Published by :
http://www.ijert.org
International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 05, May-2021

Seismic Analysis of Reinforced Concrete Frame Building with Infill Wall using ETABS

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Abstract—**Reinforced concrete frame building with masonry infill wall is a common construction practice in developing countries like India. Infill walls serve as partitions in buildings. Infill walls are typically considered as nonstructural elements and its strength and stiffness is not considered in the general design; such an approach may lead to unsafe design. This paper focuses on the study of the effect of masonry infill wall on RC frame building. Response Spectrum Method is used for analysis purpose. The analysis is done on ETABS software and the results are discussed.**

Keywords—Analysis, ETABS, frame, infill wall, masonry, nonstructural

I. INTRODUCTION

Earthquake is shaking of the ground in haphazard manner both horizontally and vertically due to sudden movement in the Earth's tectonic plates. This shaking may result in the destruction of buildings and break the Earth's surface. The seismic activity of an area defines the frequency, type and size of the earthquakes experienced over a period of time. The areas in seismic zones are prone to severe damages.

Masonry is a commonly used material in developing countries like India. Masonry infill walls are equivalent to compressive struts and generally consists of bricks or concrete blocks constructed between the beams and columns of a reinforced concrete frame. Masonry infill walls basically serve as partitions in buildings. The infill walls are considered as an architectural or non-structural element and their design guidelines are not mentioned in the present IS Code, IS 1893:2016. In traditional practice it is considered that infill walls do not take any loads and therefore the resistance of walls is generally ignored in the design guidelines which may lead to an unsafe design. But it has been observed that frames with MI walls contribute significantly, in terms of enhanced strength and stiffness under earthquake induced lateral loading. The lateral deflection and bending moments are reduced in an RC frame consisting infill wall, thereby decreasing the probability of collapse. In high rise buildings, the vertical loads such as dead load and live load do not pose much of a problem, but the lateral loads due to wind or earthquake quivers are a matter of great concern and need special consideration in the design of buildings. These lateral forces can set up undesirable vibrations as a result of horizontal and vertical shaking. Therefore, it is necessary to evaluate the effects of MI walls on the load resisting capacity of RC frames. Infill walls or panels can be modeled using different methods such as equivalent diagonal strut method, equivalent frame method, finite element method, etc.

II. AIM

The aim of the research is to study the effect of masonry infill wall on RC frame building using Response Spectrum Method on ETABS.

III. RESEARCH OBJECTIVES

1) To study the effectiveness of masonry infill to resist seismic forces.
2) To analyze the building using Response Spectrum Method on ETABS software.
3) To study the results of various parameters such as story drift, displacement and deflection.

IV. METHODOLOGY

Various IS Codes like IS 1893:2016(Part 1) and IS 456:2000 was referred for design purpose. The required architectural plan, sizes of beams and columns for analysis and design purpose is collected from a construction site of a multistorey building.

Following data is used for modelling of RC framed building:
Number of storeys: Thirteen
Seismic Zone: III
Floor Height: 3m
Depth of Slab: 150mm
Size of Beam: 200x600mm
Size of Column: 700x700mm
Live Load on floor: 4KN/m
Floor finish: 1 KN/m
Thickness of infill wall: 230mm
Materials: M25, M30, HYSD 415, HYSD 500
Density of concrete: 25 KN/m3
Density of infill: 20 KN/m3

A. Following are the steps used for modelling:

- First the grid line plan is prepared in ETABS.
- The materials like concrete, rebars are defined.
- Frame sections as beams,columns,slab,shear walls,strut are defined.
- Properties of slab, beams, columns , shear walls and strut are assigned.
- Define the static load cases and load patterns.
- Assign the loading as Dead load, Live load ,Seismic loads.
- Assign the support conditions as fixed and Analyze the model.

