Behavior of RC Framed Structures with and without Infill

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Abstract— As rapid growth in population large number of RCC buildings and Steel structures were constructed across the world for residential as well as for public and commercial purposes. Public buildings like Schools, Colleges, Government Offices, Hospitals etc, and commercial buildings like Cinema halls, Shopping mall etc. So the buildings were constructed with RC frames and in the building construction more importance and design consideration is given to RC frames and Masonry infills are considered only to cover the RC frame voids and also to give aesthetic appearance. As the masonry infills are considered only as a void filling element between vertical and horizontal resisting elements of the building frames and assuming that these infills will not resist any loads either axial or lateral. Therefore the masonry infill is not considered in the analysis of frames generally. There is no availability of any kind of realistic and simple analytical models of infill which is the one of the point to skip the infill in the analysis of RC frames. But actually the infill contributes some stiffness to the frame which can reduce the deflection in the frames under lateral load. So this negligence is one of the causes of failure of many multi-storied buildings it may be a RCC building or a steel building. In this study 2D finite element model is developed using FEM software ETABS to determine the behavior of RC framed structures with and without infill under lateral loads especially wind load. In this analysis a bare RC frame is analyzed under wind load, and RC frame with infill that is infill is modeled as a "Equivalent diagonal strut" with single and double struts of concrete and brick properties with varying sizes under lateral load (wind load) is analyzed and compared.

Key words: Infill, RC Framed

I. INTRODUCTION

A. *Bare Frame*

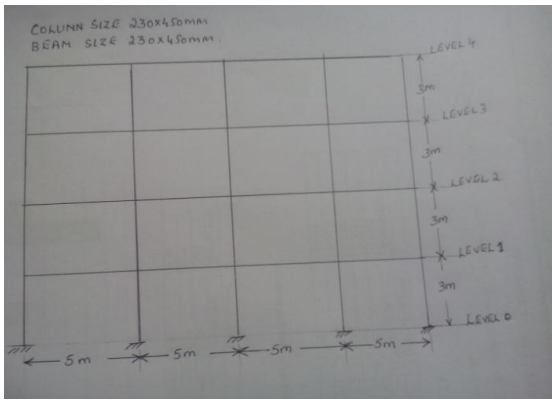

Fig. 1: Bare Frame

Bare frame is nothing but a combination of columns and beams connected with each other it made up of Reinforced Concrete without any infill that is without any masonry walls (soft storey).

B. *INFILL*

Regarding the combined behavior of the infill wall and structural frame the researchers predicted that the masonry infill walls can be considered as compression strut elements. The existence of infill walls can change the structural behavior from flexural action into axial action.

Fig. 2: Reinforced Concrete Frame with Infill

II. METHODOLOGY

A. *Finite Element Method:*

FEM or Theory of Elasticity methods can be used to study of interaction of infill with frames. But due to uncertainty in defining the interface condition between the infill with frames, an appropriate analysis method may be better acceptable. Equivalent diagonal strut can be considered as a common approximation of infilled walls.

B. *Equivalent Diagonal Method*

Geometric and material properties of the Equivalent diagonal strut are required for conventional braced frame analysis to determine increased stiffness of the infilled frame. Infill wall material and thickness can be considered for the Equivalent diagonal strut.

Many investigators have proposed various approximations for width of Equivalent diagonal strut. Originally proposed by Polyakov (1956) and subsequently developed by many investigators, width of strut depends on the length of contact betweenthe wall and the columns αh and between the wall and beam αl as shown in fig.3

