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Review on Effective utilization of RCC Shear walls for Design of Soft Storey Buildings

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ABSTRACT
Multi-storey buildings in metropolitan cities require open taller first storey for parking of vehicle and/or for retail shopping, large space for meeting room or a banking hall owing to lack of horizontal space and high cost. Due to these functional requirements, the first storey has lesser strength and stiffness as compared to upper stories, which are stiffened by masonry infill walls. Increased flexibility of first storey results in extreme deflections, which in turn, leads to concentration of forces at the second storey connections accompanied by large plastic deformation. In addition, most of the energy developed during the earthquake is dissipated by the column of the soft stories. In this process the plastic hinges are formed at the ends of column, which transform the soft stories into a mechanism. In such cases the collapse is unavoidable. Therefore, the soft stories deserve a special consideration in analysis and design.
Keywords: Analysis, ETABs, High Rise, RCC Shear Wall, Soft Storey, Seismic Performance

I. INTRODUCTION

This study investigates the analytical results and designing provisions for soft storey buildings with and without shear walls, obtained from available literature. The Indian seismic code IS 1893 (Part1): 2002 classifies a soft storey as "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 stories above. Such building act as an Inverted Pendulum during earthquake, as shown in Fig. 1(a), experiencing larger lateral loads which swing back and forth producing high stresses in columns and if columns are incapable of taking these stresses and lateral loads or do not posses enough ductility, they could get severely damaged and which can also lead to collapse of the building. Shear wall systems are one of the most feasible and hence commonly used lateral loads resisting mechanism employed in high rise buildings. Hence it is very necessary to determine the most effective location of shear walls. Shear wall arrangement must be absolutely accurate, because if not, it will cause overturning effect instead. Shear walls in buildings are symmetrically located in plan to reduce ill-effects of twist in buildings. They could be placed symmetrically along one or both directions in plan. When the mass center and stiffness center coincide with each other, the distance of shear wall from the mass center also plays an important role in the shear contribution of the shear wall. Shear walls are efficient, both in terms of construction cost and effectiveness in minimizing earthquake damage in structural and non-structural elements (like glass windows and building contents).

Fig. 1(b) and Fig. 1(c) shows failure of various soft storey buildings during past earthquakes.

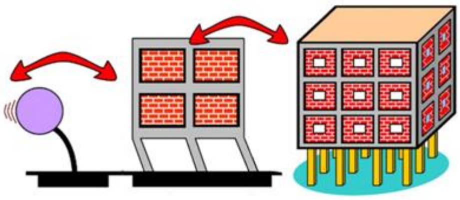

Fig.1(a): Behaviour of soft storey building as Inverted pendulum(EQ Tips 21)

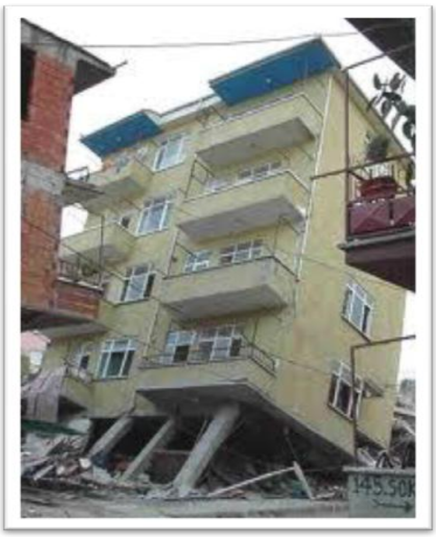

Fig.1(b): Failure of soft storey building during Earthquake in Turkey

Fig.1(c): Failure of soft storey building during Earthquake in San Francisco

II. REVIEW OF LITERATURE

[1] Dr. S. Setia and V. Sharma, They investigated the influence of some parameters on behavior of a building with soft storey. The modeling of the whole building is carried out using the computer program STAAD.Pro 2006. Parametric studies on displacement, inter storey drift and storey shear have been carried out using equivalent static analysis to investigate the influence of these parameter on the behavior of buildings with soft storey. The selected building analyzed through five numerical models. Concluded minimum displacement for corner column is observed in the building in which a shear wall is introduced in X-direction as well as in Z-direction.

[2] Misam.A and M. N. Mangulkar, In this paper it has been tried to investigate structural seismic response of a soft storey building on adding shear wall to the building in different arrangement in order to reduce soft storey effect. A (G+14) building was analysed in SAP 2000 and it was found that location and number of shear wall acts an important factor for the soft storey structures to displace during earthquake. Also the soft storey effect has been reduced as the shear wall is added to the structure. The horizontal and vertical movements of building with shear wall installed in most bays are much reduced during earthquake. So it shows that the use of shear wall effectively reduces effect of soft story on structure response in earthquake excitation. Considerable reduction in shear force, bending moment etc. is observed in dual type structural system as compared with frame system. Dual type structural system (shear wall - frame interaction) with proper location shear walls is more effective in resisting earthquake forces than the moment resisting frame system. Minimum displacement, story drift and considerable reduction for maximum forces is found, when shear walls are located at corners in the building plan.

