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SEISMIC COMPARISON BETWEEN THE USE OF FRAMED SHEAR WALL SYSTEM AND FRAMED TUBE SYSTEM IN TALL BUILDINGS

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Abstract: Due to the increase of population in urban areas there is a need to accommodate the influx in the urban areas. However due to rapid increase of land cost and limited availability of land the trend is to build high rise building. Various types of structural system have been used to facilitate the demand of high rise structures. We cannot predict or stop the natural calamities (such as earthquakes, high wind pressures etc.,) but we can prevent ourselves from them providing framed shear wall system or framed tube system in the building greatly helps in improving its resistance behavior to lateral loads. In the tall structure the lateral drift is the most critical factor to be considered while designing. To reduce the lateral deflection the stiffness of the building has to be increased considerably. The aim of present work is to study and compare the effect of using framed shear wall system and framed tube system in resisting lateral load for tall buildings with rectangular shapes. Modeling and analyzing of the building considered to be carried out by using the software ETABS. Structures with Framed Shear Wall System and Framed Tube System are considered in the work for (15, 20 and 25) story and the analysis has be carried out with various parameters of Structural behaviour have been compared.

Keywords: Influx, High rise structures, Natural calamities, earthquake, high wind pressure, lateral drifts, framed shear wall system, framed tube system, ETABS.

I. Introduction

Tall buildings emerged in the late nineteenth and twentieth century in the most of the countries all over the world. Generally these building are so-called as "Towers or Skyscrapers", however these are the worldwide architectural phenomenon. Many such buildings are built worldwide, especially in Asian countries, such as China, Korea, Japan, Malaysia, and recently in India too. Based on data published in the 2004, about 33% of the world's tall buildings were located in Asian countries

Fig 1. Geographical distribution of high-rise building

High rise buildings have always fascinated the minds of people since the start of its construction in the ancient times. The construction of such buildings began in the ancient times for defensive purposes or religious purposes (roman temples, paranoiac, churches, etc.,) but in the modern era construction of such project began in the late nineteenth and twentieth century for the purpose of either residential or administrative, than it become to meet the requirements of hotels & and other touristic needs as well. There are many reasons to establish a high rise building investment project as follows - Rapid growth of population in urban communities, Expensive land prices, Restriction of random expansion in major cities adjacent to agricultural land, High cost of setting up infrastructure for new cities, Expression of progress and civilization. Coming to the other shade of these high rise buildings, the behavior of the structure is greatly influenced by the type of lateral system provided and the selection of appropriate lateral structural system plays an important role in the efficient analysis (such as, for wind and seismic load analysis) of the structure. Few of the lateral structural systems are Shear wall system, Braced Framed system, framed tube system, Tube in Tube system and so on. In the present study we will be dealing the analysis with the presence of shear wall and framed tube systems.

A. **Source of the Study**

Generally buildings are subjected to two types of loads:

(i) Vertical load due to gravity, and

(ii) Lateral load due to earthquake and wind.

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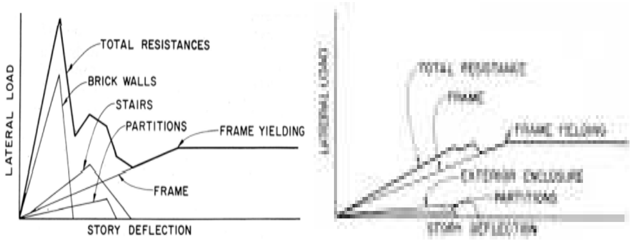

Fig 2. Lateral Load Resistance of Traditional Buildings and Modern Buildings

The old practice before 1960s had been to design buildings primarily for vertical loading and to check the adequacy of the structure for safety against lateral loads in a cursory manner. It has been established now that the design of a multi-story building is governed by lateral loads and it should be prime concern of the designer to provide adequately safe structure against lateral loads. Further, the old buildings were having substantial non-structural masonry walls, partitions and connected staircase. These provided a significant safety margin against lateral loading. The modern buildings are having light curtain walls, lightweight flexible partitions along with high strength concrete and steel reinforcement. This reduces the safety margins provided by non-structural components. Fig.2 and 3 show the schematic plot of resistance of various components against lateral loading in a traditional building and modern building, respectively. It is seen that the non-structural components in the traditional building have a large strength reserve and a lateral load many times the design lateral load could exhaust this strength reserve before yielding of the frame takes place. On the other hand, in a modern building, is only slightly lather the lateral resistance of the frame alone and no reserve capacity against lateral load is available.

