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Seismic Analysis of Space Frame with T and Square Shaped Column

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Abstract: ***The seismic analysis is becoming a popular tool for seismic performance evaluation of existing and new structures. Seismic analysis provide an adequate information on seismic demands imposed by the design ground motion on the structural system and its components. The recent advent of structural design for a particular level of earthquake performance, such as immediate post-earthquake occupancy, (termed as performance based earthquake engineering), has resulted in guidelines such as ATC-40, FEMA-356 and standards such as ASCE-41. Among the different types of analysis, seismic analysis comes forward because of its optimal accuracy, efficiency and ease of use. In the present study, the behaviour of G+8 storied R.C frame buildings (H shape in plan, with T and square Shaped column) subjected to earthquake, located in seismic zone III was discussed briefly using STAAD. Pro software. Gravity loads and laterals loads as per IS 1893-2002 are applied on the structure and it was designed using IS 456.***

Keywords: column shape, irregular structure, storey drift, displacement, seismic analysis

1. Introduction

Recent earthquake in which many concrete structures have been severely damaged or collapsed have indicated the need for evaluating the seismic adequacy of existing buildings. About 60% of land area of India is susceptible to damaging levels of seismic hazard. We can't avoid future earthquakes, but preparedness and safe building construction practices can certainly reduce the extent of damage and loss. To have a reliable estimate of a structures, sophisticated analysis tools are necessary. Nonlinear dynamic analysis is the most accurate method available for the analysis of structures subjected to earthquake excitation. By conducting seismic analysis, we can predict the weak zones in the structures and then we will decide whether the particular part is required to be retrofitted or rehabilitated according to the requirement.

In this paper, the results of seismic analysis of reinforced concrete frames designed according to the IS1893:2002 has been presented. The behaviour G+8 storied R.C frame buildings (H shape in plan, with and square shaped column) subjected to earthquake is also discussed using Staad.pro. software.

The plan irregularity can be defined as per IS 1893-2002, that plan configurations of a structure and its lateral force resisting system contain re-entrant corners, where both projections of the structure beyond the re-entrant corner are greater than 15 percent of its plan dimension in the given direction. Buildings with large re-entrant corners, (i.e., plan shapes such as L, V, +,Y, etc.) show poor performance during earthquakes. Each wing of such a building tends to vibrate as per its own dynamic characteristic, causing a stress concentration at the junctions of the wings.

2. Objectives

a) To compare the seismic performance of an irregular space frame with T and square shaped column.
b) To find out storey drift, lateral displacement, moment, shear force, deflection etc
c) To conduct seismic analysis of an H- shaped reinforced concrete building located in seismic zone III, which is modelled in STAAD Pro.

3. Methodology

Seismic analysis is employed.

3.1 Modelling of Space frame

The general software STAAD Pro. has been used for the modelling.The seismic analysis software STAAD Pro. is utilized to create a three dimensional model and analysis is studied. It is more user friendly and versatile program that offers a wide scope of features like static and dynamic analysis, non linear dynamic analysis and non linear static pushover analysis, etc. The software is able to predict the geometric nonlinear behaviour of space frames under static or dynamic loadings, taking into account both geometric nonlinearity and material inelasticity. The software accepts static loads (either forces or displacements) as well as dynamic (accelerations) actions, nonlinear static pushover and nonlinear dynamic analyses.

A two or three dimensional model with G+8 storied RC frame which includes bilinear or tri linear load-deformation diagrams of all lateral force resisting elements are first created. Here two models are created. First is the model with T shaped column and second one is the model with square shaped column is further created.

3.1.1 Building Plan and Dimension Details

Space frame used in this study are 8 storied with T and square shaped column provided in the re entrant corners are shown in figure1.Table 1 shows the specification of G+8 storied RCC space frame located in seismic zone III.

