Concrete and Structures for Interior Design Engineering

Lecture -1-

Introduction to Structures & Loads

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Course Introduction

- This course introduces basic concepts of building structures and the properties of materials that support and shape interior spaces.
- It is designed specifically for **Interior Design students** to help them understand how buildings stand, how loads are carried, and how materials like concrete, steel, masonry, timber, and composites influence both the function and aesthetics of interiors.
- Interior designers do not design the building's structure, but they work closely with structural systems.
- By learning about structures and materials, students will be able to:
  - ✓ Recognize load-bearing elements that cannot be removed.
  - ✓ Plan safe and creative interior layouts.
  - ✓ Choose appropriate materials for interiors that balance strength, durability, and aesthetics.
  - ✓ Collaborate effectively with engineers.

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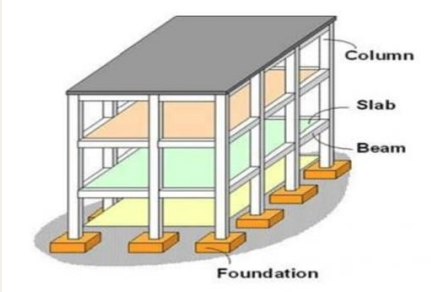
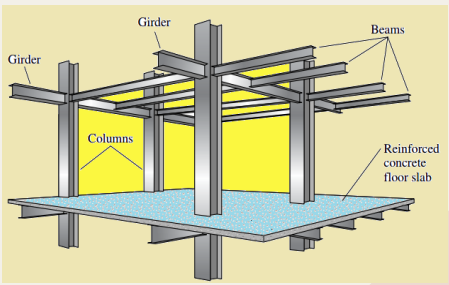
Contents

1. What is a Structure?

- A ***structure*** is the physical framework of a building that supports and carries all the forces acting on it and safely transfers them to the ground.
- Structures are designed to sustain various types of loads and possible combinations of loads that could act on them during their lifetime.
- It's often called the **"skeleton"** of a building.
- When designing a structure to serve a specified function for public use, the engineer must account for its safety, esthetics, and serviceability, while taking into consideration economic and environmental constraints.





The design of a structure involves many considerations, among which are four major objectives that must be satisfied:

- The structure must meet the performance requirement **(utility)**.
- The structure must carry loads safely **(safety)**.
- The structure should be economical in material, construction, and cost **(economy)**.
- The structure should have a good appearance **(aesthetics)**.

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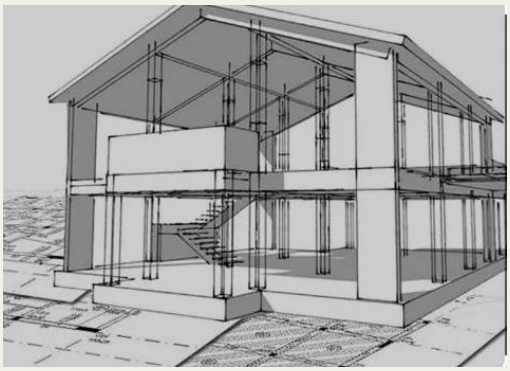
2. Functions of a Structure

- **Support:** Holds up all parts of a building - floors, walls, roof, finishes, furniture, and people.
- **Stability:** Resists environmental forces such as wind and earthquakes without collapsing.
- **Shape & Space:** Defines the size, arrangement, and openness of spaces.
- **Safety:** Ensures the building can resist all loads with an adequate safety margin.

For interior designers, understanding the structure helps in planning layouts, selecting finishes, and knowing what can or cannot be changed.



