Published by :
http://www.ijert.org
International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 10, October-2016

Dynamic Behavior of Masonry Infilled RC Frame with and without Opening

Md Ahmed Atheruddin*
P.G Student, Dept. of Civil Engineering
Lords Institute of Engineering and Technology
Hyderabad, T.S, India

Syed Mohsin
Associate Professor, Dept of Civil Engineering
Lords Institute of Engineering and Technology
Hyderabad, T.S, India

Md Haris
Associate Professor, Dept of Civil Engineering
Lords Institute of Engineering and Technology
Hyderabad, T.S, India

Md Zakir
Associate Professor, Dept of Civil Engineering
Lords Institute of Engineering and Technology
Hyderabad, T.S, India

***Abstract*— In reinforced concrete frames the masonry infill walls are a common practice in countries like India. In general, the masonry infill walls are treated as non-structural element in structural analysis and only the contribution of its mass is considered and its structural parameters like strength and stiffness is generally ignored in practice, such an approach may lead to an unsafe design. The performance of such structures during earthquakes has proved to be superior in comparison to the bare frames. The effect of masonry infill panel on the response of RC frames subjected to seismic action is widely recognized and infill behaves like compression strut between column and beam and compression forces are transferred from one node to another. Infill wall resists lateral loads but because of the openings in the infill wall the resistance may slightly reduce.**

In the present study, it is attempt to highlights the performance of masonry infill reinforce concrete (RC) frame building models that include bare frame, infill frame and different percentages of opening in infill frame. According to FEMA-273, and ATC-40 which contain the provisions of calculation of stiffness of infill frames by modelling infill as "Equivalent diagonal strut method".

The dynamic analysis of the frame models (Four & Ten story) is performed by using computer software ETABS from which different parameters are computed. The opening size of the infill has significant influence on the fundamental period, lateral displacement, inter storey drift and maximum storey acceleration, generally they increases as the opening size increases. The base shear decreases as the opening size increases

KEY WORDS: Masonry infill frame, Opening percentage, Equivalent diagonal strut method, Base Shear, Fundamental period, Lateral Displacement, Storey Drift

I. INTRODUCTION

It is a general practice in all developing countries to provide brick masonry infill walls within the columns and beams of reinforced concrete frame structures. Such composite structures formed by the combination of a moment resisting plane frames and infill walls are termed as "infilled frames". It has been known for long time that masonry infill walls affect the strength and stiffness of infilled frame structures. There are plenty of researches done so far for infilled frames, however partially infill frames are still topic of interest. Though it has been understood that the infills play a significant role in enhancing the lateral stiffness of complete structure, infills have been generally considered as non-structural elements and their influence is neglected during the modelling phase of structure leading to substantial inaccuracy in predicting the actual seismic response of framed structures. The performance of the structure can be significantly improved by the increase of strength and dissipation capacity due to the masonry infills even if in presence of an increasing in earthquake inertia forces. Experimentally it has been shown that brick walls have high initial lateral stiffness , hence masonry infills in RC frames different lateral load transfer mechanism of the structure from predominant frame action to predominant truss action.

In the present study RC frame building (four storey and ten storey) located in seismic zone III is considered by modelling of frame and infill. Modelling of infill is done with reference to FEMA-273 which contain the provision of calculation of stiffness of infilled frames by modelling infills as 'Equivalent Diagonal Strut method" and second stage analysis on the models such as bare frame, infilled frame, infilled frame with different percentage of openings has been carried out by software ETABS and then different parameters has been computed.

II. OBJECTIVES

The major objectives of the research are as follows:

- To study the behavior of RC frame with brick masonry infill by modelling masonry infill as a diagonal strut.
- To evaluate the effect of earthquake forces on four and ten story building with & without the effect of brick infill with different percentage of opening for various parameters with the help of structural analysis software ETABS.
- To generate the response of 3D frame with and without opening in masonry infills under dynamic loading.
- To compare all analytical models with the help of graphs.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 10, October-2016

III. METHODOLOGY

FEMA Approach

Equivalent Diagonal Strut method

Equivalent diagonal strut method is used for modelling the brick infill wall according to FEMA-273. The infill frame in this model is assumed as an equivalent diagonal strut with frame the pin joint at the corners of the RC frame. Based on experimental and analysis data, Mainstone and Weeks (1970) proposed an empirical equation for the calculation of equivalent strut width

w/d=0.175dz [λH]-0.4

This formula is included in FEMA 273 and is accepted from the majority of researchers dealing with the analysis of infilled frames and it has also mentioned that the equivalent diagonal strut shall have the same thickness and modulus of elasticity as the infill panel it represents.

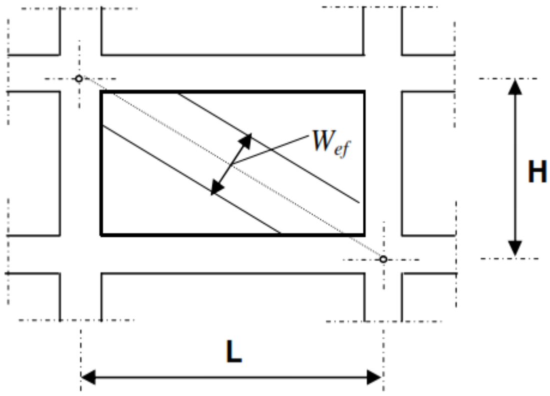

Figure 1: Equivalent Diagonal Strut Model.

$$w = 0.175 d (\lambda H)^{-0.4}$$

Where, λh is an empirical parameter expressing the relative stiffness of the column to the infill an is given by;

