Types of Structures and Structural Systems

In structural engineering, structures are categorized based on their function, form, material, and the type of load they are designed to support. The design of a structure is influenced by its use (e.g., residential, commercial, industrial), the materials available, and the environmental conditions it must withstand. Below are the main **types of structures** and **structural systems** used in engineering:

---

1. Types of Structures

A. Buildings

- **Residential Buildings**: Structures designed for housing, including single-family homes, apartments, and townhouses.
- **Commercial Buildings**: Structures used for businesses, such as offices, shopping malls, hotels, and restaurants.
- **Industrial Buildings**: Structures designed for manufacturing or storage, like factories, warehouses, and distribution centers.
- **Skyscrapers**: Tall buildings designed for office, commercial, or residential use, which require careful planning of structural systems to withstand wind, seismic forces, and gravity loads.
- **Specialty Buildings**: These may include hospitals, schools, sports arenas, and museums, which may require unique structural solutions based on their specific functions and occupancy requirements.

B. Bridges

- **Beam Bridges**: Simple structures where horizontal beams rest on supports at either end, commonly used for shorter spans.
- **Arch Bridges**: Use a curved shape to distribute loads efficiently, typically used for medium to long spans.
- **Suspension Bridges**: Rely on cables to carry loads, suitable for long spans (e.g., over rivers or deep valleys).
- **Cable-Stayed Bridges**: A combination of beam and suspension bridge types, where cables run directly from towers to the deck, ideal for medium to long spans.
- **Truss Bridges**: Made of triangular units, providing strength and rigidity, commonly used in railways and highways.

C. Dams and Retaining Walls

- **Gravity Dams**: Rely on their own weight to resist water pressure.
- **Arch Dams**: Transfer the water load to the canyon walls through a curved design.
- **Buttress Dams**: Use a series of supports or buttresses to resist the pressure of water.
- **Retaining Walls**: Structures designed to resist the lateral pressure of soil, preventing landslides or soil erosion.

D. Towers and High-Rise Structures

- **Telecommunication Towers**: Tall, slender structures designed to support antennas or communications equipment.
- **Transmission Towers**: Support high-voltage power lines across vast distances.
- **Wind Turbine Towers**: Tall structures designed to support the blades of wind turbines for generating electricity.

E. Industrial Structures

- **Silos**: Tall, cylindrical structures used for storing grain, cement, or other bulk materials.
- **Factories**: Buildings designed for industrial processes, often incorporating large spans and heavy loads.
- **Cooling Towers**: Large, vertical structures used for dissipating heat from industrial processes or power plants.

---

2. Structural Systems

Structural systems refer to the arrangement of various structural elements and how they work together to support loads and resist forces. Here are the most common structural systems:

A. Load-Bearing Wall Systems

- **Definition**: In this system, walls bear the load of the building, transferring it to the foundation.
- **Materials**: Often made of concrete, brick, stone, or timber.
- **Application**: Common in low-rise residential buildings and some commercial structures.

- **Advantages**: Simple, cost-effective for smaller buildings.
- **Disadvantages**: Limited flexibility for large open spaces due to the need for continuous walls.

B. Frame Systems

- **Definition**: A frame consists of a skeleton of vertical and horizontal members (beams and columns) that support the load of the structure.
- **Materials**: Typically made of steel, reinforced concrete, or timber.
- **Application**: Common in mid-rise to high-rise buildings and large-span structures.
- **Advantages**: Provides open spaces with fewer load-bearing walls, allowing for flexible floor plans.
- **Disadvantages**: More complex and expensive than load-bearing wall systems.

C. Truss Systems

- **Definition**: A truss is a triangular framework used to support loads. The individual members of the truss carry compressive or tensile forces.
- **Materials**: Often made of steel or timber.
- **Application**: Used in bridges, roofs, and other long-span structures.
- **Advantages**: Efficient for spanning large distances with less material.
- **Disadvantages**: Requires precise fabrication and assembly, and often needs to be supported at multiple points.

D. Shell and Folded Plate Systems

- **Definition**: These systems rely on thin, curved surfaces (shells) or folded plates to transfer loads efficiently.
- **Materials**: Concrete, steel, or composite materials.
- **Application**: Used for long-span roofs, domes, or complex architectural forms like auditoriums or sports arenas.
- **Advantages**: High strength-to-weight ratio and aesthetic versatility.
- **Disadvantages**: Complex to design and construct, requiring expertise in material behavior.

E. Cable and Membrane Systems

- **Definition**: These systems use cables or membranes (flexible surfaces) to carry loads in tension.
- **Materials**: Steel cables, fabric, or tensioned membranes.
- **Application**: Used in structures like suspension bridges, tents, and roofs of sports stadiums.
- **Advantages**: Lightweight, flexible, and aesthetically striking.
- **Disadvantages**: Requires high tension forces, and stability depends on proper design and tensioning.

F. Composite Systems

- **Definition**: Composite systems combine different materials to take advantage of their strengths. For example, reinforced concrete combines the compressive strength of concrete with the tensile strength of steel.
- **Materials**: Concrete-steel, timber-steel, etc.
- **Application**: Common in buildings, bridges, and infrastructure projects.
- **Advantages**: Optimized material performance, combining the best properties of each material.
- **Disadvantages**: Can be more expensive and require careful coordination between different material types.

G. Space Frame Systems

- **Definition**: A three-dimensional truss system that forms a rigid frame, capable of supporting loads in multiple directions.
- **Materials**: Steel, aluminum, or composite materials.
- **Application**: Large-scale structures like sports arenas, exhibition halls, and airport terminals.
- **Advantages**: Efficient in covering large areas without the need for interior supports.
- **Disadvantages**: Complex to design and construct.

Summary:

- **Types of Structures** vary by their purpose (residential, industrial, bridges, etc.) and can range from simple buildings to complex infrastructure like dams and transmission towers.

- **Structural Systems** are the design and arrangement of elements like walls, beams, columns, and trusses. These systems define how forces are distributed throughout a structure, whether through simple load-bearing walls or sophisticated frame systems.

Both the **type of structure** and the **structural system** are critical for ensuring the safety, functionality, and durability of a building or infrastructure project. Proper selection and design of these elements depend on the intended use, environmental conditions, and available resources.