Role of Masonry Infill Wall on the Seismic Behavior of Typical Ten-Storey Building

Ukarde S.S.[1] Prof. Shaikh A.N.[2]
[1]PG Student [2]Assistant Professor
[1,2]Department of Civil Engineering
[1,2]M. S. Bidve Engineering College, Latur-413512, Maharashtra, India

Abstract— Masonry infill walls are used as partition in reinforced concrete frames and are considered as a non-engineering structure for design and analysis purposes. The goal of this study is to compare different response parameters such as displacement, and bending moment and shear force in corner column of multi-storey RC frame structure with considering stiffness of infill wall and without considering stiffness of infill wall. For this purpose, a Ten-storey building is selected, which is supposed to be situated on Medium soil type and seismic zone III according to the IS 1893:2016. Openings are neglected in the building. Equivalent static method is used to check the behavior of building during earthquake using ETAB-2015. To find the width of compression struts IS 1893:2016 is used. The results are compared and shown in the form of graphs. It is concluded that the masonry infill walls may have significant effects on the seismic response of the reinforced concrete frame structures, therefore, stiffness of infill walls need to be considered during the design and analysis of the building.

Keywords: seismic, Infill wall, ETAB-2015, IS 1893:2016

I. INTRODUCTION

Masonry walls built as infill between reinforced concrete frames. Beam and column are usually considered as non-structural element. Infilled frame structures are used to provide lateral resistance in regions of high seismicity, especially in those places where masonry is still a convenient material, due to economical and traditional reasons. Infill walls act as diagonal struts and increase the stiffness of RC frame building. The increase in the stiffness depends on the wall thickness and number of frame panel with infills. Masonry infills are functioning mostly as partitions and exterior walls. There are two different approaches for designing masonry in-filled concrete frames depending on local construction site. In the first approach, masonry infill is taken as a part of structural system and they are assumed to brace the frame against horizontal loading. In the second approach, the frame is designed to carry the total vertical and horizontal loading. Moreover, masonry infill is uncoupled to avoid load being transferred to them. In earthquake prone regions like India, masonry infill walls are counted as non-structural elements. They are not taken into account at design stage. Generally the lateral deflection of a frame under lateral load is calculated by taking the stiffness of columns and beams into consideration. But the stiffness of infill is never considered in these calculations. The presence of infill increases the stiffness of the frame, which reduces the lateral deflection. Thus the deflections and internal forces for frames considering stiffness of infill are less than for frames without considering stiffness of infill. It can be expected that if the effect of infill is taken into account, the design of resulting structural elements may be significantly different.

II. METHODOLOGY

A. *Equivalent Diagonal Strut Method:*

The most accepted method for the analysis of in-filled frame structure is Equivalent Diagonal Strut Method in which entire infill is replaced by a single equivalent strut. In this method beams and column are designed as frame members which are having six DOF at every node and brick infill is replaced by a pin jointed diagonal strut. The thickness of a pin jointed diagonal strut is considered to be same as infill and its length is equal to the length of the diagonal between the two compression corners. Width of a strut is calculated by IS 1893:2016.

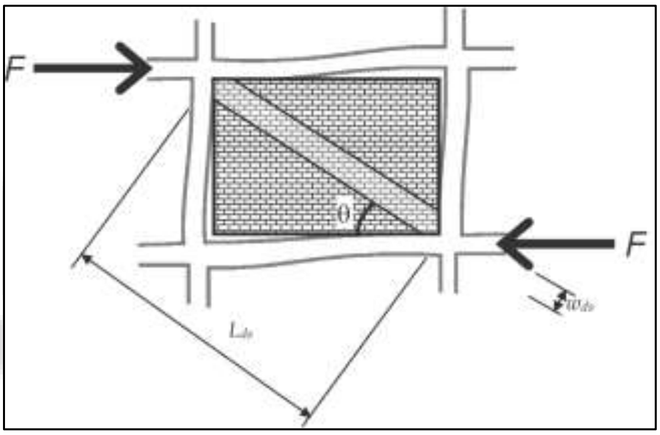


Fig. 1: Equivalent Diagonal Strut Model

AS PER IS1893:2016, Unreinforced Masonry Infill walls shall be modeled using equivalent diagonal struts as below

Em=550fm

fm =0.433fb^0.64fmo^0.36

Where,

Em= the modulus of elasticity (in MPa) of masonry infill wall.

