International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 07 | July 2021 www.irjet.net p-ISSN: 2395-0072

NUMERICAL INVESTIGATION OF POST TENSIONED HYBRID SHEAR WALL UNDER FOUNDATION STRUCTURE INTERACTION WITH ENERGY DISSIPATING ELEMENTS

Zulfath O.A[1], Abeena Mol N.M[2]

[1]*PG student, Dept. of Civil Engineering, IIPE, Nellikkuzhi, Ernakulam, Kerala, India*
[2]*Assistant Professor, Dept. of Civil Engineering, IIPE, Nellikkuzhi, Ernakulam , Kerala, India*

Abstract - *In developing countries, multi-storey buildings provide shear wall. A hybrid concrete shear wall system is the combination of traditional reinforced concrete construction with energy dissipating reinforcement and post-tensioning tendons. A major limitation with traditional post-tensioned (PT) shear wall in seismic areas is its low energy dissipation, which can be alleviated by adding extra moderate steel reinforcement externally at the intersection of the wall and the foundation , called external energy dissipating reinforcement (EEDR). This proposed system is expected to enable rehabilitation of the wall after an earthquake, as well as keep it ready for next earthquake. A detailed numerical study was performed to test feasibility of the proposed configuration using ANSYS software. Finite Element Method is an important approach in analyzing civil engineering problems numerically. In this paper, we attempt to apply the finite element analysis to explore the shear wall behavior with differently shaped openings and openings of different sizes under seismic loads. In modern high -rise buildings, shear walls are commonly used as a vertical structural element to withstand the lateral loads caused by wind and earthquakes. Four different types of eccentric loading conditions were taken for the study and more good and worse condition of loading were found . A shear wall may contain several openings due to the functional requirements such as doors and windows, which may affect the overall seismic response of the structure. The seismic nature of the building depends on the location of openings and the size of openings. The circular opening is the most suitable opening shape for the shear wall. The present study is an attempt to understand the effectiveness of shear wall on different aspect ratios of shear wall (H/L). Three different aspect ratis of shear wall (R= H/L i.e. 1,2,3) were taken. The most suitable position for door size was also computed.*

Key Words**:** Hybrid shear wall , Post Tensioned wall, energy dissipating element, Foundation structure interaction, ANSYS etc

1. INTRODUCTION

Shear walls are the structural members used to resist lateral forces, mainly caused by wind and earthquake load. These are especially important in high- rise buildings subjected to lateral loads. A major limitation with conventional post-tensioned (PT) shear wall in seismic areas is its low energy dissipation, this can be reduced by placing additional mild steel reinforcement at the intersection of the wall and the foundation, called internal energy dissipating reinforcement (EDR). While the behavior of hybrid walls with internal EDR is satisfactory, the replacement of them in post yielding condition (i.e., after an earthquake) poses a major concern. Therefore, in this study, a new simple arrangement is proposed with external-energy dissipating-reinforcement (EEDR) to facilitate its easy placement and replacement [1]. The Finite Element Method is an important approach in analyzing civil engineering problems numerically. In this paper, an effort is made to apply the finite element analysis in exploring the behavior of shear wall with different shape openings and different size openings under seismic loads. performance of shear wall with different aspect ratios, and performance of shear wall with different eccentric loading conditions.

1.1 Numerical Investigation of PT Hybrid Shear Wall

An earthquake is the sudden movement of the ground that releases elastic energy stored in earth's crust and generates seismic waves. These elastic waves radiate outward from the source and vibrates the ground. The structures are susceptible to collapse or large lateral displacements due to earthquake ground motions and require special attention to limit this displacement. When a building is subjected to seismic wave, large amount of energy is distributed within the building and the level of damage sustained by the building depends on the dissipation of this energy.

The primary function of an energy dissipation element is to reduce the damage in main structural components. Shear walls are widely used in medium and high-rise buildings in regions of high seismicity as primary lateral load bearing elements.