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

Where;
t= Thickness of masonry infill
h= Height of masonry infill
H = Height of RC frame
l= Length of the infill
L = Length of RC frame
d = diagonal length of the masonry infill.
Em= Modulus of elasticity of masonry infill
Ec= Modulus of elasticity of column
EL= Modulus of elasticity of beam
Ic= Moment of inertia of the column
IL= Moment of inertia of beam
λL= empirical parameter expressing the relative stiffness of beam to the infill
θ= Slope of the infill diagonal to the horizontal

Width of strut without opening (W)

$W = 0.175 (\lambda H)^{-0.4} * D$

Putting the value of stiffness reduction factor in above equation, width of strut has been calculated for estimation of width of strut without opening,

Width of strut with opening = Stiffness Reduction Factor as per fig 2 x W without opening

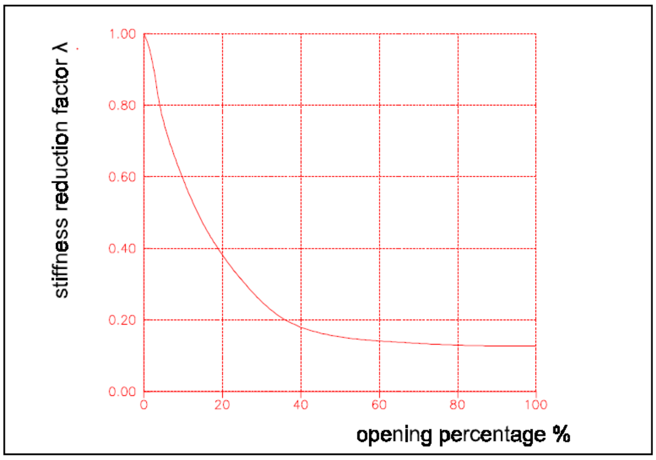

Figure 2: Stiffness Reduction Factor λ of the Infilled Frame in Relation to the Opening Percentage

IV. ANALYSIS PROBLEM

A. STRUCTURAL DETAIL

Story	Four and Ten story
Spacing of frame X direction	6 m
Spacing of frame Y direction	4.5m
Storey height	3.2 and 3.5 m
Beam	0.25m X 0.6m
Column	0.25 X 0.50m, 0.35 X 0.70 (for 4 and 10 storey building)
Slab	0.125m
Live Load	3 KN/m2 for typical floor, 1.5 KN/m2 for terrace
Dead Load	3 KN/m2 for typical floor, 2 KN/m2 for terrace
Seismic zone	III
Zone factor	0.16
Response Reduction Factor	3
Importance Factor	1
Soil Condition	Medium
Damping	5%
Grade of Concrete	M25
Grade of Steel	Fe415
Density of Concrete	25 kn/m3
Density of Brick Wall	20 kn/m3
Modulus of Elasticity of concrete	2.5 x 107 KN/m2
Modulus of Elasticity of masonry	0.35 x 107 KN/m2
Thickness of Masonry infill	0.230m
Analysis Method	Static and Dynamic(response spectrum)
Ductile Detailing Code	IS 13920-1993

B. ANALYTICAL MODEL CONSIDERED

I. Bare frame (masonry effect not considered)
II. Complete infill without opening
III. 15% opening infill frame
IV. 20% opening infill frame
V. 30% opening infill frame
VI. 40% opening infill frame

