Seismic Evaluation of Multi-Storeyed R C Framed Structural System with The Influence of Different Shear Walls and Soft Storeys

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Abstract— Masonry infills are normally considered as non-structural elements and their stiffness contributions are generally ignored in practice. But they affect both the structural and non-structural performance of the RC buildings during earthquakes. 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 occur if first and second story used as service story. Hence a combination of two structural system components i.e. Rigid frames and RC shear walls leads to a highly efficient system in which shear wall resist the majority of the lateral loads and the frame supports majority of the gravity loads. To study the effect of masonry infill with different soft storey level, 9 models of Reinforced Concrete framed building were analyzed with two types of shear wall when subjected to earthquake loading. The results of bare frame and other building models have been compared, it is observed that model with swastika and L shape shear wall with core wall are showing efficient performance and hence reducing the effect of soft storey in model3, model4 and model5

Key words: *B*are frame Masonry infill, Shear wall, Soft Story

I. Introduction

The "cloud" has been defined as many things to many Many urban multistorey buildings in India today have open first storey as an unavoidable feature. This leave the open first storey of masonry infilled reinforced concrete frame building primarily to generate parking or reception lobbies in the first storey. It has been known for long time that masonry infill walls affect the strength & stiffness of infilled frame structures. There are plenty of researches done so far for infilled frames, however partially infill frames are still the topic of interest. Though it has been understood that the infill's play significant role in enhancing the lateral stiffness of complete structures.Infills have been generally considered as non-structural elements & their influence was neglected during the modeling phase of the structure. A soft storey building is a multi-storey building with one or more floors which are "soft" due to structural design. These floors can be especially dangerous in earthquakes. As a result, the soft storey may fail, causing what is known as a soft storey collapse. Soft storey buildings are characterized by having a storey which has a lot of open space. Parking garages, for example, are often soft stories, as are large retail spaces or floors with a lot of windows. While the unobstructed space of the soft storey might be aesthetically or commercially desirable, it also means that there are less opportunities to install shear walls, specialized walls which are designed to distribute lateral forces. If a building has a floor which is 70% less stiff than the floor above it, it is considered a soft storey building. This soft storey creates a major weak point in an earthquake, and since soft stories are classically associated with reception lobbies retail spaces and parking garages

Open ground storey building having only columns in the ground storey is known as soft storey. Due to some commercial and residential activit. The presence of the soft storey at ground ,first and second storey leads to severe damage during an earthquake. To minimize the effect of soft storeys at ground, first and second storey level of the building, swastika and L shape shear wall has been used.

The main aim of the present study to know the effect of infill and shear wall on the multistory building and the influence of existence of ground, first and second soft storey. How the different shapes of shear walls reduces the effect of soft storey and how it can enhance the overall performance of the building.

II. Description Of Structural Models

The study has done on 9 different models of an eleven storey building are considered the building has five bays in X direction and four bays in Y direction with the plan dimension 25 m × 20 m and a storey height of 3.5 m each in all the floors. The building is kept symmetric in both mutually perpendicular directions in plan to avoid torsional effects. 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 V. The building is founded on medium strength soil through isolated footing under the columns. Elastic moduli of concrete and masonry are taken as 27386 MPa and 3500 MPa respectively and their poisons ratio as 0.20 and 0.15 respectively. Response reduction factor for the special moment resisting frame has taken as 5.0 (assuming ductile detailing). The unit weights of concrete and masonry are taken as 25.0 KN/m3 and 20.0 KN/m3 respectively the floor finish on the floors is 1.5 KN/m2. The live load on floor is taken as 3.5 KN/m2. In seismic weight calculations, 50 % of the floor live loads are considered. Thickness of Slab, shear wall and masonry infill wall as 0.125m, 0.2 m and 0.23m respectively

III. Analytical Model Considered For Analysis

A. Model 1

Bare frame model, however masses of brick masonry infill walls (230mm thick) are included in the model.

B. Model 2

Building model has full brick masonry infill of 230mm thick in all the stories including ground storey and top storey.

C. Model 3

Building model has no brick masonry infill in ground storey and has full brick masonry infill of 230mm thick in upper stories.

D. Model 4

Building model has no brick masonry infill wall in ground and first story and has full brick masonry infill in rest of the storeys.

