Review on Behaviour of Lateral Load Resisting System for High-Rise Building

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Abstract

As the population is increasing tremendously with every passing year and the land available for use of habitation is the same as it was a decade ago. Due to this, metro cities are getting densely populated day by day. So, the only solution to the problem is vertical growth. Now this need for the increase in the vertical height of the buildings has made the buildings tall and slender. Since buildings are getting taller and slender the primary concern of design engineers is shifting from gravity loads to lateral loads. The effect of lateral forces becomes more and more dominant as the building becomes taller and taller. Hence, traditional simple framed structures have now been replaced by complex but yet more effective structural systems that perform better in case of lateral load.

The lateral load resisting system effectively control the excessive drift due to either wind or earthquake and thus minimizes the risk of damage to building. The objective of this paper is to study, performance of lateral load resisting system in high-rise building subjected to seismic and wind load. Study of the literature is reviewed in this paper on various aspects of lateral load resisting system as; Behaviour of lateral load resisting system in High-Rise RC building, Behaviour of lateral load resisting system in High-Rise steel and composite structure, Effect of seismic and wind load on High-Rise structures

Keywords: *Lateral Load Resisting System, High-Rise Building, Seismic Load, Wind Load.*

1. Introduction

As the population is increasing tremendously with every passing year and the land available for use of habitation is the same as it was a decade ago. There has been an increase in the density of population in the urban area, since population from rural areas is migrating in large numbers to metro cities. Due to this, metro cities are getting densely populated day by day. So, the only solution to the problem is for vertical growth. Now this need for the increase in the vertical height of the buildings has made the building become tall and slender. Thus, height of the building has now become the primary point of focus of today's world.

Since buildings are getting taller and slender the primary concern of design engineers is shifting from gravity loads to lateral loads. The effect of lateral forces becomes more and more dominant as the building becomes taller and taller. These lateral forces can produce critical stresses in the structure, induce undesirable stresses and vibrations or cause excessive lateral sway of the structure. This has brought more challenges for the engineers to satisfy both gravities load as well as lateral loads, earlier buildings were designed for the gravity loads but now because of tall height and seismic zone the engineers have taken care of lateral loads due to earthquake and wind forces. So, to cater all the lateral forces, we have to design the structure very uniquely so that the structure can withstand for the maximum time period without causing any harm to the society. The Engineers and professional in the structural designing fields have found out many ways to tackle this problem. Traditional simple framed structures have now been replaced by complex yet more effective structural systems that perform better in case of lateral load.

1.1. Structural System

In the past years, structural members were assumed to carry primarily the gravity loads. However, by the advancement in structural system has made buildings taller and slender. The effect of lateral forces due to wind and earthquake becomes more and more dominant as the building becomes taller and taller. There are many structural systems that can be used for lateral resistance of tall buildings.

The various structural systems commonly used for the design of tall buildings are:

1. Rigid frame structure.
2. Braced frame structure.
3. Shear wall frame structure.
4. Braced frame and shear wall frame structure.
5. Outrigger structure.
6. Frame tube structure.
7. Braced tube structure.
8. Bundled tube structure.
9. Trussed tube.
10. Diagrid system

