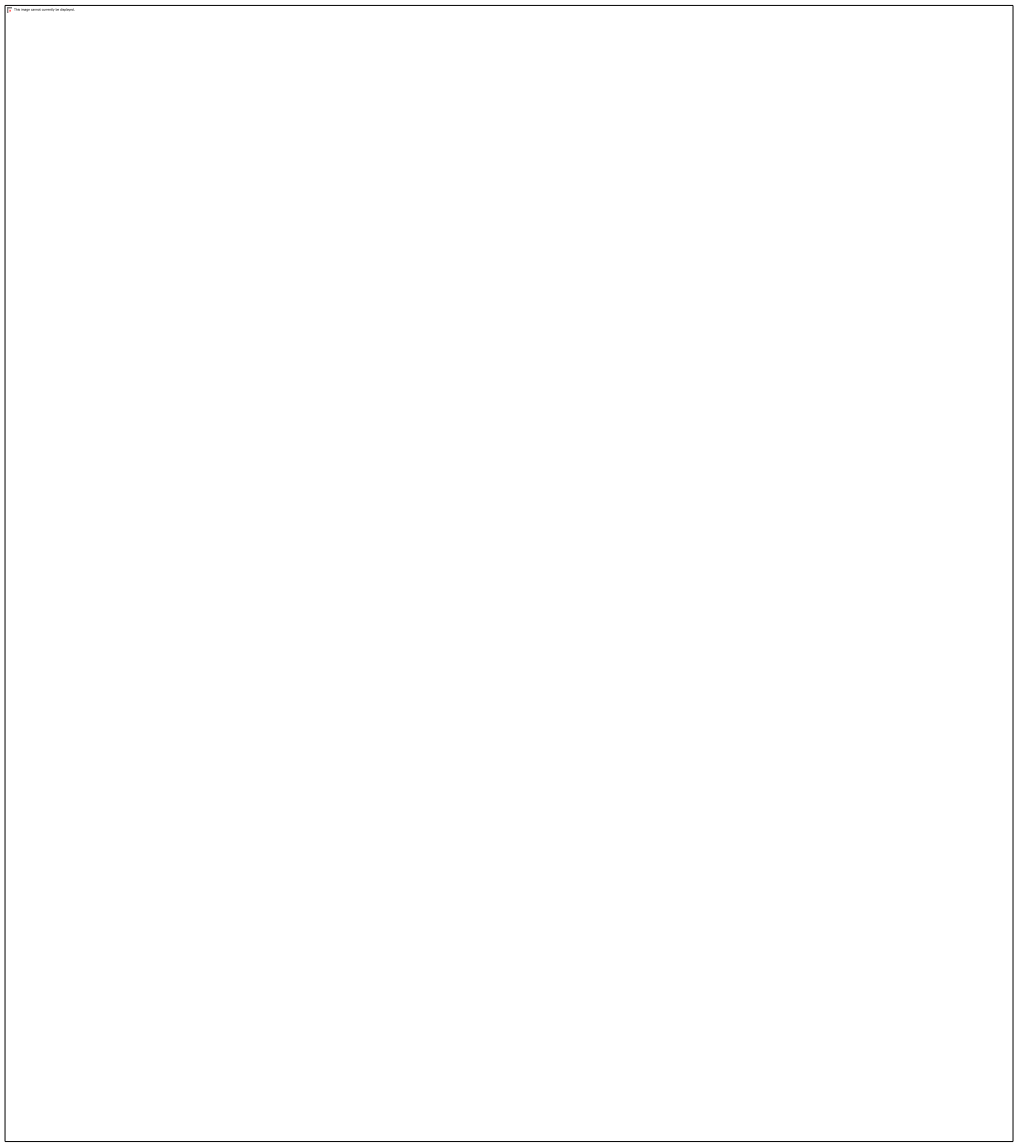
Stormwater drainage describes the collection and disposal of rainwater runoff.

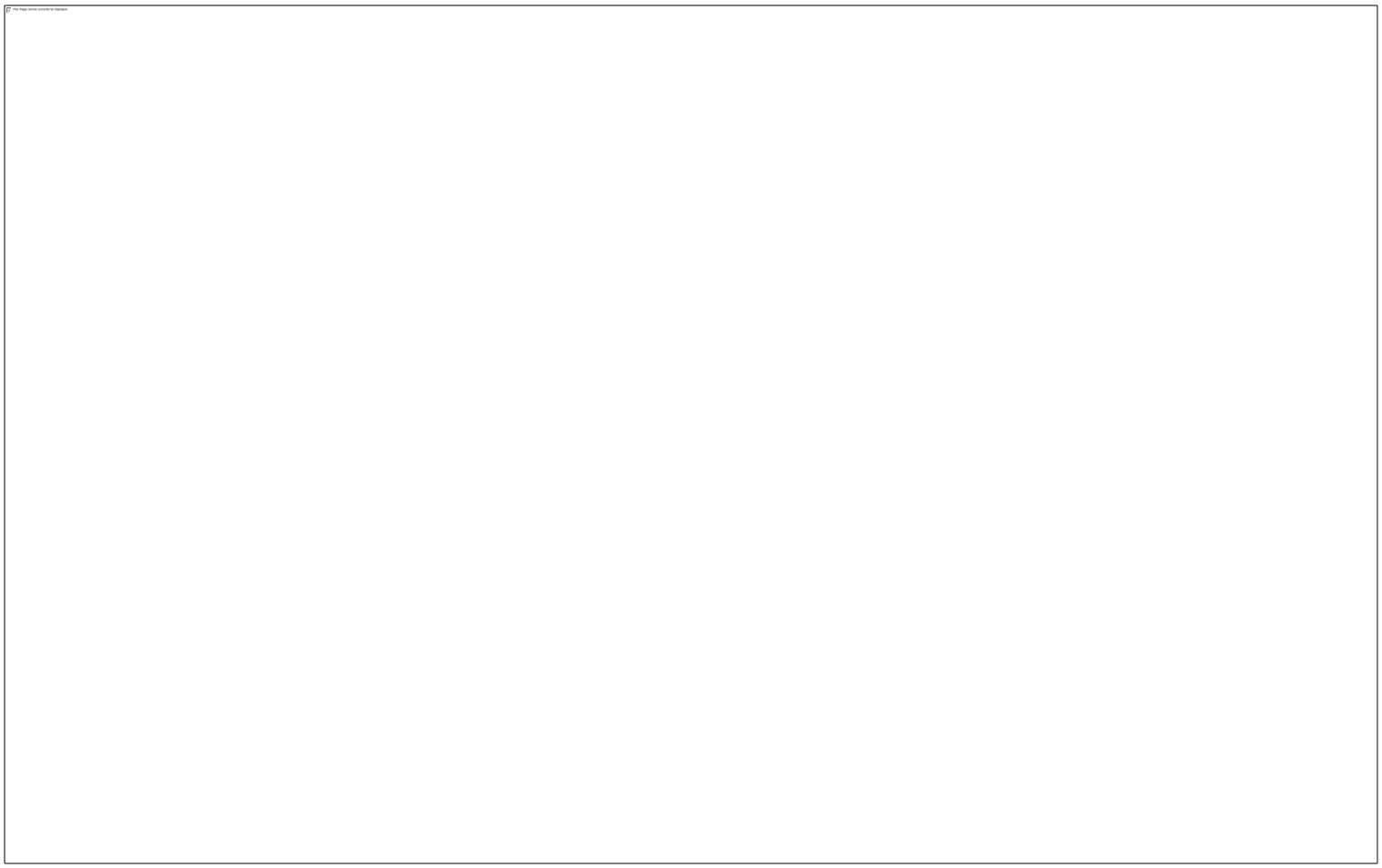
Subsurface drainage describes the removal of excess water from within the ground.

A stormwater system may include both surface channels and underground pipes.

9.0 Common drainage structures and their functions







9.1 Inspection chamber

Definition: An inspection chamber is a small access structure constructed along a drainage line to allow inspection, cleaning and maintenance of underground pipes.

Functions

Provides access to underground drainage pipes.

Allows inspection of drainage connections.

Helps locate blockages.

Provides access for cleaning equipment.

Facilitates maintenance at pipe junctions.

9.2 Manhole

Definition: A manhole is an access chamber constructed over an underground drainage system to allow inspection and maintenance by authorised personnel.

Functions

Provides access to larger underground drainage networks.

Allows inspection of drainage channels and pipes.

Facilitates maintenance and repair.

Provides access at important junctions and changes in direction.

9.3 Catch pit

Definition: A catch pit is a chamber that receives surface runoff and may retain some sediment and debris before water enters a drainage pipe.

Functions

Collects runoff from paved areas.

Allows some heavy particles to settle.

Protects downstream pipes from some debris.

Provides a point for cleaning and inspection.

9.4 Gully inlet

Definition: A gully inlet is a drainage opening or structure through which surface water enters an underground drainage system.

Functions

Collects water from surface channels.

Directs runoff into stormwater pipes.

Reduces ponding in paved areas.

May include a grating to prevent large objects entering the drain.

9.5 Soakaway

Definition: A soakaway is a structure designed to collect suitable water and allow it to infiltrate gradually into the surrounding ground.

Functions

Provides a means of managing suitable stormwater.

Reduces the amount of runoff leaving a site.

Supports groundwater recharge where conditions are suitable.

Can help manage rainwater from roofs and paved areas.

Conditions for using a soakaway

The soil must be capable of accepting the water.

The groundwater level must be suitable.

It must be located safely in relation to buildings and other structures.

It must not contaminate wells or other water sources.

It must comply with relevant design and approval requirements.

Important: A soakaway for stormwater is not automatically suitable for sewage or untreated wastewater.

9.6 Drainage outfall

Definition: An outfall is the final point at which water from a drainage system is discharged into an approved receiving facility or watercourse.

Functions

Provides a final discharge point.

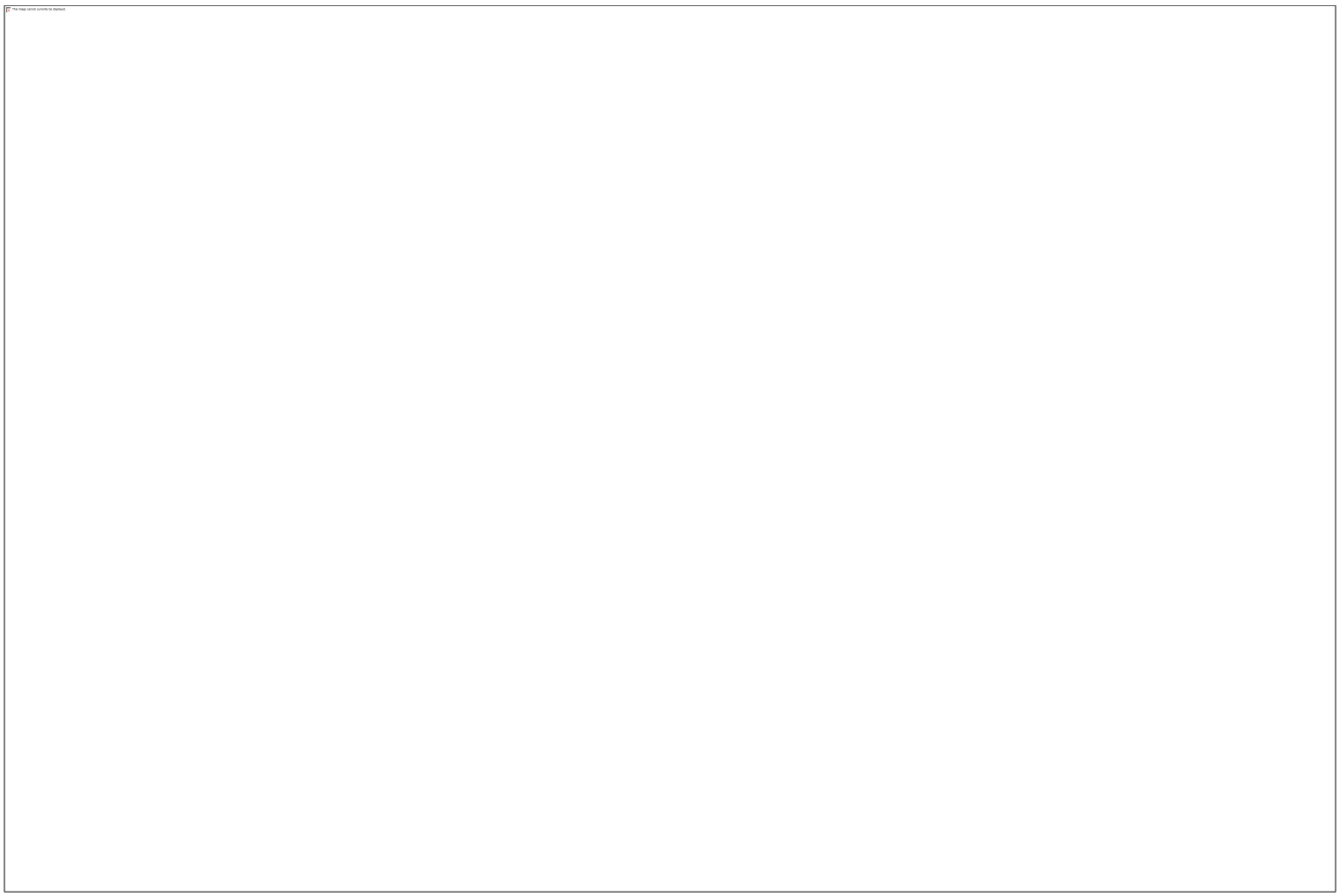
Allows collected water to leave the site.