E. Model 5:

Building model has no brick masonry infill in ground, first ,second storey and has full brick masonry infill in rest of all storeys.

F. Model 6

Building model has no brick masonry infill in ground, first ,second storey . Further, swastika type of shear wall (200mm thick) is provided at corners.

G. Model 7

Building model is same as in model 6 and a concrete core (200mm thick) is provided at the centre.

H. Model 8

Building model is same as model 5.further, L shaped shear wall (200mm thick) is provided in both x and y direction.

I. Model 9

Building model is same as model 8 and a core wall (200mm thick) is provided at the centre.

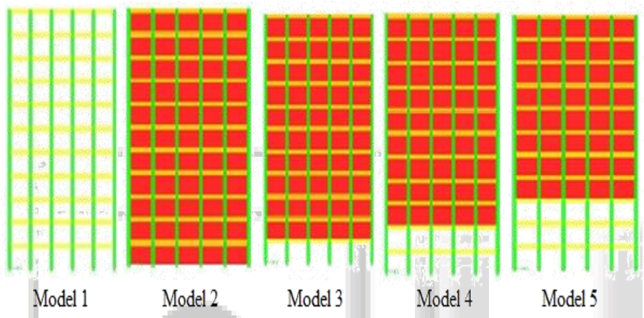

Fig. 1 : Eleven of various building models

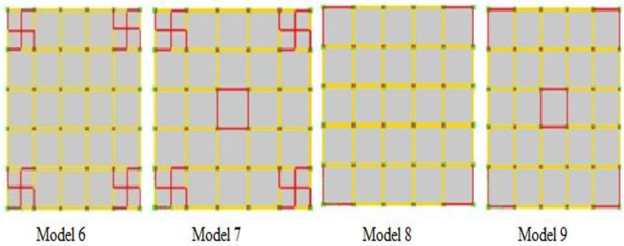

Fig. 2 : Plan of various building models

IV. MODELING OF FRAME MEMBERS, MASONRY INFILL WALL AND SHEAR WALL

The frame elements are modeled as beam elements. The masonry infill walls are modeled as four noded quadrilateral shell element of uniform thickness 0.23 and shear wall is modeled as pier element

V. RESULTS AND DISCUSSION

In this paper the results of the selected building models studies are presented. Analysis were carried out using ETABS and different parameters studied such as Fundamental natural time period, Base shear, storey displacement and storey drifts, the tables and figures are shown below.

Fundamental time period(Sec)				
	Is Code 1893-2002		Etabs Analysis	
Model No	Long	Tran	Long	Tran
1	1.1732	1.1732	1.6115	1.6115
2	0.693	.774	0.4793	0.4793
3	0.693	.774	0.6529	0.6529
4	0.693	.774	0.931	0.931
5	0.693	.774	1.141	1.141
6	0.693	.774	0.4893	0.4893
7	0.693	.774	0.4501	0.4501
8	0.693	.774	0.5373	0.5373
9	0.693	.774	0.4777	0.4777

Table 1: comparison of time period between IS code and ETAB

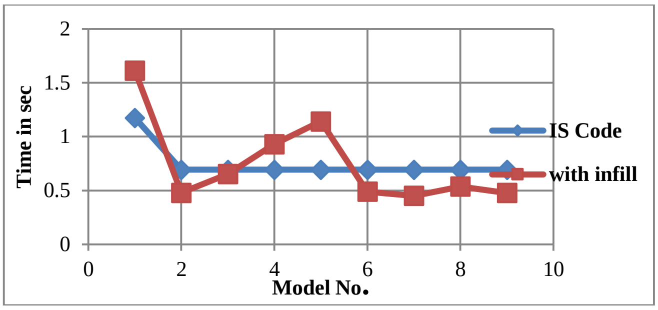

Fig. 3: Model Vs Time period for different building model along longitudinal direction

When the structural action of infill is taken the fundamental natural time got reduced 41% when compare with bare frame model for IS Code method shown in table1,it also shows natural time period for bare frame model from ETABS is 27.2% more than the IS code method .the time period of structure increases when soft storey is at ground level. as the number of soft storeys increase the fundamental natural time period is also increase. The time period get decreased suddenly when vertical shear walls of different shapes are provided at the corners.

