COST ANALYSIS OF TWO-WAY SLAB AND POST TENSION SLAB

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Abstract - *In recent times multi storey structures are widely constructed. Slabs are one of the components in the construction of buildings. The use post tension slab provides more advantages than the two-way slab. Hence the present study aim to compare various aspects like depth, material quantities, cost for two- way and post tensioned slabs. A slab of size 15.83*9.38 m slab is taken from existing building and from that slab, a panel of size 5*9.38 m is designed for two-way slab and post tension slab as per provisions of respective IS codes. The quantities of the materials are calculated and cost of construction for slabs are determined and compared. From the study it is considered that post tension slab is more economical than two-way slab.*

Key Words: **Multi storey, post tension, two way, design, comparison.**

1.INTRODUCTION:

A slab is a concrete structure constructed to provide a flat surface. Slabs are constructed to carry the heavy loads and to sustain the building. Slabs are having both long and short slabs based on the span size. The types of slabs are

1.1 Conventional slab:

Conventional slab is a slab constructed with columns and beams. The slab requires thickness of 0.1 m. Conventional slab is of two types

i.One-way slab
ii.Two-way slab

i. One-way slab:

It is slab supported by beams on two opposite sides to carry the load along one direction. For one-way slab, the ratio of longer span to shorter span is greater than or equal to 2.

$$\frac{\text{Longer Span}}{\text{Shorter Span}} \geq 2$$

ii. Two-way slab:

It is a slab supported by beams on all the four sides and the loads are carried by the supports along both directions, it is known as two-way slab. In two-way slab, the ratio of longer span (l) to shorter span (b) is less than 2

$$\frac{\text{Longer Span}}{\text{Shorter Span}} < 2$$

1.2 Post Tension Slab:

A slab tensioned against hardened concrete after the construction of the slab is called post tension slab**.** These slabs are constructed with the help of tendons or cables that transfer the load. Post tension slabs are slabs used to construct high strength structures with an economical cost. They are constructed to carry a heavy weight considering the other slabs, this slab will be a good choice considering the long spans. High strength concrete is necessary in the post tension slab as material offers high resistance in shear and tension.

2.Literature:

Jnanesh Reddy R K and Pradeep A R [01], conducted studies an attempt is made to compare the cost effectiveness of Post-Tensioned flat slab systems with respect to reinforced concrete flat slab system. The design of post-tensioned slab is done by using load balancing and equivalent frame method. The model considered is basement, ground and 4 floors with dimensions 38.13 x 28.85 m, with largest spans of 9.44 x6.16 m and the column dimensions are 750 x 750 mm. Grade of concrete considered is M30 and grade rebar is Fe 415 for columns, beams, and slabs. From the quantity estimations and costing it is observed that concrete needed for R.C.C Flat Slab construction with edge beams is 330 m^3. and that for PT Slab with drop panels is 247 m^3. Cost of steel required for the R.C.C Flat Slab construction is Rs.39,15,751 /- and the cost of steel & tendons required for PT Slab construction is Rs.34,45,148 /-.The cost of steel required is much less in case of post-tensioning slab than in the case of R.C.C Slab.i.e It is more economical to construct the structure considered with PT Slab than with the R.C.C. Slab. The thickness of the slab is also much lesser than the R.C.C slab. Hence, using a PT Slab is more advisable for a commercial building than using a R.C.C Flat Slab.

Dr.B. Ramesh Babu et.al [02], conducted studies on the flat slab of various spans, ranging from 6.0 m to 12.0 m, by reinforced concrete cement and prestressed concrete techniques. post-tensioned structures can be designed to have minimal deflection and cracking, even under full load. For smaller spans of normal building works, prestressed concrete construction becomes higher cost. So Post-tensioning is preferred for large span slabs. The objectives of the design are Slab Design, Beam Design, Column Design, Footing Design. Flat slab has many advantages over conventional slabs and hence it can be a very good option for modern constructions for structural stability and for aesthetic aspects and prospects. It can be designed and built either by conventional reinforced concrete or by post-tensioning. By post-tensioning the flat slab becomes higher cost, conventional reinforced concrete design is the preferred choice for spans up to 10 meters.

