A Study on Influence of Masonry Infill and Shear Wall on the Seismic Performance of R.C Framed Building

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Abstract— The study presents the procedure for seismic performance estimation of asymmetric R C frame buildings with ground soft storey based on a concept of the capacity spectrum method. Previous recent earthquakes in many parts of India and globe have revealed the issue regarding the vulnerability of existing buildings. The existing building structures which were designed and constructed according to earlier code provisions do not satisfy requirement of current seismic code and design practice. Many reinforced concrete buildings in urban regions lying in active seismic zone may suffer moderate to severe damages during future ground motion. Therefore it is essential to mitigate unacceptable In this study, 3D analytical model of eleven storied buildings have been generated for asymmetric buildings Models and analyzed using structural analysis tool 'ETABS". The analytical model of the building includes all important components that influence the mass, strength, stiffness and deformability of the structure. To study the effect of infill and concrete core wall & shear wall at different positions during earthquake, seismic analysis using both linear static, linear dynamic (response spectrum method) as well as non-linear static procedure (pushover) has been performed. It is an attempt to study the performance of multistoried reinforced concrete building frame due to influence/provision of masonry infill's and shear wall, five (5) building models (11 storey each) with identical building plan and asymmetry in elevation were study and analyzed. The deflections at each storey level has been compared by performing Equivalent static, response spectrum method as well as pushover method has also been performed to determine capacity, demand and performance level of the considered building models. From the below studies it has been observed that non-linear pushover analysis provide good estimate of global as well as local inelastic deformation demands and also reveals design weakness that may remain hidden in an elastic analysis and also the performance level of the structure. The result reveals that Fundamental natural period decreases when effect of infill wall and concrete core wall is considered. When the effect of infill walls are not considered, the building performance level remains within yield point to immediate occupancy level and when effect of infill walls are considered, the building performance level goes down to 'D' level, however, for concrete core wall model it remains within "Life Safety" level.

Key words: Influence of Masonry Infill & Shear Wall, R.C Framed Building

I. OBJECTIVES OF THE STUDY

1) The present project work is aimed at evaluating hypothetical existing RC framed building with the following objectives:
2) Creation of 3D building model for both elastic and inelastic method of analysis.
3) To perform lateral load analysis on different building models as per code.
4) To study the behavior of building on influence of masonry infill on the overall behavior of structure when subjected to lateral seismic forces.
5) To study the behavior of building on influence of concrete shear wall provided in different position (at Centre, corners in longitudinal and transverse direction) of the building.
6) To study the behavior of building on influence of concrete core wall provided at the center of the building.
7) To determine the collapse strength of the asymmetric building models to resist earthquake loading.

II. LITERATURE REVIEW

A project on to study the "[Effect of concrete core wall" by (Kabeyasawa, 1993; Eberhard and Sozen 1993)]1 had carried out a study on a tall building with concrete core wall subjected to different levels of earth quake ground motions of magnitude7, resulting in the mean core wall moments over height. According to this analytical result, the wall develops its plastic moment strength at the base, as intended in design, and wall base moment remains close to the plastic moment capacity as the intensity of ground motion increases. Wall moment above the base; however, continue to increase with increasing ground motion intensity even though the base has reached its plastic moment capacity. This is because lateral deformations in various "modes" and associated internal forces continue to increase as shaking intensity increases.

Design studies of tall concrete core wall buildings suggest that this behavior can lead to formation of secondary wall plastic hinges near mid height only by analyzing the building for the target hazard level.

A study on cyclic tests on ["RC frames with masonry infill's" (Murthy, C.V.R and Jain, S.K 2000)](2) was carried out with an objective to compare the performance of infill masonry frames with that of bare frames subjected to reverse cyclic displacement controlled loading. They concluded that the average initial stiffness of an infill RC frame is about 4.3 times than that of a bare frame where the masonry is unreinforced, and about 4.0 times that of bare frame when the masonry is reinforced. From strength point of view they showed that the unreinforced masonry infill frames had about 70% greater strength than bare frames; the value was about 50% higher in the case of RC infill frames. They also concluded that the yield displacement of infill frames is much smaller than that of the bare frame, and hence showed that the infill frames have considerably greater ductility.

A project on study the ["Effect of infill patterns and soft storey" by (Arlekar ,N.J. Jain K.S and Murty C.V.R.)]

