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COST ANALYSIS OF RCC BUILDING SUBJECTED TO DIFFERENT CROSS-SECTION OF COLUMN IN SEISMIC ZONE V

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Abstract

This paper presents the cost analysis of low-rise and medium-rise RCC frame building havingdifferent cross-section(i.e. circular, rectangle & square) of column. For this study, total 9 no. of models (G+3, G+7, G+11 storey buildings) were prepared in Staad.pro. These models were analyzed and designedwithResponse Spectrum Method in Zone-V as per IS: 1893-2016.After analyzing the structure, results are drawn in terms of total quantity of concrete and steel of column and total cost of the building.The results of the study show that the total cost of G+3, G+7 and G+11multi-storey building is minimum for the building having square cross-section of column and found economical and safe.

Keywords: Seismic Analysis, Cost Analysis, Different Cross-section of Column, Low-Rise Building, Medium-Rise Building, Multi-Storey Structure, Staad.Pro.

1. Introduction

Being a civil engineer, one must know how the buildings are designed as well as constructed and the parameters and components which are to be considered and their behavior. In order to familiarize with these parameters and processes, scrutinized study of various related Indian design codes must be done prior to the design. There are mainly three types of structures (material wise) as under:

- RCC Structure
- Steel Structure
- Composite Structure (steel sections encased in Concrete)

All these above-mentioned structures have different purposes and different structural components i.e. slab, beam, column foundation etc, and the loads (normally dead and live load) are to be transferred from these members in same sequence to the soil. The trend of development in India shows that majority of the construction works involves the use of Reinforced Cement Concrete.

Column should have high strength and stability in order to resist forces acting on it. Column, being the vertical member, must carry axial load and bending moment and transmit them to the foundations. The different cross-section, size and reinforcement will have different effects on the behavior of column and resisting action as well. These parameters shall be determined in such a manner that the column will transfer the load to the foundation easily without being damaged.

Cost, being the other important parameter, shall be estimated and calculated once the designing is done. The cost of concrete and reinforcement contributes 50% to the total cost of any building. But estimating and calculating these costs of building are a scrutinized process and this must be done very carefully. The cost/rates of the items (concrete and reinforcement) may vary with the project and the location where the building is to be construction. Therefore, different parameters which affect the costing of the project should be considered during the estimation process.

It is of great importance to know the behavior of column when its cross-section changes from circular to rectangular to square in RCC frame building under siesmic forces. Moreover, best suited cross-section shall also be known on the basis of the behavior of column and cost analysis of RCC frame building when analyzed and designed with Response Spectrum Method as per IS: 1893-2016.

In this paper, study was performed in software Staad.Pro software to find out the best suited cross-sectional shape of the column with respect to the area, percentage of steel and cost related to it. Different low-rise and medium-rise buildings were developed and analyzed with Response Spectrum Method for seismic zone V (as per IS: 1893-2016) with different load combinations.

Previously, many experiments were done using Staad.Pro for analyzing different types of building, such as Analyzing The Effect Of Cross-Sectional Change Of Column On Symmetrical R.C.C. Frame Structure, Analyzing The Effect Of Change In Cross-Section Of Column On Unsymmetrical R.C.C. Frame Structure, Earthquake Resistant Design Of Open Ground Storey Framed Building, Seismic Analysis of High Raised Building by Response Spectrum Method had been done, but no research work has been carried out with respect to the shape and cross-section of the column.

2. Research Program

The orientation for research program mainly focuses on:

- To study the behavior of different cross-sections of column in RCC frame building when designed as per IS: 1893-2016 and its different aspects.
- To perform dynamic seismic analysis (Response spectrum analysis) on RCC frame buildings for seismic zone-5 as per code IS: 1893-2016 in STAAD.Pro
- To calculate the total quantity of concrete and reinforcement of RCC frame building.
- To perform cost analysis on RCC frame building and compare the results between various models.

In order to perform above-mentioned study, following codes has been used:

- BIS:875-1987 (part-1) for Dead Load
- BIS:875:1987 (part-2) for Live Load
- BIS:1893-2016, for Seismic Loads
- BIS:456-2000, for Reinforced Structures

Models:

Total 9 models as mentioned below were designed using Staad.Pro:

- G+3 with circular, rectangular and square cross-section of column.
- G+7 with circular, rectangular and square cross-section of column.
- G+11 with circular, rectangular and square cross-section of column.