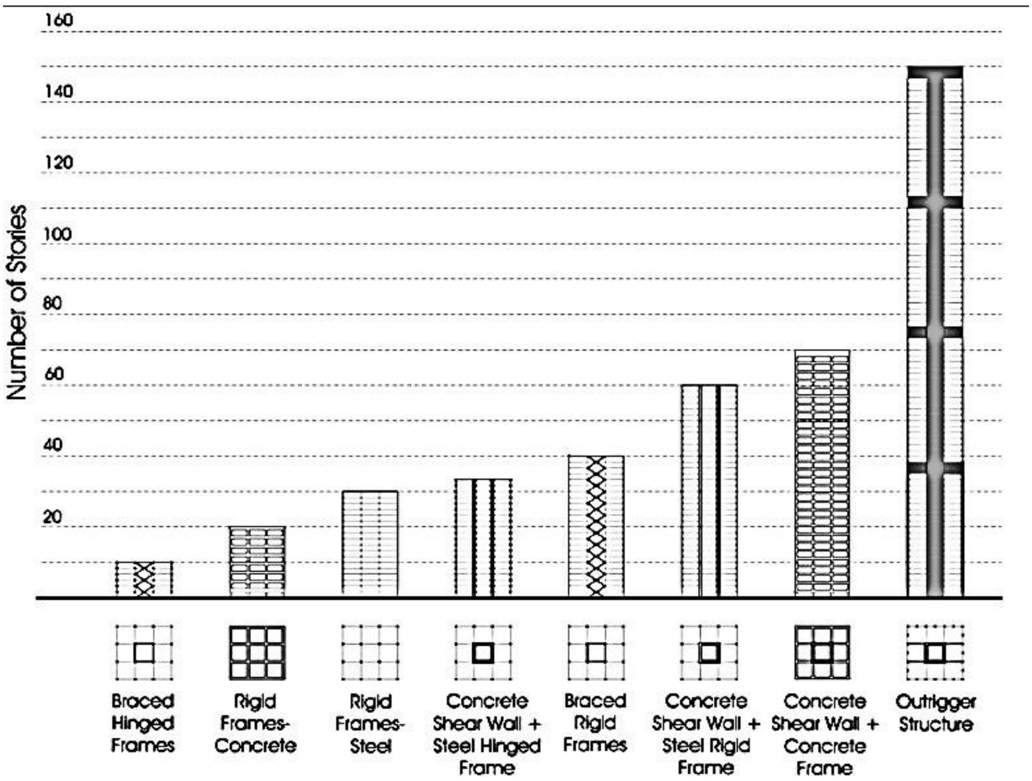


Figure 1. Different Structural Systems for High Rise Buildings

2. Overview of a few structural systems

2.1. Rigid Frame Structure

A rigid frame in structural engineering is the load-resisting skeleton constructed with straight or curved members interconnected by mostly rigid connections which resist movements induced at the joints of members. Its members can take bending moment, shear, and axial loads.

A rigid-frame high-rise structure typically comprises of parallel or orthogonally arranged bents consisting of columns and girders with moment-resistant joints. The continuity of the frame also increases resistance to gravity loading by reducing the positive moments in the girders. The advantages of a rigid frame are the simplicity and convenience of its rectangular form. Rigid frames are considered economical for buildings of up to about 25 stories, above which their drift resistance is costly to control.

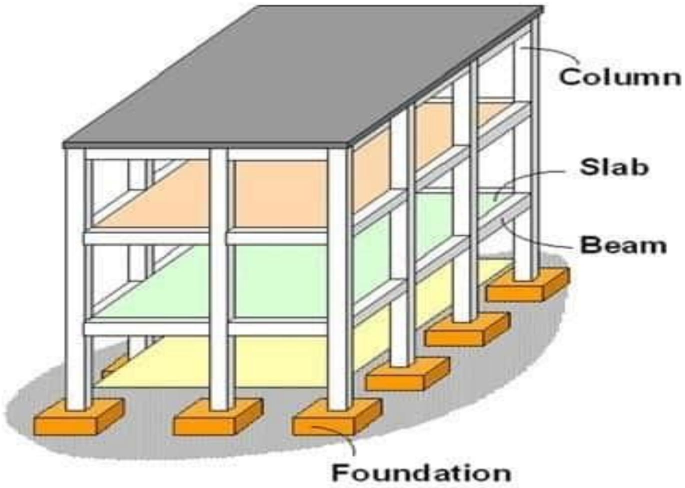


Figure 2. Typical Rigid frame structure

2.2. Shear Wall Frame System

Continuous concrete vertical wall serves both architecturally as partition and structurally to carry gravity and lateral loads. Shear walls are used in building to resist lateral force due to wind and earthquakes. Very high plane stiffness and strength makes shear walls ideally suited for tall buildings. Shear wall generally starts at foundation level and are continued throughout the building height. They act as vertical cantilevers in the form of separate planar walls and as non-planar assemblies of connected walls around elevator, stair and service shafts. Shear walls in buildings must be symmetrically located in plan to reduce ill-effects of twist in buildings**.**

When shear walls are situated in advantageous positions in the building, they can form an efficient lateral force resisting system by reducing lateral displacements under earthquake loads. Therefore, it is very necessary to determine effective, efficient and ideal location of shear wall. The figure 3. (A) shows Symmetrical location of shear wall located at the centre of the building and Figure 3. (B) shows unsymmetrical location of shear wall placed at periphery and intermediate position of the building. The placement of the shear walls at the centre may not be common for all type of building. In some situations, their location will be bought to the ends of the plan. In case of difficulty in deciding the best location, analysis of different positions is done and the best is chosen.

