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Dynamic Analysis Of High-Rise Building With Outrigger System Under Seismic Loading-A Review

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Abstract : As recognized from very offensive experience in many places of world collapse of tank and due to this heavy damages during earthquakes due to this reason many studies done for dynamic behavior of water containers, most of them are concern with cylindrical tanks. The economic lifetime of this RCC tanks are usually in the range of 40-70 years. Staging is responsible for lateral resistance of complete structure .The objectives of this is study to understand the behavior of different staging system under different tank conditions for different L/B ratio.

Keywords: High-rise Structure, Outriggers, Belt Truss, Virtual Outriggers, Seismic Analysis

I. INTRODUCTION

Tall buildings are constructed based on purpose they use whether it may be for commercial or residential purpose. Loads act on a building will be of horizontal, vertical or torsional type of load which give different effects on building. The primary function of the structural elements is to resist the gravity loading from the weight of the building and its contents. Secondary function of the vertical structural elements is to resist the wind and earthquake. The risk of horizontal and vertical load forces also increases as the height of the building increases. The moment resisting frames and braced core at certain height becomes inefficient to provide stiffness against wind and seismic loads. The lateral deflections due to this load should be prevented for both structural and non-structural damage to achieve the building strength and also stiffness against lateral loads in the analysis and design of tall buildings.

In general, for design of tall buildings both wind as well as earthquake loads need to be considered. Governing criteria for carrying out dynamic analyses for earthquake loads are different from wind loads. The distribution of lateral forces along the height of the building is included in arriving at the contribution of the higher mode effects.

The factor that governs the design for a tall and slender structure most of the times is not the fully stressed state but the drift of the building. There are numerous structural lateral systems used in high-rise building design such as: shear frames, shear trusses, frames with shear core, outrigger system, framed tubes, trussed tubes, super frames etc. However, the outriggers and belt trusses system are the one providing significant drift control for the building. As the height of structure increases its displacement, story drift, story shear of the building decreases abruptly. So, in order to restrain those parameters in the building especially under wind and earthquake loads suitable method to be taken to reduce those effect in the building.

II. REVIEW OF LITERATURE

V. D. Sawant, V.M. Bogar (2019) have worked on parameters comparison of high rise RCC structure with steel outrigger and belt truss by linear and nonlinear analysis. The basic concept of this research work was to carry out the comparative study of result obtained for the lateral deflection, base shear and story drift with steel outriggers with X- type and V- type bracing systems. The reduction I displacement with the increase in base shear for the increase in the number of outriggers. Analysed the model by response spectrum method as per the Indian Standard Codes. The results obtained by nonlinear time history analysis observed that increment in base shear is very small by using outriggers and belt trusses than the conventional building, outriggers are of the steel material the increase in base shear is very less because the dead weight of RC is more than steel. The study concluded that, the linear analysis of RCC building, with X- type bracings, the lateral displacement and top story drift get reduced by 18.47% and 22.40%. The nonlinear analysis the lateral displacement and top story drift get reduced by 14.44% and 17.46% of conventional RCC building.

Rohit B Khade, Prof. Prasad M Kulkarni (2019) presented research containing to study the effect of outriggers in symmetrical & asymmetrical buildings under earthquake & wind load on lateral displacement. The outrigger system is very effective in increasing structures flexural stiffness. The basic concept of this research work to carry out the comparative study of result obtained for the lateral displacement and story drift of both symmetrical & asymmetrical building by using equivalent static analysis method for optimum outrigger location. Equivalent static analysis strategy is utilized for estimation of structural displacement demands. They have carried out the analysis on a 40 storied high-rise building. These are 6 no. of models are examined for both irregular and regular structure. The complete comparative analysis reveals that, from economical and displacement point of view the concrete outrigger are better than the steel outriggers. The results shows that the symmetrical building shows more resistant to lateral deflection & story drift than the asymmetrical building. Story drift of the regular building is less than the story drift of irregular building.

Premalatha J, Mrinalini M (2018) investigated its performance with different configuration of belt truss system under wind forces and seismic forces. The outrigger system is one of the most common and efficient system than can be used to improve the

performance of tall building under wind & seismic forces. In this paper, the researcher studied seismic behaviour of a multi – storied RC irregular building with outrigger belt truss system. The earthquake load consider according to IS code and checked the building in max. Storey drifts, max. Storey displacements. In this study, the researcher studied the three-dimensional 30 story RC model frame with different storey. The performance of asymmetrical building with outrigger and belt truss system using Response spectrum analysis, time history analysis and static analysis due to wind forces. The study concluded that the storey drifts off this frame also is found to be reduced and indicates the increase in stiffness of the building frame. The RC frame with two belt trusses i.e. One at 0.6h and another truss at 0.4h performed better than the other models.