Amrut Manvi et.al [03], conducted studies on conventional and flat slab framed structure (B+G+3) is used. The parameters considered are quantity and cost of beam, column and slab. Weight of Flat slab structure is quite low as compared to conventional slab structure. Flat slab structure is more economical than that of conventional slab structure. The cost of flat slab structure is reduced by 15.8% compared to conventional slab structures. Flat slab structure leads to economic saving, aesthetic view when compared to the conventional slab structure. The Flat slab structures are best for high rise structure as compared to conventional slab structure. The investigation shows that, the weight of flat slab structure is less compared to conventional slab structure. The cost of flat slab structure is less by 15.8% as compared to conventional slab. The study concludes, flat slab structures are the best solution for high rise structure as compared to conventional slab structure when compared with cost of material.

Objective and scope:

The objective of present study is to compare various aspects like depth, material quantities, cost for two- way and post tensioned slabs. From the study economical slab is known that can be preferred for multi storey structures which reduces cost of construction.

3. Methodology:

A slab of size 15.83*9.38 m is taken from the existed building and from this slab a panel of size 5*9.38 m is considered as a slab for the study. The post tension slab is designed as per IS1343-1987 [04] and two-way slab is designed as per IS456:2000 [05] The loads are taken as per IS875(part-2)-1987 [06] and the cost estimation between these slabs is conducted.

The design of post tension slab is presented below.

Design of a Post tension slab

l_1=5 m, l_2=9.38m

Imposed load=3 kN/m^2

Cables four wires of 5 mm diameter

f_p=1600 N/mm^2, fck=40 N/mm^2, e_c=38 kN/mm^2

Ratio of L_y/L_x =9.38/5 = 1.876

Thickness of slab =span/50 = 5000/50 =100 mm

Self-weight of slab =0.10*24*1 = 2.4 kN/m^2

Live load on slab = 3.0 kN/m^2

Finishes etc. = 0.12 kN/m^2

Total service load = 6 kN/m^2

Total ultimate design load,

W_{ud} = (1.776*3) +(1.976*3) = 11.256 kN/m^2

Ref to table 17.3, working moments in the middle strips are given by

μ_{SX} =0.103*5.0*5^2 = 12.875 KN m/m = 12.9 kN m/m

μ_{sy}= 0.056*5.0*5^2 = 7 kN-m/m

Total moment in the middle strip (x-direction) = 12.9*0.94*9.38=113.74 KN m

Using a minimum cover of 30mm for the tendons at the centre of the slab, the distance between the top kern and the centroid of the cable= 100-20-40= 40 mm

P= total pre-stressing force required in the x-direction

P*40=113.74*10^6

P=28.43*10^5 N= 2843 kN

Assume force in each cable = 100 kN

Therefore, number of cables in x-direction (middle strip) =28

Spacing of cables =0.94*9.38*1000/28 = 315 mm

Adopt a spacing of 305 mm (four cables for metre)

Total moment in the middle strip(y-direction) =7*094*5=32.9=33 kN per m

Providing a curve of 40 mm to cables in y-direction

Distance between cables and top kern= 100-40-40 = 20 mm

Therefore, pre-stressing force required = 33*10^6/20*10^3= 1650 kN

Number of cables in y direction (middle strip) =1650/100=17

Spacing of cables = 0.94*5*1000/17=277 mm

The cable profile is parabolic with maximum eccentricity at centre and concentric at the supports

Check for limit state of collapse: -

Alternate moment (x-direction) =0103*9.38*5^2 =24.5KN m/m =25 kN m per m

A_p= (4*4*20) =320 mm^2

($A_P f_p / bd f_{ck}$) = (320*1600/1000*93*40) =0.137

Referring to table 7.1

($f_u/0.87f_p$) =1.0

Therefore f_u = 0.87*1600 = 1393 N/mm^2

and (x_u/d) = 0.29

Xu = 0.29*93 = 26.97 mm

μ_u =$f_p A_P$(d-0.42x_u)

=1392*320(93-0.42*26.97/10^6)

