OPEN ACCESS

International
Journal
Of Modern Engineering Research (IJMER)

Capacity based modal dynamic analysis with soft storey and masonry core wall as infill

Shashikumar H[1], Syed Ahamed Raza[2]

1Post Graduation Student (Structural Engineering), Ghousia College of Engineering, Ramanagaram, 562159, Affiliated to VTU, Karnataka, India.

2Assistant Professor, Department of Civil Engineering, Ghousia College of Engineering, Ramanagaram,562159 Affiliated to VTU, Karnataka, India.

ABSTRACT : *Structural engineering is a part of civil engineering dealing with the analysis and design of structures that support or resist loads. This paper deals with the study of architectural drawing and the framing drawing of the building with soft story. Buildings with soft storey are typical feature in the modern multi-storey construction in urban India. Such features are highly undesirable in a building built in seismically active areas. in this study G+6 high-rise building with soft storey subjected seismic load is been analyzed. Building is designed according to IS 456-2002. Building is assumed to be located in seismic zone 5 according to IS 1893 2002 code. Soil is considered as medium type (with mass density=2100 kg/m3 modulus of elasticity=100Mpa, poison's ratio=0.25). Linear analysis is done using linear dynamic method and nonlinear analysis by pushover analysis method. Finally, the behavior is studied by studying Diaphragm drift, point displacement, using the FEM based analytical software ETABS9.7.4.*

Key words: *Diaphragm Drift, point displacement, Performance point, linear dynamic analysis, nonlinear static analysis*

I. INTRODUCTION

1.1 General

An earthquake in other words is also known as quake or shaking. Earthquake refers to the sudden release of energy that creates seismic waves in the earth crust. The frequency, type and size of earthquake experienced over a period of time are referred on the seismicity and seismic activity of an area.

An earthquake is similar to rain in occurrence as both of them occur naturally. Earthquakes affect almost every part of the earth. They can be catastrophic or mild (similar characteristics as rain) over the course of geological time the surface of our planet earth have been shaped by natural events like earthquakes and floods. Though an earthquake lasts only for a few moments the operations within the earth takes millions and millions of years in process that cause earthquake. The cause of earthquake until very recently was an unsolved mystery. It was an equally fanciful and the subject of fanciful folklore learned speculation by peoples throughout the world.

1.2 Soft Storey

A Soft storey is defined as a storey in a building that has less stiffness, less resistance or inadequate ductility to resist the earthquake induced building stresses. A soft storey buildings are in words can be characterized by having a storey that have a lot of spaces, parking garages. For example a soft storey building can be compared as large retail spaces on floor with lots of windows. Figure 1shows the images of soft storey building. The floor of a building can be considered as a soft storey building if its floor as 70% less stiffness than the floor above it.

These types of soft storeys can create a major weak point in an earthquake, because soft storeys are associated classically with parking garages and a lot of retail spaces. They are frequently on the lower storeys of a building that they can collapse and take the whole building down. And as a result causes serious natural damage which may render the structure as the totally unusable building. RC special moment the almost resisting frames are specially detailed to enhance ductile behavior and comparative with the needs of IS codes. R C shear walls have been used very widely as the lateral load resisting system they are considered so in high rise building and also in medium buildings since they have high lateral stiffness. Shear walls have very little stiffness in perpendicular directions, but considerably have stiffness in their own plane and have satisfactory performance depends on the stiffening of floor diaphragms that resist buckling of walls.

Fig-1: Example of a soft story at the ground floor.

1.3 The problems of soft storey

The buildings that are extremely vulnerable to earthquake collapses are those containing soft stories. As one floor is flexible when compared to others and other stories that are stiffened by infill walls as a whole unit of bracing act. Most deformation is soft stories occur that is capable of taking earthquake loads than other.

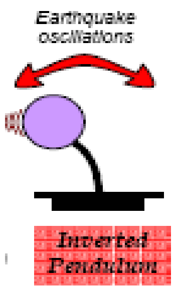

Fig2: Inverted Pendulum (Image source: EQTip21 NICEE)

Soft storey building in nature acts as a pendulum of a clock which is inverted. It swings back and forth producing high stresses in columns. If the columns are not capable of upholding these high stresses or may not possess considerable range of ductility. As the result of their sever weak point they could get seriously damaged and they can also lead to collapse of the storey building. This is also referred to an inverted pendulum. The main problem in present designs practice upper stiff masonry walls are not concentrated or are not taken into consideration in the design calculation, so the problem of an inverted pendulum is not completely rectified.

1.4Methods of analytical study

1. Linear dynamic analysis:

This approach permits the multiple modes of response of s building to be taken into account. This is required in many building codes for all except for every simple or very complex structure. the response of the structure can be divided as a combination of many special shapes that in a vibrating string correspond to the" harmonics". Computer analysis can be used to determine these modes of a structure. For each mode a response is need from the design spectrum based on the model frequency and the model mass, and they are then combined to provide an estimate of the total response of the structure.

2. Non-linear static analysis:

Pushover analysis is one of the methods available to understand the behavior of structure subjected to earthquake forces. as the name implies ,it is in the process of pushing horizontally with a prescribed loading pattern incrementally until the structure reaches a limit state. The static approximation consists of applying a vertical distribution of lateral modes to a model which captures the material non linearity of an existing structure and monotonically increasing those loads until the peak response of the structure is obtained on a base shear v/s roof displacement plot.

