Comparative Study of Various High Rise Building Lateral Load Resisting Systems for Seismic Load & Wind Load: A Review

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Abstract -*The lateral load has significant importance in architecture in new high-rise structures, as building height rises, the lateral load becomes more dominant than building gravity load or vertical load. The high-rise building works on lateral loads such as wind load and seismic load. Various lateral load resisting devices resist these loads. In this study article, various kinds of lateral load resisting systems are discussed in contrast. The key aim of the analysis is to determine the most efficient and economical device that can withstand wind and seismic loads. An effort has been made to compare different lateral load resistant structures such as Shear wall, Outrigger, RC frame with braces, diagrid system, frame tube system, etc. based on literature analysis.*

Key Words: *High rise building, Seismic load, Wind load, Rigid Frame Systems, Bare frame, Diagrid, Shear wall, Bracing, etc.*

• INTRODUCTION

A multi-story is a structure in which the building has several levels above ground. The aim of multi-story buildings is to lift the Without raising the area of the ground on which the building is designed, the floor area of the building thus saves land and, in most instances, Money-Cash (depending on the material used and land prices in the area). More productive use of the land area, particularly where space is used, is It's constrained or costly. A more gain is reduced building costs per square foot of floor area. Sometimes, the upper floors are only a repeat of the lower floors. Upper floors are freer of sounds, fumes, and dirt from the streets. The biggest concern in the world of architecture Multi-storey architecture should have a strong lateral load resistance system along with a gravity load system since it also controls the lateral load resistance system. Hey. Architecture. When a tall building, under the action of fluctuating lateral loads, is subjected to lateral or torsional deflections, a large spectrum of responses in the building can be triggered by the resulting oscillatory action. As long as the final limit state is a concern, lateral deformations can be reduced to stop the second-order p-delta effect due to the extent of gravity loading that could be necessary to precipitate failure.(Kondepudi 2015)

It has been imperative for structural engineers to build because of the growing need for high-rise structures. A system that can tolerate lateral forces that act on it. Two kinds of lateral forces act on a high-rise, primarily Building Design. The seismic force is one, and the wind force is another. Seismic power, in general, is more prevalent. Force of the storm if the height of the building reaches twice the usual dimension of the wind, that is taken into consideration. So, where, uh, when Together, forces work on a structure, strong shear forces and bending moments coins in structural elements that affect structure components A fault of theirs. The secret to dealing with this topic has already been discovered in developments in civil engineering. Similar forms of Resistance mechanisms have been implemented that can withstand these forces and pass them to the soil safely. Death load, live load, and snow load are the most common loads originating from the effects of gravity. In addition to these vertical loads, buildings are often exposed to wave, blast, or earthquake lateral loads. Lateral loads may create elevated pressures, swaying motion, or induce vibration. It is also very important for the structure to have ample vertical load strength along with enough stiffness to withstand lateral forces. The types of lateral force resistance structures used in this paper are braced core, coupled shear wall, belt outrigger, shear core, shear wall, peripheral bracing. Proper research is conducted to assess the productive scale of components such as columns, braces, etc.(Gupta 2016)

Throughout the ancient tall towers, which could be regarded as examples of recent-day high-rise buildings, they were inherently defensive or symbolic and were seldom used. Tall buildings were mostly strong, acting more as monuments than as enclosures in space. People have had to make use of the available construction materials throughout history. For example, the Pyramid of Cheops was constructed by piling enormous masonry and timber, which was used in building in the early centuries. The stretches that could be bridged by wood and stone, such as beams, lintels, or arches, were reduced. For large walls, timber was not sturdy enough, nor did it have fire-resistant qualities. Despite their outstanding strength and fire resistance, brick and stone masonry suffered from the limitation of weight. Compared to the gross floor size, the mass of masonry used to support the weight of a structural feature, i.e., columns, walls, and braces, was disproportionately high. This proportion was at the pyramids' highest worth.(Vijaya and Reddy 2018)

The construction of multi-story buildings in the last few decades is seen as part of the need attributable to the success of Tall Building. For vertical expansion in the leading downtown area for residence and business. Tall Building Infrastructure includes the use of various Systems for various height ranges of buildings, above which a separate system is needed. The need for these programs and their respective mechanisms Application ranges and the premium that will result in their ranges being expanded are necessary for a broad solution to be effective. Building Design. In order for the construction to be at least successful, the structure should use structures and materials suitable for the building. Configuration and height. To comply with the protection and least depreciation structure requirement of Tall building should be necessary Uctile, rigid and of tolerable side strength. A structural device that resists loads due to RCC's seismic and wind effects Analysis requires a framed form. For medium high-rise RCC construction, among various structural systems, RCC shear wall frame or Steel braced frame may be the choice for designers. Different work on the impacts of Steel Bracing and Shear Wall on seismic efficiency on normal and irregular buildings have been performed in the past. These structural structures are also interested in the research and study of seismic impact results.(Vishwakarma 2018)

