# ANALYTICAL STUDY ON SEISMIC RESPONSE WITH AND WITHOUT SOFT STOREYS IN MULTISTOREY 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 were 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 pr 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 frames.

**KEYWORDS**: RC frame masonry with infill wall, Bottom soft storey, Top soft storey, diaphragm drifts, storey drifts, storey shear, overturning moment, storey stiffness.

## 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.

## MODELLING OF FRAMES

MATERIAL PROPERTIES:

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

CONCRETE:

- Type of Material=Isotropic
- Mass per Volume (ρ) =2500kg/m$^3$
- Weight per Volume (W)= 25kN/m$^3$

- Characteristic compressive strength (fck)=25N/$mm^2$

STEEL REINFORCEMENT:

- Type of Material=Isotropic
- Mass per Volume (ρ)=7850kg/$m^3$
- Weight per Volume (W)=78.50kN/ $m^3$
- Yield Strength (fy)= 415N/$mm^2$

DESIGN DATA

- Support condition= Fixed Support
- Live Load for Floor= 3kN/$m^2$
- Weight of Floor finishes=1kN/ $m^2$
- 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= Nine (G+8)
- Method of Design= LSM

TYPE OF MODEL

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

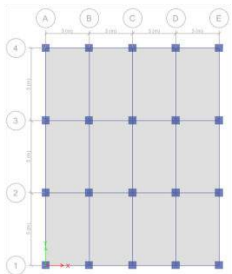


Fig.1: Plan

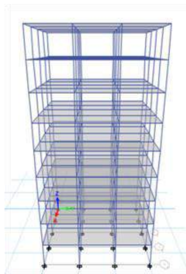

Fig.2

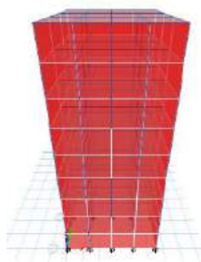

Fig.3

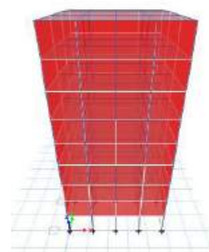

Fig.4

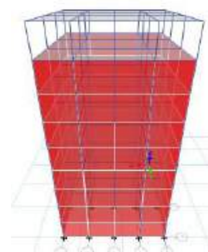

Fig.5

## ANALYTICAL RESULTS AND DISCUSSIONS

The results obtained are various parameters such as storey stiffness, storey drifts, diaphragm drifts, overturning moment, storey shear etc.

