PUSHOVER ANALYSIS FOR THE RC STRUCTURES WITH DIFFERENT ECCENTRICITY

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ABSTRACT

In present scenario, most of the buildings are often constructed with irregularities such as soft storey, torsional irregularity, unsymmetrical layout of in-fill walls, vertical and plan irregularity, etc. Past earthquake studies shows that the most of the RC buildings having such irregularities were severely damaged under the seismic ground motion. The present study is an overview of performance of the torsionally unbalanced buildings also called as asymmetric buildings subjecting to pushover analysis. In this study the effect of eccentricity between Centre of mass (CM) and Centre of story stiffness (CR) on the performance of the building is presented. The performance of the buildings is assessed as per the procedure prescribed in ATC-40 and FEMA 273.

Keywords: Eccentricity, Pushover analysis, Storey displacement, Storey drift.

I. INTRODUCTION

The most destructive of all natural disaster is earthquake. It is defined as the vibration of earth's surface due to sudden release of energy in the earth's crust. Earth quake has direct and indirect effects. The result of an earthquake is generally due to the aspects such as the load path distribution, effect of source and local site. Earthquake causes the ground to vibrate and the structures resting on it will be subjected to ground motion. Hence when earthquake happens, the structures which are subjected to dynamic loading will not be considered external loading but a loading which arises due to the lateral movement of supports. Factors contributing to structural damages during earthquake are plan irregularity, elevation irregularity, strength, stiffness, mass, torsional respectively. As mentioned early Earthquake is the most destructive of all natural disaster which causes both loss of life and loss of economy. Maximum of the losses are due to structural breakdown. Hence, it is necessary to design the structures scientifically and also considering structure's symmetry to resist moderate and severe earthquakes depending on importance of structure and site location.

II. METHODOLOGY

Many seismic methods are available to analyses a structure. Though linear analysis gives appreciable results for determining the linear behavior of structure, it fails to predict the collapse mechanism land redistribution of forces on subsequent yielding. To understand the actual behavior of the structure beyond its elastic limit and to identify the actual failure mode when structure is subjected to strong ground motion nonlinear analysis becomes important in seismic design. Hence pushover analysis is popular for determining various parameters like Initial Stiffness, Yield point, Maximum Base Shear, Maximum Displacement.

2.1 Pushover Analysis

It is a nonlinear static method used in performance based analysis. It is relatively simple to implement and gives information about deformation ductility and strength characteristics of the structure and distribution of demands which help in identifying the critical members likely to reach limit stages during an earthquake event and hence proper attention can be given while designing and detailing. In pushover analysis a set of lateral loads are applied along the height of the structure and nonlinearity effects for materials are modeled and then the structure is pushed until collapse takes place that helps in assessing the status of plastic hinges formed in the structure. Loading the structure in this way weak links and failure modes of the structure are found. Base shear and roof displacements at each step can be plotted to generate pushover curve. Load is applied incrementally on the building frame, the formation of plastic hinges, stiffness degradation, and lateral load versus roof top displacement for the structure is analytically computed. It gives an insight view of the structure's maximum base shear capacity which is capable of resisting and the corresponding inelastic drift.

III. DESCRIPTION OF MODEL CONSIDERED FOR STUDY

Type of structure	Ordinary moment resisting RC frame
Plan size	5m x 5m
Number of stories	G +3
Height of each storey	4m
Total Building height	16m
Slab	120mm
Grade of concrete	M20
Grade of reinforcing steel	Fe415
Seismic zone	Zone IV
Type of soil	III

