Behavioural Study of R.C. Structures Using Hybrid Outrigger System Under Seismic Loads

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Abstract — The prompt expansions of materials, construction technologies and structural systems have given upsurge to a substantial increase of skyscrapers over the previous decades. The reduction of the top drifts and base core overturning moments under lateral loads, such as earthquakes and wind loads, has drawn accumulative care in the structural design of tall buildings. When building height increases, the structure should have a lateral load resisting systems other than shear walls for evading the effect of lateral loads, since the shear walls when used alone are appropriate only up to 20 storied building. To overawed this encounter, the outrigger system has developed as a substitute solution, providing adequate lateral stiffness beyond the competencies of shear walls and bracing systems. Outrigger systems are one such protruding system and are deliberated to be the most prevalent and effectual because they are at ease to build and afford better lateral stiffness. The principle of using an outrigger system to develop the structural lateral stiffness and overall stability by connecting core tube and external columns through rigid horizontal cantilevers. Contingent on the connectivity between the core and the exterior columns, the outrigger system can be divided into virtual outrigger system and conventional outrigger system. The hybrid outrigger system has one conventional outrigger and one virtual outrigger at two distinct floor levels. Optimal locations for installations of outrigger systems can be originated. A concept of Virtual Outrigger is reviewed and evaluated in this study. Prominence is given to employing the Hybrid Outriggers instead of Conventional ones. Overall displacements and lateral drift can be reduced by conventional outrigger system for such heights. Outrigger systems enrich the stiffness of high-rise buildings by the introduction of rigid outriggers at different locations. The loads deliberated are as per IS codes. An ETABS model of buildings with varying heights are considered for this study.

Keywords: Conventional Outrigger System, Virtual Outrigger System, Seismic analysis, Base Shear, Drift, Displacement, IS 1893 – 2016, ETABS

I. Introduction

An earthquake test by designing software developed revealed that whenever the R.C.C. a multi-storey building has surrounded the area where any earthquake erupts, the waves making a detrimental effect on it. Therefore, resistance to lateral strength in the construction of tall buildings, strength parameters to be maintained, resistance to lateral deviations, stability to avoid structural damage and non-construction. For construction requirements, building inspectors have provided new systems to maintain the upper limits should use shear wall, truss systems, moment resistance frames, isolation systems and one of which is outrigger systems. In this system, when the structure rotates against the lateral effects it passes through the deviation and rotation. To counteract this, a strong context is given in the file of in the middle of a building connected by strong arms that oppose the whole structure and pass all the rear loads around the column connection. The operation of a multi-storey building therefore depends on the strength of the system.

The sustainability of tall buildings requires some adjustment to it because the lack of land creates demand for tall buildings such as high-rise buildings and high-rise buildings. Since loads in a structure such as vertical and horizontal loads themselves produce a large integrated load that somehow produces the structure and that load must be carried by the frame itself. As earthquakes create landslides from the ground connected to the building and the most effective method used to resist the building with the use of outrigger system.

A. Outriggers system

Outriggers are defined as the members who consist of the beams or contact plates / walls from the centre to the outside of the posts on both sides that block the structure and operation of the connecting links. The core was provided as a detachable bar holding the entire structure firmly to accommodate loads and moving equal loads out of extremes. Greater stiffness is accomplished in this type of structure than conventional frame. An outrigger combines the two elements adding a strong solid that interferes with emergency power. If an outrigger reinforced building under wind or seismic loads deflection, the outrigger connects the main wall to and away from the columns, a unit to resist lateral loads is act on replaced the full structural system.

II. Objectives of the Study

Following criteria shows the point of comparison of result parameters between various models during lateral loads under severe seismic condition for conventional building and its various cases. They are as follows: -

- To determine the effect of conventional outrigger system.
- To determine the effect of hybrid outrigger system.
- By varying the heights of building, combined effect of conventional and virtual outrigger system been evaluated.
- To determine Base shear response when seismic forces are applied in both directions to the structure when conducting outrigger core wall system.
- To determine and compare natural time period and frequency of the structure.
- To analyse and evaluate the maximum nodal displacement and drift values in X-direction & Y-Direction with most efficient case of outrigger system.

– To demonstrate and recommend the effect of stability of multi-storied building by implementing the hybrid outrigger system.

III. Modelling and Analysis of Building

Three models for G+40, G+60 & G+80 storey RC Building each of plan area 30 m x 48 m., with core wall at the centre portion of the building have been prepared and compared in zone IV as per IS 1893:2016 and compared.

