Construction Technology (DI03006011)

GTU

2024-25

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Classification of various types of civil engineering Structures. I

- **Course:** Construction Technology (DI03006011)
- **Unit 1:** Introduction to Construct Technology
- **Lecture 1:** Classification of various types of civil engineering Structures.

Lecture Agenda I

1. Introduction to Civil Engineering Structures
2. Broad Classification of Structures
3. Load Bearing, Framed, and Composite Structures
4. Components of a Residential Building
5. Cross section of wall showing all component of residential Building.
6. Summary and Q&A

Introduction to Civil Engineering Structures I

- A structure is an assembly of building materials built in such a way that it can safely sustain the loads subjected to it.
- Purpose of civil engineering structures: To provide shelter, facility, and utility to the society safely and economically.
- Examples: Residential buildings, commercial complexes, bridges, dams, retaining walls, etc.
- Design considerations: Strength, stability, durability, aesthetics, and economy.

Broad Classification of Structures I

Basis of Classification	Types of Structures
Based on structural action	Load Bearing, Framed, Composite
Based on material	Concrete, Steel, Timber, Masonry
Based on utility	Residential, Commercial, Industrial, Public
Based on structural form	Solid, Surface, Skeletal structures

Table: Classification of Civil Engineering Structures

Load Bearing Structures I

- **Concept:** In these structures, the load from the roof and floors is transmitted to the foundation entirely through walls.
- **Suitability:** Economical up to 2 to 3 stories.
- **Characteristics:**
  - Thicker walls at the bottom to bear the heavier load.
  - Less flexible in terms of room dimensions.
  - More carpet area is consumed by thick walls.
  - High mass makes it somewhat better for thermal insulation.

Framed Structures I

- **Concept:** A network of beams and columns transfers the load to the foundation. Walls act only as partitions.
- **Suitability:** Ideal for multi-storey buildings and high-rises.
- **Characteristics:**
  - Wall thickness is uniform across floors (e.g., 230 mm or 115 mm).
  - Highly flexible architectural planning.
  - Excellent resistance to seismic forces.
  - Faster construction compared to load-bearing structures.

Composite Structures I

- **Concept:** A combination of load-bearing walls and framed structural elements.
- For instance, exterior walls may be load-bearing, while the interior depends on columns and beams.
- **Application:** Often used for structures requiring large column-free spaces but with solid external boundaries.
- Typical in large industrial sheds or historical buildings retrofitted with modern frameworks.

Comparison of Load Bearing and Framed Structures I

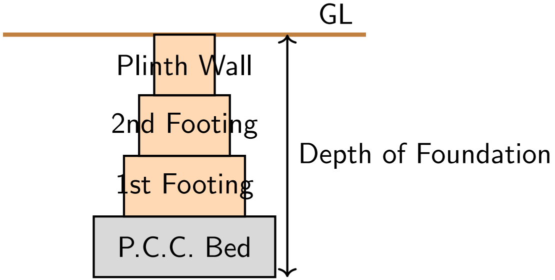
Parameter	**Load Bearing Structure**	**Framed Structure**
Load Transfer	Through walls	Through columns and beams
Wall Thickness	Increases with depth	Remains uniform
Carpet Area	Less available area	More available area
Speed of Construction	Slower	Faster
Seismic Resistance	Poor	Excellent
Suitability	Low-rise buildings	High-rise buildings

Table: Comparison Table

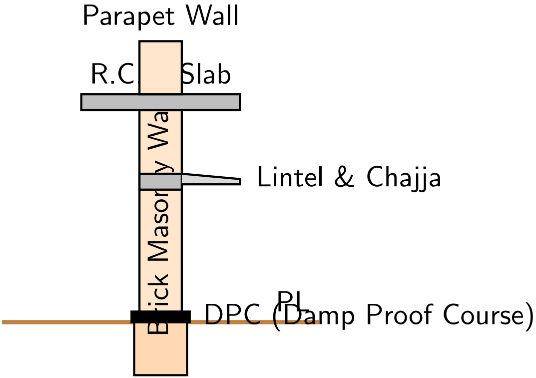
Components of a Residential Building I

- A typical residential building has two main parts:
  1. **Substructure:** The part of the building constructed below ground level (Foundation).
  2. **Superstructure:** The part of the building constructed above ground level.
- **Key Components:**
  - Foundation, Plinth, DPC (Damp Proof Course)
  - Walls, Columns, Beams, Floors
  - Doors, Windows, Ventilators
  - Stairs, Lifts
  - Roof, Parapet Wall

Cross Section of a Wall (Substructure) I



Cross Section of a Wall (Superstructure) I



Key Engineering Principles I

- **Load Distribution:** Ensuring uniform distribution of loads to prevent differential settlement.
- **Material Selection:** Choosing appropriate materials (concrete, steel, timber) based on the structural requirements and environmental conditions.
- **Factor of Safety:** Designing structures to withstand loads greater than expected, accommodating uncertainties in material strength and load estimation.
- **Serviceability:** Structure must remain functional and comfortable for occupants throughout its design life (limiting deflections, vibrations, and cracking).

Reference to Standard IS Code Specifications I

- **IS 456: 2000:** Plain and Reinforced Concrete - Code of Practice.
- **IS 800: 2007:** General Construction in Steel - Code of Practice.
- **IS 875 (Parts 1-5):** Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures.
- **IS 1893 (Part 1): 2016:** Criteria for Earthquake Resistant Design of Structures.
- Adhering to IS codes ensures structural integrity, safety, and standardization in civil engineering practices.

Summary I

- Civil engineering structures are mainly classified into load-bearing, framed, and composite types based on structural action.
- Framed structures are widely adopted today due to their speed, flexibility, and seismic performance.
- A residential building comprises the substructure (foundation) and superstructure (components above ground).
- Standard IS codes must always be referred to for parameter limits and design guidelines.

Key Takeaways & Next Lecture Preview I

- **Key Takeaways:**
  - Understanding these components is crucial for designing durable structures.
  - The cross-section of a wall reveals critical elements like DPC, lintels, and plinth levels essential for a building's longevity.
- **Next Lecture Preview:**
  - Next, we will advance to the subsequent topics and practical case studies in this unit, exploring detailed construction techniques and site investigations.

Course: Construction Technology (DI03006011)
Unit 1: Introduction to Construct Technology
Topic: Function of Various component of Building & Difference between Load Bearing & Framed Structure

Lecture Agenda I

1. Substructure and Superstructure overview.
2. Detailed functions of foundation, plinth, walls, and columns.
3. Detailed functions of floors, roofs, doors, and windows.
4. Introduction to Load Bearing and Framed Structures.
5. Detailed difference between Load Bearing & Framed Structure.

Basic Parts of a Building I

A building can be broadly divided into two main parts:

- **Substructure:** The lower portion of the building, which is constructed below ground level to transmit the load of the superstructure to the subsoil.
- **Superstructure:** The portion of the building constructed above ground level, serving the intended purpose of the building.

Foundation:

- It is the most critical part of the building.
- **Function:** To distribute the total load of the building (dead load, live load, wind load, etc.) over a large area of soil.
- It prevents differential settlement of the building.
- It provides stability against overturning due to lateral forces (wind, earthquakes).
- It protects the structure against soil moisture and roots.

Superstructure: Plinth and DPC I

Plinth:

- The portion of the structure between the ground level and the ground floor level.
- **Function:** To keep the ground floor above the surrounding ground level, protecting it from rainwater and dampness.

Damp Proof Course (DPC):

- A continuous layer of water-repellent material (like asphalt or rich concrete) provided at the plinth level.
- **Function:** To prevent capillary action of moisture from the ground into the walls, avoiding dampness.

Walls:

- Vertical members of a building.
- **Function:** Enclose the building space, provide privacy, security, and weather protection.
- In load-bearing structures, walls transmit the load from the roof and floors to the foundation.

Columns:

- Vertical structural members in a framed structure.
- **Function:** To support beams and slabs, safely transferring the compressive loads to the foundation.

Superstructure: Floors and Roofs I

Floors:

- Horizontal elements that divide the building into different levels.
- **Function:** Provide a durable and leveled surface for occupants, furniture, and equipment.

Roofs:

- The topmost covering of a building.
- **Function:** Protect the building interior against weather elements like rain, sun, wind, and snow.

Superstructure: Doors, Windows and Stairs I

Doors:

- **Function:** Provide access to the building and interconnect various rooms. Provide security and privacy.

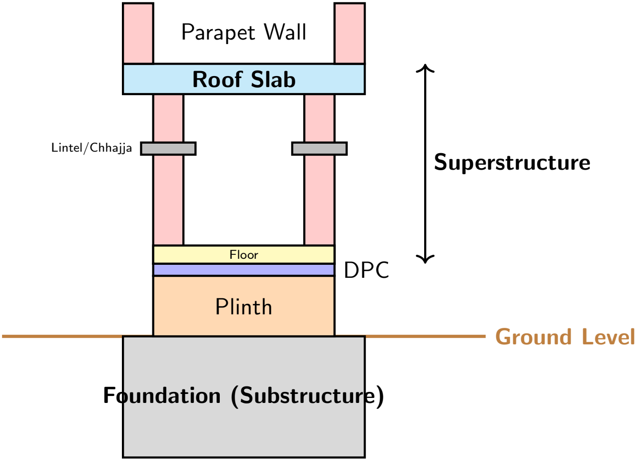
Windows:

- **Function:** Provide natural light, ventilation, and vision to the outside.

Stairs / Lifts:

- **Function:** Provide vertical circulation between different floors of the building.

Visualizing Building Components I



Introduction to Structural Systems I

A building's structural system transfers loads safely to the ground. The two primary structural systems are:

1. **Load Bearing Structure:**
   - In this system, walls carry the load of floors and roof.
   - Walls act as structural members in addition to enclosing space.
2. **Framed Structure:**
   - In this system, a framework of columns and beams carries the load.
   - Walls only act as partition or infill panels and do not carry structural loads.

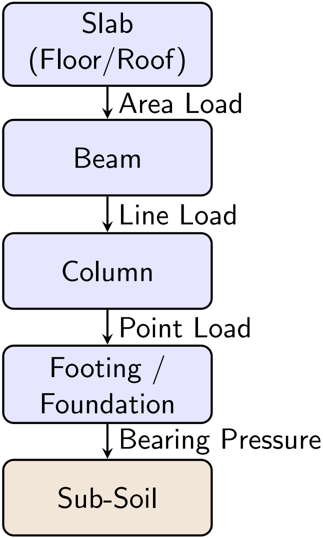
Load Bearing Structure: Characteristics I

- **Load Transfer Path:** Slab $\rightarrow$ Wall $\rightarrow$ Foundation $\rightarrow$ Soil.
- Suitable for low-rise buildings (typically up to 3 or 4 stories).
- Walls are thick and consume more floor area.
- Less flexible in terms of room layout and modifications.
- Less resistant to earthquake forces compared to framed structures.
- Construction is generally slower.

Framed Structure: Characteristics I

- **Load Transfer Path:** Slab $\rightarrow$ Beam $\rightarrow$ Column $\rightarrow$ Footing $\rightarrow$ Soil.
- Suitable for multi-story and high-rise buildings.
- Walls can be thinner as they only bear their own weight (non-load bearing).
- Provides greater flexibility in architectural planning and space utilization.
- Better resistance to seismic (earthquake) forces.
- Faster construction due to independent structural framework.

Load Transfer Path in Framed Structure I



Difference Between Load Bearing & Framed Structure I

Parameter	Load Bearing Structure	Framed Structure
Load Transfer	Loads are transferred through walls.	Loads are transferred through columns and beams.
Suitability	Suitable for low-rise buildings (1-3 floors).	Suitable for multi-story high-rise buildings.
Wall Thickness	Walls are thicker as they carry loads.	Walls can be thinner (infill walls).
Floor Area	Thicker walls reduce the usable floor area.	Thinner walls increase the usable carpet area.
Flexibility	Very difficult to alter wall positions later.	High flexibility in changing room layouts.
Earthquake Resistance	Poor resistance to seismic forces.	Good resistance to seismic forces.

Summary I

- Understanding the function of various components like foundation, plinth, walls, and roofs is crucial for a civil engineer.
- The foundation (substructure) safely transfers all building loads to the soil.
- Superstructure components provide shelter, utility, and safety.
- Load-bearing structures rely on walls for structural support, limiting their height and flexibility.
- Framed structures use a network of beams and columns, offering better strength, flexibility, and earthquake resistance.

Lecture 3: Definition, Purpose and Classification of Foundation I

Course: Construction Technology (DI03006011)
Unit 2: Foundation

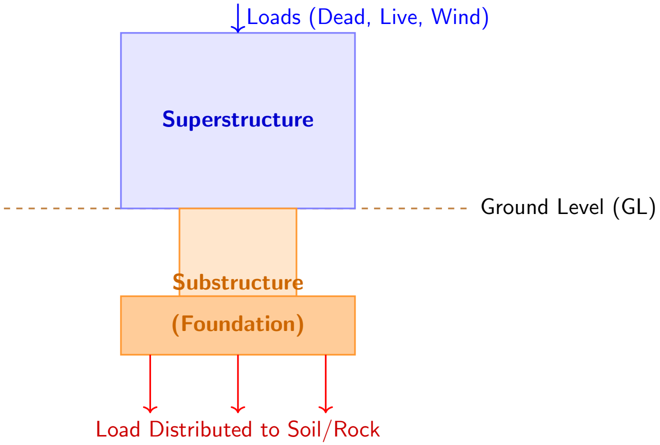
Lecture Agenda I

- Introduction to Foundation
- Purpose and Functions of a Foundation
- Basic Terminology in Foundation Engineering
- Broad Classification of Foundations
- Shallow Foundations: Types and Uses
- Deep Foundations: Types and Uses
- Shallow vs. Deep Foundations
- Summary and Key Takeaways

Definition of Foundation I

- The lowest artificially prepared part of a structure which is in direct contact with the ground.
- It transmits the load of the structure to the underlying soil or rock.
- Often referred to as the **substructure**, whereas the part above ground is the **superstructure**.
- Designed to distribute the load evenly so that the safe bearing capacity of the soil is not exceeded.

Structure Components I

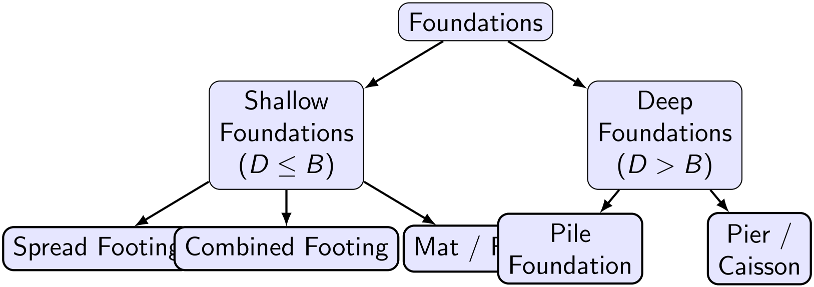


Purpose of Foundation - I I

- **Load Distribution:** To distribute the total load of the structure over a large area to prevent bearing capacity failure of the soil.
- **Minimize Settlement:** To ensure that the settlement of the structure is within permissible limits and to prevent differential settlement.
- **Stability:** To provide structural stability against lateral forces like wind, earthquakes, and water currents.

Purpose of Foundation - II I

- **Provide Level Surface:** To provide a hard and level surface for the construction of the superstructure.
- **Protection from Soil Moisture:** To safeguard the building against the effects of soil moisture and changing soil conditions (like swelling/shrinkage in black cotton soil).
- **Prevent Undermining:** To prevent undermining by burrowing animals or by scour (in case of bridges).



Where D is Depth and B is Width of the foundation.

Shallow Foundations I

- **Definition:** A foundation whose depth (D) is equal to or less than its width (B) is generally classified as a shallow foundation.
- **Usage:** Used when soil of adequate bearing capacity is available at a shallow depth near the ground surface.
- **Advantages:** Cost-effective, requires less excavation, simpler construction process, and typically no heavy equipment is needed.
- **Common Types:**
  - Isolated or Spread Footing
  - Combined Footing
  - Strap or Cantilever Footing
  - Mat or Raft Foundation

Types of Shallow Foundations I

Isolated Footing: Supports a single column. Used for moderate loads and firm soil.

Combined Footing: Supports two or more columns. Used when columns are close to each other or near a property line.

Strap Footing: Two isolated footings connected by a rigid strap beam.

Raft (Mat) Foundation: A large slab supporting multiple columns or walls. Used for low bearing capacity soil to minimize differential settlement.

Deep Foundations I

- **Definition:** A foundation whose depth (D) is significantly greater than its width (B). Usually $D/B > 4$ to 5.
- **Usage:** Employed when shallow soils lack the necessary strength or bearing capacity to support the structural loads, requiring loads to be transferred to deeper, stronger soil or rock layers.
- **Applications:** High-rise buildings, bridges, offshore structures, or areas with highly compressible soils like black cotton soil.
- **Common Types:**
  - Pile Foundation
  - Pier Foundation
  - Caisson or Well Foundation

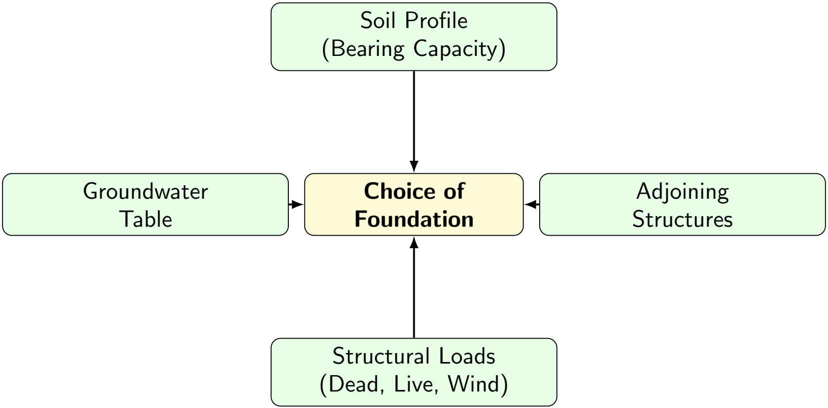
Deep Foundations: Pile Foundation I

- **Concept:** Slender structural members made of steel, concrete, or timber, driven or cast into the ground.
- **Load Transfer Mechanism:**
  - *End-bearing Piles:* Transfer load directly to a hard stratum (rock or dense soil) at the bottom.
  - *Friction Piles:* Transfer load through skin friction between the pile surface and the surrounding soil.
- **Suitability:** Ideal for weak surface soils, high water tables, and areas subjected to uplift or lateral forces.

Comparison: Shallow vs. Deep Foundation I

- **Depth to Width Ratio:**
  - Shallow: $D \leq B$
  - Deep: $D \gg B$ (Usually > 4)
- **Load Transfer:**
  - Shallow: Mostly bearing pressure on base
  - Deep: End bearing and/or skin friction
- **Cost and Complexity:**
  - Shallow: Economical, simpler to construct
  - Deep: Expensive, requires heavy machinery
- **Soil Condition Requirements:**
  - Shallow: Good bearing capacity near surface
  - Deep: Poor bearing capacity near surface

Factors Influencing Choice of Foundation I



Summary I

- A foundation is the critical link between a superstructure and the earth, ensuring safe load transfer.
- The primary purposes include load distribution, minimizing settlement, and providing structural stability.
- Foundations are broadly classified into **Shallow** and **Deep** foundations based on the depth-to-width ratio.
- The selection depends on soil bearing capacity, load magnitude, and economic considerations.
- Proper geotechnical investigation is a prerequisite for any foundation design.

Questions and Answers I

Thank You!

Questions and discussions are welcome.

Lecture Agenda I

1. Introduction to Foundations
2. Shallow Foundation: Definition, Types, and Features
3. Deep Foundation: Definition, Types, and Features
4. Difference between Shallow and Deep Foundation
5. Selection of Suitable Foundation Type as per Situation
6. Summary and Q&A

Introduction to Foundation I

- **Foundation:** The lowest part of a structure, built below ground level, which transfers the loads of the superstructure safely to the underlying soil strata.
- **Functions of foundation:**
  - Distributes the load over a sufficient area of soil so that the safe bearing capacity (SBC) of soil is not exceeded.
  - Provides a level and firm bed for the superstructure.
  - Prevents lateral movement and overturning.
  - Minimizes differential settlement.
- Foundations are broadly classified into two categories based on depth of founding strata: **Shallow Foundation** and **Deep Foundation**.
- As per Terzaghi, a foundation is considered **shallow** when its depth (D_f) is less than or equal to its width (B), i.e., $D_f \leq B$.

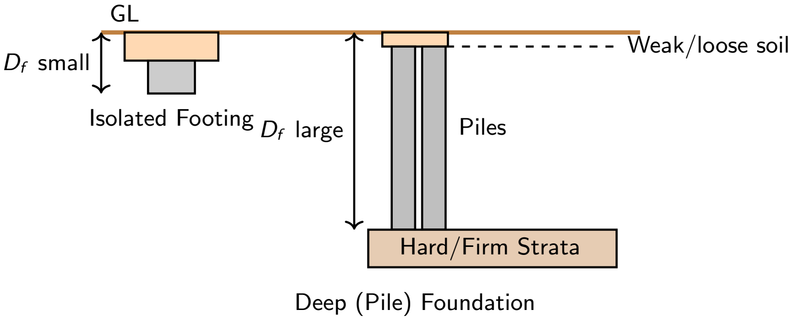
Shallow Foundation I

- **Definition:** A foundation placed near the ground surface, generally at a depth less than or equal to its width, which rests directly on the soil strata beneath it and transfers load by direct bearing.
- **Common types:**
  - Spread/Isolated footing (single column)
  - Combined footing (two or more columns)
  - Strip/Wall footing (continuous, under load bearing walls)
  - Raft/Mat foundation (covers entire building area)
  - Grillage foundation (steel beams, for heavy column loads on weak soil)
- **Suitable when:** SBC of soil is adequate near the surface and loads are moderate.
- Also called **open foundation** since it is constructed by open excavation up to the founding level.

Deep Foundation I

- **Definition:** A foundation that transfers loads to soil strata at considerable depth below the ground surface, well below the zone of seasonal moisture variation, where depth is much greater than width ($D_f > B$).
- **Common types:**
  - Pile foundation (bearing or friction piles)
  - Pier foundation (cylindrical column carried down to hard strata)
  - Well/Caisson foundation (used extensively for bridges)
  - Under-reamed pile foundation
- **Suitable when:** Top soil strata is weak, loose, or has low SBC and firm/hard strata is available only at greater depth, or when loads are very heavy (multi-storeyed buildings, bridges).
- Load transfer mechanism: **end bearing** (resting on hard strata) and/or **skin friction** (friction along the pile shaft).

Shallow vs. Deep Foundation – Cross Section I



Difference between Shallow and Deep Foundation I

Parameter	Shallow Foundation	Deep Foundation
Depth	$D_f \leq B$ (usually up to 3 m)	$D_f > B$ (can extend to 20–50 m)
Load transfer	Direct bearing on soil below base	End bearing and/or skin friction
Construction	Simple, open excavation	Requires piling rigs / boring, specialized equipment
Cost	Economical	Costlier due to equipment and skilled labour
Suitability	Good SBC soil near surface, moderate loads	Poor surface soil, heavy loads, high water table
Examples	Isolated, combined, strip, raft footing	Pile, pier, well/caisson foundation
Settlement	More sensitive to surface soil variation	Less sensitive, transfers load to stable strata

Table: Shallow vs. Deep Foundation

Selection of Suitable Foundation Type I

- **Safe Bearing Capacity (SBC) of soil:** If good SBC soil is available near the surface, shallow foundation is adequate and economical; otherwise deep foundation is needed.
- **Magnitude of structural load:** Light structures (residential, 1–3 storeys) generally use shallow footings; heavy structures (bridges, high-rises, industrial plants) require deep foundations.
- **Depth of hard strata:** If firm strata is within 3 m, shallow foundation suffices; if it lies at greater depth, piles/piers are used to reach it.
- **Water table position:** A high water table complicates open excavation, often favouring pile foundations executed with minimal dewatering.
- **Type of soil:** Expansive soils (black cotton soil) and loose sandy/filled-up soils are unsuitable for shallow foundations due to swelling/shrinkage or low bearing capacity.