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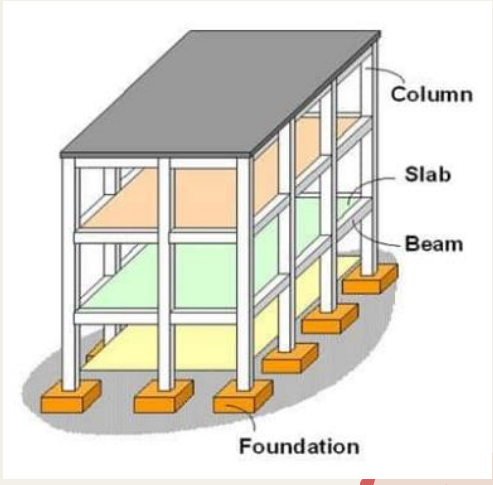
3. Structural Elements in Buildings

Structural elements are the **main parts of a building that carry loads** and keep the building stable. Interior designers should know these elements because they **affect space planning, ceiling heights, wall placement, and aesthetics. They are:**

1. **Foundations**; Transfers the load of the building safely to the ground.
2. **Columns;** Vertical members that carry loads from beams and slabs down to the foundation.
3. **Beams;** Horizontal members that carry loads from slabs and walls to columns.
4. **Slabs;** Horizontal flat surfaces that form floors and ceilings.



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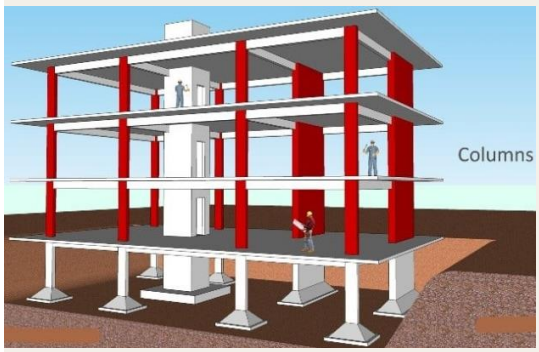

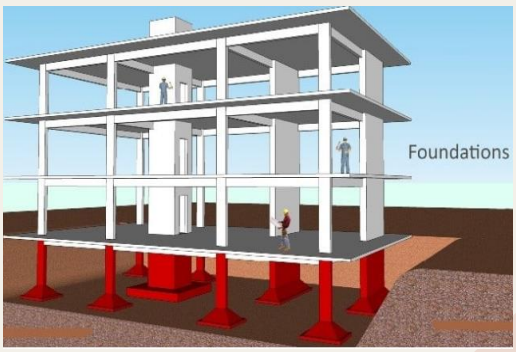

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5. Walls;

- **Load-Bearing Walls:** part of the structure, carry loads to the foundation.
- **Non-Load-Bearing Walls:** partitions for dividing spaces.

6. Shear Walls; A shear wall is a vertical structural wall made of reinforced concrete or masonry. Its main job is to resist horizontal (lateral) forces such as: Wind loads and Earthquake loads. It acts like the spine of the building, keeping it stable against sideways shaking or pushing.

7. Lintels; Small horizontal beams over doors and windows to carry loads above openings.

8. Roof Systems; Protect the building and transfer loads (like snow, wind) to the structure.

9. Stairs; Provide vertical movement between floors and carry their own weight plus user loads.

10. Trusses; Triangular steel or timber frameworks used to support large roofs or open spans.

11. Bracing Elements; Diagonal members or walls that resist lateral forces (wind, earthquake).

12. Elevator shafts; These are the vertical concrete boxes in which the elevators are provided to move up and down. The elevator is actually contained in its own concrete box. These shafts act as very good structural elements which help in resisting horizontal loads and also carry vertical loads.

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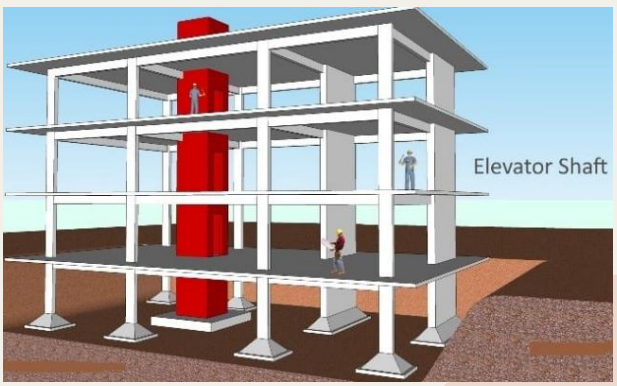