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 10, October-2016

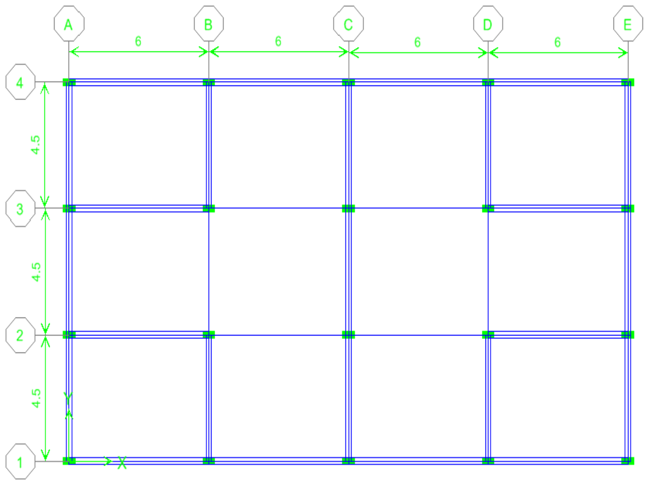

Figure 3: Plan layout for Four and Ten Story Building Models

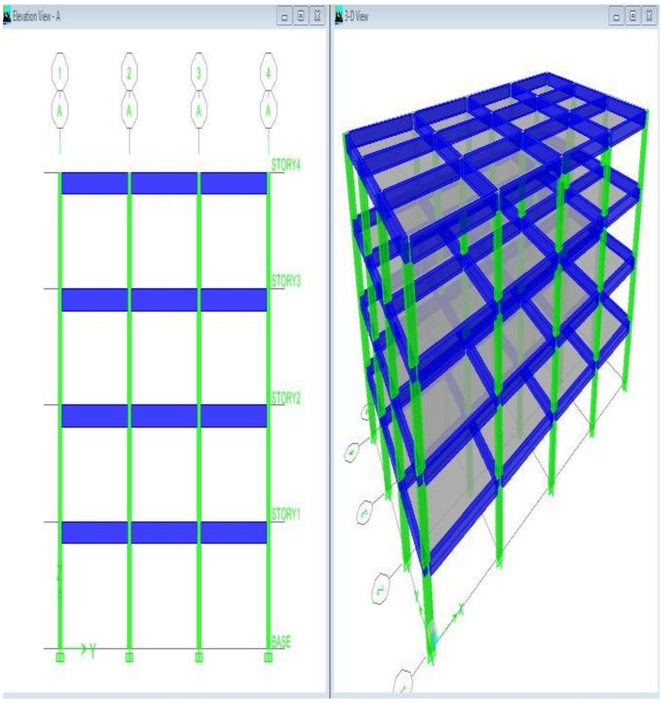

Figure 4: Bare Frame Model

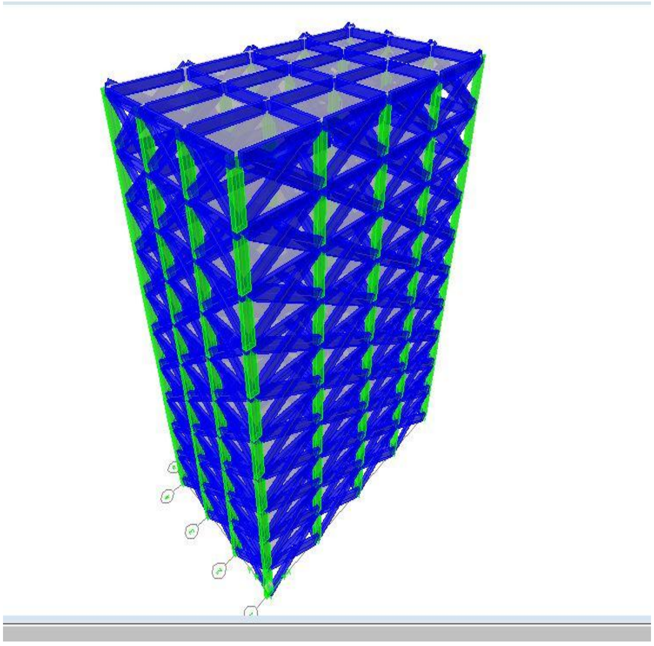

Figure 5: Fully Infilled as Strut 3D Model

The above mentioned all frames has been designed by using ETABS software. The results found to be are shown with the help of graphs for the parameters,

a) Fundamental natural time period

b) Base shear

c) Lateral displacement

d) Story drift

e) Story acceleration

V. COMPARISON OF RESULTS

Comparison of all analytical models with the help of graphs. Comparison is done between bare frame, fully infilled frame, infilled frame with 15 % opening, with 20% opening, 30% opening, and 40% openings.

