UNIT 4

Prefabrication systems in residential buildings-walls-openings-cupboards-shelves etc., planning and modules and sizes of components in prefabrication. Planning and designing of residential buildings against the earthquake forces, principles, seismic forces and their effect on buildings.

Prefabrication systems in residential buildings:

What is Prefabrication?

Prefabrication is the practice of assembling components of a structure in a factory or other manufacturing site, and transporting the complete assemblies or subassemblies to the construction site where the structure is to be located.

Why prefabrication systems are used?

50% reduction in the amount of water used for construction of a typical house. •30% reduction in construction costs. •35% reduction in construction time. •60% reduction in defects on completion. •Eco-friendly.

PRINCIPLES OF PREFABRICATION TECHNIQUES:

- Design for prefabrication, preassembly and modular construction.
- Simplify and standardize connection details.
- Simplify and separate building systems.
- Consider worker safety during deconstruction.
- Minimize building components and materials.
- Select fittings, fasteners, adhesive and sealants that allow for quicker assembly and facilitate the removal of reusable materials.
- Reduce building complexity.
- Design for reusable materials.
- Design for flexibility and adaptability.

SCOPE OF PREFABRICATION : Prefabrication is more efficient, low cost, Time saver, Reduce the Wastage, Reduce the Manpower, Maintanance is less, and can be reused in the material stream.

FIRST PREFABRICATION IN INDIA:

- Prefabrication in India began with the emergence of the Hindustan Housing Factory.
- The company was developed by the first Prime Minister of India, Pandit Jawaharlal Nehru, from West Pakistan in 1950s.
- The Hindustan Housing Factory produce the pre-stressed concrete railway sleepers to replace dilapidated wooden sleepers on Indian Railways.
- Then, The company changed its name known as the Hindustan Prefab Limited or HPL.

TRADITIONAL CONSTRUCTION METHODS:

- Traditional construction techniques involve the use of timber moulds or shuttering and scaffolding for roof spans and other structural systems.
- These temporary timber structures have a short lifespan.
- Requires more maintanance.
- Requires more manpower than the Prefabrication System.

NECESSITY FOR PREFABRICATION •

Higher quality products for clients

- Maintanance cost is low.
- Improved productivity and profitability for contractors • Environmental benefits associated with its use.
- Prefabrication System provides satisfactory results to the construction Industry.

- It found that wastage generation can reduce up to 100% after adopting prefabrication, in which up to 84.7 per cent can be saved on wastage reduction.

PREFABRICATION AS 'LOW COST HOUSING:

- Self supporting, shuttering and scaffolding is eliminated with a saving in shuttering cost.
- The mould for the precast components can be used for large number of repetitions thereby reducing the cost of the mould per unit.
- Time is saved by the use of precast elements which are casted off-site during the course of foundations being laid.
- Similar types of components are produced repeatedly, resulting in increased productivity and economy in cost too.
- The work at site is reduced to minimum, thereby, enhancing the quality of work, reliability and cleanliness.

Prefabrication systems in residential buildings:

Prefabrication has brought a substantial change in the development of construction industry worldwide over the last few decades. It ensures the strength, economy and environmental performance of the structures and hence is preferred over the onsite construction. Pre-assembly, prefabrication, modularisation, system buildings and industrialised buildings are the various terms used to describe the processes of manufacturing of modular units onsite or off-site. There are various types of modular precast building construction techniques prevalent worldwide. This article discusses the various types of prefabrication technologies along with available standards & codal provisions, its advantages, disadvantages.

