

Effect of Shear Wall Area on Seismic Behaviour of Multistoried Building with Soft Storey at Ground Floor

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ABSTRACT

The advances in three-dimensional structural analysis and computing resources have allowed the efficient and safer design of taller structures. These structures are the consequence of increasing urban densification and economic viability. The trend towards progressively taller structures has demanded a shift from the traditional strength-based design approach of buildings to a focus on constraining the overall motion of the structure. Nowadays, reinforced concrete (RC) wall-frame buildings are widely recommended for urban construction in areas with high seismic hazard. Presence of shear walls imparts a large stiffness to the lateral force resisting system of the RC building. Proper detailing of shear walls can also lead to ductile behavior of such structures during strong earthquake shaking. One of the major parameters influencing the seismic behavior of shear wall frame buildings is the shear wall area ratio. Thus shear wall area ratio is set as a key parameter which is needed to be studied. Thus an analytical study is performed to evaluate the effect of Shear Wall Area to floor area ratio (SWA/FA %) on the seismic behavior of multistoried RC structures with soft storey at ground floor. For this purpose, 9 building models that have Five, Nine and Twelve stories with various SWA/FA % in both directions are generated.

INTRODUCTION

In the last few decades, shear walls have been used extensively in countries, especially where high seismic risk is observed. The major factors for inclusion of shear walls are ability to minimize lateral drifts, inter storey displacement and excellent performance in past earthquake record. Shear walls are designed not only to resist gravity loads but also can take care of overturning moments as well as shear forces. They have very large in plane stiffness that limit the amount of lateral displacement of the building under lateral loadings. Shear walls are intended to behave elastically during moderate or low seismic loading to prevent non-structural damage in the building. However, it is expected that the walls will be exposed to inelastic deformation during less or more frequent earthquakes. Thus, shear walls must be designed to withstand forces that cause inelastic deformations while maintaining their ability to carry load and dissipate energy. Structural and non-structural damage is expected during severe earthquakes however; collapse prevention and life safety is the main concern in the design. The essential distinction between a soft storey and a weak storey is that while a soft storey is classified based on stiffness or simply the relative resistance to lateral deformation or storey drift, the weak storey qualifies on the basis of strength in terms of force resistance (statics) or energy capacity (dynamics).

It is one in which the lateral stiffness is less than 70 per cent of that in the storey above or less than 80 per cent of the average lateral stiffness of the three storey's above.

Buildings with soft storey at the ground level with open spaces for parking are known as stilt buildings. Special arrangements should be made to increase the lateral strength and the stiffness of the storey. The beams and columns of the soft storey are designed to stand two-and-a-half times the storey shear and moments calculated for specified seismic loads.

LITERATURE REVIEWS

Riddell et al. [1] (1987) a study was performed by to define the general features of the buildings located in Vina del Mar that experienced the 1985 Chile earthquake and to identify the related earthquake damage. Data of 178 low and midrise

buildings representing a stock of 322, of which 319 have shear walls, were used in the evaluation. Most of these buildings were designed with considerably high shear wall ratios (varying between 3.0 and 8.0%, with an average of 6.0%), independent of the number of stories.

Investigations indicated that the design of the RC shear walls was not in compliance with the current earthquake-resistant design code requirements. Most of the shear walls were lightly reinforced without any boundary elements or special confinement details. Despite these facts, no damage was observed in nearly 90% of the buildings with shear walls during this severe earthquake.

As an outcome of this study, it can be stated that the higher the shear wall ratio used in a building, the lower the possibility of having damage in the structural system during a strong ground motion.

Wallace (1994) and Moehle[2](1992) an analytical procedure is proposed to predict the variation of roof drift with shear wall ratio. Fig.2.1 (a) is generated following this procedure for building models having different shear wall ratios, and the effect of shear wall ratio on the behavior is obtained for different shear wall aspect ratios.

