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Modal Analysis of a Three-Dimensional Finite Element Model for a Masonry-Infilled Gable Roof

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Abstract

All developing countries use masonry infill (MI) as a standard for RC-framed structures. Usually, MI are not considered structural components; instead, their weights are included in the study and design. Recent years have seen the consideration of macro models that disperse infill mass to corners and use a diagonally supplied truss element in order to examine the impact of masonry infill on RC structures. But these models don't take MI apertures into consideration, which change the natural frequency of the structure. This study will investigate the results of the infill walls' apertures using two micro modelling techniques: the link element and the gap element. These methods use gap and link components to connect the RC frame to the infill interface. Previously published findings of shaking table experiments are used to verify the FE models.To extract the natural frequency from these models, the FEM software use modal analysis.

Keywords: *Gap element, link element, infill, modal*

1. INTRODUCTION

Researchers have spent the past forty years studying the behaviour of masonry infill frame structures in an effort to explain their design. All developing countries use brick masonry as a standard for infill walls between RC frame columns and beams. The combination of moment-resisting plane frames with masonry infill walls gives rise to the name "MI frames" for these composite structures. Possible reasons for their non-existence include the study's intricacy and a lack of understanding on the non-integral action between the masonry infill and the frame.

Masonry infill may be studied via the use of several approaches, such as macro and micro modelling. A less flexible frame, less ductility, increased inertia force, and fluctuations in natural frequency that differ from the real site conditions are all results of modelling with the complete connection against the RC frame in mind. In order to bring the building into reality and address the problems of frequency fluctuation and improper masonry infill bonding, we developed two micro-modeling techniques in FEM software.

2. OBJECTIVES

a) Investigate the structural behaviour of MI-equipped frames by developing a micro-modeling approach applicable to finite element analysis

b) To verify that the 3D RC gable roof frame structure's FE model findings are accurate by comparing them to the outcomes of shaking table tests.

3. METHODOLOGY

a) Analysing previous research on methods for micro-modeling 3D RC frames

b) using two micro-modeling techniques, the gap element and the link element, to investigate the effects of holes in three-dimensional RC frame assemblies

c) The FE models are validated using shaking table experiments employing the 3D RC frames from the earthquake engineering and vibration research centre (EVRC) at CPRI Bangalore.

d) By doing modal analysis on a 3D RC frame, we are able to get the natural frequencies and mode shapes for each occurrence.

4. MODEL DESCRIPTION

The RC structure is a three storey, two-bay structure with gable roof as shown in Fig 1. This structure is a representative model of an existing reactor APSARA building at BHABHA ATOMIC RESEARCH CENTRE (BARC), Mumbai. There is no central column in the top storey. The top roof is having asbestos sheet and with glass panels at the top storey. The three central columns are provided with hinge supports as shown in

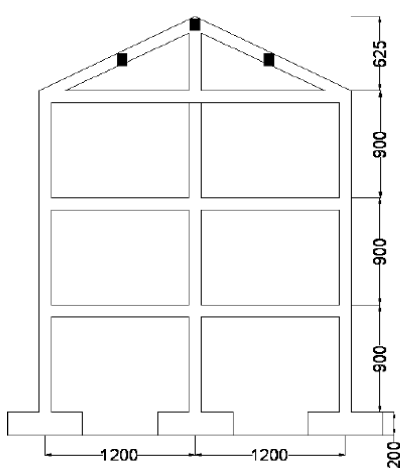

Figure 1: Dimensions of Model of a 3D-RC Structure

The structure comprises the following elements:
Foundations: Individual column footings
Columns: RC column of 75 mm x 100 mm cross-section.
Beams: RC beam of 75 mm x 100 mm cross-section.
Floor slab: RC slab of 50 mm thickness.
Grade of Concrete: M25
Reinforcement: Mild Steel with diameter of 3mm and 6mm, HYSD bars of 8mm diameter
No. of storey's: 3
No. of bays: 2 along AGF
Storey height (mm): 90
Bay width (mm): 1200
Beam (mm): 75 x 100
Column (mm): 75 x 100
Slab (mm): 50
Wall Thickness (mm):75

5. SHAKE TABLE TESTING OF 3D-RC FRAME (Chethan K, 2009)

The 3D-RC frame is mounted on the shake table and thoroughly checked for any cracks or damage after placing it on the shake table. At specified locations on the frame, accelerometers are mounted and are connected to the data acquisition system. The 3D - RC frame is mounted on the shake table as shown in Fig 1. The accelerometer locations for the 3D-RC frame are shown in Fig 2.The values obtained will be used for the validation of FE models

