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A Review on using Belt Truss at Different Locations on RCC Building

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ABSTRACT

In past decades, shear walls and x bracing are one of the most appropriate and important structural component in multi-storied building. Therefore, it is very interesting to study the structural response and their systems in multi-storied structure during lateral load i.e earthquake loading. Shear walls and belt truss contribute the stiffness and strength during earthquakes which are often neglected during design of structure and construction. The scope of present paper is to study the effect of seismic loading on placement of belts truss in building at different alternative location. This study shows the effect of belts truss and bracing belts truss which significantly affect the vulnerability of structures. In order to test this hypothesis, RCC building was considered with and without belts truss at different location. The aim of the paper is to detail and conceptualize the varied configurations of belt truss structures system and to integrate current structures into longer structures by use of belt truss system at different location. Additionally, various advantage and disadvantage associated with outriggers and belt truss system also are discussed in this paper. A close of literature review within the field of Outrigger system is applied and therefore the summary on belts truss and gaps encountered within the study are listed during this paper. This paper introduces belt truss at different location. In which, using the belt truss structural within the RCC building so as to extend the performance of the building under the earthquake load and wind loads is studied. Concept of belt truss as Virtual outrigger is reviewed within the paper.

KEY WORDS: Belt Truss, Outrigger, High Rise Building, Lateral Load Resisting System (LLRS).

1. INTRODUCTION

Tall building is need of developing scenario. Rapid development of tall building in the world has been creating impact on innovative development of structural system for tall building, result of which buildings are growing taller. As population is getting denser the provision of land is diminishing and price is additionally increasing. Hence to beat these problems multi-storey buildings is most prominent and efficient solution. Development in tall buildings involves various compound aspects as an example, Shortage of land in urban areas, Increasing demand for business and residential space, Technological Advancements, Innovations in structural systems, economic process, Concept of city skyline, Cultural signification and prestige, Human aspiration to create higher In developing country like India and increased number of population, tall buildings may well be effectively wont to meet the strain of the technologically advancing society of our generation and solve the matter of limited availability of land for construction and is most.

The development in concrete technology over the twenty-first century covering structural system, analysis, construction techniques and materials, made it possible to build tall structure. There are many design objectives for structural engineers to control the design of high-rise buildings such as safety, serviceability, durability, functionality, economic effectiveness, structural integrity and resistance to accidental actions. But, the main factors that will undermine the design are the storey drift due to earthquake loads and prevention of progressive collapse attributed to the accidental loads resulting in column loss. When the earthquake load acts on the building, the bending of the core revolves the outrigger arm, which is connected to the core of structure and brings compression and tension on columns.

2. STRUCTURAL SYSTEMS

There are two categories of structural system i.e. interior structures and exterior structures. When the major part of lateral load resisting structure is located in inner part of the building it is called interior structure and if major part of the lateral load resisting system is located on perimeter of building is called as exterior structure. One of the most effective techniques to reduce the lateral drift that are likely applied in the design of high rise structure is the use of outrigger truss and belt truss.

Advantage of core-outrigger truss are that spacing of exterior column spacing can easily meet functional and aesthetic requirements and the building's exterior framing can meet simple beam-column framing without any rigid frame connections. But there are some problems with outrigger truss that are:

a) Area occupied by truss mainly diagonal can create a floor to floor spacing problem

b) Architectural aspect

c) Connection to core, especially when shear walls are used.

To overcome this problem belt truss as a virtual outrigger truss is used in structure, as it is connected on periphery of structure. There are two categories of RCC framed structural system i.e. Interior structures and Exterior structures. When the foremost a part of the lateral load resisting system is found within the inside part of the building it's called as interior structure and if the foremost part of the lateral load-resisting system is found at the perimeter of the building, this method is categorized as an exterior structure.

Interior Structure

- Rigid Frames System
- Braced Hinged Frames System
- Shear Wall System / Hinged Shear Wall (Or Shear Truss) System
- Outrigger And Belt Truss Structure System

Exterior Structure

- Tube System/ Braced Tube System
- Diagrid Structural System
- Space Truss Structural System
- Exo-Skeleton Structural System

2.1 Outrigger and Belt Truss as Structural System

Belt truss connect all perimeter column of building in the form of truss in steel building and in the form of rigid concrete wall in RC building. Belt truss is not connected directly to shear core i.e. inner lift core but it transfer forces and moment through the floor diaphragm from outer column to shear core therefore floor diaphragm need to be stiff enough to transfer forces. The floor slabs that transfer horizontal forces from the core to the belt trusses will be subjected to in-plane shear (in addition to the usual vertical dead and live load effects) and should be proportioned and reinforced appropriately. In many applications, it will be necessary to use thicker-than-normal slabs. Belt trusses used as virtual outriggers offer many of the benefits of the outrigger concept, while avoiding most of the problems associated with conventional outriggers.

- Connection difficulty between outrigger and core is eliminated.

- There are no diagonal trusses extending from the core to the exterior of the building.

