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# Seismic Analysis of Outrigger and Flag-Wall System in High-Rise Structure with Regular and Irregular Plan

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**Abstract -** Recently there has been a considerable increase in the tall buildings with number of unsymmetrical buildings in plan, both residential and commercial. Lateral forces are the most important factors to be considered when it comes to controlling lateral deflection of the building. And for that several lateral load resisting systems have been implemented in the field since years. In present study, comparison on effectiveness of Outrigger system and flag wall system is considered. In present study G+59, G+69 and G+79 story buildings will be modelled and analyses for Reinforced cement concrete structure with double outrigger and flag wall at various height (0.4H +0.2H), (0.4H +0.6H), (0.4H +0.8H), (0.4H +1.0H) to identify its effectiveness in High rise structure in Zone IV and V and Medium Soil with Regular irregular in Plan. Dynamic wind analysis and Response Spectrum analysis was carried out. Parameters to be considered Maximum story displacement, Story Drift, Time Period and Base Shear. Modelling and Analysis was done using ETABS.

***Key Words*::**outrigger, flag-wall, response spectrum and time history analysis, rectangular-c-&t shape, e-tabs

## 1. INTRODUCTION

Tall buildings have also been used as a measure of economic strength. The availability of building land in developing countries like India is a major problem due to growth of the urban population. The solution to this problem is high-rise building. When a building's height rises, so does its complexity. Wind and earthquake lateral loads affect high-rise buildings. To withstand these lateral loads, a variety of lateral resistor systems are available. The Outrigger system is an example of a lateral resistor system. Outrigger systems are often used in tall buildings to reduce drift and displacement. On some floors, flag walls are concrete walls that do not reach the foundation. These walls add stiffness, resilience, and ductility to the structure overall. Flag walls are equivalent to outrigger system flag walls in terms of reducing overall drift, inter-story drift, and construction time. Outrigger systems are a truss or beam structure that connects the center to the outer columns. Outrigger systems are used to increase building strength while reducing overturning stiffness.

### 1.1 Outrigger system

The facility frame of the Outrigger system contains either a shear divider or a supported external portion structure with an interface between the middle portion of the structure and the outer portions of a focal core divider. These are the level individuals intended to regulate lateral load and harden the structure by securing center to the outside segment by solid even individuals referred to as an outrigger portion, while center acts for parallel forces as a solitary excess cantilever member shaft and thus combat the pivot at the top by extending and shortening activity results in malleable and compressive activity. The Victoria office tower (1965) is the first series of structural outriggers engineered by Nervi and Moreira. Outrigger systems are very common among higher structures.

### 1.2 What is outrigger System?

An Outrigger System is Stiff Beam that connect the internal core to exterior columns, the system is used as lateral load resisting system in tall building

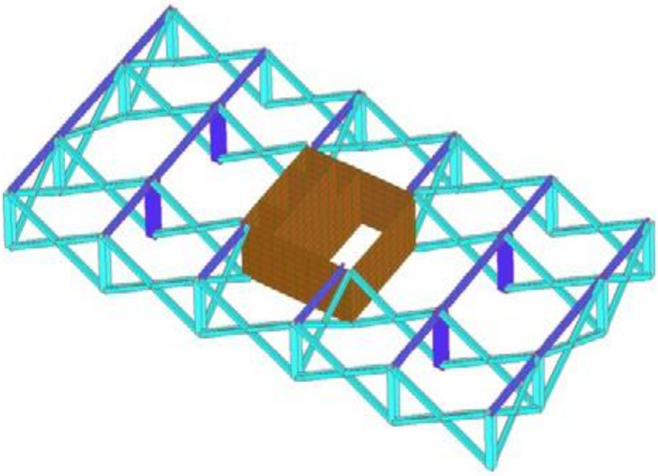


Fig-1: Outrigger with Belt Truss

### 1.3what is flag wall system

For selected floors, flag wall is concrete wall that do not hit the base. They provide the overall structure with additional stiffness, strength and ductility. They can be effective in minimizing total lateral roof drifts, inter-story drifts and, similar to outriggers, construction times. An essential component of both commercial and residential high-rise buildings are partition walls, typically constructed from brick masonry (ASCE 41-13, 2013). However, due to discontinuity, they cannot be used as outriggers. Therefore, these partition walls can be replaced easily with RC wall and can be used as structural components. Economics and improved space planning are the benefits of the flag wall system to fulfil architectural, mechanical and leasing requirements that outriggers do not often do (Hi Sun, 2012; Goma, 2016). However, if not correctly positioned, it may