Selection of Suitable Foundation Type II

- **Adjacent structures:** Deep foundations (bored piles) minimize vibration and disturbance to neighbouring buildings compared to open excavation.
- **Economy:** Overall cost including equipment mobilization must be compared; shallow foundation is preferred whenever soil conditions permit, since it is significantly cheaper.

Summary I

- Foundations are classified as shallow ($D_f \leq B$) or deep ($D_f > B$) based on the depth of the founding strata relative to width.
- Shallow foundations (isolated, combined, strip, raft) transfer load by direct bearing and are economical when good soil is near the surface.
- Deep foundations (pile, pier, well) transfer load through end bearing and/or skin friction and are used when surface soil is weak or loads are heavy.
- Selection depends on SBC, magnitude of load, depth of hard strata, water table, soil type, and overall economy.

Lecture Agenda I

1. Introduction to Pile Foundations
2. Under-Reamed Pile: Definition and Purpose
3. Features and Geometry of Under-Reamed Piles
4. Construction Procedure
5. Advantages of Under-Reamed Piles
6. Summary and Q&A

Introduction to Pile Foundations I

- A **pile** is a slender structural member driven or bored into the ground to transfer structural loads to deeper, stronger soil/rock strata.
- Conventional straight-shaft piles rely mainly on skin friction and small end bearing area, and often need large numbers of piles or deep embedment.
- In problematic soils (expansive black cotton soil, filled-up or loose soil), an enlarged bulb at the pile base – called an **under-reamed pile** – was developed in India (CBRI Roorkee) to increase load capacity without going to greater depth.
- Covered under **IS 2911 (Part 3)**: Design and Construction of Pile Foundations – Under-reamed Piles.

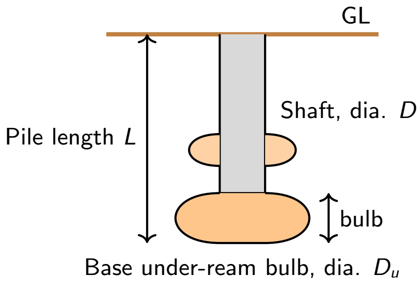
Under-Reamed Pile: Definition and Purpose I

- **Definition:** A bored cast-in-situ concrete pile provided with one or more bulb-shaped enlargements (under-reams) formed at its base or at intervals along its shaft, giving it a larger bearing/anchorage area than the shaft alone.
- **Purpose:**
  - To increase the bearing capacity and uplift/anchorage resistance of the pile without increasing its length.
  - To economically found structures in **expansive (black cotton) soils** where the top layer undergoes seasonal swelling and shrinkage.
  - To resist uplift forces caused by swelling pressure of expansive soil acting on the shaft.
  - To provide adequate support in loose or filled-up soils by anchoring below the weak zone.

Under-Reamed Pile: Definition and Purpose II

- Widely used for foundations of low-rise buildings, boundary walls, transmission line towers, and as an economical alternative to deep strip foundations in black cotton soil regions.

Under-Reamed Pile – Geometry I



Typical single or double under-reamed pile with bulb(s) formed at the base and/or at intermediate depth.

Features of Under-Reamed Piles I

- **Bulb diameter:** The under-ream (bulb) diameter D_u is generally kept **2 to 3 times** the shaft diameter D (i.e., $D_u = 2D$ to $3D$).
- **Number of bulbs:** May have a **single under-ream** at the base or **multiple under-reams** at spacing of about 1.25 to 1.5 times the bulb diameter along the shaft, depending on load and anchorage requirement.
- **Shaft diameter:** Commonly 200 mm, 250 mm, 300 mm, 375 mm, 450 mm depending on load; minimum length generally not less than 3.5 m.
- **Minimum spacing** between successive bulbs (centre to centre) is kept about $1.5D_u$ so that bulbs behave independently without overlapping zones of influence.

Features of Under-Reamed Piles II

- Can be constructed as **bored cast-in-situ** concrete piles using manual or mechanical boring augers with a special **under-reaming tool**.

Construction Procedure I

1. **Boring the pile hole:** A vertical hole of the required shaft diameter is bored to the design depth using a spiral auger (manual or power-operated).
2. **Under-reaming:** A special expandable under-reaming tool with hinged cutting blades is lowered to the required level and rotated; the blades expand outward to cut a bulb-shaped cavity in the soil.
3. **Cleaning the bore:** Loose soil/cuttings are removed from the bore and bulb cavity.
4. **Placing reinforcement cage:** A mild steel reinforcement cage (with adequate cover and spacers to keep it centred) is lowered into the bore.
5. **Concreting:** Concrete (M15–M20 grade typically) is poured and compacted, filling both the bulb cavity and the shaft; a tremie pipe is used if the bore contains water or is very deep.

Construction Procedure II

6. **Curing:** Exposed pile cap/top is cured for the standard period before loading.

Advantages of Under-Reamed Piles I

- **Higher bearing capacity** per pile due to the enlarged base area, reducing the number and length of piles required.
- **Excellent resistance to uplift** caused by swelling pressures in expansive (black cotton) soils, since the bulb acts as an anchor against upward soil movement.
- **Economical** compared to deep strip or raft foundations in black cotton soil – avoids costly deep excavation.
- **Suitable for problematic soils:** loose filled-up soil, expansive soil, and soils with fluctuating moisture content.
- **Simple, light equipment:** can be installed with hand-operated or light power augers, useful even where heavy piling rigs cannot access the site.
- **Reduced differential settlement** since bulbs anchor into more stable, less moisture-affected strata below the active zone.

Advantages of Under-Reamed Piles II

- Faster construction and lower cost than conventional under-reamed-free bored piles of comparable capacity.

Summary I

- Under-reamed piles are bored cast-in-situ concrete piles with one or more bulb-shaped enlargements at the base, with bulb diameter typically 2 to 3 times the shaft diameter.
- They are especially suited for foundations in expansive black cotton soil and loose/filled-up soils, providing both bearing support and uplift resistance.
- Construction involves boring, under-reaming with a special expandable tool, placing reinforcement, and concreting.
- Key advantages: higher capacity per pile, resistance to swelling-induced uplift, and overall economy, as governed by IS 2911 (Part 3).

Lecture Agenda I

Black Cotton Soil – The Problem I

- **Black cotton soil (BC soil)** is a highly expansive, montmorillonite-rich clay found extensively across Gujarat, Maharashtra, and Madhya Pradesh.
- **Key problem:** It exhibits large volume change with moisture – it **swells** on absorbing water (monsoon) and **shrinks and cracks** on drying (summer).
- This alternate swelling and shrinkage causes **differential heaving and settlement**, leading to cracks in walls, floors, and foundations of ordinary shallow footings.
- The zone of seasonal moisture variation (active zone) typically extends **1 to 2 m**, sometimes more, below ground level.
- Its shear strength drops drastically when wet, and it has very low SBC in the saturated state.

Foundation Techniques for Black Cotton Soil I

- **Under-reamed pile foundation:** Most common and economical solution – bulb anchors the pile below the active (moisture-variation) zone, resisting uplift due to swelling (as discussed in Lecture 5).
- **Deepening the foundation:** Taking the footing below the depth of the active zone so that seasonal moisture changes do not affect it.
- **Under-reamed pile with sand/granular filling around shaft:** A sand or loose granular collar around the pile shaft reduces the grip of swelling soil on the shaft, minimizing uplift drag.
- **Belled-out/stepped foundation:** Provides a wider base at greater depth, similar in principle to under-reaming.

Foundation Techniques for Black Cotton Soil II

- **Soil replacement/CNS (cohesive non-swelling) layer:** Removing the top expansive soil and replacing it with non-expansive cohesive soil below the footing.
- **Providing a rigid raft or plinth beam** to tie the structure together and resist differential movement rather than let each footing move independently.

Loose Soils – The Problem I

- **Loose soils** include uncompacted filled-up ground, loose sands, and made-up (reclaimed) soils with low density and high void ratio.
- **Key problems:**
  - Very low safe bearing capacity (SBC).
  - High compressibility – large settlement under load.
  - Liable to liquefaction under vibration/seismic loading if saturated loose sand.
  - Non-uniform density leads to differential settlement.
- Such soils are common in reclaimed land, old pond/tank filling sites, and river-bed deposits.

Foundation Techniques for Loose Soils I

- **Soil compaction:** Mechanical compaction (rollers, vibro-compaction, dynamic compaction/heavy tamping) to increase density and SBC before founding.
- **Increasing footing size (widening base):** Spreads the load over a larger area to keep bearing pressure within the low SBC.
- **Raft/mat foundation:** Distributes building load over the entire plan area, reducing differential settlement in weak, loose soil.
- **Pile foundation (friction or end-bearing):** Where loose strata extends deep, piles transfer load past the loose zone to firmer strata or develop capacity through skin friction over a long shaft.
- **Soil stabilization:** Grouting, chemical stabilization, or use of stone columns to improve strength and reduce compressibility.

Foundation Techniques for Loose Soils II

- **Removal and replacement:** Excavating loose soil and replacing/compacting it in layers with granular fill where depth of loose layer is limited.

Introduction to Timbering in Trenches I

- **Timbering (shoring/strutting)** is the temporary support given to the vertical sides of a trench or excavation pit using timber (or steel) members to prevent the soil from caving in.
- **Necessity:**
  - Loose or sandy soil cannot stand vertically on its own (no natural angle of repose steep enough).
  - Deep trenches (generally beyond 1.5 m) are unsafe for workers without support.
  - Nearby structures, traffic loads, or water seepage increase risk of trench collapse.
  - Protects workers, prevents delay/rework, and safeguards adjoining property.
- Also called **shoring**; the components are generically termed **sheeting, walings (waling pieces), and struts**.

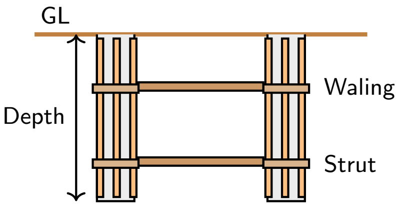
Components and Methods of Timbering I

- **Poling boards (sheeting):** Vertical or horizontal timber planks placed directly against the trench face to hold back the soil.
- **Walings:** Horizontal members placed against the poling boards, running along the length of the trench, which transfer earth pressure to the struts.
- **Struts (braces):** Horizontal timber members placed between opposite walings across the trench width to hold the sides apart.
- **Methods by depth/soil type:**
  1. **Stay bracing:** For shallow trenches (up to 2 m) in fairly firm soil – boards placed vertically at intervals with struts.
  2. **Box sheeting/close timbering:** For loose, wet, or sandy soils and deeper trenches – poling boards placed continuously (close together) covering the entire face, fully enclosing the excavation like a box.

Components and Methods of Timbering II

3. **Vertical sheeting/open timbering:** For moderately firm soils and moderate depth – boards placed vertically with gaps, spaced at intervals, sufficient where soil is more stable.
4. **Runner system:** For very loose/running soils – horizontal runners driven ahead of excavation progress to prevent soil from running into the trench before sheeting is placed.

Timbering in Trench – Cross Section I



Poling boards against trench face

Close (box) timbering: poling boards, walings, and struts supporting trench sides.

Precautions in Timbering I

- Timbering should be erected progressively as excavation proceeds – never leave an unsupported face for long.
- Struts must be wedged tightly and checked periodically as they can loosen due to soil movement or timber shrinkage.
- Removal of timbering (striking) should be done gradually, from bottom to top, only after the permanent work (foundation/pipe) is complete and backfilling has started.
- In wet or running soils, sheet piling (steel) may be preferred over timber for better water-tightness and strength.
- Regular inspection is required for any bulging, cracking, or displacement of timbering members, especially after rainfall.

Summary I

- Black cotton soil's swelling-shrinkage behaviour is best countered with under-reamed piles, deepened footings below the active zone, or CNS replacement.
- Loose soils require compaction, wider footings, rafts, or piles to control excessive settlement and low bearing capacity.
- Timbering (shoring) supports trench sides temporarily using poling boards, walings, and struts to protect workers and adjoining structures.
- Choice of timbering method (stay bracing, box sheeting, vertical sheeting, runners) depends on trench depth and soil stability.

Course: Construction Technology (DI03006011)

Unit 2: Foundation

Lecture 7: Procedure of Setting out of foundation layout

Lecture Agenda I

- Procedure of Setting out of foundation layout
- Failure of foundation and its remedial measures.
- Summary and Q&A

Introduction to Setting Out I

- Setting out is the process of transferring the foundation plan from the drawing board to the actual ground.
- It is a critical initial step ensuring the accurate execution of the construction project.
- Involves establishing base lines, reference points, and benchmarks.
- Crucial for locating the exact position of trenches for excavation, walls, and columns.
- Ensures that the building aligns correctly with property boundaries and existing structures.

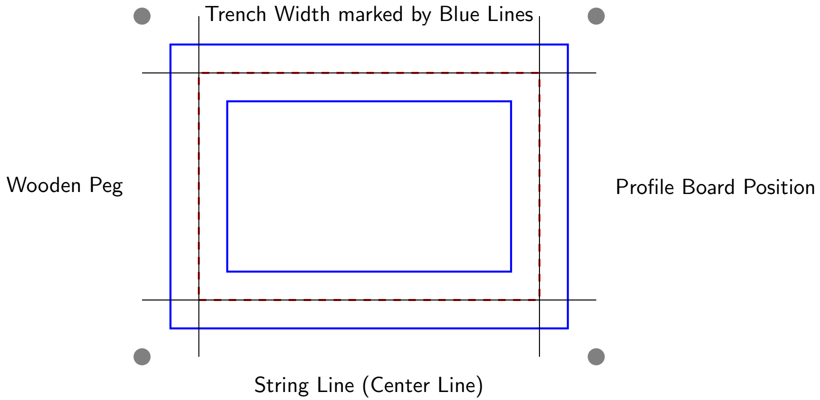
Instrument	Purpose
Measuring Tape	To measure distances accurately (Steel or fiberglass).
Theodolite/Total Station	To set out angles, straight lines, and perpendiculars.
Plumb Bob	To transfer points vertically and check verticality.
Pegs and Wooden Stakes	Driven into the ground to mark specific points.
Nails and Strings (Lines)	To establish straight lines between pegs.
Lime Powder	To mark the layout on the ground for excavation.

Table: Common instruments used for setting out.

Procedure of Setting Out - Part 1 I

- **Site Clearance:** Remove vegetation, debris, and level the ground surface.
- **Establishing the Base Line:** Often established parallel to a road center line or property boundary to serve as a reference.
- **Marking Corners:** From the base line, mark the corners of the building using dimensions from the foundation plan.
- **Right Angles:** Ensure perpendicularity using instruments (like a Theodolite) or the geometric 3-4-5 method.
- **Fixing Pegs:** Drive strong pegs at all corner points of the building.

Setting Out Layout Diagram I



Procedure of Setting Out - Part 2 I

- **Profile Boards:** Erect profile boards (horizontal wooden boards on pegs) at a safe distance from the corners.
- **Marking Trench Width:** Mark the center line, and the inner and outer trench boundaries on the profile boards.
- **Tying Strings:** Stretch string lines tightly between the profile boards across the marked points.
- **Marking Ground:** Drop a plumb bob from the strings to the ground and mark the trench layout using lime powder.
- **Checking Diagonals:** Always check the diagonals of the marked layout to ensure the foundation is perfectly rectangular or square.

Introduction to Foundation Failure I

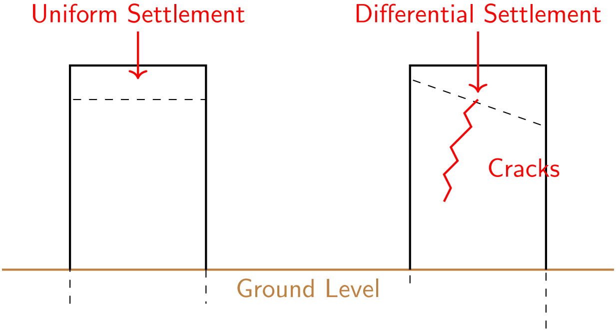
- A foundation is considered to have failed when it can no longer support the structure, leading to structural damage or collapse.
- It may not always involve catastrophic collapse; excessive settlement or cracking constitutes failure.
- Two main types of settlement: Uniform and Differential.
- Differential settlement is particularly dangerous as it induces high internal stresses in the building framework, leading to severe cracking.

Causes of Foundation Failure I

Cause	Description
Unequal Settlement	Variable soil compressibility across the site causing differential sinkage.
Soil Moisture Variation	Shrinkage and swelling of clay soils due to seasonal moisture changes.
Action of Tree Roots	Roots drawing moisture from soil or physical intrusion altering soil stability.
Lateral Soil Movement	Escape of soil from beneath the foundation due to nearby deep excavations.
Overloading	Application of loads exceeding the safe bearing capacity of the soil.
Atmospheric Action	Frost heave or drying out of shallow foundations.

Table: Common causes leading to foundation failure.

Uniform vs. Differential Settlement Diagram I



Remedial Measures for Foundation Failure I

- **Underpinning:** Strengthening the existing foundation by extending its depth or breadth so it rests on more supportive soil stratum.
- **Grouting/Chemical Injection:** Injecting cement grout or specific chemicals into the soil beneath the foundation to consolidate and stabilize it.
- **Improvement of Drainage:** Constructing proper drainage systems to prevent water accumulation which can alter soil bearing capacity.
- **Soil Compaction:** Compacting the surrounding soil to increase density and bearing strength.
- **Removal of Trees:** Removing trees that are causing moisture depletion or physical disturbance to the foundation soil.

Summary I

- Accurate setting out of foundation layout using proper instruments and procedures ensures the structural geometry is correct.
- Checking diagonals and utilizing profile boards are essential steps in the setting out process.
- Foundation failures are primarily caused by differential settlement, soil variations, overloading, or environmental factors.
- Identifying the cause of failure is critical before applying remedial measures like underpinning, grouting, or drainage improvement.
- Always refer back to the standard IS codes for parameter limits and guidelines.

Lecture Agenda I

- Introduction to Masonry Materials & Sizes
- Technical Terms in Masonry
- Types of Bonds and Joints
- Tools and Procedure for Masonry Work
- Principles of Masonry Construction
- Advantages and Disadvantages of Brick vs. Stone Masonry

Size and Materials I

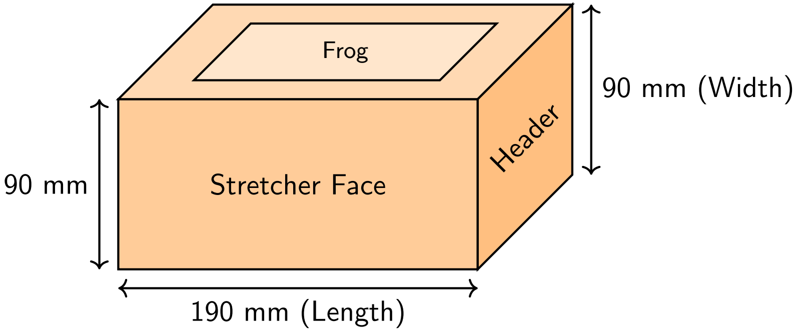
Materials Used:

- **Bricks:** Made from clay, molded, dried, and burnt in kilns.
- **Stones:** Naturally occurring rocks, quarried and dressed.
- **Mortar:** Binding material made of cement or lime and sand mixed with water.

Standard Sizes:

- **Standard/Modular Brick (India):** $190 \times 90 \times 90$ mm.
- **Nominal Brick (with mortar):** $200 \times 100 \times 100$ mm.
- **Traditional/Conventional Brick:** Typically around $230 \times 114 \times 76$ mm.
- **Stone:** Varies based on type (e.g., Rubble, Ashlar).

Size and Materials II



Technical Terms in Masonry I

- **Course:** A horizontal layer of bricks or stones.
- **Header:** A brick laid with its length perpendicular to the face of the wall.
- **Stretcher:** A brick laid with its length parallel to the face of the wall.
- **Bed:** The lower surface of the brick/stone when placed in the wall.
- **Closer:** A portion of a brick used to close the bond at the end of courses (e.g., Queen closer, King closer).
- **Bat:** A portion of a brick cut across its width (e.g., half bat, three-quarter bat).
- **Quoin:** The external corner of a wall.
- **Frog:** An indentation on the top face of a brick to form a key for mortar.

Types of Bond in Brick Masonry I

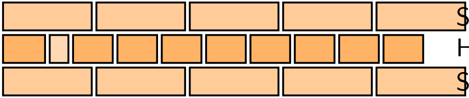
Bond is the arrangement of bricks or stones in a wall so that the vertical joints do not form a continuous line.

Common Types of Bonds:

1. **Stretcher Bond:** All bricks are laid as stretchers. Used for half-brick thick walls (e.g., partitions).
2. **Header Bond:** All bricks are laid as headers. Used for one-brick thick walls or curved walls.
3. **English Bond:** Alternate courses consist of headers and stretchers. It is considered the strongest bond. A Queen closer is placed next to the quoin header.
4. **Flemish Bond:** Each course consists of alternate headers and stretchers. Provides better appearance but slightly less strong than English bond.

Elevation of English Bond:

Types of Bond in Brick Masonry II



Joints in Masonry I

Joints are the spaces between masonry units filled with mortar.

Functions of Joints:

- Bind the individual masonry units together.
- Distribute the load evenly across the wall.
- Make the structure weather-tight and durable.

Types of Pointing/Joint Finishing:

- **Flush Joint:** Mortar is pressed flush with the wall face. It is durable and does not accumulate dust.
- **Weathered Joint:** Sloping outwards to shed water easily.
- **V-Joint:** A V-shaped groove is formed, providing an attractive aesthetic appearance.
- **Keyed Joint:** Formed with a curved tool to create a concave groove.

Procedure of Masonry Work I

Steps in Brick Masonry:

1. **Preparation of Bricks:** Bricks should be soaked in water for at least 2 hours before use to prevent them from absorbing water from the wet mortar.
2. **Preparation of Mortar:** Mixed in required proportions (e.g., 1:4 or 1:6 cement:sand) with adequate water.
3. **Laying Bricks:**
   - The first course is laid carefully on the prepared foundation or bed.
   - Bricks are laid on a full bed of mortar.
   - The frog should generally point upwards to act as a key for the mortar.
4. **Alignment and Checking:** A plumb bob is used to check verticality, and a spirit level is used for horizontal alignment. String lines ensure straightness.

Procedure of Masonry Work II

5. **Curing:** The masonry must be kept wet for 7 to 14 days to allow the cement mortar to gain strength.

Tools Used in Masonry I

- **Trowel:** Used for lifting and spreading mortar on the bed.
- **Plumb Bob:** Used to check the exact verticality of the wall.
- **Spirit Level:** Used to check the horizontal level of courses.
- **Mason's Square:** Used to check right angles at wall corners.
- **String Line (Line and Pin):** Used to maintain straightness in successive courses.
- **Brick Hammer:** Used for cutting bricks and tapping them into place.
- **Straight Edge:** Used with a spirit level to check alignment over longer lengths.

Principles of Masonry Work I

- **Proper Bonding:** Vertical joints in successive courses should not overlap. They must be staggered to prevent continuous weak paths.
- **Soaking of Bricks:** Bricks must be well-soaked so they do not absorb moisture from mortar, which would weaken the bond.
- **Uniform Courses:** Brickwork should be raised uniformly. The difference in height in different parts of the wall during construction should not exceed 1 meter.
- **Mortar Joints:** Joints should be uniform and generally not exceed 10 mm in thickness.
- **Frog Position:** Bricks should be laid with the frog facing upwards to provide a mechanical key.
- **Plumb & Level:** Work must be checked frequently for true vertical and horizontal alignments.

