ADVANCED CONSTRUCTION TECHNIQUES

&

EQUIPMENT

TH-3

6TH SEM

CIVIL ENGG.

Under SCTE & VT, ODISHA

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Advanced Construction Techniques & Equipment (TH-3)

UNIT-1

Definition :- Advanced Construction techniques are modern methods of construction that use new technology, improved materials & advanced equipment to complete project faster, safer, and with better quality than conventional methods.

Need for Advanced Construction :-

Traditional construction method's are !

- → Time-consuming
- → Labour-intensive
- → Less accurate

modern Projects require :

- → faster completion
- → High strength & durability
- → Better Safety
- → cost efficiency

objectives

- → To reduce construction time
- → minimize labour requirement
- → Improve quality control
- → Reduce wastage material
- → Ensure Safety & Sustainability
- → Handle large & complex Project

Advanced Construction Materials :-

Advanced construction materials are modern, engineered materials developed to improve :-

- strength & durability
- workability
- Sustainability
- Resistance to fire, chemicals, & corrosion

Need :-

→ Longer service life of structures
→ Faster construction
→ Reduction in dead load
→ Improved performance under earthquakes
→ Environmental Sustainability

Fiber as construction Material

Fiber is a thin, long material added to concrete, mortar or other construction materials to increase strength, durability & crack resistance.

Types of fiber's :-

1. Steel fiber :-

→ Small steel pieces (straight, hooked or crimped)
→ Steel fiber consist of short, discrete pieces of steel added to concrete to improve it's mechanical properties.

* Concrete mixed with steel fiber is called steel fiber Reinforced concrete (SFRC).

Properties :-

→ High tensile strength (≈ 1000 - 2000 MPa)
→ Length : 25-60 mm (generally)
→ Diameter : 0·3 - 1·0 mm
→ Good bond with concrete (especially hooked or deformed fiber's)
→ Improve ductility & toughness.

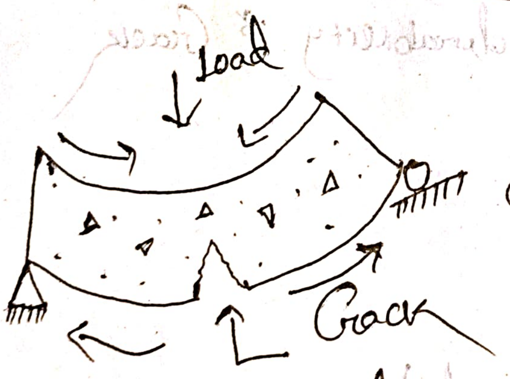
Functions :-

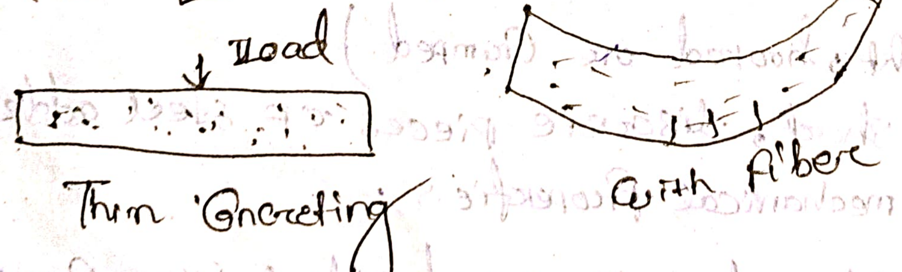
→ Control cracks due to shrinkage & temperature.
→ Improve impact resistance
→ Increase tensile & flexural strength.

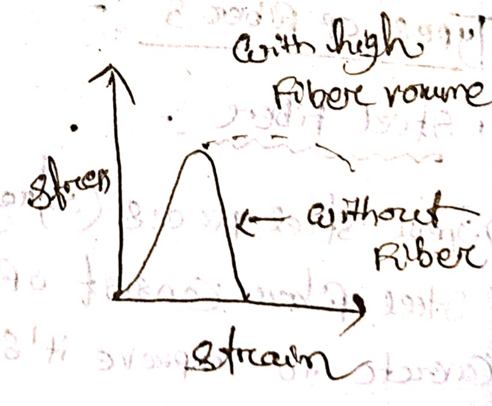
Application :-

→ Industrial floor's & pavements
→ Airport runways
→ Precast elements
→ Tunnel lining, bridge decks, Earthquake-resistance struct

* Fiber Reinforced Concrete :-







Types

* Glass fiber
* Nylon fiber
* Natural fiber (Cotton, Jute, coir, Bamboo, Sisal)
* Carbon fiber

① Natural ② Synthetic (Man-made)

→ Disadvantages of Fiber Reinforced concrete :-

→ Greater Reduction of workability.
→ High cost of material.

Synthetic (Manmade) fiber :-

→ Manufactured artificially. These are commonly used in modern construction.

(a) Metal fibers

→ Steel fiber's (Fiber reinforced concrete, pavement, industrial floo

(b) Mineral fibers

→ Glass fibers
→ Carbon fibers
{ High strength concrete, repair works, FRP products }

(c) polymer / plastic fibers

→ Poly propylene fibers
→ Nylon fibers
→ polyester fiber's
{ Crack Control, shrinkage reduction, Plaster & Concrete.

Glass Fiber's

→ Glass fiber's are fine filaments made from molten glass. when used alone or combined with resins or cements, they form strong composite materials such as fiberglass (GFRP) & glass fiber reinforced concrete (GFRC)

→ E-glass, S-glass, C-glass & A-glass..

