International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No. (02), January 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

# Comparative Study of G+10 and G+20 R.C. Moment Resisting Frame Building to Determine the Effect of Column Spacing on Economy

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**ABSTRACT**

*The spacing between columns is a major parameter, which effect the economy of the project or building. When column spacing is less than size of the panels is less and if spacing between columns are more the size of panels are more due to this reason, in reinforced concrete building, the cost of raw material may vary. In this research, a comparative study of G+10 and G+20 R.C. Moment Resisting Frame building to determine the effect of column spacing on economy. For the determining the effect of column spacing on economy, three cases (2m, 4m and 6m case) of column spacing are considered. The structure is modelled, analysed and designed as per IS 456:2000 by using E – TABS. From the E – TABS, the quantity of concrete, steel and shuttering are determined. These models are analysed to derive the relation for the optimum spacing of columns for the different height of the buildings. The aspect ratio of the building is taken 1.5 and the economical building is defined on the basis of total sum of cost of concrete, steel and shuttering.*

***Keyword: Aspect Ratio, Optimum Column Spacing, E – TABS, Multi – Storey Building, Quantity Modelling***

## I. INTRODUCTION

The population and land requirement for residential and commercial purposes is continuously increasing in urban areas, multistoried buildings are becoming common in construction industry. The low rise, high – rise buildings, apartments and multistorey buildings can be compared on the basis of required area for people but it also compared on the basis of required material for construction or cost. The cost is analyzed for sub – structure and super – structures. In this research paper, the cost is analyzed only for super – structural components. These components are column, beam and slab. The quantity of steel, concrete and shuttering is determined for each component. For multi-storey building, there are various forms of structure configuration possible. Depending upon the height of building, the form of structure is decided. The economy of such structure is governed by many factors like, form of structure, selection of material, construction technique, time required for different work to execute. Spacing of column in a Reinforced concrete building is an important factor to determine the dimensions of columns itself, beams, slab etc. Therefore, cost of the material is also influenced by span length. It has been observed that in multi-storey building, the spacing of column can plays an important role in governing the economy of structure. The present study is being undertaken to see the effect of column spacing on its cost and on the basis of that important conclusion are drawn to decide the appropriate column spacing for multi-storey building.

## II. LITERATURE REVIEW

**V. Thiruvengadam et. al. (2004)** focused the important aspect of cost implications to incorporated with seismic resistance in structure. The methodology of costing is quantified values for low to medium rise reinforced concrete multi – storey buildings. The various levels of seismic resistance depend on the seismic zone. They concluded, the requirement of concrete and shuttering materials per sq. meter of floor area varied from 0.26 $m^3$ to 0.31 $m^3$ and 1.66 $m^2$ to 1.77 $m^2$ for 2 to 10 storey building respectively and the steel required as per square meter of floor area is varied from 28 kg to 55 kg depending upon the number of storey and seismic zone. For an eight storeyed building located in seismic zone V, 69% percent more steel required with compared to non – seismic design. The cost premium for incorporating earthquake resistance as a percentage of structural cost of the building varied from 2 to 30% based on the number of storey and seismic zone.

**Chirag M Patel et. al. (2015)** studied comparative study of reinforced concrete filled steel tube structures with traditional reinforced concrete and steel structure. They studied medium to high rise building, these types of buildings are no longer economic because of increases dead load and less stiffness. They prepared CFST and RCC and Steel structure with different storey height of G+14, G+19 and B+G+20 storeys with all structural systems as frame structure is carried out. The used E – TABS software to carry out the analysis. After the analyzing, they concluded that the composite structures are more economical than that of RCC structure. Weight of composite structure reduced the foundation cost compare to RCC structure. CFST structure performs in condition of axial force, shear force and base shear compare to steel and RCC structure.

**M. Mallikarjun et. al (2016)** analysed and designed a multi – storey residential building of (Ung–2+G+10) by using most economical column method. They designed R.C.C. framed structure with using E – TABS. The main aim of this work was ensuring and enhancing the safety. Keeping careful balance between economy and safety. The concluded that economy of columns is affected by the quantity of steel. They economized the column by means of column orientation is longer span longer direction will reduce the amount of bending and as a result of area of steel is also reduced.

## III. DESIGN CRITERIA AND COMPONENT DIMENSIONS

### 3.1 Design Criteria

The following design criteria are used to prepare building model in E – TABS.

