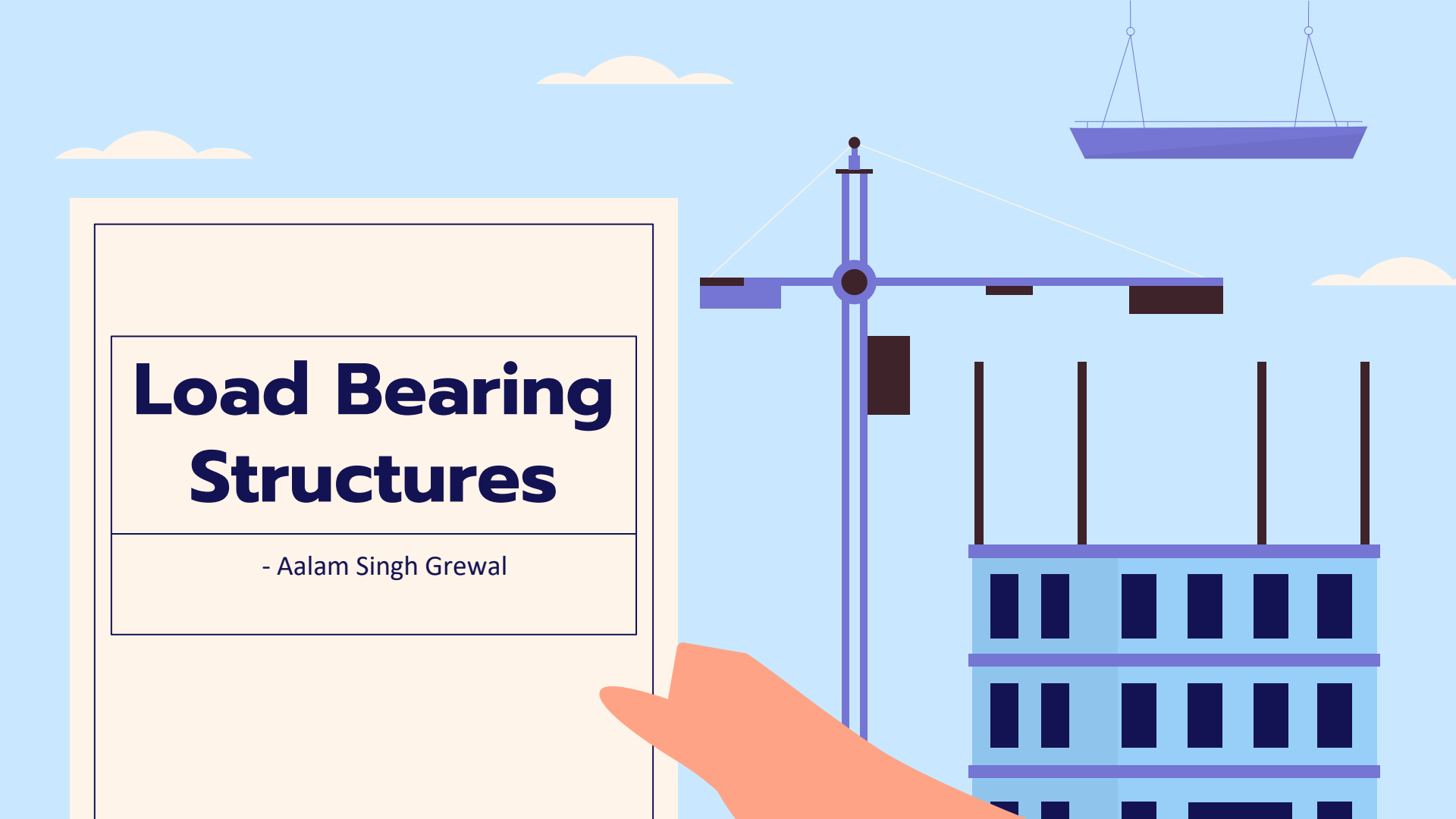
Load Bearing Structures

- Aalam Singh Grewal



What is load bearing structures?

A load-bearing structure is a structure in which loads are transferred to the foundation through walls. This type of structure doesn’t have beams and columns. The load-bearing walls are constructed over a continuous foundation and they’re designed to carry the complete load, including their load.

Load Transfer

Slabs

↓

Walls

↓

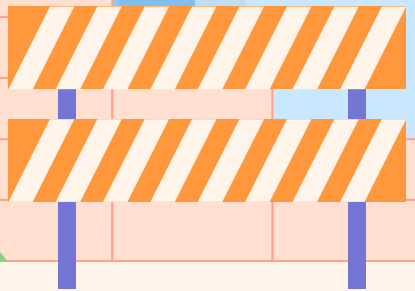
Foundation

Advantages

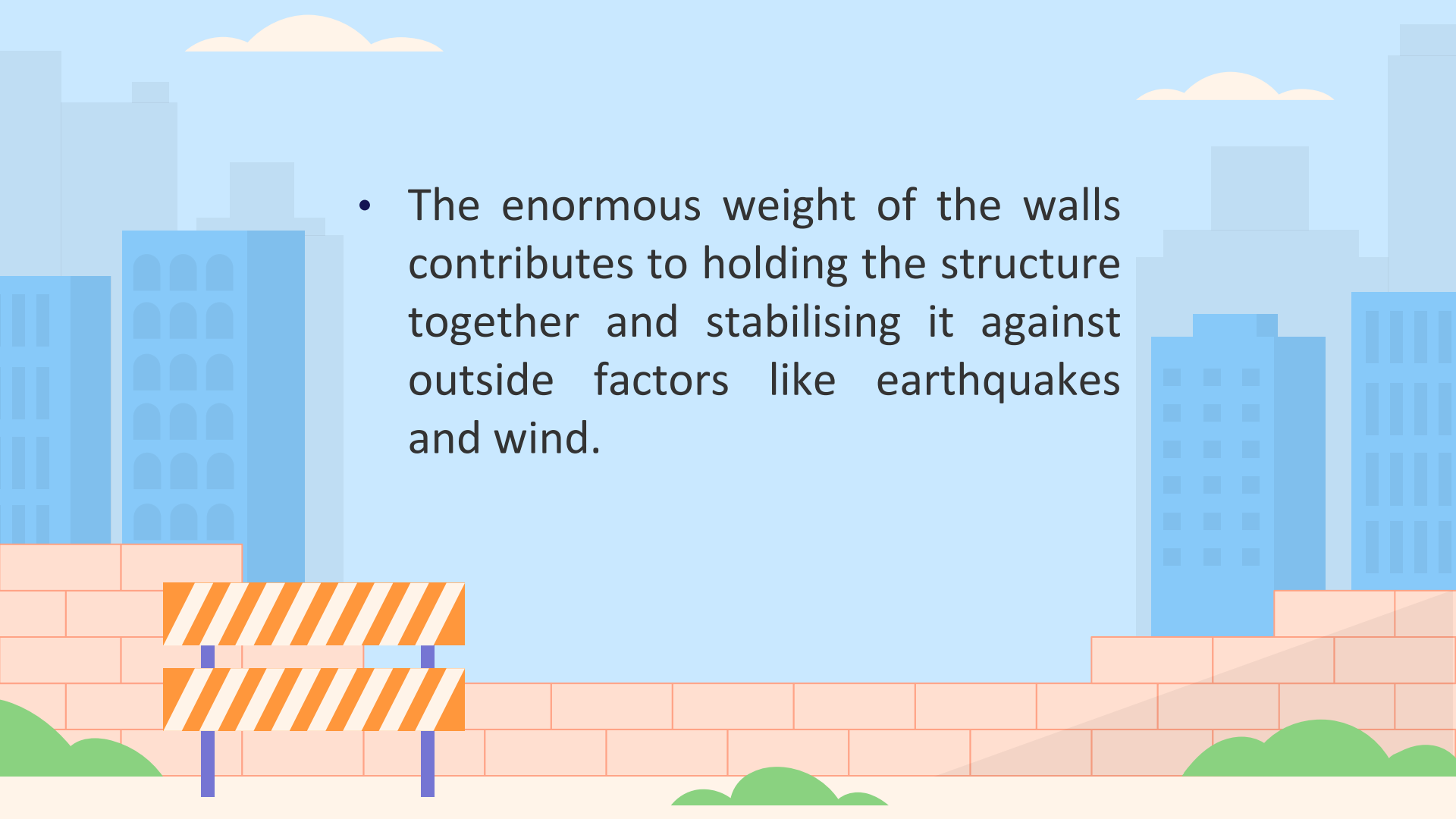
- The performance and stability of the building are ensured by the load-bearing structure or building, which is the structural system where loads of structures, such as the weight of the building itself and the living loads, are carried to the subsurface foundation through walls.