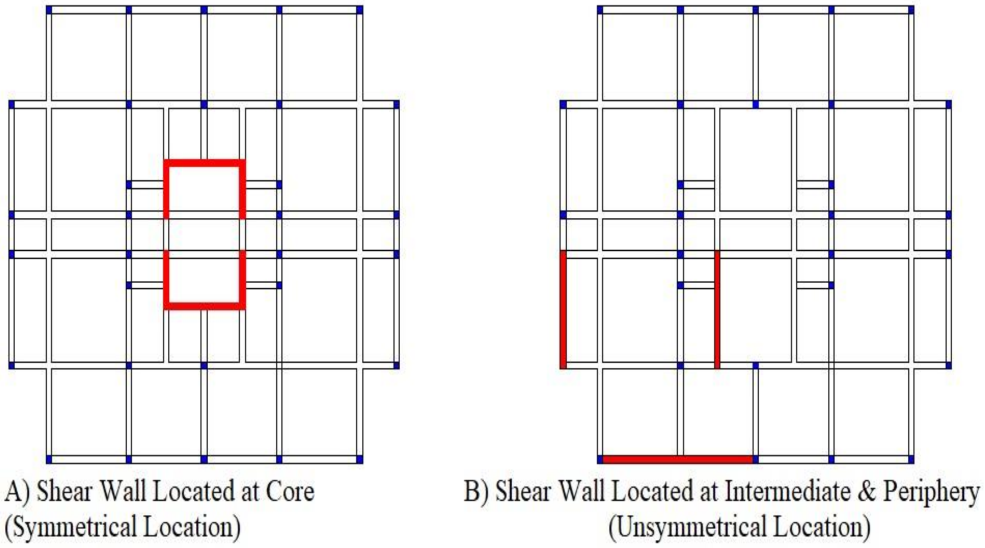


Figure 3. Symmetrical and Unsymmetrical Location of Shear Walls

2.3. Braced frame system

A braced frame is a structural system commonly used in structures to resist the lateral forces due to wind and earthquake. The members in a braced frame are generally made of structural steel, which can work effectively both in tension and compression. The beams and columns that form the frame carry vertical loads, and the bracing system carries the lateral loads. The positioning of braces, however, can be problematic as they can interfere with the design of the facade and the position of openings. Buildings adopting high-tech or post-modernist styles have responded to this by expressing bracing as an internal or external design feature.

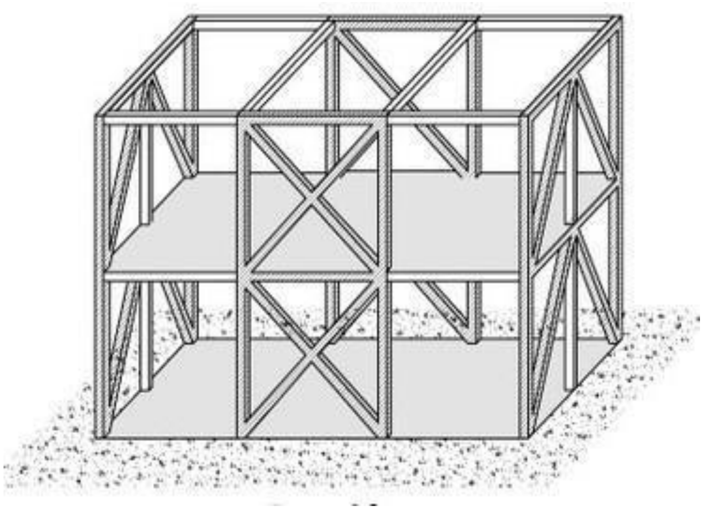


Figure 4. Bracing system

Bracing is generally regarded as an exclusively steel system but nowadays steel bracings are also used in reinforced concrete frames. The efficiency of bracing is being able to produce laterally very stiff structure for a minimum of additional material makes it an economical structural form for any height of building. A major disadvantage of diagonal bracing is that it obstructs the internal planning and the location of door and windows. For this reason, bracings are usually placed along wall and partition lines and especially around elevators, stairs and service shafts. Recently bracings are not only used to produce highly efficient structures but aesthetically attractive buildings.

Generally, braces are of two types, concentric and eccentric. Concentric braces connect at the beam column intersection, whereas eccentric braces connect to the beam at some distance away from the beam column intersection. Also, bracings are categorized as vertical bracings and horizontal bracings system depending upon the path of transferring load. Vertical bracing is placed in the form of diagonals between column lines in vertical planes to transfer horizontal forces to ground level, whereas horizontal bracing system is provided in horizontal planes at each floor level, to transfer horizontal forces to the vertical bracings.

Types of bracing

2.3.1. Diagonal bracing

Trussing, or triangulation, is formed by inserting diagonal structural members into rectangular areas of a structural frame, helping to stabilize the frame

2.3.2. Cross-bracing

Cross-bracing or X-bracing uses two diagonal members crossing each other. These only need to be resistant to tension, one brace acting to resist sideways forces at a time depending on the direction of loading.

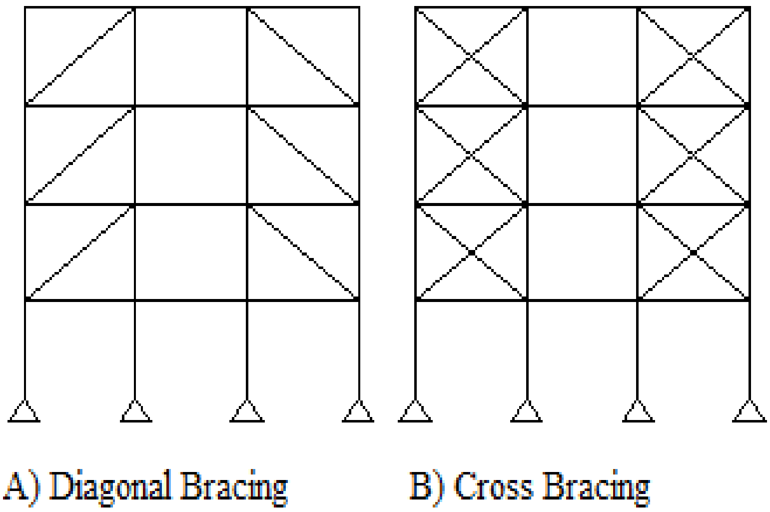


Figure 5. Diagonal and Cross Bracing

2.3.3. K-bracing

Braces connect to the columns at mid-height. This frame has more flexibility for the provision of openings and results in the least bending in floor

