Nonlinear Performance of Reinforced Concrete Frame with Infill Wall

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Abstract - *The influence of the infill wall on the global reaction of the RC structures cannot be overlooked, as evidenced by historical earthquakes and experimental testing conducted since the mid-1950s. As a result, the seismic susceptibility of these types of structures must be examined by taking into account the infill wall's influence in order to establish their degree of safety and, as a result, to identify any prospective reinforcing requirements. The non-linear analysis of the building is the subject of this study. Fully infilled and infilled with open ground floor constructions were chosen, and their behavior was compared to that of the comparable bare frames. A single strut model with characteristics calibrated using experimental data was used to mimic the behavior of the infill panel.*

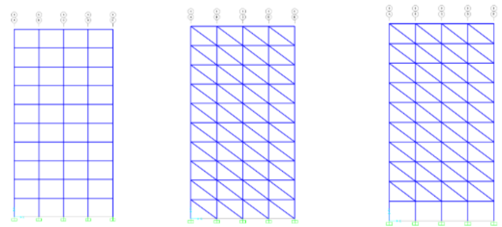
Key Words: Sap2000, modelling of infill wall, nonlinear static analysis, FEMA-356.

1.INTRODUCTION

Clay brick is a common form of material used in the world's construction industry for the construction of reinforced concrete (RC) structures' walls. Brick masonry has a high mass and accounts for 30-35 percent of the total mass of the structure. The brittle quality of brick masonry infill (BMI) makes it strong in compression. In-plane stiffness is high, whereas out-of-plane stiffness is low. Because these are particularly stiff in nature, they attract bigger seismic pressures and fail first during an earthquake. Asymmetrically placed BMI, leads to seismic torsion since the mass of the BMI is also asymmetrically positioned. This could be for aesthetic reasons or due to the provision of apertures. To asses the influence of brick infill, a non-linear approach is required which shows particular damage state.

2. Structural Modelling

A 10 storey R.C. framed structure 16m x16m in plan (Model-1) is selected for development of fragility curves. Since the example building is a new building, first a linear dynamic analysis is performed for determination of forces and moments in various frame elements and then it is designed for various load combinations specified in the IS-2000 and IS-1893.2016 code for member optimizations. To introduce the effect of brick masonry infill, an equivalent diagonal strut is assigned in model-1 as explained IS-1893-2016. Properties required to design diagonal strut for brick infill masonry 1:3, are taken from Kaushik et al (2007). To introduce the effect of soft storey all the infill struts of ground storey were removed. 10 storey RC frame without brick infill masonry (model-1), 10 storey RC frame with brick infill masonry (model-2), and 10 storey RC frame with brick infill masonry having open ground storey i.e. no infills at ground level (model-3). Elevation of all three models are presented in fig 1. Response Spectra Considered -IS 1893-2016, Seismic zone – IV, Seismic, zone factor Z = 0.24 Importance factor I = 1, Soil type = I, Response Reduction factor = 5. The loads considered are Floor finish = 1.2 KN/Sqm. Floor finish (roof) = 1.5 KN/Sqm. Live load = 3 KN/Sqm. Live load (Roof) = 1.5 KN/Sqm. Wall load = 12 KN/m. The dimension of beam and column are listed in table-1 and table-2.



Model – 1 Model – 2 Model – 3

Fig- 1: Elevation of RC frame with and without infill

Table-1 Schedule of Beam

Beam				
Title	Size in mm	Main steel		Remark
		At top	At bottom	
B1	450 x 300	4-16 Φ	4-16 Φ	Up to storey 5
B2	450 x 300	3-16 Φ	4-16 Φ	Storey 6 to 10

Table-2 Schedule of Column

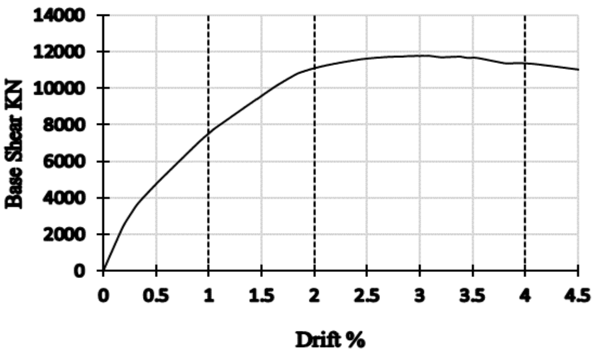
Column			
Title	Size in mm	Main steel	Remark
C1	500 x 500	14-25 Φ	Up to storey 3
C2	450 x 450	12-20 Φ	Storey 3 to 6
C3	450 x 450	8-16 Φ	Storey7 to 8
C4	400 x 400	8-16 Φ	Storey 9 to 10