International Journal of Advance Research in Science and Engineering
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ISSN: 2319-8354

Table 3.1 Design Loads

| Type of Load | Load (kN/m) |
|---|---|
| Dead Load (Beam / Roof Beam) | 13.8 / 5.0 |
| Live Load<br>Slab / Roof Slab<br>Floor Finish Load | <br>2.0 / 1.5<br>1.5 |

Table 3.2 Seismic Parameters

| Particulars | Values |
|---|---|
| Zone Factor | 0.24 |
| Importance Factor | 1.0 |
| Soil Condition | Medium Soil |
| Damping | 5% |
| Response Reduction Factor (SMRF) | 5.0 |

### 3.2 Dimensions of Building Components

Following data are considered for the design of model

Table 3.3 – Dimensional parameters for 2m, 4m and 6m spaced columns of 10 storey building

| Building Height (m) | Column Spacing (m) | Number of Storey | Column Size ($mm^2$) | Beam Size ($mm^2$) | Thickness of Slab (mm) |
|---|---|---|---|---|---|
| 35 | 2 | Up to 4 storey | 350 x 350 | 230 x 300 | 110 |
| | | From 5 to 7 storey | 300 x 300 | | |
| | | From 8 to 10 storey | 250 x 250 | | |
| | 4 | Up to 4 storey | 400 x 400 | 230 x 400 | 130 |
| | | From 5 to 7 storey | 350 x 350 | | |
| | | From 8 to 10 storey | 300 x 300 | | |
| | 6 | Up to 4 storey | 550 x 550 | 230 x 500 | 150 |
| | | From 5 to 7 storey | 500 x 500 | | |
| | | From 8 to 10 storey | 450 x 450 | | |

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Table 3.4 – Dimensional parameters for 2m, 4m and 6m spaced columns of 20 storey building

| **Building Height (m)** | **Column Spacing (m)** | **Number of Storey** | **Column Size ($mm^2$)** | **Beam Size ($mm^2$)** | **Thickness of Slab (mm)** |
|---|---|---|---|---|---|
| 70 | 2 | Up to 7 storey | 350 x 350 | 230 x 300 | 110 |
| | | From 8 to 14 storey | 300 x 300 | | |
| | | From 15 to 20 storey | 250 x 250 | | |
| | 4 | Up to 5 storey | 550 x 550 | 230 x 400 | 130 |
| | | From 6 to 10 storey | 500 x 500 | | |
| | | From 11 to 15 storey | 450 x 450 | | |
| | | From 16 to 20 storey | 400 x 400 | | |
| | 6 | Up to 5 storey | 700 x 700 | 300 x 500 | 150 |
| | | From 6 to 10 storey | 650 x 650 | | |
| | | From 11 to 15 storey | 600 x 600 | | |
| | | From 16 to 20 storey | 550 x 550 | | |

## IV. QUANTITY AND COST RESULTS

The following quantity and cost results are obtained from the analysis. Table 3.5 and Table 3.7, show the results for 10 and 20 storeys building respective.

**Table 3.5 Quantity and cost of materials for 10 storey building**

| Spacing between Columns | Material | Unit of Material | No. of Columns | No. of Beams | Quantity in Column | Quantity in Beam | Quantity in Slab | Total Cost (Lac.) |
|---|---|---|---|---|---|---|---|---|
| 2m | Concrete | $m^3$ | 247 | 462 | 640 | 630 | 950 | 88.80 |
| 4m | | | 70 | 123 | 393 | 450 | 1130 | 78.92 |
| 6m | | | 35 | 58 | 306 | 400 | 1300 | 80.24 |
| 2m | Steel | MT | 247 | 462 | 137.04 | 57.03 | 58.32 | 113.58 |
| 4m | | | 70 | 123 | 120.38 | 54.30 | 88.56 | 118.46 |
| 6m | | | 35 | 58 | 71.57 | 69.54 | 105.84 | 111.13 |
| 2m | Shuttering | $m^2$ | 247 | 462 | 11413 | 9090 | 8640 | 78.69 |
| 4m | | | 70 | 123 | 4268 | 5720 | 8640 | 50.29 |
| 6m | | | 35 | 58 | 2629 | 4720 | 8640 | 43.17 |