Manufacturing Process

→ Raw materials (silica, limestone etc) are melted in a furnace.

→ Molten glass is drawn into thin filaments.

→ Fiber's are cooled, coated & collected as strands or mats.

Properties

→ High tensile strength
→ Light weight
→ Corrosion resistant
→ Non-combustible
→ Good thermal
→ Brittle in nature

Uses

→ Glass Fiber Reinforced Concrete
→ Roofing sheets & wall panel
→ Pipe & storage tanks
→ Door's, window frame
→ Bridge decks

Advantages

→ Easy to mould into shapes.
→ Low maintenance

Disadvantages

→ Brittle failure
→ Health issue if fibers are inhaled.

*

Carbon fiber

→ Carbon fiber is a high strength, lightweight fiber made mainly from Carbon atoms.

→ It is used in the form of Carbon Fiber Reinforced Polymer (CFRP) for strengthening & retrofitting structures.

Raw materials :-

→ polyacrylonitrile (PAN) - most common
→ Pitch (Petroleum based)
→ Rayon (less common)

Manufacturing process :

→ Spinning
→ Stabilization
→ Carbonization
→ Surface treatment & Sizing

Properties :-

- Very high tensile strength
- Very light weight
- Corrosion resistant
- Electrically conductive

Uses :-

- Coloumn wrapping
- Bridge strengthening
- Repaire of damaged structures
- Rcc beam & slabs

Advantages

- Easy & fast installation
- Long service life
- No corrosion

Disadvantages

- Very high cost
- Requires skilled labour

Comparison :-

Property	Glass Fiber	Steel Fiber	Carbon Fiber
Weight	Light	Heavy	Very light
Cost	Low	Medium	High
Corrosion	Resistant	Can corrode	Resistant
Strength	Medium	High	Very High

Pre-fabricated Construction

- Components are cast in a factory & then transported to site.
- many concrete (RCC / PSC)
- Beams, columns, slabs, staircase
- Less labour & limited flexibility

Pre cast Concrete Construction

- Building components are manufactured in factory & assembled at site.
- concrete, steel, timber, Al, composi[te] etc.
- Floor units, wall panels etc.
- Minimum labour & more flexible.

Types of plastics

Plastics are Synthetic polymer materials that can be moulded into different shapes. In construction, plastics are widely used due to their light weight, Corrosion resistance, durability & low maintenance.

PVC (poly vinyl Chloride) :-

It is a Synthetic thermoplastic polymer made from vinyl Chloride monomer.

→ It's widely used in construction due to it's lightweight, Corrosion resistance, durability & low cost.

1. Flexible PVC

→ Contains plasticizers
→ Soft & flexible
→ used in Cables, houses

2. Rigid PVC

→ No plasticizer's
→ Hard & strong
→ Pipes, doors & windows

Properties :-

→ Light in weight
→ Corrosion & chemical resistant
→ Good electrical insulation
→ Durable & long life

Uses :-

→ water Supply pipes
→ Drainage pipes
→ Door / window frames
→ Roofing sheets
→ Cable insulation

RPVC :- (Rigid polyvinyl chloride)

→ It is also called uPVC (unplasticized PVC), is a type of PVC without plasticizer's. Hence, it is hard, rigid & strong making it suitable for structural & plumbing application in construction.

→ Unplasticizer - without any plasticizer's added

→ plumbing - the system & work of installing pipes, fitting to supply water.

Properties

→ Hard & rigid material
→ High strength & stiffness
→ Corrosion
→ Low maintenance
→ Long service life

Uses

→ Water supply pipes
→ Electrical conduits & covering

High Density Polyethylene (HDPE)

It is a thermoplastic polymer made from petroleum. It is widely used in civil engineering because of its high strength, flexibility & leak-proof joints.

Properties

→ High strength-to-density ratio
→ Light weight
→ Flexible & tough
→ Long service life

Uses

→ Water supply pipelines
→ Gas pipelines
→ Storage tanks
→ Geomembranes (Canals).

Advantages

→ Easy to transport
→ No corrosion
→ Low maintenance

Disadvantages

→ Low resistance to high temp.
→ Poor fire resistance

Fiber Reinforced Plastic (FRP) :-

→ It is a composite material made by reinforcing a plastic (polymer resin) with fibers such as glass, carbon or aramid.

→ It is widely used in construction due to its high strength, light weight & corrosion resistance.

Properties

→ High strength-to-weight ratio
→ Light weight
→ Corrosion resistant
→ Waterproof

Uses

→ Water tanks & pipes
→ Roofing sheets & wall panels
→ Bridge Decks & Footpaths
→ Doors, windows, partitions

Glass Reinforced plastic (GRP) :-

→ It's a composite construction material made by reinforcing glass fibers in a plastic resin matrix (Polyester, vinyl etc)

→ It's a type of FRP where reinforcing fiber is glass only.

Properties

→ Light in weight
→ High tensile strength
→ Durable with long life.

Uses

→ Roofing sheet & skylight
→ Wall cladding
→ Drainage & Sewer pipes

Advantage

→ Good Surface finish
→ Low maintenance cost
→ Easy handling

Disadvantages

→ Recycling is difficult
→ Lower fire resistance

Colored plastic sheets :-

These are factory-made plastic sheets produced in different colours, thickness & profiles.

→ They are used in building for roofing, cladding ~~&~~ greenhouse.