1.5 objectives

- To perform Dynamic static and nonlinear static analysis for the considered building model
- To find the capacity of the buildings
- To study the effect of soft story behavior
- To compare various results such as Diaphragm drift, Point displacement, as per IS 1893 PART1 2002 for the considered models.
- To find the performance point using non-linear static analysis
- To obtain pushover curve from non-linear analysis.

II. STRUCTURAL DATA

The buildings are loads to be applied on the buildings are based on the Indian standards. The study is performed for seismic zone V as per IS 1893:2002. The frames are assumed to be firmly fixed at the bottom and the soil structure interaction is neglected

Table 1: Model data of Building

Structure	**SMRF**
No of Stories	G+6
Storey Height	3m
Base Storey	3.5m
Type of Soil	Medium Soil
Seismic Zone	5
Importance factor	1
Material Property	
Grade of Concrete	M25
Grade of Steel	Fe415
Member Properties	
Beam in longitudinal x-direction size	230x400mm
Beam in transverse y-direction size	230x350mm
column Size	230x650mm
Thickness of Slab	120mm
Live Load	3.5 KN/m^2
Live Load on Roof	1.75 KN/m^2
Floor Finish	1 KN/m^2

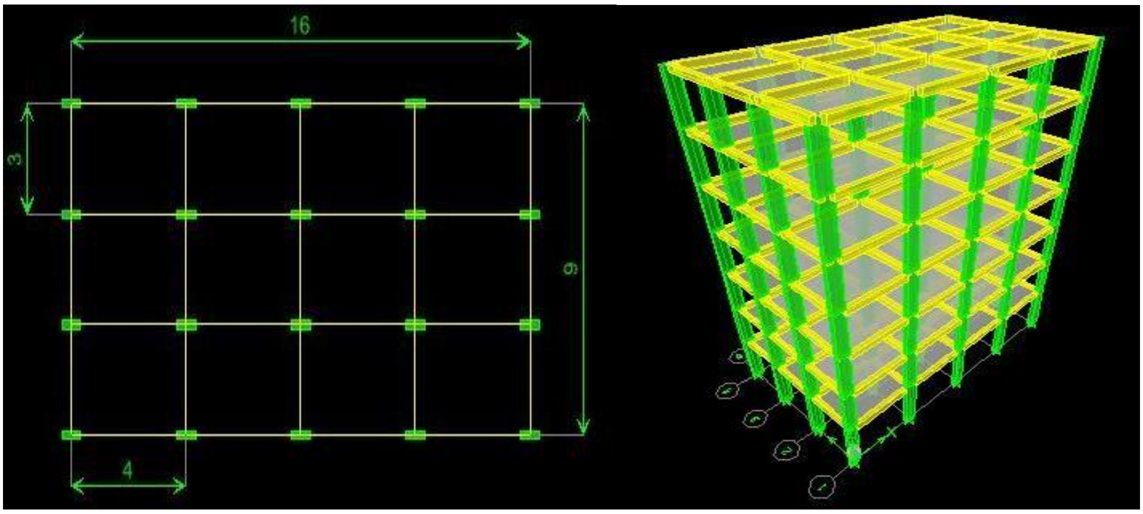

FIG-3: plan and 3D view of G+6 Storey building

III. ANALYTICAL MODELS CONSIDERED FOR ANALYSIS

Model 1: Building Modeled as Bare Frame.
Model 2: Middle storey as soft storey with core infilled masonry wall in central bay.

