EFFECT OF STOREY ON PERFORMANCE OF HIGH-RISE STRUCTURE

Namratha B K [1], Dr. Raghupasad B K[2], Dr. Amarnath K [3]

M. Tech. Structural Engineering [1] Professor[2]HOD[3]

Dept of Civil Engg TOCE[1]

The Oxford College of Engineering Bommanahalli, India[1]

ABSTRACT:Duringan earthquakestructures will suffer from severe damages due to the drastic variation in the lateral stiffness and strength. In most of the cases damages have occurred due to the presence of soft storey in the structure.It is clear in IS 1893 Part-1 (2016) that storeys below should not have stiffness lower than that of upper storeys.In this paper the dynamic analysis is done on a high-rise structure (G+29) to know the behaviour the structure under the influence of soft storey. This analysis is done by providing soft storeys at different levels in the structure by decreasing the column size when compared to the upper storeys. A comparative study is done between the symmetrical structure and structure having soft storeys at different levels in the structure. Storey displacement, drifts and stiffness of structure with soft storeys are compared with structure with no soft storey.

***Index terms*: storey displacement, drift and stiffness**

1.INTRODUCTION

1.1 GENERAL

In present days even if the cities are bigger there is a deficiency of land due to the increasing population which affected the construction of wider buildings.So, the importance was given for vertical constructionand high-rise structures are being constructed on an extensive scale.

The structures must bear their weight and it should resist wind and earthquake forces and keep the occupants safe from fire. However, they should be conveniently available, even on the upper floors, and give utilities and a pleasant atmosphere for the tenants.

1.2 SOFT STOREY

The storey which is having lateral stiffness less when compared to that of upperstorey. The soft storey can be inevitable in different levels of the structure. This condition can happen in any of the construction types such as

- Walls with huge openings.
- An uncommonly tall story height.
- Sudden decrease in the column stiffness when compared to the adjacent storeys.
- Material properties used in the infill walls.
- Soil classification
- Existence of uncommon projections. Etc

1.3 EFFECT OF EARTHQUAKE ON SOFT STOREY

Most of the harm caused to the structure because of earthquake had a great impact because of the stiffness and strength being varied across the vertical direction.The drastic changes in stiffness, strength and/or ductility createthe weakness in the structure. Those kinds of structure oscillate at the time of earthquake and the columns in the open ground storey are over stressed. If the columns donot have the necessary strength to withstand these high stresses they willbedamagedto a greater extent which can results in disintegration of the structure and leading to loss of human wellbeing and monetary loss.