Advantages and Disadvantages of Brick Masonry I

Table: Brick Masonry: Pros and Cons

Advantages	**Disadvantages**
Standard size makes construction easy and uniform.	Less durable compared to stone masonry.
Lighter in weight compared to stone.	Absorbs moisture if not properly burnt.
Good fire resistance.	Requires plastering for aesthetic and protective purposes.
Cheaper in areas where clay is abundant.	Efflorescence may occur if salts are present in the clay.
Does not require highly skilled labor.	Lower compressive strength than granite or basalt.

Advantages and Disadvantages of Stone Masonry I

Table: Stone Masonry: Pros and Cons

Advantages	**Disadvantages**
Extremely durable and long-lasting.	Heavier, requiring stronger foundations.
High compressive strength.	Irregular shapes require dressing, increasing labor cost.
Aesthetically pleasing, often left exposed (no plaster needed).	Slow construction progress.
Good resistance to weathering.	Skilled stonemasons are required.
Does not suffer from efflorescence.	Expensive if stone is not locally available.

Comparison: Brick vs. Stone Masonry I

Table: Comparison of Brick and Stone Masonry

Aspect	**Brick Masonry**	**Stone Masonry**
Strength	Moderate	Very High
Weight	Lighter	Heavier
Shape & Size	Uniform standard sizes	Irregular, requires dressing
Mortar Requirement	Less (due to uniform joints)	More (especially in rubble masonry)
Skill Required	Normal skill	Highly skilled labor
Cost	Generally cheaper	Expensive
Fire Resistance	Excellent	Good, but some stones may crack

Summary I

- Understanding the standard sizes, materials, and technical terms is the foundation of masonry work.
- Proper bonding (e.g., English, Flemish) and well-finished joints are crucial for the strength and durability of the wall.
- Adhering to the principles of masonry and following the correct procedures (soaking, alignment, curing) ensures quality construction.
- Brick masonry is versatile, cost-effective, and easy to construct, while stone masonry offers superior strength, durability, and aesthetics at a higher cost.

Lecture Agenda I

1. Recap of Lecture 8 (Brick Masonry Bonds and Principles)
2. Additional Brick Bonds: Rat-trap Bond, English Cross Bond, Facing and Backing
3. Types of Stone Masonry: Rubble Masonry
4. Types of Stone Masonry: Ashlar Masonry
5. Bond Stones and Through Stones in Stone Masonry
6. Summary and Q&A

- Lecture 8 covered standard brick and stone sizes, technical terms (header, stretcher, closer, bat, quoin, frog), and the basic bonds – **Stretcher, Header, English, and Flemish bond** – along with masonry tools, procedure, and principles.
- Today we extend this to a few **special/economical brick bonds**, and cover **types of stone masonry** (rubble and ashlar) in detail, since stone masonry construction differs significantly from the coursed brick bonds already discussed.

Rat-Trap Bond I

- **Concept:** Bricks are laid on their edge (on the vertical face, i.e., on the side/frog-side) instead of the flat bed face, forming a cavity within the wall thickness.
- Creates a wall of nominal thickness (230 mm) with an internal cavity, using **25–30% less bricks and mortar** than a conventional solid wall of the same thickness.
- **Advantages:**
  - Reduced material consumption – economical.
  - Better thermal insulation due to the air cavity.
  - Reduced dead load on the foundation.
- **Limitation:** Slightly lower load-carrying capacity than solid brick walls; not suitable for heavily loaded walls.
- Commonly promoted for cost-effective and energy-efficient low-rise housing.

- **English Cross Bond (Dutch Bond):** A variation of English bond where the stretcher course is shifted by a quarter brick in alternate courses, introducing a Queen closer next to the stretcher course as well. This produces continuous diagonal lines on the wall face and allows the use of a full number of headers, improving bonding and appearance compared to plain English bond.
- **Facing and Backing:** In thick walls, the exposed outer layer (**facing**) may be built in good-quality, well-dressed brick or stone for appearance, while the inner concealed portion (**backing**) uses cheaper or lower-grade material. Facing and backing must be properly bonded together (never built as two separate leaves) to act as one composite wall.

English Cross Bond and Facing/Backing II

- **Attached/Built-up piers:** Thickened brick projections bonded into a wall to provide additional support for concentrated loads (e.g., beams, trusses) – must be bonded, not merely butted, to the main wall.

Introduction to Stone Masonry Types I

- Stone masonry is broadly classified into two categories based on the degree of dressing (finishing) of the stones and precision of coursing:
    1. **Rubble Masonry:** Uses stones as they come from the quarry, roughly dressed or undressed.
    2. **Ashlar Masonry:** Uses accurately dressed stones with fine, uniform joints.
- Selection depends on availability of stone, required strength/appearance, and cost/labour budget.

Rubble Masonry I

- **Random Rubble Masonry:** Stones of irregular size and shape are used as quarried, with minimal dressing; laid without regular courses. Cheapest type, used for compound walls, foundations, and rough farm buildings.
- **Coursed Rubble Masonry:** Stones are roughly shaped and laid in courses of equal height (though individual stones within a course may vary in length); gives a more regular, presentable appearance than random rubble.
- **Polygonal Rubble Masonry:** Stones are dressed with polygonal (many-sided) faces that interlock closely with neighbouring stones, minimizing thin mortar joints.
- **Flint Rubble Masonry:** Uses small, hard, rounded flint stones bedded in thick mortar; used where flint is locally abundant.
- Joint thickness in rubble masonry is generally larger and less uniform (up to 20–25 mm) compared to ashlar work.

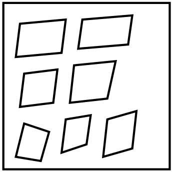
Ashlar Masonry I

- **Ashlar Fine (Ashlar Plain):** All faces of the stone are finely chisel-dressed to give perfectly smooth, true plane surfaces with very thin joints (as thin as 3 mm).
- **Ashlar Rock-faced (Ashlar Rustic):** The exposed face is left rough/projecting (natural quarry texture) while the edges are chisel-dressed true, giving a bold, rustic appearance often used for plinths and compound gates.
- **Ashlar Chamfered:** Similar to rock-faced, but the edges are chamfered (bevelled) at 45° for about 25 mm around the perimeter of each stone, giving sharper defined joints.
- **Ashlar Block-in-Course:** An intermediate type between rubble and fine ashlar – stones are brought to a fairly true size and coursed but not as finely finished as pure ashlar; more economical while retaining a coursed, regular look.

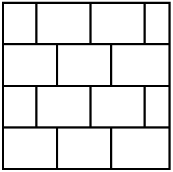
Ashlar Masonry II

- Ashlar masonry requires **highly skilled labour** and is significantly more expensive than rubble masonry due to the dressing effort involved.

Rubble vs. Ashlar – Cross Section Comparison I



Random Rubble Masonry



Ashlar Fine Masonry

Bond Stones and Through Stones I

- **Bond Stone (Through Stone):** A long stone placed at intervals through the full thickness of the wall (or overlapping from both faces in very thick walls) to tie the facing and backing together, similar in function to a header in brick masonry.
- **Spacing:** Bond stones are generally provided at about **1 metre horizontal spacing** and in every third or fourth course vertically, staggered so they do not fall in one vertical line.
- **Quoins:** Stones at the external corners of a stone wall are carefully dressed and larger in size to provide a strong, true corner (similar purpose to brick quoins).
- **Hearting (Backing):** The interior filling of a rubble wall between the two faces, consisting of smaller stone chips and mortar – must be well packed to avoid voids and later settlement.

Bond Stones and Through Stones II

- Absence of adequate bond stones is a common cause of **bulging and delamination** of thick rubble walls over time.

Summary I

- Beyond the basic English/Flemish bonds, brickwork also uses economical bonds such as rat-trap bond (cavity wall, less material) and English cross bond (better diagonal bonding), with proper facing-backing bonding in thick walls.
- Stone masonry is classified as rubble (random, coursed, polygonal, flint – roughly dressed, economical) or ashlar (fine, rock-faced, chamfered, block-in-course – finely dressed, costly but strong and attractive).
- Bond stones/through stones and properly packed hearting are essential to tie the wall together and prevent bulging or delamination.
- Choice of bond and stone-dressing type depends on required strength, appearance, budget, and availability of skilled labour.

Lecture Agenda I

1. Definition of Concrete
2. Ingredients of Concrete
3. Grades of Concrete
4. Water-Cement (W/C) Ratio
5. Production of Concrete (Batching, Mixing, Placing, Curing)
6. Types of Special Concrete
7. Quality Control of Concrete
8. Summary and Q&A

Definition of Concrete I

- **Concrete** is a composite construction material formed by mixing **cement, fine aggregate, coarse aggregate, and water** (with or without admixtures) in specific proportions, which hardens over time due to the hydration of cement.
- It behaves as an artificial stone, strong in **compression** but weak in **tension** – hence reinforced with steel bars to form **Reinforced Cement Concrete (RCC)** for tensile/flexural resistance.
- Governed in India primarily by **IS 456: 2000** (Plain and Reinforced Concrete – Code of Practice) and **IS 10262** (Concrete Mix Proportioning Guidelines).

Ingredients of Concrete I

- **Cement:** The binding material; Ordinary Portland Cement (OPC 33/43/53 grade) or blended cements (PPC, PSC) are commonly used. Typically 10–15% of concrete volume.
- **Fine Aggregate (Sand):** Particles passing 4.75 mm IS sieve; fills voids between coarse aggregate and improves workability. Should be clean, free from silt/clay/organic matter.
- **Coarse Aggregate:** Crushed stone/gravel retained on 4.75 mm sieve, typically 20 mm or 10 mm nominal size; provides bulk and strength, forms the main skeleton of concrete.
- **Water:** Initiates hydration of cement and provides workability; must be clean, potable, and free from harmful salts, oils, and organic impurities.
- **Admixtures (optional):** Chemical (plasticizers, retarders, accelerators, superplasticizers) or mineral (fly ash, silica fume, GGBS) admixtures used to modify fresh or hardened properties.

Grades of Concrete I

- Concrete is graded based on its **characteristic compressive strength** (f_{ck}) at 28 days, tested on 150 mm cubes.
- Denoted as **M followed by the strength in N/mm^2** (e.g., M20 means $f_{ck} = 20$ N/mm^2).
- **Characteristic strength:** The strength below which not more than 5% of test results are expected to fall.

Group	**Grades**
Ordinary Concrete	M10, M15, M20
Standard Concrete	M25, M30, M35, M40, M45
High Strength Concrete	M50, M55, M60 and above

Table: Grades of Concrete as per IS 456

Grades of Concrete II

- Minimum grade for RCC work as per IS 456 is generally **M20**; M25 and above for severe exposure conditions.

Water-Cement (W/C) Ratio I

- **Definition:** The ratio of the weight of water to the weight of cement used in a concrete mix.
- Governed by **Abrams' Law**: strength of concrete is inversely proportional to the water-cement ratio (for a given set of materials).
- **Typical range:** 0.4 to 0.6 for structural concrete; IS 456 specifies **maximum W/C ratio** based on exposure condition (e.g., 0.55 for mild exposure, 0.45 for severe/very severe exposure).
- **Low W/C ratio:** Higher strength and durability, but poor workability – difficult to place and compact.
- **High W/C ratio:** Better workability but reduced strength, increased porosity, bleeding, and segregation.

Water-Cement (W/C) Ratio II

- Excess water beyond what is needed for hydration ($\approx$0.23–0.25 by weight of cement for full hydration) remains as capillary pores, reducing durability.
- Workability without compromising strength is achieved by using plasticizers/superplasticizers rather than simply adding more water.

Production of Concrete I

1. **Batching:** Measuring quantities of cement, aggregates, and water by weight (weigh batching, more accurate) or by volume (volume batching, less accurate, used for small works).
2. **Mixing:** Combining ingredients uniformly using a hand mixing (small quantities) or, preferably, mechanical mixers (drum/pan mixers) or ready-mix concrete (RMC) plants for consistent quality.
3. **Transporting:** Moving fresh concrete from mixer to placement location quickly (wheelbarrows, chutes, pumps, transit mixers) before initial setting begins.
4. **Placing:** Depositing concrete in formwork in layers, avoiding segregation, within the initial setting time (approx. 30 minutes after adding water, per IS 456 minimum).

Production of Concrete II

5. **Compaction:** Removing entrapped air using needle/screed/table vibrators to achieve maximum density; over-vibration can cause segregation.
6. **Curing:** Maintaining adequate moisture and temperature for hydration to continue, typically for a **minimum of 7 days** (up to 14 days for structures with mineral admixtures), ensuring strength gain and reduced shrinkage cracking.

Types of Special Concrete I

- **Ready-Mix Concrete (RMC):** Batched and mixed at a central plant and transported to site in transit mixers; ensures better quality control and consistency.
- **Self-Compacting Concrete (SCC):** Highly flowable concrete that compacts under its own weight without external vibration, useful in congested reinforcement.
- **Fiber-Reinforced Concrete (FRC):** Steel, glass, or synthetic fibers added to improve tensile strength, crack resistance, and toughness.
- **Lightweight Concrete:** Uses lightweight aggregates (cinder, foam, aerated) to reduce density and dead load; used in partition panels and insulation.
- **High-Performance/High-Strength Concrete:** Enhanced strength and durability using low W/C ratio, silica fume, and superplasticizers; used in high-rise and special structures.

Types of Special Concrete II

- **Precast Concrete:** Cast and cured in a factory/yard under controlled conditions, then transported and erected at site (beams, slabs, poles, blocks).
- **Underwater Concrete:** Placed underwater using tremie method, designed to resist washing out of cement.

Quality Control of Concrete I

- **Slump test:** Measures workability/consistency of fresh concrete using a slump cone (IS 1199); typical slump for RCC work is 25–125 mm depending on application.
- **Compaction factor test:** Alternative workability test for low-slump/stiff mixes.
- **Cube compressive strength test:** 150 mm cubes cast, cured, and tested in a compression testing machine at 7 and 28 days as per IS 516; results compared with the specified characteristic strength f_{ck}.
- **Standard deviation and acceptance criteria:** As per IS 456, individual test results and their average must satisfy specified acceptance criteria (mean strength $\geq f_{ck} + 1.65\sigma$, no result below $f_{ck} - 4$ N/mm^2).

Quality Control of Concrete II

- **Non-destructive tests:** Rebound hammer test and ultrasonic pulse velocity (UPV) test to assess strength/quality of concrete in existing structures without damaging them.
- **Control at source:** Quality checks on cement (fineness, setting time), aggregate grading (sieve analysis), and water quality before mixing.

Summary I

- Concrete is a composite of cement, aggregates, and water whose grade (M10–M60+) denotes its 28-day characteristic compressive strength.
- The water-cement ratio (typically 0.4–0.6) governs strength and durability as per Abrams' Law; lower ratios give higher strength but need admixtures for workability.
- Production involves batching, mixing, transporting, placing, compaction, and curing (minimum 7 days) – each stage critical to final quality.
- Special concretes (RMC, SCC, FRC, lightweight, high-performance) address specific site and performance needs.
- Quality is verified through slump tests, cube strength tests, and non-destructive tests as per IS 456 and IS 516.

Lecture Agenda I

1. Scaffolding: Definition and Purpose
2. Technical Terms in Scaffolding
3. Types of Scaffolding
4. Formwork: Definition, Purpose, and Requirements
5. Centering: Definition and Purpose
6. Selection of Scaffolding/Formwork as per Situation
7. Summary and Q&A

Scaffolding: Definition and Purpose I

- **Scaffolding** is a temporary structure erected around a building to support workmen, tools, and materials during construction, repair, or maintenance work at heights that cannot be safely reached from the ground.
- **Purpose:**
  - Provides a safe working platform at various heights for masons, plasterers, and painters.
  - Facilitates movement of workers and materials (bricks, mortar, tools) to the working level.
  - Supports formwork and other temporary works where required.
- Must be strong, rigid, and stable enough to safely carry the dead load (its own weight), live load (workers, materials), and wind/impact loads.

Technical Terms in Scaffolding I

- **Standards (Uprights):** Vertical members of the scaffold that transmit the load to the ground.
- **Ledgers:** Horizontal members connecting the standards, running parallel to the wall.
- **Putlogs:** Horizontal members placed at right angles to the wall, with one end resting on the ledger and the other embedded in/resting on the wall, supporting the platform boards.
- **Bracing:** Diagonal members providing lateral stability and preventing sway of the scaffold structure.
- **Base Plate:** A plate placed under each standard to distribute load and prevent sinking into the ground.
- **Guard Rail and Toe Board:** Safety rail and board fixed at the platform edge to prevent workers/materials from falling.

Technical Terms in Scaffolding II

- **Raker:** An inclined member providing additional support/stability to tall scaffolds.

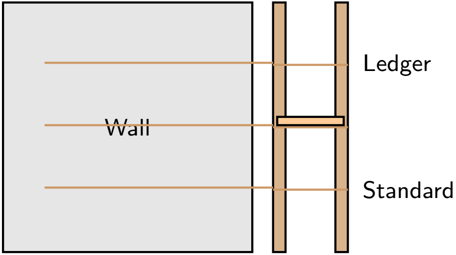
Types of Scaffolding I

- **Single (Bricklayer's) Scaffolding:** Uses a single row of standards about 1.2 m away from the wall, connected by ledgers and putlogs, with one end of the putlog resting in a hole left in the wall. Used mainly for brick masonry work.
- **Double (Mason's) Scaffolding:** Uses two independent rows of standards, both away from the wall, not relying on the wall for support at all – used for stone masonry where holes cannot be left in the wall.
- **Cantilever (Needle) Scaffolding:** Standards rest on needles/beams which themselves are supported on holes in the wall or on the floor structure – used when ground space at the base is restricted (busy roads, congested sites) or upper floors need scaffolding without loading the ground.

Types of Scaffolding II

- **Suspended Scaffolding:** A platform suspended from the roof by ropes/chains/wires, adjustable in height – used for repair, painting, and pointing work on tall building facades.
- **Trestle Scaffolding:** Platform supported on movable tripod/trestle stands – used for lightweight indoor work up to about 5 m height.
- **Steel/Tubular Scaffolding:** Made of steel tubes and couplers instead of bamboo/timber – stronger, more durable, reusable, and increasingly standard on modern sites.

Single Scaffolding – Sketch I



Putlog end embedded in wall

Formwork: Definition, Purpose, and Requirements I

- **Formwork (Shuttering):** A temporary mould made of timber, plywood, or steel, used to hold fresh concrete in the desired shape and position until it gains sufficient strength to be self-supporting.
- **Purpose:**
  - Gives the required shape and surface finish to concrete members (beams, columns, slabs, walls).
  - Supports the fresh concrete and its own weight until initial set and adequate strength are achieved.
  - Retains concrete without loss of slurry (grout-tight) and without excessive deflection.
- **Requirements:**
  - Strong enough to carry dead load of wet concrete, live load of workers/equipment, and impact of placing/vibration.
  - Rigid, true to shape/dimension, and grout-tight (no leakage of cement slurry through joints).

Formwork: Definition, Purpose, and Requirements II

- Easy to erect and strike (remove) without damaging the concrete; economical and reusable where possible.

Types of Formwork I

- **Timber Formwork:** Traditional, made of timber planks/plywood sheathing on timber studs and walers; light, easy to cut/fit to shape, but limited reuse and prone to warping/shrinkage.
- **Plywood Formwork:** Shuttering (or "form") plywood sheets on timber frames; gives a smoother finish and more reuses than plain timber boards.
- **Steel Formwork:** Steel plates/panels bolted together; very strong, gives a smooth finish, highly reusable (50+ times), but heavier and costlier initially.
- **Modern/System Formwork:** Modular aluminium or plastic panel systems, slip forms (for tall, uniform-section structures like silos, chimneys, cores, cast continuously as they slide upward), and table/flying forms for repetitive slab casting in high-rise projects.

Centering I

- **Centering** is the term specifically used for temporary formwork/support provided for **horizontal members** such as beams, slabs, and arches (as distinct from "shuttering," often used for vertical members like columns and walls).
- **Purpose:** Supports the self-weight of wet concrete slabs/beams and construction loads until the concrete attains sufficient strength to become self-supporting.
- **Components:** Sole plates (on ground), props/shores (vertical timber or adjustable steel props), head plates, joists, and the sheathing/decking on which concrete is cast.

- **Striking time (removal):** Depends on member type and grade of concrete – as a general guide per IS 456: vertical faces of columns/beams/walls – 16–24 hours; slab soffit (props left under) – 3 days; beam soffit (props left under) – 7 days; removal of props under slabs – 7 days (spans up to 4.5 m) to 14 days (spans over 4.5 m); props under beams – 14 to 21 days depending on span.

Selection of Formwork/Centering Material I

- **Nature and repetition of work:** For a few uses, timber formwork is economical; for highly repetitive casting (multi-storey buildings), steel or aluminium system formwork pays back its higher initial cost.
- **Required surface finish:** Steel/plywood formwork gives smoother exposed concrete surfaces than rough timber boards.
- **Structural shape:** Complex or curved shapes (domes, arches) are easier to form in timber/plywood; simple rectangular repetitive elements suit modular steel systems.
- **Speed of construction:** Modern systems (table forms, slip forms) drastically speed up cycle time on large projects despite higher initial investment.
- **Site conditions and cost:** Availability of skilled carpenters, transport/crane access for heavy steel panels, and overall project budget influence the choice.

Summary I

- Scaffolding is a temporary working platform (single, double, cantilever, suspended, trestle, or steel/tubular) selected based on the type of masonry, height, and site constraints.
- Formwork/shuttering (for vertical members) and centering (for horizontal members like beams and slabs) temporarily support wet concrete until it gains adequate self-supporting strength.
- Materials range from traditional timber/plywood to steel and modern modular systems, chosen based on repetition, finish requirement, and economy.
- Striking (removal) time is governed by member type and concrete grade as per IS 456 guidelines.

Lecture Agenda I

1. Recap of Lecture 11 (Scaffolding, Formwork and Centering)
2. Formwork Material Selection: Timber vs. Steel vs. Modern Systems
3. Striking (Removal) Time – Detailed Considerations
4. Scaffolding Types Revisited: Suitability as per Situation
5. Safety Considerations in Scaffolding and Formwork
6. Summary and Q&A

Recap of Lecture 11 I

- Lecture 11 introduced scaffolding (single, double, cantilever, suspended, trestle, steel/tubular) and formwork/centering with their basic definitions, purposes, components, and general striking time guidelines.
- Today we go deeper into **how to select** the right material and type for a given site situation, and the detailed factors governing removal time and safety – completing the bridge to the next topic of surface finishing (Plastering & Pointing).

Formwork Material Selection: Timber vs. Steel vs. Modern Systems I

Factor	Timber Formwork	Steel/Modern Systems
Initial cost	Low	High
Reuse cycles	Limited (10–15)	High (50+ for steel)
Surface finish	Moderate	Smooth, uniform
Weight/handling	Light, manual	Heavy, needs crane
Complex shapes	Easy to cut/fit	Needs special panels
Best suited for	Small, one-off, irregular works	Large, repetitive, multi-storey works

Table: Comparative selection of formwork material

Formwork Material Selection: Timber vs. Steel vs. Modern Systems II

- **Rule of thumb:** Break-even between timber and steel formwork typically occurs around 8–10 reuses – beyond this, steel/aluminium systems become more economical despite higher initial cost.

Striking Time – Detailed Considerations I

- Striking (removal) time depends on: **grade of concrete**, **ambient temperature**, **type of cement**, **span/loading of the member**, and whether the member becomes self-supporting or still needs propping ("re-propping").
- **Vertical formwork** (columns, walls, sides of beams) can generally be struck earlier (16–24 hours) since it carries no load once concrete has taken initial set – only needs enough strength to avoid surface damage.
- **Horizontal centering under load** (slab and beam soffits) must remain *in place much longer* since it is still resisting the member's self-weight and construction loads:
  - Slab soffit props: 7 days minimum before removal of decking, full prop removal after $\sim$7 days (short span) to 14 days (span $>$ 4.5 m).
  - Beam soffit props: full removal after 14–21 days depending on span, since beams carry more load per unit area.

Striking Time – Detailed Considerations II

- In cold weather or with blended/slow-setting cements, striking times must be **extended** since strength gain is slower; conversely, rapid-hardening cement may allow slightly earlier striking.
- Premature striking risks sagging, cracking, or even collapse of the green (immature) concrete member.