- There would not be the effect of differential shortening of core and outer column on floor diaphragm since they are stiff in their own plane and flexible in vertical plane.

- The need to locate outrigger columns where they can be conveniently engaged by trusses extending from the core is eliminated

Use of belt truss as virtual outrigger eliminate some problem related to conventional outrigger and because of the many functional benefits of belt truss system and the advantages outlined above, this system has lately been very popular for super tall buildings all over the world.

-resisting core to columns at the outside of the building. The core may encompass either shear walls or braced frames. The core is also centrally situated with outriggers extending on either side or in some cases it's going to be situated on one side of the building with outriggers extending to the building columns on the opposite side.

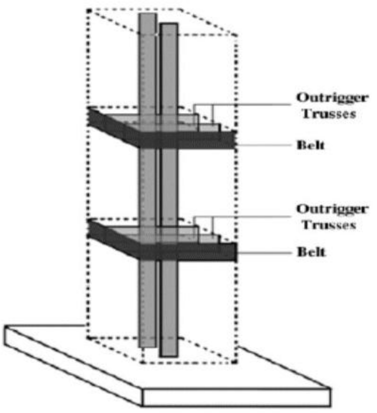

Figure 1 Multi-Level Belt Truss and Outrigger

3. OBJECTIVE OF PRESENT STUDY

The main objective of present study is use belt truss as a virtual outrigger truss placed at different location,

- To control the deflection of multi-storied building against lateral loads acting through seismic load and wind load.
- To research the various ways during which the high rise structures may be stabilized against the consequences of strong horizontal seismic loading.
- To compare building with and without belt truss.
- To study efficiency of belt truss in RC building under seismic forces.
- To obtain optimum location of belt truss for reducing storey displacement.
- To boost the seismic resistance of structure by providing only belt truss and to extend the stiffness of the structure.

4. ADVANTAGES OF OUTRIGGER STRUCTURAL SYSTEM

1. All external columns play a task in resisting overturning moment.
2. Overturning moments of the structure will be reduced through the reverse moment applied to the core wall of the structure at each outrigger connection of the structure.
3. Exterior frame of RCC building can incorporates simple beam and column framed without the requirement for rigid-frame-type connection, thus reducing the general cost of the structure.
4. Reduction or elimination of uplift pressure within the structure and net tension forces within the structure without the column and foundation system.
5. There aren't any trusses within the space between the within core and out of doors of the building.

5. LITERATURE REVIEW

1. *M Nair, R. S., Belt Trusses and Basements as „Virtual" Outriggers for Tall Buildings.*

They introduced the belt truss as virtual outrigger thanks to the actual fact that it's not connected on to the core, but still maintains the function of an outrigger. So as to stay the function as outrigger, this technique requires the ground diaphragm to convert the core overturning moment thanks to lateral load into a pair of horizontal forces. Further, this horizontal force are converted as axial forces in exterior columns. During this study a 75-story steel-framed office tower was analyzed as a three-dimensional elastic structure, the lateral displacement at the highest of the building because of wind loading was found to be 108.5 in. for the planning without outrigger and 37.1 in. for the look with belt trusses as virtual outriggers, 25.3 in. for the planning with conventional outriggers. The structure with virtual outriggers was analyzed in this paper with a ten-fold increase within the in-plane stiffness of the ground slabs at the highest and bottom of every belt truss. The displacement decreased to 31.0 in. When, additionally, the belt truss member sizes were increased ten-fold, the displacement decreased further to 26.0 in.

2. *Pudjisuryadi, P., Lumantarna, B. , Tandya, H., and Loka, I., Ductility of a 60 Story Shearwall Frame-Belt Truss (Virtual Outrigger) Building.*

They studied Shear wall-frame combined with three story belt truss as structural system within which the post-elastic behavior and ductility of this structural system are explored. The post elastic behavior of this building is measured using static non-linear push-over analysis and Dynamic non-linear Time History analysis. This study showed that plastic hinges mainly developed in beams above the truss, columns at a lower place the truss, and bottom levels of the wall. Static non-linear push over analysis show more plastic hinges developed at the lower a part of the building. The dynamic non-linear time history analysis shows smaller lateral displacement because of stiffer lower a part of the building.

3. *Z. Bayati1, m. Mahdikhani and a. Rahaei, Optimized Use of Multi-Outriggers System to Stiffen Tall Buildings.*

Z. Bayati1 proposed techniques for using belt trusses and basements as outriggers in tall. Belt trusses used as virtual outriggers in structure offer many of the advantages of the outrigger concept in the structural system, while avoiding most of the issues related to conventional outriggers. Author also studied A 80-story steel-framed office tower to research the effectiveness of belt trusses as virtual outriggers. In this paper the building has three sets of 4-story deep outriggers: between the structural Levels 77 and 73 (at the top); between structural Levels 46 and 50; and between the structural Levels 21 and 25.

