

## STRUCTURAL AND NON-STRUCTURAL COMPONENTS

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### 4.1 STRUCTURAL COMPONENTS

Building design is a complex process that involves a careful consideration of various factors to ensure the safety, functionality, and aesthetic appeal of the structure. One of the key aspects of this process is the selection and integration of structural components. These components form the backbone of a building, providing support, stability, and durability. In this chapter, we will explore the fundamental structural components commonly used in building design and their crucial roles in ensuring the integrity of a structure. In construction, the framework and skeleton of any building

are essential for its stability and support (Fig. 4.1). These are divided into two main parts: the substructure and the superstructure.

#### 4.1.1 Substructure

The substructure refers to the underlying foundation and support system of a building. It includes all components that are below ground level and support the entire structure above. Key elements of the substructure typically comprise the following:

- **Foundation:** This is the lowest part of the substructure, usually made of concrete, designed to transfer the building load to the soil underneath. Foundations can be shallow (e.g., strip, raft) or deep (e.g., pile, pier) depending on soil conditions and the structure's weight.
- **Footings:** These are structural bases, often made of reinforced concrete, placed beneath the foundation walls or columns to distribute the building's load evenly onto the foundation.
- **Piles/Piers:** In cases where the soil is less stable, piles or piers are used to transfer the building load deeper into the ground, providing additional stability and support.

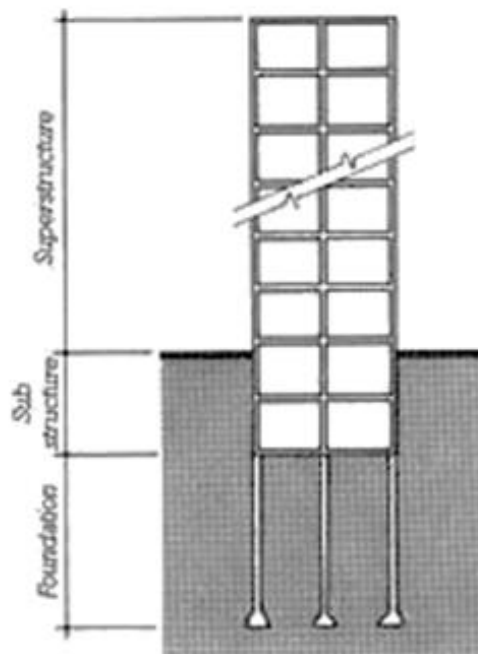


Fig 4.1: Basic structural elements

#### 4.1.2 Superstructure

The superstructure refers to the parts of the building above ground level. It rests on the substructure and comprises the visible elements that create usable spaces for occupancy. Key components of the superstructure include:

- **Columns:** Vertical load-bearing members that transfer the weight of the superstructure to the foundation. They are designed to withstand compressive forces.
- **Beams:** Horizontal members that support the floors and roof, transferring loads to the columns. Beams can be made of steel, wood, or reinforced concrete.
- **Floors:** Structural elements that provide the walking surface and divide different levels within the building. These can be made of concrete, wood, or steel.
- **Walls:** Vertical load-bearing elements that enclose the building and provide structural support and partitioning.

While the substructure ensures a stable and secure foundation for the building, the superstructure creates habitable spaces and bears the loads above ground level. Both are crucial components working together to create a safe, durable, and functional building.

## 4.2 BASIC STRUCTURAL ELEMENTS

### 4.2.1 Foundation

The foundation is the very base upon which the entire building rests. It serves the vital function of distributing the load of the structure to the underlying soil in a way that prevents settling or movement. There are various types of foundations, including shallow foundations and deep foundations (such as piles), each selected based on the specific characteristics of the site and building.

### 4.2.2 Columns

Columns are vertical structural elements that support the load from above and transfer it to the foundation. They come in various shapes and sizes, ranging from rectangular and circular to more elaborate designs. The choice of column type depends on factors such as the architectural style, load-bearing requirements, and space considerations within the building.

### 4.2.3 Beam

Beams are horizontal members that span across supports, such as columns or walls, and carry the load from the structure above. Beams come in different shapes, including I-beams, H-beams, and box beams, each with specific advantages depending on the load distribution and structural requirements.

