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SEISMIC EVALUATION OF RESIDENTIAL BUILDING WITH MASONRY WALL USING ETABS

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ABSTRACT

Past earthquakes showed poor performance of reinforced concrete framed buildings infilled with masonry wall. This study focuses on the evaluation of G+3 storeyed residential Reinforced Concrete (RC) building with brick masonry wall subjected to earthquake load. The influence of masonry on the seismic resistance of RC building is studied. The strut action with different percentage of opening for doors and windows are analysed. The building is assumed to be located in seismic zone III. The building is designed as per IS 456-2000 and the lateral loads are determined as per sixth revision of IS 1893(Part 1)-2002. This study is carried out with nonlinear parameters using pushover analysis in ETABS.

KEYWORDS: Reinforced concerete (RC), Strut, Base Shear, Displacement, Pushover analysis.

INTRODUCTION

Past earthquakes showed poor performance of reinforced concrete framed infilled with masonry wall. Various researches are done to find the measures to decrease earthquake damages. Seismic evaluation is one of the approaches for it.

Masonry Infilled frame structures are used to provide lateral stiffness in region of high seismicity. There are places where the masonry is still conventional material for the construction. Those masonry infilled frames are designed and constructed before the development of actual seismic codal provisions. In the analysis of RC structures there is a trend of ignoring the presence of brick infill due to the reasons of complicated calculations. Only frame is considered in the analysis, which saves the calculation, time and effort but the infill masonry contributes to performance of frame during the earthquake.

Many methods are suggested in the literature for modeling of brick masonry infills such as finite element, equivalent frame and equivalent strut method. New Draft Indian standard criteria for earthquake resistant design of structures part 1 describe the diagonal equivalent strut method for analysis of masonry infill in RC buildings. Infills are considered to fail in compression, so a convenient way of representing the stiffening action of the infill is by assuming it to be replaced by an equivalent strut, acting along the compressive paths. Diagonal strut model for simulating the contribution of masonry wall to the stiffness of framed structure under lateral loads is the equivalent strut model means the introduction of pin jointed struts.

Luis[1] investigated the effect of infills on the performance of RC frames subjected to earthquake ground motion. They modeled the masonry infills by equivalent strut element. The performances of a large no. of different reinforced concrete two bay frames, bare and infilled, subjected to ten ground motions were investigated. Doudoumis [2]looked into the results of finite element micro models for the determination of the diagonal struts axial stiffness, instead of using experimental results on which most of existing application formulae and diagrams are based. Amin [3] examined the effect of soft storey for multistoried RC building frame. Four building models of different storeys with same plan were analyzed using equivalent static method using ETABS. Haroon et al [4] studied the behavior of the structure subjected to seismic analysis using equivalent force method for different RC frame buildings includes bare frame and infilled frame. Niruba and Boobala [5] investigated the effect of dynamic loading on the behavior of masonry infilled RC frame and concluded that by considering the infill wall the roof displacement of the structure reduces the stiffness and the stiffness of the structure increases. Prachand[6] identified the shear forces values at different locations, by using analytical formula. The width of the strut is calculated by several researches and compared with empirical formulae. And also he observed the response of the partially infilled frame using dynamic analysis

ANALYTICAL METHOD

This study involves seismic analysis of the RC frame building with two models that includes infilled masonry frame and replacing masonry walls with equivalent diagonal struts. The parameters such as displacements, time period, base shear and natural frequency are studied. ETABS software is used for the analysis of the building. In this study the existing plan of the building located in Chennai has been chosen. Figure 1(a) shows the plan of the building and Figure 1(b) shows the elevation along A-A for RC with masonry wall and Figure 1(c) shows the elevation along A-A for RC with strut action. Table 1 shows the input data for both the models.

