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Comparison of RC Shear Wall with Openings in Regular and Irregular Building

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***Abstract* - Shear walls are structural systems which provide stability to structures from lateral loads like wind, seismic loads. An attempt is made to apply the finite element modelling in analyzing and exploring the behavior of shear wall with opening under seismic load actions. Shear walls are generally located at the sides of buildings or arranged in the form of core that houses stairs and lifts. The properties of these seismic shear walls dominate the response of the buildings, and therefore, it is important to evaluate the seismic response of the shear walls appropriately. Due to functional requirements such as doors, windows, and other openings, a shear wall in a building contains many openings. In this present study, the main focus is to determine effectiveness of shear wall with vertical opening and staggered opening in regular and irregular buildings under earthquake loads with the help of finite element software, ETABS.**

Key Words: Shear wall, ETABS, Seismic behavior, Storey drift etc.

I. INTRODUCTION

In modern high rise buildings, shear walls are generally used as a vertical structural element for resisting the lateral loads that is induced by the effect of wind and earthquakes, they will have the strength and stiffness to resist the horizontal forces. Seismic waves reasons arbitrary ground motions in all possible directions, transmitting from the epicentre. If the structure has not been designed to resist these additional forces it may fail causing loss of life and property. In this way the impacts of sidelong loads like wind loads, quake forces & impact loads, etc. are achieving growing significance and every design engineer will face the issue of giving sufficient strength & stability for the structures against the imposed total lateral loads.

Lateral forces caused by wind, earthquake, and uneven settlement loads, in addition to the weight of structure and occupants; create powerful twisting (torsion) forces. These forces can literally tear (shear) a building apart. Reinforcing a frame by attaching or placing a rigid wall inside it maintains the shape of the frame and prevents rotation at the joints. Shear wall are specially designed structural walls in building to resist lateral forces that are produce in the plane of wall due to wind, earthquake and other forces. Shear walls not only help to prevent catastrophic collapse, but they also help to prevent small-scale damage like cracked drywall and fractured tile. Shear walls play the same role in houses in high-wind zones. Shear walls are utilized to withstand the bending moments of a building, because of lateral loads. They act as vertical cantilevers to give the essential stiffness in a building.

Shear walls may have one or more openings for functional reasons such as doors, windows, and other types of openings in shear wall. Openings can be arranged vertically or in staggered manner as shown in fig1.The size and location of openings may vary depending on purposes of the openings. Properly designed and detailed buildings with shear walls have shown good performance in past earthquakes.

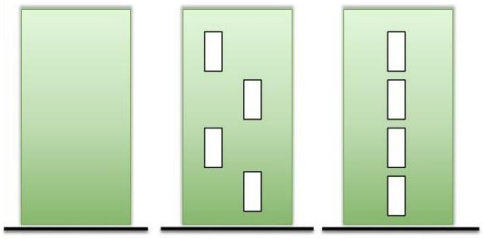

Fig:1 Shear wall without opening and with vertical and staggered opening

II. OBJECTIVES

(i) To determine the effect of vertical and staggered openings in RC shear wall in a regular building under seismic loads
(ii) To study the behavior of vertical and staggered openings in RC shear wall in a irregular building under seismic loading
(iii) Comparison of effect of openings in regular and irregular building.

III. LITERATURE VIEW

S.H.Jagadale , N.L. Shelke (2016)[9] studied the "Analysis of Various Thicknesses of Shear Wall with Opening and without Opening and their Percentage Reinforcement". In this paper the effectiveness of shear wall with various thicknesses, and also vertical opening, staggered opening and without opening has been studied and found that performance of staggered opening is better in seismic zone as compared to vertical opening and without opening in shear wall.

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Aarathi Harini T and G Senthil Kumar (2015)[1] analysed a seven storey building without opening, with vertical openings, and with staggered openings. The study was carried out using linear elastic analysis, with the help of finite element software ETABS, using response spectrum method. The comparative results showed that the time period, displacement, base shear and stress distribution around the openings depend on the arrangement of openings. They concluded that staggered openings in shear wall proved to be highly advantageous and they were found to provide better lateral resistance than shear walls with vertical openings.

N. Janardhana Reddy, D. Gose Peera, T. Anil Kumar Reddy (2015)[6] presented a study on "Seismic Analysis of Multi-Storied Building with Shear Walls Using ETABS-2013". In this work a high rise building with different places of shear walls is considered for analysis. The multi storey building with 14 storey's is analyzed for its displacement, strength and stability using ETABS-2013 software. It is evident that shear walls which are provided from foundation to the roof top, are one of the excellent mean for providing earthquake resistance in high rise buildings.