**Table-1**: Diaphragm drifts n(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 |

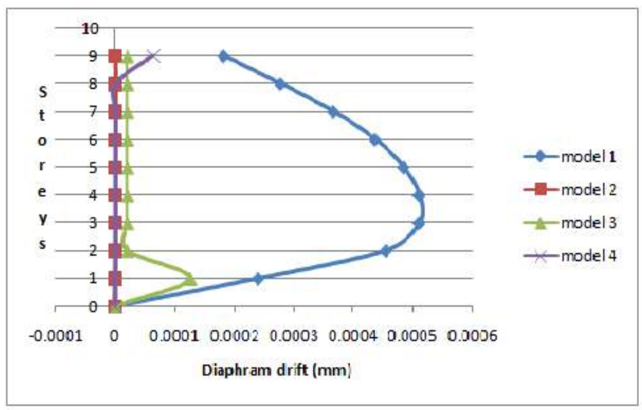


Fig.6: Diaphragm drifts (mm) in zone II

**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 |

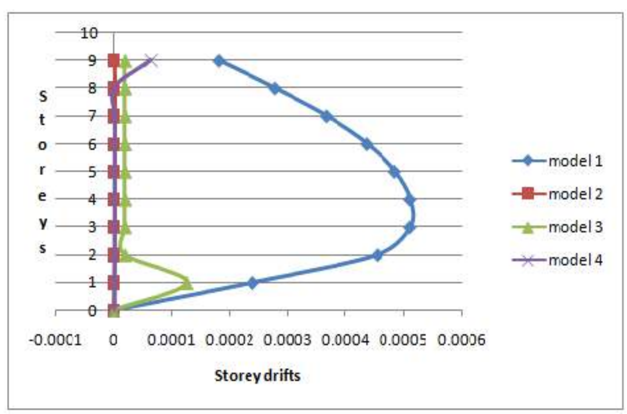


Fig.7: Storey drifts (mm) in zone II

**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 |

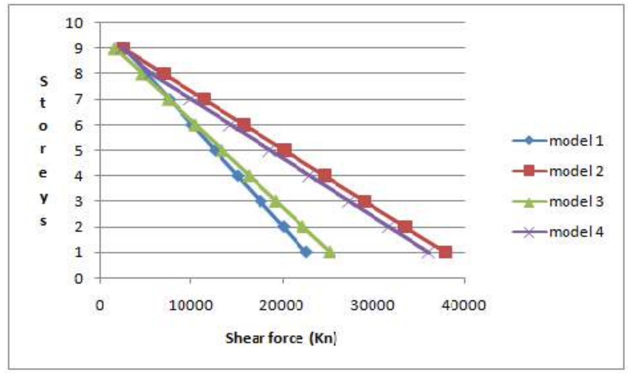


Fig. 8: Storey shear (KN) in zone II

**Table-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 |
| 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 |

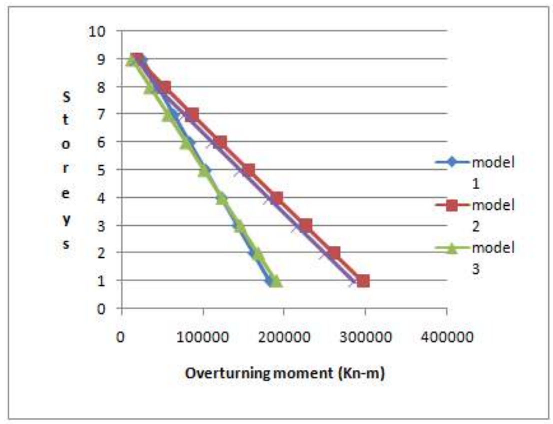


Fig. 9: Overturning moment (KN-m) in zone II

**Table-5**: 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 | 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 |