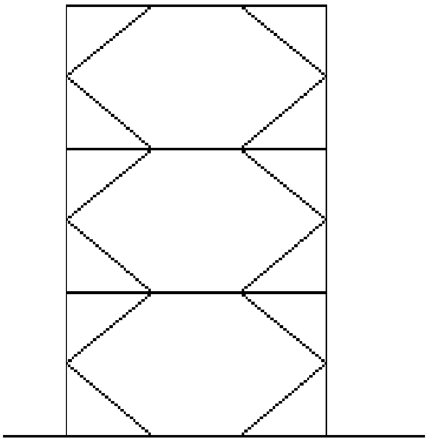


Figure 6. K-Bracing

2.3.4. V-bracing

This involves two diagonal members extending from the top two corners of a horizontal member and meeting at a centre point at the lower horizontal member, in the V shape.

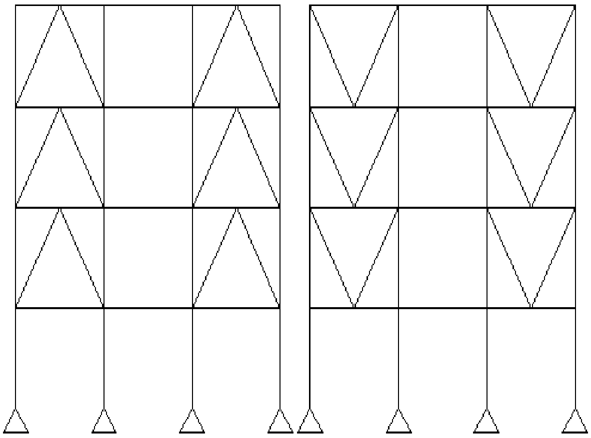
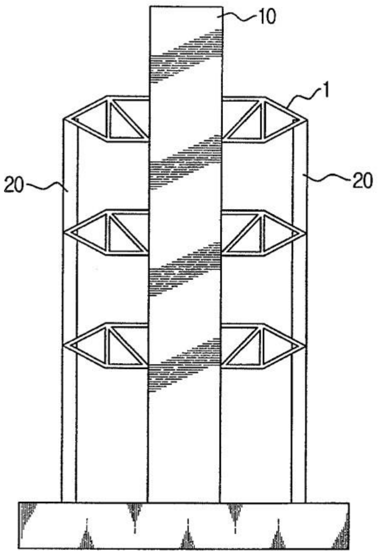


Figure 7. V-Bracing

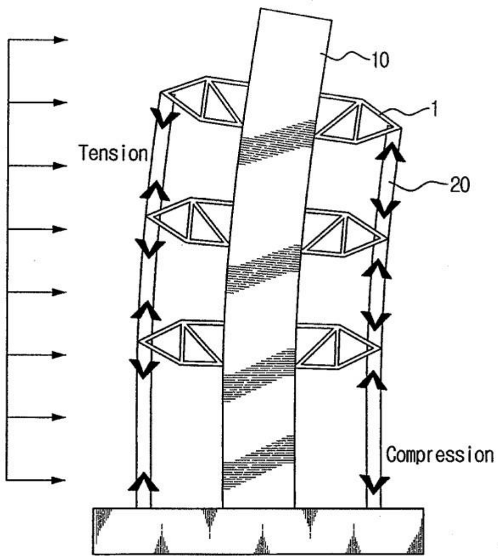
2.4. Outrigger structural system

Outriggers are very stiff horizontal arm like structures that are designed to improve the buildings resistance to overturning and strength by connecting the core to distant columns. The concept of Outrigger is not new to us as Outriggers have been used in sailing vessels in the mast of the sail to improve the stability. Despite being such and old technology, it has been recently been introduced in the structural framework of the buildings. The basic working of the Outrigger is explained in figure 8 it has very stiff trusses in a selected floor which are made out of trusses like structures having diagonal, vertical and horizontal members. This Outriggers are rigidly tied to the central core of the building.

When the lateral forces due to wind and earthquake acts on the building the building gains acceleration in a particular direction. As the core stiffness is very high as compared to the other columns it attracts maximum lateral forces and try to bend. As the Outrigger arms are very stiff and they have a rigid connection to the core, this bending of the core tries to rotate the Outrigger thus inducing the above tension-compression couple on the peripheral columns as shown in figure 8.



