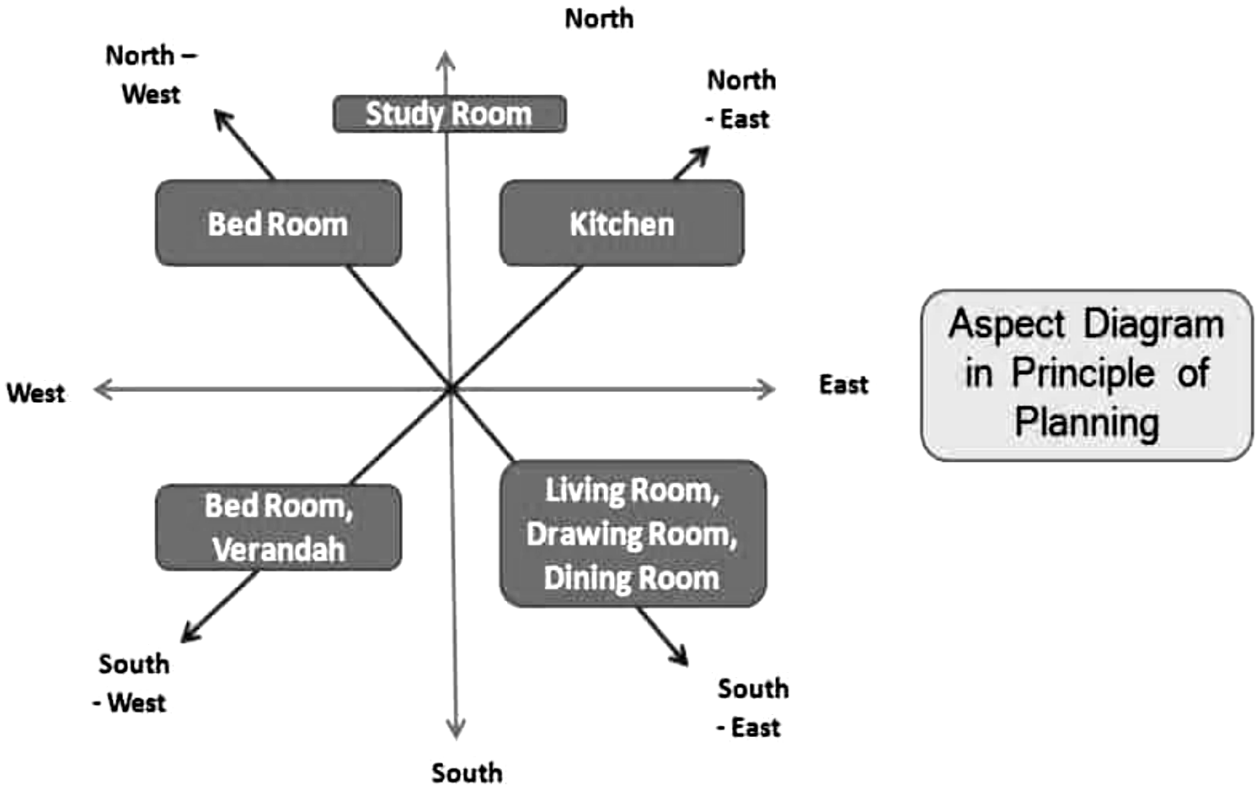
Unit 4
Historical Architecture and Modern Structural Design & Construction

HISTORICAL ARCHITECTURE AND MODERN STRUCTURAL DESIGN

INTRODUCTION TO ARCHITECTURAL EVOLUTION

Architecture is more than a building; it is a mirror of human progress. From primitive shelters to futuristic skyscrapers, the transformation of built environments showcases evolving societal, cultural, religious, economic, and technological priorities.



- **Historical architecture** served cultural, religious, royal, or communal functions.
- **Modern architecture** emphasizes functionality, sustainability, and technology integration.

Architecture's story begins with stone tools and culminates in smart cities, green buildings, and AI-assisted structural designs.

INDIAN HISTORICAL ARCHITECTURE

India's architecture evolved across *Indus, Buddhist, Hindu, Islamic, and Colonial* eras.

Indus Valley Civilization (Harappan Era)

- *Period:* 2600–1900 BCE
- *Urban Planning:* Grid system; roads at right angles.
- *Structures:* Granaries, Assembly Halls, Great Bath.
- *Sanitation:* Covered drains with inspection holes.
- *Materials:* Baked bricks, mud mortar, bitumen.

