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Optimum Position of Outrigger in G+40 RC Building

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Abstract

In modern tall buildings, lateral loads induced by wind or earthquake are often resisted by a system of coupled shear walls. But when the building increases in height, the stiffness of the structure becomes more important and introduction of outrigger beams between the shear walls and external columns is often used to provide sufficient lateral stiffness to the structure. In this paper, analysis of tall building was carried out to find the optimum position of outrigger system by using lateral loads. The three dimensional model using ETABS was considered. The objective of this paper was to study the outrigger location optimization and the efficiency of each outrigger when three outriggers are used in the structure. From the analysis, result has been found that performance of the outrigger was efficient and three optimum position of outrigger has been found i.e. at mid height of building, second at 3/4th of height and third at 1/4th of height of building.
Keywords: RC building, lateral stiffness, outrigger, storey drift, optimum position

I. Introduction

The major factor that affects the design of tall structures is its sensitivity to the lateral load. One of the important criteria for the design of tall buildings is lateral drift at top. Structural system like moment resisting frame and shear wall satisfy primary need of building but as building increases in height there is effect of lateral load i.e. wind and earthquake on building structure. There are two categories of structural system i.e. Interior structures and Exterior structures. When the major part of the lateral load resisting system is located within the interior of the building it is called as interior structure and if the major part of the lateral load resisting system is located at the building perimeter, a system is categorized as an exterior structure. Recently, belt truss and outrigger system is widely used to reduce lateral drift. The placement of outrigger trusses increases the effective depth of the structure and significantly improves the lateral stiffness under lateral load.

The outrigger structural systems not only proficient in controlling the top displacements but also play substantial role in reducing the inter storey drifts. The outrigger systems can be produced in any combination of steel, concrete and composite construction. The placement of outrigger trusses increases the effective depth of the structure and significantly improves the lateral stiffness under lateral load. Outrigger may be extended to both side of central core or core may be located at one side of building with outrigger extending to other side column. Outrigger beams connected to the shear wall and external columns are relatively more complicated and it is understood that the performance of such coupled wall systems depends primarily on adequate stiffness and strength of the outrigger beams.

A. *Objective of This Paper:*

1) To study efficiency of outriggers under seismic forces.
2) To obtain the optimum location of outrigger to reduce lateral displacement.
3) To compare building with or without outrigger system.

II. Work carried out

A G+40 reinforced concrete building was analysed using ETABS software. The lateral loads to be applied on the buildings were based on the Indian Standard. Building was analysed under wind and earthquake loads as per the recommendation of IS: 875 (Part 3) 1987 and IS 1893 (Part 1) 2002 respectively. The building was analysed for Delhi city considering its respective seismic zone basic wind speed. To improve the performance of building in lateral load outrigger was provided. The analysis was carried out for building with outrigger in the form of 300mm thick concrete wall provided at each floor from bottom to top respectively. After running analysis the maximum deflection of building were calculated and first position of outrigger were fixed at location where maximum deflection reduction occurs as compare to building without outrigger. Then to find second position of outrigger first outrigger were fixed at its position and second outrigger were provided at each floor from bottom to top respectively and maximum deflection reduction were calculated. Same procedure were followed for third position of outrigger where first and second outrigger position were fixed and third outrigger were provided at each floor from bottom to top respectively. Comparative graphs have been plotted for building with and without outrigger.

Table – 1
Details of the building

Sr No.	*Description*	*Parameter*
	Plan of Building	*30.5mx33.4m*
	Height of Building	*164 m*
	No. of stories	*G + 40*
	Type of structure	*OMRF*
	Floor to Floor height	*4 m*
	Seismic zone	*IV*
	Basic wind speed	*47 m/s*
	Core beam size	*0.4 m x 1 m*
	Column size	*G+10 750x1800mm* *11 to 20 750x1500mm* *21 to 30 750x1000mm* *31 to 40 750x750mm*
	Thickness of slab	*250 mm*
	Thickness of outrigger wall	*300 mm*
	Type of steel	*Fe415*
	Grade of concrete	*M60,M50,M40*