(a) Under normal condition



(b) Under lateral load

Figure 8. Basic working of Outrigger system

Types of Outrigger Truss System

On the basis of connectivity of core to exterior columns, this system may be divided as in two types:

2.4.1. Conventional Outrigger Concept

In the conventional outrigger concept, the outrigger trusses or girders are connected directly to shear walls or braced frames at the core and to columns located outboard of the core

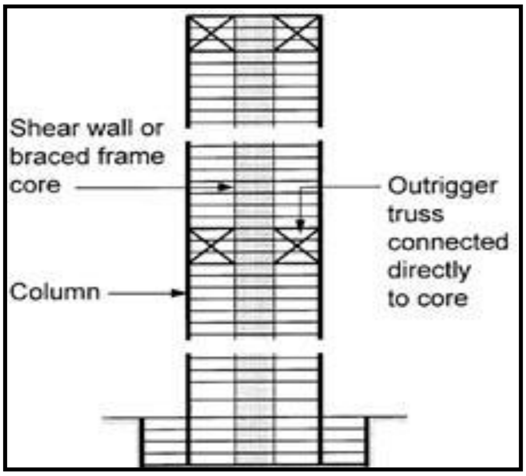


Figure 9. Conventional Outrigger Structural System

2.4.2. Virtual Outrigger Concept

In the "virtual" outrigger, the same transfer of overturning from the core to elements outboard of the core is achieved, but without a direct connection between the outrigger trusses and the core. The basic idea behind the virtual outrigger concept is to use floor diaphragms, which are typically very stiff and strong in their own plane.

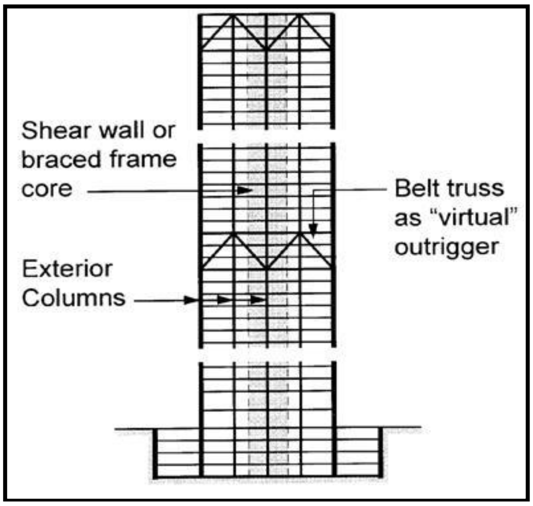


Figure 10. Virtual Outrigger Structural System

3. Literature review

3.1. Introduction

Technical papers of various journals from India and abroad are studied to understand the importance and necessity of this research in consideration of seismic resistant design. To understand the performance of the Brace framed, Shear wall and Outrigger under different conditions an extensive review of literature is performed. It presents a brief summary of the literature review. Following review of literature gives brief idea of behaviour of lateral load resisting structural system in high rise building.

3.2. Review of Literature

3.2.1. Review of Literature on Study of different Lateral Load Resisting Structural System

Khuzaim J. Shaikh et al. (2018) carried a comparison of the various structural system used in the buildings. Four different types of structural system were investigated, which includes structural wall moment resisting frame, structural wall system and outrigger structural system (Belt truss system). A 39 storey (145.35m) building have been investigated with typical storey height of 3.65m equivalent static analysis, response spectrum analysis and static wind analysis are performed. Different structural results are compared such as base shear, storey drift and storey displacement. Along with the stability check is done as per IS 456-2000. It has been concluded that outrigger system shows very less displacement and drift in G+39 storey as compared to other structures. It is concluded that outrigger system shows very less displacement and drift and hence it can be used if there is larger irregularity, which creates larger displacements and drift.

Janakkumar M. Mehta and Hitesh K. Dhameliya (2017) carried a comparative study on lateral load resisting system in high-rise buildings using ETABS software. In this study the (G+17) storey building was analyse with different shear wall configuration. The different shear wall configuration such as bare frame, shear wall along periphery, shear wall at core and periphery, shear wall at core are used for this study work is carried out for a square grid of 25m in each direction. The modelling is done to examine the effect of different cases on seismic parameters like base shear, lateral displacements, lateral drifts and model time period for the zone-V in medium soil as specified in is 1893-2002. On the basis of the results compared it is found that structure with shear wall at core system gives better performance than others.

Shubham P. Dhoke et al. (2017) presented a comparative analysis of various lateral load resisting system i.e. beam column system, frame tube system and diagrid system. Modelling and analysis of different load resisting system for G+39 storey is done in ETABS – 2015 software. The comparison of lateral load resisting system is done by using response spectrum method on the basis of various parameters such as storey displacement, storey drift, storey forces and modal time period. It is observed that stiffness of diagrid system is increase than beam column and frame tube system. On the basis of results provided by ETABS-2015 it can be concluded that the diagrid system gives good results than others as in case of time period, displacement, storey forces and storey stiffness. Overall by comparing results it is concluded that steel outrigger and belt truss system is found to be efficient in comparison to concrete outrigger and belt truss system.

