Structural Forms Systems for Tall Building Structures

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ABSTRACT: *The term structural form systems in structural engineering refers to lateral load-resisting system of a structure. The structural forms employed in the high-rise structures transfers loads through structural components which are connected with each other in an efficient manner. The commonly used structural forms can be classified into different categories, depending on the type of stresses that may arise in the structural members due to the application of loads. Sometimes two or more of the basic structural forms may be combined in a single structural form systemto form a hybrid system in order to meet the structures operational requirements.*

The structural system of a tall building is designed to deal with vertical gravity loads and mainly the lateral loads caused by wind and seismic activity. The structural system consists of only the members designed to carry the loads, all other members which does not participate in carrying loads are referred as non-structural members.

From the point of view of structural engineer, the determination of the structural systemfor a tall building structures would ideally involve the selection and arrangement of the major structural elements to resist most efficiently the various combinations of gravity and lateral loading. A major consideration affecting the structural system is the intended function of thebuilding which a building is going to serve.The paper reviews some of themajor types of structural form systems employed for modern tall buildings structures.

Keywords-*Introduction, Braced-Frame Structures, Framed Tube Structures, Outrigger-Braced Structure, Shear Wall Structures.*

1. Introduction

A ‘tall building’ or ‘high-rise building’ is a building whose height creates different conditions in the design, construction and use than those that exist in common buildings of certain region and period[1]. The tallness of a building is a matter of a person’s or community’s perception therefore, a particular definition of a tall building cannot be universally applied.Tall building structures frame requires special structural arrangements, if they are subjected to appreciable lateral loads such as high wind pressuresand earthquake loadings. In modern era, tall buildings structures are in great demands because of the following reasons which are as follows :

- Scarceness of land in urban areas
- Greater demand for business and residential space
- Economicalemergence
- Technical advancements
- Innovations in Structural Systems
- Desire for aesthetics in urban areas
- Cultural significance and prestige
- Human ambitions to build higher

Tall buildings are subjected to various types of loads during its service life time. It must be so designed to resist the gravitational and lateral forces, both permanent and transitory, that will be called on to sustain during its construction and subsequent service life. Major loads of which a tall building structures are subjected to are given below :

- Gravity loads
  - Dead loads
  - Live loads
- Lateral loads
  - Wind loads
  - Seismic loads
- Special loads
  - Impact loads
  - Blasts loads

Below figure (Fig.1) shows the different structural forms systems which are adopted in tall building structures of different height.

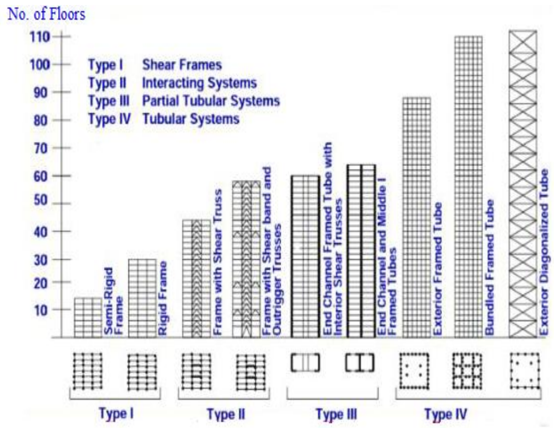


Figure 1 Different structural form for different heights of structure

2. Braced-Frame Structural System

This system is used in steel construction, it is both an efficient and economical way for improving the lateral stiffness and resistance of rigid frame system. The bracing will almost eliminate the bending of columns and beams by resisting lateral loads primarily through axial stress, thus allowing for slenderer elements. In braced frames the lateral resistance of the structure is provided by diagonal members that together with the girders, form the "web" of the vertical truss, with the columns acting as the "chords"[2]. A very well known example of braced frame structural system can be seen in the Empire State Building.

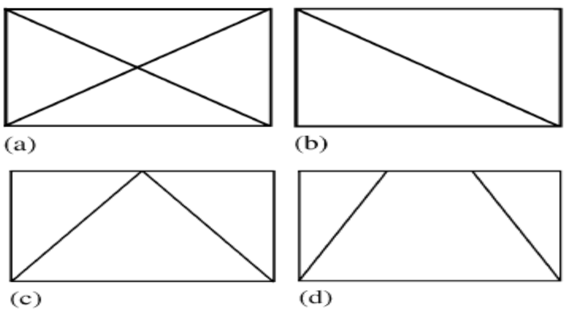
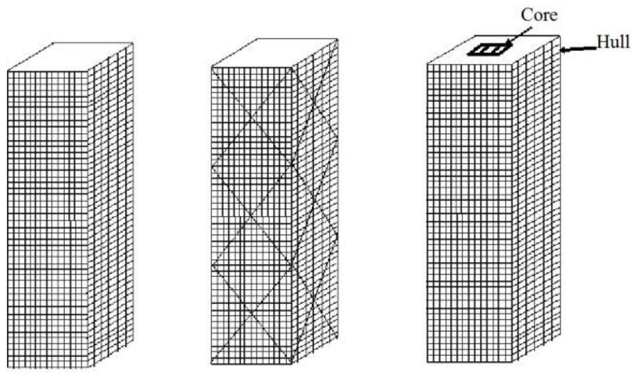


Figure 2(a) Double diagonal (b) Single diagonal (c) Chevron (d) Storey height knee

3. Framed Tube Structural System

The 'tube' system evolved from a quest to develop a bracing configuration that would place as much gravity load on the exterior columns as possible to help counter the overturning effects of lateral loads while taking advantage of exterior column's large distance to the neutral axis to resist bending moment. The solution was to create a system in which the exterior frames encircling the structure would be rigid enough to behave as nearly as possible like a three-dimensional vertical cantilever.