Issues in Prefab Construction

The joints to be provided linking the core structure and the components should be wellbuilt enough to transmit all types of stresses. The strength and stoutness of the entire building depends totally on the strength of the joint. Therefore, it is necessary to have comprehensive studies on entire system rather than component based study. Requirement of skilled labor at site and shortage of onsite automation is one of the major issues in acceptance of prefabrication technologies in construction which requires accuracy and preciseness. Thus, skill development and native automation is mandatory for installation of the prefabricated systems. During erection or transportation of heavy machinery units are likely to get damaged thus the arrangement of the units has to be done precisely and this procedure becomes clumsy in a congested area. Labor maintenance is one more issue as skilled labor is required in the prefabricated construction as it is different from in-situ construction, which requires machine oriented skills both on-site and in the manufacturing process.

Advantages of Prefab Construction

Prefabrication Technology has various advantages like overhauling the view with energy efficiency, minimal wastage and inspection struggle, dependable construction, pace of work, security, sustainability and quality .

- The requirement for formwork, shuttering and scaffolding is significantly reduced as Self-supporting ready-made components are used.
- Construction time is reduced thus resulting in lower labour costs.
- Reduced amount of waste materials than in site built construction.
- Reduction in Construction time allowing an earlier return of the principal invested.
- Building ensures accurate conformity to building standards and superior quality assurance.
- High-energy efficiency along with quality control and factory sealing.
- Prefabrication site can be positioned where skilled labour is more readily accessible and the expenses of labour, power, materials, space and overheads are minimized.

- Prefabrication allows construction all over the year irrespective of the weather (related to excessive cold, heat, rain, snow, etc.).
- Construction material wastage is less.
- Independent of climatic condition.
- In off-site construction safety and comfort level of worker are higher.

Disadvantages of Prefab Construction

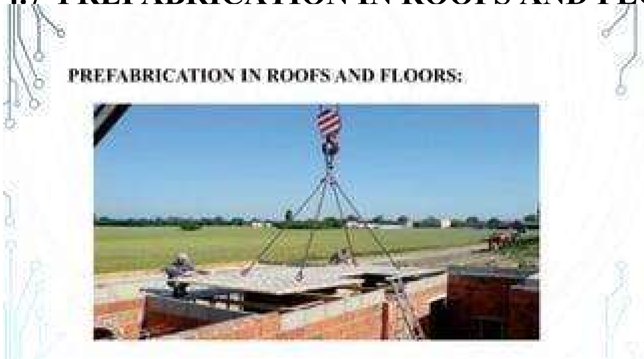
It is known to have the subsequent limitations limited options in design, decreased resell value, high initial investment, non-suitability for foundation and transportation of precast units.There are more disadvantages too. They are as follows:-

- At joints in prefabricated components leakage occurs.
- Transportation costs may be high for huge prefabricated sections.
- Increased production volume is necessary to make sure affordability through prefabrication.
- Initial construction cost is higher.
- The initial design development is time consuming.
- Huge prefabricated sections need heavy-duty cranes and accuracy measurement from handling to place in site.
- Local jobs may be lost, as it requires skilled labour.
- Design and construction of modular buildings, require high levels of collaboration among project parties, especially architect, structural engineer and manufacturer.
- Due to its shorter economic life these buildings typically depreciate more quickly than traditional site-built housing

PREFABRICATION IN WALLS:

• The number of the bricks or blocks that are broken into different sizes to fit into position at site is very large, which results in wastage of material poor quality.
• Low density bigger size wall blocks using industrial wastes like blast furnace slag and fly ash.
• They are also used as Weathering and Damp proofing • They provide Sound and Thermal insulation.

4.7 PREFABRICATION IN ROOFS AND FLOORS:



CHARACTERISTICS OF PREFABRICATION SYSTEM:

- Light weight
- Thermal insulation property
- Easy workability
- Durability in all weather conditions
- Non combustibility
- Economy in cost
- Easy availability
- Sound insulation

PREFABRICATION AS DISASTER RESISTANT:

- The greatest advantage of prefabricated buildings is being earthquake-resistant and light as they are steel constructions.

The short manufacturing period and providing fast mounting.

- Suitable for all Weathering Conditions.
- Prefabrication is good for Marine Environment.

