EFFECT OF SOFT STORY BUILDING WITH RESPECT TO DIFFERENT TYPES OF INFILLS

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ABSTRACT

Soft storey building played an important role in development of multistoried buildings in India. Functional and Social need to provide car parking space at ground level and for offices open stories at different level of structure far out-weighs the warning against such buildings from engineering community. With the availability of fast computers, so that software usage in civil engineering has greatly reduced the complexities of different aspects in the analysis and design of projects. In this paper an investigation has been made to study the seismic behaviour of soft storey building with different arrangement in soft storey building when subjected to static and dynamic earthquake loading. It is observed that, providing infill improves resistant behaviour of the structure when compared to soft storey provided. Orey We put different types of infills in Eabs 2016 and applied static and dynamic loading on nodal point model . in this paper we considered earthquake zone 3 and four storey building .

Keywords: seismic loads, soft storey, static and dynamic analysis, Etabs 2016

I. INTRODUCTION

1.1 General:

Due to increasing population since the past few years car parking space for residential apartments in populated cities is a matter of major concern. Hence the trend has been to utilize the ground storey of the building itself for parking. These types of buildings (Fig. 1.1) having no infill masonry walls in ground storey, but infilled in all upper storeys, are called Open Ground Storey (OGS) buildings. They are also known as „open first storey building" (when the storey numbering starts with one from the ground storey itself), „pilot is", or „stilted buildings"

There is significant advantage of these category of buildings functionally but from a seismic performance point of view such buildings are considered to have increased vulnerability. From the past earthquakes it was evident that the major type of failure that occurred in OGS buildings included snapping of lateral ties, crushing of core concrete, buckling of longitudinal reinforcement bars etc. Due to the presence of infill walls in the entire upper storey except for the ground storey makes the upper storeys much stiffer than the open ground storey. Thus, the upper storeys move almost together as a single block, and most of the horizontal displacement of the building occurs in the soft ground storey itself. In other words, this type of buildings sway back and forth like inverted pendulum (Fig. 1.2) during earthquake shaking, and hence the columns in the ground storey columns and beams are heavily stressed. Therefore it is required that the ground storey columns must have sufficient strength and adequate ductility. The vulnerability of this type of building is attributed to the sudden lowering of lateral stiffness and strength in ground storey, compared to upper storeys with infill walls.

The OGS framed building behaves differently as compared to a bare framed building (without any infill) or a fully infilled framed building under lateral load. A bare frame is much less stiff than a fully infilled frame; it resists the applied lateral load through frame action and shows well-distributed plastic hinges at failure. When this frame is fully in filled, truss action is introduced. A fully infilled frame shows less inter-storey drift, although it attracts higher base shear (due to increased stiffness).

A fully infilled frame yields less force in the frame elements and dissipates greater energy through infill walls. The strength and stiffness of infill walls in in filled frame buildings are ignored in the structural modeling in conventional design practice. The design in such cases will generally be conservative in the case of fully in filled framed building. But things will be different for an OGS framed building. OGS building is slightly stiffer than the bare frame, has larger drift (especially in the ground storey), and fails due to soft storey-mechanism at the ground floor as shown in Fig. 1.3. Therefore, it may be unconservative to ignore strength and stiffness of infill wall while designing OGS buildings.

Inclusion of stiffness and strength of infill walls in the OGS building frame 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 OGS buildings are not captured in the conventional bare frame analysis. An appropriate way to analyze the OGS buildings is to model the strength and stiffness of infill walls. Guidelines are given in IS 1893: 2016 (Part-1) for modeling the infill walls. As an alternative a bare frame analysis is generally used that ignores the strength and stiffness of the infill walls.

