

# Analytical Study on Seismic Response with and Without Soft Storeys in Multi-Storey RC Building

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## Abstract

In this study, the responses of soft storey were studied with the help of ETABS software. The three dimensional RC frame was considered with assumed sizes of structural members like size of columns, size of beams and thickness of slab. At first, the material properties are assumed as per code. The number of bay is assumed in “X” direction, the spacing of 3m. The number of bay is assumed in “Y” direction, the spacing of 5m. The number of floor is to be considered as nine with 3m height of each floor. There are four models are created for the analysis such as bare frame, RC frame with masonry infill wall, RC frame with bottom soft storey and RC frame with top soft storey. Live load are applied on each floor as per IS: 875 (Part 2)- 1983. The building is assumed to be situated at Zone-II (Bangalore), Zone-III (Chennai), Zone-IV (Delhi) and Zone-V (Guwahati). The dynamic analysis is performed by assuming the fixed base. In dynamic analysis was performed for all the models as per IS: 1893 (Part-I). The results obtained from the analysis were studied comparatively and tabulated for all the models. The conclusion will be given by comparing the seismic responses from dynamic analytical results of all models obtained. From the analytical results, it was clearly understood that soft storey will plays the major role in the structural integrity of RC frame.

**Keywords**— RC frame with masonry infill wall, Bottom soft storey, Top soft storey, diaphragm drifts, storey drifts, storey shear, overturning moment, storey stiffness

## I. INTRODUCTION

In India, soft storey at first floor level is an unavoidable feature due to unavailability of space as in multi storied buildings, ground storey is used for parking, or reception lobbies. The storeys above stilt floor are used for residential or commercial purpose which comprises of brick, wall panels, due to which they possess small storey drift. According to “The Indian Seismic Code”, a soft storey is defined as a building whose lateral stiffness is less than 50% of the storey above or below [IS: 1893, 2002 [1]. Dynamic analysis of such building is compulsory. The analysis suggested that the vulnerability of building at lower soft storey is comparatively much higher.

The two distinct characteristic of the building having soft storey are as follows [2] –

- Difference in flexibility, i.e. the relative horizontal displacement in the ground storey is much larger than upper storey having both column as well as wall.
- This flexible ground stories called as soft storeys. Ground storey having only columns are weaker than upper storey having both the column and walls i.e. the upper storey can bear the horizontal earthquake force more than the lower storey.

## II. MODELLING OF FRAMES

### A. Material Properties:

The following are properties of the materials that are commonly used in the analysis.

### B. Concrete:

- Type of Material = Isotropic
- Mass per Volume ( $\rho$ ) = 2500kg/m<sup>3</sup>
- Weight per Volume (W) = 25kN/m<sup>3</sup>
- Characteristic compressive Strength ( $f_{ck}$ ) = 25N/mm<sup>2</sup>

### C. Steel Reinforcement:

- Type of Material = Isotropic
- Mass per Volume ( $\rho$ ) = 7850kg/m<sup>3</sup>
- Weight per Volume (W) = 78.50kN/ m<sup>3</sup>
- Yield Strength ( $f_y$ ) = 415N/mm<sup>2</sup>

### D. Design Data

- Support condition = Fixed Support
- Live Load for Floor = 3kN/m<sup>2</sup>
- Weight of Floor finishes = 1kN/ m<sup>2</sup>
- Location of the building =  
Zone-II (Bangalore),  
Zone-III (Chennai),  
Zone-IV (Delhi),  
Zone- V (Guwahati),
- Seismic Zone factor (Z) =  
0.1 (Bangalore),  
0.16 (Chennai),  
0.24 (Delhi),  
0.36 (Guwahati)
- Importance factor = 1.0

- Type of soil = Medium(II)
- Type of Building = Residential
- Type of Frame = OMRF
- Modal Combination =SRSS
- Cross section of Column =550mmx550mm
- Cross section of Outer Beam =300mmx450mm
- Cross section of Inner Beam =230mmx450mm
- Thickness of Slab = 150mm
- Width of masonry Infill =300mm
- Height of Each Floor = 3m
- Number of spacing in “x” direction = 3m
- Number of spacing in “y” direction = 5m
- Number of storey = (G+8)
- Method of design = LSM

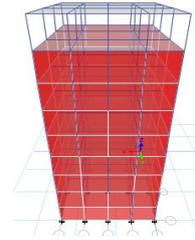


Fig.5: Model IV

**III. ANALYTICAL RESULTS AND DISCUSSION**

The results obtained are various parameter such as diaphragm drift (Table- 1, 2, 5, 13), storey drift (table- 2, 6, 10, 14), storey shear (Table- 3, 7, 11, 15), overturning moment (Table- 4, 8, 12, 16), storey stiffness (Table- 17-20) etc. For the Zone- II, III, IV, V.