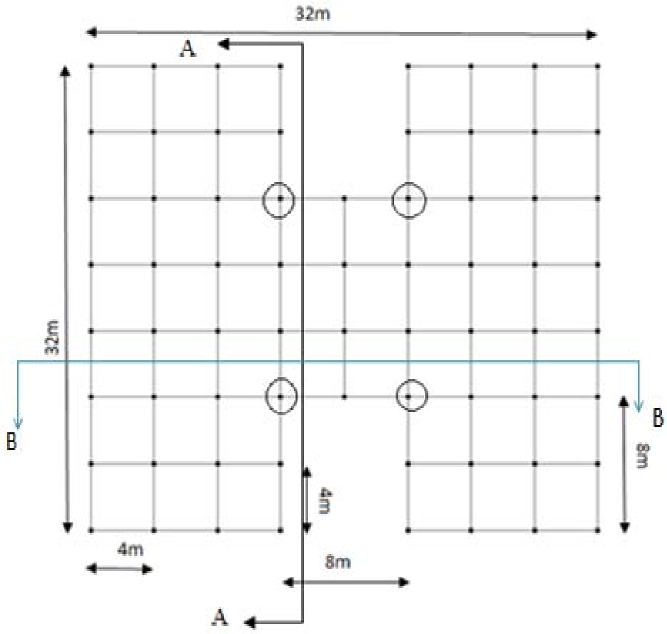

Figure 1: Plan of Building

Table 1: Details and Dimension of the Building Models

Type of structure	Ordinary moment resisting RC frame
Grade of concrete	M 40 (fck= 40 N/mm^2)
Grade of reinforcing steel	Fe 415
Plan area	896 m^2
Number of stories	G+8
Floor height	3.5m
Column size:	230x600mm
T Shape Square column	B=1.5m,D=1.5m,and tw&tf = 0.3m 600x600 mm
Beam size	230x 600mm
Wall thickness	230mm
Density of concrete	25N/ mm^3
Live Load on Floor and roof	3 kN/mm^2 and 1.5 kN/ mm^2
Plan irregularity:	H shape

a) Model-1: H shaped plan with T shaped column provided in re-entrant corners.
b) Model -2: H shaped plan with square shaped column provided in re-entrant corners.

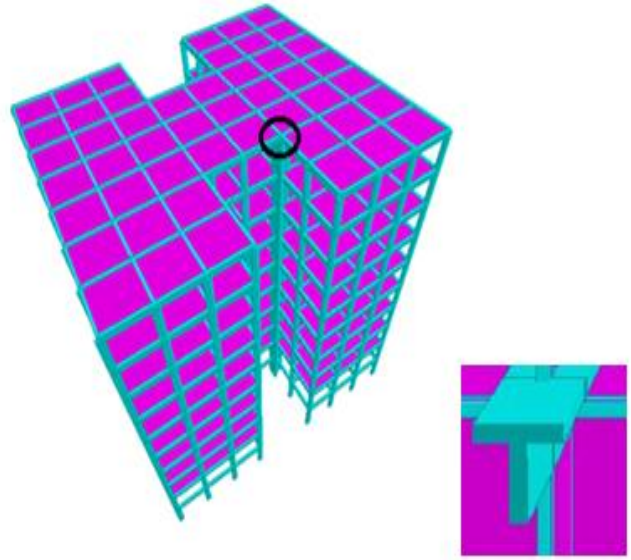

Figure 2: Building Model with T Shaped Columns (Section A-A)

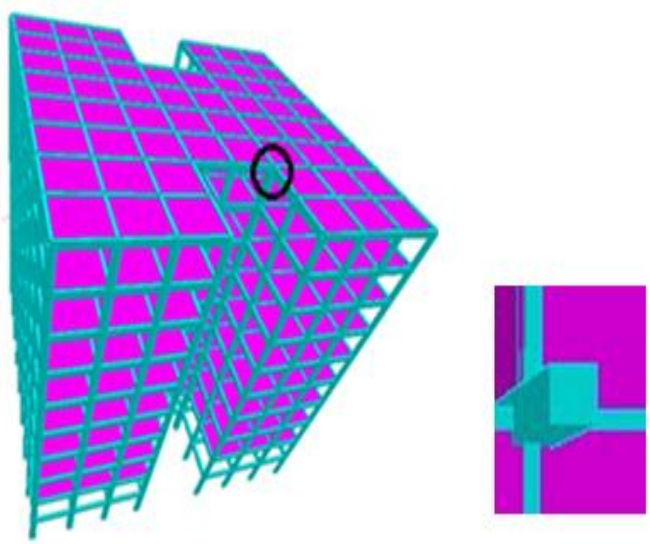

Figure 3: Building Model with Square Shaped Columns (Section A-A)

3.2 Load Formulation

Dead loads are considered as per IS 875 (Part I) – 1987 and steel tables &Live load IS 875 (Part II) -1987. In addition to the above mentioned loads, seismic loads are also be assigned.

