Analysis of Multi-Story Buildings Infill and Without Infill Walls by Simulation Tool

[1]Abhishek Shankar, [2]Dr.Ajay Swarup

[1] *M.tech Schlor, Civil Department, SSSUTMS, M.P.India*
[2] *Associate Professor, CivilDepartment, SSSUTMS, M.P.India*

ABSTRACT

The present study attempts to estimate typical variations in magnification factor of a mid rise open ground storey building accounting for the variability of compressive strength and modulus of elasticity of infill walls with various infill arrangements so that it can help designers facing trouble with heavy designs for a structure of mid-size, with the given material properties, geometry and loadings in particular. For the present study Equivalent static analysis (ESA) and Response spectrum analysis (RSA) is considered for the comparative study. The building will be analyzed for two different cases: i) Considering infill mass but without considering infill stiffness. ii) Considering both infill mass and infill stiffness. From the present results it is found that building with soft storey will exhibit poor performance during a strong shaking. But the open ground storey is an important functional requirement of almost all the urban multi-storey buildings and hence cannot be eliminated. Alternative measures need to be adopted for this specific situation. The under-lying principle of any solution to this problem is in i) increasing the stiffness of the ground storey; ii) provide adequate lateral strength in the ground storey. The possible schemes to avoid the vulnerability of open ground storey buildings under earthquake forces can be by providing stiff columns in open ground storey buildings or by providing adjacent infill walls at each corner of soft ground storey buildings.

Keywords*— Soft storey structure; Seismic Impact Analysis; Infill; OSG building; Equivalent static analysis (ESA); Response spectrum analysis (RSA);*

INTRODUCTION

Reinforced concrete frame buildings have become common form of construction with masonry infills in urban and semi urban areas in the world. The term infilled frame denotes a composite structure formed by the combination of a moment resisting plane frame and infill walls. The infill masonry may be of brick, concrete blocks, or stones. Ideally in present time the reinforced concrete frame is filled with bricks as non-structural wall for partition of rooms because of its advantages such as durability, thermal insulation, cost and simple construction technique. There is significant advantage of this type of buildings functionally but from seismic performance point of view such buildings are considered to have increased vulnerability. In the current practice of structural design in India infill walls are considered as non-structural elements and their strength and stiffness contribution are neglected. The effect of infill panels on the response of reinforced concrete frames subjected to seismic action is widely recognized and has been subject of numerous experimental and analytical investigations over last five decades. Covers a huge analysis area since every a part of the system has its own technical complexity. Therefore, it may not be conservative to ignore strength and stiffness of infill wall while designing open ground storey buildings. Performance of buildings in the past earthquakes clearly shows that the presence of infill walls has significant structural implications on them. Therefore, we cannot simply neglect the structural contribution of infill walls particularly in seismic regions where, the frame–infill interaction may cause significant changes in both stiffness and strength of the frame. Inclusion of stiffness and strength of infill walls in the open ground storey building frames decreases the fundamental time period compared to a bare frame and consequently increases the base shear demand and the design forces in the ground storey beams and columns. This increased design forces in the ground storey beams and columns of the open ground storey buildings are not captured in the conventional bare frame analysis. An appropriate way to analyse the open ground storey buildings is to model the strength and stiffness of infill walls. Unfortunately, no guidelines are given in IS 1893: 2002 (Part-1) for modelling the infill walls. As an alternative a bare frame analysis is generally used that ignores the strength and stiffness of the infill walls. The aim of this thesis is to check the applicability of the multiplication factor of 2.5 in the ground storey beams and columns for the model considered in particular, when it is to be designed as open ground storey framed building taking into account the effect of stiffness of the walls also and to study the effect of infill strength and stiffness in the seismic analysis of a mid rise open ground storey building.

