

Study of Seismic performance for soft basement of RC framed Buildings

A.S.KASNALE¹, Dr. S.S.JAMKAR²

ABSTRACT: Generally RC framed structures are designed without regards to structural action of masonry infill walls present. Masonry infill walls are widely used as partitions. Field evidence has shown that continuous infill masonry wall can help reduce the vulnerability of a reinforced concrete structure. (These buildings are generally designed as framed structures without regard to structural action of masonry infill walls. They are considered as non- structural elements)

RC frame building with open first storey is known as soft storey, which performs poorly during strong earthquake shaking. A similar soft storey effect can also appear in to position of the structure below plinth, when the ground material has removed during excoriation and refilled later.

In order to study this five reinforced RC framed building with brick masonry infill were designed for the same seismic hazard, in accordance with IS code. In the present paper an investigation has been made to study the behavior of RC frames with various arrangement of infill when subjected to dynamic earthquake loading. The result of bare frame, frame with infill, soft ground floor and soft basement are compared and conclusion are made in view of IS 1893(2002) code. It is observed that, providing infill below plinth improves earthquake resistant behavior of the structure when compared to soft basement.

Keywords: Masonry infill, RC frames soft, seismic loads.

1. INTRODUCTION

Multi storey reinforced concrete frames with masonry infills are popular form of construction in urban and semi urban areas around the world. These buildings are generally designed as framed structures without regard to structural action of masonry infill walls. They are considered as non- structural elements. The term infilled frame is used to denote a composite structure formed by the combination of a moment resisting plane frame and infill walls. Normally the RC frame is filled with bricks masonry social and functional needs, for vehicle parking, shops, reception etc. are compelling to provide an open first storey in high rise building. Parking floor has become an unavoidable feature of the urban multi storied buildings. Past earthquake has illustrated the potential hazards, associated with buildings having open first storey (first storey) built in seismically active areas. Through multi storied buildings with parking floor are vulnerable to collapse due to earthquake loads, their construction is still wide spread. Objective of present study is to find behaviour of structure below plinth. The structure below plinth is normally assumed to perform like a soft storey with loose soil material filled after excavation, To lay down the column foundation for the structure the material adjoining the column and footing is excavated and re filled after completion of foundation work. The frame thus formed above the footing level and up to the ground level is infilled with loosely filled material and fails to give similar effect of infill masonry and acts like a soft basement.

The effect of infill panels on the behaviour of RC frames subjected to seismic action is widely recognised and has been subject of numerous experimental and analytical investigations over last five decades. In the present practise of structural design in India, masonry infill panels are treated as non- structural element and their strength and stiffness contribution are neglected. In fact the presence of infill wall changes the behaviour of the frame action in to truss action, thus changing the lateral load transfer mechanism. Under lateral load infill significantly increase the stiffness resulting in possible change in the seismic demand due to the significant reduction in the natural period of the composite structural system.

2. Description of structural model

Seismic performance of various configurations of infill panels in RC frames (Shown in fig.) are compared. The main object of this study were to investigate the behaviour of multi-storey, multi bay soft storey infilled frames to evaluate their performance level when subjected to earthquake loading. For the study five different models of a six storey building are considered the building has five bays in X direction and three bays in Y direction with the plan dimension 20 m × 12 m and a storey height of 3 m each in all the floors and depth of foundation taken as 1.5 m

The building is kept symmetric in both orthogonal directions in plan to avoid torsional response. Under pure

Study of Seismic performance for soft basement of RC framed buildings

lateral forces the orientation and size of column is kept same throughout the height of the structure. The building is considered to be located in seismic zone III. The building is founded on medium strength soil through isolated footing under the columns. Elastic moduli of concrete and masonry are taken as 22361.68 MPa and 5500 MPa respectively and their poisons ratio is 0.20 and 0.15 respectively.

Different types of analytical models with the understanding of behaviour of infill panels were developed. Out of all methods, method based on equivalent structural approach is simple and easier to apply in practical design. The single strut model is the most widely used as it is simple and evidently most suitable for large structures (Das and Murty 2004)

Response reduction factor for the special moment resisting frame has taken as 5.0 (assuming ductile derailing). The unit weights of concrete and masonry are taken as 25.0 KN/m³ and 20.00 KN/m³ respectively the floor finish on the floors is 1.0 KN/m². The live load on floor is taken as 2.0 KN/m². In seismic weight calculations, only 25 % of the floor live loads are considered.

3. Model considered for analysis

Following five models are analysed as special moment resisting frame using equivalent static analysis and response spectrum analysis.

Model I: Bare model, however masses of infill walls are included in the model.

Model II: Full Infill Masonry model. Building has one full brick infill masonry wall in all stories including the first storey and below plinth.

Model III: Building has one full brick infill masonry wall in all storeys except below plinth.