### 4.2.4 Slab

Slabs are flat, horizontal surfaces that form the floors and roofs of a building. They can be solid or reinforced with materials like steel or post-tensioned cables to enhance their strength. The type of slab used depends on factors such as the span, load-bearing capacity, and intended use of the space. (Ref.Fig.2)

### 4.2.5 Walls

Walls are fundamental structural components in buildings, providing support, stability, and enclosure. They serve various essential purposes in a structure:

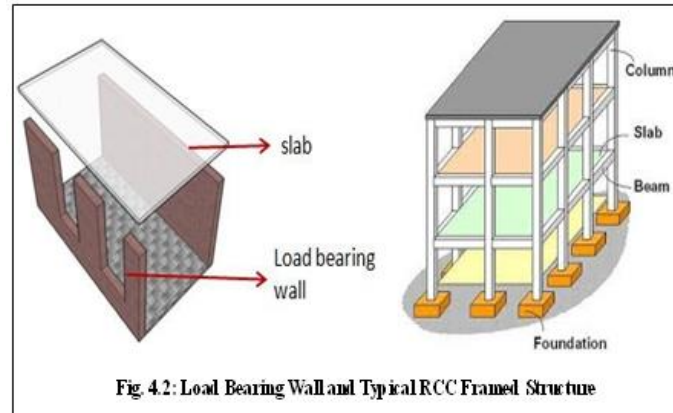


Fig. 4.2: Load Bearing Wall and Typical RCC Framed Structure

1. **Load-Bearing Support:** Load-bearing walls transfer the vertical loads (dead and live loads) from floors, roofs, and other structural elements to the foundation. These walls play a critical role in distributing the weight of the building and ensuring its stability.
2. **Structural Integrity:** Walls contribute significantly to the overall structural integrity of a building. They resist lateral forces such as wind, seismic activity, and other external forces, enhancing the stability of the structure.
3. **Partitioning and Space Division:** Internal or non-load-bearing walls divide the interior space into rooms, corridors, and compartments, providing privacy and defining functional areas within the building.
4. **Enclosure and Insulation:** Exterior walls enclose the building, providing protection against weather elements and contributing to insulation, maintaining comfortable indoor temperatures.
5. **Fire Resistance and Soundproofing:** Walls made from fire-resistant materials can act as barriers, containing fires and preventing their spread. Additionally, walls with soundproofing properties reduce noise transmission between spaces.
6. **Aesthetic and Design Features:** Walls contribute to the architectural aesthetics of a building. Different materials, textures, and finishes offer design versatility, enhancing the visual appeal of the structure.

Walls can be constructed using various materials like concrete, masonry (brick, stone, block), wood, steel, or composite materials, each with its unique properties and suitability based on factors such as structural requirements, cost, aesthetics, and local building practices.

The design and placement of walls in a structure depend on the building's architectural design, load-bearing requirements, environmental conditions, and regulatory standards. Effective wall design and construction are crucial for ensuring the safety, durability, and functionality of buildings.

1. **Load Bearing Wall:** Load-bearing walls are crucial structural components that support the weight of the building and transfer it to the foundation. These walls typically carry the vertical loads from the superstructure (such as floors and roofs) and distribute them to the foundation or the ground.

#### **Characteristics of Load-Bearing Walls:**

- Load-bearing walls are usually thicker and sturdier than non-load-bearing or partition walls.
- They are strategically placed to bear the vertical weight of the structure and help maintain its stability.

- These walls are designed and positioned based on architectural and engineering plans to ensure they can support the imposed loads without compromising the building's integrity.
2. **Internal/Partitioning Wall:** Internal or partitioning walls, in contrast, are non-load-bearing walls that divide the interior space of a building into rooms, corridors, or compartments. Unlike load-bearing walls, these walls do not support the structure above and are primarily used to define spaces, create privacy, and offer separation within the building.

**Characteristics of Internal/Partitioning Walls:**

- These walls can be made of various materials, including plasterboard, wood, glass, or lightweight bricks, depending on the desired aesthetics and functionality.
- They are thinner compared to load-bearing walls and do not carry any significant structural load from the floors or roof.
- Internal walls can be modified or removed more easily during renovations or remodeling since they do not play a role in the building's overall structural support.
- Load-bearing walls are essential for providing structural support and distributing the weight of the building, while internal or partitioning walls contribute to space division and functionality within the structure without bearing significant structural loads. Both types of walls play integral roles in constructing functional and stable buildings.