=36.37 kN m

Check for deflection under service loads: -

Equivalent load (x-direction) = 8p_e/L_x^2 = 8*400*0.03/25= 3.84 KN/m

Equivalent load (y-direction) = 8*320*0.08/87.98 = 0.58 KN/m

Therefore, unbalanced load = 5-3.84-0.58 =0.58 KN/m^2 = 0.0058 N/mm^2

Using deflection coefficient by

α = 0.00772

q = 0.00058 N/mm^2

D = Eh^3/12(1-V_c^2)

= 38000*100^3/12(1-0.18^2) = 3.27*10^9

α_{max} = 0.00772(0.00058*500^4/3.27*10^9) = 0.85 mm

Maximum permissible long-term deflection=5000/305 =16.39 =17 mm

Check for stresses: -

Unbalanced load = 0.58 kN/m^2

Moment due to this load (x-direction) = 0.103*0.58*5^2 = 1.49 kN-m

Stresses developed = 1.49*10^6/ (1000*100^2)/6 = 0.89 N/mm^2

Direct stress due to pre-stressing force = 400*1000/1000*100 = 4 N/mm^2

Therefore, maximum composed stress in concrete at the top of slab = 0.89+4 = 4.89 N/mm^2

Which is less than the permissible stress of 13 N/mm^2

Maximum shear stress = 9.38*5000*0.424/1000*93 =0.21 N/mm^2

Which is negligibly small and hence no shear reinforcements are necessary.

Following code provisions two-way slab is designed and the cost is estimated. The obtained values of the two-way slab are

Depth of the slab=195 mm

A_{st}=1070.64 mm^2 (Longer direction)

A_{st}=538.55 mm^2 (shorter direction)

Cement=3676 kg

Fine aggregate=5.66 m^3

Coarse aggregate=3.72 m^3

The cost estimation for the post tension slab and two-way slab is given in the table 3.1 and 3.2.

Table 3.1 Cost estimation for Post-Tension Slab

POST-TENSION SLAB						
particulars	**Tendons**	**length of the each**	**breadth**	**depth**	**quantity**	**explanatory note**
Main reinf	28	9.38m			28*9.38*0.78=204.8592kg	9.38m
Distributio	17	9.38m			17*9.38*0.78=124.3788kg	9.38m
Total					**329.238kg**	
	Quantity	**Rupees**			**Total Amount**	
Coarse agg	3.75m³	1240Rs/m³			4650Rs	
Fine aggre	1.88m³	360Rs/m³			676.8Rs	
Cement	1800kg	6Rs/kg			10800Rs	
Steel	329.238kg	51Rs/kg			16791.138Rs	
Total					**32917.938Rs**	

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Table 3.2 Cost estimation for Two-way slab

TWO WAY SLAB

particulars	number of bars	length of the	breadth	depth	quantity	explanatory note
steel bars main reinforcement						
top	5	10.21m			(5*10.21*0.78)=39.81kg	9.38-5(0.005)+5*18*0.012=10.21m
bottom	10	11.04m			(10*11.04*0.78)=86.112kg	9.38-10(0.005)+10*18*0.012=11.04m
distribution reinforcement						
top	5	9.85m			(5*9.85*0.78)=38.415kg	9.38-5(0.005)+5*18*0.008=9.85m
bottom	5	9.85m			(5*9.85*0.78)=38.415kg	9.38-5(0.005)+5*18*0.008=9.85m
total					202.752kg	
	Quantity	**Rupees**			**Total Amount**	
Coarse aggre	$3.72m^3$	$1240Rs/m^3$			4612.8Rs	
Fine aggrega	$5.66m^3$	$360Rs/m^3$			2037.6Rs	
Cement	3676kg	6Rs/kg			22056Rs	
Steel	202.752kg	51Rs/kg			10340.352Rs	
Total					39046.752Rs	

4. Results and discussions:

As shown in the fig 4.1, Comparing to the two-way slab, the Depth of the slab for post tension slab is 47.82% less. The Quantity of the cement for two-way slab is 9% more than post tension slab. The Quantity of the fine aggregates required for two-way slab is 18% more than the post tension slab. The Quantity of the coarse aggregates required for two-way slab is 0.54% less the post tension slab. The Quantity of the steel required for two-way slab is 7% less than the post tension slab.