The failure pattern observed in the buildings during the Jabalpur earthquake (1997) showed the vulnerability of OGS buildings. Some reinforced concrete framed building which collapsed partially, had open ground storey on one side for parking, and brick infill walls on the other side. In the aftermath of the Bhuj earthquake, the IS 1893 code was revised in 2002, incorporating new design recommendations to address OGS buildings. Clause 7.10.3(a) states: “The columns and beams of the soft storey are to be designed for 2.5 times the storey shears and moments calculated under seismic loads of bare frames.” The factor 2.5 can be told as a multiplication factor (MF). This multiplication factor (MF) is supposed to be the compensation for the stiffness discontinuity. But the IS 1893 code revised in 2016, Clause 7.10.1 states: “measure shall be taken along both directions in plan and measures are to provide structural RC wall and Braced frames in selected bays of building.” Hence the aim of this thesis is to check the applicability of RC shear wall and bracings when the building is to be designed as open ground storey framed building and to study the effect of infill strength and stiffness in the seismic analysis of low rise open ground storey building

Non-linear dynamic (NDA) analysis is considered to be the most accurate but at the same time it is most rigorous among all methods. Hence for the present study Response spectrum analysis (RSA) and Pushover analysis (PA) is considered for the comparative study. To carry out these analyses a typical building model with two different cases and support conditions are considered.

1) Considering infill strength and stiffness

2) Without considering infill strength and stiffness

Masonry infill walls are widely used as partitions all over the world. Evidences are that continuous infill masonry walls can reduce the vulnerability of the reinforced concrete structure. Often masonry walls are not considered in the design process because they are supposed to act as non-structural members or elements. Separately the infill walls are stiff and brittle but the frame is relatively flexible and ductile. The composite action of beam-column and infill walls provides additional strength and stiffness. The Fig. 1.4 shows the equivalent diagonal strut model for the infilled frame. The section of the equivalent pin-jointed strut can be identified by imposing the condition that the initial stiffness of the actual system is equal to the initial stiffness of the braced frame. The equivalent strut method is convenient for modeling the infill walls in the building. This approach aim at calculating the geometric properties and strength of an equivalent strut.

1.2 Scope:

Open ground storey (OGS) buildings are commonly constructed in populated countries like India since they provide much needed parking space in an urban environment. Failures observed in past earthquakes show that the collapse of such buildings is predominantly due to the formation of soft-storey mechanism in the ground storey columns.
∟ Number of storey and number of bays in two orthogonal horizontal directions may have a great effect on the lateral load resisting behaviour of OGS buildings. However, the conclusions drawn in the present study are based on a low-rise building (4 storeys).

∟ It is assumed in the present study that infill panels are having no window and door openings while modeling the infill walls.

∟ Point plastic flexural hinges only is considered for modeling the frame elements as the building is designed as per current design codes of practices and it is assumed no shear failure will precede the flexural failure.

∟ In the present study building models are analyzed only using dynamic analysis and nonlinear static (pushover) analysis. Although nonlinear dynamic analysis is superior to other analysis procedures, it is kept outside the scope of the present study due to time limitation.

1.3 Objectives:

Based on the literature review presented in Chapter 2, 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 OGS buildings.
2. ∟ To check the applicability of RC shear wall and bracings as per IS 1893:2016 instead of the multiplication factor of 2.5 as given in the Indian Standard IS 1893:2002 for design of low rise open ground storey building.
3. ∟ To assess the seismic behaviour of OGS buildings.

II.RESEARCH METHODOLOGY

The methodology worked out to achieve the above-mentioned objectives is as follows:
1. Review the existing literature and Indian design code provision for designing the OGS building.

2. Select a regular building model for the case study.

3. Model the selected building with and without considering infill strength/ stiffness.

4. Linear analysis of the selected building model and a comparative study on the results obtained from the analyses.

5. Nonlinear analysis of the selected building model and a comparative study on the results obtained from the analyses.

6. Observations of results and discussions.

III.MODELLING

Statement of Problem:

A RC framed building plan (Seismic Zone III) is selected for the present study. The building is fairly symmetric in plan and in elevation. This building is a G+4 storey building (15m high) and is made of Reinforced Concrete (RC) Ordinary Moment Resisting Frames (OMRF). The concrete slab is 150mm thick at each floor level. The brick wall thicknesses are 230 mm for external and internal walls. Imposed load is taken as 2.5 kN/ m2 for all floors. Roof live load is taken as 1.5 kN/ m2 for roof.