### 4.3 TYPES OF STRUCTURAL SYSTEMS

Structural systems in construction refer to the arrangement and configuration of elements that carry and transfer loads within a building or structure. There are various types of structural systems used in architecture and construction, each with its unique characteristics and suitability for different building designs. Some common types include:

- **Frame Structures:** Utilize columns and beams to create a framework supporting floors, walls, and roofs. Examples include steel frames, reinforced concrete frames, and timber frames.
- **Load-Bearing Wall Systems:** Rely on walls to bear and transfer vertical loads, providing both structural support and enclosure. Common in masonry construction where the walls carry the building's weight.
- **Truss Systems:** Comprises interconnected triangular components (trusses) to support roofs, bridges, and other structures. Trusses efficiently distribute loads while using less material compared to traditional beams.
- **Shell Structures:** Feature curved or vaulted surfaces to support loads and resist forces through their shape and material strength. Examples include domes, barrel vaults, and thin-shell structures used in roofs or specialized constructions.
- **Suspension Structures:** Employ tensioned cables or ropes to support loads by hanging elements from above. Commonly used in bridges, canopies, and some architectural designs.
- **Grid Systems:** Use a grid of intersecting beams and columns to distribute loads evenly across the structure. Efficient for large open spaces and tall buildings due to their flexibility in layout.

- **Hybrid Systems:** Combine elements of different structural systems to optimize efficiency, strength, and cost. Mixes different materials or structural concepts to achieve specific design goals.

The selection of a structural system depends on factors such as building function, architectural design, required spans, local building codes, material availability, and cost considerations. Architects and engineers choose the most appropriate system based on these factors to ensure structural integrity, efficiency, and safety while meeting the desired aesthetic and functional goals of the project.

For interior design studies, the two common types of structural systems used in construction are the Load bearing wall structure system (Fig. 4.3), and the Reinforced cement concrete framed structure system (Fig. 4.4).

- **Factors Governing Type of Selection:** The selection of a specific structural system for a building or structure is influenced by several critical factors that architects, engineers, and designers consider to ensure the structure's integrity, functionality, and efficiency.

**Some key factors governing the selection of structural systems include:**

- Building Use and Function:** The intended purpose of the building (e.g., residential, commercial, industrial) significantly influences the structural system. For instance, industrial buildings might require large open spaces, while residential buildings may focus on flexible floor plans.
- Architectural Design and Aesthetics:** Architectural considerations and design preferences play a crucial role. Some systems lend themselves better to specific architectural styles or design concepts, influencing the final appearance of the building.
- Loads and Forces:** The types and magnitude of loads the structure must support, such as dead loads (self-weight), live loads (occupancy), environmental loads (wind, seismic), and lateral forces (earthquake, wind), impact the choice of the structural system.
- Span and Height Requirements:** The required span and height of the structure impact the selection of the system. Certain systems are better suited for long spans or tall buildings while maintaining structural stability.
- Material Availability and Cost:** Material availability, cost, and construction methods significantly influence the choice of structural systems. Some systems might require specialized materials or construction techniques that affect project feasibility and budget.
- Building Codes and Regulations:** Compliance with local building codes and regulations is crucial. The selected system must adhere to safety, seismic, fire, and environmental standards stipulated by authorities.
- Construction Time and Complexity:** Construction time, ease of assembly, and complexity of construction methods are essential factors. Some systems might offer faster construction or easier installation, impacting project timelines and costs.
- Environmental Considerations:** Environmental sustainability and energy efficiency considerations might influence the choice of materials and construction techniques, promoting eco-friendly structural systems.
- Flexibility for Future Modifications:** The adaptability of the structural system to future modifications or renovations is crucial for long-term building use and functionality.

The selection of the most appropriate structural system involves a comprehensive evaluation of these factors, often requiring collaboration among architects, structural engineers, contractors, and other stakeholders to ensure that the chosen system aligns with the project's requirements, goals, and constraints.