The "Framed Tube" structural system in tall building structures has been widely used in resisting a wide range of lateral loads. It usually consists of closely spaced wide exterior columns connected at each floor level with relatively deep spandrel beams through moment connections[1]. This tubular concept is generally economically attractive,possesses torsional rigidity, and also provide greater flexibility in space planning since most framed columns are located at the perimeter of the building.A well known example of framed tube structural system is World Trade Centerwhich is 110 story high structure.



(a) (b) (c)

Figure 3 (a) Frame Tube (b) Braced-Frame Tube (c) Tube-in-Tube

4. Outrigger-Braced Structural System

Outrigger are rigid horizontal structures designed to improve building overturning stiffness and strength by connecting the core or spine to distant columns[3].Outrigger systems functions by tying together two structural systems- typically a core system and a perimeter system to yield whole structural behaviors that are much better than those of componenet system.

The benefits of an outrigger system lies in the fact that building deformations resulting from the overturning moments get reduced, on the other hand greater efficiency is achieved in resisting forces. Outrigger engages the perimeter columns in lateral load resisting action which would otherwise acts as a gravity load resisting elements.

Outrigger system performance is affected by outrigger locations through the height of the building, the number of levels of outrigger provided, their plan locations, outrigger truss depths and the primary structural materials used[3].

Outrigger systems may be formed of any combination of steel, concrete and composite constructions. This structural form system also helps in reduction and possibly the elimination of uplift and net tension forces throughout the columns and foundations.

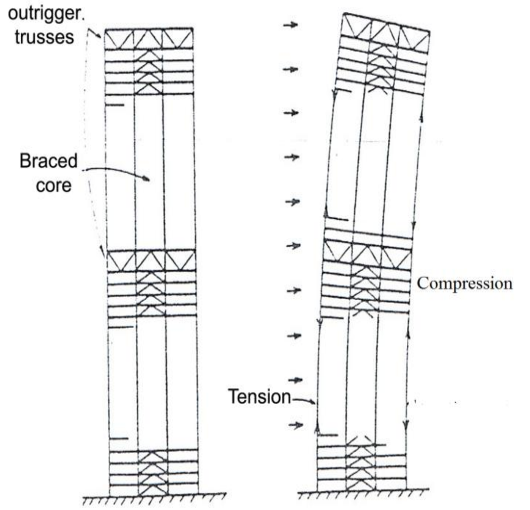


Figure 4 Outrigger Braced System

5. Shear Wall Structural System

Concrete or masonry continuous vertical walls may serve both architecturally as partitions and structurally to carry gravity and lateral loading. Their very high in plane stiffnessand strength makes them ideally suited for bracing tall building structures[2]. Because of their stiffness, shear wall structural system can be economical upto 35 stories building structure.
It is especially important in shear wall system to try to plan the wall layout so that the lateral load tensile stresses are suppressed by the gravity load stresses[2].

Shear walls are usually provided along both length and width of buildings. Shear walls are like vertically-oriented wide beams that carry earthquake loads downwards to the foundation.. Such a wall acts as a beam cantilevered out of the foundation and just as with a beam, part of its strength derives from its depth.

Although not as efficient from a strictly structural point of view, interior shear walls do leave the exterior of the building open for windows which is a more realistic situation because both wind and earthquake forces need to be resisted in both directions. Shear walls need not to be symmetrical in plan, but symmetry is preferred in order to avoid torsional effects.

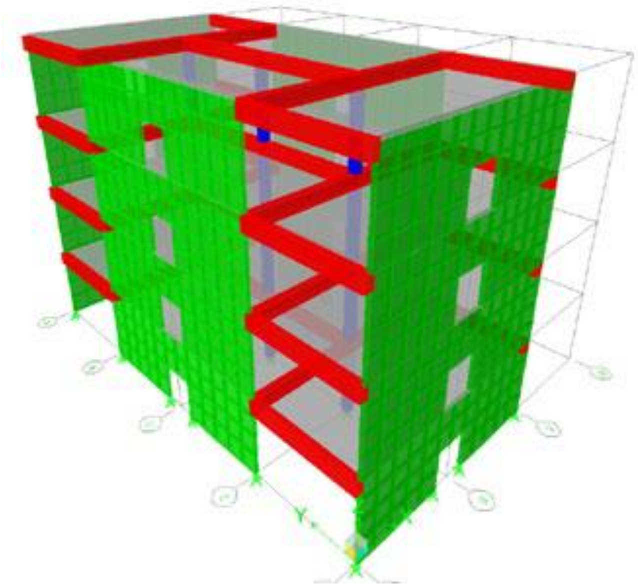


Figure 5Shear Walls(shown in green panels) along the outer perimeter of building

6. Conclusion

Having presented briefly some of the major structural forms systems employed in tall building structures, a fair conclusion can be drawn on theirimportance in the performance of tall building structures. Since, tall buildings enjoys rapid evolution and new innovations and with the development of increasingly taller buildings structures serviceability issues like lateral sway, floor vibration, and occupant comfort need to be given more attention.As the height of the building increases, lateral forces plays a dominant role. Therefore, certain provisions shall be made in order to resist these lateral forces so that building performance under the effect of lateral loadscan be improved.

References

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