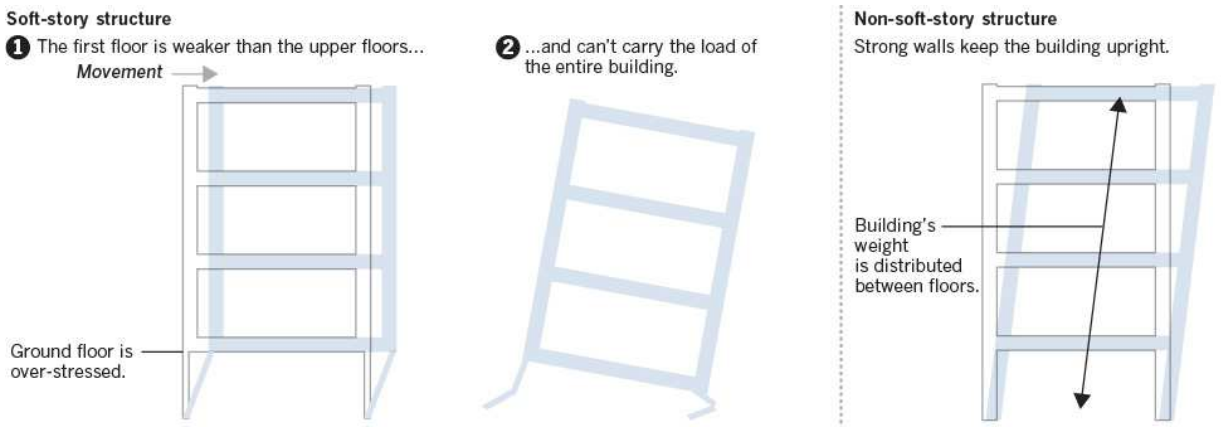

Fig 1.4 Difference between soft storey structure and symmetric structure

2.LITERATURE REVIEW

Jaswant N Arlekar et al (1997) [1] This paper states to take instant measures to prevent the indiscriminateuse of soft storey in the structure. Static and dynamic analysis is conducted on various models to know the effects of soft storey and existence of infill wall in the model. They concluded that the structures having first soft storey shows bad performance at the time of earthquake. The stiffness of the first storey should be enhanced by 50%. Stiffer columns can be used to provide sufficient stiffness and lateral strength.Soil flexibility is the important guideline to conclude the logical model of the structure.

G.V. Mulgund et al (2010) [2] Here the dynamic analysis is done to know the behaviour of RC frames by providing the infills with various arrangements. RC frames having masonry infill at the outer edge without soft storey is compared with the RC frames with soft storey. RC frames with masonry infill which doesn't have soft storey minimises the time period in bare frame and also the increases the structure stiffness. The time period is more in masonry infill having soft storey and it is less in bare frame. Also, the base shear is less with no soft storey and is more in bare frame. The value of base shear is more in masonry infill having soft storey than that of masonry infill with no soft storey and it is more when compared to bare frame. Hence the masonry infill frame performed well than the bare frame and soft storey.

F. Hejazil et al (2011) [3]In this paper they provided the bracings to the soft storey to know the seismic behaviour of the multi-storied building having soft storey. They concluded that during earthquake the major factor for soft storey to displace is location and number of bracing. The storey having bracings will have smaller displacement. Also, by providing bracings the soft storey effect will get reduced and can avoid the collapse.

Pooja Raut et al (2013) [4] has done analysis on a G+5, college structure with open ground storey. STAAD PRO was used to this investigation. The results found from this investigation were that the structural stiffness will get increased due to the infill panels and it will get reduced in infill frame when more openings are provided. There is a very huge deflection in bare frame when compared to the infill frame having openings. There is a drastic reduction in deflection when we consider the impact of infill wall. Since the action of earthquake force is larger in the last storey the deflection is also large.

N. Shivkumar et al (2013) [5]examined the dynamic analysis of the high-rise structure with soft storey to know the effect of column in the ground storey. The conclusion of this paper was, that the lateral drift will get reduced by providing the stiffer column at the soft storeyand also, by providing concrete service core drift will reduce.

Suchita Hirde, Ganga Tepugade (2014) [6]studied the effect of soft storey on a RC structure at different levels. They carried out the Non-linear pushover analysis. Conclusions are ground storey with soft storey forms plastic hinges in the column which is not all right.By providing the shear wall the plastic hinges formation can be prevented. And also, these walls reduce the lateral displacement. In the higher level, if the soft storey is provided then the displacement will get reduced.

Mohammed Shoaib ayjaz (2015) [7] In this paper the behaviour of a soft storey structure with and without bracing are compared by seismic analysis. During past earthquake the ground storey buildings with soft storey have always performed poorly in all over the world.Conclusions are due to the bracings in ground floor time period is increased. The bracings will increase the base shear. It also gives resistance to the building against earthquake.

Vihar S. Desai et al (2017) [8] has studied the capability of a structure having soft storey (G+14) at various level including ground level using linear response spectrum analysis. In addition to this study has been done to reduce the impact of soft storey on seismic response of the structure by introducing the shear wall to the structure. The summery of this study is thatthe storey displacement will get reduced with the increase in the soft storey level.The storey drift and time period will increase as the storey level gets decreased. In ground level the storey shear will be maximum and it will go on decreasing towards upper storey of the

structure. Hence it is preferable to give the soft storey at the upper levels and the effect of earthquake on soft storey can be reduced by providing shear walls.

3.METHODOLOGIES

3.1 PLAN OF THE BUILDING

The layout of plan is having 5 x 5 bays. A 30 Storey (G+29) OMRF (ordinary moment resisting frame) structure with and without soft storey at different floors are considered for the analysis.The analysis of the structure was done in ETABS 2016.