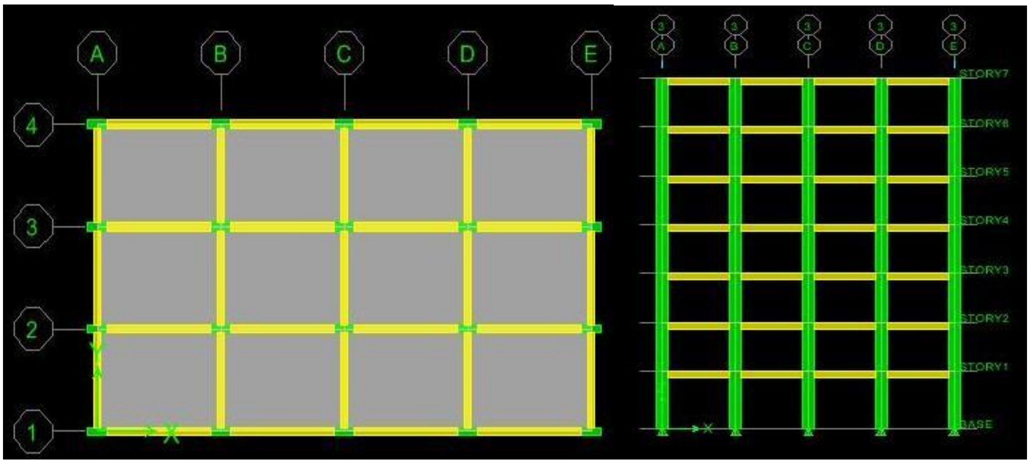

FIG-4: Plan and elevation of model 1

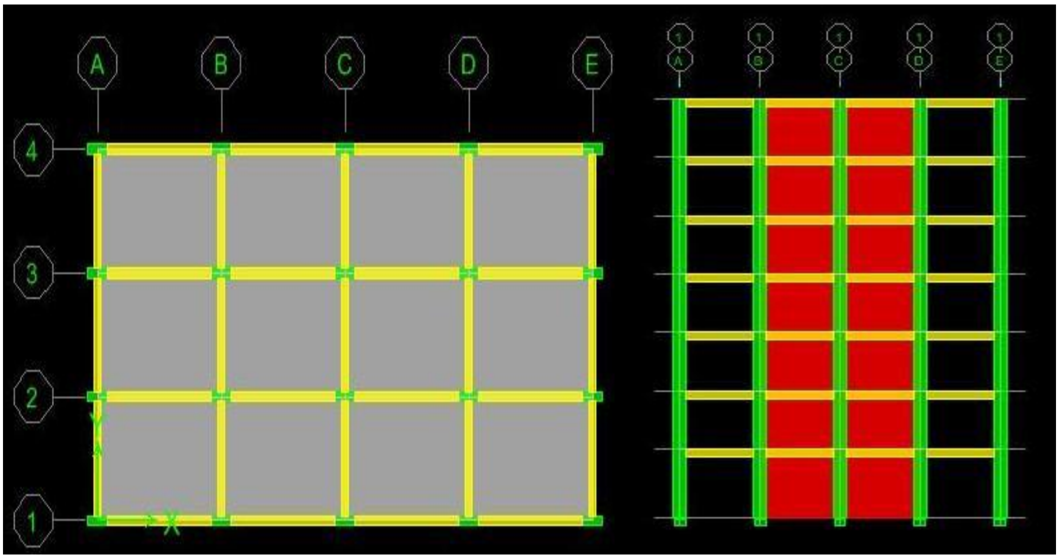

FIG-5: Plan and elevation of model 2

IV. RESULT AND DISCUSSION

4.1 Diaphragm drift

Table2: Diaphragm drifts for Model1 and Model2

STOREY	M1		M2	
	RSX	PUSHX	RSX	PUSHX
STOREY7	0.000216	0.015773	0.000025	0.009196
STOREY6	0.000356	0.016941	0.000026	0.009755
STOREY5	0.000519	0.017696	0.000027	0.009842
STOREY4	0.00068	0.017132	0.000027	0.009361
STOREY3	0.000817	0.014955	0.000025	0.008267
STOREY2	0.000869	0.011155	0.000022	0.006553

STOREY1	0.000568	0.004664	0.000015	0.003899

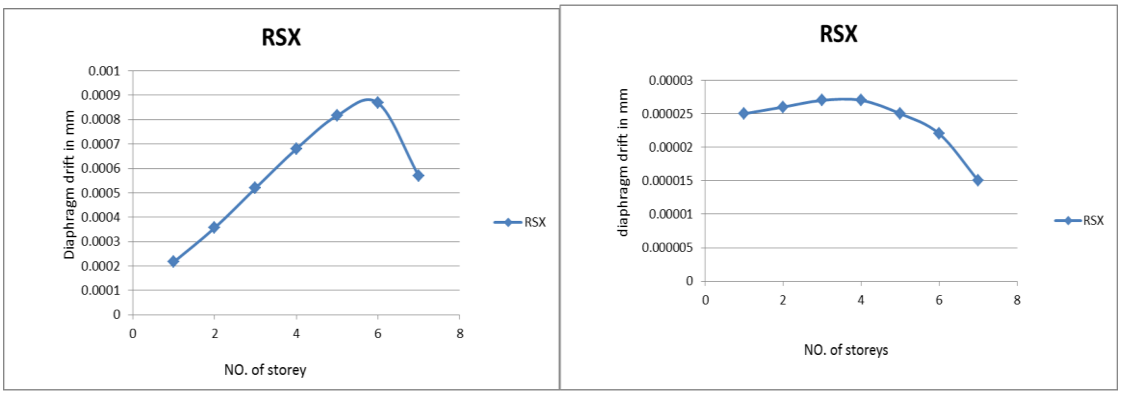

Fig-6: Diaphragm drift for model-1 along RSX and diaphragm drift for model-2 along RSX