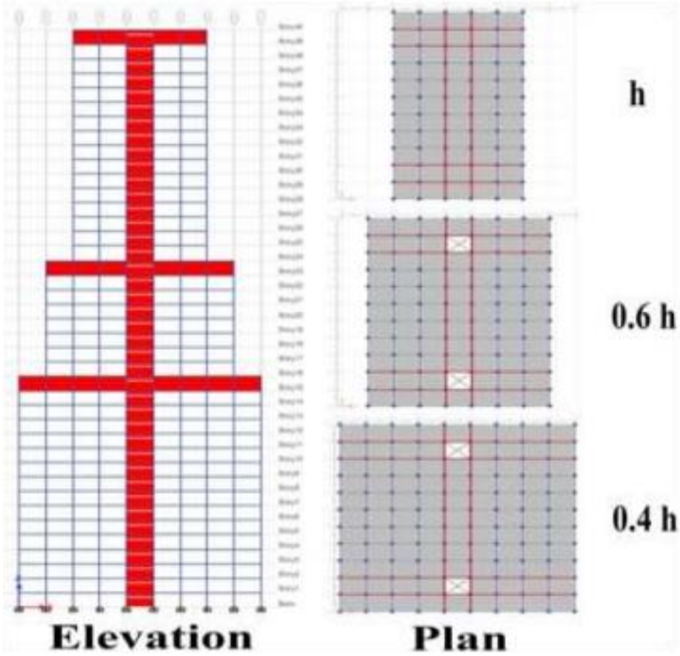



Fig-2: flag-wall system

Also lead to sudden changes in the local reaction of walls and frames.

There is little research on investigating the adequacy of flag wall system as a lateral load resist system. The seismic performance of such flag wall structural systems used as an alternative to the traditional outrigger system was evaluated in this report. The required location for flag walls is decided to enhance the use of a case study building located in a high seismic risk area. Final configuration output is measured against a maximum considered earthquake (MCE) using nonlinear analysis (ATC 72, 2010). The presented results are of practical importance as they provide an insight about the effect of flag walls on lateral response of individual components as well as overall story-level response (TBI2010) (TBI,2010).

### 1.4 Objectives:

The main objectives for present work are as follows:

- To find the response of structure under seismic and dynamic wind load.
- To find the response of outrigger and Flag wall at (0.4H + 0.2H, 0.4H + 0.6H, 0.4H + 0.9H, 0.4H + 1H) for rectangular, C shape and T shape Plan.

- To compare the response of outrigger and flag wall system.

## 2. RESEARCH METHODOLOGY AND MODELING

The following structures with different heights (G+59,G+69G+79) were subjected to wind dynamic analysis, time history method, and response spectrum analysis in this study . Lateral Maximum displacement and Base shear story drift and time period is considered for the seismic behavior of soft storey buildings. Seismic Zone IV & V is taken for time history analysis Bhuj time history is considered. considered rectangular structure in square building taken and irregular structure C-shape & T-shape taken for analysis.