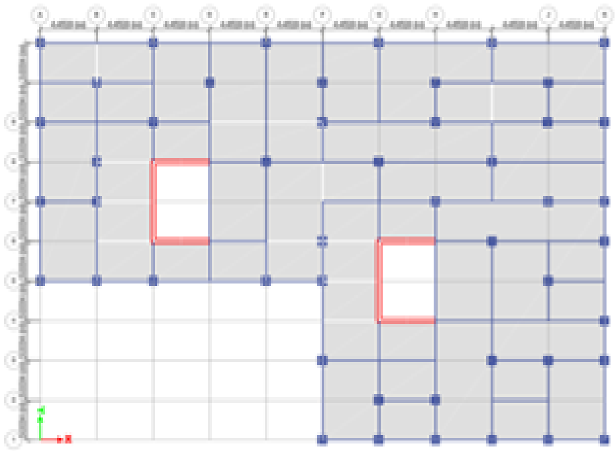

Fig. 1. Grid Plan of building

B. Modelling of equivalent Diagonal Strut

Equivalent Diagonal Strut Method is the most common method to model infill wall. An infill wall is assumed to be a brace frame in this method which is equivalent to a compression strut. As per IS 1893:2016 (Part 1), the width of the diagonal strut is given as,

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

where

$$\alpha_h = h\sqrt[4]{\frac{E_m t \sin 2\theta}{4 E_f I_c h}}$$

where, E_m and E_f are the modulus of elasticity of masonry and concrete, I_c is the moment of inertia of column, t is the thickness of masonry infill wall and θ is the angle of diagonal strut with the horizontal.

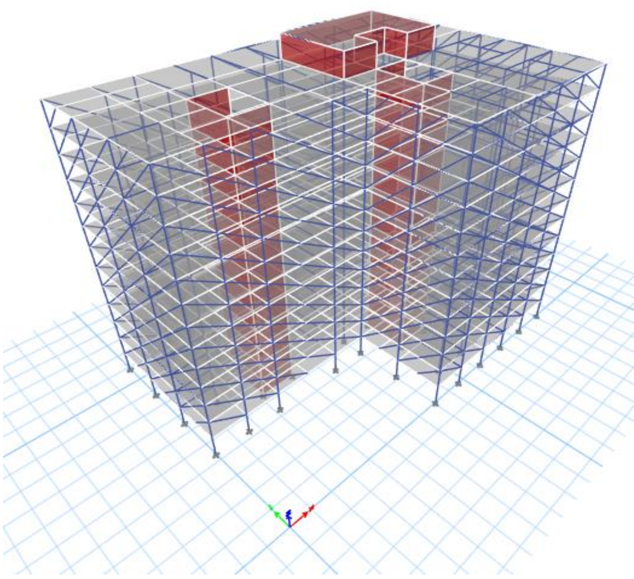

Fig. 2. 3D Model of building with infill wall

C. Response Spectrum Method

Response Spectrum Method is also known as linear dynamic analysis method. Multiple mode shapes of building are considered in this method. The contribution from each natural mode of vibration is measured which indicates the maximum seismic response of a structure. The maximum values of member forces and displacements in each mode of vibration is calculated in this method.

D. Analysis of Model

The prepared model is analyzed for identifying the effect of masonry infill wall to earthquake resisting buildings. Analysis is done by Response Spectrum Method using ETABS. This is the accurate method of analysis.
Load Patterns Used:
1. Dead load
2. Live load
3. Seismic Load (EQx)
4. Seismic Load (EQy)

Load Combinations Used:
D.L=3.75, L. L=4
1.5 (D. L+L.L)
1.5 (D. L+ EQx / EQy)
1.2 (D.L + L.L + EQx / EQy)

V. RESULTS

A. Modal Analysis:

No of modes: 40
Rz value of 1st mode = 0.0272< 0.05
First mode: Translation
Time period difference = (0.866 - 0.732) = 0.134>0.1
Modal mass participation of last mode = 95%-97%

Table No. 1. Modal Participating Mass Ratio obtained from ETABS

Mode	Period sec	UX	UY	UZ	SumUX	SumUY	SumUZ
1	0.866	0.0092	0.7747	0.0024	0.0092	0.7747	0.0024
2	0.732	0.5268	0.0001	0.0041	0.536	0.7748	0.0065
3	0.612	0.2848	0.0324	0.0016	0.8208	0.8072	0.0081
4	0.318	0.0047	0.1122	0.0712	0.8255	0.9193	0.0793
5	0.275	0.116	0.0003	0.0113	0.9415	0.9196	0.0906
6	0.258	0.0019	0.0385	0.2681	0.9435	0.9581	0.3587
7	0.247	0.0004	0.0016	0.1264	0.9439	0.9597	0.4851
8	0.237	0.0046	0.0029	0.1625	0.9484	0.9626	0.6476
9	0.228	6.674E-07	7.758E-07	0.0012	0.9484	0.9626	0.6488
10	0.228	0	0	2.6E-06	0.9484	0.9626	0.6488