Scaffolding Types Revisited: Suitability as per Situation I

Scaffolding Type	**Most Suitable Situation**
Single (Bricklayer's)	Brick masonry work where putlog holes can be left in the wall
Double (Mason's)	Stone masonry, where wall cannot take putlog holes
Cantilever (Needle)	Restricted ground space (busy road/footpath) or upper-floor work
Suspended	Facade repair, painting, pointing on tall buildings
Trestle	Light indoor work, low height (up to ∼5 m)
Steel/Tubular	Modern sites needing strength, reuse, and quick erection/dismantling

Table: Selecting scaffolding type by site situation

Scaffolding Types Revisited: Suitability as per Situation II

- As with formwork, the deciding factors are: nature of the work (masonry, plastering, painting), height, ground/space constraints, load to be carried, and duration of use (short-term hire vs. long-term ownership).

Safety Considerations in Scaffolding and Formwork I

- **Foundation/base:** Standards and props must rest on firm, level ground or sole plates – soft or uneven ground causes differential settlement and collapse risk.
- **Bracing:** Adequate diagonal bracing must be provided to prevent sway, especially in tall scaffolds and multi-tier centering.
- **Load limits:** Scaffolding and props must never be overloaded beyond their designed safe working load – avoid stacking excess material on platforms.
- **Guard rails and toe boards:** Mandatory at working platform edges to prevent falls of workers and materials.
- **Inspection:** Scaffolding and formwork/centering should be inspected before use and periodically thereafter, especially after heavy rain or wind.

- **Gradual striking:** Formwork/props should be removed gradually and in the correct sequence (props under the middle of a slab removed last) to avoid sudden load transfer and cracking.

Summary I

- Selection between timber, steel, and modern system formwork depends on reuse frequency, required finish, shape complexity, and overall economy – break-even for steel is typically around 8–10 reuses.
- Striking time depends on member orientation (vertical vs. horizontal/load-bearing), concrete grade, temperature, and cement type, with horizontal centering needing much longer support than vertical formwork.
- Scaffolding type (single, double, cantilever, suspended, trestle, steel) is chosen based on the nature of masonry/finishing work, height, ground constraints, and duration.
- Safety practices – firm base, bracing, load limits, guard rails, inspection, and gradual striking – are essential in both scaffolding and formwork/centering operations.

Lecture Agenda I

- Definition and Purpose of Plastering
- Materials and Tools Used for Plastering
- Types and Procedure of Plastering
- Definition and Purpose of Pointing
- Types and Procedure of Pointing
- Comparison: Plastering vs. Pointing

Introduction to Plastering I

Definition:

- Plastering is the process of covering rough surfaces of walls, columns, ceilings, and other building components with a thin coat of plastic mixture (mortar) to form a smooth, durable surface.
- The plastic mixture is known as plaster.

Primary Functions:

- Protects the surface from atmospheric influences (rain, heat, wind).
- Provides a smooth and aesthetically pleasing finish.
- Conceals defective workmanship or inferior materials.
- Provides a suitable base for painting or whitewashing.

Materials Used in Plastering I

The selection of materials depends on the required strength, exposure conditions, and the base surface.

- **Cement:** Ordinary Portland Cement (OPC) or Portland Pozzolana Cement (PPC) is widely used for its strength and durability.
- **Lime:** Fat lime or hydraulic lime can be used, offering good workability but lower strength than cement.
- **Fine Aggregate (Sand):** Should be clean, coarse, and free from organic impurities, clay, and silt.
- **Water:** Clean, potable water free from harmful salts and chemicals.
- **Additives (Optional):** Waterproofing compounds or fibers to prevent cracking and ingress of moisture.

Tools Used for Plastering I

Tool Name	Purpose
Gauging Trowel	Used for applying and smoothing the plaster on the surface.
Wooden Float	Used for spreading the mortar evenly and providing a level surface.
Plumb Bob	Used to ensure the verticality of the plastered surface.
Straight Edge	A long wooden or metal rule used to check the trueness of the surface.
Spirit Level	Used for checking horizontal and vertical alignments.

Table: Common Tools Used in Plastering

Types of Plastering I

Based on the binding material used, plastering is classified into:

1. **Cement Plaster:**
    - Mixture of cement, sand, and water.
    - Generally proportioned as 1:3 to 1:6 (Cement:Sand).
    - Used for external and internal walls subject to dampness.
2. **Lime Plaster:**
    - Mixture of lime, sand, and water.
    - Highly workable but sets slowly.
3. **Mud Plaster:**
    - Made from clay/mud, cow dung, and chopped straw.
    - Mostly used in rural temporary structures.
4. **Stucco Plaster:**
    - A high-quality decorative plaster applied in three coats.

Procedure of Plastering I

1. Surface Preparation
(Cleaning & Raking joints)

2. Fixing Dots and Screeds
(For uniform thickness)

3. Application of Base Coat
(Dash or Scratch Coat)

4. Application of Finishing Coat

5. Curing (Minimum 7 to 14 days)

Procedure of Plastering II

Key Steps Explained:

- **Preparation:** All joints in masonry should be raked out to a depth of 15 mm to provide a key for plaster. The surface must be cleaned of dirt, oil, and loose particles.
- **Application:** The mortar is dashed against the wall and leveled using a wooden float and straight edge.
- **Curing:** Crucial for cement-based plasters to prevent shrinkage cracks and develop full strength. Water is sprinkled for at least 7 days.

Common Defects in Plastering I

- **Blistering:** Formation of small patches swelling out beyond the plastered surface. Often caused by unslaked lime.
- **Cracking:** Hairline or wide cracks formed due to shrinkage, structural movement, or improper curing.
- **Efflorescence:** White crystalline deposits on the surface due to soluble salts in water, bricks, or sand.
- **Flaking & Peeling:** The plaster detaches from the background due to poor bond or dampness.

Introduction to Pointing I

Definition:

- Pointing is the process of finishing the mortar joints in exposed brick or stone masonry.
- Instead of covering the entire surface like plastering, only the joints are raked out and filled with high-quality mortar.

Purpose of Pointing:

- Protects the mortar joints from the adverse effects of weather (rain, frost).
- Prevents the entry of moisture into the masonry wall.
- Enhances the aesthetic appearance of the brick or stone masonry by highlighting the pattern of joints.

Suitability and Materials for Pointing I

Suitability:

- Used where the visual texture of brickwork or stonework is desired to be exposed.
- Suitable for materials that can withstand weathering (e.g., hard bricks, good quality stone).
- More economical than plastering as less mortar is consumed.

Materials:

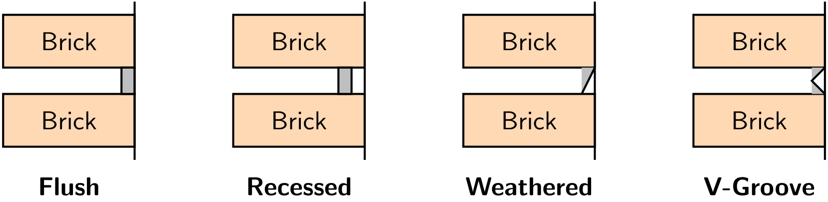
- **Mortar:** Usually cement mortar (1:3 or 1:4) or lime mortar (1:2).
- High-strength mortar is used because the exposed area is small and subject to direct weathering.

Procedure of Pointing I

The systematic procedure involves:

1. **Raking of Joints:** While the masonry is newly built, joints are raked out to a depth of 15 mm to 20 mm.
2. **Cleaning:** The raked joints and wall surface are cleaned with wire brushes and washed with water to remove dust.
3. **Wetting:** The surface is thoroughly wetted before applying the fresh pointing mortar.
4. **Filling Mortar:** Freshly prepared mortar is pressed tightly into the joints using a small pointing trowel.
5. **Tooling/Finishing:** The filled mortar is shaped to the desired profile (flush, weathered, V-groove).
6. **Curing:** Pointed surface is kept wet for 7 to 10 days to achieve strength.

Types of Pointing I



- **Flush:** Mortar is pressed hard and kept flush with brickwork edge. Does not lodge dust.
- **Recessed:** Mortar is pressed back by 5 mm. Good aesthetic appeal but can trap water.
- **Weathered:** Sloping profile throws off rain water easily.
- **V-Groove:** V-shaped groove is formed. Used for aesthetic enhancement.

Comparison: Plastering vs. Pointing I

Aspect	**Plastering**	**Pointing**
Coverage	Covers the entire surface of masonry.	Fills only the mortar joints.
Aesthetics	Hides the underlying masonry work.	Enhances and highlights the natural masonry pattern.
Cost & Material	Expensive; consumes more mortar.	Economical; consumes very little mortar.
Base Surface	Can be applied to rough or inferior quality bricks/stones.	Requires good quality bricks/stones capable of resisting weather.
Primary Purpose	To provide a smooth surface for painting or aesthetics.	To seal joints against water penetration.

Table: Difference between Plastering and Pointing

Summary I

- **Plastering** provides a protective, uniform, and smooth covering over the entire wall, concealing imperfections and providing a base for further finishing.
- **Pointing** is a localized treatment applied only to masonry joints, designed to protect the joints from weathering while exposing the natural beauty of the brick or stone.
- Proper **surface preparation and curing** are critical for both processes to ensure long-term durability and prevent defects such as cracking or peeling.
- The choice between plastering and pointing depends on aesthetic preferences, budget constraints, and the quality of the underlying masonry materials.

Course: Construction Technology (DI03006011)

Unit 3: Building Construction & Building items

Lecture 14: Definition, sources of Dampness and ill effects, Material and Methods used for Damp Proof Course (DPC)

Lecture Agenda I

- Definition of Dampness
- Sources of Dampness
- Ill Effects of Dampness on Buildings
- Definition and Purpose of Damp Proof Course (DPC)
- Ideal Requirements for DPC Materials
- Classification of DPC Materials
- Flexible, Semi-Rigid and Rigid Materials
- Methods of Damp Proofing
- Summary and Q&A

Definition of Dampness I

- **Dampness** is the presence of unwanted moisture in the structure of a building, either the result of intrusion from outside or condensation from within.
- It is one of the most common and serious defects in residential and commercial buildings.
- Dampness not only affects the aesthetic appearance of the building but also significantly reduces its structural integrity and lifespan.
- It creates unhygienic conditions for the occupants, promoting the growth of molds and fungi.

Sources of Dampness I

Moisture can enter a building from various sources:

- **Ground Moisture:** Water rising from the ground into the walls or floors through capillary action (Rising damp).
- **Rainwater Entry:** Rainwater splashing on walls, leaking roofs, defective parapets, or open joints in masonry.
- **Condensation:** Internal moisture from cooking, bathing, or human respiration condensing on cold interior surfaces.
- **Leaking Plumbing:** Defective water pipes, faulty drainage systems, or leaking sanitary fittings.
- **Construction Moisture:** Water introduced during construction (e.g., in mortar, plaster, concrete) that has not fully dried out.

III Effects of Dampness I

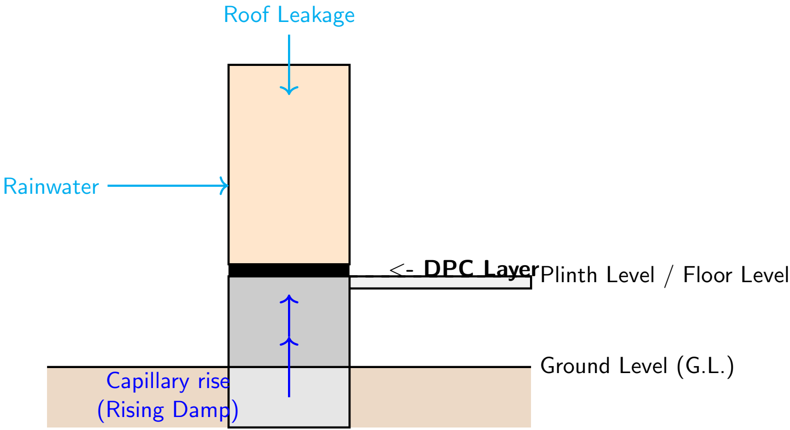
The presence of dampness causes numerous problems:

- **Structural Damage:** Causes decay of timber components, corrosion of structural steel and reinforcement, and disintegration of masonry.
- **Aesthetic Deterioration:** Leads to peeling of paint, blistering of plaster, and efflorescence (white salt deposits) on walls.
- **Health Hazards:** Promotes the growth of mold, mildew, and bacteria, aggravating respiratory problems like asthma.
- **Damage to Contents:** Deterioration of furniture, electrical fittings, carpets, and stored goods.
- **Thermal Discomfort:** Damp walls have poor thermal insulation properties, leading to higher heating and cooling costs.

What is a Damp Proof Course (DPC)? I

- **Damp Proof Course (DPC)** is a continuous layer of impervious material introduced into the structure to prevent the passage of dampness.
- **Purpose:** Its primary function is to block the upward movement of moisture through capillary action (rising damp) from the ground into the walls.
- It is usually provided at the plinth level in walls and floors.
- DPC is critical for the longevity, structural soundness, and health of the building structure.

Location of DPC and Sources of Dampness (Diagram) I



Ideal Requirements for DPC Materials I

An effective DPC material should possess the following properties:

- **Impervious:** Must be completely impervious to both liquid water and water vapor.
- **Durability:** Must be durable and have a lifespan equal to that of the building itself.
- **Strength:** Must be capable of resisting the superimposed loads from the structure without crushing or squeezing out.
- **Flexibility:** Should be flexible enough to accommodate slight structural movements without tearing or cracking.
- **Adhesion:** Should provide good adhesion to the mortar and not act as a slipping plane.
- **Chemical Resistance:** Must resist corrosion by salts and chemicals present in soil and groundwater.

Classification of DPC Materials I

Materials commonly used for Damp Proof Course can be classified into three broad categories:

1. **Flexible Materials:** Materials like bitumen felts, plastic sheeting (polythene), lead, copper, etc. They do not crack with slight structural movements and are relatively easy to handle.
2. **Semi-Rigid Materials:** Materials like mastic asphalt, which is a mixture of bitumen and fine aggregates. It offers a jointless layer.
3. **Rigid Materials:** Materials like first-class bricks, dense stones (slate), and cement concrete, often painted with hot bitumen layers for added water resistance.

Flexible DPC Materials I

- **Bitumen Felts:** Available in rolls. Laid on a leveled bed of mortar. Overlaps should be properly sealed with bitumen. Prone to damage if not handled carefully during construction.
- **Plastic Sheets (Polythene):** Black polythene film (at least 0.5 mm thick) is widely used. It is cheap, easy to lay, and highly impervious. However, it can be punctured easily by sharp objects or aggregates.
- **Metal Sheets (Lead, Copper):** Highly durable and impervious but expensive. Lead can react with cement, so it needs a protective coating. Copper is excellent but costly.

Semi-Rigid and Rigid DPC Materials I

Semi-Rigid Materials:

- **Mastic Asphalt:** A semi-rigid, durable, and highly impervious material. It is laid hot and forms a continuous, jointless membrane. Excellent for situations with high water pressure, like basements.

Rigid Materials:

- **Cement Concrete (P.C.C.):** A layer of plain cement concrete (usually 1:2:4 or 1:1.5:3 mix) of 40 to 50 mm thickness is commonly used at plinth level. It is often coated with two coats of hot bitumen.
- **Engineering Bricks / Stones:** Dense, well-burnt bricks or dense stones (like granite or slate) laid in rich cement mortar can act as a rigid DPC.

Comparison of DPC Materials (Table) I

Table: Comparison of common DPC Materials

Material	**Type**	**Advantages**	**Disadvantages**
Polythene Sheet	Flexible	Cheap, easy to lay, highly impervious	Prone to puncturing, slips
Bitumen Felt	Flexible	Good flexibility, moderate cost	Needs careful overlapping/sealing
Mastic Asphalt	Semi-rigid	Jointless, very durable, takes shape	Requires heating, specialized labor
Cement Concrete	Rigid	High strength, commonly available	Can crack with settlement
Lead Sheet	Flexible	Extremely durable, shapes easily	Expensive, reacts with wet cement

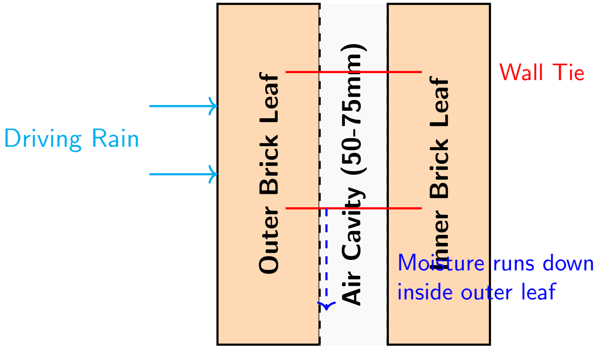
Methods of Damp Proofing I

Various methods are employed to prevent dampness, depending on the source and structure:

1. **Membrane Damp Proofing:** Introducing a water-repellent membrane (DPC layer) between the source of dampness and the part of the building adjacent to it.
2. **Integral Damp Proofing:** Adding waterproofing compounds to the concrete or mortar mix during mixing. These compounds fill the voids or repel water.
3. **Surface Treatment:** Applying moisture-repellent superficial layers (like bitumen paints, silicone solutions, or cement washes) to exposed surfaces.
4. **Cavity Wall Construction:** Constructing the main wall as two separate leaves with a continuous air cavity between them, preventing moisture transfer.

5. **Guniting:** Applying a rich cement mortar layer under pressure over the exposed surface.

Cavity Wall Construction (Diagram) I



Summary I

- Dampness is a severe threat to structural integrity and occupant health.
- Major sources include groundwater (capillary rise), rainwater, and internal condensation.
- A **Damp Proof Course (DPC)** is essential to block the upward movement of moisture.
- DPC materials can be flexible (polythene, bitumen felts), semi-rigid (mastic asphalt), or rigid (concrete, engineering bricks).
- Choice of material depends on factors like cost, loads, structural movement, and severity of dampness.
- Other methods like integral waterproofing, surface treatments, and cavity walls are also employed based on specific needs.

Lecture Agenda I

1. Termites and their Threat to Buildings
2. Types of Termite Attack on Structures
3. Principles of Anti-Termite Treatment
4. Pre-Construction Anti-Termite Treatment Procedure
5. Post-Construction (Existing Building) Treatment
6. Chemicals Used and Precautions
7. Summary and Q&A

Termites and their Threat to Buildings I

- **Termites** (white ants) are wood/cellulose-feeding insects that live in large colonies in the soil and travel through earth/shelter tubes to reach timber, paper, and other cellulose materials in a building.
- They attack timber doors/window frames, wooden flooring, roof timber, furniture, and even paper/fabric stored in the building, causing hidden structural damage that is often discovered only after severe deterioration.
- Termites can also damage non-wooden items indirectly by building mud tubes over walls, plaster, and electrical conduits to reach their food source.
- Since termite colonies are underground, treatment must primarily target the **soil surrounding and beneath the building** to create a chemical barrier that termites cannot cross.

Termites and their Threat to Buildings II

- Reference standard: **IS 6313** (Code of Practice for Anti-termite Measures in Buildings, in three parts covering constructional/foundation measures, pre-construction chemical treatment, and treatment for existing buildings).

Types of Termite Attack I

- **Subterranean termites:** The most common and destructive type in India; nest in soil and build shelter (mud) tubes upward through cracks, expansion joints, and along foundation walls to reach wooden members above.
- **Damp-wood termites:** Attack timber with high moisture content, typically in wood in direct contact with damp ground or leaking areas.
- **Dry-wood termites:** Infest dry, sound timber directly (e.g., furniture, door frames) without needing contact with soil.
- Since subterranean termites cause the majority of building damage in India, anti-termite treatment is primarily aimed at **creating a continuous chemical soil barrier** that blocks their access route from the nest to the structure.

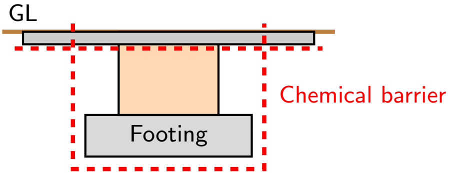
Principle of Anti-Termite Treatment I

- **Basic principle:** Create a continuous, uniform, and complete chemical barrier of soil poison (termiticide) around and beneath the foundation, in the backfill, and at all points where services or joints could allow termite entry, so that termites cannot reach the timber/cellulose components without passing through the toxic zone.
- **Key requirement – continuity:** Any gap or untreated section in the barrier (skipped joint, pipe entry, expansion joint) becomes an easy entry point for termites – treatment must be unbroken around the entire building perimeter and substructure.

Principle of Anti-Termite Treatment II

- Treatment is far more effective and economical when done **before/during construction** (pre-construction treatment) than after the building is completed (post-construction treatment), since the soil beneath the foundation and floor cannot be fully accessed later.

Anti-Termite Barrier – Schematic I



(treated soil along foundation, plinth fill & sub-floor)

Pre-Construction Anti-Termite Treatment Procedure I

1. **Treatment of foundation excavation (bottom and sides):** Chemical emulsion is sprayed on the bottom surface and sides of excavated foundation trenches/pits at the rate of about 5 litres/m^2 before laying the foundation concrete.
2. **Treatment of backfill:** After the foundation masonry/concrete is cast, the backfill earth in immediate contact with the foundation is treated in layers as it is filled, at about 7.5 litres/m^2 of vertical surface for each layer/side.
3. **Treatment at plinth level:** The top surface of the consolidated earth within plinth walls (before laying the sub-grade for flooring) is treated uniformly at about 5 litres/m^2.

Pre-Construction Anti-Termite Treatment Procedure II

4. **Treatment around pipes/conduits:** Special attention where pipes, conduits, or expansion joints pass through the foundation/floor, since these are common weak points – soil around such penetrations is treated by rodding.
5. **Treatment along external perimeter:** A trench is dug along the external wall (about 300 mm wide, down to the foundation depth) and treated similarly, to seal the periphery against lateral termite entry.

Post-Construction Treatment (Existing Buildings) I

- Used when termite infestation is detected **after** the building is already constructed, or as a preventive measure for buildings originally built without treatment.
- **Drilling and rodding:** Holes are drilled at close intervals (about 300 mm) along the plinth, floor junctions, and around affected areas, and chemical is injected under pressure into the soil.
- **Treatment of floor:** Holes are drilled through the floor near the walls and at expansion joints to inject termiticide into the soil below.
- **Treatment of voids and wall junctions:** Soil poison is applied where walls meet the floor and at construction joints, since these are common termite entry paths.

Post-Construction Treatment (Existing Buildings) II

- **Removal and treatment of infested timber:** Severely damaged wooden members are removed/replaced, and remaining sound timber is treated with a suitable wood preservative.
- **Bait systems (modern method):** In-ground termite bait stations placed around the building perimeter, using slow-acting toxicants carried back to the colony, are increasingly used as an alternative or supplement to liquid soil treatment.

Chemicals Used and Precautions I

- **Termiticides:** Modern treatments commonly use non-repellent chemicals such as chlorpyrifos (largely phased out in many regions), or newer generation termiticides like fipronil and imidacloprid, applied as a dilute emulsion in water.
- **Concentration and dosage:** Must strictly follow the manufacturer's/IS 6313 recommended dilution and application rate (litres per square metre) – under-dosing leaves gaps in the barrier, over-dosing wastes chemical and increases environmental/health risk.
- **Precautions:**
  - Treatment should not be carried out on rainy days or on waterlogged soil, as the chemical gets washed away/diluted.
  - Treated soil should not be disturbed after application; if disturbed, that portion must be re-treated.
  - Personal protective equipment (gloves, masks) must be used by workers during spraying/injection.

Chemicals Used and Precautions II

- Chemical should not be allowed to contaminate drinking water sources or wells.

- Periodic inspection (e.g., annually) after treatment helps detect any renewed termite activity early.

