

# Comparative Analysis of C Shaped RC Frame by Replacing Masonry from Strut using Response Spectrum Analysis

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**Abstract:** Infill panels are widely used as partition walls as well as external walls of the building to fill the gap between RC frames. Non-structural member may provide considerable stiffness to the building and hence may improve the performance of the RC building during ground motions. But in most of the cases, the ignorance of this property of masonry in designing of the RC frame may get an unsafe design. The effect of ground motion on RC frame building has been carried out by considering with and without the stiffness of infill wall. A comparative study is carried out with RC building using Equivalent Lateral Force method and Response Spectrum method. The masonry infill has been modeled as an equivalent diagonal strut. Response spectrum analysis is performed by using ETABS by replacing the masonry by equivalent strut for G+8 reinforced concrete frames for constant relative stiffness and the strut is reduced up to 50% and behavior of the structure is observed. The parameters such as time period, base shear, storey displacement and storey stiffness are obtained and compared.

**Keywords:** ETABS, Equivalent diagonal strut, Seismic Forces, Storey displacement, frequency, base shear, etc.

## 1. Introduction

Reinforced concrete frame structures are mainly used in commercial and industrial purpose. This infill is constructed with masonry or concrete blocks. This structure can be constructed in between columns and beams. In present design practice in India the infill panels are nonstructural member because their strength and stiffness is ignored. The infill increases the axial forces in column and it decreases the displacement, lateral deflection and bending moment of the reinforced concrete framed structure. The infill panels are classified as non-structural elements and the structures are analyzed and designed by considering them as dead load and omitting any kind of structural synergy of infill panels because the bond between masonry infill and RC frames is imperceptible at sides and top surface of the infill as the masonry infills are constantly constructed after the vital frameworks of beams, columns and slabs have accomplished tolerable strength. This assumption of omitting the effect of masonry infill is reasonable and reasonable for the structure under gravity loading as infill panels remain almost static due to their construction methods.

Despite the same is not perfect for the structures with masonry infill when subject to lateral loads. The presence of infill under lateral loads has a significant structural benefaction by elaborating the lateral stiffness, strength and energy dissipation capacity. The presence of infill also increases damping of the structures due to the producing of cracks with increasing lateral drift. Existence of openings in the infill for functional requirements decreases stiffness and strength of infilled frames.

### A. Infilled Frames

It has been generally identified that infilled frame structures show poor seismic performance, since various buildings have been found lacking in past earthquakes. One of the most crucial problems is the deterioration of stiffness, strength and energy dissipation capacity noticed under periodic loading, which results from the continuous damage of the masonry wall and the deterioration of the panel-frame. Therefore, only low to Medium displacement ductility's can be accomplished. The lack of capacity of the structural behavior has also contributed to poor performance of infilled frames. It must be identified that these composite structures exhibit a compound and markedly nonlinear response, which results against the brittle behavior of the unreinforced masonry, the ductile nonlinear component of the frame, the different deformational properties and strengths of both components, and the fluctuating conditions at the panel-frame interfaces. The infilled frames are most commonly used for low and medium-height structures all over the world in regions of high seismicity, primarily in developing countries where the labor charge is less or where masonry structures are adopted for traditional buildings. It is believed that the development of balanced design procedures is a critical issue not only to reduce the loss of life and property destruction, but also to obtain a safe and economic solution.

### B. Equivalent Diagonal Strut

The frame that contains infill will have more stiffness and possess more strength. The major defect of using infill is cracking in infill due to lateral loading. Many researches have shown that replacing an infill with equivalent strut diagonally will overcome the cracks at the central portion or at the corners

of the frames and infill connections that are laterally loaded. The equivalent diagonal strut should have the same properties as that of infill. Many researchers have given formulae for width of equivalent diagonal strut.

## 2. Literature Review

Shaharbon P.S et al., The authors have researched on the conduct of RC Frame with infill walls under seismic loads. Under brick wall condition execution of workmanship in-filled RC frames was examined in this work. The investigation was completed utilizing Etabs for five unique models having four distinctive infilled condition. Parameters like time period, natural frequency, base shear and storey drift were considered for the examination. The results furnished that if there should arise an occurrence of open story frame structure, the storey drift is extensive than upper story that may cause failure amid strong earthquake. Thus, infill frames will be better to lean towards in seismic region and furthermore it results having a less displacement.

Haroon Rasheed Tamboli et al., Have worked on seismic analysis of RC frame Structure with and without masonry infill walls. Edges with three distinctive infill parameters exposed to linear dynamic loading was considered. The investigation was completed utilizing Etabs by equivalent strut method. Parameters like time period, natural frequency base shear and storey drift. This resulted that the infilled frames increases the storey drift and furthermore infill frames builds the strength and stiffness of the structure.

