International Journal of Civil and Structural Engineering Research ISSN 2348-7607 (Online)
Vol. 4, Issue 1, pp: (374-391), Month: April 2016 - September 2016, Available at: www.researchpublish.com

Seismic Analysis of Multistorey Building with Bare Frame, Bare Frame with Slab Element and Soft Storey at Different Levels of the Building for Various Seismic Zones

D.NAGARAJU[1], D.VENKATESWARLU[2], K.NAGA LAKSHMAIAH[3]

[1]MTech Student, Department of Civil Engineering, Godavari Institute of Engineering & Technology, Rajahmundry
[2] Professor, Department of Civil Engineering, Godavari Institute of Engineering & Technology, Rajahmundry
[3]Assistant Professor, Department of Civil Engineering, QIS College of Engineering & Technology, Ongole

Abstract: **Soft storey is an unavoidable feature in the multistorey building. It is open for the purpose of parking or reception lobbies and soft storey at different levels of the building for office use. It is also called as stilts storey. Masonry infills are normally considered as non-structural elements and their stiffness contributions are generally ignored in practice, such an approach can lead to an unsafe design. In the soft storey, the inter storey drifts and seismic demands of the columns are excessive that causes heavy damage or collapse of the buildings during a severe earthquake. The masonry infill walls though constructed as secondary elements behaves as a constituent part of the structural system and determine the overall behaviour of the structure especially when it is subjected to seismic loads. In modeling, the masonry infill panels the Finite Element Method is used and the software ETABS is used for the linear dynamic analysis of all the models.**

Keywords: **Seismic Analysis, multistorey building.**

1. INTRODUCTION

Many multistorey buildings in India today have open first storey as an unavoidable feature. This is primarily being adopted to accommodate parking or reception lobbies in the first storeys. The upper storey's have brick infilled wall panels. Reinforced concrete (RC) frame buildings with masonry infill walls have been widely constructed for commercial, industrial and multistorey residential uses in seismic zone regions. Masonry infill typically consists of bricks or concrete blocks constructed between beams and columns of a reinforced concrete frame. The masonry infill panels are generally not considered in the design process and treated as architectural (non-structural) components. The presence of masonry infill walls has a significant impact on the seismic zone response of a reinforced concrete frame building, increasing structural strength and stiffness (relative to a bare frame). Properly designed infills can increase the overall strength, lateral resistance and energy dissipation of the structure.

The seismic zone force distribution is dependent on the stiffness and mass of the building along the height. The structural contribution of infill wall results into stiffer structure thereby reducing the storey drifts (lateral displacement at floor level). This improved performance makes the structural design more realistic to consider infill walls as a structural element in the earthquake resistant design of structures. Whereas the total seismic zone base shear as experienced by a building during an earthquake is dependent on its natural period, the seismic zone force distribution is dependent on the distribution of stiffness and mass along the height. soft storey having infills with openings and Infill were usually classified as non-structural elements, and their influence was neglected during the Modeling phase of the structure leading to substantial inaccuracy in predicting the actual seismic zone response of framed structures. Masonry infill has several advantages like good sound and heat insulation properties, high lateral strength and stiffness. These help to increase the strength and stiffness of RC frame and hence to decrease lateral drift, higher energy dissipation capacity due cracking of infill and friction between infill and frame. This in turn increases the redundancy in building and reduces bending moment in beams and columns.

Soft Storey

A soft storey is one in which the lateral stiffness is less than 70 percent of that in the storey above or less than 80 percent of average lateral stiffness of the three storey's above.

The following two features are characteristic of soft storey buildings:

(a) Relatively flexible ground storey in comparison to the stories above, i.e., the relative horizontal movement at the ground storey level is much larger than the storey's above. This flexible ground storey is called a soft storey

(b) Relatively weak ground storey in comparison to the storey's above, i.e., the total horizontal earthquake force (load) resisted at the ground storey level is significantly less than the storey's.

2. OBJECTIVES

Following are some objectives:-
1. The main objective of this dissertation is focus on the behavior of RC frame buildings with bare frame, bare frame with slab element, first soft storey, second soft storey, third soft storey in seismic zones II, III, IV, and zone V.
2. To study the effect of storey drifts, lateral displacement and base shear in the seismic zones II, III, IV and zone V of bare frame, bare frame with slab element, full infills, and soft storey at different levels of buildings.
3. To check the applicability of the multiplication factor of 2.5 as given in the Indian Standard IS 1893:2002 for design of bare frame, bare frame with slab element, full infills, and soft storey at different levels of building in zones II,III,IV& zone V.
4. To analyze the RC frame for dynamic analysis in relation to the storey drift and lateral displacements, base shear using software ETABS.
5. To study the comparison between the storey drifts, lateral displacements, base shear of all Models in seismic zones II, III, IV and zone V.
6. To investigate the bare frame, soft storey behavior at different levels of RC frame building for all cases so as to arrive at suitable practical conclusion for achieving earthquake resistant RC frame building.
7. To identify the storey drift where there is exceeds its permissible values of storey drifts i.e.0.004h, in each zone for different Models.
8. To study failure conditions of six Models at different storey's in each zone for all Model buildings.
9. To promote safety without too much changing the constructional practice of reinforced concrete structures.

3. INTRODUCTION TO ETABS

ETABS is objecting based, meaning that the Models are created with members that represent physical reality. Results for analysis and design are reported for the overall object, providing information that is both easier to interprets and consistent with physical nature. The ETABS structural analysis programmer offers following features-

- Static and Dynamic Analysis
- Linear and Nonlinear Analysis
- Dynamic seismic zone analysis and Static push over analysis
- Geometric Nonlinearity including P-Δ effect
- Frame and shell structural elements
- 2-D and 3-D plane and solid elements

3.1 Building Description

The Modeling of the G+10 storey with bare frame, bare frame with slab element, full wall element structure, first soft storey, two storey soft storey ,three storey's soft storey. Plan area of building is 32m x 21m, the building Models having 4 bays at 8m distance in x-direction and 3 bays at 7m distance in y- direction.

Model 1: Bare frame

Model 2: Bare frame with slab element.

Model 3: Building has full walls with external walls (230mm thick) and internal walls (115mm thick) in all storeys have and slab element.

Model 4: Building has first soft storey with external walls (230mm thick) and internal walls (115mm thick) and slab element.

Model 5: Building has two soft storey with external walls (230mm thick) and internal walls (115mm thick) and slab element.

Model 6: Building has three storey soft storey with external walls (230mm thick) and internal walls (115mm thick) and slab element.

3.2 Analyzing the data

Linear dynamic analysis has been performed as per IS 1893 (Part 1): 2002 for each model using ETABS analysis package. Lateral load calculation and its distribution along the height are done. The seismic weight is calculated using full dead load plus 25% of live load.

Following data is used in the analysis of the RC frame building Models

Table 3.2: Data relation to the RC frame building Models

Type of frame	Ordinary Moment Resisting RC Frame OMRF) fixed at the base
Seismic zones	II,III,IV,&V
Number of storey	G+10 storey
Floor height	3 m
Depth of Slab	150 mm
Size of beam	(230 × 600) mm
Size of column	(230 × 750) mm
Spacing between frames in x-direction	8 m
Spacing between frames in y-direction	7 m
Materials	M 25 concrete, Fe 415 steel and
Infill	Brick
Thickness of external infill walls	230 mm
Thickness of external infill walls	115 mm
Density of concrete	24KN/m^3
Density of infill	20 KN/m^3
Type of soil	Medium soil
Seismic zone	As per IS (1893-2002)
Seismic zone factor, Z	For zone II: 0.10 For zone III: 0.16 For zone IV: 0.24 For zone V: 0.36
Importance Factor, I	1
Response spectrum analysis	Linear dynamic analysis
Damping of structure	5 percent
Plinth height above ground level	1.8 m
Type of the building	OMRF(Ordinary moment resisting RC frame)
Wall load for the outer side for (3 m height wall)	12.42 KN/m
Wall load for the inner side for (3 m height wall)	6.21 KN/m
Wall load for the outer side for (1.8 m height wall)	6.90 KN/m
Wall load for the inner side for (1.8 m height wall)	3.45 KN/m
Total Dead load of slab	5.75 KN/ m^2
Live load	2 KN/ m^2
For Seismic zone loading only 50% of the imposed load is considered the structure is analyzed for all seismic zone by considering Medium for each seismic zone	

3.3 Materials used

a) Concrete

Concrete with following properties is considered for study.

