A Review on Outriggers and Belt Truss System under Seismic Loading in RCC Building.

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Abstract - *This article provides a brief overview of the Outrigger & Belt Truss system and explain its structural composition when lateral load is acting in modern high-rise buildings. The Outrigger is a solid beam that connects the shear or core wall to the outside column & Belt Truss are solid beams that connect the exterior columns. When this structure is subjected to lateral force, this system along with the column resists the rotation of the core so that it is significantly reduced lateral deflection and base shear that will occur in the free core. This study deals when and where to use an Outrigger & Belt Truss system in a RCC Building.*

Key Words: Outrigger System, Belt Truss System, RCC Building, Base Shear, Lateral Deflection.

1.INTRODUCTION

The construction of tall structures in urban environments is common in our country. Creating tall structures have become important due to accommodating commodity in the city, so the structure rises to the sky. With this, demand for security, safety, and maintenance of this facility have become important factor to its tenants due to the effects of wind and earthquakes. Therefore, it is imperative that tall structures require a surgical structural analysis before they are placed on the ground. As a result, creating an effective system with outrigger and belt truss becomes necessary for a building serviceability and stability.

In places like Japan, Taiwan, and other Middle Eastern countries, tall buildings have become synonymous with economic growth and prosperity in the region. These countries also have something in common - they often experience destructive natural forces such as earthquakes, hurricanes and cyclones. Therefore, the job of a structural engineer is to find new innovative concepts to make tall structures safe, as a result they came up with Outrigger and Belt Truss System.

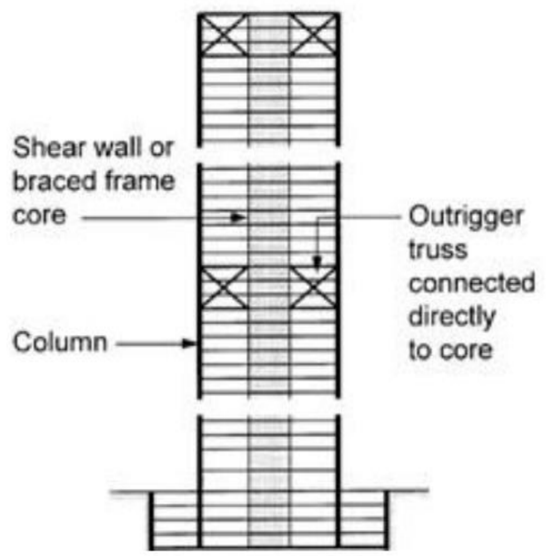
1.1 Outrigger System

Outriggers are the most effective against lateral loads often used in high-rise buildings. The concept of bracing is used in ships it strengthens the mast of the ship to resist the force of the wind. Primarily tall structure resembles the master of his ship.

Outriggers are usually in the form of steel or wall in steel and concrete structures respectively, that acts effectively as a rigid head that creates some tension-compression in outer column. Belt trusses are often provided to distribute this tension-compression on exterior columns that provide strength for most of the exterior framing columns.

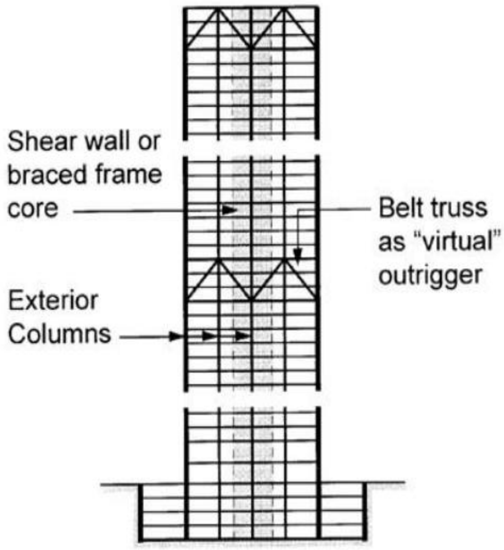
Outriggers can also be supported on mega columns at the perimeter of the building. Although this structure is mainly an internal system, arch tubes or mega columns offer a wide perimeter, thus counteracting the lateral push of the building's spread.

In the concept, Outriggers are attached to the braced frame or sheared wall directly in the core. But it is not necessary for the column to be located on the outer edges of the building.



