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Feasibility Studies on the Use of Pneumatic Interface for Mitigation of Disasters in RCC Frames with Masonry Infilling

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Abstract: Infilled frame is defined as a composite system wherein a planar frame interacts with the infilling under in-plane lateral load. As such the interaction is influenced by parameters like relative stiffness of the frame and infill, type of interface, infill characteristics, openings and their infill location, size etc. The composite action alter the behavior of the plane frame. It has been proved that the composite action enhances the lateral stiffness of the frame significantly. While this enhanced stiffness is generally desirable for resisting lateral loads at times natural disasters like earthquake it would be safer to have a flexible frame. Thus it would be desirable to have an adaptive interface enabled by pneumatic medium.

The objective of this research work is to study the effect of Pneumatic interface through air pressures on the behavior of infilled frame as compared with traditional interfaces. The scope of the work covers the study of elastic behavior of i) A seven storey RCC bare frame, ii)reinforced concrete frame with brick masonry infill and the traditional mortar interface and the RCC frame with pneumatic interface. Comparison is carried out in this work through analytical as well as experimental investigations. It is found that the use of a pneumatic interface through can ensure enable a desirable RCC frame with adaptive stiffness at the times of natural disasters.

Keywords: Infilled frame, interface, bare frame, cement mortar, pneumatic interface, cork, lead, stiffness.

1. INTRODUCTION

Usually building frames are provided with partition walls for functional reasons. It is found that the bounding frame and filler walls act compositely and alter the characteristics of the bounding frame called as infilled frames. Infilled frames with brick masonry panels are widely used in buildings as common lateral load resistant systems. Infilled frames exhibit different behavior compared to bare frames. The lateral resistance of the bare frame increases due to the interaction with infill (Satyanarayanan 1989) .Therefore composite action between the frame and infill should be considered for assessing the strength and stiffness in the design. In that case, it is possible to use smaller cross sections of frame members with lesser quantity of reinforcement thus leading to overall economy in design. The interface in infilled frames can defined as the gap between frame and infill panel. In modern practice different materials are used other than conventional cement mortar like lead, cork etc.

2. REVIEW OF LITERATURE

The available literature relating to the influence of interface other than the conventional cement mortar include the following works: Riddington and Bolourchi (1989) have used lead strip to avoid precompression on infill walls due to shortening of columns, Sahota and Riddington (2001) have further studied effect of such inclusion on the infill stresses. **Satyanarayanan et al., (2009)** have studied the effect of inclusion of lead, cork and pneumatic medium at interface on the behavior of infilled frames. The study carried out

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through both analytical and experimental work revealed that the stiffness or a infilled frame can suitably be modified by changing the air pressure at interface.

So one can have a higher interaction to get increased lateral stiffness or a low interaction to avoid disasters arising out of higher stiffness due to filler walls.

It is found that the published literature on the influence of pneumatic medium at interface on the behavior of infilled frame is limited and hence this investigation is taken up.

3. METHODOLOGY:

The investigation is carried out in the following four phases:

1. Analytical investigation.
2. Experimental investigation on a bare frame.
3. Experimental investigation on infilled frame with cement mortar interface.
4. Experimental investigation on the infilled frame with pneumatic medium raising the air pressure.

The analytical investigation first establish the finite element model for interface that can predict the behavior of infilled frame. The analysis has been carried out using a standard software package on bare frame and the infilled frame with cement mortar interface and pneumatic interface. Linear analysis has been performed to get lateral stiffness of the bare and infilled frames.

The aim is to bring out the effect of the pneumatic medium at interface on the lateral stiffness of the infilled frame. The various levels of interface pressures are studied. To simulate the effect of the properties of the materials, compressive strength, density, Poisson's ratio, modulus of elasticity and varying air pressures, taking control interface as cement mortar have been included. The influence has been studied on both experimentally and analytically on the seven storied frame model similar to the one studied by Lakshmipathy (1983) and Govindan (1986) et al. Load has been applied on three levels (7^{th}, 5^{th} and 3^{rd} i.e. floor beam levels).