### 2.1 Model configuration

| | |
|---|---|
| **Plan area** | 42m x 35m |
| No. of bay in x-direction | 7 |
| No. of bay in y- direction | 5 |
| Floor height | 3m |
| Plinth height | 3 |
| Size of column | 700mm X 700mm |
| Size of beam | 300mm x 600mm |
| Slab thickness | 150mm |
| Grade of concrete | M30 |
| Grade of steel | Fe415 |
| Type of soil | Medium |
| **Earthquake Load Details:** | **Description (As per IS-1893 2001)** |
| Earthquake zone | IV (0.24) & V (0.36) |
| Important factor | 1 |
| Parapet wall load | 4.5 KN/m |
| Live load | 3 KN/m2 |
| Wall load | 1.5 KN/m2 |
| **Flag wall and shear wall** | **Thickness** |
| thickness | 230mm |
| **Wind load Details:** | **Description (As per IS-875 part-3)** |
| city | Bhuj |
| Design speed Vb | 50 m/s |
| class | C |
| Risk coefficient, k1 | 1 |

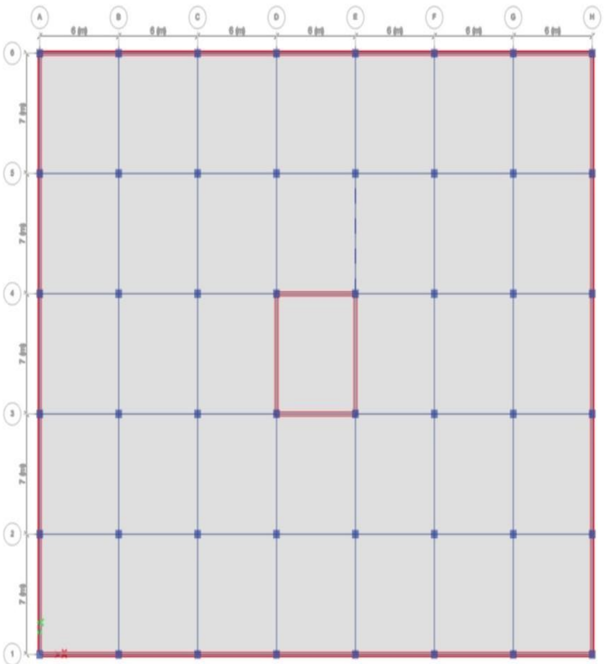


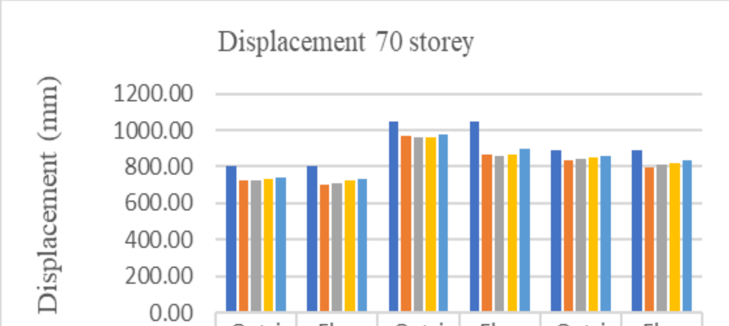
Fig. 1 Elevation of flag-wall

Fig. 4 Plan view

## 3. RESULT:

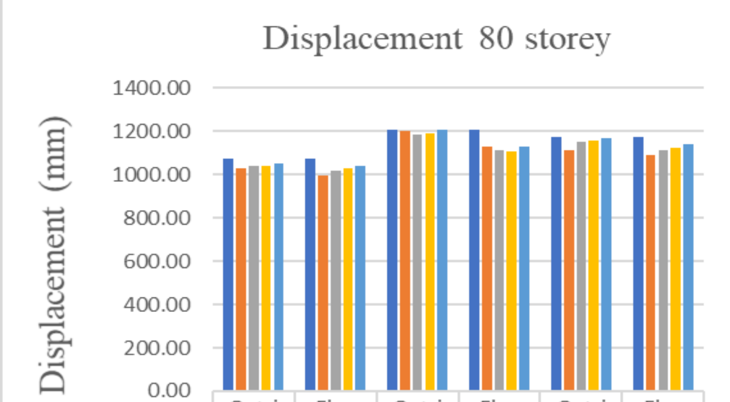

| | Outrig gur | Flag Wall | Outrig gur | Flag Wall | Outrig gur | Flag Wall |
|---|---|---|---|---|---|---|
| | Rectangular | | C | | T | |
| Bare | 723.96 | 723.96 | 748.36 | 748.36 | 728.21 | 728.21 |
| At 0.2 + 0.4 H | 632.49 | 595.96 | 715.71 | 624.70 | 629.43 | 583.49 |
| At 0.6 + 0.4 H | 651.40 | 594.66 | 697.46 | 612.21 | 619.12 | 577.20 |
| At 0.8 + 0.4 H | 637.19 | 607.66 | 702.91 | 617.79 | 625.93 | 586.49 |
| At 1.0 + 0.4 H | 652.37 | 629.53 | 710.30 | 646.02 | 640.24 | 609.14 |

Fig. 5 Maximum Displacement 60 storey




| | Outri ggur | Flag Wall | Outri ggur | Flag Wall | Outri ggur | Flag Wall |
