Seismic Analysis of Masonry Infill in Multi-Storey RC Buildings

Kumbhar S. S [1] , Rajguru R. S[2]

***Abstract*: In India, masonry infilled reinforced concrete frame is one of the most common structural system. The simplicity of construction and highly developed expertise have made the infilled frame one of the most rapid and economical structural form for reinforced concrete buildings. Masonry infills are functioning mostly as partitions and exterior walls. There are two different approaches for designing masonry infilled 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.**

Present paper describe the nature of RC frame building with G + 14 storey with different masonry infill materials like brick masonry and AAC blocks masonry is taken into considerations. Building is irregular in plan with L shape consider for analysis. Completely fill, unfilled, soft storey models are studied. Effect on various parameters like base shear, displacement, storey drift etc are taking into account. Infill walls are modelled as pin-jointed single equivalent diagonal strut. All analysis is carried on software Etabs. Result from study conducted show that infill walls increases base shear, while displacement and drift are reduce.

***Index Terms*: Compression Strut, Infill Frame, Shear, Soft Storey .**

I. INTRODUCTION

Lots of studies had been conducted both for fully infilled frames and for infills containing openings.

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Thomas (1952) and Ockleston (1955) were one of the early major contributors in connection to the interaction between wall and frame. Holmes[1] (1961) studied experimentally on steel frames infilled with brick masonry and reinforced concrete walls and developed semi-empirical design method for laterally loaded infilled frames based on equivalent strut concept. His tests suggested that brick masonry walls increase the strength of frame by around 100%. The infill was considered to fail in compression. The load carried by infill at failure was calculated by multiplying the compressive strength of material by the area of equivalent strut. He states that the width of equivalent strut to be 1/3rd of the diagonal length of infill, which resulted in the infill strength being independent of frame stiffness .

Smith has put up tremendous effort in finding out the interaction between frame and infill. He tested a number of infilled frames subjected to diagonal loading where he used the diagonal strut concept. His design curve gives the effective width of strut, the compressive

Failure load and the diagonal failure load as related to frame stiffness and infill aspect ratio. Mainstone has given equivalent diagonal strut concept by performing tests on model frames with brick infills. His approach estimates the infill contribution both to the stiffness of the frame and to its ultimate strength. The strut width equation according to him is shown in below. Liauw and Kwan studied both experimentally and analytically the behaviour of non-integral infilled frames. Finite Element method was adopted to find the effects of nonlinearities of the material and the structural interface, the initial lack of fit and friction at the interface was considered. Paulay and Preistley[2] gave the width of diagonal strut as 0.25 times the diagonal length of the strut. Hendry has also presented equivalent strut width that would represent the masonry that actually contributes in resisting the lateral force in the composite structure . In addition to these studies, large numbers of researches have been done in the past for fully infilled frames with and without openings.

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Haroon Rasheed Tamboli and Umesh.N.Karadi[3] suggested that there is a considerable difference in the base shear and hence the lateral forces of bare frame and infilled frame. Also considerable difference had observed in the time period, natural frequency and storey drift of bare frame and infilled frame.

Vikas P. Jadhao, Prakash S. Pajgade[4] The base shear experienced by models with AAC blocks had significantly smaller than with conventional clay bricks which results in reduction in member forces The performance of AAC block infill was superior to that of Conventional brick infill in RC frame. Therefore, the AAC block material can basically be used to replace conventional bricks as infill material for RC frames built in the earthquake prone region.compared the performance of frame with full infill as conventional clay bricks and AAC blocks was significantly superior to that of bare frame.

C V R Murty and Sudhir K Jain[5] conclude that buildings Masonry infill wall panels increase strength, stiffness, overall ductility and energy dissipation of the building. More importantly, they help in drastically reducing the deformation and ductility demand on RC frame members explains the excellent performance of many such buildings in moderate earthquakes even when the buildings had not been designed or detailed for earthquake forces. Most multistorey building constructions in the developing countries consist of RC frames with URM infills.

II MODELLING OF INFILL WALL

Analytical modelling of masonry infill is done by either finite element and strut type modelling. From above two methods strut type model is choose for analysis. A reinforced concrete frame will deform in a flexural mode during seismic loading, while infill panel deformation is dominated by shear. This difference in the deformation pattern causes the infill wall to resist the frame deformation through diagonal compression, which in turn results in forces applied along the contact surface between the frame and infill. FEMA 273[7] suggests method for determining width of strut, which is developed by Mainstone[6].

