

Parametric Study on Behaviour of Seven Storey Single Bay Infilled Frame with Pneumatic Interface

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Abstract

Objective: The aim of this work is to study about the behavior of seven storey single bay infilled frame with pneumatic interface under various levels of pressures with lateral loads. **Method:** Linear analysis was carried out using a finite element based software by modeling various 2D frames. The dimension and reinforcement details for the frames are chosen based on the experimental study. For infilled frame with pneumatic interface different pressure configuration at different levels shall be considered in the study. **Findings:** The study of behavior includes stiffness, bending moment, axial force and shear force. The analysis of infilled frame with cement mortar interface and bare frame was also carried out to compare the frame stiffness and member forces of these frames. Interface characteristics have also influence the structural behavior of infilled frame. It has effect on overall stiffness and of the in-plane moment of inertia of composite frame and modifies energy dissipation. **Applications:** The research idea can be implemented in construction field so that the structural failure during earthquake will be minimized. The research work has been done relevant to study the behavior of infilled frame and to adopt new technique which can improve its performance. This study can be the basis of further studies which can increase the number of parameters under various conditions.

Keywords: Bare Frame, Cement Mortar, Infilled Frame, Interface, Pneumatic Interface, Stiffness

1. Introduction

Infilled frames are widely used in different building systems. Infills serve structurally to brace the frame against horizontal loading. It is partly by its in-plane shear resistance and partly by its behaviour as a diagonal bracing strut in the frame. Infill panels show different behaviour unlike bare frames¹. Its behaviour is regarded as complex due to the interface between infill panel and surrounding frame. Therefore, most designers were neglecting the effect of infilled panels.

In seismically active region infilled frame shows high performance due to its high strength to absorb and

transfer seismic force. Many factors influence the behaviour of infilled frame like presence of opening, lateral load, type of brick used, material of interface. A reservation against their use where earthquake resistance is a factor is that the walls might be shaken out of their frames transversely and consequently, be of little use as bracing in their own planes. On the basis of substantial field evidence this fear is well justified. The high in-plane rigidity of the masonry wall significantly stiffens the otherwise relatively flexible frame, while the ductile frame contains the brittle masonry. When the frame is subjected to horizontal loading, it deforms with double curvature bending of the columns and girders. The translation of the upper

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part of the column in each storey and the shortening of the leading diagonal of the frame cause the column to lean against the wall as well as to compress the wall along its diagonal.

The interface in infilled frames can be defined as the gap between frame and infill panel. In modern practice in order to avoid transfer of load between frame and infill, make frame to show ductile behaviour. Different materials can be used interface material like cement mortar, lead, cork and pneumatic. Their Material Properties are shown in Table 1.

Figure 1 shows the behavior of masonry infill panel acts as a diagonal compression brace in the direction of the arrow, resulting in a substantial stiffening of the frame and redistribution of bending moments and shears based on Smith method.

² study the behaviour of adaptive infilled frame by using pneumatic interface with different air pressure and comparison with bare frame, the study carried out through analytical and experimental work, the study concluded that the stiffness can be changed due to changing air pressure at interface. In 2009 (Dorji) study the behaviour of infilled frame under seismic load and effect of opening³ study pertinent issues on the development and calibration of finite element models for assessing the seismic performance of the structure. In 2012 (Struvridis) presents a simplified analytical method for the assessment of the seismic performance of masonry infilled RC frame. In ⁴ studied the behaviour of multi storey infilled frame by simulating strut instead of infill panel. A seven storeys RC frame located in a high seismic risk area was taken for case study. In 2014 (Liborio Cavaleri) study the cyclic response of masonry infilled RC frame by making comparison of experimental and finite element model. In ⁵ presents the suitability of using strut model for analyzing