Summary I

- Anti-termite treatment aims to create a continuous, unbroken chemical soil barrier around and beneath the foundation to block subterranean termites from reaching timber and cellulose materials in the building.
- Pre-construction treatment (bottom/sides of excavation, backfill, plinth top surface, external perimeter) is more effective and economical than post-construction treatment, which relies on drilling and rodding.
- Correct chemical, correct dosage, and unbroken continuity of the barrier are the key success factors, following IS 6313 guidelines.
- Post-construction remedial measures include drilling/rodding, wall-floor junction treatment, timber replacement, and modern bait systems.

Course: Construction Technology (DI03006011)

Unit 3: Building Construction & Building items

Lecture 16: Purpose, Types and Material used for Construction Joints

Lecture Agenda I

- Introduction to Joints in Construction
- Purpose and Need of Construction Joints
- Construction Joints vs. Expansion Joints
- Types of Construction Joints
- Materials Used for Construction Joints
- IS Code Guidelines & Best Practices
- Summary and Q&A

Introduction to Joints in Construction I

- Large concrete structures cannot be cast in a single continuous operation due to practical constraints.
- **Joints** are introduced intentionally or inevitably to divide the structure into manageable segments.
- Proper placement and design of joints ensure the structural integrity and prevent uncontrolled cracking.
- They accommodate volume changes due to shrinkage, temperature variations, and construction sequences.

Purpose of Construction Joints I

- **Practical Limitations:** Concrete mixing, transporting, and placing capacities are limited; hence, large pours must be divided.
- **Work Shifts:** To provide a defined stopping point at the end of a day's work.
- **Formwork Re-use:** Allows the sequential movement and re-use of formwork in different sections.
- **Structural Separation:** To separate members of different structural behaviors or placement timelines (e.g., slab vs. wall).
- **Crack Control:** Although primary for shrinkage joints, construction joints also act as lines of weakness to help control where cracks occur.

When and Where to Provide Construction Joints I

- Construction joints should be pre-planned and located where they will least impair the strength of the structure.
- **Beams and Slabs:** Generally located within the middle third of the span where shear forces are minimal.
- **Columns:** Typically provided at the top of the floor slab or at the bottom of the beam/slab framing into it.
- **Walls:** Provided at regular intervals horizontally or vertically to match the pouring capacity.

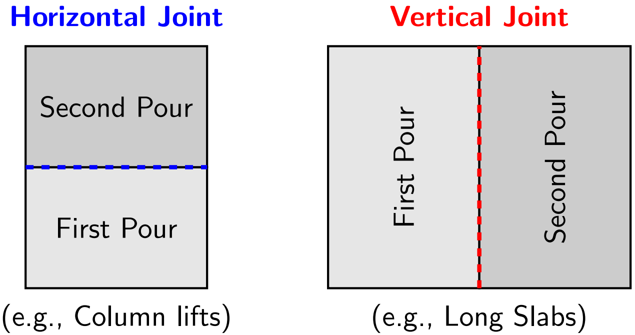
Construction Joints vs. Expansion Joints I

Parameter	Construction Joint	Expansion Joint
Definition	Formed between successive concrete pours.	Formed to separate parts of a structure to allow movement.
Purpose	To facilitate the construction process and work breaks.	To prevent stresses due to thermal expansion/contraction or seismic activity.
Movement	Generally designed to prevent relative movement.	Specifically designed to allow for expansion and contraction.
Reinforcement	Continuous across the joint to maintain structural continuity.	Discontinued across the joint.
Materials	Bonding agents, waterstops (if water-retaining).	Compressible joint fillers, flexible sealants.

Types of Construction Joints I

- **Horizontal Construction Joints:** Used primarily in columns and walls where lifts of concrete are placed one on top of another.
- **Vertical Construction Joints:** Used in long walls, beams, and slabs where the continuous pour is stopped vertically.
- Based on the interface geometry, they are further classified into:
  - Butt Joints
  - Keyed Joints (Tongue and Groove)
  - Dowelled Joints
  - Roughened Surface Joints

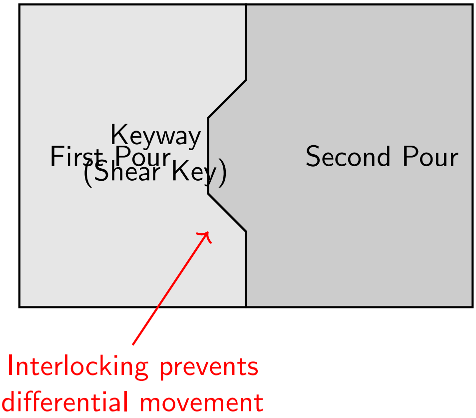
Horizontal vs. Vertical Construction Joints I



Keyed Construction Joint (Tongue & Groove) I

- A "keyway" is formed in the first placement of concrete.
- The second placement fills this key, creating an interlocking mechanism.
- Improves shear transfer across the joint, preventing lateral movement.

Keyed Construction Joint (Tongue & Groove) II



Dowelled & Roughened Joints I

- **Dowelled Joints:** Steel dowel bars are inserted across the joint to transfer heavy loads and shear stresses. Essential in industrial floors and pavements.
- **Roughened Joints:** The surface of the first concrete pour is intentionally left rough (by wire brushing or scabbling before it sets completely).
- Roughening ensures better mechanical bond and aggregate interlock with the new concrete pour.

Materials Used for Construction Joints I

- To ensure proper bonding and waterproofing, various materials are incorporated at construction joints:
- **Bonding Agents:** Epoxy resins or polymer-modified cementitious slurries applied to the old concrete surface to improve adhesion of new concrete.
- **Waterstops:** Pre-formed strips used in water-retaining structures (tanks, basements) to prevent water leakage through the joint.
- **Joint Sealants:** Elastomeric materials used to seal the exposed surface of the joint against moisture and dirt entry.
- **Retarders:** Chemical retarders sprayed on formwork to delay the setting of surface mortar, making it easier to expose aggregate for a roughened joint.

Waterstops in Construction Joints I

- Waterstops are critical in structures where water exclusion or retention is necessary.
- **Materials:**
  - PVC (Polyvinyl Chloride) - most common, flexible.
  - Rubber - highly flexible, durable.
  - Swellable Hydrophilic Strips - expand upon contact with water to seal the joint.
  - Metallic (Copper or Stainless Steel) - for high-temperature or severe chemical exposure.
- They are embedded half in the first pour and half in the second pour.

IS Code Guidelines (IS 456:2000) I

- **Location:** Concreting shall be carried out continuously up to construction joints, the position and arrangement of which shall be predetermined.
- Joints should be at right angles to the general direction of the member.
- **Preparation of Surface:** Before resuming work, the surface of the hardened concrete shall be roughened, swept clean of laitance, and wetted.
- A coat of neat cement slurry or a specialized bonding agent should be applied immediately before placing the fresh concrete.
- For columns, the joint shall be horizontal and made at the underside of the deepest beam framing into the column.

Summary I

- Construction joints are necessary due to practical constraints in concrete placement.
- They differ from expansion joints, as they are not designed to accommodate structural movement but to ensure continuity.
- Proper location (where shear forces are low) and treatment (roughening, keyways, dowels) are vital.
- Materials like bonding agents and waterstops play a crucial role in maintaining structural integrity and water-tightness.
- Adherence to IS code provisions ensures durable and safe construction.

Course: Construction Technology (DI03006011)

Unit 3: Building Construction & Building items

Lecture 17: Movement Joints – Expansion, Contraction, Isolation & Their Materials

Lecture Agenda I

- Recap: Construction Joints (Lecture 16)
- Movement Joints – Why They Are Different
- Expansion Joints – Purpose, Location, Detailing
- Contraction (Shrinkage) Joints
- Isolation (Sliding) Joints
- Comparative Cross-Sections of Joint Types
- Jointing Materials in Detail
- Spacing Guidelines and Summary

Recap and Introduction to Movement Joints I

- Lecture 16 covered **construction joints** – provided purely for convenience of concreting, with reinforcement continuous across them.
- Today's lecture covers **movement joints**, which are deliberately designed discontinuities that allow relative movement between parts of a structure.
- Movement arises from three sources: thermal expansion/contraction, drying shrinkage, and differential settlement of foundations.
- Failure to provide movement joints results in diagonal cracking, spalling, and in severe cases buckling of walls or floors.
- The three principal categories are **Expansion Joints**, **Contraction Joints**, and **Isolation Joints**.

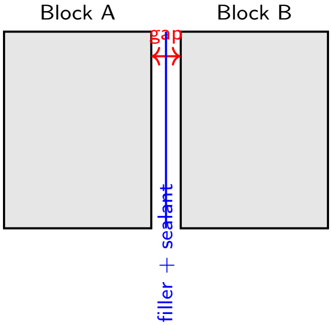
Expansion Joints – Purpose and Behaviour I

- **Purpose:** To permit free expansion and contraction of adjoining parts of a building due to temperature and moisture changes, without inducing stress.
- An expansion joint is a complete discontinuity through the full depth and width of the structure, including the foundation in long buildings.
- Reinforcement and structural members are NOT continued across the joint – a true structural break is provided.
- **Location:** Provided in long buildings (generally where length exceeds about 40–45 m), at changes in plan shape (L, T, U shaped buildings), and at junctions of old and new construction.
- Also essential in long RCC bridges, water tanks, and industrial sheds subject to large temperature variation.

Expansion Joint – Typical Detailing I

- Gap width typically 12–25 mm, decided based on length of structure, temperature range, and coefficient of thermal expansion of the material.
- Two independent sets of columns/walls are provided on either side of the joint, either as a double column line or a cantilever bracket arrangement.
- The gap is filled with a compressible filler board and sealed at the surface to prevent ingress of water and debris while still allowing movement.
- At roof/floor level, a cover plate or flashing is provided that can slide over the joint to remain weatherproof while permitting movement.

Expansion Joint – Typical Detailing II



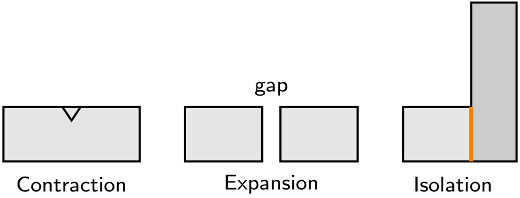
Contraction (Shrinkage) Joints I

- **Purpose:** To relieve tensile stresses that develop as concrete shrinks during drying and curing, thereby controlling the location of cracks.
- Unlike expansion joints, a contraction joint needs no gap – concrete is cast continuously, but the section is deliberately weakened along a line so that any shrinkage crack occurs neatly at that line rather than randomly.
- Formed by inserting a groove (grooving tool, saw-cut, or a strip of wood/metal later removed) to a depth of about $1/4$ to $1/5$ of the member thickness.
- Commonly used in long concrete pavements, floor slabs, boundary walls, and canal linings.
- Reinforcement, if crossing the joint, is often reduced in cross-section or debonded so the joint can open slightly under shrinkage.

Isolation (Sliding) Joints I

- **Purpose:** To structurally separate elements that behave differently or carry different loads, allowing them to move independently without transferring load or stress to each other.
- Typical locations: junction of a floor slab and a column, around machine foundations, between a new extension and an existing building, and where a partition wall meets a structural column.
- Also called **sliding joints** when a bond-breaking sheet (polythene, bituminous felt) is placed between two concrete surfaces so they can slide relative to each other.
- No reinforcement or bonding agent crosses an isolation joint – complete separation is essential to its function.
- Example: A machine foundation is isolated from the surrounding floor slab by a vertical gap filled with compressible material to prevent vibration transfer.

Comparative Cross-Section of Joint Types I



- Contraction joints: continuous concrete, weakened plane only.
- Expansion joints: full physical gap through the section.
- Isolation joints: vertical separation between two independent elements (e.g. slab and column).

Materials Used – Joint Fillers I

Filler Material	Typical Use / Property
Bitumen impregnated fibreboard	Economical, compressible filler for expansion joints in pavements and slabs.
Cork board	Highly compressible; used where a soft, resilient filler is needed (machine foundations).
Polystyrene (thermocol) sheet	Lightweight compressible filler, common in isolation joints around columns.
Rubber / neoprene strips	Resilient, weather resistant; used in bridge expansion joints.

Materials Used – Waterstops and Sealants I

- **PVC Waterstops:** Extruded PVC strips embedded across the joint (dumbbell or centre-bulb profile) to prevent water passage through movement joints in tanks, basements, and retaining walls; the centre bulb accommodates the movement.
- **Rubber Waterstops:** Similar function to PVC, more flexible and durable at low temperatures; used in dams and hydraulic structures.
- **Joint Sealants:** Polysulphide, polyurethane, or silicone based elastomeric sealants applied at the exposed face of the joint over a backer rod, keeping the gap watertight while remaining flexible.
- **Backer Rod:** A closed-cell foam rod pressed into the joint gap before sealant application, controlling sealant depth and preventing three-sided adhesion.

Materials Used – Waterstops and Sealants II

- **Bond Breaker/Isolation Membrane:** Polythene sheet or bituminous felt placed to prevent bonding between old and new concrete at isolation joints.

Spacing Guidelines and Summary I

- **Expansion joints:** Provided at intervals of about 30–45 m in RCC framed buildings depending on climate and exposure.
- **Contraction joints (pavements/floors):** Typically at 3–6 m spacing depending on slab thickness, aggregate type, and expected shrinkage.
- **Isolation joints:** Provided at every discontinuity in structural behaviour – machine bases, partition-to-column junctions, old-to-new construction interfaces.
- Selecting the correct joint type, spacing, and filler material together prevents cracking, water ingress, and structural distress over the building's service life.
- Together with construction joints (Lecture 16), these movement joints complete the full picture of jointing practice in building construction.

Lecture Agenda I

- Introduction to Grouting
- Importance, Materials, and Methods of Grouting
- Machineries used in Grouting
- Introduction to Guniting (Shotcrete)
- Importance, Materials, and Methods of Guniting
- Machineries used in Guniting
- Comparison and Summary

- **Definition:** Grouting is the process of injecting a fluid-like material (grout) into voids, cracks, or joints in masonry, concrete, or soil.
- The grout subsequently sets and hardens, binding the particles or surfaces together.
- Primarily used for strengthening, stabilizing, or reducing the permeability of a formation or structure.
- **Common applications:** Foundation repair, filling cracks in dams, stabilizing soil, and anchoring tendons.

Importance of Grouting I

- Enhances structural integrity by filling voids and cracks effectively.
- Prevents water seepage and acts as a highly efficient waterproofing agent.
- Increases the load-bearing capacity of the underlying soil or foundation.
- Reduces the settlement of structures by consolidating the subsoil.
- Economical method for repairing existing structures compared to complete demolition and replacement.

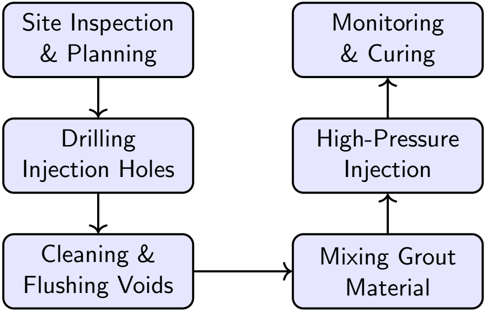
Materials Used in Grouting I

- **Cement Grout:** A mixture of Portland cement and water (sometimes sand). It is the most common material for structural repairs.
- **Chemical Grout:** Includes sodium silicate, acrylics, and polyurethanes. Primarily used for soil stabilization and waterproofing fine cracks.
- **Bentonite Grout:** Clay-based and highly expansive. Often used for sealing wells and reducing soil permeability.
- **Epoxy Grout:** Offers very high strength and chemical resistance. Used for anchoring machinery and severe structural crack repairs.
- **Admixtures:** Retarders, accelerators, and superplasticizers are added to control setting time and flowability.

Methods of Grouting I

- **Permeation Grouting:** Grout is injected into porous media (like sands and gravels) without disturbing the soil structure.
- **Compaction Grouting:** A very stiff, low-mobility grout is injected at high pressure to displace and compact the surrounding loose soil.
- **Jet Grouting:** A high-velocity fluid jet erodes the soil and mixes it simultaneously with grout to form a "soilcrete" column.
- **Fracture (Claquant) Grouting:** Grout is injected at high pressure to intentionally fracture the soil and fill the resulting fissures, densifying the soil mass.

Process of Grouting I



Machineries Used in Grouting I

Machinery	Function / Description
Grout Mixers	To mix cement, water, and admixtures uniformly to form a colloidal suspension.
Grout Pumps	To deliver the mixed grout to the injection point at the required pressure.
Agitators	A holding tank with paddles to keep the mixed grout in continuous motion, preventing settlement.
Drilling Rigs	To bore injection holes into soil, rock, or concrete structures accurately.
Packers	Expandable devices inserted into drilled holes to seal them and prevent grout backflow during injection.

Introduction to Guniting (Shotcrete) I

- **Definition:** Guniting (or shotcrete) is the process of conveying concrete or mortar through a hose and pneumatically projecting it at high velocity onto a surface.
- The high velocity of impact compacts the material dynamically, creating a dense, high-strength concrete layer.
- Traditionally, "Guniting" refers to the dry-mix process using fine aggregates, while "Shotcrete" refers to the wet-mix process with larger aggregates.
- **Common Applications:** Tunnel linings, retaining walls, swimming pools, artificial rock landscapes, and repairing damaged concrete structures.

Importance of Guniting I

- Substantially reduces the need for conventional formwork, saving time and timber resources.
- Forms an excellent bond with various substrates including old concrete, rock, and steel.
- Exhibits high early strength and low permeability due to extreme compaction during application.
- Highly adaptable to complex shapes, curved profiles, and uneven surfaces.
- Rapid application method significantly reduces overall construction and repair schedules.

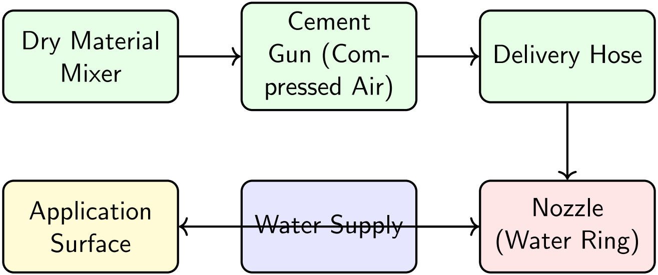
Materials Used in Guniting I

- **Cement:** Ordinary Portland Cement (OPC) is the most standard binder used.
- **Aggregates:** Fine aggregates (sand) are typical for gunite (maximum size around 10mm).
- **Water:** Must be clean and free from deleterious substances.
- **Reinforcement:** Welded wire mesh, steel fibers, or synthetic fibers are often incorporated to improve tensile and flexural strength.
- **Admixtures:** Accelerators are critical for quick setting (especially on vertical or overhead surfaces), and superplasticizers are used in wet-mix processes.

Methods of Guniting I

- **Dry-Mix Process:**
  - Dry ingredients (cement, sand) are thoroughly mixed and pneumatically conveyed through a delivery hose.
  - Water is introduced at the nozzle just before the mixture is projected onto the surface.
  - **Advantage:** Better control over the water-cement ratio; hoses are easier to clean.
- **Wet-Mix Process:**
  - All ingredients (including water) are mixed before entering the delivery hose. The wet mixture is pumped to the nozzle where compressed air is introduced to provide the projection velocity.
  - **Advantage:** Higher production rate, significantly less dust generation, and lower rebound (wastage).

Dry-Mix Guniting Process Flow I



Machineries Used in Guniting I

Equipment	Purpose
Batching Mixer	To proportion and mix the dry or wet ingredients accurately.
Air Compressor	Provides compressed air to propel the dry mix or add velocity to the wet mix at the nozzle.
Delivery Hoses	Heavy-duty, abrasion-resistant hoses to transport the material.
Nozzle Assembly	The critical terminal component where water (dry-mix) or air (wet-mix) is introduced.
Shotcrete Pump	Used specifically in the wet-mix process to push the fluid concrete through the hose.

Summary I

- **Grouting** is primarily an internal application used for filling voids, stopping leaks, and stabilizing foundations by injecting fluid materials.
- **Guniting/Shotcrete** is a surface application technique that uses high-velocity pneumatic projection for new structural construction and repairs.
- Both techniques rely heavily on specialized machineries (mixers, high-pressure pumps, compressors, specialized nozzles) to achieve the desired material properties.
- Selection between dry-mix and wet-mix guniting depends on project requirements like production rate, rebound limits, and site conditions.
- Understanding the specific material behaviors and mechanical requirements is crucial for ensuring durable and stable structures.

Course: Construction Technology (DI03006011)

Unit 3: Building Construction & Building items

Lecture 19: Plumbing and Electrification Fittings, Tools & Laying Procedure

Lecture Agenda I

- Introduction to Household Plumbing Systems
- Plumbing Fitting Accessories (Pipes, Fittings, Valves)
- Plumbing Tools
- Laying Procedure for Water Supply and Drainage Pipes
- Introduction to Household Electrification
- Electrical Fitting Accessories
- Electrical Tools
- Wiring/Laying Procedure and Summary

Introduction to Household Plumbing Systems I

- Household plumbing comprises two independent networks: the **water supply system** (fresh water under pressure) and the **drainage/sanitary system** (waste water/sewage under gravity).
- Supply pipes are always concealed or run above fixtures under pressure; drainage pipes must always maintain a downward gradient to allow gravity flow.
- A good plumbing layout minimizes pipe length, avoids crossing structural members, and provides easy access for future repair through inspection chambers/traps.
- Materials commonly used: Galvanized Iron (GI), Cast Iron (CI), uPVC/CPVC, and increasingly composite/PPR pipes for hot water lines.

Plumbing Fitting Accessories – Pipes and Joints I

Accessory	**Function**
Elbow (90°/45°)	Changes direction of pipe run.
Tee	Branches a line into two directions from one main line.
Coupling/ Socket	Joins two straight pipe lengths in line.
Union	Allows quick disconnection of a pipe section for repair.
Reducer	Connects pipes of two different diameters.
Nipple	Short threaded piece for connecting two fittings closely.

Plumbing Fitting Accessories – Valves and Fixtures I

- **Gate Valve:** Full-bore on/off control with minimal flow resistance; used as the main stop-cock at the inlet.
- **Globe Valve:** Provides fine flow regulation, though with higher head loss than a gate valve.
- **Ball Valve / Stop Cock:** Quarter-turn valve for quick shut-off, common at fixture connections (basins, WC).
- **Check (Non-Return) Valve:** Permits flow in one direction only, preventing backflow into the supply line.
- **Ferrule:** Connects the consumer's service pipe to the municipal water main.
- **Fixtures:** Wash basin, water closet (WC), urinal, kitchen sink, bib cock, and shower – each with its own trap and connection accessories.

Plumbing Tools I

- **Pipe Wrench:** Adjustable jaw wrench for gripping and rotating GI pipes and fittings.
- **Pipe Cutter:** Cuts pipes cleanly and squarely without burrs.
- **Pipe Vice:** Clamps pipe firmly on a workbench while threading or cutting.
- **Die and Stock (Threading Set):** Cuts external threads on GI pipe ends for screwed joints.
- **Plunger and Drain Auger:** Used for clearing blockages in drainage lines.
- **Solvent Cement Applicator and Hacksaw:** Used for cutting and solvent-welding uPVC/CPVC pipe joints.
- **Spirit Level and Plumb Bob:** Ensure correct slope/gradient and vertical alignment of pipe runs.

Laying Procedure – Water Supply Pipes I

- **Step 1 – Marking:** Mark the pipe route on walls/floor as per the approved layout, avoiding structural beams and columns.
- **Step 2 – Chasing:** Cut chases (grooves) in walls or lay conduit in slabs/floors for concealed piping before plastering.
- **Step 3 – Fixing:** Support pipes with clamps/saddles at regular intervals (about 1–1.2 m for horizontal GI runs); position fittings (elbows, tees) at direction changes.
- **Step 4 – Jointing:** Screwed and sealed (PTFE tape/jointing compound) for GI pipe; solvent-cement welded for uPVC/CPVC.
- **Step 5 – Testing:** Pressure test the system (hydraulic test, typically 1.5 times working pressure) to check for leaks before concealing.
- **Step 6 – Finishing:** Chases are filled with mortar and plastered flush once testing is complete.