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Stairs

Lintels

Roofs

Bracelets

Trusses

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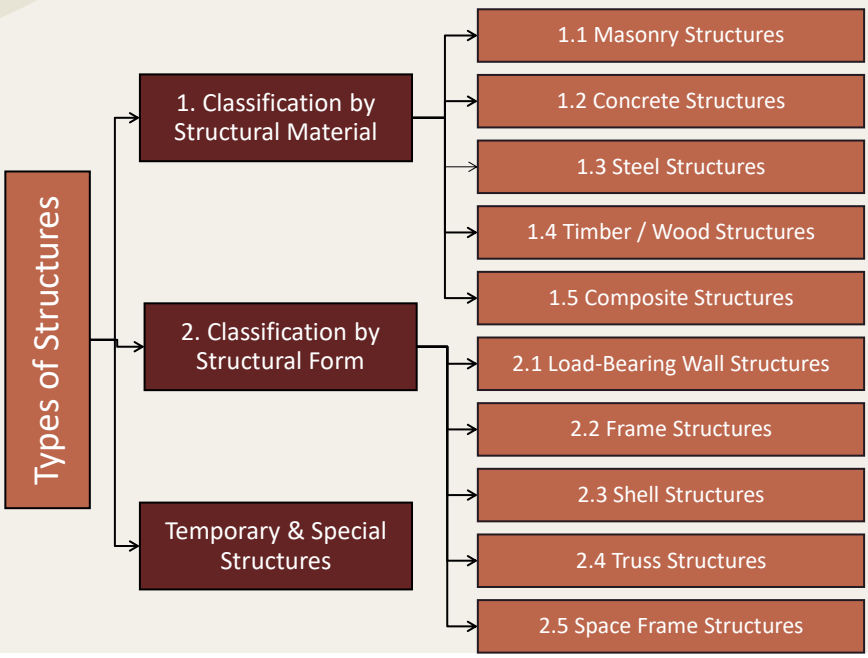
4. Types of Structures



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4. Types of Structures

1. Classification by Structural Material

1.1 Masonry Structures

- ✓ The construction of building units bonded with mortar.
- ✓ Built mainly from brick, stone, or concrete blocks.
- ✓ Walls act as both load-bearing elements and space dividers.
- ✓ Common in older residential or low-rise buildings.
- ✓ Interior design limitation: walls cannot be easily removed without reinforcement.
- ✓ Example: Traditional brick houses, old commercial buildings.

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1.2 Concrete Structures

- ✓ A concrete structure is a building system in which the main load-carrying elements - such as beams, columns, slabs, and foundations - are made of reinforced concrete (RC).
- ✓ Concrete is a mixture of cement, water, fine aggregates (sand), and coarse aggregates (gravel).
- ✓ On its own, concrete is strong in compression but weak in tension.
- ✓ To overcome this, steel reinforcement bars (rebar) are added, because steel is strong in tension. The combination is called Reinforced Concrete (RC), which can resist both compressive and tensile forces.

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1.3 Steel Structures

- ✓ A steel structure is a building system in which the main load-bearing framework, including columns, beams, girders, and trusses — is made of structural steel.
- ✓ Structural steel is a manufactured product (rolled or welded sections such as I-beams, H-columns, channels, and hollow tubes).
- ✓ Steel is very strong in both tension and compression, unlike plain concrete which is weak in tension.
- ✓ Steel frames are often combined with concrete floor slabs to provide flat walking surfaces while the steel frame supports most of the loads.

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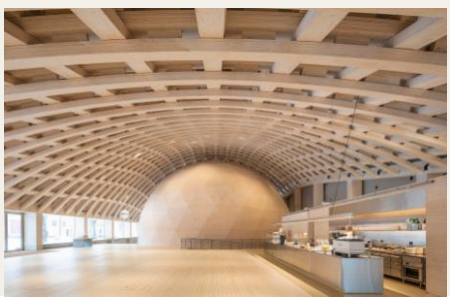
1.4 Timber / Wood Structures

A timber (or wood) structure is a building system in which the main load-bearing elements - such as posts (columns), beams, joists, trusses, wall panels, and sometimes floors and roofs are made from wood or engineered wood products.

