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Seismic Behaviour of Asymmetric RCC Structure with Different Shear Wall Area To Floor Area Ratio

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Abstract - *Earthquakes represent one of the most significant threats to human life, having devastated numerous cities across all continents. In India, the collapse of many structures during seismic events has resulted in substantial loss of life and property. Consequently, there is an increasing emphasis on assessing the structural integrity of reinforced concrete (RC) frames to withstand intense ground motions. To mitigate losses following earthquakes, both experimental and analytical research on seismic design methodologies advocates for the incorporation of shear walls in earthquake-resistant designs. This study conducts an analytical investigation to evaluate the impact of different shear wall area to floor area ratios on the seismic performance of reinforced concrete asymmetric building by using ETABS software. G+12 vertically irregular building is considered for analysis purpose. Three different shear wall to floor area ratios (0.5, 1 & 1.5) are considered for analysis of structure. Result have shown that with increase in shear wall area to floor area storey displacement, storey drift & time period of building reduces but there is increase in base shear value as floor area to shear wall area increases. Variation of results between ratio 1 & 1.5 is less & only a slight effect is observed when shear wall area to floor area ratio is increased above 1.5.*

Index Terms – *Shear wall area to floor area ratio, Vertically Irregularity, Asymmetric Building, Seismic Analysis*

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I.INTRODUCTION:

India is an emerging nation characterized by extensive infrastructure development, the establishment of smart cities, and the construction of numerous high-rise buildings. Additionally, India is a subcontinent with a history of significant seismic activity, having experienced many destructive earthquakes. The country is categorized into five distinct seismic zones based on varying geological conditions. Zone V exhibits the highest seismicity, while Zone II has the lowest. Many key cities in India, which are vital for business and feature numerous high-rise constructions, are situated in either Zone IV or Zone V. Consequently, these buildings are particularly susceptible to intense seismic forces, necessitating that they be designed to withstand earthquakes. This requirement calls for advancements in structural design, incorporating various elements specifically engineered to resist seismic impacts. Such elements may include cross bracings, different types of dampers, and shear walls. Shear walls serve as critical structural components that counteract both gravity and lateral loads on buildings, primarily providing lateral stiffness and thereby mitigating the majority of seismic forces during an earthquake. Due to their advantages in structural design, the use of shear walls has become increasingly prevalent. However, their placement within a structure is crucial and requires thorough assessment. This study seeks to determine the optimal shear wall area to floor area ratio for an asymmetric building, aiming to deliver a more stable and cost-effective design solution for any asymmetric high-rise structure. In this study three different shear wall to floor area ratio (0.5,1 &1.5) of a asymmetric building with vertical irregularity is considered for analysis purpose by using ETABS software.

II.LITERATURE REVIEW:

The subsequent section provides a summary of research articles authored by various individuals across different publications.

Burcu Burak and Hakki Gurhan Comlekoglu (2013) [1] has made an analytical study to evaluate the effect of shear wall area to floor area ratio on the seismic behaviour of midrise RC structures. Main parameters considered in this study that affect the overall seismic performance of the buildings are the roof and interstory drifts and the base shear responses. Results indicate that at least 1.0% shear wall ratio should be provided in the design of midrise buildings to control the drift. In addition, when the shear wall ratio increases beyond 1.5%, it is observed that the improvement of the seismic performance is not as significant.

S.A. Halkude, C.G. Konapure, S.M.Birajdar (2015) [2] Carried out investigation on varying percentage length of a shear wall with aspect ratio (L/B) 1 for seismicity. The seismic parameters are considered as storey shear, displacement, drift, base shear, stiffness and natural period. Results shows that when shear walls are placed away from the C.G. then, the seismic parameters such as storey displacements, drift, and natural period are found more; but other parameters such as storey shear, base shear and stiffness of structure become less.

Hanif Satria Aji, Anis Rosyidah, Jonathan Saputra (2022) [3] aimed to find the variations in the shear walls placement on the structure's response under the Direct Displacement Based Design (DDBD) method. Results showed that Percentage of base shear decreased as the height of building increases. This research indicates the significant differences in the x-direction shear force and the y direction moment The shear walls are suggested to be placed according to the building's condition and the earthquake ground site's class to produce an optimal structure to resist earthquake loads.