Dr. H. M. Somasekharaiah et al. (2016) carried out comparative study on lateral force resisting system for seismic loads. The main aim of this study is to analyse the behaviour of commonly used lateral force resisting systems. In this study systems like shear wall, steel bracing system, masonry infill, outrigger is applied to a 20-storey symmetrical RC building, analysed as per IS 1893-2002 (Part 1) and performance are compared. Total five models of 20 Storey each are considered for modal analysis, equivalent static analysis, response spectrum analysis and analysis work are carried out by using ETABS 2015 software. The results obtained from analysis are investigated and compared. On comparing the results obtained, shear wall shows the good resistance for earthquake load compared to the other systems which is consider for the analysis

Piyush Gupta and Dr. Neeraja (2016) carried analysis of various RCC lateral force resisting systems and their comparison using ETABS software. The scope of this study is confined to RCC structures only. In this study, the emphasis is given on the structure having lateral force resisting system. The systems line shear wall, shear core, outrigger with belt system, coupled shear wall and bracings are applied to 30 Storey symmetrical RC building. They have used a square grid of 35m in each direction of 5m bay in each direction. This study pointed to compare these systems and ranking them all in terms of their efficiency. Static and dynamic analysis has been carried out and results have been compared and cost evaluation is done. Several books and IS codes have been referred to obtain the results up to maximum accuracy.

Rasool Owais and Tantray Manzoor Ahmad (2016) carried comparative analysis between commonly used lateral load resisting system in reinforced concrete buildings. In present study they have used square grid of 12m in each direction of 4m bay in each direction. Software used sis STAAD Pro. The work has been carried out for the different cases of systems like shear wall, bracing and moment resisting frame for maximum height of building 9m. Seismic zone V and types of soil medium is considered for the present study. Objective of study is to check efficiency by comparing modal displacements, relative displacement of beams, maximum moments and shear force in beam and thereby predicting their efficiency from the results obtained. Conclusion made is that bracing type system of lateral load resisting system is most effective in reducing displacements and forces in the members and is economical way of increasing the lateral stiffness of the building.

Thejaswini R. M. and Rashmi A. R. (2015) presented work on a particular type of irregular building considering different structural forms. Seven models are developed in ETABS software with codal provisions. These models are analysed for response spectrum method and wind load. When seismic analysis is considered some of the major factors come into picture like lateral displacement, Storey drift and stability of columns in particular storey due to lateral forces and when the building is in irregular configuration torsion irregularity will also become an important factor. In this present work all, this point is considered and the result obtained are tabulated, graphs are plotted and compared. The results show that the tube structure and 'L' shape shear wall are more stable and does not have torsion irregularity and also the displacement is less compared to other general structures. Drift can be controlled by providing outrigger at optimum location of the building

Abhijeet Baikerikar and Kanchan Kanagali (2014) Carried out a research work using square grid of 20m in each direction of 5m bay in each direction, software used is ETABS 9.7.0. The work has been carried out for different cases using shear wall and bracings for the different heights, maximum height considered for the study is 75m. The modelling is done to examine the effect of different cases along with different heights on seismic parameters like base shear, lateral displacements and lateral drifts. The study has been carried out for the zone V and all types of soils as specified in IS 1893-2002. It is was observed that as the height of building increases lateral displacement and drift increases. One of the important conclusions made from the study is that as the soil changes from hard to soft there is massive increase in base shear, lateral displacement and lateral drifts. Extreme care should be taken in soft soil.

Shruti Badami and M. R. Suresh (2014) carried an investigation to examine the most common structural system that are used for reinforced concrete tall buildings under the action of gravity and wind loads. These systems include Rigid Frame, Shear Wall, Wall Frame Interaction and Outrigger. The basic modelling technique and assumptions are made by 'ETABS' program in 3-D modelling. Design considerations are made according to Indian standards. This comparative analysis has been aimed to select the optimal structural system for a certain building height. Square grid was used and G+15, G+30, G+45, G+60 storey models were analysed using ETABS software for medium soil and seismic zone II. The structural efficiency is measured by the time period, Storey displacement, drift, lateral displacement, base shear value and core moments. The recommendations for each structural system are based upon limiting the wind drift of the structure and increasing the lateral stiffness. It has been observed that as the height of the building increases the importance of lateral load action rises in an accelerating rate.

3.2.2. Review of Literature on Study of Shear Wall System and Braced Frame System

A.P. Nagendra Babu and S. Jain Shahab (2017) carried comparative study of shear wall in multi-stored R.C. building using G+10 storey by placing the shear walls at different locations. The performance of the building is analysed for all zones II-V. It is concluded that shear wall at centre shows stiffer behaviour as compare to shear wall at edge. Also, when shear wall is provided on edge the maximum storey displacement of building increases as compared to central position. Dynamic analysis reduces the storey drift, storey displacement and storey shear of the building and shear wall provided at edge increases the time period as well as the storey drift of buildings.

Arathi Thamarakshan and Arunima S. (2017) studied analytical behaviour of knee braced frame with different bracing configuration like cross knee bracing, diagonal knee bracing and chevron knee bracing by pushover analysis and time history analysis. They concluded that cross braced configuration system is more effective under seismic loading as compared to diagonal and chevron braced configuration system. The cross braced configuration system reduces the drift of steel building also increases the stiffness at the same time and diagonal bracing system has least resistance to seismic forces.

