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Analytical Study of Tall Building with Outrigger System

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Abstract - *Today's increased need for housing in metropolitan cities leads to the emergence of high rise buildings. Tall buildings are becoming more and more slender and this leads to more possible sway during the occurrence of lateral loads. When building height increases tremendously, the structure should have lateral load resisting system other than shear walls for avoiding the effect of these loads, since the shear walls when used alone are suitable only up to 20 stories high. Outrigger systems are one such prominent system and are now considered to be the most popular and efficient because they are easier to build, save on costs and provide good lateral stiffness. Outrigger structures is an efficient structural form in which the central core is connected to the outer columns. The structural concept of these systems is that when the central core tries to tilt, its rotation at the outrigger level induces a tension-compression couple in the outer columns acting in opposition to that movement. Most importantly, outrigger structures can strengthen a building without disturbing its aesthetic appearance and this is a significant advantage over other lateral load resisting systems. This paper presents the results of an investigation on storey displacement and storey drift in RC building frame with rigid outriggers, through Response Spectrum Analysis using the software ETABS 2017.*

Keywords: Outrigger structural system, Response spectrum Analysis, Storey Displacement, Storey Drift.

1. INTRODUCTION

Mankind is always fascinated for Tall building. In Early era the symbol of economic power and leadership is the skyscraper. There has been a demonstrated competitiveness that exists in present mankind to proclaim to have the tallest building in the world. The design of tall and slender structures is controlled by three governing factors, strength (material capacity), stiffness (drift) and serviceability (motion perception and accelerations), produced by the action of lateral loading, such as wind. Outrigger structural system encompass of a central core wall either shear wall or braced frames with outrigger truss connecting between core and the peripheral columns. These are the horizontal members designed to control overturning moment and stiffens the building by fastening the core to the exterior column through stiff horizontal members referred as a outrigger member, where as core acts a single-redundant cantilever beam for lateral forces and hence battle the rotation at the top by stretching and shortening action results in tensile and compressive action consequentially restoring couple by combating twisting of core thus cap truss be positioned as a restraining spring at the apex which considerable reduces the lateral deflection and base moments.

1.1 Objectives

My research project aims at doing seismic evaluation for a RC building using Response Spectrum Analysis Method. The main objectives of the proposed work are:

- To study the behavior of outriggers in high rise building under earthquake excitations.
- To arrive at the best outrigger position from top and one fourth height, top and two fourth height, top and three fourth height.

2. DESCRIPTION OF THE MODEL

In the present study a framed model having outrigger system at different positions of a G+40 storey regular building is considered.43m width of building is considered with 3 bays with two bays of 14m and one bay with15m along both X and Y direction. Earth quake analysis is carried out considering the 3D frames as per IS 1893:2002. The Typical plan and elevation of the models considered for the study is shown. The details of the building data are same as shown in Table 1. Regular structure are analyzed for Zone V. Seismic evaluation for a concrete building is carried out using nonlinear analysis method. Analysis is carried out to determine the effects of story displacement and story drift with outriggers located at different positions of a G+40 regular multi-story building. Four models are analysed in zone III. All the 4 models have same plan whereas the position of outriggers are changed in each model.

MODEL 1: Building Without Outrigger System.

MODEL 2: Building with Outrigger at One Fourth and Top.

MODEL 3: Building with Outrigger at Two Fourth and Top.

MODEL 4: Building with Outrigger at Three Fourth and Top.

Typical plan, elevation and 3D view are shown from Fig 1 to Fig 5.

Table -1: Parameters considered for Analysis

Storey height	3.5m
Beam size	0.3x0.42m
Column size	1.2x1.5m (Column 1) 1.5x1.5m (Column 2)
Shear Wall	1 m thick
Outrigger size	0.888x0.888 m
No. of storeys	40
Wind speed	39m/s
Terrain category	II
Structural class	B
Topography	Flat
Grade of steel	Fe 345
Grade of concrete	M 45,M 60
Young's Modulus Of Concrete	$2.5x10^{\acute{}}$ kN/$m^{2\tilde{}}$

