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Effect of Outrigger Stiffness in the Seismic Performance of the Structure

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Abstract –In this paper, six structures with different outrigger floor stiffness (Single and X bracing) have been compared on order find its effect on parameters such as Storey drift, Storey Displacement, Storey forces and moments. Both seismic coefficient method and response spectrum Method have been applied. 40, 60 and 80 storey models were compared with double stiffness. It was found that at lower heights the increased stiffness of X bracing were effective in reducing the lateral sway and drift but as the height increases the effect is found out to be negligible.

Key Words: Outrigger, Comparison, Response spectrum, High Rise

1. INTRODUCTION

The use of outrigger systems has been increasing as the need for high rise structures is increasing. Varies studies have been done with respect to outriggers and its effect on the performance of the structure. It has shown from various studies that the Stiff outrigger floor reduces the drift and sway to the structure effectively. In this study we thus try to find the effect of increasing the stiffness of the outrigger using X bracing on the structure. For this we shall analyze six models, 40 , 60 and 80 storey for each normal and X bracing and study its effect in the performance of the structure. All Other parameters remaining the same.

2. Model Description

In this paper 6 Model of varying outrigger thickness and heights were analyzed and studied. The following office building was taken. The model data and preliminary data is given below.

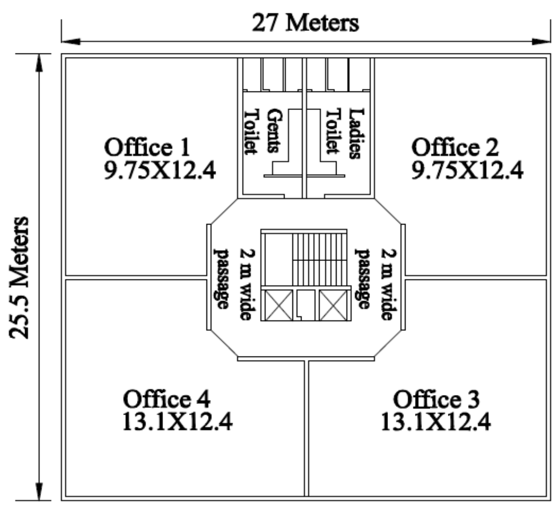

Fig 1 Typical floor plan for office building

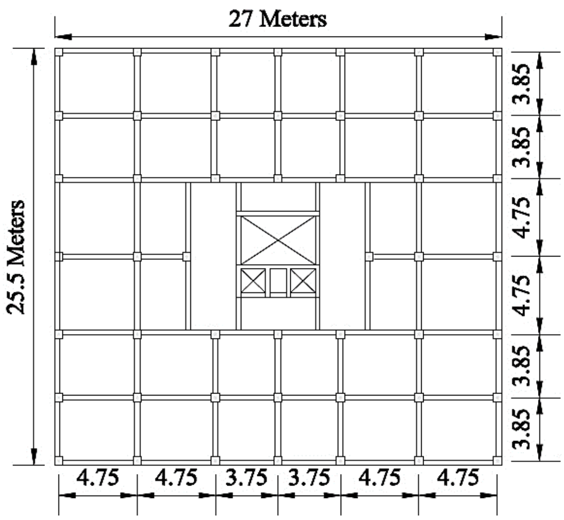

Fig 2 Typical structural Layout

Table 1 Preliminary data for design

Type of Structure	Special RC moment resisting frame (SMRF)
Number of storeys	G+40, G+60, G+80
Height of storey	3.0m
Thickness of slab	0.150m
Thickness of external wall	0.230m
Thickness of internal wall	0.150m
Grade of reinforcing steel	Fe500
Density of concrete	25kN/m³
Density of brick	20kN/m³
Thickness of slab	150 mm
Grade of concrete in slab	M30, M40, M50 For 40,60 and 80 Storey Respectively
Grade of concrete in beam & column	M30, M40, M50 For 40,60 and 80 Storey Respectively
Columns for 40 storey models	700X700 M30 -1 F TO 10 F 600X600 M30 -11 F TO 20 F 500X500 M30 -21 F TO 30 F 400X400 M40 -31 F TO 40 F

