Seismic Response of RC Building with Specially Shaped Columns: A Comparative Study

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Abstract: Moment Resisting RC Frames in multi storey buildings predominantly make use of rectangular column system and they are widely practiced and globally accepted as default support system. Because of the availability of varieties of software for standard designs and ease of construction, rectangular columns are widely practiced in construction industries. The specially shaped columns, i.e., L,T and + shaped if strategically positioned at corner, peripheral and intermediate position respectively in a multi storey building frame, it would not only promise better structural response but will be more useful to articulately manage the floor space due to its special shape. Hence to verify the structural performance of moment resisting RC frames at different heights with these L, T and + shaped columns, an attempt is made in this work to model G+3, G+7 and G+13 storey SMRF in ETABS environment. Comparing the results for the similar frames with rectangular column as supporting system. A seismic analysis is performed on all these frames by response spectrum method by using built-in library of specially shaped columns and the results for storey drift, natural frequency and storey displacement for all these different height frames are acquired. The results obtained are depicted in this work with a comparison of SMRF with rectangular columns and for all these parameters, comparison is depicted in graphical and tabular form which shows clear advantage of use of specially shaped columns, to resist seismic performance of multi storey RC frame.

Keywords **– Specially Shaped Columns, Seismic, RC Building, Comparison, ETABS**

1. INTRODUCTION

The specially shaped column, i.e., L,T and + shaped have special advantage of their c/s geometry that promise better performance in terms of moment resisting capacity, deflection, base shear, etc. in either direction. It is learnt that most of the softwares are not capable of design of such specially shaped columns, most standard softwares don't have not inbuilt capacity to design such specially shaped columns. Undergraduate and postgraduate curriculum mostly not cover the design of column with such sections due to its complex design procedure and most importantly there exist rare literature, books and design aids which enable structural engineers to practice it at par with rectangular columns. Rectangular columns are mostly adopted due to ease of construction and design. Column is one of the most critical structural engineering element and it can be said that all RC building frames exhibit Rectangular, Square or Circular columns sections only in the state. A comparative study on RC frame with different floors with conventional rectangular shape and with special shapes (L, T and + shape) are aimed to be explored to investigate the suitability of types of columns section in different cases. An attempt is made in this work to study the seismic analysis of RC frame by means of comparison between two frames. In which one frame consists of rectangular columns and another frame consists of L, T and + shaped columns at corner, periphery and interior respectively. Also different storey heights are taken to find the best possible combination for each storey level. Present work is aiming to carry out the comparative study for the seismic performance of columns in resisting lateral and axial load with biaxial moments during earthquake. To study the position, orientation and type of section dominant for different heights of regular RC frame. The modelling of G+3, G+7 and G+ 13 storied RC frames in ETABS for static and dynamic analysis with rectangular and specially shaped column section is carried out. To study the superiority of L, T and + shaped columns over conventional columns.

2. MODELLING OF RC BUILDING WITH IRREGULAR PLAN GEOMETRY

2.1 Geometry and Modelling:

Here plan of an existing structure- Karmyogi Bhavan, which is an office building in Gandhinagar, Gujarat is taken for modelling and analysis. The building has L shaped plan geometry and it is a G+7 storey building. It is situated in seismic zone III, site type-2. The original model has rectangular columns. Since the building has irregular plan geometry, 4 expansion joints are provided in the original structure but to study the effects of different columns in irregular plan geometry, the expansion joints have been removed and then this study is carried out.

So two different models consisting of rectangular columns only in one model and another model with L, T, + shaped columns is analyzed at 3 different storey levels with same plan area of 77.7m x 77.7m. In this study, a G+3, G+7 and G+ 13 storey building with 3.2 m height for each storey is modeled. Storey heights are assumed to be same for all buildings including base. The buildings are assumed to be fixed at base. The floors of all buildings act as rigid diaphragms. Same dimensions for columns and beams are taken for models at same respective storey heights to ensure clear results. Loading pattern is also similar for models of same height. Comparison in terms of lateral displacement, storey drift and time period is shown. Best suitable system at respective storey levels can be seen.

In this paper, two buildings with G+7 storey height are discussed for modelling, analysis and conclusion of results. Different parameters taken for this study are mentioned in tables 1-3.

