# Seismic Retrofitting Strategies for Soft- Ground-Storied Building

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**Abstract - The multistoried buildings with open (soft) ground floor are inherently vulnerable to collapse due to earthquake load, their construction is still widespread in the developing nations. Social and functional need to provide car parking space at ground level far outweighs the warning against such buildings from engineering community. In the present paper, an investigation has been performed to study the behaviour of the columns at ground level of multistoried buildings with soft ground floor subjected to dynamic earthquake loading. The structural action of masonry infill panels of upper floors has been taken into account by modelling them as diagonal struts. Finite element models of six, nine and twelve storied buildings are subjected to earthquake load in accordance with equivalent static force method as well as response spectrum method. It has been found that when infill is incorporated in the FE model, modal analysis shows different mode shapes indicating that dynamic behaviour of buildings changes when infill is incorporated in the model.**

***Key Words*: *Soft Story, Large Openings, seismic performance, earthquake, response spectrum analysis.***

## 1. INTRODUCTION

A soft story known as weak story is defined as a story in a building that has substantially less resistance or stiffness or inadequate ductility (energy absorption capacity) to resist the earthquake-induced building stresses. Soft story buildings are characterized by having a story which has a lot of open space.
[Draft IS: 1893, 2002]. Whereas the total seismic base shear as experienced by a building during an earthquake is dependent on its natural period, the seismic force distribution is dependent on the distribution of stiffness and mass along the height. In buildings with soft first storey, the upper storey's being stiff undergone smaller interstorey drifts. However, the inter-storey drift in the soft first storey is large [2]. Due to the presence of infill walls in the entire upper storey except for the ground storey makes the upper storey much stiffer than the open ground storey.

### 1.1 Soft Story Failure

Due to shortage of land and for effective use of the sites for new constructions, multi-purpose buildings have been built. Most common structural system for lower stories of these buildings has been moment-resisting space frame because it can usually accommodate a parking area, commercial space, open spaces or gardens for architectural reasons. Due to these kinds of provisions, the lateral displacement of the whole structure is governed mostly by the deformation at the lower stories. Hence, it may be essential to estimate the demand and supply in the force and deformation of the members at this part of the building to achieve a reasonable design of these structures.

## 2. LITERATURE REVIEW

Ari Wibow et.al (1), He carried out for Collapse behaviour assessment of precast soft storey building. The major aim of this is to study the load deflection behaviour of soft storey buildings when subjected to lateral loading. Soft-storey consists of the precast concrete columns with relatively weak connection at each end. The objective of this experimental investigation was to study the load-deflection behaviour and the collapse modelling of soft storey buildings when subjected to lateral loading.

Ranjit V. Surve et.al (2), He had an Observation on Performance based Analysis of Multistoried building with soft stories at different levels. The pushover is expected to provide information on the many of responses characteristics that cannot be obtained from an elastic static or dynamic analysis. As we shift soft storey to higher level yielding occur less than the lower level soft storey and lower intensity hinges are forming after maximum number of the push-over steps. Base Shear: Base shear is an estimate of the maximum expected lateral force that will occur due to seismic ground motion at the base of a structure. As height of the building increases the value of base shear also increases due to the increase of seismic weight of the building.

Sharany Haque, Khan Mahmud Amanat et.al (3), Research presented highlighted the importance of explicitly recognizing the presence of the open ground story in the analysis of the complete bare frames neglecting the presence of infills in the upper story, is brought out through the study of an example building with different analytical models

Suchita Hirde and Ganga Tepugade et.al (4), Discussed the performance of a building with soft storey at different level along with at ground level. The nonlinear static pushover analysis is carried out. Concluded it is observed that plastic hinges are developed in columns of ground level soft storey which is not acceptable criteria for safe design. Displacement reduces when the soft storey is provided at higher level.

Hiten L. Kheni and Anuj K. Chandiwala et.al (5), Investigate many buildings that collapsed during the past earthquake exhibited exactly the opposite strong beam weak column behavior means columns failed before the beams yielded mainly due to soft storey effect. For proper assessment of the storey stiffness of buildings with soft storey building, different models were analyzed using software. Concluded the displacement estimates of the codal lateral load
patterns are observed to be smaller for the lower stories and larger for the upper stories and are independent of the total number stories of the models.