Model IV: Building has no wall in the first storey and one full brick infill masonry wall in upper stories and below first storey.

Model V: Building has no wall in first storey and basement and one full brick infill masonry wall in upper stories, above first storey.

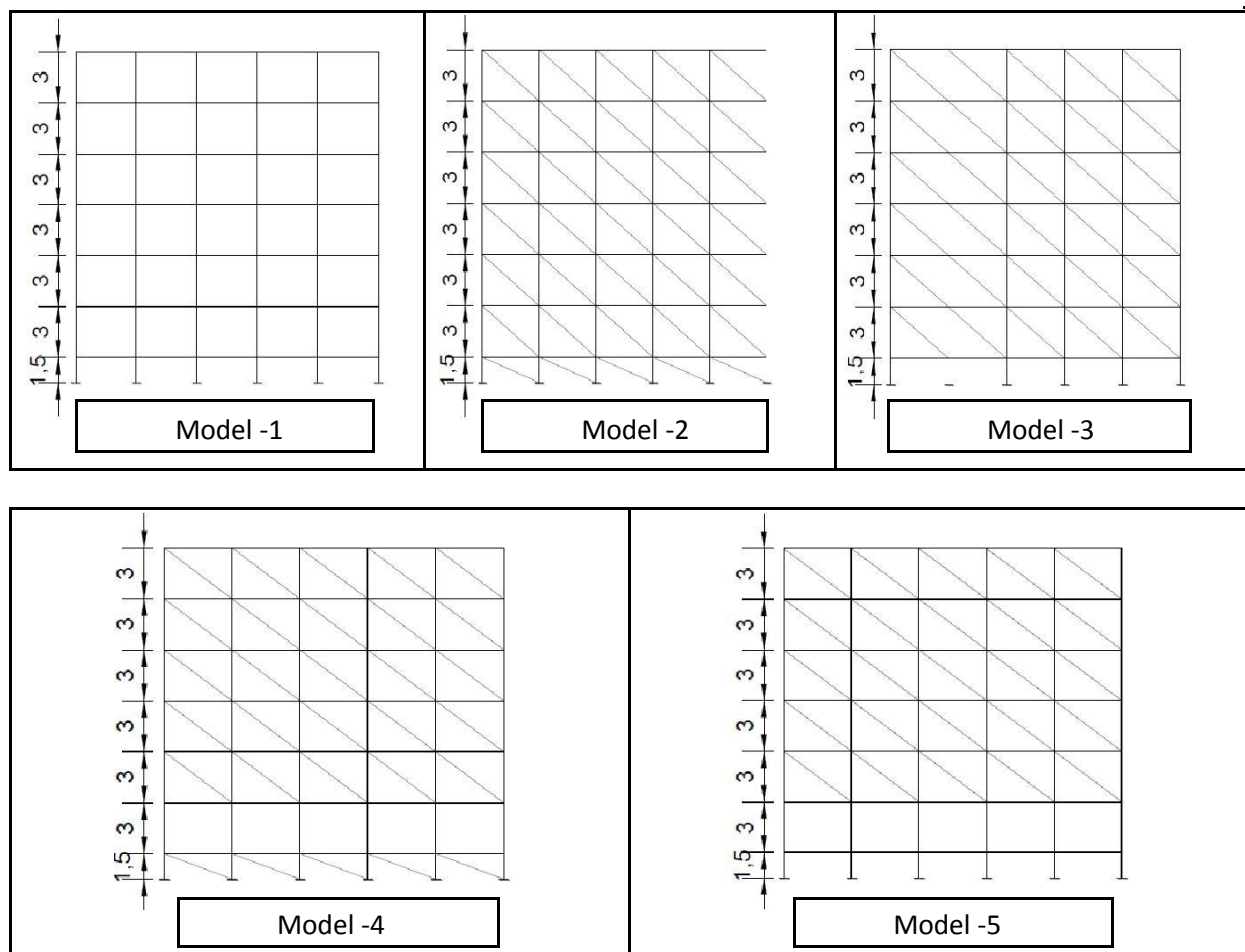


Fig. 1: Elevation of Seven Storey Reinforced Concrete Building

$$\lambda_h = \sqrt[4]{\frac{E_m t \sin 2\theta}{4 E_c I_c h_m}}$$

3.1 Modelling of frame members and masonry infill

The frame members are modelled with rigid end conditions, the floors are modelled as diaphragms rigid in plane and walls are modelled as panel elements without any opening. The frames with unreinforced masonry walls can be modelled as equivalent braced frames with infill walls replaced by equivalent diagonal strut. The single strut model is the most widely used as it is sample and suitable for large structures. As per FEMA 356(2000) stated as the elastic in plane stiffness of a solid unreinforced masonry infill panel, prior to cracking shall be represented with an equivalent diagonal compression strut of width, W_{eff} given by equation below. The equivalent, strut shall have the same thickness and modulus of elasticity as the infill panel it represents.

$$W_{eff} = 0.175 (\lambda_h h_{col})^{-0.4} r_m$$

where

h_{col} is column height between centrelines of beams, h_m is height of infill panel, E_c is modulus of elastic of frame material, E_m is expected elasticity of infill material, I_c is moment of inertia of column, r_m is diagonal length of infill panel & t is thickness of infill panel and equivalent strut, θ the slope of infill diagonal to the horizontal.