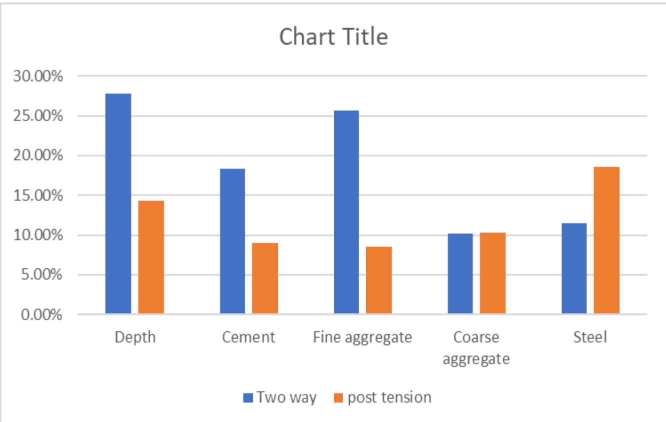

Fig.4.1 Quantity of materials

As shown in the fig 4.2, the overall cost of the slabs are Rs. 39,046/- for the construction of solid slab, Rs. 32,917/- for the construction of post tension slab. By using the overall costs, the two-way slab requires more cost for the construction of slab and post tensioned slab requires less amount for the construction. When compared to cost of solid slab, post tension slab is having 15% less cost.

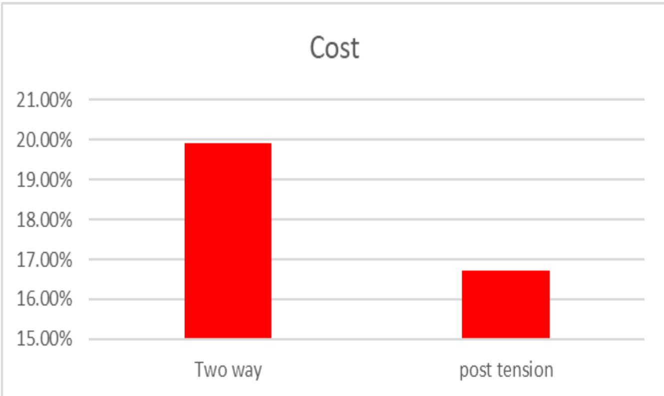

Fig.4.2 Cost of slabs

5. Conclusions

- The slab, post tension slab is 47.82% lesser than two-way slab.
- The cement requirement of Post tension slab is 9% less than two-way slab.
- The requirement of fine aggregates for post tension slab is 18% less than two-way.
- For the coarse aggregate, post tension slab is 0.54% less than two-way slab.
- Quantity of Steel required for two-way slab is 7% less than the post tension slab.
- Considering the factors like depth cement, coarse aggregate, fine aggregate and steel requirements, the cost of Post tension slab is 15% less than that of two-way slab.

Hence post tensioned slab can be recommended for multi storey structures which reduce cost of construction.

REFERENCES:

1. Comparative study of post tensioned and RCC flat slab in multi-storey commercial building by Jnanesh reddy R K,Pradeep A R,ISSN:2395-0072,Volume:4,June 2017.

2. Analysis on design of flat slab structure by Dr. B. Ramesh Babu 1, Rangana Manoj Kumar2, C. Umamaheshwar3, ISSN(Online): 2319-8753, Vol. 6, Issue 1, January 2017.

3. Cost comparison between conventional and flat slab structures by Amrut manvi, Sandeep gouripur and Dr. kishor S. Kulkarni, ISSN:2395-0056, Volume-2, June-2015.

4. IS 456:2000, Plain and Reinforced Concrete; – Code of Practice (Fourth revision), Bureau of Indian Standards, New Delhi, India.

5. IS1343-1987, Indian standard code of practice for pre-stressing concrete, Bureau of Indian Standards, New Delhi, India.

6. IS 875 (part-2)-1987, Code of practice for design loads for buildings and structures, Bureau of Indian Standards, New Delhi, India.

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