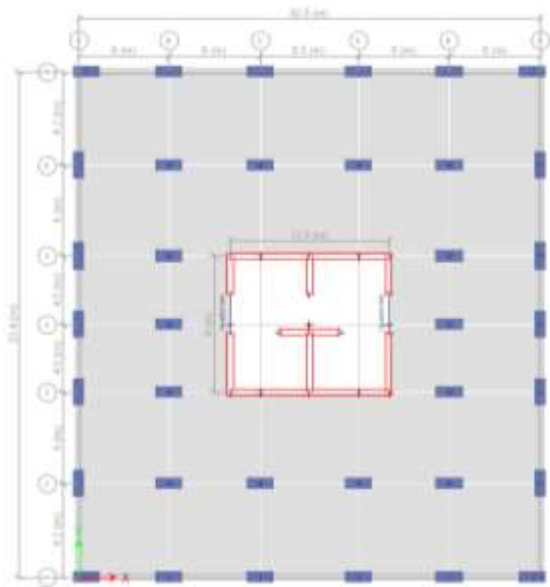


Fig. 1: Plan of building

B. Modelling:

Building consists of reinforced concrete flat slab model without drop and column head. The model is regular shaped symmetrical plan with dimensions 30.5mX33.4m and G+40storey. The plan has centrally located concrete core of size 10.5mX9m. The storey height is assumed to be 4m. The three dimensional analysis for the model is carried out. After performing the wind and seismic analysis on building model deflection and drift result where evaluated. To control deflection and drift outrigger were provided in the building and their positions were calculated for maximum deflection reduction.

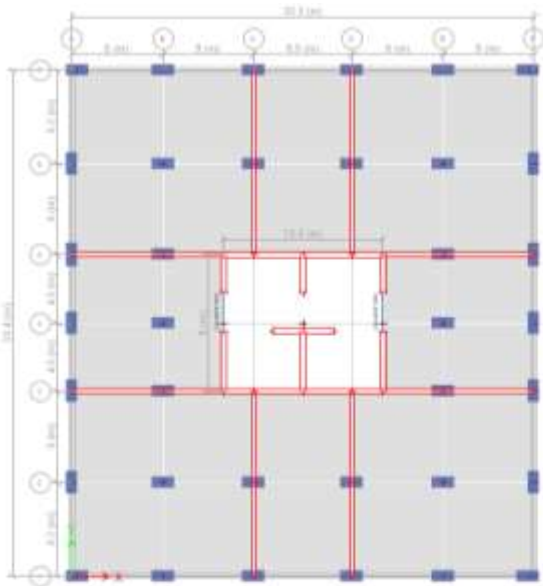


Fig. 2: Plan of building with outrigger

III. RESULT

Building deflection has been studied for various load cases for building without outrigger and building with outrigger using ETABS software. The objective of this paper is to see the variation of load-displacement and storey drift graph and check the displacement of the building. The results obtained from analysis are compared and discussed as follows.

A. Maximum Deflection and Storey Drift for single outrigger:

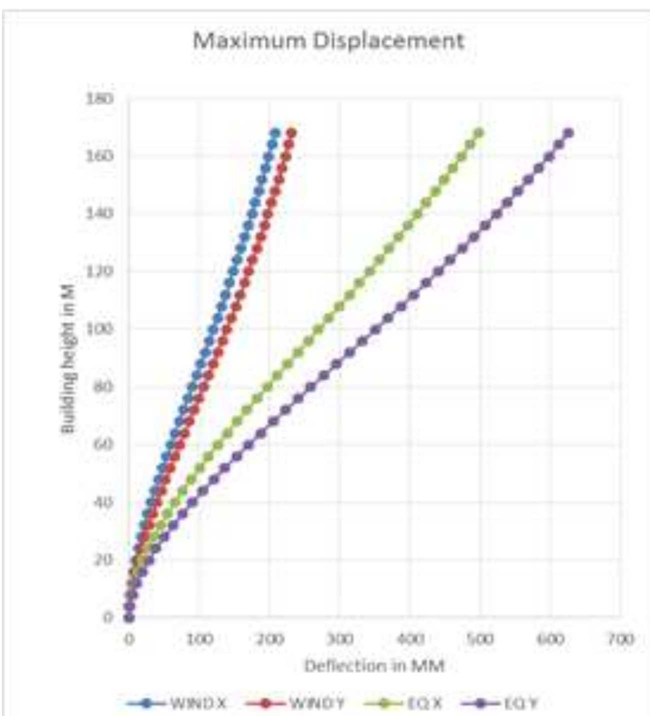


Fig 3 (a)