3.2 Analysis of the building

Equivalent static analysis has been performed as per IS 1893 (pan R) 2002 for each model using ETABS 9.5 (computer and structures) software. Lateral load calculation and its distributed along the height is done. The seismic weight is calculated using full dead load plus 25% of live load. The result obtained from analysis are compared with response to the following parameters.

3.3. Fundamental time period:

Table 1 shows comparison of time period by IS code method and analysis using ETABS software

Fundamental time period (sec.)				
Model	I.S. Code 1893-2002		ETABS Analysis	
	longitudinal	transverse	longitudinal	transverse
Model 1	0.695	0.695	1.331	1.331
Model 2	0.392	0.585	0.487	0.487
Model 3	0.392	0.585	0.538	0.538
Model 4	0.392	0.585	0.858	0.858
Model 5	0.392	0.585	0.916	0.916

It is observed that model 1 gives higher time period compared to other models. Due to inclusion of infill in models, time period get reduced.

4. Results and discussions

Table 2: Displacement for each model along longitudinal direction

DISPLACEMENT (mm)										
	MODEL I		MODEL II		MODEL III		MODEL IV		MODEL V	
STOREY	ux	uy	ux	uy	ux	uy	ux	uy	ux	uy
7	21.9757	46.3674	6.3349	10.1389	6.4069	10.7879	7.6456	16.1195	7.957	17.1591
6	20.3903	43.5082	5.9081	9.3452	5.9825	10	7.2476	15.3902	7.562	16.4359
5	17.5813	37.685	5.2134	8.1116	5.2919	8.7747	6.6001	14.2474	6.9191	15.3016
4	13.7341	29.7458	4.2581	6.5264	4.3419	7.1993	5.7031	12.771	6.0277	13.8353
3	9.248	20.5564	3.1049	4.6915	3.1937	5.3756	4.6335	11.0609	4.9659	12.1361
2	4.5929	10.7986	1.7947	2.6964	1.889	3.3967	3.2422	9.1071	3.5842	10.2297
1	0.6997	1.45	0.4264	0.6693	0.5064	1.3878	0.4794	0.6518	0.6589	1.4731

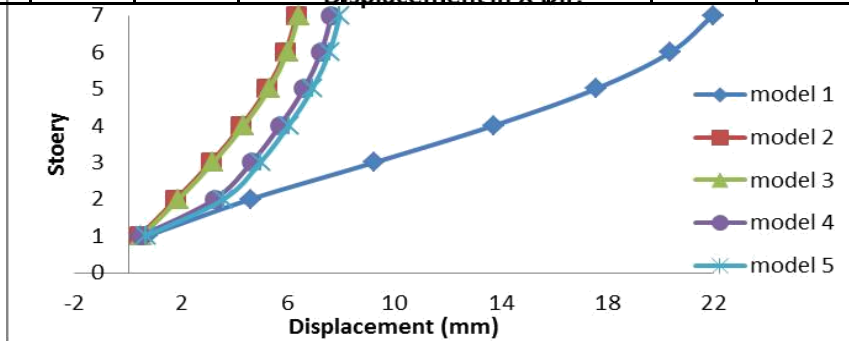


Fig. 2: Comparison of Displacement Vs Storey

Table 3: Storey Drift for each model along longitudinal direction

STOREY DRIFT										
	MODEL I		MODEL II		MODEL III		MODEL IV		MODEL V	
STOREY	ux	uy	ux	uy	ux	uy	ux	uy	ux	uy
7	0.531	0.956	0.148	0.266	0.147	0.264	0.138	0.244	0.137	0.242
6	0.937	1.941	0.237	0.417	0.236	0.414	0.22	0.386	0.219	0.383
5	1.283	2.646	0.323	0.532	0.321	0.529	0.302	0.495	0.3	0.492
4	1.495	3.063	0.387	0.614	0.385	0.61	0.361	0.573	0.359	0.569
3	1.554	3.253	0.438	0.666	0.436	0.661	0.468	0.651	0.469	0.648
2	1.299	3.118	0.459	0.704	0.464	0.706	0.934	2.847	0.983	2.921
1	0.466	0.967	0.284	0.446	0.338	0.925	0.32	0.435	0.439	0.982