B. Inter-Storey Drift Ratio:

Inter storey drift ratio should be less than 0.004
To be checked for EQx and EQy
Drift ratio for EQx = 0.001464
Drift ratio for EQy = 0.001683
Hence, passed.

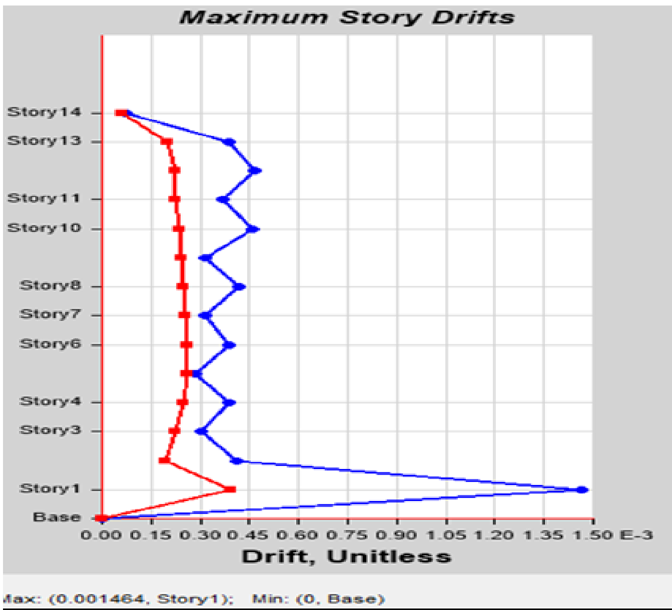

Fig. 3. Maximum story drift in X direction

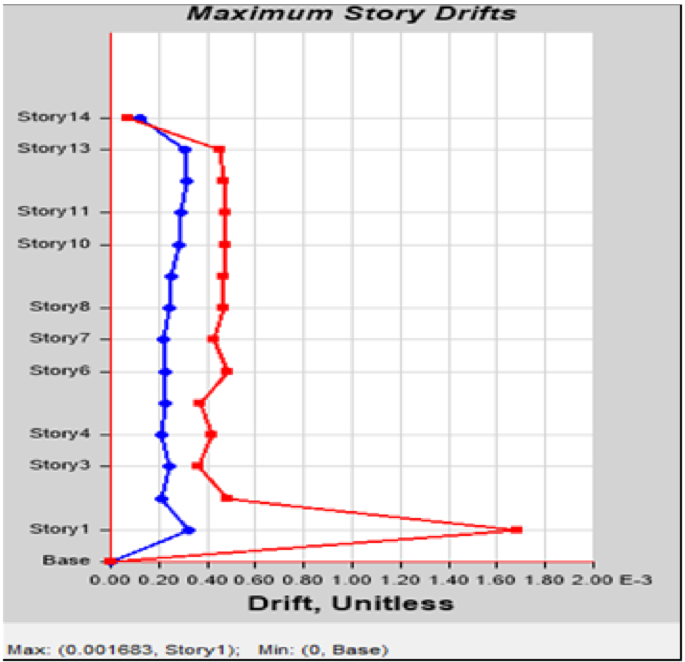

Fig. 4. Maximum story drift in Ydirection

C. Maximum Displacement Against Earthquake:

Maximum Displacement Against Earthquake:
Maximum displacement against earthquake should be less than = H / 250 mm
H = 39000mm
To be checked for EQx and EQy
H/250= 39000/250 = 156mm
Maximum displacement against earthquake EQx = 11.59mm
Maximum displacement against earthquake EQy = 15.79mm
Hence, Passed.