- A load-bearing structure is a part of a building that securely transfers the load to the subsurface foundation. Walls withstand the self-weight of a structure, the load of the roof, and the load of the floor.

- The most beneficial application of load-bearing is evident in this structural system, and it serves a variety of purposes, including sustaining loads, separating the area, insulating the building from heat and sound, etc.

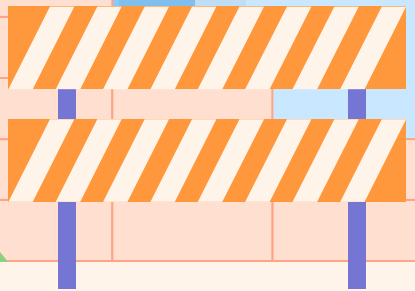


- The enormous weight of the walls contributes to holding the structure together and stabilising it against outside factors like earthquakes and wind.

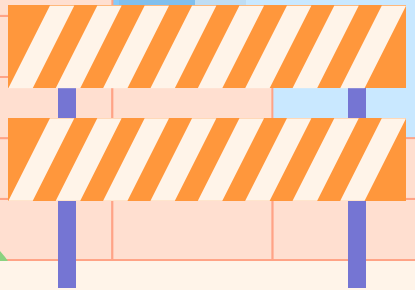


Disadvantages

- Buildings with up to three stories are best suited for this load-bearing structure.
- Compared to other construction techniques, load-bearing masonry structures require more man hours and take longer to build.



- Masonry structures don’t offer enough weatherproof thermal insulation.
- The placement of the walls cannot be changed after construction has begun.



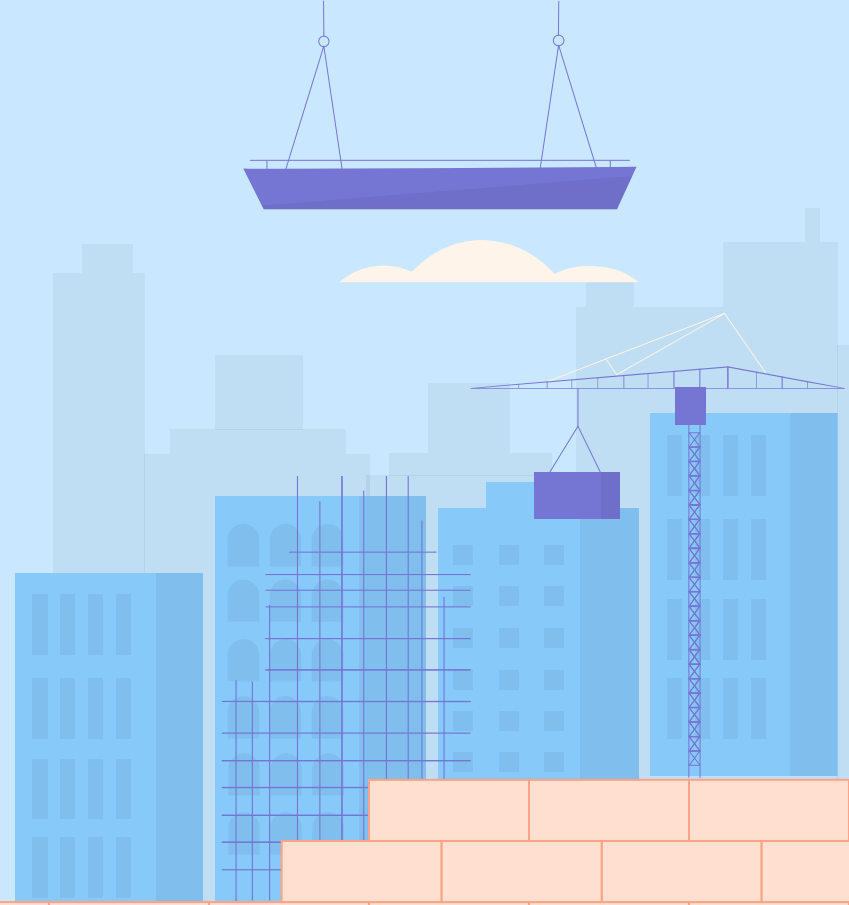
- The masonry walls' combined weight is heavy, which ultimately makes the building heavier overall.
- In comparison to frame structures, non-reinforced units are unable to withstand the high tensile and shear stresses, which results in poor resistance of masonry walls or poor performance against earthquake loads.

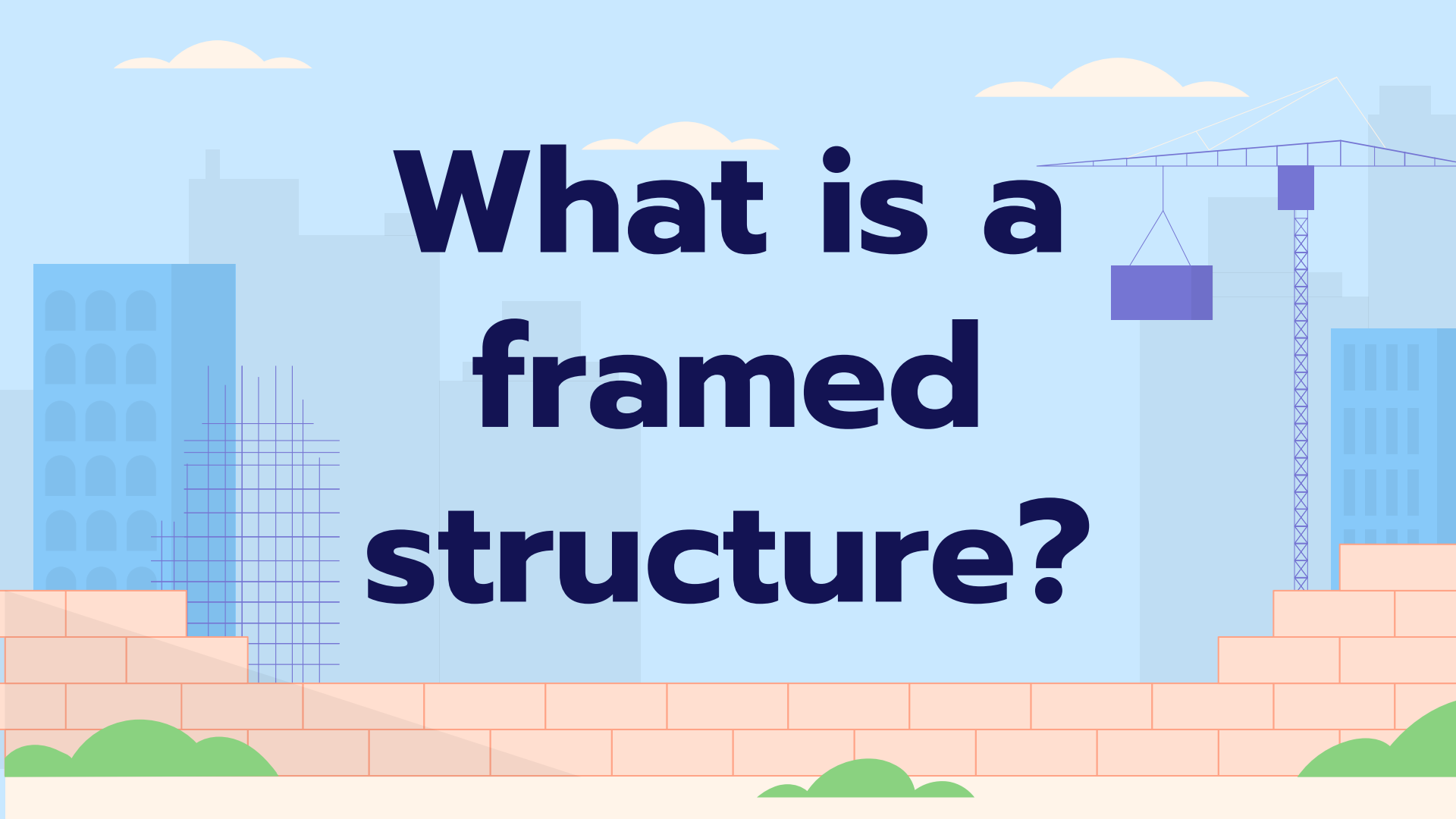
Load bearing structure
vs
Framed structure

Load bearing structures	Framed structures
These structures are suitable for 2 – 3 stories.	These structures are suitable for a large number of stories.
In this type of structures, structural system the path followed is: Slab >> Walls >> Foundation	In this type of structures, structural system the path followed is: Slab >> Beams >> Columns >> Foundation
Walls are thicker hence floor area is reduced.	Walls are thinner hence more floor areas are open for use.
After the construction of the structural movement of the walls are not possible.	The position of walls can be changed whenever necessary.
Almost all walls in the structure are provided with a foundation.	No wall is provided with any type of foundation and does not go below the plinth beam.
Walls are usually constructed with concrete, bricks or stone.	Columns supporting beams, beams supporting slabs, all are made up of RCC
Large-span areas are not possible.	There is no limitation for span areas
Resistance to earthquakes is poor	Resistance to earthquake forces is good
There is a limitation for the opening in the walls which affects the lighting and ventilation in the rooms.	Large openings in walls are possible.
The carpet area is reduced as we go down in multi-storey buildings due to an increase in the thickness of walls as we go down.	The thickness of the walls is uniform throughout the building, therefore carpet area remains the same.