- Characteristic compressive strength (fck) = 25 MPa
- Poisons Ratio = 0.2
- Density = 24KN/m3
- Modulus of Elasticity (E) = 5000 x √ fck= 25000 MPa

b) Steel

Steel with following properties is considered for study.

- Yield Stress (fy) = 415 MPa
- Modulus of Elasticity (E) = 2x105MPa

c) Masonry infill

Clay burnt brick, Class A, confined unreinforced masonry

Compressive strength of Brick, fm = 10 MPa

Modulus of Elasticity of masonry (Ei) = 550 x fm = 5500 MPa

Poisons Ratio = 0.15

3.4 Load calculations

1. Gravity loading: (As per IS: 456 – 2000 & IS: 875 (Part II)-1987) For Dead Load (DL) Intensity of external wall (for 3m height) = 12.42KN/m

Intensity of internal wall (for 3m height) = 6.21KN/m

Intensity of external wall (1.8 m height) = 6.90KN /m

Intensity of internal wall (1.8 m height) = 3.45KN/m

Intensity of slab load = 3.75 KN /m2

Intensity of floor finish load =1 KN /m2

Intensity of roof treatment load = 1.5 KN /m2

Intensity of live load (LL) = 2 KN /m2.

2. Lateral loading: (as per IS1893-2002) Lateral loading consists of earthquake loading. Earthquake loading has been calculated by the program and it has been applied to the mass center of the building. Since the building under consideration was in Zones II, III, IV, & zone V with standard occupancy so the result was computed for the worst case of load combination i.e. (0.9DL+1.5EQX) by Code. The Response reduction factor, R = 3 for OMRF (Ordinary moment resisting RC frame). Importance factor, I = 1, Soil Type = II (Medium Soil), Seismic zone factor, Z = 0.10 for zone II, Z = 0.16 for zone III, Z = 0.24 for zone IV, & Z = 0.36 for zone V.

3. Load combination: the multistorey building under consideration was in Zones II, III, IV, and zone V with standard occupancy so the result was computed for the worst case of load combination have been taken i.e. (0.9DL+1.5EQX) by Code.

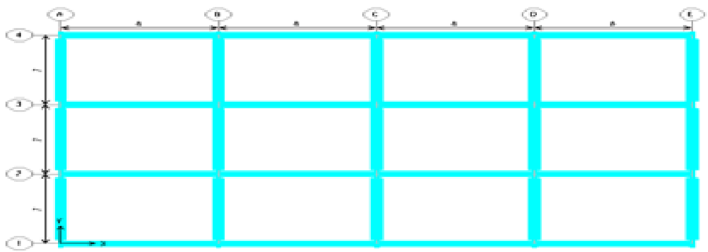
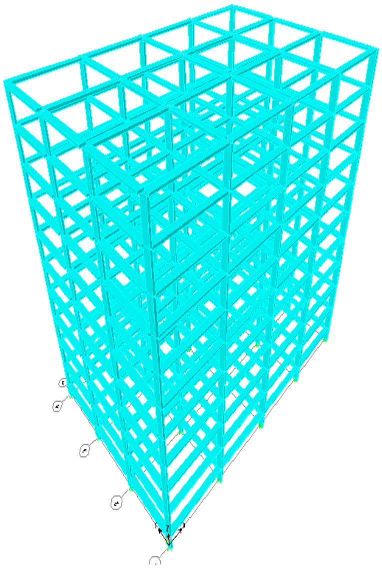


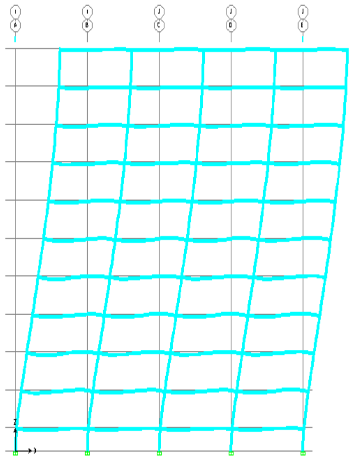
Fig 3.1: Plan for G+10 storey building

3.5 RC frame building Models considered in the thesis:

1. Model 1: Bare frame
2. Model 2: Bare frame with slab element.
3. Model 3: Building has full walls with external walls (230mm thick) and internal walls (115mm thick).
4. Model 4: Building has first soft storey with external walls (230mm thick) and internal walls (115mm thick).
5. Model 5: Building has two stories soft storey with external walls (230mm thick) and internal walls (115mm thick) from ground level.
6. Model 6: Building has three stories soft storey with external walls (230mm thick) and internal walls (115mm thick) from ground level

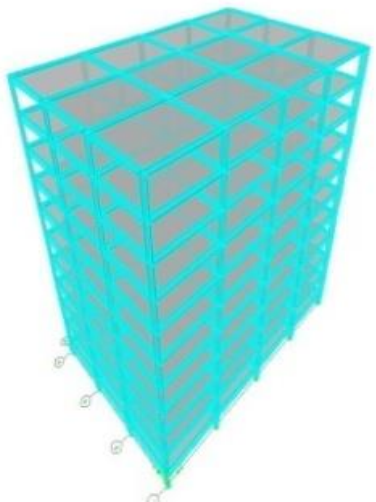
Prepared Models

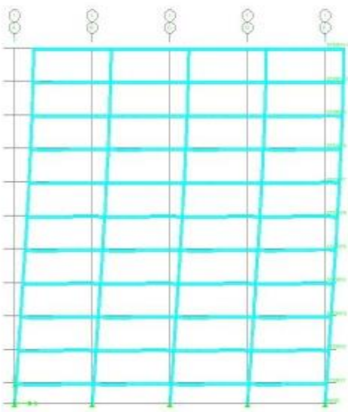




a) 3D view **b) Lateral displacement**

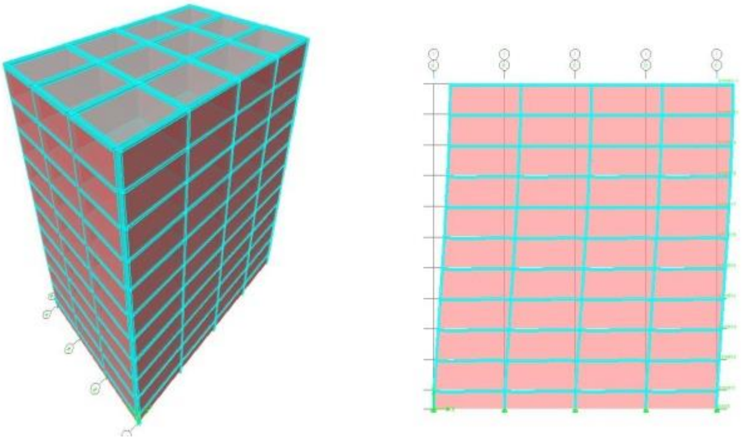
Fig 3.2: Model 1: G+10 RC bare frame building