Innovations:

- Early use of standardized bricks.
- Hydraulic engineering (e.g., Great Bath, wells).

Buddhist Architecture

- *Period:* 3rd Century BCE – 5th Century CE
- *Main Forms:*
    - Stupa: Sacred mound for relics. E.g., Sanchi, Amaravati.
    - Chaitya: Rock-cut prayer hall with vaulted ceilings.
    - Vihara: Monastery with cells around courtyard.

Symbolism: Dome = cosmic world, railing = sacred boundary, umbrella = high status.

Hindu Temple Architecture

1. *Nagara Style (North India)*
    - Curved Shikhara (tower above sanctum)
    - Amalaka (circular capstone)
    - Examples: Sun Temple (Modhera), Kandariya Mahadeva (Khajuraho)
2. *Dravidian Style (South India)*
    - Gopuram: Pyramidical entrance tower
    - Vimana: Tower over sanctum
    - Mandapa: Pillared halls
    - Examples: Brihadeshwara (Thanjavur), Meenakshi Temple (Madurai)
3. *Vesara Style (Hybrid)*
    - Fusion of Nagara + Dravidian
    - Examples: Chennakeshava Temple (Belur), Hoysaleswara Temple (Halebidu)

Indo-Islamic Architecture

Period: 12th–18th century

Key Characteristics:

- Arches (true and corbelled), Domes, Minarets
- Jali Work: Intricate stone screens
- Geometrical ornamentation, absence of idol worship
- Symmetrical Gardens: Charbagh layout

Examples:

- Qutub Minar (Delhi) – earliest Indo-Islamic monument
- Taj Mahal (Agra) – pinnacle of Mughal architecture
- Fatehpur Sikri – Red sandstone city

GLOBAL HISTORICAL ARCHITECTURE

Egyptian Architecture (c. 3000 BCE)

- *Purpose:* Religious & royal tombs.
- *Structures:* Pyramids (Giza), Sphinx, Temples (Luxor, Karnak)

- *Techniques:* Post-and-lintel, massive blocks, astronomical alignment

Greek Architecture (1100 BCE – 200 BCE)

- *Philosophy:* Harmony, order, and symmetry.
- *Orders:*
    - Doric: Simple, sturdy
    - Ionic: Scroll-like capital
    - Corinthian: Floral ornamented capital
- *Structures:* Parthenon (Athens), Theatres

Roman Architecture (753 BCE – 476 CE)

- *Inventions:*
    - Concrete, Arches, Domes, Aqueducts
- *Structures:* Pantheon, Colosseum, Roman Baths
- *Road Network:* Connected vast empire; model for modern highways

Gothic Architecture (12th–16th Century Europe)

- *Features:*
    - Flying Buttresses, Pointed Arches, Ribbed Vaults
    - Stained Glass Windows
- *Structures:* Notre-Dame (Paris), Chartres Cathedral

Renaissance Architecture (14th–17th Century)

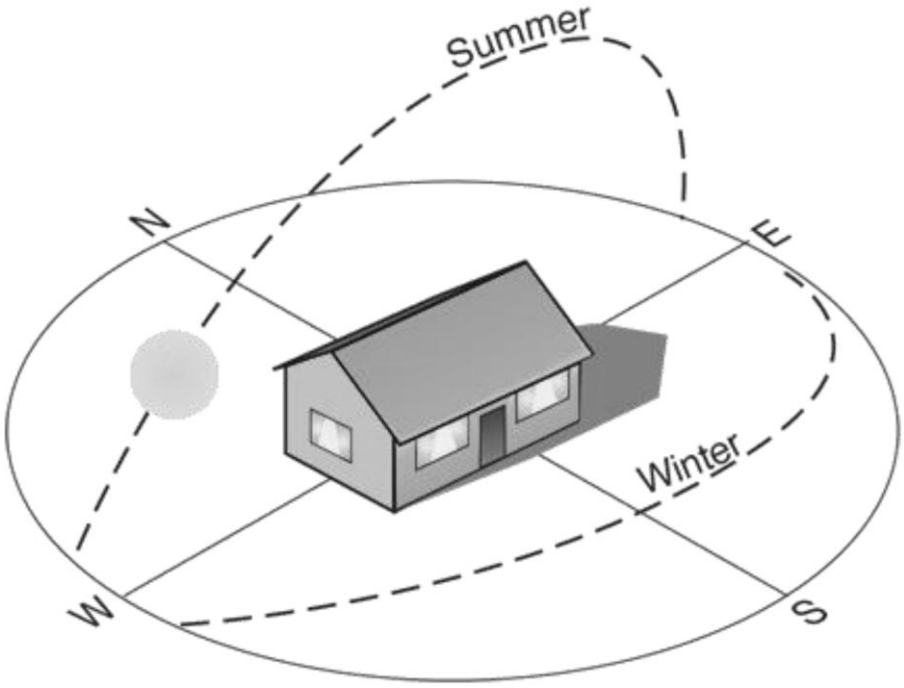
- *Revival:* Classical Roman-Greek design
- *Key Features:*
    - Symmetry, Proportion, Columns, Domes
- *Famous Works:* Florence Cathedral (Brunelleschi), St. Peter's Basilica (Michelangelo)