Columns for 60 storey models	800X800 M40 -1 F TO 10 F 700X700 M40 -11 F TO 20 F 600X600 M40 -21 F TO 30 F 500X500 M40 -31 F TO 40 F 400X400 M40 -41 F TO 50 F 300X300 M40 -51 F TO 60 F
Columns for 80 storey models	1000X1000 M50 -1 F TO 10 F 900X900 M50 -11 F TO 20 F 800X800 M50 -21 F TO 30 F 700X700 M50 -31 F TO 40 F 600X600 M50 -41 F TO 50 F 500X500 M50 -51 F TO 60 F 400X400 M50 -61 F TO 70 F 300X300 M50 -71 F TO 80 F
Beam Sized for all Structures	230 mm X 750 mm
Grade of concrete in shear wall	M30, M40, M50 For 40,60 and 80 Storey Respectively

Table 2 Dead and live loads considered

Dead load	Self weight of slab, beam, column, shear wall, brick wall and parapet wall
Live load	For intermediate floor=4kN/m² For terrace floor=1.5 kN/m²
Floor finish	For intermediate floor=1kN/m²For terrace floor=1.5 kN/m²

Table 3 Wind and seismic load data

Seismic zone	III,
Soil condition	Medium soil
Importance factor	1
Zone factor	0.16
Damping ratio	5%

The outriggers were placed and 20th storey for 40 storey model and 30th storey for 60 storey model. For the 80 storey model two outriggers were place at 1/3rd height and 2/3rd height i.e 20th and 60th storey. The 3d model of both normal (Soft) and X bracing (Stiff) outriggers are shown below.

