Dynamic Analysis of RC Building with Different Cross-section of the Column

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Abstract - *In this research work, we studied the RCC structure with a different cross-section of the column, where four models created with the help of the ETABS software ie RC structure with rectangular column represent model-1, RC structure with square column represent model-2, RC structure with circular column represent model-3, and RC structure with T shape of the cross-section column represent model-4. The method used for the analysis of these four models is the Time history method with the help of the ETABS software and the data taken for providing the time history analysis is EL CENTRO. The code used for the seismic analysis of these models is Indian Standard code 1893 part-1:2016, and the frame is considered as the Special Moment-Resisting Frame (SMRF). Here we will compare the stability of these models based on the seismic parameter such as the base shear, storey displacement, storey drift, storey overturning moment, fundamental period.*

Key Words: *RC structure, Column orientation, Rectangular Column, Square Column, circular Column, T Shape column, time history analysis, IS 1893 part-1:2016.*

1. INTRODUCTION

By increasing the height of the building it becomes susceptible to lateral loads such as earthquakes and wind. The stiffness playing governing role in the analysis and design of the structure in tall buildings when subjected to lateral loads. To carry the lateral loads and control the excessive lateral deflection of buildings, the provision of an efficient structural system with a reasonable height limit is a good solution for such an issue. A moment resisting frame is a structural system that is capable of carrying the lateral loads in low to mid-rise buildings. SMRF carries the lateral loads by combined axial-shear-bending action of beams and columns. Based on the strong column- weak beam design concept, columns should be stiff compared to beams to prevent the shear mode of deformation of the structure. Selection of appropriate shape, size, and orientation for columns in the building (especially rectangular plan building) are the main factors that control the overall stiffness of the building structure. In addition to providing lateral stiffness, columns are responsible for the deflection shape of the building structure. The main aim of the current paper is to find out the effect of the seismic force in the different cross-sections of the columns on the seismic response of building structures. A G+15 storey RC building has modeled in ETABS software with different column square, circular, T section, and rectangular shape), column shapes (size (the varying sectional area across the building height), and column orientation to find out the effect of each one on stiffness and seismic response of the building. We know that in the case of the high rise RC structure, the cross-section of the column plays a very important role so we consider the different cross-section of the column.

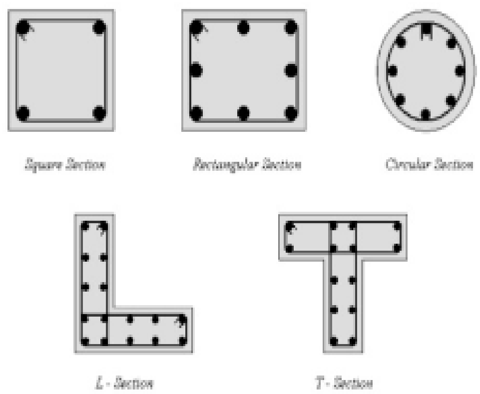

Fig-1: Type of Column

1.1 Column Orientation

The orientation of columns is kept symmetrical as far as possible, on both sides of the layout. If you have a rectangular column Orientation will be a mix of the architectural demands (which usually involves fewer protruding faces from the wall face) and the structural demand which keeps the lateral and axial forces in mind. The orientation may not affect the vertical axial forces sustained by the structure, but the lateral forces have to be counteracted and a greater section modulus of a column is expected in the direction of the lateral Bending moment. So, yes larger face for larger moments.

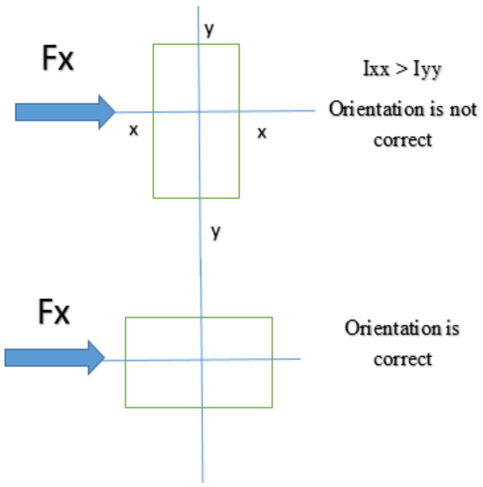

Fig-2: Column Orientation

2. METHODOLOGY

Dynamic analysis done in all models by using the "Time History Data" and data of the earthquake for time history analysis is taken from EL CENTRO and magnitude was 6.9. The focus of that earthquake was about 3Km from the ground surface and this type of earthquake is known as the shallow earthquake because the depth of the focus of the earthquake is less than 75Km.