3.2 GENERAL DESCRIPTION OF BUILDING:

- Type of structure: Ordinary moment resisting frame
- Number of storeys: 30 (G + 29)
- Seismic zone: III
- Floor Height: 3m
- Grade of steel: Fe500, Fe415
- Grade of concrete: M25

3.3 MODEL DISCRIPTION

The analysis was done to know the impact of soft storey on a high-rise structure by decreasing the column size when compared to the upper stories.

3.3.1 Model 1:

A symmetrical model of bay 5m x5m having of 30 (G + 29) storey without soft storey is considered for the analysis.

The Sizes of column is given as,

- For storey 1st to 10^{th}: 700mm x 700mm
- For storey 11 to 20^{th}: 550mm x 550mm
- For storey 21 to 30^{th}: 400mm x 400mm

And Size of beam: 350mm x 800mm

3.3.2 Model 2

A RC structure having soft storey in first floor is createdby decreasing the column size when compared to the upper storeys. The size of the column in first storey is decreased by **500mm x 500mm.** Rest of the dimensions remains the same.

3.3.3 Model 3

In this analysis a RC structure is having soft storey in first and fifth floors. The size of the column in first and fifth storeys are decreased by **500mm x 500mm.**

3.3.4 Model 4

In this analysis thestructure is having soft storey in First. Fifth and Tenth floors. The column size in soft storeys are decreased by **500mm x 500mm.**

3.3.5 Model 5

The structure is having soft storey in first, fifth, tenth, fifteenth and twentieth floors by decreasing the column size by**350mm x 400mm.**

4.RESULTS AND DISCUSSION

The results obtained for storey displacement, storey drift and storey stiffness are compared below.

