Wind Analysis and Design of Multi Bay Multi Storey 3D RC Frame

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Abstract

Any Tall building can vibrate in both the directions of along wind and across wind caused by the flow of wind. Modern Tall buildings designed to satisfy lateral drift requirements, still may oscillate excessively during wind storm. These oscillations can cause some threats to the tall building as buildings with more and more height becomes more vulnerable to oscillate at high speed winds.

This paper presents the study of wind analysis on buildings with different number of storeys using E-TABS. The research work includes a total number of forty five models of multi storey buildings. The models are categorised based on aspect ratio of the building. With an aspect ratio of 1, fifteen models are used with five storey, fifteen storey and thirty five storey height. Five different case are used in the model with five storey as mentioned, bare frame with wall loads, shear wall in X and Y direction, RC double diagonal bracing in X and Y direction. Similarly the fifteen and thirty five storey models were analyzed. Also the same numbers of models were analyzed with aspect ratios of 1.5 and 2.0. A comparison of lateral displacements and maximum storey drifts in X and Y directions are made for all the models.

Keywords – Shear wall, Double diagonal bracing, Aspect ratio, E-TABS.

1. Introduction

1.1 General

Windstorms pose a variety of problems in buildings particularly in tall buildings causing concerns for building owners, insurers, and engineers alike. Hurricane winds are the largest single cause of economic and insured losses due to natural disasters, well ahead of earthquakes and floods. The sway at the top of a tall building caused by wind may not be seen by a passerby, but may be of concern to those occupying its top floors. In buildings experiencing wind motion problems, objects may vibrate, doors and chandeliers may swing, pictures may lean, and books may fall off shelves.

Alfa Rasikan, M G Rajendran (1) has discussed Wind Behaviour of Buildings with and without Shear Wall. They concluded that the displacement for a 15 storey building with shear wall was 20.18% less than the 15 storey building without shear wall and the displacement for 20 storey building with shear wall was 14.6% less than the 20 storey building without shear wall. Hence it is found that building with shear wall resists wind load effectively. M.D. Kevadkar and P.B. Kodag (2) has discussed Lateral Load Analysis of R.C.C. Building. It is found that the X type of steel bracing system significantly contributes to the structural stiffness and reduces the maximum story drift and lateral displacement of R.C.C building than the shear wall system. P. S. Kumbhare and A. C. Saoji (3) have discussed the effectiveness of changing reinforced concrete shear wall location on multi-storeyed building. Shear wall frame interaction systems are very effective in resisting lateral forces. Abdur Rahman, Saiada Fuadi Fancy and Shamim Ara Bobby (4) have discussed the analysis of drift due to wind loads and earthquake loads on tall structures. The drift on high rise structures has to be considered as it has a notable magnitude.

1.2 Strengthening of RCC building with 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 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.

1.3 Strengthening of RCC building with RC Double diagonal Bracing

Bracing systems are used to resist horizontal forces (wind load, seismic action) and to transmit them to the foundations. Bracings hold the structure stable by transferring the loads sideways (not gravity, but wind or earthquake loads) down to the ground and are used to resist lateral loads, thereby preventing sway of the structure. Bracing increases the resistance of the structure against side sway or drift. The higher the structure, the more it is exposed to lateral loads such as wind load, since it has higher tendency to sway.

2. Modelling

The E-TABS software is used to develop 3D model and to carry out the analysis. The lateral loads to be applied on the buildings are based on the Indian standards. The building consists of reinforced concrete elements.

- 5, 15, 35 storied building with different aspect ratios 1.0, 1.5 and 2.0 analyzed for bare frame models.
- 5, 15, 35 storied building with different aspect ratios 1.0, 1.5 and 2.0 analyzed by providing Shear wall in X and Y directions.
- 5, 15, 35 storied building with different aspect ratios 1.0, 1.5 and 2.0 analyzed by providing Bracing in X and Y directions.

