ANALYSIS OF SOFT STOREY EFFECT AT DIFFERENT LEVELS IN A FRAMED STRUCTURE WITH AND WITHOUT SHEAR WALL FOR DIFFERENT SEISMIC ZONE

Sanjay G K[1], Dr. B Shivakumara swamy[2]

[1]*Mtech, Department of civil engineering, Dr Ambedkar Institute of Technology, Bengaluru, Karnataka, India*
[2]*Professor and Head, Department of civil Engineering, Dr. Ambedkar Institute of Technology, Bengaluru, Karnataka, India*

Abstract - *Soft storey is the one which the lateral stiffness is less than that in the storey above. The Storey lateral stiffness is the total stiffness of all seismic force resisting elements resisting lateral earthquake shaking effects in the considered direction (IS 1893 Part 1):2016. In urban India in the modern multi storey constructions open first storey is a typical feature. In seismically active regions the buildings built with open storey are undesirable. Due to the advantage of open space for the purpose of parking and for commercial use soft storey is adopted in high rise buildings. As all know the buildings with soft storey leads stiffness irregularity in a structure, because of this the structure undergoes unequal storey drifts, plastic hinges will be formed and this may leads to collapse of the structure. In this study tried to determine the performance of a building with soft storey (G+15) at various level and also we tried to check the results of the same structure along with "shear wall". Static analysis and linear response spectrum analysis are done using the software SAP2000 and the results obtained from the structure like storey displacement, storey shear, Storey drift and time period were compared with the structure with and without shear wall for seismic zone III & V.*

Key Words: **Soft storey**, **Shear wall, Response spectrum analysis, Displacement, SAP2000**

1. INTRODUCTION

The basic fundamental earthquake resistant design concept is the strong column - weak beam criteria, so to ensure safety of the users ie., the beam should yield before the columns get failed. We can observe that from the past earthquakes lot of buildings that collapsed because of the opposite strong beam – weak columns behavior ie., the columns failed before the beams get yielded. This happens due to the provision of soft storey.

Soft storey is one which the lateral stiffness is less than that in the storey above (IS 1893 Part 1:2016). The storey lateral stiffness is the total stiffness of all seismic force resisting elements resisting lateral earthquake shaking effects in the considered direction. The buildings which have open space are characterized as soft storey buildings. In India many high rise buildings have open space in first storey, this became a common feature now a days. The main purpose of this adaptation is to provide parking facility or for commercial use, these type of buildings are known as "open ground storey (OGS)" buildings.

1.1 Location of soft storey

In the multi storey building the soft storey can be formed at any level to serve various purposes and to fulfill required function necessity, due to various needs a soft storey is also unavoidable and thus it becomes very important to study the performance of a soft storey building and study its effect. Generally in a structure the weak or soft storey is provided at the ground storey level but open storey can be provided at any other floor level.

1.2 OBJECTIVES

The following are the objectives of the present study.

- To analyze the soft storey effect in a framed structure at different levels.
- To study the behavior of the structure with a soft storey at different floor level.
- To find out the optimum level of the soft storey in a framed structure.
- To study the behavior of the structure with soft storey at different level for different seismic zone.

1.3 METHODOLOGY

Following method is adopted for the analysis,

1. Extensive literature review is carried out.
2. Using the software SAP2000 analysis of the buildings having soft storey is done.
3. Various parameters like displacement, storey drift, and storey shear and time period were obtained.
4. Based on the results obtained conclusion has been done.

2. MODELING

This contains the modeling of the building which has G+ 15 storeys having soft storey at different levels, the equivalent static analysis and response spectrum analysis has been carried out using the software SAP2000.