Common types

→ PVC sheets
→ Acrylic sheets
→ FRP / GRP

Properties

→ Light weight
→ Available in attractive colours
→ Water Proof
→ Easy to cut, drill & fix.

Use of plastic as Construction materials :- Plastic are Synthetic polymer materials used in construction due to their light weight, durability & flexibility.

→ Use :- Water supply & drainage pipe, Door, Roofing sheets etc.

Artificial Timber's :-

Artificial timber is a man-made substitute for natural wood, manufactured from synthetic or processed materials to mimic the appearance & properties of wood.

→ used where natural timber is scarce, expensive or not durable.

Properties of Artificial Timber :-

→ High compressive & bending strength.
→ Resistant to termites, fungi & insects.
→ Less prone to warping, twisting or cracking.
→ Easier to handle than solid timber.

Uses :-

→ Furniture (tables, chairs, wardrobes)
→ Door & window frames
→ Flooring & ceiling panels, Door & window frames

Ex:- Plywood, Fiber board

Types

1. Plywood :- Made of thin layer's (Veneers) glued together with grains at right angles.
2. Block Board :- Core of softwood strips glued together, faced with Veneers.
3. Fiber Board / Hardboard / Medium Density :- Made from wood fiber & synthetic resin.
4. Veneer Boards :- Thin layers of wood glued on low-cost core material
5. plastic Laminates / Synthetic Timber :- Made from resin + fiber or wood powder.

Strength of Artificial Timber :-

→ Plywood ; Bending strength 30-40 N/mm²

→ Blockboard : Bending strength 25-35 N/mm²

→ MDF / Hard Board : Compressive strength 20-30 N/mm²

→ plastic laminates : depends on resin content, usually 25-30 N/mm²

Miscellaneous Materials

Miscellaneous materials are special construction materials that are conventional (like cement, steel or concrete) but are used to enhance properties, aesthetics or performance in construction.

→ Examples : Acoustic materials, wall cladding, plastic boards, micro-silica, artificial sand, bonding agents, adhesives etc.

Types, properties & uses :-

Acoustic material :- These are materials used to control, absorb or reduce sound in a space by reducing noise.

Properties :- Sound-absorbing, light in weight, porous, vibration resistant.

Uses :- Reducing noise in auditoriums, studios, halls, partition wall.

Wall cladding :- It's a layer of material applied to the exterior or interior wall to provide protection.

Properties :- Decorative, durable, weather resistant, fire resistant.

Uses :- Exterior / interior walls, paneling, aesthetic finishes.

Plastic Boards :- These are man-made panels made from thermo-plastic or reinforced plastic materials like PVC, FRP etc.

Properties :- Light weight ; Corrosion-resistant, moisture proof, easy to cut & shape.

Uses :- partitions, False ceiling, door, panels, etc.

Artificial Sand :- It is Crushed rock or stone sand produced by mechanical means as a substitute for natural river sand.

Properties :- Uniform particle size, clean, stronger than natural sand, ecofriendly.

Uses :- concrete, plastering, masonry, replacement of river sand.

Bonding Agents :- It is a material applied to improve adhesion betn two surfaces, typically old & new concrete or plaster.

Properties :- Adhesive, improves adhesion between old & new concrete, resists water.

Uses :- plastering, repairing cracks, patching old concrete, tile fixing.

Adhesive (construction Glues) :- These are materials used to bond two surface together by forming bond.

properties :- High bonding strength, Water Proof, chemical resistant.

Uses :- fixing tiles, Veneers, laminates, plywood, wooden/glass panel.

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Prefabricated Construction	Pre Cast Concrete Construction
→ Construction in which building component's are manufactured in factory & assembled at site.	→ Construction in which concrete members are cast in molds before use.
→ Broad concept - includes concrete, steel, timber, glass, composite materials.	→ Narrow concept - only concrete element's.
→ concrete, steel, wood, aluminium, plastic, etc.	→ Cement, sand, aggregate, steel (RCC/PSC).
→ Factory or casting yard.	→ Factory or site casting yard.
→ walls, slabs, beams, columns, staircase, frame etc	→ Beams, columns, slabs etc.
→ Ex:- Modular Building	→ Culverts, RCC Beams.
	→ Less labour & limited flexibility

UNIT-2

Prefabrication

Introduction

Prefabrication is a construction technique in which building components are manufactured in a factory or casting yard & then transported to the construction site for assembly.

→ These component's may include walls, beams, columns, slabs, staircases, door's, windows etc.

Necessity :-

→ Prefabrication is necessary due to :

1. Rapid construction : Buildings can be completed in a shorter time.
2. Shortage of skilled labour : Factory production needs less site labour.
3. Uniform quality : Controlled manufacturing ensures accuracy & strength.
4. Economy in mass production : cost reduces when components are produced in large number's.
5. Less wastage of materials : factory conditions minimize material loss.
6. All-weather construction : work is not affected by rain or climatic conditions.
7. Urban housing demand : fast solution for housing shortage.

Scope of Prefabrication :-

The scope of prefabrication is very wide in modern construction:

→ Residential Buildings (mass housing projects)

→ Industrial Buildings (factories, warehouses)

→ Commercial " (office, shopping complexes)

→ Institutional building (school, college)

→ Temporary structures (site offices, labour quarters)

→ Disaster-relief housing

History of Prefabrication :-

→ Prefabrication was first used in ancient civilizations (very old) for simple structures.

→ In the 17th century, Prefabricated wooden houses were used in Europe.

→ During world war I and II, Prefabrication gained importance to meet urgent housing & military needs.