4. DETAILS OF FRAME

In this work $1/4^{th}$ scaled model of single bay seven storey frame is considered, the three models are used for bare frame, infilled frame with cement mortar interface and air pressure infilled frames in Figures 1, 2 and 3.

Bounding frame made of reinforced concrete, brick masonry used as filler of infill panel and for interface use different material like cement mortar, and pneumatic interface. The interface thickness is kept as 5 mm. The details of the frame model considered are given in Table 1.

Table 1
Details of Seven Storey Frame Model taken up for study

Details	*Mix Particulars by weight*	*Cross sectional Dimensions (in mm)*	*Reinforcement*
Beams In all floors	1:1.44:2.44 M20	100 × 150	Main rod - 4 Nos of 10 mm dia RTS rod Stirrups - 6 mm dia 2 legged at 40 mm c/c
Columns	1:1.44:2.44 M20	100 × 200	Main rod-Longitudinal: 5.1% at bottom reduced gradually towards top Stirrups-6mm dia 2 legged at 40 mm c/c

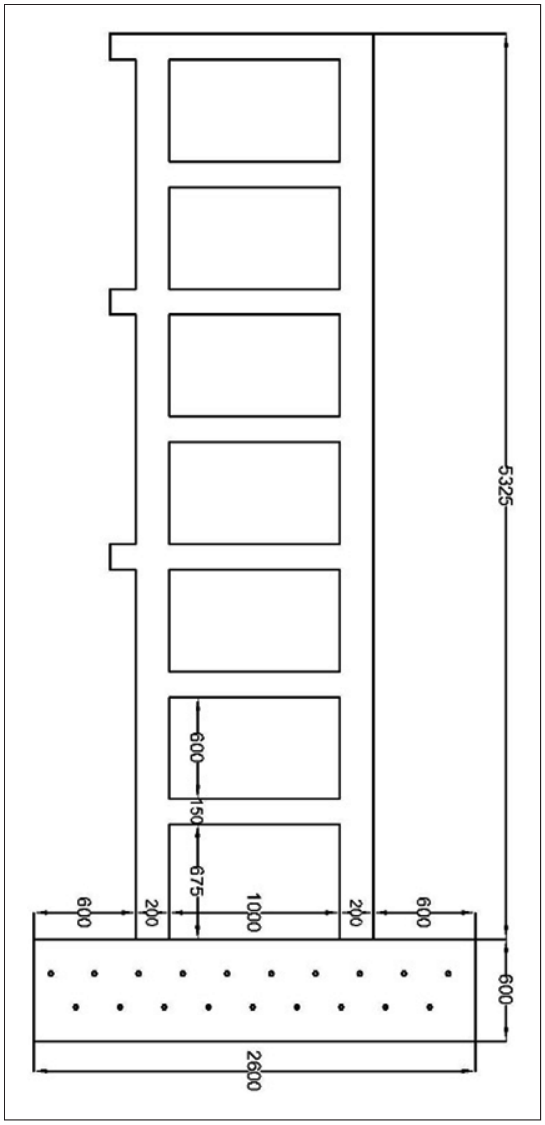


Figure 1: Model of Seven storey bare frame

The instrumentation details are shown in Figure 3.

5. MATERIAL PROPERTIES

Different material has been used in this work with specific properties according to experimental work as illustrated in Table 2 are adopted for concrete, steel, masonry and cement mortar. Air pressure has been introduced using a cycle tube at interface.

Table 2
Material properties

Material	*Density kN/m^3*	*E Value N/mm^2*	*Compressive Strength N/mm^2*
Concrete	25.18	23332	20
Steel	77	2×10^5	-
Brick Masonry	18	1491	30
Cement Mortar	8	10360	30