2.1 Modeling of Structure

All models are prepared in the Etabs software which is developed by the CSI company and the version of the software was 17 and analysis of the models done with the help of the IS code 1893 part-1 2016. All parameter of the building Such as the material parameter, Section parameter, load parameter, and seismic parameter which are given below:

2.1.1 Material Parameter

The parameter of the material which is used in the building is given below in table-1:-

Table -1: Material Parameter

S.No	Material Name	Grade
1	Concrete	M25 for Beam
2	Concrete	M30 for Column and Slab
3	Longitudinal Steel	HYSD500
4	Tranverse Steel	HYSD415

2.1.2 Geometry and Seismic Parameter of the building

In this parameter, we take the following parameter for the RCC building which is shown in the following table-2:-

Table -2: Geometry and Seismic Parameter of building

S.No	Building Parameter	Dimension
1	Beam	550mm X 400mm, M25
2	Rectangular Column	600mm X 450mm, M30
3	Square Column	500mm X 500mm, M30
4	Circular Column	D= 525mm, M30
5	T-Column	Total depth =550mm, total width = 600mm, flange thinkness = 155mm, Web thickness = 250mm, M30
6	Slab	155mm, M30
7	Bottom storey height	3.5m
8	Height of every floor	3m
9	Total height of building	48.5m
10	Area of the building	24mX28m
11	Span of beam	4m
12	Importance Factor (I)	1.2
13	Response Reduction Factor (R)	5
14	Zone Factor (z)	0.24
15	Type of the Soil	2nd
16	Eccentric ratio	0.05
17	Magnitude	6.9
18	Time history data	ELCENTRO

2.1.3 Load Parameter

In the following table-3, the load value is given which act on the structure such as dead load, live load and wall load on the beam:

Table -3: Load Parameter

S.No	Load parameter	Value
1	Wall load	14 KN/m
2	Live load	3KN/m^2
3	EX and EY	According to IS 1893 part-1:2016

2.1.4 Plan, 3D view, and Cross Section RC Rectangular Column (Model-01)

The figure of the Model-01 is given below which represent the Plan, and 3D view of the model-1:

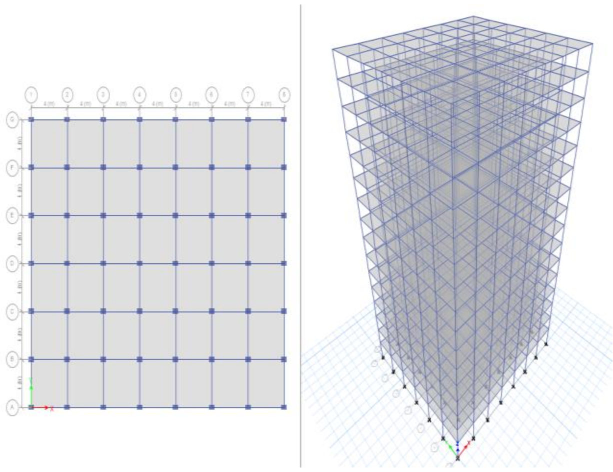

Fig -3: Plan and 3D View of Model-01

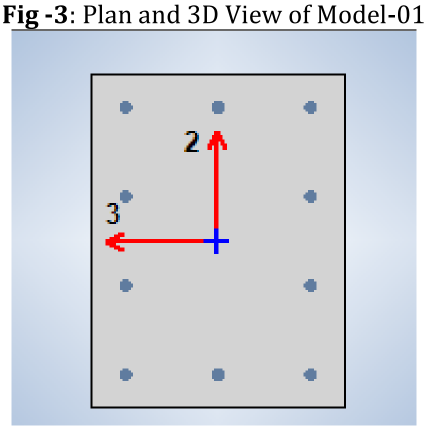

Fig -4: Cross Section of RC Rectangular Column (Model-01)

2.1.5 Cross Section RC Square Column (Model-02)

The cross-section of the square column in the building (Model-02) is given below in figure and plan, elevation and 3D view same as model-01.

