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Use of Shear Wall Belt at Optimum Height to Increase Lateral Load Handling Capacity in Multistory Building: A Review

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Abstract—*Due to the increase in the demand of high rise and fascinating structure with vertical & horizontal irregularity, different themes, and increasing height day by day leads to new challenges and requirement of new safety measures. To resist from earthquake and expressly wind effect due to increasing stature as the stiffness of the building is increases with increasing height we need to adopt some preventing structural system. Some of them are bracings, shear wall, outrigger system etc. In this study outrigger system is taken for analysis due the fact that is found the most optimal system for high rise buildings and skyscrapers. In this system the external columns are connected to main inner or outer core by means of outrigger beams at different floors to resist against story drift and rotating action of core due seismic and wind forces. In this study various papers allied to this topic are reviewed in which an enormous work is done in this field earlier. With the help of review of research paper we came to know about the conclusive outcome which forms the research objectives of our further study.*

Keywords— Belt supported system, Lateral load capacity, Optimum height, Shear strip cases Shear wall belt, Staad pro.

I. INTRODUCTION

In the present situation of overcrowding and increasing trend of luxurious and fascinating lifestyle in the fast growing nation, the building sector faces new challenges day by day specially the structural engineers to fulfill the dreams. To fulfill such type of need various researchers have done a lot of work and a lot new techniques are developed for every new generated problem comprises of bracings, outriggers, RC shear wall and shear core, steel plate shear walls, box systems, base isolation, dampers, seismic invisibility cloak, rocking frame, etc. One of the solution adopted for our analysis for such kind of problems is outrigger system or we can say the application of this system i.e. use of shear wall belt at optimum height to make the structure capable of handling lateral loads developed due to earthquake forces or may be due to wind effects in case of high rise building or twin tower or skyscrapers as per the need of hour.

Here to face a lot of research work is done in the field of lateral load resisting system where various such kinds of systems are analyzed against various constraints separately for specific conditions and limitations. Shear wall and shear core both are optimized within the building against various parameters but the use of shear wall as shear wall belt like outrigger beam system is not analyzed till now.

In the present study various research papers are studied and reviewed to know the current challenges and so the further research is carried on the suggested objectives and problem statement generated from the review of research work. In the further study a 25 storied residential building having a standard plan and plinth area of 825 m^2 is analyzed. Various cases with shear strip belt at different locations are planned and analyzed against various parameters by Staad Pro software. Response spectrum method will be used along with SRSS combinations as per IS 1893 to determine various seismic parameters along transverse as well as longitudinal direction.

So a detailed review and study is required in the field of connected or linked structure for their stability analysis which helps in suggesting the recent situation the further need of research to optimize the suggested case contrary to various parameters. So a G+24 storied residential model is created with 16 different cases against several seismic parameters. They are as follows:-

CASE A = General structure without shear wall
CASE B = General structure with shear wall at corners
CASE B1 = Structure with shear belt at 0 m
CASE B2 = Structure with shear strip at 1st floor
CASE B3 = Structure with shear strip at 3rd floor
CASE B4 = Structure with shear strip at 5th floor
CASE B5 = Structure with shear strip at 7th floor

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CASE B6 = Structure with shear strip at 9th floor
CASE B7 = Structure with shear strip at 11th floor
CASE B8 = Structure with shear strip at 12th floor
CASE B9 = Structure with shear strip at 13th floor
CASE B10 = Structure with shear strip at 15th floor
CASE B11 = Structure with shear strip at 17th floor
CASE B12 = Structure with shear strip at 19th floor
CASE B13 = Structure with shear strip at 21st floor
CASE B14 = Structure with shear strip at 23rd floor

Response spectrum analysis is performed and the building is analyzed for Zone 5, having Zone factor, 0.36.