- ✓ Modern wood structures often use engineered timber products such as laminated veneer lumber (LVL), glued-laminated timber (Glulam), cross-laminated timber (CLT), and plywood panels, which are stronger and more stable than traditional sawn lumber.
- ✓ Wood is lightweight, renewable, easy to shape, and gives a warm natural aesthetic, but it is generally less durable and weaker under heavy loads compared to steel or reinforced concrete.



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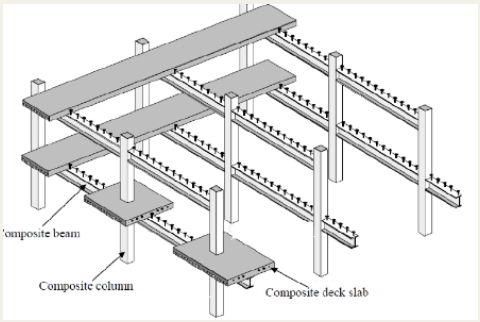
1.5 Composite Structures

A composite structure is a building system that combines two or more different materials in a way that they work together as a single structural unit, each material contributing its best properties.

- ✓ The main idea is to optimize performance - using each material where it is most effective.
- ✓ Commonly, one material provides compressive strength while another offers tensile strength or lightweight efficiency.
- ✓ Composite construction is widely used in modern architecture because it allows slimmer, lighter, stronger, and more elegant structures.



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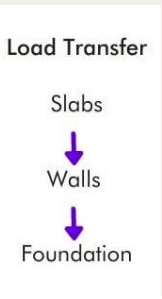
2. Classification by Structural Form or System

Structures can also be grouped by how they carry the building's loads.

2.1 Load-Bearing Wall Structures

- The walls support most of the building's weight.
- Floors and roofs rest on these walls.
- Common in small, low-rise houses or old buildings.
- Limitation: You cannot easily remove or move walls, as they hold up the building.



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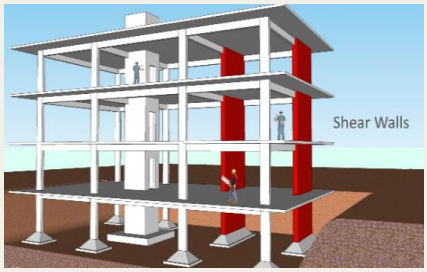
2.2 Frame Structures

- Beams and columns form a skeleton that supports the whole building.
- Walls are not structural; they only divide spaces inside.
- This is the most common system in modern multi-story buildings.
- Interior design advantage: Easy to change layouts by adding, removing, or moving partitions.



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2.3 Shell Structures

- Use thin, curved surfaces (like domes, arches, folded plates, or fabric roofs).
- The shape itself carries the loads, so less material is needed.
- Good for large open spaces without columns.
- Examples: Stadium roofs, airport terminals.

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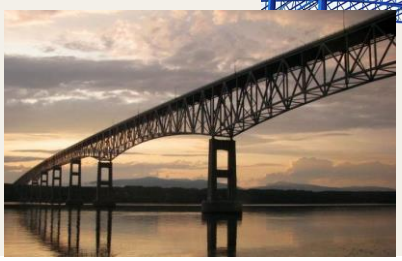
2.4 Truss Structures

- Made from triangular elements of steel or timber joined together.
- Used to span long distances, especially for roofs in halls, warehouses, bridges.
- Interior impact: Creates big open spaces without many interior supports.