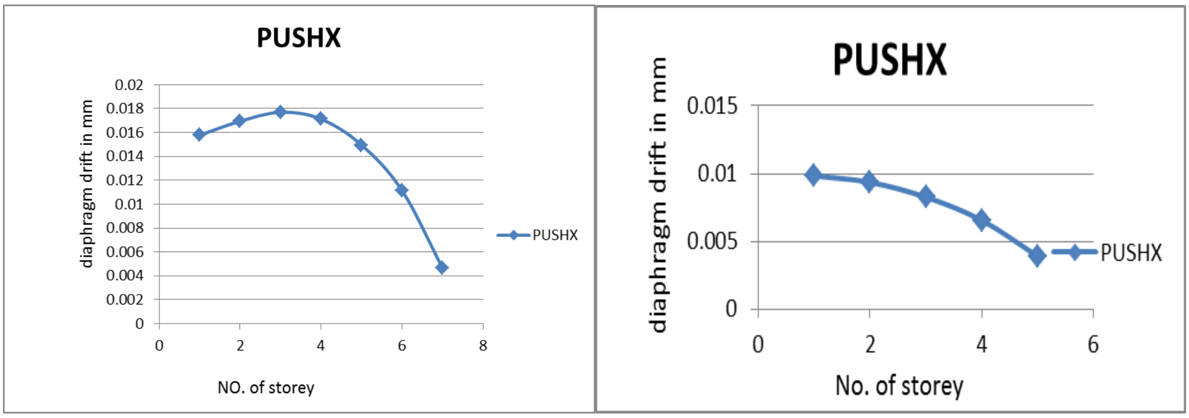

Fig-7: Diaphragm drift for model-1 along PUSHX and diaphragm drift for model-2 along PUSHX

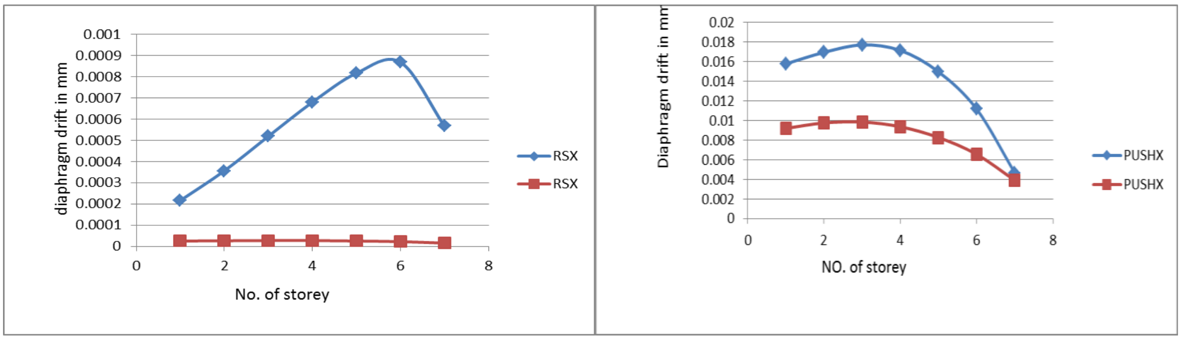

Fig-8: Diaphragm drifts Comparison for model-1, model-2 along RSX and diaphragm drift comparison for model-1, model-2 along PUSHX

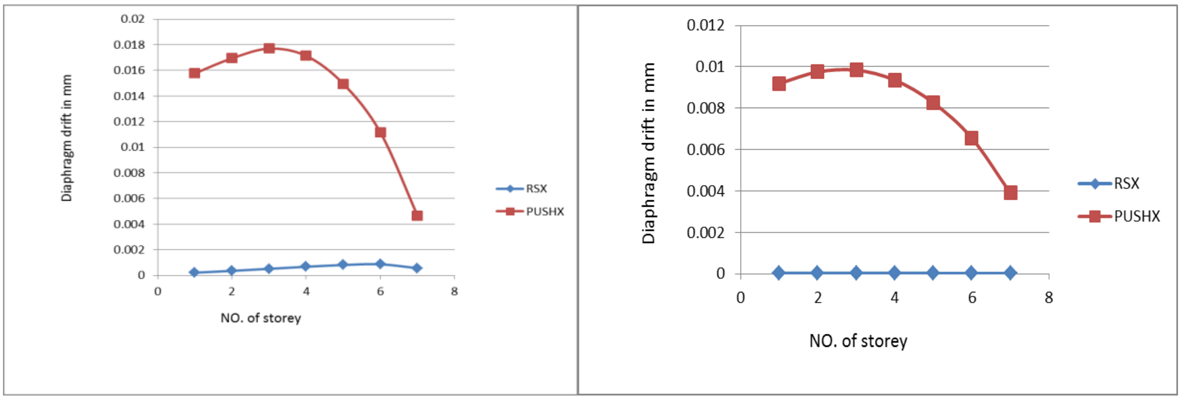

Fig-9: Diaphragm drifts Comparison for model-1 along RSX, PUSHX and diaphragm drift comparison for model-2 along RSX, PUSHX

4.2 Point displacement

TABLE-3: Point displacement for model-1 and model-2

STOREY	M1		M2	
	RSX	PUSHX	RSX	PUSHX
STOREY7	0.0124	0.2887	0.0005	0.1668
STOREY6	0.0117	0.242	0.0004	0.1401
STOREY5	0.0106	0.1921	0.0004	0.1118
STOREY4	0.0091	0.1405	0.0003	0.0833
STOREY3	0.007	0.0907	0.0002	0.0562
STOREY2	0.0046	0.0473	0.0001	0.0322
STOREY1	0.002	0.0153	0.0001	0.0132