**E. Type of Model**

- Model I = Bare frame (Fig.2)
- Model II= RC frame with infill wall (Fig.3)
- Model II = RC frame with bottom soft storey (Fig.4)
- Model IV= RC frame with top soft storey (Fig.5)

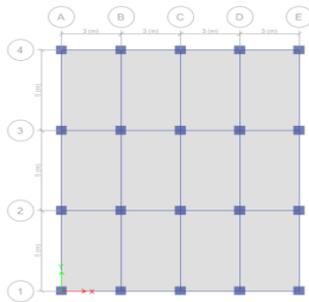


Fig.1: Plan

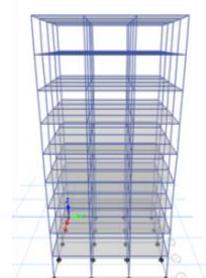


Fig.2: Model II

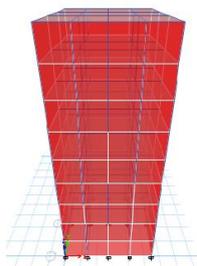


Fig.3: Model III

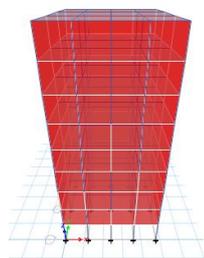
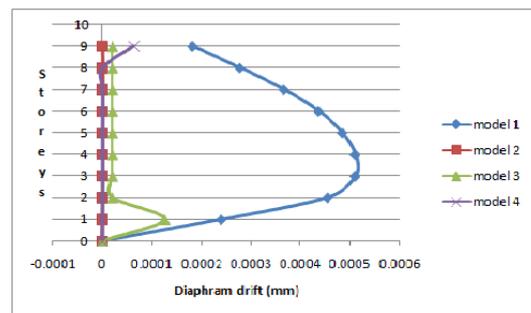


Fig.4: Model IV

**Table-1: Diaphragm Drifts (mm) in Zone II**

STOREY LEVEL	MODEL I	MODEL II	MODEL III	MODEL IV
9	0.000182	1.43E-07	0.00002	0.000064
8	0.000278	1.6E-07	0.00002	1.83E-07
7	0.000367	1.72E-07	0.00002	1.88E-07
6	0.000437	1.76E-07	0.00002	1.92E-07
5	0.000485	1.74E-07	0.00002	1.87E-07
4	0.000511	1.65E-07	0.00002	1.75E-07
3	0.000511	1.48E-07	0.00002	1.55E-07
2	0.000455	1.24E-07	0.00002	1.27E-07
1	0.00024	8.81E-08	0.000125	8.74E-08
0	0	0	0	0



**Fig.6: Diaphragm Drifts (mm) in Zone II**

**Table- 2: Storey Drifts (Mm) in Zone II**

STOREY LEVEL	MODEL I	MODEL II	MODEL III	MODEL IV
9	0.000182	1.43E-07	0.00002	0.000064
8	0.000278	1.6E-07	0.00002	1.83E-07
7	0.000367	1.72E-07	0.00002	1.88E-07
6	0.000437	1.76E-07	0.00002	1.92E-07
5	0.000485	1.74E-07	0.00002	1.87E-07
4	0.000511	1.65E-07	0.00002	1.75E-07

3	0.000511	1.48E-07	0.00002	1.55E-07
2	0.000455	1.24E-07	0.00002	1.27E-07
1	0.00024	8.81E-08	0.000125	8.74E-08
0	0	0	0	0

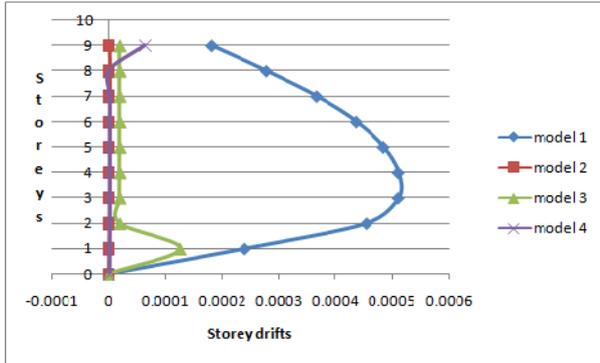


Fig.7: Storey Drifts (mm) in Zone II

5	102848.8	155931.1	101025.4	145755.9
4	122537.6	190853.5	123096.4	180419
3	142259.8	225900.1	145167.4	215213.4
2	161996.8	261016.5	167238.3	250081.8
1	181737.5	296163.9	189386.1	284983

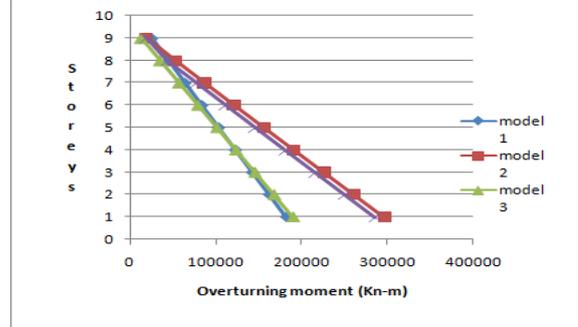


Fig.9: Overturning Moment(kn-m) in Zone II

Table-3: Storey Shear (KN) in Zone II

STOREY LEVEL	MODEL I	MODEL II	MODEL III	MODEL IV
9	2625.91	2548.319	1698.879	2480.819
8	5122.446	6962.511	4641.674	5642.263
7	7618.981	11376.7	7584.469	9988.955
6	10115.52	15790.9	10527.26	14335.65
5	12612.05	20205.09	13470.06	18682.34
4	15108.59	24619.28	16412.85	23029.03
3	17605.12	29033.47	19355.65	27375.73
2	20101.66	33447.67	22298.44	31722.42
1	22598.19	37861.86	25246.37	36069.11