S.Niruba et al., Have worked on the analysis of masonry infill in a multi-Storied building. Structural impact of brick infill when it isn't considered in the design of columns and furthermore in other structural components was considered. Both bare framed and in-filled frame models of the building were considered and nonlinear static investigation was performed. Also, brick walls have significant in-plane stiffness of the frame against lateral load was clarified. It was inferred that there is a amplification of infill in expanding the strength, stiffness and frequency of the structure and that relies upon the position and load on infilling. Additionally, it was noticed that the lateral deflection was decreased subsequently in-filled frame contrasted with the deflection of the frame without infill.

Md. Irfanullah et al., displayed a research on seismic assessment of RC framed structures with impact of masonry infill panel. The investigation was done utilizing Etabs by equivalent diagonal strut method. The models comprised of six RC confined structures with brick masonry in-fills, exposed to linear dynamic loading. From the outcomes it was seen that giving infill beneath plinth and in swastika design in the ground floor enhances earthquake safe conduct of the structure contrasted with soft story. Likewise, it was presumed that the arrangement of infill wall improves the execution in terms of storey displacement and storey control and increment in lateral stiffness.

## 3. Analysis

### A. Equivalent Static Analysis

The equivalent static analysis or linear static analysis is bit simple technique, which will substitute to the response spectrum method. In this work, the time period considered will be negligible and forces are applied in a linear format.

The procedure involves:

- The design lateral forces are calculated based on seismic weight and seismic co-efficient method.
- The forces shall be distributed at different levels by standard procedure based on height.

### B. Response Spectrum Analysis

Response spectrum analysis is a linear dynamic analysis. In the analysis the mode shapes and modal mass participation factors are considered in the analysis and hence it will be treated as practical. All the building or structures will not respond to earthquake out of its frequency of vibration. These frequencies of the structure are called as eigenvalues and the shape of each mode generates which is known as eigenvector. In general, starting 3 modes are important to consider. And as per code it should cover a factor of 90% of modal mass participation.

### C. Proposed Methodology

In this present study, the reinforced concrete frames with masonry infill are modelled and analysed using ETABS. The models are analysed using ETABS for one aspect ratio by using the equivalent strut width formula given by past researchers. By replacing the masonry infill with this equivalent strut which has same properties that of masonry infill, models are modelled and Response spectrum analysis is carried out. The strut width is reduced by using reduction factor and same analysis has been repeated. The analytical results such as time period, base shear, storey displacement and storey stiffness are obtained and compared with different relative stiffness.

## 4. Modeling of Square Shape Structure

Modelling of G+8 storey, 6-bay by 4-bay reinforced concrete building is considered for the analysis in ETABS software. The material considered for analysis RC is M-30 grade concrete and Fe-500 grade reinforcing steel:

Dimension of column: 230x500 mm

Dimension of beam: 230x500 mm

Floor height: 3m

Slab thickness: 150 mm

Concrete grade: 30

Zone factor: 0.10

Soil type: II

Live load: 3KN/m<sup>2</sup>

For this present work we have adopted of formula for width of equivalent diagonal strut given by the researchers Sanjay S J and Bharath H K

$$W = \exp[-1.46907 + 0.24469 - 0.07601 * (\lambda h)^2] * d * R$$

$$R = \exp[-0.01185 - 4.88321 - 1.08327 * (A)^2]$$

W= Width of strut  
 $\lambda h$ = Relative stiffness  
d= Length of diagonal strut  
R= Reduction factor which is as below.

Table 1

% Reduction of Strut Width	
% Reduction	Strut Width in mm
Solid infill	1310
5	1010
10	785
20	467
30	271
40	153
50	85

### 5. Modeling

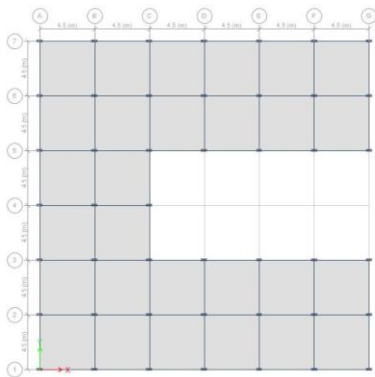


Fig. 1. Plan of the buildings

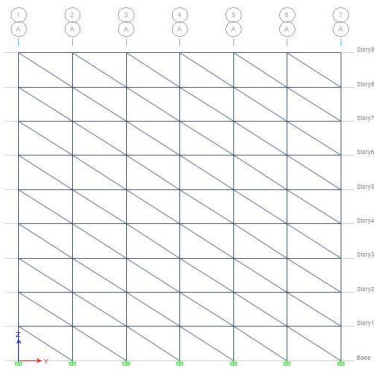


Fig. 2. Elevation View

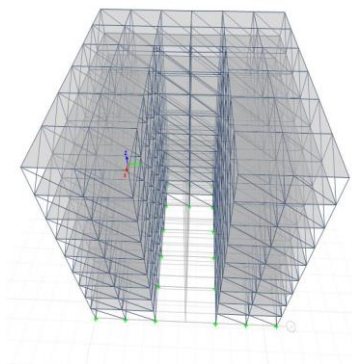


Fig. 3. 3D View of building

### 6. Results

This section describes the results and discussion of the models analysed in ETABS by linear analysis.