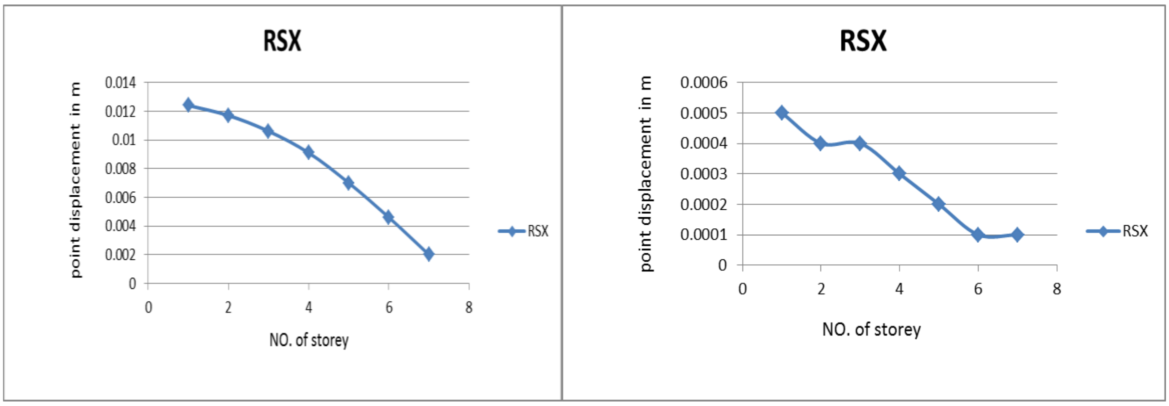

Fig-10: point displacement for model-1 along RSX and point displacement for model-2 along RSX

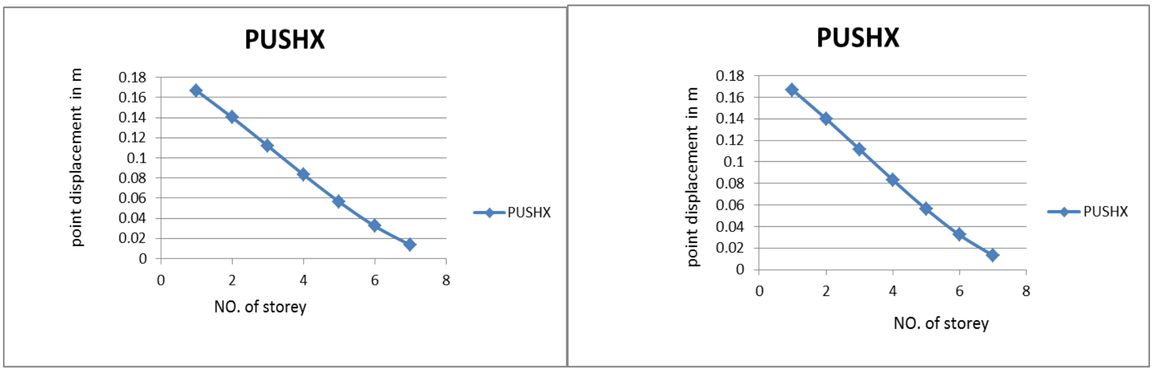

Fig-11: point displacement for model-1 along PUSHX and point displacement for model-2 along PUSHX

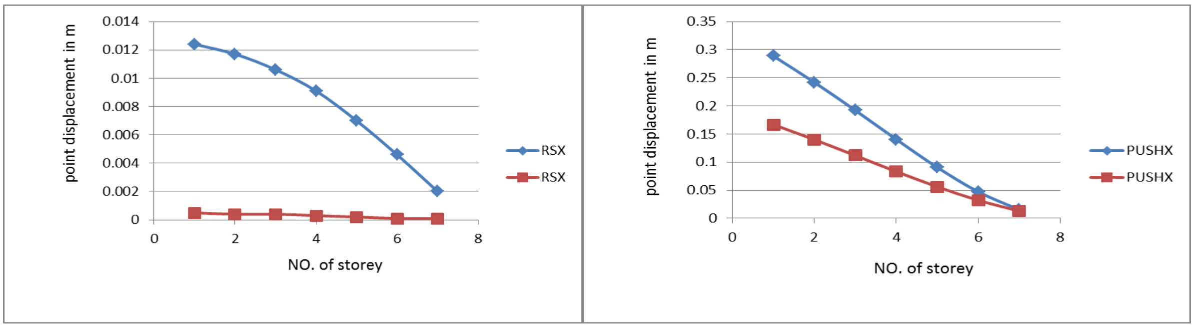

Fig-12: point displacement Comparison for model-1, model-2 along RSX and point displacement comparison for model-1, model-2 along PUSHX