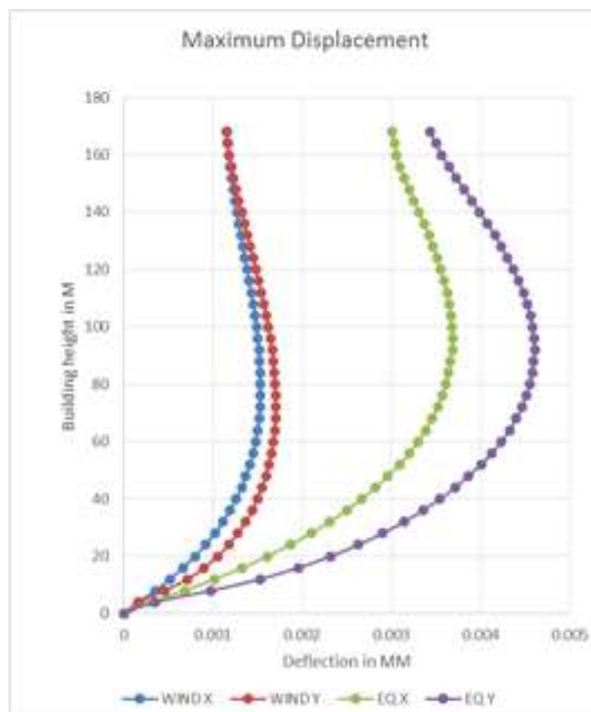
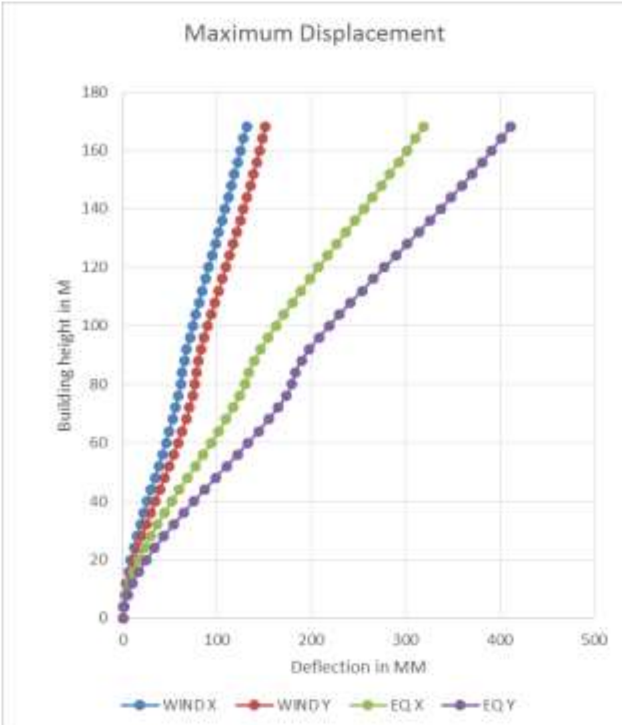


Fig 3 (b)

Fig. 3(a) and (b): Maximum Displacement and Storey Drift at Top for Building without outrigger