Laying Procedure – Drainage Pipes I

- Drainage pipes (CI or uPVC) must be laid at a continuous downward gradient (commonly 1:40 to 1:60 for small-diameter branch drains) towards the outfall/soak pit or sewer connection.
- Vertical soil and waste stacks are kept as straight as possible; bends are avoided or provided with access doors for rodding.
- Every fixture (WC, basin, sink) is connected through a **trap** (P-trap or S-trap) that retains a water seal to prevent foul gases entering the room.
- Inspection chambers are provided at every change of direction, junction, or gradient, and at intervals not exceeding about 30 m on straight runs.
- Pipes are tested for leaks (smoke test or water test) before backfilling or concealing in the floor/wall.

Introduction to Household Electrification I

- Household electrification covers the complete internal wiring from the meter/main switch board to individual points (lights, fans, sockets, appliances).
- Common systems: **Casing-capping wiring** (surface, economical), **Conduit wiring** (PVC or metal conduit concealed in walls/slabs, most common in modern construction), and **Concealed/PVC sheathed wiring**.
- Every installation must comply with the Indian Electricity Rules and relevant IS codes (e.g., IS 732 for wiring installations) for safety of occupants.

Electrical Fitting Accessories I

Accessory	Function
Switch (1-way/2-way)	Makes/breaks the circuit to a light or appliance point.
Socket outlet (5A/15A)	Provides power connection point for portable appliances.
MCB (Miniature Circuit Breaker)	Protects circuit from overload and short circuit.
ELCB/RCCB	Detects earth leakage and disconnects supply to prevent shock.
Distribution Board (DB)	Central point housing MCBs and distributing circuits to the house.
Junction/Pull Box	Facilitates cable pulling and branching inside conduit runs.

Electrical Tools I

- **Line Tester (Screwdriver Tester):** Checks for the presence of live voltage in a wire or point.
- **Wire Stripper/Cutter:** Removes insulation from cable ends without damaging the conductor.
- **Combination Plier and Insulated Screwdriver Set:** General purpose tools for making and tightening connections safely.
- **Fish Tape/Wire Puller:** Used to draw cables through concealed conduits.
- **Multimeter:** Measures voltage, current, and continuity for testing and fault-finding.
- **Chase Cutter/Hammer Drill:** Cuts grooves in masonry/concrete walls for concealed conduit.

Laying Procedure – Conduit Wiring I

- **Step 1 – Layout Marking:** Mark positions of switch boards, points, and conduit routes as per the electrical drawing.
- **Step 2 – Chasing:** Cut chases in walls or embed conduit in the slab/beam formwork before concreting (for concealed work).
- **Step 3 – Conduit Laying:** Fix PVC conduit with saddles/clips; maintain a minimum bend radius to allow easy cable pulling; leave draw wires inside.
- **Step 4 – Cable Drawing:** Pull insulated copper conductors (typically PVC insulated, sized as per load) through the conduit after all chasing/concreting work is complete.
- **Step 5 – Termination:** Connect wires at switch boards, sockets, and the distribution board, with proper earthing of all metal fixtures.

- **Step 6 – Testing:** Insulation resistance test and continuity test are carried out before energizing the installation.

Summary I

- Household plumbing requires correctly selected pipes, fittings, valves, and traps, laid with proper slope and tested before concealment.
- Plumbing tools (wrench, cutter, threading die, solvent applicator) enable clean, leak-free jointing of GI and uPVC pipework.
- Household electrification relies on switches, sockets, MCBs, and distribution boards installed through concealed conduit wiring for safety and neatness.
- Electrical tools (tester, stripper, multimeter) ensure safe termination and verified, tested circuits before handover.
- In both systems, correct laying procedure and testing before concealment are essential to avoid costly rework later.

Lecture Objectives and Agenda I

Learning Objectives:

- Analyze the fundamentals of the purpose and necessity of construction machineries.
- Understand the core practical principles governing mechanization in construction.

Agenda:

1. Introduction to Construction Machineries
2. The Shift: Manual vs. Mechanized Construction
3. Primary Purpose of Construction Machineries
4. Necessity of Construction Machineries
5. Classification of Construction Equipment
6. Factors Influencing Machinery Selection
7. Challenges in Mechanization
8. Summary and Q&A

Introduction to Construction Machineries I

- In modern civil engineering projects, the scale and complexity have increased significantly.
- Traditional manual methods are often insufficient to meet tight deadlines, quality standards, and safety requirements.
- **Construction machineries** refer to the heavy equipment, vehicles, and tools specially designed for executing construction tasks.
- The integration of these machines marks the transition from labor-intensive to capital- and technology-intensive construction.

- **Manual Construction:** Relies heavily on human labor. Suitable for small-scale projects where time is not a critical constraint.
- **Mechanized Construction:** Utilizes advanced machinery to perform tasks. Essential for mega-projects like dams, highways, and high-rise buildings.

The Shift: Manual vs. Mechanized Construction II

Table: Comparison: Manual vs. Mechanized

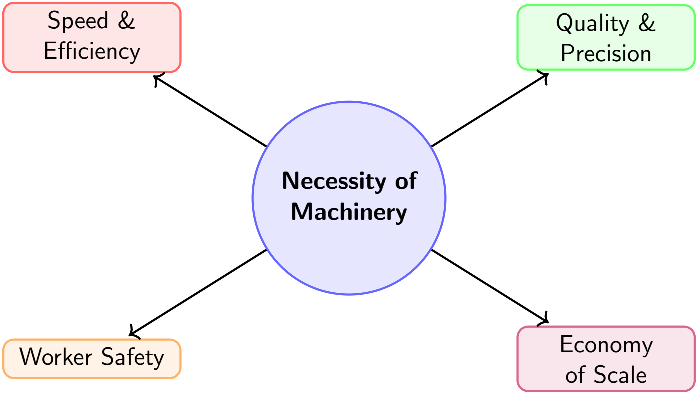
Parameter	Manual Method	Mechanized Method
Speed	Slow and inconsistent	Fast and continuous
Quality	Prone to human error	High precision and uniform
Safety	High risk to workers	Reduced direct risk
Cost (Long term)	Higher labor costs	Economical for large scale
Scale	Limited to small works	Suitable for mega projects

Primary Purpose of Construction Machineries I

The purpose of deploying machinery in construction can be summarized by the following key objectives:

- **Timely Completion:** To accelerate the rate of construction and meet strict project deadlines.
- **Quality Control:** To achieve a high standard of workmanship that is practically impossible with manual labor.
- **Cost Optimization:** To reduce overall project costs by substituting expensive manual labor with efficient machine hours on large-scale works.
- **Task Feasibility:** To perform operations that are beyond human physical capacity, such as lifting extremely heavy loads or massive earth-moving.

Necessity of Construction Machineries I



The core necessities revolve around overcoming human limitations and optimizing project parameters.

Necessity 1: Speed and Efficiency I

- Modern infrastructure projects operate on very tight schedules.
- Delay in construction leads to cost overruns and delayed economic benefits.
- **High Output:** Machinery can work continuously without fatigue, resulting in significantly higher output per hour compared to manual labor.
- **Example:** An excavator can remove hundreds of cubic meters of earth in a day, a task that would take weeks for a crew of manual laborers.

Necessity 2: Handling Heavy and Complex Loads I

- Construction components have become massive. Precast concrete elements, heavy steel girders, and large bridge segments are common.
- Human labor cannot physically lift or maneuver these heavy components.
- **Cranes and Hoists:** The necessity of machinery like tower cranes and mobile cranes is absolute for vertical and horizontal transportation of heavy loads on site.
- Without machinery, the construction of high-rise buildings and long-span bridges would be impossible.

Necessity 3: Quality and Precision I

- Uniformity and precision are critical for the structural integrity and aesthetic appeal of a project.
- **Consistency:** Machines deliver consistent results. For instance, an asphalt paver lays a uniformly thick and compacted layer of road surface, which is difficult to achieve manually.
- **Batching Plants:** Concrete batching plants ensure exact proportions of water, cement, and aggregates, ensuring the concrete meets design strength specifications consistently.

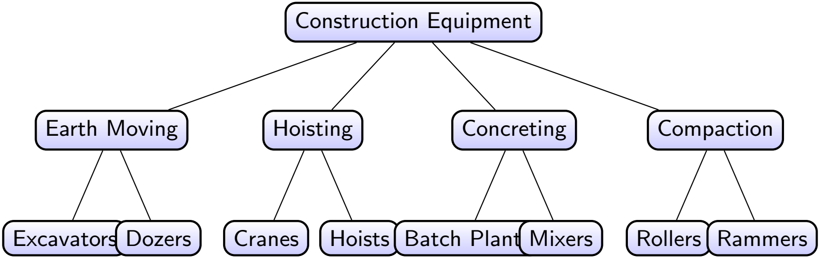
Necessity 4: Safety of Workforce I

- Construction is inherently hazardous. Engaging manual labor in risky environments (e.g., deep excavations, working at heights) increases accident rates.
- **Risk Mitigation:** Machinery takes over the most dangerous tasks. Earthmoving equipment prevents trench collapses from burying workers.
- **Reduced Physical Strain:** Using equipment reduces ergonomic injuries, back strains, and long-term health issues among the workforce.

Necessity 5: Economy on Large Scale Projects I

- While the initial capital investment for machinery is high, the unit cost of work decreases significantly on large projects.
- **Cost-Benefit Analysis:** The cost of operating a machine per cubic meter of earth excavated or concrete poured is much lower than the equivalent labor cost.
- Equipment reduces the dependency on a large workforce, thereby saving on labor management, housing, and welfare amenities on site.

Classification of Construction Equipment I



Different tasks necessitate specific categories of equipment tailored for optimal performance.

Factors Influencing Machinery Selection I

Even though machinery is necessary, selecting the *right* machinery is crucial:

- **Magnitude of the Project:** Large projects justify heavy, specialized equipment.
- **Site Conditions:** Soil type, topography, and weather conditions dictate the type of undercarriage (e.g., crawler vs. wheeled).
- **Availability of Spares and Service:** Equipment must have reliable local support to minimize downtime.
- **Economic Considerations:** Cost of owning vs. hiring, operating costs, and salvage value.

Challenges in Mechanization I

Despite the clear necessity, utilizing machinery comes with challenges:

- **High Initial Investment:** Requires significant capital outlay, which can strain cash flows for contractors.
- **Skilled Operators Required:** Machines need trained operators. Improper operation can lead to accidents or machine damage.
- **Maintenance Costs:** Regular servicing, repairs, and part replacements add to the operating expenses.
- **Idling Costs:** If machinery is not utilized optimally, the idle time results in major financial losses.

Summary I

- The purpose of construction machinery is to transform how we build, shifting from manual labor to mechanized efficiency.
- The necessity is driven by the demand for **speed, quality, safety, and economy** in modern infrastructure projects.
- Without mechanization, handling massive structural elements and achieving precise quality control is virtually impossible.
- However, successful mechanization requires careful selection, skilled operation, and diligent maintenance to be economically viable.

Thank You!

Are there any questions regarding the purpose and necessity of construction machineries?

Next Lecture Preview: We will explore specific types of earth-moving equipment, their components, and their operational mechanisms in detail.

Course: Construction Technology (DI03006011)

Unit 4: Construction Machineries

Lecture 21: Important Factors Affecting Selection of Construction Machineries

Lecture Agenda I

- Recap: Purpose and Necessity of Machinery (Lecture 20)
- Why Selection Matters
- Factor 1: Nature and Volume of Work
- Factor 2: Site Conditions
- Factor 3: Machine Characteristics (Capacity, Output)
- Factor 4: Economic Factors
- Factor 5: Availability, Maintenance and Managerial Factors
- Summary of Selection Criteria

Why Machinery Selection Matters I

- Choosing the wrong machine for a job leads to low output, high idle time, increased cost per unit of work, and possible project delay.
- An oversized machine results in wasted capital and fuel; an undersized machine cannot meet the required output and delays the schedule.
- Selection is not a single decision – it is a balance of technical suitability, site constraints, and economics.
- The selected fleet must work together efficiently (e.g., number of trucks must match the loading rate of the excavator – "matching factor").

Factor 1: Nature and Volume of Work I

- **Type of Operation:** Whether the work is excavation, hoisting, compaction, or concreting decides the broad category of machine required.
- **Quantity of Work:** For small quantities, hiring or using smaller general-purpose equipment is economical; large volumes justify high-capacity, specialized machines.
- **Nature of Material:** Hard rock requires a hydraulic breaker or ripper-dozer, while soft soil can be handled by a simple excavator bucket.
- **Haul Distance:** Short leads suit dumpers/tractor-trailers; long-distance transport favours trucks or belt conveyors.

Factor 2: Site Conditions I

- **Topography:** Undulating or hilly terrain favours crawler-mounted machines (better traction, lower ground pressure) over wheeled machines.
- **Soil/Ground Bearing Capacity:** Soft or marshy ground requires low ground-pressure equipment (crawler tracks) to avoid sinking.
- **Space Constraints:** Congested urban sites limit the size and swing radius of cranes and excavators that can be deployed.
- **Weather and Climate:** Heavy rainfall regions demand equipment with good drainage/traction; hot climates require machines rated for high ambient temperature operation.
- **Working Space and Approach Roads:** Availability of access roads determines whether large equipment can even reach the site.

Factor 3: Machine Characteristics – Capacity and Output I

- **Rated Capacity:** Bucket capacity of excavator/loader, load capacity of crane/dumper – must match the scale of the task.
- **Output Rate:** Expected production per hour (e.g. m^3/hr of excavation) must meet the project schedule requirement.
- **Mobility and Manoeuvrability:** Turning radius, ground clearance, and travel speed affect how efficiently the machine works within the site layout.
- **Versatility:** A machine that can be fitted with multiple attachments (breaker, ripper, grab) offers greater utilization on varied tasks.
- **Power Source Compatibility:** Diesel-driven versus electrically powered equipment depends on site power availability and emission norms.

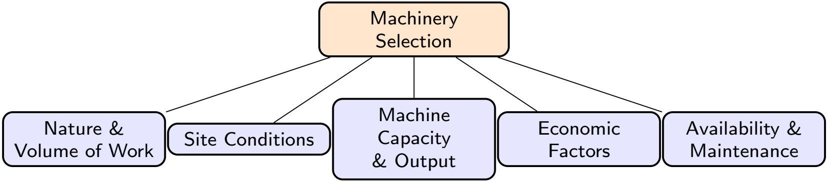
Factor 4: Economic Factors I

Economic Aspect	Consideration
Initial (Capital) Cost	Purchase price versus project budget and duration of use.
Owning vs. Hiring	Buy if utilization is high and long-term; hire for short, one-off tasks.
Operating Cost	Fuel, lubricants, operator wages per hour of operation.
Depreciation & Resale	Loss in value over life, and expected resale/salvage value.
Cost per Unit Output	Total owning + operating cost divided by output – the key comparison metric.

Factor 5: Availability, Maintenance and Managerial Factors I

- **Availability of Spares and Service:** Equipment brands with a strong local dealer network minimize breakdown downtime.
- **Ease of Maintenance:** Simpler machines with readily available consumables reduce maintenance cost and delay.
- **Availability of Skilled Operators:** A machine is only as efficient as the operator handling it; local operator skill availability matters.
- **Safety Features:** ROPS/FOPS (roll-over/falling-object protective structures), reversing alarms, and visibility aids reduce accident risk.
- **Life of Equipment and Project Duration:** Machine life should be reasonably matched to the expected duration of continuous use on the project.

Selection Factors – Overview Diagram I



Summary I

- Selecting construction machinery is a multi-factor decision balancing technical, site-specific, and economic considerations.
- Key factors: nature/volume of work, site conditions (soil, topography, space), machine capacity/output, economics (owning vs. hiring, cost per unit output), and availability of spares/skilled operators.
- Correct selection ensures optimum output, controlled cost per unit of work, and adherence to project schedule.
- These factors set the foundation for studying specific machinery types (excavating, hoisting, compaction, batching plants) in the next lecture.

Title I

- Course: Construction Technology (DI03006011)
- Unit 4: Construction Machineries
- Lecture 22: Classify the different types of Construction.

Lecture Agenda I

- 1. Introduction to Construction Classification
- 2. Broad Categories of Construction
- 3. Detailed Types (Residential, Commercial, Industrial, Civil)
- 4. Comparison and Influencing Factors
- 5. Summary and Q&A

Introduction to Construction I

- Construction is the process of building, altering, repairing, or demolishing structures.
- Projects vary widely in scale, scope, purpose, and complexity.
- Classification helps in standardizing building codes, safety regulations, and resource allocation.
- Different types of construction require specific machineries, materials, and expertise.

Broad Categories of Construction I

- **Residential:** Homes, apartments, and housing estates.
- **Commercial:** Offices, retail stores, and shopping malls.
- **Institutional:** Schools, hospitals, and government buildings.
- **Industrial:** Factories, power plants, and refineries.
- **Heavy Civil/Infrastructure:** Roads, bridges, dams, and airports.

Classification Diagram I

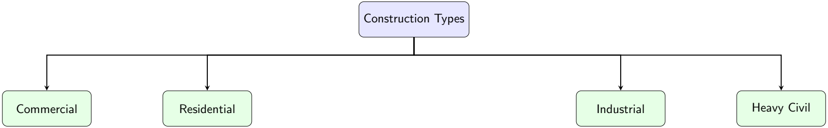


Figure: Major Types of Construction Projects

Residential Construction I

- Involves building, repairing, and remodeling structures for housing people.
- **Examples:** Single-family homes, townhouses, condominiums, and apartment complexes.
- **Characteristics:**
  - Usually uses wood-frame or masonry construction.
  - Funded by individual owners or real estate developers.
  - Follows local residential building codes and zoning laws.

Commercial Construction I

- Projects designed for commercial and business purposes.
- **Examples:** Office buildings, shopping centers, restaurants, and hotels.
- **Characteristics:**
  - Emphasizes structural integrity, safety, and aesthetics.
  - Often utilizes steel, concrete, and glass materials.
  - Subject to strict commercial building codes and fire safety regulations.

Industrial Construction I

- Highly specialized construction for manufacturing and industrial processes.
- **Examples:** Refineries, chemical plants, manufacturing facilities, and power generation plants.
- **Characteristics:**
  - Requires specialized engineering and design.
  - High emphasis on safety, environmental regulations, and structural loads.
  - Often involves the installation of heavy machinery and equipment.

Heavy Civil / Infrastructure Construction I

- Focuses on public infrastructure designed to serve communities and industries.
- **Examples:** Highways, bridges, tunnels, dams, railways, and airports.
- **Characteristics:**
  - Usually funded by government agencies or large public-private partnerships.
  - Involves massive earthmoving operations and heavy construction machinery.
  - Projects span long durations and cover large geographical areas.

Comparison of Construction Types I

Type	Primary Material	Typical Scale	Complexity
Residential	Wood, Brick, Concrete	Small to Medium	Low to Medium
Commercial	Steel, Concrete, Glass	Medium to Large	Medium to High
Industrial	Steel, Reinforced Concrete	Large	Very High
Heavy Civil	Concrete, Steel, Asphalt	Very Large	Very High

Table: Key Differences Among Construction Types

Factors Influencing Construction Methods I

- **Site Conditions:** Soil type, topography, and groundwater levels.
- **Project Scale:** Determines the type of heavy machinery required.
- **Budget and Time Constraints:** Influence material choice and construction speed.
- **Environmental Regulations:** Impact waste management and sustainable practices.

Role of Machineries in Different Types I

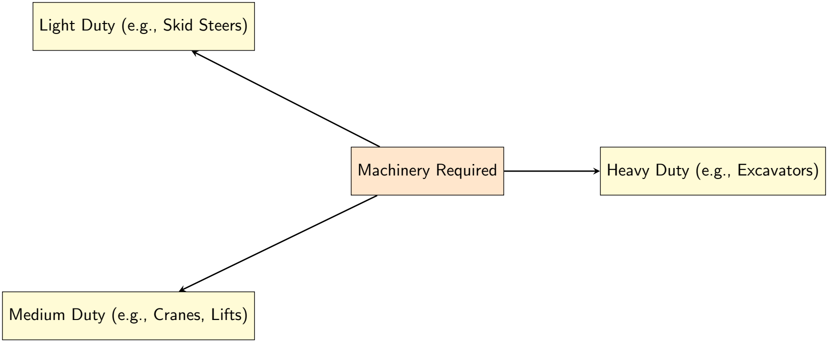


Figure: Machinery Requirements by Construction Type

Summary I

- Construction can be broadly classified into residential, commercial, industrial, and heavy civil.
- Each classification has distinct characteristics, material requirements, and regulatory standards.
- The choice of construction machinery is heavily dependent on the type and scale of the project.
- Understanding these classifications is fundamental for planning and executing civil engineering projects successfully.

Any Questions?

Thank you for your attention!

Course: Construction Technology (DI03006011)

Unit 4: Construction Machineries

Lecture 23: Excavating, Earthmoving, Hoisting, Transportation, Compaction & Batching/Mixing Plant Machinery

Lecture Agenda I

- Excavating and Earthmoving Equipment
- Hoisting Equipment (Cranes, Hoists)
- Transportation Equipment (Short & Long Distance)
- Compaction Equipment (Rollers)
- Concrete Production – Batch Mix Plant
- Bitumen Hot Mix Plant
- Aggregate Production Plant
- Comparative Summary Table

Excavating and Earthmoving Equipment – Excavator I

- **Feature:** Hydraulically operated boom, arm, and bucket mounted on a crawler or wheeled base, capable of 360° slew.
- **Working Procedure:** The bucket digs into the soil, curls to retain material, the boom/arm lifts and swings, and the operator dumps the load into a truck or spoil heap.
- **Output:** Depends on bucket capacity (0.3–2 m^3 typical), cycle time ($\approx$20–30 s), and soil type; commonly 80–150 m^3/hr for medium machines.
- **Suitability:** Trenching, foundation excavation, basement digging, and loading trucks; crawler type suited to soft/uneven ground, wheeled type to hard, mobile-access sites.

Excavating and Earthmoving Equipment – Dozer, Loader, Scraper I

- **Bulldozer:** A crawler tractor with a front-mounted blade; pushes and levels loose soil over short distances (up to about 100 m efficiently); used for clearing, stripping topsoil, and rough grading.
- **Wheel Loader:** Front bucket loads loose material into trucks/hoppers rapidly; suited to stockpile handling and loading operations rather than digging hard ground.
- **Scraper (Motor Scraper):** Cuts, loads, hauls, and spreads soil in a single unit; economical for large-volume earthmoving over medium distances (300 m–3 km) such as highway embankment formation.
- **Backhoe Loader:** Combines a front loader bucket and rear excavator arm on one wheeled chassis; versatile for small trenching, pipe-laying, and material handling on compact sites.

Hoisting Equipment – Cranes I

- **Feature:** A hoisting machine with a boom/jib, wire rope, and hook, capable of lifting and placing heavy loads vertically and horizontally.
- **Tower Crane:** Fixed vertical mast with a horizontal/luffing jib; used for tall building construction where high lift height and long reach are required; output depends on load moment capacity (tonne-metres) and cycle time.
- **Mobile Crane:** Truck- or crawler-mounted telescopic/lattice boom crane; highly mobile, used where the crane must relocate frequently across a site.
- **Working Procedure:** Load is attached to the hook via slings, boom/jib is luffed and slewed to position, and the load is lowered precisely under a signaller's/operator's control.

Hoisting Equipment – Cranes II

- **Suitability:** Placing precast elements, steel erection, formwork/material lifting to height; selection based on maximum lift height, radius, and load required.

Hoisting Equipment – Hoists I

- **Material Hoist:** A vertical guide-rail mounted cage/platform, powered by an electric winch, used to lift bricks, mortar, and small materials to upper floors – not rated for passenger use.
- **Passenger-cum-Material Hoist:** A larger, code-rated cage for both workers and materials on high-rise construction sites, fitted with safety interlocks and overload cut-offs.
- **Working Procedure:** Cage travels along a fixed mast guided by rollers; winch motor raises/lowers via wire rope; safety gear locks the cage to the mast in case of rope failure.
- **Suitability:** Multi-storey building sites where a crane is uneconomical for repetitive small-load vertical transport.