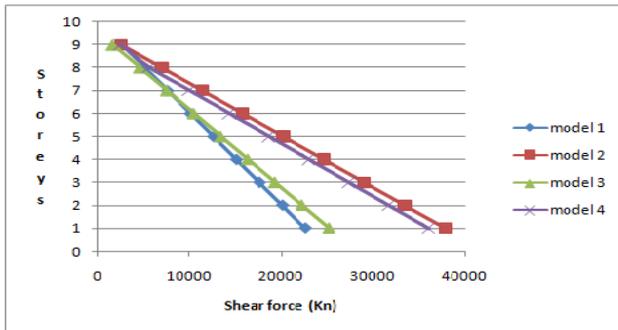


Fig. 8: Storey Shear (KN) in Zone II

Table-5: Diaphragm Drifts (mm) in zone III

STOREY LEVEL	MODEL I	MODEL II	MODEL III	MODEL IV
9	0.000194	1.21E-07	1.20E-05	5.02E-03
8	0.000296	1.38E-07	1.20E-05	1.33E-07
7	0.000391	1.49E-07	1.20E-05	1.36E-07
6	0.000466	1.53E-07	1.20E-05	1.43E-07
5	0.000514	1.52E-07	1.20E-05	1.43E-07
4	0.000546	1.45E-07	1.20E-05	1.37E-07
3	0.000545	1.31E-07	1.20E-05	1.50E-07
2	0.000485	1.12E-07	1.20E-05	1.07E-07
1	0.000256	8.20E-07	1.20E-05	7.87E-07
0	0	0.00E+00	0.00E+00	0.00E+00

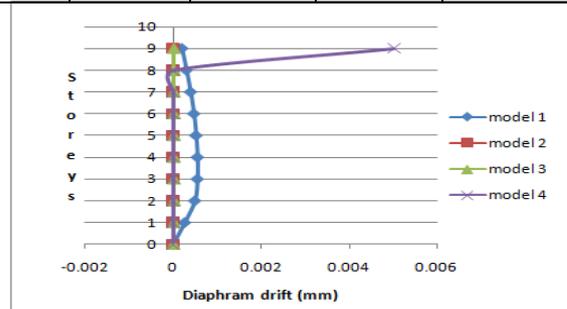


Fig.10: Diaphragm Drifts (mm) in zone III

Table-4: Overturning Moment (KN-m) in Zone II

STOREY LEVEL	MODEL I	MODEL II	MODEL III	MODEL IV
9	25058.65	19112.39	12741.59	18943.64
8	44279.81	52684.66	34812.56	43375.44
7	63682.82	86753.54	56883.52	77135.59
6	83219.43	121202.6	78954.48	111298

Table-6: Storey Drifts (mm) in Zone III

STOREY LEVEL	MODEL I	MODEL II	MODEL III	MODEL IV
9	0.000194	1.21E-07	1.20E-05	5.02E-03
8	0.000296	1.38E-07	1.20E-05	1.33E-07
7	0.000391	1.49E-07	1.20E-05	1.36E-07
6	0.000466	1.53E-07	1.20E-05	1.43E-07

5	0.000517	1.52E-07	1.20E-05	1.43E-07
4	0.000546	1.45E-07	1.20E-05	1.37E-07
3	0.000545	1.31E-07	1.20E-05	1.50E-07
2	0.000425	1.12E-07	1.20E-05	1.07E-07
1	0.000256	8.20E-07	1.20E-05	7.87E-07
0	0	0.00E+00	0.00E+00	0.00E+00

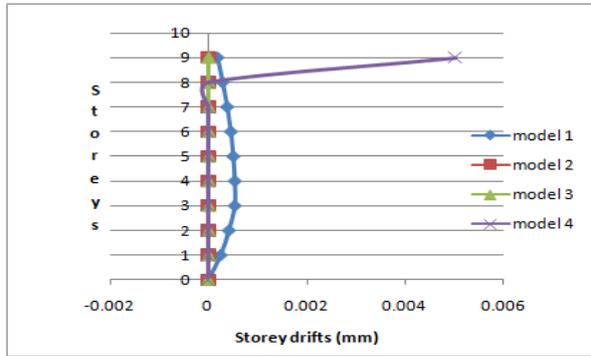


Fig.11: Storey Drifts (mm) in Zone III

Table-7: Storey Shear (KN) in Zone III

STOREY LEVEL	MODEL I	MODEL II	MODEL III	MODEL IV
9	1750.607	1698.879	1698.879	1653.879
8	3414.964	4641.674	4641.674	3761.509
7	5079.321	7584.469	7584.469	6659.304
6	6743.678	10527.26	10527.26	9557.099
5	8408.034	13470.06	13470.06	12454.89
4	10072.39	16412.85	16412.85	15352.69
3	11736.75	19355.65	19355.65	18250.48
2	13401.11	22298.44	22298.44	21148.28
1	15065.46	25241.24	25246.37	24046.07

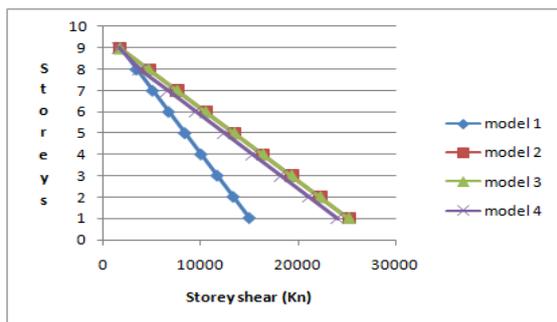


Fig.12: Storey Shear (KN) in Zone III

Table- 8: Storey Overturning Moment (KN-m) in Zone III

STOREY LEVEL	MODEL I	MODEL II	MODEL III	MODEL IV
9	13129.55	12741.59	12741.59	12629.09

8	25612.23	34812.56	34812.56	28661.31
7	38094.9	56883.52	56883.52	50619.78
6	50577.58	78954.48	78954.48	72578.24
5	63060.26	101025.4	101025.4	94536.7
4	75542.93	123096.4	123096.4	116495.2
3	88025.61	145167.4	145167.4	138453.6
2	100508.3	167238.3	167238.3	160412.1
1	6538.318	189309.3	189386.1	182370.5