Framed structures

By -Abhishek Kunwar




What is a framed structure?

A framed building is a structure formed by the framed elements usually in the form of columns and beams, as well as further strengthened as necessary by the introduction of rigid floor membranes and external walls to resist gravity and other lateral loads. These structures are generally used to overcome the large forces, moments developing due to the applied loading.

Components of framed structure

Frames are generally used in building and are composed of beams and columns that are either pinned or fixed connected, like trusses. Frames extend in two or three dimensions. Frames can be of any material i.e. RCC, steel, wood etc. In case of framed structure, the loads of floors, roofs and panel walls are supported by the beams which ultimately transmit these loads to the columns. In framed structure, load transfer path is from slab/floor to beam, beam to column and column to footing, i.e. to ground.

Column

A structure as a whole system is divided into number of different parts mainly comprising of footing, column, beam and slab. Columns are basically vertical members which span from substructure to superstructure and play a crucial role in transfer of load from top of structure to bottom footing.

Beam

A beam is a horizontal structural member in a building to resist the lateral loads applied to the beams axis. The structural member which resists the forces laterally or transversely applied to the (beam) axis is called beam.

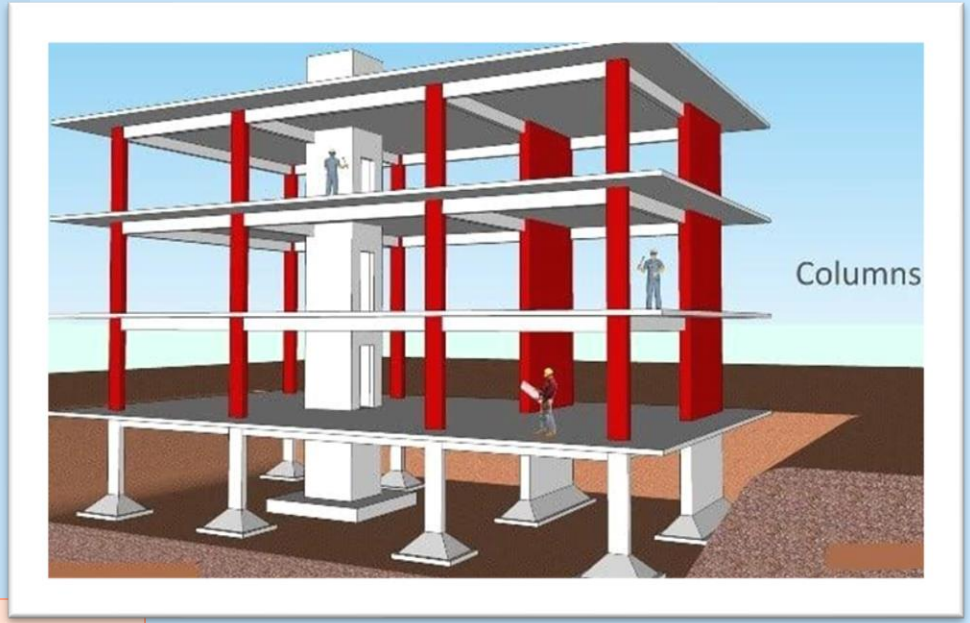
Advantages

- Speed construction due to simplicity in geometry-consist of only columns and beams as the main structural elements.
- Rigid and stable-able to resist tremendous vertical(dead load) and lateral loads(wind).
- Reduced dead load-absent of thick shear wall etc.
- Roofed over at a earlier stage-every floor slab being finished becomes an cover to protect the lower floors from sun and rain.
- Offer large unobstructed floor areas-without obstacle between columns
- Flexible utilization of space
- Easily altered within limits of frame-regular or non-regular grid system is very adaptable in spatial arrangement
- Offsite preparation possible-especially for prefabricated construction using precast concrete or structural steel elements

Disadvantages

- In frames structures, span lengths are usually limited when normal reinforced concrete (generally less than about 13 m , but up to about 15 m). Otherwise spans greater than that, can cause lateral deflections.
- Generally, frames are flexible structures and lateral deflections control the design process for buildings with greater than about 4 stories.

Thank you



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High Rise Building Technology & Load Transfer Mechanism

-Amitoj Singh

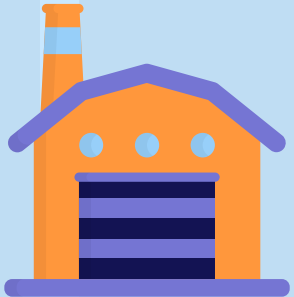
Content:

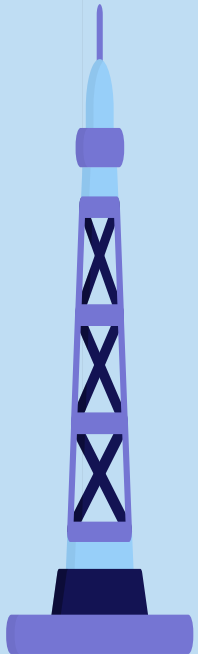
HIGH RISE BUILDING:

- DEFINITION & INTRODUCTION
- DEMAND FOR HIGH RISE BUILDING
- GEOGRAPHICAL DISTRIBUTION OF HIGH RISE BUILDING
- EVOLUTION OF STRUCTURAL SYSTEMS
- CONSTRUCTION METHODS
- CONSTRUCTION MATERIAL
- FOUNDATION TYPE

LOAD TRANSFER MECHANISM IN A STRUCTURAL SYSTEM:

- INTRODUCTION
- TYPES OF LOAD PATHS
  - ❑ Gravity load path
  - ❑ Lateral load path