Following are the models considered for the analysis,

Case1: Bare frame

Case2: Models without Shear wall

- Soft storey at GF
- Soft storey at GF,5,10 Floor
- Soft storey at 3,9 & 10 Floor

Case3: Models with Shear wall

- Soft storey at GF
- Soft storey at GF,5,10 Floor
- Soft storey at 3,9 & 10 Floor

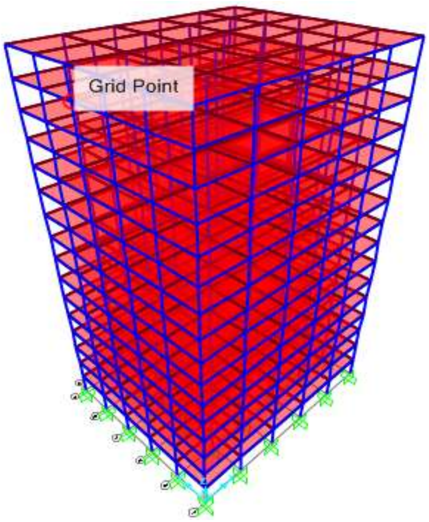

Fig 1. Bare frame model.

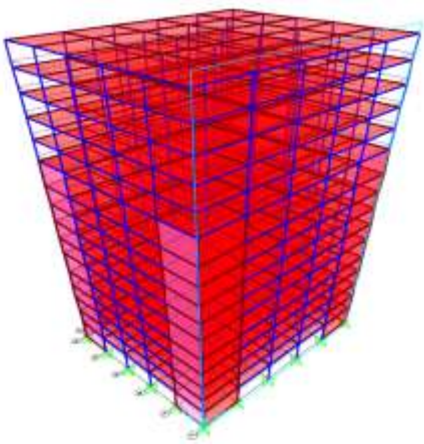

Fig 2. Model with soft storey and shear wall upto soft storey

Table -1: Structural Description

Data for building	Dimension
No. of storey	G+15
Plan dimension	30X25m
Typical storey height	3.2m
Slab thickness	150mm (M25)
Wall thickness	200mm
Shear wall thickness	200mm (M30)
Beam size	200X600mm(M25)
Column size	600X600mm(M30)
Floor finish	2 kN/m2
Live load	3 kN/m2
Grade of Steel	Fe 415
Earthquake data	Zone III & Zone V, Type II medium soil, Importance factor 1

3. ANALYSIS

The equivalent static analysis and response spectrum analysis is done for the buildings by considering they are located in seismic zone III & V.

4. RESULTS AND DISCUSSIONS

The various parameters like displacement, storey drift, time period, and storey shear are obtained by carrying equivalent static analysis and response spectrum analysis for the different models considered in this study.

4.1 Displacement

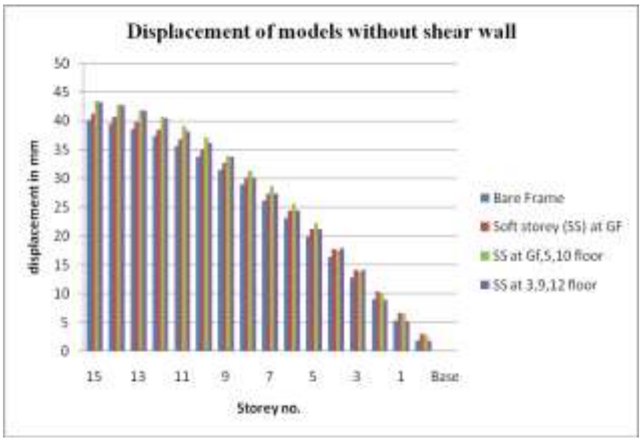

Fig 3: Graph of displacement of model without shear wall for Zone III in x direction.

Fig. 3 shows the graph of displacement of building in X direction for models Bare frame, soft storey at GF, soft storey at GF,5,10 floor, soft storey at 3,9,12 Floor obtained by dynamic analysis for zone3.Soft storey at GF,5,10 floor has higher displacement compare to other models. The maximum displacement of the building found to be 43.43mm in the model having soft storey at GF.