→ After world war II, many countries adopted Prefabrication for mass housing.

→ In India, Prefabrication started gaining popularity after independence, especially for housing boards, railways, and public sector Projects.

→ Today, Prefabrication is widely used with RCC, steel, and composite structures.

Current Uses of Prefabrication :-

Prefabrication means manufacturing building components in a factory & then assembling them at the construction site.

Uses

1. Residential Buildings
   - → Prefabricated houses
   - → Low-cost housing Projects
   - → Apartment & villas

2. Commercial Buildings
   - → Offices
   - → Shopping malls
   - → Hotels

3. Industrial Structures
   - → Factories
   - → Warehouses
   - → Workshops

4. Infrastructure Projects
   - → Bridges (Precast girders)
   - → Flyovers
   - → Railway platforms

5. Public Buildings
   - → Schools
   - → Hospitals

6. Temporary Structures
   - → Site offices
   - → Labour Camps

Types of Prefabrication :-

Prefabrication Systems are classified based on how the structure Component's are manufactured and assembled.

1. Large Panels System
→ Large walls & slab panels are made in factory.
→ Assembled at site using Cranes.
→ Used in mass housing & apartments.

2. Frame System
→ Consist of Precast Columns & beams
→ Structure is formed like RCC frame.
→ Suitable for multistorey buildings.

3. Slab - column System
→ Pre cast slabs are supported directly on columns.
→ No beams are used.
→ Used in parking buildings & offices.

4. Box System (3D System)
→ Transported & placed at site.
→ Used in hostels, hotels, toilets.

5. Component System
→ Small Components like door's, windows, stairs, lintels are prefabricated.
→ Used in normal buildings.

6. Mixed / Composite System :-
→ Combination of Precast & Cast-in-situ construction.
→ Common in modern construction.

Classification of Prefabrication :-

Prefabrication Can be classified in different ways based on — components, structure & method of construction.

1. Based on Structural System :-

→ Panel System : Large wall & floor panels are Prefabricated.

→ Frame System : Precast beams and columns are used.

→ Box (cellular) System : complete room units are manufactured in factory.

→ slab - column System : slabs directly rest on columns.

2. Based on Size of Components :-

→ Small component Prefabrication (Door's, windows, lintels, stairs)

→ Large component Prefabrication (wall panels, floor slabs)

→ Complete Unit Prefabrication (Full room or building units)

3. Based on Material Used :-

→ Precast concrete Prefabrication

→ Steel Prefabrication

→ Timber Prefabrication

→ Composite Prefabrication → Light Gauge steel System.

4. Based on Method of Construction :-

→ On-site Prefabrication - Component's cast near the site

→ Off-site Prefabrication - Component's made in factory and transported

5. Based on Degree of Prefabrication :-

→ Partial Prefabrication (Some component's are Prefabricated)

→ Full Prefabrication (Entire building units are Prefabricated)

Advantages of Prefabrication :-

1. Saves Time
   → Fast construction
   → Suitable for mass housing
2. Better quality control
   → Factory production gives uniform quality.
3. Less Labour Required
   → Reduces site labour work
4. Reduces material wastage
   → Controlled production in factory.
5. Economical for Large Project
   → Cost effective for repeated designs
6. Less weather Effect
   → Work not much affected by rain or climate.
7. Clean construction site
   → Less debris & pollution

Disadvantages of Prefabrication :-

1. High initial cost
2. Transportation Problem
3. Need Heavy Equipment (Cranes required for lifting)
4. Limited Design flexibility
5. Skilled Supervision Required
6. Joint Problems

Theory of Prefabrication :-

Prefabrication is a construction method in which building components are manufactured in factory under controlled conditions & then transported to site for assembly.

→ It improves speed, quality & economy in construction.

Basic Concept :

→ Standardization → Quick assembly
→ Mass Production
→ mechanized construction

→ Under controlled means a situation where all important factors are carefully kept constant so that the result is accurate & not affected by outside disturbances.

Ex:- In a laboratory, concrete cubes are tested under controlled condition (fixed temperature & proper curing time) to get correct compressive strength result.

Process of Prefabrication :-

1. Planning and Design
→ Prepare architectural and structural drawings.
→ Follow modular coordination (standard sizes)
→ Design joints & connection carefully
→ Plan transportation.

2. Production of Components (factory work)
beams, columns, slabs & panels.
→ Casting of elements like beams, columns, slabs & panels.
→ Use steel moulds or formwork
→ Provide reinforcement as per design
→ Proper curing of concrete & quality control check

3. Storage
→ Store finished components in yard
→ Keep on level ground
→ Protect from damage

4. Transportation
→ Transport to site
→ Use trucks or trailers
→ Handle carefully to avoid cracks.

5. Erection and Assembly
→ Lift components using cranes
→ Fix in posn as per drawing
→ Connect using bolts, welding etc
→ Check alignment & level

6. Finishing work
→ Seal joint
→ Apply plaster or surface finishing
→ Final inspection.

Design Principles of Prefabricated System :-

1. Standardization (use standard sizes of components)
2. Modular coordination (Design based on module +(standard unit)
   → Standard unit generally 100mm or 300mm.
   → It ensure easy fitting & interchangeability
   → Reduces wastage & cutting at site
3. Simplicity in Design
   → Design should be simple, Avoid complicated shapes.
4. Ease of Transportation
   → Components should be designed considering: vehicle capacity,
   → Road width & weight limit.
   → Element's should not be too heavy or too large.
5. Ease of Erection and Assembly
   → Connection should be simple (bolted or welded)
   → Provide lifting hooks or inserts.
6. Structural Stability
   → Structure must resist: Dead load, Live load, wind load etc
7. Durability
   → use good quality materials
   → Provide Protection against ; corrosion, moisture & weathering.
8. Quality Control :
   → Proper curing and finishing should be done before transportat
   → Factory Production ensures better quality.
9. Flexibility and future Expansion
   → Design should allow future modification or extension.
10. Economy
    → Reduce material waste
    → Save labour cost
    → Reduce construction time.