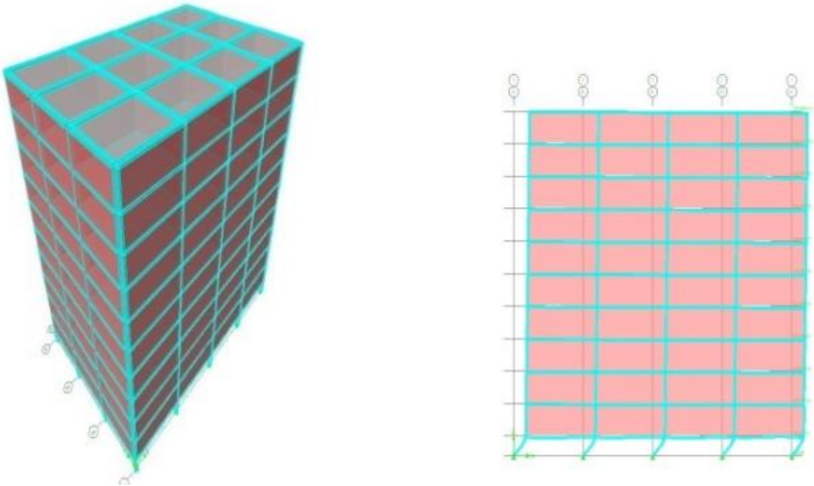
a) 3D view **b) Lateral displacement**

Fig 3.3: Model2: G+10 RC bare frame building with slab element



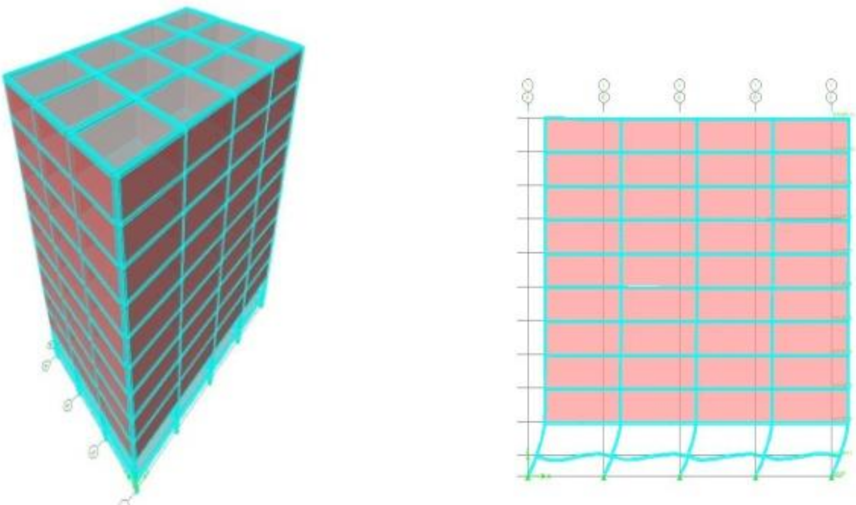
a) 3D view b) Lateral displacement

Fig 3.4: Model 3: G+10 RC building of full infill wall with slab element



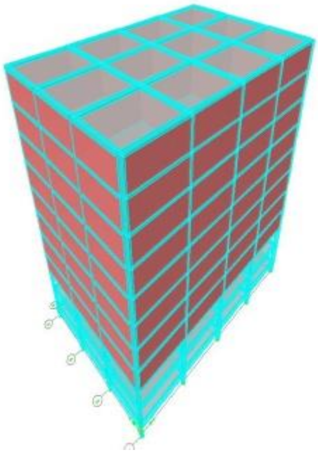
a)3D view b) Lateral displacement

Fig 3.5: Model 4: G+10 RC first soft storey building with slab element

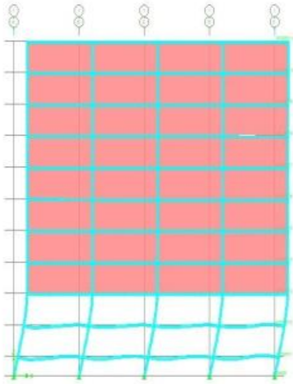


a) 3D view b) Lateral displacement

Fig 3.6: Model5: G+10 RC two soft storey building with slab element



a) 3D view



b) Lateral displacement

Fig 3.7: Model6: G+10 RC three soft storey building with slab element

4. RESULTS AND DISCUSSIONS

Case 1: Seismic Zone II

Table 4.1: Comparison of storey drifts (mm) of all building Models in seismic zone II at all storey levels

Storey No.	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
Storey 1	3.500	**3.730**	1.240	**5.270**	**6.880**	**7.830**
Storey 2	7.720	3.370	2.940	0.150	4.010	5.930
Storey 3	**8.720**	3.240	**3.320**	0.100	0.080	1.880
Storey 4	8.880	3.160	3.310	0.120	0.050	1.070
Storey 5	8.660	3.060	3.210	0.110	0.060	1.040
Storey 6	8.220	2.900	3.050	0.110	0.050	1.040
Storey 7	7.550	2.660	2.790	0.110	0.050	1.040
Storey 8	6.650	2.340	2.450	0.100	0.050	1.040
Storey 9	5.590	1.930	1.990	0.090	0.040	1.030
Storey 10	4.970	1.420	1.410	0.070	0.040	1.030
Storey 11	5.800	0.870	0.800	0.080	0.050	1.040

Case 2: Seismic Zone III

Table 4.2 Comparision of storey drifts (mm) of all building Models in seismic zone III at all storey levels

Storey No.	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
Storey 1	5.174	**5.968**	1.989	**8.419**	**10.999**	**11.328**
Storey 2	12.079	5.384	4.698	0.244	6.407	7.887
Storey 3	13.946	5.181	**5.307**	0.165	0.123	4.587
Storey 4	**14.203**	5.057	5.3	0.189	0.076	0.097
Storey 5	13.861	4.889	5.143	0.183	0.087	0.058
Storey 6	13.151	4.633	4.871	0.182	0.081	0.065
Storey 7	12.082	4.26	4.469	0.173	0.079	0.059
Storey 8	10.617	3.749	3.912	0.16	0.073	0.055
Storey 9	8.833	3.083	3.177	0.142	0.066	0.050
Storey 10	7.316	2.265	2.257	0.116	0.055	0.042
Storey 11	7.180	1.377	1.268	0.106	0.063	0.055

Case 3: Seismic Zone IV

Table 4.3Comparision of storey drifts (mm) of all building Models in seismic zone IV at all storey levels

Storey No.	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
Storey 1	7.408	**8.937**	2.983	**12.621**	**16.499**	**17.991**
Storey 2	17.894	8.074	7.047	0.365	9.601	11.829
Storey 3	20.913	7.770	**7.960**	0.247	0.182	6.869
Storey 4	**21.304**	7.586	7.949	0.282	0.113	0.142
Storey 5	20.790	7.334	7.714	0.274	0.129	0.087
Storey 6	19.726	6.949	7.307	0.272	0.121	0.096
Storey 7	18.12	6.391	6.704	0.26	0.118	0.088
Storey 8	15.913	5.624	5.867	0.24	0.108	0.083
Storey 9	13.162	4.623	4.765	0.213	0.098	0.074
Storey 10	10.451	3.391	3.384	0.174	0.081	0.062
Storey 11	9.024	2.048	1.897	0.148	0.082	0.070

Case 4: Seismic Zone V

Table 4.4Comparison of storey drifts (mm) of all building Models in seismic zone V at all storey levels

Storey No.	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
Storey 1	11.79	3.06	2.84	0.21	0.11	0.09
Storey 2	15.15	5.08	5.08	0.26	0.12	0.09
Storey 3	19.66	6.93	7.15	0.32	0.15	0.11
Storey 4	23.86	8.44	8.80	0.36	0.16	0.12
Storey 5	27.18	9.59	10.06	0.39	0.18	0.13
Storey 6	29.59	10.42	10.96	0.41	0.18	0.14
Storey 7	31.18	11.00	11.57	0.41	0.19	0.13
Storey 8	**31.95**	11.38	11.92	0.42	0.17	0.21
Storey 9	31.36	**11.66**	**11.94**	0.37	0.27	10.29
Storey 10	26.62	12.11	10.57	0.55	14.39	17.74
Storey 11	10.76	**13.40**	4.47	**18.92**	**24.75**	**25.99**

4.2 Comparison of maximum storey drifts of all building models at different storey levels in all seismic zones.

Drift is the displacement of one level relative to the other level above or below. The storey drift in any storey shall not exceed 0.004 times the height of storey height, Height of Storey = 0.004(h) = 0.004(3000) = 12mm.

