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Comparative Study of G+25 and G+40 R.C. Moment Resisting Frame Building to Determine the Effect of Column Spacing on Economy

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ABSTRACT

The spacing between columns may affect the economy of the project or building. When column spacing is less than size of the panels and beam are less. If spacing between columns are more the size of panels and beam 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+25 and G+40 R.C. Moment Resisting Frame building is done to determine the effect of column spacing on economy. For determining the effect of column spacing on economy, 2m and 4m 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

With increase in population, the land requirement for residential and commercial purposes is continuously increasing in urban areas, multistoried buildings are becoming common in construction industry. The 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 (vertical and horizontal 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 spacing between columns affect the length of the beam and number of slab panels are varied.

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.

Markandeya Raju Ponnada (2015) studied the effect of column spacing on economy of G+5 R. C. Moment Resisting Frame. He prepared model in STAAD PRO. For 30m x 30m plot area and he varied this plot area between 1 to 4 range of aspect ratio. He concluded after getting results that building which is having aspect ratio 1, building is most economical building.

Geeta Mehta et. al. (2016) optimized of member size and materials for multistoreyed RCC buildings using E – TABS. They prepared G+9, G+11, G+13 and G+15 RCC structure for seismic zone V. the loading and all other relevant considerations are made for office buildings. After analysing, they concluded that the cost of structure is dominated by the cost of structural steel. In ordinary RCC framed structure the cost of structural steel is approximately 70% of the total cost of the structure but after repeated trials for optimization of structural elements the cost of structural steel was reduced by 10%.

III. DESIGN CRITERIA AND COMPONENT DIMENSIONS

3.1 Design Criteria

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

Table 3.1 Design Loads

Type of Load	Load (kN/m)
Dead Load (Beam / Roof Beam)	13.8 / 5.0
Live Load Slab / Roof Slab Floor Finish Load	 2.0 / 1.5 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 and 4m spaced columns of 25 storey building

Building Height (m)	Column Spacing (m)	Number of Storey	Column Size (mm^2)	Beam Size (mm^2)	Thickness of Slab (mm)
87.5	2	Up to 7 storey	400 x 400	230 x 300	110
		From 8 to 13 storey	350 x 350		
		From 14 to 19 storey	300 x 300		
		From 20 to 25 storey	250 x 250		
	4	Up to 7 storey	700 x 700	230 x 500	130
		From 8 to 13 storey	650 x 650		
		From 14 to 19 storey	600 x 600		
		From 20 to 25 storey	550 x 550		

Table 3.4 – Dimensional parameters for 2m and 4m spaced columns of 40 storey building

Building Height (m)	Column Spacing (m)	Number of Storey	Column Size (mm^2)	Beam Size (mm^2)	Thickness of Slab (mm)
140	2	Up to 10 storey	550 x 500	230 x 400	110
		From 11 to 20 storey	500 x 500		
		From 21 to 30 storey	450 x 450		
		From 31 to 40 storey	400 x 400		
	4	Up to 10 storey	900 x 900	230 x 600	130
		From 11 to 20 storey	850 x 850		
		From 21 to 30 storey	800 x 800		
		From 31 to 40 storey	750 x 750		

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 25 and 40 storeys building respective.

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 3.5 Quantity and cost of materials for 25 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	2311	1575	2375	250.44
4m			70	123	2372	1400	2825	263.88
2m	Steel	MT	247	462	677.84	142.58	145.80	434.79
4m			70	123	506.78	122.90	221.40	382.99
2m	Shuttering	m^2	247	462	31735	22725	21600	205.36
4m			70	123	16011	16825	21600	146.98