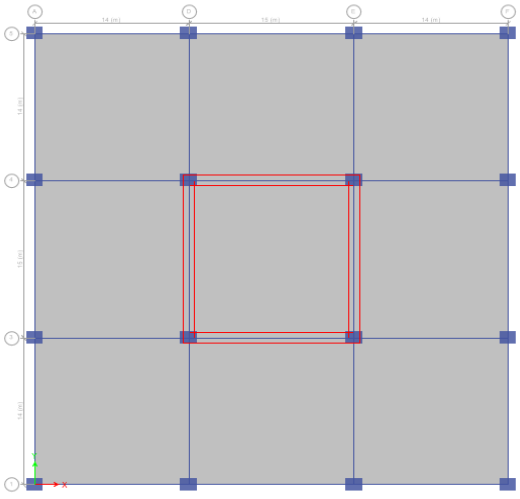

Fig -1: Plan with RC Shear Core

Model 1: Building Without Outrigger System

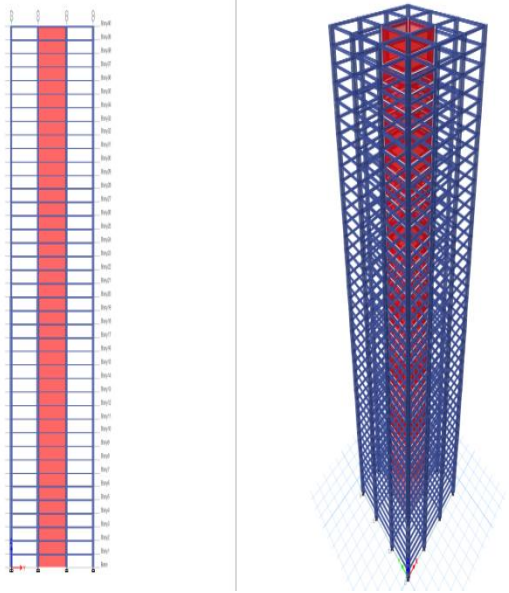

Fig -2: Elevation of frame without outrigger

Model 2: Building with Outrigger at One Fourth and Top

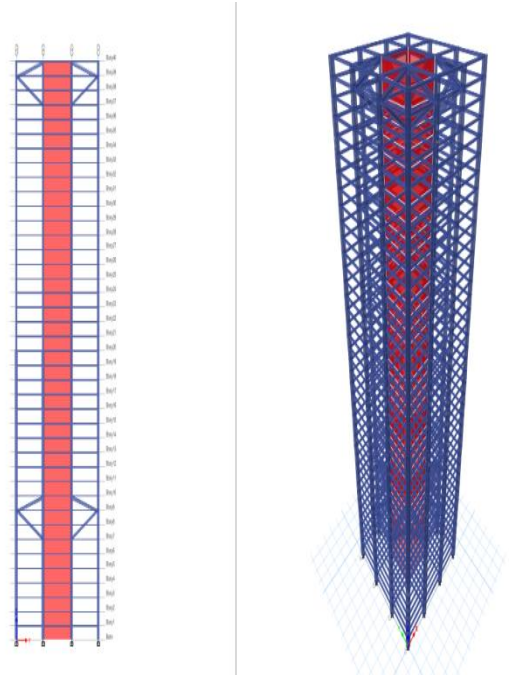

Fig-3: Elevation and 3D View of Outrigger placed at top and one fourth height

Model 3: Building with Outrigger at Two Fourth and Top.

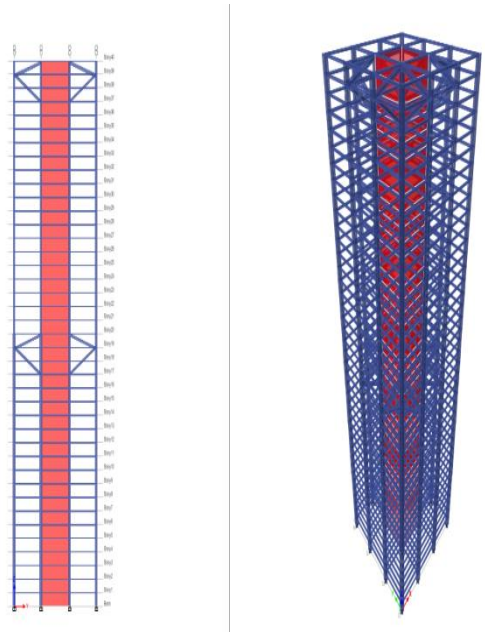

Fig -4: Elevation and 3D View of Outrigger placed at op and two fourth height

Model 4: Building with Outrigger at Three Fourth and Top

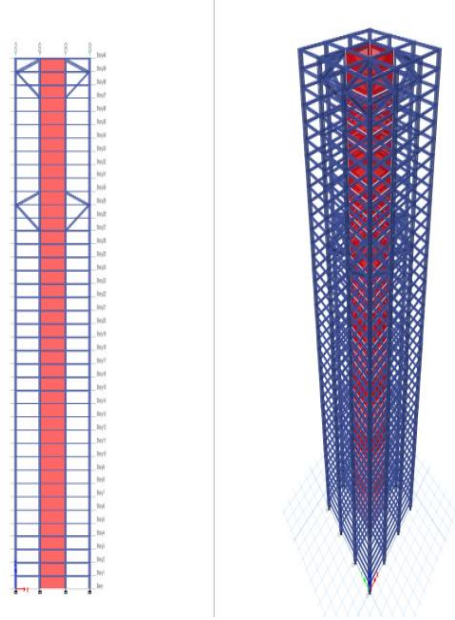

Fig -5: Elevation and 3D View of Outrigger placed at top and three fourth height

Three models are prepared by varying the position of outrigger. Models are prepared by placing the outriggers at One fourth and Top, Two fourth and Top and Three fourth and Top. These Three models have to be compared with a building (model 1) without outrigger and select an extreme suitable positioning of outrigger without the failure of structure.