Storey Height	3.25m
Total no. of bays	4 in each Direction
Panel size	6 x 7 m

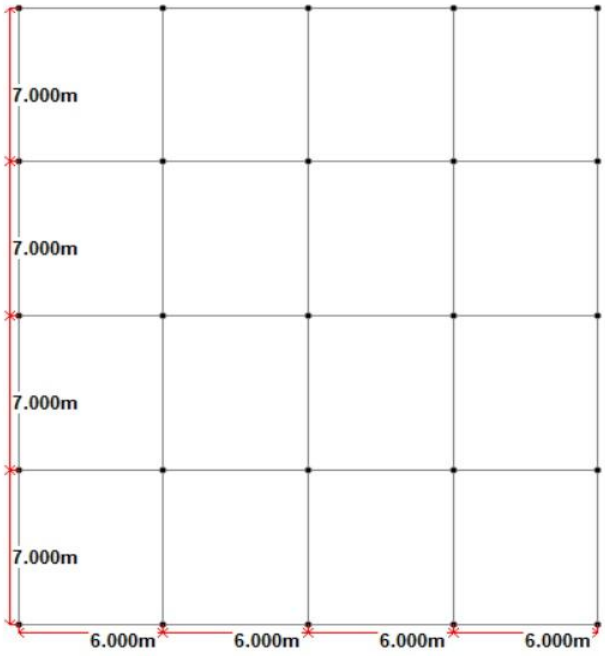

Fig-1: Plan of Building

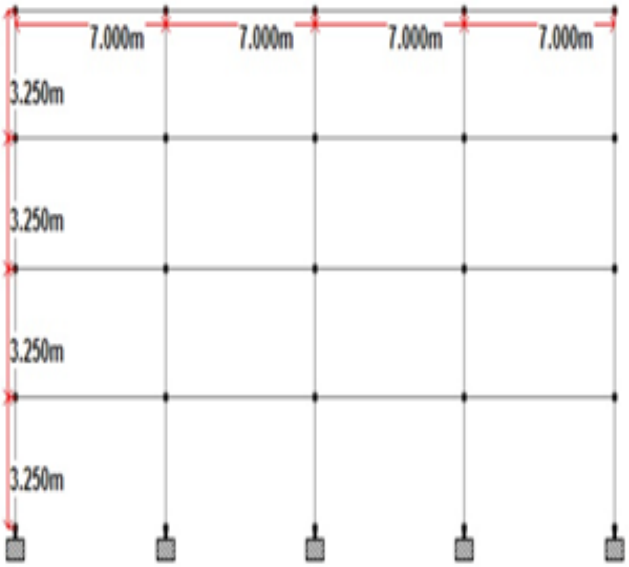

Fig-2: Elevation of G+3 Storey Building.

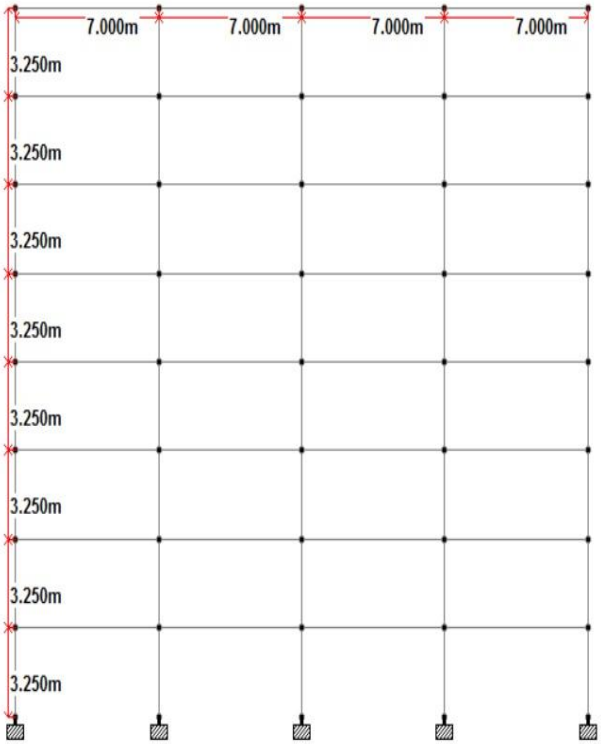

Fig-3: Elevation of G+7 Storey Building.