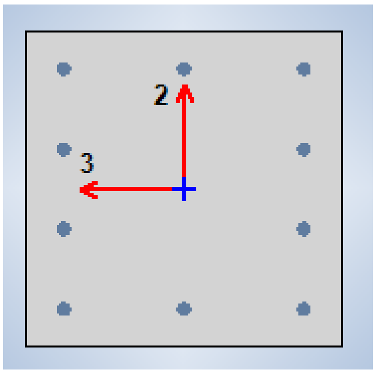

Fig -5: Cross Section of RC Square Column (Model-02)

2.1.6 Cross Section RC Circular Column (Model-03)

The cross-section of the circular column in the building (Model-03) is given below in figure and plan, elevation and 3D view same as model-01.

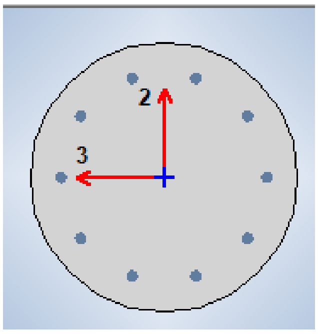

Fig -6 Cross Section of RC Circular Column (Model-03)

2.1.7 Cross Section RC T-Shaped Column (Model-04)

The cross-section of the T-shaped column in the building (Model-04) is given below in figure and plan, elevation and 3D view same as model-01.

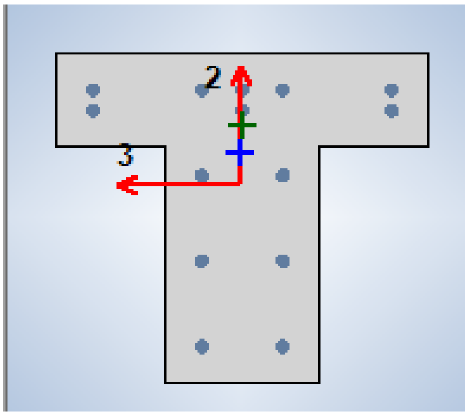

Fig -7 Cross Section of RC T-Shaped Column (Model-04)

3. ANALYSIS

All models are analyzed with the help of the Etabs software by using Dynamic Analysis by defining time History data. We had taken the following seismic parameter for comparing all models with each other:

i. Base Shear due to EX

ii. Storey Drift due to EX

iii. Storey Displacement due to EX

iv. Storey Overturning Moment due to EX

v. Natural period and Frequency.

3.1 Base Shear Due to EX

The base shear is defined as maximum lateral force act on each floor due to vibrating the ground surface on which the structure stabilized.

The graph of the base shear of all models is given below due to earthquake in the X-direction. The value of the base shear is different because the dimension of the building in the Y direction is different.

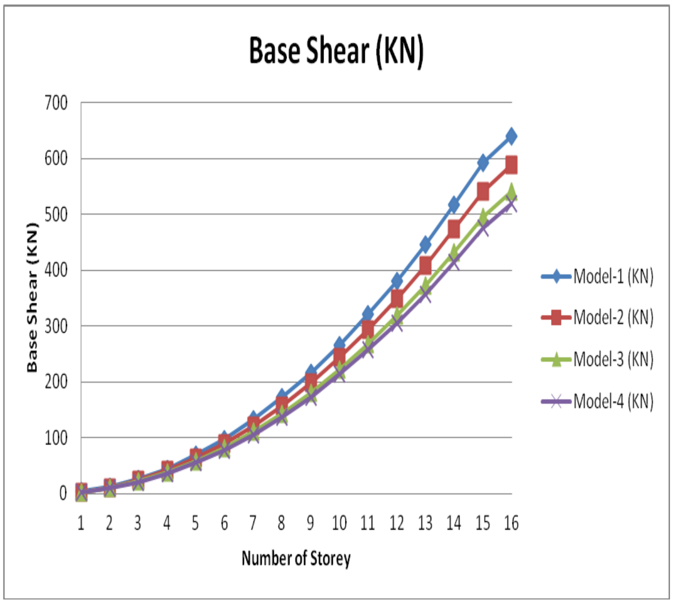

Chart -1: Base Shear Due to EX

From the graph, we found that the value of the base shear is low in model-04 as compared to all model so during the earthquake in the X Direction.

