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# Behavior of the Infill Walls under in Planelateral Loads in Reinforced Concrete Frames

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**ABSTRACT:** Autoclaved Aerated Concrete (AAC) Infill walls are widely used as partitions in reinforced concrete frames and usually considered as non-structural elements in designs. In this study, Experimental program was performed on reinforced concrete frame with Infill wall and bare frame specimens with varied construction precision and autoclaved aerated concrete thickness. Two specimens, in which one specimen with infill and other without infill panel were tested and analysed to investigate the effects of interaction between the AAC infill and bare frame. Experimental tests were performed on shake table. Also, lateral load resisting capacity of AAC with infill and without infill were analysed in ansys. Taking into account of similitude requirements the artificial mass simulation model has been utilised during specimen design process. The test results indicate that proposed flexible column-infill connection details can effectively improve the seismic performance and lateral load carrying capacity of AAC infilled RC frame structures by resisting story drift up to 35%. In addition, the ductility and energy dissipation capacity of the frame system can be considerably improved. A review of the various approaches has been presented in this paper that addresses the performance of infill walls under lateral loads.

**KEYWORDS:** AAC Infilled Frame, Dynamic forces, lateral load, Shake table

## I. INTRODUCTION

The Reinforced concrete (RC) frames are widely used for housing construction not only in India but in many other countries of the world. Past earthquake disasters show more destruction of masonry infill wall. At the time when earthquake effect on buildings it was seen that there is highly non-linear inelastic behaviour and there is interaction between infill panel and surrounding frame. Many researchers observed that stability of building is increased because of infill walls. Also found that inertia force is reduced during earthquake. The practice of using infill walls has been under scrutiny as it has both positive and negative effects on the behaviour of structure under lateral load. General way in which the panel is expected to behave when there is lateral deformation of the frame is by the considerations of the "Equivalent strut" behaviour. Reinforced concrete frame expected to deform due to the lateral force the infill panel is stiffer because of in plane effect that we looking at will have lower deformations compared to the bare frame. Because these deformations are different you may have an increase in the compression that occur across or compression strut can form and this is the resisting mechanism once the interaction between the frame and panel gets activated so it is possible to examine the interaction between frame and the panel in the form of an equivalent strut that forming and starts creating additional resisting mechanism in moment resisting frame.

Though infill walls do not affect the behaviour of frames under gravity loading, lateral stiffness and strength of frames increase significantly under the action of lateral loads. Therefore, unsymmetrical distribution of mass owing to randomly placed infills can actually change the structural response to earthquake load. Infills are generally provided for partitioning, and the position of infills can change throughout the life span of the building due to change in the functional requirements thus changing the lateral load behaviour, which is difficult to predict. Large number of experimental and analytical studies has been undertaken in the past to investigate the behaviour of such frames under lateral loads. The failure of infill with openings under the action of lateral loads is mainly due to the concentration of stresses near the openings. Ultimate limit state of the damage in RC infill panel the infill panel would have failed with certain mechanism and can collapse and get expelled from the frame and this can be leads to falling hazard.

## II. LITERATURE SURVEY

Analysed five models such as model RC bare frame, model, RC frame with fully infill wall, model, RC infill frame with openings, model, RC frame replaced by equivalent strut, model, RC frame replaced by equivalent strut for openings in infill wall having plan dimension 22m x 15m and number of floors G+5. **Chandrala S. et al. [1]** determined parameters such as drift, shear force and lateral stiffness were determined. Percentage reduction in story displacement with respect to model 1 is 67.48%, 67.5%, 51.22%, 40.65%. Observed that story displacement was maximum in reinforced concrete bare frame and minimum in reinforced concrete frame with fully infill masonry wall.

Studied behavior and ductility of H.S.R.C frames with infill wall. Experimental programme was conducted on four frames. F1 is bare frame of beam with cross section of 12x20 cm and length 1.85m and two columns with cross section of 12x20 and height 1.5m. second specimen F2 is similar for F1 but used infill wall thickness 12cm from holes red red bricks. specimen F3 infill is used with thickness 12cm from cement bricks. In the fourth specimen F4 infill wall is used with half scale frames and tested under cycling loading. **Mohamed et al. [2]** Concluded that lateral load resistance for infilled frames F2, F3 and F4 were greater than bare frame F1 by about 184, 61 and 99% respectively. Observed that energy dissipation for the infilled frames is higher than the bare frame.