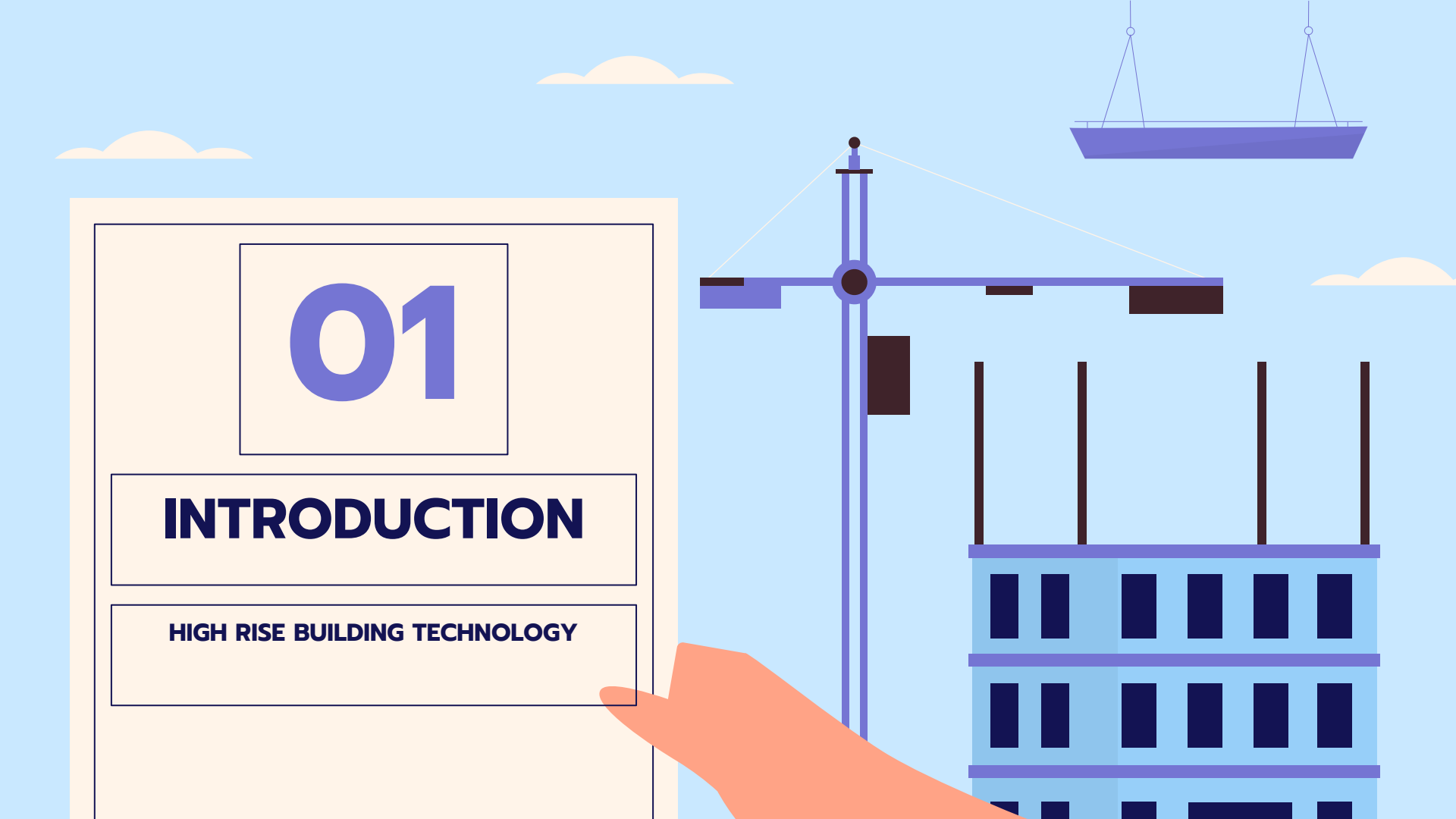


HIGH RISE BUILDING TECHNOLOGY

01

INTRODUCTION

HIGH RISE BUILDING TECHNOLOGY



HIGH RISE BUILDING TECHNOLOGY

High-rise building, also called high-rise, multistory building tall enough to require the use of a system of mechanical vertical transportation such as elevators. The skyscraper is a very tall high-rise building.

- **Emporis standards:** "A multi-story structure between 35-100 meters tall, or a building of unknown height from 12-39 floors is termed as high rise."
- **Building code of Hyderabad, India:** "A high-rise building is one with four floors or more, or one 15 meters or more in height."
- **The International Conference on Fire Safety:** “Any structure where the height can have a serious impact on evacuation"
- **Massachusetts United States General Laws:** "A high-rise is being higher than 70 feet (21 m)."

02

DEMAND FOR HIGH RISE BUILDING

HIGH RISE BUILDING TECHNOLOGY

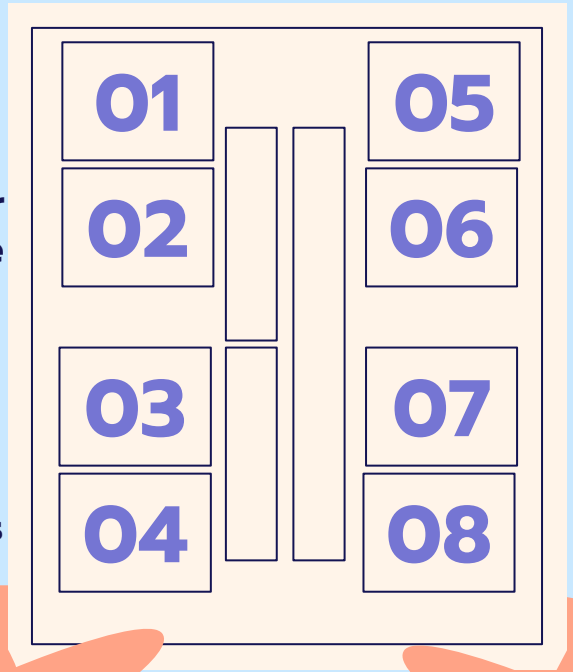
Demand for High Rise building

01 Scarcity of land in urban areas

02 Increasing demand for business and residential space

03 Innovations in Structural Systems

04 Technological advancements



05 Desire for aesthetics in urban settings

06 Cultural significance and prestige

07 Concept of city skyline

08 Human aspiration to build higher

03

GEOGRAPHICAL DISTRIBUTION OF HIGH RISE BUILDING

HIGH RISE BUILDING TECHNOLOGY

Geographical Distribution of High rise building

- Kingdom Tower, Jeddah: 1,000+ meters (3,280+ feet)
- Burj Khalifa, Dubai: 828 meters (2,717 feet)
- Ping An Finance Center, Shenzen: 660 meters (2,165 feet)
- Seoul Light DMC Tower: 640 meters (2,101 feet)
- Signature Tower, Jakarta: 638 meters (2,093 feet)
- Shanghai Tower, Shanghai: 632 meters (2,073 feet)
- Wuhan Greenland Center, Wuhan: 606 meters (1,988 feet)
- Makkah Royal Clock Tower Hotel, Makkah: 601 meters (1,972 feet)
- Goldin Finance 117, Tian Jin: 597 meters (1,957 feet)
- Lotte World Tower, Seoul: 555 meters (1,819 feet)
- Doha Convention Center and Tower, Doha: 551 meters (1,808 feet)
- One world trade centre, New York City: 541 meters (1,776 feet)
- Chow Tai Fook Guangzhou, Guangzhou: 530 meters (1,739 feet)
- Tianjin Chow Tai Fook Binhai Center, Tian Jin: 530 meters (1,739 feet)
- Dalian Greenland Center, Dalian: 518 meters (1,699 feet)
- Pentominium, Dubai: 516 meters (1,693 feet)
- Busan Lotte Town Tower, Busan: 510 meters (1,674 feet)
- Taipei 101, Taipei: 508 meters (1,667 feet)
- Kaisa Feng Long Centre, Kaisa: 500 meters (1,640 feet)
- Shanghai WFC, Shanghai: 492 meters (1,614 feet)

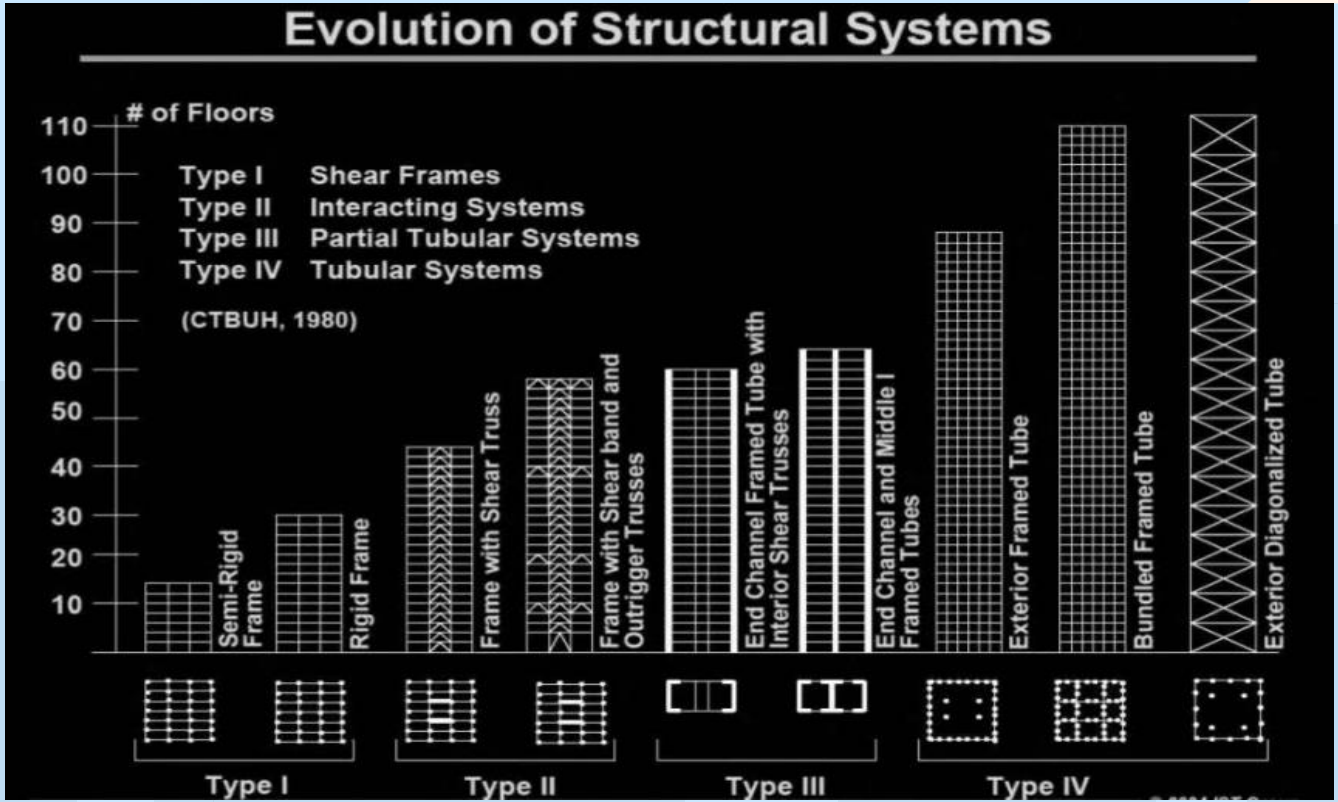
https://www.skyscrapercenter.com/tallest-in-2020

