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Review on Shear Wall for Soft Story High-Rise Buildings

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Abstract—Severe structural damage suffered by several modern buildings during recent earthquakes illustrates the importance of avoiding sudden changes in lateral stiffness and strength. Recent earthquakes that occurred have shown that a large number of existing reinforced concrete buildings are vulnerable to damage or even collapse during a strong earthquake. While damage and collapse due to soft story are most often observed in buildings, they can also be developed in other types of structures. 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. So, in this paper highlights the importance for immediate measures to prevent the indiscriminate use of soft first story in buildings, which are designed without regard to the increased displacement, ductility and force demands in the first story and this paper argues the importance of novel design approach which has an advantage of interaction between rigid frames and shear walls. A combination of the two structural components leads to a highly efficient system, in which the shear wall resists the majority of the lateral loads in the lower portion of the building, and the frame supports the majority of the lateral loads in the upper portion of the building

Keywords — High rise buildings, RC frame linear behavior of shear wall, Soft Story /Weak Story.

I. INTRODUCTION

Urbanization and Growth of high rise buildings-United Nation sources predict that between 1990 and 2020 the urban population of developing countries will increase by 160%, a total Increase of 2.2 billion people. More and more large cities or even 'mega-cities' (defined by the United Nations (UN) as a city with a population of over eight million) will be created. The process of urbanization has been a common feature throughout the past decades, as communities generally intended to settle in favorable locations and to focus their commercial, political and cultural activities around central points which leads towards growth of High-rise Building.

Many urban high rise buildings in India today have open first story as an unavoidable feature. The base floors of the existing buildings are generally arranged as garages or offices. No walls are built in at these floors due to its prescribed usage and comfort problems. But upper floors do have walls separating rooms from each other for the residential usage. In these arrangements, the upper floors of most buildings are more rigid than their base floors. As a result, the seismic behaviors of the base and the upper floors are significantly different from each other. This phenomenon is called as the soft-story irregularity. "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." If a building has a floor which is 70% less stiff than the floor above it, it is considered a soft story building (UBC-1997, IBC-2003 and ASCE-2002). This soft story creates a major weak point in an earthquake, and since soft stories are classically associated with retail spaces and parking garages, they are often on the lower stories of a building, which means that when they collapse, they can take the whole building down with them, causing serious structural damage which may render the structure totally unusable.

II. PROBLEM STATEMENT

The most destructive and unfortunately the most general irregularity in India stock of building structures that lead to collapse is certainly the soft story irregularity. The commercial and parking areas with higher story heights and less infill walls reduce the stiffness of the lateral load resisting system at that story and progressive collapse becomes unavoidable in a severe earthquake for such buildings.

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 story, the upper story's being stiff, undergo smaller inter-story drifts. However, the inter-story drift in the soft first story is large. The strength demands on the columns in the first story for third buildings are also large, as the shear in the first story is maximum. For the upper story's, however, the forces in the columns are effectively reduced due to the presence of the Buildings with abrupt changes in story stiffness's have uneven lateral force distribution along the height, which is likely to locally induce stress concentration. This has adverse effect on the performance of buildings during ground shaking.

Soft story's are subjected to larger lateral loads during earthquakes and under lateral loads their lateral deformations are greater than those of other floors so the design of structural members of soft stories is critical and it should be different from the upper floors. 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.

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Nevzat Kirac et al[1] "Following factors or parameters affect the weak-story irregularity formation in structures;

- Height of the weak-story.
- Existence of mezzanine floor.
- Rigidity and distribution of columns in weak-story.
- Overhang and cantilever projection existence in weak-story.
- Infill wall material properties.
- Soil class and properties.
- Floor number.
- Seismic conditions."

These factors must be considered for eliminating the destructive effects of the weak-story irregularity.

If weak story present in buildings, measures must be taken for preventing the adverse effects of this irregularity.

III. REVIEW OF LITERATURE

Shear walls are one of the most efficient lateral force resisting elements in multistoried buildings. Shear walls are incorporated in conjunctions with steel or reinforced concrete moment resisting frame to resist the major portion of lateral load induced by an earthquake.