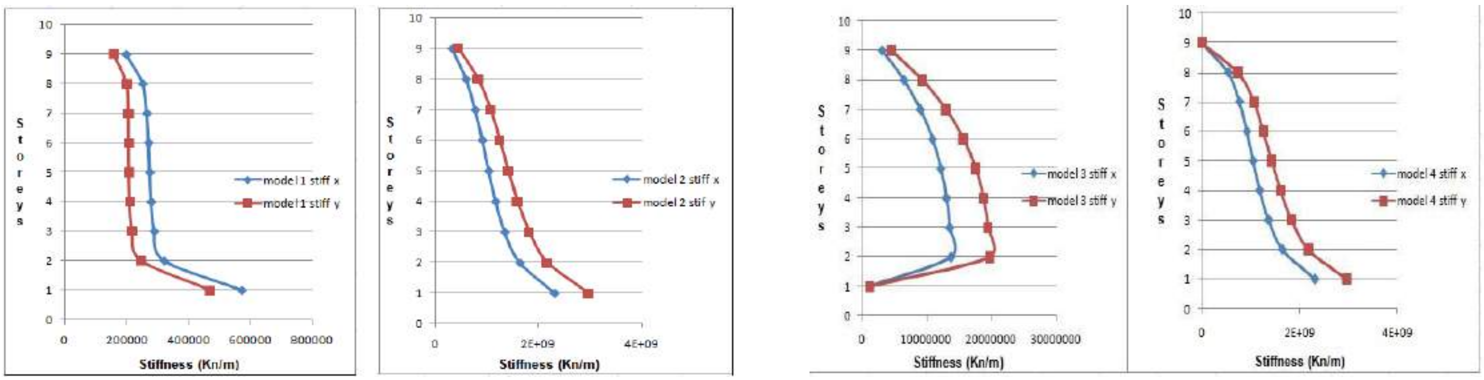


Fig.10: Storey Stiffness (KN/m) in zone II

**Table-6**: 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 |

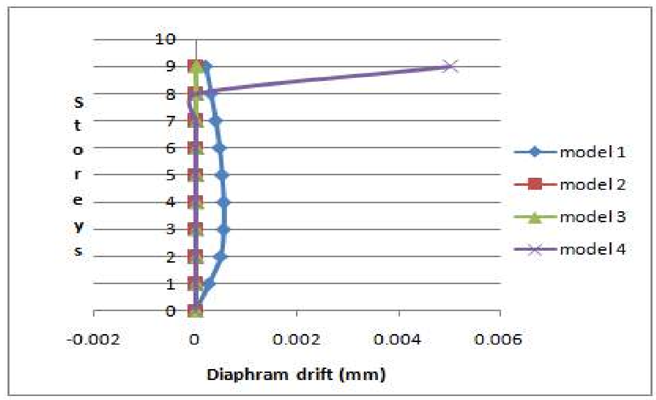


Fig. 11: Diaphragm drifts (mm) in zone III

**Table-7**: 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 |

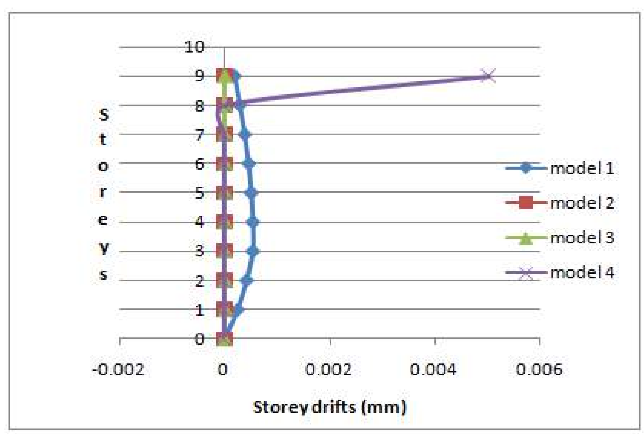


Fig. 12: Storey Drifts (mm) in zone III

**Table-8**: 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 |

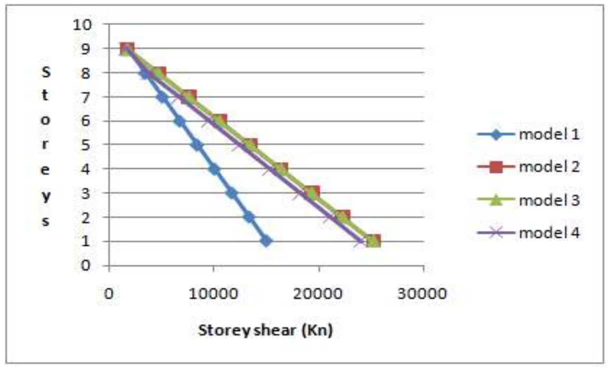


Fig. 13: Storey Shear (KN) in Zone III

**Table- 9**: 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 |

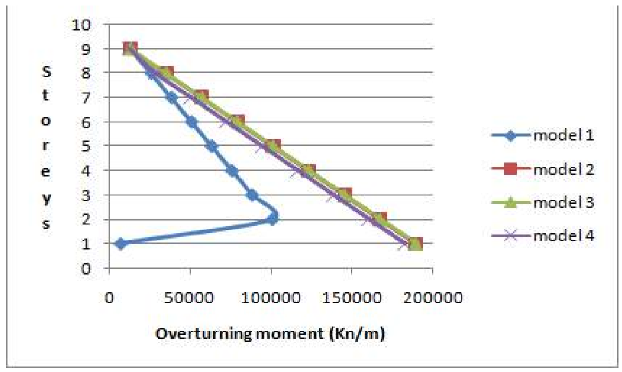


