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COMPARATIVE STUDY BETWEEN RECTANGULAR AND SPECIALLY SHAPED R.C. COLUMN ON SEISMIC RESPONSE FOR MULTISTORIED BUILDING

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ABSTRACT

In a RC building, columns are structural elements that are predominantly subjected to axial load,and moments, and transfers them from the super structure to the substructure. Various shapes of the columns are used. Some common shapes are square, rectangular, circular columns and some special shapes of columns are L-shaped, T- shaped and plus (+) shaped columns, which are not commonly used but gives more indoor space than commonly used shapes of column. Specially shaped columns avoid obstructions in a room which increases usable floor area. The objective of this study is to assess the comparative seismic and wind performance of buildings with Rectangular columns and buildings with specially shaped columns of a multistoried building. The proposed building is analyzed using equivalent static analysis for zone II in Dhaka city. The parameters are considered moment of inertia of column, maximum story drift, lateral displacement etc. The Bangladesh National Building Code (BNBC), 2006 has been considered in the computer aided analysis performed by ETABS 2016. Seismic analysis was performed by equivalent static force method. Based on the results, calculations are drawn showing the effectiveness of different shapes of the column under the effect of seismic loads.

Keywords: *Rectangular column, Special shape column, Seismic analysis, lateral displacement, Drifts.*

1. INTRODUCTION

It is the prime duty of a civil engineer to ensure safety to the life of occupants of a building by replacing conventional construction practices by modified techniques so that huge population can be accommodated in given area and large commercial space can be created in a confined area for upgrading the living environment. So, it is important to replace conventional construction practices with modified one. Buildings, which are generally designed for office, institutional or commercial use, are among the most distinguished space definitions in the architectural history of urbanization in the twentieth century. They are primarily a reaction to the rapid growth of urban population and the demand by business activities to be as close to each other as possible. Many researches and studies have been done in order to mitigate excitations and improve the performance of buildings against lateral load. Columns play very important role in buildings because total load is transferred through columns. (Gumble, 2015) Various shapes of columns are used in the construction such as rectangular columns, Square columns, circular columns, T-shaped columns, L-shaped columns, Cross (+) shape columns, where Rectangular, Square and Circular columns are called as Regular columns and T-shape columns, L-shape columns, Cross (+) shape columns are called as specially shaped columns. (Yang, 2008)

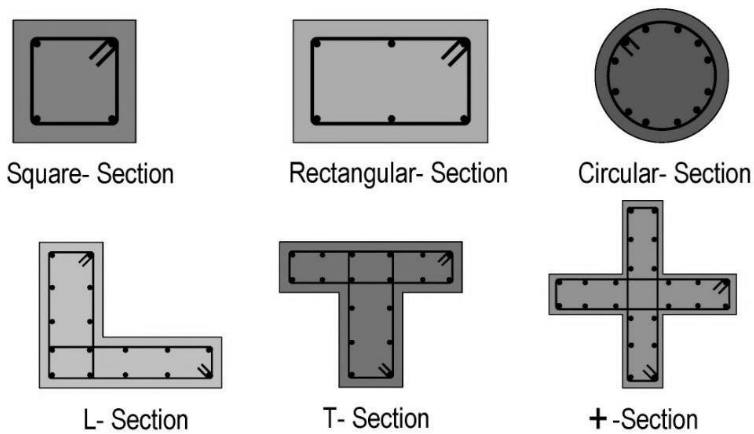


Figure 1: Section of column with lateral and longitudinal reinforcement

This project involves the numerical analysis of effect of column shape on the response to wind and earthquake load and makes a comparison of rectangular column shaped building & special column shaped building by using ETABS software and also checks out the specification detailed in BNBC 2006.

2. METHODOLOGY

A 20 storied arbitrary building with plan area of 4144 sq. ft is considered for this study. The models are of same plan area and same height. The material properties of the models are also same.Total analysis has been performed by ETABS, the leading structural design and analysis-based software. Here total loading is applied as distributed loading. Modeling is performed with great care. All model maintains same area and heights. Before analyze the models, the models are re-checked once again.

2.1 SPECIFICATION OF MODEL COMPONENTS

Table 1 has information about column sizes and Table 2 is about the material properties used at the building.