The plan details of model are as given below:

Model 1- G+7 Storey Building with Rectangular Columns

Model 2- G+7 Storey Building with L, T and + Shaped Columns

2.2 Preliminary Data

Table 1: Preliminary Data

Sr. No.	Parameters	Values	Units
1	Grade of Concrete	25	N/mm^2
2	Grade of Steel	415	N/mm^2
3	Storey Height	3.2	m
4	Parapet Height	1	m
5	Thickness of Slab	150	mm
6	Area- LxB	77.7x77.7	m

Table 2: Loading Data

Sr. No.	Parameters	Values	Units
1	Live Load	4	kN/m^2
2	Roof Live Load	1.5	kN/m^2
3	Floor Finish Load	1	kN/m^2
4	Wall load (External Wall)		
	For 900 mm Beam Depth	6.9	kN/m
5	Parapet Load	4.6	kN/m

Table 3: Dimensions of Columns

Sr. No.	Storey	Sizes	
		Rectangular Columns	L,T,+ shaped columns
1	G+7	300x1200	300x750 (L shape)
			300x750 (T shape)
			300x750 (+ shape)

3. SEISMIC ANALYSIS

Structures should be well designed under earthquake loading accounting the specified seismic design philosophies so that they can sustain moderate to strong earthquakes. The modelling and analysis for this study is done in ETABS v16 software and is carried out according to the code IS 1893(Part1)-2016. Load combinations are taken according to IS code IS 1893(Part 1): 2016. Along with these load combinations, Load Pattern is defined for Dead, Live, EQX and EQY. Shell loads, frame loads are calculated and applied. Time period is calculated for different storey heights. Also type of soil, seismic zone factor is entered from IS 1893(Part1)-2016. The standard response spectrum for type of soil considered is applied to building for the analysis in ETABS 2016 software. Linear Static Analysis is performed and then Dynamic analysis is carried out for the building as specified by code. Dynamic analysis is carried out by Response spectrum method.

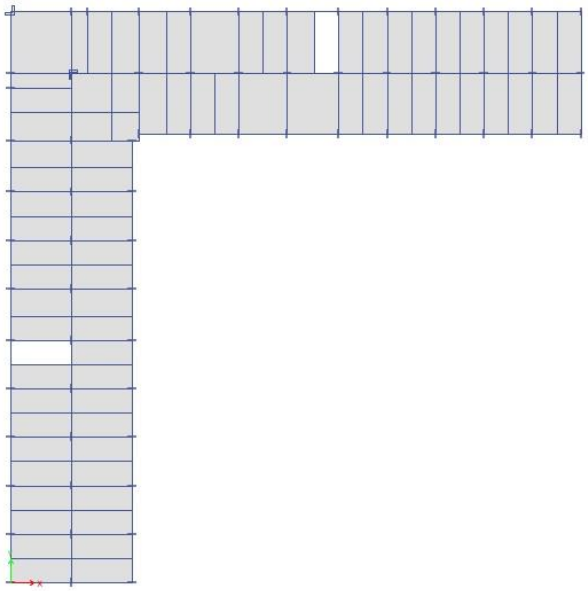

Figure 1: Plan View of G+ 7 Model with Rectangular Shaped Columns

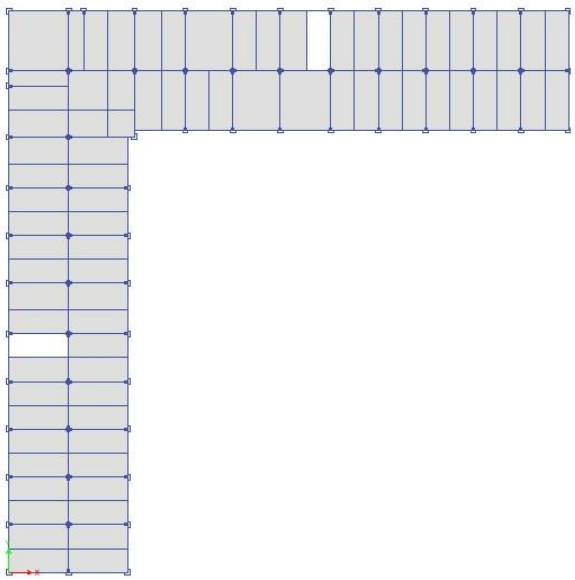

Figure 2: Plan View of G+ 7 Model with Specially Shaped Columns

4. RESULTS AND COMPARISON

The results are represented in graphical format. Comparison is done for parameters - Storey Displacement, Storey Drift and Time Period between models of same storey height.