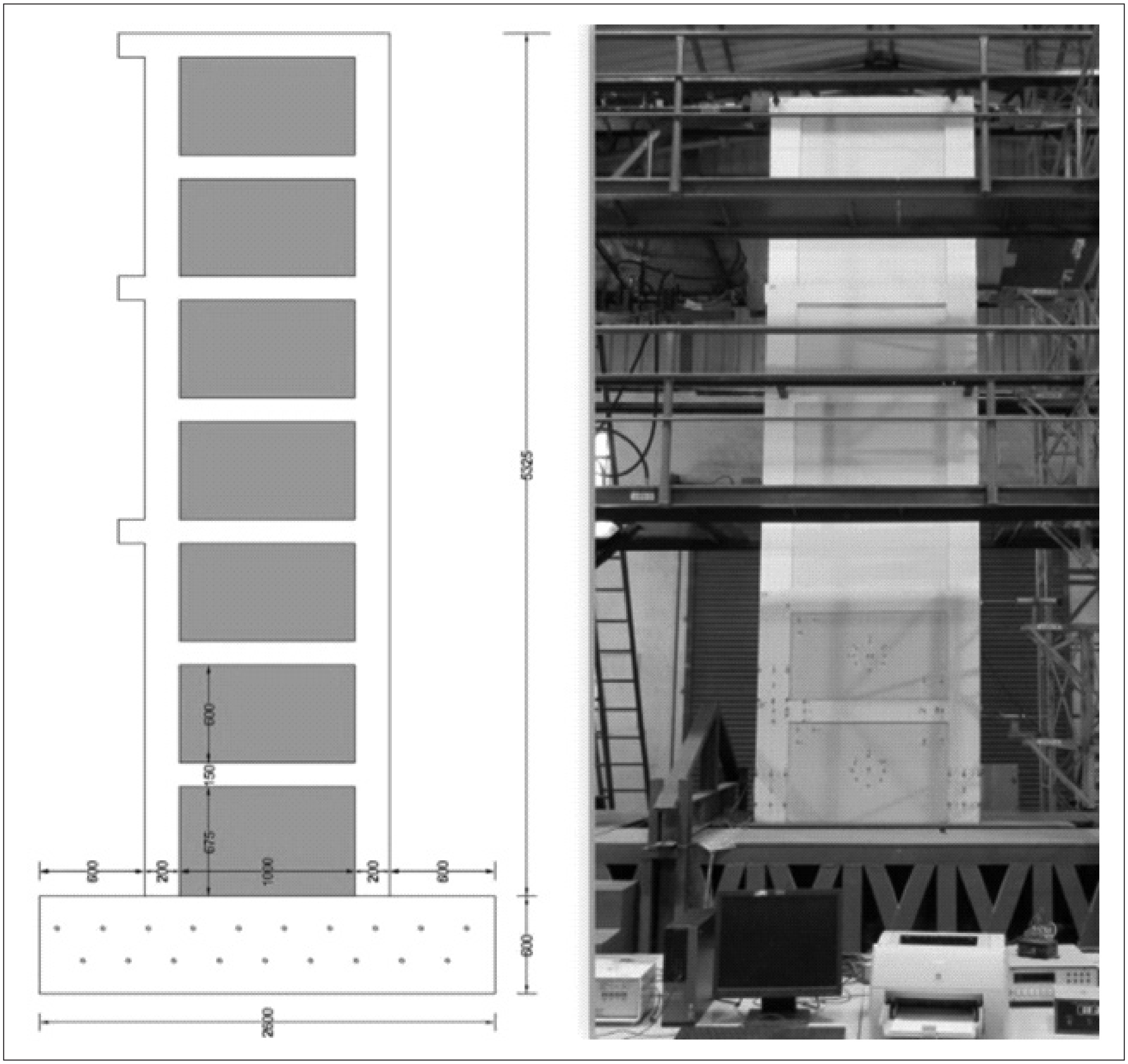


Figure 2: Model of Seven Storey Infilled Frame

6. ANALYTICAL MODELING OF FRAME

For bounding frame beam element is used, for infill panel four noded plane stress rectangular elements discretized to (16 × 16) as ideal discretization, for the interface link elements and four noded rectangular elements are used with 30 kN/mm as stiffness for link element.