TRANSITION TO MODERN ARCHITECTURE

Key Catalysts

- *Industrial Revolution:* Iron and steel mass production
- *Scientific Design:* Engineering calculations for strength, stress
- *Material Science:* Invention of reinforced concrete (RCC)

From Art to Engineering

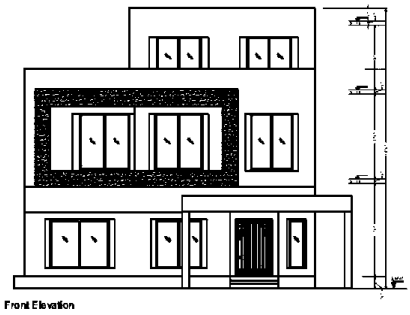


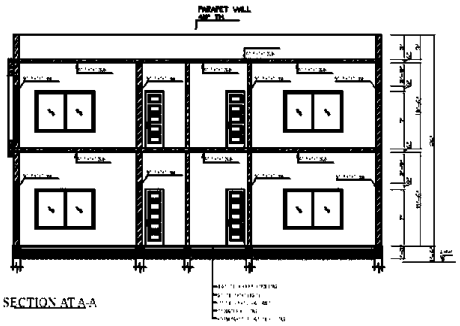
Historical Focus	Modern Design Priority
Decoration & Symbolism	Functionality and Minimalism
Thick stone walls	Lightweight steel/RCC frames
Local materials	Global sourcing (glass, steel)
Manual craftsmanship	Machine fabrication, prefabs

MODERN STRUCTURAL SYSTEMS

Load-Bearing Structures

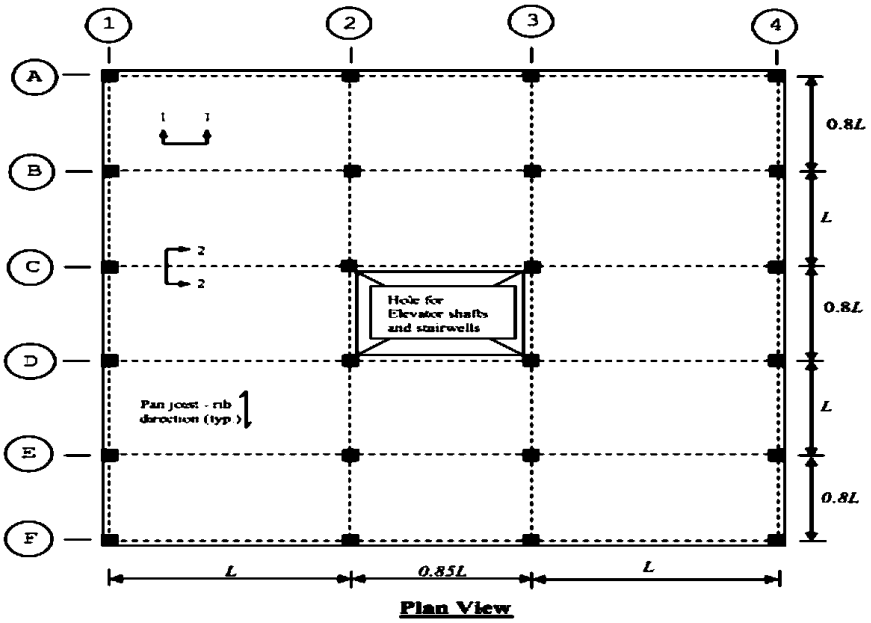
- Walls are structural and carry entire load.
- Used in traditional buildings up to 3 stories.
- *Limitations:* Restricted openings and height.