Table 1: Specifications of model components

Model component	Specification
Square column	Total depth-24in, Total width-24in
L shaped column	Total depth-40in Total width—40in Horizontal and Vertical leg thickness-8in
T shaped column	Total depth-40in Total width-40in Flange and Web thickness-8in
Cross (+) shaped column	Total depth-40in Total width-40in Flange and Web thickness-8in

Table 2: Material properties

Concrete	Grade of concrete	3 ksi
Steel	Grade of steel	60 ksi

Figure 2 has the plan and 3D view of the model building that was used for the analysis. The Plan was done using AutoCAD software.

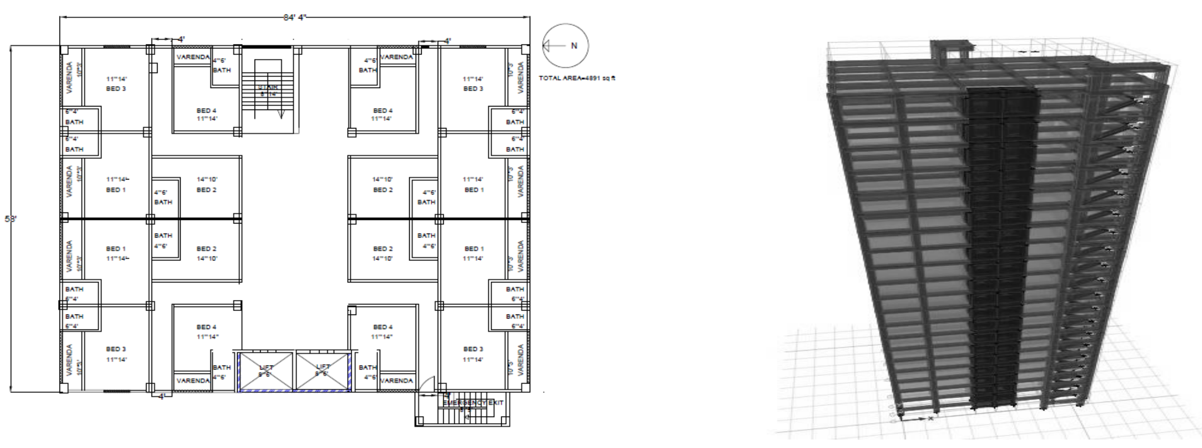


Figure 2: Plan view and 3D model of the building

2.2 ANALYSIS AND RESULT

2.2.1 CASE 1

In this case usual building is considered as specified in above. Column size considered 24” x 24”. Plan of the building is shown

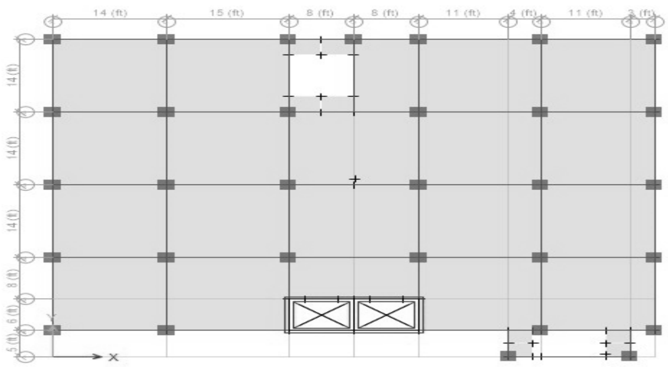
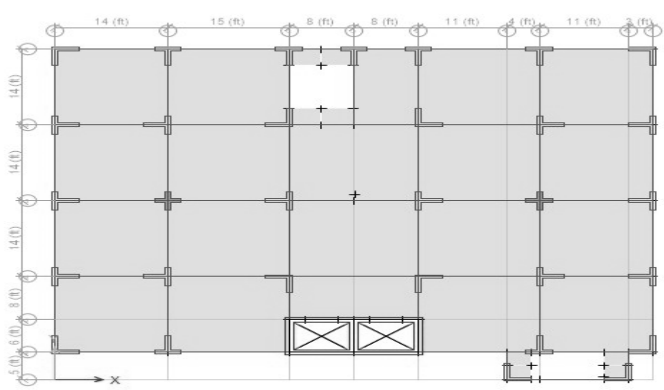


Figure 3: Plan view of rectangle shaped column

2.2.2 CASE 2

In this case square column is changed into specially shaped column. Plan of the building is shown in figure 4.



