Performance Evaluation of Flag Wall on Irregular shaped High-rise RCC Building under Seismic load

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***Abstract*— Development in High rise building in our country can be seen due to rapid increase in urbanization. Tall buildings are difficult to design. As height of building increases, the stiffness of building decreases. Tall buildings are subjected to lateral loads like earthquake and wind. So, it is important to have outrigger systems that reduces the effect of lateral loads on High rise buildings. Although conventional outrigger systems can be used, but virtual outriggers like flag walls can be used and some short comings of outrigger systems can be overcome. The present study includes analyzing of a 40 storey RCC building using response spectrum method for building located in zone-III. The shape of building is with vertical irregularities with Flag walls at different levels. The building is analyzed and compared for different combinations of flag wall and core. The results included parameters like time period, top storey displacement, storey drift and storey shear.**

Keywords*— Flag wall, outrigger systems, virtual outrigger systems, seismic analysis, high rise.

I. INTRODUCTION

The tall buildings have been seen as a symbol of economic power. In developing country like India, due to rapid urbanization and population growth, the restriction to construction land is major problem. Solution to this problem is to create High rise building. Complexity increases with increase in height of building.

High-rise buildings are subjected to lateral loads like wind and earthquake. To resist this lateral loads, many lateral resisting systems are available. Outrigger system are one such lateral resisting system. Outrigger systems are widely used in tall buildings to reduce drift and displacement of tall building.

Outrigger systems are combination of truss or beams that connect core to outer columns. Outrigger systems are used to improve strength of building and reducing the overturning stiffness. In past few years many innovations are seen to improve efficiency of the outrigger systems. Figure 1, shows simple outrigger systems which have a cantilever horizontal member that connects core to outer column. With this connection, the moment arm of core is increased and that increases the lateral stiffness of system. Over turning moment from core is transferred to outer columns with the help of outriggers.

Outrigger systems can be useful but it has several problems that limits the use of outrigger system in real world. Use of outrigger trusses can constraint the use of floor where outriggers are provided. The connections of the outrigger trusses to the core can be very complicated especially when a concrete shear wall core is provided. This disadvantage of conventional outrigger can be overcome with the help of flag wall.

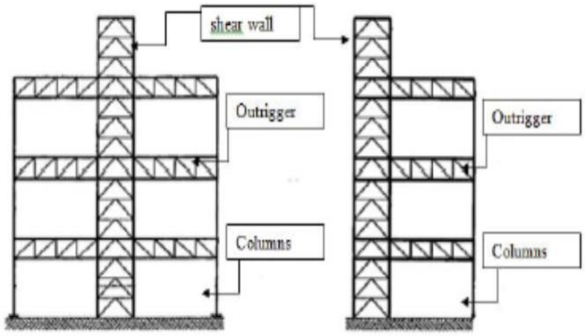

Figure 1: Outrigger system with Central Core and Offset Core

Flag walls are Concrete walls on selected floors, not reaching to foundation. These walls provide additional stiffness, strength and ductility to overall structure. Similar to outrigger system flag walls are effective in reducing overall drift, inter-storey drift and building period. Conventional outrigger trusses involve tying core to outer columns and space is wasted due to diagonal members of outrigger system. The space can be saved by providing isolated RC walls known as flag walls as an alternative.

II. REVIEW OF LITERATURE

Anju *et al.* (2016) conducted a study on evaluating the effect of outrigger system in multi-storeyed irregular buildings. It was found that there was a significant reduction in value for lateral displacement, story drift, overturning moment and story shear for irregular building with multiple outriggers as compared to the buildings without outriggers.

Bayati *et al.* (2008) explained the use of virtual outriggers (belt truss) to improve the effectiveness of conventional outriggers. Results shows that the belt trusses can help overcome the drawback of conventional outrigger as there is no diagonal truss consuming space between the core and the building exterior. Also, the complex connection between core and outrigger trusses can be eliminated.

Sukhdeve (2016) found out the optimum location of outrigger in G+40 storey RC building. Study shows for single outrigger, mid height of the structure gives best result.