04

EVOLUTION OF STRUCTURAL SYSTEMS

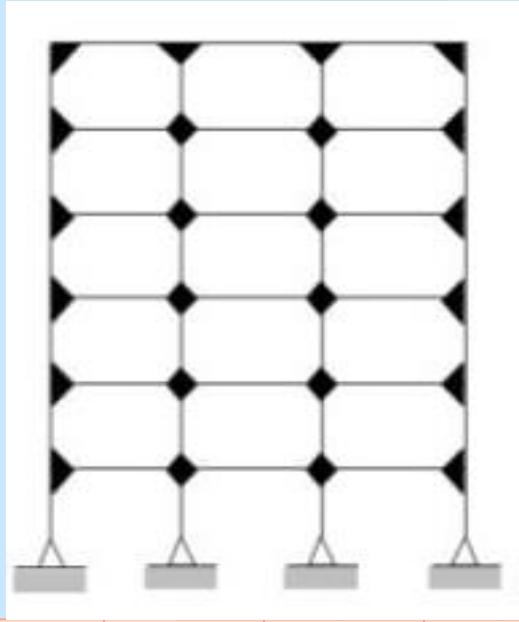
HIGH RISE BUILDING TECHNOLOGY

EVOLUTION OF STRUCTURAL SYSTEMS



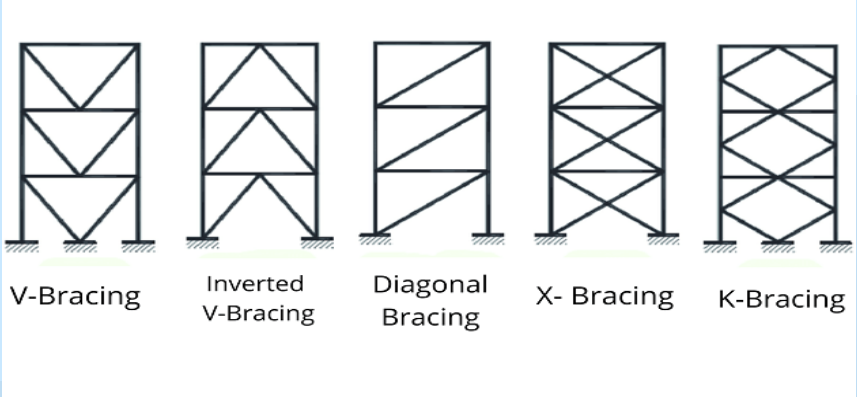
Shear Frame System

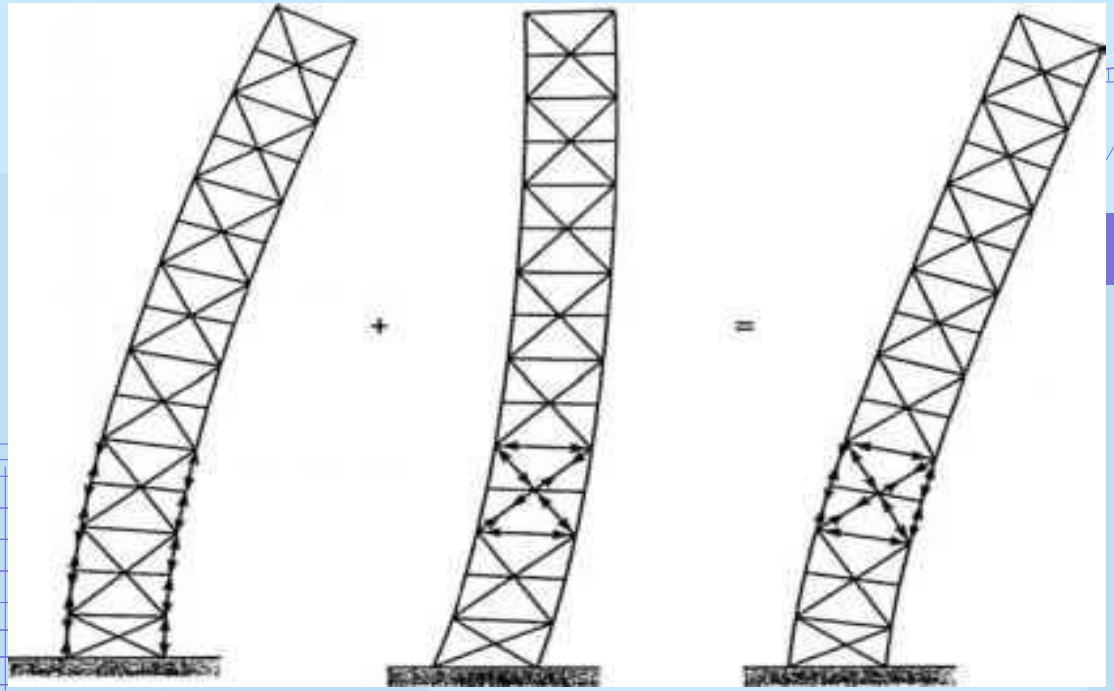
- Rigid joints are essential for stability
- Not effective for heights over 30 storeys
- Resists lateral deformation by joint rotation



Braced Frame System

- Lateral forces are resisted by axial actions of bracing and columns
    - More efficient than a rigid frame.
        - Steel bracing members or fill in bays.





Shear Wall System

- Shear wall is a structural member in a reinforced concrete framed structure to resist lateral forces such as wind forces. Shear walls are generally used in high-rise buildings subject to lateral wind and seismic forces. In reinforced concrete framed structures the effects of wind forces increase in significance as the structure increases in height. Codes of practice impose limits on horizontal movement or sway.

Limits must be imposed on lateral deflection to prevent:

- Limitations on the use of building.
- Adverse effects on the behavior of non-load bearing elements.
- Degradation in the appearance of the building.
- Discomfort for the occupants.

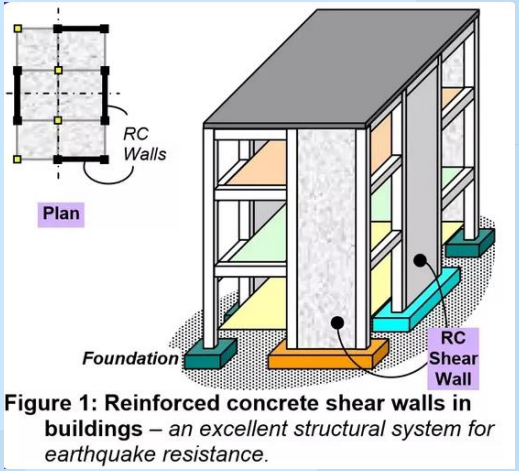


Figure 1: Reinforced concrete shear walls in buildings – *an excellent structural system for earthquake resistance.*

05

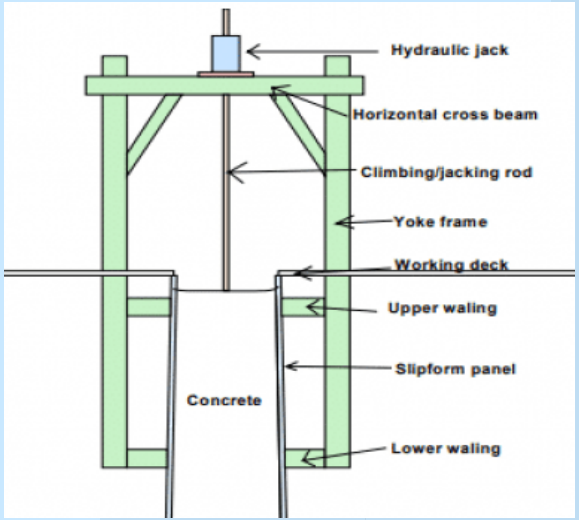
CONSTRUCTION METHODS & TECHNIQUES

HIGH RISE BUILDING TECHNOLOGY

CONSTRUCTION METHODS & TECHNIQUES

1). Slip form construction

Slipform construction technique is an alternative for conventional formwork system which helps in continuous vertical and horizontal construction. The slipform helps to conduct continuous pouring of the concrete to the moving formwork. The process stops only when the required length of casting is completed. The property of cement and concrete to gain sufficient strength to stay in shape once cast within the initial setting time of 30 minutes lead to the development of slip form construction technique. The height of the formwork is designed such a way that, during the pouring of the upper level formwork, the concrete poured in the below formwork would have gained initial setting. The concrete exposed when the formwork moves up will remain firm.