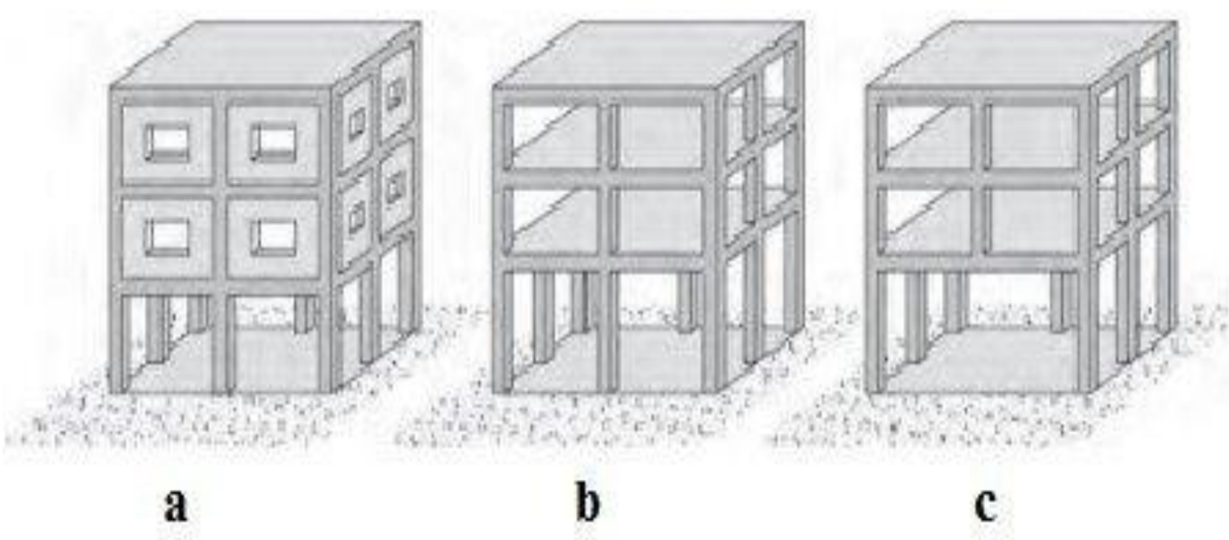

Fig. 1: Examples of failure of buildings with soft storey at ground floor

OBJECTIVES

The salient objectives of the present study have been identified as follows:

1. To study the effect of infill strength and stiffness in the seismic analysis of open ground storey (OGS) buildings.
2. To check the applicability of the multiplication factor of 2.5 as given in the Indian Standard IS 1893:2002 for design of mid rise open ground storey building.
3. To assess the effect of varying the infill arrangements on the analysis results by taking various combinations of infill thickness, strength, modulus of elasticity and openings.

NEED FOR THE PROPOSED WORK

The presence of infill walls in upper storeys of open ground

storey (OGS) buildings accounts for the following issues:

i) Increases the lateral stiffness of the building frame.
ii) Decreases the natural period of vibration.
iii) Increases the base shear.
iv) Increases the shear forces and bending moments in the ground storey columns.