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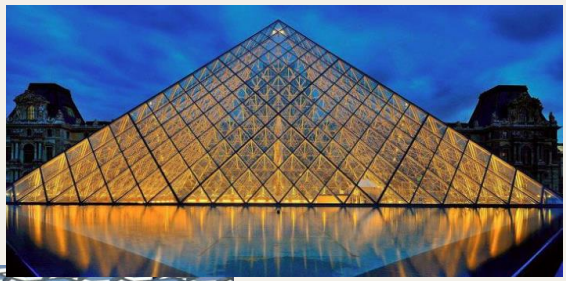
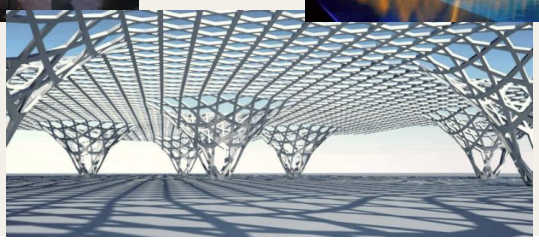
2.5 Space Frame Structures

- A 3D grid made of steel members.
- Light but strong, can cover very large areas (e.g., sports arenas, exhibition halls).
- Often allows natural light to enter and gives a feeling of openness.

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3. Temporary & Special Structures

- Scaffolding, exhibition pavilions, tents, canopies.
- Often light, modular, and easy to assemble/dismantle.
- Important in events and adaptive interior spaces.

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5. Role of Structure in Interior Design

The structure has a direct influence on interior layouts and aesthetics:

•Column and Beam Layout:

- Spacing between columns sets maximum room widths.
- Beams affect ceiling heights where false ceilings, or lighting can be installed.

•Load-Bearing Walls:

- These walls cannot be easily removed for new openings or space remodeling without structural reinforcement.

•Shear Walls and Core Walls:

- Often surround staircases or elevators; critical for stability and usually fixed in place.

•Open Spaces vs. Partitioned Spaces:

- Long open spans require stronger beams or special slabs (ribbed, waffle, post-tensioned).
- Designers need to know where such systems are used.

•Aesthetic Integration:

- Exposed concrete or steel members can become part of the interior style (industrial, minimalist, etc.).

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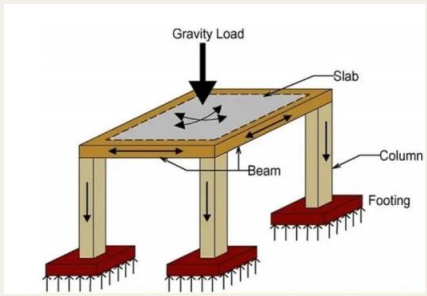
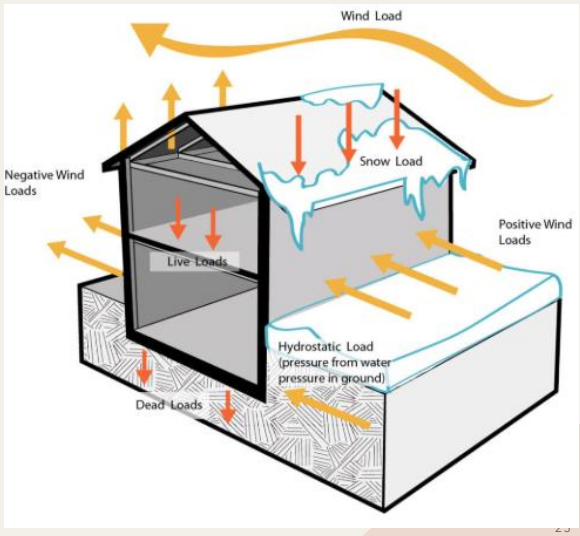
6. What are Loads?

- A load is any force, weight, or pressure that acts on a building's structure.
- The structure must carry these loads safely and transfer them down to the ground without collapsing or cracking.
- Example: The weight of a sofa, the people sitting on it, the wind pushing against a window, all are loads.





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Why Loads Matter for Interior Designers?

