Performance Evaluation under Seismic Load with Reinforced Concrete Flag walls of High-Rise Building

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ABSTRACT

Due to urbanization there has been a considerable growth in the development of high-rise buildings in India mostly in Delhi and Mumbai which are the metropolitan cities. Restriction of land to be used for the construction and expansion of population due to migration in the cities are the main problems. For structural engineers in designing the tall structure given this demand, housing needs becomes very challenging. Due to dynamic loads such as wind and earthquake load high-rise structures are very critical. The outrigger system is a resisting system which is developed to resist such lateral loads. An outrigger system is One such interior lateral load resisting system. Conventional outrigger system used in trusses in the mechanical floors and therefore reduces the usable space. Hence a flag wall (RC walls not reaching foundation) as these walls behave similarly to the outrigger system. Because they save spaces for the operation and can be used as a new alternative. The main objective of this paper is to study the 65-storey three-dimensional model subjected to dynamic earthquake load using response spectrum analysis over a behavior of flag wall systems. Using ETABS (Version.2016) software with Indian standards codal provisions for all the models the analysis is done. The results show that, flag system has a significant effect in reduction of lateral displacement and storey drift of high-rise buildings.

Keywords—Flag walls, Outrigger system, lateral resisting system.

1. INTRODUCTION

High-rise housing takes great pride in technological competence. In today's world skyscrapers are the symbol of economic power and leadership. In developing countries like India height of the structure is the only solution to accommodate the growing population because population growth and restriction of land for construction is a major problem.

Complexity increases with increase in height of the structure. Wind and seismic are the two important lateral forces that need to be considered while analyzing high-rise structures. To resist these lateral forces there are many lateral resisting systems. Lateral Resisting systems can be classified broadly into exterior lateral resisting system and interior lateral resisting system. One such internal lateral resisting system is the outrigger system. Outrigger systems are widely used in tall buildings to reduce the drift and displacement of tall buildings.

Usage of conventional outrigger system consumes the rentable space in the mechanical floors due to trusses. This disadvantage of conventional outrigger systems can be overcome by using Flag Walls in the structure. Application of Flag wall could be proved economical as compared to the conventional system due to the freedom to use the rentable space which was a disadvantage in case of using conventional outrigger system.

1.1 Reinforced Concrete Flag Walls

Flag walls are reinforced concrete walls (RC walls) in selected floors, not reaching the foundation which provides additional stiffness, strength and ductility to the overall structure. They can be effective in reducing overall lateral drifts, inter-storey drifts and building periods similar to outriggers (S. A. Reddy and N. Anwar, 2018). These walls behave similar to outriggers hence the main advantage using flag wall is that they do not utilize space for the operations. As in the case of the conventional outriggers trusses are involved in tying together the core and the perimeter column space in between is wasted, this space could be saved by using isolated RC walls known as flag walls as an alternative.

2. OBJECTIVE OF THE STUDY

The primary aim of the study is to investigate the application of flag walls as an alternative to outrigger system.

- To study the performance of RC high rise building with and without flag walls.
- To analyze & evaluate performance of RC high rise buildings in terms of storey displacement, storey drift, base shear and time period dynamic earthquake load.
- To find out the best configuration of flag wall system subjected to dynamic seismic load.

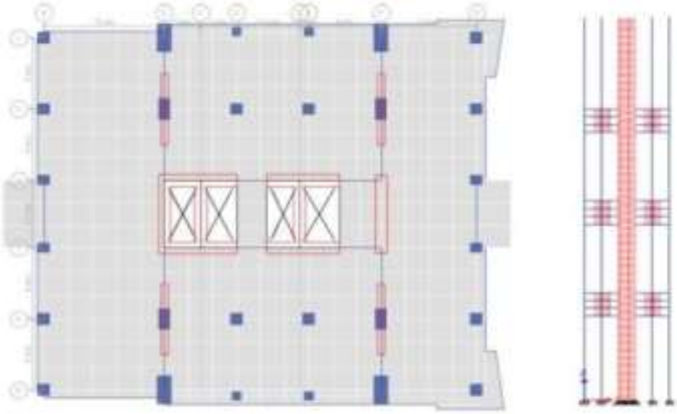

Fig 1. Typical floor plan of flag wall system (S. A. Reddy and N. Anwar, 2018)

3. METHODOLOGY

A 65 floor high-rise L-shaped building was considered in this study. Three models were modeled and analyzed using ETABS software. Typical floor plan and elevation is shown below.