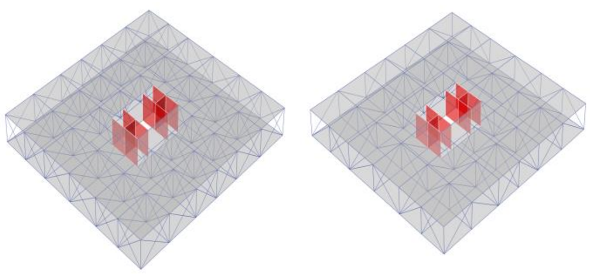

Fig 3 Typical structural Layout

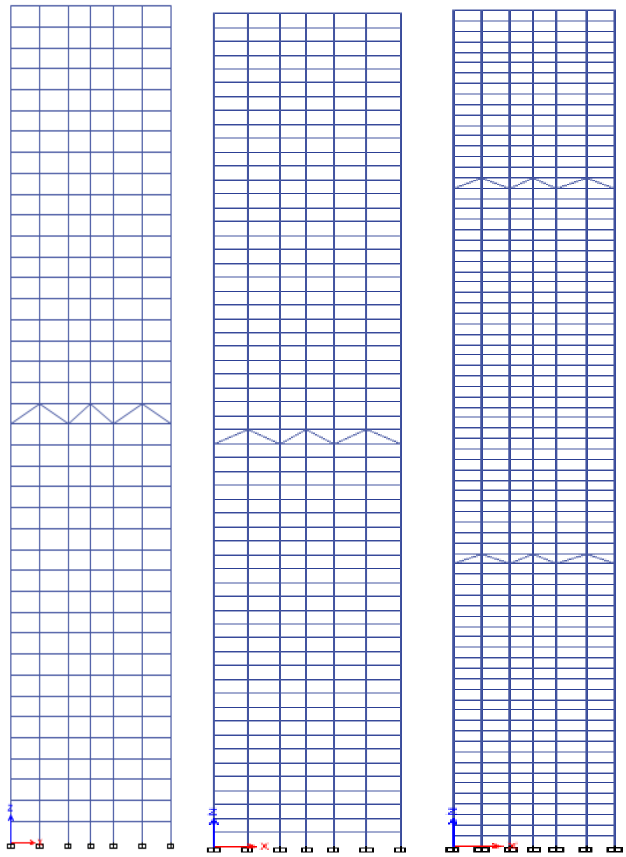

Figure 4 Elevations of Soft Outrigger Structures

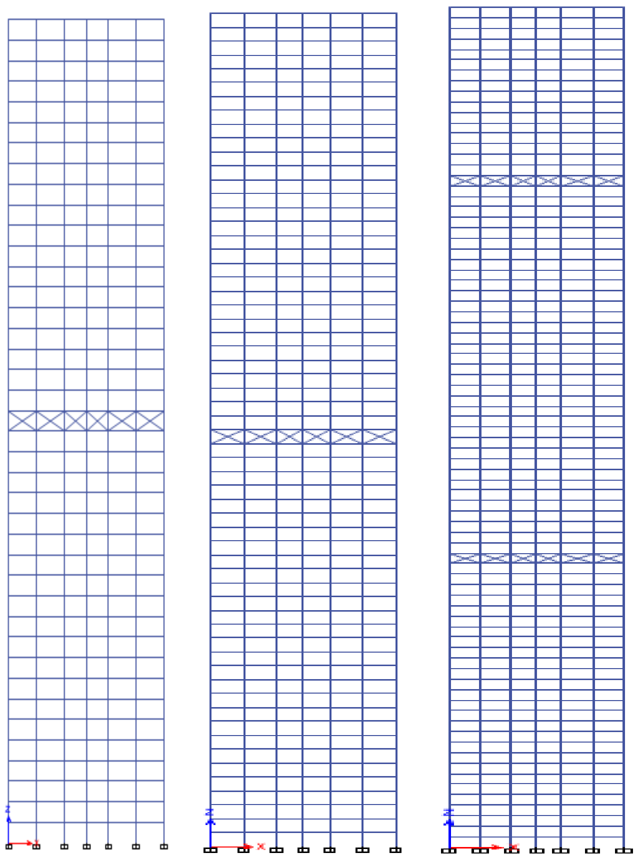

Figure 5 Elevations of Stiff Outrigger Structures

3. Results

The results obtained from the analysis are shown in graphical form below. The storey Drifts and displacements of the structures in EQ land SPEC cases are compared to each other.

