A Review on Comparing the Effect Earthquake on High Rise Building with Shear Wall and Flanged Concrete Column

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Abstract

The present research states three type of models, moment resisting frame i.e. model 1, Shear wall building concentrically located along X- axis on outer periphery of building i.e. model 2, and Concrete column flange concentrically located on outer periphery along the X-axis i.e. model 3. Models of the three structures with same loading were created on STADDPro and were analyzed and further they were compared for their suitability. For 10 storey building and 3 bays along X-axis of 4m each and 4 bays along Z-axis of 4m each were considered and loads were applied as per the IS specifications.

The analysis was conducted as per the specifications of IS standards IS 13920, IS 1893, IS 875, IS 456. From the result it is seen that there is decrease of approximately 10% in Lateral storey shear and Base shear when the moment resisting frame was introduced with shear wall. Thus the model 2 and model 3 possessed 10% less lateral force and base shear as compared to the model 1. Also the results of Axial force, bending moment, Node displacement were found satisfactorily less than the moment resisting frame. If cost is been compared, then model 3 can be stated as economical in all sense since for the same configuration and load it greater stability and stiffness as checked from the node displacement results.

Keywords— *Software Analysis, High rise Building, Structure Elements , STADD PRO 3D.*

I. INTRODUCTION

At any particular point, the ground acceleration may be described by horizontal components along two perpendicular directions and a vertical component. In most instances only the structural response to the horizontal components of ground motion is considered since buildings are not sensitive to horizontal or lateral distortions. These horizontal forces, equal to mass times acceleration, represent the inertia forces that occur at the critical instant during the largest cycle of vibration, of maximum deflection and zero velocity, as the structure responds to earthquake motion. The effect of the vertical component of ground motion is generally considered not to be significant and is neglected except in cantilevers. For most structures, experience seems to have justified the viewpoint. In most instances, further simplification of the actual three-dimensional response of a structure is achieved by assuming that the design horizontal acceleration components will act non-concurrently in the direction of each principal plan-axis of a building. In addition to ground acceleration, rocking and twisting (rotational) components may be involved. Rocking and tensional effects, due to the horizontal components of ground motion, occur as a result of ground compliance and the non-coincidence of the centers of mass and rigidity. However, the rotational components of earthquake ground motion are usually negligible.

In virtually all earthquake design practice the structure is analyzed as an elastic system; it is acknowledged that the structural response to strong earthquakes involves yielding of the structure, so that the response is inelastic. The effect of yielding in a structure is two-fold. On one hand, stiffness is reduced so that displacements tend to increase. On the other hand, hysteretic yielding absorbs energy from the structure, increasing damping and reducing displacements.

The properties of a building are lateral stiffness, lateral strength and ductility.

Lateral stiffness refers to the initial stiffness of the building, even though stiffness of the building reduces with increasing damage. Increasing the column size increases both stiffness and mass of buildings. But, when the percentage increase in stiffness as a result of increase in column size is larger than the percentage increase in mass, the natural period reduces. As the height of building increases, its mass increases but its overall stiffness decreases. Lateral stiffness of columns along longer direction is more. Thus, it is important to have uniform distribution of stiffness in a building to ensure uniform distribution of lateral deformation and lateral forces over the plan and elevation of a building.

Lateral strength refers to the maximum resistance that the building offers during its entire history of resistance to relative deformation. Lateral strength of an RC building depends on many factors, including structural configuration adopted, material strengths and ductility's, relative sizes of structural members, amounts of reinforcement used in members, and strength and stiffness of joints between members.

Ductility towards lateral deformation refers the ratio of the maximum deformation and the idealized yield deformation. Ductility of a building is its capacity to accommodate large lateral deformations along the height. It is quantified as the ratio of maximum deformation that can be sustained just prior to collapse (or failure, or significant loss of strength) to the yield deformation. Thus, a ductile building exhibits large inelastic deformation capacity without significant loss of strength capacity. In a ductile building, the structural members and the materials used therein can stably withstand inelastic actions without collapse and undue loss of strength at deformation levels well beyond the elastic limit. Ductility helps in dissipating input earthquake energy through hysteretic behavior. Earthquake-resistant design of buildings relies heavily on ductility for accommodating the imposed displacement loading on the structure.

II. RESULT AND DISCUSSION

A 10 storied RCC building in zone III is modeled using STADDPro software and the results are computed. The configurations of all the models are discussed in previous chapter. Three models were prepared based on different configuration, Model 1 for non shear wall type of multistoried building, Model 2 for same building with Shear wall type and model 3 for same building with Column flange type. These models are analyzed and designed as per the specifications of Indian Standard codes IS1893, IS 13920, IS 875 and IS 456: 2000. The equivalent static method or seismic coefficient method had been used to find the design lateral forces along the storey in X and Z direction of the building since the building is unsymmetrical.