To find out effectiveness of shear wall and double diagonal bracing to RCC building there is need to study parameters as Lateral displacement and Story drift for that there is need to do static and dynamic analysis of structure.

Table 2.1: Preliminary Data:-

No. Of stories	5, 15, 35
Storey Height	3.00 m
Material property	
Grade of concrete	M25
Grade of Steel	Fe 415
Member Properties	
Thickness of slab	0.15 m
Beam Size	0.30 x 0.60 m
Column Size	0.60 x 1.0 m
Thickness of Shear wall	0.23 m
Thickness of Bracing	0.3 x 0.6 m

The building is located in Delhi. Therefore the wind velocity of the building is 47 m/s.

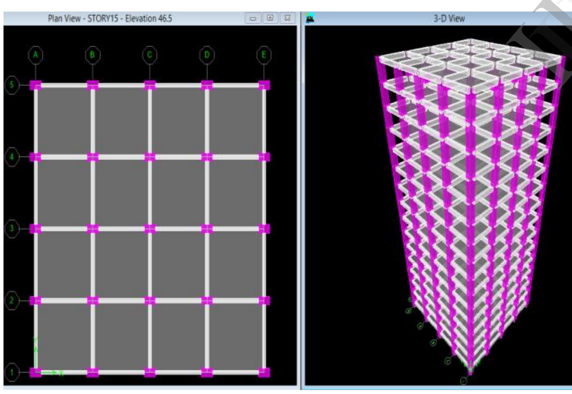

Figure 2.1 Bare frame model

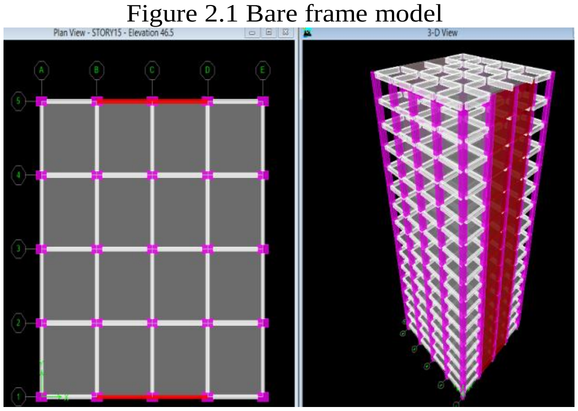

Figure 2.2 Shear wall in X-direction

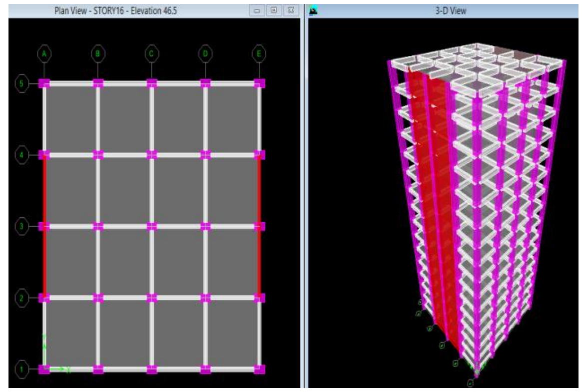

Figure 2.3 Shear wall in Y-direction

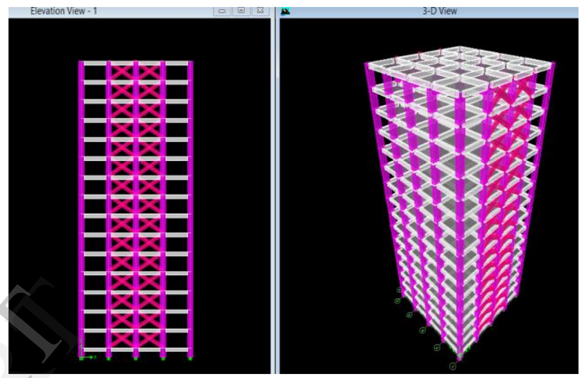

Figure 2.4 Double diagonal bracing in X-direction

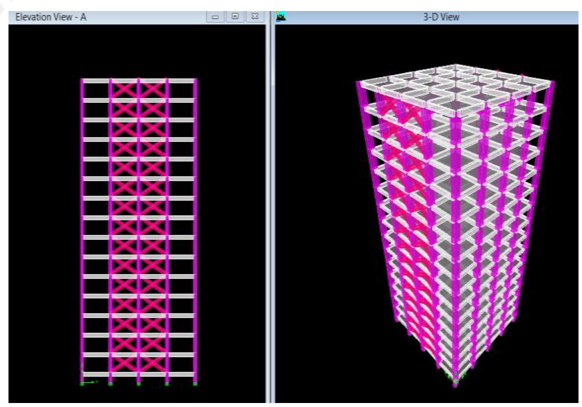

Figure 2.5 Double diagonal bracing in Y-direction.

3. Result and Discussion

Analysis of 5, 15, 35 storied Bare frame model, Shear wall in X and Y models and Bracing in X and Y models with three different aspect ratios is done using standard software, from the analysis results obtained, Bare frame model, Shear wall in X and Y directions and Double diagonal bracing in X and Y directions are compared. The comparison of these results to find effective lateral load resisting system is as below.

3.1 Lateral Displacement