Transportation Equipment – Short Distance I

- **Wheelbarrow/Hand Trolley:** Manual transport of concrete, mortar, or debris over very short distances (up to 50 m); low output but flexible on congested sites.
- **Site Dumper (Skip/Swivel Dumper):** Small self-propelled hydraulic-tip dumper carrying 1–3 tonnes; ideal for short-lead haulage (up to about 300 m) within a congested site.
- **Belt Conveyor:** Continuous rubber-belt system for moving loose material (aggregate, excavated soil) short to medium distances rapidly and continuously, minimizing manual/vehicle traffic.
- **Suitability:** Congested or confined sites, repetitive small loads, and where truck access is restricted.

Transportation Equipment – Long Distance I

- **Tipper/Dump Truck:** Rigid or articulated trucks (typically 10–30 tonne capacity) for hauling excavated earth, aggregate, or debris over long site or public-road distances; hydraulic ram tips the body for quick unloading.
- **Tractor-Trailer:** Tractor unit with a detachable trailer; economical for very large haul volumes and long, better-quality haul roads.
- **Transit Mixer (Ready-Mix Truck):** Rotating drum truck that transports ready-mixed concrete from the batching plant to site, continuously agitating to prevent segregation and setting en route.
- **Output:** Governed by truck capacity, round-trip cycle time (loading + haul + unloading + return), and road/traffic conditions; matched to the loading machine's output (the "matching factor").

Compaction Equipment – Rollers I

Roller Type	**Suitability**
Smooth-wheeled Roller	Compacting granular base, sub-base, and finishing asphalt surfaces.
Pneumatic Tyred Roller	Kneading action; good for cohesive soils and asphalt for uniform density.
Sheepsfoot (Padfoot) Roller	Cohesive clayey soils; feet penetrate and knead soil from within, ideal for embankment fill.
Vibratory Roller	Combines weight with vibration; effective compaction of granular soils and asphalt with fewer passes.

Compaction Equipment – Rollers II

- **Working Procedure:** Roller passes repeatedly over the spread and levelled layer; number of passes and layer thickness are controlled to achieve the specified field density (checked by sand-replacement/core-cutter test).
- **Output:** Expressed as compacted area or volume per hour, depending on roller width, speed, and number of passes required.

Concrete Production – Batch Mix Plant I

- **Feature:** An automated/semi-automated plant with separate storage bins for aggregates, cement silo, water tank, and admixture dosing, feeding a weigh-batcher and mixer.
- **Working Procedure:** Aggregates and cement are weigh-batched as per the mix design, discharged into a pan/twin-shaft mixer along with water and admixture, mixed for a fixed cycle time, then discharged into a transit mixer or hopper.
- **Output:** Rated in m^3/hr (small plants: 15–30 m^3/hr; large plants: over 60 m^3/hr) depending on mixer capacity and batching cycle time.
- **Suitability:** Large-volume concreting works (high-rise buildings, bridges, pavements) where consistent, quality-controlled concrete is required continuously.

Bitumen Hot Mix Plant I

- **Feature:** A plant that dries and heats aggregates, then coats them with heated bitumen to produce Hot Mix Asphalt (HMA) for road surfacing.
- **Working Procedure:** Cold aggregates are fed proportionally, dried and heated in a rotary drum dryer, screened by size into hot bins, weigh-batched, mixed with heated bitumen (typically at 150–170°C) in a pugmill mixer, and discharged for immediate transport.
- **Types:** Batch-type hot mix plant (discrete batches, better quality control) and drum-mix (continuous) plant (higher output, continuous production).
- **Output:** Ranges from about 40 tonnes/hr for small batch plants to over 150 tonnes/hr for large continuous plants.

Bitumen Hot Mix Plant II

- **Suitability:** Road construction and resurfacing projects requiring large, continuous volumes of asphalt mix produced close to the paving site.

Aggregate Production Plant I

- **Feature:** A stone crushing and screening plant that converts quarried rock into graded aggregates of required sizes for concrete and road works.
- **Working Procedure:** Raw stone is fed into a primary crusher (jaw crusher) for initial size reduction, followed by a secondary crusher (cone/impact crusher) for finer reduction, then passed through vibrating screens to separate different aggregate grades; oversize material is recirculated.
- **Output:** Typically expressed in tonnes/hr of finished aggregate (small plants: 25–50 tonnes/hr; large plants: 200+ tonnes/hr), depending on crusher capacity and feed rate.
- **Suitability:** Large infrastructure and building projects requiring a steady, quality-controlled supply of graded aggregate, often located near the quarry to minimize transport cost.

Comparative Summary of Construction Machinery I

Machinery Type	Typical Use	Output Basis
Excavator	Digging, loading	m^3/hr
Dozer/ Scraper	Earthmoving, grading	m^3/hr, haul distance
Tower/ Mobile Crane	Vertical/lateral hoisting	Load moment (t-m)
Dumper/ Tipper	Short/long haulage	Trips/hr, tonnes
Roller	Compaction	Passes, area/hr
Batch Mix Plant	Concrete production	m^3/hr
Hot Mix Plant	Bitumen mix production	tonnes/hr
Crusher Plant	Aggregate production	tonnes/hr

Summary I

- Excavating/earthmoving machinery (excavators, dozers, scrapers, loaders) handles soil cutting, loading, and grading, selected as per soil type and haul distance.
- Hoisting equipment (cranes, hoists) moves heavy loads and materials vertically on high-rise and industrial projects.
- Transportation equipment ranges from short-lead dumpers/conveyors to long-haul tippers and transit mixers, matched to the loading equipment's output.
- Compaction rollers are selected based on soil type (smooth, pneumatic, sheepsfoot, vibratory) to achieve specified density.
- Batching, hot-mix, and aggregate production plants provide the continuous, quality-controlled material supply essential for large concrete and road construction projects.

Summary II

- Correct feature-output-suitability matching across all these machines ensures an efficient, well-balanced construction operation.

Course: Construction Technology (DI03006011)

Unit 5: Building Maintenance & Safety Measures

Lecture 24: Causes of Failure of Structures; Purpose and Necessity of Building Maintenance

Lecture Agenda I

- Introduction to Structural Failures
- Design and Construction-Related Causes of Failure
- Material and Environmental Causes of Failure
- Foundation and Load-Related Causes of Failure
- Introduction to Building Maintenance
- Purpose of Building Maintenance
- Necessity of Building Maintenance
- Summary

Introduction to Structural Failures I

- A **structural failure** occurs when a building or its component loses its ability to perform its intended function – ranging from minor cracking to complete collapse.
- Failures can be sudden (collapse) or progressive (gradual deterioration such as spalling, corrosion, or excessive deflection).
- Causes of failure are broadly grouped as: **design deficiencies**, **construction faults**, **material deficiencies**, **environmental/natural causes**, and **foundation/overloading issues**.
- Investigating failure causes is essential both for forensic engineering and for planning preventive maintenance.

Design-Related Causes of Failure I

- **Inadequate Design:** Under-estimation of loads (dead, live, wind, seismic), incorrect structural analysis, or use of outdated codes.
- **Improper Detailing:** Insufficient reinforcement, wrong bar spacing, inadequate development length, or missing shear reinforcement at critical sections.
- **Lack of Redundancy:** A design with no alternate load path fails catastrophically if one member is damaged (progressive/disproportionate collapse).
- **Change of Use:** Structure designed for one loading (e.g., residential) later used for a heavier purpose (e.g., storage/industrial) without re-verification.

Construction-Related Causes of Failure I

- **Poor Workmanship:** Incorrect mixing/placing of concrete, inadequate compaction, honeycombing, and improper curing.
- **Deviation from Drawings:** Unauthorized alterations, omission of reinforcement, or wrong bar bending during execution.
- **Substandard Materials:** Use of inferior quality cement, contaminated water, or under-strength steel to cut costs.
- **Inadequate Supervision:** Absence of qualified site supervision allows errors to go undetected until they manifest as defects or failure.
- **Premature Loading:** Removing formwork or applying load before concrete attains sufficient strength.

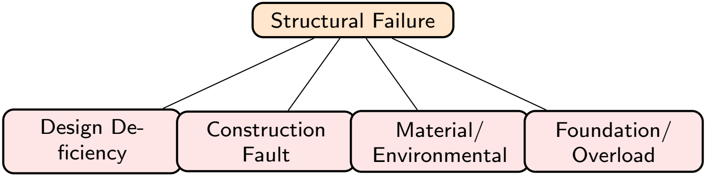
Material and Environmental Causes of Failure I

- **Corrosion of Reinforcement:** Ingress of moisture and chlorides/carbonation corrodes steel, causing expansive rust that cracks and spalls the cover concrete.
- **Chemical Attack:** Sulphate attack, alkali-aggregate reaction, and acidic ground water degrade concrete over time.
- **Weathering:** Freeze-thaw cycles, temperature variation, and prolonged dampness weaken material bonds.
- **Fire Damage:** High temperatures reduce concrete and steel strength and cause spalling of the cover.
- **Natural Calamities:** Earthquakes, floods, cyclones, and landslides impose loads far beyond the structure's design capacity.

Foundation and Load-Related Causes of Failure I

- **Differential Settlement:** Uneven settlement of foundations due to variable soil strata causes cracking and tilting of the superstructure.
- **Inadequate Bearing Capacity:** Foundation not designed for actual soil bearing capacity, or soil investigation not properly carried out.
- **Overloading:** Loads exceeding the design capacity – additional floors added without structural strengthening, or heavy machinery installed without verification.
- **Erosion/Scour:** Loss of soil support around foundations near water bodies or due to poor drainage.
- **Vibration and Impact:** Repeated vibration from heavy traffic or machinery, or impact from vehicle collision, weakening structural members over time.

Causes of Structural Failure – Overview I



Introduction to Building Maintenance I

- **Building Maintenance** is the set of technical and administrative actions carried out to retain or restore a building and its services to a condition where it can perform its required function.
- Every structure, regardless of quality of original construction, deteriorates progressively due to the causes of failure discussed above along with normal wear and ageing.
- Maintenance is a continuous, planned activity – not a one-time reaction to visible damage.
- It directly follows from understanding failure causes: knowing why structures fail allows maintenance to be targeted and preventive rather than merely corrective.

Purpose of Building Maintenance I

- **Preserve Structural Safety:** Detect and rectify defects (cracks, corrosion, dampness) before they progress to structural failure.
- **Retain Functional Efficiency:** Keep services – plumbing, electrical, HVAC – in proper working order for occupant comfort and use.
- **Maintain Aesthetic and Property Value:** Regular upkeep (painting, finishing) preserves the visual appeal and market/resale value of the property.
- **Ensure Occupant Safety and Compliance:** Statutory requirement for many public buildings; prevents hazards such as falling plaster or short circuits.
- **Extend Service Life:** Timely intervention significantly extends the useful/economic life of the structure.

Necessity of Building Maintenance I

- **Prevents Minor Defects Becoming Major Failures:** A small crack or leak, if untreated, leads to reinforcement corrosion and eventually structural distress – far more costly to repair.
- **Economic Necessity:** Preventive maintenance costs a fraction of the cost of major repair or reconstruction after neglect (a "stitch in time" principle).
- **Legal/Statutory Necessity:** Building owners are often legally responsible for ensuring the structure remains safe for occupants and the public.
- **Continuity of Use:** Essential for buildings housing critical functions (hospitals, schools, industries) where downtime is unacceptable.
- **Sustainability:** Well-maintained buildings consume fewer resources over their lifetime than buildings requiring frequent major reconstruction.

Summary I

- Structural failures arise from design deficiencies, poor construction practice, material/environmental degradation, and foundation or overloading issues.
- Understanding these causes is the foundation for effective preventive maintenance planning.
- Building maintenance serves to preserve safety, functionality, aesthetics, and value of a structure throughout its service life.
- It is necessary both economically (avoiding costly major repairs) and for legal/safety compliance, making it an essential ongoing activity, not an optional one.

Course Information I

- **Course:** Construction Technology (DI03006011)
- **Unit 5:** Building Maintenance & Safety Measures
- **Lecture 25:** Types of Maintenance work

Lecture Agenda I

1. Types of Maintenance work
2. Maintenance report & its estimate
3. Procedure for repairing plaster work
4. Procedure for replacing old door/window frame
5. Summary and Q&A

Introduction to Building Maintenance I

- Building maintenance refers to the actions performed to keep a building and its services in a good condition or to restore it to a functional state.
- Continuous degradation occurs due to weathering, usage, and aging.
- Effective maintenance prevents minor defects from becoming major structural failures.
- Enhances the lifespan and economic value of the property.

Objectives of Building Maintenance I

- **Preservation:** Keep the building in its original state as much as possible.
- **Safety:** Ensure the safety of occupants by fixing hazardous elements.
- **Functionality:** Maintain the operational efficiency of utilities (water supply, electrical, etc.).
- **Aesthetics:** Retain the visual appeal of the structure.

Classification: Types of Maintenance Work I

- Maintenance Work
  - Routine / Day-to-Day
  - Annual / Periodic
  - Special / Preventive

Routine or Day-to-Day Maintenance I

- Performed continuously to keep the building functional.
- Does not require extensive planning or large budgets.
- **Examples:**
  - Cleaning of premises and drainage lines.
  - Repairing leaky taps or minor plumbing issues.
  - Fixing loose door hinges and window latches.
  - Replacing fused electrical bulbs or switches.

Annual or Periodic Maintenance I

- Planned activities carried out at regular intervals (mostly annually).
- Helps in preserving the aesthetic and structural integrity.
- **Examples:**
  - White washing, color washing, and painting of walls.
  - Painting of steel and woodwork to prevent corrosion and termite attacks.
  - Cleaning of water tanks and septic tanks.
  - Checking and cleaning roof gutters before the monsoon.

Special Maintenance and Repairs I

- Undertaken to prevent heavy damage or when specific components fail.
- Usually requires technical expertise and a larger budget allocation.
- **Examples:**
  - Re-plastering deteriorated walls.
  - Waterproofing of leaky roofs.
  - Major repairs to flooring or structural members.
  - Complete replacement of a damaged plumbing line.

Comparison: Preventive vs Corrective Maintenance I

Feature	Preventive Maintenance	Corrective Maintenance
Approach	Proactive (Before failure)	Reactive (After failure)
Cost	Lower long-term cost	High immediate repair cost
Downtime	Planned and minimal	Unplanned and extensive
Example	Cleaning gutters, painting	Fixing a collapsed roof

Table: Preventive vs Corrective Maintenance

Maintenance Report I

- A systematic document prepared after a detailed inspection of the building.
- **Contents of the Report:**
  - Identification of defects and their locations.
  - Probable causes of the defects.
  - Recommendations for suitable remedial measures.
  - Urgency of repairs (Immediate, Short-term, Long-term).
- Essential for budget allocation and prioritizing repair works.

Preparation of Maintenance Estimate I

1. Site Inspection & Defect Identification

↓

2. Measurement of Repair Area/Quantities

↓

3. Selection of Repair Methodology

↓

4. Abstract of Cost (using current rates)

↓

5. Approval & Allocation of Funds

Procedure for Repairing Plaster Work I

- **Step 1: Preparation of Surface**
  - Remove loose, dead, or cracked plaster using a hammer and chisel.
  - Scrape the underlying masonry joints to a depth of 12 mm to provide a key for new plaster.
  - Clean the surface with a wire brush and wash thoroughly with water.
- **Step 2: Application**
  - Wet the surface adequately before applying the new mortar.
  - Apply the cement mortar (usually 1:4 or 1:6 mix) to match the thickness of the old plaster.
  - Finish the surface smoothly to align perfectly with the adjacent old plaster.
- **Step 3: Curing**
  - Keep the patched area wet for at least 7 to 10 days to prevent shrinkage cracks.

Procedure for Replacing Old Door/Window Frame I

- **Step 1: Removal of Old Frame**
  - Carefully detach the door or window shutters from the hinges.
  - Break the masonry surrounding the holdfasts using a chisel and hammer.
  - Extract the old frame without causing excessive damage to the surrounding wall.
- **Step 2: Preparation for New Frame**
  - Clean the exposed masonry and remove loose debris.
  - Ensure the new frame (wood, metal, or uPVC) is painted with an anti-termite or anti-corrosive primer.

Procedure for Replacing Old Door/Window Frame (Cont.) I

- **Step 3: Fixing the New Frame**
  - Place the new frame in position and check for perfect plumb and level using a plumb bob and spirit level.
  - Secure the frame by embedding holdfasts into the masonry with cement concrete blocks (1:2:4 mix).
- **Step 4: Finishing**
  - Fill the gaps between the frame and masonry using cement mortar.
  - Plaster the repaired edges and cure the cement works properly.
  - Fix the shutters onto the new frame after curing is complete.

Summary I

- Maintenance is classified into routine, annual, and special maintenance, depending on frequency and scale.
- A thorough maintenance report and precise estimate are vital for budget approval.
- Repairing plaster requires proper surface preparation, application, and extensive curing.
- Replacing frames involves careful extraction, aligning the new frame in plumb, securing holdfasts in concrete, and finishing the edges.

Course: Construction Technology (DI03006011)

Unit 5: Building Maintenance & Safety Measures

Lecture 26: Importance of Safety in Construction; Causes of Accidents in Construction Work

Lecture Agenda I

- Introduction to Construction Safety
- Importance of Safety – Human Aspect
- Importance of Safety – Legal and Economic Aspects
- Importance of Safety – Project and Organizational Aspects
- Statistics and Hazardous Nature of Construction
- Causes of Accidents – Human Factors
- Causes of Accidents – Technical and Site Factors
- Causes of Accidents – Managerial Factors and Summary

Introduction to Construction Safety I

- Construction is consistently ranked among the most hazardous industries worldwide due to working at height, heavy machinery, electrical hazards, and constantly changing site conditions.
- **Construction safety** refers to the set of practices, procedures, and equipment aimed at preventing accidents, injuries, and fatalities on a construction site.
- Unlike a factory, a construction site is a temporary, ever-changing workplace – new hazards emerge daily as the work progresses, making safety management especially challenging.
- Safety is the joint responsibility of the employer/contractor, site supervisors, and every individual worker.

Importance of Safety – Human Aspect I

- **Protection of Life:** The foremost purpose of safety measures is to prevent injury and loss of life among workers.
- **Health and Well-being:** Prevents long-term occupational illnesses (respiratory issues from dust, hearing loss from noise, musculoskeletal disorders).
- **Morale and Productivity:** Workers in a safe environment feel secure and perform with greater confidence and efficiency; fear of accidents reduces productivity.
- **Family and Social Impact:** An accident affects not just the worker but their family's livelihood and the wider community.

Importance of Safety – Legal and Economic Aspects I

- **Legal Compliance:** Safety on construction sites is mandated by law (e.g., Building and Other Construction Workers Act, and relevant IS codes such as IS 3764 for excavation safety, IS 4014 for scaffolding); non-compliance can lead to penalties, work stoppage, or prosecution.
- **Cost of Accidents:** Direct costs (compensation, medical expenses, equipment damage) and indirect costs (project delay, loss of reputation, increased insurance premiums) are far higher than the cost of prevention.
- **Insurance and Liability:** Contractors with good safety records benefit from lower insurance premiums and reduced legal liability.

Importance of Safety – Project and Organizational Aspects I

- **Schedule Adherence:** Accidents halt work for investigation and recovery, directly delaying project completion.
- **Quality of Work:** A safety-conscious, well-organized site typically also reflects better workmanship and quality control.
- **Reputation:** Contractors known for strong safety records win more tenders and retain skilled workers.
- **Sustainable Industry Growth:** A safe industry attracts and retains a skilled workforce, essential for the sector's long-term growth.

Hazardous Nature of Construction Work I

- Construction accidents are frequently referred to internationally as the "Fatal Four": falls from height, being struck by objects, electrocution, and being caught in/between equipment or collapsing structures.
- Falls from height (scaffolding, roofs, floor openings) are consistently the single largest cause of construction fatalities.
- The temporary, constantly changing nature of a site (new excavations, incomplete structures, moving machinery) means hazards must be continuously reassessed, unlike a fixed factory floor.

Causes of Accidents – Human Factors I

- **Lack of Training/Awareness:** Workers unfamiliar with safe procedures or hazards of a specific task.
- **Carelessness/Negligence:** Not using provided personal protective equipment (PPE), taking shortcuts to save time.
- **Fatigue:** Long working hours, inadequate rest, leading to reduced alertness and slower reaction time.
- **Working Under Influence:** Alcohol or substance use severely impairs judgment and coordination.
- **Improper Communication:** Miscommunication between crane operators, riggers, and ground staff during lifting operations.

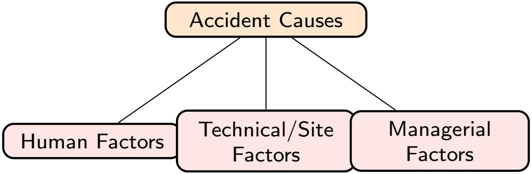
Causes of Accidents – Technical and Site Factors I

- **Unsafe Equipment:** Poorly maintained machinery, defective scaffolding, or damaged lifting tackle.
- **Unguarded Openings and Edges:** Absence of barricades/guardrails around floor openings, excavations, and roof edges.
- **Electrical Hazards:** Exposed wiring, overloaded circuits, and work near live overhead lines.
- **Poor Housekeeping:** Cluttered walkways, protruding nails, and scattered debris causing trips and falls.
- **Inadequate Lighting and Ventilation:** Especially in excavations, tunnels, and confined spaces.
- **Unstable Excavations:** Trenches without shoring/battering collapsing onto workers.

Causes of Accidents – Managerial Factors I

- **Inadequate Supervision:** Absence of a dedicated safety officer or vigilant site supervisor.
- **No Safety Policy/Planning:** Lack of a documented site-specific safety plan, risk assessment, or method statement before starting hazardous work.
- **Insufficient PPE Provision:** Contractor failing to provide helmets, harnesses, safety shoes, or gloves.
- **Time and Cost Pressure:** Prioritizing speed over safety to meet tight deadlines or reduce cost.
- **Lack of Emergency Preparedness:** No first-aid facility, emergency evacuation plan, or trained first-responders on site.

Causes of Accidents – Overview I



Summary I

- Safety in construction is vital for protecting human life, ensuring legal compliance, controlling costs, and maintaining project schedules and reputation.
- Construction remains one of the most hazardous industries, with falls from height being a leading cause of fatal accidents.
- Accident causes fall into three groups: human factors (carelessness, fatigue), technical/site factors (unsafe equipment, unguarded openings), and managerial factors (poor planning, inadequate supervision).
- Understanding these causes is the essential first step toward the safety equipment and precautions covered in the next lecture.

Course: Construction Technology (DI03006011)

Unit 5: Building Maintenance & Safety Measures

Lecture 27: Safety Equipment; Classification of Damages; Safety Precautions

Lecture Agenda I

- Safety Equipment – Personal Protective Equipment (PPE)
- Safety Equipment – Site/Collective Safety Equipment
- Classification of Damages due to Accidents
- Safety Precautions – Excavation Work
- Safety Precautions – Demolition Work
- Safety Precautions – Erection of Concrete Framed Structures
- Safety Precautions – Masonry Work
- Summary

Safety Equipment – Personal Protective Equipment (PPE) I

Equipment	Function	Feature/ Spec
Safety Helmet	Protects head from falling objects/impact	HDPE shell, IS 2925 rated
Safety Harness	Arrests fall while working at height	Full-body, shock-absorbing lanyard
Safety Shoes	Protects feet from crushing/puncture	Steel-toe cap, anti-slip sole
Safety Goggles	Shields eyes from dust/ debris/sparks	Impact-resistant polycarbonate lens
Hand Gloves	Protects hands from cuts, chemicals, heat	Leather/ rubber, task-specific
Ear Protection	Reduces exposure to high noise levels	Ear plugs/muffs, NRR rated
Reflective Jacket	Improves worker visibility on site	High-visibility fluorescent fabric
Dust/ Respiratory Mask	Filters airborne dust and fumes	N95/half-face respirator

Safety Equipment – Site/Collective Safety Equipment I

- **Safety Nets:** Suspended below elevated work areas to arrest falling workers or debris; positioned close enough to limit fall distance.
- **Guardrails and Barricades:** Rigid rails around floor openings, excavation edges, and stair openings to prevent accidental falls.
- **Toe Boards:** Fixed at the base of guardrails/scaffolds to prevent tools and materials from falling to lower levels.
- **Warning Signs and Barricading Tape:** Alert workers to hazards (deep excavation, live wiring, ongoing crane operation).
- **Fire Extinguishers:** Portable units (CO_2, dry powder, foam) positioned at strategic points to control fire outbreaks.