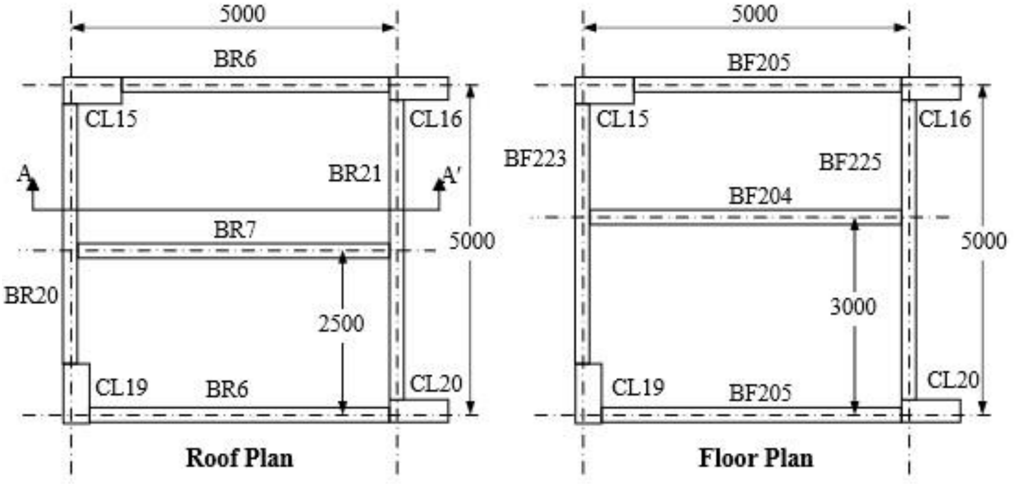

Fig 3.1: Roof and Floor Plan Of Model

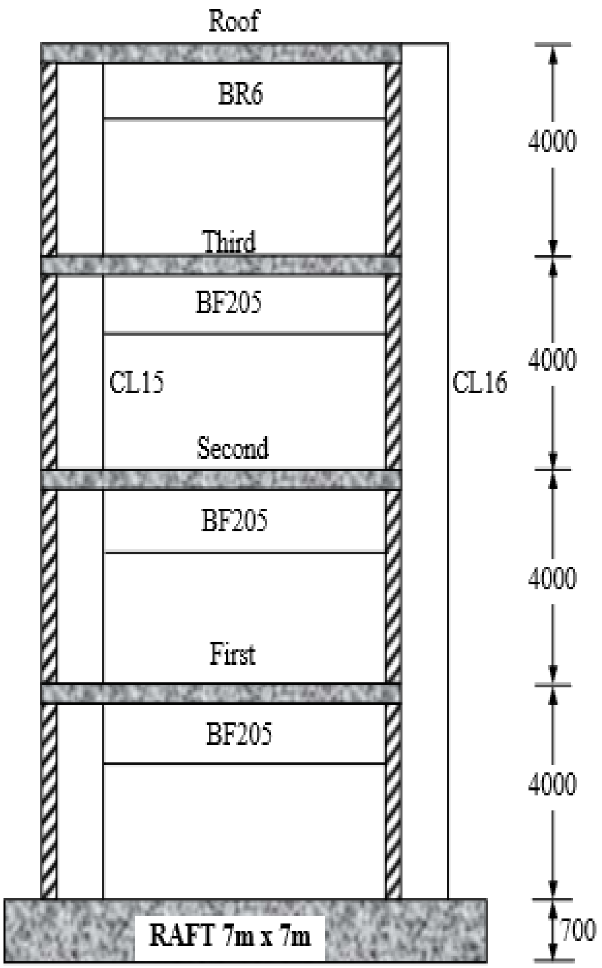

Fig 3.2: elevation of the model considered

4 models with same plan and elevation but different column orientation were considered for the study. i.e., model with different eccentricities. Eccentricity is the difference between Centre of mass (CM) and Centre of rigidity (CR).The eccentricities (E) are as below.