From table 2 and Fig 4 it is clearly evident that the base shear obtained from IS code procedure is least as compare with equivalent static analysis and response spectrum analysis .response spectrum analysis shows the curve fluctuate very significantly lies in between IS code and equivalent static analysis apart from bare frame model all the models are in a straight line obtained from IS code method. The maximum decreased base shear are obtained in soft storey models in equivalent static analysis and response spectrum analysis.

Model .No	IS Code (KN)		Equivalent Static (Etabs)		Response spectrum (Etabs)	
1	4219.26	4219.226	4485.05	4030.76	2901.42	2901.42
2	7058.7	6324.03	13903.76	13903.8	11908.2	11004.5
3	6931.56	6210.12	13767.76	11471.2	11453.3	11242.5
4	6677.27	5982.3	9365.86	7702.23	9219.69	7549.81
5	6422.98	5754.48	6935.95	6003.95	6652.02	5792.29
6	6959.97	6235.58	13565.8	13565.8	11729.2	11755.5

7	7057.86	6323.58	13605.19	13605.2	11581.6	11583
8	6492.95	5817.17	12672.8	12672.8	11308.6	11320.3
9	6590.82	5904.85	12712.16	12712.2	11065	11055.6

Table 2: Comparison of Base shear with IS code, linear static analysis and Response spectrum analysis for various building models

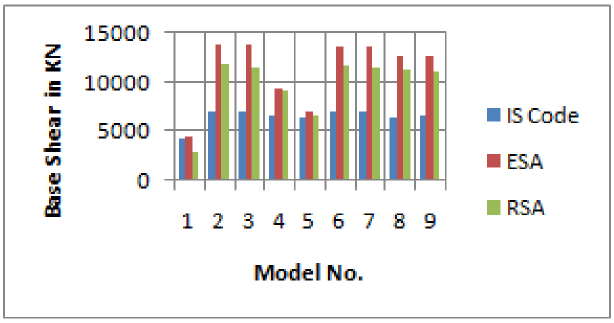

Fig. 4: Comparison of Base shear with IS code, ESA and RSA for various building models

STOREY DRIFT									
	MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 5	MODEL 6	MODEL 7	MODEL 8	MODEL 9
STOREY	Ux	Ux	Ux	Ux	Ux	Ux	Ux	Ux	Ux
11	0.458	0.22	0.223	0.162	0.127	0.163	0.153	0.16	0.155
10	0.775	0.269	0.271	0.194	0.151	0.19	0.176	0.191	0.181
9	1.096	0.309	0.31	0.221	0.171	0.217	0.199	0.22	0.206
8	1.363	0.337	0.339	0.241	0.186	0.239	0.219	0.243	0.225
7	1.57	0.355	0.356	0.253	0.195	0.257	0.234	0.26	0.24
6	1.72	0.361	0.364	0.258	0.199	0.27	0.244	0.273	0.25
5	1.819	0.358	0.362	0.257	0.193	0.279	0.251	0.283	0.257
4	1.868	0.346	0.351	0.243	0.242	0.295	0.26	0.306	0.27
3	1.85	0.324	0.326	0.296	1.571	0.415	0.337	0.545	0.403
2	1.671	0.297	0.361	1.797	2.177	0.382	0.303	0.531	0.375
1	0.927	0.238	1.197	1.523	1.296	0.227	0.181	0.337	0.238

Tabel 3: Story Drift

STOREY DISPLACEMENT									
	MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 5	MODEL 6	MODEL 7	MODEL 8	MODEL 9
STOREY	Ux	Ux	Ux	Ux	Ux	Ux	Ux	Ux	Ux
11	52.9	12	15.6	19.1	22.8	10.2	8.9	11.7	9.8
10	51.3	11.2	14.8	18.5	22.3	9.6	8.3	11.2	9.3
9	48.6	10.2	13.9	17.8	21.8	8.9	7.7	10.5	8.6
8	44.8	9.2	12.8	17	21.2	8.2	7.0	9.7	7.9
7	40.0	8	11.6	16.2	20.6	7.4	6.3	8.9	7.1
6	34.5	6.7	10.4	15.3	19.9	6.5	5.5	8.0	6.3
5	28.5	5.5	9.1	14.4	19.2	5.5	4.6	7.0	5.4
4	22.1	4.2	7.8	13.5	18.5	4.6	3.8	6.0	4.5
3	15.6	3	6.6	12.7	17.7	3.6	2.9	4.9	3.6
2	9.1	1.9	5.5	11.6	12.2	2.1	1.7	3.0	2.1
1	3.2	0.8	4.2	5.3	4.5	0.8	0.6	1.2	0.8