Results for Four Story Building

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 10, October-2016

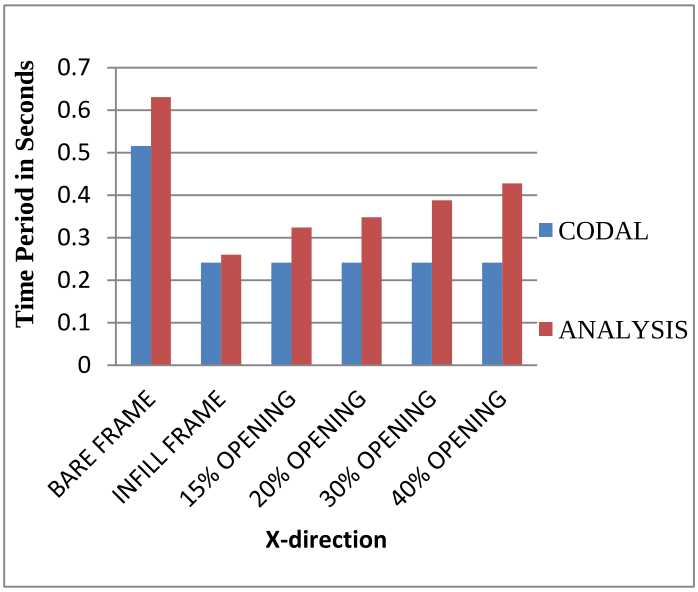

Figure 6: Variation of Fundamental Natural Time Period in X-direction

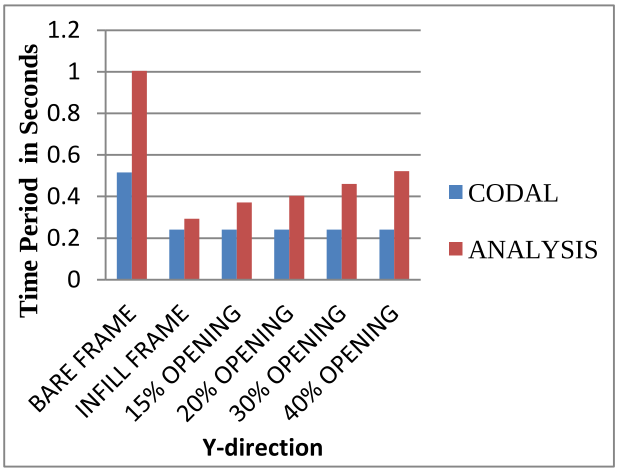

Figure 7: Variation of Fundamental Natural Time Period in Y-direction

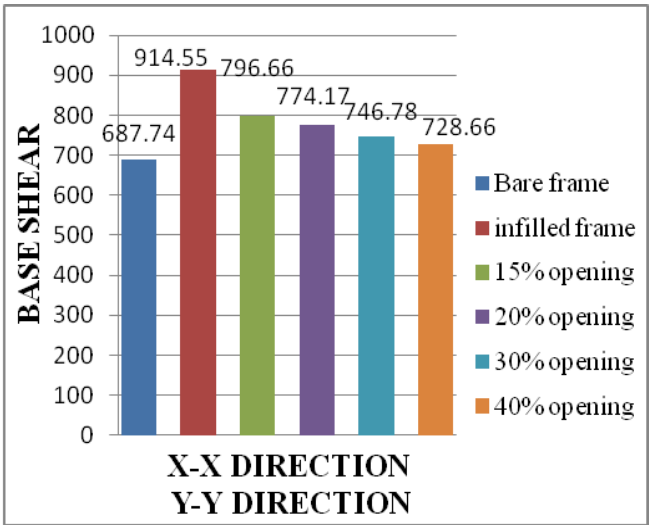

Figure 8: Variation of Base Shear in Static Analysis

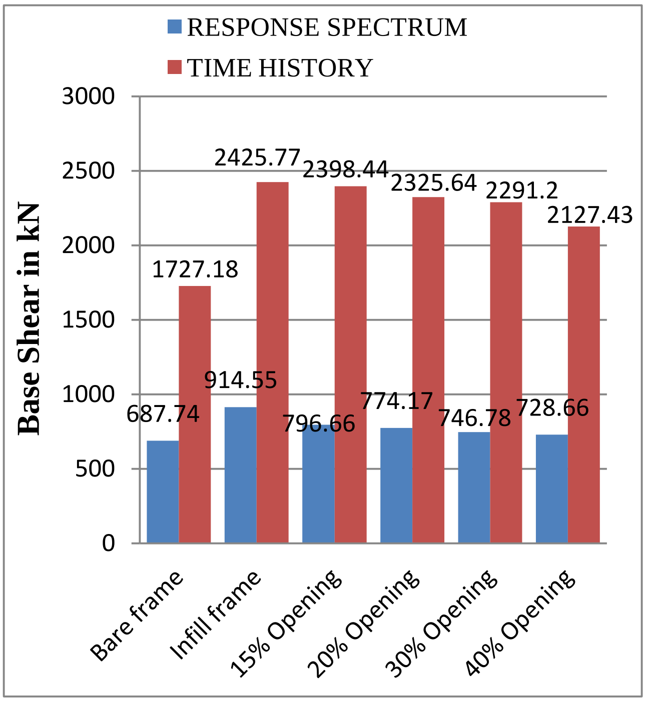

Figure 9: Variation of Base Shear in Dynamic Analysis

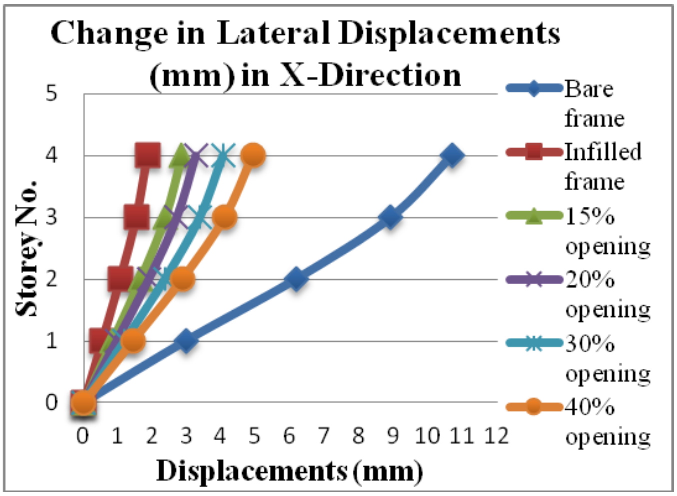

Figure 10: Displacement vs. Story no. in U_x direction

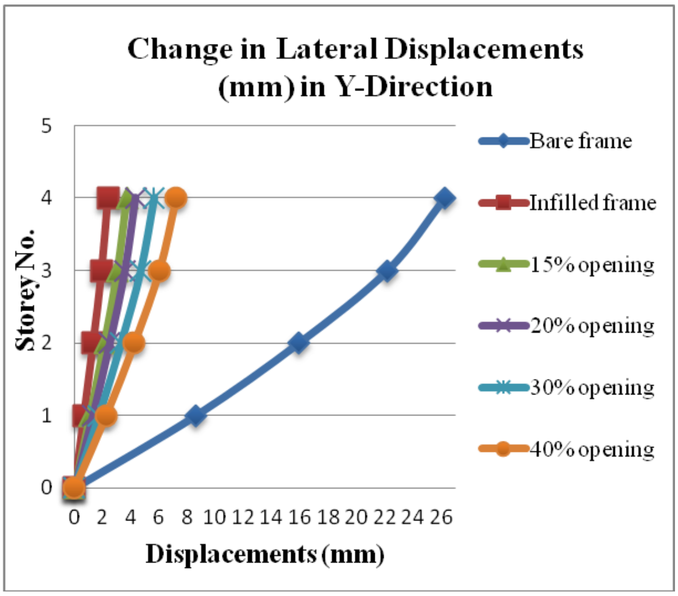

Figure 11: Displacement vs. Story no. in U_y direction

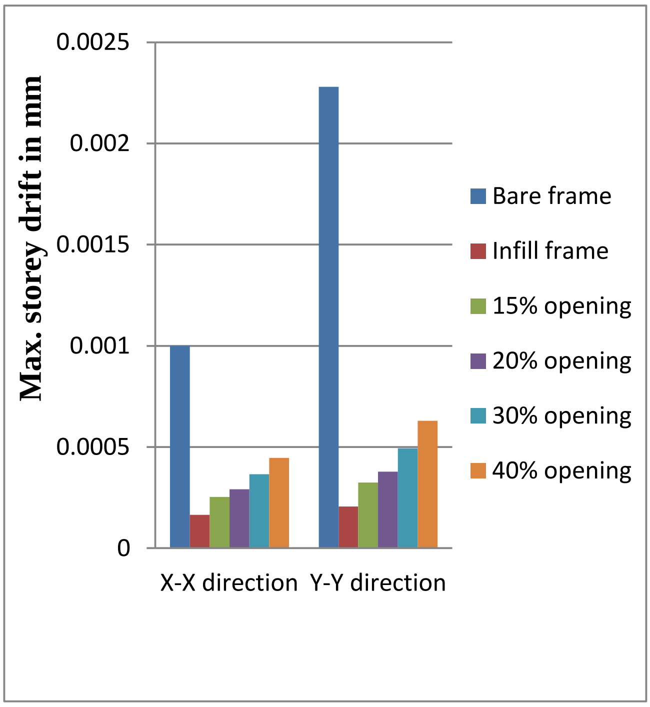

Figure 12: Maximum Storey Drift in U_x and U_y direction at the level of 2nd storey