Hassan and Sozen[4] (1997) "Seismic Vulnerability Assessment of Low-Rise Buildings in regions with infrequent earthquakes" A simplified method proposed which enables ranking an inventory of low-rise (up to five stories) monolithic RC buildings based on their seismic vulnerability level from low to high by using column and wall indexes. This method requires only structural dimensions as the input and is based on effective wall and column indexes plotted in a two-dimensional form. The wall index including RC and masonry infill walls is the ratio of the effective wall area at the base of the building to the total floor area. The column index is the ratio of the effective column area at the base to the total floor area. The effective areas proposed to be taken as the area of 100% of RC walls, 10% of non-reinforced infill walls, and 50% of columns.

METHODOLOGY

Earthquake and its occurrence and measurements, its vibration effect and structural response have been continuously studied for many years in earthquake history and thoroughly documented in literature. Since then, the structural engineers have tried hard to examine the procedure, with an aim to counter the complex dynamic effect of seismically induced forces in structures, for designing of earthquake resistant structures in a refined and easy manner. This re-examination and continuous effort has resulted in several revisions of Indian Standard: 1893: (1962, 1966, 1970, 1975, 1984, and 2002) code of practice on the "Criteria for Earthquake Resistant Design of Structures" by the Bureau of Indian Standards (BIS), New Delhi. In order to properly interpret the codes and their revisions, it has become necessary; that the structural engineers must understand the basic design criteria and procedures for determining the lateral forces. Various approaches to seismic analysis have been developed to determine the lateral forces, ranging from purely linear elastic to non-linear inelastic analysis. Many of the analysis techniques are being used in design and incorporated in codes of practices of many countries. However, this chapter is restricted to the method of analysis described or employed in IS 1893 (Part I): 2002 of "Criteria for Earthquake Resistant Design of Structures" essentially to buildings although in some cases that may be applied to other types of structures as well.

CASE STUDY

Most building codes prescribe the method of analysis based on whether the building is regular or irregular. Almost all the codes suggest the use of static analysis for symmetric and selected class of regular buildings. For buildings with irregular configurations, the codes suggest the use of dynamic analysis procedures such as response spectrum method or time history analysis.

Seismic codes give different methods to carry out lateral load analysis, while carrying out this analysis infill walls present in the structure are normally considered as non- structural elements and their presence is usually ignored while analysis and design. However, even though they are considered as non-structural elements, they tend to interact with the frame when the structures are subjected to lateral loads.

In the present study lateral load analysis is performed on twelve buildings models that have five eight and twelve stories with the same plans, but different shear wall area ratios are generated for the application of Response Spectrum and Linear Static analysis. Response Spectrum Analysis and Linear Static analysis both are carried out by using seismic code IS 1893:2002. The Shear wall area ratio is determined by dividing the total shear wall area in one principal direction to the plan area of the ground floor ($\sum A_w/A_p$). In this analytical study, shear wall area ratio of about 0.93, 1.2 and 1.47% are selected along X-

direction and 0.54, 0.70 and 0.85% are selected along Y- direction to investigate the seismic behavior of multistoried RC buildings with ground floor as soft storey.