The frame is modeled with bounding frame of reinforced concrete, brick masonry as infill panel and interface materials used are cement mortar and pneumatic air medium. The Horizontal load considered as unit joint load. Total horizontal load distributed as joint load acting at 7^{th}, 5^{th}, 3rd level. The air pressure applied in the pneumatic interface is (2, 4, 6, 8) psi. The analytical results of the frames displacement are shown in Figure 4 & 5. The values are listed in the Table 3.

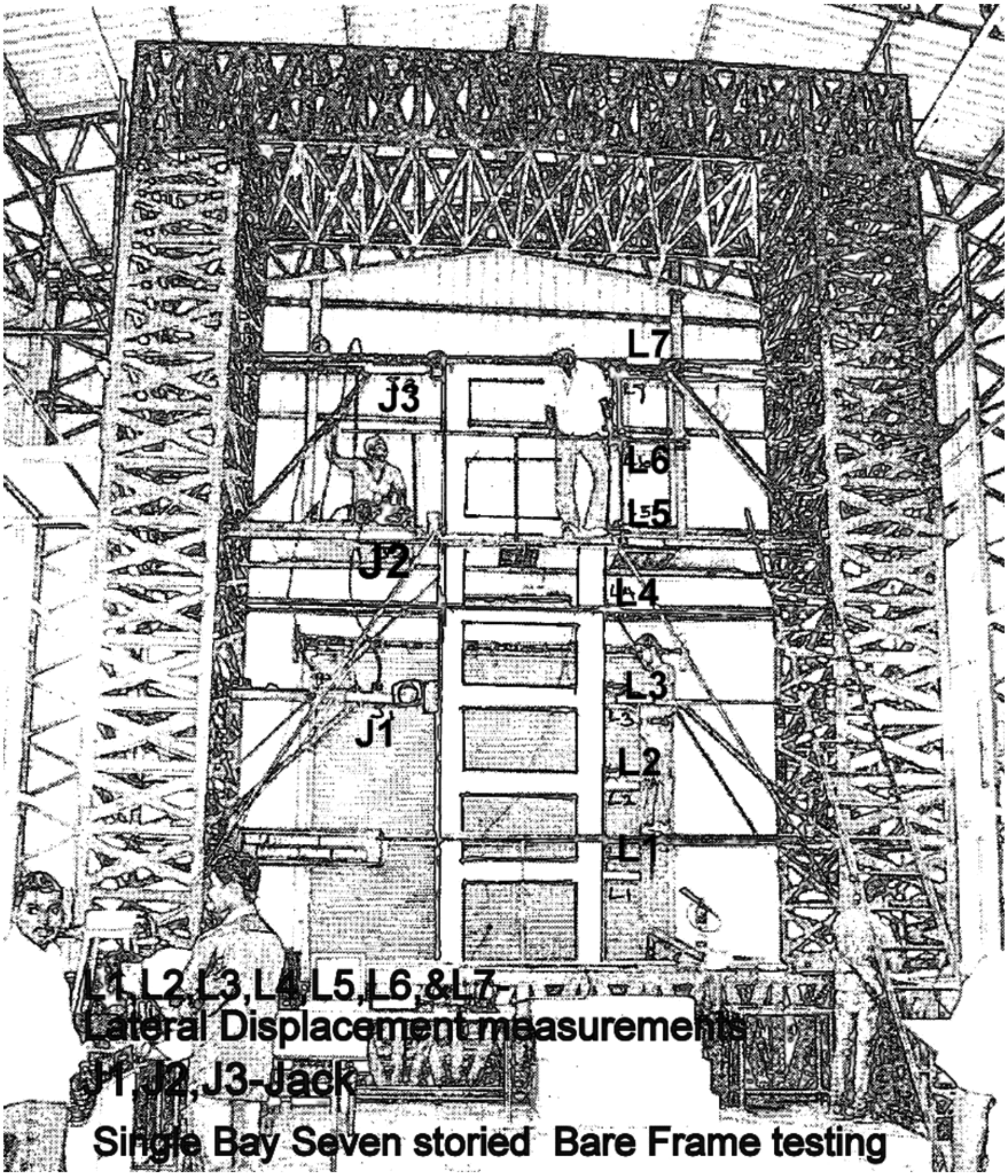


Figure 3: Testing of Seven storey bare frame

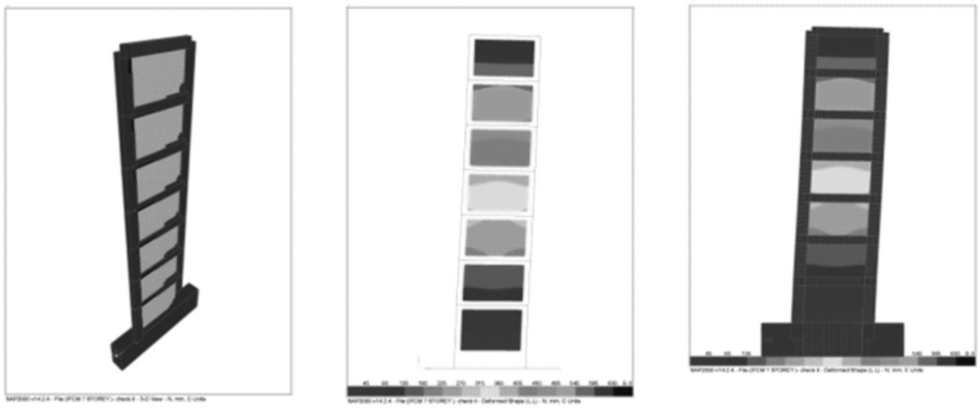
Bare frame

3D view

Deflected skeleton view

Deflected extruded view

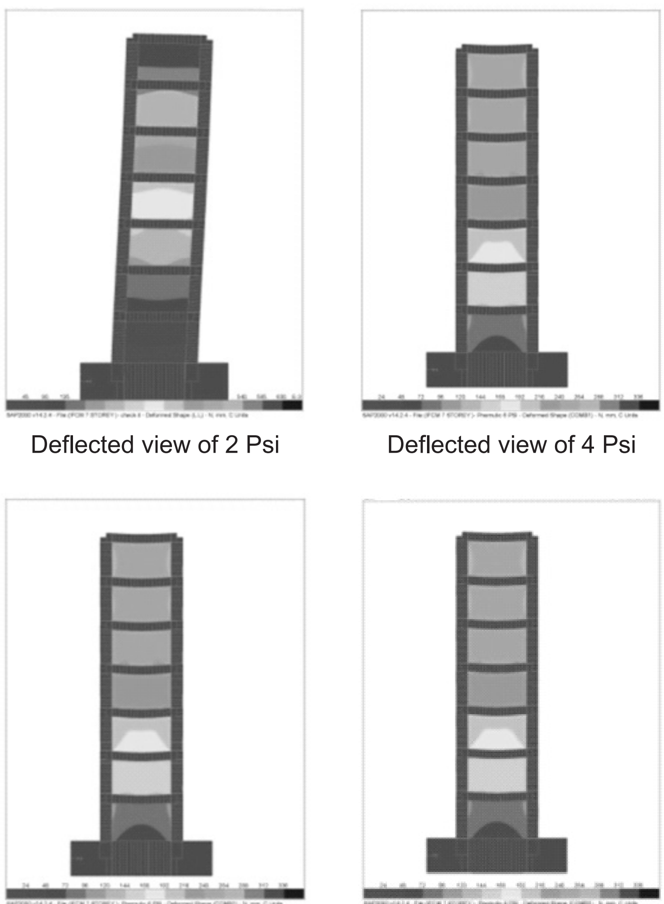
Infilled frame



3D view | Deflected skeleton view | Deflected extruded view

Figure 4: Analytical results of seven storey bare frame & Infilled frame

Infilled Pneumatic frame



Deflected view of 2 Psi | Deflected view of 4 Psi

Deflected view of 6 Psi | Deflected view of 8 Psi

Figure 5: Analytical deflected pattern of sevenstorey frame with air presence Pneumatic medium

7. RESULTS AND DISCUSSIONS

From the results of analytical and experimental investigations on the frame, the lateral stiffness is calculated as shown in Table 3. It is obtained by dividing the total base shear by the value of corresponding top most floor lateral displacement and shown in Table 3, from the plot of load vs deflection graphs shown in Figure 4.