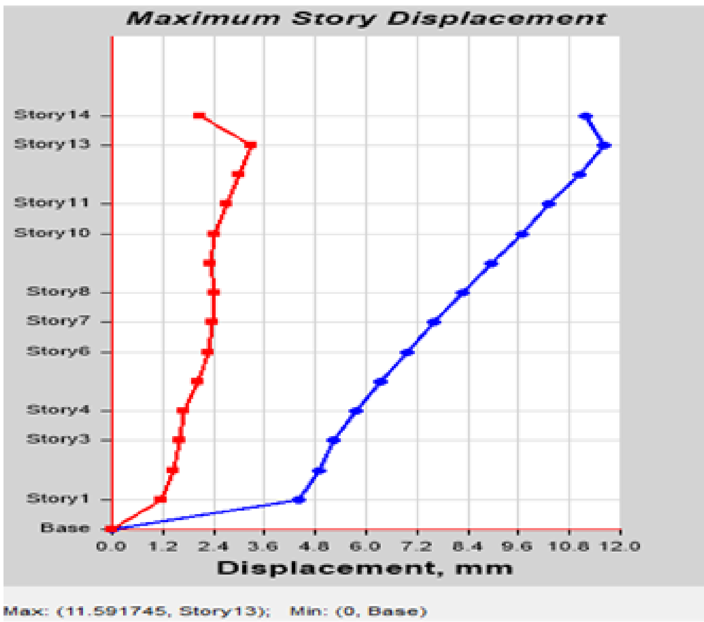

Fig. 5. Maximum Displacement in X direction

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 05, May-2021

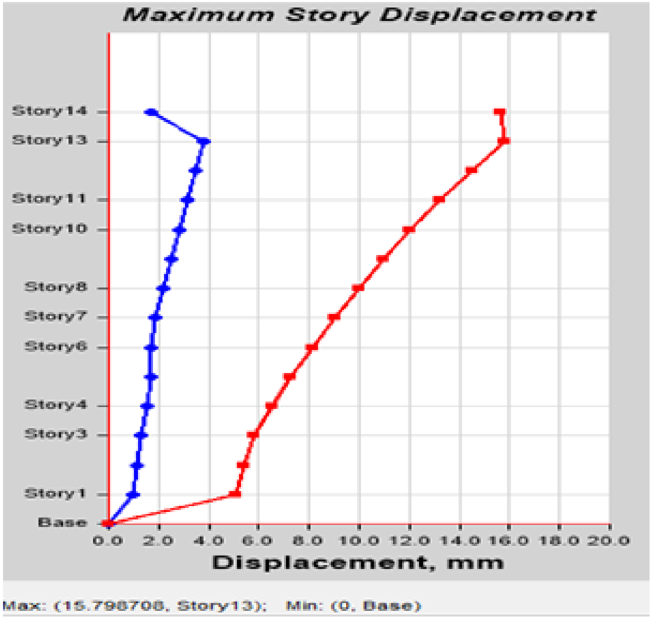

Fig. 6. Maximum displacement in Y direction

D. Check for Deflection

Load combination used = D.L =1, L.L =1

Maximum deflection < SPAN/350 or 20 mm (AS per IS 456:2000)

Creep Coefficient: 3

Span = 6006.8 mm

(Deflection of slab – axial deformation of nearest column) x 3 < SPAN /350 or 20mm

(31.13 – 27.088) x 3 < 6006.8/350 = 12.126 < 17.16

Hence, passed.