B. *Maximum Deflection and Storey Drift for single outrigger*



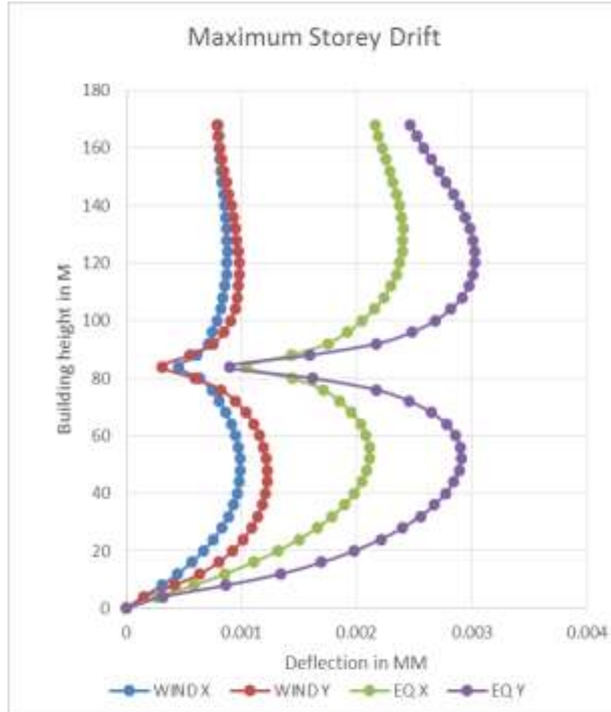
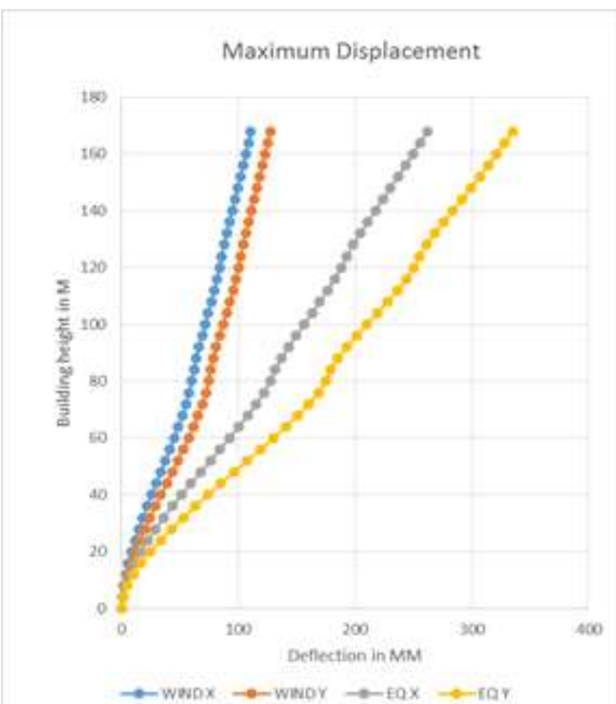


Fig 4 (a) Fig 4 (b)

Fig. 4(a) and (b): Maximum Displacement and Storey Drift at Top for Building with single outrigger

C. *Maximum Deflection and Storey Drift for double outrigger*



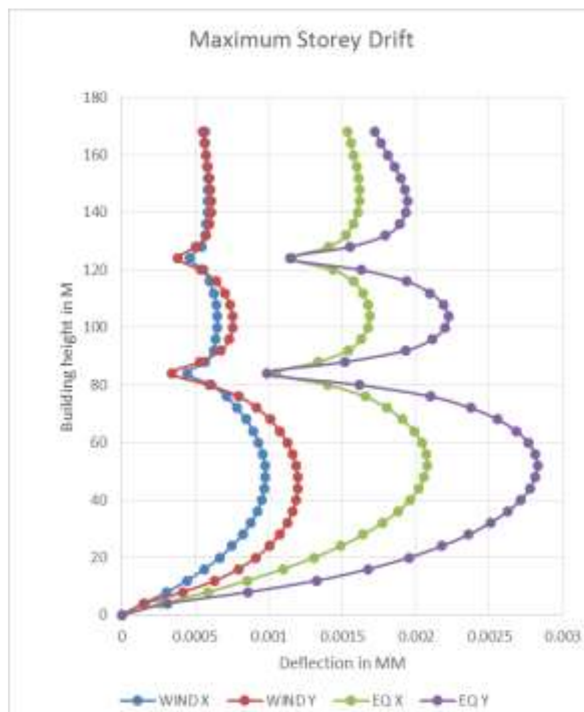
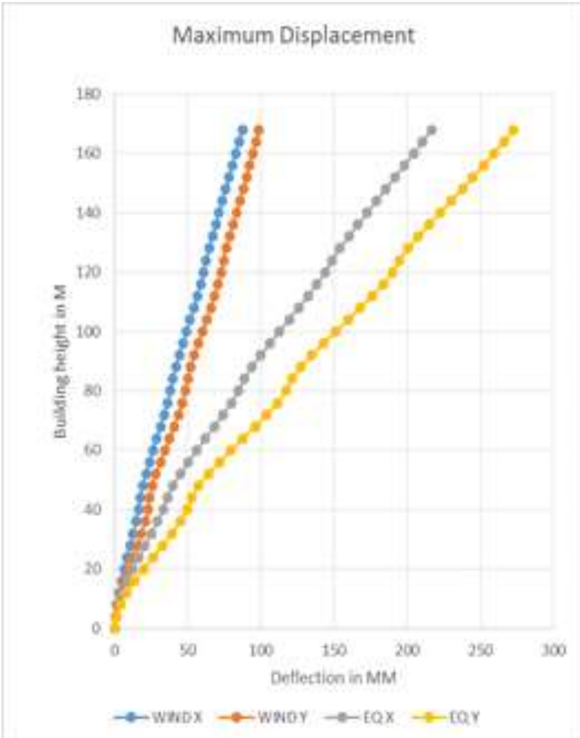