3. RESULTS AND DISCUSSION

As mentioned earlier the selected building models are analyzed. Response spectrum analysis of four building models is carried out to study the displacement and story drift.

3.1 Variation in Storey Displacement and Storey Drift

Table -2: Variation in Storey Displacement and Storey drift for four outrigger models

Outrigger Position	Storey Displacement(mm)	Storey Drift(mm)
Without Outrigger	189.3	0.00176
At one fourth and Top	59	0.00088
At two fourth and Top	61.16	0.00098
At three fourth and Top	51.5	0.00059

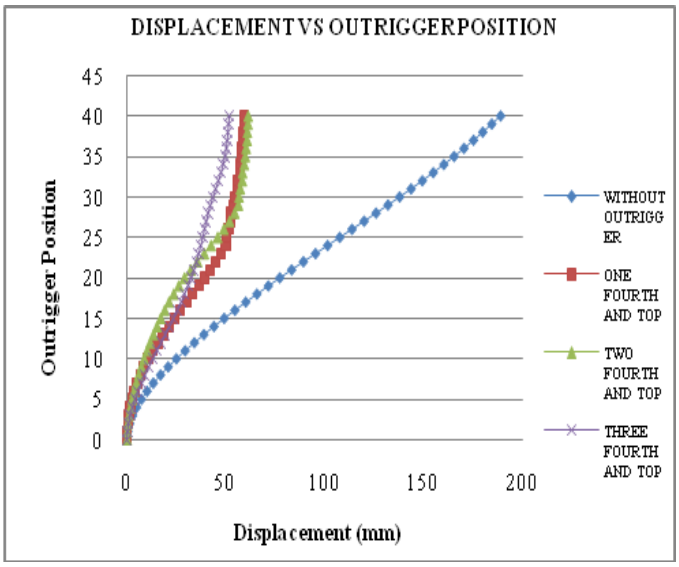

Chart -1: Variations of Storey Displacement

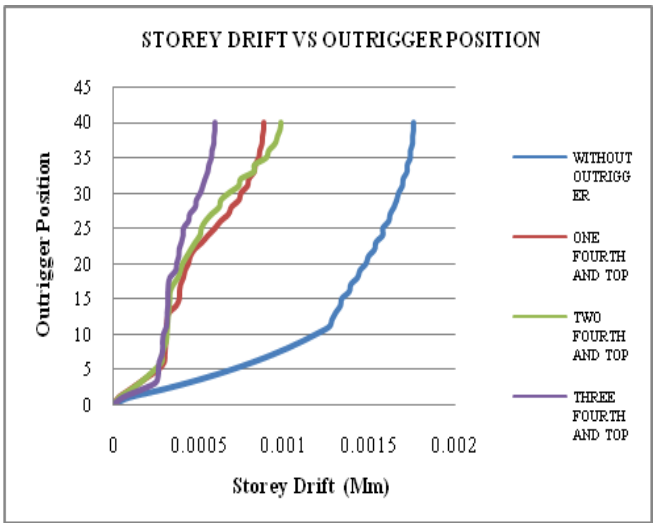

Chart -2: Variations of Storey Drift

The four models of outriggers placed at one fourth and top, two fourth and top, three fourth and top and a model without outrigger system are analyzed. The storey displacement and storey drift are decreasing as the number of storeys are increasing. The maximum drift and displacement are shown by the building without outrigger. The outrigger placed at three fourth and top storey is having minimum storey displacement and storey drift which is 51.5mm and 0.00059 mm respectively.

4. CONCLUSIONS

This study assessed the overall behaviour of outrigger in building under lateral loads from which the following conclusions can be drawn based on the above results. The selected models where analysed using the response spectrum method and the conclusions obtained from the analysis are:

- The percentage reduction in storey displacement and storey drift for building with outrigger positioned at three fourth and top are 72% and 66% respectively compared to building without outrigger system.

Hence we can concluded that the building with outrigger positioned at three fourth and top of the total height of building is good in terms of storey displacement and storey drift and a notable reduction was observed while evaluating the storey displacement and storey drift by Response Spectrum Analysis.

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