1.2 Geometry and material properties

Different models have been created using ANSYS software with the properties like yield strength, poisson's ratio, etc as per the Table 1. The length of post tensioned hybrid shear wall selected for analysis is 2830 mm, width is 1000mm and thickness 100mm. The foundation beam have a size of

1200x300x100 mm as shown in Fig –1. The various applicable conditions of PT hybrid shear walls that are selected for this project can be divided mainly into four category as;

1. Models with different aspect ratio
2. Models with different shape openings
3. Models with different opening sizes
4. Models with different eccentric loading conditions

Table -1: Material Properties

Properties	PT Tendon	EDR
Modulus of elasticity MPa	2×10^5	206×10^3
Compressive strength MPa	-	-
Poisson's ratio	0.3	0.3
Yield strength MPa	1650	550
Ultimate strength MPa	1850	650

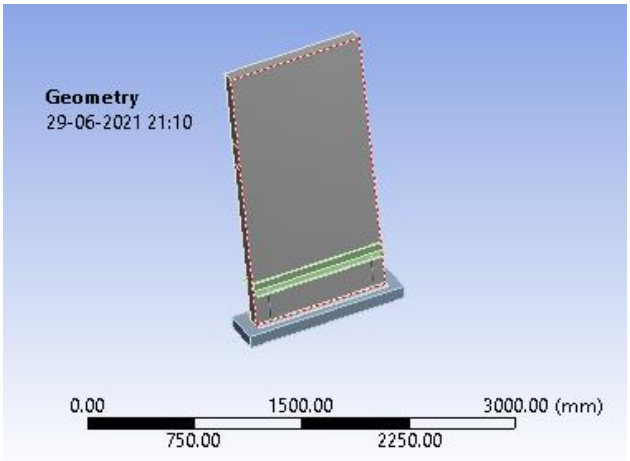

Fig -1: Geometry of the Model

1.3 PT hybrid shear wall with varying aspect ratio

Table -2: Dimension Details of Model 1

SHEAR WALL		FOUNDATION BEAM	
Height	2200 mm	Length	2200 mm
Width	2000 mm	Width	300 mm
Thickness	100 mm	Depth	100 mm

Table -3: Dimension Details of Model 2

SHEAR WALL		FOUNDATION BEAM	
Height	4400 mm	Length	2200 mm
Width	2000 mm	Width	300 mm
Thickness	100 mm	Depth	100 mm

The main goal of this research is to find out up to which dimension the effectiveness of shear wall is maintained. The

present study is an attempt to understand the effectiveness of shear wall on different aspect ratio of shear wall (H/L). Three different aspect ratio (1,2,3) of shear wall has been taken,by varying the height of the building . At the end, three different aspect ratio compared with corresponding shear force. Dimension details of three models are shown in Table 2,3 and 4.

Table -4: Dimension Details of Model 2

SHEAR WALL		FOUNDATION BEAM	
Height	6600 mm	Length	2200 mm
Width	2000 mm	Width	300 mm

Thickness	100 mm	Depth	100 mm

1.4 PT hybrid shear wall with different shape openings

The PT hybrid shear wall still keeps the same but they have rectangular and circular opening at three equidistant positions.