- Live Load

Floor load:
Live Load Intensity specified (Public building) = 3kN/m^2
Live Load at roof level =1.5 kN/m

4. Analysis

After assigning the loads to the structure, seismic analysis is done to evaluate the maximum shear force, bending moment and the dynamic results in the form of storey drift and lateral displacements. Seismic evaluation of RC space frame with T and equivalent square column is carried out. After this analysis the behaviour of the buildings are compared in terms of storey drift, displacement and base shear. And the seismic analysis is carried out in X directions. The maximum value of bending moment, shear force and the axial force of this model with T and square shaped column are shown in the figure 4 and figure 5.

Beam	L/C	Node	Axial Force kN	Shear-Y kN	Shear-Z kN	Torsion kNm	Moment-Y kNm	Moment-Z kNm
140	12	25	659.312	1015.156	-23.722	0.662	41.244	2122.428
140	16	25	503.882	1014.286	-24.712	0.674	42.656	2121.361
142	16	27	-37.392	1012.062	27.757	0.664	-47.014	2118.697
142	12	27	117.979	1011.130	28.745	0.676	-48.427	2117.506
123	12	8	690.699	944.254	6.877	-0.030	-10.325	2026.828
123	16	8	535.109	943.142	7.921	-0.044	-11.749	2025.362
121	16	6	-68.115	939.815	-10.996	-0.082	15.918	2020.985
121	12	6	87.486	938.712	-12.035	-0.095	17.333	2019.539
142	7	27	1565.672	812.556	16.556	0.442	-28.726	1699.712
140	7	25	1999.493	807.187	-25.496	0.675	43.177	1689.734
121	7	6	1540.437	757.884	-3.504	-0.061	4.257	1627.442
123	7	8	2023.494	748.396	11.595	-0.036	-17.793	1609.489
140	12	93	-559.117	-1015.156	23.722	-0.662	41.784	1430.617
140	16	93	-443.765	-1014.286	24.712	-0.674	43.836	1428.639
142	16	95	97.510	-1012.062	-27.757	-0.664	-50.137	1423.521
142	12	95	-17.783	-1011.130	-28.745	-0.676	-52.181	1421.449
142	1	27	-180.299	675.640	17.517	0.431	-29.929	1413.654
140	1	25	180.491	675.320	-17.464	0.461	29.849	1413.173
123	1	8	201.149	627.650	6.324	-0.043	-9.256	1348.776
121	1	6	-201.011	627.647	-6.291	-0.042	9.198	1348.769
123	12	76	-590.503	-944.254	-6.877	0.030	-13.744	1278.062
123	16	76	-474.991	-943.142	-7.921	0.044	-15.974	1275.636
121	16	74	128.232	-939.815	10.996	0.082	22.567	1268.369
121	12	74	12.710	-938.712	12.035	0.095	24.791	1265.954
142	7	95	-1485.516	-812.556	-16.556	-0.442	-29.221	1144.234
140	7	93	-1919.337	-807.187	25.496	-0.675	46.059	1135.420
121	7	74	-1460.281	-757.884	3.504	0.061	8.008	1025.150
123	7	76	-1943.338	-748.396	-11.595	0.036	-22.789	1009.897
142	1	95	180.299	-675.640	-17.517	-0.431	-31.381	951.085
140	1	93	-180.491	-675.320	17.464	-0.461	31.276	950.447
123	1	76	-201.149	-627.650	-6.324	0.043	-12.879	847.998
121	1	74	201.011	-627.647	6.291	0.042	12.821	847.994
323	14	93	50.779	251.266	-5.179	0.331	9.925	694.947
323	18	93	-4.729	250.656	-5.474	0.326	10.511	693.720

