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Review Article

Seismic Analysis of G+15 RCC Building Frames: A Comparative Study with and without Masonry Infill Walls - A Review

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A B S T R A C T

In regions like India where seismic activity is prone, reinforced concrete frames with masonry infill walls are a prevalent practise. Masonry infill walls are typically treated as nonstructural elements in structural analysis, only their mass contribution is taken into account. Their structural characteristics, such as strength and stiffness, are typically ignored. Structures in seismically active regions are particularly susceptible to catastrophic damage. A structure must endure lateral loads that could cause severe strains in addition to gravity force. Reinforced concrete frames are still the most widely used in building construction today. It is known as a brick infill wall or panel when brick or masonry is used to cover the vertical space left by the columns and beams in reinforced concrete frames. In this study, diagonal strut will take the role of the infill walls, analysis will be done. contrasting the outcomes of the computerised model study for constructions made of G+ 15 that have and don't have infill. For the purposes of comparison, we examine the results for base shear, lateral floor displacement, story drift by buildings.

Keywords: G+15, Bare, Infill, Story Drift, Base Shear, Time Period, Natural Frequency

Introduction

In seismically vulnerable areas around the world, Reinforced Concrete (RC) frame buildings with masonry infill walls have been built in large numbers for commercial, industrial, multi-family residential usage. Brick masonry or concrete block walls are frequently used as masonry infill for RC frame columns and beams. Typically, these panels are viewed as non-structural parts and are not taken into account throughout the design process. Brick masonry infill panels have been utilised extensively as interior and external partition walls in countries like India for both aesthetic and practical demands. Although the infill of brick masonry is thought to be non-structural, it has its own stiffness and strength. Therefore, if the impact of brick masonry is taken into account during analysis and design, the total structure's strength and stiffness may be observed to significantly increase. The provision of taking into account the effect of infill is not present in the current code, IS 1893(Part-I): 2000 of practise. It makes sense that the final structure can differ dramatically if the effect of infill is included throughout the study and design of the frame. Additionally, infill, if present in all storeys, considerably reduces the maximum displacements by contributing to the energy dissipation capacity. Therefore, even if it depends a lot on the features of the ground motion, the contribution of masonry is crucial, especially for frames that weren't built with seismic pressures in mind. The story where this dramatic shift in stiffness happens is referred to be a soft story when it occurs along the height of the building. A soft tale is one whose lateral stiffness is less than 50% of the story above or below, as defined by IS 1893(Part-I): 2000. This study uses a diagonal strut to represent the brick masonry infill and takes into account its strength and stiffness. Time period, base shear, natural frequency, story drift are the primary factors taken into account in the study to compare the seismic performance.

Objectives

The silent objectives of the present study have been identified as follows:

1. To study the effects of building analysis of G +15 story structure with and without infill walls.
2. To study the effect of brick infill on the stiffness of the structure.
3. To study the effects of three different models to find which will gives the good performance in analysis of structure w.r.t stiffness, base shear and story drift.

Literature Review

Past studies also carried out on the behavior of RC frame with in-fills and the modeling, analysis of the RC frame with and without in-fills.

V.K.R.Kodur, M.A.Erki and J.H.P.Quenneville considered a three story RC frame building models for the analysis. These RC frames were analyzed for three cases i) Bare frame ii) Infilled frame iii) Infilled frame with openings. Based on the analysis results they found that Base shear of infilled frame is more than infilled frame with openings and bare frame. Time period of infilled frame is less as compare to infilled frame with openings and bare frame. The natural frequency of infilled frame is more as compare to infilled frame with openings and bare frame.

Mehmet Metin Kose studied the different RC frame models that were bare frame, frame without open first story and frame with open first story. Based on the results obtained from different computer models, it was found that the number of floors (height of building) was the primary parameter affecting the fundamental period of building. The fundamental period of frame without open first story is less than frame with open first story and bare frame.

Jaswant N.Arlekar, Sudhir K.Jain and C.V.R.Murty analyzed the different building models that include building with masonry infill walls in all the story and building with no walls in the first story and bare frame building model. Static and dynamic analysis of building models were performed using software ETABS. It was seen that the natural period of the building by ETABS analysis do not tally with the natural period obtained from the empirical expression of the code IS 1893-1984. The natural period of infilled frame is less as compare to soft first story frame and bare frame building models. Also from the analysis they concluded that RC frame building with soft story perform poorly during strong earthquake shaking. The drift and the strength demands in the first story column are very large for building with soft first story.

P.M. Pardhan, P.L. Pardhan, R.K. Maske highlighted the need of knowledge on partial infilled frames and the composite action and also summarize the findings till date done by various researches on the behavior of partial infilled frames under lateral load. The infill contributes in the stiffening of the frame and it was reported that the infills can increase the stiffness of the frame 4 to 20 times (referring to number of literature).