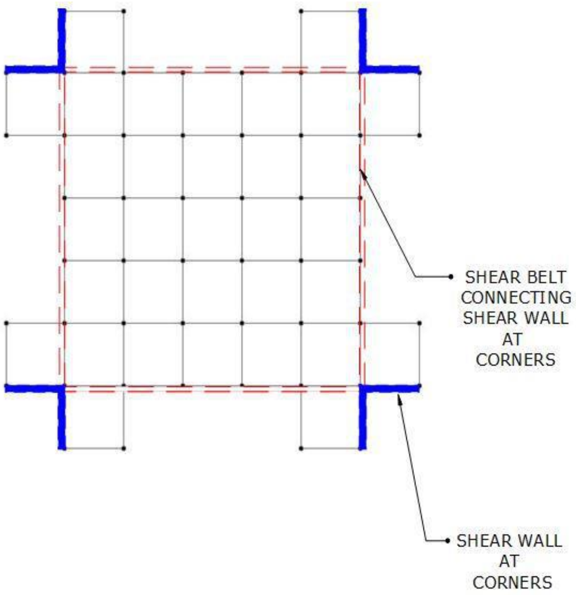

Fig. 1: Structure with shear strip connected with Shear Wall at Corners

II. REVIEW OF LITERATURE

Abbas Haghollahi, Mohsen Besharat Ferdous, Mehdi Kasiri, in this paper studies are carried out in 2 steel framed high rise building 20 & 25 storied high braced by outrigger and belt truss system. This investigation is done by response spectrum and non- linear time history analysis by SAP software. The aim of this study is to find the optimum location of outrigger beams against lateral load within the building. The result of the study shows that stories drift ratio is kept away from the outcomes of response spectrum analysis. On the contrary the procedures trend is reversed for time history analysis. Outrigger beam location critically influences the structure's lateral behavior under seismic load. Outrigger and belt truss optimum location is at 10th and 14th story for 20 and 25 storied model respectively by response spectrum method on the other hand optimum location is 14th and 16th storey for 20 and 25 storied model respectively by time history analysis. Still the study claims that the optimum location is preferably upper levels for each specific case as per site condition.

Shivacharan K, Chandrakala S, Karthik N M, in this paper an effort is made to explore the effect of belt truss and outrigger location in a building when subjected to both the cases of seismic and wind load one by one. Assumption made for wind load calculations is based on IS 875 (Part III) and similarly earthquake load by IS 1893 (Part I):2002. To analyze the response of above study a 30 storied vertically irregular multistory building model is proposed providing belt truss and outriggers at different levels are analyzed against various parameters. Drift and displacement of the structure under compression is studied. Linear static analysis is conducted for evaluation of outrigger and belt truss performance by E tabs software. The result of the study shows that our assumption of using outrigger and belt truss is proved efficient against lateral load and stiffness is increases in high rise structure. More precisely it can be stated that outrigger optimum location is 0.5 times of its height.

Mohd Abdus Sattar et. al. ,this paper involve the comparative study limited to RC high rise building of 15, 20 and 25 stories with shear core, outrigger and belt truss. The plan area of the building is bay frame in the spread area of 40mX40m having columns placed at 5m apart from center to center. But the study is carried out for L shaped plan for floor rigidity with several models built without and outrigger and belt truss and 4 more cases with shear wall core and stringer beam with variable location of both one at a time each so as to understand the effect of each system effectively. The study is conducted by E tabs software for both wind loads and earthquake loads against various factors. The conclusions of the research shows presence of combination of double core shear wall, stringer beam and floor rigidity increases the stiffness of the structure. Floor rigidity is not necessarily increased for dead load and live load on floors. Combination of double core and stringer beams show a minimum of column forces and moments and also the drift and displacement is relatively less. Also corner columns have lesser moment as compared to outer one.

J.C.D. Hoenderkamp, in this paper optimum location of outriggers on shear wall with basement fin extensions was found by graphical means for preliminary design of multistory high rise building against horizontal loading. In this method we need seven parameters comprises of shear wall bending stiffness, fin-walls and outrigger, outrigger racking shear stiffness, bending stiffness by exterior column, shear wall's rotational stiffness and foundation of column. Clubbing all the parameters provide a base for optimization for optimum level of outrigger and displayed in graphical form. All the study is carried out in form of characteristics equations to find the optimum location of outriggers. The assumption of basement fin wall reduce the translational stiffness of the piles to zero value and so providing an infinite value for characteristics non dimensional parameter. The mishmash of shear wall braced with outrigger and additionally providing basement fin wall facilitates optimum location of outrigger and maximum horizontal displacement.

P.M.B. Raj Kiran Nanduri et. al., focuses their study on analyzing the behavior of outrigger system, optimization of its location and its efficiency while using three outriggers in a structure. Various models are framed for a 30storied high rise building with belt truss and outrigger placed in structure against both wing and seismic loadings for lateral displacement reduction. The analysis is done for Reinforced concrete high rise building of 90m height with a plan area of 38.5mX38.5m with column to column spacing of 5.5m by E tabs software. A total of seven different models are framed with or without outriggers placed at various locations. The result of the study shows that stiffness is increased by the use of aforesaid system also structural efficiency is improved. It is also found that placing of outrigger at the top is not so effectual but the use of second outrigger with cap truss at middle height of the structure is more efficacious.