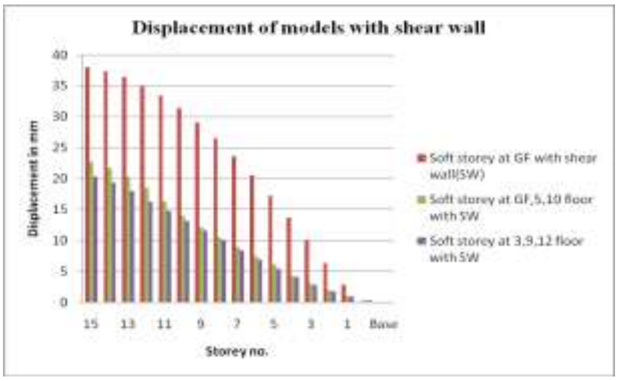

Fig 4: **Graph of displacement of model with shear wall for Zone III in x direction.**

Fig. 4 shows the graph of displacement of building in X direction for models Bare frame, soft storey at GF, soft storey at GF,5,10 floor, soft storey at 3,9,12 Floor obtained by dynamic analysis for zone3. Soft storey at GF has higher displacement compare to other models. The maximum displacement of the building found to be 37.93mm in the model having soft storey at GF.

Fig 5: **Graph of displacement of model without shear wall for Zone V in x direction.**

Fig. 5 shows the graph of displacement of building in X direction for models Bare frame, soft storey at GF, soft storey at GF,5,10 floor, soft storey at 3,9,12 Floor obtained by dynamic analysis for zone 5.Soft storey at GF,5,10 floor has higher displacement compare to other models. The maximum displacement of the building found to be 97.73mm in the model having soft storey at GF,5,10 floor.

Fig 6: **Graph of displacement of model with shear wall for Zone V in x direction.**

Fig. 6. shows the plots of displacement of building in X direction for models Bare frame, soft storey at GF, soft storey at GF,5,10 floor, soft storey at 3,9,12 Floor with shear wall upto the level of soft storey obtained by dynamic analysis for zone 5. Soft storey at GF has higher displacement compare to other models. The maximum displacement of the building found to be 85.35mm in the model having soft storey at GF.

4.2 Time period

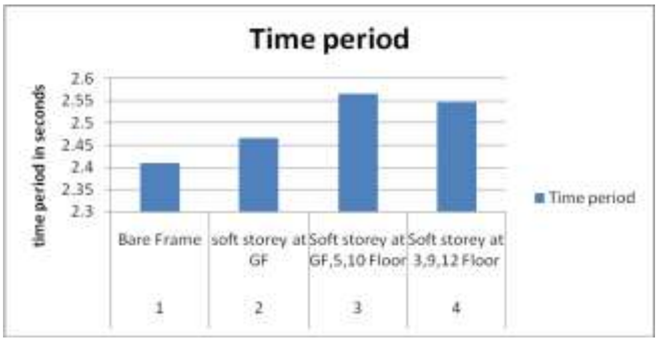

Fig 7: **Graph of time period of models without shear wall for seismic zone III & V.**

The above Fig.7 shows the time period of the models bare frame, having soft storey at ground floor, soft storey at GF, 5, 10 floor and soft storey at 3,9,12 floor without shear wall for the seismic zone 3 and zone 5. The maximum time period 2.566 seconds for the model soft storey at GF, 5, 10 floor.

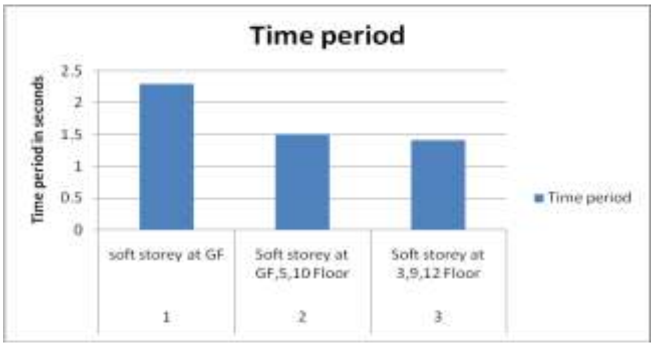

Fig 8: **Graph of time period of models with shear wall for seismic zone III & V.**

The above Fig.8 shows the time period of the models having soft storey at ground floor, soft storey at GF, 5, 10 floor and soft storey at 3,9,12 floor with shear wall for the seismic zone 3 and zone 5.The maximum time period 2.30508 seconds for the model soft storey at Ground floor.

