

Design of Structures to Resist Multi Hazards

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ABSTRACT: Large parts of the world are subjected to one or more natural hazards, such as earthquakes, tsunamis, landslides, tropical storms, costal inundation and flooding. In recent decades, rapid population growth and economic development in hazard-prone areas have greatly increased the potential of multiple hazards to cause damage and destruction of buildings, bridges, power plants, and other infrastructure; thus posing a grave danger to the community and disruption of economic and societal activities. Although an individual hazard is significant in many parts of the world, in certain areas more than one hazard may pose a threat to the constructed environment. In such areas, structural design and construction practices should address multiple hazards in an integrated manner to achieve structural performance. This report provides the drift ratio and percentage reduction in displacement comparison at different storey in columns for framed buildings with and without shear wall for various load combinations using sap 2000.

KEYWORDS: multi-hazard, drift ratio, percentage reduction in displacement

I. INTRODUCTION

India faces threat from a variety of natural hazards such as floods, droughts, landslides, cyclones, earthquakes and winds. A structure could be subjected to more than one critical type of hazards during its service life – multi hazard. In the present study, earthquake and wind are the two hazards considered in the context of design of buildings for multi hazards. Normally, when structures are designed against hazards, it is usual to assume that only one such hazard will act on the structure at a time and the design is routine. In the case of buildings situated on a Seismic area and located close to a sea coast, such as the ones in Chennai, they are liable to be hit by an earthquake and cyclone, though at different times. Nevertheless, the structure is to be designed to resist both these hazardous Conditions.

A. EFFECT OF EARTHQUAKE ON BUILDING

The RC frame participates in resisting the earthquake forces and the earthquake shaking generates inertia forces in the building, which are proportional to the building mass. Since most of the building mass is concentrated at floor levels, the earthquake induced inertia forces primarily develop at the floor levels. These forces travel downwards to reach the foundation from where they are dispersed into the ground. The structural elements, beams, columns, slabs and walls at lower storeys experience higher earthquake forces and hence are designed to be stronger than those at higher levels. Fig.1 shows collapse of reinforced concrete columns during earthquake.



Fig.1 Collapse of reinforced concrete columns (and building) during 2001 Bhuj (India) earthquake

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B. WIND EFFECTS ON BUILDING

Several factors such as terrain category, size, shape, height, and slenderness of the structure influence its design wind loads and its response. The effect of wind on the structure as a whole is determined by the combined action of external and internal pressures acting upon it. In all cases, the calculated wind loads act normal to the surface to which they apply. The stability calculations as a whole shall be done considering the combined effect, as well as separate effects of imposed loads and wind loads on vertical surfaces, roofs and other part of the building above general roof level. Buildings shall also be designed with due attention to the effects of wind on the comfort of people inside and outside the buildings.

C. SHEAR WALL STRUCTURES

Shear walls are vertical elements of the horizontal force resisting system. Shear walls are constructed to counter the effects of lateral load acting on a structure. When shear walls are designed and constructed properly, and they will have the strength and stiffness to resist the horizontal forces. In the last two decades, shear walls became an important part of mid and high-rise residential buildings. As part of an earthquake and wind resistant building design, these walls are placed in building plans reducing lateral displacements under the lateral loads. So shear-wall frame structures are obtained. 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 structures. Shear wall buildings are usually regular in plan and in elevation.

II. ANALYTICAL STUDIES

A G+10 storied building is to be analyzed. The plan consists of 3 bays of span 4m along X direction and 3 bays of span 4m along Y direction as shown in Fig.2 with a storey height of 3m each. The typical hypothetical building is to be studied for the effect of lateral loading (earthquake and wind forces). Similar dimensioned framed building and shear wall building is designed and various results are compiled and analyzed.

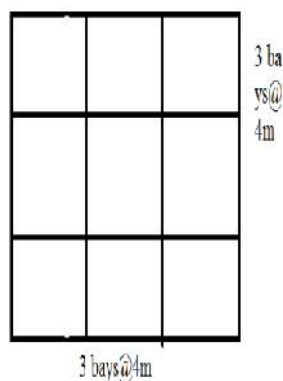


Fig.2 Plan of the building

PUSHOVER ANALYSIS

Pushover analysis is a numerical method which provides solutions to problems that would otherwise be difficult to obtain. In the present studies, analysis was carried out by using SAP 2000-V14 software to predict drift ratio and percentage reduction in displacement on structures. Analysis was carried on G+10 framed buildings with and without shear wall.