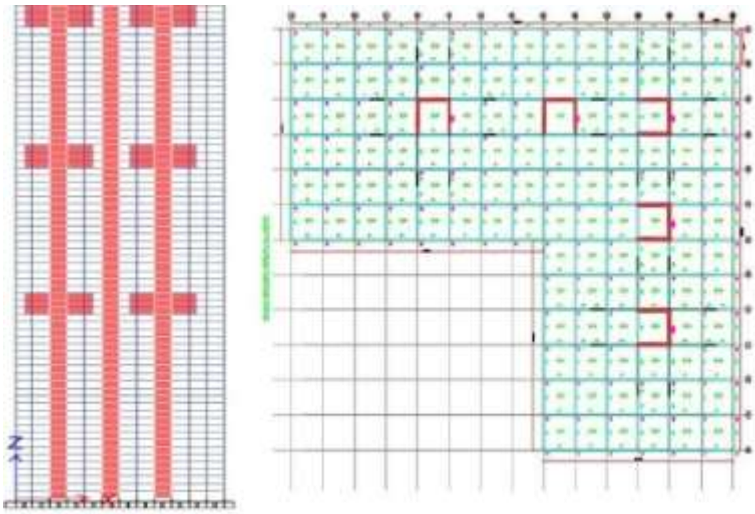

Fig. 2 Plan and elevation model

4. INPUT PARAMETERS

A G+65 high-rise structure with irregular L-shaped plan is modeled in this study. Material Properties of each element are discussed below. Also the position of flag walls is also discussed in this section. Five models were analyzed and effect due to static and dynamic earthquake load was determined. A convention SMRF (Special Moment Resisting Frame) system, structure having only core wall system, flag walls at mid height, flag walls placed at two locations (0.3 h and 0.5 h) also flag walls placed at three locations (0.3 h ,0.5 h and 1 h).

Table 1. Input Parameters

Particulars	Dimensions
Beam Size	650mm x 650mm
Column Size	1250mm x 1250mm
Wall Thickness	950 mm
Spacing Between Frame	4m
Floor Dimension in X Direction	65 m
Floor Dimension in Y Direction	75

5. RESULT AND DISCUSSIONS

Three parameters are compared in this study. Mainly displacement, storey drifts and time period are compared for all the models.

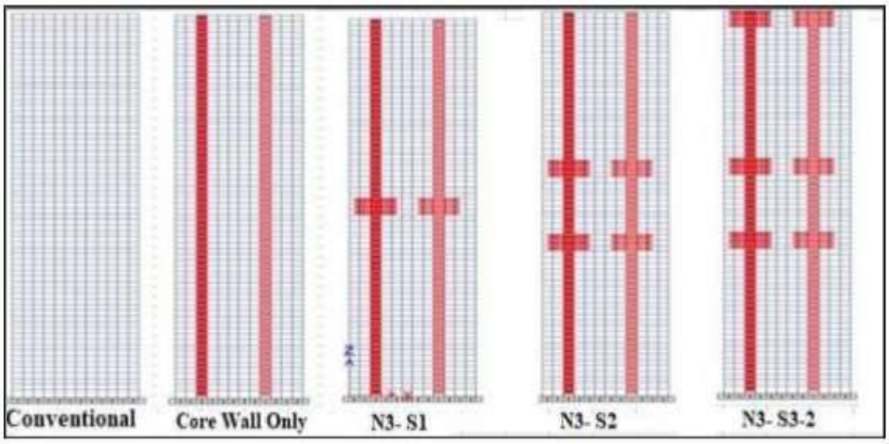

Fig. 3 Elevation models considered in the study.