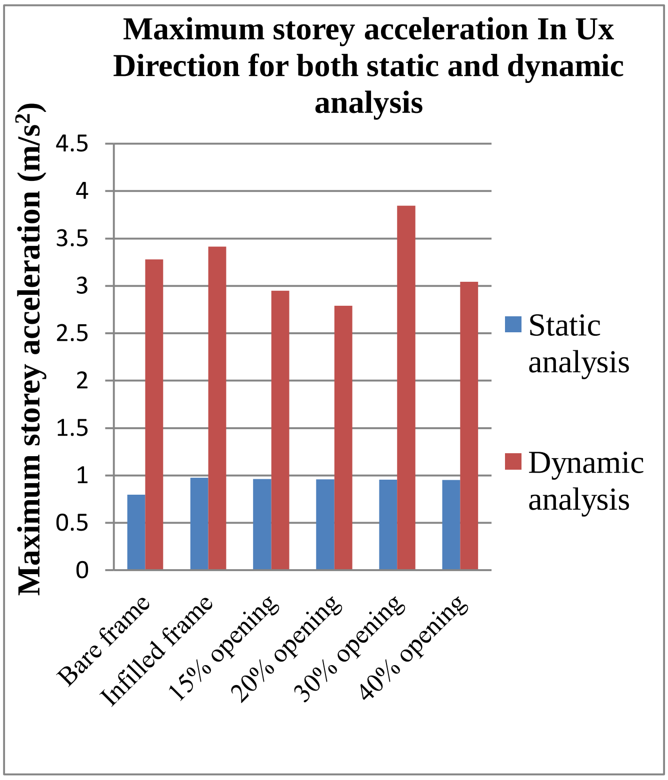

Figure 13: Variation of Maximum story acceleration for both static and dynamic analysis in U_X direction for four storied building

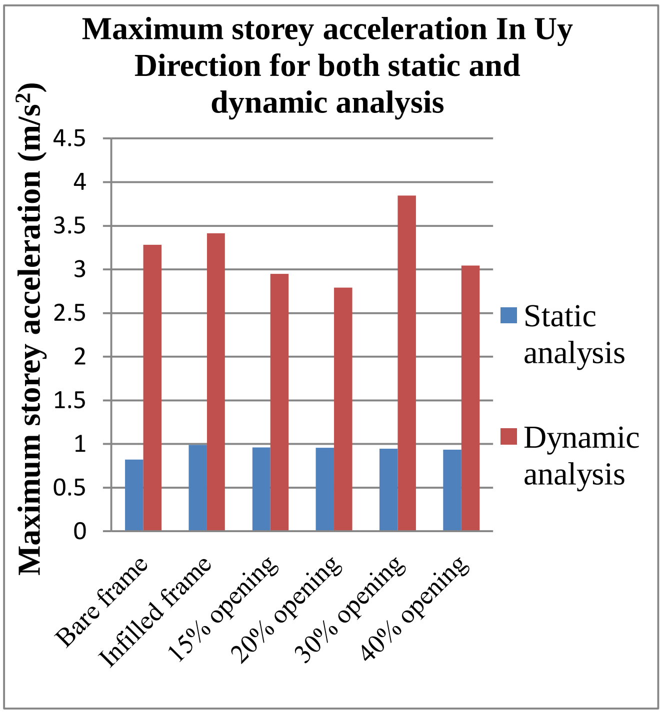

Figure 14: Variation of Maximum story acceleration for both static and dynamic analysis in U_Y direction for four storied building

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 10, October-2016

RESULTS FOR TEN STORY BUILDING

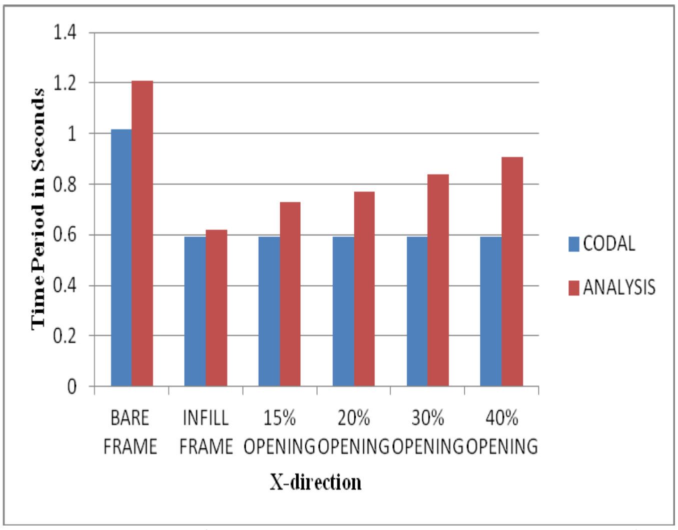

Figure 15: Variation of Fundamental Natural Time Period in X-direction for Ten story building