SPECIMEN MODELLING

Analysis was carried out on G+10 storey building. Figure 3 & 4 shows the 3D modeling of framed building with and without shear wall. The applied lateral loads were based on load combinations using IS-875 Part 1-5. The ductile detailing provisions were carried out on framed building with shear wall.

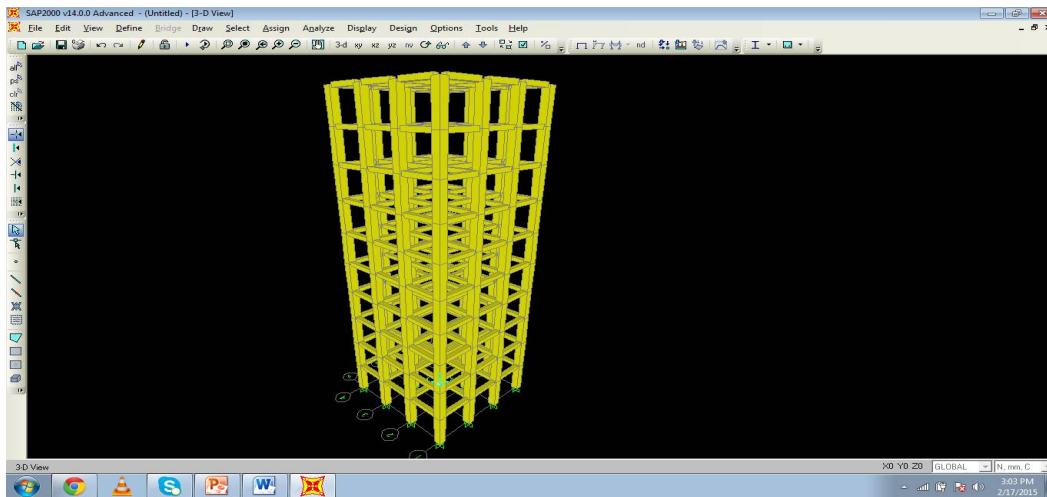


Fig.3 Framed building without shear wall

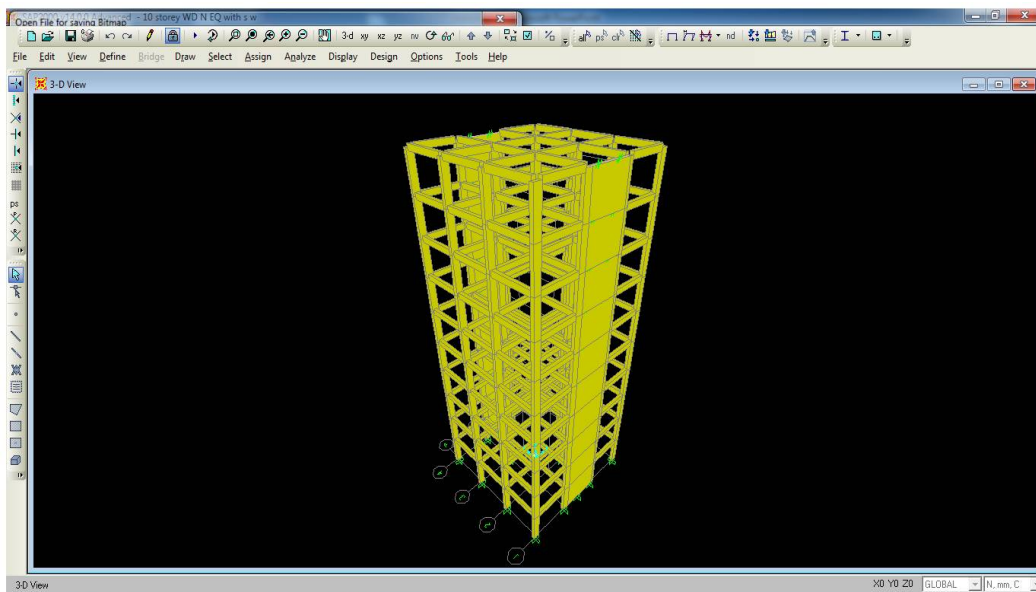


Fig.4 Framed building with shear wall

III. RESULTS

The Drift ratio and percentage reduction in displacement were obtained from SAP 2000. Table 1 & 2 shows the lateral loads due to earth quake and wind force respectively. It is observed that the shear wall building have low drift ratio when compared to normal framed building. The percentage of reduction in displacement is high in shear wall building when compared to normal framed building.