|---|---|---|---|---|---|---|
| | Rectangular | | C | | T | |
| Bare | 801.83 | 801.83 | 1047.16 | 1047.16 | 893.64 | 893.64 |
| At 0.2 + 0.4 H | 722.38 | 703.25 | 967.97 | 870.04 | 838.70 | 795.75 |
| At 0.6 + 0.4 H | 728.57 | 712.33 | 962.55 | 861.55 | 842.09 | 808.57 |
| At 0.8 + 0.4 H | 733.86 | 721.47 | 964.88 | 867.52 | 847.75 | 818.04 |
| At 1.0 + 0.4 H | 740.22 | 732.14 | 975.19 | 895.28 | 856.23 | 834.46 |

Fig. 6 Maximum Displacement 70 storey




| | Outri ggur | Flag Wall | Outri ggur | Flag Wall | Outri ggur | Flag Wall |
|---|---|---|---|---|---|---|
| | Rectangular | | C | | T | |
| Bare | 1074.04 | 1074.04 | 1208.26 | 1208.26 | 1174.04 | 1174.04 |
| At 0.2 + 0.4 H | 1027.07 | 996.67 | 1201.98 | 1126.68 | 1113.52 | 1091.73 |
| At 0.6 + 0.4 H | 1040.84 | 1017.84 | 1186.78 | 1113.98 | 1150.54 | 1111.13 |
| At 0.8 + 0.4 H | 1042.36 | 1028.64 | 1188.87 | 1108.36 | 1157.52 | 1123.12 |
| At 1.0 + 0.4 H | 1049.68 | 1040.78 | 1204.66 | 1130.87 | 1167.35 | 1142.54 |

fig. 7 Maximum Displacement 80 storey.


| | Outri ggur | Flag Wall | Outri ggur | Flag Wall | Outri ggur | Flag Wall |
|---|---|---|---|---|---|---|
| | Rectangular | | C | | T | |
| Bare | 8507.24 | 8507.24 | 6357.61 | 6357.61 | 5888.05 | 5888.05 |
| At 0.2 + 0.4 H | 8534.10 | 8613.41 | 6429.35 | 6389.75 | 5934.05 | 6022.25 |
| At 0.6 + 0.4 H | 8583.01 | 8737.28 | 6401.50 | 6483.05 | 5941.57 | 6017.01 |
| At 0.8 + 0.4 H | 8618.90 | 8731.56 | 6520.33 | 6414.25 | 5969.41 | 6060.78 |
| At 1.0 + 0.4 H | 8591.31 | 8680.34 | 6392.22 | 6461.60 | 5928.27 | 5988.71 |