[3] S. Hirde and G. Tepugade, Four models with soft storey at different levels are considered along with soft storey at ground level and these models with incorporation of shear walls are considered. Pushover analyses of the models with and without shear walls are carried out. This study highlights the poor seismic performance of G+20 RCC building with soft storey. After retrofitting of all the models with shear walls hinges are not developed in any of the columns. Provision of shear walls results in reduction in lateral displacement. Displacement reduces when the soft storey is provided at higher level. After retrofitting the base shear carrying capacity is increased by 8.45% to 13.26%.

[4] S. Arunkumar and Dr. G. N. Devi, The study includes the analysis of soft storey building with ETABS software by pushover analysis method and the results and conclusion of the analysis is to be included. A 10 storey building with and without shear wall in soft storey has been analysed and different parameters such as base shear, storey force, storey drift, displacements are compared. Their study concludes that building with shear wall in soft storey exhibits 30% – 40% higher base shear than the other one. Also the inter-storey drift of building with shear wall is minimum i.e. 0.0019 as compared to 0.0057 of the other one. IS code value for inter-storey drift for the corresponding building is 0.004. Building with shear wall attracts more storey force and moments about 5% - 10% then the building without shear wall.

[5] Prof. S. S. Patil and Mr. S. D. Sagare, They studied a building with open ground storey to bring out the importance of explicitly recognizing the presence of soft ground storey in the analysis. Usually the most economical way to eliminate the failure of soft storey is by adding shear walls. The shear walls are one of the most efficient lateral force resisting elements in high rise buildings. This paper deals with occurring of soft storey at lower level in high rise building subjected to earthquake has been studied. Also has been tried to investigate on adding of shear wall to structures in order to reduce soft storey effect on seismic response of building.

[6] A.S. Kasnale and Dr. S.S. Jamkar, They investigated the behaviour of multi-storey building to evaluate their performance level when subjected to earthquake loading. For this study five different models of a six storey building are considered. Equivalent static analysis has been performed as per IS 1893-2002 for each model using

ETABS 9.5. The IS code methods are describing very insufficient guidelines about infill wall design procedures. It is observed that the ETABs provide overestimated values of fundamental period. It can be concluded that provision of infill wall enhances the performance in terms of displacement control, storey drift and lateral stiffness.

[7] J. N. Arlekar, S. K. Jain and C.V.R. Murty, Their work highlights the importance of explicitly recognizing the presence of the open first storey in the analysis of the building. The error involved in modeling such buildings as complete bare frames, neglecting the presence of infills in the upper stories, is brought out through the study of an example building with different analytical models. This paper argues for immediate measures to prevent the indiscriminate use of soft first stories in buildings, which are designed without regard to the increased displacement, ductility and force demands in the first storey columns. Alternate measures, involving stiffness balance of the open first storey and the storey above, are proposed to reduce the irregularity introduced by the open first storey. The effect of soil flexibility on the above is also discussed in this paper.

[8] P. Tiwari, P. J. Salunke and N. G. Gore, In this paper, they have studied the applicability of the Multiplication Factor of 2.5 as given by IS Code 1893 Part-1(2002), for Low Rise and Medium Rise Open ground storey Building. A G+4, G+7 and G+10 RC framed Open ground storey building is considered in Seismic zone-V with Special Moment Resisting Frame (SMRF) is analyzed and Modeled in Etabs Software. They concluded that for different types of analysis such as equivalent static analysis, response spectrum analysis and pushover analysis, the value of multiplication factor is less by 40% - 45% than what is prescribed by IS Code of 2.5 Value for (G+4) building. Similarly for (G+7) its 36% - 40% and for (G+10) its 32% - 35% less value than which is given by IS Code of 2.5.

[9] P. B .Lamb, Dr R.S. Londhe, They studied a building with the help of different mathematical models considering various methods for improving the seismic performance of the building with soft first storey. Analytical models represent all existing components that influence the mass, strength, stiffness and deformability of structure. The equivalent static and multimodal dynamic analysis is carried out on the entire mathematical 3D model using the software SAP2000 and the comparisons of these models are presented. Finally, the performance of all the building models is observed in high seismic zone V.

[10] IS 1893 (Part 1) : 2002, Indian Seismic Code recommends some design criteria to be adopted after carrying out the earthquake analysis, neglecting the effect of infill walls in other stories. The column and beams of the soft storey are to be designed for 2.5 times the storey shears and moments calculated under seismic loads specified. Besides the columns designed and detailed for the calculated storey shears and moments, shear wall placed symmetrically in both directions of the building as far away from the centers of the building as feasible: to be designed exclusively for 1.5 times the lateral storey shear force calculated.

III. CONCLUSION

From the study of literature presented in this paper, conclusions are drawn out on the responses of soft storey building with effective utilization of shear walls as,

i. Introducing shear wall in a building is a effective method to reduce the soft storey effect.
ii. The steel quantity in column is effectively reduced by inducing shear walls in soft storey buildings.
iii. Changing the position of shear wall will affect the attraction of forces, so that wall must be in proper position.
iv. The beams connected with the shear walls are considerably heavy in design.
v. Providing shear walls at adequate locations substantially reduces the displacements due to earthquake.
vi. Shear walls placed at corners of the building gives lesser lateral displacement but creates maximum base shear.
vii. The shear wall should be located away from the centroid of the building and should be placed symmetrically in plan to avoid torsional effects.
viii. Storey drift of soft storey building provided with shear wall is lesser than that without shear wall.
ix. Provision of diagonal struts is also one of the effective method for reducing the soft storey effect other than shear walls.

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