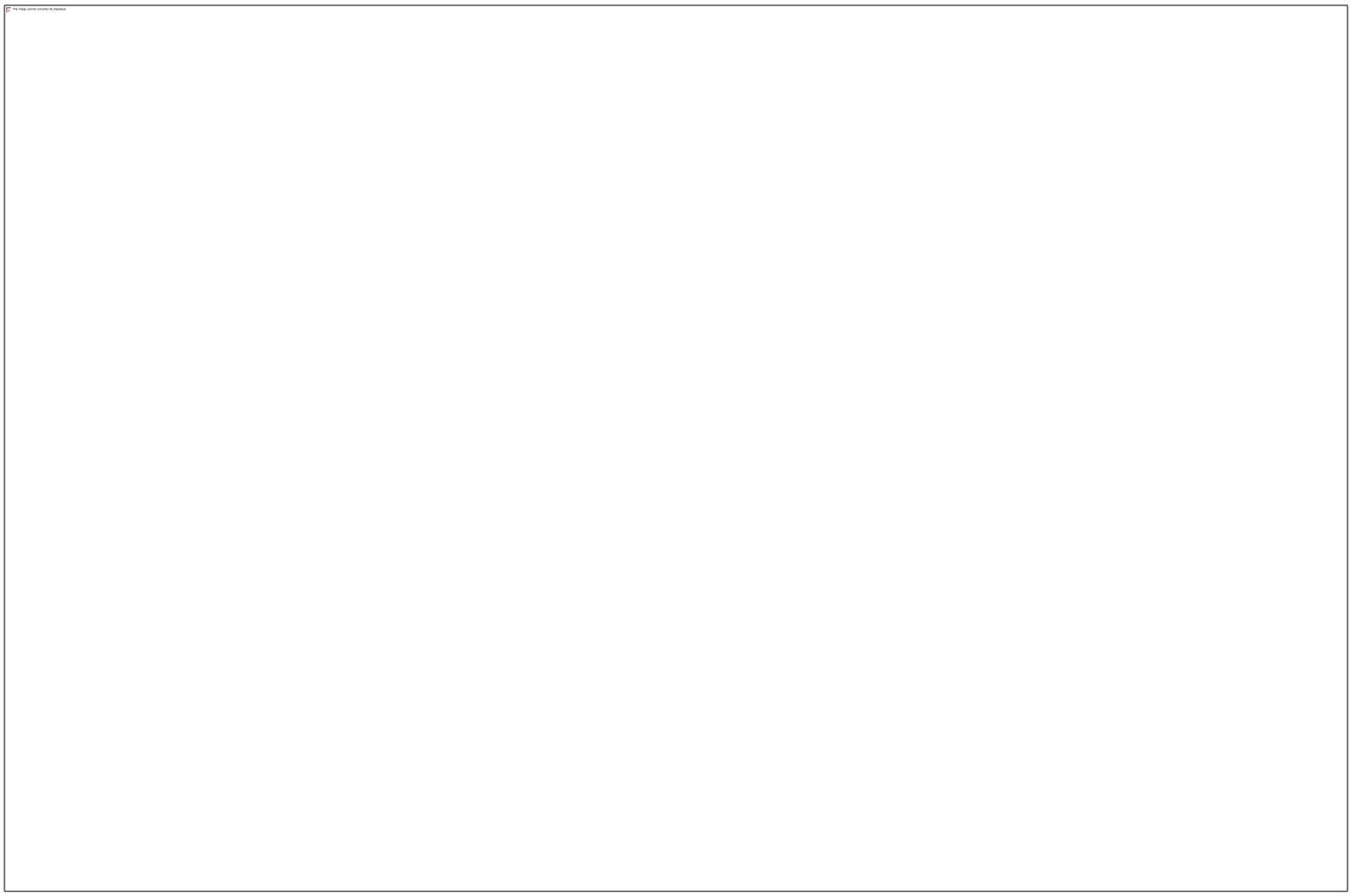
Helps direct water towards a suitable receiving system.

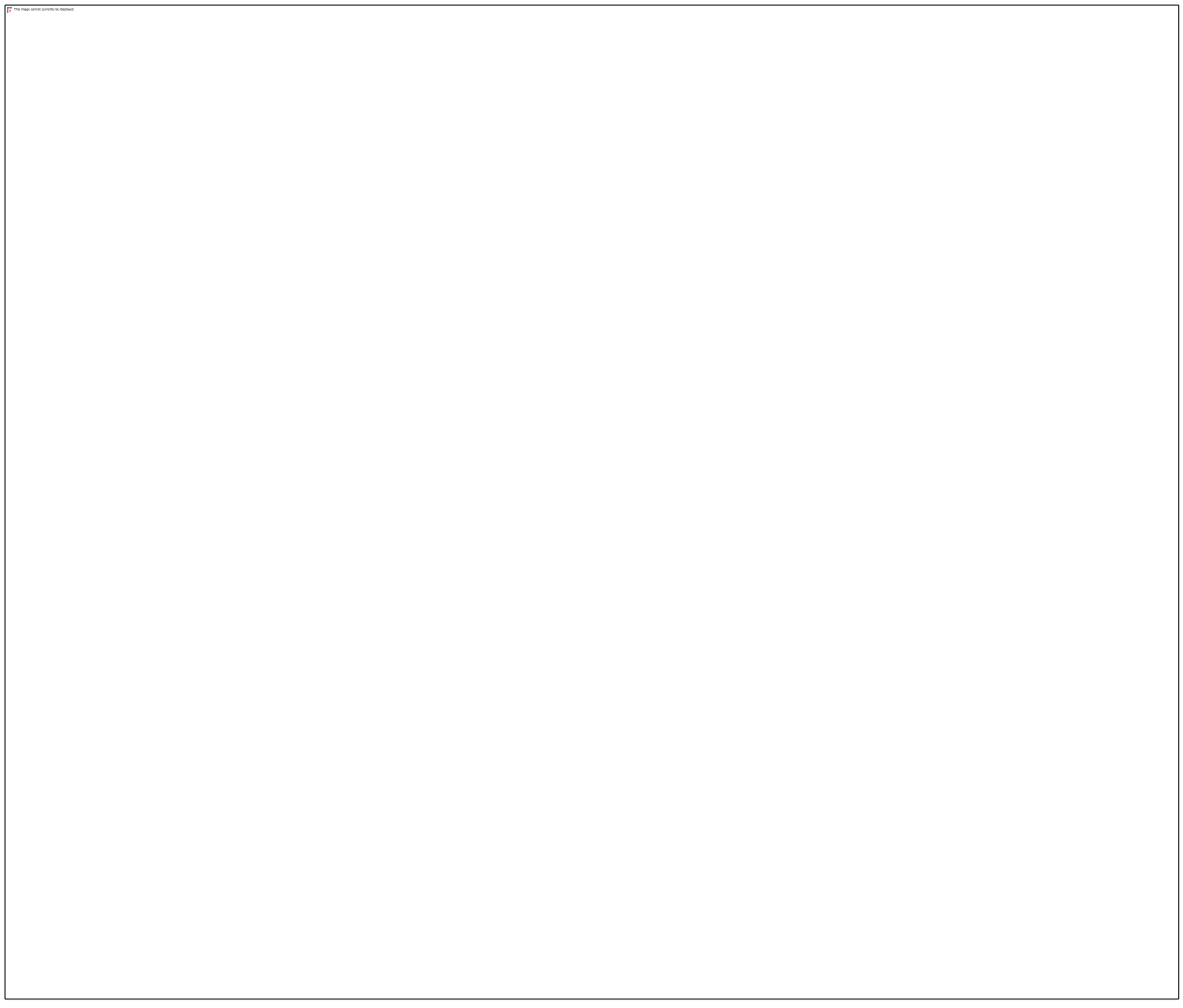
Should be designed to prevent erosion and flooding.

10.0 Maintenance of drainage systems

An efficient drainage system requires regular inspection and maintenance to ensure that water flows freely.







10.1 Importance of drainage maintenance

Prevents blockage of drainage pipes and channels.

Maintains the flow of water.

Reduces the risk of flooding.

Prevents foul smells from poorly maintained wastewater drains.

Extends the service life of drainage structures.

Helps identify damaged pipes and chambers early.

Reduces costly repairs.

Protects buildings and surrounding land.

10.2 Maintenance practices

Remove leaves, soil and rubbish from surface drains.

Clean roof gutters regularly.

Check downpipes for blockage.

Remove sediment from catch pits.

Inspect drainage channels for cracks and damage.

Check inspection chambers and manholes.

Inspect exposed pipes for leakage.

Repair damaged covers and gratings.

Check that stormwater outlets are not blocked.

Inspect subsurface drainage outlets for free discharge.

Remove roots and sediment using suitable methods.

Maintain erosion protection around outlets.

Keep unauthorised waste out of drainage systems.

Repair collapsed or damaged drainage sections.

Ensure that maintenance workers use suitable PPE and safe access procedures.

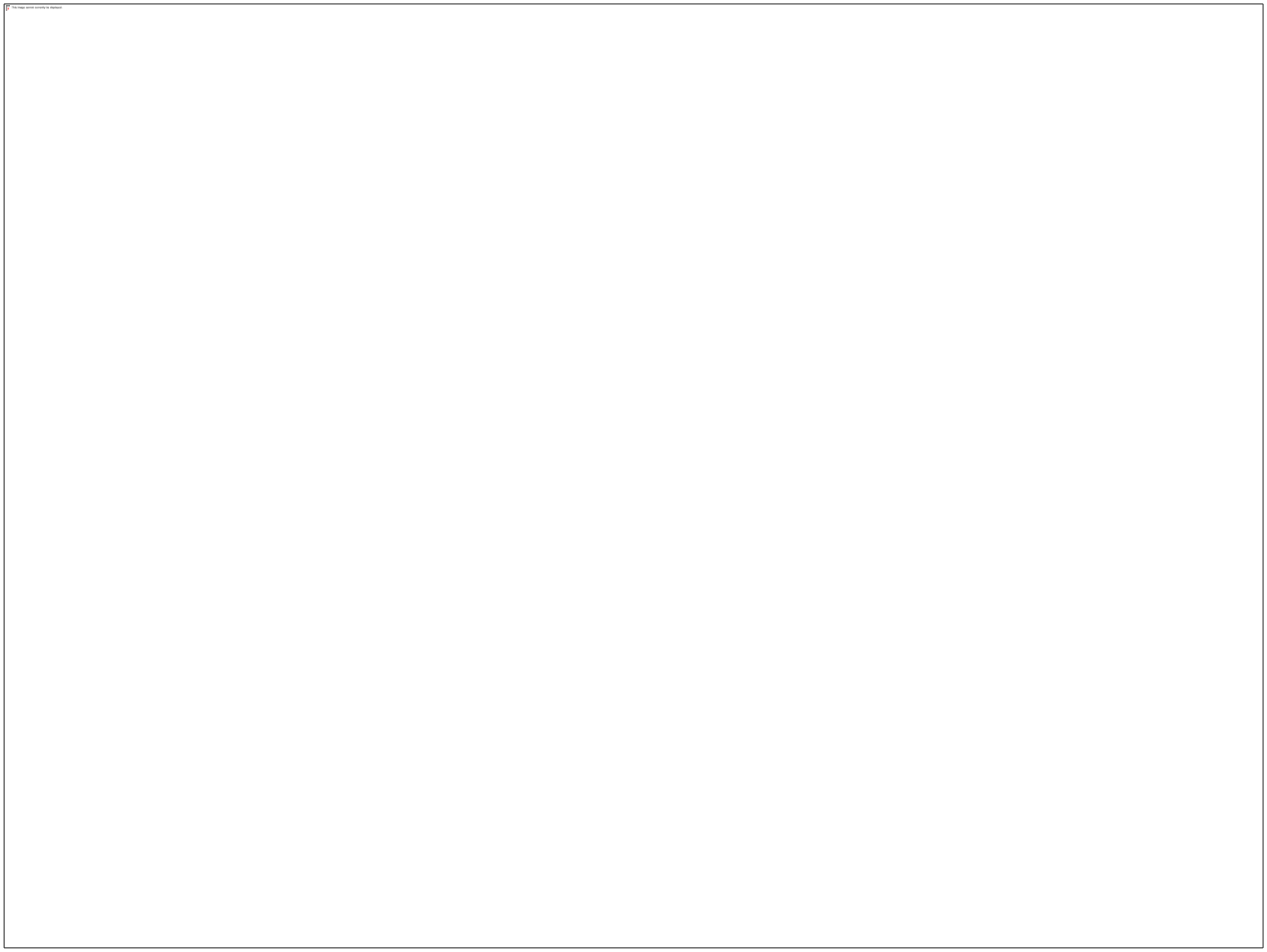
10.3 Common drainage problems and their remedies

Problem	Possible cause	Remedy
Flooding around a building	Inadequate drainage capacity or blocked drains	Clear drains and review the drainage design.
Water stagnating in channels	Poor gradient or blockage	Remove obstruction and correct levels where necessary.
Blocked stormwater pipe	Leaves, soil or rubbish	Clean the pipe using suitable equipment.
Soil erosion near an outlet	Uncontrolled discharge or high flow velocity	Provide suitable outlet protection.
Water entering a basement	Groundwater pressure or defective waterproofing/drainage	Investigate and provide an appropriate waterproofing and drainage solution.
Collapsed drainage	Poor installation, ground movement or	Replace the damaged section and

pipe	excessive loading	correct the cause.
Foul smell from a drainage system	Defective trap, blockage or poor ventilation	Inspect traps and drainage ventilation.
Waterlogging in a landscaped area	Poor soil drainage or high groundwater	Investigate and provide suitable surface or subsurface drainage.
Overflowing catch pit	Accumulated sediment or blocked outlet	Remove sediment and clear the outlet.
Flooding during heavy rainfall	System undersized for runoff or receiving system overloaded	Review the drainage capacity and discharge arrangement.