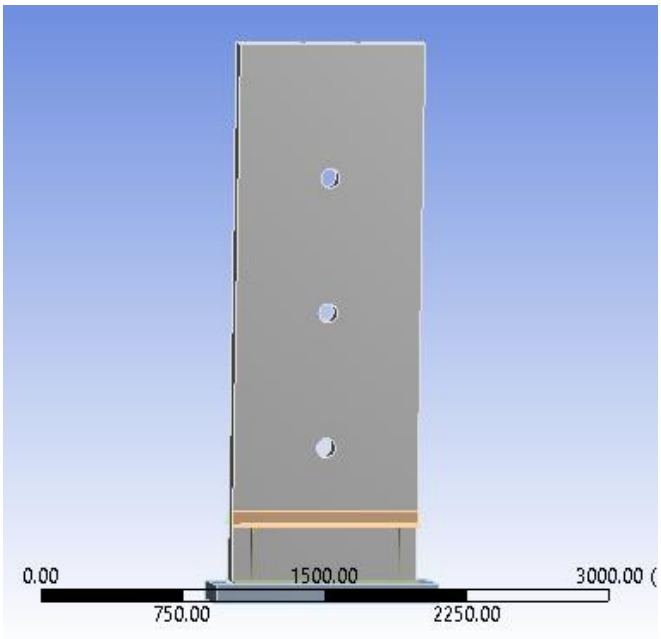

Fig -2: Geometry of the Model with circular opening

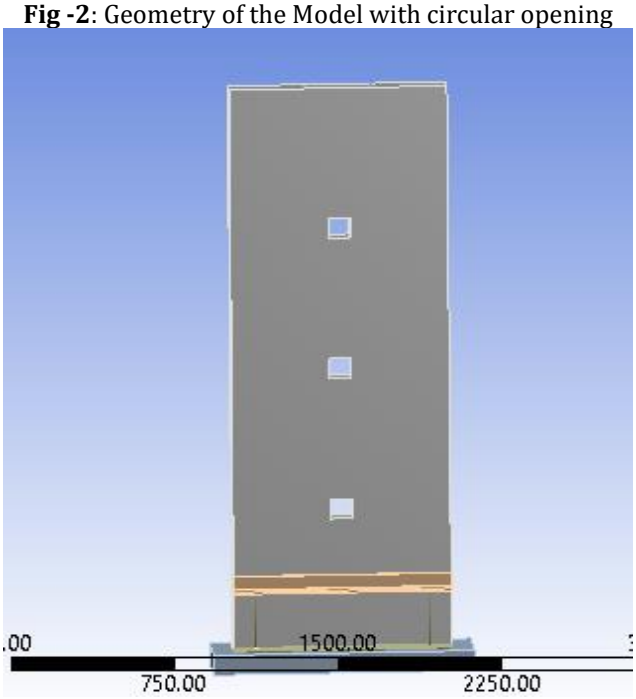

Fig -3: Geometry of the Model with rectangular opening

In case of shear wall bottom end is fixed and load is applied on the top of the shear wall.

1.5 PT hybrid shear wall with different opening sizes

In this study models with different sized circular and rectangular openings are considered. In the section of rectangular sized opening, models with opening sizes 60 mm, 80mm and 100mm are considered. In the case of circular sized opening, models with opening sizes 80mm diameter, 100mm diameter and 110mm diameter are considered.

1.6 PT hybrid shear wall with door size opening

Shear walls generally start at the foundation level and are continuous throughout the building height. This study aims to analyze the behavior of shear wall with door sized openings in three different positions and compare them with each other, as far as the seismic response is considered. PT hybrid shear walls having 2830mmX1000mmX100mm size and foundation beam having size 1200mmX300mmX100mm is considered for the present study. A door sized opening (0.28mX1.85m) is placed in three different positions from the bottom to top of the wall (0.1m,0.2m and 0.3m from the bottom of the wall).

1.7 PT hybrid shear wall with different eccentric loading conditions

The primary purpose of all kinds of structural systems used in the building type of structures is to support gravity loads. The most common loads resulting from the effect of gravity are dead load, live load and snow load. Besides these vertical loads, buildings are also subjected to earthquake loads. Earthquake loads can develop high stresses, produce sway movement or cause vibration. Shear walls offer an economic means to provide lateral load resistance in multi-storey buildings. The various applicable eccentric loading conditions of PT hybrid shear walls that are selected for this project can be divided mainly into four category as;

1. 3 point lateral load
2. 2 point lateral load at top of the shear wall
3. 2 point lateral load at bottom of the shear wall
4. 2 point lateral load at top and bottom only

The geometry of four models with different eccentric loading conditions are shown below.