The lateral displacements for five and fifteen storey building with respect to ground obtained from equivalent static method and for thirty five storey building obtained from gust factor approach are presented below.

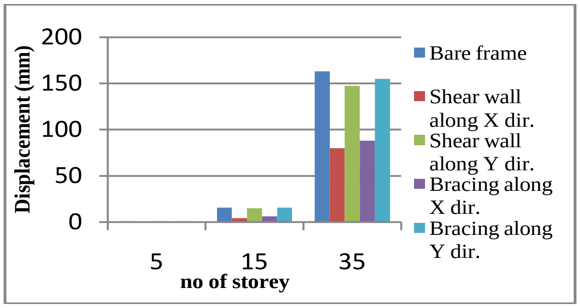

Fig 3.1 Comparison of Lateral displacement Vs Storey No. for varoius models with aspect ratio 1.0 along X-direction.

Considering thirty five storey height, it has been found that models shear wall along X-direction, shear wall along Y-direction, bracing along X-direction, bracing along Y-direction has 50.92%, 9.63%, 46.01%, and 4.9% respectively less displacement as compared to the bare frame model in X-direction and in Y-direction models shear wall along X-direction, shear wall along Y-direction, bracing along X-direction, bracing along Y-direction has 14.85%, 57.14%, 7.43% and 48.57% respectively less displacement as compared to the bare frame model. The displacement along X-direction is least for the model (shear wall along X-direction) as compared to the rest of the models. Similarly displacement along Y-direction is least for the model (shear wall along Y-direction). Further it has been observed that providing shear wall along the two directions (X and Y) the displacement is less compare to the models provided with the bracing along the two directions (X and Y).

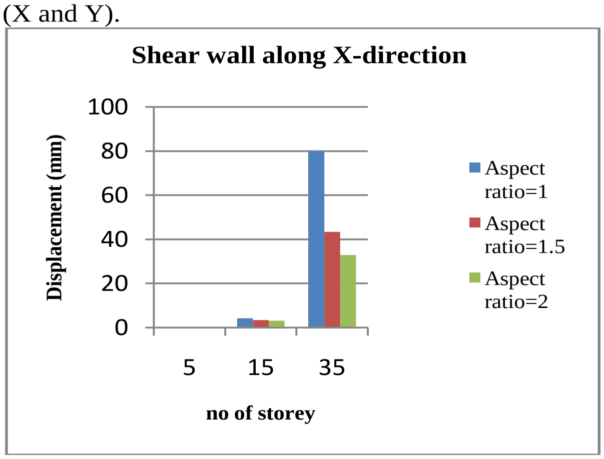

Figure 3.2 Comparison of Lateral displacement Vs Storey No. for Shear wall along X-direction with different aspect ratios along X-direction.