The "Shear-wall" is referred to as a wall that is subject to lateral loads in its plane. The degree to which the lateral load on the frame is shared by this wall is controlled by the wall's stiffness and strength characteristics. The shear-wall increases frame strength, stiffness, and ductility. As far as high-rise architecture is concerned, the word shear-wall is simply a misnomer. The shear-walls are designed to withstand earthquakes and wind-driven lateral forces. They may be used as outer, internal, or elevator shafts or stair-case enclosure cores. These shear-walls may be of any form as seen in Fig, such as rectangle, slope, channel, and broad Fig. 1. The shear-walls in frame buildings are most widely used as lateral load resisting materials. The action of shear-walls depends on their ratio of height to width, and the shear-wall may be squat or thin based on the height to width ratio. Shear controls the design of squat shear-walls, while flexure controls the design of slender shear walls. In flexure mode, the slender walls are most widely used and mainly deformed like a free-standing cantilever, as seen in Fig. 2.(Vishwakarma 2018)

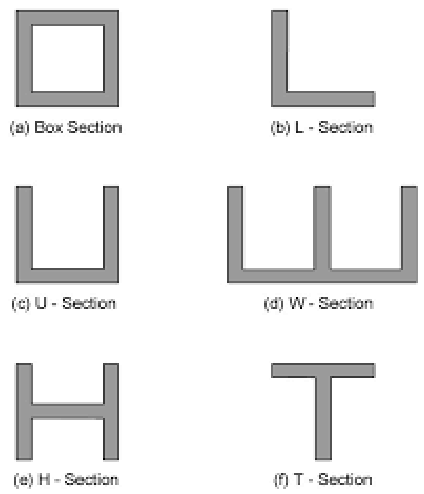

Fig. 1 Shapes shear walls.

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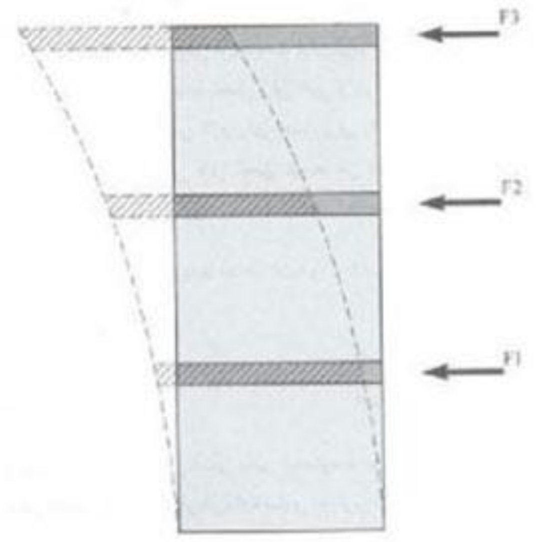

Fig. 2 Deformed shape of shear-wall under lateral load

https://www.google.com/url?sa=i&url=http%3A%2F%2Fwww.cwejournal.org%2Fvol10noSpecial%2Finvestigation-of-rc-shear-wall-dimensions-and-arrangement-on-the-rc-structure-seismic-behavior%2F&psig=AOvVaw3tNOSr1RSXM_Sq2eM3Bize&ust=1609562968113000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCMDv_7D5-e0CFQAAAAAdAAAAABAD

There's a shortage of land for the purpose of building nowadays. This is why the market for high-rise buildings is growing. If the height of the building is elevated, the lateral load impact is increased. To solve this, the safest high-rise building construction method is tubular structures. There are various types of tubular systems, such as the Framed Tube system, Tube-In-Tube system, Bundled Tube system, Braced Tube system, Tube System, Super Frame Tubing. The Tube-In Tube construction of these forms is more stable under lateral load, allows for more internal space, and helps save 30 percent of steel. There are typically systems of steel, concrete, and composites. The-In-Tube Tube The arrangement consists of an outer peripheral tube and an inner core tube consisting of tightly spaced columns. This central tube usually absorbs loads of gravity and primarily lateral loads are drawn from the outer peripheral tube. The inner center is used to include staircases, as well as elevator space. Mr. Fazlur Rahman Khan developed this device and the 43-story DeWitt-Chestnut Apartment in Chicago, designed in 1966, was the first residential building built using this system. As Shown in Fig.3 ,(Kulkarni 2019)

Fig. 3 Tube system in tall building.

https://www.google.com/url?sa=i&url=https%3A%2F%2Fstructurae.net%2Fen%2Fstructures%2Fbuildings%2Fbraced-frame-tubes&psig=AOvVaw1BloDB1g1TVssyr1wu3NJ2&ust=1609564009632000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCIjKs7f7-e0CFQAAAAAdAAAAABAQ

2. Literature Review

(Halis Gunel and Emre Ilgin 2006) In this analysis, based on the basic reaction mechanism/structural actions to withstand lateral loads, structural structures that can be used for the lateral resistance of tall buildings are classified. The following description for the structural structures of tall buildings is proposed in this analysis for all styles, including steel buildings, reinforced concrete buildings, and composite buildings.