4.1 Storey Displacements

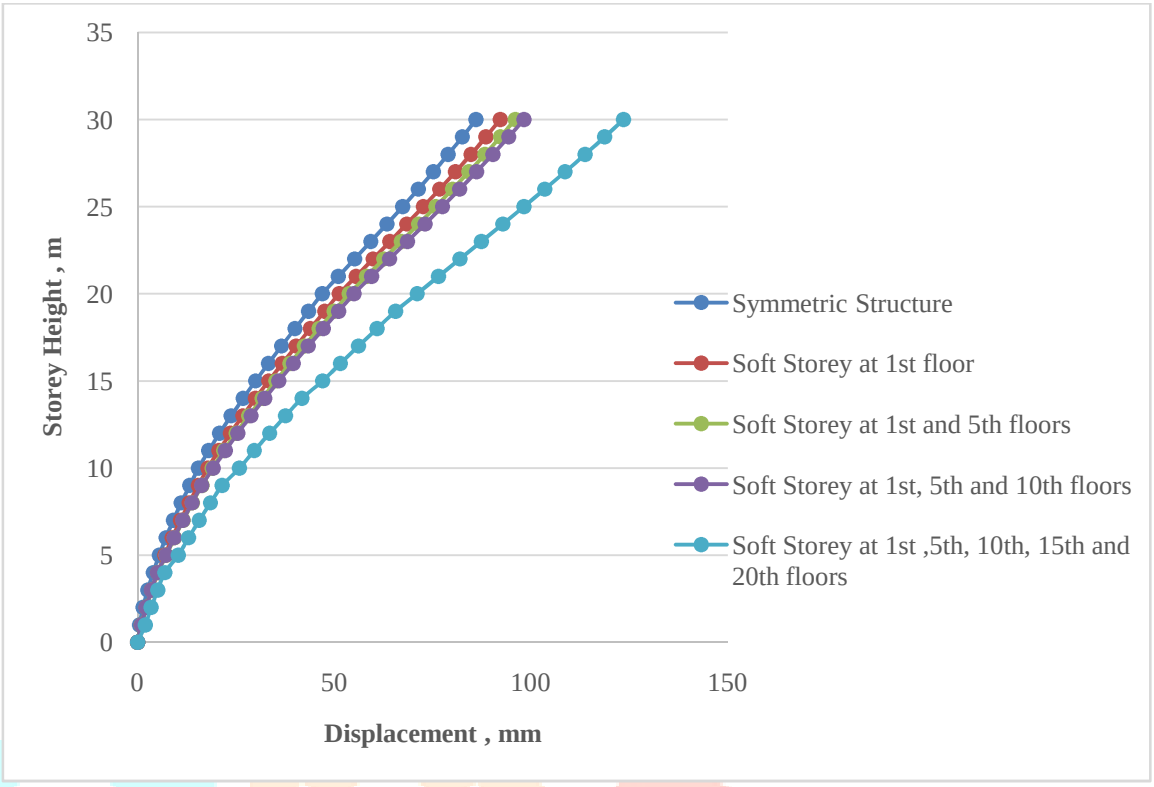

Fig 4.1.1 Storey displacement comparison between symmetrical structure and structure with soft storey provided at different levels

- The figure 4.1.1 shows the displacement Vs storey height graph for symmetrical and structures with soft storeys at different levels. It states that the displacement of the structure with no soft storey is less, however with increase in number of soft storey the displacement will be increased.

4.2 Storey Drift

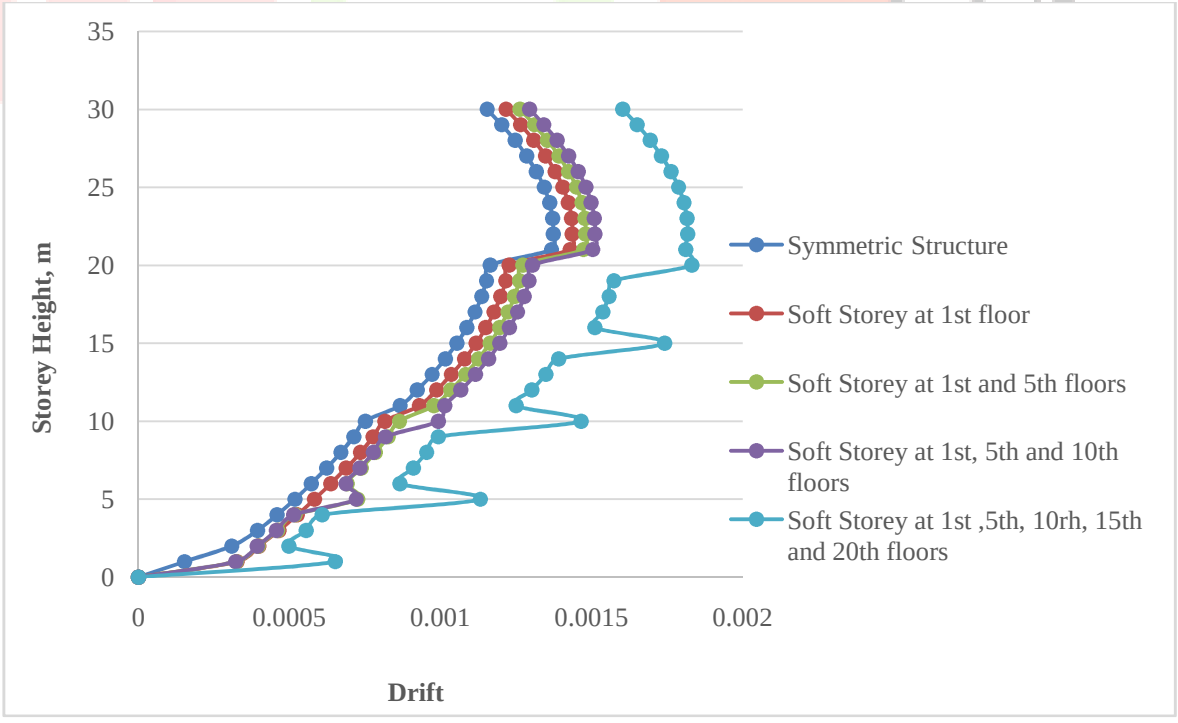

Fig 4.2.1 Comparison of Storey drift between symmetrical structure and structure with soft storey provided at different levels

- The figure 4.2.1 states that the drift of the structure with no soft storey is less. It is observed that drift is increased with the increase in the number of soft storeys.