Observed several parameters experimentally and analytically like opening size and location, aspect ratio of openings, connection between frames and infill wall, material properties, failure modes etc. **H.B Kaushik et al. [3]** proposed article to intended to review and compare past relevant studies and seismic codes of different countries on in-plane lateral load behaviour and modelling approaches for masonry infill RC frames with openings. Review of past studies did large number of experimental and analytical studies in the past, there are many gap areas in this field. Past research has been carried out in parts, and more importantly, addresses only the local concerns in that region.

Experimental program was performed on masonry-infilled frame specimens with varied construction precision and masonry thickness. A total of five portal frame specimens, which consist of four masonry-infilled frames and a bare frame **Minjae Kim et al. [13]** Performed experimental tests and the results were analysed to investigate the effects of construction precision and interaction between the masonry infill and the frame. The test results indicated that the gap in the masonry infill decreased strength by 75% to 80% and stiffness by 55% to 70%. A comparison between the measured and predicted peak strength using the current code shows that the code equations underestimate the strength by up to 70%. The maximum strengths of the specimens calculated using the proposed model were in good agreement with the experimental results.

## III. METHODOLOGY

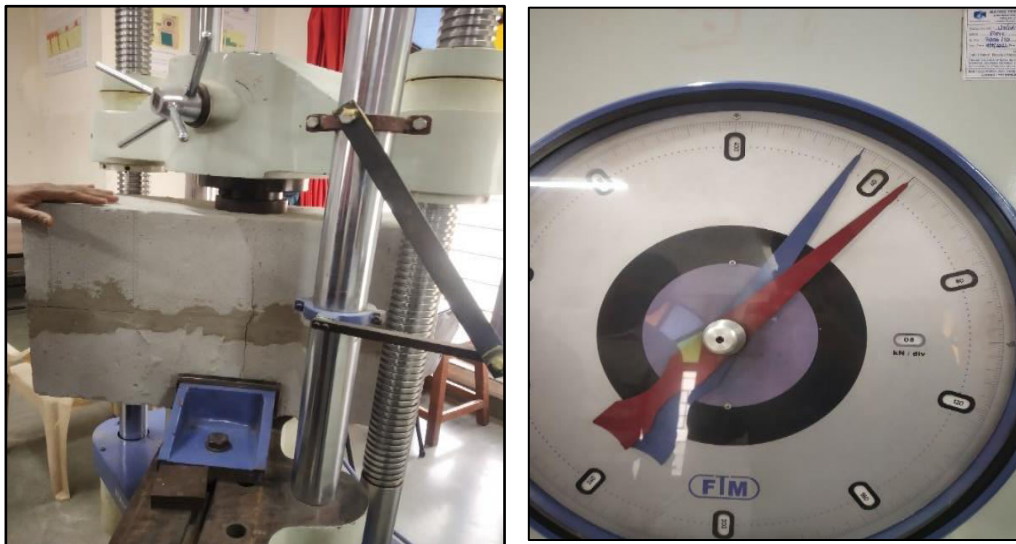
- a) Selecting a structure to study response.
- b) Collecting experimental data based on the response of a structure.
- c) Applying earthquake force for predicting the response of the similar structure.
- d) Testing of specimen
- e) Verifying results.

A detailed investigation is carried out through a comprehensive experimental programme followed by analysis of results. Prism test was performed on Autoclaved Aerated Concrete bricks on Universal Testing Machine. To know the compressive strength of Autoclaved Aerated Concrete Bricks experimental investigations were performed. To find out modulus of elasticity RC frame with infilled wall as an Autoclaved Aerated Concrete infill was modelled on ETABs by time history analysis where EL CENTRO place Earthquake was applied. Performed dimensional analysis by Buckingham  $\pi$  Theorem on prototype structure. 1/10 scaled steel frame tested on shake table for different frequencies. Lateral load resisting capacity Autoclaved Aerated Concrete infilled wall was analysed. Also, studied possible damage limitations.

#### IV. RESULTS

**Table 1 Dimensions of Prototype and Model**

Parameters	Dimensions of prototype	Dimensions of model
Strut length	2788 mm	464 mm
Width	3 m	300 mm
Length	3 m	300 mm
Height	3 m	300 mm
Beam	200X380 mm	10X20 mm
Column	200X380 mm	10X20 mm



**Figure 1 Prism Test Results**

**Table 2 Stiffnesses of the Members**

Structure	Dimension (mm)	Shear force (kN)	Displacements (mm)	Stiffness (N/mm)	Aspect Ratio
RC infill wall Full Scale	200X380	1.92	0.278	6906	0.52
RC infill wall Half Scale	90X160	0.391	0.0538	7123	0.56
S.S frame with Strut	10X20	0.0069	0.001	6890	0.5