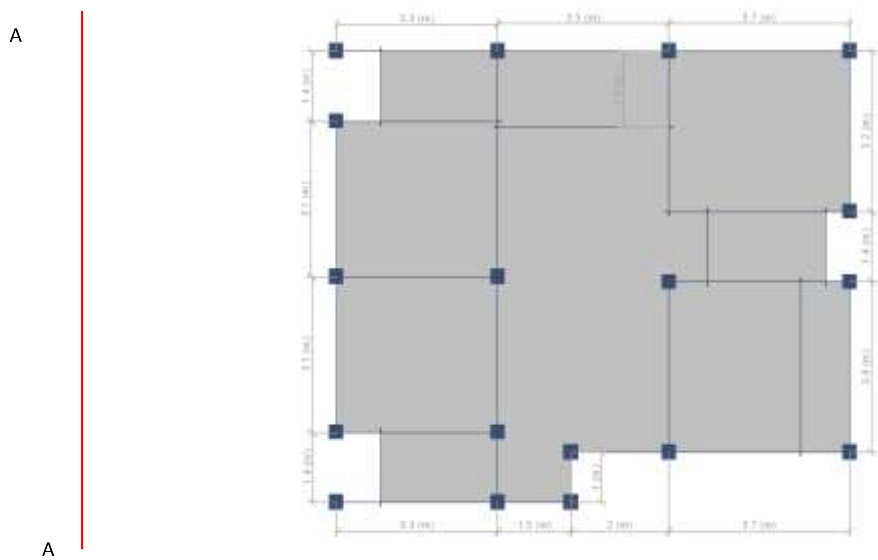

Fig 1(a) Plan of the RC building

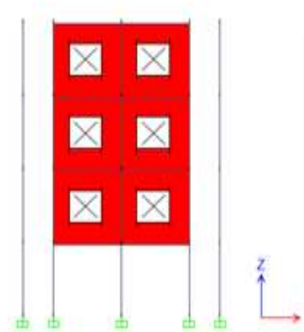

Fig 1 (b) RC with masonry

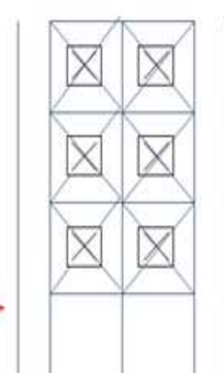

Fig 1(c) RC with strut

Table 1:Input Data

Length x Width	**10.5mx9m**
No of storey	**G+3**
Main beam	**250mm x 400mm**
Secondary beam	**230mm x 400mm**
Column	**300mm x 300mm**
Slab Thickness	**120 mm**
External Wall thickness	**230mm**
Internal wall thickness	**115mm**
Grade of Concrete	**M20**
Modulus of Elasticity of concrete	**22360.679 Mpa**
Modulus of Elasticity of brick masonry	**13800 Mpa**
LL on all storeys except roof	**3kN/m^2**
LL on roof	**1.5 kN/m^2**
Seismic Zone	**III**
Response reduction factor (R)	**3**
Damping	**5%**
Importance factor	**1**
Zone factor	**0.16**
Time period (calculated as per IS 1893 :2002 part1	**0.3333sec**

Modal Analysis

After modelling the structure, sesmic weights are calculated and assigned to each floor of the structure. Modal analysis is done and as the result of modal analysis we get mode shapes and fundamental time period. Table 2 gives the seismic weight of all the storeis.

Table 2: Sesmic weight of all the floors

Storey	**4**	**3**	**2**	**1**
Total weight (kN)	**903.61**	**1326.88**	**1326.88**	**1326.88**

Figure 2(a) and 2(b) shows the mode shapes for both RC with masonry wall and with equivalent diagonal struts.

