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Comparative Analysis of Different Lateral Load Resisting Systems in High Rise Building for Seismic Load & Wind load: A Review

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Abstract: In modern high rise buildings, lateral load has great significance in design as the height of building increases, lateral load becomes more dominant than gravity load or vertical load of building. Lateral load such as Wind load and Seismic Load are act on the high rise building. These loads are resisted by various lateral load resisting systems. In this review paper, the comparison different types of lateral load resisting systems are discussed. The study mainly focuses on determining the most effective and economical system which can resist wind load and seismic load. Based on literature review, an attempt has been made to compare various lateral load resisting systems such as Shear wall, Outrigger, RC frame with bracings, diagrid system, Frame tube system etc.

***Keywords**: High rise building, Seismic load, Wind load, Outrigger, Bare frame, Diagrid, Shear wall, Bracing etc.*

I. INTRODUCTION

In modern world, high rise building is playing a crucial role in the development of any country. It shows the potential of the country in the development of Infrastructure. India has faced many disaster such as earthquake, tsunami etc. Earthquake has become more frequent in some part of the country. So, the introduction of Earthquake resistant design of structure has held more importance after 2001 bhuj earthquake. IS 1893 has also been modified. There are lots of research work has been done and still it is going on. As the earthquake is natural disaster, we cannot predict it but surely we can protect us by means of some strategies. Lateral load resisting system is provided to resist seismic load and wind load. These systems have evolved by the time and requirement of the building. It has been observed that design of multistorey building is governed by lateral loads and it should be prime concern of the every structural engineer to provide adequate lateral load resisting system. Lateral load resisting systems such as shear wall, Bundle tube, Frame tube, Diagrid, outrigger etc, which are used according to the load acting on it and type and height of the building. These systems increase the stiffness of the structure and absorb lateral forces acting during earthquake and wind. In this Review paper, different Lateral load resisting systems are compared in terms of various parameters such as storey displacement, storey drift, Modal time period, storey forces for seismic load using response spectrum method and top storey displacement, axial forces, material consumption and time period using Gust factor approach as per IS 875 (Part-3)-1987 using ETABS-2015 software.

A. Beam-Column System

beam-column system is simply the frame structure made up of beam, column and slab. There is no provision of any resisting system against the lateral load. Beam is a horizontal structural member transfers the load from slab to column and column which is a vertical member which transfers the load to foundation which ultimately transfer the load to the ground soil.

B. Shear wall

It is a RCC wall constructed to resist lateral displacement having thickness varies from 140mm to 500mm depends on height and number of stores. Walls are placed throughout the height but sometimes it may be discontinuous. Location of shear wall can be changed as per requirement of the building to resist the lateral loads.

C. Outrigger

Outrigger is used to resist drift at particular storey. It is a horizontal structure which is connected to exterior column and the core to minimize the effect of lateral displacement in the top storey. Outrigger in two or three numbers depending upon the height of the building and storey displacement.

D. Bracing System

Bracing members are arranged in different forms as per requirement of resisting lateral load such as wind and seismic load. It reduces the bending moment and shear force in columns. Bracing system is more beneficial in retrofitting of existing building against lateral loads. It increases the stiffness and strength against seismic loading with little addition of weight into the structure.

E. Frame tube System

This system is a combination of shear wall and beam-column system. In this system location of the shear wall in the core of the building which forms the high strength tube like structure inside the building.

F. Diagrid System

This system consists of grids of RCC or steel placed in a structure diagonally with certain specific geometry. In diagrid system, all vertical columns at the periphery is removed and replaced by inclined columns. Diagrid is particular type of truss which made up of a series of triangulated truss system.

II. LITERATURE REVIEW

Md Muddasar Basha (2016) compared different lateral load resisting system such as shear wall, steel bracing and outrigger for 20 storey high rise building. He observed from the result obtained by response spectrum method using ETABS software that shear walls have more structural weight whereas steel bracings have less weight. Displacement can be controlled due to increase in mass. Shear wall gave better performance due to increase in base shear. The frequency was much higher in shear wall whereas it was least in Outrigger. It gave better stiffness due to higher ductility as reinforcement present in shear wall. Outrigger didn’t give any improved result except drift. Steel bracings can be used where earthquake magnitude is low. It is cheaper than other two systems. He concluded that shear wall was the best in this comparison for earthquake resistant design. [1]

Shubham P Dhoke and Bhavini V. Ukey (2017) studied about different lateral load resisting systems such as Beam-Column system, Diagid system, Frame tube system etc. They had performed analysis in ETABS 2015 software to determine which of them was more beneficial and economical as Lateral load resisting system for 40 storey high rise building. The comparison for these systems had carried out using response spectrum method on the basis of different parameter such as storey displacement, storey drift, storey forces and modal time period in both vertical and lateral direction. The results show that the modal time period in diagrid structure is minimum so, the stiffness of the diagrid structure is more. Storey forces and storey displacement indiagrid system is less compared to frame tube and beam-column system during earthquake loading. Stiffness of the diagrid system is relatively high than any other systems. Diagrid system is more beneficial than other systems in earthquake loading. [2]