**Table 3 Results of Compressive Strength of AAC Bricks**

Model No.	Applied Load (kN)	Failure Load (kN)	Area (mm <sup>2</sup> )	Compressive Strength (MPa)
1	48 X 0.8	38.4	200 X 230 = 46000	0.83
2	52.1 X 0.8	41.6	46000	1.105
3	56 X 0.8	44.8	46000	0.97
Average Compressive Strength of Prism- (f'm)				0.301MPa

**Table 4 Comparisons of Results Obtained by the Scaling Law and Analytical Study**

Prototype	Model		% Of Deviation
	Result Obtained by Scaling Law	Result Obtained by Experimental Result	0.6%
0.2 mm	0.02 mm	0.026858 mm	



**Figure 2 With & Without Infill Wall Test on Shake Table**

Table 5 Lateral Force Vs Stiffness

Sr. No.	Lateral Force (kN)	With Infill		Without Infill	
		Deformation (mm)	Stiffness (kN/mm)	Deformation (mm)	Stiffness (kN/mm)
1	50	2.03	24.63	2.68	18.65
2	100	4.13	24.21	5.4	18.51
3	150	6.2	24.19	8	18.75
4	200	8.32	24.03	10.7	18.69
5	250	10.4	24.04	13.4	18.65
6	300	12.5	24	16	18.75
7	350	14.55	24.05	18.7	18.75
8	400	16.26	24.6	21.33	18.75

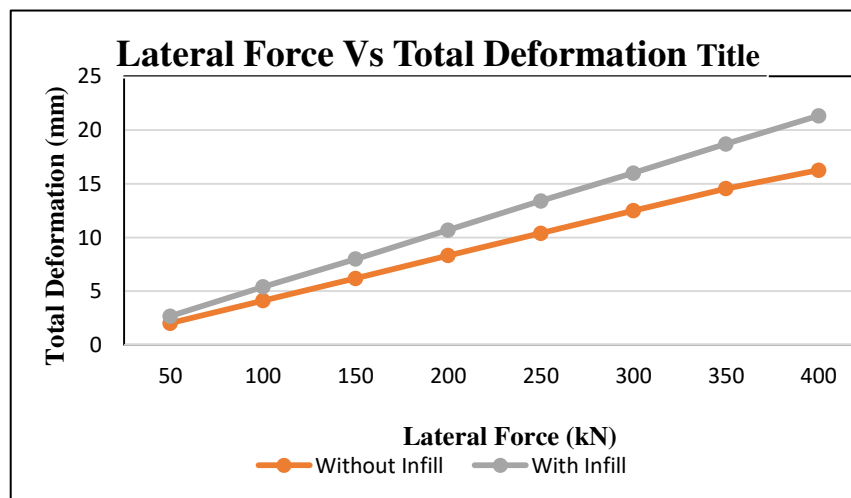


Figure 3 Lateral Force Vs Total Deformation

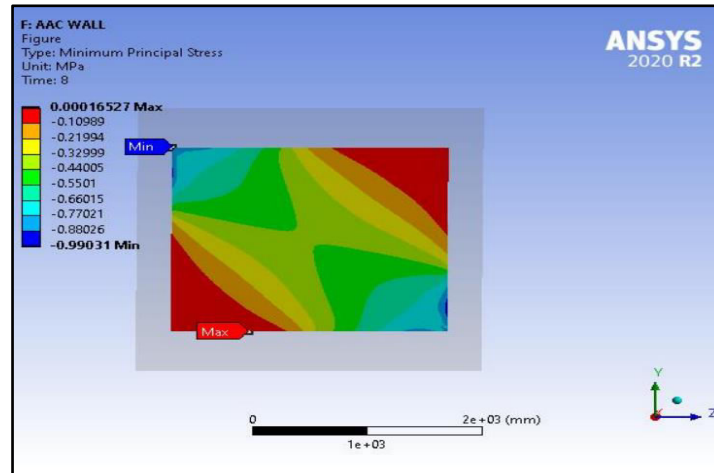


Figure 4 Failure pattern of AAC infill wall subjected to lateral force

Table 6 Lateral Force Vs Bending Moment

Sr. No.	Lateral Force (kN)	Maximum Bending Moment (kN.m)	
		With infill	Without infill
1	50	24.5	34.1
2	100	49.18	67.8
3	150	73.76	101
4	200	98.35	135.79
5	250	122.94	169.75
6	300	147.53	203.68
7	350	172.72	237.63
8	400	196.7	277.58