Safety Equipment – Site/Collective Safety Equipment II

- **Scaffolding with Guardrails (IS 4014):** Provides a safe working platform at height, with toe boards and mid-rails.
- **First-Aid Kit and Emergency Signage:** Immediate treatment for minor injuries and clear evacuation route marking.

Classification of Damages due to Accidents I

- **Based on Severity:**
  - *Minor Injury:* First-aid treatable injury with no lost work time (small cuts, bruises).
  - *Major/Disabling Injury:* Requires medical treatment and results in lost work days (fractures, deep wounds).
  - *Fatal:* Results in death of the worker.
- **Based on Nature of Damage:**
  - *Personal Damage:* Injury or death of workers/site personnel.
  - *Property/Structural Damage:* Damage to the structure, formwork, or adjoining property.
  - *Equipment Damage:* Loss or breakdown of machinery/tools involved in the accident.
  - *Environmental Damage:* Spillage of hazardous material, dust, or pollution caused by the accident.
- **Based on Cause:** Fall-related, struck-by, electrical, caught-in/between, and collapse-related damages.

Safety Precautions – Excavation Work I

- Provide adequate **shoring, shuttering, or battering of sides** for trenches deeper than about 1.5 m to prevent collapse (as per IS 3764 guidelines on excavation safety).
- Keep excavated soil (spoil) at least 1–1.5 m away from the edge of the trench to avoid additional surcharge load causing collapse.
- Provide safe means of access/egress (ladders) at intervals not exceeding about 30 m along the trench.
- Barricade the excavation and provide warning signs/lights, especially near public access or at night.
- Check for underground utilities (water, gas, electric cables) before starting excavation.
- Inspect trenches daily and after rainfall for signs of instability before allowing workers to enter.

Safety Precautions – Excavation Work II

- Provide dewatering arrangements to prevent water accumulation, which can destabilize the sides.

Safety Precautions – Demolition Work I

- Conduct a detailed structural survey before demolition to plan the correct sequence (generally reverse order of construction, top to bottom).
- Disconnect all electrical, gas, and water services before starting work.
- Barricade the entire demolition zone and restrict public access with adequate exclusion distance.
- Provide workers with full PPE (helmets, dust masks, goggles) due to high dust and debris generation.
- Avoid undermining or removing load-bearing members before upper floors/loads are cleared, to prevent premature or unplanned collapse.
- Use controlled methods (mechanical, section by section) rather than indiscriminate methods near occupied or adjoining structures.

Safety Precautions – Demolition Work II

- Continuously monitor adjoining structures for vibration-induced damage during the demolition process.

Safety Precautions – Erection of Concrete Framed Structures I

- Ensure formwork and shuttering are designed and checked for adequate strength before pouring concrete, to prevent formwork collapse.
- Provide props and staging that are properly braced and founded on firm ground, checked for stability before loading.
- Provide safety nets, guardrails, and edge protection at all open floor edges during construction of upper floors.
- Ensure workers use safety harnesses when working near unprotected edges or at height during column/beam erection.
- Do not remove formwork/props until concrete has achieved sufficient strength as verified by cube test results or standard stripping time guidelines.

Safety Precautions – Erection of Concrete Framed Structures II

- Ensure lifting/hoisting of reinforcement cages and precast elements is carried out by trained riggers with tested lifting tackle.

Safety Precautions – Masonry Work I

- Ensure scaffolding used for masonry work is erected as per IS 4014, with a stable base, proper bracing, guardrails, and toe boards.
- Do not overload scaffold platforms with excess bricks/mortar beyond their rated capacity.
- Stack bricks and building materials safely away from edges to prevent them from falling onto workers below.
- Provide safe access (ladders/stairs) to working platforms; avoid climbing on the masonry wall itself.
- Ensure newly built masonry walls are adequately supported/braced against wind or accidental impact until fully cured and stable.
- Wear PPE (gloves, safety shoes, eye protection) especially when cutting bricks/blocks or handling mortar with lime/cement.

Summary I

- Safety equipment includes both personal protective equipment (helmets, harnesses, shoes) and collective/site equipment (nets, guardrails, barricades, scaffolding).
- Damages from accidents are classified by severity (minor, major, fatal) and by nature (personal, property, equipment, environmental).
- Specific safety precautions apply to each major activity: shoring and access in excavation, planned sequential demolition, formwork/edge protection during concrete framing, and stable scaffolding/bracing in masonry work.
- A systematic approach combining the right equipment, hazard awareness, and activity-specific precautions is essential to minimize construction accidents.

Course: Construction Technology (DI03006011)

Unit 6: Recent Advancement in Construction Technology

Lecture 28: Importance of Technologies used in Construction Industries

- Why the Construction Industry Needs New Technology
- Category 1: Digital Design & Modelling (BIM)
- Category 2: Off-Site Construction (Prefabrication)
- Category 3: Additive Manufacturing (3D Printing)
- Category 4: Aerial Survey & Monitoring (Drones)
- Category 5: Connected Sites (IoT Sensors)
- Overall Importance to the Industry
- Looking Ahead: Benefits and Recent Advancements

Why the Construction Industry Needs New Technology I

- The construction sector has historically had one of the lowest rates of productivity growth compared to manufacturing and other industries.
- Projects worldwide commonly face cost overruns, schedule delays, material wastage, and a high rate of workplace accidents.
- Growing project scale and complexity (high-rises, infrastructure, smart cities) has outpaced what purely manual/traditional methods can efficiently deliver.
- Modern technology addresses these gaps directly – improving accuracy, speed, safety, and resource efficiency across the entire project lifecycle.

Why the Construction Industry Needs New Technology II

- Before studying individual benefits (Lecture 29) and specific advancements (Lecture 30) in detail, it is important to understand *why* each broad category of technology matters.

Category 1: Digital Design and Modelling – BIM I

- **Building Information Modeling (BIM)** is a process built around a shared, data-rich 3D digital model of a facility, used from design through construction to operation.
- **Why it matters:** It replaces disconnected 2D drawings with a single coordinated model, so architects, structural engineers, and MEP (mechanical/electrical/plumbing) teams work on the same information.
- Clashes between structural members and service ducts/pipes can be detected and resolved on-screen before construction starts, avoiding costly on-site rework.
- Forms the digital backbone that other technologies (drones, IoT, prefabrication) increasingly connect to, making it the foundation of the modern digital construction workflow.

Category 2: Off-Site Construction – Prefabrication I

- **Prefabrication** involves manufacturing structural and finishing components (wall panels, beams, bathroom pods) in a factory, then transporting and assembling them on site.
- **Why it matters:** Factory conditions allow tighter quality control, weather-independent production, and significantly faster on-site assembly compared to fully cast-in-situ construction.
- Reduces on-site labour requirements and construction-related waste, while improving worker safety since much fabrication moves off the live site.
- Particularly important for repetitive elements in housing, and for large infrastructure projects where speed of erection is critical.

Category 3: Additive Manufacturing – 3D Printing I

- **3D Printing in construction** uses computer-controlled extrusion of concrete or other materials to build components or entire structures layer by layer, directly from a digital model.
- **Why it matters:** Enables complex architectural forms that would be difficult or costly with conventional formwork, while depositing material precisely where needed.
- Offers a pathway to rapid, low-cost housing construction, which is significant given global housing shortages.
- Still an emerging technology, but its importance lies in demonstrating how digital design (BIM) can be translated directly into physical construction with minimal manual intervention.

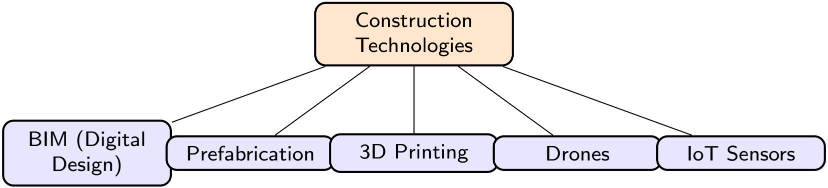
Category 4: Aerial Survey and Monitoring – Drones I

- **Drones (UAVs)** equipped with cameras, LiDAR, and thermal sensors are used for topographic surveying, progress monitoring, and site inspection.
- **Why it matters:** A drone can survey a large site in a fraction of the time required for a manual total-station survey, and can safely inspect hazardous or hard-to-reach locations (tall structures, steep slopes) without exposing workers to risk.
- Provides frequent, up-to-date aerial imagery that can be compared against the BIM model to track actual progress versus planned schedule.
- Important for large linear projects (roads, pipelines) and high-rise buildings where ground-based survey and inspection are slow or unsafe.

Category 5: Connected Sites – IoT Sensors I

- **Internet of Things (IoT)** refers to networks of smart sensors embedded in equipment, materials, and structures that continuously collect and transmit data.
- **Why it matters:** Sensors on machinery track usage and predict maintenance needs before breakdown; sensors embedded in concrete monitor curing temperature and strength gain in real time.
- Enables real-time tracking of material deliveries, equipment location, and even worker safety (via wearable sensors), improving both efficiency and site safety.
- Forms the basis for "smart buildings" after handover, where the same sensor network continues to optimize energy use and maintenance during the building's operational life.

Technology Categories – Overview I



Overall Importance to the Industry I

- Collectively, these technologies shift construction from a purely manual, reactive process to a data-driven, planned, and coordinated one.
- They directly target the industry's biggest pain points: cost overrun, schedule delay, material waste, quality inconsistency, and worker safety.
- Digital tools like BIM increasingly act as the common thread connecting design, prefabrication planning, drone-based progress tracking, and IoT-based monitoring into one integrated workflow.
- Adoption is becoming a competitive necessity – contractors and consultants who apply these technologies deliver projects faster, safer, and with fewer disputes over quality or scope.

Looking Ahead I

- This lecture introduced *why* each broad category of technology matters to the modern construction industry.
- Lecture 29 will detail the specific **benefits** of adopting these technologies – efficiency, cost savings, safety, and quality improvements – in greater depth.
- Lecture 30 will cover **recent advancements** in detail, including 3D printing, robotics, drones, VR/AR, modular construction, and green building technology.
- Together, these three lectures build a complete picture: why technology matters, what benefits it delivers, and what specific advancements are shaping the industry today.

Benefits of using Technologies in Construction.

Course: Construction Technology (DI03006011)
Unit 6: Recent Advancement in Construction Technology
Lecture 29

Lecture Agenda I

- Introduction to Construction Technology
- Overview of Key Technologies
- Major Benefits of Technology Adoption
    - Efficiency & Productivity
    - Cost Savings & ROI
    - Safety Enhancements
    - Quality & Project Management
- Traditional vs. Modern Construction
- Future Trends & Challenges
- Summary and Q&A

Introduction to Construction Technology I

- Construction technology refers to the collection of innovative tools, machinery, software, and other advancements used during the construction phase of a project.
- It aims to improve field productivity, increase safety, and reduce delays or cost overruns.
- The construction industry, historically slow to adopt new technologies, is now rapidly embracing digital transformation.

Key Technologies Transforming Construction I

- **Building Information Modeling (BIM):** 3D model-based process for planning, designing, constructing, and managing buildings.
- **Drones (UAVs):** Used for site surveys, inspections, and monitoring progress.
- **Internet of Things (IoT):** Smart sensors on equipment and materials for real-time tracking.
- **3D Printing:** Additive manufacturing for building components or entire structures.
- **Artificial Intelligence (AI) & Machine Learning:** Predictive analytics for risk mitigation and schedule optimization.

Technology Ecosystem in Construction I

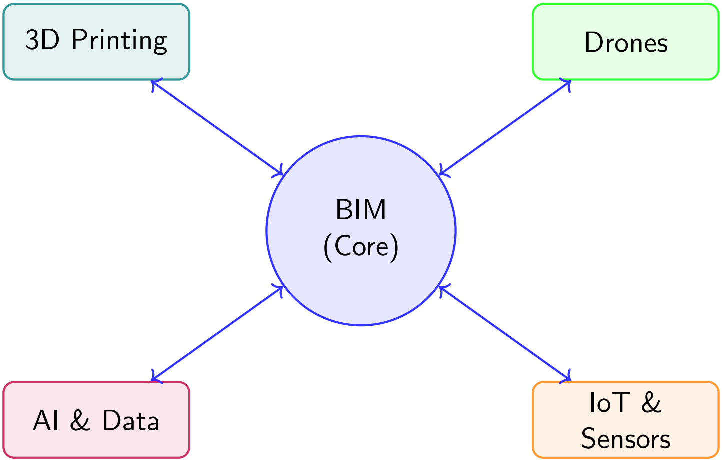


Figure: Integration of Modern Technologies around BIM

Benefit 1: Improved Efficiency & Productivity I

- Technology automates repetitive and time-consuming tasks.
- **Real-time data:** Allows project managers to make informed decisions quickly, preventing delays.
- **Prefabrication & Robotics:** Off-site construction and automated machinery speed up the building process significantly.
- Reduces rework by identifying clashes and design flaws early in the BIM phase before actual construction begins.

Benefit 2: Enhanced Safety on Site I

- Construction sites are inherently dangerous, but technology mitigates risks.
- **Wearables:** Smart helmets and vests monitor workers' vitals and detect hazardous environments (e.g., toxic gases, extreme temperatures).
- **Drones & Robotics:** Used for inspections in hard-to-reach or dangerous areas, keeping human workers out of harm's way.
- **VR/AR Training:** Workers can undergo safety training in simulated hazardous environments without actual risk.

Benefit 3: Cost Reduction & ROI I

- Initial investment in technology may be high, but the long-term ROI is substantial.
- **Material Waste Reduction:** Accurate quantification through BIM and 3D printing minimizes excess material ordering and waste.
- **Labor Optimization:** Automation reduces dependency on manual labor for repetitive tasks, lowering labor costs.
- **Maintenance Prediction:** IoT sensors predict equipment failure, reducing costly unplanned downtime.

Benefit 4: Quality & Project Management I

- **Higher Precision:** Laser scanning and GPS-guided equipment offer unparalleled accuracy, reducing human error.
- **Single Source of Truth:** Cloud-based project management software ensures all stakeholders access real-time updates.
- **Seamless Collaboration:** Connects office and field teams, preventing costly miscommunications and delays.
- **Improved Aesthetic Finishes:** Automated tools lead to higher structural integrity and better overall finishes.

Environmental Benefits & Sustainability I

- Technology plays a crucial role in "Green Construction".
- **Energy Analysis:** BIM software simulates building energy performance during the design phase to optimize natural lighting and HVAC efficiency.
- **Reduced Footprint:** Optimized logistics and reduced waste contribute to a lower carbon footprint during construction.
- **Smart Buildings:** Post-construction, IoT systems optimize energy usage, heating, and cooling based on occupancy.

Comparison: Traditional vs. Modern Construction I

Aspect	Traditional Methods	Modern Technology-Driven
Design	2D CAD or Manual Drafting	3D/4D/5D BIM
Surveying	Manual total stations	Drones and Laser Scanning
Communication	Paper-based, prone to delay	Cloud-based, real-time
Safety	Reactive protocols	Proactive (Wearables, IoT)
Waste	High material waste	Optimized, low waste

Table: Traditional vs. Modern Construction Practices

Impact of Technology on Project Lifecycle I

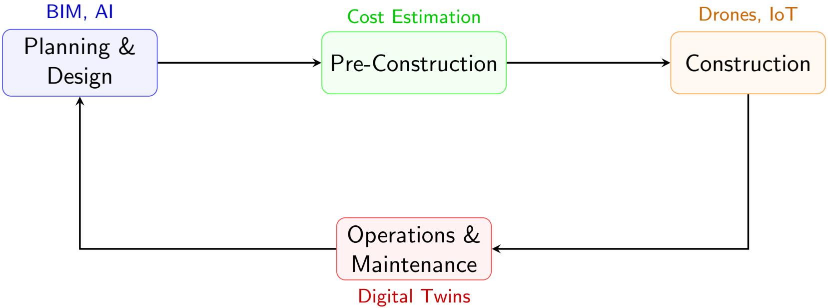


Figure: Technology integration across the project lifecycle

Challenges in Adopting New Technologies I

- **High Initial Costs:** Software, hardware, and training require significant upfront investment.
- **Skill Gap:** Shortage of workers skilled in operating advanced machinery, drones, or software.
- **Cultural Resistance:** Traditional mindset and reluctance to change long-established workflows.
- **Data Security:** Increased reliance on cloud services and IoT makes projects vulnerable to cyberattacks.

Summary I

- The adoption of technology in construction is no longer a luxury but a necessity for staying competitive.
- Key benefits include drastically improved safety, efficiency, quality, and cost savings.
- Core technologies like BIM, IoT, and Drones are fundamentally changing how structures are designed and built.
- Overcoming the initial investment and skill gap challenges will pave the way for a smarter, more sustainable construction industry.

Questions?

Feel free to ask any questions related to the benefits of using technologies in construction.

Course: Construction Technology (DI03006011)

Unit 6: Recent Advancement in Construction Technology

Lecture 30: 3D Printing, Robotics, Drones, VR/AR, Modular Construction & Green Buildings

Lecture Agenda I

- 3D Printing in Construction: Uses, Features, and Limitations
- Robotics and Automation
- Drones for Surveying and Monitoring
- Virtual and Augmented Reality (VR/AR)
- Wearable Technology
- Modular and Prefabricated Construction
- Green Building Technology
- Summary and Q&A

3D Printing in Construction: Uses and Features I

Uses:

- Printing structural components (walls, foundations, etc.) using concrete or other composite materials.
- Creating complex architectural shapes that are difficult with traditional formwork.
- Rapid prototyping and building low-cost housing.

Features:

- **Speed:** Significantly faster construction times.
- **Waste Reduction:** Precise material placement minimizes waste.
- **Design Freedom:** Enables free-form and complex geometries without extra costs.

3D Printing in Construction: Limitations I

- **Material Constraints:** Limited to specific mixtures that can be extruded and cure rapidly.
- **High Initial Cost:** Expensive equipment and setup costs.
- **Size Restrictions:** Printed components are limited by the size of the 3D printer (gantry or robotic arm).
- **Regulatory Hurdles:** Lack of standardized building codes for 3D printed structures.
- **Surface Finish:** Often produces a ribbed texture that may require additional finishing work.

Uses and Features:

- **Bricklaying Robots:** Automate the masonry process, increasing speed and consistency (e.g., SAM - Semi-Automated Mason).
- **Autonomous Heavy Equipment:** Self-driving dozers, excavators, and loaders equipped with GPS and sensors.
- **Exoskeletons:** Wearable robotics to enhance human strength and reduce fatigue.

Limitations:

- High capital investment and maintenance costs.
- Need for specialized training to operate and maintain.
- Challenges in adapting to unpredictable or highly unstructured site environments.

Comparison of Automation vs. Traditional Methods I

Parameter	Traditional Construction	Automated Construction
Speed	Slower, dependent on labor	Faster, continuous operation
Precision	Subject to human error	High consistency and accuracy
Initial Cost	Lower equipment cost	High capital investment
Safety	Higher risk of injuries	Reduced human exposure to hazards
Flexibility	High adaptability on site	Limited to pre-programmed tasks

Table: Comparison of Construction Methods

Drones for Surveying and Monitoring I

Uses:

- Topographic surveying and mapping using photogrammetry and LiDAR.
- Progress tracking and site inspections.
- Thermal imaging to detect heat loss or electrical issues.

Features & Limitations:

- **Features:** Access hard-to-reach areas safely, rapid data collection, high-resolution imagery.
- **Limitations:** Limited battery life (typically 20-40 mins), restricted by weather conditions (high winds, rain), and strict aviation regulations.

Virtual and Augmented Reality (VR/AR) I

- **Virtual Reality (VR):** Immerses the user in a fully digital environment. Used for design reviews, client walk-throughs, and safety training before construction begins.
- **Augmented Reality (AR):** Overlays digital information (like BIM models) onto the physical world. Used on-site to compare the 'as-built' environment with the design model.

Limitations:

- Hardware can be bulky or fragile for rough site conditions.
- Requires reliable internet connectivity on site for real-time model syncing.
- High initial setup costs for creating accurate models.

Wearable Technology I

Uses and Features:

- **Smart Helmets:** Equipped with AR visors, cameras, and sensors to detect fatigue or hazardous conditions.
- **Smart Vests:** GPS and vital sign tracking to monitor worker health and location.
- **Smart Boots:** Detect falls, shocks, or carry capacity to alert supervisors of accidents.

Limitations:

- Privacy concerns among workers regarding continuous monitoring.
- Battery life constraints for all-day use.
- Cost of outfitting an entire workforce.

Modular and Prefabricated Construction I

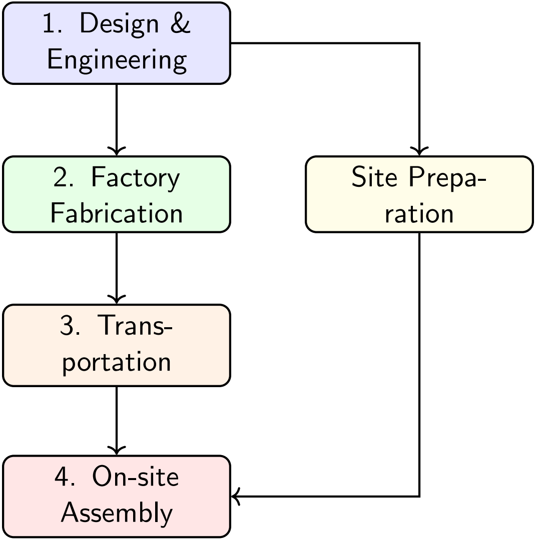
Uses & Features:

- Building components (or entire rooms) are manufactured in a controlled factory environment and transported to the site for assembly.
- **Features:** Significantly reduces construction time (up to 50%), improves quality control, reduces material waste, and is less affected by weather conditions.

Limitations:

- Transportation constraints: Large modules require special permits and logistics.
- Decreased design flexibility once production begins.
- Requires high upfront coordination and early design finalization.

Modular Construction Workflow I



Green Building Technology I

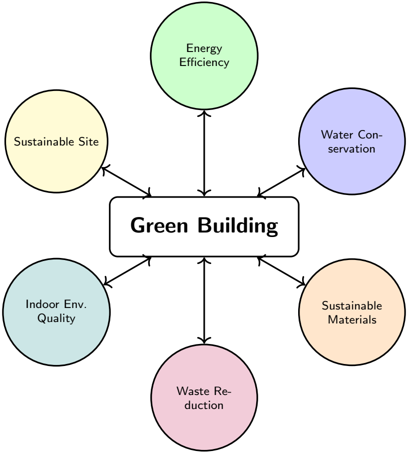
Uses & Features:

- Designing structures that are environmentally responsible and resource-efficient throughout their life-cycle.
- Features include solar panels, green roofs, rainwater harvesting, energy-efficient HVAC, and use of sustainable/recycled materials.
- Aims to achieve certifications like LEED or IGBC.

Limitations:

- Higher initial construction costs (often offset by long-term savings).
- Availability of certified sustainable materials can be limited locally.
- Requires specialized contractors and consultants.

Core Components of Green Building I



Summary I

- Modern technologies like 3D printing and robotics are transforming the speed and precision of construction but require high initial investments.
- Drones, VR/AR, and wearables improve site monitoring, safety, and visualization.
- Modular construction shifts work to controlled environments, enhancing quality and speed.
- Green building technologies are essential for sustainable development and reducing the environmental footprint of structures.

Questions?

Thank you for your attention!