Fig. 3.1 presents typical floor plans showing different column and beam locations. The cross sections of the structural members are equal in all frames and all storeys

Five models have been considered for the purpose of the study.

∟ Model 1- Four storey(G+4) building as Bare frame.

∟ Model 2- Four storey(G+4) building with full infill wall.

∟ Model 3- Four storey(G+4) building with open ground storey and infill wall.

∟ Model 4- Four storey(G+4) building with shear wall in open ground storey and infill wall.

∟ Model 5- Four storey(G+4) building with steel bracing in open ground storey and infill wall.

The following seismic parameters were used to calculate the seismic forces and design.

Zone factor = 0.36 (Zone V)

Importance factor = 1.5 (Commercial Building)

Response reduction factor = 5 Special moment resting frame (SMRF)

The other detailed description is as follows:

1. Size of Building: 18m X 18m.

2. Floor to floor height: 3.0 m

3. Bracing ISMC 300

4. Slab thickness: 150 mm

5. Wall thickness: 230 mm

6. Grade of concrete (Beam): M25

7. Grade of concrete (Column):M25

8. Grade of steel: Fe 415

9. Density of concrete: 25 kN/m3

10. Density of masonry wall: 20 kN/m3

11. Size of Beam:300X450mm

12. Size of Column: 350X250mm

13. Live load on roof : 1.5 KN/m2

14. Live of on all other floors : 2.5 KN/m2

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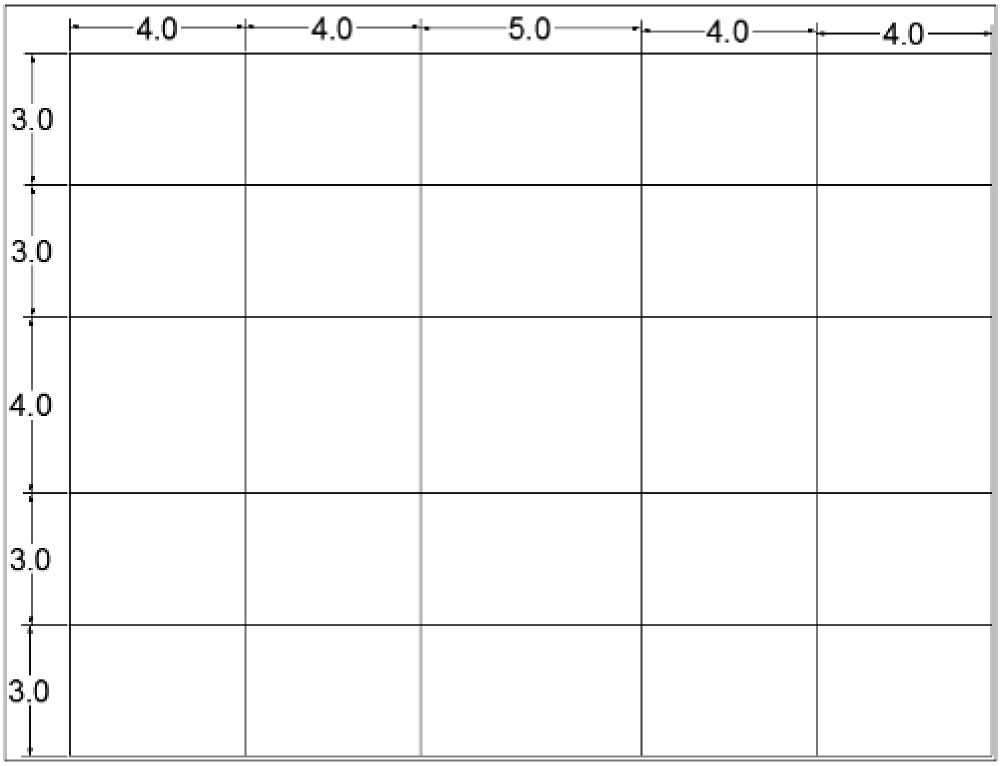

