ANALYTICAL STUDY OF BEHAIVOUR OF R.C.C BUILDING WITH VARYING RATIO OF SHEAR WALL AREA TO FLOOR AREA

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Abstract

Reinforced concrete (RC) wall-frame buildings are broadly suggested for urban construction in areas under high seismic zone. Existence of shear wall systems are one of the most commonly used lateral-load resisting systems in tall structures. There are lots of literatures available to design and analyze the shear walls. However the decision about the effect of shear wall to floor area ratio’s in multi-storey building is not much discussed in any literatures. One of the major parameters influencing the seismic behaviour of wall-frame buildings is the shear wall ratios. Therefore, it is important to evaluate the capacity of buildings with different shear wall ratios against seismic force demand.

The Research work is an analytical study to evaluate the effect of varying shear wall area proportion with respect to floor area on the seismic behaviour of RC structure. Varying proportion of shear wall are applied on different models and analysed for response spectrum by using finite element software package ETABS 15.0.0 version.

Keywords: Shear wall, floor area, storey drift, ETABS

1. Reinforced concrete shear walls

Shear wall are straight up element during the sideways power resist arrangement. They send out sideways services commencing the diaphragm over in the direction of the diaphragm underneath or towards the groundwork. The distribution of shear stress is proportional to the time of inertia of the cross sections of the walls. The displacements in every floor or level square measure the results of the flexural deformations within the walls. Investigation on different sturdy ground movements discovered that nicely designed laterally restrained buildings performed good in past disasters. However, previous investigations’ observed that the buildings that have high shear wall area to floor area ratios with walls that doesn’t have any particular seismic design remained when high magnitude earthquakes occured. Providing shear walls can reduce the drifts and improve structural stability. This infact drew attention of educational researchers to shear wall frame buildings. Engineers would like sensible and straightforward ways to predict the structural behavior before testing various analysis. The shear wall area to floor area magnitude relation is additionally recognized as an important specification moving the world achievement of building. Within the gift study, totally different shear wall area to floor area magnitude relations area unit accustomed recommend comfortable shear wall ratio to be used at the preliminary style stage of buildings.

2. Literature review on response spectrum method and shear walls

Study confirmed the common features of the building that were effected in vina del mar(1985 Chile earthquake) to notify the damages to the buildings due to the ground movements caused by the earthquake. He collected the required data of 178 buildings in the locality having a set of 322,of which 319 are having shear wall which are being used in the analysis[1]. More than 75% of the structures are designed with shear wall ratio’s (ranging from 3% to 8% at an average of 6%). These walls are not properly designed according to the available design codes but most of the buildings were not damaged. In fact most of the shear wall’s are normally reinforced with no boundary elements but 90% of the buildings were not damaged. So from these studies it was observed that buildings with higher shear wall ratio’s are not damaged in case of strong ground movements. Researcher [2] proposed that presence of structural walls imparts a large stiffness to the lateral stiffness of the building. Proper detailing of walls can also lead to ductile behaviour of such structures during strong earthquake shaking. One of the major parameters influencing the seismic behaviour of wall frame buildings is the wall-area ratio. A five storey wall-frame building located in a strong earthquake zone is designed against the critical load combinations. Next, the wall-area ratio of the building is varied and the corresponding structural wall configurations are obtained. From the results it was observed that presence of structural walls reduces the force demand in columns. Also, the demands in the walls and the interior columns in the building are compared for varying the wall-area ratio. It has been observed that increasing the shear wall area ratio in the particular method used for placing the shear walls reduces the demand in the structural wall and in various columns in the building. Researcher[3] studied the behaviour of different types of shear walls (shapes and height) in resisting the lateral loads caused by the earthquake ground movements. Also he studied different analysis methods and their accuracies in analysing the building at the time of earthquake. As an out come
of the studies made by him he stated that the static analysis can be used for the regular plan buildings that are less than 25m in height. For the buildings higher than 25m and those are unsymmetrical response spectrum method is used. From the studies he concludes that the square shape shear walls are more effective and the L shape walls are least effective. Researcher [4] planned resolution for shear wall location and effectiveness of shear wall with four completely dissimilar model. Model’s one is blank frame system and different 3 area unit twin kind structural system. From results it's discovered that in an ten story building, with the shear shut in small length at end of building is cheap as compare with different model with giant span shear wall. From this it are often over that enormous measurement of shear wall isn't effectual in ten storeys or below ten storeys buildings. it's discovered that RCC wall is cheap and effectual in tall structures. If the scale of shear wall area unit giant then major quantity of straight force area unit taken by shear wall. provided that shear walls at ample locations considerably reduce the displacements thanks to earthquake. Researcher [5] studied impact of shear wall configurations on moment resisting frame is studied. For this study 5-storeied RC structure situated in seismal zone-V is taken into account with four shear walls with five completely dissimilar configuration’s of shear wall. These frames square measure analyzed for seismal forces to measure performances in term of base shear, level drift, member force and joint displacement’s. The structure with shear wall’s at centre positioned at external bays show important decline of order twenty ninth to eighty three in lateral dislocation. The decrease in bending moment’s is more or less seventieth to eighty fifth for inner and external severally. Shear and axial force’s in columns reduced by eighty six and forty fifth severally. supported the results, the most effective placement of shear walls at mid-side’s is seen to achieve higher in major range of case. Researcher [6] carried out a study in which three different positions of shear walls are considered .The strength of RC building is determined for shear wall at different location. Inclusion of shear wall has become important in resisting the lateral forces. From the present study he observed that the shear wall located at exterior perimeter are more effective. It also increased the building resistance to twisting. Researcher [7] described the importance of the shear walls in the multi-storied buildings. Here they performed the seismic analysis by using response spectrum method. They concluded by comparing the response spectrum and equivalent static method. By comparison they observed that due to the consideration of all the modes of vibrations the lateral loads values of response spectrum method are much closer than that of equivalent static method. Here they change the location of the shear walls and observed that the position of the core shear wall was much effective in taking the moment ,shear and reducing deflection . In the case the bending moment was taken by wall is around 60% of the total external moment and frame shared 40% of the overall bending moment so the shear wall relieves the frame in taking the bending moment at the base position. Finally they concluded that the sharing of shear wall frame reduced the deflection, drift index ,bending moment and shear capacity. Researcher [8] concluded moments in columns decreased whenever shear walls are used in multi-storey structure with irregular stiffness in vertical plane. RCC walls are effective provided along the perimeter of the structure.