Homes studied experimentally on steel frames infilled with brick masonry and reinforced Concrete walls and developed semi- empirical design method for laterally loaded infilled Frames based on equivalent strut concept. His tests suggested that reinforced concrete walls increase the strength of frame by 400% whereas the brick masonry infills increase around 100%. He indicated that the presence of vertical load increased the strength by about 15% and that openings in walls might reduce strength up to 40% based on the composite behavior. The infill was considered to fail in compression. The load carried by infill at failure was calculated by multiplying the compressive strength of material by the area of equivalent strut. He states that the width of equivalent strut to be one third of the diagonal length of infill, which resulted in the infill strength being independent of frame stiffness. The load carried by the frame was then calculated by assuming that the strut was shortened by an amount which was its length multiplied by the strain at failure in the infill material. Subsequently, many investigators developed the strut width value related to the length of contact between wall and the columns and between the wall and the beams.

In 1961 Holmes stated that width of diagonal is given by, $w = dz/3$

Where, dz = Diagonal length of infill panel

Das and C.V.R. Murty (2004) carried out non-linear pushover analysis on five RC frame buildings with brick masonry in-fills, designed for the same seismic hazard as per Euro-code, Nepal Building Code and Indian and the equivalent braced frame method given in literature. In-fills are found to increase the strength and stiffness of the structure, reduce the drift capacity and structural damage. In-fills reduce the overall structure ductility, but increase the overall strength. Building designed by the equivalent braced frame method showed better overall performance.

Methodology

The following methodology was developed to meet the aforementioned goals:

- For the study and design of the earthquake-resistant building, review the body of available research and Indian design code provisions
- When modelling, taking into account G+15 buildings with and without infill

Model the chosen structure without infill walls, taking into account the strength and stiffness of the infill.

Model the chosen structures' infill walls as diagonal struts while taking into account the strength and stiffness of the infill. Model the infill wall as a diagonal strut with pinned supports for the end conditions.

- Additionally, based on the results of the seismic load study, manually design the building
- Results of time period, tale drift, lateral displacement, other model parameters with and without infill were observed

It is suggested in the current work to use Response spectrum analysis to conduct seismic analysis on multi-story RCC buildings. An approach using STAAD PRO software that takes into account bare and infill frames.

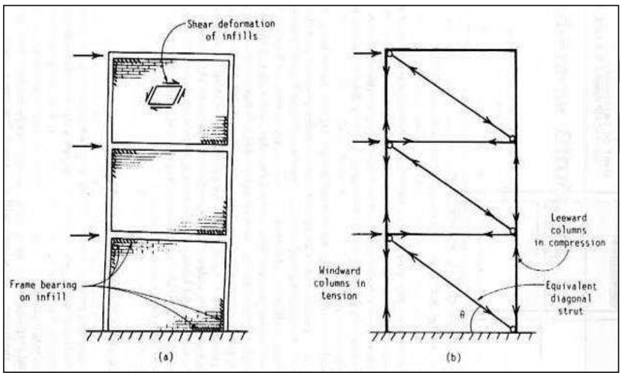

Figure 1

Modeling

A study is undertaken which involves seismic analysis of RC frame buildings with different models that include bare frame and infilled frame. The parameters such as base shear, time period, natural frequency, story drift and lateral displacement are studied. The software STAAD PRO is used for the analysis of the entire frame models.

Analyzing the data

Following data is used in the analysis of the RC frame building models

Type of frame: Special RC moment resisting frame fixed at the base

- Seismic zone: Three (3)
- Number of story: 10
- Floor Height: 3.5 m
- Plinth Height: 1.5 m
- Depth of slab: 150 mm
- Spacing between frames: 5 m
- Live load on floor level: 3 kN/2
- Live load on roof level: 1.5 kN/2
- Floor Finish: 0.6 kN/2
- Material: M40 concrete, Fe 500 steel and Brick infill
- Thickness of infill wall: 230 mm
- Density of concrete: 25 kN/m3
- Density of infill: 20 kN/m3
- Type of soil: Medium
- Response spectra: As per IS 1893(Part-1):2002
- Damping of structure: 5%

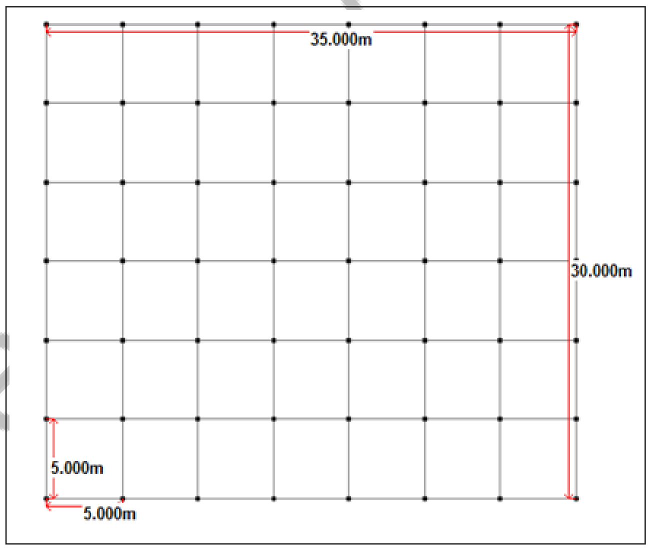

Figure 2

Wall Infill Modelling

The infill wall is modelled using the Equivalent Diagonal Strut Method. In this method, the frame is modelled as a beam or truss element, the infill wall is idealised as a diagonal strut. The elastic analysis makes use of frame analysis tools. The assumption underlying the idealisation is that there is no connection between the frame and the infill. The diagonal strut's breadth is specified as