Table 3.1: Values of eccentricities for different models from ETABS

Model	CM_X	CM_Y	CR_X	CR_Y	$E_X=CM_X \sim CR_X$	$E_Y= CM_Y \sim CR_Y$	$E = \sqrt{E_X{}^2 + E_Y{}^2}$
Actual Model	2.44	2.54	1.22	3.10	1.22	0.56	1.34
Model 1	2.44	2.54	2.07	2.50	0.37	0.04	0.37
Model 2	2.43	2.54	3.26	3.09	0.82	0.56	0.99
Model 3	2.44	2.54	2.29	3.98	0.14	1.44	1.45

The values of eccentricities were rounded up and the models were renamed as below

Actual model: model with column orientation as shown in the Fig. 3.3 with eccentricity 1.34

e = 0.4: model 1 with column orientation as shown in the Fig.3.4 with eccentricity 0.4

e = 1: model 2 with column orientation as shown in the Fig. 3.5 with eccentricity 1

e = 1.5: model 3 with column orientation as shown in the Fig. 3.6 with eccentricity 1.5

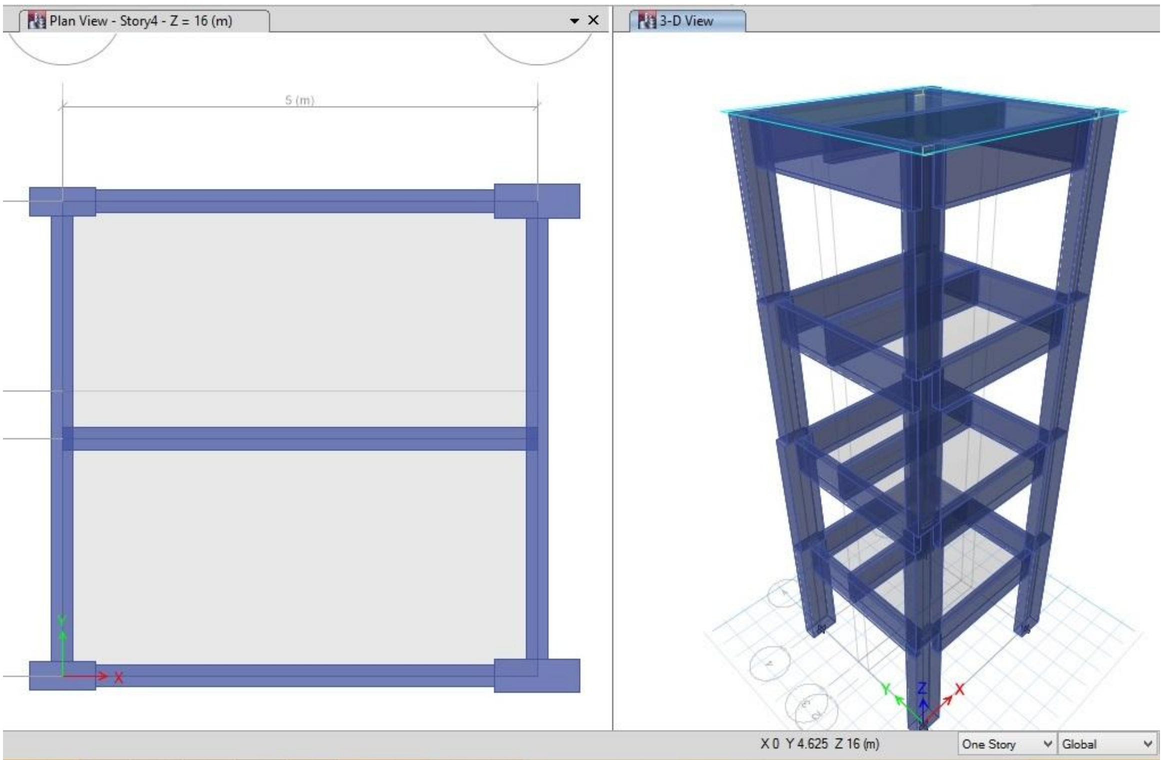

Fig. 3.3: e=0.4

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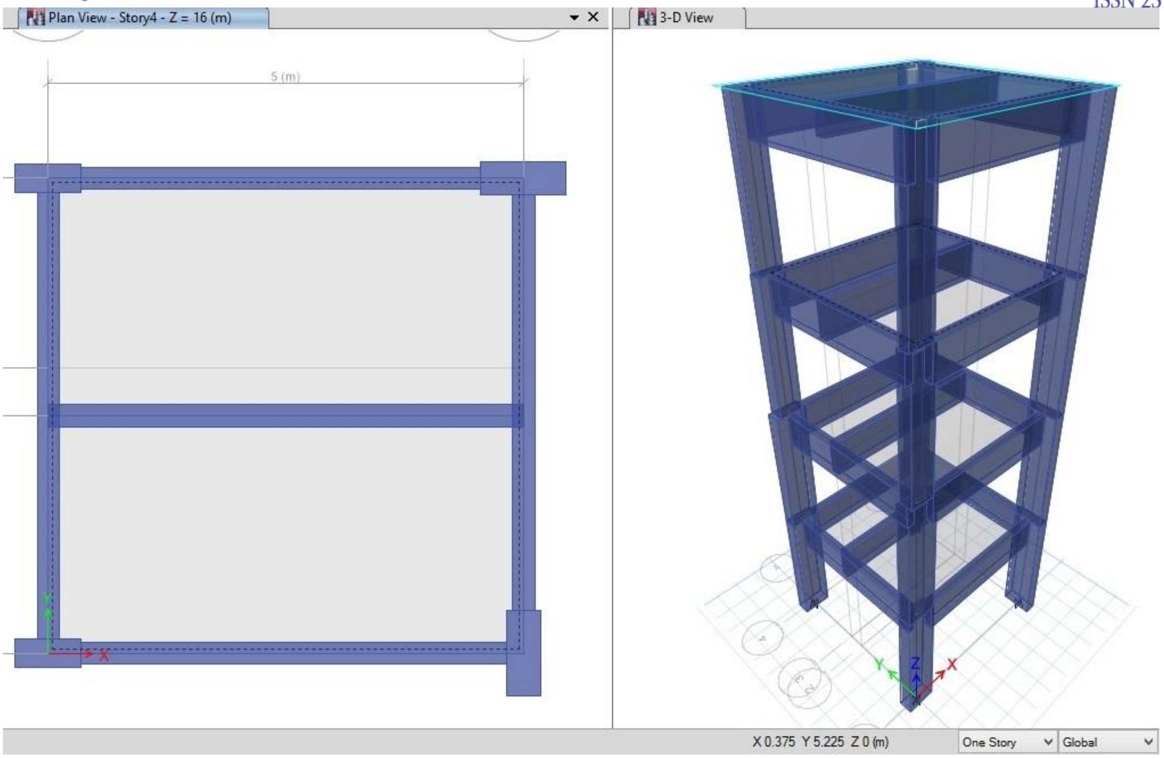