Types of Prefabricated Elements :-

1. **Structural Elements :-**
   - → columns → slabs
   - → Beams → Footings

2. **Non-structural Elements :-**
   - → wall panels → Door's & windows
   - → partition panels

3. **3D Elements :-**
   - → Box units
   - → Toilet units
   - → Staircase blocks

Modular Coordination :-

Modular Coordination is a system of planning and design where dimensions of building components are based on a standard module.

* Standard Module :
  Basic module = 100 mm (10cm)
→ All dimensions are multiple of this module

Ex :- If module (m) = 100mm
→ wall length = 3000mm (30m)
→ Door width = 900 mm (9m)
→ window height = 1200mm (12m)

→ All building parts like : walls, Door's, columns are designed as this.

Purpose
- → Saves time & cost
- → Provides uniformity in construction
- → makes mass production easy

Advantages
- → Easy planning & designing
- → Better quality control
- → Faster construction
- → Interchangeability of components.

Indian standard Recommendation for Modular planning :-

Modular planning in India is based on IS 6820 - Recommendation on Modular Coordination in Buildings.

1/ Basic Module (M)

→ The basic module = 100mm
→ Denoted by letter M
→ All building dimensions should be multiples of 100 mm.

Ex:- 1M = 100 mm
3M = 300 mm
6M = 600 mm
12M = 1200 mm

2/ Principles of modular planning (As per IS 6820)

a. Use of Basic module

All horizontal & vertical dimensions should be multiples of 100mm

b. Use of multi modules

For larger dimensions, multimodules like:

→ 3M (300mm) → 12 M (1200 mm)
→ 6M (600mm) → 15 M (1500 mm)
→ 30M (3000 mm) are recommended.

3/ Coordination of Dimensions

→ Size of rooms
→ Thickness of walls
→ Door & window openings should follow modular sizes

4/ Coordination Space

→ Joints
→ Finishing
→ Tolerance

5/ Standardization

→ Building components should be standardized for easy replacement & interchangeability

Advantages of modular planning :-

→ Reduces wastage
→ Saves time
→ Economical Construction
→ Easy Prefabrication
→ Better coordination betn components

Unit - 3

Earthquake Resistant Construction

Building Configuration :-

Earthquake :- An earthquake is the shaking of the ground caused by sudden release of energy inside the earth. To reduce damage and collapse of buildings, proper earthquake resistant construction techniques must be adopted.

→ In india, earthquake resistant design is guided by Bureau of Indian standards (BIS) codes such as IS 1893 & IS 4326.

Building Configuration :- Building configuration refer's to the size, shape and arrangement of structural element's of a building in plan and elevation.

→ Good configuration reduces earthquake forces & prevent's collapse

Principles of good building configuration :-

1. Simple and Symmetrical shape :- Building should be rectangular or square in plan,
   - → Symmetry reduces torsion (twisting effect)
   - → Avoid irregular shapes like L, T, U, H plans.
2. Uniform mass Distribution :- weight should be evenly distributed
   - → Avoid heavy loads on upper floor's
   - → Heavy water tank's should be properly supported.
3. Uniform stiffness :- Stiffness should be same on all sides.
   - → Avoid soft storey (open ground floor for parking).
   - → Columns & wall's should be uniformly placed.
4. Regular Elevation :- Height should be uniform
   - → Avoid sudden setback
   - → Avoid floating columns

5. Proper Separation Gap :- Provide seismic separation (...) adjacent buildings.

→ Prevent's pounding effect during shaking.

6. Strong Foundation :-

→ Foundation should be on firm soil

→ Avoid construction on loose or filled soil.

Advantages of Proper Configuration :-

→ Reduces damage

→ Improves stability

→ Prevents collapse

→ Saves life & Property

Lateral Load resisting structures :-

* Lateral loads are horizontal forces acting on a structures — due to : → Earthquake
  → wind
  → Blast forces

* Lateral load resisting structure is a structural System designed to Safely resist horizontal forces and transfer them to the foundatio without collapse.

Types of lateral load resisting Systems :-

1. Moment Resisting Frame (Rigid frame)

→ consists of beams & columns rigidly connected.
→ Resists lateral loads by bending action.
→ Suitable for low to medium rise buildings.

Advantages	Disadvantages
→ Architectural flexibility	→ more deformation

2. Braced frame System

→ Diagonal bracing member's are Provided.
→ Braces resist lateral loads through tension & Compression.
→ Very stiff System.

Types
→ X-bracing
→ V-bracing
→ K-Bracing

3. Shear wall System

→ Reinforced Concrete walls resist horizontal forces.
→ Very effective for earthquake resistance.
→ Used in multistorey buildings.
→ High Stiffness & Reduces sway

4. Dual System :- combination of moment frame + shear wall or bracing
→ used in high-rise buildings
→ Provides both strength & stiffness

5. Tube structures :- Used in tall buildings
→ Enterior columns act like a tube.
→ Suitable for skyscrapers.

functions
→ Resists horizontal forces
→ Prevents emcessive sway
→ Protects structural elements
→ Transfers load safely to foundation.