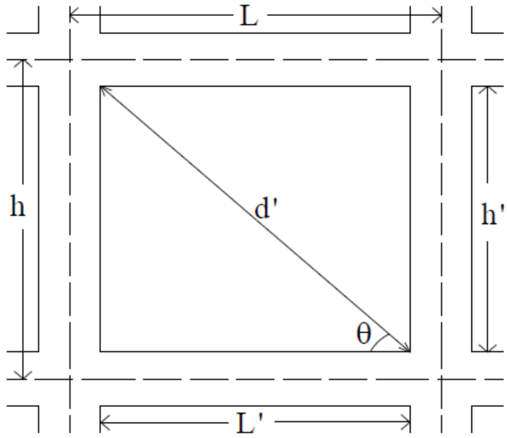

Fig. 1 : Key parameters for modeling infill as an equivalent compression strut

$$W = 0.175D(\lambda_1 H)^{-0.4}$$

$$\lambda_1 H = H[E_m t \sin 2\theta / 4E_c I_c h_m]^{0.25}$$

where,

H = height of the frame,

θ = angle made by the strut with the horizontal,

Ec = Young's modulus of column

Ic = Moment of inertia of column

Em, t and hm are the Young's modulus, thickness and height of masonry infill respectively.

III MATERIALS AND METHODS

A study is undertaken which involves seismic analysis of RC frame buildings with different models that include bare frame, infilled frame and open first storey frame. Different infill material like conventional clay bricks and AAC blocks masonry is taken into considerations.The parameters such as base shear, time period, storey drift are studied. The software ETABS is used for the analysis of the entire frame models

Following data is used in the analysis of the RC frame building models

- Type of frame: Special RC moment resisting frame fixed at the base
- Seismic zone: ш
- Number of storey: G+14
- Floor height: 3. m
- Depth of Slab: 120 mm
- Size of beam: (230 × 450) mm
- Size of column: (400 × 600) mm

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- Spacing between frames:
  5 m along X direction
  3 m along Y directions
- Floor finish: 2 KN/m2
- Terrace water proofing: 1.5 KN/m2
- Materials: M 25 concrete, Fe 415 steel , Brick infill and AAC block infill
- Thickness of infill wall: 230 mm
- Density of concrete: 25 KN/m3
- Density of brick infill: 18 KN/m3
- Density of AAC block infill : 7 KN/m3
- Poison Ratio of concrete : 0.2
- Poison Ratio of brick masonry : 0.16
- Poison Ratio of AAC masonry : 0.25
- Compressive strength of concrete 5000 $\sqrt{25}$ = 250000 Mpa
- Compressive strength of brick masonry : 5 Mpa
- Compressive strength of AAC masonry : 4 Mpa
- Live load on floor: 3 KN/m3
- Type of soil: Medium
- Response spectra: As per IS 1893(Part-1):2002[8]
- Damping of structure: 5 percent

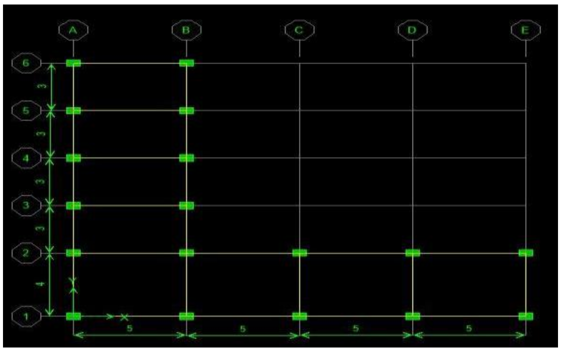

Fig 2 : Plan of irregular building

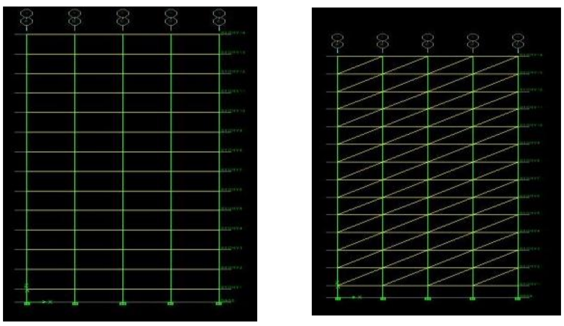

Fig 3 : Bare and Complete Fill model

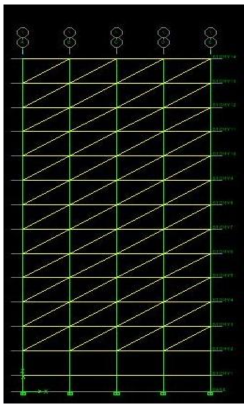

Fig 4 : Soft Storey model

IV RESULT AND DISCUSSION

The seismic analysis of all the frame models that includes bare frame, infilled frame and open first storey frame has been done by using software ETABS and the results are shown below. The parameters which are to be studied are time period, base shear and storey drift.