Arvind R. Patel, Dr. K. B. Parikh (2015)[2] studied the "Effect on Location of Shear Wall with Opening in RC Irregular Structure Subjected to Seismic Load & blast load". A study on an irregular high rise building with shear wall was studied to understand the lateral loads, story drifts and torsion effects. From the results it is inferred that optimum shear walls are more resistant to lateral loads in an irregular structure.

Sharmin Reza Chowdhury, M.A. Rahman, M.J.Islam (2012)[8] studied the "Effects of Openings in Shear Wall on Seismic Response of Structures". This study is carried out on 6- story frame-shear wall buildings, using linear elastic analysis with the help of finite element software, ETABS under earthquake loads in equivalent static analysis. The results reveal that stiffness and seismic responses of structures is affected by the size of the openings as well as their locations in shear wall.

IV. METHODOLOGY

A Modelling of Building

Here the study is carried out for the behaviour of G+10 storied RC building with shear wall in regular and irregular plans. Floor height provided 3m. And also the properties are defined for the structure.

B Building plan and dimensional details

The Following are the specification of G+ 10 storied RC building located in seismic zone V resting on medium soil type. The complete detail of the structure including modelling concepts is given Table 1. Buildings modelled using ETABS are shown in Fig: 2 to Fig:13

Table1: Structural data required for analysis

Parameter	Values
Concrete grade	M25
Reinforcement grade	Fe 500
Thickness of slab	150mm
Dimension of beam	300mm X 600mm
Dimension of column	300mm X 600mm
Floor height	3.0 m
Shear wall thickness	300 mm
Opening of shear wall	1.2m X 1.2m

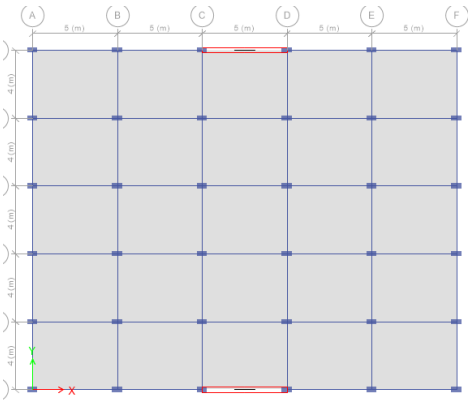

Fig 2: Plan of Regular Building with shear wall

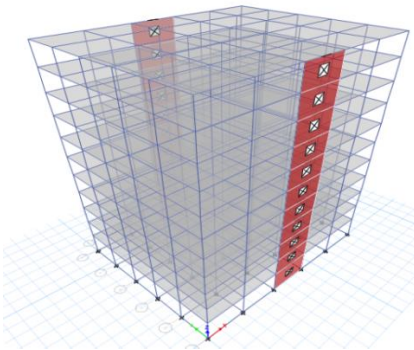

Fig.3 Regular building model with shear wall having vertical opening

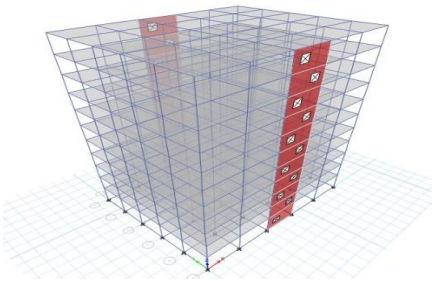

Fig.4 Regular building model with shear wall having staggered opening

Fig 5: Plan of H shaped Building with shear wall

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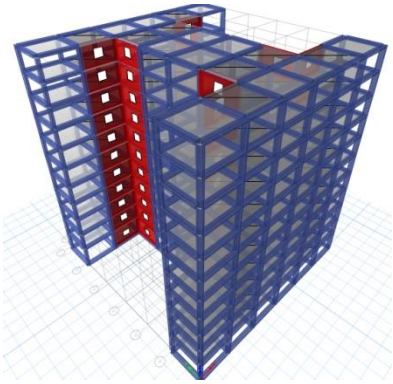