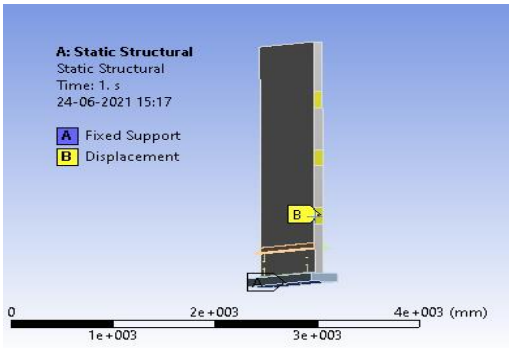

Fig -4: 3point lateral load condition

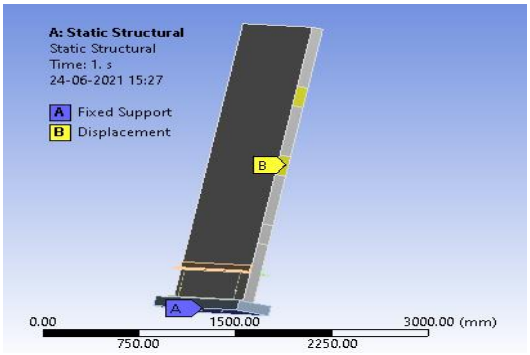

Fig -5: 2 point lateral load at top of the shear wall condition

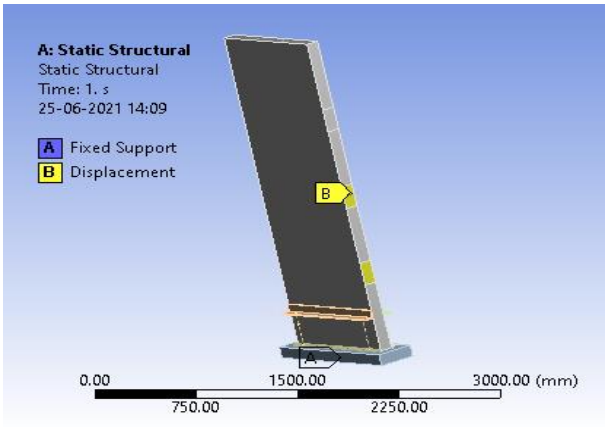

Fig -6: 2 point lateral load at bottom of the shear wall condition

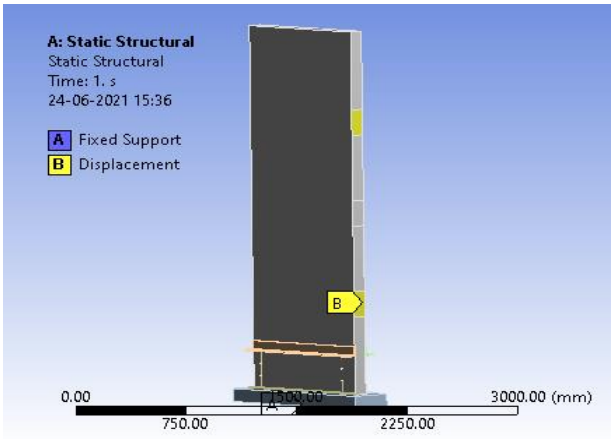

Fig -7: 2 point lateral load at top and bottom only condition

2. RESULT AND DISCUSSIONS

The equivalent stress and total deformations for various PT hybrid shear wall models obtained from finite element analysis done in ANSYS 16.1 are shown below.

Chart 1 is the Graphical representation of models with different aspect ratio. From the analysis, As the aspect ratio increases, the shear force carrying capacity decreases. As the aspect ratio of shear wall increases (height of shear wall increases), the shear force carrying capacity of the shear wall decreases. In case 1 (H/L=1) the shear force carrying capacity of the shear wall higher than case 2 (H/L=2) and case3 (H/L= 3).

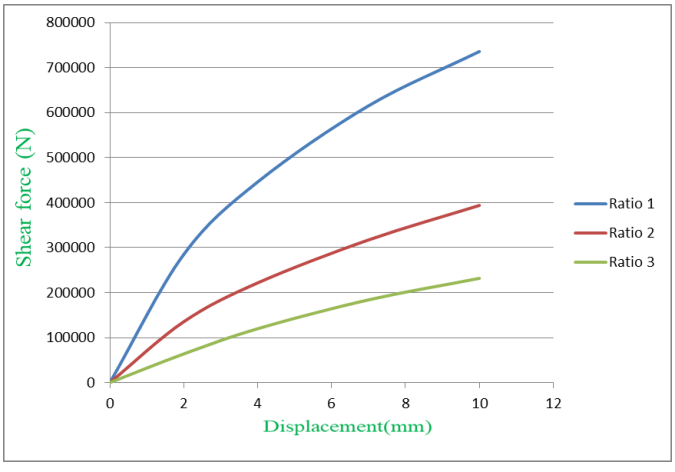

Chart -1: Graphical representation of models with different aspect ratio

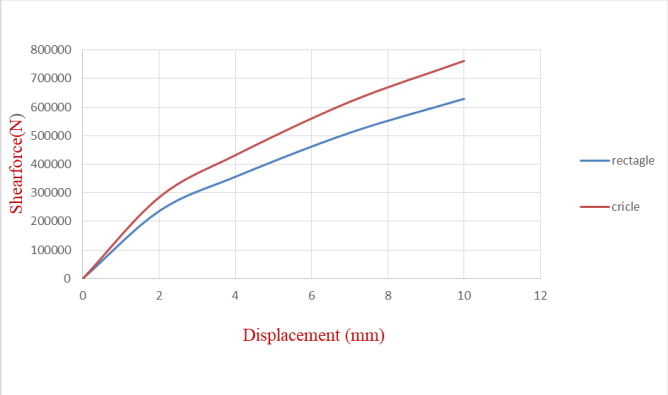

Chart -2: Graphical representation of models with rectangular and circular opening