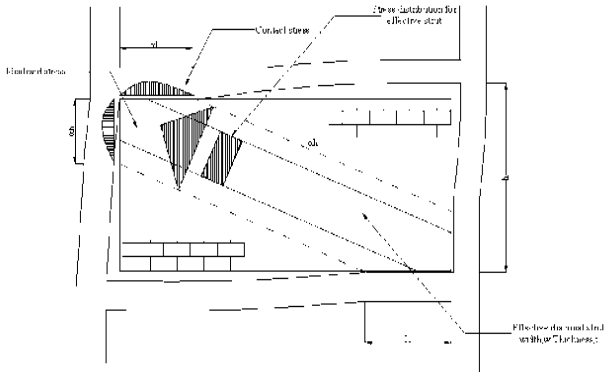

Fig. 3 Equivalent Diagonal Strut

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The proposed range of contact length is between ¼ and 1/10 of the length of panel. Stafford smith (1966) developed the formulation for αh and αl on the basis of beam on an elastic foundation. The following equation are proposed to determine αh and αl, which depend on the relative stiffness of the frame and infill on the geometry of panel.

$$\alpha_h = \frac{\pi}{2}\left[\frac{4E_f I_c h}{E_m t \sin 2\theta}\right]^{\frac{1}{4}} \quad \alpha_l = \pi\left[\frac{4E_f I_b L}{E_m t \sin 2\theta}\right]^{\frac{1}{4}}$$

$$W = \tfrac{1}{2}\sqrt{\alpha h^2 + \alpha l^2}$$

Where, E_f and E_m = elastic modulus of frame and masonry respectively,
t, h, L = thickness, height and length of the infill, respectively,
I_c, I_b = Moment of Inertia of the column and beam of the frame, respectively,

III. Modeling and Analysis

A. Details of Reinforced Concrete 2D Frame:

G+3 storey frame
Center to center distance of column: 5m
No of bays: 4
Floor to floor height: 3m
Size of beam: 230x450mm: Grade of concrete: M25
Size of column: 230x450mm: Grade of concrete: M25
Loading: Wind load of 15kN up to 3rd floor and 8kN at the top.
Method: The analysis of 2D frame is performed by using Finite Element Method (E-TABS software).

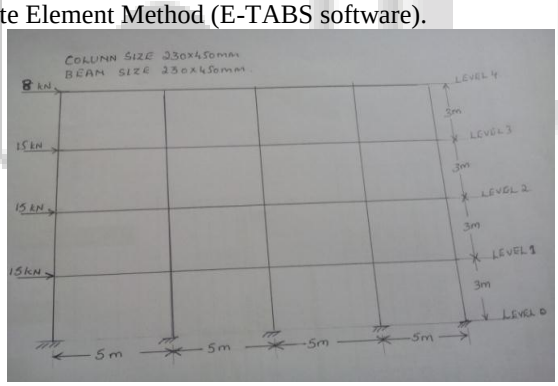

Fig. 4: Bare Frame Lateral loading

B. Details of RC frame with Infill with Single strut:

where infill is modeled as strut with 100x100m,150x150mm, 200x200mm and 230x940mm size strut with both Concrete block and brick property.

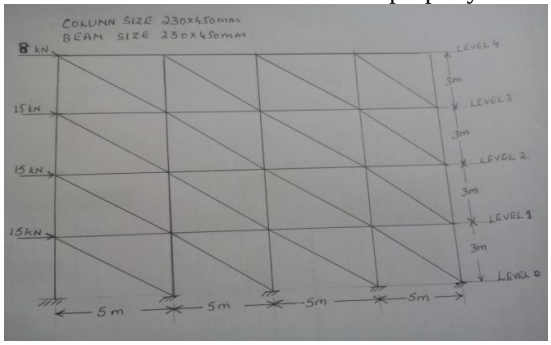

Fig.5 RC Frame with single strut subjected to Lateral loading

C. Details of RC frame with Infill with Double strut:

Where infill is modeled as strut with 100x100m,150x150mm, 200x200mm and 230x940mm size strut with both Concrete block and brick property.