Fm= compressive strength of brick masonry prism (in MPa)

fb =compressive strength of brick, in MPa.

fmo= compressive strength of brick mortar, in MPa

For URM infill walls without opening, width Wds of equivalent diagonal strut shall be taken as:

$$\text{Wds} = 0.175\ (\alpha h\ )^{-0.4}\ \text{Ld}$$

$$\alpha_h = \ \ \text{h}\sqrt[4]{\frac{Em\ t\ sin2\theta}{4EIh}}$$

Where,

Em = moduli of elasticity of the materials of the URM infill.

Ef = moduli of elasticity of the materials RC MRF.

t= the thickness of the infill wall, and

h= the height of the infill wall,

θ= angle of the diagonal strut with the horizontal.

From the above equation we can calculate the strut width of in-filled wall

B. *Equivalent Static Method*

1) *Calculation of design horizontal seismic coefficient*

The total design seismic base shear (VB along any principal direction shall be determined by following expression.

$$V_B = A_h * W$$

where, W is the total weight of the building calculated using the structural details and Ah is calculated as shown below:

$$A_h = \left(\frac{Z}{2}\right) * \left(\frac{I}{R}\right) * \left(\frac{S_a}{g}\right)$$

Where, Z is zone factor, I is Importance factor, R is response reduction factor and Sa/g is spectral acceleration coefficient.

2) *Design lateral force at each floor i*

The design lateral force, Vb shall be distributed along the height of the building using equation 3.

$$Q = \frac{V_{b*W_i*h_i^2}}{\sum_{i=1} W_j*h_i^2}$$

Where, Q_i = Design lateral force at floor i
W_i = Seismic weight of floor i
h_i = Height of floor i measured from base and
n = Number of story's in the building

III. PROBLEM FORMULATION

For this study, a G+9 Storey building with 3 meters height for each Storey, regular in plan is considered. The building is designed in compliance to the Indian Code of Practice for Earthquake Resistant Design of Structures. The building is modeled using software ETABS 2015. Models are studied for comparing lateral displacement, axial force, and shear force in corner column.

Number of story	Ten
Floor height	3 m
LOADING	
Live load	4 Kn/m2 at typical floor
	1.5 Kn/m2 at terrace
Floor finish	1 Kn/m2
Water proofing	2 Kn/m2
Terrace finish	1 Kn/m2
Earthquake load	as per IS1893 PART I 2016
Response reduction factor	5
Location	Latur
Earthquake zone	III
Zone factor	0.16
Importance Factor	1.5
SECTION PROPERTY	
Size of column	600x600mm
Size of beam	300x600mm
Depth of slab	150mm
Infill wall thickness	230mm
MATERIAL PROPERTIES	
CONCRETE	
Grade of Concrete	M30
Weight per unit volume	25Kn/m3
Modulus of Elasticity E	27386.13 Mpa
MASONARY	
Unit weight of masonry	19Kn/m3
Modulus of Elasticity of masonry	2457mpa
Poisson's ratio	0.15
Compressive strength of masonry prism	4.46Mpa
Mortar Ratio	01:03
STEEL	
HYSD reinforcement of grade Fe415 confirming to IS:1786 is used throughout	

Fig. 1: Elevation of infill frame Model with Strut

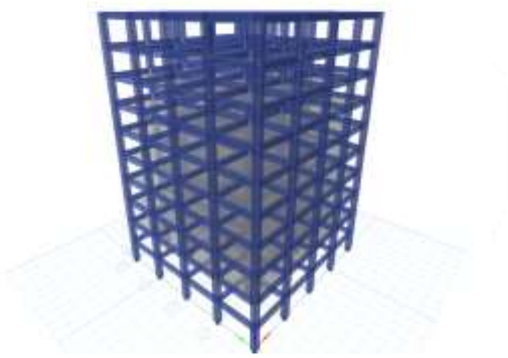


Fig. 2: Elevation of bare frame Model without Strut

IV. RESULT AND DISCUSSION

The seismic analysis of bare frame (without considering stiffness of infill wall), and In-filled frame (with considering stiffness of infill wall) has been done by using software ETABS and the results are shown below. The parameters which are to be studied are displacement, bending moment & shear force in corner column.