IJARSE
ISSN: 2319-8354

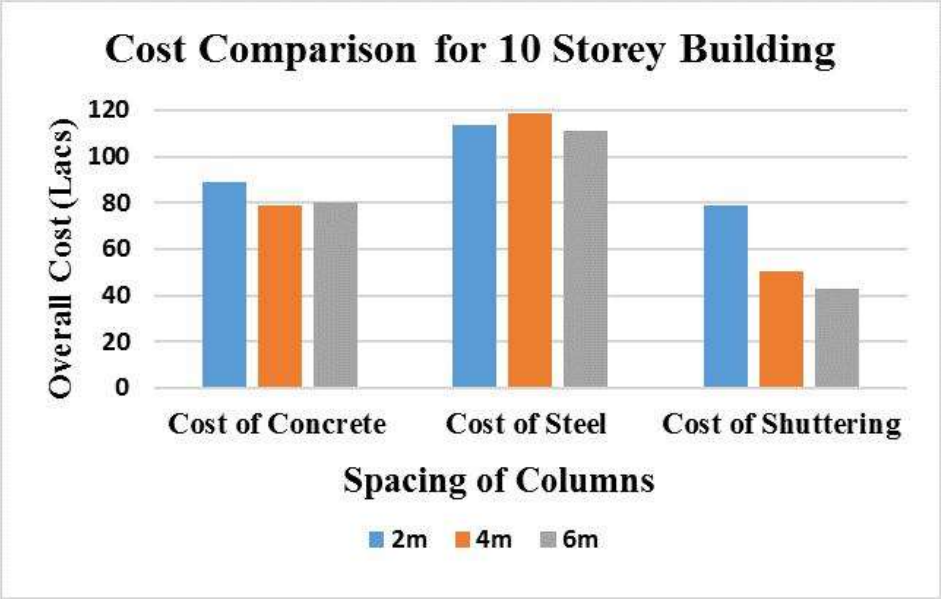


**Fig. 3.1 Cost comparison for 10 storey building**

From fig. 3.1, it is observed that in case of cost of concrete, the 4m case is having minimum cost of material but in case of steel, it has maximum cost. Same as in 6m case is having minimum cost of shuttering. The overall cost of shown in Table 3.6, which shows the 6m case is most economical case for 10 storey building. The graphical representation of Table 3.6 is shown in fig. 3.2.

**Table 3.6 Summary of 10 storey building**

| Column Spacing Case | Quantity of Concrete ($m^3$) | Quantity of Steel (kg) | Quantity of Shuttering ($m^2$) | Overall cost (Cr.) | % Variation in Cost |
|---|---|---|---|---|---|
| 2m | 2220 | 252.39 | 29143 | 2.812 | - |
| 4m | 1973 | 263.24 | 18628 | 2.477 | - 11.91 |
| 6m | 2006 | 246.95 | 15989 | 2.345 | - 16.61 |

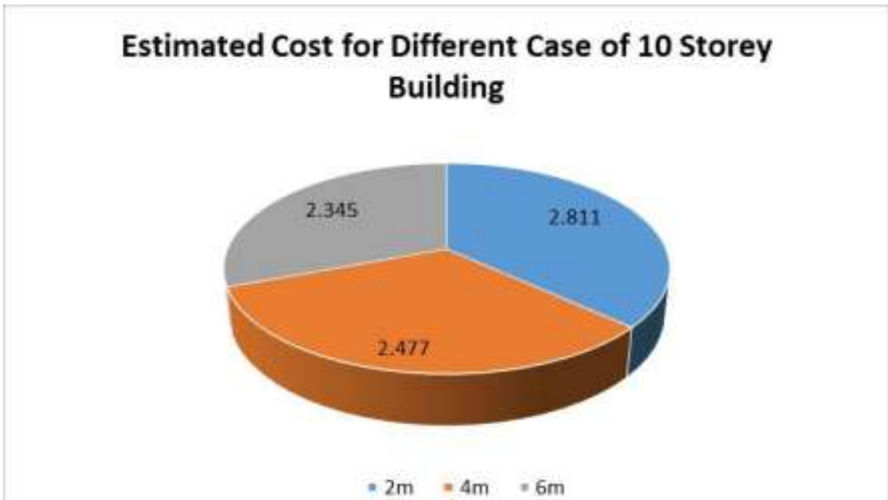


**Fig. 3.2 Estimated cost for different case of 10 storey building**

International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No. (02), January 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

The cost of concrete, steel and shuttering is 4000 rupees per cubic meter, 45 rupees per kilograms and 270 rupees per square meter is taken respectively.