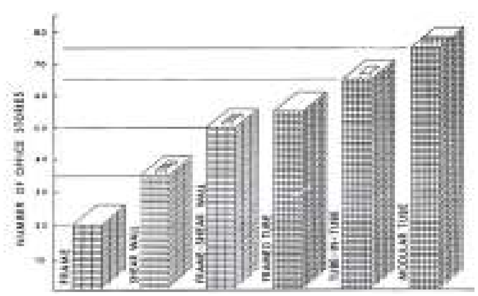

Fig 3. Comparison of Structural Systems in Concrete

B. Shear-walled frame systems

Shear-walled frame systems are utilized in both reinforced concrete and composite construction. Shear walls may be described as vertical cantilevered beams, which resist lateral wind and seismic loads acting on a building and transmitted to them by the floor diaphragms. Shear walls are generally parts of the elevator and service cores, and frames to create a stiffer and stronger structure. These elements can have various shapes such as, circular, curvilinear, oval, box-like, triangular, or rectilinear. This system structurally behaves like a concrete building with shear walls resisting all the lateral loads. The 86-story-high Metropolitan Tower (1987) in New York is a good example of this system.

C. Framed-tube systems

Framed-tube systems, are proper for steel, reinforced concrete and composite construction, and represent a logical evolution of the conventional frame structure. Slice braced frame and shear-walled frame systems become inefficient in very tall buildings, framed tube becomes an alternative of these systems. The primary characteristic of a tube is the employment of closely spaced perimeter columns interconnected by deep spandrels, so that the whole building works as a huge vertical cantilever to resist overturning moments.

II. Modelling & Analysis

A. Structural Details:

Plan Dimension : 30m x 30m

Thichness of slabs : 0.150m

Column Dimensions

- 15-Story Structure
  (From 0m to 30m height) - 500mmx500mm
  (From 30m to 45m height) - 450mmx450mm
- 25-Story Structure
  (From 0m to 30m height) - 550mmx550mm
  (From 30m to 60m height) - 500mmx500mm
  (From 60m to 75m height) - 450mmx450mm
- 35-Story Structure
  (From 0m to 30m height) - 600mmx600mm
  (From 30m to 60m height) - 550mmx550mm
  (From 60m to 90m height) - 500mmx500mm
  (From 90m to 105m height) - 450mmx450mm

Shear Wall Thickness

- 15-Story Structure
  (From 0 m to 45m height) - 250mm thick concrete wall
- 25-Story Structure
  (From 0 m to 45m height) - 300mm thick concrete wall
  (From 45m to 75m height) - 250mm thick concrete wall
- 35-Story Structure
  (From 0 m to 45m height) - 350mm thick concrete wall
  (From 45m to 90m height) - 300mm thick concrete wall
  (From 90m to 105m height) - 250mm thick concrete wall

Floor height : 3m

Height of Structures Considered

15 Story Structure : 45m

25 Story Structure : 75m

35 Story Structure : 105m

Loads:

Dead Load
- Floor finish = 1 KN/m²
- Wall load = 7.5 KN/m²

Live Load = 4 KN/m²

Earthquake Load
- Spectrum load for Zone – 2,
- Response reduction factor – 5,
- Importance factor – 1.5,
- Soil Type – medium values *(from IS : 1893 – 2002)*

Materials Details:

Grade of concrete

- (For columns & shear walls) = M50
- (For beams & slabs) = M30

Grade of steel = Fe 500

Lateral Load Resisting Structural Systems

- Framed Shear Wall System.
- Framed Tube System.

Analysis is carried out on structural programing software ETABS with the parameters assigned below. Slabs are considered as membrane .Shear wall is considered as shell.