Prefabrication Components:

- Flooring
- Roofing
- Beams
- Columns
- Walls
- Staircase
- Lintels
- Sunshade/Chajja projections

Materials:

- Concrete
- Steel
- Treated wood
- Aluminium
- Cellular concrete
- Lightweight concrete elements
- Ceramic products

Systems of Prefabrication:

- OPEN PREFAB SYSTEM - Open prefab system is based on use of basic structural elements to form whole/part of a building.

Components :

- Reinforced Concrete
- Hollow core slab
- Hollow blocks & battens
- Precast planks & battens
- Precast joists & tiles
- Cellular concrete slabs
- Presetressed/reinforeced concrete slabs, beams & columns
- Precast lintels & chajjas
- Reinforced concrete waffle slabs/shells
- Room size reinforced/prestressed concrete panels
- Reinforced concrete/ Prestressed concrete walling elements • Reinforced concrete/presetressed concrete trusses. **Systems of Prefabrication:**

Open prefab system is further divided into two types :

- Partial Open Prefab
- Full Open Prefab
- **PARTIAL OPEN PREFAB** emphasizes the use of precast roofing and flooring components and minor elements like lintels, chajjas, kitchen sills etc. It could be in-situ framework/load bearing walls.
- **FULL OPEN PREFAB** includes almost all structural components such as beams, columns, slabs. Filler walls **may be of bricks or other material available.**

- **LARGE PANEL PREFAB SYSTEM -** Large panel prefab system is based on the use of large prefab components as in large panels for walls, floors, roofs, balconies, staircase etc. Casting could be done on site or off site.

Planning and designing of residential buildings against the earthquake forces

Why Earthquake-Resistant Structures?

Earthquakes are defined as rapid shaking of the ground caused by the shift of rock and tectonic plates underground. The ground seems solid, but the upper crust of earth is deep and long periods of time cause pressure to build up between plates and fissures. When the pressure gives, seismic vibrations and violent shaking reverberate to the surface, immediately affecting miles of land. After the initial quake, aftershocks can occur resulting in further damage.

Earthquakes can virtually happen anywhere in the U.S., but the high-risk areas include California, Oregon, Washington, Alaska, Missouri, Arkansas, Tennessee, Kentucky, South Carolina, and New England. These areas are held to higher, stricter building standards as published by the NEHRP Recommended Seismic Provisions. The buildings may have to endure radical movement and foundation shifts in order to minimize damage and protect the people inside and around them. If they fracture or collapse, no emergency plan can protect the people from harm. Earthquake-resistant building designs consider the following characteristics that influence their structural integrity: stiffness and strength, regularity, redundancy, foundations, and load paths

Stiffness and Strength

When designing earthquake-resistant buildings, safety professionals recommend adequate vertical and lateral stiffness and strength – specifically lateral. Structures tend to handle the vertical movement caused by quakes better than the lateral, or horizontal, movement. Without considering earthquakes, professionals still focus on a building's vertical stiffness and strength as it has to support itself. However, earthquakes introduce new directional forces that may not be prepared for. Buildings will shift left and right during the event, and, if not built properly, will quickly destabilize.

Regularity

This characteristic refers to the movement of the building when pushed in lateral directions. Safety professionals and building designers want the building to move equally so as to dissipate the energy without placing too much force on one side or another. If a building is irregular, then weaknesses will become apparent when the building sways. The weakness will compromise and the structure will see concentrated damage – which compromises the structure as a whole.

Redundancy

Possibly one of the most important safety characteristics when designing for safety, redundancy ensures there are multiple strategies in place in case one fails. These can potentially add to the building cost, but redundancies prove their worth if/when a natural disaster such as an earthquake occurs. Safety professionals advise equally distributing mass and strength throughout the structure so strength isn't solely reliant on one factor.