CONSTRUCTION METHODS & TECHNIQUES

2). Climb form construction

Climbing formwork, also known as jump form, is a special type formwork for vertical concrete structures that rises with the building process. While relatively complicated and costly, it can be an effective solution for buildings that are either very repetitive in form (such as towers or skyscrapers) or that require a seamless wall structure (using gliding formwork, a special type of climbing formwork).

Various types of climbing formwork exist, which are either relocated from time to time, or can even move on their own (usually on hydraulic jacks, required for self-climbing and gliding formworks).

CONSTRUCTION METHODS & TECHNIQUES

3). Table form construction

Table formwork is used for the concrete pouring of wall. The application of large areas formwork has greatly increased the construction efficiency and reduced the cost. The system is convenient for construction and it is easy to control the quality. The system has two parts, formwork and pull-push props. The formwork is made of plywood, timber beam and steel waling. Pull-push props can be designed according to the project or simply select the standard props. Tie-yoke and tie-rod are used to reinforce the corner. Timber beam formwork is a highly efficient and convenient system for medium area slab project. They can be transported to next position as whole table units whether by trolley or by crane lift.

- **Main features of table formwork:**

For any storey heights and slab thickness.
Fast in transportation and concrete casting due to pre-assmebled table unit.
Thus save more than a half time & labor cost compared with slab flex 20 formwork.
Can choose shoring props or towers according to different loadings and height.

CONSTRUCTION METHODS & TECHNIQUES

4). System column formwork

These are designed for specific maximum concrete pressures. The concrete placement rates have to be adjusted to keep the concrete pressure within the specified limits. The assembled formwork has to be restrained at the base properly to avoid displacement, and grout loss during concreting.

Column formwork is a type of concrete formwork. Concrete formwork is a mold made of steel, aluminum, timber, plastic, or other materials in which wet concrete is poured to achieve a desired shape and size for construction.

CONSTRUCTION METHODS & TECHNIQUES

5). Vertical Panel system

Crane-lifted panel systems are commonly used on building sites to form vertical elements and usually consist of a steel frame with plywood, steel, plastic or composite facing material.

The systems are normally modular in nature, assembly times and labor costs are considerably lower than traditional formwork methods with far fewer components required. They offer greater opportunities for reuse for different applications on site. Panel systems are extremely versatile and the larger crane-lifted versions can be used for constructing standard concrete walls, perimeter basement walls, columns and in conjunction with jump form climbing systems.

06

CONSTRUCTION MATERIALS

HIGH RISE BUILDING TECHNOLOGY

CONSTRUCTION MATERIALS

The structural materials used in high-rise buildings are typically one or a combination of (reinforced or pre-stressed) concrete, structural steel and composite systems.

Structural material systems for high-rise buildings should be chosen by carefully considering architectural, economical and site factors. The economic drivers vary by geography as the relative costs of material, labour, time and space vary from one location to another. Other factors to consider in choosing the structural material include:

- Local market preference/availability;
- Project size/height;
- Building form (regular vs complex);
- Design considerations (fire performance, dynamic performance,
- Adaptability, and the like);
- Site location/access; and speed of construction.

Preferences and the economic viability of the different structural materials that are used in tall buildings' construction are also changing.

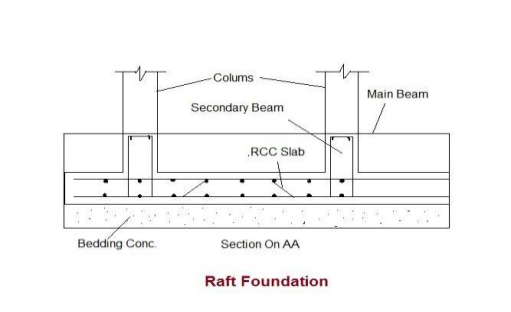
Driving economic design in the construction of high-rise buildings isn't the same all over the world. What is cost-effective in one country won't necessarily be cost-effective half way around the world. Materials, labour cost, the value of time and the value of space all need to be carefully weighed in order to drive economic design.

07

FOUNDATION TYPE

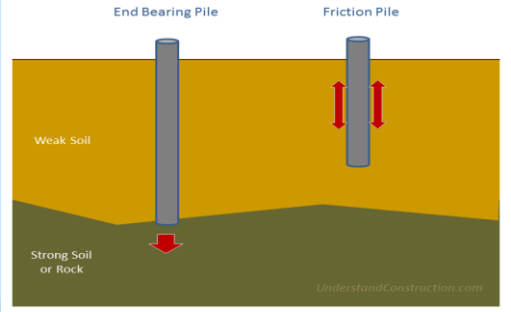
HIGH RISE BUILDING TECHNOLOGY

FOUNDATION TYPE



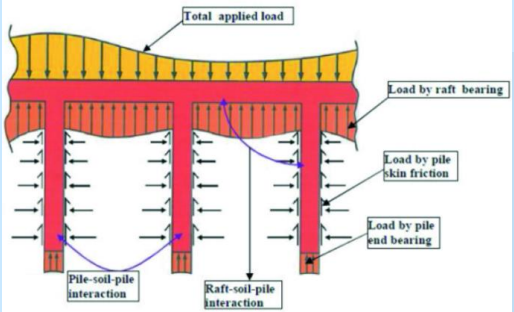
RAFT FOUNDATION

A raft foundation is a reinforced concrete slab under the whole of a building or extension, 'floating' on the ground as a raft floats on water. This type of foundation spreads the load of the building over a larger area than other foundations, lowering the pressure on the ground



PILE FOUNDATION

Pile foundations are deep foundations. They are formed by long, slender, columnar elements typically made from steel or reinforced concrete, or sometimes timber. A foundation is described as 'piled' when its depth is more than three times its breadth.



COMBINED RAFT AND PILE

The piled raft is a foundation constructed by combining both the piles and a raft foundation. Firstly, the piles are constructed and then the raft is placed combining all the piles.

Interaction of the pile, soil, and raft is the key factor considered in designing the piled raft foundation. The efficient use of the interaction leads to end up with the economical design.