### 4.3.1 Load-Bearing Wall System

Load-bearing wall systems are structural systems where walls carry and transfer vertical loads, providing both structural support and enclosure to a building. These walls are essential components in the overall structural integrity of a structure. Various types of load-bearing wall systems include:

Load-bearing walls serve as Facades, Enclosures, Separators, and Fire barriers and carry floor and roof loads to the foundation.

Load-bearing wall systems play a crucial role in distributing vertical loads from floors, roofs, and other structural elements to the foundation. These walls are strategically placed based on engineering and architectural designs to ensure structural stability and overall support for the building. They contribute significantly to the building's strength, stability, and resistance against various forces, making them integral components in the construction of safe and durable structures.



**Fig4.3: Typical Load bearing structure of brick masonry**

### 4.3.2 Reinforced Cement Concrete (RCC) Framed Structure System

Reinforced Concrete Structures are one of the most popular structural elements. It is very much competitive with steel if economically designed and executed practically where labour for cantering and formwork is cheap. The philosophy for Reinforced Concrete Structures tells us that Concrete is strong in compression but very weak in tension. Hence for simplicity of design, its tensile strength is neglected. Wherever tension occurs cracks are likely to occur perpendicular to the tensile force. Hence, steel reinforcement is provided and all tension is considered to be resisted by steel. Due to tension developed by the moment, main reinforcement is placed on the tension face to arrest the cracks and provide tensile strength to the member.



Fig.4.4: Typical RCC Framed Structure

#### Advantages of Reinforced Concrete Structure:

- i. It is good in compression as compared to most other materials used for construction besides being good in tension.
- ii. Its resistance to fire is better than steel so capable of resisting fire for a longer time.
- iii. It has a long service life with low maintenance costs.
- iv. In some structures like piers, dams, and footings; it is the most economical structural material.
- v. It can be cast to any shape required, making it the most economical structural material.
- vi. It yields rigid members with minimum deflection.
- vii. The yield strength of steel is about 15 times the compressive strength of structural concrete and well over 100 times its tensile strength.
- viii. By using steel in concrete the cross-sectional dimension would be reduced.
- ix. Less skilled labours are required for erection as compared to other structural systems.

#### Disadvantages of Reinforced Concrete Structure:

- i. It needs meticulous mixing, casting, and curing, all of which affect the final strength of the member.
- ii. The cost of formwork used to cast concrete is relatively high.
- iii. It has low compressive strength as compared to steel which leads to large sections of columns/beams in multi-storey buildings, Cracks development in concrete due to shrinkage and the application of live loads is high.
- iv. If concreting is not done properly the steel starts corroding thereby losing strength and ultimately the life gets reduced. Also, the repairs are then very expensive and difficult.
- v. The design of a structure may be regarded as the process of selecting proper materials and proportioned elements of the structure. To fulfill its purpose, the structure must meet its conditions of safety, serviceability, economy, and functionality.
- vi. RCC-framed structure systems are widely employed in residential buildings, commercial complexes, bridges, and infrastructure projects due to their reliability, strength, and adaptability to various architectural designs and structural requirements. The use of reinforced concrete enhances the load-carrying capacity and overall stability, making it one of the most preferred structural systems in modern construction practices.