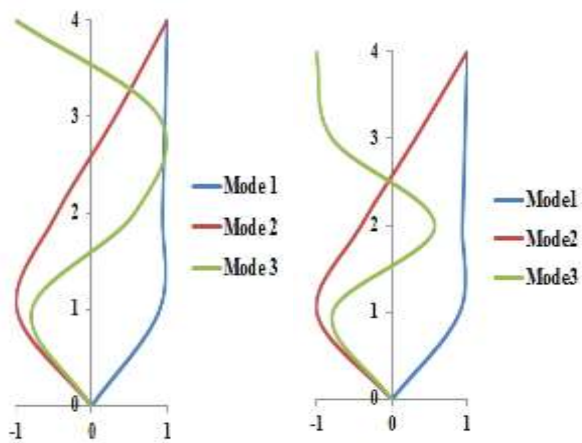

Fig 2(a) RC with masonry *Fig 2(b) RC with strut*

Table 3 provides the time period and frequency for the infill wall modal and Table 4 provides the time period for RC with strut action

Table 3: Time period for RC with masonry

Mode1	Mode 2	Mode3
0.427sec	0.042 sec	0.03sec

Table 4: Time period for RC with strut action

Mode1	Mode2	Mode3
0.933	0.0993	0.089

After the modal analysis nonlinear static pushover analysis is done. For the analysis lateral loads are required and these are calculated by two methods i.e. seismic co-efficient method and Response spectrum method. Both the methods referred from IS 1893(Part 1)-2002 and response spectrum method is carried out using the modal participation factor and modal masses. Table 5&6 provides the lateral loads by seismic coefficient and Response spectrum method.

Table 5:- Lateral loads by seismic coefficient method

Storey	4	3	2	1
Lateral load (Q_i) kN	142.51	260.23	312.55	325.65

Table 6:- Lateral loads by Response spectrum method

Storey	4	3	2	1
Lateral load (Q_i) kN	67.9	162.76	254.66	339.5

Strut model

The main object of this study is to investigate the behavior of residential building with masonry wall and to evaluate its performance level when subjected to lateral i.e. earthquake loading. Various types of analytical models with the behavior of masonry are developed. Out of all methods as per sixth revision of IS 1893(part 1)-2002 draft codes states that the unreinforced masonry infill wall shall be modeled by using equivalent diagonal strut.

Modeling of RC building

The RC frame members are modeled with fixed end conditions, the walls are modeled with opening and some without openings as per the existing plan. The RC building with masonry walls can be modeled as equivalent braced frames with masonry walls replaced by equivalent diagonal struts. As per draft code ends of diagonal struts shall be pin jointed to RC frame. For masonry wall without any opening, width W_{ds} of equivalent diagonal strut shall be taken as 1/3 of diagonal length L_d of the masonry wall as shown in figure 3.For masonry with openings width W_{do} of equivalent diagonal strut shall be taken as

$$W_{do} = \rho_w W_{ds}$$

Where ρ_w= reduction factor, which account for opening in infill walls. For walls with a central opening, ρ_w shall be taken as

$$\rho_w = \begin{cases} 1 & \text{if } A_r \leq 0.05 \\ 1-2.5A_r & \text{if } 0.05 < A_r < 0.4 \\ 0 & \text{if } A_r > 0.4 \end{cases}$$

A_r = Opening ration
= Area of opening / total area of masonry wall

Thickness of the equivalent diagonal strut shall be taken as thickness of original masonry wall.

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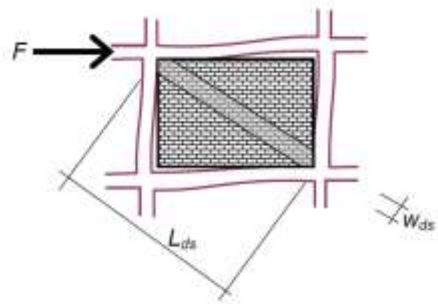

Fig 3 Details of equivalent diagonal strut of masonry infill wall

RESULTS AND DISCUSSION

From pushover analysis, the results following are obtained. Figure 4 shows the graph between Base shear (kN) and displacement (mm) and Figure 5 shows the graph between Spectral acceleration (g) and Spectral displacement (mm).Spectral acceleration and spectral displacements are inversely proportional to each other. From the two graphs it has been shown that the displacement of the RC structure with Strut action is less compared with RC structure with masonry infill wall. But the base shear is more for RC structure with masonry comparing with RC with strut action. Acceleration has to be calculated by using 1.36x (Z/2), where Z is the zone factor. By observing the capacity and demand curves meeting at a point for both models, means the building is safe against the applied load.