Fig. 14: Storey overturning moment(KN-m) in zone II

**Table-10**: 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 |

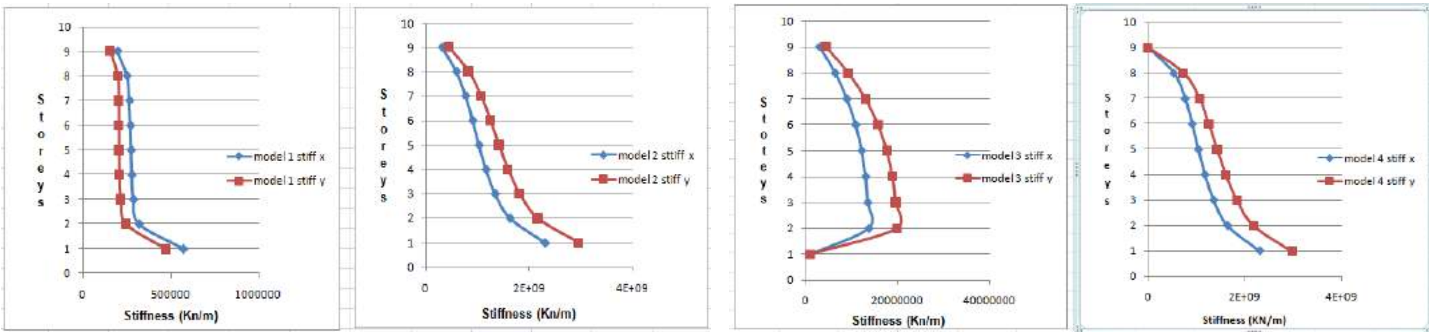


Fig. 15: Storey Stiffness (KN/m) in zone III

**Table-11**: 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 |

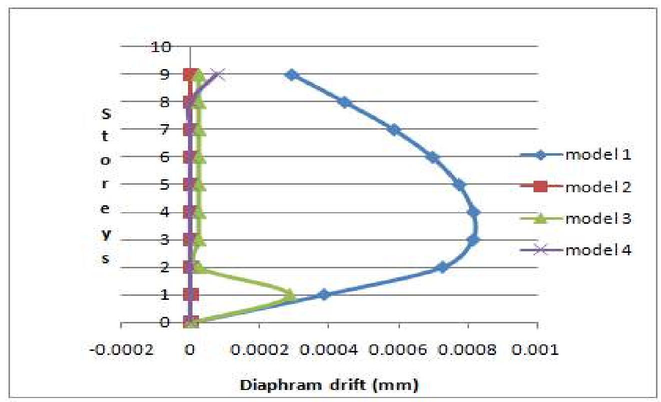


Fig. 16: Diaphragm drifts (mm) in zone IV

**Table-12**: 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 |

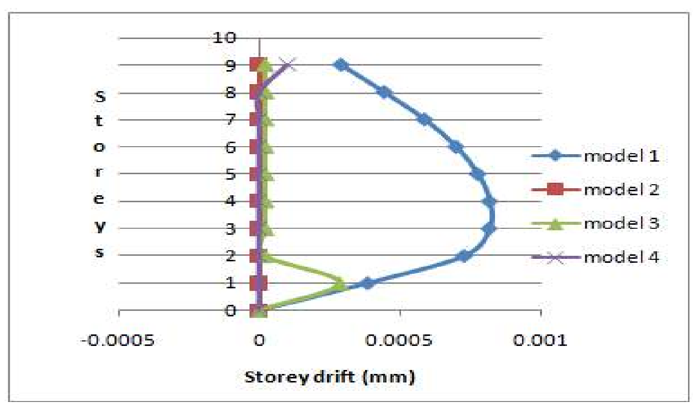


Fig.17: Storey drifts (mm) in zone IV