08

ADVANTAGES & DISADVANTAGES

HIGH RISE BUILDING TECHNOLOGY

ADVANTAGES & DISADVANTAGES OF HIGH RISE BUILDINGS

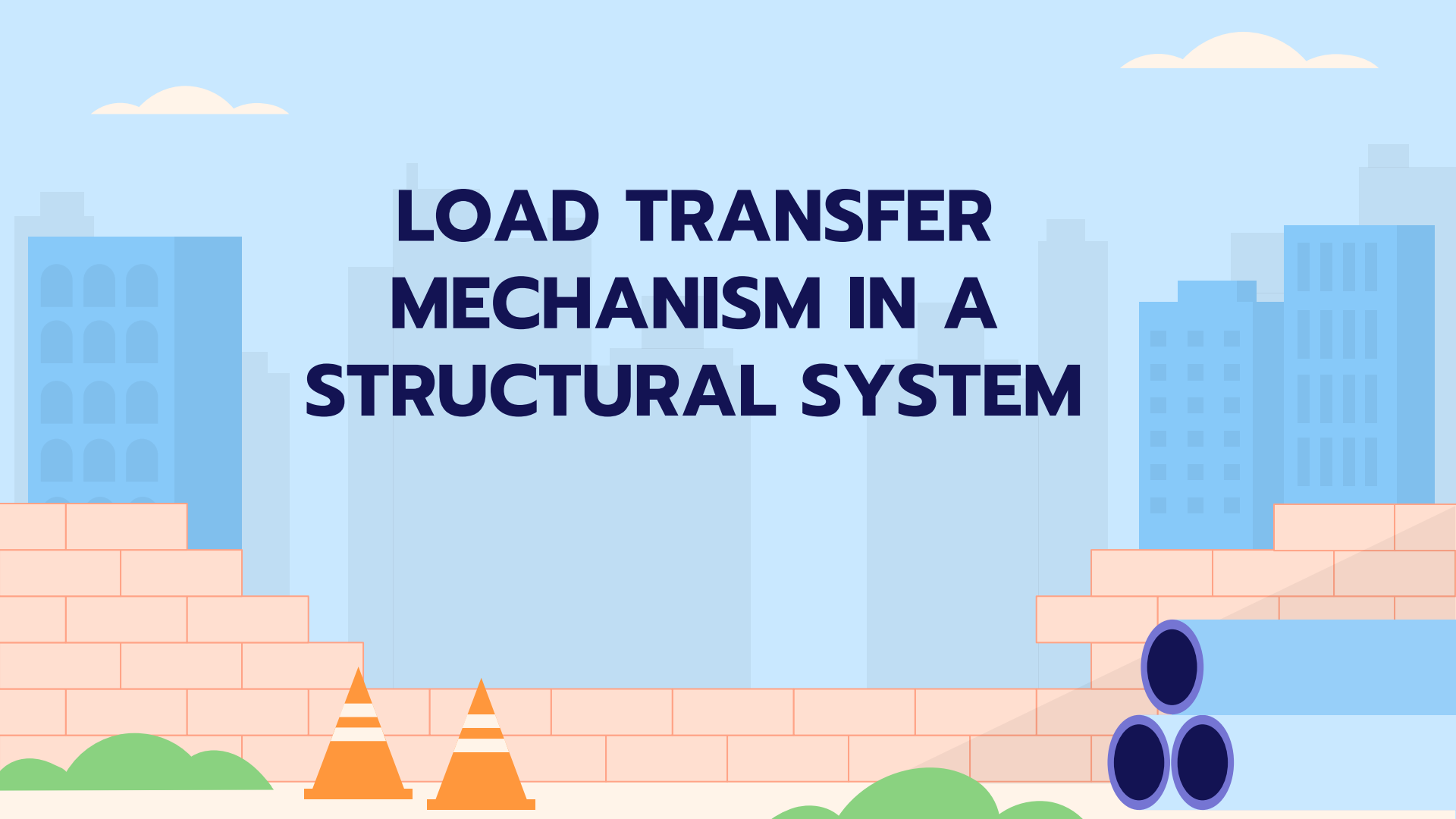
Advantages:

- They save space and accommodate more residents as compared to shorter buildings.
- The higher floors are relatively more airy and receive more sunlight.
- Taller buildings are a better option for the idea of a green building since they are more lit, airy and provide more surface area to install solar panels.
- They are much more economical as buying a small land and constructing a tall building is more affordable than purchasing a widespread land.

Disadvantages:

- The construction of very tall buildings requires highly skilled engineers and architects to design the building, thus increasing the total cost.
- Very tall buildings bear wind forces and seismic forces apart from dead and live loads.
- Buildings above 100 story height face the problem of oscillation, sometimes resulting in crashing of windowpanes.
- The foundations of very tall buildings with smaller construction land are under tremendous load and failing of soil may lead to collapse of the building.
- Constant oscillations may give a nauseating feeling to the residents of the building.

LOAD TRANSFER MECHANISM IN A STRUCTURAL SYSTEM



01

INTRODUCTION

LOAD TRANSFER MECHANISM IN A STRUCTURAL SYSTEM

LOAD TRANSFER MECHANISM IN A STRUCTURAL SYSTEM

The process of transfer of exposed load from one structural element to the other structural element is called as load transfer mechanism. Load transfer mechanism basically depends on the elements on which load transfers, this is referred to as load path. Based on the load path the pattern of load transfer mechanism varies which in turn depend on the type of load which the structure has to transfer.

Generally there are two types of load paths:

1. Gravity load path
2. Lateral load path

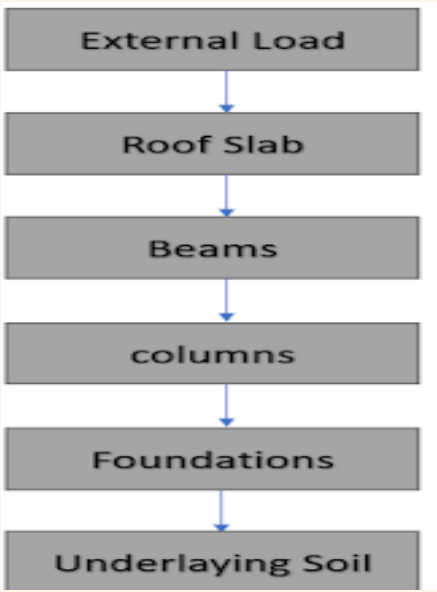
02

GRAVITY LOAD PATH

LOAD TRANSFER MECHANISM IN A STRUCTURAL SYSTEM

GRAVITY LOAD PATH

In this type of load path the vertical gravity load; which includes the dead load of the structure and live load on the structure acts on the slab are efficiently transferred to beams, from beams it is then transferred to columns and from columns to the supports, finally from the supports to the underlying earth.



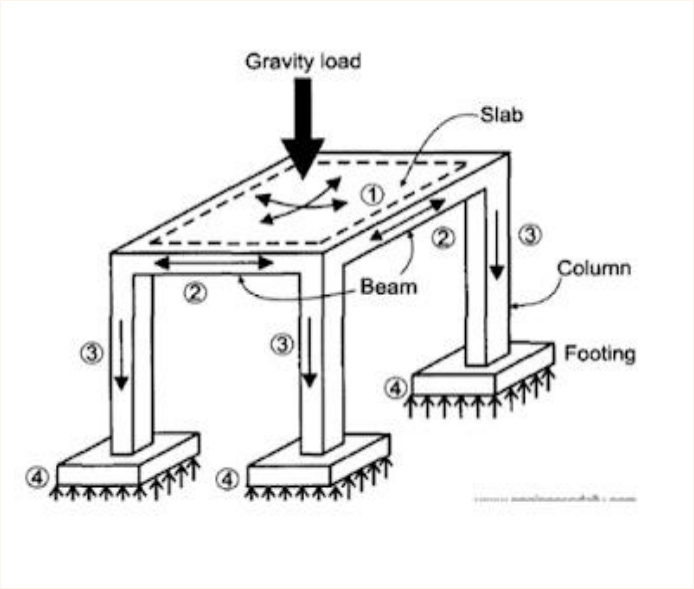
GRAVITY LOAD PATH

Pattern of load transfer in gravity load path

- In case of transfer of the load from slab to the adjacent beams the triangular or trapezoidal pattern is followed, which in turn causes additional torsional moment on the beam at its ends.
- The loads received by the slabs on the beams at the joints will causes in bending of the beam and the results to form 3 reactions at its end position

1. One in vertical direction - acts as an axial load on the neighboring column.
2. One in horizontal direction – acts as a shear force on the neighboring column.
3. Moment at the end of the beam - acts as a bending moment on the neighboring column.

- The loads on the columns transfer to the supports efficiently and further to the foundation soil. The structure can be said to be stable if the upward pressure by the foundation soil is equally resisted by the load on the structure.



03

LATERAL LOAD PATH

LOAD TRANSFER MECHANISM IN A STRUCTURAL SYSTEM

LATERAL LOAD PATH

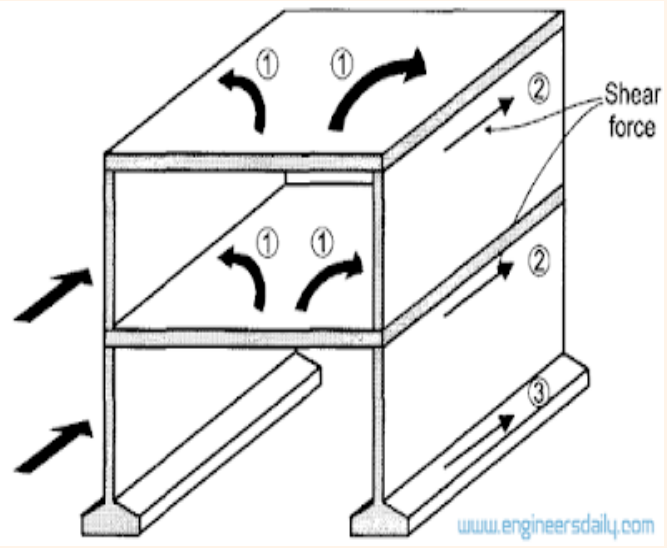
LATERAL LOAD PATH:

In this type of load path the lateral loads; which are the earthquake loads and wind loads are transferred efficiently through the building. The components of the lateral load paths are

- Horizontal components such as roof, floor and foundation.
- Vertical components such as shear wall and frames.