2.1 Non-linear modelling of structure

The plastic hinges are based on the default hinge model which is defined in SAP2000. For beam section, the moment M3 hinge type was used as well as the column section, which is the Interacting P-M2-M3. Geometric nonlinearity has been considered by incorporating P-Δ effect in the analysis. For non-linear modelling of equivalent diagonal strut axial deformation (ductile) hinge is assigned.

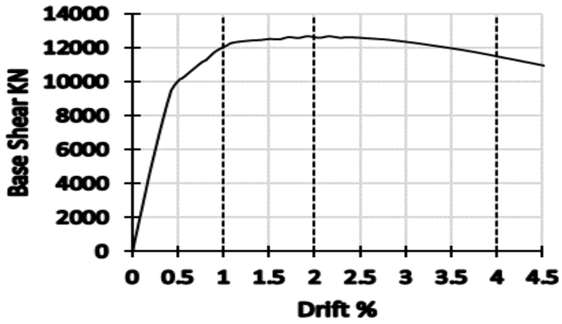
3. Pushover Analysis

Pushover analysis (POA) was carried out on all three models. In this analysis, lateral load applied plays an important role in evaluating the structure performance according to the pushover analysis. In this analysis, as suggested in FEMA-356, A uniform lateral load was applied to perform the analysis. POA was performed by incrementally increasing the magnitude of lateral load and analyzed using SAP2000v21 software. Based on the results of this analysis, the capacity curve managed to be developed. The percentage of drift was calculated. In this study, the percentage of drift is limited to 4% as suggested in FEMA-356.



(a)

(b)



(c)

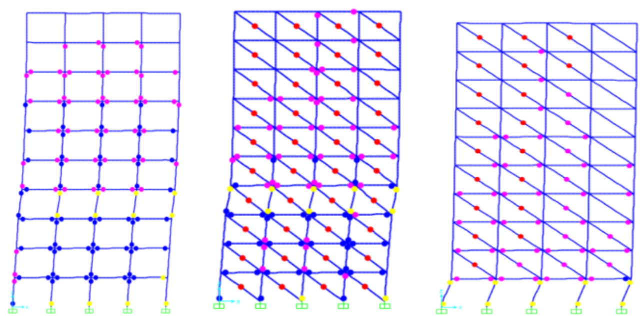
Fig. 2 Capacity Curve (a) model-1,(b) model-2,(c) model-3

As per the performance levels suggested in FEMA-356, the performance of the three model is listed in table-3.

Table-3: Performance level- FEMA 356

	Model-1		Model-2		Model-3	
	Drift %	Base Shear KN	Drift %	Base Shear KN	Drift %	Base Shear KN
IO	1	7561	1	19136	1	12126
LS	2	11110	2	18432	2	12572
CP	4	11345	4	10983	4	11390

4. Plastic hinges



(a) (b) (c)

Fig.3 Plastic hinge formation at Drift 4% (a) model-1, (b) model-2,(c) model-3

Figure-3 shows the plastic hinge pattern when the structure is pushed to 4% drift. In model three a soft storey mechanism is observed.

3. CONCLUSIONS

After performing non-linear static analysis for three models a capacity curve is derived which gives idea about behavior of structures under lateral loading.

1. According to the graph, maximum base shear for bare frame is 11775 KN at the drift of 2.97%, Infill frame is 19564 KN at the drift of 1.47% and for open ground storey is 12592 KN at the drift of 2.31%. which shows that masonry infill increases the stiffness of structure and resist more lateral load.

2. As performance levels defined in FEMA-356 for IO, LS and CP are marked on capacity curve for 1%, 2% and 4% drift. Value of base shear drops after LS i.e 2% drift for brick masonry infill frame, which is due to failure of infill masonry, whereas for bare frame the curve is smooth and value of base shear is constantly increasing.

3. In open ground storey. A soft storey mechanism is observed in this model. The columns of these storey are failed due to change stiffness.

4. values of base shear for Bare frame are in increasing order whereas for infill and open ground storey, base shar drops after 2% drift. Due to failure of infill masonry.

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