Table 2. Loading Conditions

Load Type	Value
Live Load on Floor	4.4 KN/m^2
Live Load on Terrace	1.8 KN/m^2
Floor Finish	1.8 KN/m^2
Water Proofing On Terrace	2.8 KN/m^2
Wall Load on Beams, 230 mm Thickness Wall	18.1 KN/m

Table 3. Seismic Parameters

Load Type	Value
Seismic Zone	IV
Zone Factor	0.28
Response Reduction Factor, R	4.8
Soil Type	II, Medium
Importance factor	1.4

5.1 Time Period

Comparing SMRF (Special Moment Resisting Frame) System less time period required by flag walls application. By fig 3 comparing to the other models at three levels for three storey deep walls, flag walls has a lowest time period 21% of reduction is there in model 1. In time period of flag wall system that to be of conventional SMRF System

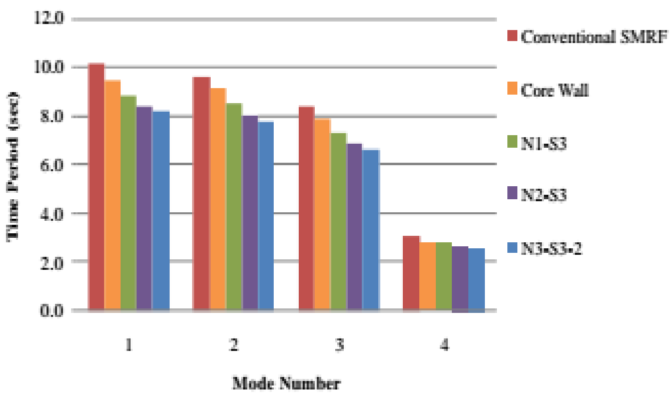

Fig. 4 Variation of Time Period

5.2 Figures and Tables

The result studied, of G+65 storey model when subjected to dynamic earthquake in X-direction from the result is observed that Maximum displacement of structure is noted at 335.422 mm in flag wall displacement while that of SMRF system maximum displacement of the structure observed to be 401.34 mm in N2-S3-2 case.

The reduction is achieved by 16% by application of flag walls at 0.3h,0.5h and at the top in N2-S3-2 case. Due to seismic force along y-direction,31% of reduction is achieved compared to conventional systems.