A. Rigid Frame Systems.
B. Braced Frame and Shear-walled Frame Systems.
C. Outrigger Systems.
D. Framed-tube Systems.

E. Braced-tube Systems.
F. Bundled-tube Systems

In the end, the authors concluded that developments in concrete manufacturing, such as the manufacture of ultra-high-strength concrete, with the exception of outrigger structures, could be extended to reinforced concrete in all the structural systems mentioned above.

And it will implement tall structures with modern structural classifications that can be called "mixed systems." 'Mixed systems' use the mixture of two or three of the six different systems referred to above.

(Lakshmanan et al. 2009) Long-term hourly wind speed data has been obtained from 70 Indian Meteorological Department meteorological centers. The wind details of the daily gust for each location, the annual upper limit wind velocity (in kmph) was processed. The intense value quantiles were extracted using the Gumbel likelihood paper approach. A wind speed design foundation for a return time for each site a 50-year duration was also measured. In the contemporary wind zone chart for the construction of buildings/structures, site-specific adjustments in design wind speeds are illustrated and revision to the map is recommended.

(Arya, Hussain, and Khan 2014) The investigation outcome of wind speed and structural reaction of the building frame on sloping ground has been tested and analyzed in this research article. Considering the varying geometries of the frame and ground slope. Combination of the Consideration is provided to static and wind loads. There are several types of sloping soil. In combination, 60 events will be evaluated in different wind zones and three different building frame heights. STAAD-Pro software was used for the purpose of the study. In terms of Storey wise drift, shear force, moment, axial force, support reaction, and displacement, findings are gathered that are objectively analyzed to count the consequences of a variety of ground slope.

(1 Shaival J. Patel 2016) Different Forms of Tubular Structures Contrast' in this analysis, one study Steel layout of each framed tube system and optimum segment packaged tube system with 64 floors with symmetric design area and similar loading condition using ETABS. This research takes into account various parameters such as fundamental time span, maximum top story lateral displacement, maximum foundation shear, steel weight, and maximum story drift.

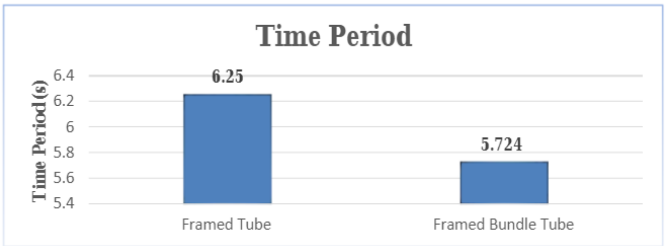

Fig.4. Time Period

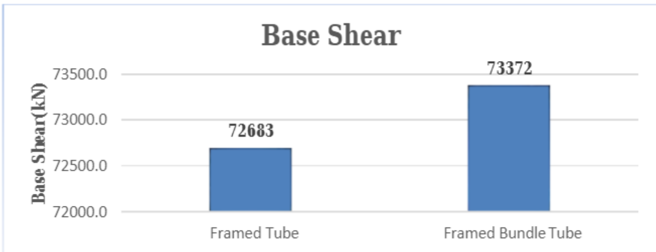

Fig.5. Base Shear

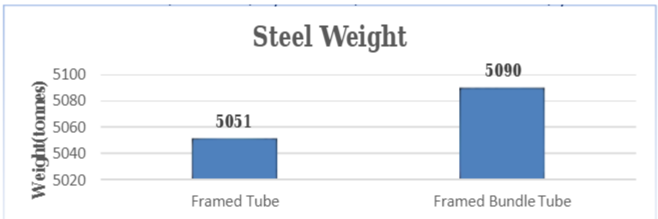

Fig.6. Steel weight

In terms of lateral displacements, tale drift, base shear, and rigidity, the Packed Tube structural system has emerged as a safer option for the lateral load resisting system. It is stiff enough to withstand wind forces up to higher elevations. In contrast to the framed tube system, this system offers wide spacing between exterior columns for bundled tube systems and even close tubes to provide attractive views such as shears tower.

(Gunawardena et al. 2017)With growing cities, urban habitats around the world are getting more congested and the need for tall buildings is as strong as ever. Sri Lanka has been Experiencing this fact at present, the skyline of Colombo grows increasingly with a vast number of diverse high-rise buildings coming up. The reaction of the tall Wind power buildings is a crucial design criterion, and both traditional force-based designs and performance-based solutions are required. This paper addresses these problems and the technical strategies they need to effectively construct a high building that is not only robust, safe, and solid under wind loads, but also offers practical and highly efficient design in an excellent manner.