Foundations

A stable foundation is a major characteristic of building a large structure regardless of natural disaster risks. It is critical for a building's long-term survival, and a stronger foundation is necessary to resist an earthquakes powerful forces. Different areas have unique foundational characteristics that define how a structure's base needs to be reinforced. Professionals have to closely observe how the ground reacts and moves before building. Buildings designed to withstand violent earthquakes have deep foundations and driven piles. To stabilize these drastic measures, the foundations are connected so they move as a unit.

Continuous Load Path

Tying into the stable foundation characteristic, structural and nonstructural components of a building need to be interconnected so inertial forces dissipate. Multiple points of strengths and redundancies share the force instead of the quake splitting the foundation apart. This is the continuous load path characteristic that safety professionals, architects, and engineers must remain wary of during design. If the structure is not comprehensively tied together, components will move independently and collapse will be imminent. The continuous load path is the earthquake's journey through the building – laterally and vertically. It is vital the path is intact or else it won't be able to dissipate an earthquake's powerful shudders.

Earthquakes happen less frequently than other natural disasters, but building earthquakeresistant buildings protects against all natural disasters. Safety professionals keep people's safety a priority when researching and developing protective strategies for structural integrity. Due to the amount of synergy needed to develop earthquake-resistant building provisions, safety professionals work closely with other fields. They have to appreciate multiple factors they may not be experts in and communicate with other professionals to find the most effective solutions.

seismic forces and their effect on buildings:

Earthquake is the most dangerous natural phenomenon that generates sizable destruction in structures. It is reported that two sources of mistakes which would seriously endanger structures are ignoring the ways an earthquake affects buildings and shoddy construction practices.

That is why a proper understanding of the seismic effects on a structure is extremely important, and designers and contractors should consider the influence of seismic forces on buildings in order to be able to set prevention measures against failures and collapses.

As earthquake hits structures, it generates inertia forces which could be greatly destructive causing deformations and, horizontal and vertical shaking. These effects are discussed and presented below.

1. Inertia Forces in Structures

The generation of inertia forces in a structure is one of the seismic influences that detrimentally affect the structure. When an earthquake causes ground shaking, the base of the building would move but the roof would be at rest. However, since the walls and columns are attached to it, the roof is dragged with the base of the building.

The tendency of the roof structure to remain at its original position is called inertia. The inertia forces can cause shearing of the structure which can concentrate stresses on the weak walls or joints in the structure resulting in failure or perhaps total collapse. Finally, more mass means higher inertia force that is why lighter buildings sustain the earthquake shaking better.