Seismic Zone II

Table 4.5: Comparison of Maximum storey drifts in each building Model for zone II

Storey No.	Model	Maximum storey drifts(mm)	Permissible drift(mm)
storey 4	Model 1	8.88	12
storey 1	Model 2	3.73	12
storey 3	Model 3	3.32	12
storey 1	Model 4	5.27	12
storey 1	Model 5	6.88	12
storey 1	Model 6	7.83	12

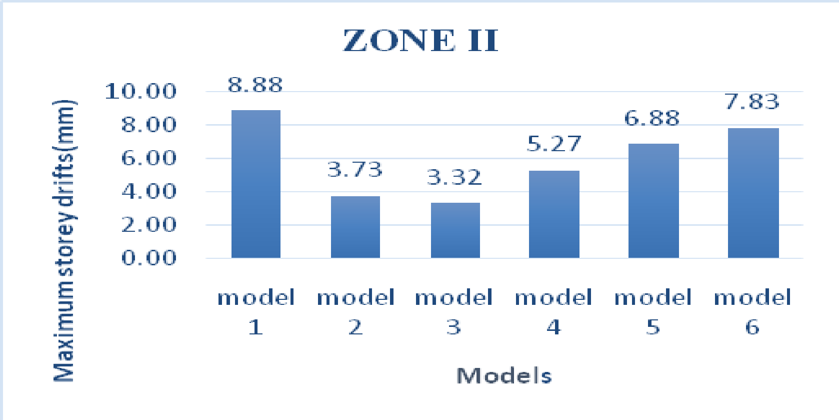


Fig 4.1: Comparison of Maximum storey drifts (mm) for all building Models in zone II

Seismic Zone III

Table 4.6 Comparison of Maximum storey drifts in each building Model for zone III

Storey No	Model	Maximum storey drifts(mm)	Permissible Storey drift (mm)
storey 4	Model 1	14.20	12
storey 1	Model 2	5.96	12
storey 3	Model 3	5.30	12
storey 1	Model 4	8.41	12
storey 1	Model 5	10.99	12
storey 1	Model 6	11.32	12

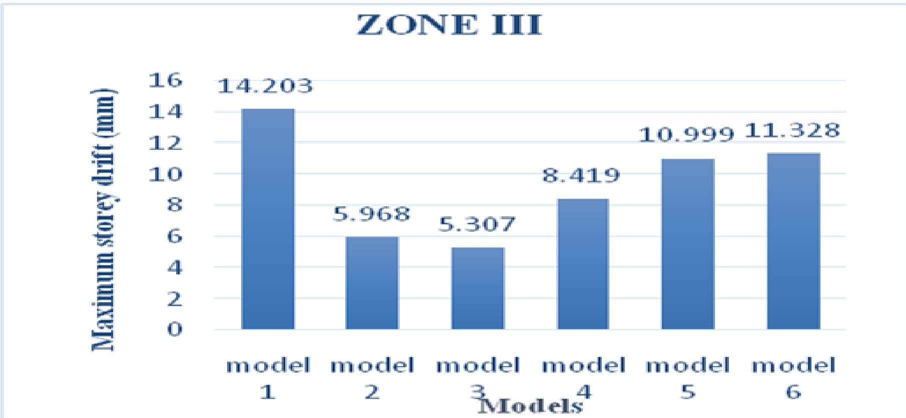


Fig 4.2: Comparison of maximum storey drifts (mm) in all building Models in zone III

Seismic zone IV

Table 4.7 Comparison of Maximum storey drifts in each building Model for zone IV

Storey No.	**Model**	**Maximum storey drifts (mm)**	**permissible drift (mm)**
storey 4	Model 1	21.304	12
storey 1	Model 2	8.937	12
storey 3	Model 3	7.949	12
storey 1	Model 4	12.621	12
storey 1	Model 5	16.499	12
storey 1	Model 6	17.991	12

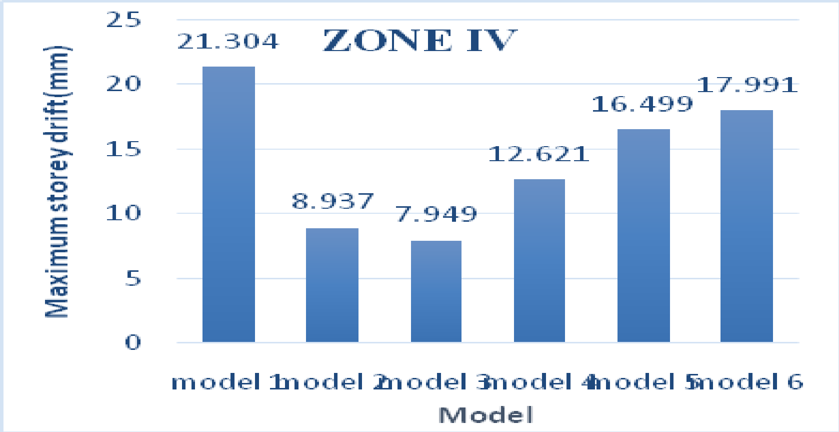


Fig 4.3: Comparison of Maximum storey drifts (mm) for all building Models in zone IV

Seismic zone V

Table 4.8 Comparison of Maximum storey drifts in each building Model for zone V

Storey No	Model	Maximum storey drifts (mm)	Permissible storey drifts (mm)
storey 8	Model 1	31.95	12
storey 11	Model 2	13.40	12
storey 9	Model 3	11.94	12
storey 11	Model 4	18.92	12
storey 11	Model 5	24.75	12
storey 11	Model 6	25.99	12
Storey No	Model	Maximum storey drifts (mm)	Permissible storey drifts (mm)
storey 8	Model 1	31.95	12
storey 11	Model 2	13.40	12
storey 9	Model 3	11.94	12
storey 11	Model 4	18.92	12
storey 11	Model 5	24.75	12
storey 11	Model 6	25.99	12
Storey No	Model	Maximum storey drifts (mm)	Permissible storey drifts (mm)
storey 8	Model 1	31.95	12
storey 11	Model 2	13.40	12
storey 9	Model 3	11.94	12
storey 11	Model 4	18.92	12
storey 11	Model 5	24.75	12
storey 11	Model 6	25.99	12

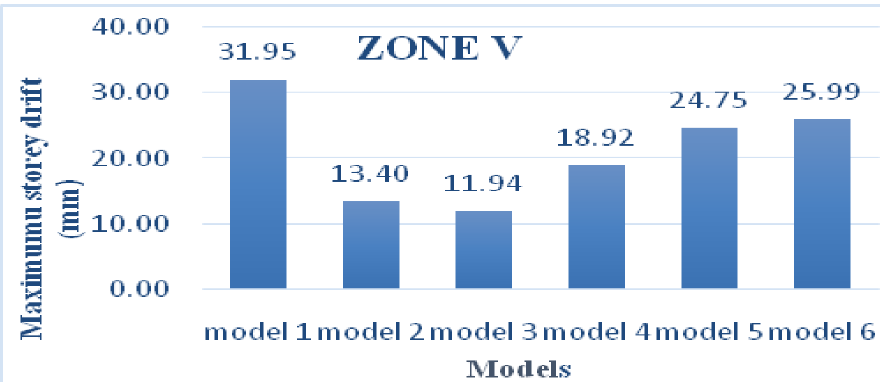


Fig 4.4: Comparison of maximum storey drifts (mm) in all building Models in zone V

Lateral displacements of Model 1 in zones II, III, IV, and zone V

The graphs showed the variation of lateral displacements of bare frame (model 1) in all seismic zones II, III, IV and zone V respectively.