4.3 Storey Stiffness

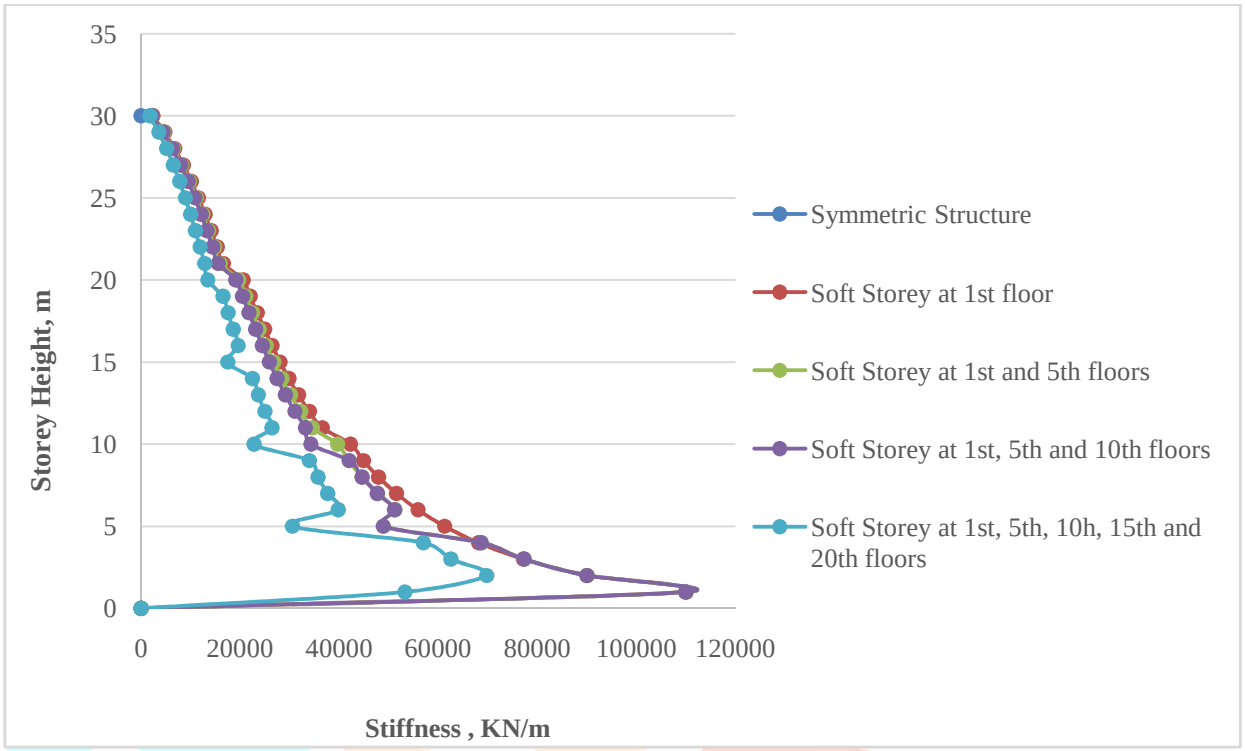

Fig 4.3.1. Comparison of Storey stiffness between symmetrical structure and structure with soft storey provided at different levels

- The figure 4.3.1 shows the distribution of storey stiffness over height. It may be observed that stiffness is lower than that of the upper storeys at 5^{th}, 10^{th}, 15^{th} and 20^{th} floors.

5.PUSHOVER ANALYSES

The pushover analysis is done for Model 5 i.e. Soft storey in first, fifth, tenth, fifteenth and twentieth floors. Thecolumn size given for the soft storeysare - **350mm x 400mm.** The rest of thedimensions remains the same.

Step	Displacement, mm	Force, kN
0	0	0
1	91.295	25
2	182.589	50
3	273.884	75
4	365.179	100
5	456.473	125
6	547.768	150
7	639.063	175
8	730.357	200
9	890.753	225
10	1136.762	250