#### A. Storey displacement

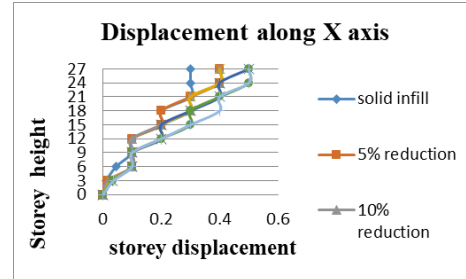


Fig. 4. Comparison of storey displacement with respect to strut width reduction along x direction.

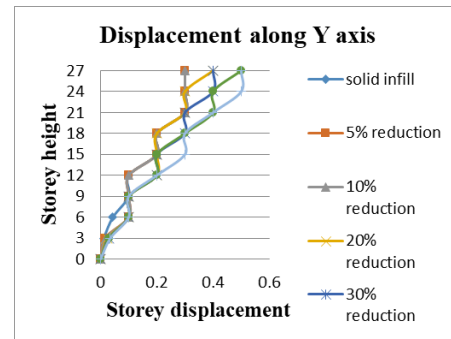


Fig. 5. Comparison of storey displacement with respect to strut width reduction along Y direction

#### B. Base Shear

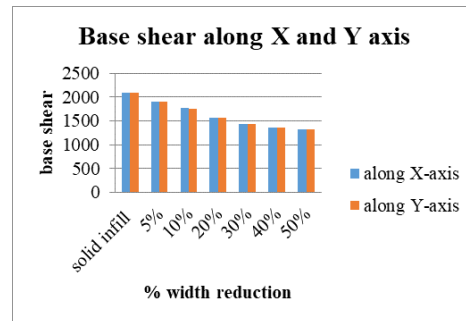


Fig. 6. Comparison of base shear with respect to strut width reduction along x and y direction

#### C. Time period

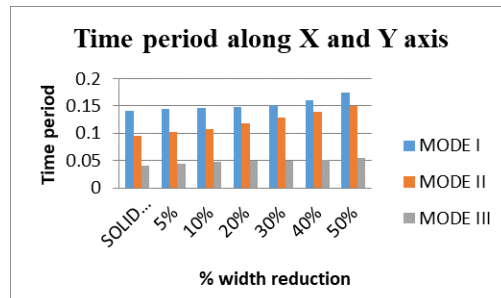


Fig. 7. Comparison of time period with respect to strut width reduction along x and y direction

D. Storey Stiffness

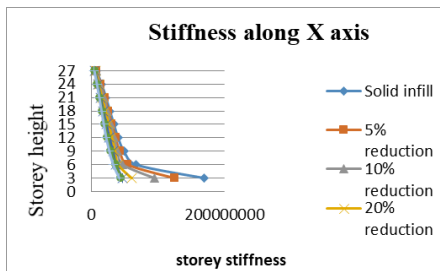


Fig. 8. Comparison of storey stiffness with respect to strut width reduction along x direction

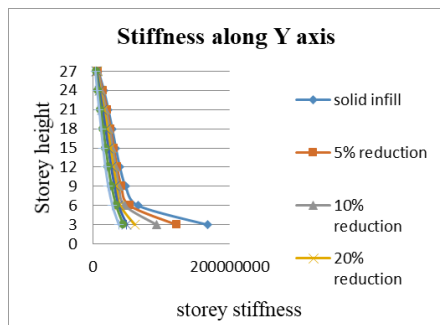


Fig. 9. Comparison of storey stiffness with respect to strut width reduction along y direction

7. Conclusion

In this study, models regular building (G+8) stories with the varying strut width reduction 5%, 10%, 20%, 30%, 40%, 50% are modelled and analyzed for linear dynamic analysis. The structure is analyzed to study the behavior of the structure for the vertical and the horizontal loads and also behavior of the structure with the reduction in the strut width response of the structure for the dynamic loadings are analyzed using FEM software ETABS.

The following conclusions are being made by the results obtained from the present study:

1. Storey displacement of model, conventional structure is having higher displacement compared with its frames with high aspect ratio and storey displacement increases as the strut width gets reduced and it is more

along Y-axis than X-axis.

2. The storey shear is more for RC frame with masonry solid infill and least for 50% width reduction. Base shear gets decreases as the width of the strut decreases.
3. Time period values are obtained from analysis as per the IS1893-2002, the value of the time period gets increases with the gradual decrease in the strut width. The solid infill increases the stiffness and reduces flexibility due to which time period decreases.
4. It is observed that all the models have higher time period given by Equivalent Static Method. The provision of infill wall clearly justifies the reduction in time period for empirical formula.
5. The contribution of infill increases the stiffness of the frame, Story stiffness decreases as the width of the strut decreases. Story stiffness is more along x direction
6. But there is no general trend for lateral force values by Response Spectrum method. While the values for bare RC frame is most at 1st floor level, but in case of frame with infill, lateral force value is most at 2nd floor level. That forces values decreases with increase in floor levels.

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