Details of Models:

Model 1 – G+40 building with central core

Model 2 – G+40 building with central core & conventional outrigger system installed at H/4 & 3H/4

Model 3 – G+40 building with central core & hybrid outrigger system (conventional outrigger system installed at H/4) & (Virtual Outrigger System installed at 3H/4)

Model 4 – G+60 building with central core

Model 5 – G+60 building with central core & conventional outrigger system installed at H/4 & 3H/4

Model 6 – G+60 building with central core & hybrid outrigger system (conventional outrigger system installed at H/4) & (Virtual Outrigger System installed at 3H/4)

Model 7 – G+80 building with central core

Model 8 – G+80 building with central core & conventional outrigger system installed at H/4 & 3H/4

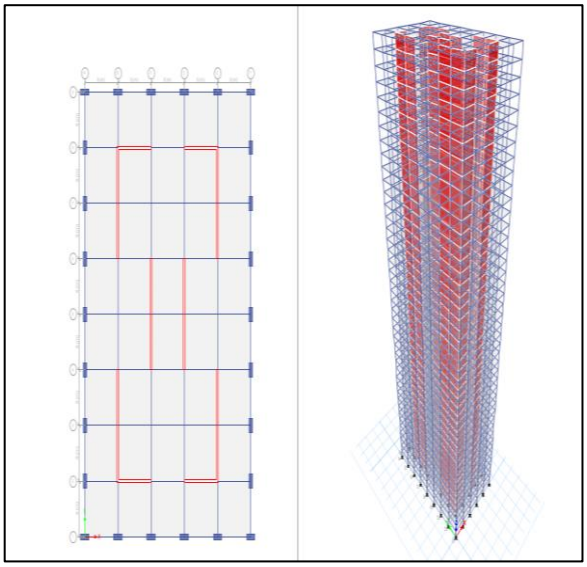
Model 9 – G+80 building with central core & hybrid outrigger system (conventional outrigger system installed at H/4) & (Virtual Outrigger System installed at 3H/4)

The dimensions of beams, columns and slab are kept constant for the purpose of analysis. Other data used for the purpose of analysis have been taken from IS 1893:2016

General Properties	
No. of storeys	G+40 , G+60 & G+80
Typical Storey Height	3.5 m.
Size of Perimeter Column connected with Core wall	600 mm x 1500 mm
Size of Beam	300 mm x 600 mm
Thickness of Slab	150 mm.
Thickness of Core Wall	300 mm.
Material Properties	
Grade of Concrete	M 40
Grade of Steel Rebar	Fe 550
Type of Loading	
Wall Load	12.5 KN/m
Live Load	3 KN/m^2
Floor Finishing	1.5 KN/m^2
Seismic Details (IS 1893:2016)	
Seismic Zone	IV
Zone Factor	0.24
Importance Factor	1
Type of Soil	II - Medium
Building Type (R)	5 (SMRF)

The response spectrum method plays an important role in analysis and design of multi storied buildings for seismic loads. The maximum response of the building is estimated directly from the elastic and inelastic design spectrums. The building codes are characterized for earthquake motions are based on simplification of the response spectrum method, so this method is extremely significant in the analysis and design procedures. The load combinations will be used for analysis of these models will be according to IS code 1893:2016.

Model 1 -



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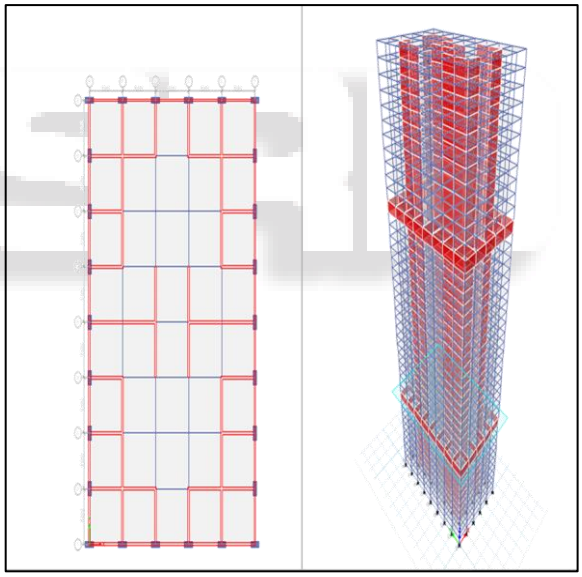