Table -5: Comparison of rectangular and circular opening

TYPE	MAX. DISPLACEMENT (mm)	MAX. SHEAR FORCE (KN)
RECTAGULAR OPENING	10 mm	629.090 KN
CIRCULAR OPENING	10 mm	761.750 KN

From the above analysis, (chart 2)it is clear that the shear walls with circular opening have more shear force resisting capacity than shear walls with rectangular opening. Actually, circular shape is the seismic resistant shape. Maximum shear force in the PT hybrid shear wall with circular opening is 761.75 kN, which is 17.41 % more than the value of PT hybrid shear wall with rectangular opening.

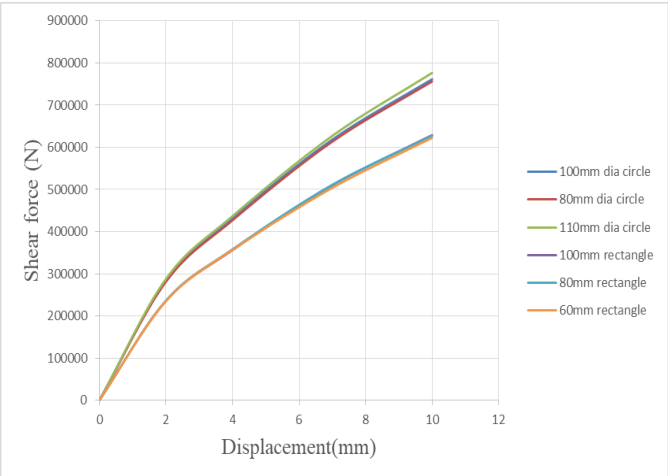

Chart -3: Graphical representation of models with different opening size

From the above analysis, it is clear that the shear wall may contain many openings due to the functional requirements such as doors and windows, which may largely affect the overall seismic response of the structure. The seismic behavior of the building not only depends on the shape of the openings but also on the size of openings. The shear force carrying capacity in 110 circular dia openings agreed quite well than that of other size of openings.

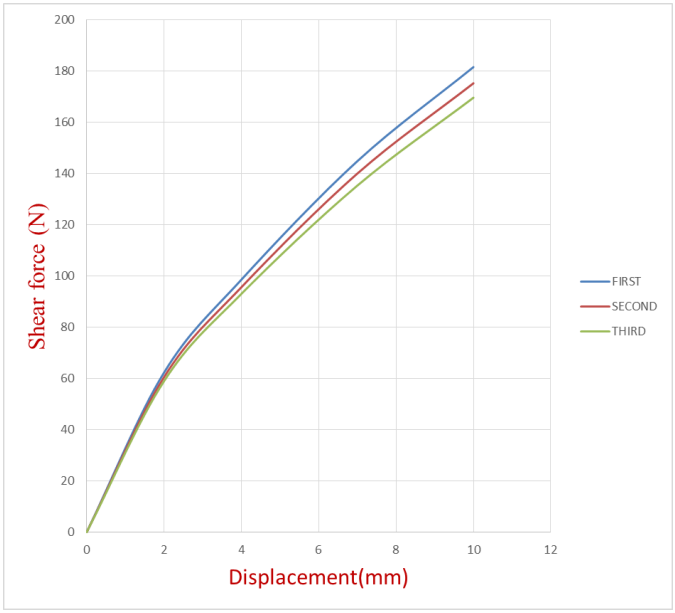

Chart -4: Graphical representation of models with door size opening

From the above analysis, it is clear that the first position is the best position compared to the other two positions. In a shear wall the suitable position for a door opening is more close to the foundation beam.