Shivacharan *et al.* (2016) performed analysis of outrigger system for a tall building with vertical irregularities subjected to lateral loads. They analysed a 30-story building with change in dimension after every 10 story. Six location of outrigger systems were analysed and it was found the first outrigger at mid height of structure gave highest reduction in top story displacement.

Reddy *et al.* (2018) evaluated the seismic performance of high rise building with flag walls. They compared five configurations of flag walls are effective alternative to the outrigger systems but flag walls create concentration of forces. This can be controlled by symmetrical placement of flag walls. Flag walls placed closer tp the core can provide better results.

Sitapara *et al.* (2016) reviewed the feasibility of high-rise outrigger structural system in seismically active regions. They discussed about type of structural systems, types of outriggers and factors affecting the effectiveness of outrigger systems. They also provided information about the advantages and disadvantages of outrigger systems.

Rathore *et al.* (2017) reviewed many national and international research papers related to outrigger structural system in high-rise buildings. They have pointed out the findings and concluded that there are a small number of researches done on virtual outrigger systems and damped outrigger systems.

III. METHODOLOGY

The building data used for analysis and design is as follows.

Building Plan Dimension:

1. from base – 0.4h : 30m x 40m.
2. from 0.4h – 0.6h : 25m x 40m.
3. from 0.6h – top : 20m x 40m.

No. of storey: 40

Floor to floor height: 3m

Sizes of beams: 350mm x 800mm

Sizes of columns: 800mm x 800mm

Thickness of slab: 150mm

Grade of steel: Fe500

Grade of Concrete: M30

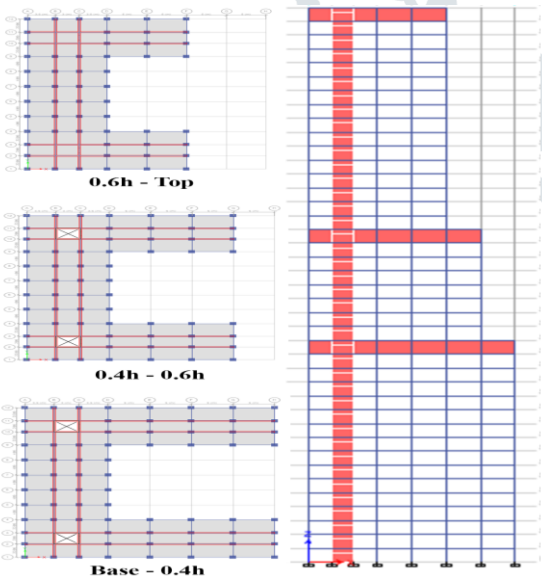

Figure 2: Plan and Elevation of model

The building is analyzed by response spectrum analysis in ETABS 2016 considering soil type II which is dense soil and soft rock and seismic source A which is a fault capable of producing large magnitude events and which have a high rate of seismic activity. Figure 2 shows plan and elevation of the model.

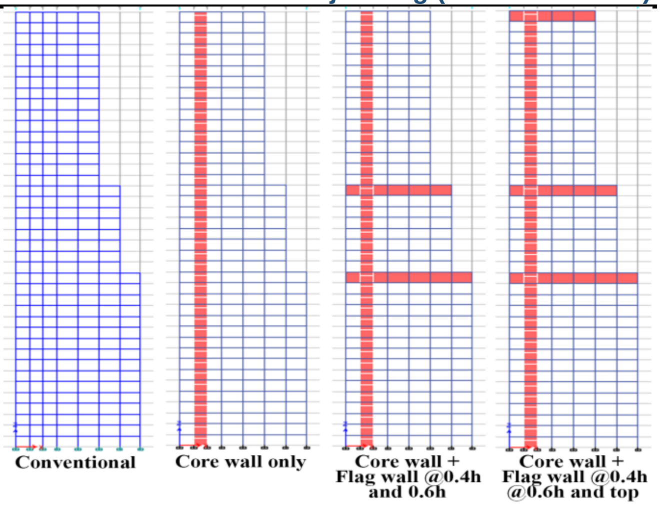

Figure 3: Elevations of model considered in this study

IV. RESULTS AND DISCUSSION

Results are obtained by using response spectrum analysis are presented in graphical and tabular form.