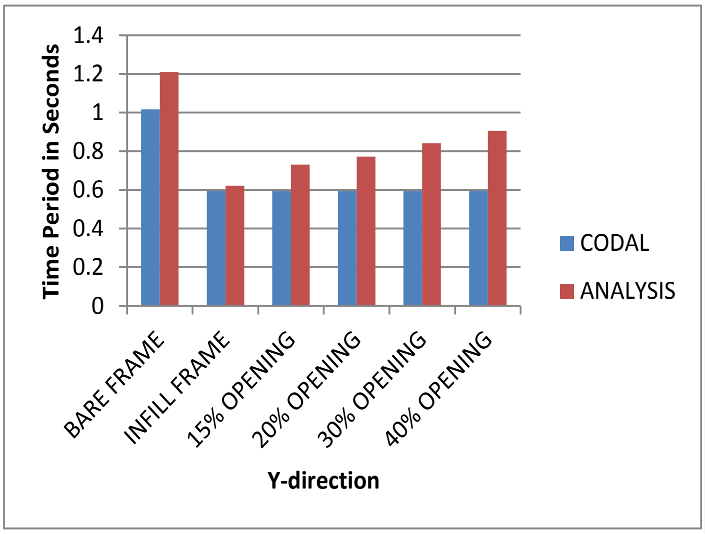

Figure 16: Variation of Fundamental Natural Time Period in Y-direction for Ten story building