Pattern of load transfer in lateral load path:

- Roofs and floors which are also called as diaphragms; transfers load to the shear walls(also termed as the primary load resisting elements).
- Shear walls can also resist the gravity loads efficiently and further transfers the collective load to the foundation; inturn foundation collects loads from all the stories and then transfers it into the underlying soil.

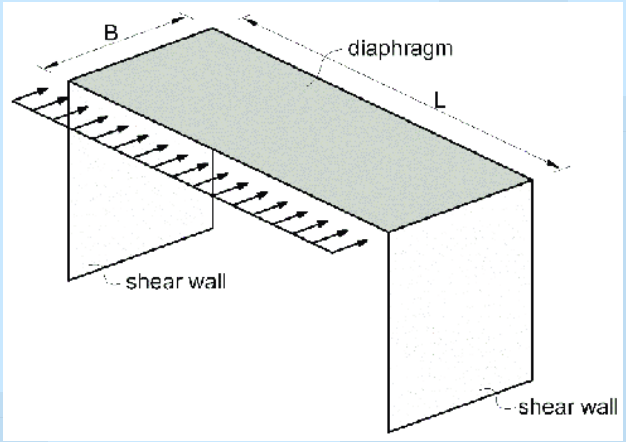



04
DIAPHRAGM FLOOR

Diaphragm Floor

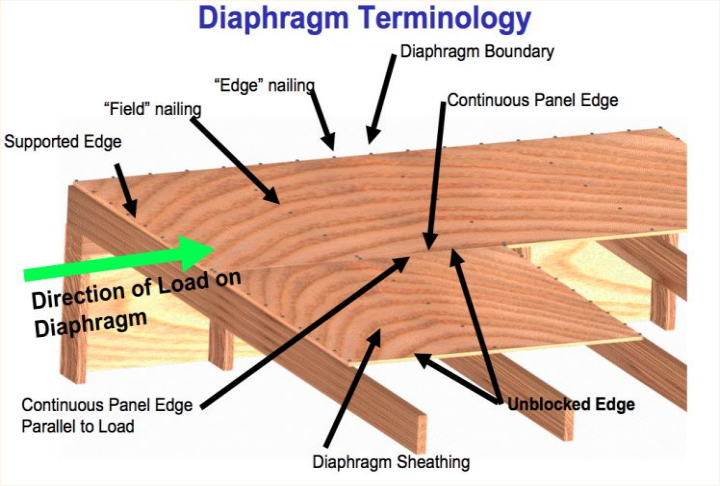
A horizontal system (roof, floor or other membrane or horizontal bracing) acting to transmit lateral forces to vertical-resisting elements. The floors and roof of a building, in addition to resisting gravity loads, are also generally designed to act as diaphragms, a diaphragm is a structural element that transmits lateral loads to the vertical resisting elements of a structure.

In this respect, they are required both to distribute seismic forces to the main elements of horizontal resistance, such as frames and shear walls, and also to tie the structure together so that it acts as a single entity during an earthquake. The robustness and redundancy of a structure is highly dependent on the performance of the diaphragms. Precast floors without an in-situ topping are not generally recommended in seismic areas.



Diaphragm Floor

In a ductile structure, diaphragms will almost always be required to remain elastic, so that they can sustain their function of transferring forces to the main lateral-resisting structure, and tying the building together. Diaphragms should in principle therefore have the strength to sustain the maximum forces that may be induced in them by the chosen yielding mechanism within the rest of the structure.



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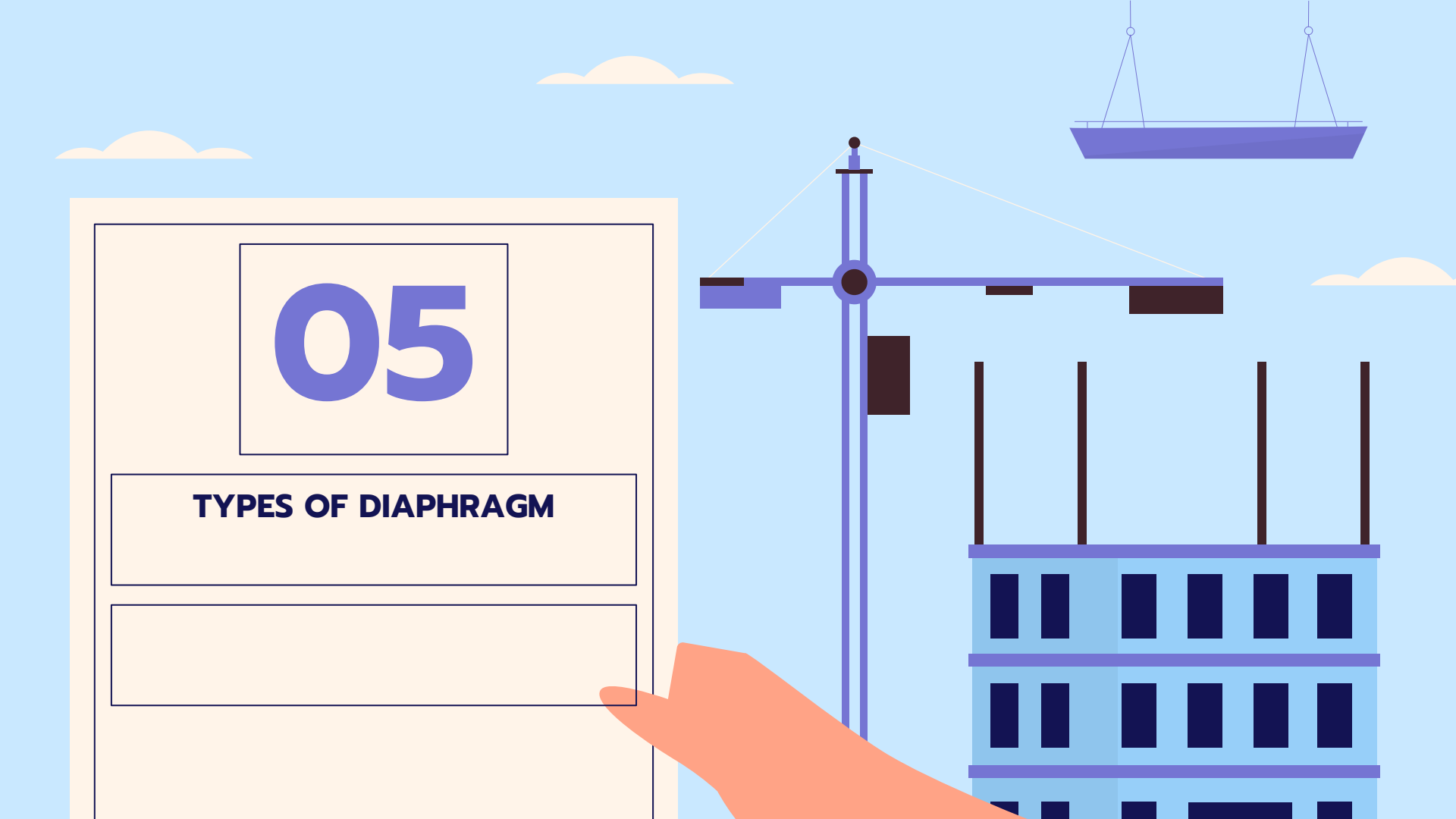
TYPES OF DIAPHRAGM



TYPES OF DIAPHRAGM

Rigid Diaphragms: A diaphragm may be considered rigid when its midpoint displacement, under lateral load, is less than twice the average displacements at its ends. Rigid diaphragm distributes the horizontal forces to the vertical resisting elements in direct proportion to the relative rigidities. It is based on the assumption that the diaphragm does not deform itself and will cause each vertical element to deflect the same amount. Rigid diaphragms capable of transferring torsional and shear deflections and forces are also based on the assumption that the diaphragm and shear walls undergo rigid body rotation and this produces additional shear forces in the shear wall.

FLEXIBLE DIAPHRAM: Roofs or floors including, but not necessarily limited to, those sheathed with plywood, wood decking, or metal decks without structural concrete topping slabs. Metal decks with lightweight fill may or may not be flexible. Diaphragms are considered flexible when the maximum lateral deformation of the diaphragm is more than two times the average story drift of the associated story. A diaphragm is considered flexible, when the midpoint displacement, under lateral load, exceeds twice the average displacement of the end supports. It is assumed here that the relative stiffness of these non-yielding end supports is very great compared to that of the diaphragm.

Quiz

- **Which frame structure is more stable?**
  - Shear Frame System
  - Braced Framed System
- **What is shear Wall?**
- **As per CTBUH, which type of structural system is used to construct the building with more than 100 floors?**
- **What is Slip form construction technique?**
- **What is load path, and types of load path?**

THANKS!!

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