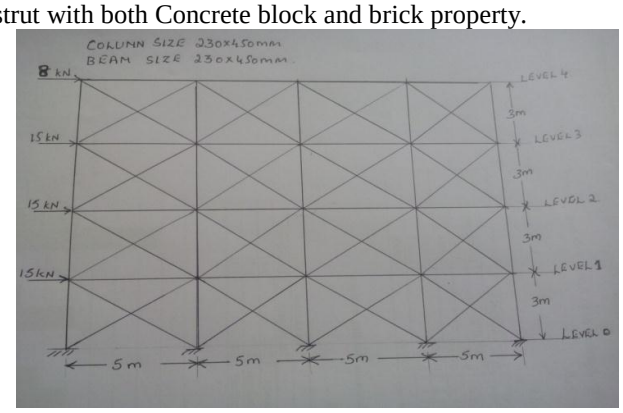

Fig. 6: RC Frame with Double strut subjected to Lateral loading

IV. Result and Discussion

This study was conducted to know the Behavior of RC frame with and without infill. Infill contributes some stiffness to the RC frame so it is important to consider the infill in design of reinforced concrete frame.

In this study the RC frame without infill that is bare frame when subjected lateral loads is analyzed and RC frame with infill that is the infill is modeled as strut with different sizes like 100x100, 150x150, 200x200 and 230x940mm with properties of concrete block and brick equivalent diagonal strut under wind load is analyzed.

After analyzing the frame with different sizes and materials the frame with infill which gives the minimum moments under lateral load that strut is selected and the same 2D model of G+3 is analyzed with double strut of size 230x940mm for Least and extreme Wind speed and earth quake zone factors.

A. Maximum Bending moments developed in the Bare frame are:

Beam moments in kN.m	16.5
External Column moment in kN.m	8.7
Internal column moment in kN.m	17.4

Table 1: Maximum Bending moments

B. Maximum Bending moments developed in the frame with Single strut:

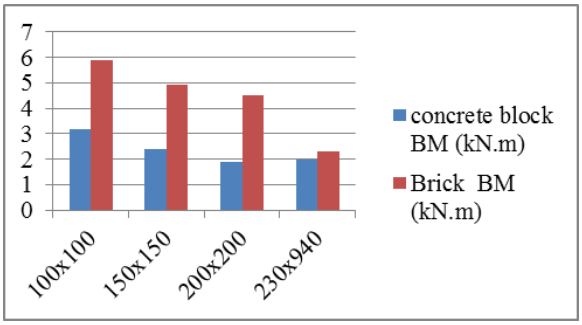

Fig. 7: Maximum Beam Moments developed due to Lateral loading (X- axis represents size of strut and Y- axis represents bending moment in kN-m)

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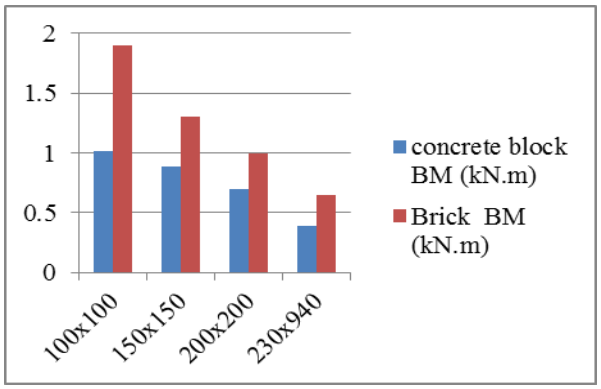