Fig 6: H shaped Building model with shear wall having vertical opening

Fig 7: H shaped Building model with shear wall having staggered opening

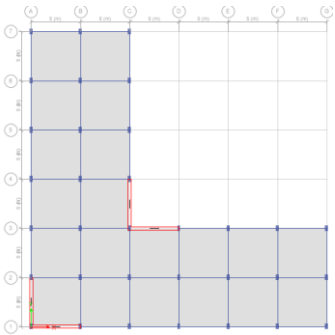

Fig 8: Plan of L shaped Building with shear wall having vertical opening

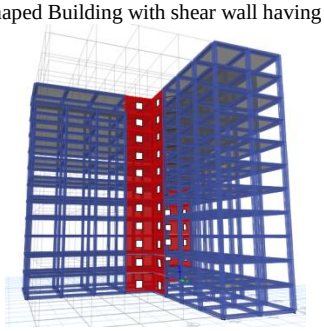

Fig 9: L shaped Building model with shear wall having vertical opening

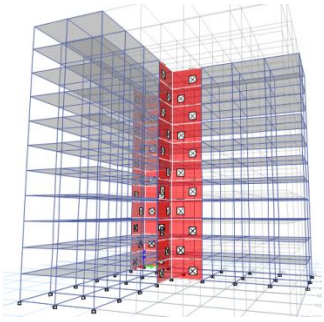

Fig 10: L shaped Building model with shear wall having staggered opening

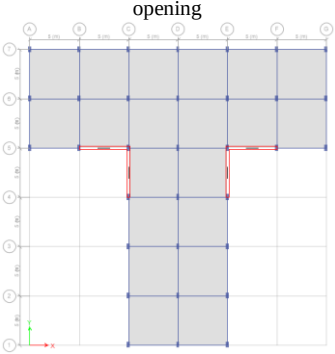

Fig 11: Plan of T shaped Building with shear wall having vertical opening

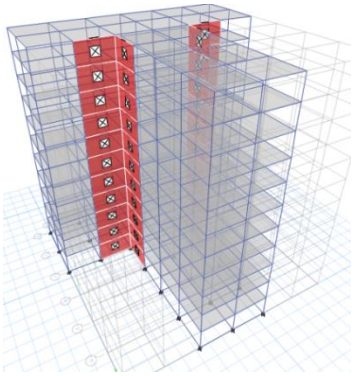

Fig 12: T shaped Building model with shear wall having vertical opening

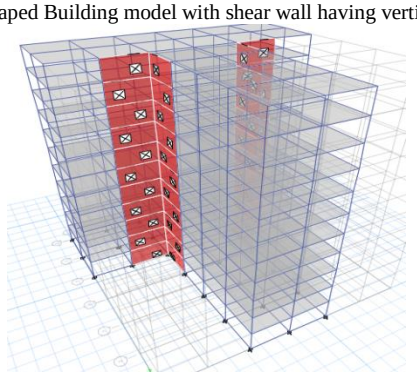

Fig 13: T shaped Building model with shear wall having staggered opening

C. Assigning loads

- Dead load
  Dead load intensity = 1.5 kN/m^2
- Live load

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Live Load Intensity specified (Public building) = 3kN/m^2

- Wall weight

Wall weight = 12 kN/m

V SEISMIC ANALYSIS OF BUILDING

A. Seismic parameters considered (as per 1893(PART 1): 2002)

Table 5.1: Parameters considered for seismic analysis

Zone	V
Importance factor	1.5
Response reduction factor	5
Soil type	II
Damping ratio	5%

VI ANALYSIS RESULTS

A. Displacement, Storey drift and Base shear of G+10 regular building

Graphical representation of displacement, storey drift and base shear values are shown in Fig: 14 to Fig16

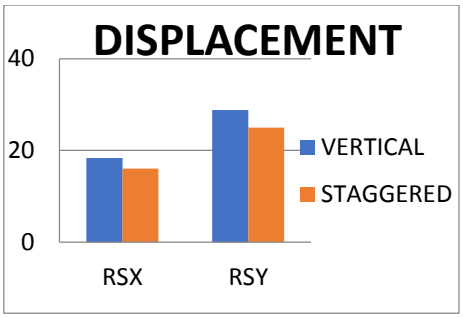

Fig: 14 Variation of displacement for regular building with vertical and staggered opening

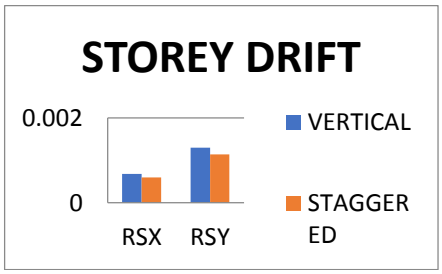

Fig: 15 Variation of storey Drift for regular building with vertical and staggered opening