Building Characteristics :-

Building characteristics are the important features of a building that affect its strength, stability, safety & performance, especially during earthquake & wind loads.

Important characteristics :-

1. Strength :- Ability to resist loads without failure.
→ Includes compressive, tensile and shear strength.
→ Strong materials like RCC & steel improve strength.

2. Stiffness :- Ability to resist deformation (bending or sway).
→ More stiffness = less displacement during earthquake.
→ Shear walls increase stiffness.

3. Ductility :- Ability to undergo deformation without sudden collapse.
→ Very important in earthquake zones
→ Steel r/f improves ductility.

4. Symmetry :- Building should be symmetrical in plan & elevation.
→ Prevents torsional effect
→ Rectangular shape is preferred.

5. Regularity :- Uniform mass & stiffness distribution.
→ Avoid soft storey & sudden setbacks.

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→ Avoid soft storey. & sudden setbacks.

6. Continuity :- Continuous load path from roof to foundation.
→ Columns & walls should align properly.

7. Redundancy :- multiple load paths available.
→ If one element fails, other's carry load.

8. Proper foundation :- strong & stable foundation.
→ Avoid weak soil or filled ground.

Effect of structural irregularities - Vertical irregularities :-

* Structural Irregularities increase the risk of damage during earthquake.
* Vertical irregularities occur when there is sudden change in mass, stiffness, strength, or geometry along the height of a building.

→ They cause uneven distribution of earthquake forces & may lead to collapse.

Plan Configuration

Plan Configuration refers to the shape & layout of a building in plan (top view).

→ A proper plan Configuration is very important because it affects how the building responds to seismic forces.

Importance

→ During an earthquake, lateral forces act on the structure. If the plan shape is irregular, it may cause:

- → Torsion (twisting of building)
- → Uneven stress distribution
- → Concentration of forces at corners
- → Structural damage or collapse

→ A simple & symmetric plan perform better during earthquakes.

Types of plan Configuration :-

(A) Regular plan Configuration (Preferred)

A building is considered regular when:

- Shape is simple (square or rectangular)
- Mass & stiffness are uniformly distributed
- No sudden projections or setbacks
- Centre of mass and centre of rigidity are close.

★ Example of good plan shapes:

- Square, Rectangular & Circular

(B) Irregular Plan Configuration (Avoid if possible)

Irregular plans cause torsional effects and stress concentration.

Common irregular shapes:

- L-shaped
- T-shaped
- U-shaped
- H-shaped
- Plus-shaped

Guidelines for Good plan Configuration :-

- Prefer simple rectangular shape
- Maintain symmetry in both directions
- Uniform distribution of mass & stiffness
- Avoid large projections and setbacks
- Provide seismic separation joints for irregular shapes
- Align column & walls properly.

Plan Configuration Problems :-

1. Torsional Irregularity

- **Problem** : occurs when the centre of mass and centre of rigidity do not coincide.
- **Effect** : Building twists during earthquake
  one side experiences more displacement
  columns on one side may fail.

Reason : Uneven distribution of walls or columns
Heavy load on one side

2. Re-entrant Corners

Problem : Inside corners in shapes like :

- L-shape
- T-shape
- U-shape

Effect : Stress concentration at inner corners
Cracks & separation during shaking

3. Diaphragm Discontinuity

Problem : Large openings in slab (for staircases, lifts, atrium)

Effect : Floors cannot transfer seismic forces properly
Uneven load distribution

4. Non-parallel Lateral Load Resisting System

Problems: Columns or shear walls not aligned in both directions

Effect: Uneven resistance to earthquake forces
Additional torsion

5. Out-of plane Offsets

Problm: Vertical elements (columns / walls) are not aligned

Effect: weak load transfer path
Sudden failure risk

6. Large Projections & Setbacks

Problm: Sudden change in plan dimension

Effect: Stress concentration
Structural discontinuity

Safety considerations During Additional Construction and Alteration of Existing Building:

When adding floors or altering an existing building, Proper Safety measure must be taken to avoid structural failure, especially in seismic areas.

1. Structural Assessment Before Construction
   - Inspect foundation, columns, beams & slabs.
   - Check cracks, settlement, corrosion of reinforcement.
   - Verify original design drawings and load capacity.
   - Conduct structural audit by a qualified engineer.

2. Check Load Carrying Capacity
   - Ensure foundation can take additional load
   - Check whether columns & beams are strong enough.
   - Provide strengthening (jacketing, additional columns) if required.

3. Foundation Safety
- Verify soil bearing capacity
- Avoid unequal settlement
- Strengthen foundation if extra storey is added.

4. Structural Strengthening Measures
If existing structure is weak:
- RCC jacketing of columns & beams
- Steel plate bonding
- Addition of shear walls (new)
- FRP wrapping

5. Seismic Safety
- Ensure proper load path from roof to foundation
- Avoid plan & vertical irregularities
- Maintain symmetry
- Provide seismic separation joints if needed

6. Temporary Construction Safety
During alteration work:
- Provide proper scaffolding (Temporary structure)
- Avoid removing load-bearing walls
- Provide shoring & propping.
- Ensure worker safety measures (helmets, safety belts).

7. Utility and Service Safety
- Check electrical and plumbing lines.
- Prevents leakage or short circuit.
- Ensure proper ventilation during work.