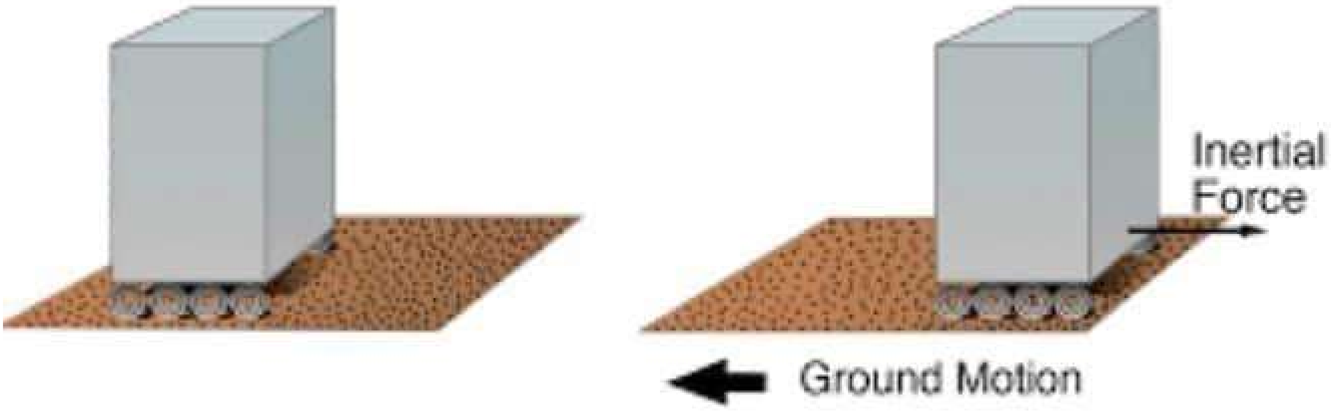


Fig. 1: Direction of Inertia Forces

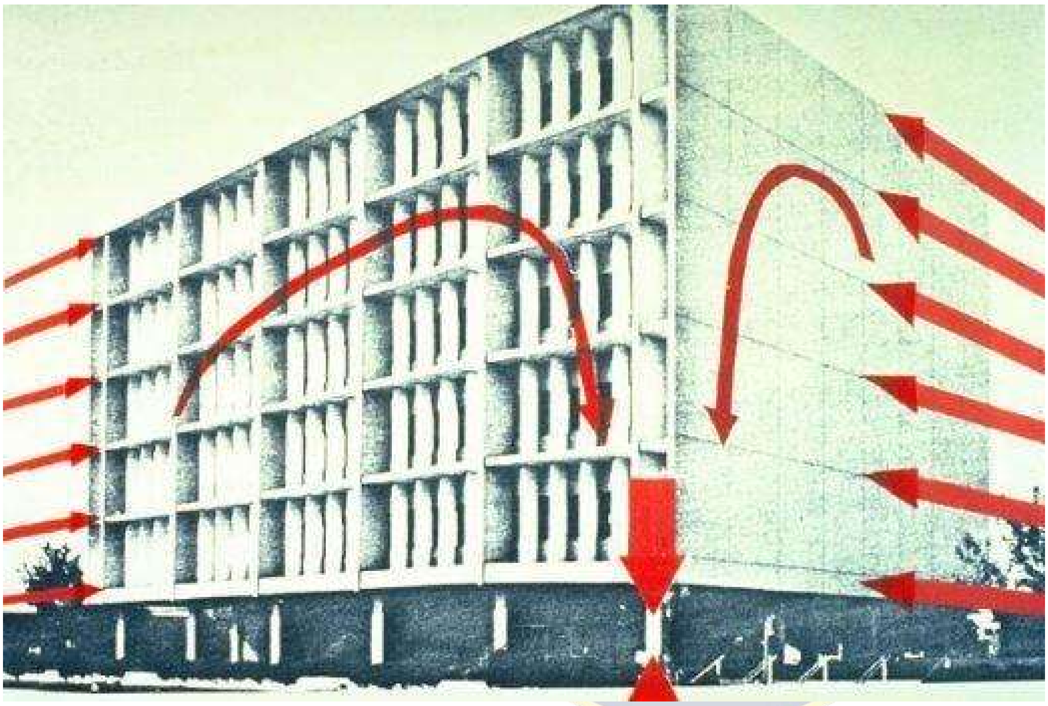


Fig. 2: Development of Great Inertia Forces in the Six Storey of Imperial County Services Building

2. Effect of Deformations in Structures

When a building experiences earthquake and ground shaking occurs, the base of the building moves with the ground shaking. However, the roof movement would be different from that of the base of the structure. This difference in the movement creates internal forces in columns which tend to return the column to its original position.

These internal forces are termed stiffness forces. The stiffness forces would be higher as the size of columns gets higher. The stiffness force in a column is the column stiffness times the relative displacement between its ends.