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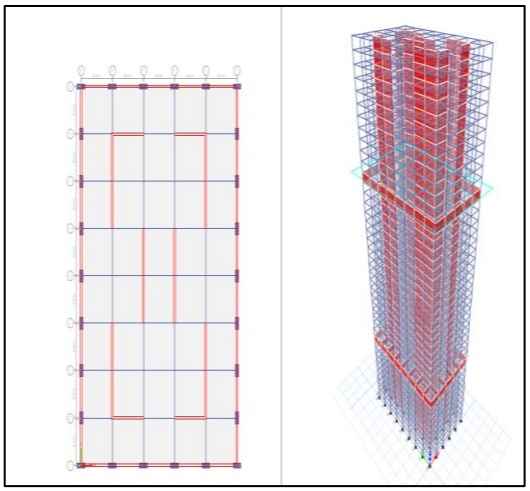

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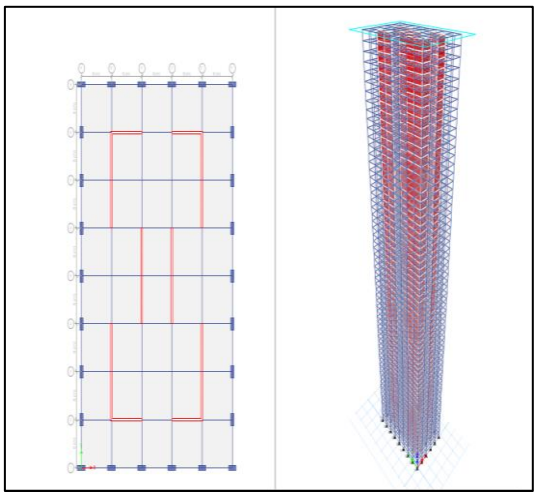

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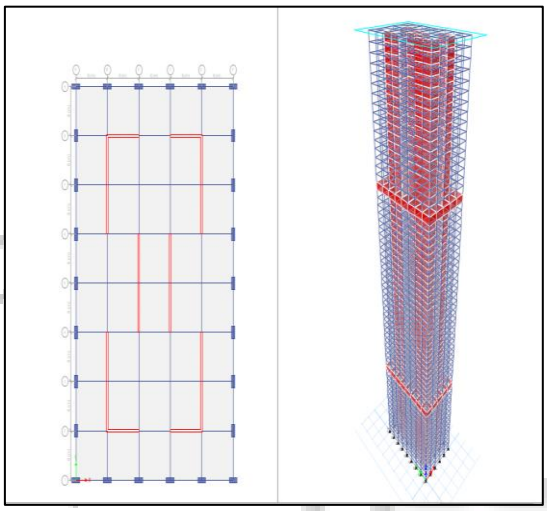

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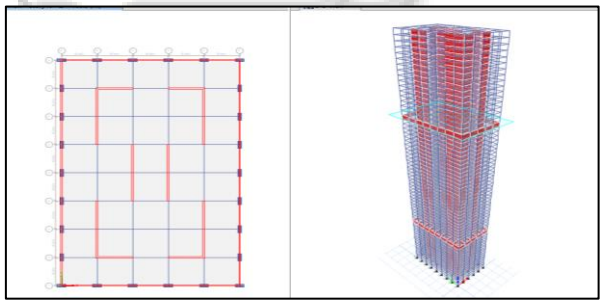
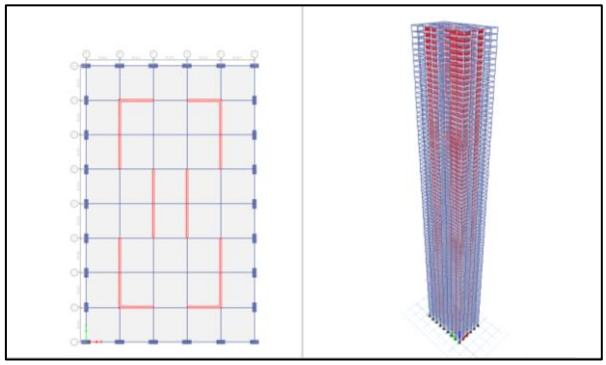