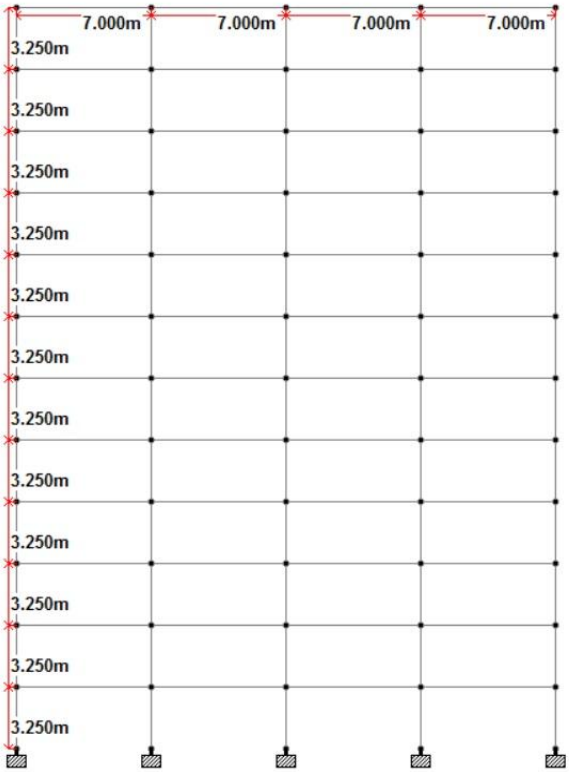

Fig-4: Elevation of G+11 Storey Building.

Input Data for preparing RCC frame structures:

Common data:

a) Grades of Material:

- Grade of Concrete is M-25.
- Grade of Steel reinforcement is Fe-500.

b) Earthquake parameters (as per IS: 1893-2016):

Seismic Zone	V
Response reduction factor	5 (SMRF)
Importance factor	1.2

c) For the purpose of analyzing the structure, following variable loads have been taken into consideration:

Dead Load :(As per the calculations)

Load on outer walls	13.8 kN/m
Load on inner walls	6.9 kN/m
Load on parapet	2.6 kN/m
Load on slab	6 kN/sqm

Live Load: (As per IS: 875 Part-II)

Load on all floors	3 kN/sqm
Load on Roof	1.5 kN/sqm

d) Load Combinations:

As per the codal requirements, different load combinations applied for determining the loads and forces in the purposed structures are given as under:

- 1.5(DL+LL)
- 1.2(DL+LL)
- 1.2DL+1.2LL+1.2EQ (x direction)
- 1.2DL+1.2LL+1.2EQ (-x direction)
- 1.2DL+1.2LL+1.2EQ (z direction)
- 1.2DL+1.2LL+1.2EQ (-z direction)
- 1.2DL+1.2LL+1.2EQ (y direction)
- 1.2DL+1.2LL+1.2EQ (-y direction)
- 1.5DL
- 1.5DL+1.5EQ (x direction)
- 1.5DL+1.5EQ (-x direction)
- 1.5DL+1.5EQ (z direction)
- 1.5DL+1.5EQ (-z direction)
- 1.5DL+1.5EQ (y direction)
- 1.5DL+1.5EQ (-y direction)
- 0.9DL+1.5EQ (x direction)
- 0.9DL+1.5EQ (-x direction)
- 0.9DL+1.5EQ (z direction)
- 0.9DL+1.5EQ (-z direction)
- 0.9DL+1.5EQ (y direction)
- 0.9DL+1.5EQ (-y direction)

Variable data:

The member properties assigned to the structural of different storey buildings for the design procedure have been mentioned below:

a) Concrete properties for G+3 building:

Beams: 380x300mm

Columns:

Circular	**Rectangular**	**Square**
750 mm	675x600 mm	600x600mm

b) Concrete properties for G+7 building:

Beams:

Upto 4th floor	450x450 mm
Beyond 4th floor	380x380mm

Columns:

Circular	**Rectangular**	**Square**
Upto 4th floor		
825mm	750x600mm	675x675mm
Beyond 4th floor		
675mm	600x525mm	525x525mm

c) Concrete properties for G+11 building:

Beams:

Upto 4th floor	675x450 mm
5th to 8th floor	450x450 mm
Beyond 8th floor	380x380 mm

Columns-

Circular	**Rectangular**	**Square**
Upto 4th floor		
900mm	975x675mm	825x825 mm
5th to 8th floor		
750mm	750x600mm	675x6750 mm
Beyond 8th floor		
600mm	600x525mm	525x525mm

3. Results

Following are the models which were prepared, analyzed and designed for the study titled as "Cost Analysis Of Rcc Building Subjected To Different Cross-Section Of Column In Seismic Zone V":

- 3 models for G+3 (building having circular, rectangular and square cross-section of column).
- 3 models for G+7 (building having circular, rectangular and square cross-section of column).
- 3 models for G+7 (building having circular, rectangular and square cross-section of column).