Figure 4: Maximum Value of Bending moment, Shear force of model with T Shaped Columns

Beam	L/C	Node	Axial Force kN	Shear-Y kN	Shear-Z kN	Torsion kNm	Moment-Y kNm	Moment-Z kNm
159	16	28	-18.841	280.352	1.219	-0.419	-0.791	507.081
159	12	28	66.622	280.285	1.904	-0.382	-1.732	507.007
157	12	26	307.144	279.940	0.644	-0.454	-1.317	506.569
157	16	26	242.492	279.687	0.513	-0.452	-1.267	506.249
139	12	8	250.225	270.239	3.165	-0.494	-5.242	489.204
139	16	8	209.526	270.143	3.675	-0.505	-6.090	489.134
137	16	6	-84.303	269.785	-4.750	-0.546	7.870	488.712
137	12	6	-41.255	269.681	-4.944	-0.547	8.184	488.566
159	16	105	45.560	-280.352	-1.219	0.419	-3.475	474.151
159	12	105	-22.091	-280.285	-1.904	0.382	-4.932	473.992
157	12	103	-262.612	-279.940	-0.644	0.454	-0.938	473.221
157	16	103	-215.773	-279.687	-0.513	0.452	-0.529	472.654
139	12	85	-205.694	-270.239	-3.165	0.494	-5.835	456.632
139	16	85	-182.807	-270.143	-3.675	0.505	-6.772	456.366
137	16	83	111.022	-269.785	4.750	0.546	8.757	455.533
137	12	83	85.786	-269.681	4.944	0.547	9.119	455.319
159	7	28	889.378	223.880	-0.625	-0.456	1.821	405.136
157	7	26	1125.402	223.768	-0.621	-0.294	0.419	404.997
139	7	8	1132.753	216.328	4.436	-0.497	-7.306	391.619
137	7	6	894.320	215.622	-2.754	-0.365	4.623	390.763
159	7	105	-853.753	-223.880	0.625	0.456	0.367	378.446
157	7	103	-1089.777	-223.768	0.621	0.294	1.753	378.189
139	7	85	-1097.127	-216.328	-4.436	0.497	-8.219	365.529
137	7	83	-858.695	-215.622	2.754	0.365	5.015	363.915
159	1	28	-98.024	186.968	0.128	-0.316	0.414	338.128
157	1	26	97.010	186.204	0.211	-0.300	-0.794	337.179
139	1	8	98.984	179.999	2.960	-0.348	-4.907	326.020
137	1	6	-99.251	179.960	-2.974	-0.363	4.932	325.955
159	1	105	98.024	-186.968	-0.128	0.316	-0.860	316.260
157	1	103	-97.010	-186.204	-0.211	0.300	0.056	314.537
139	1	85	-98.984	-179.999	-2.960	0.348	-5.451	303.978
137	1	83	99.251	-179.960	2.974	0.363	5.475	303.904
191	12	60	56.227	111.702	0.026	-0.059	-0.026	199.162

Figure 5: Maximum Value of Bending moment, Shear force of Model with Square Shaped Columns

5. Results and Discussion

After analysing the models various results are obtained. And these results are evaluated by preparing various graphs. The results of the analysis for model T shaped column and the model with square shaped column are represented in the form of lateral displacement and storey drift as shown in Figure.6 and Figure7.Table2 and Table 3 shows the values of lateral displacement and storey shear for both models in each storeys. The graphs are compared to understand which model is more effective in resisting lateral loads.