From the figure, it has been observed that as the aspect ratio increases the displacement value decreases in X-direction because of increase in stiffness of the structure along that direction. Further it has been observed that as the aspect ratio increases the displacement value increases in Y-direction.

3.2 Storey Drifts

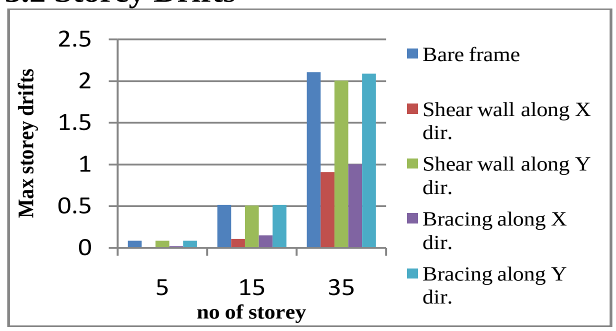

Figure 3.3 Comparison of Max storey drifts Vs Storey No. for varoius models with aspect ratio 1.0 along X-direction.

Considering thirty five storey height, it has been found that models shear wall along X-direction, shear wall along Y-direction, bracing along X-direction, bracing along Y-direction has 56.82%, 4.75%, 52.34%, and 0.855% respectively less storey drift as compared to the bare frame model in X-direction and in Y-direction models shear wall along X-direction, shear wall along Y-direction, bracing along X-direction, bracing along Y-direction has 12.00%, 63.27%, 2.40% and 56.13% respectively less storey drift as compared to the bare frame model. The storey drift along X-direction is least for the model (shear wall along X-direction) as compared to the rest of the models. Similarly storey drift along Y-direction is least for the model (shear wall along Y-direction). Further it has been observed that providing shear wall along the two directions (X and Y) the story drift is less compare to the models provided with the bracing along the two directions (X and Y).

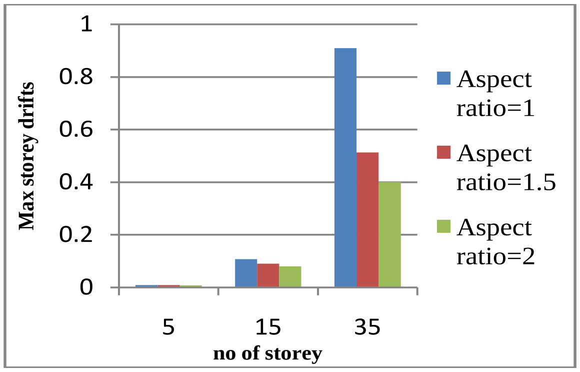

Figure 3.4 Comparison of Max storey drifts Vs Storey No. for Shear wall along X-direction model with different aspect ratios along X-direction.

From the figure, it has been observed that as the aspect ratio increases the storey drift value decreases in X-direction because of increase in stiffness of the structure along that direction. Further it has been observed that as the aspect ratio increases the storey drift value increases in Y-direction.

Shear wall and Bracing significantly decrease in the story drift compared with bare frame model which is within limit as per clause no 7.11.1 of IS-1893 (Part-1):2002.

4. Conclusion

1) RC shear wall acts as better lateral load resisting element when compared to the RC double diagonal bracing.
2) The presence of RC shear wall influences the overall behaviour of structures when subjected to lateral forces. Hence RC shear wall can be considered as displacement and drift control structural element.
3) The concept of using RC shear wall is one of the advantageous concepts which can be used to strengthen structure.
4) Since the lateral displacement is less for five and fifteen storey buildings. Thus the design of buildings of low to medium height the wind effects can be ignored which is usually practiced.
5) The lateral displacements are found within the limit as specified by code (IS 456-2000) in both static and dynamic analysis.
6) Maximum storey drifts found within the limit as specified by code (IS 1893-2002 part-1) in both static and dynamic analysis.

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