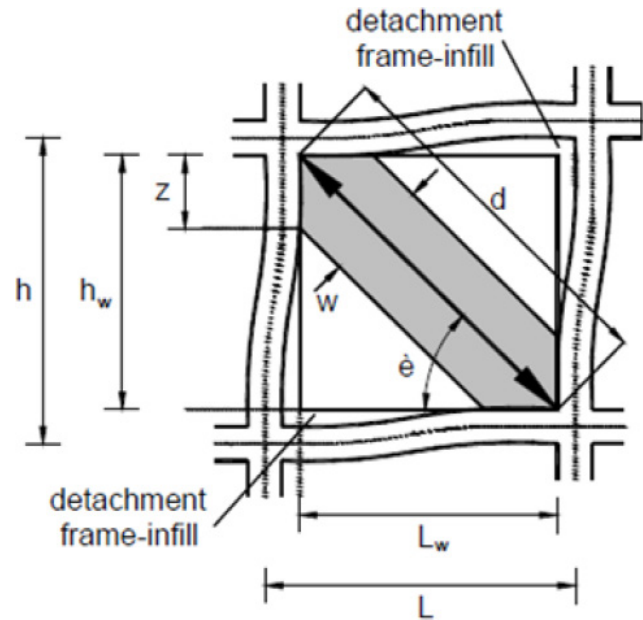


Figure 1. Behavior of infilled frame.

the seismic responses of single-storey single-span reinforced concrete frames having different arrangement of masonry infill wall with openings by comparing its results with those using wall element model.

Thus the use of infill walls changes significantly the seismic responses of building during earthquakes, lateral stiffness and strength which is higher than conventionally designed ones. The parameters like aspect ratio, external loads, and longitudinal and transverse reinforcement are influential.

2. Analytical Study

Seven storey frame is chosen because the effect of wind load started above 5 storey height. The frame is modeled with bounding frame of reinforced concrete⁶, brick masonry as infill panel and interface materials used are cement mortar and pneumatic air medium. The air pressure applied in the pneumatic interface is (2, 4, 6, 8) psi. Air pressure value is equivalent to (1 psi = 1.43 N/mm²). The load considered is only horizontal load. Total horizontal load = 3 kN, distributed 1 kN each at 7th, 5th, 3rd level.

2.1 Modeling of Frame

1/4th scaled model of single bay seven storey bare frame and infill frame are modeled. For bounding frame 2 noded linear beam link element having six degrees of freedom at each node is used. For infill panel four noded plane

Table 1. Material properties

Name of Materials	Properties of Materials			
	Modulus of Elasticity (kN/mm ²)	Density (kN/mm ³)	Compressive strength (N/mm ²)	Poisson's Ratio
Concrete	25.18	30129	36.31	0.15
Steel	76.96	2x105	-	0.3
Brick	1030	18	30	0.15
Cement Mortar	10360	17.8	30	0.15

stress rectangular element discretizes to (16x16) as ideal discretization, Discretization is a FEM concept in which the element is divided into small mesh and study the behaviour of each mesh alone and accumulate all of them together. This lead to get more accurate result⁷. For the interface link elements and rectangular elements is used with 30000 kN/mm as stiffness for link element. The thickness of interface is 5mm in all cases. The model of seven storey single bay bare frame is shown in Figure 2.