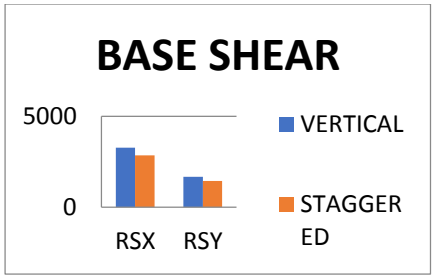

Fig: 16 Variation of Base shear for regular building with vertical and staggered opening

B. Displacement, Storey drift and Base shear of G+10 L shaped building

Graphical representation of displacement, storey drift and base shear values are shown in Fig: 17 to Fig: 19

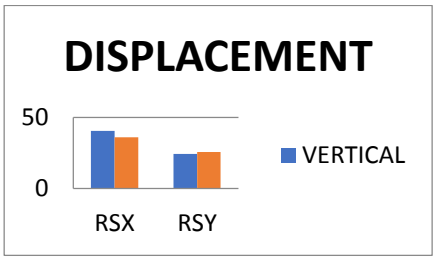

Fig: 17 Variation of displacement for L shaped building with vertical and staggered opening

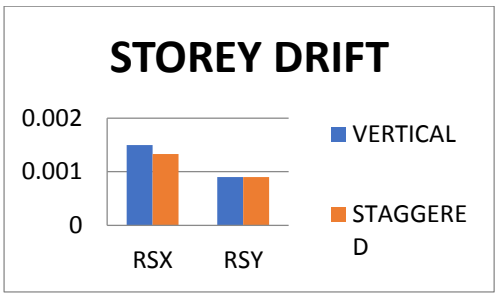

Fig: 18Variation of storey Drift for L shaped building with vertical and staggered opening

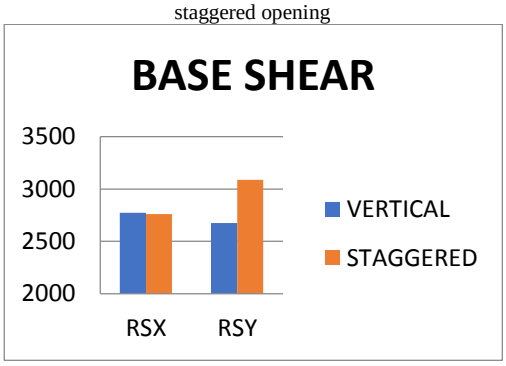

Fig: 19 Variation of base shear for L shaped building with vertical and staggered opening

C. Displacement, Storey drift and base shear of G+10 H shaped building

Graphical representation of displacement, storey drift and base shear values are shown in Fig: 20 to Fig: 22

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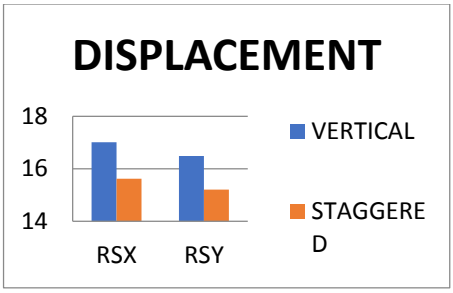

Fig: 20 Variation of storey displacement for H shaped building with vertical and staggered opening

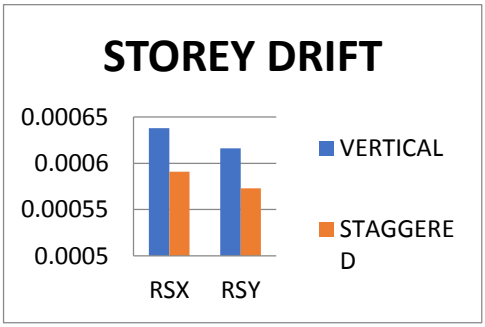

Fig: 21 Variation of Storey Drift for H shaped building with vertical and staggered opening

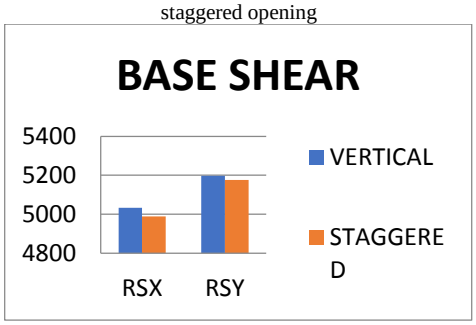

Fig: 22 Variation of Base shear for H shaped building with vertical and staggered opening

D. Displacement, Storey drift and Storey shear of G+10 T shaped building

Graphical representation of displacement, storey drift and base shear values are shown in Fig: 23 to Fig: 25.