11.0 Safety precautions during drainage construction

Drainage construction involves excavation, underground pipe installation, handling wastewater and working around machinery. Appropriate safety precautions must therefore be observed.



1. **Wear appropriate PPE**

Use safety boots, gloves, helmets, reflective clothing and eye protection.

Use respiratory protection where dust or harmful substances may be present.

2. **Protect excavations**

Provide suitable trench support or safe excavation slopes where required.

Prevent workers from entering unstable trenches.

Provide barriers around open excavations.

3. **Identify underground services**

Locate buried water pipes, electrical cables and communication lines before excavation.

Use approved methods when working near existing services.

4. **Use suitable tools and machinery**

Operate excavation equipment only by trained and authorised persons.

Inspect tools and machinery before use.

5. **Prevent falls**

Provide safe access and egress into excavations.

Cover or barricade open chambers and drainage pits.

6. **Avoid contact with contaminated water**

Use suitable protective clothing when handling sewage or polluted water.

Wash hands and equipment after the work.

7. **Provide safe lifting methods**

Use correct techniques when lifting heavy concrete covers, pipes and drainage materials.

Use mechanical lifting equipment where necessary.

8. **Control dust**

Use appropriate dust-control measures during excavation and cutting.

9. **Prevent electrical accidents**

Keep electrical equipment and connections away from standing water.

Use suitable electrical protection for pumps and other equipment.

10. **Maintain good housekeeping**

Keep materials and excavated soil away from access routes.

Remove waste materials safely.

11. **Control water discharge**

Ensure pumped water and runoff are directed to approved discharge points.

Prevent erosion and flooding of neighbouring properties.

12. **Avoid entering confined spaces without proper procedures**

Manholes and deep drainage chambers may contain toxic gases or have insufficient oxygen.

Entry must only take place under appropriate confined-space procedures, atmospheric testing, supervision and rescue arrangements.

12.0 Environmental considerations in drainage systems

Drainage systems should be designed and maintained to protect the environment and surrounding communities.

12.1 Prevention of soil erosion

Construct suitable channels to control runoff.

Protect exposed soil during construction.

Provide suitable energy-dissipation structures at outlets.

Avoid discharging concentrated water onto unprotected ground.

12.2 Prevention of water pollution

Prevent sewage from entering stormwater drains.

Avoid disposing of cement slurry, oils, paints and chemicals into drainage channels.

Provide suitable wastewater treatment before discharge where required.

Keep construction waste away from watercourses.

12.3 Protection of natural watercourses

Avoid blocking natural streams and drainage routes.

Do not redirect water in a way that causes flooding elsewhere.

Provide suitable protection where drainage outlets discharge into watercourses.

Obtain relevant approvals where required.

12.4 Water conservation

Harvest suitable roof runoff.

Use storage tanks where appropriate.

Reuse treated water for suitable non-potable purposes.

Promote infiltration where the soil and groundwater conditions permit.

12.5 Proper waste management

Remove sediment and rubbish from drains.

Dispose of drainage waste at suitable locations.

Avoid using drainage channels as rubbish disposal points.

13.0 CBE learning activities and practical experiences

These activities enable learners to connect classroom learning with real construction practices in Kenya.

Activity 1: Observation of drainage systems around the school

Task: In groups, inspect the drainage facilities around the school under the guidance of the teacher.

Instructions:

Identify open surface drains.

Identify covered drains.

Identify stormwater channels.

Identify roof gutters and downpipes.

Identify inspection chambers and manholes where visible.

Observe areas where water collects.

Identify possible drainage defects.

Suggest suitable improvements.

Expected outcome: Learners identify drainage systems and explain their functions in a real building environment.

Activity 2: Classification of drainage systems

Classify the following drainage facilities according to their functions:

Open concrete drain.

Roof gutter.

Underground perforated pipe.

French drain.

Inspection chamber.

Stormwater catch basin.

Soil drainage pipe.

Wastewater drainage pipe.

Learners should present their classification in a table and explain their answers.

Activity 3: Drawing drainage layouts

Task: Draw the following subsurface drainage patterns:

Radial.

Herringbone.

Fan.

Grid.

Parallel.

Branching.

Requirements:

Use suitable drawing instruments.

Give each drawing a title.

Show the main collector.

Show lateral drainage lines.

Indicate the direction of water flow using arrows.

Mark the outlet.

Label the important parts.

Activity 4: Preparation of a site drainage plan

Task: Prepare a simple drainage layout for a proposed school compound.

The plan should show:

School buildings.

Roads and footpaths.

Open surface drains.

Roof gutters and downpipes.

Stormwater collection points.

Inspection chambers.

Proposed drainage outlet.

Learners should explain why they selected the proposed drainage routes.

Activity 5: Construction of a miniature drainage model



Task: Construct a model showing how surface and subsurface drainage systems operate.

Suggested materials:

Cardboard.

Sand.

Small plastic pipes.

Gravel.

Transparent containers.

Water.

Locally available modelling materials.

Procedure:

Prepare a model of a sloping site.

Construct a small open drainage channel.

Install a miniature underground drainage pipe.

Connect the drainage pipe to a collection chamber.

Pour water onto the model surface.

Observe the direction of water movement.

Record the results.

Explain the differences between surface and subsurface drainage.

Activity 6: Investigation of drainage problems in the community

Task: Investigate drainage problems in the local community.

Learners should identify:

Areas that experience flooding.

Blocked drainage channels.

Areas affected by soil erosion.

Waterlogged grounds.

Poorly directed stormwater outlets.

They should propose practical solutions using appropriate drainage methods.

REVISION QUESTIONS

DARINAGE SYSTEM

SECTION A: MULTIPLE-CHOICE QUESTIONS

Instructions: Answer all questions. Choose the correct answer from the alternatives provided.

1. What is drainage?

A. The process of supplying water to buildings.
B. The process of collecting and removing excess water.
C. The process of mixing concrete.
D. The process of constructing foundations.

2. Which of the following best describes a drainage system?

A. An arrangement of pipes and channels used to remove unwanted water.
B. A system used for supplying electricity.
C. An arrangement used for supporting roof coverings.
D. A system used for mixing building materials.

3. Which drainage system removes water flowing on the ground surface?

A. Subsurface drainage.
B. Surface drainage.
C. Soil drainage.
D. Ventilation system.

4. The main purpose of stormwater drainage is to:

A. Supply drinking water.
B. Remove rainwater runoff.
C. Supply hot water to bathrooms.
D. Store sewage inside buildings.

5. Which of the following is a component of a stormwater drainage system?

A. Roof gutter.
B. Door frame.
C. Roof truss.
D. Window sill.

6. Subsurface drainage is mainly used to remove:

A. Dust from buildings.
B. Excess groundwater from the soil.
C. Smoke from rooms.
D. Solid waste from kitchens.

7. Which of the following is commonly used in a subsurface drainage system?

A. Perforated pipe.
B. Timber door.
C. Ceiling board.
D. Roofing tile.

8. The material placed around a perforated drainage pipe to facilitate water movement is commonly:

A. Timber sawdust.
B. Coarse gravel.

C. Roofing felt.
D. Plaster.

9. The main function of geotextile fabric in subsurface drainage is to:

A. Increase pipe diameter.
B. Separate soil from drainage aggregate and reduce clogging.
C. Supply water to the pipe.
D. Support roof coverings.

10. Which drainage layout resembles the bones of a fish?

A. Radial.
B. Grid.
C. Herringbone.
D. Parallel.

11. In a radial drainage layout, drainage lines are arranged:

A. In a series of parallel lines only.
B. Around or towards a central collection arrangement.
C. In a rectangular grid only.
D. Without an outlet.

12. Which drainage pattern consists of pipes running alongside one another?

A. Fan.
B. Parallel.
C. Radial.
D. Branching.

13. A drainage layout made up of intersecting pipes forming rectangular sections is called:

A. Grid layout.
B. Fan layout.
C. Radial layout.
D. Herringbone layout.

14. Which drainage layout resembles the branches of a tree?

A. Parallel.
B. Branching.
C. Grid.
D. Radial.

15. A fan drainage layout is characterised by:

A. Pipes arranged in a circular tank.
B. Pipes spreading out in a fan-like pattern.
C. Pipes arranged only in straight parallel lines.
D. Pipes without a collector.

16. Which structure provides access for inspection and maintenance of underground drainage pipes?

A. Roof gutter.
B. Inspection chamber.

C. Window frame.
D. Door threshold.

17. A manhole is mainly constructed to:

A. Store roof materials.
B. Provide access to underground drainage systems.
C. Support a roof.
D. Supply water to taps.

18. The point at which water leaves a drainage system is called:

A. Inlet.
B. Outfall.
C. Cistern.
D. Trap.

19. Which of the following is the main purpose of a catch pit?

A. To supply drinking water.
B. To collect surface runoff and retain some sediment.
C. To support building foundations.
D. To store cement.

20. A soakaway is designed to:

A. Store sewage permanently.
B. Allow suitable water to infiltrate into the surrounding ground.
C. Increase water pressure.
D. Supply water to a building.

21. Which of the following is a temporary drainage method used during construction?

A. Sump pumping.
B. Roof trussing.
C. Wall plastering.
D. Floor screeding.

22. Dewatering refers to:

A. Adding water to concrete.
B. Removing or controlling groundwater in an excavation.
C. Washing construction tools.
D. Painting underground pipes.

23. Which of the following may result from poor site drainage?

A. Improved foundation stability.
B. Waterlogging and flooding.
C. Increased ventilation.
D. Improved roof strength.

24. An important function of drainage around foundations is to:

A. Direct excess water away from the foundation area.
B. Increase the amount of water entering the soil.

C. Prevent the setting of concrete.
D. Increase the weight of the building.

25. Which of the following may cause blockage of stormwater drains?

A. Regular cleaning.
B. Leaves, soil and rubbish.
C. Correct pipe installation.
D. Proper drainage gradients.

26. What is the main purpose of a diversion drain on a construction site?

A. To supply water to a building.
B. To redirect runoff away from a selected area.
C. To store building materials.
D. To support excavation machinery.

27. Which of the following is an advantage of an open surface drain?

A. It is easy to inspect and clean.
B. It never collects rubbish.
C. It occupies no ground space.
D. It does not require maintenance.

28. Which of the following is an important consideration when preparing a drainage layout?

A. Colour of doors.
B. Ground slope and soil conditions.
C. Number of windows only.
D. Type of ceiling finish.

29. Which of the following is a suitable way of preventing soil erosion at a drainage outlet?

A. Discharging water directly onto loose soil.
B. Providing suitable outlet protection.
C. Blocking the outlet.
D. Increasing the speed of runoff without control.

30. Why should surface and subsurface drainage systems be maintained regularly?

A. To increase blockages.
B. To ensure effective water flow and reduce flooding.
C. To increase stagnant water.
D. To weaken the drainage pipes.

SECTION B: STRUCTURED QUESTIONS

Instructions: Answer all questions. Give clear explanations and provide examples where necessary.

1. Introduction to drainage systems

a) Define the term drainage. (2 marks)

b) Explain the meaning of a drainage system. (2 marks)

c) State six purposes of providing drainage systems on a construction site. (6 marks)

d) Explain five problems that may result from poor drainage around a building. (10 marks)

2. Types of drainage systems

a) State four types of drainage systems used in buildings and construction sites. (4 marks)

b) Explain the meaning of surface drainage. (2 marks)

c) Describe five characteristics of surface drainage systems. (5 marks)

d) State four examples of surface drainage facilities. (4 marks)

3. Surface drainage

a) Define an open surface drain. (2 marks)

b) State four materials that may be used to construct surface drains. (4 marks)

c) Explain five advantages of open surface drainage channels. (10 marks)

d) State four disadvantages of poorly maintained open drains. (4 marks)

4. Stormwater drainage

a) Define stormwater drainage. (2 marks)

b) State six sources of stormwater on a construction site. (6 marks)

c) Name eight components of a stormwater drainage system. (8 marks)

d) Explain four benefits of providing an effective stormwater drainage system. (8 marks)

5. Subsurface drainage

a) Define subsurface drainage. (2 marks)

b) State five situations in which subsurface drainage may be required. (5 marks)

c) Name six components of a subsurface drainage system. (6 marks)

d) Explain five advantages of subsurface drainage. (10 marks)

e) State three disadvantages of subsurface drainage. (3 marks)

6. Drainage layouts

a) What is meant by a subsurface drainage layout? (2 marks)

b) Name six layouts of subsurface drainage systems. (6 marks)

c) Explain the characteristics of the following drainage layouts:

i. Radial layout. (3 marks)

ii. Herringbone layout. (3 marks)

iii. Fan layout. (3 marks)

iv. Grid layout. (3 marks)

v. Parallel layout. (3 marks)

vi. Branching layout. (3 marks)

7. Comparison of drainage layouts

a) Differentiate between radial and herringbone drainage layouts. (4 marks)

b) State four advantages of a parallel drainage layout. (4 marks)

c) Explain three situations in which a branching drainage layout may be suitable. (6 marks)

d) State four factors that influence the choice of a drainage layout. (4 marks)

8. Layout of a subsurface drainage system on a site

a) State eight items of information shown on a subsurface drainage layout plan. (8 marks)

b) Explain six factors to consider when preparing a drainage layout. (12 marks)

c) State five reasons why inspection chambers are provided in drainage layouts. (5 marks)