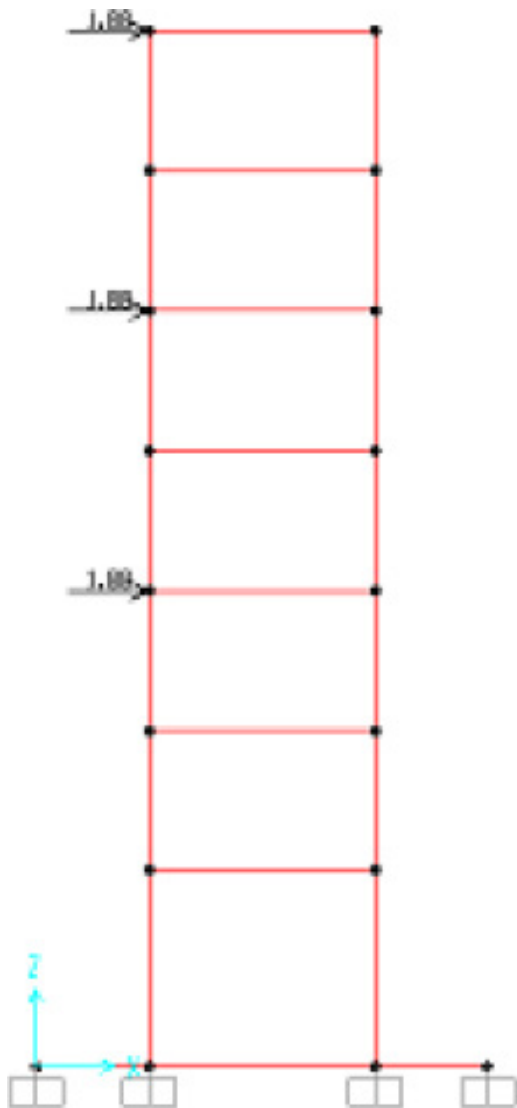


Figure 2. Model of bare frame.

3. Theoretical Study

The theoretical calculations for the estimation of plastic moment capacity of member section are carried out for the model. Using the plastic analysis⁸ the plastic moment of various sections of column and beam is found out as follows.

$$\begin{aligned} M_{pc1} &= 25.598 \text{ kNm} \\ M_{pc2} &= 17.46 \text{ kNm} \\ M_{pc3} &= 13.215 \text{ kNm} \\ M_{pc4} &= 8.964 \text{ kNm} \\ M_{pb} &= 6.162 \text{ kNm} \\ \text{Ultimate load} &= 44.51 \text{ kN} \end{aligned}$$

4. Results and Discussion

4.1 Qualitative Results of Frames

The qualitative analytical results of the frames of Bare frame (BF), Infilled Frame with Cement Mortar interface (IFCM), Infilled Frame with Pneumatic interface of various pressure (IFPu) for Bending Moment (BM), Shear Force (SF), Axial Force (AF), displacement (δ) and Link Axial Force (LAF) are shown in Figure 3 to Figure 5.

4.2 Quantitative Results of Frames

The values of deformation, axial force, shear force and bending moment are found out using the software and a comparison has been made between various frames such as bare frame, IFCM, Infill frame with pneumatic interface of various pressure.

4.3 Comparison of Frame Stiffness

The frame stiffness of all the frames are found out and is given in Table 2. By comparing bare frame and infill frame with cement mortar interface it is found that the IFCM is 2.27 times stiffer than bare frame.

4.4 Comparison of Member Forces of Frames

The member forces of bare frame and infill frame with cement mortar interface have been found out by keeping constant horizontal load as given in Table 3.