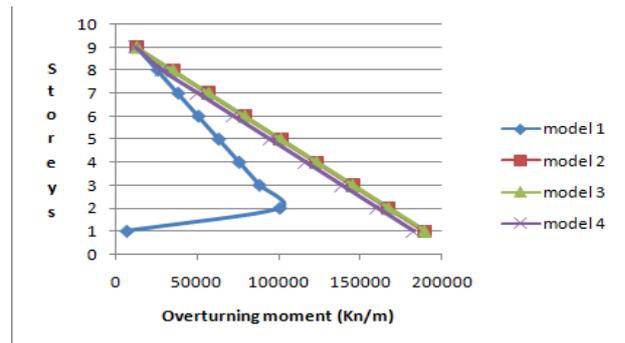


Fig.13: Storey Overturning Moment (KN-m) in Zone II

Table-9: Diaphragm drifts (mm) in Zone IV

STOREY LEVEL	MODEL I	MODEL II	MODEL III	MODEL IV
9	0.000291	2.29E-07	0.000022	0.000078
8	0.000444	2.56E-07	0.000022	2.45E-07
7	0.000587	2.74E-07	0.000022	2.53E-07
6	0.000699	2.82E-07	0.000022	2.64E-07
5	0.000776	2.79E-07	0.000022	2.62E-07
4	0.000818	2.64E-07	0.000022	2.49E-07
3	0.000817	2.37E-07	0.000022	2.25E-07
2	0.000728	1.99E-07	0.000022	1.89E-07
1	0.000385	1.41E-07	0.000287	1.35E-07
0	0	0	0	0

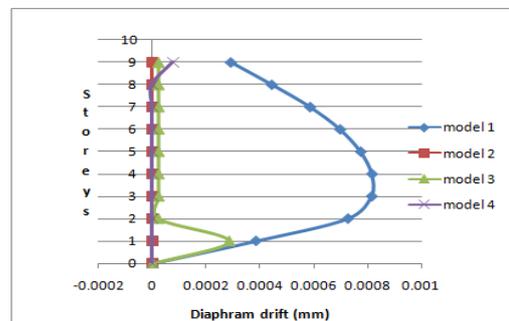
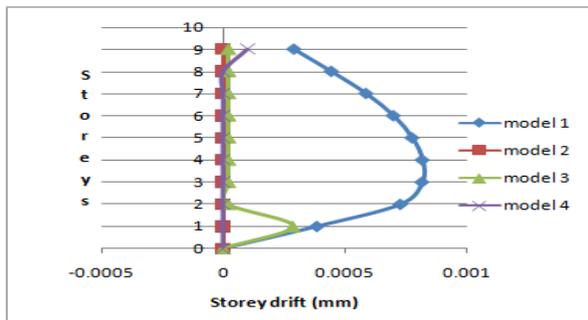


Fig.14: Diaphragm Drifts (mm) in Zone IV

**Table-10: Storey Drifts (Mm) In Zone IV**

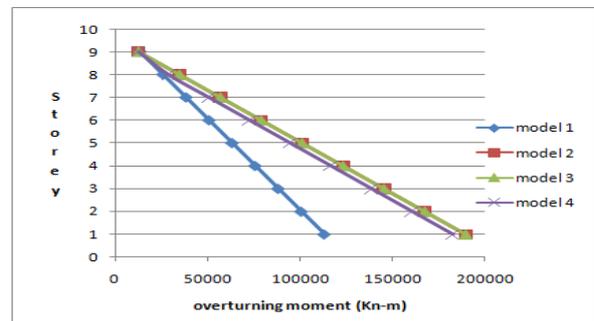
STOREY LEVEL	MODEL I	MODEL II	MODEL III	MODEL IV
9	0.000291	2.29E-07	0.000022	0.0001
8	0.000444	2.56E-07	0.000022	2.45E-07
7	0.000587	2.74E-07	0.000022	2.54E-07
6	0.000699	2.82E-07	0.000022	2.64E-07
5	0.000776	2.79E-07	0.000022	2.62E-07
4	0.000818	2.64E-07	0.000022	2.49E-07
3	0.000817	2.37E-07	0.000022	2.25E-07
2	0.000728	1.99E-07	0.000022	1.89E-07
1	0.000385	1.41E-07	0.000287	1.35E-07
0	0	0	0	0