### 4.3.3 Differences between Load bearing and RCC Framed structure are:

RCC Framed Structure	Load Bearing Structure
<ul style="list-style-type: none"> <li>The load transfer path is from slab to beam, beam to column, and column to footing.</li> </ul>	<ul style="list-style-type: none"> <li>The load transfer path is from slabs to walls and walls to footing.</li> </ul>
<ul style="list-style-type: none"> <li>Multi-storey buildings can be constructed.</li> </ul>	<ul style="list-style-type: none"> <li>Limited storeyed buildings only be constructed.</li> </ul>
<ul style="list-style-type: none"> <li>Though resistant to Earthquake, if not properly designed can be more hazardous.</li> </ul>	<ul style="list-style-type: none"> <li>Less resistant to Earthquake.</li> </ul>
<ul style="list-style-type: none"> <li>The carpet area available is more.</li> </ul>	<ul style="list-style-type: none"> <li>The carpet area available is less.</li> </ul>
<ul style="list-style-type: none"> <li>Mostly used as a form of construction.</li> </ul>	<ul style="list-style-type: none"> <li>Rarely used form of construction nowadays.</li> </ul>
<ul style="list-style-type: none"> <li>Excavation for this type of construction is less.</li> </ul>	<ul style="list-style-type: none"> <li>Excavation for this type of construction is more.</li> </ul>
<ul style="list-style-type: none"> <li>It is less labour intensive.</li> </ul>	<ul style="list-style-type: none"> <li>It is more labour intensive.</li> </ul>
<ul style="list-style-type: none"> <li>The speed of construction is higher.</li> </ul>	<ul style="list-style-type: none"> <li>The speed of construction is less.</li> </ul>
<ul style="list-style-type: none"> <li>It is less material intensive.</li> </ul>	<ul style="list-style-type: none"> <li>It is more material intensive.</li> </ul>
<ul style="list-style-type: none"> <li>It consumes less brick.</li> </ul>	<ul style="list-style-type: none"> <li>It consumes more brick.</li> </ul>
<ul style="list-style-type: none"> <li>It consumes more cement &amp; and steel.</li> </ul>	<ul style="list-style-type: none"> <li>It consumes less cement &amp; and steel.</li> </ul>
<ul style="list-style-type: none"> <li>It is a greener way of construction.</li> </ul>	<ul style="list-style-type: none"> <li>It is not a greener way of construction as more bricks are used and making bricks emits more gases and also consumes the fertile top crust of soil.</li> </ul>
<ul style="list-style-type: none"> <li>It is prone to corrosion.</li> </ul>	<ul style="list-style-type: none"> <li>It is not affected by corrosion.</li> </ul>
<ul style="list-style-type: none"> <li>The cost of repairs is more.</li> </ul>	<ul style="list-style-type: none"> <li>The cost of repair is less.</li> </ul>
<ul style="list-style-type: none"> <li>Life is reduced if not done properly.</li> </ul>	<ul style="list-style-type: none"> <li>Life is less affected by the technique of work.</li> </ul>
<ul style="list-style-type: none"> <li>The thickness of the wall can be maintained uniformly throughout.</li> </ul>	<ul style="list-style-type: none"> <li>The thickness of the wall cannot be maintained uniformly throughout.</li> </ul>
<ul style="list-style-type: none"> <li>There is great flexibility in architectural design as there is no need to construct walls over walls. Hence room layouts on different floors can be different.</li> </ul>	<ul style="list-style-type: none"> <li>There is no flexibility in architectural design as walls need to be constructed over walls.</li> <li>And hence rooms on different floors cannot be changed.</li> </ul>
<ul style="list-style-type: none"> <li>There is flexibility in changing room dimensions.</li> </ul>	<ul style="list-style-type: none"> <li>It is not possible to change room dimensions.</li> </ul>

The selection and integration of structural components in building design are critical for creating a safe, durable, and functional structure. Architects and interior designers must carefully consider factors such as load distribution, building materials, and environmental conditions to ensure the long-term stability and integrity of the building.

## 4.4 NON-STRUCTURAL COMPONENTS

While structural components provide the foundation and support for a building, non-structural elements contribute significantly to its functionality, aesthetics, and overall user experience. In this chapter, we will delve into the

diverse world of non-structural components, exploring their roles, materials, and design considerations in the construction and interior design of the spaces.

#### **4.4.1 Basic Non-Structural Elements**

Non-structural building components are elements within a building that are not primarily responsible for supporting the structure but serve various functional, aesthetic, or service-related purposes. These components contribute to the usability, comfort, and overall functionality of a building. Some examples of non-structural building components include:

1. **Interior Partitions:** Walls or dividers within the building are used to separate spaces or rooms but do not bear any load from the structure.
2. **Ceilings and Floor Finishes:** Ceilings provide a finished surface beneath the roof structure, while floor finishes (like tiles, carpets, or wood) cover the structural floor system.
3. **Interior Doors and Windows:** These elements provide access and ventilation within the building but do not contribute to the building's structural integrity.
4. **Cladding and Exterior Finishes:** External finishes like siding, stucco, or brick provide weather protection and aesthetic appeal but don't bear structural loads.
5. **Architectural Features:** Decorative elements, such as cornices, moldings, or ornamentation, enhance the building's aesthetics without affecting its structural stability.
6. **Plumbing and Electrical Systems:** Pipes, conduits, and wiring run throughout the building to provide water supply, drainage, and electricity but are not part of the load-bearing structure.
7. **Interior Fitments and Fixtures:** Furniture, cabinetry, shelving, and fixtures (e.g., sinks, and countertops) are non-structural components that enhance functionality and usability within the building.
8. **Mechanical and HVAC Systems:** Heating, ventilation, and air conditioning systems are essential for comfort but do not support the building structure.

