

## REVIEW ON BEHAVIOR OF SOFT STOREY IN BUILDING

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**Abstract** - In high rise building or multi storey building, soft storey construction is a typical feature because of urbanization and the space occupancy considerations. These provisions reduce the stiffness of the lateral load resisting system and a progressive collapse becomes unavoidable in a severe earthquake for such buildings due to soft storey. This storey level containing the concrete columns which were unable to provide adequate shear resistance, hence damage and collapse are most often observed in soft story buildings during the earthquake. In the current study the focus is on the investigation of the effect of a soft storey on the behaviour of a structure and effect of masonry infill on structure.

**Key Words:** Soft Storey.

### 1. INTRODUCTION

Reinforced-concrete framed structure in recent time has a special feature i.e. the ground storey is left open for the purpose of social and functional needs like vehicle parking, shops, reception lobbies, a large space for meeting room or a banking hall etc. Such buildings are often called open ground storey buildings or soft story buildings.

Again when a sudden change in stiffness takes place along the building height, the story at which this drastic change of stiffness occurs is called a soft story. The Indian code (clause no. 4.20) classifies a soft storey as, It is one in which the lateral stiffness is less than 70 percent of that in the storey above or less than 80 percent of the average lateral stiffness of the three storeys above (IS 1893:2002). Soft storey can form at any level of a high rise building to fulfill required functional necessity and serve various purposes.



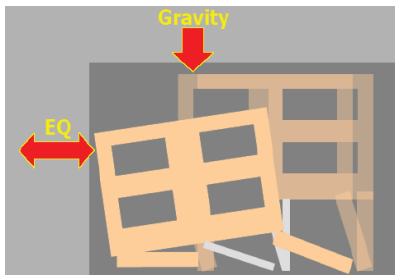
**Fig -1:** Soft storey in reinforced concrete buildings

In the present study, seismic performance of 3D building frame with intermediately infill frame was studied. Performance of R.C. frame was evaluated considering different models for the soft storey. The main objective of the study was to investigate the behavior of high rise, multi-bay soft storey building with and without infilled frames and to evaluate their performance levels when subjected to earthquake loading.

### 2. BEHAVIOR OF SOFT STOREY UNDER EARTHQUAKE

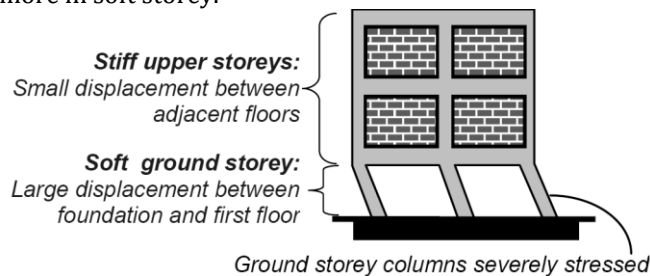
Many building structures having soft stories, suffered major structural damage and collapsed in the recent earthquakes. Large open areas with less infill and exterior walls in ground floor compared to upper floors are the cause of damages. In such buildings, the stiffness of the lateral load resisting systems at those stories is quite less than the stories above or below.

During an earthquake, if abnormal inter-story drifts between adjacent stories occur, the lateral forces cannot be well distributed along the height of the structure. This situation causes the lateral forces to concentrate on the story having large displacement. In addition, if the local ductility demands are not met in the design of such a building structure for that story and the inter-story drifts are not limited, a local failure mechanism or, even worse, a story failure mechanism, which may lead to the collapse of the system, may be formed due to the high level of load deformation effects.



**Fig -2:** Collapse mechanism of a building structure having a soft story.

Lateral displacement of a story is a function of stiffness, mass and lateral force distributed on that story. It is also known that the lateral force distribution along the height of a building is directly related to mass and stiffness of each story. If the P-delta effect is considered to be the main reason for the dynamic collapse of building structures during earthquakes, accurately determined lateral displacements calculated in the elastic design process may provide very important information about the structural behavior of the system. Therefore dynamic analysis procedure is required in many of the actual codes for accurate distribution of the earthquake forces along the building height, determining modal effects and local ductility demands efficiently. The upper stories moves as single block as there is presence of infill masonry which makes it stiffer. Hence displacement is more in soft storey.