1.2 Belt Truss System

As discussed, Belt trusses are often provided to distribute this tension-compression on exterior columns that provide strength for most of the exterior framing columns. So, in this concept, the structure that connects the core and the perimeter system is eliminated immediately and replaced by a belt truss with a combination of a rigid and strong diaphragm. The moment produced in the core is converted into a horizontal couple in top and bottom basement floors.



1.3 Components of Outrigger and Belt Truss System

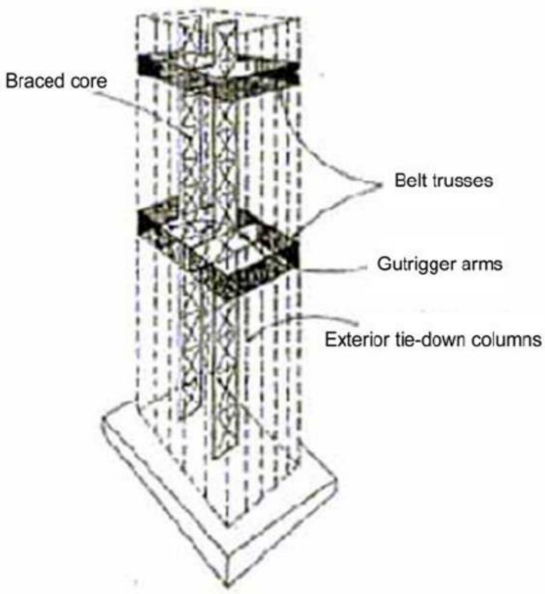
Basically, outrigger and belt-truss systems consist of four parts:

Internal structural system: It can be steel core, concrete core or composite core.

External structure system: It is frame tube system, moment-resisting frame or mega-frame.

Outriggers: These are rigid connections connecting internal and external structural systems. These can be wall, truss, beam, or hybrid that is, one part is wall and the other part a truss.

Perimeter Belt: A connection connecting all or part of the perimeter column together. This can be a wall, a truss or a deep beam.



2. LITERATURE REVIEW

This chapter presents the overview and the interpretation of the past works based on the related topic which provide sufficient and necessary information for this study. Literature survey is important factor to understand the previous work done around the proposed topic.

2.1 Thejas H K, Laxmi S, Abhilash D T," Comprehensive Analysis of Outrigger Building System", International Journal of Civil Engineering and Technology (IJCIET) (2020).

In this study, the analysis is done by considering tall vertical irregularity of 30th storey of 7x7 bay for 1 to 10th storey and 7x6 bay 11th to 20th storey and 7x5 Bay 21st to 30th storey. The analysis was performed to find the optimal position of the outrigger and the belt truss system using the lateral loads. A 3D model is considered and developed to accommodate gravity load and the first and second outriggers are placed. In this study wind load is calculated using IS 875 (Part 3) and design earthquake load calculated by IS 1893 (part-1): 2000 code to obtain drift, deflection and story shear.

As a Conclusion, from the results in high-rise buildings, the use of outrigger systems and truss belt increases stiffness and makes the structure effective in lateral loads. The maximum drift at the top of the structure, if only the core is used is about 206.9 mm, which can be reduced by the appropriate selection of the lateral system. When one outrigger is at 0.67h drift is about 130.4 mm. Using second outrigger at 0.67h there is reduction of 16.64% and 13% in drift and deflection. The ideal location for the second outrigger is mid-height of the building. It can be concluded that the optimum location of the outrigger is in the range of 0.5 times the height (0.5h).

2.2 Daril John Prasad, Srinidhilakshmish Kumar," Comparison of seismic performance of outrigger and belt truss system in a rcc building with vertical irregularity", International Journal of Research in Engineering and Technology (2016).

The main objective of this research is to compare outrigger, belt truss and outrigger with belt truss with their position is constant in all models. In this research a 30-storey structure with vertical irregularities is subjected to seismic analysis using finite element software ETABS as per IS 1893 (Part-1): 2002 and compare parameters like base shear, lateral displacement and story drift.

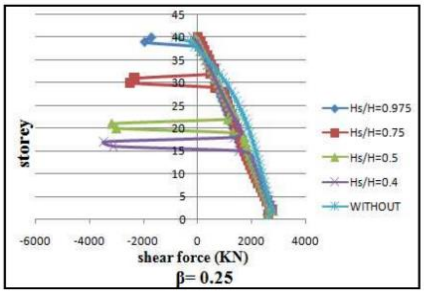
As a Conclusion, when it comes to base shear and lateral load, buildings built with only belt truss performs better than buildings with only outrigger and with both outrigger and belt truss.