Fig. 5 (a): Fig. 5 (b):

Fig. 5(a) and (b): Maximum Displacement and Storey Drift at Top for Building with double outrigger

D. Maximum Deflection and Storey Drift for triple outrigger:



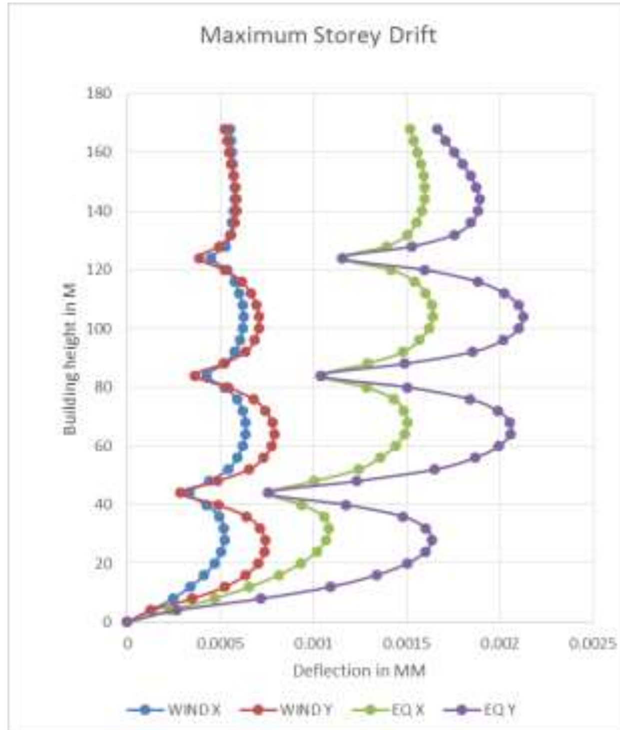


Fig. 6 (a): Fig. 6 (b):

Fig. 6(a) and (b): Maximum Displacement and Storey Drift at Top for Building with triple outrigger

IV. OBSERVATIONS & CONCLUSIONS

- The maximum deflection at the top of structure when only flat slab with core is employed is around 625.7mm and this is reduces up to 411.18mm by providing first outrigger at mid height of structure i.e. 29.45% deflection reduction occurs for first position of outrigger.
- The maximum deflection at top of structure reduces up to 335.15mm by providing second outrigger at 3/4th height of structure i.e. 43.94% deflection reduction occurs for second position of outrigger.
- The maximum deflection at top of structure reduces up to 272.77mm by providing third outrigger at 1/3rd height of structure i.e. 54.98 % deflection reduction occurs for third position of outrigger. The Axial force goes on decreasing as infill wall with different openings like corner and centre are provided.
- The use of outrigger structural systems in high-rise buildings increases the stiffness and makes the structural form efficient under lateral load.
- Outrigger system is not only proficient in controlling the overall lateral displacement but also very capable of reducing the inter-storey drifts in tall building.

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