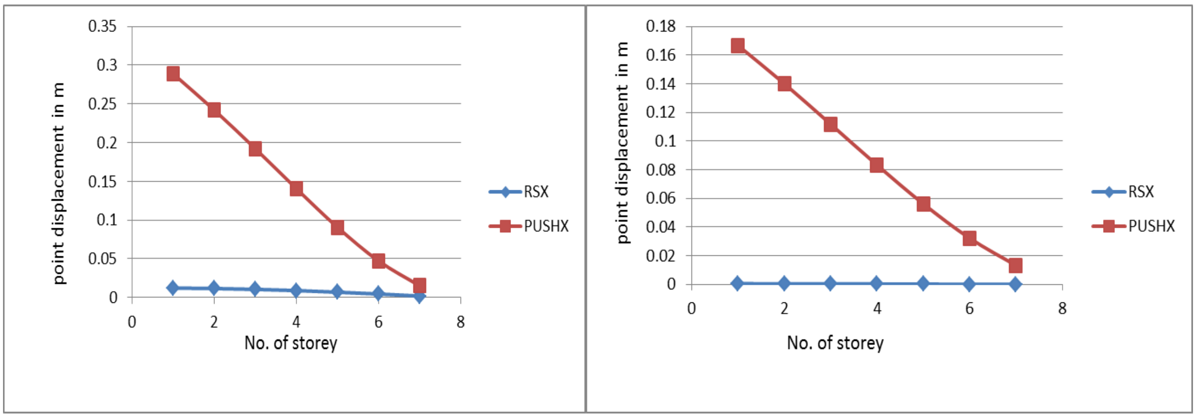

Fig-13: point displacement Comparison for model-1 along RSX, PUSHX and point displacement comparison for model-2 along RSX, PUSHX

4.3 Pushover curve

TABLE-4: Pushover curve for model-1along push-x direction

Step	Displacement	Base Force
0	0	0
1	0.0109	302.3803
2	0.0245	520.1588
3	0.0396	619.8984
4	0.0836	769.8989
5	0.1716	890.4653
6	0.2576	1007.349
7	0.2923	1054.502
8	0.2923	1019.466
9	0.2926	1022.562
10	0.2926	1014.525
11	0.293	1017.305
12	0.2934	1019.376
13	0.2934	977.6752
14	0.2934	970.9983
15	0.2955	987.9894
16	0.2968	993.376
17	0.2887	804.0239

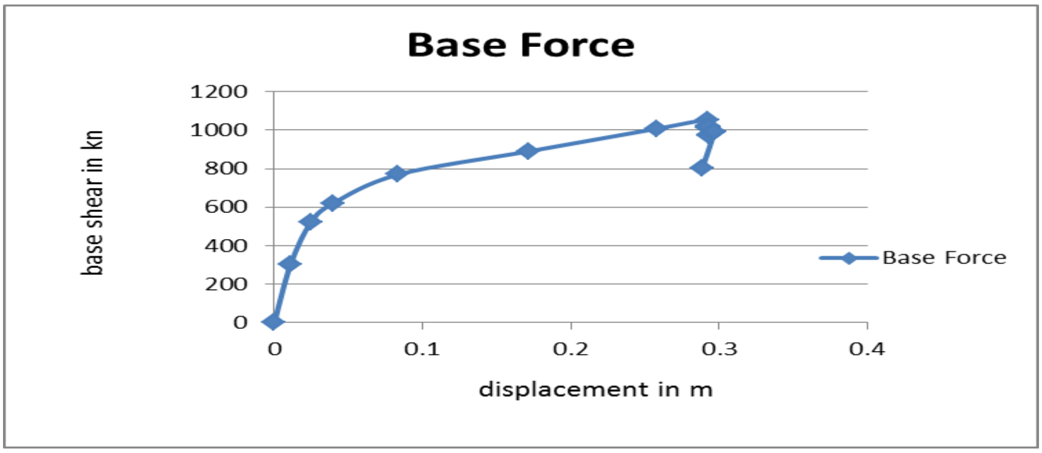

Fig-14: pushover curve for model-1along push-x direction

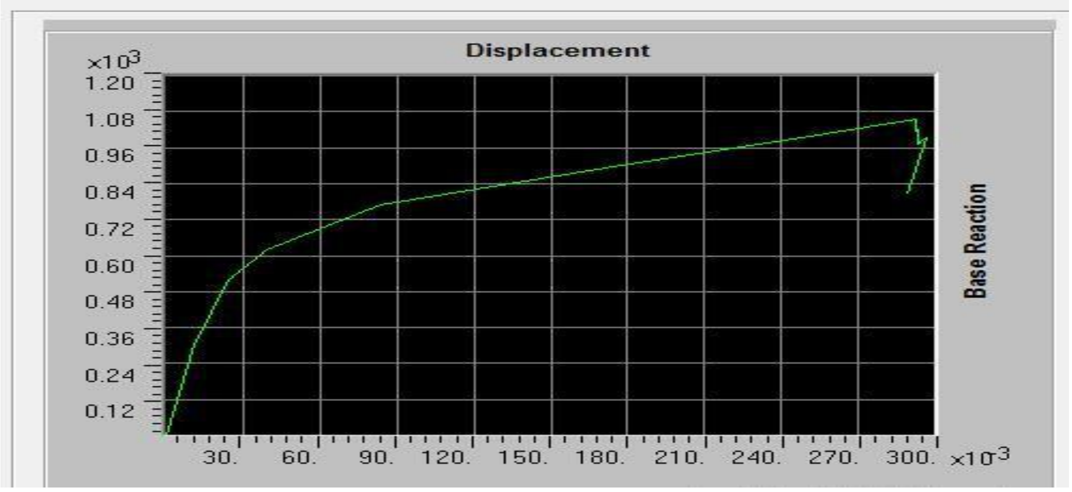

Fig-15: pushover curve for model1 along pushx from ETABS 9.7.4

TABLE-5: Pushover curve for model-1along pushy direction

step	Displacement	Base force
0	0	0
1	0.013	151.6557
2	0.0299	275.254
3	0.033	284.9082
4	0.0461	305.7073
5	0.1507	391.4946
6	0.2476	447.2836
7	0.2597	453.6121
8	0.2597	441.6676
9	0.2608	445.5754
10	0.2611	445.5754
11	0.2618	447.1434
12	0.2618	425.2926
13	0.2627	429.7528
14	0.2649	434.3407
15	0.2665	436.3749
16	0.2713	439.2636
17	0.2713	349.6201
18	0.2754	369.4944
19	0.2843	386.8912
20	0.2817	339.4035

