Structural behaviors of Soft Story Buildings under Seismic Action

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Abstract— Now days the high rise or multi story building, soft story construction is a typical feature because of suburbanization and the space occupancy deliberations. .Due to massive growth in population, parking spaces is big attentions for the apartments in the towns. Hence new tendency for utilize the ground story for a parking's, also for office spaces or conference hall etc., soft story at different levels of structure are constructed. After 26th January 2001, Gujarat Earthquake and other earthquakes in India, there is a nation-wide attention to the seismic defenselessness assessment of existing buildings. In the past earthquake has shown that the buildings with simple and uniform shapes are subjected to less damage. Regularity and continuity of stiffness in the horizontal planes as well as in vertical direction is very important from earthquake safety point of view. A building with discontinuity is subjected to concentration of forces and deformations at the point of discontinuity which may leads to the failure of members at the junction and collapse of buildings. Opening in first story is a typical feature in the recent multistory constructions in urban India. Such features are highly undesirable in buildings built in seismically active areas; this has been verified in numerous experiences of strong shaking during the past earthquakes. Though 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 like India. This story level consisting with the concrete columns which are not able to provide tolerable shear resistance, hence damages and collapses are may often observe in soft story buildings during the earthquake. In this experimental study, the focus is on the investigation of the effect of a soft story on the behavior of a structure and effect of masonry infill on building construction.

Key words: Seismic Analysis, Soft First Story, Inter Story Drift

I. INTRODUCTION

RCC framed structure in present period has an exceptional feature i.e. the ground story is left open for the perseverance of social and purposeful desires like vehicle parking, shops, a large space for meeting room or a community hall etc. These buildings are called soft story buildings.

If 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. Soft story buildings, having first stories much less rigid than the story's above are particularly susceptible to earthquake damage because of large, unreinforced openings on their ground floors. Behavior of soft story building to seismic forces has to be critically examined considering various geometrical and seismic parameters as per IS 1893:2002. Soft story can form at any level of a high rise building to fulfill required functional necessity and serve various purposes.

However, Soft story is unexpected change of lateral story stiffness within the structure. An irregularity in vertical configuration tends to create sudden changes in strength or stiffness that may concentrate earthquake forces or other forces in an unpredictable manner.

An Soft Story is one in which the lateral stiffness is less than 70 percent of that in the story above or less than 80 percent of the average lateral stiffness of the three story above

A. Extreme Soft Story

An extreme soft story is one in which the lateral stiffness is less than 60 percent of that in the story above or less than 70 percent of the average stiffness of the three story above.

Fig. 1: Shows the soft story at ground floor, no infill walls are provided at ground story and fig. 2 shows soft stories at different floors used for office spaces

Fig. 2: Example of soft storey at different levels

II. BEHAVIOR OF SOFT STOREY UNDER EARTHQUAKE

The Soft Story structures were suffered with massive 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 occur between adjacent stories then, 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.

Lateral displacement of a story is a role of stiffness, mass and lateral force distributed on that story. This has 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 story.

Fig. 2: Failure due to large lateral displacement in soft story

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 story. As the walls do not exist in the soft story floor, columns are forced and severely stressed more those in that story. If the columns are not capable to resist shear they may be damaged or lead to collapse.

Several building structure having parking or commercial areas in their first stories, suffered major structural damages and collapsed in the recent earthquakes. Large open areas with less infill and exterior walls and higher floor levels at the ground level result in soft stories and hence damage. In such buildings, the stiffness of the lateral load resisting systems at those stories is quite less than the stories above or below. In Fig. 3, the lateral displacement diagram of a building with a soft story under lateral loading is shown.

Fig. 3: Soft story behavior of a building structure under lateral loading

III. OBJECTIVES

Several research papers are available to understand the behavior of soft story when provided at ground level but very few papers are available when soft story is provided at upper level. However there is little work carried out by researcher related to finding vulnerability of existing RCC building with soft story at different levels in multistory building. Hence it is proposed to study vulnerability of existing RCC building with soft story at GL along with at intermediate floor using nonlinear static analysis.

The important aim of performance based earthquake engineering is to avoid total disastrous damage and to restrict the structural damage caused to the performance limit of the structure and to check its performance level.

In this research work try to emphasize the measures should take to improve capacities of the columns in the soft first story.

IV. IRREGULARITIES IN SOFT STORY BUILDINGS

Most of the constructions damaged suffer from this irregularity. This irregularity is often found in buildings where open first or ground story. 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 story is higher than others, or one story is weaker than others. A soft or weak story exists if the height of that story is at least 15% greater than story 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

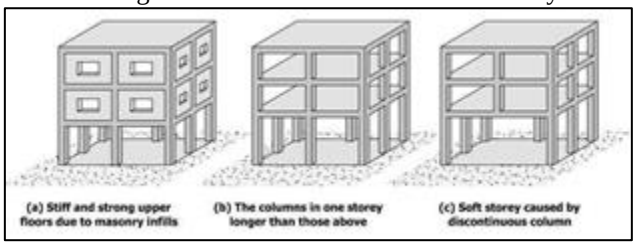

Fig. 4: Irregularities in buildings

V. CAUSE OF FAILURE IN SOFT STORY

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 nonstructural elements and building is designed as framed structures without regard to structural action of masonry infill walls. The soft story 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 story and the upper story tends to remain elastic. Hence the building is totally collapsed due to soft story effect.

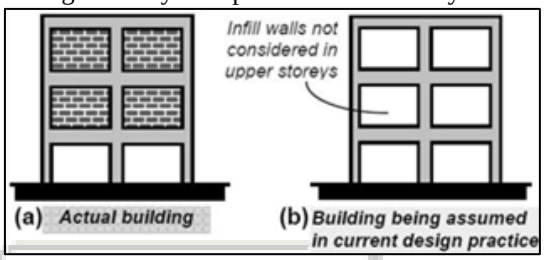

Fig. 5: Assumptions made in current design practice are not consistent with the actual structure

VI. CONCLUSIONS

1) From the above it is seen that, when the effect of soft story is considered then the deflection has increase at that particular floor.
2) RC frame buildings with open first story are known to perform poorly during in strong earthquake.
3) The measures should take to improve capacities of the columns in the soft first story.

   Since the behavior of the soft story is different during a quake, the structural member undergoes damage and to provide member to withstand that additional forces due to soft story heavy or bulky member need to be provided. This increase financial input.
4) Thus proper care, expert design and detailing are needed in soft story buildings

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