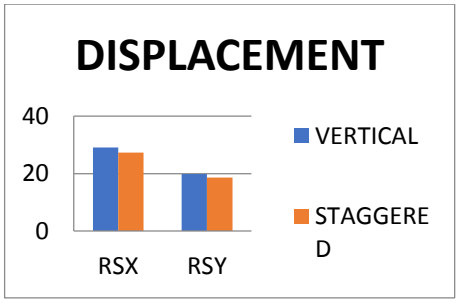

Fig: 23 Variation of storey displacement for T shaped building with vertical and staggered opening

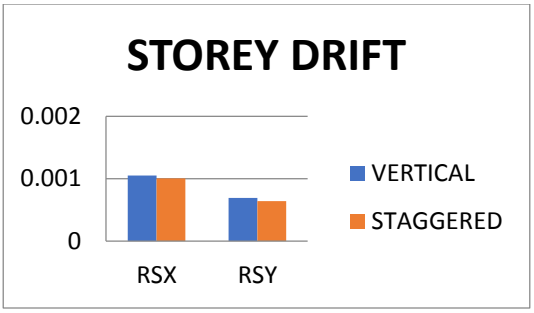

Fig: 24 Variation of Storey Drift for T shaped building with vertical and staggered opening

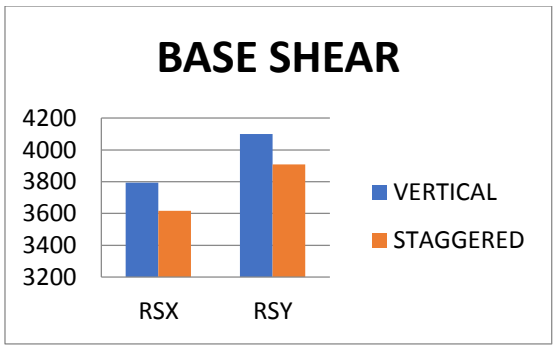

Fig: 25 Variation of storey shear for T shaped building with vertical and staggered opening

VII. CONCLUSIONS

The present study focuses to determine effectiveness of shear wall with vertical opening and staggered opening in regular and irregular buildings under earthquake loads with the help of finite element software, ETABS. The G+10 storied rectangular, L, H and T shaped buildings with shear wall having vertical and staggered openings are analysed using response spectrum analysis. From the above study, following conclusions were drawn.

- G+10 regular building with shear wall having staggered opening shows better dynamic behaviour based on displacement (percentage reduction of 12.92% in X direction and 13.15% in Y direction compared to vertical openings), storey drift (percentage reduction of 11.176% in X direction and 12.307 in Y direction compared to vertical openings) and base shear (percentage reduction of 12.53% in X direction and 13.13% in Y direction compared to vertical openings) values in X and Y directions.
- G+10 L shape building with staggered opening shows better performance in terms of displacement (percentage reduction of 11.239 % in X direction compared to vertical openings) and base shear (percentage reduction of 0.44% compared to vertical openings) in X- direction. But L shaped building with shear wall having vertical opening shows better performance in terms of displacement (percentage reduction of 5.4% compared to staggered openings) and base shear (percentage reduction of 13.37% compared to staggered openings) in Y – direction.

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- Shear wall with staggered opening shows better performance compared to shear walls with vertical openings in H shaped G+10 building based on displacement (percentage reduction of 8.17% in X direction and 7.75% in Y direction compared to vertical openings), storey drift (percentage reduction of 6.739% in X direction and 6.98% in Y direction compared to vertical openings) and base shear (percentage reduction of 0.896% in X direction and 0.401% in Y direction compared to vertical openings) values in both X and Y directions.
- Shear wall with staggered opening shows better performance compared to shear walls with vertical openings in T shaped G+10 building based on displacement (percentage reduction of 5.99% in X direction and 5.8% in Y direction compared to vertical openings), storey drift (percentage reduction of 4.65% in X direction and 7.51% in Y direction compared to vertical openings) and base shear (percentage reduction of 4.676% in X direction and 4.69% in Y direction compared to vertical openings) values in both X and Y directions.

Hence we can concluded that regular building with shear wall having staggered opening shows better results in terms of displacement, storey drift and storey shear. In the case of irregular buildings (H shaped and T shaped) buildings with staggered opening shows better results in terms of displacement, storey drift and storey shear in both X and Y directions. But in case L shaped irregular building, building with shear wall having vertical openings shown good results in terms of displacement and base shear in Y direction.

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