9. Installation of subsurface drainage systems

a) Name five materials required when installing a subsurface drainage system. (5 marks)

b) Describe the procedure for installing perforated drainage pipes in a gravel-filled trench. (10 marks)

c) State five safety precautions to observe during drainage trench excavation. (5 marks)

10. Importance of efficient drainage

a) Explain eight reasons why efficient drainage is important in buildings. (16 marks)

b) State four ways in which poor drainage can affect building foundations. (4 marks)

11. Drainage structures

a) Define an inspection chamber. (2 marks)

b) Explain four functions of an inspection chamber. (4 marks)

c) Differentiate between a catch pit and a manhole. (4 marks)

d) Explain the function of an outfall in a drainage system. (2 marks)

e) State four factors to consider when locating a soakaway. (4 marks)

12. Temporary drainage during construction

a) Explain the meaning of temporary drainage. (2 marks)

b) State five examples of temporary drainage arrangements used on construction sites. (5 marks)

c) Explain the procedure for carrying out sump pumping during construction. (8 marks)

d) State five benefits of dewatering an excavation. (5 marks)

13. Surface, stormwater and subsurface drainage

a) Differentiate between surface drainage and subsurface drainage. (4 marks)

b) Explain the difference between stormwater drainage and foul drainage. (4 marks)

c) Give four examples of facilities used in stormwater drainage. (4 marks)

d) State four reasons why stormwater and foul drainage should not be interconnected without an approved design. (4 marks)

14. Drainage maintenance

a) Explain the importance of maintaining drainage systems. (6 marks)

b) State eight maintenance practices carried out on drainage systems. (8 marks)

c) Identify six common drainage defects and give a suitable remedy for each. (12 marks)

15. Environmental protection

a) State five ways of preventing soil erosion caused by uncontrolled runoff. (5 marks)

b) Explain five ways of preventing water pollution during construction activities. (10 marks)

c) State five environmental benefits of an effective drainage system. (5 marks)

16. Practical drawing questions

a) Draw and label a radial subsurface drainage layout. (5 marks)

b) Draw and label a herringbone drainage layout. (5 marks)

c) Draw and label a fan drainage layout. (5 marks)

d) Draw and label a grid drainage layout. (5 marks)

17. Practical application question

A contractor is constructing a school on a site that experiences waterlogging during the rainy season. The site has a gentle slope, clay-rich soil and several low-lying areas.

a) Identify four drainage problems that may affect the construction site. (4 marks)

b) Suggest four drainage measures that could be adopted. (8 marks)

c) Explain four factors the contractor should consider when choosing the drainage layout. (8 marks)

d) State five benefits of providing an efficient drainage system for the completed school. (5 marks)

STRAND 4.0: BUILDING SERVICES

SUB-STRAND 4.4: BUILDING CONSTRUCTION PROJECT – DESIGN PROCESS FOR A PROJECT

Introduction

Building construction projects begin with identifying a need or problem and developing a suitable solution. A successful project does not start by simply choosing materials and beginning construction. It follows a systematic design process that enables learners and construction professionals to understand a problem, investigate possible solutions, develop ideas, prepare drawings, select materials, estimate costs, construct models and evaluate the final product.

In Grade 11 Building Construction, learners apply the design process to solve real-life problems in homes, schools and the community. They develop practical skills in problem-solving, creativity, communication, collaboration, critical thinking, decision-making and responsible use of resources.

Examples of possible school-based projects in Kenya include:

Designing a simple rainwater harvesting system for a school.

Developing a handwashing station using locally available materials.

Designing a suitable waste collection point.

Making a model of a small classroom or a simple store.

Designing a water-drainage channel to reduce waterlogging in a school compound.

Developing a simple tool-storage rack for a workshop.

Designing a low-cost drying rack for construction materials.

1. Meaning of a Building Construction Project

A **building construction project** is a planned activity involving the design, preparation, construction, improvement or maintenance of a building or building-related facility to meet a particular need.

A project may involve constructing a new structure, modifying an existing one, or producing a model or product that solves a construction-related problem.

Examples:

Constructing a classroom block to provide additional learning space.

Building a water tank stand to support a school water-storage tank.

Making a model roof truss to demonstrate roof construction.

Constructing a concrete drainage channel to direct stormwater away from buildings.

Designing a simple ramp to improve access to a building.

Characteristics of a building construction project

It has a specific purpose: Every project is undertaken to meet an identified need or solve a particular problem.

It has a beginning and an end: A project is planned to start and finish within an agreed period.

It uses resources: It requires materials, tools, equipment, labour, money and time.

It follows planned procedures: Activities are organised in a logical sequence.

It produces an outcome: The final result may be a building, facility, construction component, model or design proposal.

It requires evaluation: The outcome is assessed to determine whether it meets the intended requirements.

It involves decision-making: Choices are made concerning design, materials, construction methods, cost and safety.

2. Meaning of the Design Process

The **design process** is a systematic sequence of activities followed to identify a problem, investigate it, develop possible solutions, select the most suitable solution, prepare drawings and material requirements, produce a model or product, and evaluate the outcome.

The design process helps learners avoid making decisions without sufficient information.

Importance of following the design process

Helps identify the actual problem: It enables the designer to understand the real need before proposing a solution.

Promotes creativity: It encourages learners to develop different ideas rather than depending on one solution.

Reduces wastage: Proper planning helps avoid unnecessary use of materials and money.

Improves quality: Drawings, modelling and evaluation help identify weaknesses before construction.

Promotes safety: Possible hazards can be identified and addressed during planning.

Supports cost control: Estimating materials, labour and other expenses helps keep the project within budget.

Encourages teamwork: Learners can share responsibilities and work together.

Promotes environmental responsibility: Designers can consider locally available, reusable and environmentally suitable materials.

Improves decision-making: Different solutions can be compared before selecting the most appropriate one.

Encourages innovation: Learners can improve existing products or develop new solutions to local challenges.

3. Stages of the Design Process

The design process involves the following main stages:

Needs assessment.

Identification and definition of the problem.

Research and investigation.

Data collection and analysis.

Development of design concepts.

Selection of the most suitable design.

Preparation of design drawings.

Preparation of a material list.

Cost estimation.

Modelling or prototype development.

Testing and evaluation.

Feedback and improvement.

Presentation of the final design or product.

The stages are related and may be repeated when evaluation reveals a weakness that needs correction.

4. Data Collection and Analysis

4.1 Meaning of data collection

Data collection is the systematic process of gathering relevant information about an identified problem to help the designer develop an appropriate solution.

Data provides evidence about the problem, the users, the site, available materials, costs and requirements of the proposed product.

For example, before designing a handwashing station for a school, learners need to establish:

The number of learners who will use the station.

The available water supply.

The most suitable location.

The type of basin required.

The available drainage arrangements.

The materials that can be obtained locally.

The amount of money available.

4.2 Methods of collecting data

1. **Observation**

Involves carefully examining a situation to identify existing conditions and challenges.

The designer visits the proposed project site and observes how the problem occurs.

Example: Observing learners struggling to wash their hands because the school has no suitable handwashing facility.

2. **Interviews**

Involve asking relevant people questions to obtain information about a problem.

Information may be obtained from teachers, learners, parents, technicians, builders and school administrators.

Example: Interviewing the school headteacher to establish the number of learners who need the facility.

3. **Questionnaires**

These are written questions given to respondents to obtain information.

They are useful when collecting information from many people.

Example: Asking learners about their preferred location and design of a handwashing station.

4. **Measurements**

Involve determining the dimensions of the proposed construction site or product.

Measurements may include length, width, height, depth and available working space.

Example: Measuring the available space where the handwashing station will be installed.

5. **Photography**

Involves taking photographs of the existing situation, proposed site or similar products.

Photographs provide visual evidence for reference during design.

Example: Taking photographs of existing handwashing facilities in nearby schools.

6. **Document study**

Involves examining existing drawings, reports, manuals, catalogues and technical information.

It helps the designer understand construction requirements and available solutions.

Example: Studying drawings of simple water-storage stands.

7. **Internet research**

Involves obtaining relevant information from reliable online sources.

It can provide information about construction materials, product designs, safety and construction methods.

Example: Researching different types of handwashing stations.

4.3 Importance of data collection

Helps the designer understand the actual problem.

Provides information about users' needs.

Helps determine suitable materials.

Establishes the dimensions of the proposed product.

Helps identify the most appropriate location.

Provides information for estimating costs.

Helps identify possible safety risks.

Prevents unsuitable design decisions.

Provides a basis for comparing alternative designs.

4.4 Analysis of collected data

Data analysis is the process of examining, organising and interpreting collected information to identify important findings that can guide the design.

For example, information collected about a school handwashing station may be analysed as follows:

Information collected	Design implication
Many learners use the facility	Provide adequate capacity and more than one tap where appropriate
Water is stored in a tank	Include a stable tank-supporting structure
Space is limited	Develop a compact design
The site has poor drainage	Include suitable wastewater disposal
Timber and steel are locally available	Compare their suitability for the supporting frame
The school has a limited budget	Consider economical and durable materials

5. Development of Design Concepts

5.1 Meaning of concept development

Concept development is the process of generating, exploring and developing different ideas that could be used to solve an identified problem.

At this stage, the designer considers several possible solutions before selecting the most suitable one.

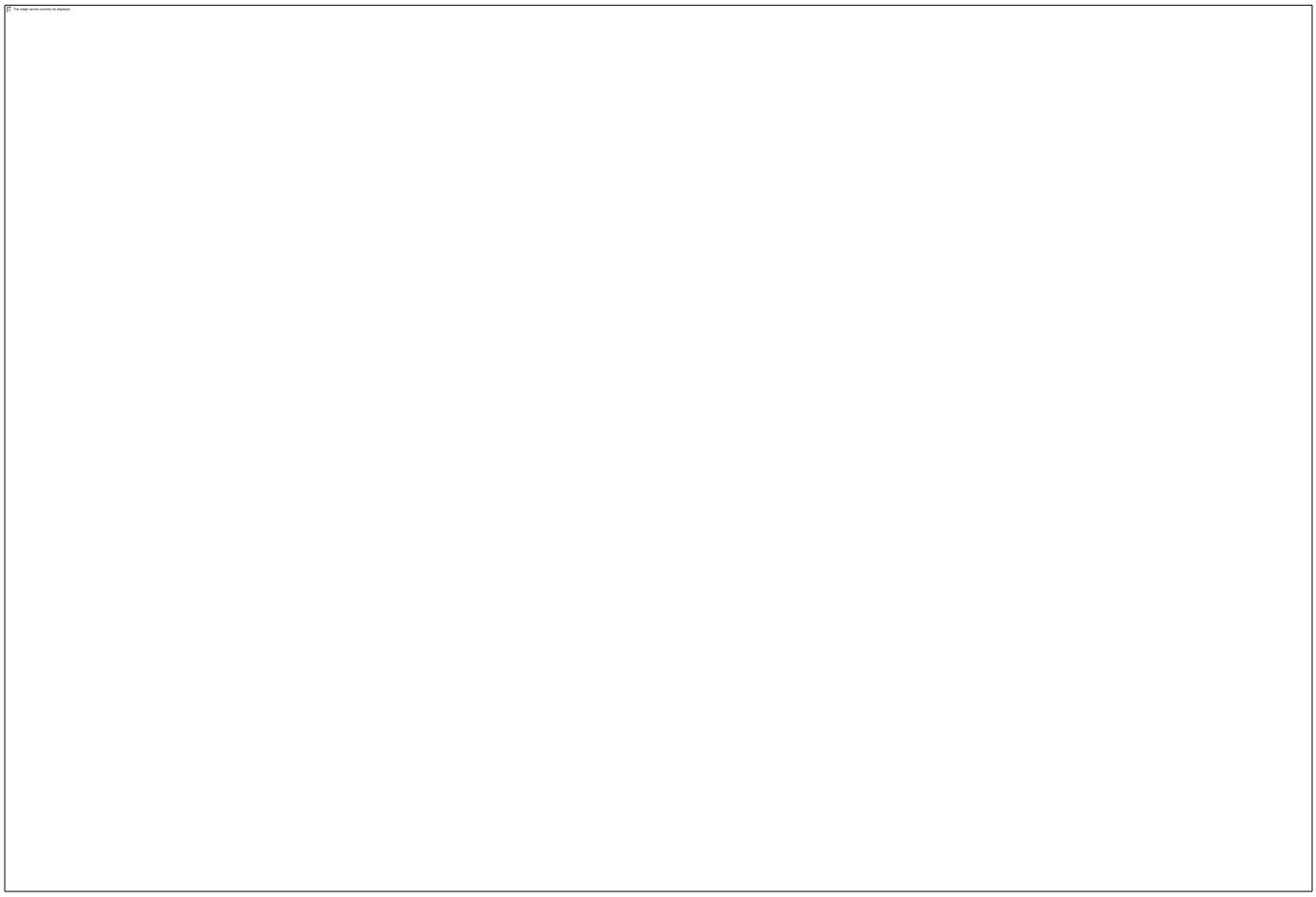
For example, learners designing a handwashing station may develop the following concepts:

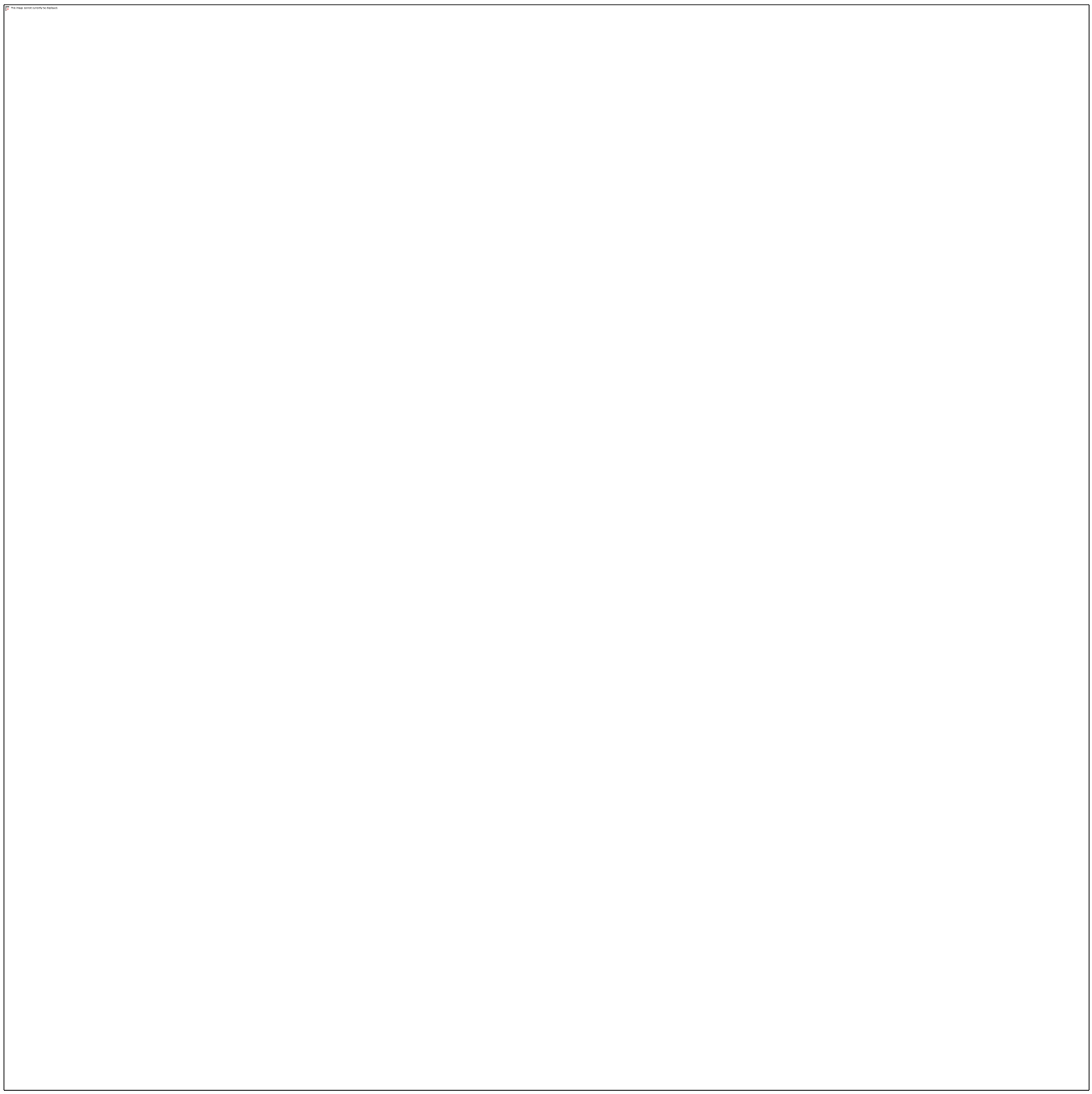
Concept A: A simple stand with a plastic water container and tap.

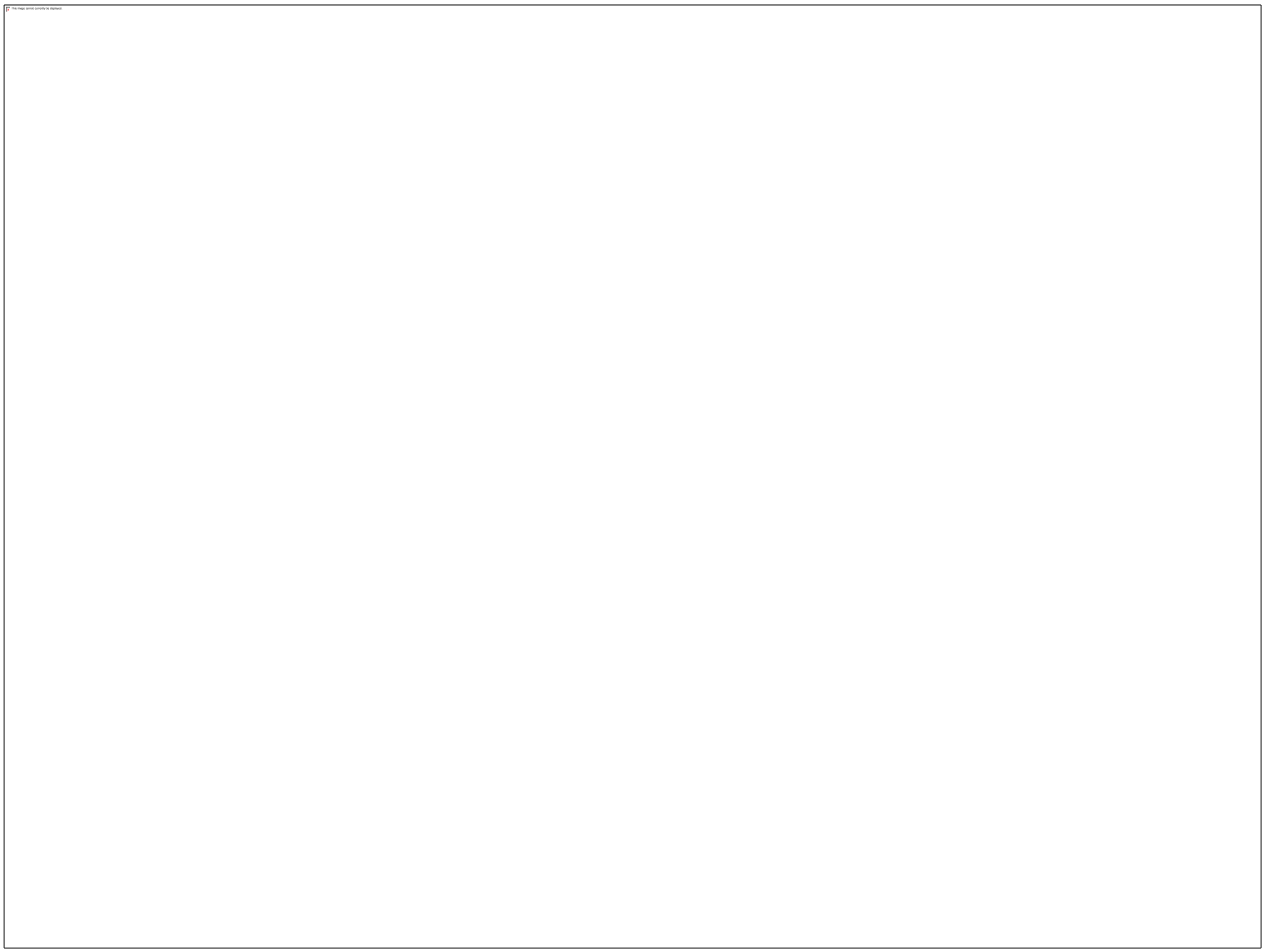
Concept B: A raised water tank supported by a steel frame, with a basin and drainage pipe.

Concept C: A masonry-supported tank with several washing points.

Concept D: A portable handwashing unit that can be moved to different locations.







5.2 Sources of design ideas

Design ideas may be obtained from:

Existing products.

Personal experience.

Observation of local problems.

Consultation with experts.

Research in books and technical publications.

Discussions with other learners.

Community practices.

Internet research.

Previous construction projects.

Creative thinking and experimentation.

5.3 Techniques used in concept development

a) Brainstorming

Brainstorming is a group activity in which participants suggest many possible solutions to a problem without immediately criticising the ideas.

Importance:

Encourages creativity.

Promotes participation.

Produces several possible solutions.

Encourages teamwork.

Helps learners consider different viewpoints.

b) Sketching

Sketching involves making quick freehand drawings to communicate an idea.

Importance:

Helps visualise the proposed product.

Shows the general shape and arrangement of components.

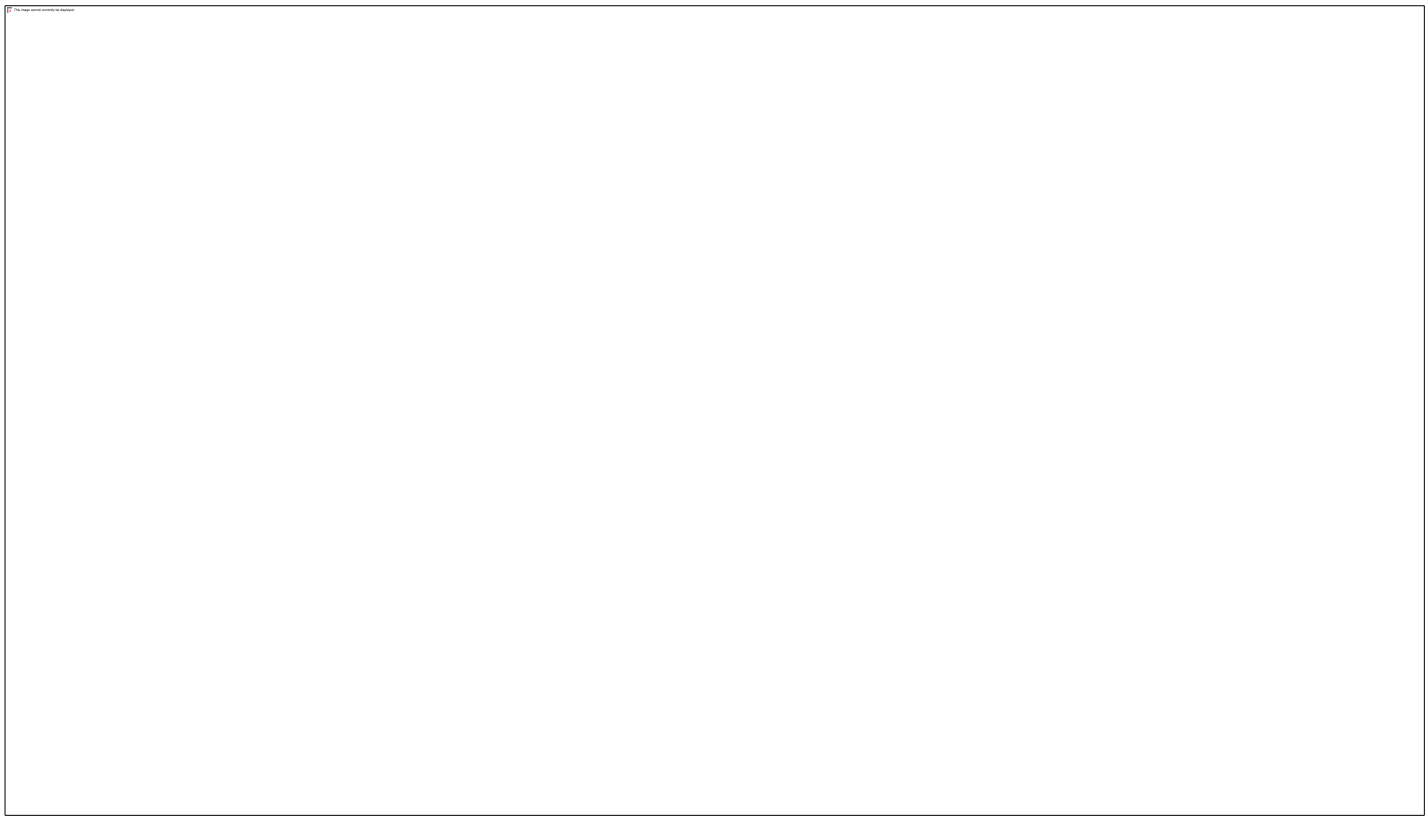
Makes it easier to compare ideas.

Helps identify possible design weaknesses.

c) Mind mapping

A mind map is a diagram used to organise ideas around a central problem or topic.

Example:



d) Consultation

Consultation involves seeking advice from people with relevant knowledge and experience.

Examples include consulting:

Building technicians.

Plumbers.

Carpenters.

Welders.

Teachers.

School administrators.

e) Researching existing designs

Learners examine existing products to understand their construction, strengths, weaknesses and possible improvements.

5.4 Factors to consider when developing design concepts

Functionality: The product should perform the intended task effectively.

Safety: It should not expose users to unnecessary danger.

Cost: The proposed solution should be affordable.

Durability: Materials and components should withstand the intended use.

Availability of materials: Materials should be obtainable locally or through reliable suppliers.

Ease of construction: The design should be achievable using available skills, tools and equipment.

Appearance: The product should have an acceptable and attractive appearance.

Maintenance: It should be easy to clean, repair and maintain.

Environmental impact: The design should minimise waste and environmental damage.

Accessibility: The product should be convenient for its intended users, including people with disabilities.

6. Selection of the Most Suitable Design

After generating several concepts, the designer evaluates them and selects the one that best meets the identified needs.

6.1 Criteria for selecting a design

Ability to solve the identified problem.

Cost of construction.

Availability of materials.

Strength and stability.

Safety of users.

Ease of construction.

Durability.

Ease of maintenance.

Environmental suitability.

Suitability for the available site.

6.2 Design selection matrix

A design selection matrix is a table used to compare alternative designs against selected criteria.

The following is an illustrative example. Scores range from 1 (poor) to 5 (excellent).