3.2 Storey Drift

Storey drift is defined from clause 4.21 from IS code 1893 part-1 2016; it is the relative displacement between the floor above or below storey under the consideration. The graph of the storey drift of all models is given below due to earthquake in X and Y direction (X and Y direction represent the horizontal directions) the value of the storey drift is given at that load combination where the value of the storey drift is maximum.

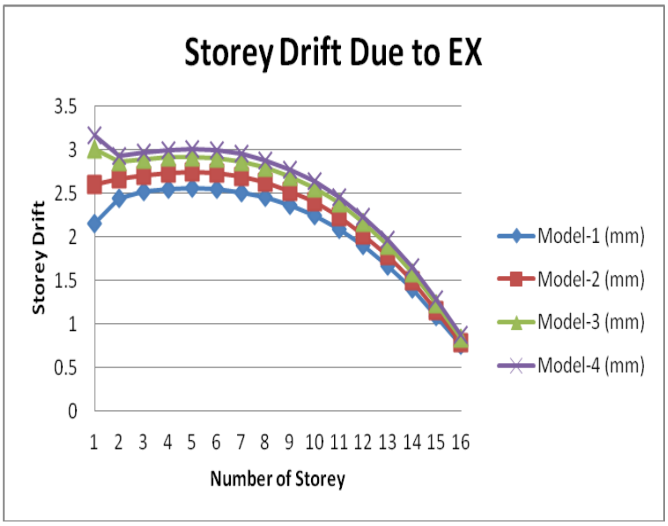

Chart -2: Storey Drift Due to EX

From the above graph, we found that the value of the storey drift is maximum in model-04 as compared to all models. According to IS code 1893 part-1 2016, the value of the storey drift should not be exceeding than 0.004 height of storey (floor), by using this, all model is safe.

3.3 Storey Displacement

Storey displacement is defined as a measurement of the displacement of the floor from the ground surface which is displaced due to the effect of the earthquake. The graph of the storey displacement of all models is given below, which represent the maximum storey displacement.

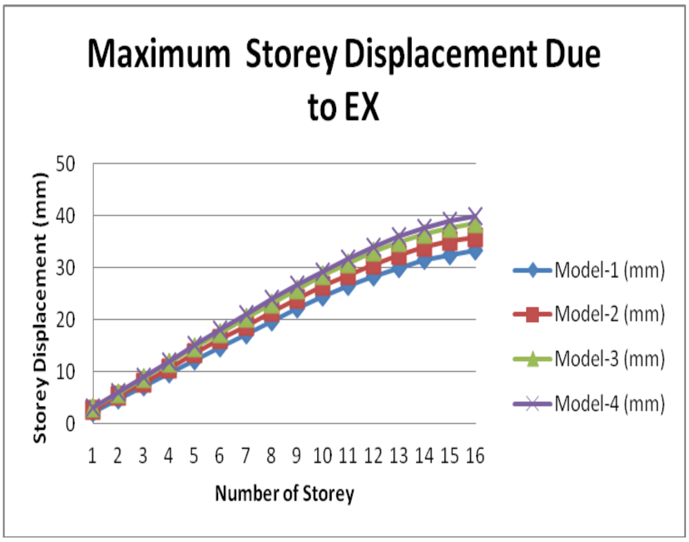

Chart -3: Maximum Storey Displacement

From the above graph, the value of the storey displacement is maximum in model-04 as compared to all models.

3.4 Storey Stiffness

The storey stiffness is defined as the ratio of the storey shear to storey drift.