Roy Shyam Sundar, Gore. N. G (2017) have carried out a comparative study and analysis of tall RC structure with & without outrigger system subjected to seismic and wind loading. The behaviour of tall RC structure in terms of time period, base shear, base moment, storey displacement & storey drift. Compare the effect of outriggers by both equivalent static and dynamic analysis method (RSM) along with gust factor analysis. The deflection and displacement are within the permissible limits as specified by IS Code-1893:2002. Due to reduction of lateral stiffness with the increases in height of structures, outrigger system has been proposed in the present study to minimize the effect due to loss of stiffness. To execute this study researches, have G+50 3D model in ETABS and to analyse the structure using finite element analysis approach. It can be concluded from this study that the outrigger system provides reduction in displacement, drift and base moment, which will further the size and depth of foundation. The use of outrigger system in high rise structure increases the stiffness and makes the structure more efficient under seismic and wind loading.

Bishal Sapkota, Surumi R.S, Jeyashree T.M (2017) the investigation on the seismic performance of a high-rise building with outrigger belt truss system and damper as energy dissipation system. Utilization of outrigger and belt truss framework is a possible method to improve the structural behaviour of the high rise building under lateral loads. Non-linear time history analyses of three-dimensional building models were performed by using SAP2000 software program. The aim of this investigation a series of time history analysis of the building with outrigger systems and with dampers are carried out using three different seismic waves. In this study the researcher studied the 40 storey RC building with different numbers and locations of outrigger belt truss systems and dampers are compared with that of the conventional building. The result concluded that, Seismic performance of the building with dampers as energy dissipation system is superior to the building with outrigger belt truss frameworks. Both structural systems i.e., outrigger belt truss and dampers can increase the performance of the building while subjected to earthquake ground motion by reducing the lateral deflection of the building.

Kasi venktesh, B. Ajitha (2017) this study the behaviour of outrigger & outrigger location optimization and the efficiently of each outrigger when three outriggers are used in the structure. In this research paper the author's objective to study the use of belt truss and outrigger placed at different location subjected to earthquake and wind load. The locations of outriggers and lateral displacement. The present study to RC multi storied symmetrical building. In RCC structure is taken into consideration and the analysis is done as per IS Code. The model considered is a 60m high rise RC building frame. The building represents 20 stories building. The location of the building is assumed to be Hyderabad, (zone II). The study concluded that the optimum location of the outrigger is between 0.5 times its building heights. The use of belt truss and outrigger system in high rise buildings increase the stiffness and makes the structural form efficient under lateral load.

Chetan Patel Y G, Kiran Kuldeep K N (2017) presented the study on behaviour of outriggers for tall buildings subjected to lateral load. Their study included analysis of RCC structure having different methods of outrigger and belt truss system. The emphasis was given to the story drift, deflection, core wall bending moment and optimum position of outrigger and belt truss. The main object of this paper to study the use of conventional and virtual system subjected to wind and earthquake load as per IS Code. To perform the analysis ETABS has been used. Researchers analysed several 32 storey RC building having a constant storey height. The results were concluded that the main disadvantage of providing outrigger system is that it will occupy floor area space to overcome this difficulty providing conventional with belt truss at top only and virtual belt truss at mid height of building can increase the stiffness and lateral load resisting efficiency of building. The lateral load resisting efficiency of the building increase with increase in the stiffness on providing outrigger and belt truss system.

Komal Jain. J, Mr. G. Senthil Kumar (2016) presented an analytical study on outrigger structure using non- linear dynamic time history analysis. The aim behind the study was the various factors such as drift, displacement, base shear and time history analysis that is calculated using static & dynamic analysis. In this study, with the complexity of vertical stiffness distribution with the existence of belt truss, static non- linear pushover analysis. For the analysis of this problem research have chosen different storey ht. of both symmetrical and asymmetrical RC structure with central core wall with outrigger, without outrigger and outrigger with belt truss the different position in building. The earthquake load considers according to Indian standard code. This study it is concluded that the performance of the building improves if the outrigger is placed at the mid height of the building. The outrigger with belt truss system is effective in controlling drift of the building. From time history analysis the accelerations are low for outrigger based high rise structure which makes it more stiff and rigid.

Anju Akbar, Sadic Azeez (2016) presented research involving investigation of the effect outrigger system in a multi storied irregular building. An outrigger is a stiff beam that connects the shear wall with exterior column and it reduce the lateral load and overturning moment by resisting the rotation of the core. This paper presents the result of investigation based on displacement, drift ad overturning moment reduction. The analysis was done by response spectrum analysis method as per IS Code using ETABS software. Researchers analysed several 40 storied building with core shear wall. The analysis and design of complete core and outrigger system is not that simple distribution of forces between the core and outrigger system depends on relative stiffness of each element. The result concluded that the storey drift of the irregular building gets reduced by the presence of multiple outrigger system. The presence of belt truss also influences the story drift of the building.