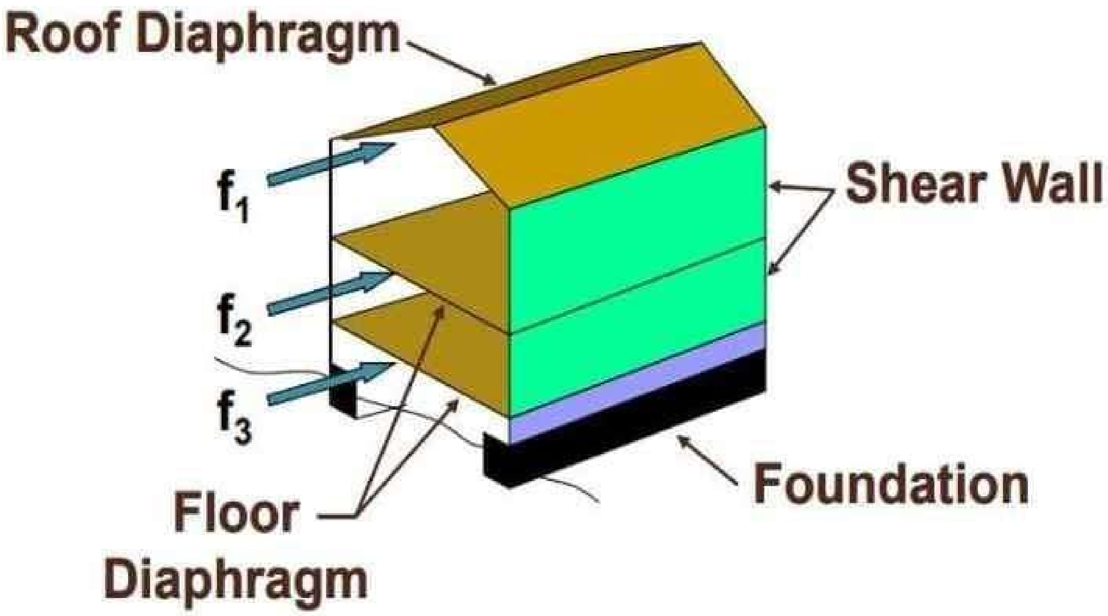


Fig. 3: Lateral Force Resisting System in a House

3. Horizontal and Vertical Shaking

Earthquake causes shaking of the ground in all the three directions X, Y and Z, and the ground shakes randomly back and forth along each of these axis directions. Commonly, structures are designed to withstand vertical loads, so the vertical shaking due to earthquakes (either adds or subtracts vertica l loads) is tackled through safety factors used in the design to support vertical loads.

However, horizontal shaking along X and Y directions is critical for the performance of the structure since it generates inertia forces and lateral displacement and hence adequate load transfer path shall be provided to prevent its detrimental influences on the structure.

Proper inertia force transfer path can be created through adequate design of floor slab, walls or columns, and connections between these structural elements. It is worth mentioning that the walls and columns are critical structural members in transferring the inertial forces. It is demonstrated that, masonry walls and thin reinforce concrete columns would create weak points in the inertia force transfer path.

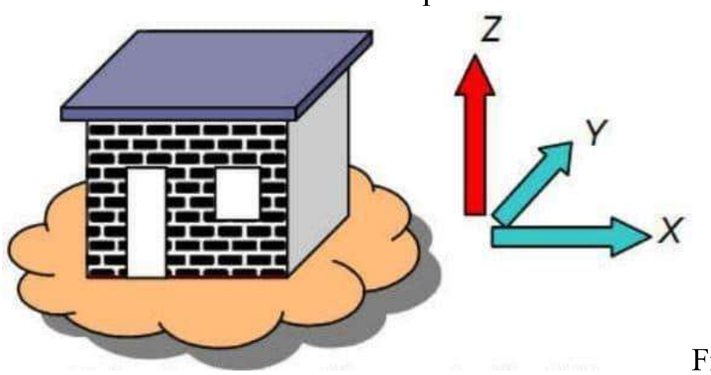


Fig. 4: Principal Directions of a Building

4. Other Effects

Apart from the direct influences of earthquakes on a structure which are discussed above, there are other effects such as liquefaction, tsunami, and landslides. These are the indirect effects of strong earthquakes that can cause sizable destruction