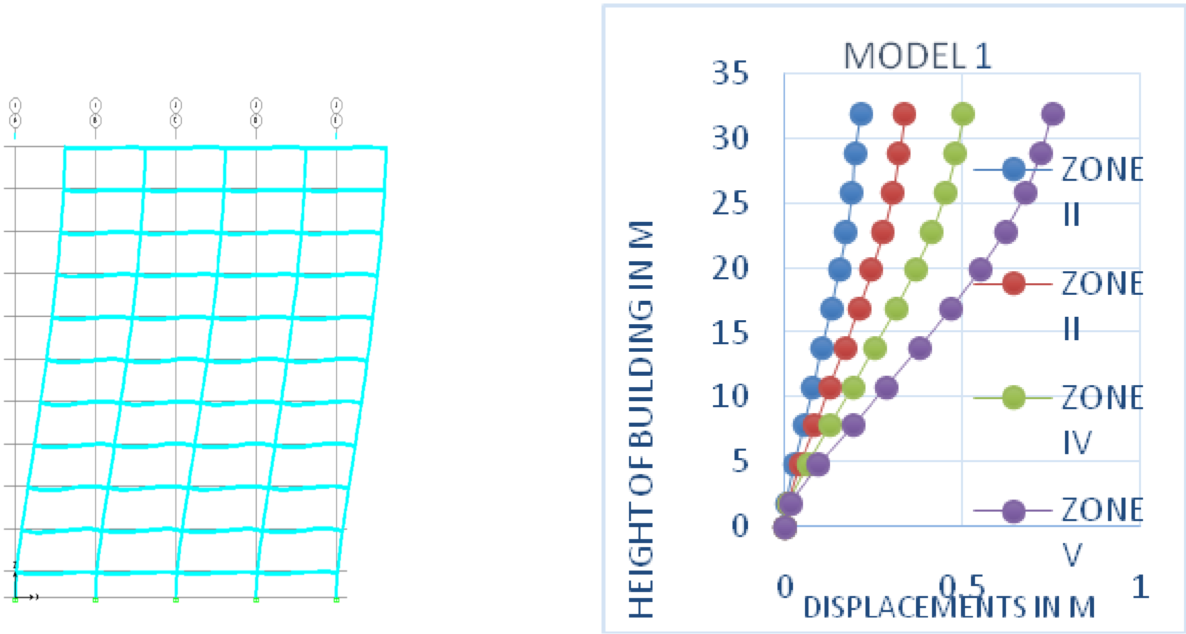


Fig 4.5: Comparison of lateral displacement in model 1Lateral displacement for For all Seismic zones

Lateral displacements of Model 2 in zones II, III, IV, and zone V

The graph showed the variation of lateral displacements for bare frame with slab element (Model 2) in all seismic zones II, III, IV and zone V respectively.

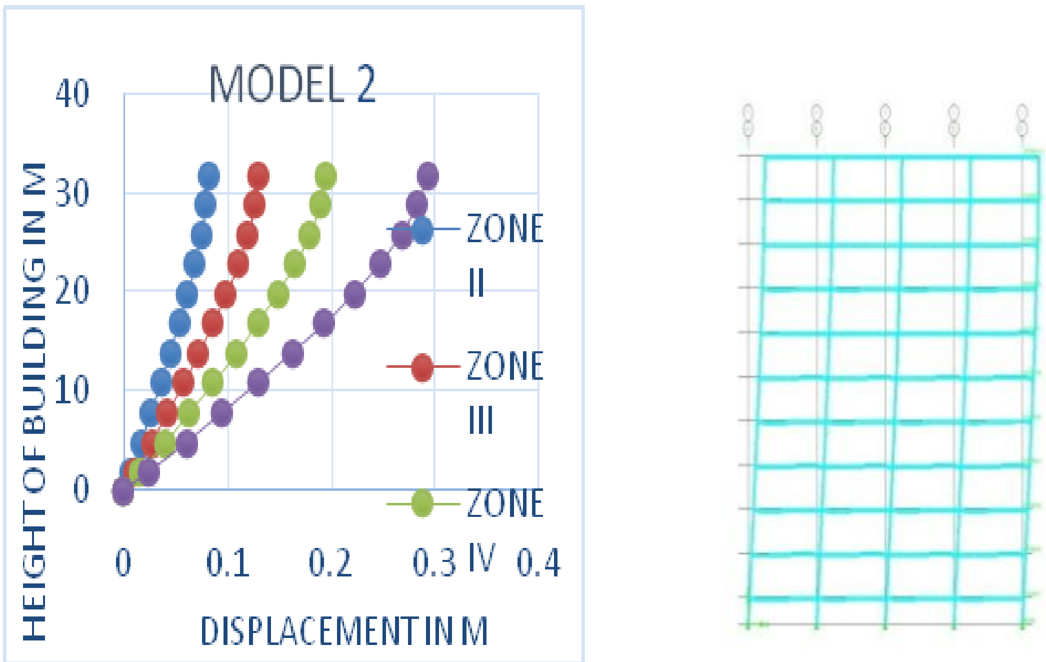


Fig 4.6: Comparison lateral displacement Lateral displacement in Model 2for all seismic zones for all zones

Lateral displacements of Model 3 in zone II, III, IV, & zone V

The graph showed the variation of lateral displacements for bare frame with slab element and with full infill's (Model 3) in zone II, III, IV, and zone V.

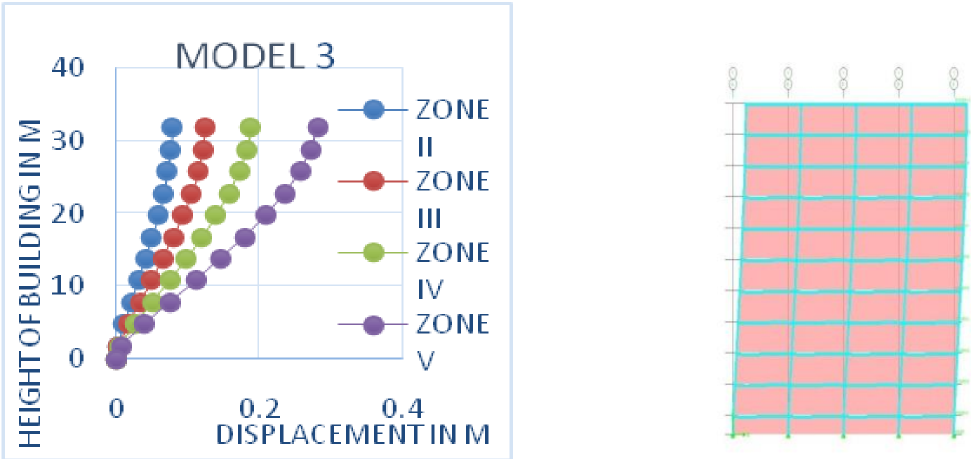


Fig 4.7: Comparison of lateral displacement Lateral displacement in Model 3 for all zones

Lateral displacements of Model 4 in zone II, III, IV, & zone V.