Model 7 –



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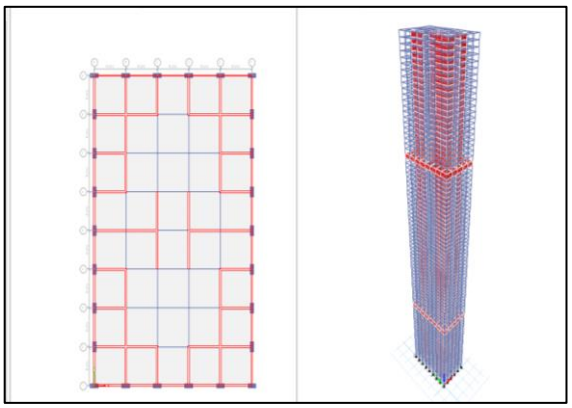

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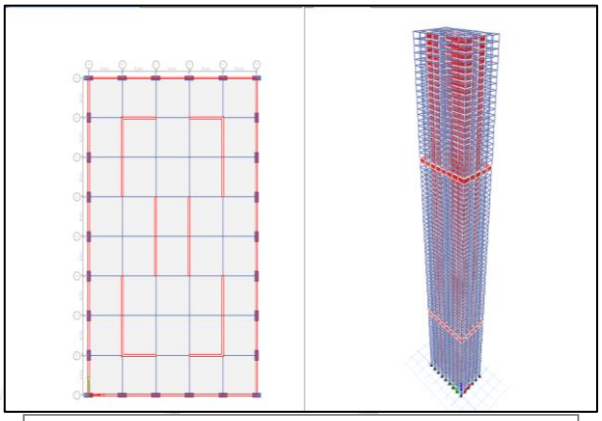