**Table 3.7 Quantity and cost of materials for 20 storey building**

| Spacing between Columns | Material | Unit of Material | No. of Columns | No. of Beams | Quantity in Column | Quantity in Beam | Quantity in Slab | Total Cost (Lac.) |
|---|---|---|---|---|---|---|---|---|
| 2m | Concrete | $m^3$ | 247 | 462 | 1564 | 1260 | 1900 | 188.96 |
| 4m | | | 70 | 123 | 1100 | 900 | 2260 | 170.50 |
| 6m | | | 35 | 58 | 955 | 1020 | 2600 | 183.00 |
| 2m | Steel | MT | 247 | 462 | 447.32 | 114.06 | 116.64 | 305.11 |
| 4m | | | 70 | 123 | 182.69 | 108.60 | 177.12 | 210.79 |
| 6m | | | 35 | 58 | 202.91 | 90.10 | 211.68 | 227.11 |
| 2m | Shuttering | $m^2$ | 247 | 462 | 22653 | 18180 | 17280 | 156.91 |
| 4m | | | 70 | 123 | 11770 | 11440 | 17280 | 109.32 |
| 6m | | | 35 | 58 | 6380 | 9440 | 17280 | 89.37 |

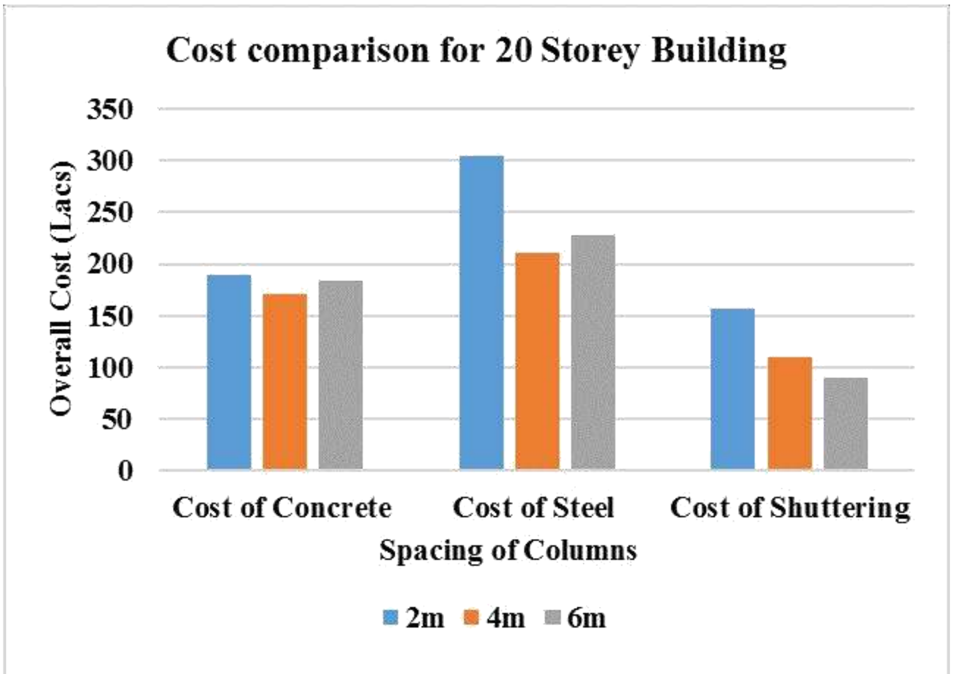


**Fig. 3.3 Cost comparison for 20 storey building**

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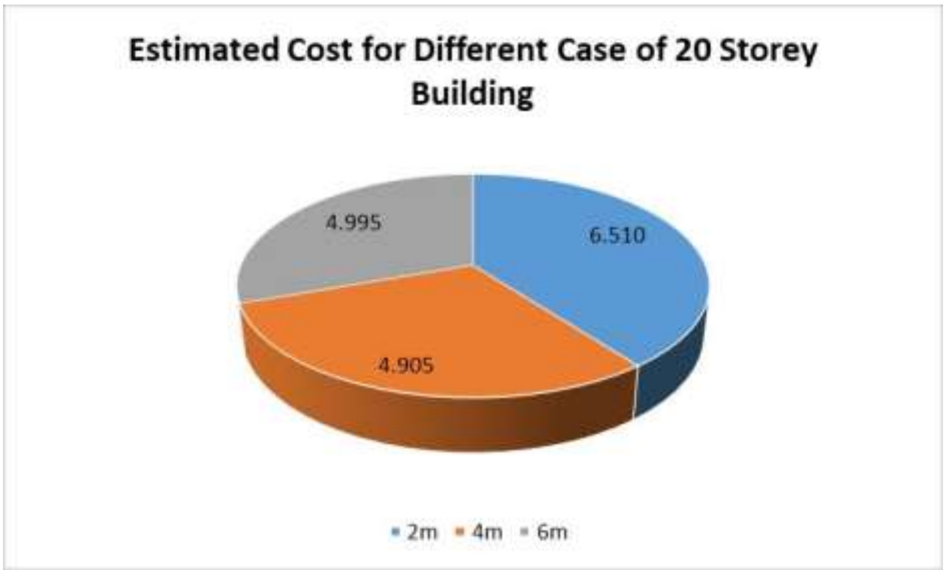