Fig. 1 Plan

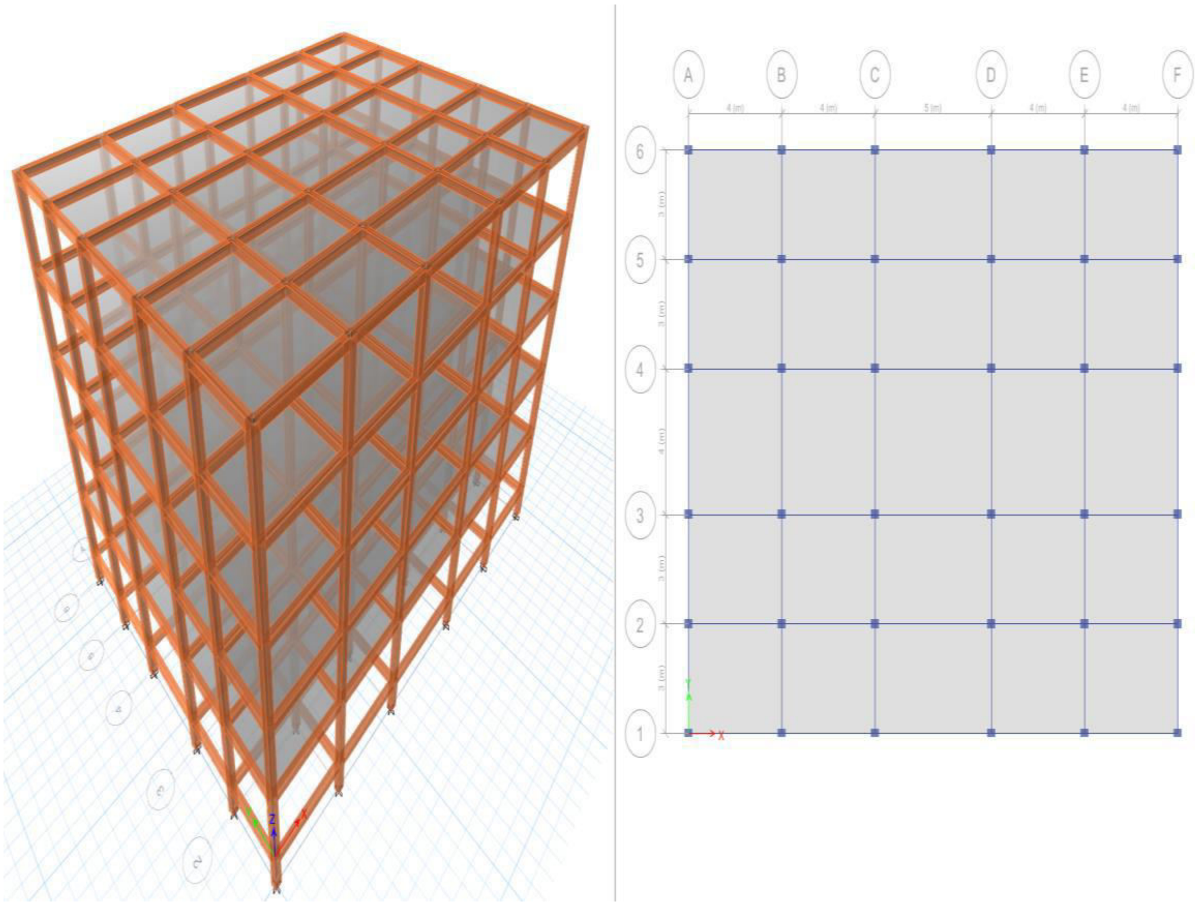

Fig. 2 Elevation

IV. RESULT

A. Base Shear

Type of Model	X direction	Y direction
Model 1	421.9964	370.6374
Model 2	1191.9774	1200.4485
Model 3	1133.9105	1134.4894
Model 4	1147.9397	1149.6263
Model 5	1134.2595	1131.9367

Table 1. Story Shear

Figure 5.1 shows table of maximum base shear in kN in X direction and Y direction of G+4 building. It shows that base shear values of bare frame is minimum. Base shear of frame with infill wall and open ground storey is higher than bare frame building. Base shear value is increased up to 60% by adding shear wall and steel bracing in open ground storey.