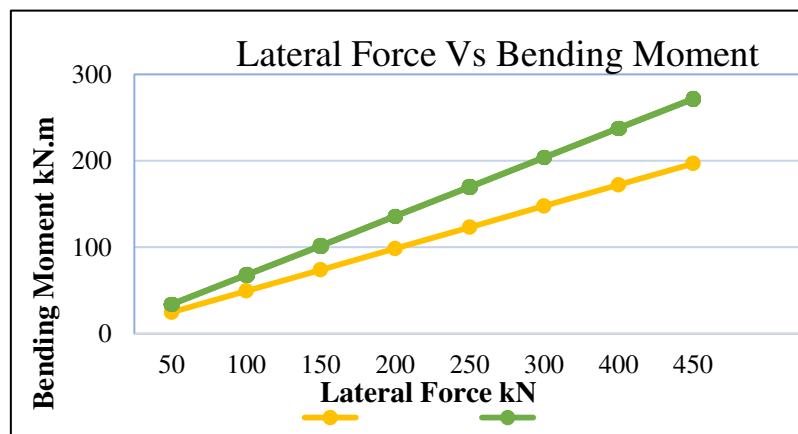
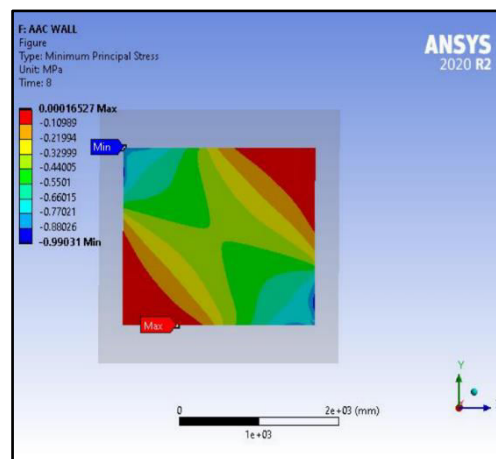


Figure 5 Lateral Force Vs Bending Moment

## V. DISCUSSION

Deformation is decreased because of frame with infill wall. Reduction in deformation up to 40% by frames with infill wall. At lateral force of 300kN deformation is 11.851mm it is within limit of deformation. According to IS 1893 this deformation is within the limit of story drift. Here, for RC frame with AAC infill wall at lateral force of 300kN the minimum principal stress is 0.99MPa which is less than 1.78MPa calculated by experiment within limit of storey drift. Deformation refers to modifications of the shape or size of an object due to applied forces or a change in temperature. Basically, deformation is nothing but the change in shape to its original shape of an object. SI unit of deformation is mm. For RC frame without infill wall carries lateral force of 200kN having deformation of 11.73mm within a limit of storey drift as per IS 1893: 2016. If we consider effect infill wall in RC frame it provides 40% more resistance to the RC frame within limit of storey drift. Current study carried out for single bay frame; the results for multi bay frame will vary according to stiffness of frame



**Figure 6 Failure pattern of AAC infill wall subjected to lateral force**

When lateral force act on RC frame with infill wall there is interaction between reinforced concrete frame and infill material. Force is transferred from infill material diagonally from top corner to bottom corner. Maximum compression occurs at corners if infill frame. In figure 6 blue colour indicates that maximum compression. Variation of lateral force and bending with and without infill wall in RC frame shows that, bending moment is decreased in RC frame with AAC infill wall. Bending moment is 277.58 nm. for RC frame without infill wall and 196.7 kN/m for RC frame with infill wall at 400 kN lateral force. Reduction in bending moment by 41% with infill in RC frame.

## VI. CONCLUSION

From the discussion based on experimental and analytical results, the following conclusions are drawn:

1. Deformation is reduced with consideration of RC frame with infill wall.
2. The effect of infill wall in RC frame provides more resistance to the earthquake force.
3. The failure pattern of masonry infill wall in RC frame subjected to lateral force is in diagonal compression.
4. Cracks are occurred in compression zone diagonally because of maximum compression at corners of masonry infill wall.
5. If we consider effect infill wall in RC frame it provides 40% more resistance to the RC frame within limit of storey drift.
6. Comparing masonry infill wall in RC frame with AAC infill wall in RC frame, Effect of masonry infill wall in RC frame provides more resistance to earthquake force.
7. Stiffness is increased up to 35% because of infill masonry wall in RC frame.
8. Whenever thickness of infill wall decreases the lateral load resistance of frame decrease by significant value, because infill wall with small thickness takes over more buckling of which to do its failure at small lateral load.
9. Bending moment is reduced up to 41% because of infill wall.





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