The graph showed the variation of lateral displacements for bare frame with first soft storey (Model 4) in zone II, zone III, zone IV, and zone V.

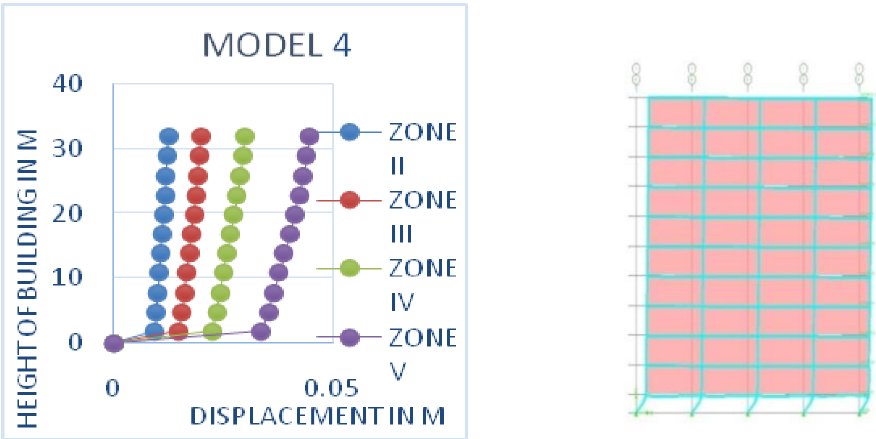


Fig 4.8: Comparison of lateral displacement Lateral displacement in Model 4 for all zones

Lateral displacements of Model 5 in zone II, III, IV, & zone V

The graph showed the variation of lateral displacements for two soft storey frame with slab element (Model 5) in zone II, zone III, zone IV, and zone V respectively.

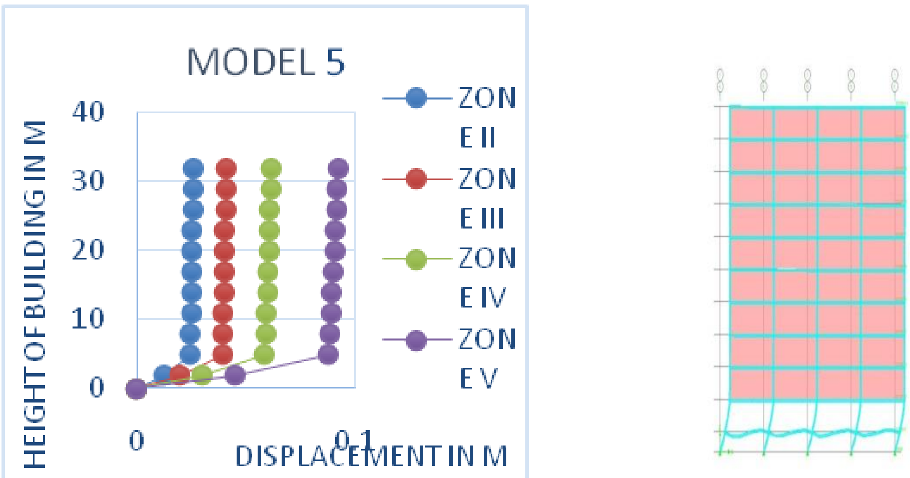
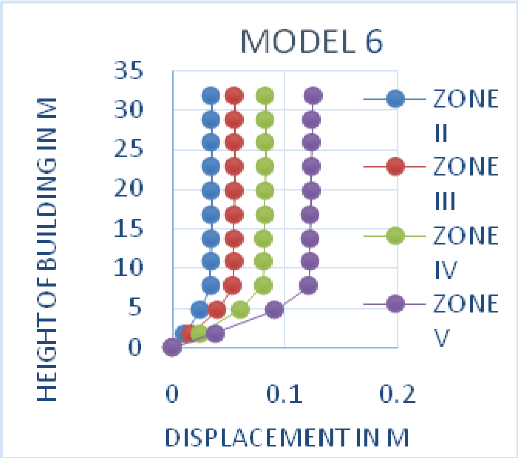


Fig 4.9: Comparison of lateral displacement Lateral displacement in Model 5 for all zones

Lateral displacements of Model 6 in zone II, III, IV, & zone V

The graph showed the variation of lateral displacements for three soft storey frame with slab element (Model 6) in zone II, zone III, zone IV, and zone V respectively.



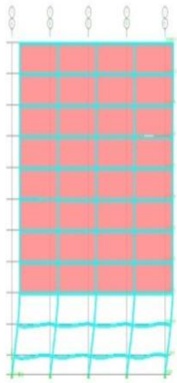


Fig 4.10: Comparison of lateral displacement in lateral displacement in Model 6 for all zones

Design Seismic Base Shear (Vb): It is the total design lateral force at the base of a structure. Hence after analyzing the building the results obtained for six Models in zone II, III, IV and zone V for load combination of (0.9DL+1.5EQX)and there comparisons are presented in tabular Form.

4.4. Comparison of base shear in all building Models for all seismic zones

Base shear is calculated by using IS 1893-2002 method for all six models in Tables and Figures; illustrate the comparison of base shear using linear dynamic analysis. Base shear is a very important parameter for earthquake resistant design of buildings.

Table: 4.9 Comparison of base shear of all building Models for seismic zone II

Zone II						
Base Shear(KN)						
Height of buildings(m)	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
31.8	-19.48	-74.3	-325.14	-140.27	-103.89	-102.29
28.8	-19.48	-74.3	-325.14	-140.27	-103.89	-102.29
28.8	-37.8	-137.56	-670.54	-289.29	-214.25	-210.95
25.8	-37.8	-137.56	-670.54	-289.29	-214.25	-210.95
25.8	-52.51	-188.33	-947.73	-408.88	-302.81	-298.16
22.8	-52.51	-188.33	-947.73	-408.88	-302.81	-298.16
22.8	-63.99	-227.98	-1164.21	-502.27	-371.98	-366.26
19.8	-63.99	-227.98	-1164.21	-502.27	-371.98	-366.26
19.8	-72.74	-257.88	-1327.46	-572.7	-424.14	-417.62
16.8	-72.74	-257.88	-1327.46	-572.7	-424.14	-417.62
16.8	-79.05	-279.4	-1444.99	-623.41	-461.7	-454.6
13.8	-79.05	-279.4	-1444.99	-623.41	-461.7	-454.6
13.8	-83.25	-293.93	-1524.3	-657.62	-487.04	-479.55
10.8	-83.25	-293.93	-1524.3	-657.62	-487.04	-479.55

10.8	-85.83	-302.82	-1572.87	-678.58	-502.56	-494.83
7.8	-85.83	-302.82	-1572.87	-678.58	-502.56	-494.83
7.8	-87.17	-307.46	-1598.21	-689.51	-510.65	-501.16
4.8	-87.17	-307.46	-1598.21	-689.51	-510.65	-501.16
4.8	-87.68	-309.22	-1607.8	-692.79	-513.72	-502.93
1.8	-87.68	-309.22	-1607.8	-692.79	-513.72	-502.93
1.8	-87.75	-309.46	-1608.86	-693.13	-514.11	-503.17
0	-87.75	-309.46	-1608.86	-693.13	-514.11	-503.17