Table.1 Lateral loads due to Earth quake

Storey	Weight W_i (kN)	Height h_i (m)	$W_i \times h_i^2 \times 1000$	Q_i (kN)
1	1332	3	11988	2.04
2	1332	6	47962	8.18
3	1332	9	107892	18.40
4	1332	12	191808	32.72
5	1332	15	299700	61.13
6	1332	18	431668	73.62
7	1332	21	687412	100.21
8	1332	24	767332	130.89
9	1332	27	971028	166.66
10	1162	30	1036800	176.88

Table.2 Lateral loads due to Wind Pressure

H	V_b	K_2	V_z	P_z	A	Force	Force
3	60	0.88	44	1161.6	48	66766.8	66.7668
6	60	0.88	44	1161.6	48	66766.8	66.7668
9	60	0.88	44	1161.6	48	66766.8	66.7668
12	60	0.904	46.2	1226.824	48	68839.662	68.839662
15	60	0.94	47	1326.4	48	63619.2	63.6192
18	60	0.964	48.2	1393.944	48	66909.312	66.909312
21	60	0.986	49.26	1466.3376	48	69866.2	69.8662
24	60	1	60	1600	48	72000	72
27	60	1.016	60.76	1646.3376	48	74176.2	74.1762
30	60	1.03	61.6	1691.36	24	38192.4	38.1924

Load Combinations

Earthquake

- 1.5(D.L + L.L)
- 1.5(D.L ± E.Q)
- 1.2(D.L + L.L ± E.Q)
- 0.9D.L ± 1.5E.Q

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Wind

- 1.5(D.L ± W.L)
- 1.2(D.L + L.L± W.L)

Combination of Earthquake and Wind

- 0.9D.L + 1.5E.Q +0.9W.L
- 0.9D.L + 0.9E.Q +1.5W.L

For these combinations of load Storey wise displacement (mm) in extreme column for a framed building with and without shear wall are determined in sap 2000 and has been charted drift ratio and percentage reduction in displacement. Figure 5 & 6 shows the values of drift ratio for framed building with and without shear wall. Fig.7 shows the drift ratio for both frame and shear wall building.