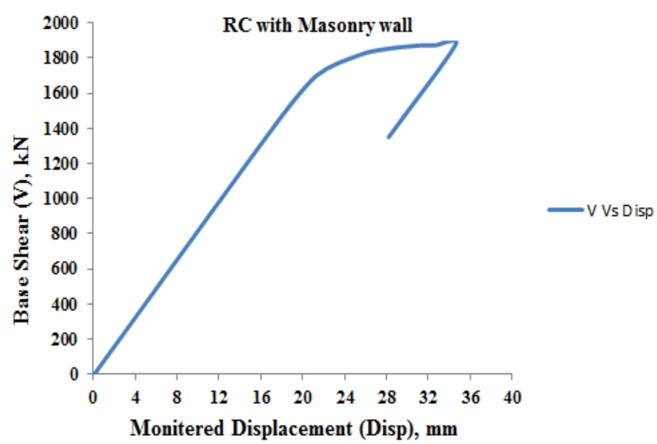

Fig 4(a) Base Shear vs Monitored Displacement for masonry

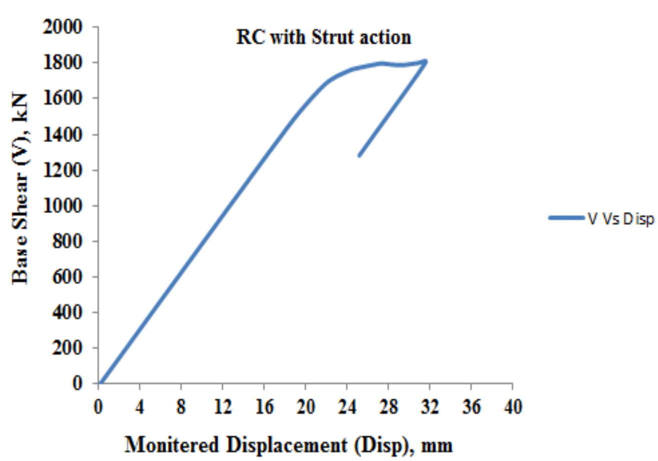

Fig 4 (b) Base Shear vs Monitored Displacement for Strut action

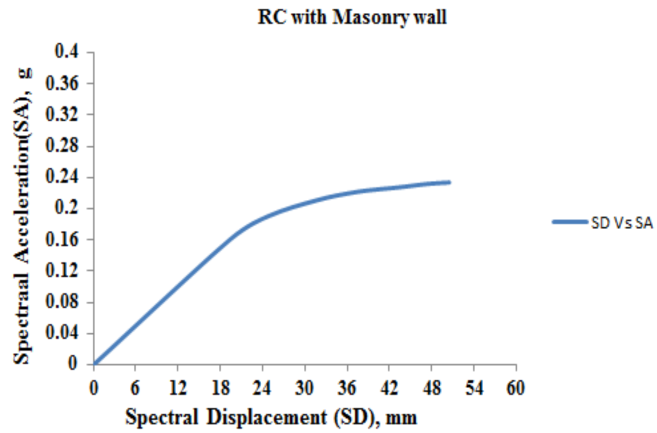

Fig 5(a) Spectral acceleration Vs. Spectral Displacement for masonry

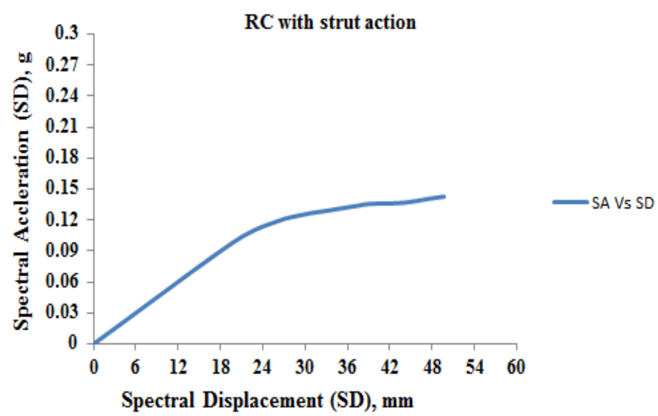

Fig 5(b) Spectral acceleration Vs. Spectral Displacement for strut action

Figure 6 shows that the capacity and demand curve for RC with masonry, capacity and demand curve are meeting at one point shows the building is in safe against the applied seismic load.