RESULTS AND DISCUSSION

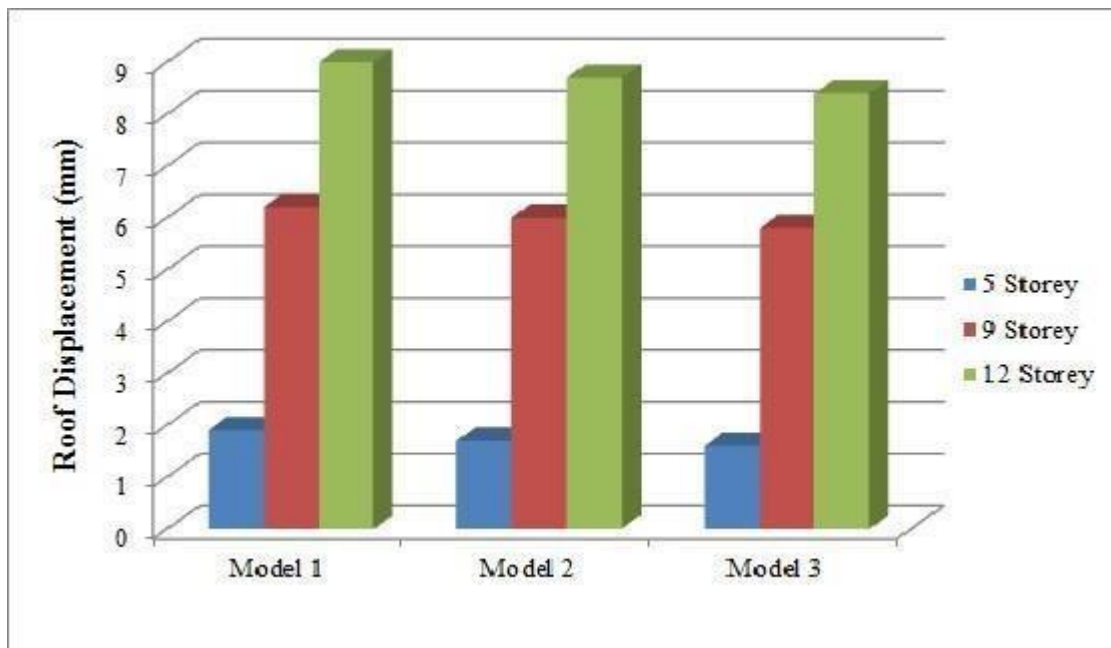
In this chapter, the results of the 5, 9 and 12 storey building models are presented and discussed in detail. The result includes all building models which are computed using the Response Spectrum Analysis and Linear Static Analysis. The analysis of the different building models is performed by using E-TABS analysis package.

The results of Fundamental natural period of vibration, relationship between shear wall area and Base shear, relationship between shear wall area and roof displacement and storey displacement for the different building models for each of the above analysis are presented and compared. An effort has been made to study the effect of shear wall area to floor area ratio by considering ground floor as soft storey in the analysis.

The relationship between shear wall and base shear is directly related to Structural stiffness, which may increase the base shear acting on building. However, shear walls significantly improve seismic performance by reducing displacement, drift and structural damage.

Therefore, shear walls Are one of the most effective structural elements used for earthquake-resistant design of buildings. The below graphs represents the relationship between SW area vs. Roof Displacement for different types of building Models performed by using Response Spectrum Analysis.

Fundamental Natural Period



It is observed that the Fundamental natural period of five storey building for Model-1 is more than the codal provision when comparing it with analytical results. Whereas in Model-2 by increasing the shear wall area ratio, natural period is almost similar to codal provision. Thus, by increasing the shear wall area ratio there is a considerable reduction in time period. It can be clearly understood from table no 5.1 and 5.2 that by increasing shear wall area ratio in both x and y direction reduction in the time period takes place.

CONCLUSIONS AND SCOPE FOR FURTHER STUDY

Conclusions

On the basis of the results of the analytical investigation of 5, 9 and 12-storey RC building models with increasing shear wall to floor area ratio (SWA / FA) % by considering the ground floor as soft storey, the following conclusions are drawn:

- In case of response spectrum analysis, it is observed that base shear values are increasing with increase in SWA / FA % for all the models.
- In case of Linear Static Analysis also it is observed that base shear values kept increasing with increase in SWA / FA %.
- For SWA / FA % = 0.93% (X) 0.54% (Y) a significant decrease in roof displacement is observed as compared to lower SWA / FA %. The decrease in roof displacements becomes less pronounced with increase in SWA / FA % beyond 1.2% (X) 0.7% (Y).
- This indicates that SWA / FA % of 1.2% (X) 0.7% (Y) is effective in reducing the roof displacements.
- Storey Displacement in both the case of Response Spectrum and Linear Static Analysis indicates that, the decrease in displacement with increasing shear wall area to floor area ratios is in between 1.2% (X) 0.7% (Y) and 1.47% (X) 0.85% (Y).

Scope for Further Study

Further it would be desirable to study more cases before reaching definite conclusion about the behavior of RC frames buildings. Studies can be conducted on high rise buildings (Multistoried) by providing more thickness of shear walls, providing shear wall at various other locations and also by providing dual system, which consists of shear wall (or braced frame) and moment resisting frame.

The study can also be done on Sloping grounds, various damping mechanisms and its applications on structures, and also by conducting the structures having base isolation system.

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