Fig. 8 Base shear 60 storey

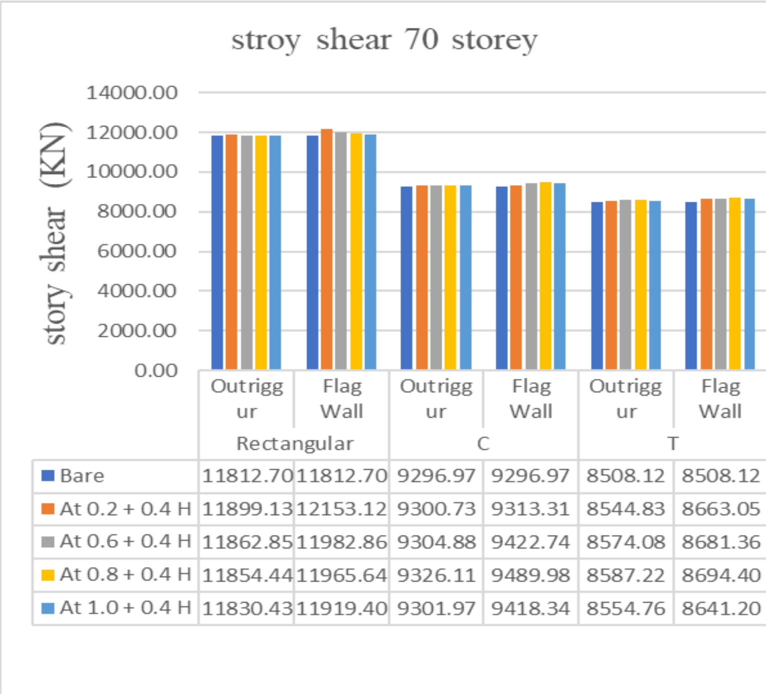



Fig. 9 Base shear 70 storey

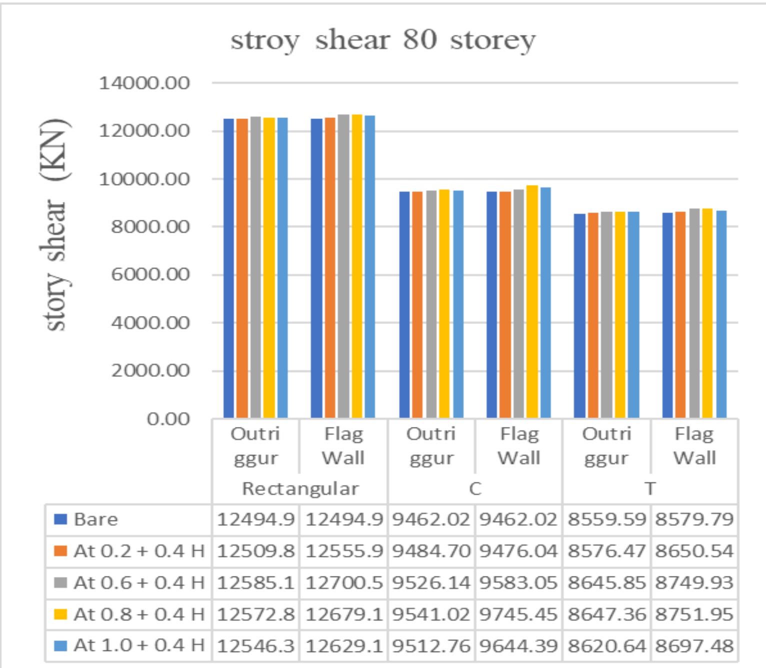



Fig. 10 Base shear 80 storey

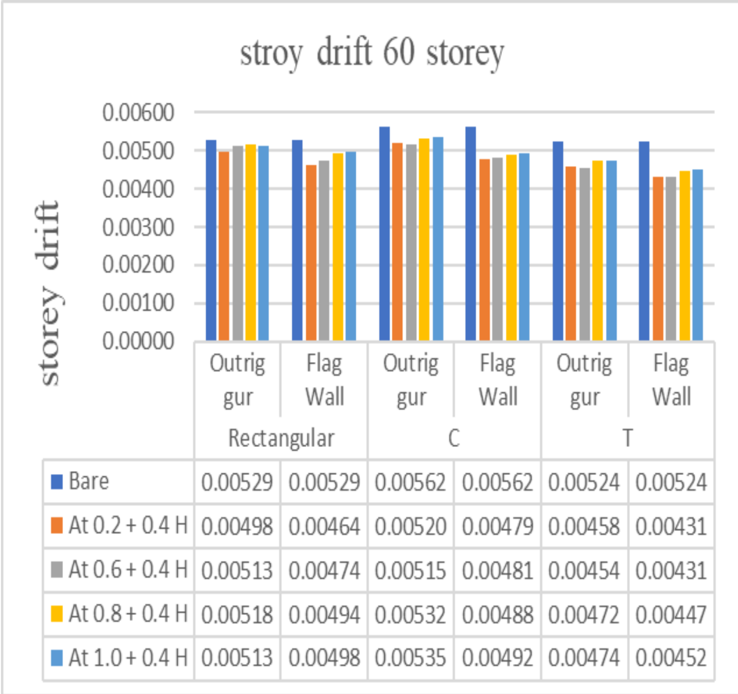



Fig. 11 story drift 60 storey

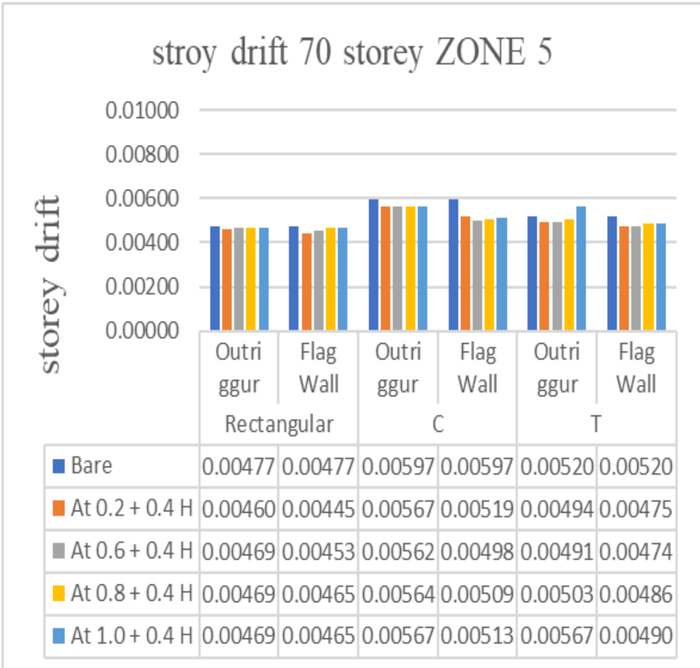



fIg.12 story drift 70 storey


| | Rectangular Outriggur | Rectangular Flag Wall | C Outriggur | C Flag Wall | T Outriggur | T Flag Wall |
|---|---|---|---|---|---|---|
| Bare | 0.00599 | 0.00599 | 0.00681 | 0.00681 | 0.00620 | 0.00620 |
| At 0.2 + 0.4 H | 0.00556 | 0.00552 | 0.00660 | 0.00619 | 0.00610 | 0.00587 |
| At 0.6 + 0.4 H | 0.00586 | 0.00553 | 0.00649 | 0.00596 | 0.00609 | 0.00577 |
| At 0.8 + 0.4 H | 0.00565 | 0.00561 | 0.00657 | 0.00604 | 0.00617 | 0.00594 |
| At 1.0 + 0.4 H | 0.00565 | 0.00572 | 0.00661 | 0.00603 | 0.00601 | 0.00614 |

Fig. 13 story drift 80 storey

## 4. Conclusions

- The values of Maximum Displacement least for location of outrigger and flag wall system is (0.4H+0.2H).
- The values of Base Shear least for location of outrigger and flag wall system is (0.4H + 1.0H).
- The values of Drift least for location of outrigger and flag wall system is (0.4H+0.6H).
- Maximum displacement is less in flag wall compared to outrigger.
- Maximum displacement is observed in C type of plan compared to T and Rectangular shape.
- In case of lateral loading C shape is most venerable compared to Rectangle and T shape.
- So, overall, the high-rise structure with flag wall is more efficient at (0.4H + 1.0H).

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