JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

# A REVIEW PAPER ON ANALYSIS OF OUTRIGGER MULTISTOREY STRUCTURE

**HaiderFareedQureshi[1],Er. Vikas Garg[2]**
[1]M.TECH Scholar,Global Research Institute Of Management & Technology,Radaur,Yamunanagar Affilated To Kurukshetra University Kurukshetra,Haryana,India
[2]Assistant Professor,Civil Engineering Department,Global Research Institute Of Management & Technology,Radaur,Yamunanagar Affilated To Kurukshetra University Kurukshetra,Haryana,India

**Abstract**: Design of tall structures is governed by horizontal loads due to wind and earthquake. Hence it is necessary to provide appropriate lateral load resisting system. One of such system is outrigger structural system. The objective of this thesis is to study the static and dynamic behavior of the outrigger by reducing the outrigger depth. In this thesis, 30 storey steel structures are considered. Structure with central braced core and structure with different depth of outrigger arm is compared. Here the depth of the outrigger is reduced to 2/3rd and 1/3rd of the typical storey height. In the present thesis linear dynamic statistical method response spectrum is used. The analysis results showed that the lateral displacement and storey drift increases with the decrease in depth of outrigger. The mainly compared parameters are the lateral displacement and storey drift.

**Index Terms–outrigger, dynamic, storey height**

## I. INTRODUCTION

Advances in construction technology materials structural systems and analytical methods for analysis and design facilitated the growth of high rise buildings. Structural design of high rise buildings is governed by lateral loads due to wind or earthquake. Lateral load resistance of structure is provided by interior structural system or exterior structural system.Outrigger is a rigid horizontal member which connects the central core to the exterior columns which transfers the core moment into the connected exterior columns. The use of the belt-truss on the facades is it engages the adjacent columns of the exterior frame in the cantilever behavior.Outrigger structural system consists of two systems, the core and perimeter system. The lateral stiffness of a multi-storey building can be greatly reduced by tying the peripheral columns to the central core through deep girders. In steel buildings core is made of either vertical truss or shear wall and outrigger is made up of horizontal truss. Outrigger mobilize the axial stiffness of the columns in resisting the lateral load and at the same time reduces the bending moment in columns and beams.

## II. OBJECTIVES

Outrigger structural system increases the stiffness and makes the structural form very efficient under lateral loading. Outrigger reduces the overturning moment on the core and transfer the reduced moment to columns outside the core by the action of tension compression coupled, which take advantage of the increase moment arm between these columns. The present thesis is aimed at investigating comparative lateral load resistance between structure with central braced core and structure with outrigger system. Here the depth of the outrigger is reduced to different depths in each model and analyzed and then compared. The depth of the belt-truss is maintained same in all the models i.e.the depth of the typical storey height. The structure will be analyzed in ETABS v2013

## III. LITERATURE REVIEW

This literature review shows some of the recent contributions related to outrigger system and past efforts most closely related to the needs of the present work.

KiranKamath et al[1]. studied the static and dynamic behavior of an outrigger system for high rise building. They have compared the performances of structure with outrigger and without outrigger by varying its relative flexural rigidity and also the optimized the position of the out riggers using the software ETABS. Based on their analysis the results were, the optimum location of the outrigger was at the mid height of the structure for both static and dynamic cases. The outrigger placed at the top of the structure was less efficient compared to when it was located at the mid height of the structure. However, placing outrigger at the top of the structure reduced the storey drift by 50%. There was a considerable reduction in the bending moment in the core when outriggers were added. The outriggers were efficient in reducing the displacements as well as inter storey drifts.

Z Bayati et al[2]. studied optimization of multi-outriggers to stiffen high rise buildings. They had performed a case study on 80 storey steel framed structure and investigated the effectiveness of the belt truss as virtual outrigger, in this design of conventional outrigger and virtual outrigger were compared. The results were, the lateral displacements of top of the structure were found to be 70cm for conventional outriggers and 95cm for the virtual outrigger and the displacements for the structure without outrigger were found out to be 275cm.