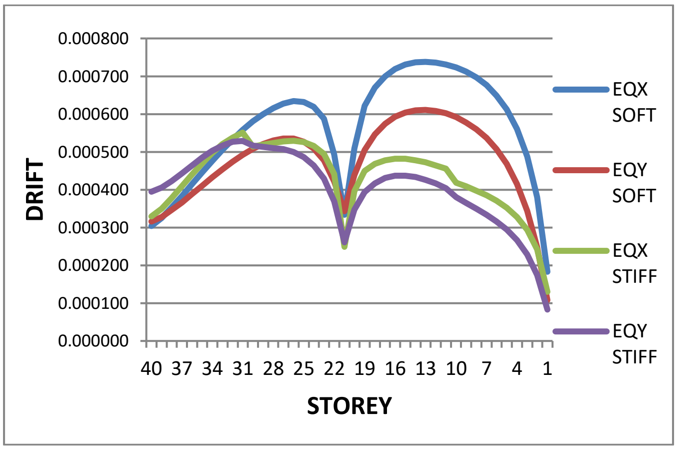

Figure 6 Drift in EQ in 40 Storey Model

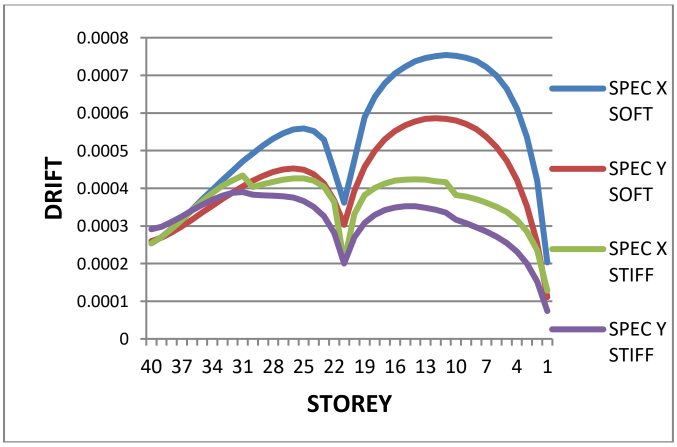

Figure 7 Drift in SPEC in 40 Storey Model

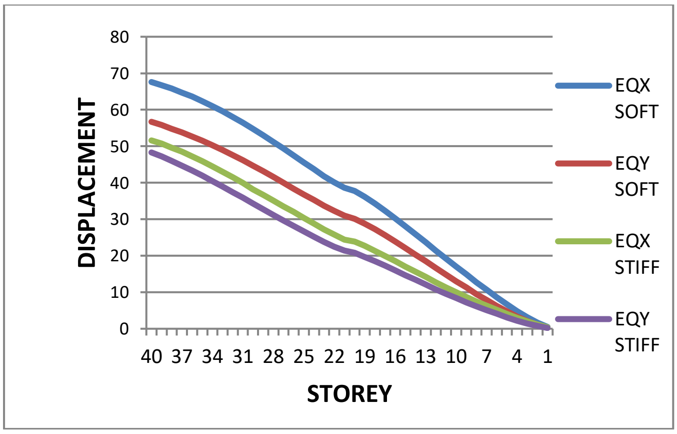

Figure 8 Storey Displacement in EQ in 40 Storey Model

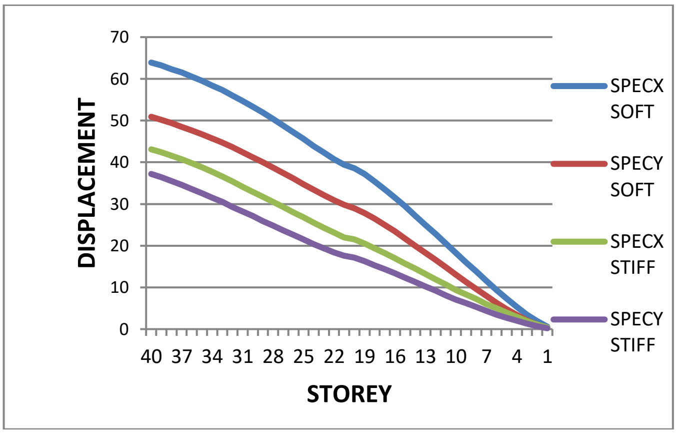

Figure 9 Storey Displacement in SPEC in 40 Storey Model