**Fig -3:** failure due to large lateral displacement in soft storey

Again During an earthquake, more moment and shear strength fall on the columns and walls in the entrance floors than the one in the upper storeys. As the walls do not exist in the soft storey floor, columns are forced and severely stressed more those in those storeys. If the columns are not capable to resist shear they may be damaged or lead to collapse.



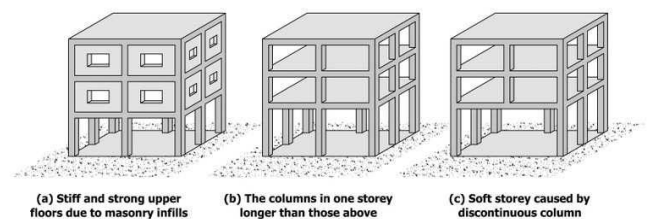
**Fig -5:** Damages in columns during earthquake

## 1.2 Irregularities In Soft Storey Buildings

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Most of the constructions damaged suffer from this irregularity. This irregularity is often found in buildings where open first or ground storey. As a result of investigation on this and other irregularities, it was observed that Codes of Earthquake are not sufficient. For this reason, it comes into forefront that it is necessary for these irregularities to be controlled at the stage of project and construction. It should be known that controlling is one stage in building quake-resistant constructions, and it should be applied.

If one storey is higher than others, or one storey is weaker than others. A soft or weak storey exists if the height of that storey is at least 15% greater than storeys above or below; or if it has at least 30% fewer columns in the case of a frame system, or at least 30% less full-height structural or infill wall length in the case of a wall or infill wall system



**Fig -4:** Irregularities in buildings

## 2.2 Cause of Failure In Soft Storey

Present code of practice does not include provision of taking into consideration the effect of infill. It can be understood that if the effect of infill is taken into account in the analysis and design of frame, the resulting structures may be significantly different.

The common practice of building design considers infill as non structural elements and building is designed as framed structures without regard to structural action of

masonry infill walls. The soft storey effect and presence of infill in any building changes the behavior of frame action due to the relative changes of stiffness of the frame by a factor of three to four times and lateral load distribution. Such buildings are required to be analyzed by the dynamic analysis and designed carefully. As the dynamic ductility demand during probable earthquake gets concentrated in the soft storey and the upper storey tends to remain elastic. Hence the building is totally collapsed due to soft storey effect.

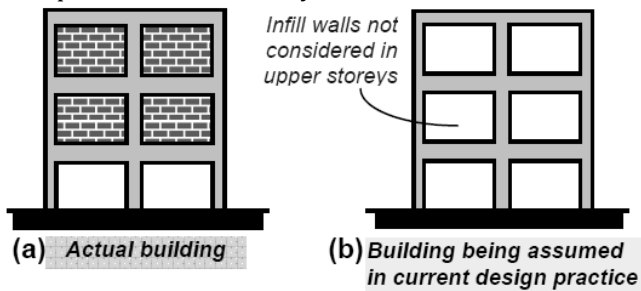


Fig -6: Assumptions made in current design practice are not consistent with the actual structure

### 3. CONCLUSIONS

- From the above it is seen that, when the effect of soft storey is considered then the deflection has increase at that particular floor.
- RC frame buildings with open first storeys are known to perform poorly during in strong earthquake shaking.
- The measures should take to improve capacities of the columns in the soft first storey.
- Since the behaviour of the soft storey is different during a quake, the structural member undergoes damage and to provide member to withstand that additional forces due to soft storey heavy or bulky member need to be provided. This increase financial input.
- Thus proper care, expert design and detailing are needed in soft storey buildings

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