$$a_{hx} = \frac{\pi}{2}\sqrt[4]{\frac{4E_f.I_c.h}{E_m.t.\sin 2\theta}}$$

$$a_{l} = \frac{\pi}{2}\sqrt[4]{\frac{4E_f.I_b.l}{E_m.t.\sin 2\theta}}$$

Where,

E_m and E_f = Elastic modulus of the masonry wall and frame material (i.e., concrete), respectively

L, h, t = Length, height and thickness of the infill wall, respectively

I_c, I_b = Moment of inertial of column and the beam of structure, respectively

$\Theta = \tan^{-1\ h}$

Θ = = angle of inclination of diagonal strut

$Wd = {}^{1}\sqrt{}ah^2 + al2$ 2

$Ld = \sqrt{}h^2 + al2$

$Ad = t. Wd$

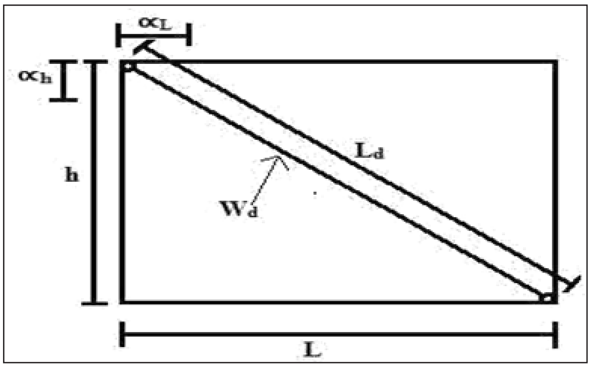

Figure 2

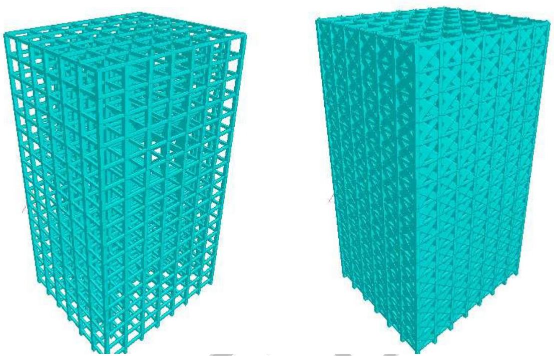

Figure 3. 3-D View of G+15 With and Without Infill Strut building

The equation to determine the equivalent or effective strut width (w_d), length (L_d) and area of strut (A_d), where the strut is assumed to be subjected to uniform compressive stress.

Results and Discussion

The seismic analysis of the entire frame models that includes bare frame, infilled frame and open first story frame has been done by using software STAAD PRO and the results are shown below. The parameters which are to be studied are time period, natural frequency, base shear and story drift.

Table 1

Parameters	Bare	Infill
Tx (Sec)	1.478	0.341
Tz (sec)	1.375	0.316
ωx (Hz)	0.677	2.933
ωz (Hz)	0.727	3.168
Vbx (kN)	5017.85	11713.74
Vby (kN)	4646.66	13127.94

Where

Tx – Time period in X direction in seconds Tz – Time period in z direction in seconds ωx – Natural frequency in X direction in Hz ωz – Natural frequency in z direction in Hz VBx – Base shear in X direction in KN VBz – Base shear in z direction in KN.

Absolute Story Drift

Table 1

Floor Ht	Bare	Infill
-1.5	0	0
0	0.621	0.277
3.5	4.616	0.339
7	6.292	0.35
10.5	6.696	0.385
14	6.641	0.41
17.5	6.399	0.428
21	6.067	0.442
24.5	5.689	0.449
28	5.284	0.453
31.5	4.86	0.45
35	4.413	0.443
38.5	3.937	0.44
42	3.42	0.427
45.5	2.857	0.419
49	2.25	0.396
52.5	1.628	0.381
56	1.079	0.355

Conclusion

The findings of the change in time period, base shear, story drift of the buildings for all the structures of G+15 models were observed from the analysis seismic performance of RC framed buildings with and without infill wall. The stiffness of the building is much less in the bare-frame model when compared to equivalent diagonal strut models for seismic load analysis, whereas the strut models that took into account the stiffness of infill as strut have more stiffness of the building and are also more cost-effective in section area of steel. As a result, the strut model provides a realistic representation of a building's performance during a seismic examination of buildings.

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