2.3 SIESMIC LOAD

For seismic analysis, the equivalent static force method is used in this paper.In BNBC Bangladesh has been divided into three seismic zones based on the possibility of severe intensity of seismic ground motion. These are: Zone I, Zone II& Zone III (Fig.1). Zone III is the most severe zone among these zones. (BNBC,2006)

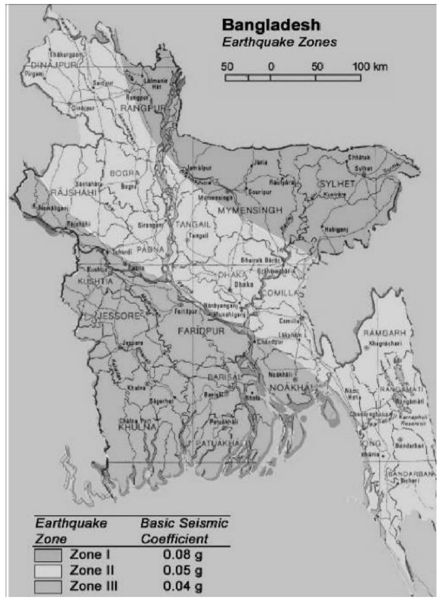


Figure 5: Earthquake zone in Bangladesh

Dead load includes the self-weight of the building components. Live loads are taken from BNBC. The selected city is Dhaka. According to seismic zoning map of Bangladesh, Dhaka is under zone II. The total load calculations have been done as per BNBC 2006. The corresponding equations are as follows:

$$V = \frac{ZIC}{R}W \quad (1)$$

Where, V=Base Shear,
Z= Seismic zone coefficient,
I= Structure importance coefficient,
R= Response modification coefficient,
W= Total dead load +some specified live load
C= Numerical coefficient

$$C = \frac{1.25S}{T^{2/3}} \quad (2)$$

S= Site coefficient for soil characteristics
T= Time period
And $T = (h_n)^{3/4}$ (3)
h_n = height of the building

2.4 LOADING

The created model is subjected to uniformly distributed load which are provided to its intensity. Loading parameters are:

•Dead load
•Live load
•Self-weight

•Seismic load

Table 3: Vertical load

Dead load	**Self-weight**	**Program calculated automatically**
	Floor finish	25psf
	Wall load	.5 k/ft
	Parapet wall load	.15k/ft
	Partition wall	30psf
Live load	On floor	60psf
	On stair	100psf

2.5 ANALYSIS

After creating the model, the structure is ready to be analyzed. Before the analysis all the systems, properties and loading conditions are rechecked once again. Reaction, moment, displacements and story drift are obtained from this analysis

3 RESULT AND DISCIUSSION

Analysis for all the building models are carried out. After the analysis performed corresponding results have been obtained. The results are shown in tabular, bar-chart and graphical form. From those table and chart, we can easily find out the variations between different models.

3.1 COMPARISON OF MOMENT OF INERTIA

Table 4: Moment of inertia comparison

Column shape	**Cross section area (in^2)**	**I_X (in^4)**	**I_Y (in^4)**
Square column	576	27648	27648
L shaped column	576	80440.89	80440.89
T shaped column	576	80440.89	44032
Cross(+) shaped column	576	44032	44032

From table 4, it is shown that the moment of inertia of L shaped column is highest. Then T shaped and cross shaped has higher value. Square column has the least moment of inertia. Moment of inertia does not affect the strength of section directly but it affects another property of section, radius of gyration. Which ultimately defines the strength of section.