Tabel 4: Storey Displacement

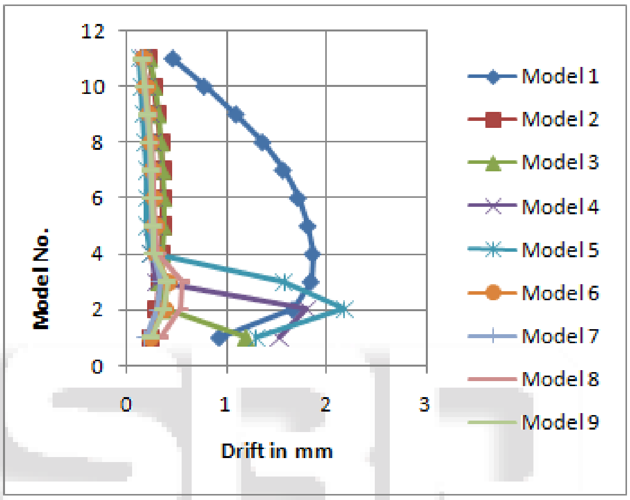

Fig. 5: Story Vs drift for different building models

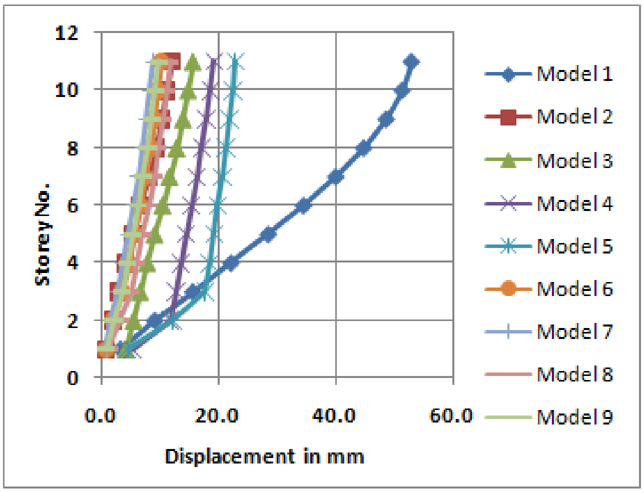

Fig. 6: Storey Vs Displacement for different building models

When masonry infill stiffness taken into consideration, Model 2 shows considerable reduction in storey drift .When Model5 is compared with model 2 storey drifts considerably increased to 86.35% .when shear wall is added either in swastika or L shape the storey drift are considerably reduced hence provision of concrete shear wall will reduce the soft storey effect [refer Table3 and Fig 5].

From [Fig 6 and Table 4] shows bare frame model has highest displacement in all the building models.

When masonry stiffness taken into consideration model 2 shows considerable reduction in displacement .The displacement value linearly vary from ground to top floor in both the directions. When comparison is made for model 2, model 3, model 4, model 5, model6, model7, model 8 ,model 9 with the bare frame model 1, the percentage of reduction in displacement are 77.31%,70.51%,63.89%,56.89%,80.71%,83.17%,77.88% and 81.47% as compare with bare frame.

VI. CONCLUSION

(1) Fundamental time period decreases when the effect of masonry infill wall and concrete shear wall is considered.
(2) The time period is not correctly obtained from the IS Code method for the different models compared with ETABS Analysis.
(3) The seismic base shear obtained from IS Code is not in a good agreement with the values obtained from ESA &RSA using ETABS.
(4) The story drifts are found within the limit as specified by the code IS 1893(Part-1): 2002.
(5) The storey drift value goes on increase as the soft story exist in ground, first and second story level. The drift suddenly reduced when shear wall of different shapes are provided.
(6) Swastika and L shaped shear wall with central core wall reduces the effect of soft storeys and also reduces story displacements.
(7) Consideration of stiffness of masonry infill and shear wall greatly influences the overall performance of the structure. Simply they cannot be neglected

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