Abeen Mol N M, Rose Mol K George (2016) presented research involving the performance of different outrigger structural systems. The outrigger structural system is one of the horizontal load resisting systems. The objective of this thesis to study the use of outrigger

at various locations in a 30-storey building. Two types of analysis are carried out time history & pushover analysis. Find the performance of outriggers at various storeys with various types of bracings and evaluate the efficiency of outrigger in different stories of the high-rise building. The main aim of study focuses on analysing the performance of the outrigger structures with conventional structures due to make it economical. Which is 90m high rise building frame. The study concluded that the outrigger structural system for tall building substantially increases stiffness and stability against lateral loads. The lateral displacement is observed to be increase as the storey height increases.

Sreelekshmi S, Shilpa Kurian (2016) the study of outrigger systems for high rise buildings. Outrigger systems are one such prominent system and are considered to be most popular because they are easier to build and provide good lateral stiffness. In tall buildings, lateral loads i8nduced by earthquake & wind were battled by an arrangement of coupled shear walls. The results of an investigation on drift, displacement and base shear reduction in steel building frame with rigid outriggers. Outrigger braced structure is an efficient structural form in which the central core is connected to the outer columns. In this study, different shear wall was considered and a best arrangement is determined by using time history analysis. The model considered is 120 m high rise steel building frame and it represents 40 storied building. The roofs & floors were modelled as rigid diaphragms. Outrigger were provided at top, one fourth, and three fourth and mid height. Cap trusses were provided in all these cases. The results were concluded when the outriggers are provided at top and ¾th ht. the Displacement value satisfies. The limiting value 0.002 times the building height. The introduction of double outrigger results in 65.49 % and 78.87% displacement and drift reduction respectively. The bare shear also reduction is 60.94%.

Daril John Prasad, Srinidhilakshmish Kumar (2016) presented research containing Comparison of Seismic Performance of Outrigger and Belt Truss System in a RCC Building with Vertical Irregularity. The main object of this paper is to compare models with outrigger, belt truss and outrigger with belt truss in which their position remains constant in all the models. Compares the parameters such as base shear, lateral displacement and storey drift. The analysis of structure was done by equivalent static and response spectrum method as per Indian standard code practice. This paper aims in concluding the efficient lateral load resisting system. In this study, 30 storey models having vertical irregularity were taken as per IS 1893 (Part-1): 2002 using finite element software ETABS. It was observed through this research that, the base shear is increasing for building with outrigger and building with outrigger with belt truss. The displacement is increasing by for building with outrigger. Since building with outrigger and belt truss may be uneconomical and also reduces the working space, building with only belt truss can be chosen as the lateral load resisting element in buildings with vertical irregularity. The storey drift is increasing by 25.6 % to 39.4 % for building with outrigger and 45 % to 46.6 % for building with belt truss.

III. CONCLUSION

From the studies carried out so far it has become evident that the behaviour of Outrigger system is dependent upon many factors. Some of the major factors of influence are listed below;

1. The stiffness and location of the outrigger truss system.
2. The stiffness and location of the Belt truss system.
3. Geometry of the tall building.
4. Storey drift ratio was reduced when outrigger was introduced in structural system.
5. Time period of structural model depend on stiffness and seismic mass of structure. Time period increase as stiffness increase at constant seismic mass of structure and decrease with increase in seismic mass at constant stiffness.

REFERENCES

[1] Krutagn Patel, Prof.Vishalkumar Patel, Dr. Snehal Mevada “Design and Analysis of Core and Outrigger Structural System”. International Research Journal of Engineering and Technology. Volume 7, Issue: 06, June 2020.

[2] Kushagra Ashara, Keval Patel, Abbas Jamani “Comparative Study on Performance of RC Building with Outrigger System Incorporating Buckling Restrained Bracings”. International Research Journal of Engineering and Technology, Volume: 07, Issue: 06, June 2020.

[3] Mohd. Imran Mohd. Azahar, Hemant B. Dahake “Effective Position of Shear Walls and Braces as an Outrigger Systems in Tall Building”. International Journal of Scientific Development and Research, Volume 4, Issue 5, May 2019.

[4] Mr. Raeed Aslam Bhatkar, Prof. Narayan Gorakh Gore “Comparative Study of the Two Most Effective & Popular Structural System Viz. Outrigger and Diagrid Structural System”. International Research Journal of Engineering and Technology, Volume 06, Issue 07, July 2019.