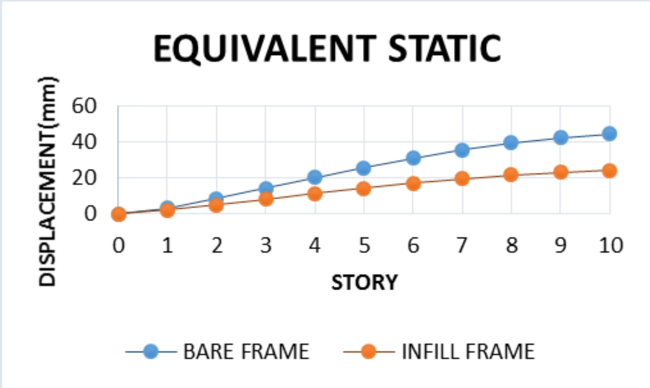
A. *Displacement*

The maximum story displacement was found to be more for bare frame model as Compared to the infill frame model. It is due to the fact that consideration of infill Enhances the strength and stiffness characteristic of the moment resisting Reinforced concrete structures

story	Displacement(mm)	
	Infill frame	Bare frame
1	2.2	3.1
2	5	8.5
3	8.2	14.4
4	11.3	20.2
5	14.2	25.8

6	17	31.1
7	19.6	35.7
8	21.7	39.6
9	23.3	42.5
10	24.3	44.4

Table 1: storey displacement



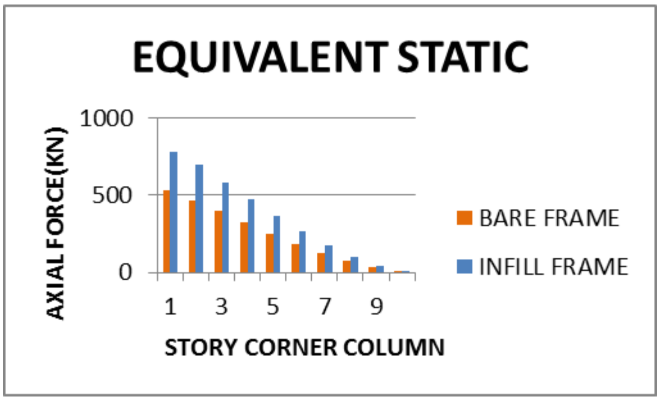
Graph 1: displacement vs. storey

B. Axial force

The corner columns were chosen for the bare, infill and it was found that the introduction of infill causes the increase in axial forces in Columns. The comparison of axial forces for the bare frame and infill frame are shown in the following table.

Column No	Axial force(KN)	
	Infill frame	Bare frame
1	783.25	530
2	699.07	469.52
3	583.85	396.87
4	470.42	323.3
5	363.29	252.22
6	264.08	185.76
7	175.34	126.02
8	100.49	75.41
9	43.72	36.59
10	10.18	11.96

Table 2: Axial force in corner column



Graph 2: column axial force vs. storey

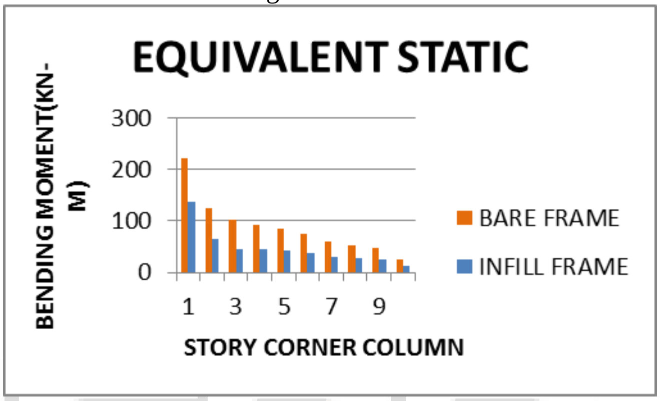
C. Bending Moment in Corner Column (KN-m)

The corner columns were chosen for the bare, infill and it was found that the considering stiffness of infill causes the reduction in bending moment of column.

The comparison of bending moment in corner column for the bare frame (without considering stiffness of infill wall) and infill frame(with considering stiffness of infill wall) are shown in the following table.