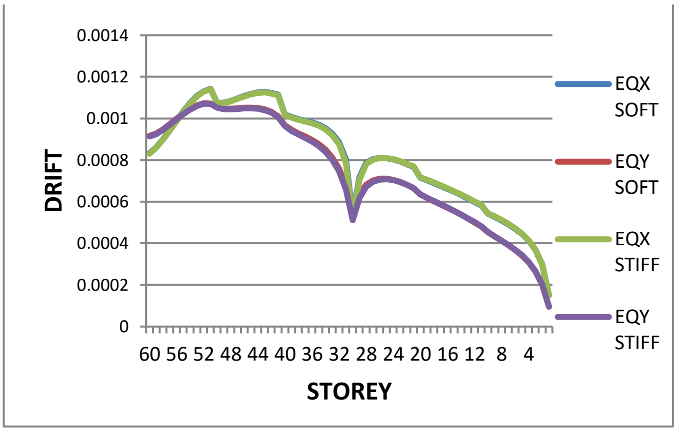

Figure 10 Drift in EQ in 60 Storey Model

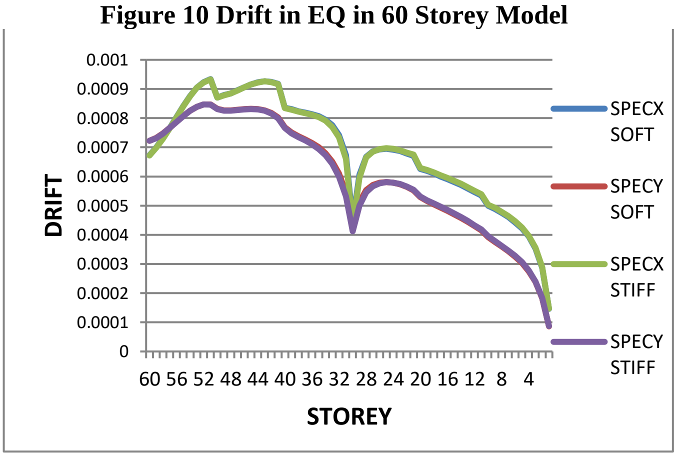

Figure 11 Drift in SPEC in 60 Storey Model

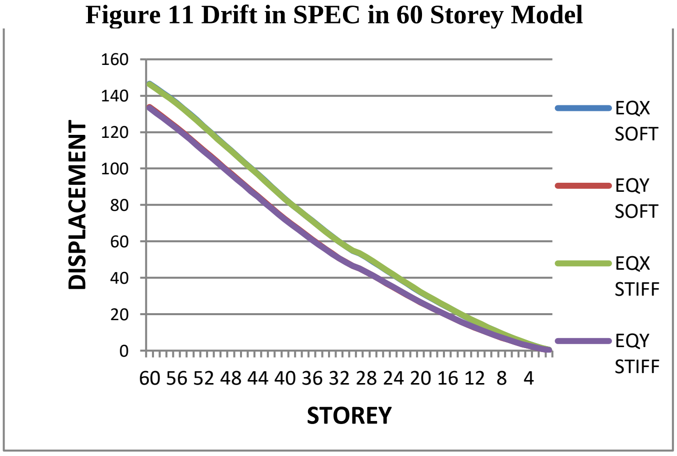

Figure 12 Storey Displacements in EQ in 80 Storey Model

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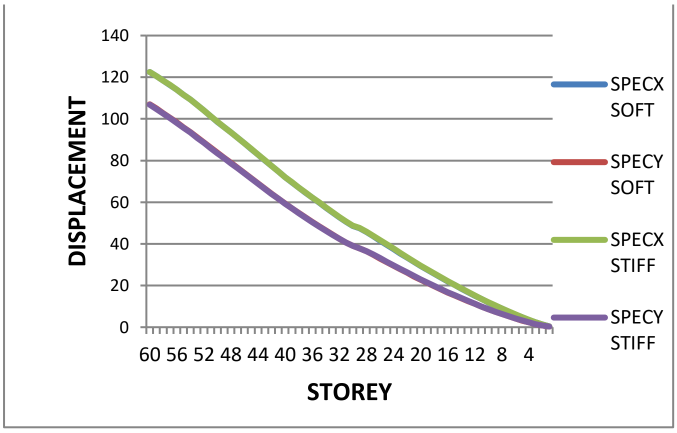