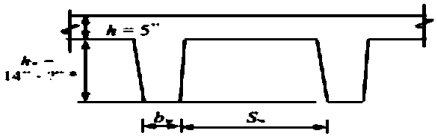


Frame Structures (RCC/Steel)

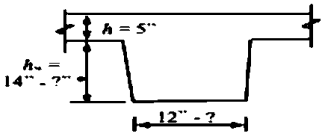
- Beams & columns form skeleton.
- Load transferred to foundation via joints.
- Allows large spans, curtain walls.
- *Example:* All modern skyscrapers, malls, schools



Plan View



Section 1-1
(Joists)



Section 2-2
(Beams)

L (ft)	35
f'_c (ksi)	4
f_y (ksi)	60
b_w (in.)	8
S_w (in.)	53

*Use standard pan joist void depth for 53" modules (14", 16", 20" or 24")

Shell Structures

- Curved surfaces: Domes, Hyperbolic paraboloids
- Lightweight, resist loads through form
- *Used in:* Stadiums, Auditoriums

Space Frame Structures

- 3D truss grid; strong yet light
- Economical for large areas (airport roofs)
- *Material:* Steel or aluminium

MATERIALS: EVOLUTION AND COMPARISON

Material	Traditional Use	Modern Use
Stone	Forts, Temples	Façade cladding, Landscaping
Brick	Houses, Temples	Fly ash bricks in high-performance walls
Timber	Roofs, Doors	Engineered wood, laminate structures
Concrete	Rare (Romans only)	RCC, precast, post-tensioned members
Steel	Not used historically	Beams, trusses, towers
Glass	Stained glass	Facades, solar control, skylights

FAMOUS MODERN STRUCTURES

Name	Design Feature	Country
Burj Khalifa	Tallest building (828 m), RCC+Steel frame	UAE
Millau Viaduct	World's tallest bridge, cable-stayed	France
Sydney Opera House	Shell structure with ribbed domes	Australia
The Shard	Glass skyscraper	UK
Lotus Temple	Petal-like concrete shells	India

ARCHITECTURAL CONSERVATION AND HERITAGE PROTECTION

Need

- Preserve cultural identity, historical knowledge
- Combat damage from pollution, urbanization, neglect

Techniques

1. *Preservation:* Preventing further deterioration
2. *Restoration:* Returning to original form
3. *Reconstruction:* Rebuilding missing parts
4. *Adaptive Reuse:* Changing function (e.g., palace to hotel)

Legal Framework

- ASI Act, 1958
- Environment Protection Act, 1986
- Heritage Bye-laws under 74th Amendment

Indian Agencies

- *ASI:* Maintains 3,600+ protected monuments
- *INTACH:* Community participation in conservation
- *UNESCO:* India has 42 World Heritage Sites

CONSTRUCTION

INTRODUCTION TO CONSTRUCTION MATERIALS

Construction materials are substances used to build structures like buildings, roads, bridges, and dams. These materials can be natural (stone, wood) or artificial (concrete, steel, bricks).

Classification of Materials

Type	Examples	Description
Natural	Stone, wood, sand, clay	Directly from nature
Artificial	Cement, concrete, bricks, steel	Processed or manufactured
Composite	RCC, plywood	Combination of materials for enhanced performance

BUILDING CONSTRUCTION MATERIALS (WITH PROPERTIES)

1. Bricks

- Made from clay; burnt in kilns
- *Types:* First-class, second-class, third-class, wire-cut
- *Properties:*
  - Uniform size and shape
  - Good compressive strength (3.5–10 N/mm²)
  - Thermal insulation
  - Fire resistance
- *Uses:* Walls, columns, arches, paving

2. Stone

- Natural, durable, and strong
- *Types:*
  - Granite: Very strong, used in foundations
  - Sandstone: Easy to carve, used in decorative work
  - Marble: Polished finish, used in interiors
- *Properties:*
  - High compressive strength (100–250 N/mm²)
  - Weather-resistant
- *Uses:* Foundations, walls, facades, floors