A. Time Period

Application of Flag Wall reduces the time period as compared to SMRF (Special Moment Resisting Frame) system. It can be seen from Fig. 4 that the flag wall at 0.4h and 0.6h has the lowest time period as compared to other models. For mode 1, there is a reduction of about 11% in the time period of flag wall can be seen for core wall + flag wall at 0.4h and 0.6h as compared to SMRF system.

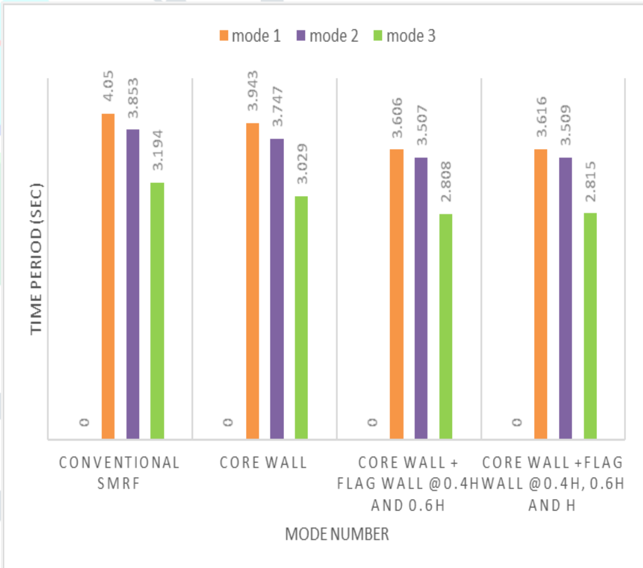

Figure 4: Variation of Time period

B. Lateral Storey Displacement

From the results studied when G+40 storey model are subjected to earthquake in X-direction it can be noted that the maximum top storey displacement from conventional SMRF system is observed to be 91.684mm while for structure with flag wall at 0.4h, 0.6h and top is 82.807mm. Around 10% change in top storey displacement is achieved. Similarly, for earthquake in y direction around 16% change in top storey displacement can be seen for Core wall only.