Akram Khelaifia, Rachid Chebili, Ali Zine (2023) [4] emphasizes the optimal placement and shear wall–floor area ratio in building design. Non-linear analyses were conducted on an eight-story building located in a high seismic zone, exploring different scenarios of shear wall positions and ratios to floor area. The findings indicate that concentrating shear walls in the middle of the structure yields superior performance compared to peripheral distributions during the design phase. Employing shear walls that completely infill the frame and form compound shapes (e.g., Box, U, and L) enhances reliability in terms of inter-story

III.OBJECTIVES:

1. To evaluate the effect of shear wall area to floor area ratio on seismic behaviour of Symmetric RCC building.
2. Modelling of asymmetric G+12 building on ETABS Software.
3. Analysis of effect of shear wall area to floor area ratio on seismic behaviour of asymmetric RCC building.
4. To study the parameters - storey drift, lateral displacement, base shear, building time period.

IV.METHODOLOGY:

1. Selection of asymmetric building plan for modelling & analysis.
2. Modelling of G+12 RCC building on ETABS Software.
3. Preparation of building models that have twelve storeys with the same floor plans but different shear wall areas and arrangements shall be prepared for analysis.
4. Selection of Shear Wall to Floor area ratios for analysis of building using software.
5. Analysis of Models with different Shear Wall to Floor area ratios.

A. Structural Modelling of Buildings

Table 1 has Structural Data which has been used for the Modelling. Modelling is done by using ETABS software Vertically asymmetric building is considered for analysis purpose.

Table -1: Structural Modelling Details

Structural Details	
Type of Structure	RCC Structure with shear wall
No. of Stories	G+12
X Direction Width	25 m
Y Direction Width	25 m
Live Load	2.5 kN/m2
Floor Finish	1.25 kN/m2
Seismic Zone	V
Importance Factor	1
Wall Thickness	200 mm
Concrete Grade	M 25
Steel Grade	Fe 500
Slab Thickness	150 mm
Beam Size	300 x 600 mm
Column Size	300 x 800 mm
Type of soil	Medium

RCC Building is modelled in ETABS software with vertical geometric irregularities. Three different Shear wall area to floor area ratio are considered & accordingly three different models are made for analysis purpose.