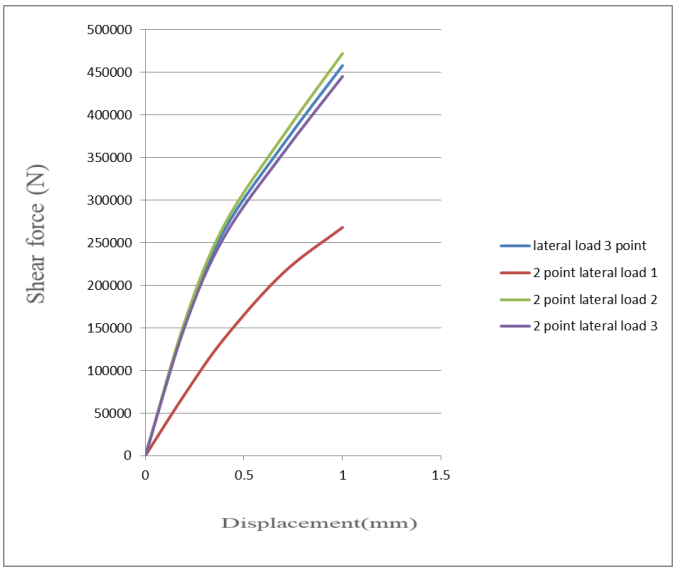

Chart -5: Graphical representation of models with different eccentric loading conditions

For this type of study, four models are considered. First is having 3 point lateral load. Second model is having 2 point

lateral loads at top end of the shear wall. Third model is having 2 point lateral loads at bottom of the shear wall. Fourth model is having 2 point lateral loads at top and bottom of the shear wall only, and middle portion is avoided from the action of loading. Model 3 (2 point lateral load at bottom of the shear wall) can with stand more shear force. 2 point lateral load at top of the shear wall is the more worse eccentric loading condition. At the top of the shear wall more load resisting reinforcement and supports are necessary.

3. CONCLUSIONS

From the study, following conclusions were arrived,

- As the aspect ratio of shear wall increases,(height of the shear wall increases) the capacity to with stand the shear force decreases. There is a large difference between the maximum shear force affordable by the shear wall. The second model have moderate value. So aspect ratio 2 is better for shear walls.

- By comparing the shear walls with rectangular and circular opening, the shear walls with circular opening have better performance. Actually circular shape is a seismic resistant geometry
- Analysis done with shear wall having door size opening in three different positions from the bottom of the foundation beam, it is clear that the door opening very close to the foundation beam is more efficient to withstand seismic and wind loads.

- The seismic behavior of the building not only depends on the shape of the openings but also on the size of openings. The shear force carrying capacity in 110 circular dia openings agreed quite well than that of other size of openings. Large opening sizes have better performance than small opening sizes considered in the study. In the case of rectangular size opening, 100 mm rectangular openings have more efficiency. In case of different rectangular opening sizes there is a small difference between their load carrying capacity.
- The study about the various eccentric lateral loading conditions in a PT hybrid shear wall reveals that Model 3 (2 point lateral load at bottom of the shear wall) can with stand more shear force. 2 point lateral load at top of the shear wall is the more worse eccentric loading condition. So at the top of the shear wall more load resisting reinforcement and supports are necessary.

Shear walls with different opening sizes and different reinforcing patterns can be further analyzed for future research work, so that the failure mechanism of shear walls with openings can be understood in a better way and a proper design code can be formulated for practice.

REFERENCES

[1] **Prachi Taori , Suresh Ranjan Dash & Goutam Mondal**, (2020) "Seismic Response of Post Tensioned Hybrid Shear Walls with External Energy Dissipating Reinforcement (EEDR)",journal of earthquake engineering

[2] **Sara Honarparast** & **Omar Chaallal,** (2019) "Experimental Seismic Performance Evaluation of Coupling Beams: Comparison of Old with Modern Codes",journal of earthquake engineering

[3] **Mahendra Kumar**, (2018) "Seismic Behavior of Buildings with Shear Wall", International Journal of Engineering Research & Technology

[4] **Pradeep Pujar, Amaresh,** (2017) "Seismic Analysis of Plan Irregular Multi-storied Building with and without Shear Walls",IRJET Impact Factor value: 5.181 ISO 9001:2008 Certified Journal Page 1405

[5] **Nehal A. Bhavsar, Noopur A. Shah, Satyen D. Ramani,** (May 2016) "Study on Effectiveness of Shear Wall on Different Building Aspect Ratio ", Journal of Emerging Technologies and Innovative Research Volume 3, Issue 5

[6] **Aarthi Harini T and G. Senthil Kumar,** (March-2015) "Behavior of R.C. Shear Wall with Staggered Openings under Seismic Loads", International Journal For Research In Emerging Science And Technology, Volume-2, Issue-3