Elements or members of building should be designed and constructed to resist the effects of design lateral force. STADDPro gives the lateral force distribution at various levels and at each storey level. Lateral force of earthquake is predominant force which needs to be resisted for any structure to be earthquake resistant. The equivalent static method had been adopted to find out the lateral force in STADDPro. The Table No. 5.1 shows Storey height and the distribution of the lateral force and the base shear at each storey level in X-direction. The average percentage decrease in lateral force for model 2 and model 3, when compared with model 1, shows that there is approximate decrease of 10% for both the models.

Table 5.1 Lateral Force at different floor level along X-direction

Floor Height	Lateral Force			Percentage force decrease from model 1	
	Model 1	Model 2	Model 3	Model 2	Model 3
33	112.37	99.06	98.9	11.85	11.97
30	162.65	148	148	9.03	9.18
27	131.75	119.8	120	9.03	9.2
24	104.1	94.69	94.5	9.03	9.19
21	79.698	72.5	72.4	9.03	9.19
18	58.553	53.27	53.2	9.03	9.18
15	40.662	36.99	36.9	9.03	9.19
12	26.024	23.67	23.6	9.03	9.2
9	14.638	13.32	13.3	9.03	9.19
6	6.506	5.918	5.91	9.04	9.19
3	1.626	1.48	1.48	8.98	9.04
Average Percentage (%)				9.28	9.43

Table 5.2 shows base shear values at different floor level along X- Direction. Base shear is cumulative of lateral force from top storey to bottom storey. Thus the value of bottom floor shear is maximum and value of top storey shear is minimum. Introducing shear wall and column flange shows approximate 10% reduction in the base shear for model 2 and model 3 when compared with model 1. The values for each storey is cumulative of top storey thus it differs from storey to storey.

Table 5.2 Base shear at different floor level along X direction

Floor Height	Base Shear			Percentage force decrease from model 1	
	Model 1	Model 2	Model 3	Model 2	Model 3
33	112.372	99.061	98.917	11.85	11.97
30	275.02	247.019	246.635	10.18	10.32
27	406.765	366.865	366.26	9.81	9.96
24	510.86	461.558	460.784	9.65	9.80
21	590.558	534.057	533.16	9.57	9.72
18	649.111	587.322	586.34	9.52	9.67
15	689.773	624.311	623.267	9.49	9.64
12	715.797	647.984	646.898	9.47	9.63
9	730.435	661.3	660.191	9.46	9.62
6	736.941	667.218	666.099	9.46	9.61
3	738.567	668.698	667.578	9.46	9.61
Average Percentage				9.81	9.96

The Table No. 5.3 shows Storey height and the distribution of the lateral force and the base shear at each storey level in Z-direction. The percentage decrease in lateral force for model 2 and model 3, when compared with model 1, shows that there is approximate decrease of 10% for both the models, on each storey.

Figure 5.3 shows a graph of storey height Vs Lateral force in Z-Direction and it is evident that the lateral force for Model 1, Model 2, and Model 3 differs from each other storey wise. It is seen that for a particular model as the storey height increases the lateral force also increases except in the parapet level since the loads on the parapet level are less. Lateral force or storey shear for model 1, model 2 and model 3 are different and approximately 10% decrease in lateral force for model 2 and model 3 is seen at each storey level when compared with model

Table 5.3 Lateral Force at different floor level along Z-direction

Floor Height	Lateral Force			Percentage decrease from model 1	
	Model 1	Model 2	Model 3	Model 2	Model 3
33	128.897	113.629	113.464	11.85	11.97
30	186.567	169.716	169.442	9.03	9.18
27	151.119	137.47	137.217	9.03	9.20
24	119.403	108.618	108.424	9.03	9.19
21	91.418	83.161	81.019	9.03	11.38
18	67.164	61.098	61.001	9.03	9.18
15	46.642	42.429	42.358	9.03	9.18
12	29.851	27.155	27.106	9.03	9.20

9	16.791	15.274	15.248	9.03	9.19
6	7.463	6.789	6.777	9.03	9.19
3	1.866	1.697	1.697	9.06	9.06
Average Percentage (%)				9.29	9.63

Table 5.4 shows base shear values at different floor level along Z- Direction. Base shear is cumulative of lateral force from top storey to bottom storey. Thus the value of bottom floor shear is maximum and value of top storey shear is minimum. Introducing shear wall and column flange shows approximate 10% reduction in the base shear for model 2 and model 3 when compared with model 1. The values for each storey is cumulative of top storey thus it differs from storey to storey.