8. Legal and Approval Requirements
- Obtain approval from local authority.
- Follow building by-laws.
- Ensure compliance with fire safety rules.

Additional strengthening measures in masonry building - Corner reinforcement, lintel band, sill band, plinth band, roof band, gable band etc :-

In earthquake-prone areas, masonry buildings are weak in tension & shear. To improve their performance during shaking, special strengthening measures are provided.

1. Corner Reinforcement :-

→ Vertical steel bars are provided at the corners of walls.
→ Bars are placed inside reinforced concrete (RC) pockets or confined masonry.
→ Helps resist tensile stresses at wall junctions.
→ Prevent's separation of walls at corners during earthquake.

Purpose :- To increase stability & prevent cracking or failure at wall intersections.

2. Plinth Band :-

→ A reinforced concrete band provided at plinth level (just above ground level).
→ Connects all walls together's at foundation level.

Functions :- Reduces differential settlement.
→ Provides uniform load distribution
→ Improves overall rigidity of structure

3. Sill Band :-

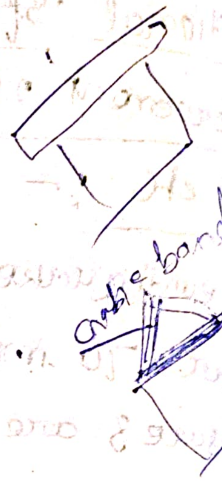
→ Provided at window sill level.
→ continuous RC band running through all walls.

functions :- Reduces crack formation below windows.
→ Control damage in walls with large openings.
→ Improves box action of building.

4. Lintel Band :-

→ Provided at lintel level (above doors & windows)
→ one of the most important earthquake-resistant features.

Functions :- Ties all walls together
→ Reduces bending & shear cracks.
→ Transfer lateral loads safely.



5. Roof Band

→ Provided at roof level in buildings with flexible roofs.
→ Acts like a tie beam at top of walls.

Functions :- Prevents wall separation at roof level.
→ Increases structural integrity.

6. Gable Band

→ Provided at gable wall top in sloped roof buildings.
→ Especially important in buildings with pitched roofs.

Functions :- Prevent's collapse of triangular gable wall.
→ Reduces out-of-plane failure.

Unit-4

Retrofitting of Structure's

Retrofitting is the Process of Strengthening an existing building to improve its performance against earthquakes, loads or deterioration without demolishing it.

→ It is mainly done for old buildings that were not designed as per modern seismic codes.

Objectives

→ Increase strength of structure
→ Improve stiffness
→ Increase ductility
→ Repair damaged structural member's
→ Enhance safety & service life

Need

→ Old buildings not designed for earthquake loads.
→ Change in building use (increase in old) → poor construction quality
→ Structural deterioration (cracks, corrosion)
→ To comply with updated building codes

Common Retrofitting Techniques

1. Jacketing :- Providing additional concrete, steel or fibre wrapping around structural members.

Types :- Column jacketing
Beam jacketing
Slab jacketing

Purpose :- Increases load carrying capacity
Improves ductility

2. Steel plate Bonding :- Steel plates are fixed to beams or columns using bolts or epoxy.

→ Improves flexural & shear strength.

3. FRP Wrapping :-

→ Fiber Reinforced polymer sheets are wrapped around members.
→ Lightweight & corrosion-resistant.
→ Increases strength and confinement.

4. Adding shear walls

→ New reinforced concrete shear walls are added.
→ Reduces lateral displacement
→ Improves earthquake resistance.

5. Adding Bracings

→ Steel bracing systems are installed.
→ Increases lateral stiffness.

6. Base Isolation (Advanced method)

→ Isolators are installed between foundation and superstructure
→ Reduces earthquake force transfer.

Advantages of Retrofitting :-

→ Economical compared to reconstruction.
→ Increases building life.
→ Improves safety
→ Less time consuming.

Seismic Retrofitting of Reinforced Concrete (RC) Building :-

Seismic retrofitting is the process of strengthening an existing reinforced concrete (RC) building to improve its resistance against earthquake forces.

→ It's required when the building was not originally designed as per seismic codes or has suffered structural damage.

Objectives

- → Increase lateral strength.
- → Improve ductility.
- → Reduce excessive drift (sway).
- → Prevent brittle failure.
- → Ensure life safety during earthquake.

Reasons for Seismic Retrofitting

- → Old buildings designed without seismic provisions.
- → Soft storey at ground floor.
- → Poor detailing of reif.
- → Increase in seismic zone classification.
- → Structural damage after earthquake.

Methods of Seismic Retrofitting in RC Buildings :-

1. **Column Jacketing** :- Additional concrete with r/f is added around existing columns.
   - → Increases axial, flexural and shear strength.
   - → Most commonly used method.

2. **Beam Jacketing** :- Strengthening beams by adding concrete or steel plates.
   - → Improves moment capacity.

3. **RC Shear Wall Addition** :- New reinforced concrete shear walls are added.
   - → Increases stiffness & reduces lateral displacement.

4. **Steel Bracing** :- Steel diagonal members provided in frames.
   - → Improves lateral load resistance.

5. **FRP Wrapping** :- Fiber Reinforced polymer sheets wrapped around columns / beams.
   - → Increases ductility & confinement.
   - → Lightweight and easy to apply.

6. Base Isolation (Advanced method) :-

→ Installation of isolators at foundation level.

→ Reduces seismic force transferred to structure.

7. Infill Wall Strengthening :-

→ Strengthening masonry infill walls with mesh or shotcrete.