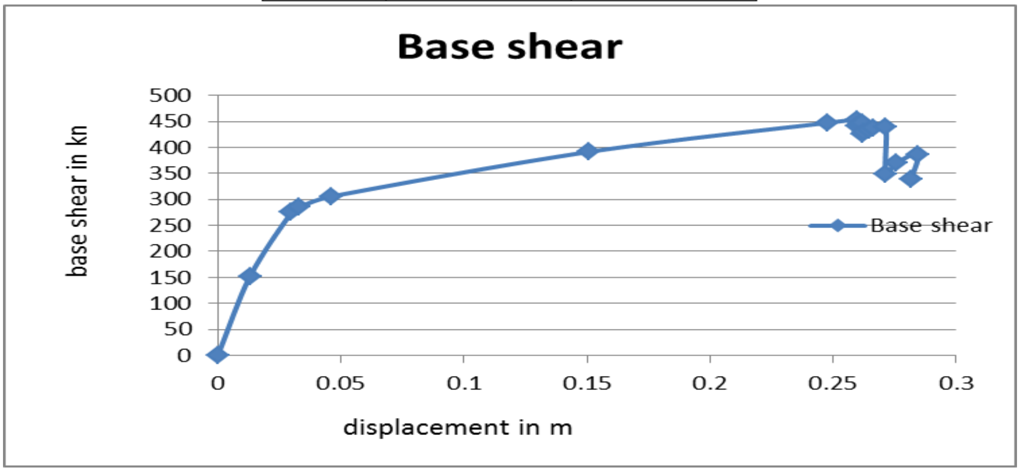

Fig-16: pushover curve for model-1 along push-y

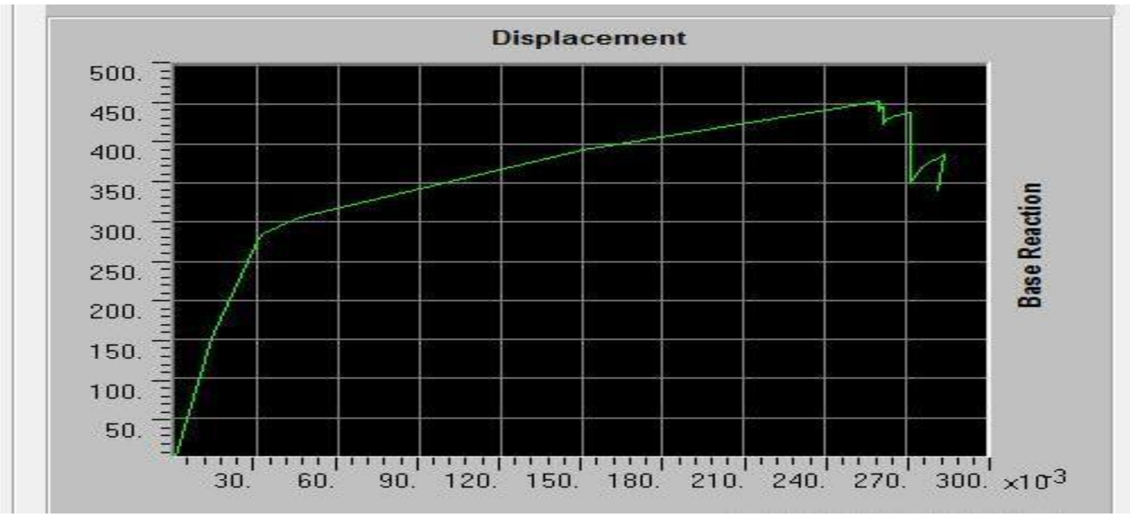

Fig-17: pushover curve for model1along pushy from ETABS 9.7.4

4.4 Performance point

TABLE-6: spectral displacement and spectral acceleration for capacity curve and demand curve

Step	Sd(C)	Sa(C)	Sd(D)	Sa(D)
0	0	0	0.082	0.483
1	8.19E03	0.048	0.082	0.483
2	0.019	0.083	0.076	0.336
3	0.031	0.099	0.076	0.248
4	0.063	0.127	0.088	0.178
5	0.122	0.155	0.108	0.137
6	0.18	0.18	0.122	0.122
7	0.204	0.189	0.127	0.118
8	0.204	0.183	0.126	0.114
9	0.204	0.184	0.126	0.114
10	0.204	0.183	0.126	0.113
11	0.204	0.183	0.126	0.113
12	0.205	0.183	0.127	0.113
15	0.206	0.178	0.126	0.11
16	0.207	0.179	0.127	0.11