Selection criterion	Concept A	Concept B	Concept C
Functionality	3	5	4
Safety	3	5	4
Affordability	5	4	2
Durability	2	5	5
Ease of construction	5	4	2
Total	18	23	17

Conclusion: Concept B obtains the highest score and is therefore selected for further development in this example.

The scores should be based on evidence and the requirements of the actual project.

7. Design Drawings

7.1 Meaning of a design drawing

A **design drawing** is a graphical representation of a proposed product or structure showing its shape, dimensions, components and arrangement.

Design drawings communicate construction ideas to the people involved in making or constructing the product.

7.2 Importance of design drawings

Communicate the designer's ideas clearly.

Show the shape and arrangement of components.

Provide dimensions for construction.

Guide the selection and cutting of materials.

Help determine the quantities of materials required.

Help estimate the project cost.

Reduce errors during construction.

Provide a reference during inspection and evaluation.

Assist in explaining the project to clients and other stakeholders.

Help identify design problems before construction begins.

7.3 Types of design drawings

a) Freehand sketch

A freehand sketch is a drawing made without using drawing instruments.

Uses:

Recording initial ideas.

Communicating rough concepts.

Exploring different design arrangements.

b) Orthographic drawing

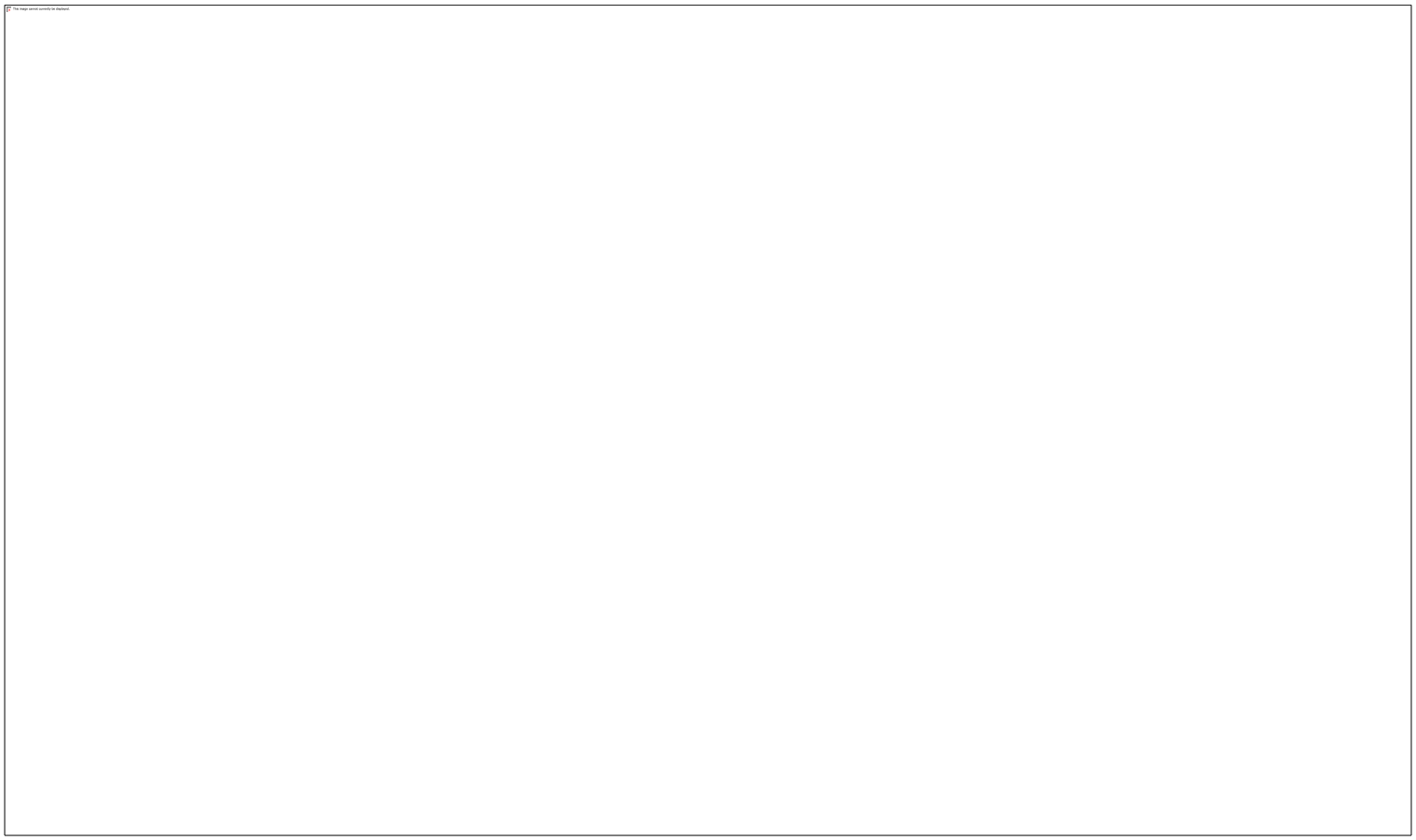
An orthographic drawing represents an object using separate two-dimensional views.

The common views are:

Front elevation.

Plan.

Side elevation.



c) Isometric drawing

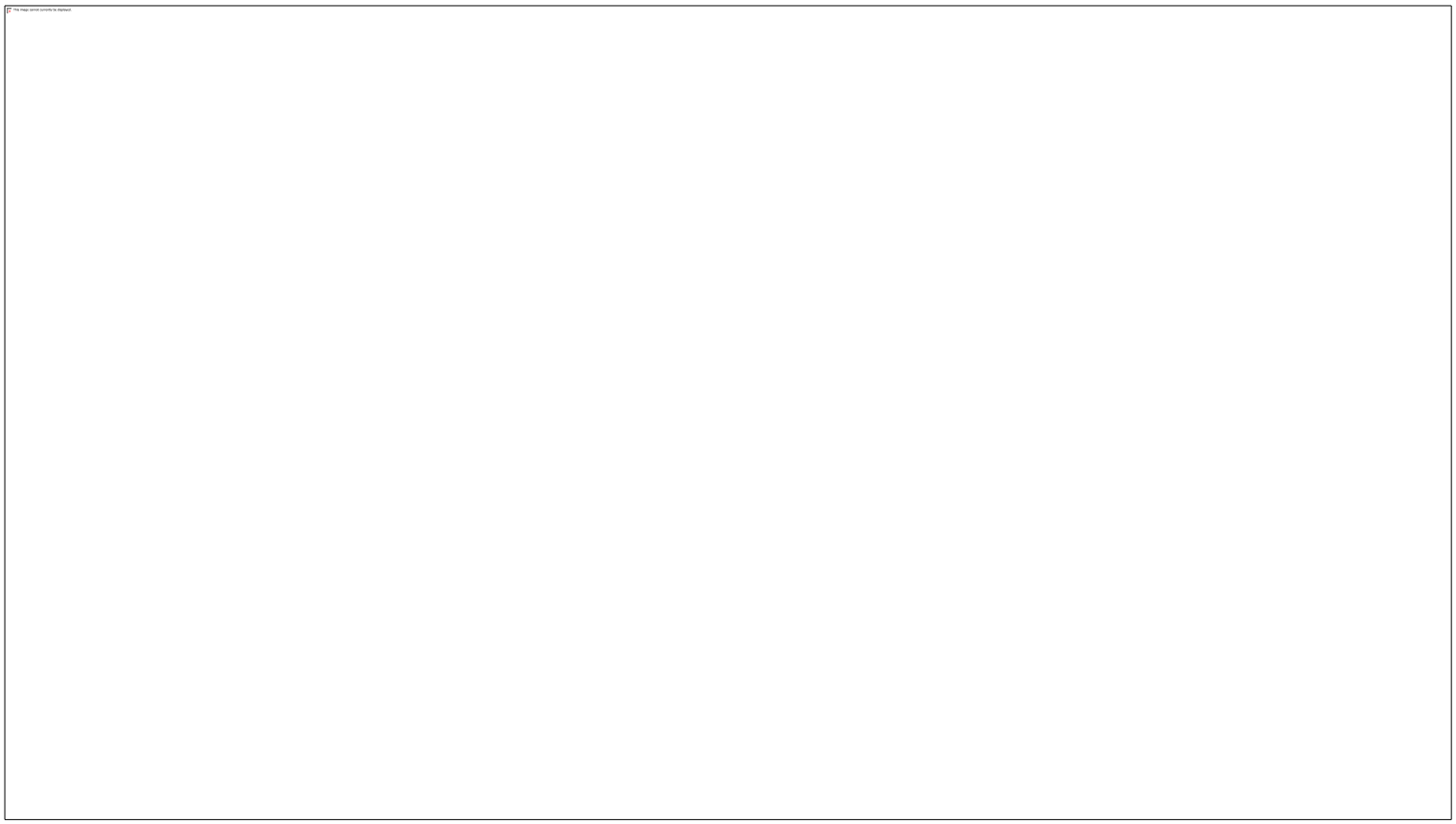
An isometric drawing represents a three-dimensional object on a two-dimensional surface, showing three principal directions.

Uses:

Showing the general appearance of a product.

Communicating the arrangement of components.

Helping the viewer visualise the finished product.



d) Detailed working drawing

A working drawing provides sufficient technical information to guide the construction or manufacture of a product.

It may show:

Dimensions.

Materials.

Component details.

Fixing arrangements.

Sections and construction details.

7.4 Important information shown on a design drawing

A good design drawing should include:

Title of the project.

Drawing title.

Scale, where applicable.

Dimensions.

Labels of components.

Material specifications where necessary.

Different views where required.

Relevant notes.

Drawing number or reference.

Date and name of the designer, where required.

7.5 Qualities of a good design drawing

Neat and clear.

Accurate.

Properly labelled.

Correctly dimensioned.

Uses suitable drawing conventions.

Has appropriate line types and thicknesses.

Shows the necessary views.

Uses a suitable scale.

Easy to interpret.

Contains relevant construction information.

8. Preparation of a Material List

8.1 Meaning of a material list

A **material list** is a document showing the materials required to complete a particular construction project, together with their descriptions, specifications and quantities.

It is prepared after the design has been developed sufficiently to determine the components and materials required.

8.2 Importance of a material list

Helps identify all materials required.

Guides purchasing and procurement.

Helps estimate the project cost.

Prevents unnecessary purchases.

Reduces material wastage.

Helps plan transportation and storage.

Supports project scheduling.

Helps ensure that suitable materials are selected.

Makes it easier to monitor material usage.

Helps identify shortages before construction begins.

8.3 Information contained in a material list

A material list may contain:

Item number.

Name of material.

Description or specification.

Unit of measurement.

Quantity required.

Unit price.

Total price.

Remarks.

8.4 Example of a material list for a simple handwashing station

The following is an illustrative material list. Actual quantities and specifications must be determined from the final drawing and site conditions.

No.	Material	Description	Unit	Quantity
1	Steel sections	Suitable sections for supporting frame	Length	As designed
2	Water tank	Suitable storage capacity	No.	1
3	Basin	Suitable washing basin	No.	1
4	Water tap	Suitable tap and fittings	No.	1
5	Water pipes	Suitable water supply pipe	Length	As required
6	Drainage pipe	Suitable wastewater pipe	Length	As required
7	Bolts and nuts	Suitable fixing sizes	Set	As required
8	Paint	Suitable protective coating	Litre	As required
9	Cement	For any required concrete or masonry work	Bag	As designed
10	Sand	Suitable construction sand	m^3	As designed
11	Ballast	Suitable aggregate, where required	m^3	As designed

Important: The supporting frame must be designed to safely carry the full tank when filled with water. Structural members, connections and foundations should be selected and checked by a suitably competent person. The drainage arrangement must also be appropriate for the site.

9. Cost Estimation

9.1 Meaning of cost estimation

Cost estimation is the process of calculating the approximate amount of money required to complete a construction project.

It involves identifying the materials, labour, tools, equipment, transportation and other expenses required.

Cost estimation helps determine whether a proposed project can be completed within the available budget.

9.2 Importance of cost estimation

Helps establish the total expected project cost.

Assists in preparing a project budget.

Helps determine whether the project is affordable.

Guides purchasing decisions.

Helps prevent overspending.

Supports financial planning.

Helps compare alternative designs.

Identifies expensive components that may require redesign.

Helps in requesting funds or financial support.

Provides a basis for monitoring expenditure.

9.3 Main components of project cost

a) Material cost

This is the amount spent on purchasing materials required for the project.

Examples:

Cement.

Sand.

Steel sections.

Timber.

Pipes.

Nails.

Paint.

Water tanks.

b) Labour cost

This is the amount paid to workers for carrying out project activities.

Examples:

Masonry work.

Welding.

Carpentry.

Plumbing.

Painting.

General construction work.

c) Tools and equipment cost

This includes the cost of hiring, using or acquiring tools and equipment.

Examples:

Hammers.

Spanners.

Drilling machines.

Measuring tapes.

Welding machines.

Cutting equipment.

d) Transportation cost

This is the cost of moving materials, equipment and workers to the project site.

e) Site preparation cost

This is the cost of preparing the site before construction begins.

Examples:

Clearing vegetation.

Removing unsuitable materials.

Levelling the site.

Setting out the project.

f) Contingency allowance

This is an amount included in the budget to cater for unforeseen expenses.

Examples:

Unexpected price increases.

Minor design adjustments.

Additional materials required due to unforeseen conditions.