3.2 MAXIMUM DISPLACEMENT DUE TO EARTHQUAKE LOAD

Load combination used for analysis $1.05DL+ 1.275LL+ 1.4E_{qx}$In X direction and for Y direction Load Combination used was $1.05DL+ 1.275LL+ 1.4E_{qy}$ (BNBC,2006)

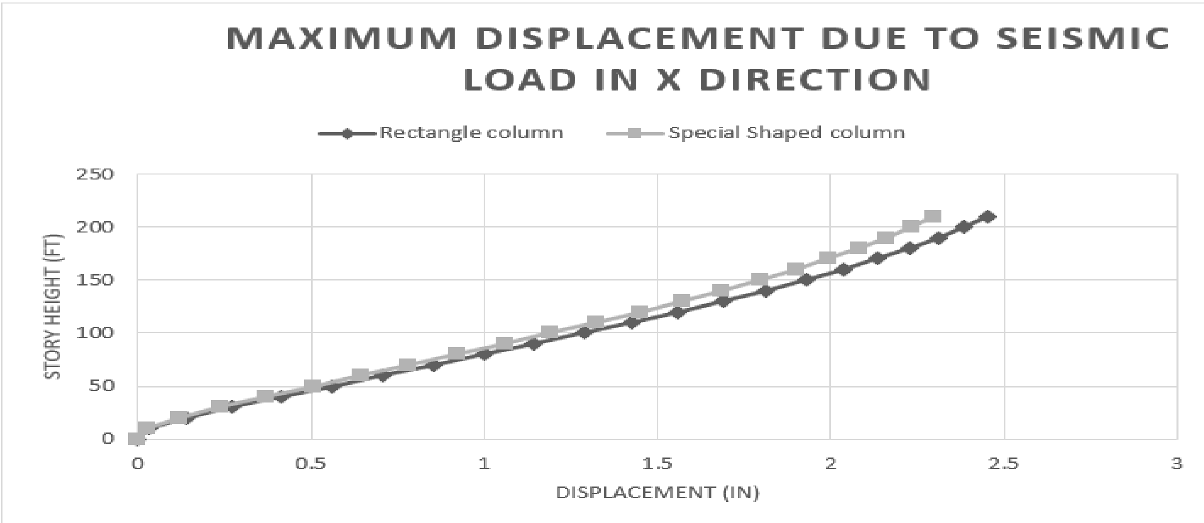


Figure 6: Variation of displacement of 20 story building along X

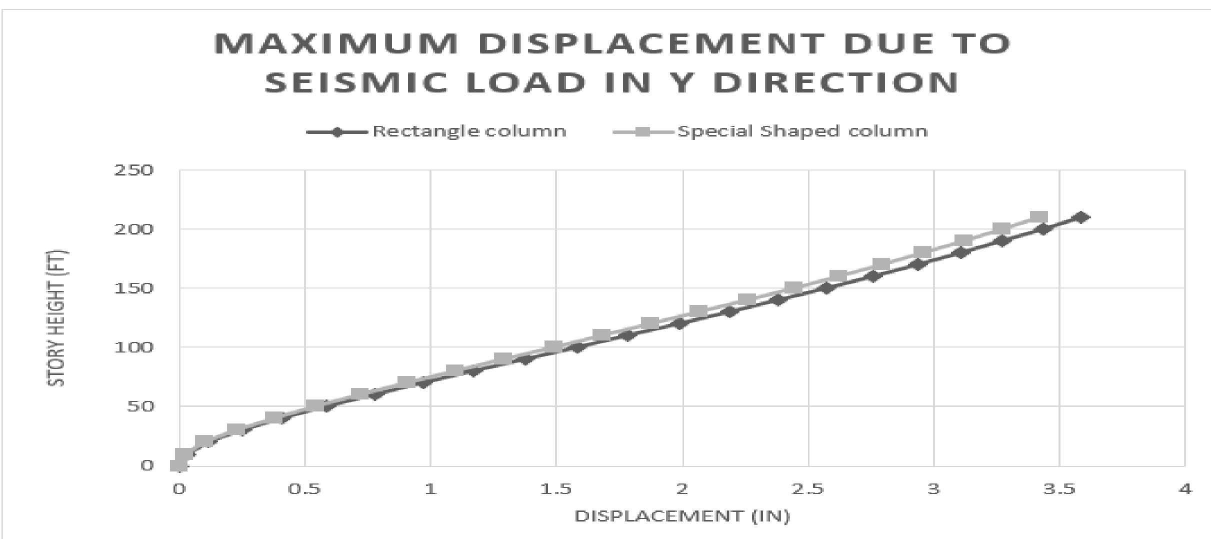


Figure 7: Variation of displacement of 20 story building along X

The figure 7 & 8 shows that with the increment of story height, the displacement due to seismic load in X direction and Y Direction increases non-linearly. It is clearly seen that the displacement is lower for the special shaped column than the rectangular shaped column