B. Modal Period and Frequency

Model	Model 1	Model 2	Model 3	Model 4	Model 5
1	0.99	0.424	0.862	0.477	0.553
2	0.869	0.365	0.728	0.389	0.473
3	0.826	0.346	0.715	0.315	0.371
4	0.326	0.134	0.142	0.131	0.135
5	0.279	0.117	0.125	0.114	0.119
6	0.269	0.108	0.112	0.101	0.119
7	0.193	0.074	0.071	0.071	0.119
8	0.159	0.066	0.063	0.063	0.119
9	0.157	0.063	0.06	0.06	0.118
10	0.14	0.055	0.053	0.053	0.103
11	0.116	0.048	0.047	0.047	0.086
12	0.11	0.047	0.046	0.046	0.086

Table 2. Modal period and frequency

Figure 5.2 shows table of modal period in sec of G+4 building. It shows that modal periods of bare frame and open ground storey frame are higher than frame with shear wall and bracing in ground storey.

C. Story Drift

Storey	Model 1	Model 2	Model 3	Model 4	Model 5
Storey6	0.901	0.171	0.148	0.156	0.16
Storey5	1.637	0.296	0.26	0.276	0.275
Storey4	2.257	0.405	0.349	0.39	0.387
Storey3	2.721	0.48	0.578	0.514	0.537
Storey2	2.928	0.625	6.414	0.861	1.719
Storey1	0.586	0.782	1.493	0.849	1.16

Table 3. Story Drift

Figure 5.3 table graph of storey drift in mm of G+4 building in X direction. It shows that drift value is highest at upper storey in frame with infill and open ground storey building is lowest for frame with shear wall and bracing in ground storey.

D. Maximum lateral Displacement

Type of Model	X direction	Y direction
Model 1	16.293	18.414
Model 2	6.58	8.637

Model 3	15.463	17.332
Model 4	6.042	8.439
Model 5	7.863	10.418

Table 4. Maximum lateral Displacement

Figure 4 shows table of maximum lateral displacement in mm of G+4 building in X and Y directions. It shows that maximum lateral displacement is highest for bare frame building. Maximum lateral displacement is reduced up to 75% by adding shear wall and bracing in open ground storey

V. CONCLUSION

RC frame buildings with open ground storeys are known to perform poorly during in strong earthquake shaking. The lateral strength of a building is sum of all the stiffness from column. shear wall and bracing are added at each storey. So the low strength in the lowest floor causing the failure occurs especially during earthquake. For a building that is not provided any lateral load resistance component such as bracing or shear wall, the strength is consider very weak and easy fail during earthquake.

VI. REFERENCES

[1] Aditya deshmukh, *"Earthquake resistant design of low-rise open ground storey framed building",* @IJMTER-2015

[2] Akhilesh Yadav and Dr. A. K. Mishra, *"Earthquake resistant design of open ground storey low rise building",* International Journal of Science Technology and management, 2017.

[3] Amol Karemore and Shrinivas Rayadub, *"Study on Effect of Zone on Magnification Factor for Open Ground Storey Buildings",* International Journal of Innovative and Emerging Research in Engineering Volume 2, Issue 5, 2015.

[4] C. M. Ravi Kumar, K. S. Babu Narayan and Reddy D. Venkat, *"Methodology for Probabilistic Seismic Risk Evaluation of Building Structure Based on Pushover Analysis",* OJAD 2014, 2(2):13-20.

[5] Deepak and Mr. Vaibhav Gupta, *"Earthquake Resistant Design of Low-Rise Open Ground Storey Framed Building",* International Journal of Engineering Science and Computing, July 2016.

[6] Diana Samoila, *"Masonry infill panels - analytical modeling and seismic behavior",* Vol. 3, Issue 8 (August. 2013).

[7] ETABS User‟s Manual, *"Integrated Building Design Software, Computer and Structure Inc. Berkeley"*, USA.

[8] IS:1893 (Part 1):2016, *"Criteria For Earquake Resistant Design Of Structures",* sixth edition 2016.