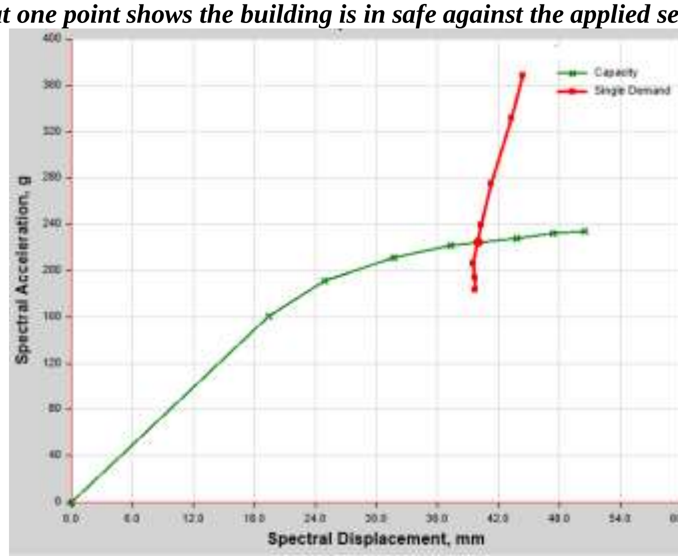

Fig 6 Capacity and Demand curve for RC with masonry

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Table 5:- Initial stiffness for both the models

	Initial Stiffness (kN/mm)
RC with Masonry	52.04
RC with Strut action	57.1

Acceleration is inversely proportional to displacement. Figure 7 shows the capacity and demand curve meeting at one point means the building is in safe against the applied seismic load.

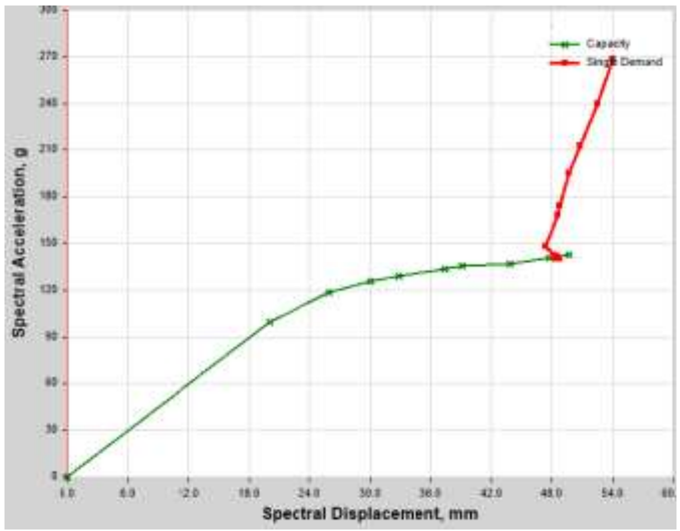

Fig 7 Capacity and Demand curve for RC with strut action

Initial stiffness of the RC with strut action is 9% more than the initial stiffness of the RC with masonry wall. Spectral acceleration of RC with strut action is 1.64 times more than that of RC with masonry. Spectral displacement of RC with masonry is 1.02 times more than that of RC with strut action.

CONCLUSION

The infill in RC framed building under study is modeled as brick masonry wall with openings and as diagonal strut. The frames are evaluated for seismic resistance by push over analysis. The responses of the frames as stiffness, base shear, displacement and acceleration from both the approaches are nearly same. The investigation clearly shows that the diagonal strut approach is very effective in simulating the seismic response of RC frame with masonry infill.

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