Table 1: Width of diagonal strut

Material	3M	4M	5M
Conventional Brick	1.40	1.13	0.94
AAC Brick	1.36	1.10	0.92

Time period

For moment resisting frame building without brick infill panel

$T_a = 0.075\, h^{0.75}$

$= 0.075 \times 41^{0.75}$

$= 1.215$ sec

For moment resisting frame building with brick infill panel

$T_a = 0.09\, h / \sqrt{d}$

$= 0.09 \times 41 / \sqrt{20}$

$= 0.825$ sec along X direction

$T_a = 0.09\, h / \sqrt{d}$

$= 0.09 \times 41 / \sqrt{16}$

$= 0.9225$ sec along Y direction

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Table 2 : Base shear

Parameters	Bare frame		Open first storey frame		Infilled frame	
	Brick	AAC	Brick	AAC	Brick	AAC
Base shear (X)	946.023	687.15	1349.87	997.36	1393.32	1012.05
Base shear(Y)	946.023	687.15	1205.876	890.97	1244.69	904.02

Table no 3: Storey drift in X direction

Storey	Bare frame		Open first storey frame		Infilled frame	
	Brick	AAC	Brick	AAC	Brick	AAC
14	0.94	0.64	0.466	0.38	0.48	0.39
13	1.24	1.08	0.52	0.43	0.53	0.43
12	1.58	1.4	0.57	0.47	0.59	0.48
11	1.89	1.66	0.60	0.511	0.62	0.519
10	2.199	1.9	0.64	0.54	0.66	0.549
9	2.415	2.07	0.65	0.558	0.67	0.56
8	2.588	2.224	0.66	0.567	0.67	0.567
7	2.69	2.32	0.65	0.561	0.66	0.532
6	2.74	2.38	0.64	0.549	0.65	0.549
5	2.75	2.38	0.60	0.517	0.61	0.522
4	2.68	2.34	0.56	0.49	0.56	0.48
3	2.43	2.11	0.65	0.57	0.50	0.44
2	1.8	1.53	1.41	1.07	0.45	0.39
1	0.69	0.60	0.71	0.555	0.47	0.35

Table no 4: Storey drift in Y direction

Storey	Bare frame		Open first storey frame		Infilled frame	
	Brick	AAC	Brick	AAC	Brick	AAC
14	0.22	0.21	0.14	0.129	0.157	0.28
13	0.3	0.28	0.16	0.149	0.18	0.32
12	0.37	0.35	0.178	0.163	0.193	0.36
11	0.44	0.41	0.20	0.179	0.219	0.40
10	0.49	0.47	0.211	0.193	0.234	0.429
9	0.53	0.50	0.22	0.201	0.242	0.449
8	0.57	0.53	0.227	0.209	0.249	0.46
7	0.60	0.56	0.234	0.212	0.250	0.47
6	0.63	0.59	0.23	0.215	0.250	0.471
5	0.655	0.60	0.227	0.212	0.246	0.46
4	0.66	0.61	0.224	0.2098	0.238	0.454

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3	0.63	0.58	0.278	0.26	0.225	0.432
2	0.49	0.45	0.60	0.49	0.089	0.419
1	0.20	0.18	0.306	0.25	1.74	0.34

Table no 5: Storey displacement in X direction

Storey	Bare frame		Open first storey frame		Infilled frame	
	Brick	AAC	Brick	AAC	Brick	AAC
14	9	6	3	2	2	2
13	8	6	3	2	2	2
12	8	6	2	2	2	2
11	7	5	2	2	2	2
10	7	5	2	2	2	1
9	6	4	2	2	2	1
8	6	4	2	1	1	1
7	5	3	1	1	1	1
6	4	3	1	1	1	1
5	3	2	1	1	1	1
4	2	2	1	1	1	0
3	1	1	1	1	0	0
2	1	0	1	0	0	0
1	00	0	00	0	0	0

V CONCLUSION

In this paper fourteen storey RC frame building models are studied that includes bare frame, infill frame and open first storey frame and infill material of brick and AAC blocks. The parameters which are studied are time period, base shear and storey drift.

- The base shear of infilled frame is 32 % more than bare frame and hence there will be a considerably difference in the lateral force along the height of the building.
- The storey drift of bare frame is more than infilled frame and it is less than of bare frame around 50 %
- Base Shear of AAC infill is less than around 27% than conventional bricks.
- Drift of AAC infill model at 1st floor is than around 25% .
- Displacement at 14th floor for infill model is much less than bare model.
- It is found that infill not take into account for analysis, but the infill affects on the increase of ductility, stiffness and the flexural strength of the members.

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