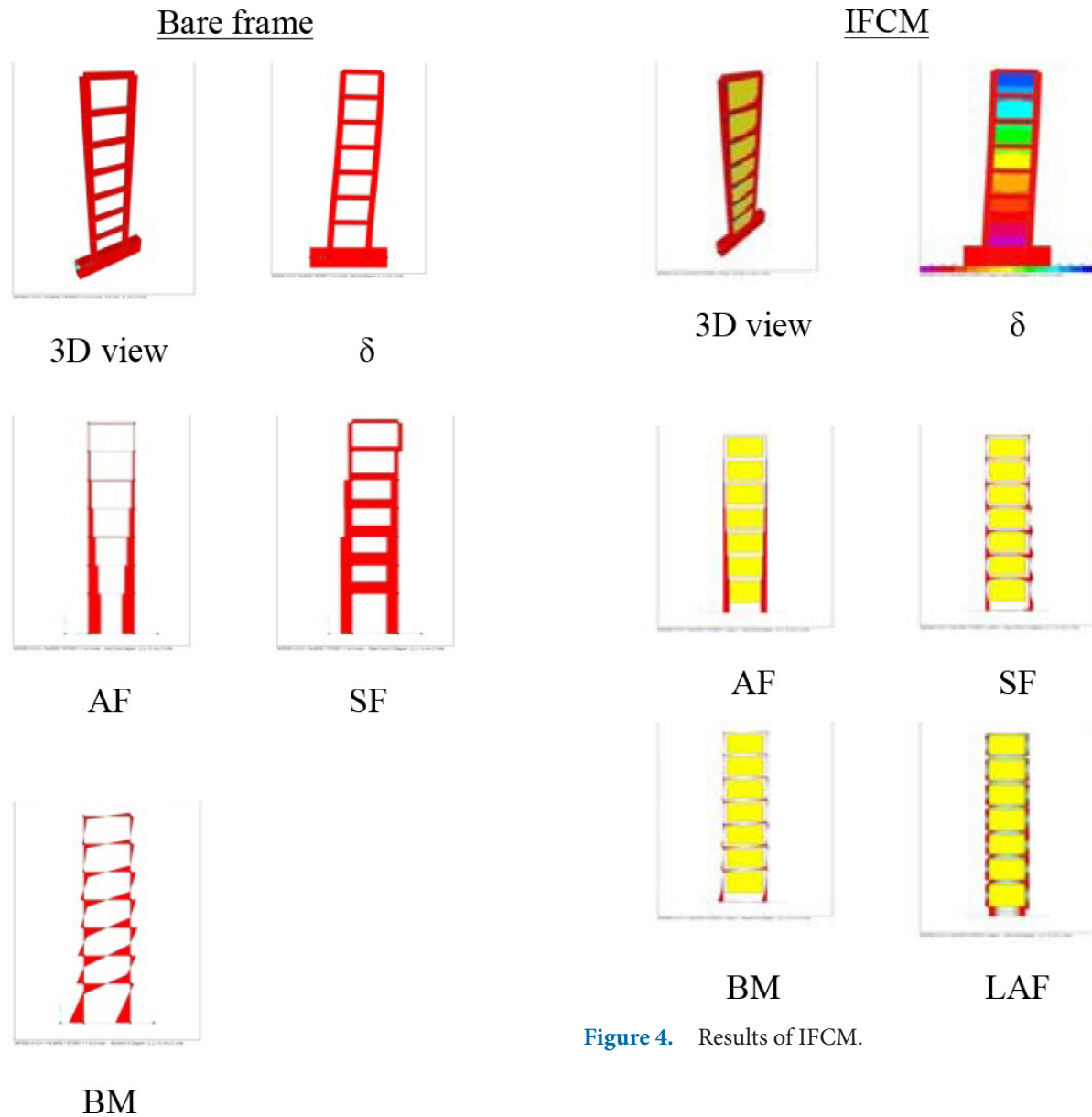


Figure 4. Results of IFCM.

Figure 3. Results of bare frame.

Table 2. Comparison of frame stiffness

Frames	Unit deformation (mm)	Overall stiffness (kN/mm)	IFPU/IFCM
BF	1.4216	2.1102	-
IFCM	0.6259	4.793	-
IFPu 2psi	1.3242	2.2655	0.4726
IFPu 4psi	1.3917	2.1556	0.4497
IFPu 6psi	1.4592	2.0559	0.4289
IFPu 8psi	1.5267	1.9650	0.4099

Table 3. Comparison of member forces

Member Forces	Bare Frame	IFCM	IFPU/BF
Axial force (kN)	8	8.234	1.0292
Shear force (kN)	1.507	0.7834	0.5198
Moment (kNm)	1.274	0.716102	0.5620
Deformation (mm)	1.4216	0.6259	0.4402