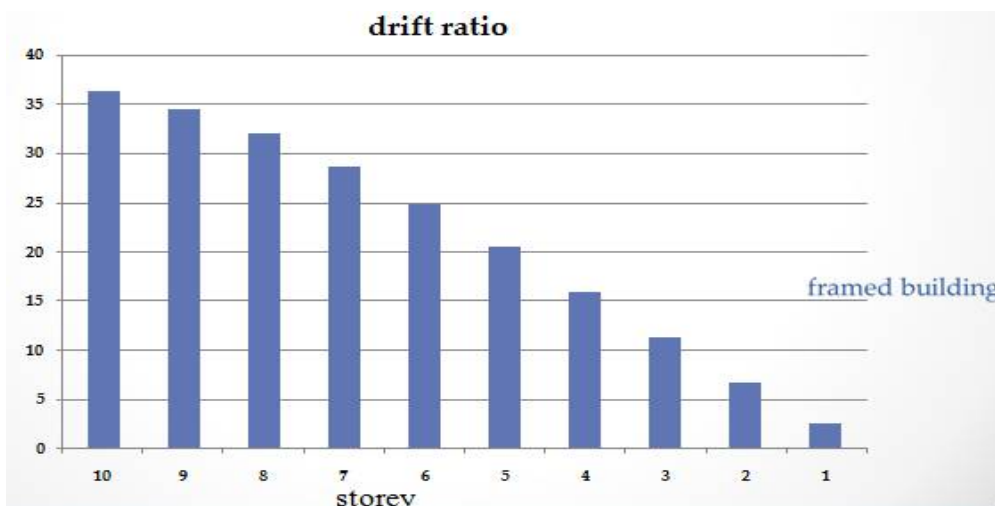


FIG.5 Drift ratio for frame building without shear wall

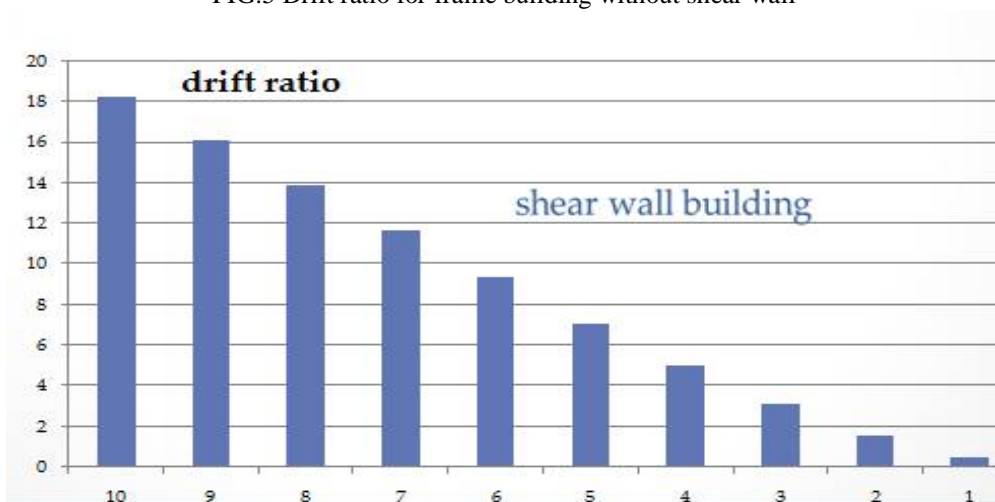


FIG.6 Drift ratio for frame building with shear wall

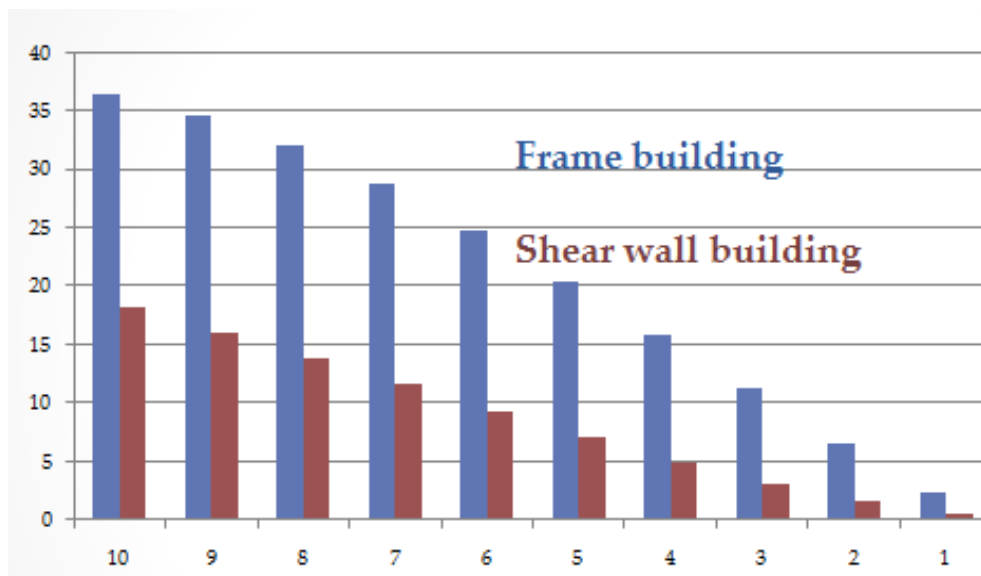


FIG.6 Drift ratio for frame and shear wall building
Drift ratio =displacement / storey height

IV. CONCLUSION

Designing against multiple hazards is more than doubly difficult when compared with designing against a single hazard, especially when those multiple hazards are wind and earthquake. Many favorable features of wind-resistant design are unfavorable for earthquake resistant design and vice versa. Heavy structures resist wind better and light structures resist earthquake better. Flexible structures attract greater wind forces. Stiff structures generally attract greater earthquake forces. By adding shear wall percentage reduction of displacement can increase.

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