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Effect of Infill Masonry Wall on Seismic Performance of R.C. Building

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***Abstract*: Reinforced concrete frames with masonry infill walls are widely used systems as an internal partition and external walls in many parts of the world. The infill walls are used for mainly partition and insulation purposes rather than structural purposes and usually not considered as structural elements in structural design. However, during earthquakes, these infills contribute to the response of the structure and the behavior of infilled frame buildings is different from that predicted for bare frame structures. For this purpose, models of (G+5) and (G+9) RC framed building assumed to be located in Seismic zone-IV have been considered. Masonry walls stiffness is included in the models by converting them into equivalent diagonal strut according to IS 1893:2016 CL 7.9.2.2. Linear Dynamic analysis (Response Spectrum Analysis) has been performed as per IS: 1893:2016. The results are compared for the parameters like natural period, storey shear, storey drift, displacement among the models considered.**

***Keywords*: infill masonry wall, unreinforced masonry wall, FEA software, seismic analysis.**

1. Introduction

The infill walls are commonly used as building components but they are not taken into consideration while the process of structural design being carried out. General practice of building analysis, the strength and stiffness of masonry walls aren't taken under consideration. Common practice has always been to ignore the infills during the planning and therefore the analysis of the concrete framed structures because of its highly non-linear nature which is difficult to be simulated

However, during earthquakes, these infill walls contribute to the response of the structure and therefore the behavior of infilled framed buildings is different from that predicted for bare frame structures. The Load transfer mechanism changes from frame action to truss action.

2. Literature Review

Hossein Mostafaei and Toshimi Kabeyasawa (2004) found that the presence of infill masonry wall reduced the actual damages to the structure due to the strong earthquake motion. Nurbaiah Mohammad Noh et al. (2017) studied the procedure adopted for the selection of a suitable model to be used in the assessment of the global performance of RC frames with URM infill walls subjected to in-plane lateral loads. While macro modelling for infill panel, three different hysteretic models, available in OpenSees, are investigated by them. Matjaz Dolsek and Peter Fajfar (2008) found that that masonry infill highly increases the stiffness and strength of a structure as long as the seismic demand does not exceed the deformation capacity of the infills.

3. Methodology

The most accepted method for the analysis of infill frame structures is equivalent strut method in which the entire infill is replaced by a single equivalent strut. In this method, beams and columns are designed as frame members which having 6 degrees of freedom at every node and the brick infill is replaced by a pin jointed diagonal strut. The thickness of the pin jointed diagonal strut is considered to be the same as infill and its length is equal to the length of the diagonal between the two compressions corners. Relative stiffness of the frame and infill, contact length and the aspect ratio are general parameters that govern the effective width of the equivalent diagonal.

A. *Procedure*

1. The masonry infill walls are replaced with diagonal compression member (or) strut with appropriate mechanical properties.
2. The thickness of the strut is equal to the thickness of the wall.
3. The strut is assigned with hinges at both ends in order to take care of moment at strut frame intersection.

B. *Modelling*

1. For the study, (G+5) and (G+9) buildings both having plan (20 m along x-direction and 15 m along y-direction) were considered to be located in Zone IV.
2. The total height of building is 21 m for 6 storey and 33 m for 10 storey building with ground floor height of 3 m and inter storey height of 3 m in both buildings.
3. M25 grade concrete and Fe 500 steel is used.
4. The live load on floors is taken as 3kN/m^2. The thickness of external and internal infill wall was taken as 230 mm. For both 6 storey and ten storey building 3 models for each case is considered.

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C. Conversion of Wall into Equivalent Diagonal Strut

Various methods for determining the equivalent strut parameters for an infill wall are available which are widely used in various parts of world

1. Indian code IS 1893 (part1) :2016
2. Mainstone (1971)/FEMA 306/ ASCE/SEI 41-06/ ERDC/CERL
3. HOLMES (1961)
4. Liauw and Kwan (1984)/Crowley and Pinho (2006)
5. Turkish code, TEC (2007)