Table 5.1 Displacement vs force values from pushover analysis

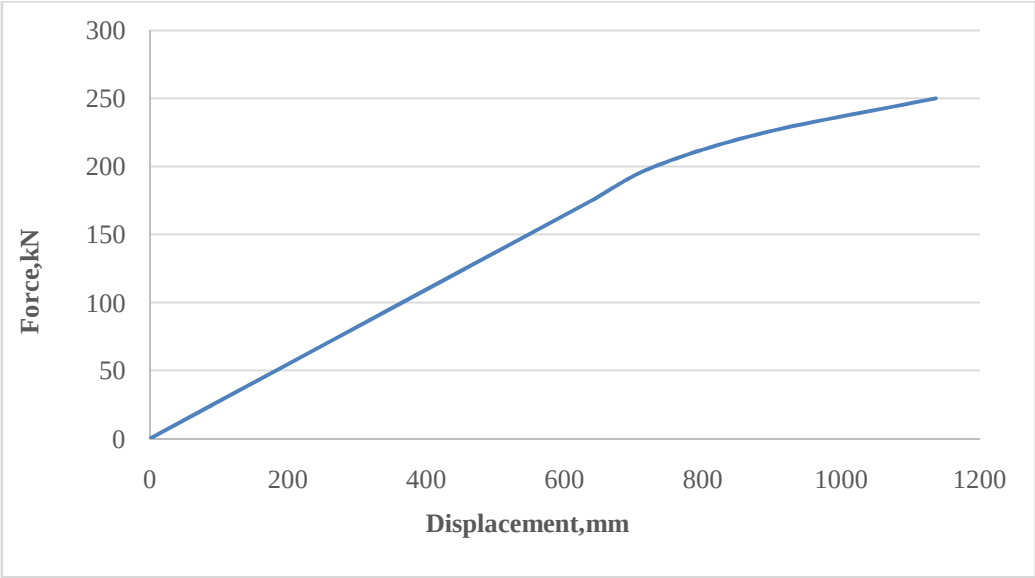

Fig 5.2 Curve obtained for displacement Vs force from the analysis

6.RESULTS OBTAINED FOR ZONE 5

All the 5 models which were analysed for zone III are also analysed for zone V and results for displacement, drift and stiffness are given below.

6.1Storey Displacement

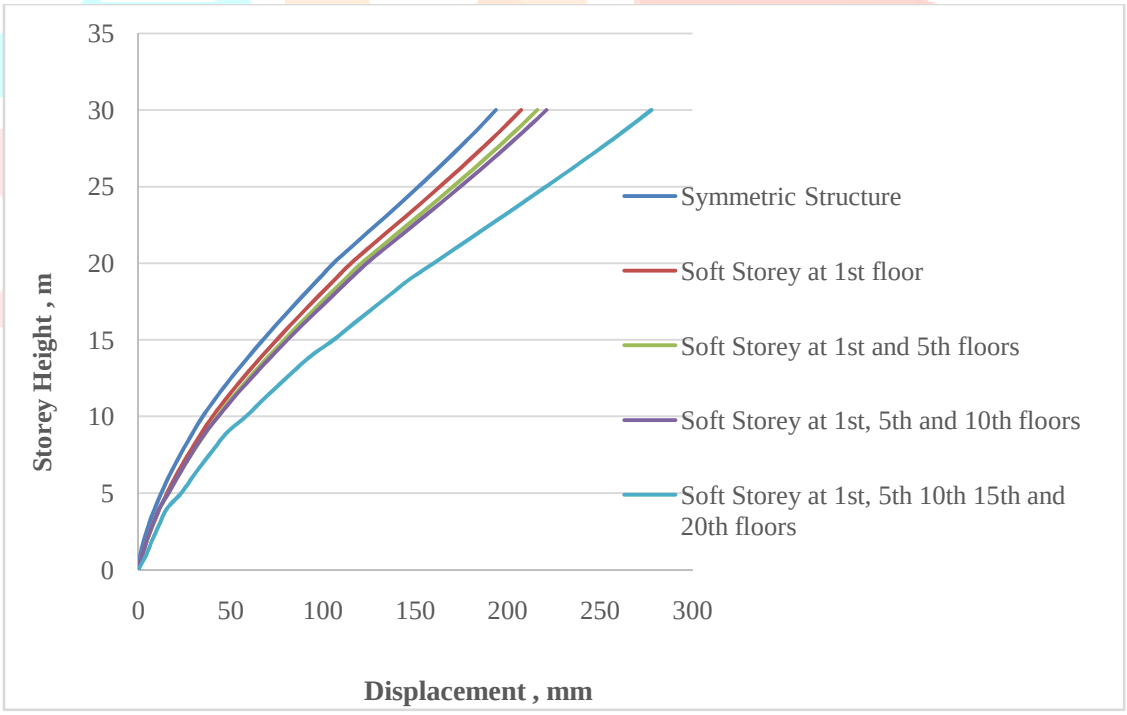

Fig 6.1.1 Storey Displacement for RC structure in Zone V

- The figure 6.1.1 shows the displacement Vs storey height graph for zone V. It shows that the displacements have increased with the increase in the number of soft storeys.