4.3 Base shear

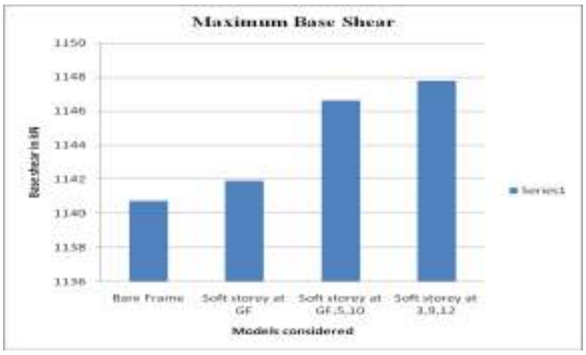

Fig 9.Base Shear for models without Shear wall in seismic zone III in x-direction.

The above Fig.9 shows the storey maximum base shear v/s various models considered in the analysis. It is observed that the maximum base shear value 1147.77 kN is occurred in the model having soft storey at 3, 9 and 12th floor without shear wall in the X direction located in seismic zone3. It is also observed that, as the level of the soft storey increases the base shear of the structure also increases.

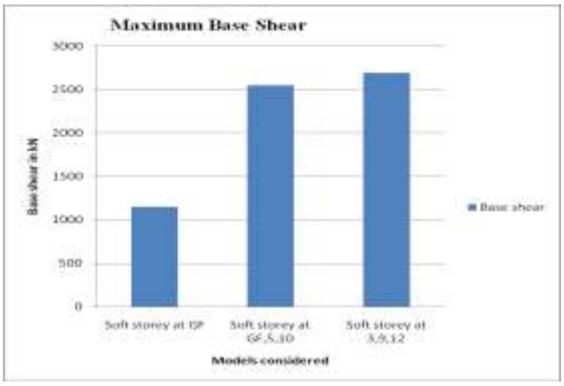

Fig 10.Base Shear for models with shear wall in seismic zone III in x-direction.

The above Fig.10 shows the storey maximum base shear v/s various models considered in the analysis. It is observed that the maximum base shear value 2686.6 kN is occurred in the model having soft storey at 3, 9 and 12th floor with shear wall in the X direction located in seismic zone3. It is also observed that, as the level of the soft storey increases the base shear of the structure also increases.

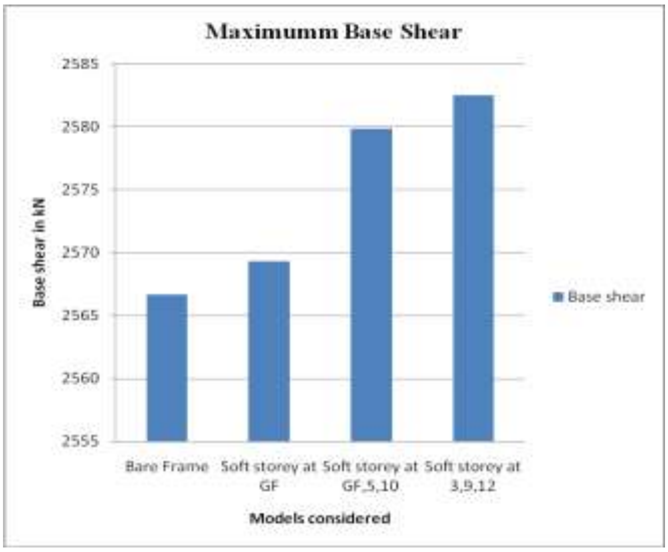

Fig 11. Base shear for models without shear wall in seismic zone V in x-direction.

The above Fig.11 shows the storey maximum base shear v/s various models considered in the analysis. It is observed that the maximum base shear value 2582.4884 kN is occurred in the model having soft storey at 3, 9 and 12th floor without shear wall in the X direction located in seismic zone5. It is also observed that, as the level of the soft storey increases the base shear of the structure also increases.