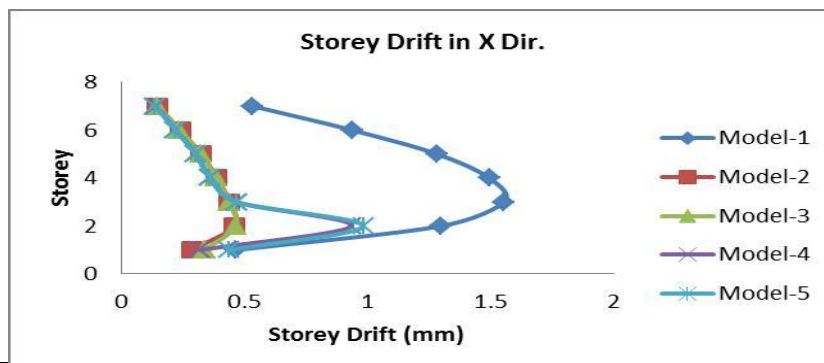


Fig. 3: Comparison of Storey Drift Vs Storey

Framed structure after excavation below plinth level (i. e. substructure portion) generally filled with loose soil material. This gives effect of soft basement to the structure. However, in such case, if it is modelled with infill masonry, its lateral stiffness changes. In this study five models are thoroughly analysed with empirical method given by IS code 1893-2002 and software ETABs.

The Results obtained by both methods are agreeing well with each other. The provision of infill wall, in this study, justified the reduction in time period compared with the case in which it is not provided. It is also observed that lateral stiffness in different models under consideration are increasing with the addition of infill compared to situation when infill is not provided.

In model-4, stiffness is increased by 38% compared to „Bare Model I.

In case of time period of framed structure, the results are having good agreement in longitudinal direction but showing somewhat overestimated values in transverse direction by ETAB analysis compared to IS code method. The time period for Model IV is 0.858 whereas Model I has 1.331. It shows that the use of infill wall below plinth level reduces the time period.

The storey drift of Model IV is 30% less compared to Model I at the first floor level. It is therefore concluded that the infill wall can be a good solution to reduce the storey drift at basement level. The study also reveal the displacement control is on higher side in Model 4, where infill in the basement is considered compared to Model -1 a bare frame.

At storey 2 level, the storey displacement of Model-4 is 30% lesser than Model 1 and at top storey level the displacement of Model 4 is 66% lesser than Model 1. The reduction in displacement at storey level 2 has given its effect to further reduce top displacement in the same structure.

5. CONCLUSIONS

The IS code methods are describing very insufficient guidelines about infill wall design procedures. Software like ETABs is used as a tool for analysing effect of infill on the structural behaviour. It is observed; ETABs provide overestimated values of fundamental period. According to relative values of all parameters, it can be concluded that provision of infill wall enhances the performance in terms of displacement control, storey drift and lateral stiffness.

REFERENCES

- [1] Das2, D., Murty, C.V.R (2004) “Brick Masonry infills in seismic design of RC framed buildings: Part 1- Cost implications”. *Indian Concrete Journal* 2004, vol.78 No.7: 39-43
- [2] Reddy, M.K., Rao, D.S.P., Chandrasekaran, A.R., (2007), “Modeling of RC Frame Buildings with Soft Ground Storey”, *Indian Concrete Journal*, Vol.81, No. 10: 42-49
- [3] Kormaz, K.A., Demir, F., Sivri, M., (2007), “Earthquake Assessment of R/C Structures with Masonry Infill Walls” *International Journal of Science and Technology*, Vol. 2, No. 2: 155-164
- [4] Kaushik, H.B., Rai, D.C., Jain, S.K., (2009), “Effectiveness of Some Strengthening Options for Masonry Infilled RC Frames with Open First Storey” *Journal of Structural Engineering*, Vol. 135, No. 8: 925-937
- [5] Dolsek, M., Fajfar, P., (2008), “ The Effect of Masonry Infills on the Seismic Response of a Four-Storey Reinforced Concrete Frame – A Deterministic Assessment”, Science Direct, *Engineering Structures*, Vol. 30: 1991-2001
- [6] Hong hao, Guo-Wei M., Yong L., 2002, “Damage Assessment of Masonry Infilled RC Frames Subjected to Blasting Induced Ground Excitations”, *Engineering Structure*, Vol.24, No.6, pp.671-838.
- [7] Harpal singh, Paul, D.K., Sastry, V.V., 1998, “Inelastic Dynamic Response of Reinforced Concrete Infilled Frames”, *Computers and Structures*, Vol.69, pp. 685-693.
- [8] IS 1893 (Part 1), (2002) “Criteria for Earthquake Resistant Design of Structures.” *Bureau of Indian Standards, New Delhi*
- [9] Kose M.M., and Karlioglu., (2008). “Effect of Infills on High-Rise Buildings: A CaseStudy”, *Structural Design Tall Spec..Building* 18: 907-920