Column	Bending Moment (KNm)	
	infill frame	Bare frame
1	138.01	222.97
2	65.2	124.02
3	45.31	101.87
4	45.97	92.8
5	41.46	84.48
6	36.41	74.01
7	29.5	60.28
8	26.56	53.78
9	24.73	48.44
10	11.52	26.12

Table 3: Bending moment in corner column



Graph 3: bending moment vs. storey corner column

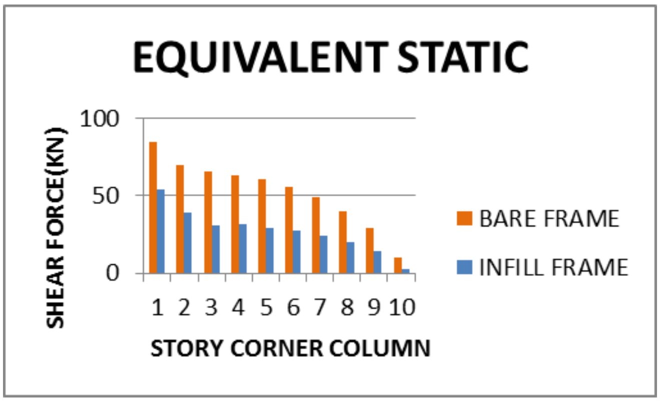
D. Shear Forces in Corner Columns (KN)

It was observed that the impact of infill reduces the shear forces on beam and columns.

The effect of stiffness of infill on shear force in corner column as shown in table.

Story column	Shear force(KN)	
	Bare frame	infill frame
1	84.81	54.19
2	69.45	38.95
3	65.88	30.87
4	63.5	31.27
5	60.31	29.43
6	55.67	27.24
7	49	24.07
8	40.17	19.65
9	29.32	14.43
10	9.69	2.97

Table 4: Shear Force in corner column



Graph 4: Shear force vs. storey corner column

V. CONCLUSION

Based on above study the following conclusions are drawn

- The seismic requirement of the structure in terms of storey drift and the maximum average roof displacement of the structure are markedly enhanced by the introduction of infill. As compared to bare frame the maximum roof displacement in infill frame is reduced up to 46%.
- The response of the structure in terms of bending moments and shear forces is greatly enhanced by considering stiffness of the infill. Both bending moment and shear force in beams and columns are reduced appreciably due to masonry infill.
- As compared to the bare frame, the bending moment in corner column of infill frame is reduced up to 55%.
- As compared to the bare frame, the shear force in corner column of infill frame is reduced up to 69.34%.
- Primary frame action of a moment resisting frame is converted to the primary truss action due to the introduction of the infill leading to the increased axial forces in column in infill frame model.
- As compared to the bare frame, the axial force in corner column of infill model is increased up to 45%.

REFERENCES

[1] Goutam mondal and Sudhir K. Jain, 2008 " Lateral Stiffness of Masonry Infilled Reinforced Concrete (RC) Frames with Central Opening" Earthquake Spectra, volume 24, No. 3
[2] Jaswant N.Arlekar, Sudhir K.Jain, and C.V.R.Murty, 1997 "Seismic Response of Frame Buildings with Soft First Storeys" Proceedings of the CBRI Golden Jubilee Conference on Natural Hazards in Urban Habitat, New Delhi.
[3] Hossain Mohammad Muyeed-Ul-Azam and Khan Mahmud Amanat 2005. "ffect of Infill as a Structural Component on the Column Design of Multi-storied Building". UAP Journal of Civil and Environmental Engineering Vol. 1, No. 1.
[4] Mehmet Metin Kose, 2009 "Parameters affecting the fundamental period of RC buildings with infill walls" Engineering Structures 31), 93-102.
[5] P.M.Pradhan, P.L.Pradhan, R.K.Maskey "Kathmandu University Journal of Sciences, Engineering and Technology,Vol.8 No I, February 2012.
[6] B.Srinavas and B.K.Raghu Prasad "The Influence of Masonry in RC Multistory Buildings to Near- Fault Ground Motions" Journal of International Association for Bridge and Structural Engineering (IABSE) 2009, PP 240-248.
[7] IS1893 (Part 1) 2016: Indian Standard Criteria for Earthquake Resistant Design Of Structures. Part 1 General Provision and Buildings (Fifth Revision)
[8] Mehmet Metin Kose "Parameters affecting the fundamental period of RC buildings with infill walls" Engineering Structures 31 (2009), 93-102.J. K. Author, "Title of thesis," M.S. thesis, Abbrev. Dept., Abbrev. Univ., City of Univ., Abbrev. State, year.