3.3 STORY DRIFT DUE TO EARTHQUAKE LOAD

Story drift is the difference of displacement between two consecutive stories divided by the height of that story. Mathematically, story drift at 20th floor= (displacement at 20th floor – displacement at 19th floor) / floor clear height

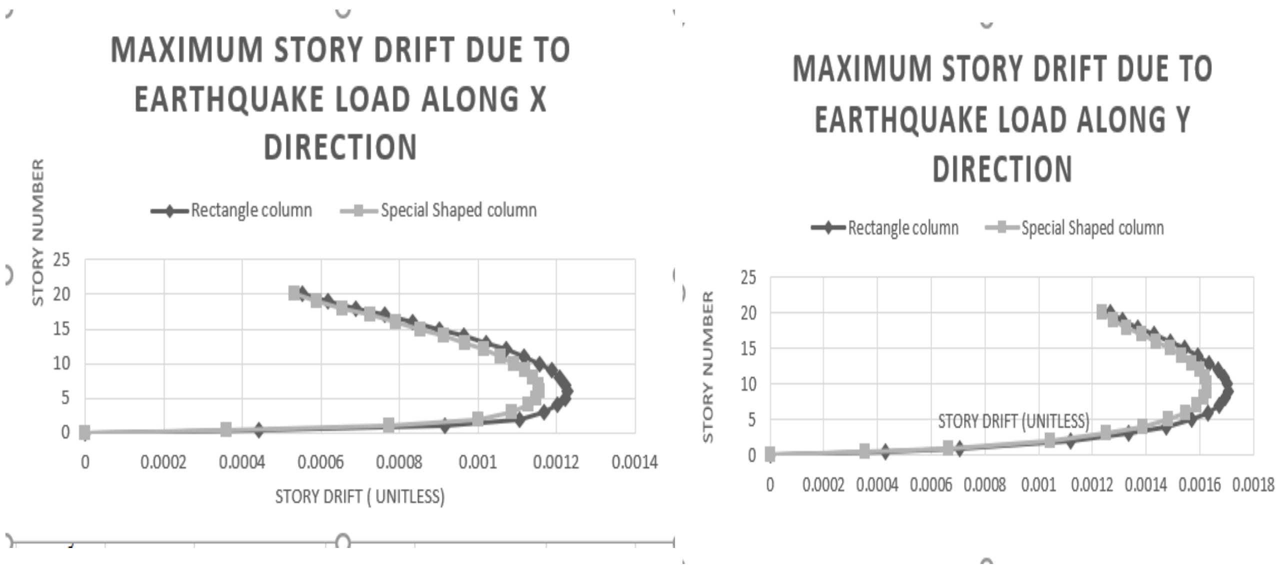


Figure 8: Variation of maximum story drift due to seismic load in X& Y direction

Since the mass is in Z direction, the cumulative mass increases from top to bottom story, story drift due to seismic load in X direction increases from top to bottom story. But due to fixed support at the bottom of the structure it becomes zero at base. The figure 9 shows that story drift is lower for special shaped column structure.

4. CONCLUSIONS

The buildings were analyzed by using"equivalent static force method" according to BNBC code. A numerical investigation is carried out to evaluate the effect of building shape on drift and displacement due to seismic load. From theresults, the following broad conclusions can be made in this respect:

1) Displacement depends on the relative stiffness of frame. In this study, displacement in rectangle column building is the highest due to seismic load. It is due to the fact that, Square column has the least moment of inertia. Moment of inertiaaffects another property of section, radius of gyration. Which ultimately defines the strength of section.
2) The special shaped column building is safer and considering all conditions the special shaped column
3) Story drift is in special shaped column structure is less then rectangular column structure
4) Specially shaped columns give more usable floor area at the corner of room as compared to rectangular column in R.C. structure. And no obstruction will be created by the offset of column in case of special shaped column

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