Results were obtained for the above-mentioned structures from the post-processing of Staad.Pro. The results were represented in tabular manner for the purpose of comparison between similar type of buildings having different cross-section of the column. Then cost analysis was done in order to fullfil the main objective of the study.

Three different locations (i.e. A, B, C) of column were chosenin order to obtain results as shown in Fig-5:

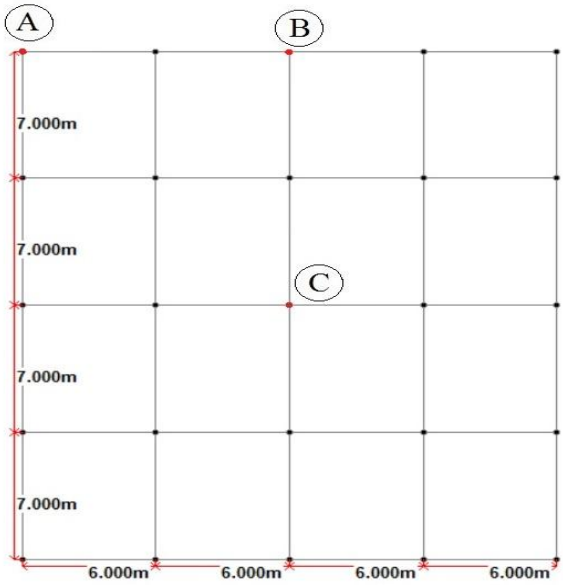

Fig-5: Location of the points A, B, C.

3.1. Results obtained for G+3 Building:

Table: 1 Cross-Sectional Area Of Column.

Shape of Column	Cross-sectional Area
Circular	0.44 m^2
Rectangular	0.41 m^2
Square	0.36 m^2

Table: 2 Perctantage Of Reinforcement Provided.

Shape of Column	% of Steel Provided		
	A	B	C
Ground Floor			
Circular	2.34	2.41	2.48
Rectangular	2.48	2.48	2.79
Square	2.68	2.72	3.14
4^{th} Floor			
Circular	0.81	0.89	0.81
Rectangular	0.89	0.99	0.89
Square	0.88	1.25	0.88

Table: 1 and Table: 2 shows the cross-sectional area and percentage of reinforcement provided in different cross-sections of column for G+3 building.

Table: 3 Total Quantities Of Concrete And Steel.

Building type	Concrete (m^3)	Steel (tonne)
Building Having Circular Column	301.4	50.15
Building Having Rectangular Column	250.2	50.9
Building Having Square Column	235.6	51.6

Table: 4 Total Cost Of Concrete And Steel.

Building type	Concrete (lakhs)	Steel (lakhs)
Building Having Circular Column	13.56	20.06
Building Having Rectangular Column	11.3	20.36
Building Having Square Column	10.6	20.64

Note: Following are the rates of concrete and steel taken for the purpose of cost analysis:

- Cost of concrete per cumec = Rs4500/-
- Cost of steel per kg = Rs40/-

Table:3 represents the total quantities of concrete and steel, whereas, table: 4 represents the total cost of concrete and steel for G+3 building.

Table: 5 Total Cost Of G+3 Building.

Building type	Total Cost Of G+3 Building in lakhs
Building Having Circular Column	33.62
Building Having Rectangular Column	31.66
Building Having Square Column	31.24

Table: 5 shows the result of cost analysis performed on G+3 storey building having different cross-section of column and it was concluded that the total cost of G+3 building is minimum for the building having square cross-section and found economical.

3.2. Results obtained for G+7 Building:

Table: 6 Cross-Sectional Area Of Column.

Shape of Column	Cross-sectional Area
Upto 4th floor	
Circular	0.54 m^2
Rectangular	0.45 m^2
Square	0.46 m^2
from 5th to 8th floor	
Circular	0.36 m^2
Rectangular	0.32 m^2
Square	0.28 m^2

Table: 7 Perctantage Of Reinforcement Provided.

Shape of Column	% of Steel Provided		
	A	B	C
Ground floor			
Circular	2.35	2.64	3.03
Rectangular	2.79	3.07	3.92
Square	2.58	3.01	3.53
5th floor			
Circular	1.45	1.74	1.79
Rectangular	1.78	1.84	2.29
Square	2.04	2.63	2.85
8th floor			
Circular	0.94	1.37	0.84
Rectangular	1.14	1.58	1
Square	1.36	2.04	1.14

Table: 6 and Table: 7 shows the cross-sectional area and percentage of reinforcement provided in different cross-sections of column for G+7 building.