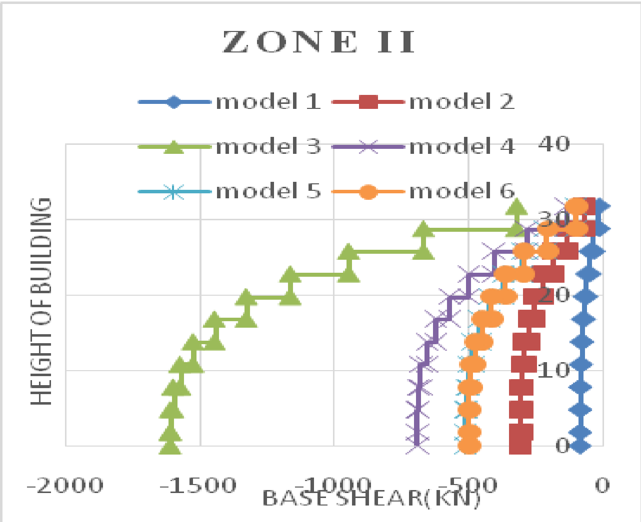


Fig4.11: Comparison of base shear (KN) in all building models for seismic zone II

Table 4.10 Comparison of base shear in all building Models for seismic zone III

Zone III						
Base Shear(KN)						
Height of buildings(m)	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
31.8	-31.17	-118.88	-520.22	-224.44	-166.22	-163.66
28.8	-31.17	-118.88	-520.22	-224.44	-166.22	-163.66
28.8	-60.49	-220.1	-1072.9	-462.86	-342.79	-337.53
25.8	-60.49	-220.1	-1072.9	-462.86	-342.79	-337.53
25.8	-84.01	-301.32	-1516.4	-654.2	-484.5	-477.05
22.8	-84.01	-301.32	-1516.4	-654.2	-484.5	-477.05
22.8	-102.39	-364.76	-1862.7	-803.63	-595.17	-586.02
19.8	-102.39	-364.76	-1862.7	-803.63	-595.17	-586.02
19.8	-116.39	-412.6	-2123.9	-916.32	-678.63	-668.2
16.8	-116.39	-412.6	-2123.9	-916.32	-678.63	-668.2
16.8	-126.47	-447.04	-2312	-997.45	-738.71	-727.36
13.8	-126.47	-447.04	-2312	-997.45	-738.71	-727.36
13.8	-133.2	-470.28	-2438.9	-1052.2	-779.26	-767.28

10.8	-133.2	-470.28	-2438.9	-1052.2	-779.26	-767.28
10.8	-137.33	-484.52	-2516.6	-1085.7	-804.09	-791.73
7.8	-137.33	-484.52	-2516.6	-1085.7	-804.09	-791.73
7.8	-139.48	-491.94	-2557.1	-1103.2	-817.04	-801.85
4.8	-139.48	-491.94	-2557.1	-1103.2	-817.04	-801.85
4.8	-140.29	-494.75	-2572.5	-1108.5	-821.95	-804.69
1.8	-140.29	-494.75	-2572.5	-1108.5	-821.95	-804.69
1.8	-140.4	-495.14	-2574.2	-1109	-822.57	-805.08
0	-140.4	-495.14	-2574.2	-1109	-822.57	-805.08

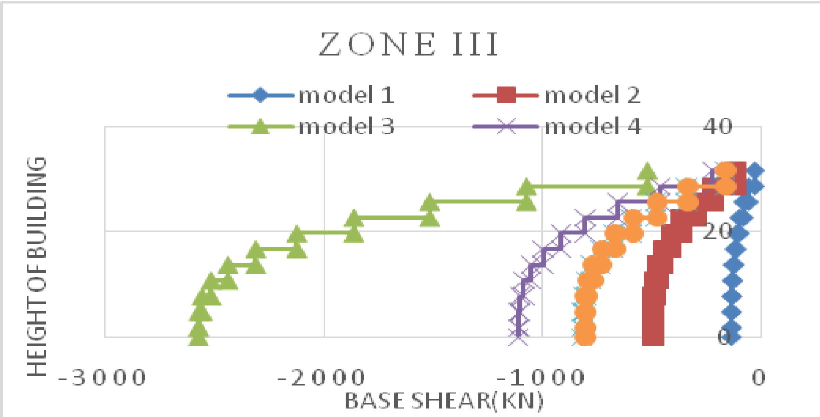


Fig4.12: Comparison of base shear (KN) in all building models for seismic zone

Table 4.11Comparison of base shear in all building Models for seismic zone IV

Zone IV						
Base Shear(KN)						
Height of buildi (m)	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
31.8	-46.75	-178.32	-780.33	-336.65	-249.33	-245.49
28.8	-46.75	-178.32	-780.33	-336.65	-249.33	-245.49
28.8	-90.73	-330.15	-1609.3	-694.29	-514.19	-506.29
25.8	-90.73	-330.15	-1609.3	-694.29	-514.19	-506.29
25.8	-126.02	-451.99	-2274.6	-981.3	-726.75	-715.58
22.8	-126.02	-451.99	-2274.6	-981.3	-726.75	-715.58
22.8	-153.58	-547.14	-2794.1	-1205.5	-892.75	-879.03
19.8	-153.58	-547.14	-2794.1	-1205.5	-892.75	-879.03
19.8	-174.59	-618.9	-3185.9	-1374.5	-1017.9	-1002.3
16.8	-174.59	-618.9	-3185.9	-1374.5	-1017.9	-1002.3
16.8	-189.71	-670.56	-3468	-1496.2	-1108.1	-1091
13.8	-189.71	-670.56	-3468	-1496.2	-1108.1	-1091
13.8	-199.8	-705.42	-3658.3	-1578.3	-1168.9	-1150.9
10.8	-199.8	-705.42	-3658.3	-1578.3	-1168.9	-1150.9

10.8	-205.99	-726.77	-3774.9	-1628.6	-1206.1	-1187.6
7.8	-205.99	-726.77	-3774.9	-1628.6	-1206.1	-1187.6
7.8	-209.21	-737.91	-3835.7	-1654.8	-1225.6	-1202.8
4.8	-209.21	-737.91	-3835.7	-1654.8	-1225.6	-1202.8
4.8	-210.44	-742.13	-3858.7	-1662.7	-1232.9	-1207
1.8	-210.44	-742.13	-3858.7	-1662.7	-1232.9	-1207
1.8	-210.6	-742.71	-3861.3	-1663.5	-1233.9	-1207.6
0	-210.6	-742.71	-3861.3	-1663.5	-1233.9	-1207.6

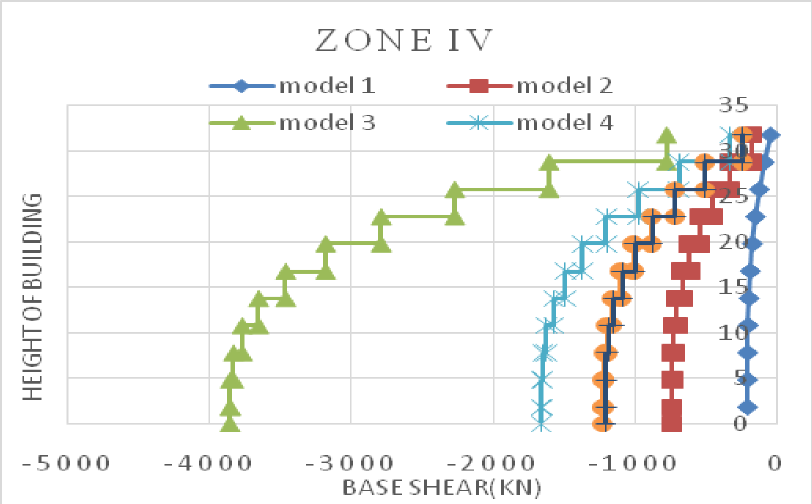


Fig4.13: Comparison of base shear (KN) in all building models for seismic zone IV