(3) of Department of Civil Engineering, I.I.T.Kanpur for these study they had taken about Nine different models of the building are studied . Linear elastic analysis is performed for the nine models of the building using ETABS analysis package .They studied various parameters like storey stiffness, natural period, lateral displacements ,bending moments and shear force in columns. And they came to following conclusion .RC frame buildings with open first storey are known to perform poorly during in strong earthquake shaking. The drift and the strength demands in the first storey columns are very large for buildings with soft ground storey. It is not very easy to provide such capacities in the columns of the first storey. Thus, it is clear that such buildings will exhibit poor performance during a strong shaking. This hazardous feature of Indian RC frame buildings needs to be recognized immediately and necessary measures taken to improve the performance of the buildings. The open first 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 (a) increasing the stiffness's of the first storey such that the first storey is at least 50% as stiff as the second storey, i.e., soft first storey are to be avoided, and (b) providing adequate lateral strength in the first storey.

A project on [“Seismic assessment of RC Framed buildings with brick masonry infill's” by (Mulgund G.V)](4), in this study, five different models of an eight storey building symmetrical in the plan are considered. Usually in a building 40% to 60% presence of Masonry infill’s (MI) are effective as the remaining portion of the Masonry infill’s (MI) are meant for functional purpose such as doors and windows openings (Pauley and Priestley, 1992). In this study the buildings are modeled using 40 % Masonry infill’s (MI) but arranging them in different manner, after performing pushover analysis it was seen that the performance of fully masonry infill panels was significantly superior to that of bare frame and soft storey frames. The present study also demonstrates use of nonlinear displacement based analysis methods for predicting performance based seismic evaluation. It has been found that the IS code provisions do not provide any guidelines for the analysis and design of RC frames with infill panels. It has been found that calculation of earthquake forces by treating RC frames as ordinary frames without regards to infill leads to underestimation of base shear. The configuration of infill in the parking frame changes the behavior of the frame therefore it is essential for the structural systems selected, to be thoroughly investigated and well understood for catering to soft ground floor.

III. INTRODUCTION

A. Shear Wall

Shear walls are the main vertical structural elements with a dual role of resisting both the gravity and lateral loads. Wall thickness varies from 150 mm to 500 mm, depending on the number of stories, building age, and thermal insulation requirements. In general, these walls are continuous throughout the building height a shear wall may be tall shear wall or low shear wall also known as squat walls characterized by relatively small height-to-length ratio. Houses with many rooms separated by structural walls with minimal openings are good examples of shear wall buildings. Figure illustrates shear walls.

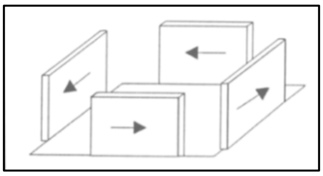

Fig. 1: Shear Wall

B. Effect of Shear Wall

Reinforced concrete walls are strength and important elements frequently used in constructions in seismic areas because they have a high lateral stiffness and resistance to external horizontal loads, these shear walls may be added solely to resist horizontal forces or concrete walls enclosing stairways elevated shafts and utility cores may serve as shear walls. Shear walls not only have a very large in plane stiffness and therefore resist lateral load and control deflection very efficiently but they also helps in reductions of structural & nonstructural damage. The building incorporated with shear wall sufficiently ductile will be much away from seismic vulnerability and building failure in the earthquake sensitive zones thus resulting in increased life safety & low property loss.

C. Purpose of Constructing Shear Wall

Shear walls are not only designed to resist gravity/vertical loads (due to its self-weight and other living/moving loads), but they are also designed for lateral loads of earthquakes/ wind. The walls are structurally integrated with roofs/ floors (diaphragms) and other lateral walls running across at right angles, thereby giving the three dimensional stability for the building structures. Shear wall structural systems are more stable. Because, their supporting area (total cross-sectional area of all shear walls) with reference to total plans area of building, is comparatively more, unlike in the case of RCC framed structure. Walls have to resist the uplift forces caused by the pull of the wind. Walls have to resist the shear forces that try to push the walls over. Walls have to resist the lateral force of the wind that tries to push the walls in and pull them away from the building.