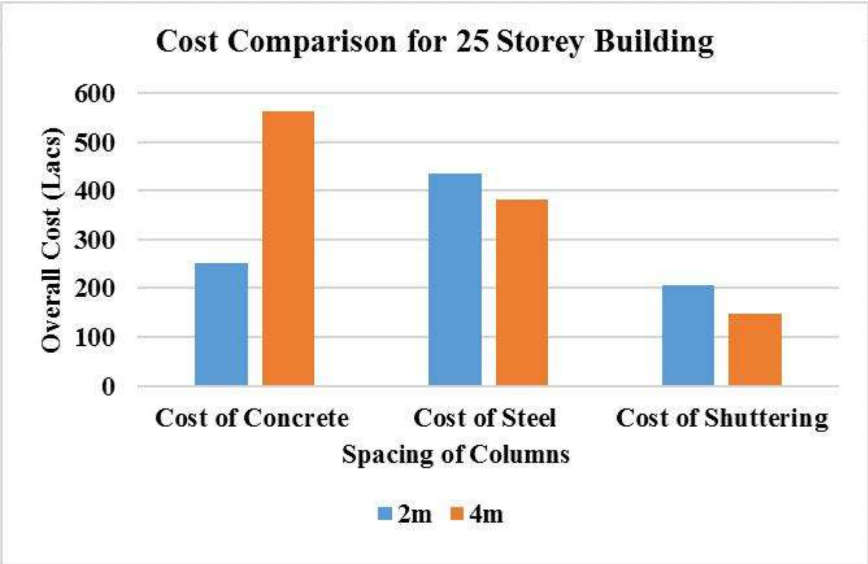

Fig. 3.1 Cost comparison for 25 storey building

From fig. 3.1, it is observed that in case of cost of concrete, the 2m case is having minimum cost of material but in case of steel, it has maximum cost. Same as in case of shuttering 4m case is having maximum cost of shuttering. The overall cost of material is shown in Table 3.6, which shows the 4m case is most economical case for 25 storey building. The graphical representation of Table 3.6 is shown in fig. 3.2.

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Table 3.6 Summary of 25 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	6261	966.22	76060	8.906	-
4m	6597	851.09	54436	7.938	- 10.87

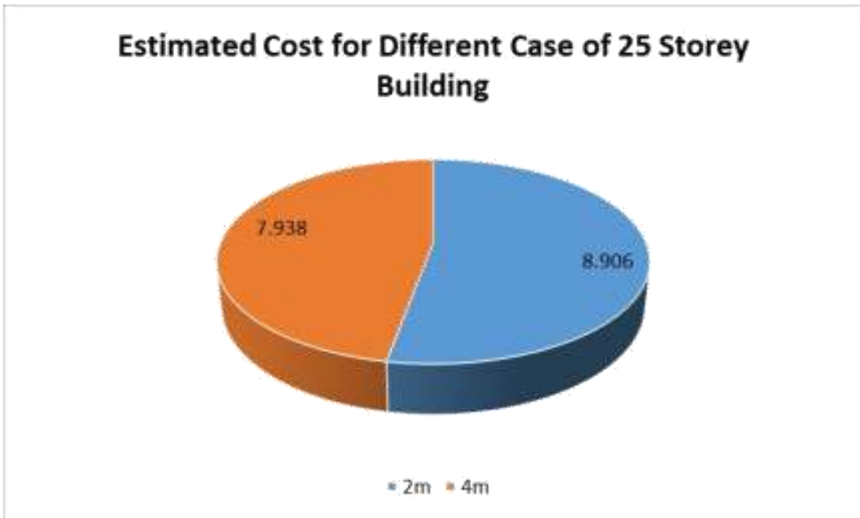

Fig. 3.2 Estimated cost for different case of 25 storey building

Table 3.7 Quantity and cost of materials for 40 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	7730	2520	3800	562.00
4m			70	123	6520	2680	4520	548.80
2m	Steel	MT	247	462	1429.95	228.12	233.28	851.11
4m			70	123	1875.96	272.60	354.24	1126.26
2m	Shuttering	m^2	247	462	76090	44160	34560	417.99
4m			70	123	33340	30960	34560	266.92

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	14050	1891.35	154810	18.31	-
4m	13720	2502.80	98860	19.42	+ 6.06

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 in 2m but in case of shuttering, the minimum cost is determined in 4m case. The overall cost of material is shown in Table 3.8, which shows the 2m case is most economical case for 40 storey building. The graphical representation of Table 3.8 is shown in fig. 3.4.