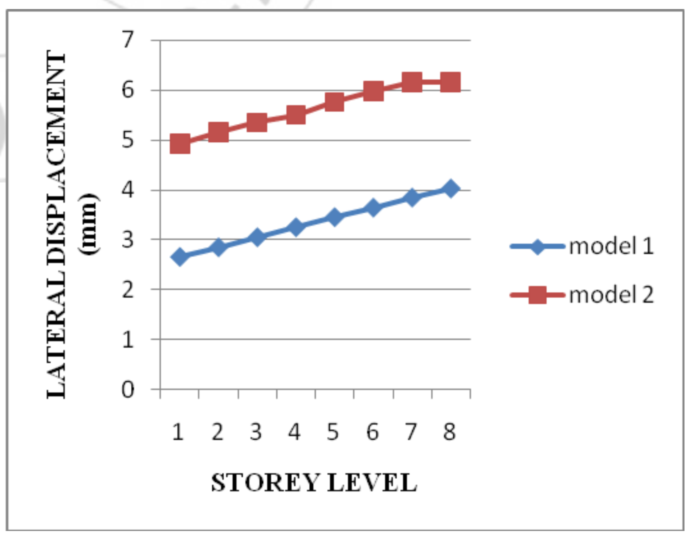

Figure 6: Maximum Lateral Displacement(mm) in X Direction

Table 2: Lateral Displacement Values in mm

Storey level	*Lateral displacement (mm)*	
	Model 1	*Model 2*
1	2.66	4.92
2	2.85	5.15
3	3.05	5.35
4	3.25	5.56
5	3.45	5.76
6	3.64	5.97
7	3.84	6.16
8	4.02	6.35

From the graph, the lateral displacement of the two models are increased from the first floor to the 8 th floor and the displacement is maximum at the top floor. And the displacement of the model 2 is higher as compared to the model 1.

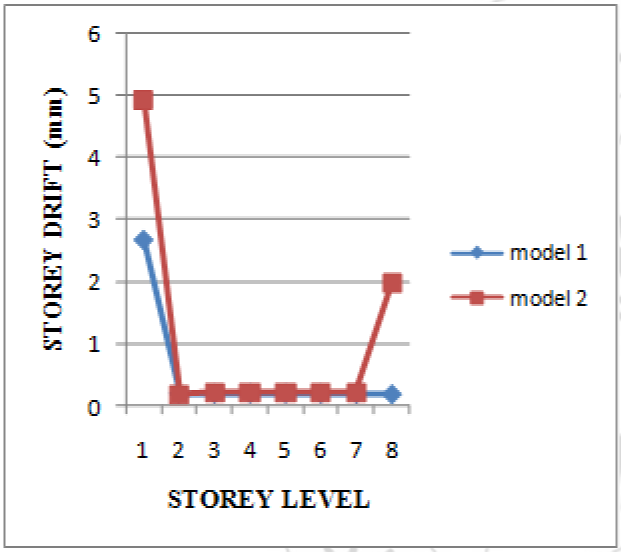

Figure 7: Maximum Storey Drift (mm) in X direction

Table 3: Storey Drift Values in mm

Storey level	*Storey drift*	
	Model 1	*Model 2*
1	2.660	4.925
2	0.195	0.185
3	0.196	0.211
4	0.199	0.211
5	0.200	0.212
6	0.198	0.210
7	0.193	0.205
8	0.185	1.970

The resulting storey drift values of the two models are maximum in the first floor. And the storey drift value of the model 2 is higher as compared to the model 1.

6. Conclusions

In this study irregular plan configuration is selected because, as per IS 1893-2002, that plan configurations of a structure and its lateral force resisting system contain re-entrant corners, where both projections of the structure beyond the re-entrant corner are greater than 15 percent of its plan dimension in the given direction. Buildings with large re-entrant corners, (i.e., plan shapes such as L, V ,Y, etc.) show poor performance during earthquakes. Each wing of such a building tends to vibrate as per its own dynamic characteristic, causing a stress concentration at the junctions of the wings. In this study I choose T and square shaped column for this re-entrant corners and analyse the models.

The main conclusions obtained from the analysis of models are summarized below:

- The lateral displacements, storey drift for the model with square shaped columns is higher than those developed in the model with T shaped columns. On the basis of safety criteria, the lateral displacement, storey drift for an irregular space framed structure should be low as possible.
- It is found that model with T shaped column can resist more base shear than model with square shaped column.
- The behaviour of model with T shaped column is better than model with square shaped column when the comparison is in terms of storey drift, base shear and lateral displacement.
- The performance of T shaped column RC frame is better than the square shaped column RC frame.

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