(J. Shaligram and K.B Parikh 2018) the lateral load has been researched as having significant significance in architecture. The horizontal load becomes more prominent than the building's gravity load as the height of the building rises. The high rise system is affected by lateral loads such as wind load and seismic load. Various lateral load resisting devices resist these loads. The comparison of various kinds of lateral load resisting systems is studied in this article. In considering the seismic zone of that house, the primary purpose of this paper is to propose an efficient lateral load resistance device for high-rise construction. The author concludes that different lateral load tolerant systems are implemented to different building heights. For low-rise structures, the steel bracing system can be used, and for medium-rise structures, the shear wall can be used. Compared to steel bracing, a shear wall is inexpensive because of its high structural weight. For high-rise construction, the Diagrid method is productive and economical. From this article, for high-rise construction, the diagrid system is the most effective lateral load resistance system.

(S. Made et al 2019) Research on steel structure study was carried out by considering various lateral load resisting mechanisms, including diagrid, traditional moment, and bracing. In the diagrid system, the diagonal member effectively resisted lateral and vertical load, and because of its aesthetic appearance, this system is now more common. The author finds three G+10 steel tower buildings in this analysis by adding the diagrid structure, moment-resistant, and brace frame. The finite element applications ETABS and induced seismic loading were modeled on all three forms of buildings. A study of the response continuum has been carried out. In compliance with codes from AISC 360-10 and ASCE/SEI 7-10. The structural steel weight of both versions is then compared to assess quality. The author concluded that against seismic loading, the diagrid method is more successful than the brace frame and moment frames. The rigidity of the diagrid system is greater than that of other instruments. Also, the diagrid system's structural weight is small. Moreover, the observations reveal that the moment frame has the longest natural duration, but it is more stable than other systems.

3. CONCLUSIONS

From the latter literature, the following conclusions are drawn.

- It is apparent from the above findings that shear wall frame interaction systems are very successful in resisting earthquake or wind-load-induced lateral forces. Shear walls may be used as a primary vertical load-carrying portion for residential construction, thereby serving the load and dividing space. Compared to the dual form structural structure, the frame type structural system is inexpensive and can be used for medium-rise residential buildings found in elevated areas. The composite structure is light weight thus the base shear and base moments are very lees as compared to conventional RCC frame structure beside this shear force in RCC structure is also considerably more than the composite structure due to heavy weight.
- In terms of lateral displacements, tale drift, base shear, and rigidity, the Packed Tube structural system has emerged as a safer option for the lateral load resisting system. It is rigid enough to endure wind forces up to higher altitudes. For RCC, the time period is lower than for composite structures. Besides being more ductile, composites resist lateral load better than RCC structures.
- Compared to traditional frames, displacements on each story and story drifts are found to be less diagrid.
- When the belt is given at the top and in the middle position, the outrigger is most efficient.
- In terms of both efficiency and cost, construction with braces at the periphery proved to be the most efficient one.
- For the square-shaped device with the center on the central side, the maximal displacement for the solution continuum and corresponding static analysis is the least.
- It can be inferred that due to a wide range of buildings, the in-depth understanding in the field of wind analysis and design of building structures is insufficient when conducting the exhaustive survey of the literature available n building structure. The IS codes have given such rules on the basis of which, when exposed to wind loads, building systems should be built. The literature survey on the efficiency and action of building structures when exposed to wind loads indicates that it has become necessary to develop a methodology to research the response of building structures to wind loads.
- In the 30-storey buildings with the Shear wall system and Framed tube system, the lateral roof displacements

are very similar (difference of almost 2 percent). Shear wall system is favoured as the shear wall system is economical relative to the Framed tube system. The shear wall serves as the building's vertical cantilever, the wall is stiff for shorter distances, so as the length grows, the stiffness of the wall reduces, but for even higher heights it becomes inefficient. Roof displacement is decreased by 52.5 percent in the Shear wall system, where it is reduced by 50 percent relative to the Plain frame system as in the Framed tube system.

- The framed tube is very effective in resisting lateral loads (both wind and earthquake loads) relative to the shear wall structures for the 40, 50, and 60-floor structures. Compared to earthquake loads, the framed tube structure is able to resist higher percentages of wind loads. The reduction in the lateral displacements in the construction of the 60-story tube due to the combination of wind loads is 45.4 percent, while the combination of earthquake loads is 17.8 percent relative to the structure of the simple frame.

- For the building with the shear wall device, maximum base shear is measured for the 30-story structure. Maximum Base Shear is observed for framed tube framework systems for 40, 50, and 60 story structures.

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