**Fig.15: Storey Drifts (Mm) In Zone IV**

**Table-12: Storey Overturning Moment (KN-M) In Zone IV**

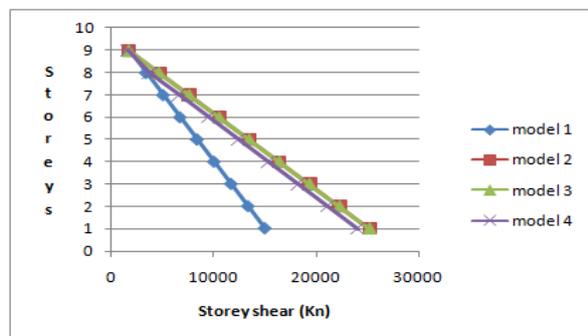
STOREY LEVEL	MODEL I	MODEL II	MODEL III	MODEL IV
9	13129.55	12741.59	12741.59	12629.09
8	25612.23	34812.56	34812.56	28661.31
7	38094.9	56883.52	56883.52	50619.78
6	50577.58	78954.48	78954.48	72578.24
5	63060.26	101025.4	101025.4	94536.7
4	75542.93	123096.4	123096.4	116495.2
3	88025.61	145167.4	145167.4	138453.6
2	100508.3	167238.3	167238.3	160412.1
1	112991	189309.3	189309.3	182370.5



**Fig.17: Storey Overturning Moment (KN-M) In Zoneiv**

**Table-11: Storey Shear (KN) in Zone IV**

STOREY LEVEL	MODEL I	MODEL II	MODEL III	MODEL IV
9	1750.607	1698.879	1698.879	1653.879
8	3414.964	4641.674	4641.674	3761.509
7	5079.321	7584.469	7584.469	6659.304
6	6743.678	10527.26	10527.26	9557.099
5	8408.034	13470.06	13470.06	12454.89
4	10072.39	16412.85	16412.85	15352.69
3	11736.75	19355.65	19355.65	18250.48
2	13401.11	22298.44	22298.44	21148.28
1	15065.46	25241.24	25241.24	24046.07

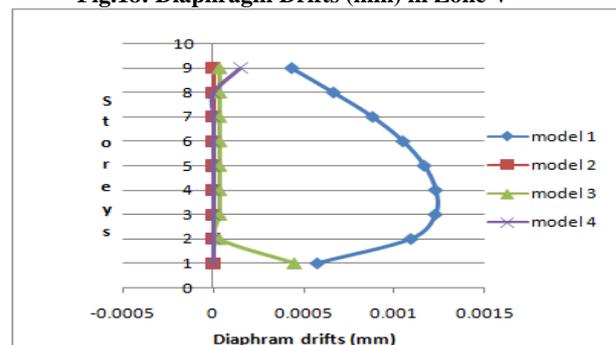


**Fig.16: Storey Shear (KN) in Zone IV**

**Table-13: Diaphragm Drifts (mm) in Zone V**

STOREY LEVEL	MODEL I	MODEL II	MODEL III	MODEL IV
9	0.000437	3.43E-07	0.000035	0.000151
8	0.000666	3.84E-07	0.000035	3.67E-07
7	0.000881	4.12E-07	0.000035	3.8E-07
6	0.001048	4.23E-07	0.000035	3.96E-07
5	0.001164	4.18E-07	0.000035	3.93E-07
4	0.001227	3.96E-07	0.000035	3.74E-07
3	0.001225	3.56E-07	0.000035	3.38E-07
2	0.001091	2.98E-07	0.000035	2.84E-07
1	0.000577	2.11E-07	0.000449	2.03E-07

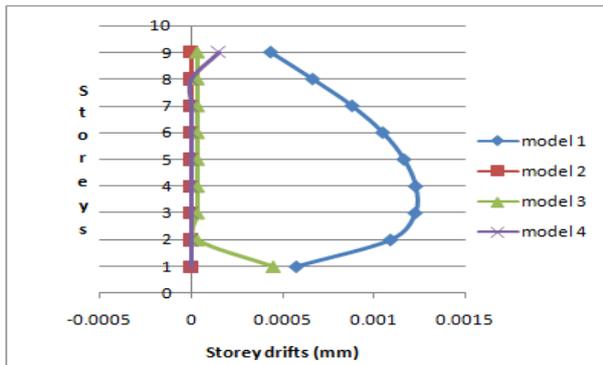
**Fig.18: Diaphragm Drifts (mm) in Zone V**



**Table-14: Storey Drift (mm) in zone V**

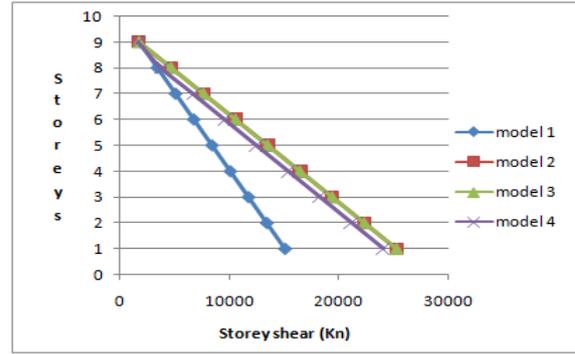
STOREY LEVEL	MODEL I	MODEL II	MODEL III	MODEL IV
9	0.000437	3.43E-07	0.000035	0.000151
8	0.000666	3.84E-07	0.000035	3.67E-07
7	0.000881	4.12E-07	0.000035	3.8E-07
6	0.001048	4.23E-07	0.000035	3.96E-07
5	0.001164	4.18E-07	0.000035	3.93E-07
4	0.001227	3.96E-07	0.000035	3.74E-07
3	0.001225	3.56E-07	0.000035	3.38E-07
2	0.001091	2.98E-07	0.000035	2.84E-07
1	0.000577	2.11E-07	0.000449	2.03E-07