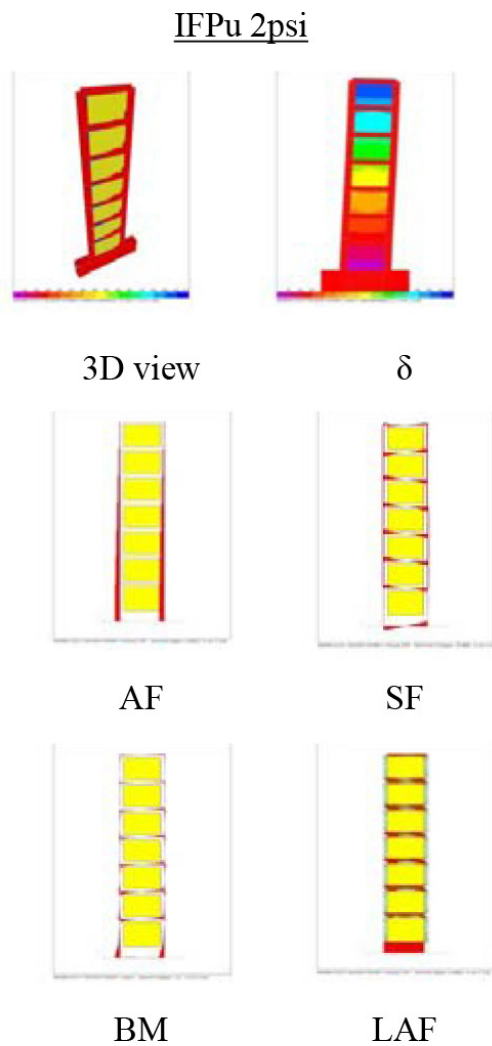


Figure 5. Results of IFPu 2psi.

The member forces like shear force, moment and deformation are decreasing for infilled frame. Axial force is slightly increasing for IFCM compared to bare frame shown in Figures 6 and 7.

5. Conclusion

The analytical study was carried out for single bay, seven storey RC frame with and without infill. For the infill frame cement mortar and pneumatic air medium are used as interface medium. From results of seven storey frame can infer that

- IFCM is 2.27 times stiffer than bare frame
- IFPu(2psi) is 0.4726 times stiffer than IFCM

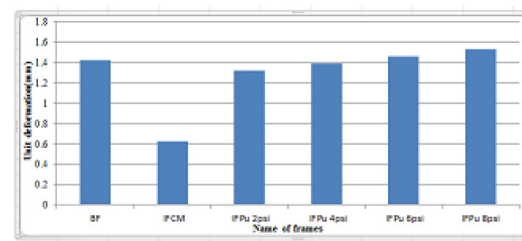


Figure 6. Comparison of unit deformation in frames.

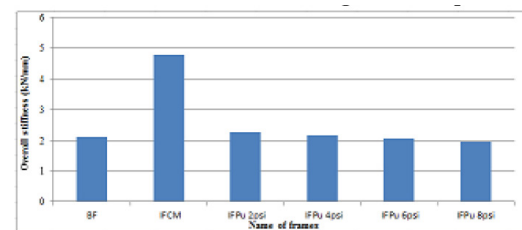


Figure 7. Comparison of overall stiffness in frames.

- IFPu(4psi) is 0.4497 times stiffer than IFCM
- IFPu(6psi) is 0.4289 times stiffer than IFCM
- IFPu(8psi) is 0.4099 times stiffer than IFCM
- IFCM has the highest stiffness as compared to other frames
- The axial force of IFCM is 1.0292 times more than that of bare frame
- The axial force of IFCM is 1.0292 times more than that of bare frame
- The shear force of IFCM is 0.5198 times that of bare frame
- The moment of IFCM is 0.5620 times that of bare frame
- The deformation of IFCM is 0.4402 times that of bare frame

Comparison of results of the frames is carried out. It is found that IFCM has the highest stiffness as compared to other frames⁶. The overall stiffness of infill frame with pneumatic interface is decreasing with increasing air pressure. IFPu(8psi) has stiffness less than that of bare frame. The member forces like shear force, moment and deformation are decreasing for infilled frame. Axial force is slightly increasing for IFCM compared to bare frame.

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7. References

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