6.2 Storey Drift

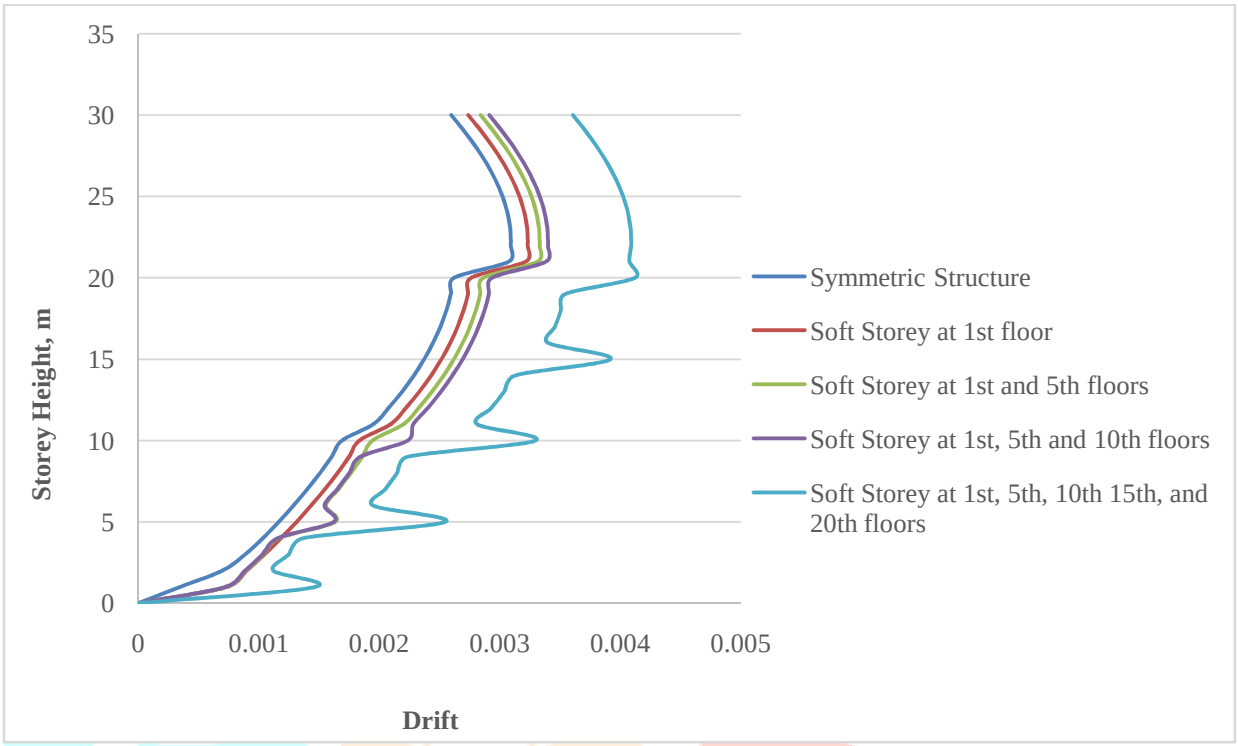

Fig 6.2.1 Storey Drift for RC structure in Zone V

- The figure 6.2.1 shows the graph for storey drift over storey height. It is observed that the drift is increased in the structure which is having soft storey in first, fifth, tenth, fifteenth and twentieth storeys.