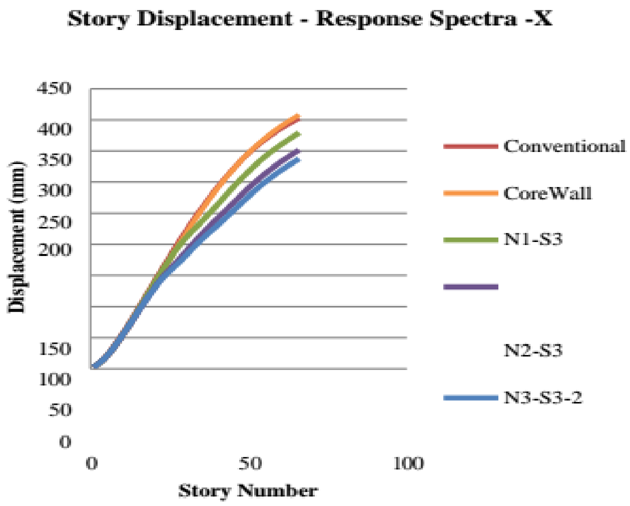

Fig.5 Variation of storey displacement along X-direction

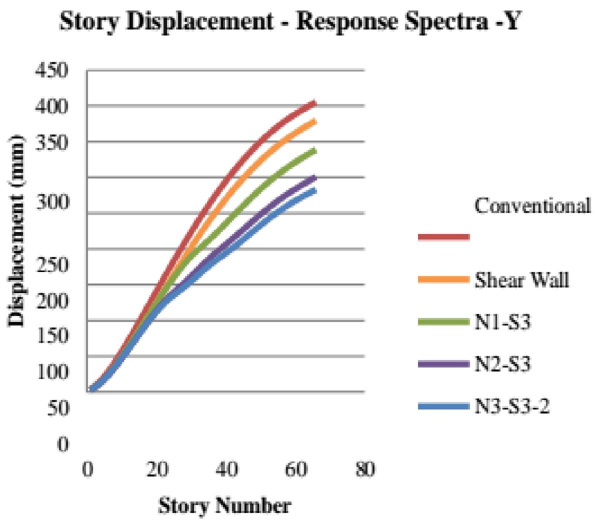

Fig 7. Variation of storey displacement along Y-direction

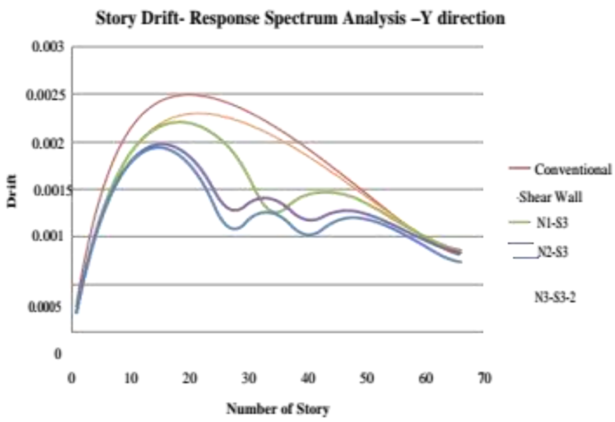

Fig 8. Variation of storey drift along Y-direction

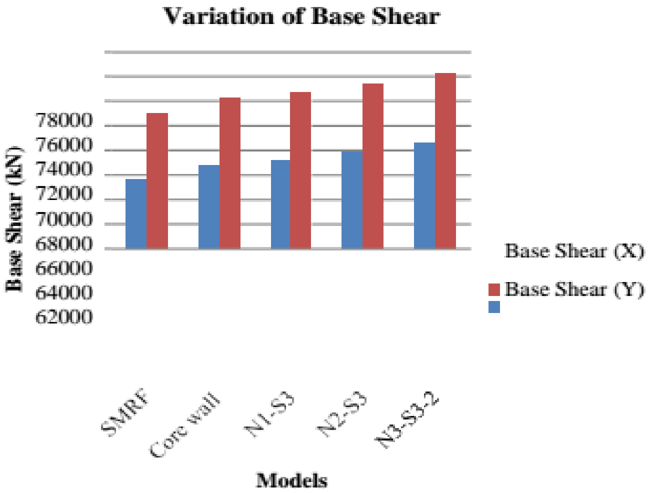

Fig 8. Variation of Base Shear

5.3 Lateral Storey Drift

From the result studied, due to flag wall at 0.3h,0.5h and top, reduction by 51% is observed in storey drift when G+65 storey is subjected to dynamic seismic load along X-axis in (N3-S3-2). Also ,in reduction up to 38% is achieved when dynamic seismic load acts on a structure.

5.4 Base Shear

Due to an increase in self weight of the flag walls. Small increase in base shear along both directions. When the structure is subjected to earthquake load. Small increase in base shear found in X and Y- direction

6. CONCLUSIONS

Result obtained in terms of Time period, Story displacement and base shear with and without of flag walls In analysis of G+65 storey. The study of performance of evaluation of G+65 Storey by application of flag walls and use it as an alternative to outrigger system which is of conventional system.

The following conclusions are made from the present study. Due to the introduction of flag walls, the time period decreased considerably by 21% and at top storey (N1-S3-2) reduces considerably. Reduction in drift up to 48%-51% as observed at 27 th floor. When at 0.3h,0.5h flag walls are used In structure subjected to dynamic seismic load along X and Y direction respectively. In X direction up to 16 % story displacement due to flag walls and by 31% in Y direction for N3-S3-2 MODEL when structure load is subjected to dynamic seismic load compared to SMRF System. Due to an increase in self weight of flag walls, the addition of a small percentage of increase in base share in the structure. It can be observed in result flag wall systems could be used as an alternative to conventional RCC systems as it saves spaces and performance of flag walls system is better than conventional systems. Increase in stiffness and Structure can be more efficient when subjected to Dynamic Seismic load when flag wall use.

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