Fig. 3.4: e=1

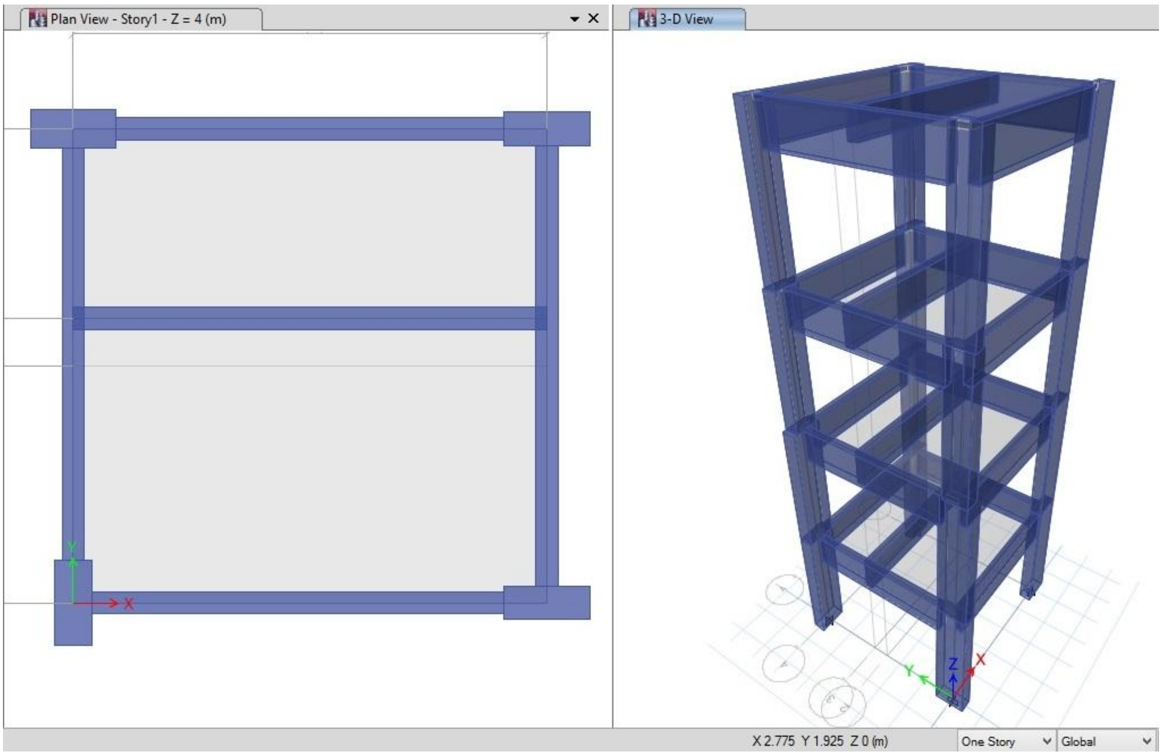

Fig. 3.5: Actual model

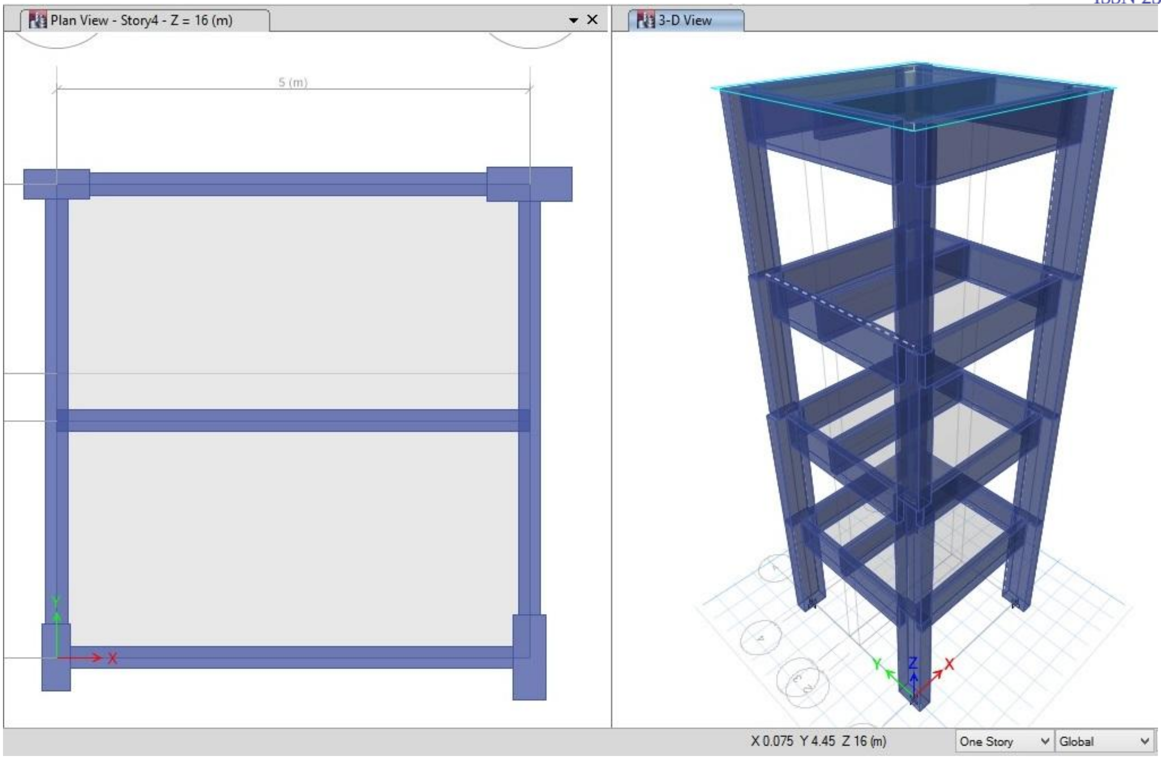

Fig. 3.6: e=1.5

IV. RESULTS AND DISCUSSIONS

4.1 Storey Displacements

Storey displacement is the movement of each storey in horizontal direction when subjected to lateral loads. Table 5.1 shows the values of displacements at each storey level for four different models.

Table 4.1: Storey displacement for models with different eccentricities in X and Y direction.

Storey level	Storey displacement in X direction in mm				Storey displacement in Y direction in mm			
	e =0.4	e=1	e=1.34	e=1.5	e =0.4	e=1	e=1.34	e=1.5
Story4	38.2	37.1	33.5	40.2	41.1	41.5	38.7	38.6
Story3	29.8	29.2	26.2	31.5	32.8	31.6	31.1	30.6
Story2	18.3	17.9	16.5	20.2	21.9	20.3	20.1	19.5
Story1	7	7	6.6	8.5	10	8.6	8.6	7.7
Base	0	0	0	0	0	0	0	0