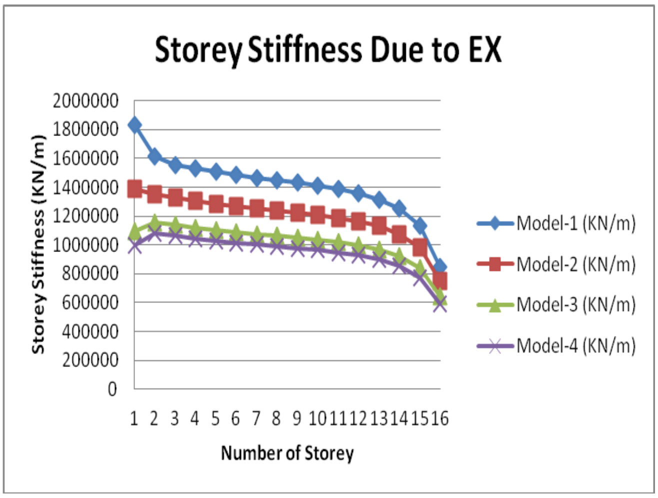

Chart -4: Storey Stiffness Due to EX

From the above graph, we found that the value of the storey stiffness is less in model-04 as compared to all models.

3.5 Natural Time and Frequency

Clause 3.18 from is code 1893 part-2016, the natural period is defined as the time taken by the structure to complete one cycle of the oscillation in its natural mode (k) of oscillation. The graph of the natural periods of all models is given below with table:

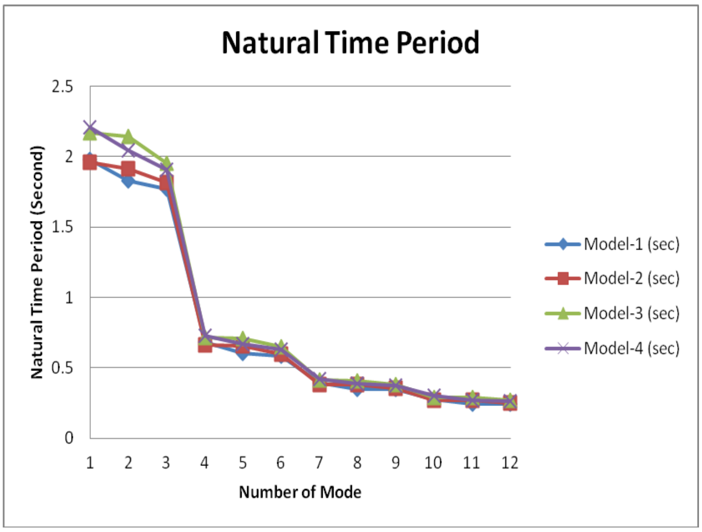

Chart -5: Natural Time Period

From the above graph, the value of the natural period is minimum in model-02 as compared to model-01 and model-03, and model-04. And there is the maximum natural period in the RCC building. The value of the natural period should be from 0.05 to 2.0sec.

4. CONCLUSIONS

After analysis of these four models of the different cross-section of the column with the help of the ETASB software, we found some conclusion which is given below:

i. After comparing the value of the base shear of all models, we found that model-04 which is T- shape RC column has a minimum value of the base shear due to the seismic force in the X-direction. The value of the base shear in model-01 is 18.8066% higher than model-04 at the top floor, model-2 have 11.5158% higher, and model-03 have 3.8026% higher than model-04 at the top floor.

ii. Concerning the Indian standard code 1893 part-1:2016, the value of the RC structure which has G+20 storey, the value of fundamental period should not be greater than 2.0second, but in the model-03 and model-04 have a fundamental period of more than 2.0 second. To reduce the fundamental period of model-03 and model-04 need to redesign or providing damper, or base isolation. The minimum value of the fundamental period exists in model-02 (RC Square column).

iii. According to the Indian Standard Code 1893 part-1:2016, the maximum value of the storey displacement should not be greater than H/250, where H- is the total height of the structure in millimetre. The maximum displacement occurs in the Model-04 at the seismic load in the X-direction.

iv. Storey stiffness is defined as the ratio of the base shear and storey drift, the value of the storey stiffness will increase when the value base shear increase or value of the storey drift decrease. The value of the storey stiffness of the model-01(RC Rectangular Column) has a higher value as compared to all others models, its because the value of the base shear in the model-01 IS higher than all models.

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