Table 4.12Comparison of base shear in all building Models for seismic zone V

Zone V						
Base Shear(KN)						
Height of build (m)	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
31.8	-70.13	-267.48	-1170.5	-504.98	-373.99	-368.24
28.8	-70.13	-267.48	-1170.5	-504.98	-373.99	-368.24
28.8	-136.09	-495.22	-2413.9	-1041.4	-771.29	-759.43
25.8	-136.09	-495.22	-2413.9	-1041.4	-771.29	-759.43
25.8	-189.03	-677.98	-3411.8	-1472	-1090.1	-1073.4
22.8	-189.03	-677.98	-3411.8	-1472	-1090.1	-1073.4
22.8	-230.37	-820.71	-4191.1	-1808.2	-1339.1	-1318.6
19.8	-230.37	-820.71	-4191.1	-1808.2	-1339.1	-1318.6
19.8	-261.88	-928.35	-4778.9	-2061.7	-1526.9	-1503.4
16.8	-261.88	-928.35	-4778.9	-2061.7	-1526.9	-1503.4
16.8	-284.56	-1005.9	-5202	-2244.3	-1662.1	-1636.6
13.8	-284.56	-1005.9	-5202	-2244.3	-1662.1	-1636.6
13.8	-299.71	-1058.1	-5487.5	-2367.4	-1753.3	-1726.4
10.8	-299.71	-1058.1	-5487.5	-2367.4	-1753.3	-1726.4

10.8	-308.98	-1090.2	-5662.3	-2442.9	-1809.2	-1781.4
7.8	-308.98	-1090.2	-5662.3	-2442.9	-1809.2	-1781.4
7.8	-313.82	-1106.9	-5753.5	-2482.2	-1838.3	-1804.2
4.8	-313.82	-1106.9	-5753.5	-2482.2	-1838.3	-1804.2
4.8	-315.65	-1113.2	-5788.1	-2494.1	-1849.4	-1810.5
1.8	-315.65	-1113.2	-5788.1	-2494.1	-1849.4	-1810.5
1.8	-315.9	-1114.1	-5791.9	-2495.3	-1850.8	-1811.4
0	-315.9	-1114.1	-5791.9	-2495.3	-1850.8	-1811.4

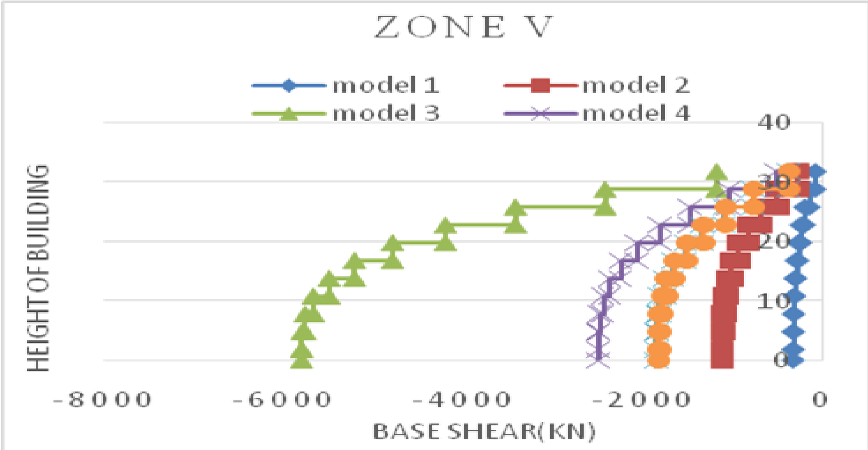


Fig4.14: Comparison of base shear (KN) in all building for seismic zone V

5. SUMMARY

Linear Dynamic Analysis has been performed on six types of RC building Models such as R.C bare frame, R.C bare frame with slab element, R.C building with first soft storey, R.C building with second soft storey and R.C building with third soft storey from ground level of the building in zones II, III, IV & zone V as per IS 1893: 2002.

5.1 Conclusion

The IS code methods describing very insufficient guidelines about infill wall design procedures. Software like ETABS is used as a tool for analyzing the effect of infill on the structural behavior. It is observed that ETABS provide overestimated values of storey drift, lateral displacement and base shear. According to relative values of all parameters, it can be concluded that provision of infill wall enhances the performance in terms of displacement, storey drift and lateral stiffness.

- The storey drifts observed of the structure are found within the limit as specified by code (IS: 1893-2002, part-1) in linear dynamic analysis.
- Storey drift value is more in the storey 11 of bare frame as compared to the soft storey at different levels of building.
- The presence of masonry infill influences the overall behavior of structures when subjected to lateral forces. Lateral displacements and storey drifts are considerably reduced while contribution of the infill brick wall is taken into account.
- Infilled frames should be preferred in seismic zones more than the open first storey frame, because the storey drift of first storey of open first storey frame is very large than the upper storey's, this may probably cause the collapse of structure.
- Lateral displacement of bare frame Model is higher than other Models because of less lateral stiffness of storey, due to absence of infill walls. The lateral displacements were observed in model 2 are reduced to 13.14%, 20.68% 30.74% and 45.82% as compared to the model 1 in zone II, III, IV and zone V respectively

- First storey displacement of soft first storey Model is maximum than other Models due to absence of infill in the first storey. In soft first storey frame, there is sudden change in drifts between first and second storey in all seismic zones.
- Concluded that the providing of infill wall in RC building controlled the displacement, storey drifts and lateral stiffness.
- The increase in base shear in models III, IV and V was 71.64%, 94.54%, 87.34%, 82.93%, and 82.56% respectively when compared to the model 1 in all zones.
- Base shear is more in full infilled Model (model 3) as compared to the other R.C building models.
- Bare frame has a lesser value of base shear as compared to the other R.C building Models.
- Base shear was more in the zone V for bare frame and that in the medium soil, the increase in base shear in zones III, IV and zone V was 36.87%, 57.66%, and 71.67% respectively as that of Zone II.

Scope of work

Soft storey is a typical feature in the modern multistorey constructions in urban India. Such features are highly undesirable in buildings built in seismically active areas. In normal practice, only the load due to masonry infill were considered, and do not consider the composite action. It will be interesting if the comparison made between the storey drifts, lateral displacement and base shear in zones II, III, IV, & zone V.

REFERENCES

[1] C.V.R.Murty, "Why Are Open Ground Storey Buildings Vulnerable in Earthquakes", Indian Institute of Technology Kanpur, Earthquake tip 21, December 2003.

[2] D. B. Karwar and Dr. R. S. Londhe (2014), Performance of RC Framed Structure by Using Pushover Analysis, International Journal of Emerging Technology and Advanced Engineering.

[3] Dhadde Santosh (2014), Evaluation and Strengthening of Soft Storey Building, International Journal of Ethics in Engineering & Management Education.

[4] ETABS (Version 9.7) “ETABS User’s Manual Revision 9.7”

[5] F. Demir and M. Sivri “Earthquake Response of Masonry Infilled Frames” ECAS2002 International Symposium on Structural and Earthquake Engineering, October 14, 2002, Middle East Technical University, Ankara, Turkey

[6] FEMA-273, (1997), NEHRP Guidelines for the Seismic Rehabilitation of Buildings, Federal Emergency Management Agency, Washington, D. C, October.

[7] Goutam Mondal and S.K.Jain (2008),” Lateral Stiffness of Masonry Infilled RC Frame with Central Opening”, Earthquake Spectra, Vol. 24, N0.3, PP.701-723, Aug 2008.