[5] Nehal M. Ayash, Mohamed H. Agamy “Non-Linear Seismic Analysis of High Raised RC Buildings with Outrigger Systems”. International Journal of Scientific & Engineering Research Volume 10, Issue 1, January 2019.

[6] N.G. Gore, S. K. Ukarande "Performance of Dual-Outrigger Structural System in Geometrically Irregular Shaped High-Rise Building". International Journal of Engineering Science Invention, Volume 8, Issue 05, May 2019.

[7] Premalatha J, Mrinalini M "Seismic Behaviour of a Multi-Storeyed Reinforced Concrete Irregular Building with Outrigger Belt Truss System". International Journal of Engineering and Advanced Technology, Volume-8, Issue-2S, December 2018.

[8] Rohit B. Khade, Prof. Prashant M. Kulkarni "Effect of Wind Load on Structural Performance of Dimensionally Regular & Irregular High-Rise Buildings with Different Outrigger Systems". International Journal of Engineering and Management Research. Volume- 9, Issue- 4, August 2019.

[9] Roy Shyam Sundar, Gore. N. G "A Study on Tall RC Structure with Outrigger System Subjected to Seismic and Wind Loading". International Journal of Engineering Research & Technology. Volume 6, Issue 02, February-2017.

[10] Sreelekshmi. S 1, Shilpa Sara Kurian "Study of Outrigger Systems for High Rise Buildings". International Journal of Innovative Research in Science, Engineering and Technology, Volume 5, Issue 8, August 2016.

[11] Varsha Virde, Dr. R. Singh, Alok Rathore "Analysis of High-rise Building with Outrigger Using Non-Dimensional Parameter". International journal of advanced research in engineering and technology, Volume 11, Issue 3, March 2020.

[12] V.D. Sawant, V.M. Bogar "Parameters Comparison of High-Rise RCC Structure with Steel Outrigger and Belt Truss by Linear and Non-Linear Analysis". International Journal of Engineering Trends and Technology, Volume 67 Issue 7, July 2019.

[13] M.K. Prajapati and S.Jamle, " Strength Irregularities in Multi-Storied Building Using Bass-isolation and Damper in High Seismic Zone: A theoretical review", International Journal of advanced Engineering Research and Science (IJAERS) Journal, Volume-7 Issue-3 ISSN: 2349-6495 (P) 2456-1908 (0) March 2020.

[14] M.K. Prajapati and S.Jamle, "Analysis of Multi Story RC Frame Irregular Step-up Structure with Fixed Base and Base – isolation Damper Support in High Seismic Zone", Journal of XI'AN University of Architecture & Technology Journal (JXAT) Journal, Volume XII, Issue IX, ISSN No: 1006-7930, September 2020.

[15] M.K. Prajapati "Analysis of Setback Structure considering Different Isolation Techniques : A Review" International Journal for Research in Applied Science & Engineering Technology (IJRASET), Volume8, Issue XI, ISSN 2321-9653, Nov 2020.

[16] M.K. Prajapati " Analysis of static and Dynamic forces on Irregular Reinforced Residential building under seismic exertion using the ETAB System" International journal of Research in Engineering, Science and Management (IJRESM) ,Volume-4,Issue-1,ISSN:2581-5792, January-2021.

[17] M.K. Prajapati "detailed analysis of pervious concrete" Journal of engineering, computing and architecture (JECA), Volume 11, Issue 3, ISSN NO: 1934-7197, march 2021.

[18] M.K. Prajapati "Waste management system in Ujjain" Journal of engineering, computing and India architecture (JECA), volume 11, Issue 3, ISSN NO: 1934-7197, march 2021.

[19] M.K. Prajapati "Analysis of a high rise building frame considering lateral load Resisting member: A review, International journal of civil engineering and technology (IJCIET), volume-12, Issue-3, ISSN NO: 0976-6308, march 2021.

[20] M.K. Prajapati , Sanskar Gupta and Prateek Saxena, " A review on partial replacement of fly ash, marble dust and crushed concrete aggregate in concrete mixture, International journal of high technology letters (HTL), volume 27, Issue 7, ISSN NO: 1006-6748, July-2021.

[21] M.K. Prajapati, Mohini Dharwe and Prateek Saxena, "Traffic signal control system design : A case study of ghans mandi square Ujjain city India, Journal of XI'AN University of Architecture and Technology(JXAT) Journal, volume XIII, Issue VII, ISSN NO : 1006-7930, July -2021.

[22] M.K. Prajapati, "Structural behavior of building under the seismic load:-A brief review" International journal for innovation engineering and management research (IJIEMR), volume-11, issue 01, ISSN NO: 2456-5083, January-2022.