IV. DESCRIPTION OF THE SAMPLE BUILDING

A. Model 1

Building has no walls in the first storey. The building is modeled as bare frame. However masses of the walls (230mm thick) are included on the upper stories. In addition to wall masses the other load like floor finish and imposed live load is also considered in all stories.

B. Model 2

Building has no walls in the first storey and one full brick infill masonry walls (230mm thick) in the upper storeys. Stiffness and mass of the walls are considered in addition to the wall masses other loads like floor finish and imposed live load is also considered in all stories.

C. Model 3

Building has no walls in the first storey and one full brick infill masonry walls (230mm) thick in the upper stories and also a structural concrete shear wall (200mm) thick is provided in both longitudinal and transverse direction at the exterior panel, in addition to wall masses other load like live load and floor finish is also considered in all stories.

D. Model 4

Building has no walls in the first storey and full brick infill masonry walls (230mm thick) in upper stories. The building is enhanced by a structural concrete core wall of thickness (200mm) at Centre, the mass and stiffness of walls is considered. In addition to the wall masses other loads like floor finish and imposed live load is also considered in all stories.

E. Model 5

Building has no walls in the first storey and one full brick infill masonry walls (230mm) thick in the upper storey and also a structural concrete shear wall (200mm) thick is provided in both longitudinal and transverse direction at all exterior corners, in addition to wall masses other load like floor finish is added to all stories.