**Fig.19: Storey Drift (mm) in Zone V**



**Table-15: Storey Shear (KN) in Zone V**

STOREY LEVEL	MODEL I	MODEL II	MODEL III	MODEL IV
9	1750.607	1698.879	1698.879	1653.879
8	3414.964	4641.674	4641.674	3761.509
7	5079.321	7584.469	7584.469	6659.304
6	6743.678	10527.26	10527.26	9557.099
5	8408.034	13470.06	13470.06	12454.89
4	10072.39	16412.85	16412.85	15352.69
3	11736.75	19355.65	19355.65	18250.48
2	13401.11	22298.44	22298.44	21148.28
1	15065.46	25241.24	25246.37	24046.07

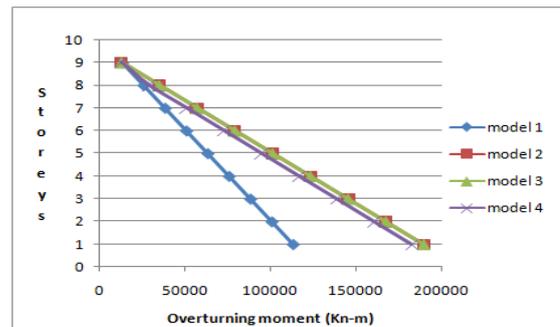


**Fig.20: Storey Shear (KN) in Zone V**

**Table-16: Storey Overturning Moment (KN-m) in Zone V**

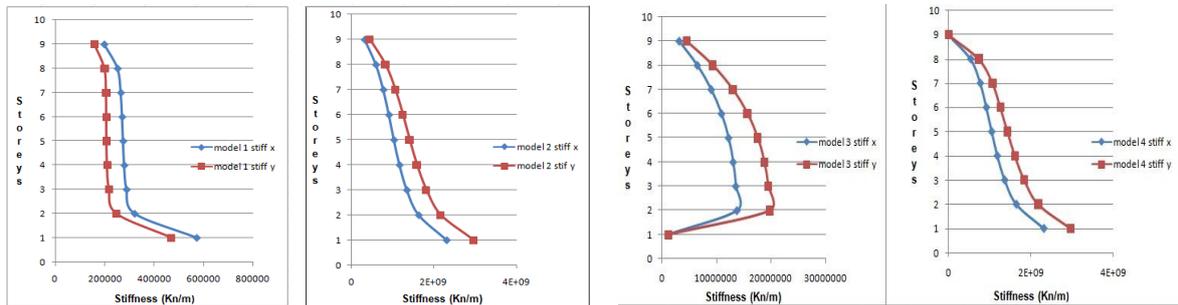
STOREY LEVEL	MODEL I	MODEL II	MODEL III	MODEL IV
9	13129.55	12741.59	12741.59	12629.09
8	25612.23	34812.56	34812.56	28661.31
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4	75542.93	123096.4	123096.4	116495.2
3	88025.61	145167.4	145167.4	138453.6
2	100508.3	167238.3	167238.3	160412.1
1	112991	189309.3	189386.1	182370.5

**Fig.21: Storey Overturning Moment (KN-m) in Zone V**



**Table-17: Storey Stiffness (KN/m) in Zone II**

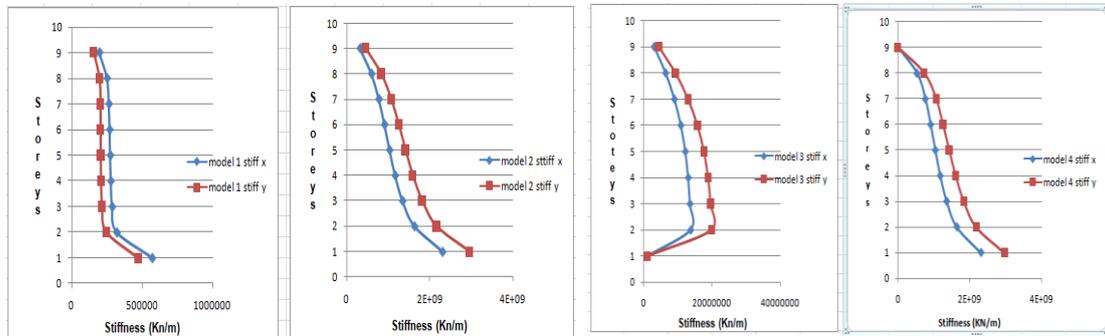
STOREY LEVEL	MODEL I		MODEL II		MODEL III		MODEL IV	
	stiff x	stiff y	stiff x	stiff y	stiff x	stiff y	stiff x	stiff y
9	197804.6	158612.7	3.24E+08	4.55E+08	3139618	4516359	785064.6	679083.5
8	252167.3	199027.5	5.98E+08	8.3E+08	6479245	9318822	5.36E+08	7.33E+08
7	265378.8	205583.9	7.78E+08	1.07E+09	9031672	12988473	7.69E+08	1.07E+09
6	270883.3	206763.6	9.14E+08	1.25E+09	10906898	15684332	9.16E+08	1.26E+09
5	274736.2	207456.5	1.04E+09	1.42E+09	12213085	17562343	1.05E+09	1.43E+09
4	279258.8	209599.9	1.17E+09	1.59E+09	13055015	18772895	1.18E+09	1.61E+09
3	288554.1	217235.1	1.35E+09	1.82E+09	13543667	19479054	1.36E+09	1.84E+09
2	321212.1	247525	1.63E+09	2.17E+09	13750216	19767340	1.65E+09	2.18E+09
1	573088.6	470070.4	2.31E+09	2.96E+09	1200955	1217436	2.32E+09	2.97E+09