→ Prevents out-of-plane failure.

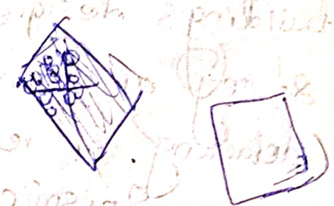
Advantages

→ Economical compared to demolition

→ Improves safety and performance.

→ Extends service life

→ Reduces risk of collapse.



Sources of Weakness in RC frame building :-

In a Reinforced Concrete Engineering, weakness in an RC frame building can occur due to several structural and construction-related reasons. These are important for building.

→ Main Sources of Weakness

1. Poor quality of materials :-

* Low-grade cement, bad sand or weak aggregates.
* Rusted or undersized steel bars.
* Reduces strength and durability

2. Improper design :-

* Inadequate beam or column size
* Wrong load calculation
* Lack of earthquake-resistant detailing

3. Poor workmanship during construction :-

* Improper compaction of concrete
* Honeycombing & voids (porous, hollow, beehive like voids)

4. Soft Storey effect :-
→ Ground floor without infill walls (open parking / shops)
→ Causes excessive sway during earthquake

5. Irregular building configuration :-
→ Plan irregularity (L-shape, T-shape etc)
→ Vertical Irregularity (Sudden change in stiffness or mass)

6. Weak beam-column joints :-
→ Lack of Proper anchorage and stirrups
→ Joint failure is common in earthquakes

7. Overloading or change in use :-
→ Adding extra floors later
→ Heavy machinery or storage load not considered in design

8. Poor foundation conditions :-
→ Low soil bearing capacity
→ Unequal settlement leading to cracks

9. Lack of maintenance & deterioration :-
→ Corrosion of reinforcement
→ Water leakage & carbonation of concrete.

Classification of Retrofitting Techniques and Their Uses :

1. Local Retrofitting Techniques :-
→ Strengthening of individual structural members

Methods & Uses :
→ Column jacketing (RC / steel jacketing)
* Increases column strength and stiffness
* used when columns are weak or cracked

→ Beam strengthening
* Increases flexural and shear capacity
* Used when beams show excessive deflection or cracks.

→ Slab strengthening
* Improved load capacity of slab
* Used when slab is overloaded or deteriorated

2. Global Retrofitting Techniques :–

Strengthening of whole building system

Methods & Uses :–

* Addition of shear walls
  → Increases lateral strength & earthquake resistance
  → Reduces building sway
* Braced frame system
  → Improves overall stiffness
  → Used in multi-storey buildings
* Infill wall strengthening
  → Improves lateral load resistance
  → Useful in RC frame structures

3. Foundation Retrofitting :–

Strengthening foundation & soil

Methods & Uses ;

• Underpinning :- Increases foundation depth & load capacity
• Soil stabilization / grouting :- Improves soil bearing capacity
  → Reduces unequal settlement

4. Seismic Retrofitting Techniques :–

Special methods for earthquake-prone areas

methods & Uses :

→ Providing bands (plinth band, lintel band, roof band)
  * Improves box action of building.

→ Corner strengthening & stitching · cracks

* Prevents separation of walls.

→ Base Isolation / energy dissipation devices

* Reduces earthquake forces transmitted to structure.

Unit-5

Building Services

Building Services are the Systems installed in a building to make it Comfortable, Safe and Functional for occupants.

→ These are the facilities and Systems Provided in a building for water Supply, Sanitation, electrical Supply, Ventilation, Fire Safety & Communication.

→ Cold water distribution System in a high-rise building Supplies Safe potable water from Source to different floors at required Pressure & quantity.

Methods of Cold water Distribution in High-Rise Buildings :-

1. Down-Feed System (Overhead Tank System)

Working

→ Water is pumped from underground Sump to overhead tank.
→ From overhead tank, water flows by gravity to all floors.

Uses / Advantages

→ Simple & economical
→ Less pump operation time
→ Reliable during power failure.

2. Up-Feed System (Direct Pumping System)

Working

→ Pumps deliver water directly to distribution available
→ Less structural load on roof

Advantages :

→ Suitable where roof tank Space is not available.
→ Less structural load on roof.

Disadvantages:

→ Dependent on electricity
→ Pressure fluctuation possible

3. Hydropneumatic System

Working:-

→ Water stored in pressure tank.
→ Air pressure maintained by compressor.
→ Provides uniform pressure at all floors.

Uses / Advantages:

→ Constant water pressure
→ No need of large overhead tank

Layout of Cold Water Installation (General Arrangement):-

Main Components

→ Water source (municipal supply / bore well)
→ Underground sump tank
→ Pumping unit
→ Rising main (Vertical pipe)
→ Overhead tank / Pressure tank
→ Distribution pipes on each floor
→ Services connections to kitchen, bathroom, WC etc.

Layout Explanation:-

1. Water enters underground sump from source
2. Pump lifts water through rising main
3. Water stored in overhead tank.
4. From tank, water distributed by gravity through down-take pipes.
5. Branch pipes supply water to fixtures on each floor.

Hot Water Supply System :-

Hot water supply supply provides heated water for bathing, washing kitchen & cleaning purposes in residential & public building.

Methods / Systems of Hot Water Supply :-

1. Independent (Local) Heating System

Ex :- Electric geyser
Immersion Heater

Uses

- Suitable for small houses & individual bathrooms
- Simple installation
- Less pipe heat loss

Disadvantages

- Not economical for large buildings