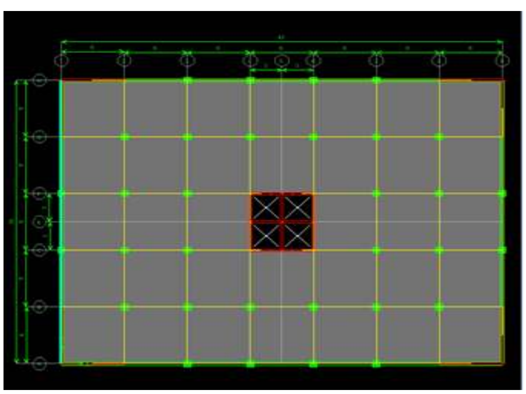

Fig 4. Considered plan of the Building

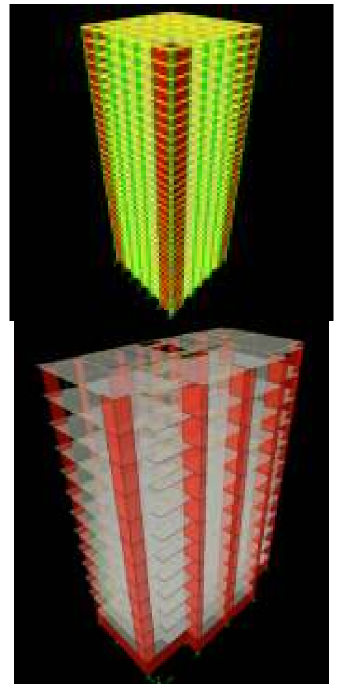

Fig 5. 3-D model of framed tude and Shear wall framed Building

III. Results and Discussions

A. Story shear

Table 1. Maximim Story Shear in X direction

Floors	Frame Shear Wall System	Framed Tube System
15	3255.6825	3976.3725
25	3686.55	4486.041667
35	3919.0725	4753.8575

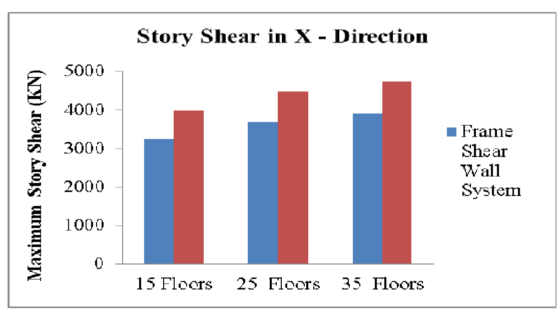

Fig 6. Maximim Story Shear w.r.t to shear wall and framed tube building (in X direction)

Story shear in Y direction

Table 2. Maximim Story Shear in X direction

Floors	Frame Shear Wall System	Framed Tube System
15	2752.6275	3361.9575
25	3106.25	3781.458333
35	3310.53625	4016.11875

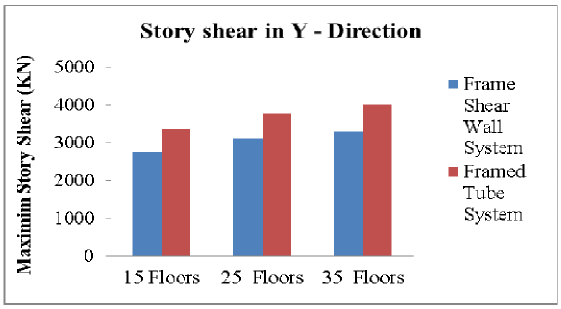

Fig 7. Maximim Story Shear w.r.t to shear wall and framed tube building (in Y direction)

Base Shear force:

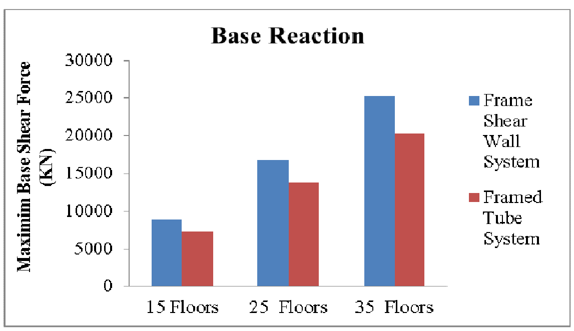

Fig 8 Maximum Base rection for shear wall and framed tube buildings for Earthquake loads