9.4 Methods of calculating project cost

Material cost:

Material Cost=Quantity×Unit PriceMaterial Cost=Quantity×Unit Price

Total material cost:

Total Material Cost=∑Individual Material CostsTotal Material Cost=∑Individual Material Costs

Total project cost:

Total Project Cost=Material Cost+Labour Cost+Tools and Equipment Cost+Transport Cost+Other Allowance sTotal Project Cost=
Material Cost+Labour Cost+Tools and Equipment Cost+Transport Cost+Other Allowances

9.5 Illustrative cost estimate

The following figures are hypothetical teaching examples, not current supplier quotations.

Item	Quantity	Unit price (KSh)	Total (KSh)
Steel sections	4 lengths	1,200	4,800
Water tank	1	5,000	5,000
Basin	1	1,500	1,500
Tap and fittings	1 set	800	800
Pipes	4 lengths	250	1,000
Bolts and nuts	1 set	500	500
Paint	1 tin	1,000	1,000
Total materials			14,600

Additional project expenses:

Expense	Estimated cost (KSh)
Labour	3,000
Transportation	1,000
Tools and equipment	500

Site preparation	500
Subtotal of additional expenses	5,000

Estimated Subtotal=14,600+5,000=KSh 19,600

If a contingency allowance of 10% is used:

Contingency=0.10×19,600 =KSh 1,960

Estimated Total=19,600+1,960 =KSh 21,560

The actual project cost should be established using current quotations, accurate measurements, suitable material specifications and realistic labour rates.

10. Modelling and Prototype Development

10.1 Meaning of modelling

Modelling is the process of producing a simplified physical or digital representation of a proposed product or structure to demonstrate its shape, arrangement, appearance and operation.

A model allows the designer to examine an idea before constructing the full-size product.

10.2 Meaning of a prototype

A **prototype** is an initial working version of a product developed to test its design, operation and performance before final production or construction.

A model may only demonstrate appearance and arrangement, while a prototype may be designed to demonstrate actual function.

10.3 Importance of modelling

Helps visualise the proposed product.

Makes it easier to identify design weaknesses.

Helps determine whether components fit together.

Supports testing of different design arrangements.

Helps communicate ideas to other people.

Reduces errors during full-scale construction.

Encourages creativity and innovation.

Helps assess the suitability of materials.

Supports evaluation of the proposed design.

Saves time and resources when problems are identified early.

10.4 Materials used in making models

Cardboard.

Mounting board.

Paper.

Timber offcuts.

Thin plastic sheets.

Foam board.

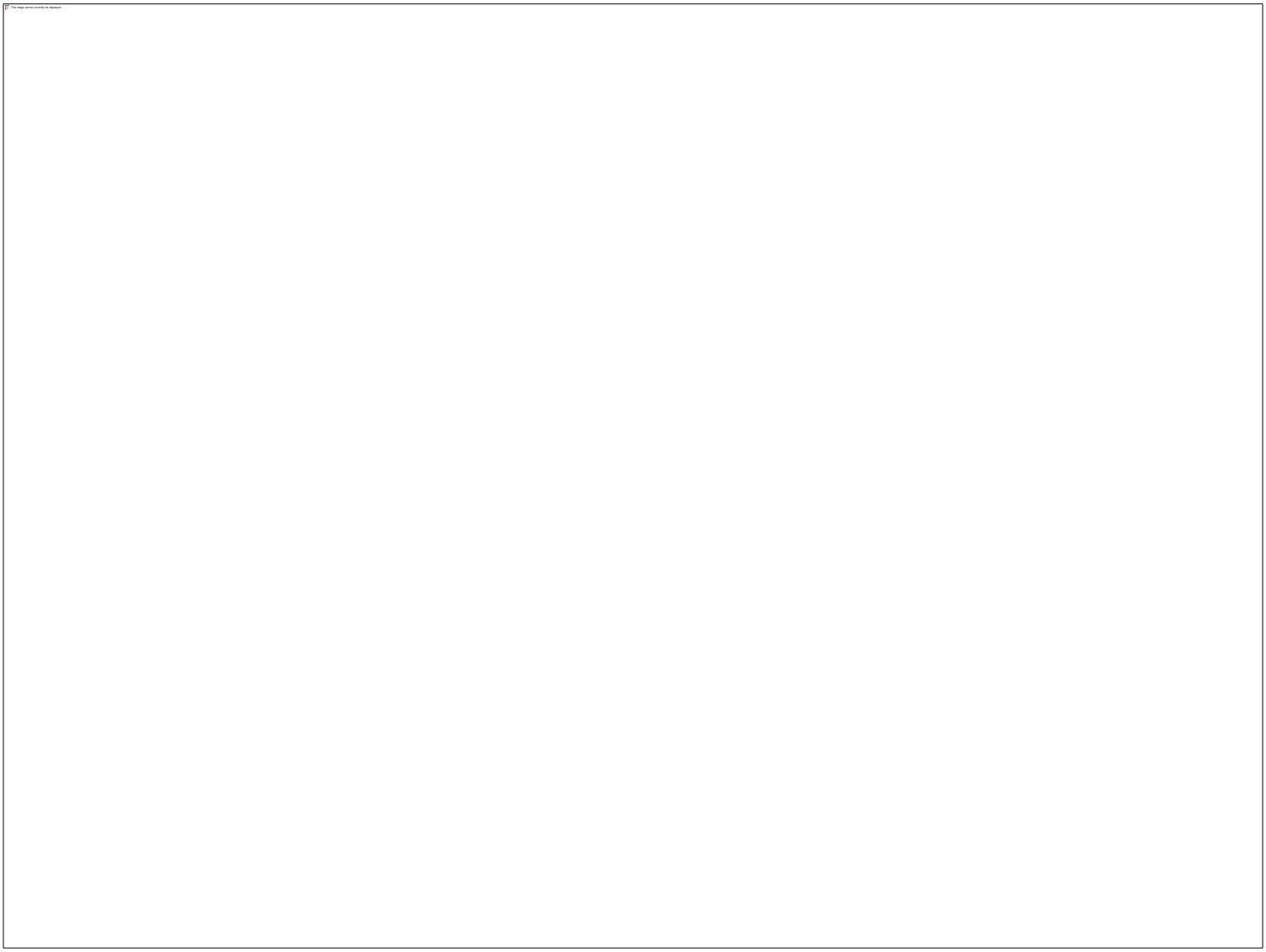
Clay.

Recycled containers.

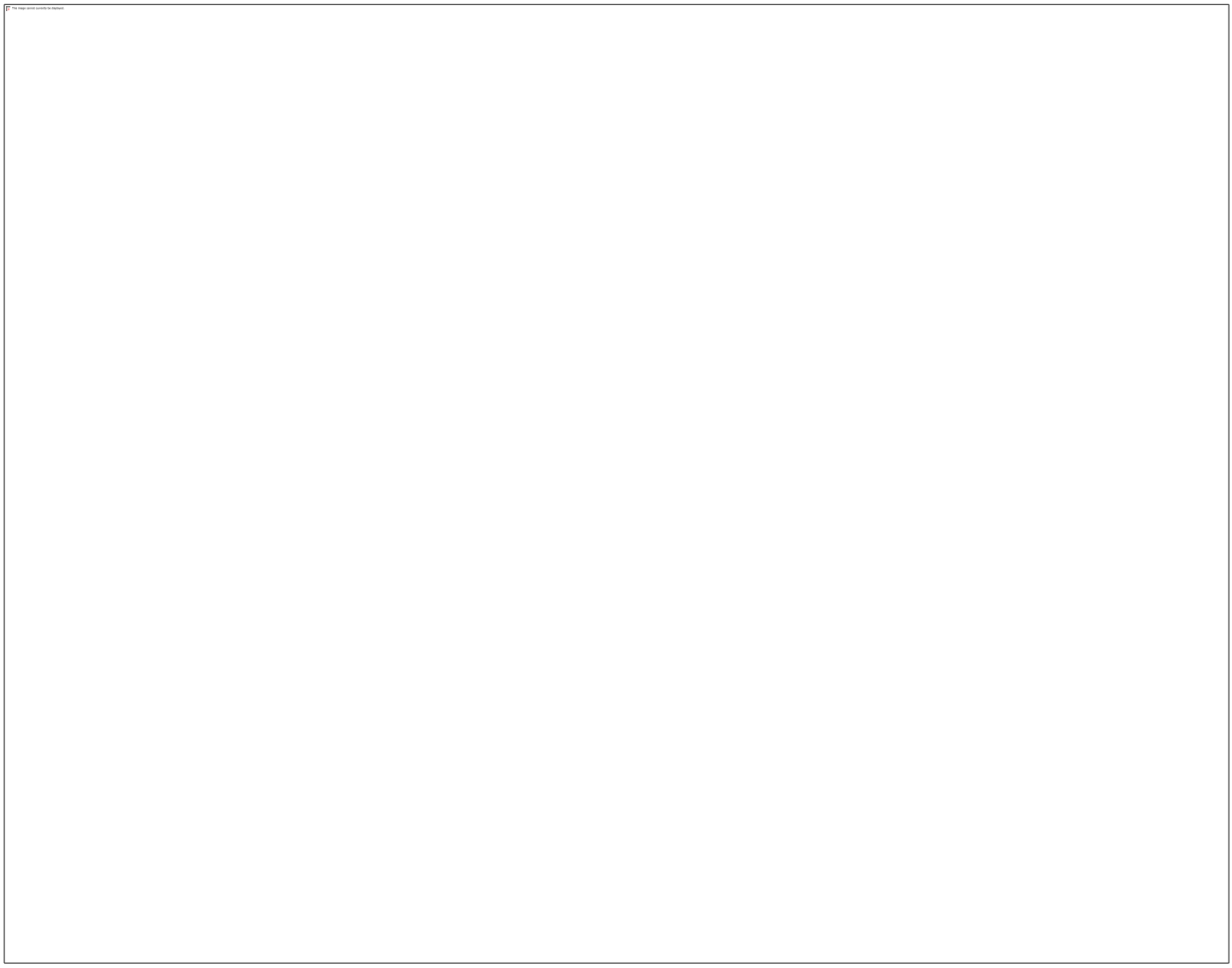
Thin metal sheets.

Adhesives.

String and wire.







10.5 Types of models

a) Physical model

A physical model is a three-dimensional representation made using physical materials.

Example: A small cardboard model of a classroom block.

b) Scale model

A scale model is made using dimensions reduced or enlarged in a consistent proportion.

Example: A classroom model made at a scale of 1:50.

c) Working model

A working model demonstrates some or all of the functions of the actual product.

Example: A miniature water-supply model in which water flows from a raised container through a pipe to a tap.

d) Digital model

A digital model is developed using computer software to represent a proposed product or structure.

Example: A three-dimensional digital model of a roof truss.

10.6 Steps in developing a physical model

Study the selected design.

Identify the components to be represented.

Determine the scale of the model.

Select suitable model-making materials.

Prepare the required tools.

Measure and mark the components.

Cut the materials accurately.

Assemble the model.

Fix the components securely.

Label important parts.

Inspect the completed model.

Make necessary adjustments.

10.7 Safety precautions during model-making

Use cutting tools carefully.

Work on a suitable workbench.

Wear appropriate protective equipment.

Avoid using damaged tools.

Keep sharp objects away from the edge of the workbench.

Use adhesives and paints in well-ventilated areas.

Dispose of waste materials properly.

Maintain a clean working environment.

11. Testing and Evaluation of the Design Product

11.1 Meaning of testing

Testing is the process of checking a product or model under specified conditions to establish whether it performs the intended function.

11.2 Meaning of evaluation

Evaluation is the systematic assessment of a design, model or completed product to determine how well it meets the identified needs and design requirements.

11.3 Importance of testing and evaluation

Determines whether the product solves the identified problem.

Identifies defects and weaknesses.

Checks the safety of the product.

Determines whether the product performs effectively.

Helps assess the quality of workmanship.

Establishes whether the materials are suitable.

Helps determine whether the project meets the budget.

Identifies areas requiring improvement.

Provides evidence of project performance.

Helps determine whether the final product is ready for use.

11.4 Aspects considered during evaluation

a) Functionality

The product should perform the task for which it was designed.

Example: A handwashing station should provide water conveniently for washing hands.

b) Strength and stability

The product should withstand the loads and forces expected during normal use.

Example: A water tank stand should safely support the weight of a full tank.

c) Safety

The product should not expose users to avoidable hazards.

Example: The frame should have stable supports, secure joints and no dangerous sharp edges.

d) Durability

The product should withstand the expected environmental conditions and frequency of use.

e) Cost effectiveness

The product should provide satisfactory performance without unnecessary expenditure.

f) Appearance

The product should have a neat and acceptable finish.

g) Ease of maintenance

The product should be easy to inspect, clean, repair and maintain.

h) Environmental suitability

The product should minimise pollution, waste and unnecessary resource consumption.

11.5 Methods of evaluating a design product

Physical inspection.

Measurement.

Functional testing.

Observation during use.

Comparison with design drawings.

Comparison with the original design requirements.

User assessment.

Cost comparison.

Inspection of workmanship.

Review of safety provisions.

11.6 Example: Evaluating a handwashing station

Evaluation area	What to check
Functionality	Does water flow through the tap?
Stability	Does the supporting frame remain stable?
Safety	Are the joints secure and edges safe?
Drainage	Is wastewater directed to a suitable disposal point?
Durability	Are materials suitable for outdoor conditions?
Accessibility	Can intended users reach the tap and basin comfortably?
Maintenance	Can the tank, tap and basin be cleaned easily?
Appearance	Is the finished product neat?

Safety note: A full-size tank support must not be tested by learners through uncontrolled loading. Its structural capacity should be assessed using an appropriate design and competent supervision.