Table 5.4 Base shear at different floor level along Z- d

Floor Height	Base Shear			Percentage decrease from model 1	
	Model 1	Model 2	Model 3	Model 2	Model 3
33	128.897	113.629	113.464	11.85	11.97
30	315.464	283.345	282.906	10.18	10.32
27	466.583	420.815	420.123	9.81	9.96
24	585.986	529.433	528.547	9.65	9.80
21	677.404	612.594	609.566	9.57	10.01
18	744.568	673.692	670.567	9.52	9.94
15	791.21	716.121	712.925	9.49	9.89
12	821.061	743.276	740.031	9.47	9.87
9	837.852	758.55	755.279	9.46	9.86
6	845.315	765.339	762.056	9.46	9.85
3	847.181	767.036	763.753	9.46	9.85
Average Percentage				9.81	10.12

5.4 Shear Force and Bending Moment calculation:-

Sr. No.	**Model Name**	**Fy kN**	**Percentage Decrease compared to model 1**	**Fz kN**	**Percentage Decrease compared to model 1**
1	Model 1	112.705	0.00	78.886	0.00

2	Model 2	109.834	2.55	83.32	-5.62
3	Model 3	108.855	3.42	81.521	-3.34

From the table it is clear that when the model 2 and model 3 are compared with model 1, there is percentage decrease in shear force. A graphical representation of the table is shown in figure 5.6.

Table 5.7 shows maximum bending moment for different models in y and z direction. From the table it is clear that when the model 2 and model 3 are compared with model 1, there is percentage decrease in shear force in y direction and increase in z direction. Also for model 3 there is reduction in bending moment percentage than in case of model 3. Thus it shows that model 3 is most preferable. A graphical representation of the table 5.7.

Table 5.7 :- Maximum Bending Moment

Sr. No.	**Model Name**	**Mz kNm**	**Percentage Decrease compared to model 1**	**My kNm**	**Percentage Decrease compared to model 1**
1	Model 1	162.172	0.00	144.148	0.00
2	Model 2	167.05	-3.01	140.132	2.79
3	Model 3	163.015	-0.52	136.293	5.45

STADDPro models of the bending moment can be visualized in figure 5.8 for Model 1, Model 2 and Model 3. **Figure 5.8 :- Maximum Bending Moment For Model 1, Model 2, Model 3**

5.5 Maximum Node Displacement:-

Node displacement of any structure represents the deflection of the structure whenever any load or load combination is applied on the structure. Since the building is analyzed for Earthquake resistance, displacements in all the three directions are shown in table 5.8. Maximum displacements in X- Direction and Z- Direction for load combinations are stated in the table.

Table 5.8:- Maximum Node Displacement

Model Name	**Direction of Displacement**	**Load / Load Combination**	**Resultant Displacement (mm)**
Model 1	Max X (mm)	1.5(DL+EQX)	98.664
Model 2		1.5(DL+EQX)	45.328
Model 3		1.5(DL+EQX)	50.849

Model 1	Max Z (mm)	1.5(DL+EQZ)	105.226
Model 2		1.5(DL+EQZ)	96.911
Model 3		1.5(DL+EQZ)	95.414

III. CONCLUSION

Three different models are studied in this present research. A building with moment resisting frame named as model 1, for the same building shear walls are introduced symmetrically concentrically at outer edge and named as model 2, third type of model named model 3 is newly introduced as column flange type providing opening for shear wall. STADD Pro software is used for analysis and the results obtained were satisfactory and following are the concluded remarks that can be established from the results.

- Lateral force or storey shear at each consecutive storey level for model 1 is more as compared to model 2 and model 3. Model 3 has least lateral force on consecutive story’s as compared to model 1 and model 2.
- Approximately on an average 10% lateral force or storey shear is decreased by introducing Shear wall for same configuration as of model 1. Model 2 and Model 3 have 10% less storey shear as compared to Model 1.
- Base shear for model 1 is higher than model 2 and model 3. Approximately 10% decrease in base shear is calculated after introducing shear wall (Model 2) and flange column (model 3).
- Storey shear and base shear in both the directions i.e. along X-direction and along Z-direction for model 2 and model 3 are decreased by nearly same amount i.e. approximately 10% when compared to model 1.
- There is a pattern of reduction in node displacement for model 2 and model 3 when compared with model 1. This briefly states that the building is stiff with shear walls and column flanges. Whereas the model 3 becomes economical as the concrete is reduced being approximate similar stiffness is acquired due to less consumption of concrete.

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