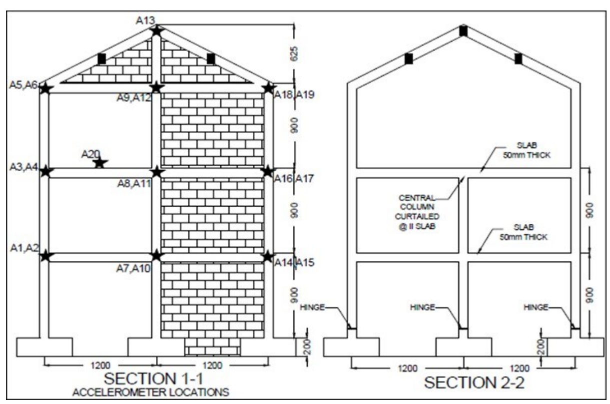

Figure 2: Accelerometer locations for the 3D-RC Structure

DIRECTION	FREQ.(HZ) (SHAKE TABLE)
AGF	10.75
PGF	6.00, 14.75

Table 1: Natural Frequencies obtained from shake table tests

Note:
AGF-Along the gable frame
PGF-Perpendicular to the gable frame

For 3D RC Infilled Frame condition,
Fundamental natural period, $T_a=\frac{0.09h}{\sqrt{d}}$
Where, h= avg height of the building (3.0125m)
d=base dimension of the building along the considered direction of shaking (2.4m)

$T_a=\frac{0.09x3.012}{\sqrt{2.4}}$
T_a=0.175 sec
Natural frequency= 5.714Hz

MODEL		IS 1893 2016 (PART-1)	SHAKE TABLE TEST	GAP ELEMENT	LINK ELEMENT
BARE FRAME	BF-AGF	5.83	**	7.969	
	BF-PGF-1	5.83	**	6.456	
	BF-PGF-2	**	**	17.00	
3D RC GABLE FRAME	MI-AGF	5.71	10.75	10.734	9.278
	MI-PGF-1	5.71	6	6.581	5.857
	MI-PGF-2	**	14.75	15.885	16.021

Table 2: Natural frequency (Hz) for both Bare frame and 3D RC gable infilled frame.

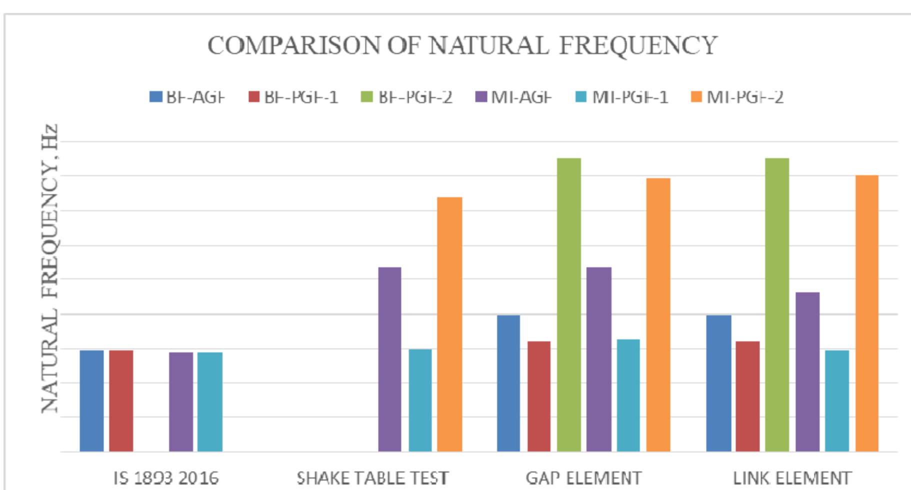

Figure 3: Natural frequency (Hz) for both bare frame and 3D RC gable infilled frame

6. CONCLUSIONS

The results of the shaking table test and the Gap and Link element micro modelling techniques are quite similar, suggesting that these two methods may be employed effectively for finite element analysis of 3D MI RC structures. The importance of openings and different RC frame topologies is ignored by the general technique suggested by IS code for finding natural frequency. A small number of models corroborate the results of the natural frequency experiments. As the proportion of apertures increases, the frequency of the AGF direction naturally decreases. The reasoning for this is because the structure's stiffness has been decreased, whereas the PGF The natural frequency has been largely unaffected by the changes in mass and stiffness in this path. The natural frequency decreases as the opening position increases in the AGF direction, beginning at the top corner and moving down to the bottom corner and eventually to the centre, illustrating the impact of openings at different locations.

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