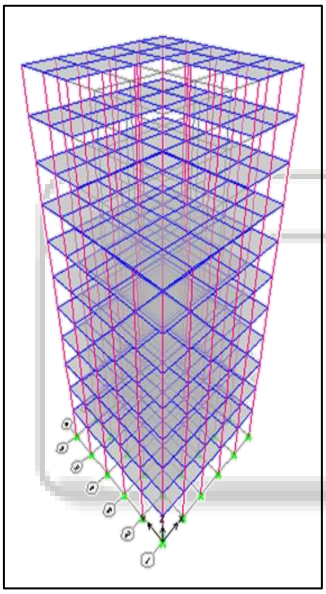
Fig. 2: Model 1

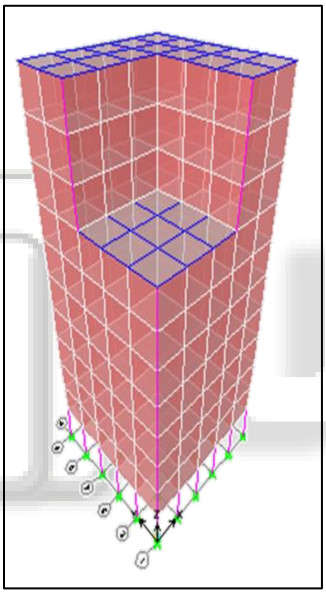
Fig. 3: Model 2

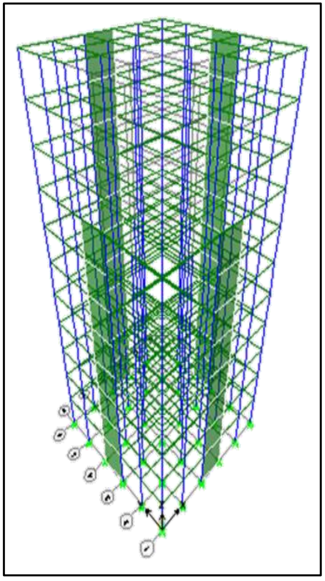
Fig. 4: Model 3

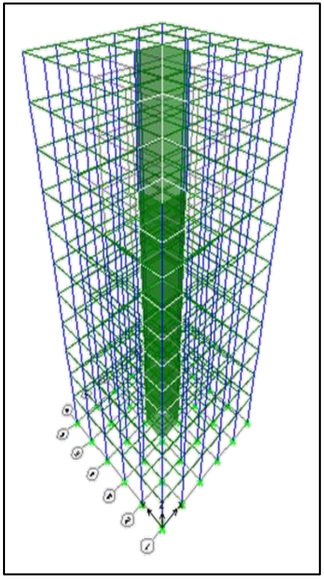
Fig. 5: Model 4

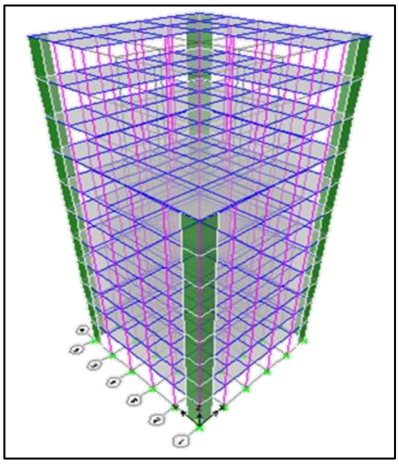
Fig. 6: Model 5

V. COMPARISON RESULTS

A. Design Seismic Base Shear for Asymmetric building models in longitudinal and transverse direction

Model No	V_{Bx} (KN)	V_{BY} (KN)
Model 1	814.26	814.26
Model 2	2666.24	2666.24
Model 3	2680.42	2680.42
Model 4	2672.61	2679.88
Model 5	2673.26	2680.53

Table 1: Models

B. Lateral Displacements

The maximum displacements at each floor level with respect to ground are presented in Table-5.4 to 5.8 for equivalent static response spectrum and pushover analysis. For better comparability the displacement for each model along the two directions of ground motion are plotted in graphs as shown in figure-5.1 to 5.6.

In the three dimensional model, however, there are six degrees of freedom with the two translational degree of freedom along X, Y-axes and rotation degree of freedom about Z (vertical)-axis playing significant role in the deformation of the structure. Apart from the translation motion in a particular direction, there is always an additional displacement due to the rotation of floor. Due to this the maximum displacement at floor levels obtained by three-dimensional analysis are always greater than the corresponding values obtained by one-dimensional analysis.

Moreover, the floor rotation is maximum at the top floor, gradually reducing down the height of the building to an almost negligible rotation at the lowest basement floor.

Storey No.	Asymmetric Building 1					
	Equivalent Static Method		Response Spectrum Method		Pushover Analysis Method	
	u_x	U_Y	U_X	U_Y	U_X	U_Y
11	20.63	34.75	14.71	18.84	26.46	29.75
10	19.85	33.70	14.26	18.38	25.84	29.17
09	18.67	31.93	13.55	17.61	24.87	28.20
08	17.19	29.46	12.65	16.51	23.57	26.76
07	15.58	26.47	11.65	15.14	22.04	24.86
06	13.65	22.98	10.41	13.47	20.02	22.42
05	11.42	19.10	8.92	11.52	17.47	19.43

04	8.98	14.95	7.22	9.29	14.39	15.90
03	6.42	10.67	5.32	6.83	10.80	11.86
02	3.87	6.42	3.29	4.21	6.83	7.47
01	1.55	2.57	1.34	1.72	2.86	3.11

Table 2: Lateral Displacements (mm) along Longitudinal and Transverse direction for Asymmetric building model-1

Storey No.	Asymmetric Building 2					
	Equivalent Static Method		Response Spectrum Method		Pushover Analysis Method	
	U_X	U_Y	U_X	U_Y	U_X	U_Y
11	5.97	8.17	3.73	4.62	11.19	11.94
10	5.56	7.78	3.55	4.45	10.69	11.49
09	5.11	7.32	3.35	4.26	10.14	10.98
08	4.63	6.81	3.12	4.04	9.55	10.43
07	4.23	6.30	2.93	3.81	9.02	9.86
06	3.81	5.76	2.72	3.57	8.45	9.24
05	3.39	5.22	2.51	3.31	7.85	8.58
04	2.97	4.68	2.29	3.04	7.21	7.90
03	2.58	4.16	2.06	2.76	6.56	7.19
02	2.23	3.68	1.84	2.49	5.91	6.49
01	1.87	3.16	1.60	2.17	5.14	5.65

Table 3: Lateral Displacements (mm) along Longitudinal and Transverse direction for Asymmetric building model 2

Storey No.	Asymmetric Building 3					
	Equivalent Static Method		Response Spectrum Method		Pushover Analysis Method	
	U_X	U_Y	U_X	U_Y	U_X	U_Y
11	4.28	5.06	2.37	2.55	14.77	15.23
10	3.92	4.73	2.20	2.40	13.84	14.40
09	3.52	4.34	2.01	2.23	12.79	13.47
08	3.08	3.92	1.80	2.04	11.65	12.46
07	2.72	3.49	1.62	1.85	10.66	11.39
06	2.36	3.03	1.43	1.64	9.60	10.24
05	1.98	2.57	1.24	1.42	8.46	9.01
04	1.62	2.12	1.04	1.19	7.26	7.72
03	1.27	1.68	0.84	0.96	6.01	6.39
02	0.95	1.26	0.64	0.74	4.75	5.03
01	0.65	0.86	0.45	0.51	3.38	3.57