**Fig.22: Storey Stiffness (KN/m) in Zone II**

**Table-18: Storey Stiffness (KN/m) in Zone III**

STOREY LEVEL	MODEL I		MODEL II		MODEL III		MODEL IV	
	stiff x	stiff y	stiff x	stiff y	stiff x	stiff y	stiff x	stiff y
9	197804.6	158612.7	3.24E+08	4.55E+08	3139618	4516359	785064.6	679083.5
8	252167.3	199027.5	5.98E+08	8.3E+08	6479245	9318822	5.36E+08	7.33E+08
7	265378.8	205583.9	7.78E+08	1.07E+09	9031672	12988473	7.69E+08	1.07E+09
6	270883.3	206763.6	9.14E+08	1.25E+09	10906898	15684332	9.16E+08	1.26E+09
5	274736.2	207456.5	1.04E+09	1.42E+09	12213085	17562343	1.05E+09	1.43E+09
4	279258.8	209599.9	1.17E+09	1.59E+09	13055015	18772895	1.18E+09	1.61E+09
3	288554.1	217235.1	1.35E+09	1.82E+09	13543667	19479054	1.36E+09	1.84E+09
2	321212.1	247525	1.63E+09	2.17E+09	13750216	19767340	1.65E+09	2.18E+09
1	573088.6	470070.4	2.31E+09	2.96E+09	1200955	1217436	2.32E+09	2.97E+09



**Fig.22: Storey Stiffness (KN/m) in Zone III**

Table-19: Storey Stiffness (KN/m) in Zone IV

STOREY LEVEL	MODEL I		MODEL II		MODEL III		MODEL IV	
	stiff x	stiff y	stiff x	stiff y	stiff x	stiff y	stiff x	stiff y
9	197804.6	158612.7	3.24E+08	4.55E+08	3240186	5795062	785064.6	679083.5
8	252167.3	199027.5	5.98E+08	8.3E+08	6686547	11952733	5.36E+08	7.33E+08
7	265378.8	205583.9	7.78E+08	1.07E+09	9320421	16655245	7.69E+08	1.07E+09
6	270883.3	206763.6	9.14E+08	1.25E+09	11255526	20109569	9.16E+08	1.26E+09
5	274736.2	207456.5	1.04E+09	1.42E+09	12603624	22517680	1.05E+09	1.43E+09
4	279258.8	209599.9	1.17E+09	1.59E+09	13472952	24071192	1.18E+09	1.61E+09
3	288554.1	217235.1	1.35E+09	1.82E+09	13977998	24984837	1.36E+09	1.84E+09
2	321212.1	247525	1.63E+09	2.17E+09	14190749	25331459	1.65E+09	2.18E+09
1	573088.6	470070.4	2.31E+09	2.96E+09	1247621	1263718	2.32E+09	2.97E+09

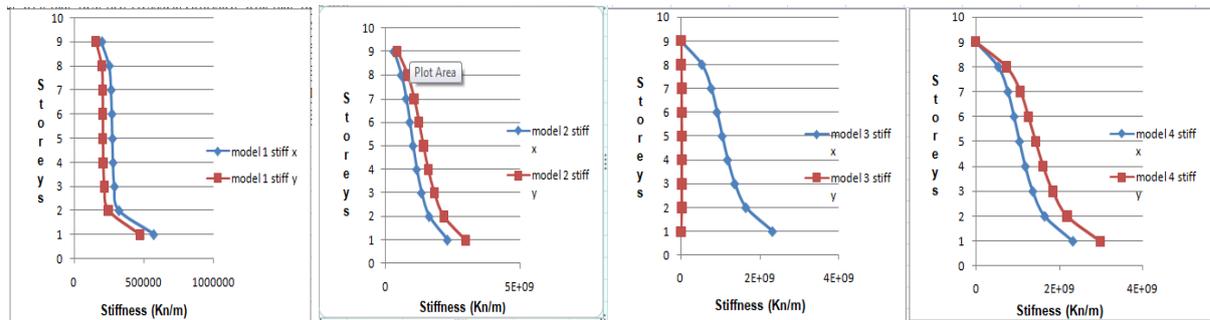


Fig.23: Storey Stiffness (KN/m) in Zone IV

Table-20: Storey Stiffness (KN/m) in Zone V

STOREY LEVEL	MODEL I		MODEL II		MODEL III		MODEL IV	
	stiff x	stiff y	stiff x	stiff y	stiff x	stiff y	stiff x	stiff y
9	197804.6	158612.7	3.24E+08	4.55E+08	3139618	4516359	785064.6	679083.5
8	252167.3	199027.5	5.98E+08	8.3E+08	6479245	9318822	5.36E+08	7.33E+08
7	265378.8	205583.9	7.78E+08	1.07E+09	9031672	12988473	7.69E+08	1.07E+09
6	270883.3	206763.6	9.14E+08	1.25E+09	10906898	15684332	9.16E+08	1.26E+09
5	274736.2	207456.5	1.04E+09	1.42E+09	12213085	17562343	1.05E+09	1.43E+09
4	279258.8	209599.9	1.17E+09	1.59E+09	13055015	18772895	1.18E+09	1.61E+09
3	288554.1	217235.1	1.35E+09	1.82E+09	13543667	19479054	1.36E+09	1.84E+09
2	321212.1	247525	1.63E+09	2.17E+09	13750216	19767340	1.65E+09	2.18E+09
1	573088.6	470070.4	2.31E+09	2.96E+09	1200955	1217436	2.32E+09	2.97E+09