As per Clause No 7.9.2.2 if IS 1893 (part1) The URM infill walls shall be modelled by using equivalent diagonal struts as below:

a. Ends of diagonal struts shall be considered to be pin-jointed to RC frame
b. For URM infill walls without any opening, width of equivalent diagonal strut shall be taken as:

$$w_{ds} = 0.175\alpha_h^{-0.4} L_{ds}$$

c. Calculated thickness of infill wall = 390 mm

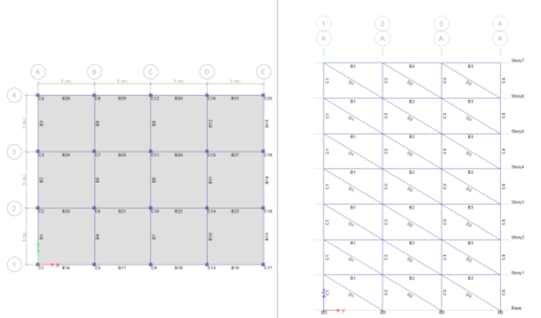

Fig. 1. Etabs Model of G+5 Building Model having fully infilled walls

4. Results

1. *Fundamental time period of buildings:* The fundamental time period of fully infill frame in both longitudinal and transverse direction are less than those in bare frame as well as infill frame with soft ground storey. Time period obtained from IS code are (0.366, 0.409) i.e., Tx and Ty respectively for six storey building and (0.607, 0.679) for ten storey building which seems to be much lesser than those obtained from analytical models.
2. *Lateral Displacement & Storey Drift:* Inclusion of infills in model increases the stiffness of building and reduces displacement. For bare frame system drifts are maximum for both buildings (6 and 10 storey). In case of open ground storey, lack of infill in storey 1 has resulted in higher drift values.
3. *Axial Force and Bending Moment:* Forces on column have been studied. Since the load transfer mechanism of building after inclusion of infills shifts from predominant frame action to truss, axial forces on column increases and bending moment gets reduced.

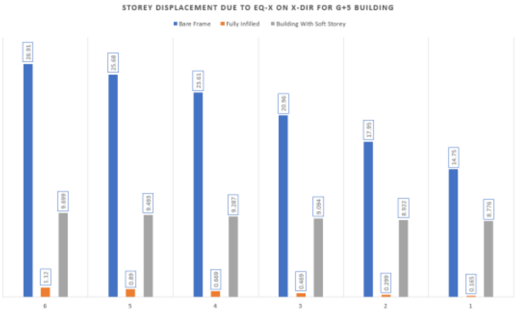

Fig. 2. Storey displacement on X-Dir due to EQ-X

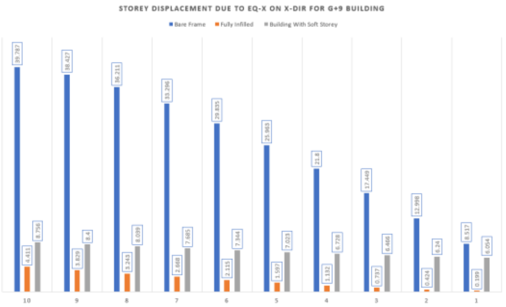

Fig. 3. Storey displacement on X-Dir due to EQ-X

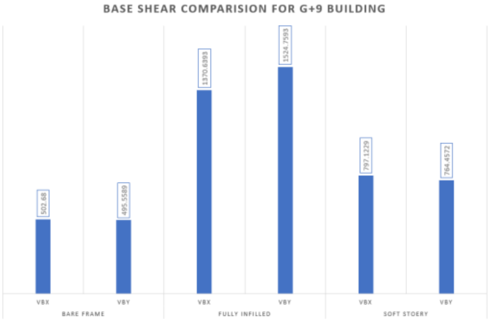

Fig. 4. Base shear for G+9 building

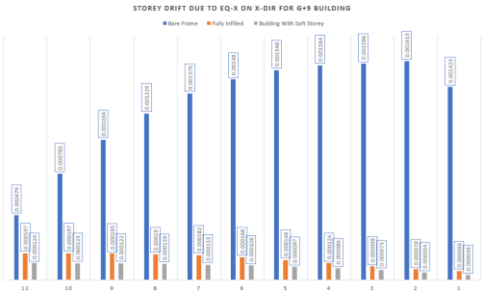

Fig. 5. Storey drift for G+9 building due to EQ-X

5. Conclusion

The study was carried out on set of G+5, G+9 building for different infill configurations. From the study following conclusions are drawn.

1. Lateral strength of infill frame is higher compared to bare frame & soft storey.
2. The base shear of fully infill frame is more than bare frame and soft story frame due to braced frame action
3. When infill stiffness is incorporated the fundamental time period of structure reduces and structure attracts maximum base shear.

4. Storey drift of building reduces after provision of infill. For bare frame storey drift is maximum for both cases (G+5, G+9)
5. Axial forces on columns increased and bending moment has decreased due to inclusion of infill walls

As stated in results, there are significant differences in seismic response of frames with and without infill walls

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