Figure 13 Storey Displacements in SPEC in 60 Storey Model

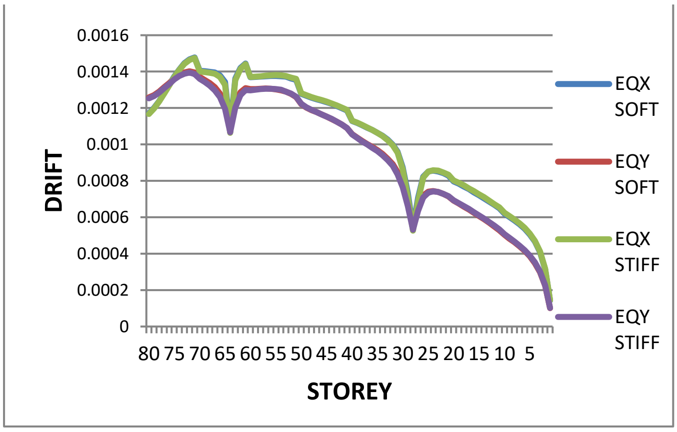

Figure 14 Drift in EQ in 80 Storey Model

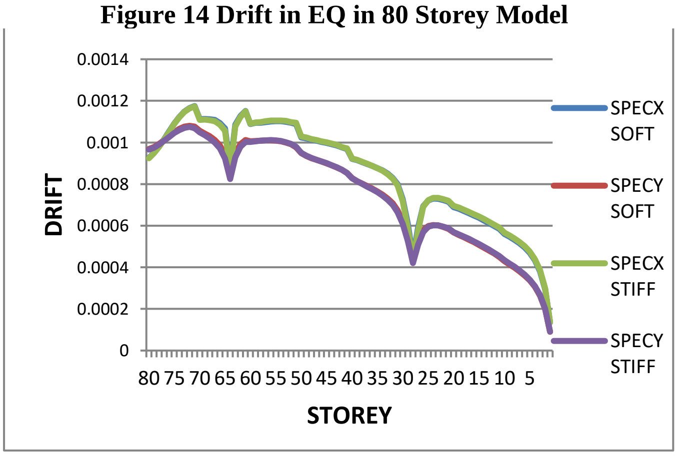

Figure 15 Drift in SPEC in 80 Storey Model

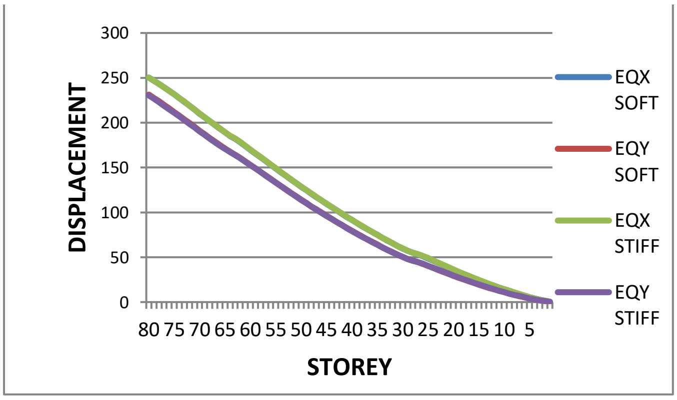

Figure 16 Storey Displacements in EQ in 80 Storey Model

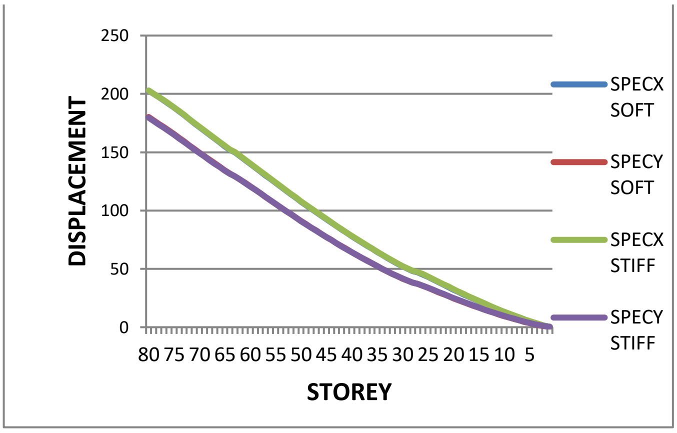

Figure 17 Storey Displacements in SPEC in 80 Storey Model

4. Discussion

The following tables represent the percentage variation of parameters such as Drift and Displacement in the different models.

1.Top Storey Drift Comparison

Table 4- 40 Storey models

	SOFT	STIFF	%VARIATION
EQX	0.000304	0.000329	7.598784
EQY	0.000316	0.000395	20
SPEC X	0.000254	0.000254	0
SPEC Y	0.00026	0.000291	10.65292

Table 5- 60 Storey model

	SOFT	STIFF	%VARIATION
EQX	0.000833	0.00083	0.361446
EQY	0.000916	0.000914	0.218818
SPEC X	0.000673	0.000672	0.14881
SPEC Y	0.000722	0.000722	0

table 6- 80 Storey model

	SOFT	STIFF	%VARIATION
EQX	0.001171	0.001168	0.256849
EQY	0.001259	0.001254	0.398724
SPEC X	0.000926	0.000924	0.21645
SPEC Y	0.000969	0.000966	0.310559

2.Top Storey Displacement Comparison

Table 7- 40 Storey model

	SOFT	STIFF	%VARIATION
EQX	67.6	51.6	31.00775
EQY	56.7	48.3	17.3913
SPEC X	63.9	43.1	48.25986
SPEC Y	50.9	37.2	36.82796

Table 8- 60 Storey model

	SOFT	STIFF	%VARIATION
EQX	146.6	146.3	0.205058
EQY	133.8	133.3	0.375094
SPEC X	122.5	122.5	0
SPEC Y	107	106.8	0.187266

Table 9- 80 Storey models

	SOFT	STIFF	%VARIATION
EQX	250.3	250.3	0
EQY	231.3	230.4	0.390625
SPEC X	202.8	202.9	0.049285
SPEC Y	180.2	179.6	0.334076

The above table shows that there is about 7 to 20% reduction in drift and 17 to 48% reduction in displacement at the top when X bracing is used in the structure. However for the models where the is 180m and 240m that is the 60 and 80 storey model the reduction is reduced to about 0.3% which indicated that it is negligible. Also for the two outrigger model for 80 storey both the outriggers were replaced by X bracing, yet it did not have any significant effect of Drift and Displacement.

5. CONCLUSIONS

Thus from the above graphs and tables It was evident that increasing the stiffness of the outrigger by providing X bracing was Effective for the 40 Storey model but as we increase the height of the structure to 60 and 80 storey the X bracing were not as effective. Rather The effect negligible and thus other parameters need to be studied for further reduction in the drift and displacement is necessary from safety and serviceability point of view.

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