12. Feedback and Improvement

12.1 Meaning of feedback

Feedback is information, comments or recommendations provided by users, teachers, clients, technicians or other stakeholders about the performance, quality and suitability of a design or product.

Feedback helps the designer identify strengths and weaknesses and make appropriate improvements.

12.2 Sources of feedback

Intended users.

Teachers.

Project supervisors.

Building technicians.

Plumbers.

Carpenters.

Engineers.

School administrators.

Community members.

Other learners.

12.3 Importance of feedback

Helps identify weaknesses that may have been overlooked.

Provides suggestions for improvement.

Helps determine whether users are satisfied.

Improves the functionality of the product.

Enhances safety.

Helps improve the appearance of the product.

Encourages continuous learning.

Promotes teamwork and communication.

Helps the designer make informed decisions.

Improves the quality of the final product.

12.4 Examples of feedback and possible improvements

Feedback received	Suggested improvement
The tap is too high for younger learners	Adjust the tap height to suit intended users
The water tank stand shakes	Review the structural design and improve stability
Water collects around the station	Improve the drainage arrangement
The basin is too small	Select a suitably sized basin
The product is difficult to clean	Modify the design to improve access for cleaning
The metal frame is exposed to rain	Apply an appropriate protective coating

12.5 Steps in using feedback

Collect comments from users and other stakeholders.

Record the feedback.

Identify repeated or important concerns.

Determine the causes of the problems.

Identify possible improvements.

Decide which improvements are practical and necessary.

Modify the design or product.

Test the improved product.

Record the changes made.

Present the improved design or product.

13. Design Product and Final Project Presentation

13.1 Meaning of a design product

A **design product** is the proposed or completed solution developed to address an identified problem.

It may be a physical object, building component, construction model, facility or technical design.

Examples:

A rainwater harvesting system.

A handwashing station.

A model roof truss.

A drainage channel.

A tool-storage rack.

A small building model.

13.2 Characteristics of a good design product

Solves the identified problem.

Meets the needs of intended users.

Is safe to use.

Is functional.

Is durable.

Is affordable.

Is easy to maintain.

Uses suitable materials.

Has acceptable workmanship.

Is environmentally responsible.

13.3 Components of a final project presentation

A completed project should be presented with relevant supporting information.

Project title: A clear name describing the project.

Problem statement: A brief explanation of the problem being solved.

Needs assessment: Information showing the need for the project.

Research findings: Relevant information gathered during investigation.

Design concepts: Alternative ideas considered.

Selected design: The chosen solution and reasons for selecting it.

Design drawings: Relevant sketches and technical drawings.

Material list: Materials, specifications and quantities.

Cost estimate: Expected project expenditure.

Model or prototype: Physical or digital representation, where applicable.

Completed product: The final solution, where construction has been undertaken.

Evaluation report: Findings from testing and inspection.

Feedback: Comments received from users and stakeholders.

Improvements: Changes made after evaluation.

Conclusion: A statement showing whether the project achieved its purpose.

Practical CBE Project: Designing a School Handwashing Station



Project situation

A school has a large number of learners, but the available handwashing facilities are inadequate. Learners experience difficulties accessing water after using the toilets and before eating meals.

The school administration requests learners to develop a suitable handwashing station using locally available materials.

Project task

Work individually or in groups to identify the problem, investigate possible solutions, prepare a design, develop a model and present a cost estimate.

Stage 1: Needs assessment

Find out:

The number of learners requiring the facility.

The available water source.

The available space.

The preferred location.

The needs of younger learners and learners with disabilities.

Stage 2: Problem definition

Write a clear statement explaining the problem.

Sample problem statement:

The school has inadequate handwashing facilities, making it difficult for learners to wash their hands conveniently. There is therefore a need to design an affordable, safe and durable handwashing station using locally available materials.

Stage 3: Research and data collection

Use observation, interviews, measurements and document study to obtain relevant information.

Stage 4: Concept development

Develop at least three possible designs and sketch each one.

Stage 5: Design selection

Compare the designs using criteria such as:

Cost.

Safety.

Functionality.

Durability.

Availability of materials.

Ease of maintenance.

Stage 6: Drawing preparation

Prepare:

A freehand sketch.

A front elevation.

A side elevation.

A plan.

An isometric drawing, where appropriate.

Stage 7: Material list

Prepare a list showing the materials, descriptions, units and quantities.

Stage 8: Cost estimate

Determine the estimated cost of materials, labour, tools, transportation and other expenses.

Stage 9: Modelling

Construct a small-scale model to demonstrate the design.

Stage 10: Evaluation

Assess whether the model meets the intended requirements.

Stage 11: Feedback and improvement

Present the model to classmates and the teacher. Record their comments and improve the design.

Expected project outcomes

By completing this project, learners should be able to:

Identify a real-life construction-related problem.

Conduct a needs assessment.

Collect and analyse information.

Generate alternative design concepts.

Prepare relevant design drawings.

Prepare a material list.

Estimate project costs.

Construct a model.

Evaluate a design product.

Use feedback to improve a design.

REVISION QUESTIONS

SECTION A: MULTIPLE-CHOICE QUESTIONS

Instructions: Answer all questions. Choose the correct answer from the alternatives provided.

1. What is a building construction project?

A. An unplanned building activity.

B. A planned activity undertaken to meet a particular construction need.

C. A process of purchasing building materials only.

D. An activity involving the demolition of all buildings.

2. The systematic sequence followed to develop a solution to an identified problem is known as:

A. Site clearance.

B. Cost control.

C. Design process.

D. Material storage.

3. Which of the following is the first important consideration when initiating a design project?

A. Painting the product.

B. Purchasing materials.

C. Identifying the need.

D. Constructing the final product.

4. The process of identifying and understanding the needs of intended users is called:

A. Needs assessment.

B. Modelling.

C. Procurement.

D. Evaluation.

5. Which method of data collection involves asking people questions directly?

A. Observation.

B. Interview.

C. Measurement.

D. Photography.

6. A written set of questions used to obtain information from respondents is called a:

A. Drawing.

B. Material schedule.

C. Questionnaire.

D. Cost estimate.

7. Which of the following is an example of primary data collection?

A. Reading an old textbook.

B. Studying a published report.

C. Observing an existing drainage problem.

D. Reading a manufacturer's catalogue.

8. The process of examining collected information to identify important findings is known as:

A. Data analysis.

B. Modelling.

C. Painting.

D. Procurement.

9. Generating several possible solutions to an identified problem is known as:

A. Site setting out.

B. Concept development.

C. Cost calculation.

D. Maintenance.

10. Which technique encourages group members to suggest many ideas?

A. Brainstorming.

B. Excavation.

C. Levelling.

D. Welding.

11. A quick drawing used to communicate an initial design idea is called a:

A. Working drawing.

B. Freehand sketch.

C. Site plan.

D. Structural report.

12. Which factor should be considered when selecting a design?

A. Availability of materials.

B. Colour of the classroom wall only.

C. Number of textbooks in the library.

D. Age of the designer only.

13. A table used to compare alternative designs against selected criteria is called a:

A. Material schedule.

B. Design selection matrix.

C. Site diary.

D. Payment certificate.

14. A drawing showing the front, plan and side views of an object is known as:

A. Isometric drawing.

B. Freehand sketch.

C. Orthographic drawing.

D. Perspective photograph.

15. Which drawing represents a three-dimensional object on a two-dimensional surface?

A. Isometric drawing.

B. Floor plan only.

C. Section drawing only.

D. Site boundary plan.

16. The document showing materials and their required quantities for a project is called:

A. Site report.

B. Material list.

C. Inspection certificate.

D. Project diary.

17. Which of the following is a reason for preparing a material list?

A. To increase material wastage.

B. To prevent unnecessary purchases.

C. To eliminate the need for drawings.

D. To avoid project planning.

18. Cost estimation refers to:

A. Measuring the height of a building.

B. Calculating the expected project expenditure.

C. Preparing a site boundary.

D. Painting a finished structure.

19. The cost of paying workers for their services is known as:

A. Material cost.

B. Labour cost.

C. Transport cost.

D. Equipment storage cost.

20. An allowance made for unexpected project expenses is called:

A. Profit margin.

B. Material wastage.

C. Contingency allowance.

D. Labour schedule.

21. A simplified physical representation of a proposed product is called a:

A. Model.

B. Contract.

C. Receipt.

D. Specification.

22. A prototype is mainly developed to:

A. Replace all design drawings.

B. Test the design and performance of a product.

C. Increase construction expenses.

D. Avoid evaluation.

23. Which of the following is a suitable material for making a simple architectural model?

A. Cardboard.

B. Fresh concrete only.

C. Heavy structural steel only.

D. Wet soil only.

24. A model made using a consistent reduced proportion is called a:

A. Working drawing.

B. Scale model.

C. Site report.

D. Material list.

25. The process of checking whether a product performs its intended function is called:

A. Testing.

B. Procurement.

C. Excavation.

D. Brainstorming.

26. Which of the following is an aspect considered during product evaluation?

A. Functionality.

B. The designer's handwriting only.

C. The age of the building owner.

D. The colour of the measuring tape.

27. Information and recommendations provided by users about a product are known as:

A. Specifications.

B. Feedback.

C. Excavation.

D. Setting out.

28. What should a designer do after receiving useful feedback?

A. Ignore all comments.

B. Destroy the original drawings.

C. Consider and implement appropriate improvements.

D. Stop the project immediately.

29. Which of the following demonstrates environmental responsibility in design?

A. Using materials carelessly.

B. Increasing unnecessary waste.

C. Considering reusable materials and proper waste disposal.

D. Discharging wastewater onto neighbouring land.

30. Which document provides technical information to guide the construction of a product?

A. Working drawing.

B. Attendance register.

C. Shopping list without specifications.

D. Personal diary.

SECTION B: STRUCTURED QUESTIONS

1.
a) Define a building construction project.

b) Explain five characteristics of a building construction project.

2.
a) What is meant by the design process?

b) Explain six reasons why the design process is important in building construction.

3.
a) Define needs assessment.

b) Describe five activities carried out when conducting a needs assessment.

4. A school has inadequate water-storage facilities.

Explain how a learner can identify and define this problem before developing a suitable solution.

5.
a) Define data collection.

b) Describe six methods used to collect data during a building construction project.

6. Explain five reasons why data analysis is important during the design process.

7.
a) What is concept development?

b) Explain five techniques used when developing design concepts.

8. State and explain eight factors considered when selecting the most suitable design concept.

9.
a) Define a design drawing.

b) Explain five importance of design drawings in building construction projects.

10. Differentiate between the following types of drawings:

a) Freehand sketch and working drawing.

b) Orthographic drawing and isometric drawing.

11. State eight qualities of a good design drawing.

12.
a) Define a material list.

b) Explain six reasons why a material list is prepared before construction.

13. Prepare a material list for a simple school waste-bin shelter, showing the material descriptions, units and estimated quantities.

14.
a) Define cost estimation.

b) Explain five components of cost estimation in a building construction project.

15. A learner requires 8 lengths of timber, each costing KSh 750, to construct a model structure.

a) Calculate the total cost of timber.

b) If transportation costs KSh 500, calculate the total expenditure before other expenses.

16.
a) Differentiate between a model and a prototype.

b) Explain five importance of modelling in building construction projects.

17. Describe the steps followed when developing a physical model of a simple building.

18.
a) Define testing and evaluation.

b) Explain six aspects considered when evaluating a completed design product.

19. Explain five sources of feedback during a building construction project.

20. Describe the steps followed when using feedback to improve a design product.

21. A school wants to construct a drainage channel to prevent water from collecting around classrooms.

a) Identify the problem.

b) State five pieces of information that should be collected before developing the design.

c) Suggest three possible design concepts.

d) State five factors to consider when selecting the best design.

22. Explain how a learner can demonstrate creativity, critical thinking and collaboration while undertaking a building construction project.

SECTION C: PRACTICAL PROJECT TASK

Project: Design and model a simple school waste-bin shelter.

Instructions:

Working in groups, undertake the following activities:

Identify a waste-disposal problem within the school compound.

Conduct a needs assessment.

Collect information through observation and interviews.

Analyse the collected information.

Develop three alternative design concepts.

Select the most suitable design.

Prepare a freehand sketch.

Prepare relevant orthographic or isometric drawings.

Prepare a material list.

Prepare a cost estimate.

Construct a scale model using locally available materials.

Present the model to classmates.

Collect feedback from the teacher and other learners.

Improve the design based on the feedback.

Prepare a short project report.

Suggested project assessment checklist

Assessment area	Evidence expected
Problem identification	Clear statement of the problem
Needs assessment	Relevant users' needs identified
Research	Appropriate information collected
Concept development	At least three design ideas
Design selection	Justified choice of design
Drawings	Neat and correctly labelled drawings
Material list	Suitable materials and quantities
Cost estimation	Correct calculations and realistic costs
Model construction	Neat and appropriate model
Evaluation	Relevant testing and inspection

Feedback	Comments recorded
Improvement	Appropriate modifications made
Teamwork	Effective participation and cooperation
Safety	Appropriate use of tools and materials

Key terms to remember

Term	Meaning
Needs assessment	Identifying the needs of intended users
Problem definition	Clearly stating the problem to be solved
Research	Systematic investigation to obtain relevant information
Data collection	Gathering information about a problem
Data analysis	Examining information to guide decisions
Concept development	Generating and developing possible solutions
Design drawing	Graphical representation of a proposed product
Material list	Record of materials and quantities required
Cost estimation	Calculating the expected project expenditure
Modelling	Creating a representation of a proposed product
Prototype	An initial version developed for testing
Evaluation	Assessing the quality and suitability of a product
Feedback	Information used to assess and improve a design