K. B. Mohankumar and Vinayak Vijapur (2016) carried a comparison of seismic analysis of G+12 building stiffened with bracings and shear wall. The performance of the building is analysed in zone –III zone-IV and zone-V, with soil types II (medium). The analysed structure is symmetrical, G+12, special RC moment-resisting frame (SMRF). Modelling of the structure is done as per ETABS 2015 software. Time period of the structure in both the direction is retrieve from the software and as per is 1893 (part - I) 2002 seismic analysis has undergone the lateral seismic force of RC frame is carried out using linear static method as per is 1893: 2002 (part-I) for different earthquake zones A comparative analysis is done in terms of base hear, displacement modal time period and modal frequency, storey acceleration and storey drift. The results are then graphically represented and also in tabular form and our compared for determining the best performance of building against lateral stiffness.

R. Bharath Reddy et al. (2015) carried a comparative study on lateral load resistance of multi-storied structure with bracing systems. A five storied RC building has been modelled and then analysed considering the combination of gravity and seismic forces the performance of the same structure has been investigated for different types of bracing system such as cross and diagonal bracing using a concrete section and steel section respectively. The performance of the same building has been evaluated in terms of lateral displacements of members, storey drift, axial force and bending moment in columns at different critical. The effectiveness of various bracing systems on the structure has also been investigated. More importantly, the reduction in lateral displacement has been found out for different types of bracing system in comparison to building with no bracing for zone-III and zone-IV. From the present study it has been found that the crossed 'X' bracing reduces more lateral displacements and thus significantly contributes to greater structural stiffness to the structure.

R. S. Mishra et al. (2015) carried a comparative study of different configuration of shear wall location in soft storey building subjected to seismic load. This study is concentrated to analyse the seismic behaviour of structure (Special moment resisting Frame, SMRF). The study has been carried out using STAAD Pro software, IS 1893:2002, IS 13920:1993 and IS 456:2000. The building under analysis consist of 11 floors and has 5 bays along both direction with a span of 4m each, floor to floor height is 3m, ground floor to first floor height is 2.80m. The building has been located in seismic zone-II (Bhilai region, Chhattisgarh) of India. While analysing using STAAD pro, soft storey has been observed at 1st and 11th floor. A comparison has been done by placing shear wall at different location in the building subjected to seismic load. These locations consist of shear wall being placed at periphery at intermediate position and in the core. On the basis of results, it has been concluded that, intermediate position of shear wall is best suited with respect to core and periphery positions of the structure.

3.2.3. Review of Literature on Study of Outrigger Structural System

Prajyot A. Kakde and Ravindra Desai (2017) presented comparative study of outrigger and belt truss structural system for steel and concrete material. In today's modern era it has become need to undertake development in tall structure to accommodate the present population as the cities are growing fast and land availability is becoming lesser for human beings. The outrigger and best truss system comprise of a main concrete core connected to exterior columns by relatively stiff horizontal members such as bracings termed as outriggers. On the basis of connection to the core there are two types of outrigger truss system, conventional and virtual outrigger system. High rise building of 70 storey having 30x30 m plan dimension with each storey height of 3m with core shear wall of 10mx10m is taken into consideration. After performing analysis and studying the results it came to conclusion that steel outrigger system is found to be efficient in controlling the lateral loads and has proved to be economical

Abdul Karim Mulla and Srinivas B. N. (2015) presented a research containing comparative study on behaviour of the outrigger in regular and vertical irregular structure. They studied the two models of 20 storey in which one was regular building with and without outrigger and another irregular building with and without outrigger which changes the shape along the height. The models were analysed under equivalent static method and response spectrum method and checked in storey drift, natural time period and lateral displacement. Models were also analysed varying the seismic zones as per the Indian standards. Steels bracing were used for belt truss with the RC frame. It was concluded that concrete outrigger is more efficient than the steel outrigger when it compares story displacement. Irregular building with vertical floor irregularity due to the reduced self-weight is more effective than regular building but at the same time it reduces the stiffness of the building. To increase the stiffness of the building particularly in irregular building, location of the outrigger is the most important factor is to be considered.

Srinivas Suresh Kogilgeri and Beryl Shanthapriya (2015) presented a study of behaviour of outrigger system on high rise steel structure by varying outrigger depth. It says that the outrigger system is one of the efficient systems used for high structures to resist lateral load resisting system. In this system the belt truss tis all the external columns to the periphery of the structure and outrigger connect these belt trusses to the centre core of the structure thus restraining the exterior column from rotation. The structure is assumed to be located at Bangalore for analysis .40 storey steel structure is considered. The plan dimension of the structure is symmetrical about both axis It concluded that the use of outrigger structural system increases the stiffness of the structure by connecting the building core to the distant column and makes the whole system to act as a single unit in resisting the lateral load.

Vijaya Kumari Gowda M. R. and Manohar B. C. (2015) studied dynamic analysis of tall structure system by introducing belt truss at top and mid height of building. Comparative study was carried out by using different types of belt truss which includes X, V, inverted V, diagonal etc. for different seismic zone criteria to understand the importance of belt truss. To execute this study researchers have modelled 30 storied 3-dimensional models by implementing different types of belt truss and analysed the model by equivalent static analysis and response spectrum method as per the Indian Standard codes. It is found from the study that for reducing lateral displacement and story drift, Concrete belt truss is more efficient compared to structural steel belt truss as it gives negligible results. Each type of trusses gives different results for different seismic zones, therefore based on economic conditions researchers have concluded that inverted V-type of belt truss is one of the best types of belt truss in all seismic zones to increase the efficiency of the building.