A. Rutenberg, D. Tal, presents a numerical study and results of the study to investigate the drift reduction with rigid outriggers against various lateral load distributions in uniform and non -uniform belted structure. The assumption of the analysis are axial rigidity of periphery column and flexural rigidity of core, belts arm are infinitely rigid, neglecting shear deformations and frame action is precluded by pinning floor girders. On the basis of above analysis author makes an effort to study to investigate the influence caused by location of outrigger perimeter column to core stiffness ratio and variation of stiffness. The result of the study shows that outrigger efficiency is fully achieved by use of two outriggers for full mobilization of perimeter columns. Also the outriggers are not placed very proximate to the base of the structure.

J.C.D. Hoenderkamp, has made an attempt to analyze horizontally loaded tall building performances laterally supported by vertical trusses and horizontal offset riggers that are placed in the front face of the structure along the direction of lateral loading. The analyses is performed against various structural parameters viz. trussed frames, façade rigger and perimeter frame. Several structural properties are discussed like location of façade rigger, horizontal deflection reduction, bending moment of trusses and belt truss. The outcomes of the study are increasing thickness of floor slab affects movement of faced rigger, increment in the deflection reduction and also it is significant too. By increasing the restraining moment there is an increment in the reduction of the bending moment. This method shows positive signs for allowing façade riggers perpendicular to the direction of horizontal loading.

Abeena mol N M, Rose mol K George, this research work is carried out on a 30 storied high rise core wall building. For this study a building with plinth area 38.5m X 38.5m is taken for consideration. This study is carried out by time history analysis and push over analysis. Maximum storey displacement is taken as key parameter to evaluate the performance of various outrigger systems with respect to conventional structure by E tabs software. Also we need to make this model economic along with structurally feasible. The aim of the study also includes excessive drift control due to lateral load and to evaluate the outrigger efficiency at various levels in multistory building. The results of the study shows with the increment of storey height lateral displacement are also increases. Also the major concluding outcome is stiffness and stability substantially increases against lateral loads while using outrigger structural system for high rise building.

Akshay A. Khanorkar, Mr. S. V. Denge, Dr. S. P. Raut, in this review paper the work is done on study of various research work done previously in the field of outrigger system. In some cases belt truss is used to resist lateral load and alter deflection. In some studies outrigger is proved better than belt truss system. In some research paper belt truss used in steel building to connect the entire periphery column, in this paper shear core is not directly connected to belt truss. Similarly a lot of research paper shows various techniques and methodologies adopted to resist lateral load i.e. both wind load and seismic forces against various constraints and also various valuable results and solution is also obtained which shows the use of outrigger and belt truss system along with shear wall and shear core is much beneficial and efficient. The conclusive outcomes of this study is the author find needs to further research on stiffness irregularity along with structural height.

Goman W. M. Ho, in this paper the special review is presented on the outrigger system that how the system works in tall buildings, its development history and its application. This paper initially tells about the early phase of high rise building, the first high rise building "Equitable Life assurance Building", a 40m tall building in New York (1870). Further the concept of evolution of structural resisting elements and development of structural systems which helps in fulfilling the dream of today's skyscrapers. Later the concept of outrigger is discussed in the paper which explains that perimeter and internal core is needed to be coupled and work as a system to resists the lateral load. After that location and topology is discussed in which the location identified in some paper is discussed. Also design issues are discussed. After that various types of adjustable outrigger system is suggested, some of them are cross jack system, Shim-plate correction method and retro casting techniques in outrigger construction. Various other methods are discussed like damped outrigger system and concrete outrigger system with structural fuse.

III. CONCLUSIONS AND OUTLINE OF PROPOSED WORK

So far by reviewing and studying numerous research papers it has been analyzed that in the field of stability of multistoried twin tower against seismic and wind loads it is required to analyze the connected structure with various possibilities of structural stability by various means and its optimum location in the building. Here we come at conclusion drawn from studying the above review the position location of connector in the building is optimized so as to resist seismic loading.

The conclusive outcomes drawn from the study are enlisted below:

1. A multistoried building is taken for analysis with 13 floors in which floor twins is modeled up to 12th floor. Total of 13 cases are proposed with floor twins are varies floor height and the optimum condition is identified to resist seismic action. The tower is analyzed for zone 4 against medium soil type.
2. The study is conducted for both the directions viz. lateral and longitudinal direction.
3. Study is completed against various seismic parameters consists maximum displacement and storey drift in bot X & Z direction.
4. Conclusively the optimum case out of various cases is suggested with the help of above numerical data and Staad analysis.
5. The main focus is the shear strip which is a modified part of shear wall, its width and thickness are fixed but height at which it behaves as a optimum case can be a major study.

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