**Fig. 3.4 Estimated cost for different case of 20 storey building**

From fig. 3.3, it is observed that in case of cost of concrete, the 4m case is having minimum cost of concrete and same as in case of steel, the cost of steel is minimum cost but in case of shuttering, the minimum cost is determined in 6m case. The overall cost of material is shown in Table 3.8, which shows the 4m case is most economical case for 20 storey building. The graphical representation of Table 3.8 is shown in fig. 3.4.

The cost of concrete, steel and shuttering is 4000 rupees per cubic meter, 45 rupees per kilograms and 270 rupees per square meter is taken respectively.

**Table 3.8 Summary of 20 storey building**

| Column Spacing Case | Quantity of Concrete ($m^3$) | Quantity of Steel (kg) | Quantity of Shuttering ($m^2$) | Overall cost (Cr.) | % Variation in Cost |
|---|---|---|---|---|---|
| 2m | 4720 | 678.02 | 58113 | 6.510 | - |
| 4m | 4260 | 468.42 | 40490 | 4.905 | - 24.65 |
| 6m | 4575 | 504.69 | 33100 | 4.995 | - 23.27 |

## V. DISCUSSION

After completing the cost analysis of 10 storey and 20 storey building, it is observed that when number of storey increases the quantity of material also increases. In case of concrete, the minimum quantity is determined in 4m case for 10 and 20 storey building. Same as in case of steel, the minimum quantity is obtained for 6m case and 4m case for 10 storey and 20 storey building model respectively. In 10 storey building, the quantity of steel increases to 4m but when spacing between columns increase till 6m, the quantity of steel decreases. Similarly, in 20 storey building, the quantity of steel is increased from 4m case of column. The quantity of shuttering shows that when spacing between column increases, the quantity of shuttering decreases.

In cost estimation, it is observed that the overall cost is reduced 11.91% and 16.60% by 2m case in 4m and 6m case respectively for 10 storey building. Same as in 20 storey building, the overall cost is reduced 24.65% and 23.27% by 2m case in 4m and 6m case respectively.

## VI. CONCLUSIONS

The following conclusions are made from the present study.

- The minimum quantity of concrete, steel and shuttering are obtained for 4m, 6m and 6m case respectively in 10 storey building but in 20 storey building, the minimum quantity of concrete, steel and shuttering are obtained for 4m, 4m and 6m case respectively.
- For 10 storey building, it is observed that quantity of concrete is inversely proportional to quantity of steel. The minimum quantity of concrete is obtained 1973 $m^3$ for 4m case but same as in 4m case the quantity of steel is maximum from the all cases which is 263.24 MT but when number of storey increases (20 storey building), the quantity of concrete and quantity of steel is directly proportional. The maximum quantity of concrete is 4720 $m^3$ obtained for 2m case and same as, the maximum quantity of steel is 678.02 MT obtained.
- The quantity of shuttering increases with increasing the number of storey and decreases with increasing the spacing between the columns.
- From the cost analysis, it is observed that the overall cost is reduced 16.60% for 6m case and 24.65% for 4m case by 2m case cost. Hence, in 10 storey building the 6m case and in 20 storey building the 4m case is most economical case.
- From the cost analysis it is also observed that when the height of building increases the most economical case is obtained for minimum spaced column model or building.

## VII. ACKNOWLEDGEMENTS

I would like to express my profound gratitude and indebtedness to my guide Dr. B. P. Suneja and my best friend Er. Jitendra Khatti who have always been a constant motivation and guiding factor throughout the research time in and out as well. Dr. B. P. Suneja is professor and head of department of Civil Engineering department in University Teaching Department, RTU, Kota and Er. Jitendra Khatti is PhD. Scholar, who is doing PhD. from Civil Engineering department of University Teaching Department, RTU, Kota. It has been a great pleasure for me to get an opportunity to work under them and complete the research work successfully.

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