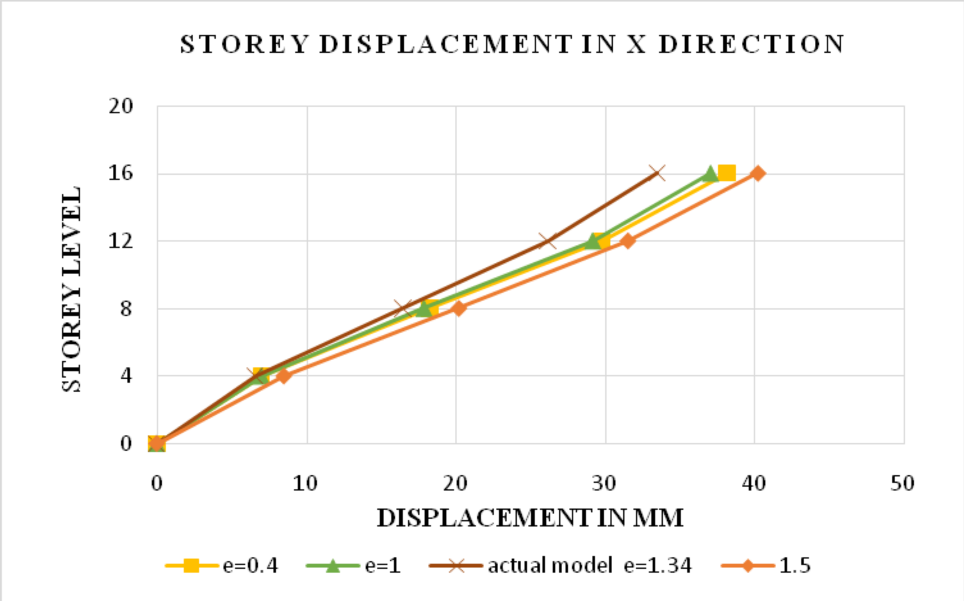

Fig. 4.1: Storey displacement for all the models in X direction

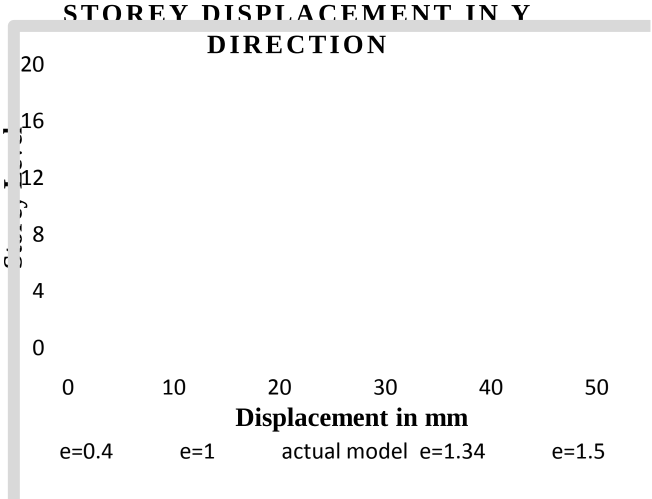

Fig. 4.2: Storey displacement for all the models in Y Direction

Figure 4.1 and Figure 4.2 shows the displacement of each storey along the height of the building for models along X and Y direction respectively. From the data presented in table 5.1 for displacement of the building in X and Y direction, it can be observed that, the displacement in the actual model is varying almost linearly from base to the roof. The same behaviour is observed for all the models. In the X direction the storey displacement in all the storeys decreases with increase in eccentricity up to e = 1.34(actual model) but the storey displacement increases in the model with e = 1.5 this is because, in the model with e = 1.5 2 columns are oriented in X direction and 2 columns are oriented in Y direction but in the other models, all columns are oriented in X direction (e = 0.4) and one column oriented in the Y direction (e = 1, e = 1.34). The displacement in top storey decreases from 38.2mm to 33.5mm with increase in eccentricity from e = 0.4 to e = 1.34 (actual model) but in the model with e = 1.5 the displacement is increased to 40.2mm. The storey displacement in the Y direction is

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gradually decreasing with increasing eccentricity in all the models. The displacement in top storey decreases from 41.1mm to 38.6mm with increase in eccentricity from e = 0.4 to e = 1.5.

4.2 Storey Drift

Drift is the relative motion of each storey of the building with respect to storey below. Drifts indicate the lateral movement of the building model. Table 5.2 shows the values of storey drift at each storey level for four different models.

Table 4.2: Storey drift for models with different eccentricities in X and Y direction.

Storey level	Storey drift in X direction				Storey drift in Y direction			
	e =0.4	e=1	e=1.34	e=1.5	e =0.4	e=1	e=1.34	e=1.5
Story4	0.002094	0.001995	0.001844	0.002168	0.002235	0.002478	0.001903	0.002232
Story3	0.002892	0.002812	0.00241	0.002829	0.00273	0.002827	0.002733	0.002791
Story2	0.002811	0.002719	0.002484	0.002921	0.002982	0.00292	0.002885	0.002938
Story1	0.001753	0.001757	0.001645	0.002132	0.002489	0.002149	0.002148	0.001928
Base	0	0	0	0	0	0	0	0