A significant amount of research work on various structural aspects of shear walls has been done by many investigators and till date the structural walls are among the major concern in the research area. Such as

Khan and Sbarounis [2] proposed a novel design approach of combining the frame with shear wall for soft story building to minimize the weak story effects during earthquake. The lateral load resistance of tall wall-frame building structures comprising a combination of moment-resisting frames and shear walls that are reduced in size or terminated entirely at intermediate heights is investigated. Nollet and Smith [3] investigated the behavior of wall frame structure using two-dimensional models, in which shear walls were reduced in size or terminated entirely at intermediate heights and proposed that curtailment of walls was not necessarily detrimental to the performance of the structures. Frank*et al* [4] carried out experiments on wood shear walls and found that walls with oversized large panels resisted more load. Jaswant N. Arlekar *et al*[5] focused on immediate measures need to be adopted to prevent seismic responses of soft first story's in buildings, by avoiding the existents of soft first story's and by providing adequate lateral strength in the first story. Wen and Song [6] had carried out the redundancies of SMRF and dual systems by considering various structural configuration (number of bays and shear walls), ductility capacity, uncertainty in demand and capacity, interaction between walls and moment frames, and three-dimensional (3-D) motions and found that in a dual system the number of shear walls had a small effect on structural reliability under earthquake. Rahul Rana et al [7] had discussed the importance of Pushover analysis as a useful tool of Performance Based Seismic Engineering to study post-yield behavior of a structure which requires less effort and deals with much less amount of data than a nonlinear response history analysis. Zhao and Abolhassan [8] discussed the advantages and disadvantages of traditional RC Shear walls and steel walls. They found that composite shear walls, that is, steel plate shear wall with RC wall attached to one side of it using bolts can mitigate most of the disadvantages of both RC and steel shear walls and take advantage of the best characteristics of the 2 construction materials affected the maximum base shear caused by earthquakes of steel and concrete.

Han-Seon Lee and Dong-Woo Ko[9] analyses seismic response on high-rise RC bearing-wall structures with three types of irregularity at the bottom stories and states that the existence of shear wall reduces remarkably shear deformation at the lower frame, but had almost a negligible effect on the reduction of the overturning deformation, base shear, and overturning moment (OTM).

O. Esmaili, S. Epackachi, M. Samadzad and S.R. Mirghaderi [10] studied the structural aspects of one of the tallest RC buildings, located in the high seismic zone, with 56 stories. In which shear wall system with irregular openings were utilized under both lateral and gravity loads, concluded that confinement of concrete in shear walls is a good way to provide more level of ductility and getting more stable behavior. M. Ashraf*, Z.A. Siddiqi and M.A. Javed [11] proposes that the proper placement of shear wall at a point of coinciding center of gravity and centroid of the building by carrying out experiment on multistory building by changing shear walls location which were subjected to lateral and gravity loading in accordance with UBC provisions.

Shahabodin. Zaregarizi [12] had done comparative study on shear walls and concrete infill's to improve seismic performance on existing buildings and found that concrete infill's have considerable strength while Brick one has lower strength and such combination of concrete and brick infill's can reduces the negative effects of brick and concrete infill's. Anshuman. S , Dipendu Bhunia , Bhavin Ramjiyani[13]focused on the solution for shear wall location in multistory building based on its both elastic and elastic-plastic behaviors. R. S. Malik, S. K. Madan, V. K. Sehgal [14] analyzed the effect of height on the curtailment of shear wall. R.C special moment resisting frames and concluded that that curtailment of shear wall up to 50% height of the building had a marginal effect on the distribution of horizontal story shear among the shear wall frames and interior frames. But height of the building has a significant role in story shear distribution.

S. V. Venkatesh, H. Sharada Bai [15] discussed, the difference in structural behavior of 10 story basic moment resisting RC frames when provided with two different types of shear wall as Lateral (earthquake) Load Resisting Structural systems (LLRS) concluded that External shear walls serve as an alternative to internal shear walls in retrofitting seismically deficient structures, particularly when it is not possible to vacate the building during retrofitting.

IV. CONCLUSION AND RECOMMENDATIONS

RC frame buildings with open first story's are known to perform poorly during in strong earthquake shaking .The large opening on the lowest floor causing the stiffness is relative low compare to the stiffness at the story above thus there is need of immediate measure to prevent to indiscrimate use of soft story in building which are design without regard to increase the displacement ,ductility and force demand in the first story this paper highlight the various factors which are responsible for failure of high rise building under seismic forces and also argues the importance of shear wall as a one of the efficient approach to eliminate seismic failure of soft story high rise building

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This paper has tried to discuss various aspects regarding shear wall discussed by many of the investigators on adding shear wall to the building in different arrangement in order to reduce soft story effect on structural seismic response in earthquake excitation. It was found that location , number and curtailment of shear wall acts an important factor for the soft story structures to displace during earthquake.

From the review of literature its shows that use of shear wall is a good way to provide more level of ductility and getting more stable behavior and appear to be an novel approach to reduce effect of soft story in seismic response .in the other hand, vulnerability level of existing high rise building can be increased by adding different arrangement of shear wall on building and it will help for retrofitting of structure to resist the major portion of lateral load induced by an earthquake

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