Dhadde Santosh et.al (6), Investigate nonlinear pushover analysis is conducted to the building models using ETABS and evaluation is carried for non-retrofitted normal buildings and retrofitting methods are suggested like infill wall, increase of ground story column stiffness and shear wall at central core. Concluded storey drift values for soft storey models maximum values compare to other storeys and the values of storey drift decreases gradually up to the top.

Mr. D. Dhandapany et.al (7), Investigate the seismic behavior of RCC buildings with and without shear wall under different soil conditions. Analyzed using ETABS software for different soil conditions (hard, medium, soft). The values of Base shear, Axial force and Lateral displacement were compared between two frames. Concluded The design in STAAD is found to be almost equal results to compare in ETABS for all structural member.

Misam. A and Mangulkar Madhuri. N. et.al (8), discussed about severe structural damage suffered by several modern buildings during recent earthquakes illustrates the importance of avoiding sudden changes in lateral stiffness and strength. The lower level containing the concrete columns behaved as a soft story in that the columns were unable to provide adequate shear resistance during the earthquake. Usually the most economical way to eliminate such failure in a building is by adding shear wall to soft stories. In this paper occurring of soft story at the lower level of high rise buildings subjected to earthquake has been studied. Also has been tried to investigate on adding of shear wall in various arrangements to the structure.

Ranjit V. Surve, Prof. D.S. Jagtop and Y.P. Pawar et.al (9), investigated on finding the best place for soft storey in high rise building with ground level and also focused on natural time period of multistoried structure. He concluded that shifting of the soft storey to higher level results in reduction of number of hinges and if soft storey is provided at ground level, the base shear was found to be maximum.

Haque and khan et.al (10) concluded that value of base shear is doubled for equivalent static method which is safer design for the columns of soft ground floor.
Base Shear: Base shear is an estimate of the maximum expected lateral force that will occur due to seismic ground motion at the base of a structure. As height of the building increases the value of base shear also increases due to the increase of seismic weight of the building.

Farghaly et.al (11) demonstrated that structures collapsed whenever exposed to quake of PGA magnitude was under 0.25 g, however the slope slant stays stable inside a high seismic tremor extent

Yoshimura et.al (12) uncovered that structure with a base shear quality as 60% of the all out weight at that point breakdown of structures are unavoidable. Mrugesh et al.

reasoned that as the number of story expands parallel burden conveying limit doesn't increment yet relating relocation increments.

## 3. RESULT

Dynamic analysis for RC Frame building with soft storey is done by using response spectrum analysis and time history analysis for earthquake zone III as per Indian standard code. Loads are calculated and distributed as per the code IS: 875 (part-1 to 3) 1987. The effect of location of soft storey at different height of building and effect of shear wall up to the height of soft storey is evaluated. There is significant change in seismic parameters like storey displacement, storey drift, storey shear and time period and is noticed and discussed below.

Table 1 :Displacement for all the models Displacement for all the models

| | Horizontal | Vertical | Horizontal | Resultant |
|---|---|---|---|---|
| | X mm | Y mm | Z mm | mm |
| Model-1 | 38.463 | 9.615 | 31.198 | 39.402 |
| Model-2 | 57.377 | 9.615 | 46.461 | 58.449 |
| Model-3 | 39.2 | 9.565 | 30.396 | 40.31 |
| Model-4 | 58.432 | 9.565 | 45.564 | 59.798 |
| Model-5 | 36.579 | 9.618 | 33.838 | 37.126 |
| Model-6 | 54.562 | 9.618 | 50.34 | 55.021 |
| Model-7 | 39.695 | 9.456 | 37.677 | 40.112 |
| Model-8 | 57.257 | 9.456 | 55.138 | 57.608 |