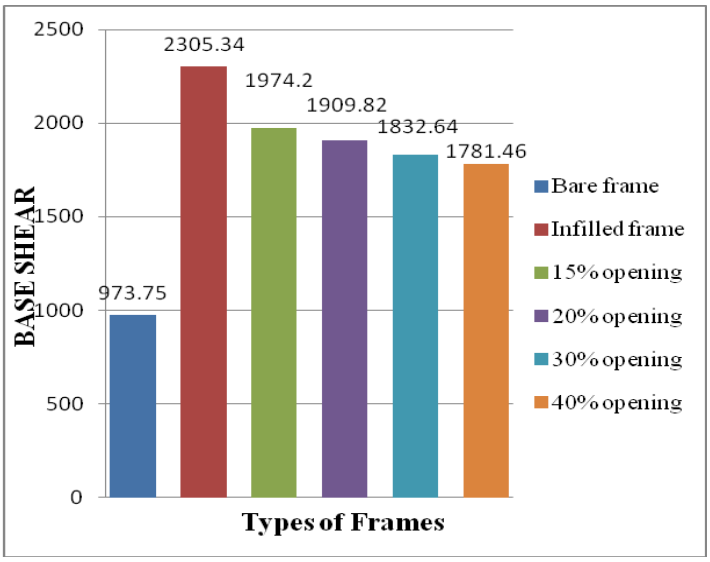

Figure 17: Variation of Base Shear in Static Analysis for Ten story building

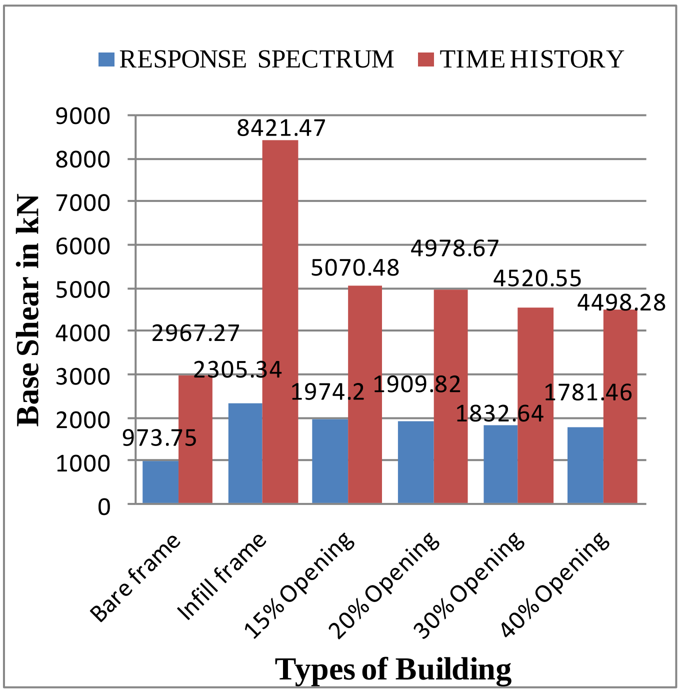

Figure 18: Variation of Base Shear in Dynamic Analysis for Ten story building

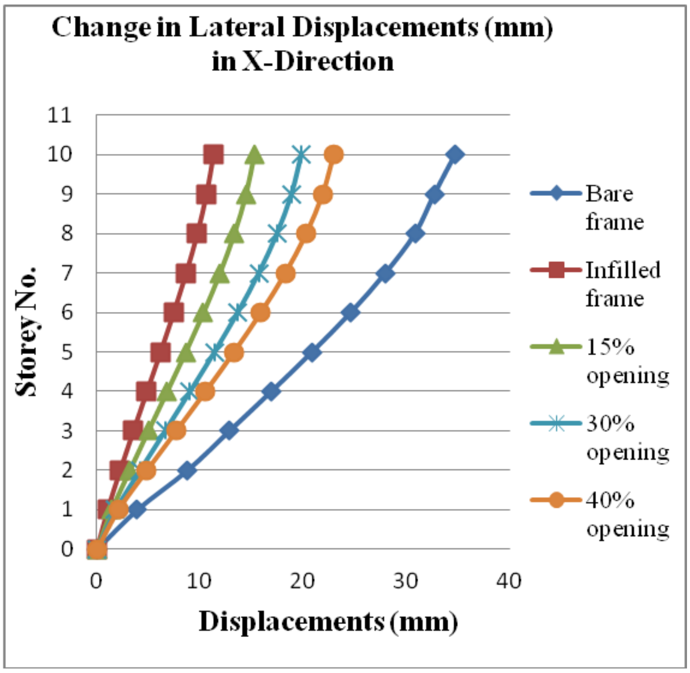

Figure 19: Displacement vs. Story no. in U_x direction for Ten storey building

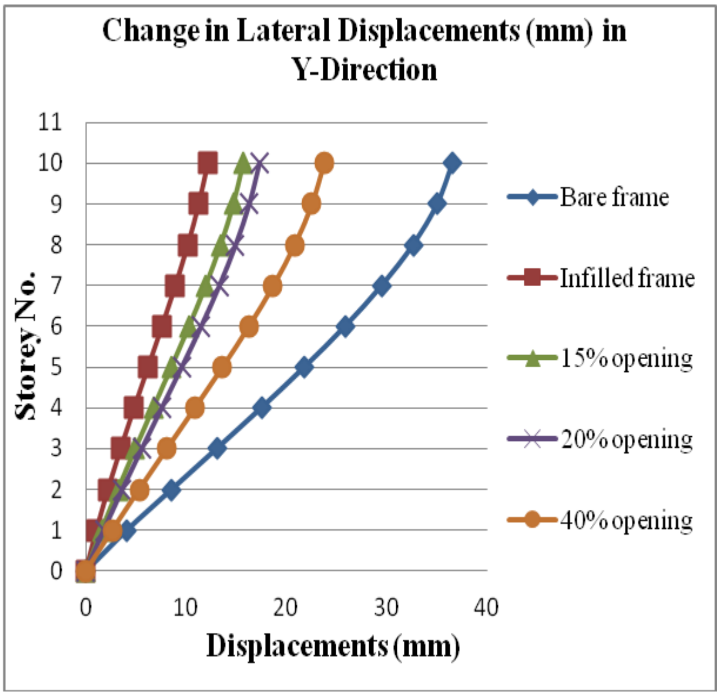

Figure 20: Displacement vs. Story no. in U_y direction for ten storey building

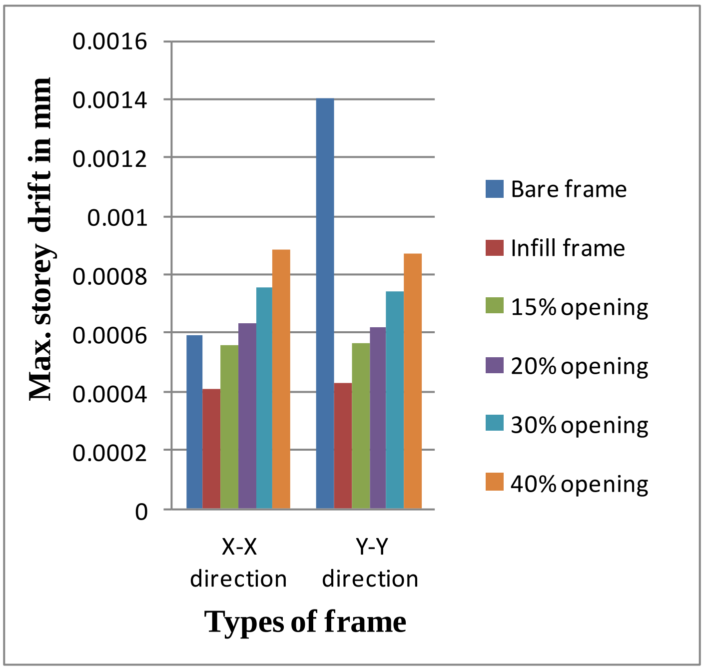

Figure 21: Maximum Storey Drift in Ux and Uy direction at the level of 4th and 5th storey in ten storey building

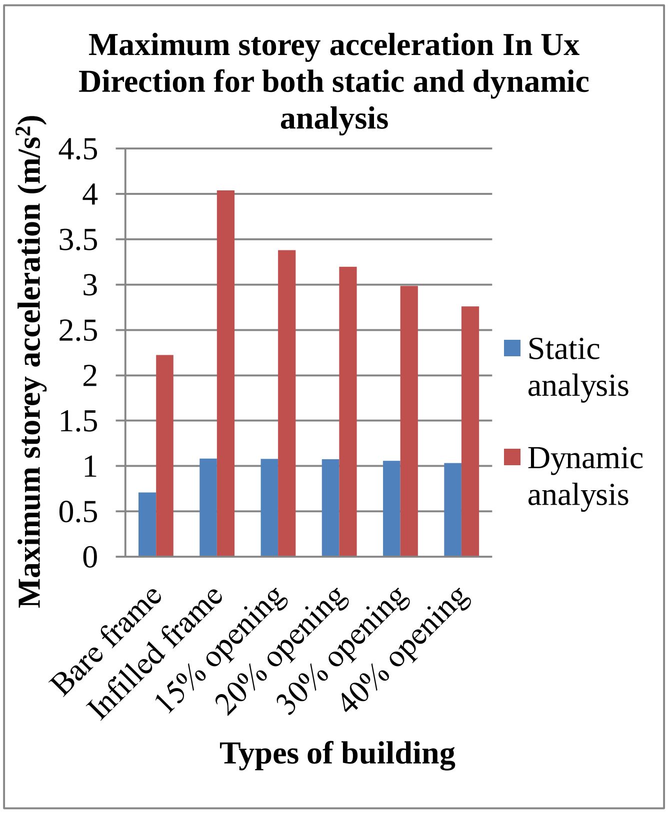

Figure 22: Variation of Maximum story acceleration for both static and dynamic analysis in U_X direction for Ten storied building