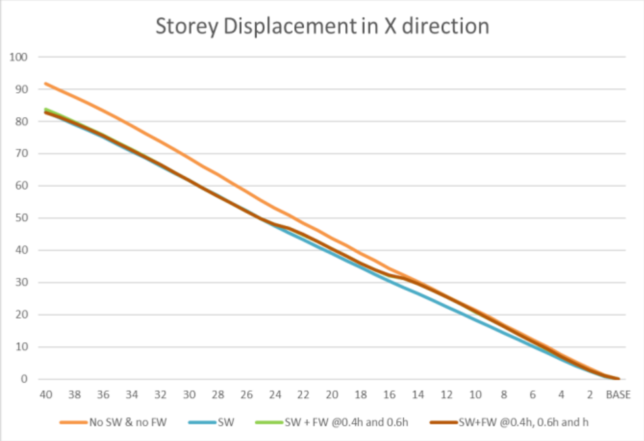

Figure 5: Storey displacement in X-direction

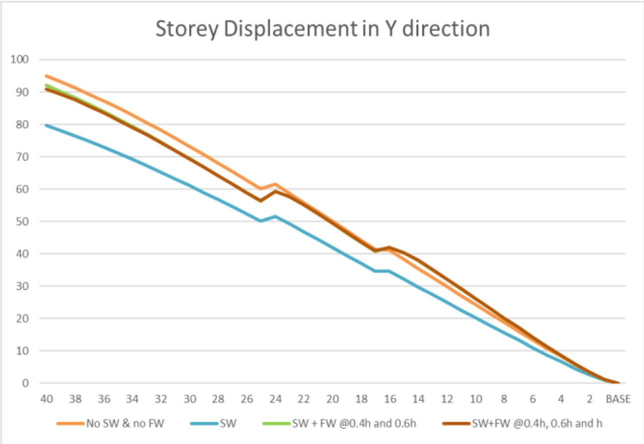

Figure 6: Storey displacement in Y-direction

C. Storey Drift

From the results obtained after analysing G+40 storey building subjected to dynamic seismic load in X-direction, around 56% reduction on storey drift can be seen at 16th floor due to flag wall at @0.4h, 0.6h and top. Figure 7 shows plot of story drift vs storey in X-direction. Similarly, for seismic load in Y- direction, story drift reduces by around 45% at storey 16th due to presence of flag wall at 0.4h, 0.6h and top as seen in figure 8.

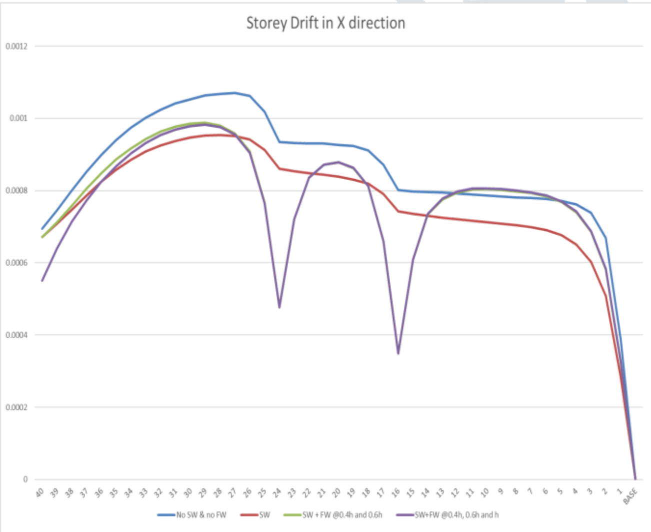

Figure 7: Storey dfift in X-direction

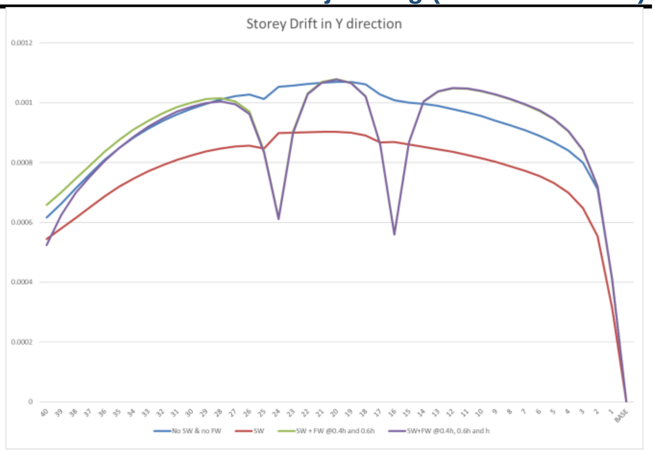

Figure 8: Storey dfift in Y-direction

V. CONCLUSIONS

The results obtained from analyzing G+40 storey building with and without flag walls subjected to dynamic earthquake load are in terms of time period, storey displacement and storey drift. Main objective of the paper is to study the performance of flag wall in a irregular shaped building and to use it as an alternative to conventional outrigger systems.

Following conclusions are drawn based on results obtained by using response spectrum analysis are:

1. Time period considerably decreased by 11% due to introduction of flag walls as compared to conventional SMRF system.
2. Storey drift reduces from 45% to 56% is achieved at 16th floor when flag walls are used at locations 0.4h, 0.6h and top.
3. Top storey displacement of around 10% to 16% is achieved when flag walls are provided at 0.4h, 0.6h and h.
4. A small increase in base shear can be seen due to self-weight of the flag walls.
5. From the result it can be observed that the flag wall system performs better than the conventions RCC SMRF system and could be used as an alternative to conventional outrigger system as it saves space.

Also, the use of Flag wall system in high-rise buildings increases the stiffness and makes the structure efficient under dynamic seismic load.

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