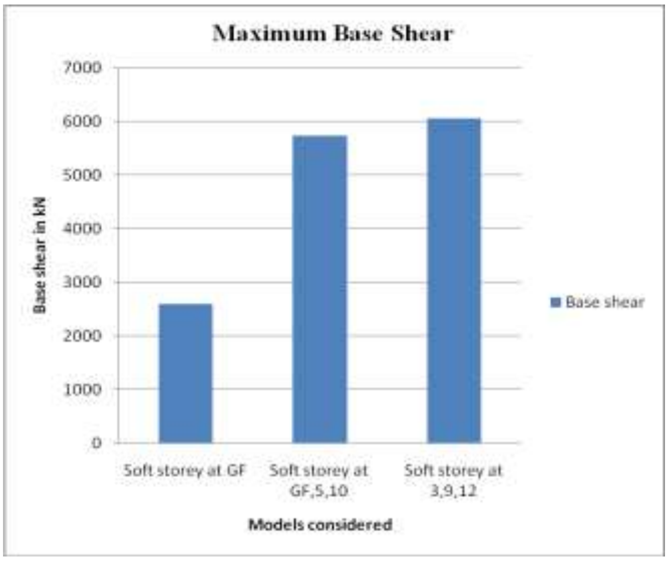

Fig 12. Base shear for models with shear wall in seismic zone V in x-direction.

The above Fig.12 shows the storey maximum base shear v/s various models considered in the analysis. It is observed that the maximum base shear value 6044.85 kN is occurred in the model having soft storey at 3, 9 and 12th floor with shear wall in the X direction located in seismic zone5. It is also observed that, as the level of the soft storey increases the base shear of the structure also increases.

4.4 Storey drifts

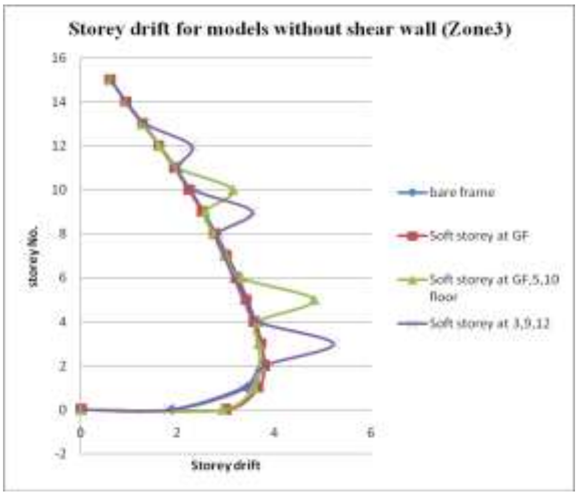

Fig.13: Storey drifts for models without Shear wall for zone3 in x-direction

The above Fig.5.11 shows the storey drift v/s storey number graph, it is observed that the drift is maximum in the storeys where the soft storey is located. The maximum value of storey drift in the X direction 4.809648 is occurred in the building having soft storey at GF,5, and 10 floor without Shear wall located in seismic zone 3.

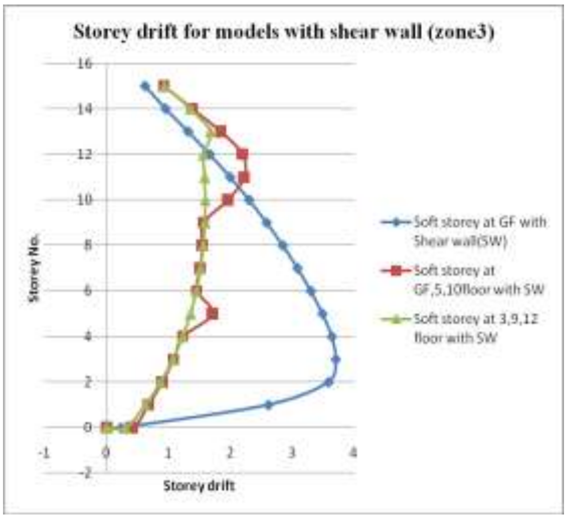

Fig.14: Storey drifts for models with Shear wall for zone3 in X-direction

The above Fig.14 shows the storey drift v/s storey number graph, it is observed that the drift is maximum in the storeys where the soft storey is located. The maximum value of storey drift in the X direction 3.70142 is occurred in the building having soft storey at Ground floor and with Shear wall located in seismic zone 3. It is also observed that the storey drift is considerably reduced when the shear wall is introduced upto the level of soft storey provided.