3. Aims and objectives of the present study

The objectives of present study is regarding 15 storied RC framed building with distinctive shear wall to floor area ratio’s designed for gravity and seismic loads, the structure is evaluated by response spectrum analysis using ETABS as tool. The shear walls used in the study does not have any openings. To investigate the seismic behaviour of a 15 storied RC framed building with distinctive \( \frac{A_w}{A_p} \) such as 0.00%, 4.80%, 9.60%, 14.40%, 19.20%. Various responses in terms of storey drifts, storey displacements and base shear of building have been studied.

![Figure 1.1 Plan of RCC building](image)
Figure. 1.2 Plan with 4.80% SW ratio

<table>
<thead>
<tr>
<th>S. No.</th>
<th>( A_w ) = Shear wall area ((\text{m}^2))</th>
<th>( A_p ) = Floor plan area ( (\text{m}^2) )</th>
<th>( \frac{A_w}{A_p} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>450</td>
<td>9375</td>
<td>4.8%</td>
</tr>
<tr>
<td>2</td>
<td>900</td>
<td>9375</td>
<td>9.6%</td>
</tr>
<tr>
<td>3</td>
<td>1350</td>
<td>9375</td>
<td>14.4%</td>
</tr>
<tr>
<td>4</td>
<td>1800</td>
<td>9375</td>
<td>19.2%</td>
</tr>
</tbody>
</table>

Table 1.1 \( \frac{A_w}{A_p} \) of 15 storied Building

Figure. 1.3 Plan with 9.60% \( \frac{A_w}{A_p} \)

Figure. 1.4 Plan with 14.40% \( \frac{A_w}{A_p} \)
4.2.4 Sections Considered

Dimension of beam= 0.3 m x 0.45 m, Dimension of column= 0.60 m x 0.60 m
Thickness of slab:150 mm, Thickness of shear wall: 150mm.

4.2.5 Material properties M30 grade concrete structure with HYSD 500

4.2.6 Loads considered (As per IS875 part II)

- Dead load = Self weight of structure
- Live load = 3 kN/m²
- Wall load on exterior beams = (3-0.45) x (0.23+.012+.015) x 20 =13.107 kN/m
- Wall load on interior beams = (3-0.65) x (0.2+.012+.015) x 20 =11.577 kN/m
- Floor load on top roof = (.015 x 25) + (0.012 + 0.15) x 20 =7 kN/m²
- Floor load on each floor = (.15 x 25) + (0.012 + 0.075) x 20 =5.5 kN/m²

Wind load
- Wind speed = 50 m/s, Wind exposure parameter, Wind ward coefficient = 0.7,
- Leeward coefficient =0.2, Wind coefficient, Terrain category = 2, Structure class = B
- Risk coefficient (k1 factor) = 1, Topography (k3 factor) = 1

Seismic loads
- Response reduction factor = 5, Seismic zone factor = 0.36 (zone-v), Soil type = medium soil
4.3 Modelling Assumptions

The following assumptions were made in creating models of building for seismic evaluation in this study.

- Diaphragm was assumed to be rigid. That is, the floor was assumed to be rigid in the plan of diaphragm but flexible in bending.
- Lateral load is assumed to be acted only at floor level.
- Joints are assumed to rigid.
- Footings fixed.

4.4 Conclusion.

- It is observed that as the height of the building is increasing the percentage of reduction in story drift is less pronounced for different shear wall ratios compared with the normal building.
- As $A_w/A_p$ increases the lateral displacements decreases. There is a significant high loss in displacement between 4.80% and 9.60% shear wall ratio. At least 14.40% shear wall to floor area ratio should be provided to control the displacements. As per figure 1.1 to 1.10.
- The base shear percentage carried by shear walls increases as shear wall to floor area ratio increase, but this trend reduces for shear wall ratios greater than 14.40%.
- Compared to normal building shear walled building is having 45-65% decrease in story displacements and story drifts.

References


Author

Geeta Mehta, She is the corresponding author of the research article. She has completed her Masters in structural Engineering from punjab Engineering college, Chandigarh and pursuing PhD from Lovely Professional University. She has 12 years experience in teaching. She has published 15 research papers on various topics. Guided 17 M. Tech Thesis