Model	Shear Wall area to floor area ratio
MODEL 1	0.5
MODEL 2	1
MODEL 3	1.5

Table -2: Shear Wall Area to Floor Area Ratio Consideration

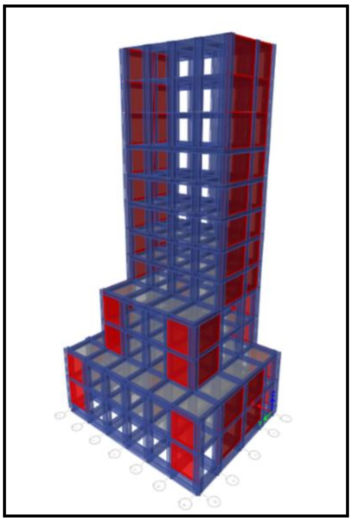

Fig -1: Isometric View for Model 1 with Shear wall Area to Floor Area Ratio 0.5

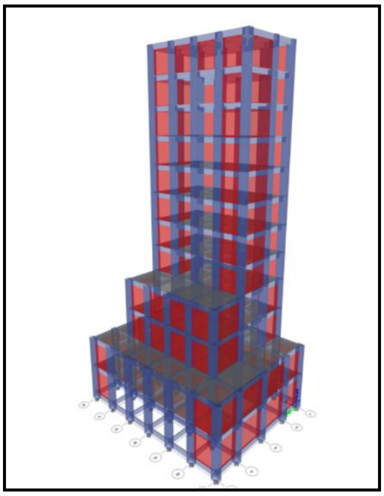

Fig -2: Isometric View for Model 1 with Shear wall Area to Floor Area Ratio 1

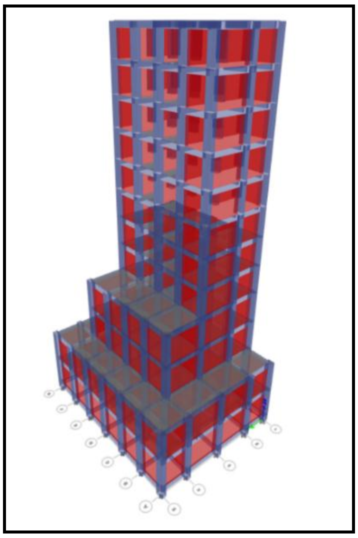

Fig -3: Isometric View for Model 1 with Shear wall Area to Floor Area Ratio 1.5

V. RESULTS

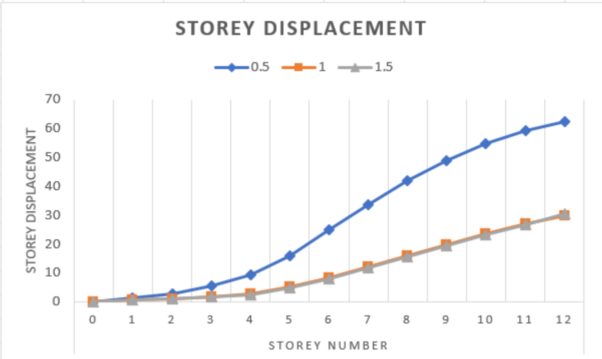

Fig -4: Storey displacement Vs storey number with shear wall to floor area ratios 0.5,1 & 1.5

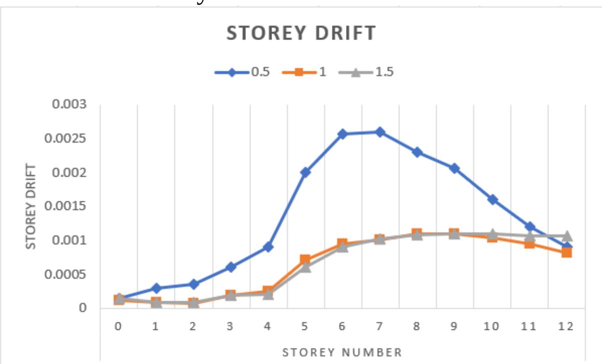

Fig -4: Storey displacement Vs storey number with shear wall to floor area ratios 0.5,1 & 1.5

	Base Shear (KN)	
Shear wall area to floor area ratio	EQX	EQY
0.5	1697.41	2569.75
1	3031.54	3031.54
1.5	3544.62	3544.62

Table -3: Results of Base Shear for Shear wall to floor area ratio 0.5,1 &1.5

	Time Period (Sec)	
Shear wall area to floor area ratio	EQX	EQY
0.5	0.824	0.433
1	0.458	0.483
1.5	0.459	0.351

Table -4: Results of Time period for Shear wall to floor area ratio 0.5,1 &1

From above figures and table we found out that,

1. Maximum storey displacement of 62.29mm is observed for model with shear wall area to floor area ratio 0.5, whereas for ratio 1 & 1.5 displacement is 29.65mm & 30.27mm respectively.

2. Maximum storey drift of 0.0025 is observed on shear wall area to floor area ratio 0.5.

3. Base shear values increase with increase in shear wall to floor area ratio. For ratio 0.5 base shear of 1697.41 KN in x direction is observed whereas for ratio 1 & 1.5 values are slightly similar.

4. Time period of building is reduced as shear wall area to floor area ratio increases.

VII. CONCLUSION

1. When Shear Wall area to floor area ratio increases storey displacements decreases. For ratio 1% significant variation in displacement is observed. Less variation is seen between Ratio 1% & Ratio 1.5%.
2. As shear wall ratio increases storey drift is observed to be reduced. Storey drift variation are mainly observed at Floor 5 where major irregularity of structure is seen.
3. With increase in shear wall to floor area ratio base shear values are observed to be increased.
4. Time period of building is observed to be reduced with increase in shear wall to floor area ratio.
5. Although it is observed that with increase in shear wall ratio to floor area ratio seismic behaviour of building becomes better but it also increases the cost of building.
6. Also it is not practically possible to increase the shear wall ratio to floor area ratio beyond 1% because of opening which are necessary for ventilation & light.

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