Fig. 8 Maximum External column Moments developed due to Lateral loading

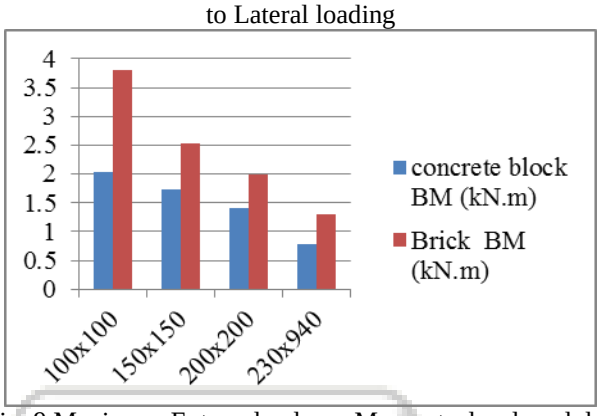

Fig. 9 Maximum External column Moments developed due to Lateral loading

C. Maximum Bending moments developed in the frame with Double strut:

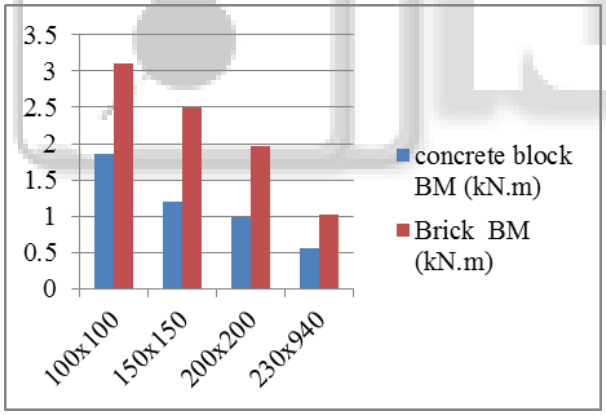

Fig. 10: Maximum Beam Moments developed due to Lateral loading

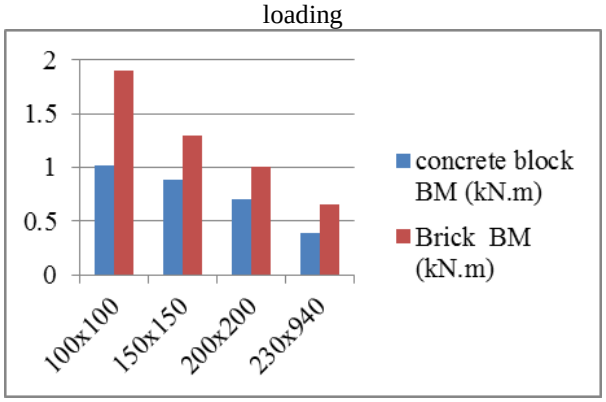

Fig. 11 Maximum External column Moments developed due to Lateral loading

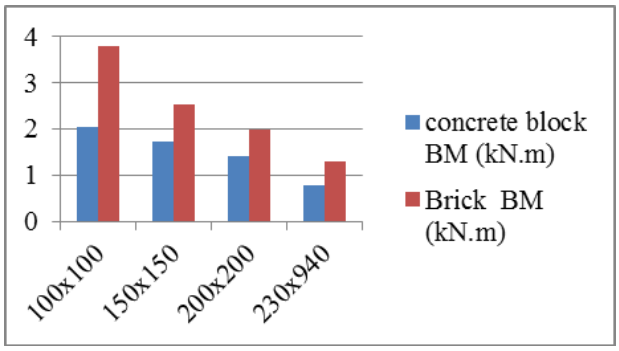

Fig.12 Maximum Internal column Moments developed due to Lateral loading

From the above results strut size 230x940mm of concrete block property gives the minimum Bending moment value then this strut selected for analysis of same 2D frame for Extreme and Least wind loads and Earth quake zones respectively and the results found are:

	Wind speed 33m/sec	Wind speed 55m/sec	Seismic zone factor 0.1	Seismic zone factor 0.36
Beam moments	2.6	8.99	0.13	0.47
External column moment	1.7	5.14	0.09	0.25
Internal column moment	3.4	10.28	0.18	0.5

Table 2: Maximum Bending moments

V. Conclusion

From the analytical result following conclusions have been done

1) While designing rc frame should considered stiffness of the infill.
2) Infill is just not material which can be used only as void filling agent or for aesthetic appearance of the building so more importance should be given to the infill which reduces the deflection in the building under lateral loads.
3) In the above analysis double strut 230x940mm size of concrete block gives minimum displacement and minimum Bending moment compared to other.
4) If infill is considered in the design of RC frames the combined effect of RC frame and infill can with stand sever lateral loads such as Earth quake.
5) For infill concrete blocks and bricks are used but out of these two concrete blocks are more effective than the clay bricks.

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