4. *S. Fawzia and T. Fatima, Deflection Control in Composite Building by Using Belt Truss and Outriggers Systems.*

S. Fawzia et investigated deflection control by effective utilization of belt truss and outrigger system on a 60-storey composite building vulnerable to wind loads. a 3 dimensional Finite Element Analysis is performed with one, two and three outrigger levels. The reductions in lateral deflection are 34%, 42% and 51% respectively as equivalence to a model with none outrigger system. there's an appreciable decline within the storey drifts with the introduction of those stiffer arrangements. The employment of outrigger and therefore the belt truss has built the serviceability of the structure.

5. *Po Seng Kian, Frits Torang Siahaan, the Use Of Outrigger and Belt Truss System For High-Rise Concrete Buildings.*

Po Seng Kian studied the employment of outrigger and belt truss system for high-rise concrete building subjected to wind and earthquake load. For the 2 dimensional 40–storey models, 65% maximum displacement reduction may be accomplished by providing first outrigger at the highest and second outrigger at the center of the structure height. For the three dimensional 60–storey structural models subjected to the earthquake load, about 18 a discount in maximum displacement are often accomplished with optimum location of the outrigger truss located at the highest and therefore the 33rd level.

6. *M. R. Jahanshahi, R. Rahgozar, Optimum Location of Outrigger-belt Truss in Tall Buildings Based on Maximization of the Belt Truss Strain Energy.*

M. R. Jahanshahi presented methodology for determining the optimum location in the structural system of an outrigger-belt truss system, supported maximizing the outrigger-belt truss system's strain energy, an Optimum location for outrigger-belt truss system is calculated for 3 kinds of lateral loadings, i.e. uniform and triangularly of the structural load distributed loads along structure's height, and the concentrated load at top of the structure. Optimum location of outrigger-belt truss system for accumulated load at top of the constitution, uniformly and triangularly distributed loadings along height of the structure were calculated respectively as 0.667, 0.441 and 0.490 of structure's height as measured from the bottom. The results show that the proposed method is fairly accurate.

7. *M. R. Jahanshahi a, R. Rahgozar a, M. Malekinejad, A Simple Approach to Static Analysis of Tall Buildings with a Combined Tube-intube and Outrigger-belt Truss System Subjected to Lateral Loading.*

M. R. Jahanshahi presented an efficient technique for static analysis of high rise buildings with conjunctive tube-in-tube and outrigger-belt truss structural system while considering shear lag effects in the structure. Within the method of replacing the discrete structure of the building with an elastically equivalent continuous one, the structure is modeled as two parallel cantilevered flexural-shear beams in the building that are constrained at the outrigger-belt truss location by a rotational spring. Supported the principle of minimum total mechanical energy, simple closed form solutions are derived for stress and displacement distributions. Standard load cases from IS codes, including uniformly distributed loads, triangularly distributed loads and point loads at top of the structure are considered for study.

8. *Radu Hulea, Bianca Parv, Monica Nicoreac and Bogdan Petrina, Optimum Design of Outrigger and Belt Truss Systems Using Genetic Algorithm.*

In this paper Radu Hulea showed the outrigger and belt truss systems are efficient structures for drift control and base moment reduction in tall buildings where the core unaccompanied isn't rigid enough to resist lateral loads. Perimeter of columns are mobilized for increasing the effective width of the structure in the building for better results, and that they developed tension within the windward columns and compression within the leeward columns. Optimum locations for the outriggers are affected thanks to the influence on the highest replacing and base moment within the core. it absolutely was analyzed the optimal position for 2 to seven outriggers and belt trusses, reaching to achieve minimum bending moment and minimum drift.

9. *Mohd Abdus Sattar, Sanjeev Rao,Madan Mohan, Dr. Sreenatha Reddy, Deflection Control in High Rise Building Using Belt Truss and Outrigger System.*

Mohd Abdus Sattar studied the utilization of belt truss and outrigger placed at different location of concrete building subjected to wind and earthquake loading. the placement of belt truss and outrigger for reducing lateral displacement, building drifts and core moments where obtain. Analysis is distributed for study of rigid core and floor rigidity of 15, 20 and 25 storey L shape building for structure with outrigger, belt truss and without outrigger, belt truss. From present study it is concluded that floor rigidity isn't required to be increased beyond that needed for the load carrying of load and superload on floors, Moments in Corner column are less equivalence to the center column, Moments in outer periphery columns are less equivalence to the moments in interior columns.

6. CONCLUSIONS

1. Researchers have utilized various techniques and methods for locating uses of belt truss in tall structure.
2. Belt truss with stiffer floor diaphragm individually can minimize deflection as that of conventional outrigger but outrigger with belt truss can escapes maximum deflection than individual belt truss or outrigger.
3. Differing kinds of research were conducted as per the assorted accessible standards. The common parameters designed by various researchers within the above paper were different position of belt truss, lateral drift, core moment, and column reaction.
4. Various researches focused on obtaining the optimum position of belt truss for satisfying deflection criteria and also the optimum position of belt truss for satisfying deflection additionally as moment criteria.
5. Belt truss system is effective for all variety of composite, steel and concrete structures.
6. Belt truss is cost effective structural system which is one among the foremost developing structural systems in new construction.

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