Interior designers often add or change loads inside a building:

- Moving walls or adding heavy partitions.
- Adding furniture, bookcases, aquariums, or decorative water features.
- Creating mezzanine floors or installing large chandeliers.
- If these loads exceed what the building was designed for, it can lead to:
  - ✓ Cracks in walls or floors.
  - ✓ Sagging or vibration.
  - ✓ Even structural failure.

That's why designers must understand loads and consult engineers before major changes.

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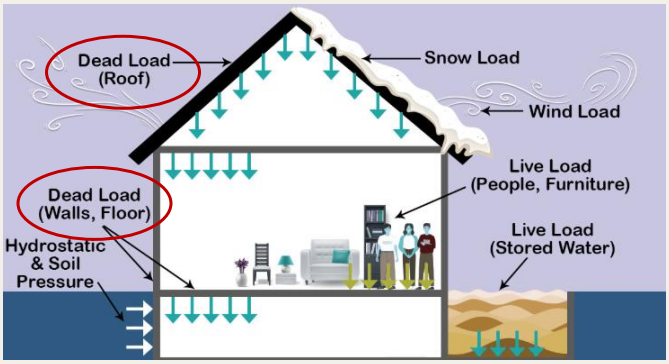
7. Types of Loads?

A. Dead Loads (DL) (Permanent Loads)

Dead loads are the fixed, unchanging weights in a building.

- ✓ **Self-weight of structural members:** Beams, columns, slabs, walls, and roof.
- ✓ **Weight of permanent finishes:** Floor tiles, plaster, ceilings, built-in cabinets.
- ✓ Dead loads generally act in the vertical direction.

Once the building is completed, these loads remain constant throughout its life.



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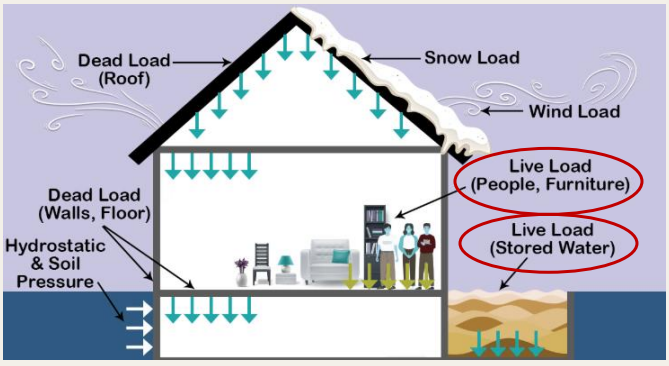
B. Live Loads (LL) (Imposed Loads)

Live loads are the temporary or movable weights that can change during use.

- ✓ **Occupants:** People walking, sitting, or working inside the building.
- ✓ **Furniture and equipment:** Sofas, tables, cabinets, storage racks, beds.
- ✓ **Movable partitions:** Walls that can be shifted or added later.

Live loads vary over time - for example, a classroom has higher loads when full of students than when empty.



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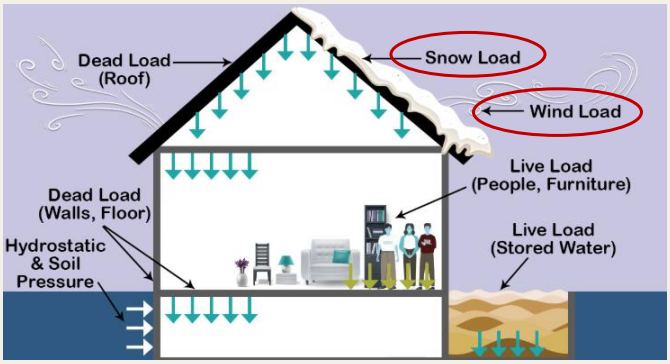
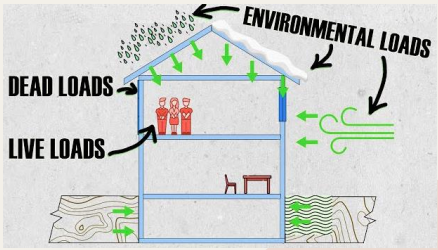
C. Environmental Loads

These loads come from natural forces acting on the building.