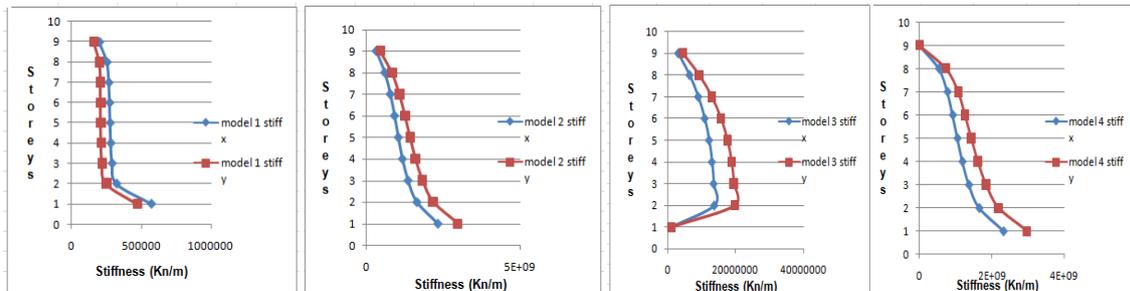


Fig.24: Storey Stiffness (KN/m) in Zone V

From the above table and graphs it can be observed that the bare frame model yields highest value in all the zones. Whereas comparing with the other models, model II which is RC frame with infill wall gives the significant values.

#### IV. DISCUSSION

Using etabs-15.2 software the soft-storey for multi storey building in zone-II, zone-III, zone-IV and zone-V is analysed by keeping the soft storey at top and bottom of the building. From the very limited study done an attempt has been made to draw the following specific conclusion, the result of the study shows that soft-storey floor will have very determinant effect on structural behaviour of building and structural capacity under storey shear, storey moment, diaphragm drifts and story drifts which are affected by the structural irregularities.

#### V. CONCLUSION

1. It is seen that by providing the infill diaphragm drift, storey drift are considerably reduced.
2. The models such as soft storey there we come to conclusion that there is a significant decrease in storey shear, moment and stiffness of soft storey as in comparison to the RC infill frame.
3. From the seismic response of all the models during earthquake in all the zones, it was clearly observed and understood that the open soft storey at ground floor will be more vulnerable during ground motion.
4. The analysis proves that soft storey are harmful and the effect of stiffness irregularity on the structure is also dangerous in seismic zone. Therefore, as far as possible soft storeys in a building must be avoided in higher seismic zone. But, if soft storeys have to be introduced for any reason, they must be designed properly following the conditions of IS 1893-part-1: 2002 and IS-456: 2000, and joints should be made ductile as per IS 13920:2002. The structural design has been done using limit state method. In this structure we have considered ductile detailing for the design of structural elements in order to resist the earthquake forces.

#### REFERENCES

- [1] J.N. Arlekar, S. K. Jain and C.V.R. Murty, "Seismic Response of RC Frame Buildings with Soft First Storeys," Dept. of Civil Engineering, IIT Kanpur, India. (CBRI) 1997.
- [2] Abhishek Arora "Alternative Approach to Soft Storey in Seismic Analysis of R.C.C Building Structures," Department of Civil Engineering, SDDIET, (Kurukshetra University), Haryana, India, SSRG International Journal of Civil Engineering (SSRG-IJCE) – EFES April 2015
- [3] Chopra A.K., Clough D.P., Clough R.W., 1973 "Earthquake Resistance of Building with a „SOFT“ First Storey", Earthquake Engineering and Structural Dynamics, Vol.1, 347-355,
- [4] Murty C V R, August 2004. the Classroom section, a series of short articles, 'Earthquake Tips', related to earthquakes design

- & construction of buildings. IIT Kanpur and BMTPC, New Delhi.
- [5] Murthy. C.V.R 2004 – Earthquake Tips, Indian Institute of Technology Kanpur, Sponsored by Building Materials and Technology Promotion Council, New Delhi,
  - [6] Premalatha.J, Palanisamy.M and Neelamegam.P 2011 "Analytical Study On Seismic Responses Of Masonry Infill Wall In Multi-Storeied Structures" International Conference On Earthquake Analysis And Design Of Structures EQADS 2011 Department Of Civil Engineering, PSG College Of Technology, Coimbatore, India
  - [7] Sugamya. K, Jaya Prakash. K, February-2016 "Sesimic Evaluation Of Multistoried Building With Ground Soft Story And With Infills By Using Etabs" International Journal Of Science Engineering And Advance Technology, IJSEAT, Vol. 4, Issue 2
  - [8] IS 456: 2000. "Indian Standard Code of Practice for plain and reinforced Concrete", Bureau of Indian Standards, New Delhi."
  - [9] IS 1893(Part-I) 2002: Criteria for Earthquake Resistant Design of Structures, Part-I General Provision and Buildings (Fifth Revision) Bureau of Indian Standards, New Delhi.
  - [10] IS: 875(part 1) – 1987 – Code of practice for design loads (Other than earthquake) for buildings and structures – Dead loads.
  - [11] IS: 875(part 2) – 1987 – Code of practice for design loads (Other than earthquake) for buildings and structures – Imposed loads.