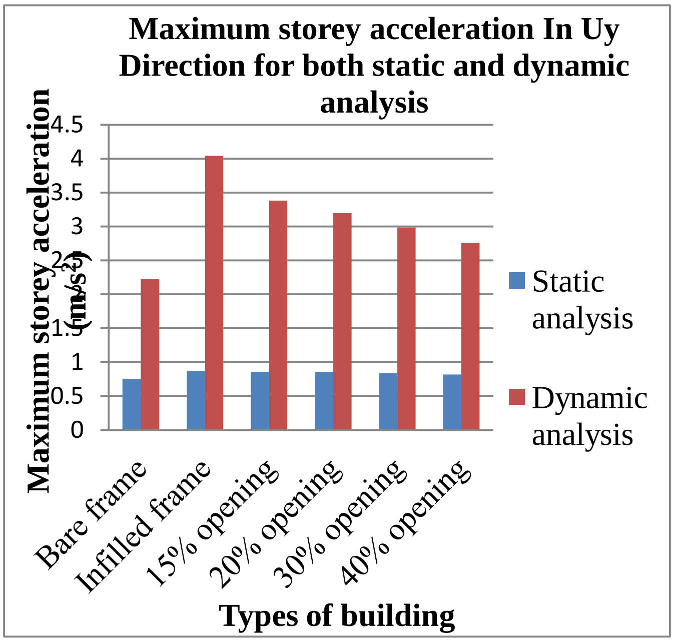

Figure 23: Variation of Maximum story acceleration for both static and dynamic analysis in U_y direction for Ten storied building

VI. CONCLUSION

1) Introduction of infill panels in the RC frame reduces the time period of bare frame. Bare frame leads to over estimation of natural period and under estimation of lateral forces.

2) The increase in the opening percentage leads to a decrease on the lateral stiffness and increase in the 20% time period of infilled frame for every 10% increase in the opening percentage.

3) The presence of infills leads, in general, to increase the base shear compare to bare frame. In case of infill frame with different opening percentages the base shear is reduces compare to complete infilled frame.

4) The opening size of the infill has a significant influence on the fundamental period, lateral displacement; inter storey drift and maximum storey acceleration, generally they increases as the opening size increases, indicating that the decrease in stiffness is more significant than the decrease in mass.

5) The lateral displacement and inter storey drift with the increase in opening size as the frame become more flexible. The lateral displacement increases by an average value of 28% for every 10% increase in opening size and there is corresponding increase in inter storey drift.

6) The presence of infill in the RC frame increases the maximum storey acceleration of bare frame.

7) The increase in opening size there will be decrease in maximum storey acceleration for both static and dynamic analysis.

8) For four storey building the maximum storey acceleration is nearly same for bare frame, infill frame and percentages of opening in dynamic analysis.

9) For ten storey building the maximum storey acceleration decreases by an average value of 10% for every 10% increase in opening size, hence according to IS 1893 (part-1) 2002 dynamic analysis is made only if the height of the building greater than 90 m.

ACKNOWLEDGMENT

The author gratefully acknowledges the encouragement and support given by the Lords Institute of Engineering and Technology.

REFERENCES

[1] Holmes, M., (1961), “Steel Frames with Brickwork and Concrete Infilling”, Proceedings of the Institution of Civil Engineers, Vol. 19, August, pp. 473-478

[2] Mainstone, R.J., (1971), “On the Stiffness and Strengths of Infilled Frames”, Proceedings of the Institution of Civil Engineers, Supplement IV, Paper No. 7360S, pp. 57-90.

[3] Mulgund G. V and Dr. Kulkarni A. B, “Seismic assessment of RC frame buildings with brick masonry infills”, International journal of advanced engineering sciences and technologies,Vol. No. 2, Issue No. 2, pp.140 – 147.

[4] P.G. Asteris (2003) “Lateral Stiffness of Brick Masonry Infilled Plane Frame”.Journal of structural engineering, pp 1071-1079.

[5] Rahul P. Rathi and Dr. P.S. Pajgade (2012), “Study of Masonry Infilled R.C. Frame With & Without Opening”, International Journal of Scientific & Engineering Research Volume 3, ISSN 2229-5518, pp.1-7.

[6] Pankaj Agarwal and Manish Shrikhande, “Earthquake resistance design of structures”

[7] S.K.Duggal, “Earthquake resistance design of structures”

[8] Indian Standard, IS 456-2000 “Plain and Reinforced Concrete-Code of Practice,” BIS, New Delhi, India.

[9] Indian Standard IS 1893-2002, “Criteria for earthquake resistant design of structures”, Part 1: General Provisions and Buildings, Fifth Revision, BIS, New Delhi, India.

[10] Indian Standard, IS 875(Part 1)-1987, “Code of practice for design loads (other than earthquake) for building and structures” Part 1, Dead loads – unit weights of building materials and stored materials, BIS, Manak Bhawan, New Delhi, India.

[11] Indian Standard, IS 875(Part 2)-1987, “Code of practice for design loads (other than earthquake) for building and structures” Part 2 - Imposed loads, BIS, Manak Bhawan, New Delhi, India

[12] Indian Standard, IS 875(Part 3)-1987, “Code of practice for design loads (other than earthquake) for building and structures”, Part 3 - Wind loads, BIS, Manak Bhawan, New Delhi, India

[13] Indian Standard, IS 875(Part 5)-1987 “Code of Practice for Design Loads (other than earthquake) for Buildings and Structures” Part 5 - Special loads and combination BIS, Manak Bhawan, New Delhi, India.

[14] FEMA-273, (1997), NEHRP Guidelines for the Seismic Rehabilitation of Buildings.