Table 4: Lateral Displacements (mm) along Longitudinal and Transverse direction for Asymmetric building model-3

Storey No.	Asymmetric Building 4					
	Equivalent Static Method		Response Spectrum Method		Pushover Analysis Method	
	U_X	U_Y	U_X	U_Y	U_X	U_Y
11	3.95	5.95	2.77	2.82	13.80	15.24
10	3.58	5.57	2.62	2.69	12.87	14.34
09	3.17	5.12	2.46	2.53	11.85	13.36
08	2.73	4.63	2.27	2.36	10.75	12.29
07	2.35	4.14	2.12	2.19	9.74	11.19
06	1.96	3.64	1.95	2.01	8.67	10.02
05	1.57	3.12	1.78	1.82	7.53	8.78
04	1.19	2.62	1.59	1.63	6.35	7.49
03	0.83	2.13	1.41	1.43	5.14	6.18
02	0.50	1.68	1.23	1.25	3.92	4.86
01	0.21	1.24	1.03	1.04	2.67	3.49

Table 5: Lateral Displacements (mm) along Longitudinal and transverse direction for Asymmetric building model-4

Storey No.	Asymmetric Building 5					
	Equivalent Static Method		Response Spectrum Method		Pushover Analysis Method	
	U_X	U_Y	U_X	U_Y	U_X	U_Y
11	4.27	5.36	2.47	2.78	13.73	14.43
10	3.95	5.04	2.32	2.64	12.99	13.75
09	3.58	4.67	2.15	2.48	12.17	12.99
08	3.19	4.25	1.96	2.30	11.27	12.14
07	2.86	3.83	1.79	2.11	10.46	11.25
06	2.51	3.38	1.61	1.90	9.57	10.28
05	2.16	2.93	1.43	1.69	8.61	9.24
04	1.81	2.47	1.23	1.46	7.59	8.13
03	1.48	2.04	1.04	1.23	6.53	6.98
02	1.18	1.63	0.85	1.00	5.45	5.82
01	0.87	1.19	0.63	0.75	4.16	4.42

Table 6: Lateral Displacements (mm) along Longitudinal and Transverse direction for Asymmetric building model-5

VI. CONCLUSIONS

1) Fundamental natural period decreases when effect of infill wall and concrete core wall is considered.
2) Storey drifts are found within the limit as specified by code (IS 1893-2002 Part-1) in both linear and dynamic and non-linear static analysis.
3) Base shear at first hinge is less and displacement at first hinge is more for asymmetric bare frame model and vice versa for other models.
4) The presence of masonry infill influences the overall behavior of structures when subjected to lateral forces. Joint displacements and storey drifts are considerably reduced while contribution of infill brick wall is taken into account.
5) The presence of concrete core wall at the center has not affected much on the overall behavior of the structure when subjected to lateral forces, as compared to other models.
6) When the effect of infill walls are not considered, the building performance level remains within yield point to immediate occupancy level and when effect of infill walls are considered, the building performance level goes down to ‘D’ level, however, for concrete core wall model it remains within “Life Safety” level.
7) Ductility ratio is maximum for bare frame structure and it get reduced when the effect of infill wall is considered. It indicates that these structures will show adequate warning before collapse.
8) Bare frame structures are having highest response reduction factor as compared to infill frame structures. It indicates that bare frame structures are capable of resisting the forces still after first hinge.
9) In case of core wall structure it can be seen that almost all hinges are formed in link beams. To function properly under severe earthquake loading, the core wall requires ductile link beams that can undergo large inelastic deformations.
10) In case of shear wall at exterior corners the structure is subjected to less displacement in almost all cases

against the structure with core wall and shear wall at Centre , but the nonlinear hinge is found at

11) very less displacement and base shear. From the above study we conclude that model-3 i-e asymmetric R C frame building with shear wall at center of the exterior panel shows better performance among the others for the given seismic parameters

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