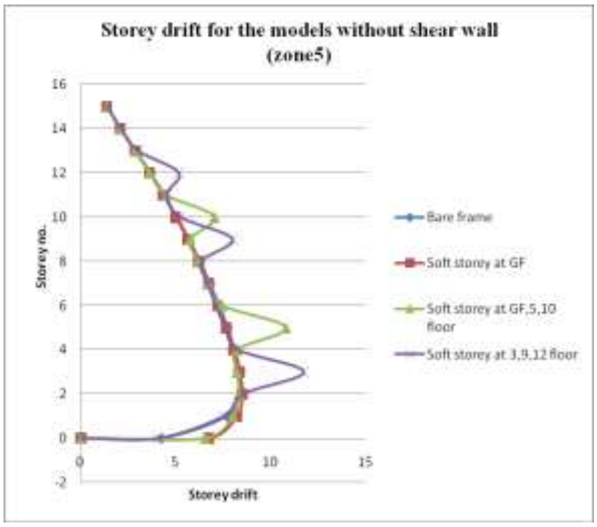

Fig.15: Storey drifts for models without Shear wall for zone5 in X-direction

The above Fig.15 shows the storey drift v/s storey number graph, it is observed that the drift is maximum in the storeys where the soft storey is located. The maximum value of storey drift in the X direction 11.75436 is occurred in the building having soft storey at 3,9 and 12th floor without Shear wall located in seismic zone 5.

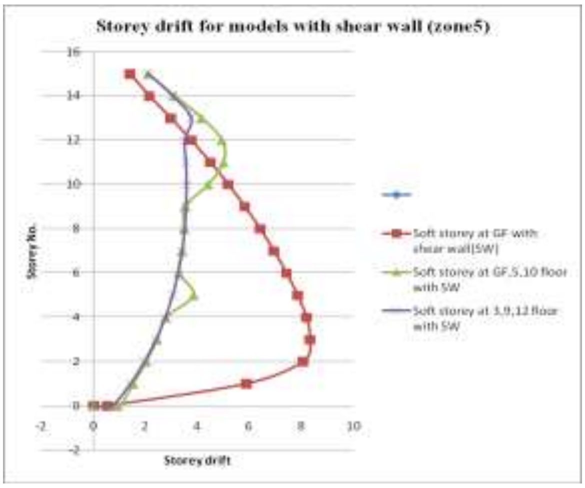

Fig.5.17: Storey drifts for models with Shear wall for zone5 in X-direction

The above Fig.5.17 shows the storey drift v/s storey number graph, it is observed that the drift is maximum in the storeys where the soft storey is located. The maximum value of storey drift in the X direction 8.32819 is occurred in the building having soft storey at Ground floor and with Shear wall located in seismic zone 5. It is also observed that the storey drift is considerably reduced when the shear wall is introduced upto the level of soft storey provided.

5. CONCLUSIONS

Following conclusions were drawn from the present study,

- Building having soft storey at GF,5,10 floor level without shear wall has highest value of displacement in both X & Y direction in zone III
- The displacement value is considerably reduced in the buildings with shear wall upto the soft storey level in both X & Y direction.
- The structure having soft storey at GF,5,10 floor has the more value of time period in both seismic zone III & V compared to the other models.
- Displacement and storey drift value is higher in the model having soft storey at GF,5,10 floor.
- Storey drifts varies with the shear wall provided in the structure.
- Base shear increases with the level of soft storey increases. Base shear is 2.34 times & 4.39 times higher in the structure located in seismic Zone 5 with shear wall in X&Y direction respectively compared with bare frame to the structure having soft storey at 3,9 & 12th floor.
- The soft storey at 3,9,12 floor with shear wall is the optimum level for the soft storey provision as the displacement is less compared to other model.

FUTURE SCOPE OF WORK

- Study the effect of soft storey in a building at different level with shear wall throughout the height of the building and also the shear wall at the centre of the building.
- Study the effect of soft storey at different level for structure having irregularity in plan.
- The structure can be analyzed in different soil type and seismic zone.

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BIOGRAPHIES

Sanjay G K.
M Tech, Structural Engineering,
Department of Civil Engineering,
Dr. Ambedkar Institute of Technology,
Bengaluru-560056

Dr. B. Shivakumara Swamy
Professor and Head,
Department of Civil Engineering,
Dr. Ambedkar Institute of Technology,
Bengaluru-560056