Tausif J. Shaikh (2017) studied about the wind analysis of high rise building having outrigger and diagrid. He compared different lateral load resisting systems such as outrigger and diagrid system provided in the high rise building of 108m. He performed wind analysis by using gust factor approach as per IS;875 (Part-3)-1987 and lateral wind load was calculated “along Wind” response. In this paper different models were analysed and compared by changing angle of inclination and location of outrigger. Comparison and analysis had been made in terms of top storey displacement, axial force, material consumption and time period. The study shows that material consumption in outrigger structural system is 17% higher than diagrid structural system. So it can be concluded that diagrid system is economical. Time period for diagrid structure is very less compared to outrigger which means diagrid system is stiffer than outrigger. Diagrid structural system is more feasible in architectural planning and provide higher structural efficiency for high rise buildings.[3]

Rasool .owais&Tantray (2016) analysed lateral load resisting system such as bracing system and shear wall system in staad pro v8i and compared the result in terms of nodal displacement, relative displacement of beams, maximum bending moment and shear force. The results shows that nodal displacement in shear wall both translational and rotational is least compared to bracing system. Bending moment, shear force and relative displacement in bracing system is lesser than shear wall and moment resisting frame. Bracing system is the most effective for reducing displacement and forces in the member. It is economical for increasing lateral stiffness of the building. [4]

Janakkumar M. Mehta (2017) studied about the shear wall as lateral load resisting system for high rise building. He performed analysis of G+ 17 high risesbuilding with different shear wall configuration in ETABS software. The modelling had been done to examine seismic parameters like base shear, lateral displacements, lateral drift and modal time period for zone V in medium soil as specified in IS:1893-2002. He concluded from the analysis that base shear in shear wall was more compared to bare frame. Lateral displacement and drift were less in shear wall. It had been observed that maximum reduction of 62 % in displacement and storey drift was obtained when shear wall placed in centre (core) of the building whereas shear wall provided at periphery showed less time period than other model. He concluded that time period decrease with increase in lump mass of structure. [5]

Piyushgupta (2016) analysed various structural system for resisting lateral loads such as braced core, coupled shear wall, Outrigger with belt, shear core, shear wall and bracing at periphery in ETABS software. Static and dynamic analysis was carried out and results were compared in terms of displacement storey drift and stiffness. He ranked these lateral load resisting systems on the basis of their effectiveness. The study shows that outrigger is most effective when belt is provided at top and middle position. When shear wall is provided at middle periphery, it becomes most effective in resisting lateral load. Inverted V-shape bracing system is the best in terms of cost and effectiveness. It has been noted that inverted V-shape bracings system is most effective and braced core system is less effective. [6]

Abhijeetbaikerikar (2014) studied about some lateral load resisting systems such as shear wall, bracings and moment resisting frame. He performed the analysis in ETABS 9.7.0 on square grid of 25m in each direction of 5 m bay in each direction for different cases of shear wall and bracings for different height. The study carried out for zone V and all types of soil specified in IS 1893-2002 and compared the results on the basis of lateral displacement, base shear, time period and drift obtained for variable heights using response spectrum method. He concluded that frame consisting shear wall and bracings showed lower lateral displacement and drift. For soft soil, base shear, lateral displacement and lateral drift were massively increased. Time period was lowered after placing the shear wall and bracings. The best and efficient result can be obtained when shear wall is provided in middle of the building. [7]

Khushbujani(2013) carried out analysis and design of 36 storey high rise building consists of diagrid system provided for different storeys in ETABS software. The results of analysis were compared in terms of Time period, Top storey displacement and inter-storey displacement. The results show that most of the lateral load is resisted by the diagrid columns and vertical gravity load is resisted by both internal columns as well as peripheral diagonal columns. Diagrid structural system is more efficient and effective in lateral load resistance. Lateral load and gravity load is resisted by axial force on diagonal members on periphery of the structure. This system provides flexibility in planning and designing the interior space and faces of the building. [8]

III.CONCLUSION

From the literature review, it has been concluded that steel bracings can be used as lateral load resisting system of multistorey building of 10 to 20 storeys whereas Shear wall can be used for 20 to 35 storey building as lateral load resisting system. But shear wall has more structural weight compared to steel bracings which might be uneconomical for 10 to 15 storeys. Diagrid system is the most effective and economical for the high rise building having storeys greater than 35 and it gives flexibility in planning of building space and elevation of the building. So, it is the most suitable lateral load resisting system in high rise building for seismic load and wind load.

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