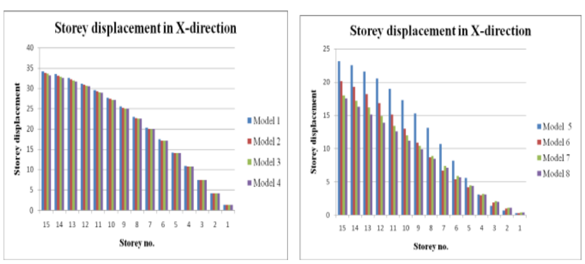


Figure 3: Storey number v/s storey displacement

Table 2 :Reactions for all the models

| | Horizontal | Vertical | Horizontal | Moment | | |
|---|---|---|---|---|---|---|
| | Fx kN | Fy kN | Fz kN | Mx kNm | My kNm | Mz kNm |
| Model-1 | 784.671 | 15557.1 | 361.155 | 670.206 | 4.971 | 1187.11 |
| Model-2 | 1089.22 | 15720.2 | 537.584 | 1000.49 | 7.217 | 1761.92 |
| Model-3 | 1374.82 | 15491.6 | 364.739 | 674.213 | 4.974 | 1196.46 |
| Model-4 | 1753.24 | 15491.6 | 542.41 | 1006.51 | 7.23 | 1775.57 |
| Model-5 | 340.907 | 15560.5 | 793.423 | 681.331 | 9.061 | 1160.11 |
| Model-6 | 508.144 | 15560.5 | 1084.2 | 1021.67 | 13.283 | 1717.43 |
| Model-7 | 350.249 | 20474.1 | 5161.47 | 720.213 | 10.859 | 1239.9 |
| Model-8 | 520.67 | 23481.8 | 5941.4 | 1077.66 | 15.76 | 1828.27 |

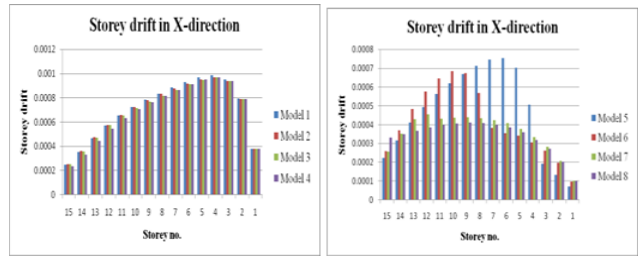


Figure 2 : Storey number v/s storey drift

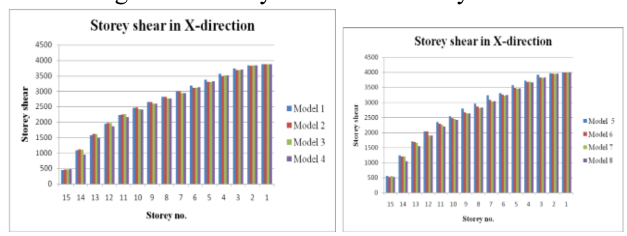


Figure 3: Storey number v/s storey shear

Table 3: Storey number v/s storey shear

| | Fx kN | Fy kN | Fz kN | Mx kNm | My kNm | Mz kNm |
|---|---|---|---|---|---|---|
| Model-1 | 15557.1 | 370.222 | 433.014 | 3.96 | 670.206 | 1187.11 |
| Model-2 | 15557.1 | 541.378 | 622.644 | 5.724 | 1000.49 | 1761.92 |
| Model-3 | 15491.6 | 364.028 | 448.412 | 4.128 | 677.159 | 1196.46 |
| Model-4 | 15491.6 | 530.812 | 635.771 | 5.963 | 1006.51 | 1775.57 |
| Model-5 | 15560.5 | 411.346 | 399.074 | 3.556 | 681.331 | 1160.11 |
| Model-6 | 15560.5 | 593.225 | 584.929 | 5.121 | 1021.67 | 1717.43 |
| Model-7 | 15349.4 | 476.038 | 396.397 | 4.044 | 720.213 | 1189.29 |
| Model-8 | 15349.4 | 656.407 | 591.684 | 5.466 | 1077.66 | 1753.41 |

## 4. SUMMARY

From Study of above literature it is seen that, the study has been carried out to reduce the effect of soft story by different techniques such as infill walls, stiffening of columns, bracing systems & with the use of that we will reduce the seismic effect on soft story building.

## 5. CONCLUSION

1. Model 2 i.e. structure with (G+20) with infill wall shows lowest storey Drift among all the models.
2. Modal Time Period is also lowest in M2. Base shear is increased by 24.32% in M1. Longitudinal Storey displacement is minimum in M2 model.
3. The displacement is decreased by 59.69% in M2 as compared to M1, whereas dis
4. placement in Y direction is decreased by 67.69% in M11.

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