6.3 Storey Stiffness

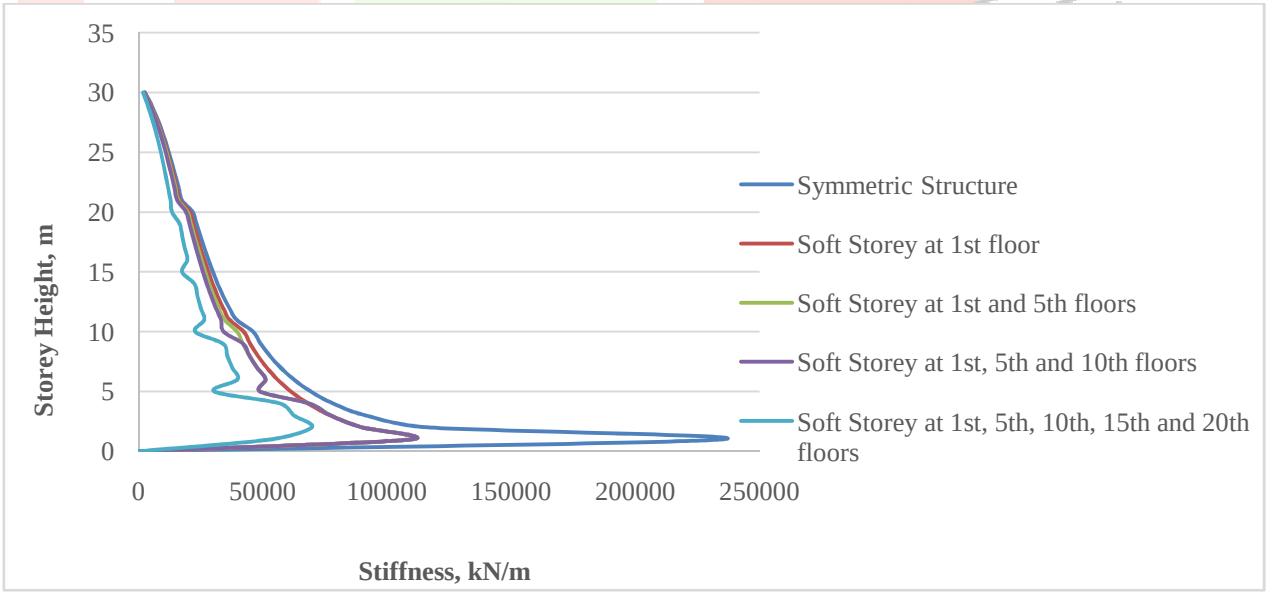

Fig 6.3.1 Storey Stiffness for RC structure in Zone V

- The figure 6.3.1 shows the graph for storey drift Vs storey height. The stiffness of the structure which is having soft storeys have reduced when compared with its upper storeys. Hence according to IS **1893 Part-1(2016)** it states that if the stiffness of the storey is less than that of the above storey then the structure might get severely damaged during the earthquake.

7.COMPARISION OF STOREY DISPLACEMENT BETWEEN ZONE III AND ZONE V

The maximum storey displacement comparison is done between zone III and zone V and the results obtained are given below.

7.1 Storey Displacement

MAXIMUM DISPLACEMENT		
Soft Storey	**Zone III**	**Zone V**
Without soft storey	86.001	193.502
At 1st floor	92.159	207.357
At 1st and 5th floors	96.004	216.008
At 1st, 5th and 10th floors	98.192	220.932
At 1st, 10th and 20th floors	123.479	277.829

Table 7.1.1 Comparison of Storey Displacement of a RC structure between Zone III and Zone V

- From above results it is clear that there is a drastic change in the displacement from lower zone to higher zones. So, it is not advisable to build the soft storey in higher zones.

8.CONCLUSIONS

The conclusion of this study was to know how well the structure with soft storey can behave when it is subjected to earthquake by response spectrum method. The following are the reasons why we should avoid giving soft storey in a structure.

- The study shows that there is a drastic change in the displacement when the soft storeys were introduced that would result in decrease in the strength of the structure and also leads to collapse.
- The storey drift of the structure was increased due to the effect of soft storey. Hence the structure will tend to fail under moderate to severe earthquakes.
- The stiffness of the structure was reduced and the result of this is that the structure will lose its capacity to act well under earthquake forces and it might affect the age of the structure as well.
- There is a drastic change in the displacement from lower zone to higher zones. So, it is not advisable to build the soft storey in higher zones.

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