P.M.B. Raj Kiran Nanduri et.al. (2013) studied the behaviour of the outrigger system in 30 storey reinforced concrete building, in which the outrigger placed in between central core and exterior column of the building. They also investigated the optimization of the outrigger location and the efficiency of each outrigger under the wind load and earthquake load. The analysed the building by installing the multi outrigger system with several combinations such as without outrigger, with outrigger and outrigger with belt truss at the different position in building. Belt truss was placed along the periphery of the building. The earthquake load and wind load consider according to Indian standard code and checked the building in lateral displacement, drift, bending moment and column axial force. The study concluded that the maximum reduction in lateral displacement occurred when the outrigger and belt truss placed at top and mid height of the building. Using the concrete section instead of steel section in outrigger it shows that outrigger performs better because of the rigid connection with core of a building

Kiran Kamath et. al. (2012) presented a study on behaviour of outrigger system in tall building under the static and dynamic condition. The aim behind the study was to give the structure to a lateral stability against the lateral load acting by wind load and earthquake load. For that the author examined the three-dimensional 40 storeys of reinforced concrete structure with central core wall with outrigger and without outrigger by varying the relative flexural rigidity of the structure and placing the outrigger at different location by taking the relative height ratio. Relative height ration equals to height where the outrigger placed by total height of the building. The analysis was done by equivalent static method and response spectrum method considering the historical earthquakes occurred in California region. And it was found that placing the outrigger at mid height is more effective than placing at top height of the building. They also suggested that though the outrigger at top is less efficient but it has observed that by pacing the outrigger at top it reduces the top storey drift and peak acceleration considerably. Overall, by increasing the flexural rigidity of the outrigger and placing outrigger at mid height of the building gave the better result in lateral displacement, shear force, bending moment and storey drift of the building.

N. Herath et al. (2009) studied the high-rise building under the earthquake load by adopting the outrigger beam system. The idea behind this study was to increase the stiffness and strength of the building by using the outrigger beam connecting the core and exterior column of the building to resist the lateral load acting on structure. The study also aimed to optimizing the location of the outrigger beams in structure in order to achieve maximum stiffness and economy in building. In this study a concrete outrigger beams were used instead of steel truss beams which were proved to be very effective as the connections of the RC outrigger beam to exterior columns worked better than its connections with steel truss. Researchers analysed several 50 storied RC frames with different location of outrigger beams by response spectrum method and it was found that the optimum location of the 2nd outrigger beam was near the mid height of the building. The researchers were analysed the models by considering the 9-ground acceleration of actual earthquakes in past to study the displacement and the drift of building.

4. Conclusion

From the above literature we conclude that

- Paper suggest to use different structural system based on different height of structure and plan shape
- Use of rigid moment resisting structural system become inefficient for more than 30 storeys
- From different bracing system X- type of bracing is found to be most efficient in reducing overall response of building i.e. displacement, story drift and deflection as compared to other types of bracings.
- As displacement is better controlled by shear wall system, it proves to be alternative for building in earthquake prone area due to increase in mass and stiffness of the structure.
- Analysis of building with different location of Shear wall shows that shear wall provided at core of the building shows stiffer behaviour and maximum reduction in storey drift value.
- Stability of structure will boast and sway columns can be avoided by implementing 'L' shaped Shear walls along the corners of the structure.
- The usage of outrigger system in the building increase the efficiency of the building when compared to building without outrigger under the action lateral loads.
- Maximum reduction in lateral displacement is observed when outrigger and belt truss system is placed at top and mid height of the building.
- By analysing several RC frames with different location of outrigger beams it is found that the optimum location of the 2nd outrigger beam is near the mid height of the building.
- Using the concrete sections instead of steel section in outrigger it shows that outrigger performs better because of the rigid connections with core of a building.
- Dynamic analysis reduces storey shear storey displacement, storey drifts, etc., this shows that dynamic analysis gives improved estimate of force and there for analysis of building become more accurate as well as economical

5. Gaps in Literature

Based on literature review we studied with reference to Lateral Load Resisting structural system, there is certain absence of research work which is not studied earlier, as mentioned below

1. From the earlier research work till now, various, research have carried out study for geometrically regular shaped building (i.e. square or rectangular shape) by incorporating different lateral load restating system. However, there is an absence of scientific research dealing with geometrically irregular shape in plan (i.e. C shape, L shape)
2. Various research has carried out investigation considering static and dynamic under elastic limits, we can also analyse the building by wind analysis.
3. Research have also preformed studies on the behaviour of lateral load resisting system by considering simple grids in place of real building plane
4. In the earlier research work, most of the study based on lateral load resisting system is done up to 40 story building here it can be extended to super high-rise building.

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