LITERATURE REVIEW

Inclusion of stiffness and strength of infill walls in the open ground storey building frames decreases the fundamental time period compared to a bare frame and consequently increases the base shear demand and the design forces in the ground storey beams and columns. This increased design forces in the ground storey beams and columns of the open ground storey buildings are not captured in the conventional bare frame analysis. An appropriate way to analyze the open ground storey buildings is to model the strength and stiffness of infill walls. Unfortunately, no guidelines are given in IS 1893: 2002 (Part-1) [1] for modelling the infill walls. In Infill thickness, strength, modulus of elasticity and openings are analyzed by two methods mentioned above. The modelling and analysis for the study is done with the aid of commercial software ETABS v 9.7.1[2] in compliance with the codes IS 456-2000[3] and IS 1893-2002. In existing systems, third party auditor demanding local copy of user outsourced data. So this will increase the possibility of the following research papers are consulted for obtaining an in-depth understanding of Asokan (2006) studied how the presence of masonry infill walls in the frames of a building changes the lateral stiffness and strength of the structure. This research proposed a plastic hinge model for infill wall to be used in nonlinear performance based analysis of a building and concludes that the ultimate load (UL) approach along with the proposed hinge property provides a better estimate of the inelastic drift of the building[7]. D Menon et. al. (2008) concluded that the MF increases with the height of the building, primarily due to the higher shift in the time period. Also when large openings are present and thickness of infills is less, there is a reduction in MF. The study proposed a multiplication factor ranging from 1.04 to 2.39 as the number of storey increases from four to seven[8]. J. Dorji and D.P. Thambiratnam(2009) concluded that the strength of infill in terms of its Young's Modulus (E) has a significant influence on the global performance of the structure. The stresses in the infill wall decrease with increase in (E) values due to increase in stiffness of the model. The stresses varies with building heights for a given E and seismic hazard[9] Sattar and Abbie (2010) in their study concluded that the pushover analysis showed an increase in initial stiffness, strength, and energy dissipation of the in filled frame, compared to the bare frame, despite the wall's brittle failure modes. Likewise, dynamic analysis results indicated that fully-infilled frame has the lowest collapse risk and the bare frames were found to be the most vulnerable to earthquake-induced collapse. The better collapse performance of fully-infilled frames was associated with the larger strength and energy dissipation of the system, associated with the added walls[10]. Dukuze (2000) investigated the failure modes of infilled structure on single storey specimens with and without opening. In general, three types of failures were observed under an in plane load such as sliding of bed joints, tensile cracking of

DESCRIPTION OF STRUCTURAL MODEL

The description of the structure and other important parameters are given below :

Geometry: The building has five bays in X direction and four bays in Y direction with the plan dimension 22.5 m × 14.4 m and a storey height of 3.5 m each in all the floors and depth of foundation taken as 1.5 m.

Material properties: M-25 grade of concrete and Fe-415 grade of reinforcing steel are used for all the frame models, The unit weights of concrete and masonry are taken as 25.0 kN/m3 and 20.0 kN/m3, The poison ratio of concrete is 0.2 and of masonry is 0.15.

Table 1: Details of Structure

Type of structure	Residential building (G+5)
Plan dimensions	22.5 m X 14.4 m
Total height of building	21m
Height of each storey	3.5m
Depth of foundation	1.5m
Bay width in longitudinal direction	4.5m

Bay width in transverse direction	3.6m
Size of beams	230 mm X 400 mm
Size of columns	400 mm X 400 mm
Thickness of slab	125mm
Thickness of walls	230 mm & 115 mm
Seismic zone	IV
Soil condition	Medium (type II)
Response reduction factor	5
Importance factor	1
Floor finishes	1 kN/m^2
Live load at roof level	1.5 kN/m^2
Live load at all floors	3 kN/m^2
Grade of Concrete	M25
Grade of Steel	Fe 415
Density of Concrete	25 kN/m^3
Density of brick masonry	20 kN/m^3
Design philosophy	Limit state method conforming to IS 456-2000

MODEL CONSIDERED FOR ANALYSIS

Following five models are analysed using equivalent static analysis and response spectrum analysis -

i) Model I: Bare frame model (reinforced concrete frame taking infill masonry weight, neglecting effect of stiffness).

ii) Model II: Building with strong infill (effect of stiffness is also considered in addition to taking weight of infill).

iii) Model III: Building with strong infill having openings (model II with openings at certain panels).

iv) Model IV: Building with weak infill (effect of stiffness is also considered in addition to taking weight of infill).

v) Model V: Building with weak infill having openings (model IV with openings at certain panels).