Junais Ahmed et al[3] attempted to reduce the fundamental time period in slender high rise building by using outriggers and optimize the location of outriggers. They modelled 30, 40, 50 and 60 storey structure in ETABS software and the variation in the fundamental time period of the structure without outrigger and different location of the outrigger is examined. The results were, the time period was found to be lesser when the outrigger was provided at the 1/3rd distance from the top and bottom of the structure without the cap truss. KiranKamath et a[4] studied the performance of the multi - outrigger structure when subjected to seismic loads. The model was created using ETABS software. Here the relative height of the outrigger was varied and performance of the outrigger was studied based on bending moment, shear force, storey drift and lateral displacement for the relative axial rigidity values. The results were when the displacement of the structure is considered there was a remarkable reduction in the lateral displacement at the top of the structure for the multi-outrigger with a relative height of 1.5 when compared to th structure without outrigger. Considering the bending moment criteria and comparing model without outrigger and model with multi outrigger with a relative height of 6.67, considerable reduction in the bending moment was seen.

M R Jahanshahi et a[5] studied optimization of the location of outrigger-belt truss on tall structures based on the maximization of the belt truss strain energy. Here the tall structure with combined system of shear core, framed tube and outrigger-belt is considered. The framed tube is modelled as a cantilever beam with box cross section. Effect of shear core and an outrigger belt truss is modelled as a rotational spring at the outrigger belt location. They were analyzed for three loading conditions, i.e., triangularly and uniformly distributed along the height of the structure and concentrated load at the top of the structure. The conclusions were for uniformly, triangularly distributed and concentrated load the optimum location were 0.441, 0.490 and 0.667 respectively, of structures height from the base of the structure.

Raj KiranNanduri et al.[6] studied the optimum location of outrigger system for high rise structure subjected to wind and seismic load. They considered a 30 storey building with with belt-truss system and subjected it to wind and seismic load and analyzed and compared and lateral displacement reduction is found out. The conclusions were, the maximum displacements of the structure with core were found to be 50.63mm and this is reduced by placing the outrigger at the top storey with belt truss to 48.20mm and without belt truss to 47.63mm. The optimum location of the second outrigger was found out to be the middle height of the structure.

N Herath et al[7] studies the behaviour of outriggers in high rise structure subjected to seismic load. 50 storey structure was considered for the analysis and subjected to three different peak ground acceleration to velocity ratios. Response spectrum analysis was carried out to determine the behaviour of the outrigger system. Parameters such as inter storey drifts and lateral displacements were considered. The conclusions were the optimum location of the outrigger was found out to be 0.44 to 0.48 times the height of the structure from its base.

K M Bajoria et al[8] studied the behaviour of high rise building with and without bracings subjected to earthquake. They considered a G+40 structure without infill. 5% modal damping has been considered.

Different parameters like displacement, storey shear and modal time period were examined. The conclusions were base shear increased up to 38%. There was significant reduction in the displacement about 60%. There was a reduction of 65% in modal time period.

Gerasimids S et al[9] studied the optimum outrigger location for high rise steel structure subjected to wind loading. 30 storey 2D structures subjected to wind load was used for the analysis. The structure was modelled by using basic elements such as core, steel columns and outriggers. They considered two outriggers for the analysis. They evaluated parameters like storey drift, column axial force and moments. The conclusions were the optimum location of the second outrigger was at the 0.5H of the structure, when only drift control criteria are considered. There was increase in the column compression force in the 9th floor.

Karthik N M et al[10] studied the optimum location of outrigger for high vertical irregular structures. They considered 30 storey structure vertical irregularities and subjected to earthquake and wind loading. Linear static analysis was conducted. Parameters like displacement, drift, storey shear and axial load were evaluated. The structure was optimized for first and second location of outrigger. The conclusions were the optimum location of out rigger was found to be 0.5times its height. The percentage reduction of drift and deflection was increased with the addition of the belt truss.

## IV. CONCLUSIONS

In this study, structure with varied depth of outrigger and structure with central braced core are analyzed and compared for static and dynamic load cases. As we can see from the comparison results that the difference in the percentage reduction of lateral displacement and storey drift is quite less when the outrigger depth is reduced from full storey height to 1/3rd of storey height. Hence one can reduce the outrigger depth to 1/3rd of storey height as it doesn't obstruct the living space much. Recommendation Outrigger should be provided at core and intermediate level in order to reduce column sizes and also to reduce displacement of the structure.

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