**Table-13**: 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 |

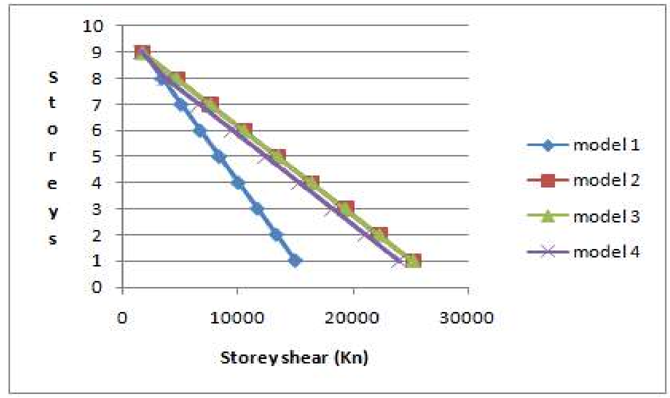


Fig. 18: Storey Shear (KN) in zone IV

**Table-14** 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 |

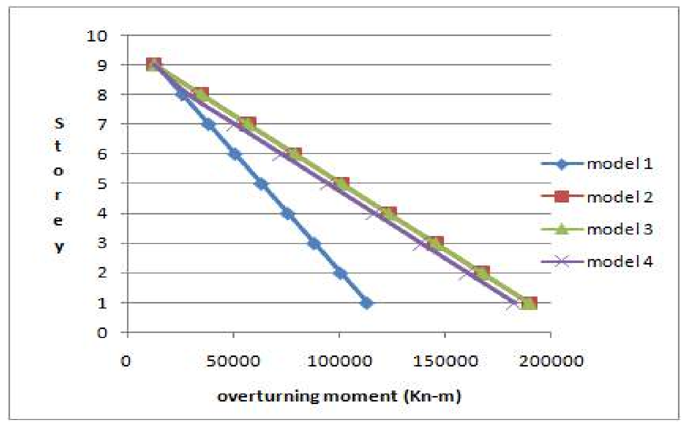


Fig.19: Storey overturning moment (KN-m) in zone IV

**Table-15**: 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 |

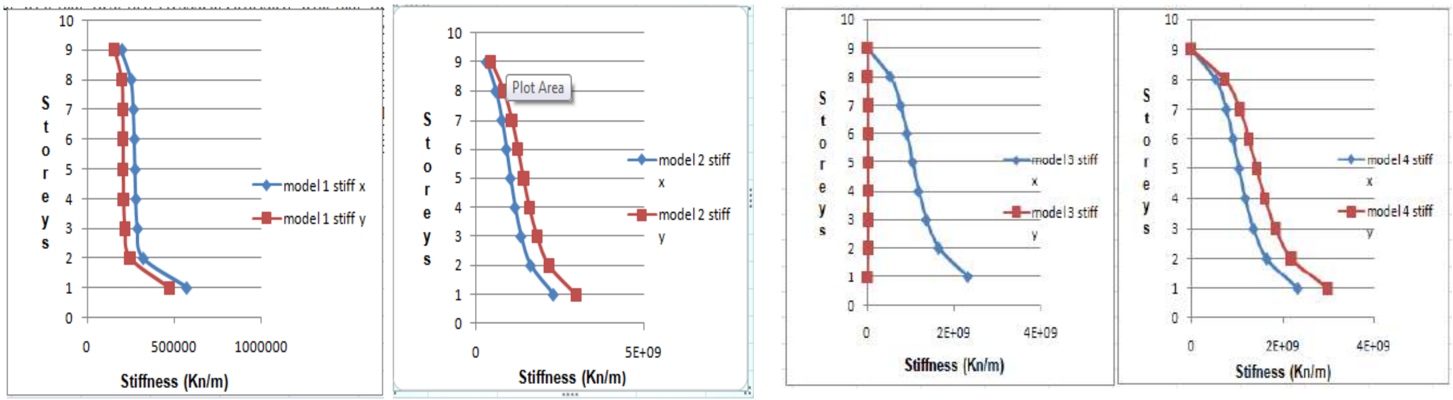


Fig.20: Storey stiffness (KN/m) in zone IV

**Table-16**: Diaphragm drifts (mm) in zone V

| STOREY LEVEL | MODEL I | MODEL II | MODEL III | MODELIV |
|---|---|---|---|---|
| 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 |