3. Timber (Wood)

- Natural material from trees (hardwood and softwood)
- *Properties:*
  - Lightweight, easy to work
  - Good insulator
  - Susceptible to termites and decay
- *Uses:* Doors, windows, furniture, roofs
- *Seasoning:* Removes moisture to prevent shrinkage and cracking

4. Cement

- Binding material made by calcining limestone and clay
- *Types:*
  - OPC (Ordinary Portland Cement)
  - PPC (Portland Pozzolana Cement)
  - Rapid Hardening Cement

- *Properties:*
  - Sets in 30 min, hardens over time
  - Reacts with water (hydration)
- *Uses:* Concrete, mortar, plaster

5. Concrete

- Composite material: Cement + sand + aggregates + water
- *Types:*
  - Plain Cement Concrete (PCC)
  - Reinforced Cement Concrete (RCC)
  - Precast Concrete
- *Properties:*
  - Compressive strength: 15–40 N/mm²
  - Durable, mouldable, fire-resistant
- *Uses:* Slabs, beams, foundations, columns

6. Steel

- Alloy of iron with carbon and other elements
- *Types:*
  - Mild steel (Fe 250/Fe 415)
  - TMT bars
- *Properties:*
  - High tensile strength
  - Ductile and elastic
  - Corrosion-prone (needs coating)
- *Uses:* RCC reinforcement, industrial buildings, trusses

7. Glass

- Transparent material made from silica
- *Types:*
  - Float glass, laminated glass, toughened glass
- *Uses:* Windows, partitions, facades
- *Properties:*
  - Brittle
  - Allows daylight
  - Heat and sound insulation (in treated forms)

8. Aluminium

- Lightweight, corrosion-resistant
- *Uses:* Window frames, panels, facades
- *Properties:*
  - Malleable
  - Weather-resistant

9. Plastic and PVC

- Synthetic polymers
- *Uses:* Pipes, window frames, water tanks
- *Properties:*
  - Lightweight
  - Waterproof
  - Non-biodegradable (environmental concern)

CONSTRUCTION TECHNIQUES

1. Load-Bearing Construction

- Traditional method
- Walls bear the load from roof and floors
- *Materials:* Bricks, stone masonry
- *Advantages:* Simple, less costly
- *Limitations:* Not suitable for high-rise buildings

2. Framed Construction

- Load is transferred via beams and columns
- *Materials:* RCC, steel
- *Benefits:*
    - More flexibility in design
    - Larger spans possible
    - Used in multistorey buildings

3. Precast Construction

- Structural components are cast and cured in a factory
- Assembled on-site
- *Examples:* Precast beams, slabs, staircase units
- *Advantages:*
    - Faster construction
    - Better quality control
    - Less labour-intensive

4. Modular Construction

- Uses pre-fabricated units/modules
- Quicker assembly
- Repetitive and standardized design
- Popular in:
    - Hostels, hospitals, site offices

5. Traditional Construction Methods

- Vernacular architecture using local materials:
    - Cob walls, mud plaster, lime mortar
    - Bamboo for roofing
    - Thatch for insulation
- Eco-friendly and climate-responsive

TOOLS AND EQUIPMENT USED IN CONSTRUCTION

Tool	Purpose
Trowel	For applying and spreading mortar
Plumb Bob	Checking vertical alignment
Spirit Level	Ensuring horizontal levels
Hammer	Driving nails
Concrete Mixer	Mixing concrete ingredients
Vibrator	Removing air pockets from concrete
Scaffolding	Temporary structure for working at heights
Hoists & Cranes	Lifting heavy materials

SUSTAINABLE CONSTRUCTION & GREEN MATERIALS

Eco-Friendly Practices

- Use of renewable and recycled materials
- Energy-efficient building designs
- Water harvesting and greywater reuse
- Solar panels and wind energy

Green Building Materials

Material	Eco Benefit
Fly Ash Bricks	Utilizes industrial waste
Bamboo	Renewable and strong
Recycled Steel	Reduces mining
Earth Blocks	Low embodied energy
Lime Mortar	Breathable and low carbon footprint

Green Certifications

- GRIHA (Green Rating for Integrated Habitat Assessment – India)
- LEED (Leadership in Energy & Environmental Design – Global)