Table: 8 Total Quantities Of Concrete And Steel.

Building type	Concrete (m^3)	Steel (tonne)
Building Having Circular Column	730.1	135.6
Building Having Rectangular Column	609.4	138.1
Building Having Square Column	598.4	137.7

Table: 9 Total Cost Of Concrete And Steel.

Building type	Concrete (lakhs)	Steel (lakhs)
Building Having Circular Column	32.85	54.24
Building Having Rectangular Column	27.5	55.24
Building Having Square Column	27	55.08

Note: Following are the rates of concrete and steel taken for the purpose of cost analysis:

- Cost of concrete per cumec = Rs4500/-
- Cost of steel per kg = Rs40/-

Table: 8 represents the total quantities of concrete and steel, whereas, table: 9 represents the total cost of concrete and steel for G+7 building.

Table: 10 Total Cost Of G+7 Building.

Building type	Total Cost Of G+7 Building i lakhs
Building Having Circular Column	87.09
Building Having Rectangular Column	82.74
Building Having Square Column	82.01

Table: 10 shows the result of cost analysis performed on G+7 storey building having different cross-section of column and it was concluded that the total cost of G+7 building is minimum for the building having square cross-section and found economical.

c. Results obtained for G+11 building:

Table: 11 Cross-Sectional Area Of Column.

Shape of Column	Cross-sectional Area
Upto 4^{th} floor	
Circular	0.64 m^2
Rectangular	0.66 m^2
Square	0.68 m^2
from 5^{th} to 8^{th} floor	
Circular	0.44 m^2
Rectangular	0.45 m^2
Square	0.46 m^2
Beyond 8^{th} floor	
Circular	0.28 m^2
Rectangular	0.32 m^2
Square	0.28 m^2

Table: 12 Perctantage Of Reinforcement Provided.

Shape of Column	% of Steel Provided		
	A	B	C
Ground floor			
Circular	1.53	1.89	2.4
Rectangular	1.46	1.79	2.38
Square	1.41	1.65	2.3
5^{th} floor			
Circular	1.40	2.22	2.84
Rectangular	1.43	2.14	2.79
Square	1.48	2.15	2.75
9^{th} floor			
Circular	2.06	2.63	2.77
Rectangular	1.78	2.04	2.04
Square	2.28	2.85	3.19
12^{th} floor			
Circular	1.4	2	1.11
Rectangular	1.14	1.78	1
Square	1.47	2.13	1.31

Table: 11 and Table: 12 shows the cross-sectional area and percentage of reinforcement provided in different cross-sections of column for G+11 building.

Table: 13 Total Quantities Of Concrete And Steel.

Building type	Concrete (m^3)	Steel (tonne)
Building Having Circular Column	1239.8	207.8
Building Having Rectangula Column	1139.2	212.8
Building Having Square Column	1135.5	210.4

Table: 14 Total Cost Of Concrete And Steel.

Building type	Concrete (lakhs)	Steel (lakhs)
Building Having Circular Column	55.8	83.12
Building Having Rectangular Column	51.3	85.12
Building Having Square Column	51.1	84.16

Note: Following are the rates of concrete and steel taken for the purpose of cost analysis:

- Cost of concrete per cumec = Rs4500/-
- Cost of steel per kg = Rs40/-

Table: 13 represents the total quantities of concrete and steel, whereas, table: 14 represents the total cost of concrete and steel for G+11 building.

Table: 15 Total Cost Of G+11 Building.

Building type	Total Cost Of G+11 Building in lakhs
Building Having Circular Column	138.92
Building Having Rectangul Column	136.42
Building Having Square Column	135.26

Table: 15 shows the result of cost analysis performed on G+11 storey building having different cross-section of column and it was concluded that the total cost of G+11 building is minimum for the building having square cross-section and found economical.

4. Conclusion

Total 9 different models (G+3, G+7, G+11 with three different cross-sections of column i.e. rectangular, square and circular) were analyzed and designed in staad.pro with Response Spectrum Method in Zone V as per IS: 1893-2016 and results were recorded from the post-processing of software Staad.pro. Conclusions drawn from the cost analysis are as follows:

- The total cost of G+3 building is minimum for the building having square cross-section and found economical and safe.
- The total cost of G+7 buildingis minimum for the building having squarecross-section and found economical and safe.
- The total cost of G+11 building is minimum for the building having squarecross-section and found economical and safe.

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