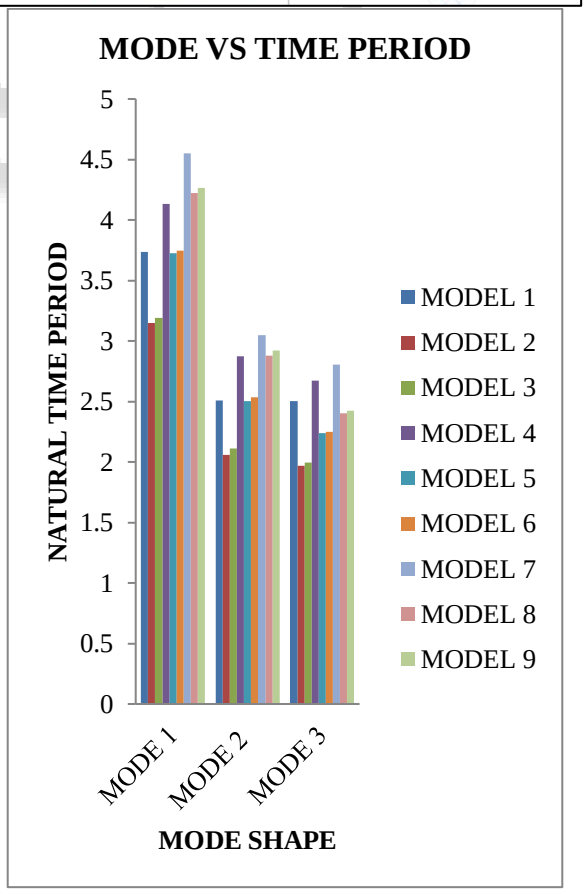

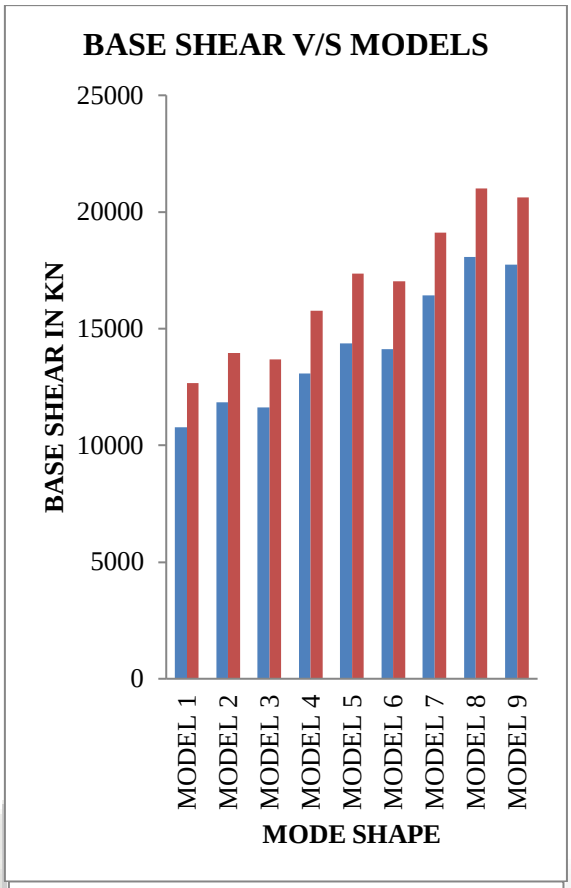

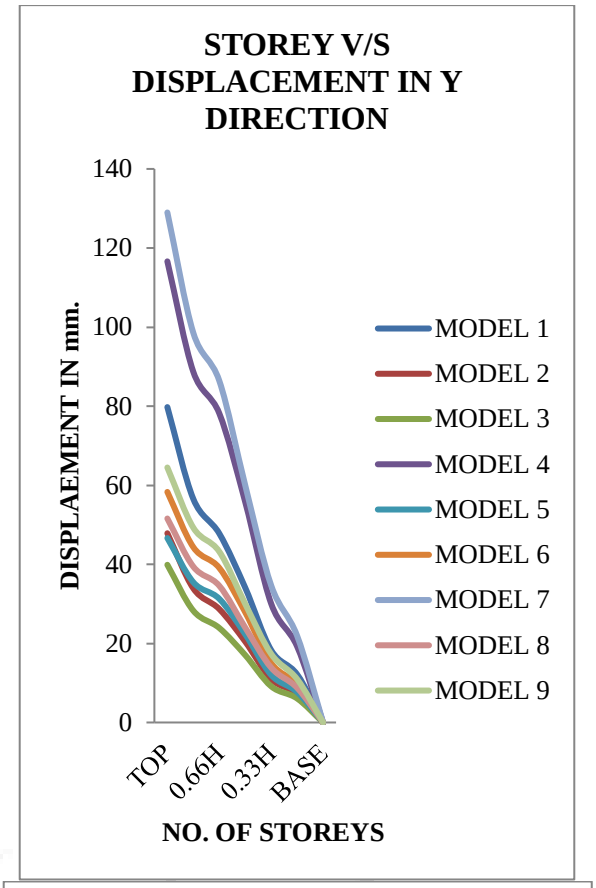

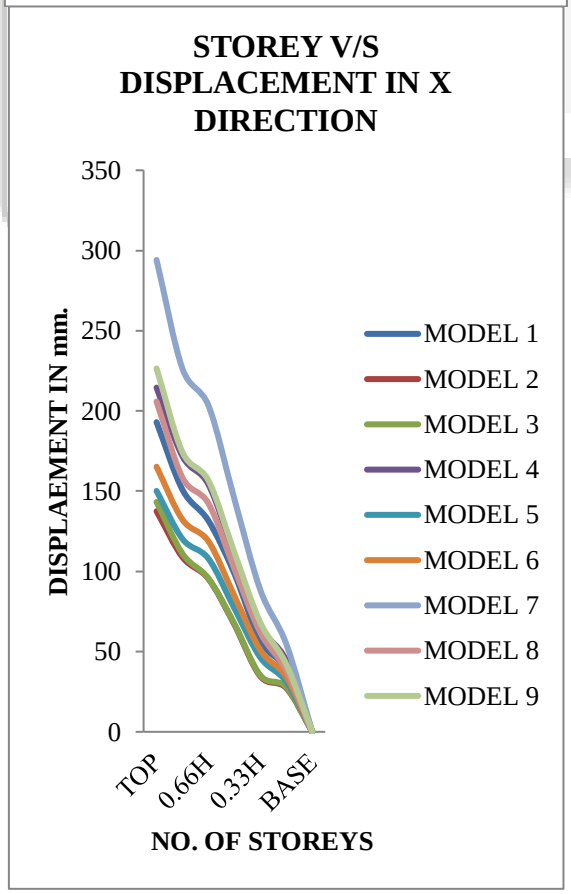

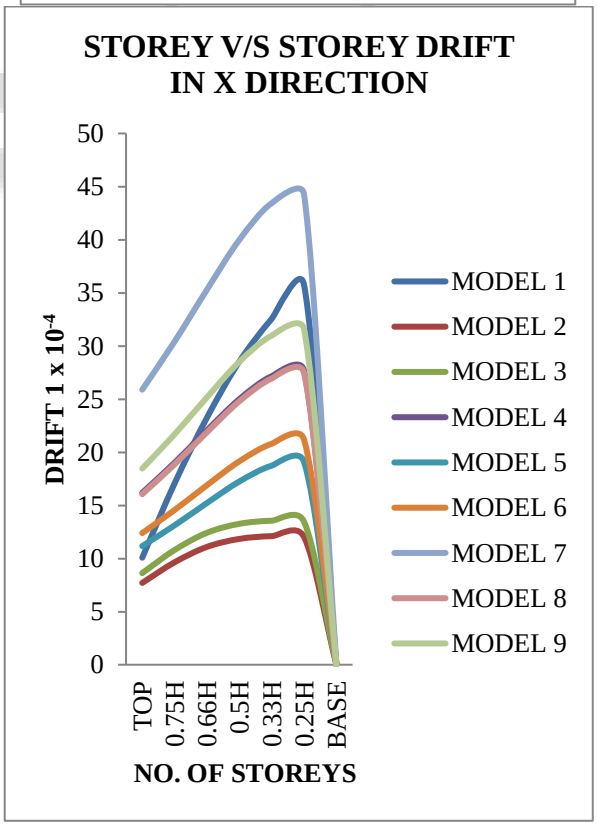

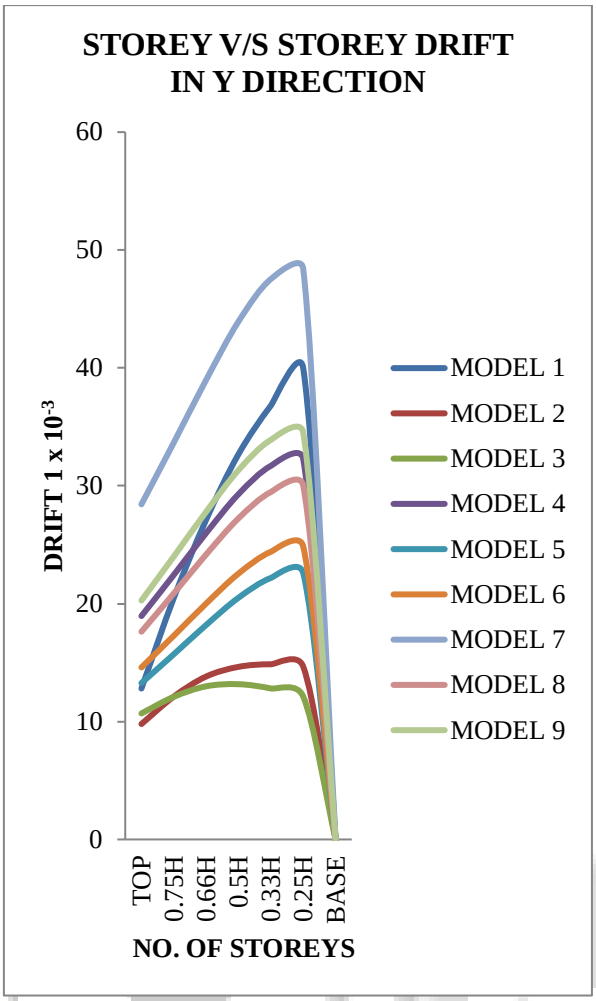

IV. Conclusion

In this research, the technique of using Virtual Outrigger with predefined locations has been proposed based on its behaviour due to the applied lateral loads. Analysis has been carried out using ETABS structural software for various models discussed earlier.

Based on the outcomes obtained following are the conclusions made:

- The multi outrigger system used in building its increase the performance of the building as compared to single outrigger system.
- Using the outrigger system in building it increases the stiffness and the strength of the building and also resists the lateral load causes due to the earthquake load and wind load.
- Comparing the virtual outrigger with the conventional outrigger, virtual outrigger also gives good results.
- Using the outrigger system, the more stability and stiffness achieves to the building and reduces the deflection of the building by 23% with the use of conventional outrigger system while it reduces up to 26% with the use of hybrid outrigger system.
- Outrigger improved the performance of the building by reducing inner storey drift up to 28% with the use of conventional outrigger system while it reduces up to 25% with the use of hybrid outrigger system.
- Base shear in structure using outrigger system is 18% more than the other systems because of high seismic weight which gives high response during earthquake.
- Time period of conventional structure is 30% more than outrigger structures.
- In such rectangular buildings, by providing outrigger at different locations, top storey drift and displacement in x and y direction with varying heights of building. Location and type of outrigger plays a very important role in the design of tall buildings.

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