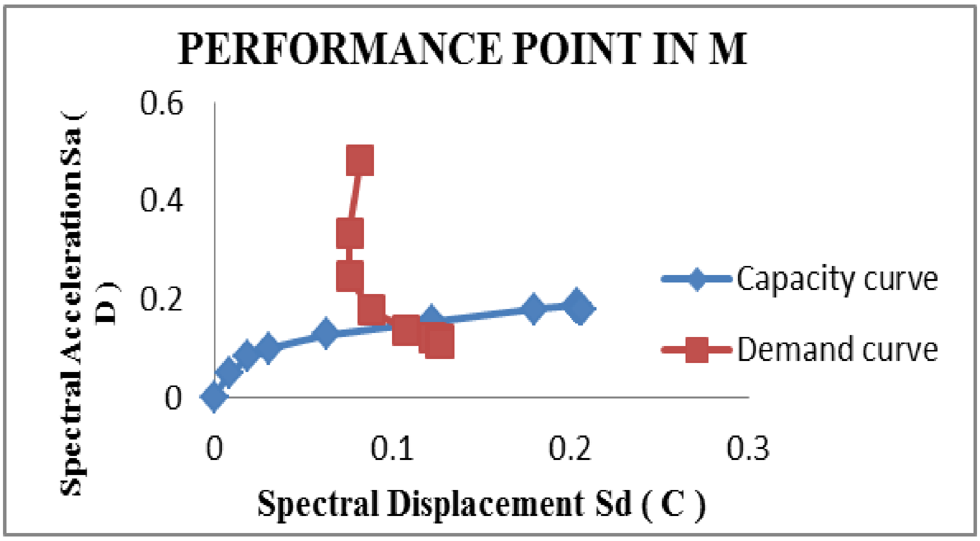

Fig-18: performance point for model-1

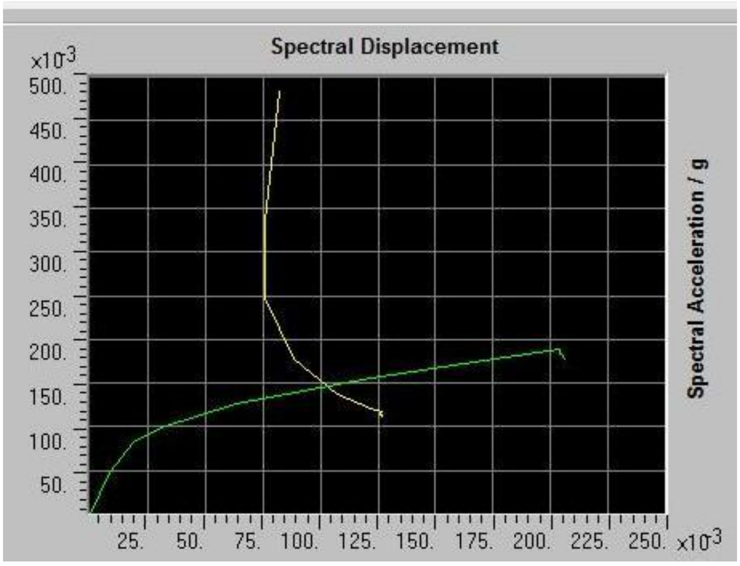

Fig-19: performance point for model-1 from **ETABS 9.7.4**

V. Conclusion

1. The diaphragm drift are obtained are tabulated in the table-2 in the longitudinal x-direction and the graph is obtained by plotting storeys in x-axis and diaphragm drift in y-axis, as shown in fig-9. Which shows that as the storey increases diaphragm drift decreases.

2. The point displacements are obtained are tabulated in the table-3 in the longitudinal x-direction and the graph is obtained by plotting storeys in x-axis and point displacement in y-axis, as shown in fig-13.This shows that as the storey increases point displacement decreases.

3. Diaphragm drift obtained from pushover analysis is much greater than diaphragm drift obtained dynamic static analysis as shown in table: 2.

4. Pushover curve is obtained by plotting displacement along x axis and base shear along y axis which gives the nonlinear behaviour of considered model as shown in fig -15.

5. Capacity of building is determined by capacity spectrum analysis.

References

[1]. Ashraf Habibullah and Stephen Pyle (1998), “three dimensional nonlinear static pushover analysis”,
[2]. jaswant n. arlekar, sudhir k. jain andc.v.r. murty (1997)seismic response of RC frame buildings with soft first storeys proceedings of the cbri*golden jubilee conference on natural hazards in urban habitat*, 1997, new Delhi. Department of civil engineering, i.i.t.kanpur, Kanpur 208016
[3]. Applied Technology Council (ATC-40) (1996), prepared a report on “Seismic Evaluation and Retrofit of Concrete Buildings”
[4]. IS 1893 - 2002 (Part -1): “Criteria For Earthquake Resistant Design Of Structures”,
[5]. Amit V. Khandve , international journal on “Seismic Response of RC Frame Buildings with Soft Storeys”
[6]. Kiran Kamath1, Madhusudan G. Kalibhat2, Prasad S.K.3, Ramya R. Pai4 “seismic performance of soft storey rc frames at different storey levels from pushover analysis”.
[7]. S R Satish Kumar & J L Srinivasan (2012) “Performance Based Design of Reinforced Concrete Open Ground Storey Buildings”