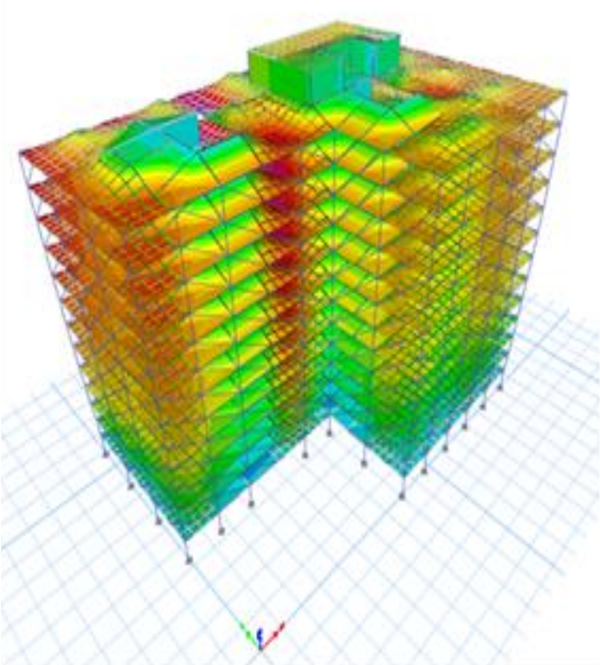

Fig. 7. Maximum Deflection

E. Maximum Story Displacement by Response Spectrum Analysis

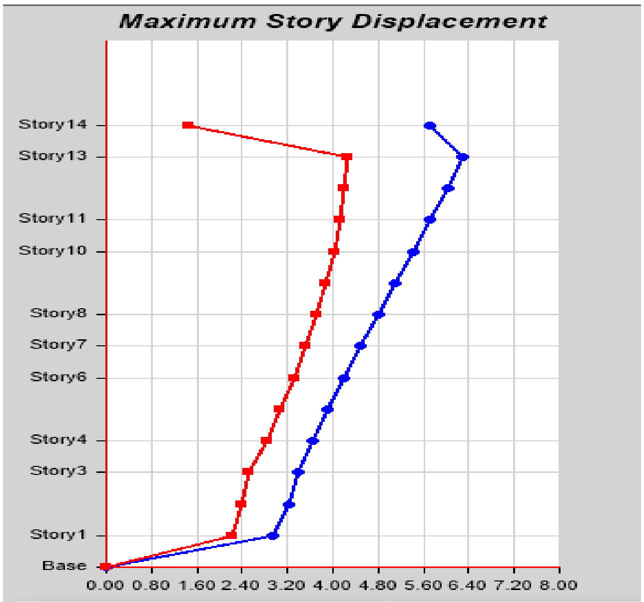

Fig. 8. Maximum story displacement obtained by response spectrum in X direction

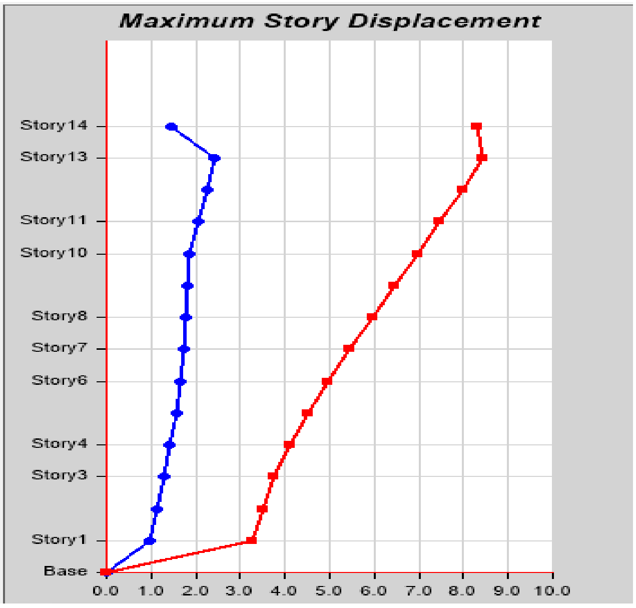

Fig. 9. Maximum story displacement obtained by response spectrum in Ydirection

VI. CONCLUSION

To analyze the effect of infill masonry wall on the response of multi storey RC framed building the Dynamic Response Spectrum Analysis is carried out, based on the results following points are concluded:

From the results of the Response Spectrum Analysis, it was concluded that the RC framed building with Infill walls has good resistance to earthquake and can sustain the vibrations due to earthquake.

Based on the study of seismic analysis, following points are summarized:

1. In the modal analysis as the modal mass participation of the highest mode is more than 90% thus it indicates the stiffness is more.

2. The masonry infill walls reduce the time period in modal analysis.

3. It can be observed that the maximum displacement against earthquakes and the inter-storey drift ratio is very less because of infill walls as compared to the bare frames.

4. From the graphs of Response Spectrum Analysis in X- direction and Y- direction it was observed that the displacement is lesser because of stiffness.

Thus, the Masonry Infill Walls in RC framed buildings make the structure more stiff for Earthquake excitations and can be used to reduce the lateral deflection.

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