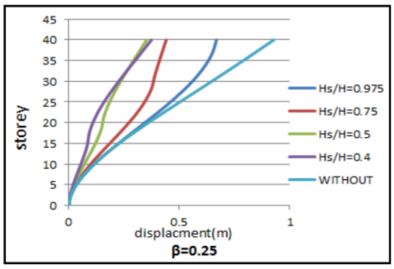
2.3 Sathyamurthy K, Kavitha A. S," Dynamic Analysis of Outrigger Braced Systems in High Rise Steel Building", International Journal of Informative & Futuristic Research (2017).

According to this study, chevron braces can be more effective in high-rise buildings in controlling displacement and drift without increasing the base shear. The use of outrigger in three different stories, in addition to bracing, is considered very effective in reducing storey displacement. This study shows that placing three outriggers on the 10th, 20th, and 30th floors in a 40-storey building not only controls the total lateral displacement, but also reduces the inter storey drift in tall buildings, and for the G+40 steel structure, 10th, 20th, and 30th storey level can be considered as the best situation. Therefore, it is concluded that the use of bracing and outrigger systems in tall buildings increases stiffness and makes the structure effective in lateral load.

2.4 Sandesh Kumar Shirole Y, Dr. B.K Raghu Prasad, Dr. Amarnath K," Study of behaviour of outriggers in a high rise building under seismic loading", International Research Journal of Engineering and Technology (2016).

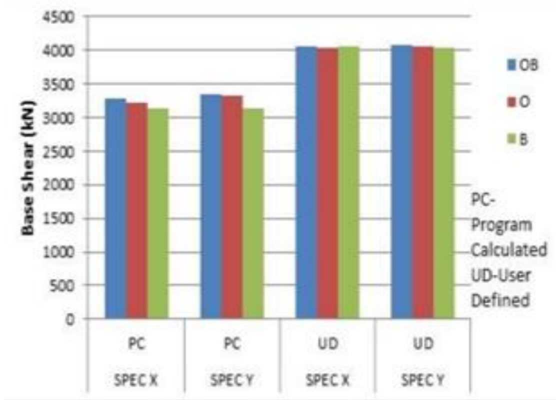
As per study, The displacement of the building was found to be the lowest when outrigger was placed on the 20th floor and was reduced from 81.59 mm to 17.31 mm when no outriggers were used. The maximum story displacement at top most story in the building is reduced by 34.1% when using the outrigger when compared to when no outrigger used. When the outriggers are placed on the 15th storey, the base force is 128.2 kN and the displacement is 60.1 mm at the performance point was found to be the lowest compared to the base force and displacement at performance when the outriggers are placed on the 5th, 20th, 30th and no outriggers... are used. The optimum location of the outrigger was found to be 0.66 times the height above the base of the building.





2.5 Kiran Kamath, N. Divya, Asha U Rao," A Study on Static and Dynamic Behaviour of Outrigger Structural System for Tall Buildings", Bonfring International Journal of Industrial Engineering and Management Science (2012).

According to this paper, the use of outrigger structural systems in concrete buildings increases stiffness and makes the structure effective in lateral loads. Based on the results of the analysis: If the criterion is considered in lateral displacement, the optimal position of the outrigger is in the middle of the height for static and dynamic behaviour of structure. Outrigger when placed on top of a building is less efficient, but in some cases, it can be safer to locate it on top of a building, so even if it is not as effective as mid-rise, the benefit of placing it on top is very effective, reducing drift by up to 50%. There is a significant reduction in the forces in core, especially the bending moment when the outrigger system is added.



3. CONCULSION & SCOPE FOR FUTURE STUDY

1. The use of outrigger in the construction industry increased efficiency compared to buildings without outrigger in case of bearing lateral load.
2. Outrigger plays an important role in increasing structural flexural strength by reducing base shear under seismic load action.
3. Displacement in the structure system of tall buildings is reduced, when the size of outrigger member is increased.

4. By providing shear wall in the central core building will reduce forces in the core.
5. In RCC Building, concrete Outriggers are more efficient than steel outrigger in tall RCC Building.
6. When it comes to storey drift, buildings with outrigger and belt truss systems perform better than buildings with only outrigger and belt truss systems.

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