- ✓ **Wind loads:** Horizontal pressure from strong winds on walls, roofs, and tall windows.
- ✓ **Seismic (earthquake) loads:** Side-to-side shaking forces during an earthquake.
- ✓ **Snow loads:** Weight of snow accumulating on roofs in cold climates.
- ✓ **Temperature effects:** Expansion or contraction of materials due to heat or cold.

These loads must be considered during building design to ensure safety in different environments.





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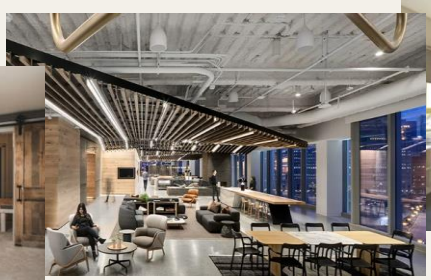
D. Loads Relevant to Interior Designers

Interior designers often add special loads that were not in the original design:

- ✓ Heavy furniture and storage: Large bookshelves, cabinets, safes.
- ✓ Water features and aquariums: Water is heavy (1,000 kg per cubic meter).
- ✓ Heavy cladding or stone finishes: Thick marble, granite, or decorative concrete panels.
- ✓ Mezzanines, sculptures, chandeliers: Concentrated loads that need strong support.

Any addition of heavy loads should be discussed with a structural engineer to avoid overloading floors or ceilings.



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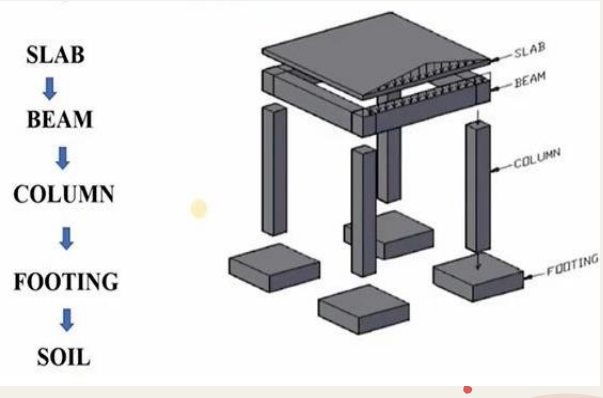
8. Concept of Load Path

✓ A load path is the route by which loads travel from where they act in the building down to the ground.

Here's how loads typically move:

Furniture / people / fixtures
↓
Floor slab (spreads loads to beams)
↓
Beams (carry loads to vertical supports)
↓
Columns or load-bearing walls (transfer loads down)
↓
Foundation (spreads loads to ground)
↓
Soil



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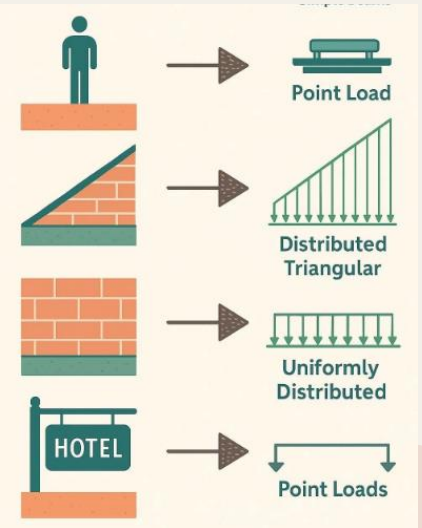
9. Distribution of Loads

- Understanding the types of loads in construction is essential for every engineer, for those passionate about building safety.
- Whether it's a person standing, a sloped brick wall, a uniform wall, or a hanging signboard - each applies a different type of load on a structure.

Here's a quick breakdown:

1. **Point Load** – Concentrated at a single point, like a person standing.
2. **Triangular Load** – Increases gradually, as seen in sloped walls.
3. **Uniformly Distributed Load (UDL)** – Spread evenly, common in standard brick walls.
4. **Point Loads with Moment** – From hanging structures like boards or signage.



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