Table 3
Initial lateral stiffness of frames

Case	*Initial Lateral Stiffness Value kN/mm*			*Experiment Rate IF/BF*
	From Literature	*Analytical*	*Experimental*	
BF	1.5*	1.73	1.52	–
IFCM	2.5**	3.8	2.63	1.73
IFP (2psi)	–	2.2	1.68	1.11
IFP (4psi)	–	2.4	1.75	1.15
IFP (6psi)	–	2.5	1.81	1.19
IFP (8psi)	–	2.75	1.89	1.24

*Lakshmipathy (1983) **Govindanetal (1986)

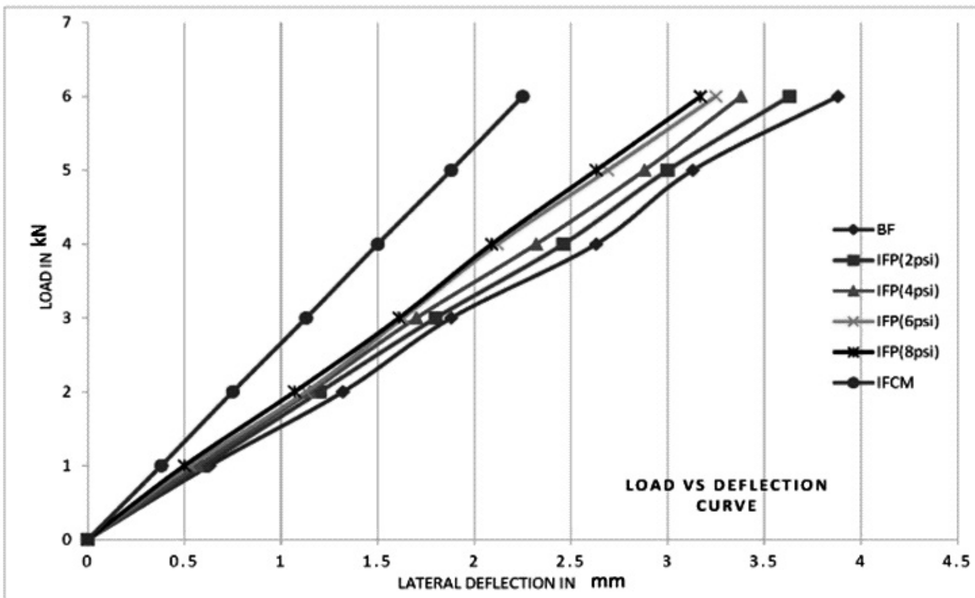


Figure 4: Load Vs deflection curves

From the results obtained the following points are observed.

(i) Provision of infill with cement mortar at interface increases to stiffness of bare frame by (2.63/1.52) 1.7 times.

(ii) The increase in the interface air pressure increases the stiffness of the infilled frames as shown in Figure 4.

(BF) Bare Frame, (IFCM) Infilled frame with cement mortar interface, (IFP (2psi)) Infilled frame with pneumatic interface using (2psi) as air pressure value.

The change in the stiffness of the infilled frame with the change in interface pressure can be used to modify the behavior from nearly bare frame to that of conventional infilled frame, theoretically. This can be used to create adoptive behavior of the system to minimize the disaster possibility under earthquakes due to composite actions of frame and infill viz. torsional mode of failure, failure of column due to partial infilling etc.

8. CONCLUSIONS

Based on the results obtained from present investigation, the following conclusions are made.

1. The ratio of stiffness of IFCM is 1.7 times that of similar Bare Frame.
2. The stiffness of IFP (2psi) is 1.1 times greater than BF.

3. The stiffness of IFP (8psi) is 1.24 times greater than BF.
4. The stiffness of IFP is increased with increasing air pressure at initial levels.
5. IFCM has the highest stiffness compared with other Infilled frames listed here.

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