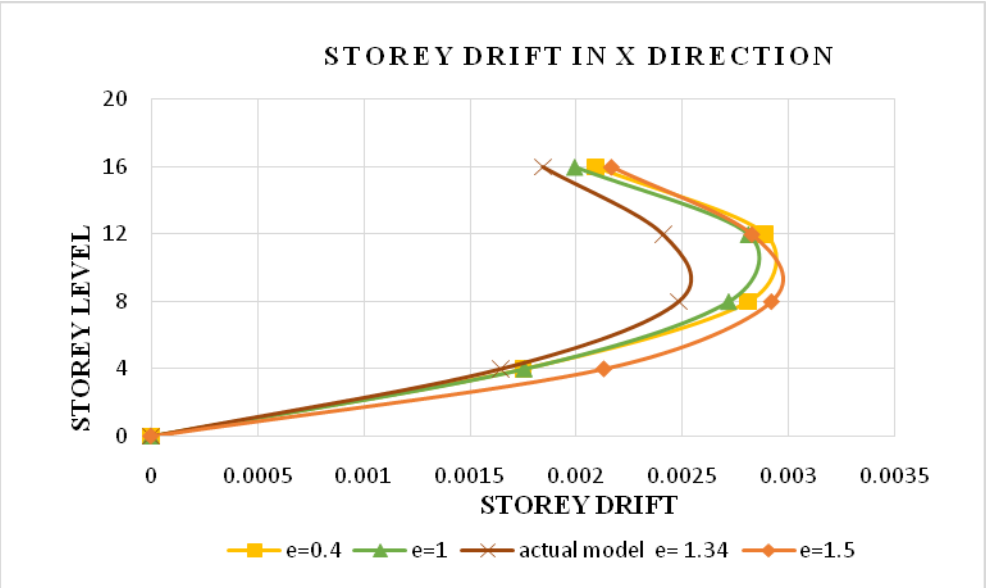

Fig. 4.3: Storey drift for all the models in X direction

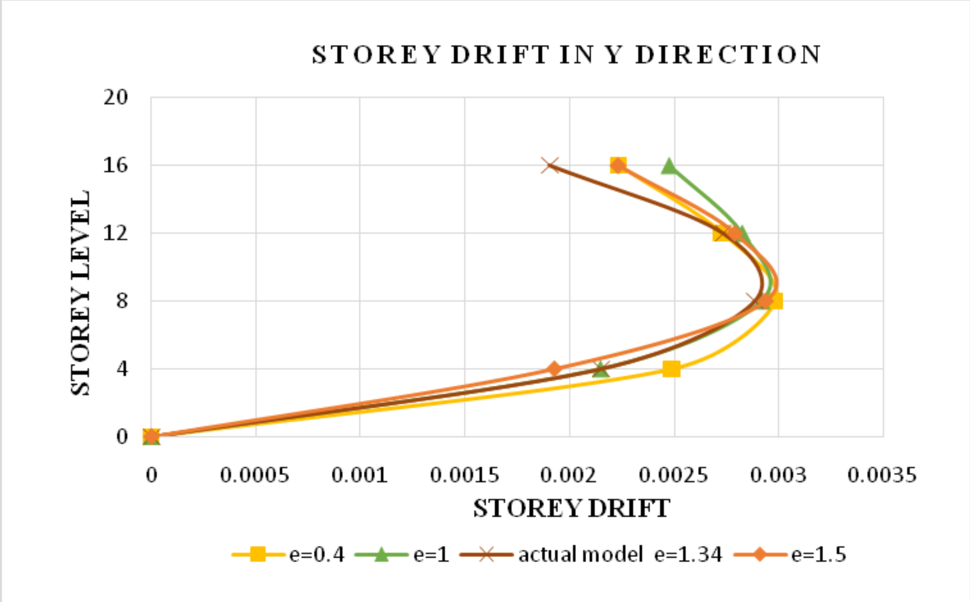

Fig. 4.4: Storey drift for all the models in Y direction

Figure 4.3 and Figure 4.4 shows the storey drift along the height of the building for each model in X and Y direction respectively. From the data tabulated in table 4.2 it can be observed that the storey drift is zero at the base and more at storey 2 and 3 for all the models. In the X direction, storey drift in 2 storey decreases from 0.002811 to 0.002484 with increase in eccentricity from e = 0.4 to e = 1.34 (actual model) but it is increased to 0.002921 in model with e = 1.5 this is because 2 columns are oriented in X and Y direction. The storey drift in model with e = 1 and e = 1.34(actual model) are not same though one column is oriented in Y direction, this is because the column which is oriented in Y direction in both the models is different i.e., in actual model CL19 and in model with e = 1 CL20 is oriented in Y direction. In the Y direction the drift is zero at the base and it is almost same for all the models in 2 and 3 storey. The actual model shows drift of 0.001903 and model with e = 1 shows 0.002478 drift at top storey though one column is oriented in Y direction this is again because not same columns are oriented in Y direction.

V. CONCLUSION

- Lateral displacement capacity of the structure decreases with increase in eccentricity in both X and Y direction.
- Storey drift decreases with increases in eccentricity in X direction but it is almost same with increase in eccentricity in Y direction.

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Biographaical Data:

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