While these components do not contribute to the building's structural stability, they are crucial for the building's functionality, aesthetics, and usability. Architects and designers integrate these non-structural elements into the building's design to fulfill various functional, aesthetic, and service requirements, ensuring a comfortable and visually appealing space for occupants.

#### **4.4.2 Doors and Windows**

Doors and windows are crucial elements in building design, serving as points of entry, exit, and natural light penetration. Doors come in various styles and materials, including solid wood, glass, metal, and composite materials. Similarly, windows vary in design, such as casement, sliding, and fixed, and can be constructed using materials like aluminum, wood, or PVC. The choice of doors and windows depends on factors like aluminum, wood, or PVC. The choice of doors and windows depends on factors like aesthetics, energy efficiency, and security requirements.

### 4.4.3 Chajja (Overhanging Roof)

Chajja, or overhanging roof projections, is a traditional architectural element found in many buildings. It serves both functional and aesthetic purposes, providing shade, protecting walls from rain, and adding visual interest to the façade. Chajjas can be constructed using materials like reinforced concrete, metal, or wood, and their design is influenced by factors such as climate, architectural style, and orientation of the building.

### 4.4.4 Parapet Wall

Parapet walls are low protective walls at the edge of a roof, terrace, or balcony. They serve as safety barriers, preventing people from accidentally falling off elevated surfaces. Parapets also contribute to the architectural aesthetics of a building and can be adorned with decorative elements. Materials commonly used for parapet walls are bricks, stone, and reinforced cement concrete.

### 4.4.5 Railing

Railings are protective barriers installed along staircases, balconies, and elevated platforms to prevent falls. In addition to their safety function, railings contribute to the overall design aesthetic. They can be crafted from materials such as wrought iron, stainless steel, glass, or wood, and their design may vary from simple and utilitarian to intricate and decorative.

### 4.4.6 Partition and Panelling

Partitions and paneling are used to divide interior spaces into functional areas. Partitions can be permanent or movable, made of materials such as drywall, glass, or wood. Paneling, on the other hand, refers to decorative coverings applied to walls, often enhancing aesthetics or providing acoustic insulation. Both elements play a crucial role in shaping the interior layout and ambiance of a building.

### 4.4.7 Cladding

Cladding involves covering the exterior surface of a building with materials that provide protection, insulation, and aesthetics. Common cladding materials include stone, metal, glass, and composite materials. Cladding not only shields the building from the elements but also contributes to its visual appeal, allowing for a wide range of architectural expressions.

- **Dado:** Dado refers to the lower portion of an interior wall, Kitchen walls, and bathroom area, typically covered with a different material than the rest of the wall. This can be for decorative purposes, protection against wear and tear, wet areas or to accommodate functional elements like electrical conduits. Materials used for dado can include tiles, wood, stone, metal, or other finishes, adding texture and visual interest to interior spaces.

Non-structural components play a crucial role in shaping the form, function, and aesthetic appeal of buildings. Architects and interior designers must carefully consider the selection of materials, design elements, and functional requirements to create a harmonious and well-balanced living or working environment. As technology and design

trends evolve, the palette of options for non-structural components continues to expand, allowing for innovative and sustainable solutions in both building construction and interior design.

### **End of Chapter Exercise**

1. Prepare a report on the structural analysis of any one building in a nearby local area with a well-documented case study.
2. Suggest any four non-structural components used in interior designing that contribute to the interior aesthetics and functionality of the space.
3. Design a small Pavilion or Gazebo for an outdoor recreational area with appropriate structural materials considering budget, climate, strength, durability, and sustainability.

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