Lateral Roof Displacement

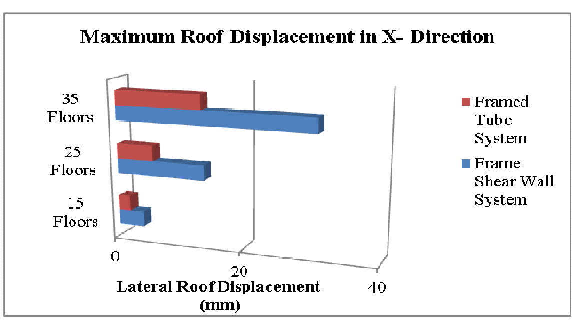

Fig 9. MaximumRoof displacement for shear wall and framed tube buildings for gravity loads (in X direction)

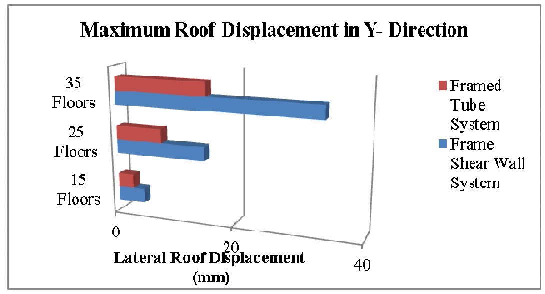

Fig 10. MaximumRoof displacement for shear wall and framed tube buildings for gravity loads (in X direction)

The Displacement due to the earthquake load for the (15, 25 and 35) story building show in the below graphs.

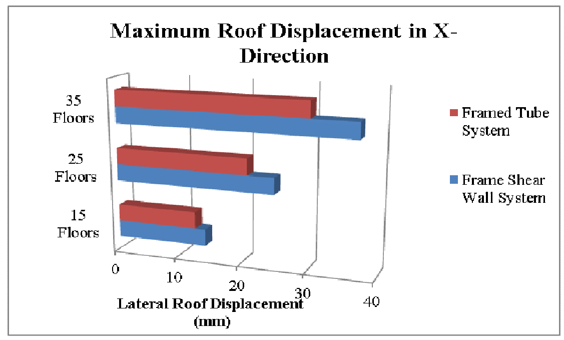

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Fig 11. Lateral displacement w.r.t shear wall and framed tube buildings for earthquake load (in X direction)

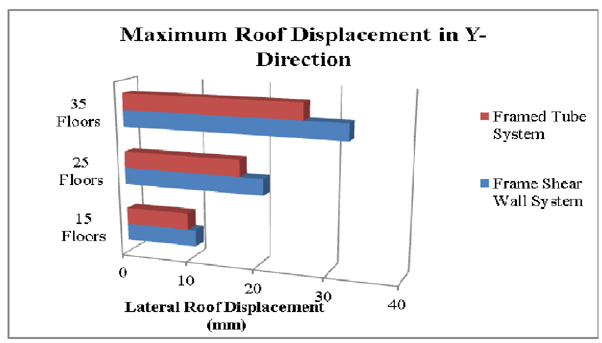

Fig 12. Lateral displacement for earthquake load for shear wall and framed tube buildings (in Y direction)

IV. Conclusion

- It is evident from the observing result that the lateral roof displacements in above mentioned story structures Framed Shear Wall System and Framed Tube System. As the Framed Shear Wall System is economical compared to the framed tube system Framed Shear Wall System is preferred upto 20 floors building. The shear wall acts as a vertical cantilever for the building, the wall is stiff for shorter lengths but as the length goes on increasing stiffness of the wall decreases, hence it gets ineffective for much higher heights such as greater than 20 floors.

For the higher rise story structures the Framed Tube is very much effective in resisting lateral loads (both Wind and Earthquake loads) compared to the Shear Wall Structures.

- For the structure with Framed Tube System, the maximum support reactions for outer periphery supports are much less compared to that of the Shear wall structure as the columns are very close to each other this will help its stiffness participation as a result the amount of reactions will be less in Tube System when compared to Shear Wall System.
- Maximum Base Shear for (15, 25 and 35) story structures is observed for structure with Framed Tube System.

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