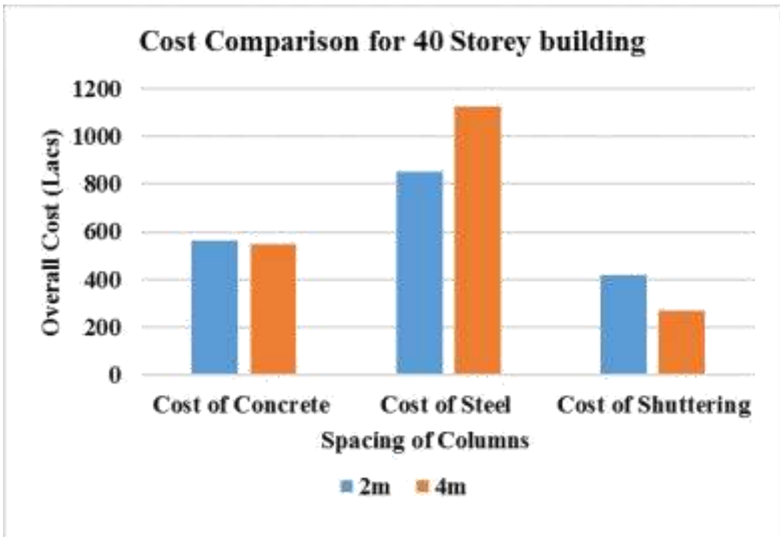

Fig. 3.3 Cost comparison for 40 storey building

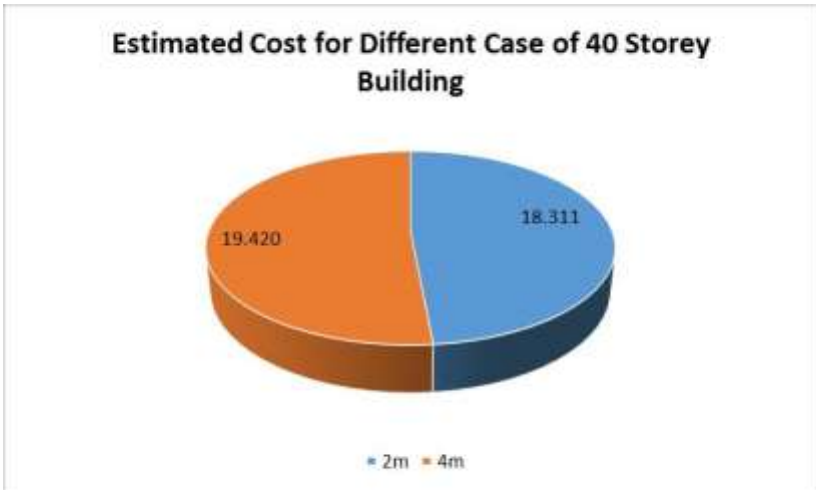

Fig. 3.4 Estimated cost for different case of 40 storey building

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.

V. DISCUSSION

After completing the cost analysis of 25 storey and 40 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 2m case and 4m in 25 storey and 40 storey building model respectively. Same as in case of steel, the minimum quantity is obtained for 4m case and 2m case for 25 storey and 40 storey building model respectively. In 25 storey building, the quantity of steel is decreases from 2m but when spacing between columns decreases, the quantity of steel increases. Similarly, in 40 storey building, the quantity of steel is increased in 4m case. 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 10.87% by 2m case in 4m case for 25 storey building. Same as in 40 storey building, the overall cost is increase 6.06% by 2m case in 4m case respectively.

VI. CONCLUSIONS

The following conclusions are made from the present study.

- From the overall quantity of concrete and steel, when the spacing between columns increases the quantity of concrete increases but the quantity of steel decreases in 25 storey building but in 40 storey building case, when spacing between column increases the quantity of concrete decreases but the quantity of steel increases.
- From the both building case, it is observed that when quantity of concrete decreases the quantity of steel increases. In 40 storey building case, the 4m case is having 13720 m^3 quantity of concrete and 2502.80 MT quantity of steel.
- 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 10.87% for 4m case and increased 6.06% for 4m case by 2m case cost. Hence, in 25 storey building the 4m case and in 40 storey building the 2m 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. In 40 storey building case, 2m case is most economical case. Hence, tube in tube structures are more economical to R. C. Moment Resisting Frame structures.

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