RESULTS

Node number	Without infill			With infill			Ratio		
	Ux_1 mm	Ry_1 rad	Rz_1 rad	Ux_2 mm	Ry_2 rad	Rz_2 rad	Ux_2/Ux_1	Ry_2/Ry_1	Rz_2/Rz_1
26	0.05	0	0	-0.09	0	0	-1.63	**	**
27	0.02	0	0	-0.09	0	0	-5.63	**	**
56	0.02	0	0	-0.09	0	0	-4.43	**	**
57	-0.03	0	0	-0.10	0	0	3.39	**	**
86	-0.02	0	0	-0.10	0	0	4.50	**	**
87	-0.07	0	0	-0.10	0	0	1.42	**	**
116	-0.14	0	0	-0.10	0	0	0.71	**	**
117	-0.20	0	0	-0.11	0	0	0.54	**	**
118	-0.24	0	0	-0.12	0	0	0.50	**	**
119	-0.27	0	0	-0.13	0	0	0.47	**	**
120	-0.31	0	0	-0.14	0	0	0.44	**	**
146	-0.01	0	0	-0.10	0	0	7.07	**	**
147	-0.05	0	0	-0.11	0	0	2.00	**	**
148	-0.09	0	0	-0.11	0	0	1.22	**	**
149	-0.13	0	0	-0.12	0	0	0.91	**	**
150	-0.17	0	0	-0.13	0	0	0.76	**	**

Table5.1:Comparision of displacement of roof nodes for gravity load

CONCLUSIONS

i) The structural member forces, deformations do vary with the different parameters associated with the infill walls. Such variations are not considered in current codes and thus the guidance for the design of buildings having infill walls is incomplete and specifically for buildings with soft ground storey it is imperative to have design guidelines in detail.

ii) Infill panels increases the stiffness of the structure and the increase in the opening percentage leads to a decrease on the lateral stiffness of infilled frame. Therefore behaviour of building varies with the change in infill arrangements. This indicates that modelling of reinforced concrete frame building without infill wall (panel) or bare frame model may not be appropriate for the examine.

iii) The examine result shows that column forces at the ground storey increases for the presence of infill wall in the upper storeys. But design force magnification factor found to be much lesser than 2.5. This is particularly true for mid-rise open ground storey buildingsstructure. It is seen from response spectrum analysis that the magnification factor decreases when the stiffness of infill panels are decreased either by reducing infill strength (thickness and modulus of elasticity) or by providing openings in the infill panels.

REFERENCES

1. Agarwal P. and Shrikhande M. (2006). Earthquake resistant design of structures. *PHI Learning Pvt. Ltd.,* New Delhi.

2. Al-Chaar G., Issa M. and Sweeney S.(2002). Behaviour of masonry infilled non-ductile RC frames. *ASCEJournal of Structural Engineering.* 128(8), 1055-1063.

3. Arlekar J.N., Jain S. K. and MurtyC.V.R(1997). Seismic response of RC frames buildings with soft first storeys. *Proceedings of CBRI golden jubilee conference on natural hazards in urban habitat,* New Delhi.

4. Asokan A. (2006). Modelling of Masonry Infill Walls for Nonlinear Static Analysis under Seismic Loads. *MS Thesis.* Indian Institute of Technology Madras, Chennai.

5. Asteris P. G.(2003). Lateral stiffness of brick masonry infilled plane frames. *Journal of Structural Engineering.* 129(8), 1071-1079.

6. Chopra A. K. (1973). Earthquake resistance of buildings with a soft first storey. *Earthquake and Structural Dynamics*. 1, 347-355.

7. Chug R.(2004). Studies on RC Beams. Columns and Joints for Earthquake Resistant Design. *M. Tech Project Report*. Indian Institute of Technology Madras, Chennai.

8. Crisafulli F. J.(1999). Seismic Behaviour of reinforced concrete structures with masonry infills. *Ph.D. Thesis*. University of Canterbury, New Zealand.

9. Das S. andNau J.M. (2003). Seismic design aspects of vertically irregular reinforced concrete buildings. *Earthquake Spectra*. 19, 455-477.

10. Davis R.(2008). Earthquake Resistant Design of Open Ground Storey RC Framed Buildings. *Ph.D. Thesis*. Indian Institute of Technology Madras, Chennai.

11. Davis R., Menon D. and PrasadA. M. (2008). Evaluation of magnification factorsfor open ground storey buildings using nonlinear analyses.*The 14th World Conference on Earthquake Engineering,* Beijing, China.

12. Deodhar S. V. and Patel A.N.(1998) Ultimate strength of masonry infilled steel frames under horizontal load. *Journal of Structural Engineering. Structural Engineering Research Centre*. 24, 237-241.

.