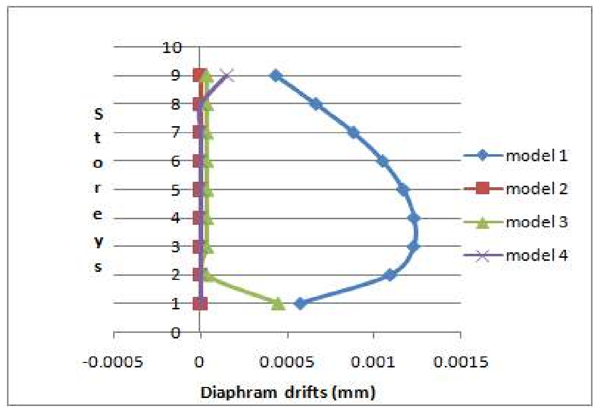


Fig.21: Diaphragm drifts (mm) in zone V

**Table-17**: 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 |

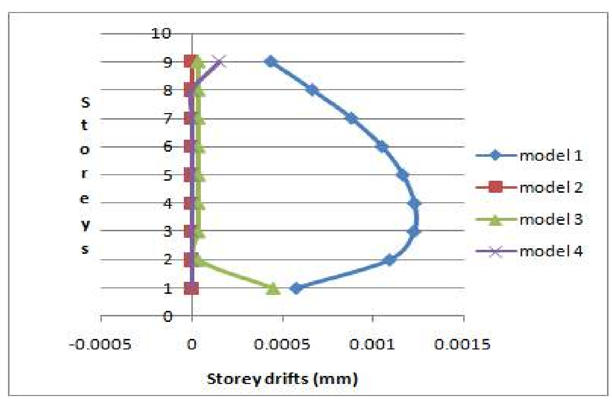


Fig.22: Storey Drift (mm) in zone V

**Table-18**: 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 |

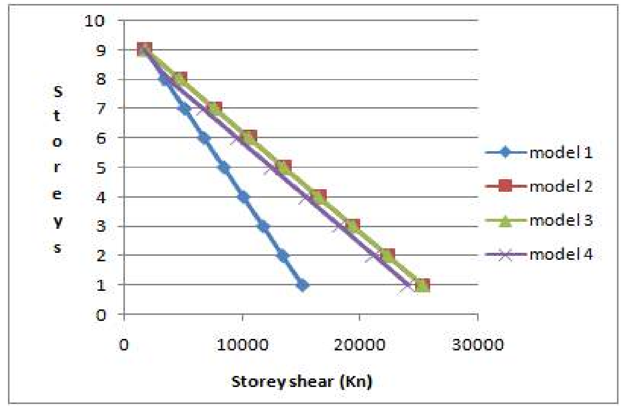


Fig.23: Storey shear (KN) in zone V

**Table-19**: 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 |
| 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 | 189386.1 | 182370.5 |

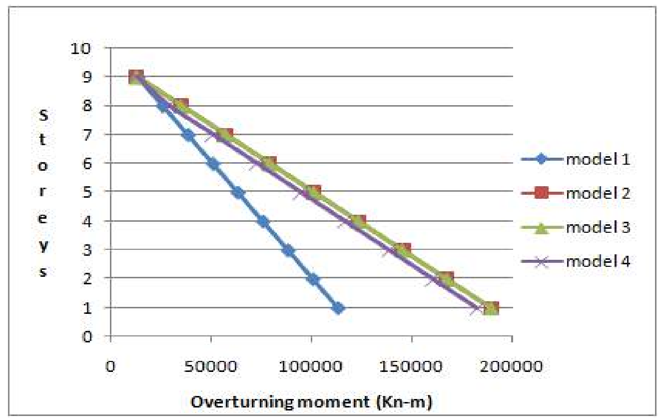


Fig. 24: Storey overturning moment (KN-m) in zone V

**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 |

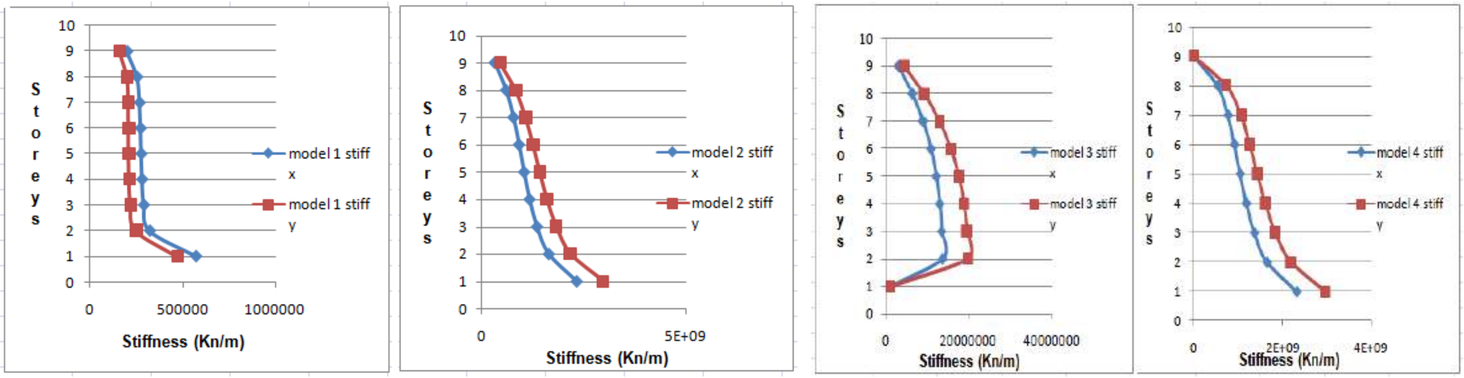


Fig.25: Storey stiffness (KN/m) in zone V

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.

## DISCUSSION

Using etabs-15.2 software the soft-storey for multi storey building in zone-2, zone-3, zone-4 and zone-5 is analyzed 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 behavior of building and structural capacity under storey shear, storey moment, diaphragm drifts and story drifts which are affected by the structural irregularities.

## 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

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