A. Maximum Storey Displacement

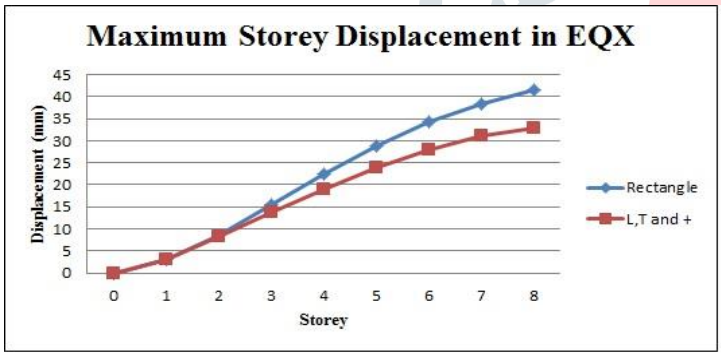

Figure 3: Maximum Storey Displacement in EQX in G+7 storey building

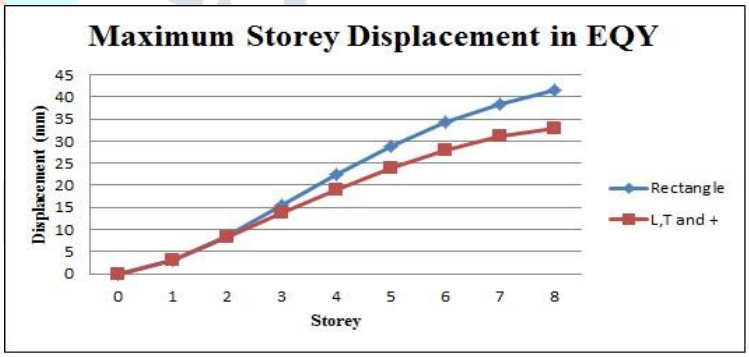

Figure 4: Maximum Storey Displacement in EQY in G+7 storey building

B. Maximum Storey Drift

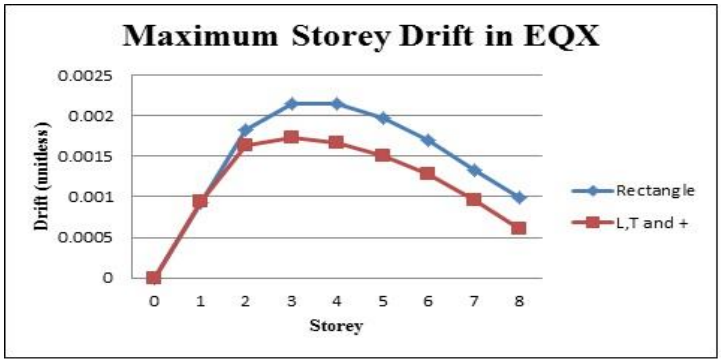

Figure 5: Maximum Storey Drift in EQX in G+7 storey building

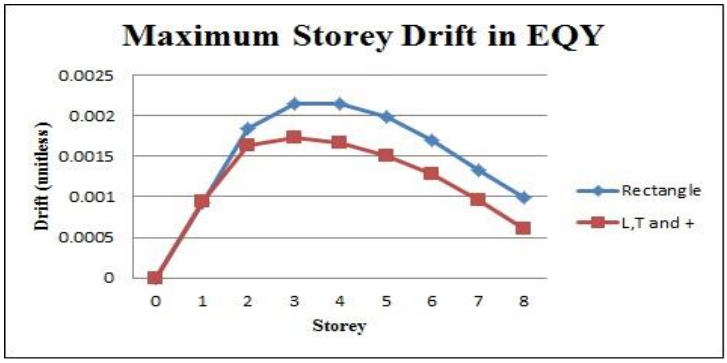

Figure 6: Maximum Storey Drift in EQY in G+7 storey building

C. Time Period

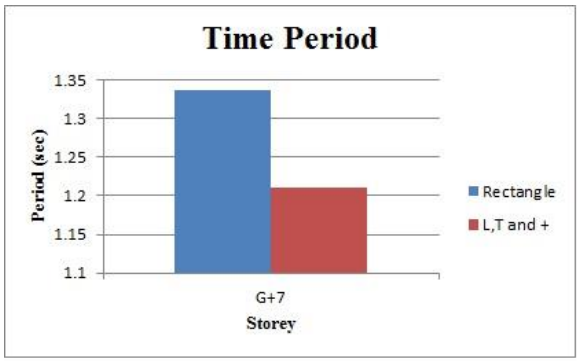

Figure 7: Time Period

5. CONCLUSION

For an irregular plan geometry taken it can be concluded that :

- From the above graphs for maximum storey displacement, maximum storey drift and time period it can said that the use of specially shaped columns for the same plan area with rectangular columns gives better results.
- It can be seen that after application of earthquakes in both the directions, the performance of L, T and + shaped column building gives better performance in both the directions in mentioned storey heights.
- The time period obtained for specially shaped columns is significantly less than its counterpart.
- The original plan of Karmyogi Bhavan, Gandhinagar which is a G+7 storey building having rectangular columns is compared for different parameters with G+7 storey building having specially shaped column building (with the same dimensions of column).
- The results clearly depict that the building frame with specially shaped columns has better results in all the parameters taken for comparison.
- Graphs show that frame with specially shaped columns give lesser displacement, lesser storey drift comparatively.
- Henceforth, it can be said that the use of specially shaped columns can be adopted by following suitable codal provisions.

6. FUTURE SCOPE

The cost comparison of the building with specially shaped columns can be done with building having rectangular columns. The same concept can be studied for steel structure instead of RCC. The cost for one rectangular column can be compared with L shape, T shape and + shaped column. The quantity of concrete and steel used in structure can be compared and beneficial outputs could be obtained. The total number of columns could be reduced if specially shaped columns are adopted for larger spans.

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