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Comparative Study on Design of Slabs

P.V.L. Narasinga Rao[1], S. Sai Nithin[2], Sk. Javed Ali[3] and V.S. Vani[4]

Under Graduates [1-3] and Assistant Professor[4]

Department of Civil Engineering

Gitam (Deemed to be university)

Visakhapatnam, Andhra Pradesh

India

ABSTRACT

*Slabs are generally preferred in the modern structures. Slabs are generally constructed in small for the residential buildings while they are long in the construction of auditoriums, classrooms as well as commercial buildings. The objective of the present study is to determine and compare the number of materials required for a particular type of slab and to perform the cost analysis for a span of 9.38*5 m. The slabs considered for the present study are two-way, post tension, grid and flat slabs. By designing and analyzing the slabs it is concluded that flat slab requires more depth than the post tension slab and flat slab construction is high in cost than the post tension slab.*

Key Words: *Slab size, Design of slabs, Analysis.*

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1. INTRODUCTION

A slab is a structure used to support the surface in horizontal direction. Slabs are small for residential structures while they are long in auditoriums, class rooms as well as in many commercial buildings. The design of the long span slabs can be done in many ways. There are many types of slabs in the construction field. There are different types of slabs used for construction.

1.1 Flat slab: It is a reinforced concrete slab supported directly by concrete columns or caps. They do not have beams. The minimum thickness is 0.2 m.

1.2 Conventional slab: It is supported by beams and columns. It requires more shuttering and reinforcement work. Thickness of slab is 0.1m. If concrete receives heavy loads the thickness will be increased to 0.15 m.

1.3 Waffle Slab: It is a type of slab with holes underneath, giving an appearance of waffles. It is usually used where large spans are required to avoid many columns interfering the space. Hence thick slabs spanning between wide beams are required. Waffle slab also holds a greater amount of load compared with conventional concrete slabs.

1.4 Post Tension Slab: The slab which is tensioned after constructing slab is called Post tension slab. In Post tension slab the reinforcement is replaced with cables/ steel tendons. Post-tensioning provides a means to overcome the natural weakness of concrete in tension and to make better use of its strength in compression. In this type of slab cables are tied instead of reinforcement. Post tension slab the spacing is more than 2 m.

2. LITERATURE

Vikunj k. Tilva et al [01], conducted studies on the cost comparison between flat slabs with drop and without drop in four storey resisting building. A four storey building having panel of dimensions 6 x 6 m is used for the design. Projected cost for flat slab without drop slab is 29% higher than with drop slab. The cost of flat slab of depth 225 mm without drop Rs.6,69,355/, Flat slab of depth 150 mm with 50 mm drop Rs.5,18,504/-. The cost comparison for flat slab 6 x 6m with drop and without drop, shows that slab with drop is preferable for the economic point of view.

Boskey Vishal Bahoria and Dhananjay K. Parbat [02], Conducted a study on the Reinforced Cement Concrete slabs and the Post Tensioned Flat Slabs by considering the seismic effect. In this the design of post-tensioned flat slab is done by using load balancing and equivalent frame method; for this a plan of the office building (G+4) is considered. In this design the building is considered into four cases they are case1 as post tension flat slab, case 2 as reinforced concrete flat slab, case 3 as post tension flat slab with reinforced cement concrete beam and case 4 as reinforced cement concrete slab with reinforced cement concrete beam. By economic point of view the post-tensioned flat slab is the most economical among all four floor systems and the reinforced concrete slab is the costlier one for this span. By considering the thickness, the thickness of reinforced concrete flat slab is 12.5% greater than the post-tensioned flat slab and for that thickness the cost is 27% greater than the post-tensioned flat slab. The post-tensioned flat slab is more economical than the post-tensioned slab with reinforced concrete beams.

Objective and scope: The objective of present study is to compare various aspects like depth, material quantities, cost for various types of slabs such as two- way slab, flat slab, grid slab and post tensioned slabs. From the study economical slab that suits for construction is known.

3. METHODOLOGY

Four slabs with dimension 9.38*5 m is chosen for the study. They are designed using limit state method. The loads on the slab is according to IS875(Part 2)-1987[03]. The two-way slab, flat slab and grid slab is designed according to IS456: 2000[04]. The post tension slab is designed according to IS1343-1987[05].

The design of grid slab is presented below.

L_1 = 9.38 m

L_2 = 5 m

Size of floor = 5 m *9.38 m

Assume spacing of beams=1.5 m

Design of top slab

Size of slab=1.25*1.25m

$\frac{l_y}{l_x} = 1$

Thickness of slab = $\frac{l_y}{35} = \frac{1256}{35}$ = 35.71 mm (simply supported)

It thickness selected be 90mm since reinforcement are going to be placed at mid depth to avoid bar bending problem in such short span.

Load on Slab

Self-weight=0.09*1*1*25 = 2.25 kN /m^2

weight of floor finish = 1 kN/m^2

Live Load = 3 kN /m^2

Total load=6.25 kN/m^2

Factored load = 1.5 (6.25) = 9.375 kN/m^2

From table 26 in Is 456 -2000 for SS with $\frac{ly}{lx} = 1$

α_x = 0.056 α_y = 0.056

$M_y = m_x$ = 0.056*9.375*1.28 = 0.82031 kN – mm

Effective depth of slab = $\frac{90}{2}$ - $\frac{1}{2}$ Ǿ

=45 - $\frac{1}{2}$x 8 = 41 (Above 8mm Ǿ bars)

M_u, lim = 0.138 f_{ck} bd^2 = 4.364 x 10^6 N - mm

= 4.639 kN-m > M_y & M_x

Thickness of sufficient

M_u= 0.87$f_y A_{st}$d (1–$\frac{A_{st}\, f_y}{bd\, f_{ck}}$)

0.82031x 10^6 = 0.87* 415* A_{st}*41(1 – $\frac{Ast\ 415}{1000x\ 41\ x\ 20}$)

55.414 = A_{st} – 5.060x 10^4 A_{st} ^{2}

A_{st}, min = 57.06 mm^2

Using 6mm bars

S=$\frac{\frac{\pi}{4}d^2}{57.06}$*1000=495.51mm

Provide 6mm bars at 500 mm c/c

Design of ribs / grids:

Depth is between$\frac{1}{20}$ to $\frac{1}{25}$ i.e. between 200mm to 250mm let depth be 250mm

overall depth be 300mm

Depth of rib= 300-90= 210 mm

Width of rib should be not less than ¼ x 250 = 52.5 mm

Let width be 100 mm

Distance b/w 2 adjacent beams=1.25-0.1=1.15 m

To find total dead weight of beams & top slab, we can treat slab as thick slab of depth 300mm.

with hallow portion size = 1.15 x 1.15 m and

depth =300-90 = 210 mm

Totally here are $\frac{9.38}{1.15}$ x $\frac{5}{1.15}$ = 35.46 Such hallow portions

Therefore

Self-weight of grid floor= (0.3*9.38*5-1.15* 1.15*0.21*35.46)25=105.55 kN

Self us free used are = $\frac{105.55}{436*5}$ = 2.25 kN/m^2

Weight of floor finish= 1 kN/m^2

Live Load=3 kN/m^2

Total=6.25 kN/m^2

factored load=1.5* 6.25= 9.37KN/m^2 Per metre width of slab

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Factored load for metre length of beam =

Span = 1.15* 9.37=10.77 kN/m

From table 26 $\frac{l_y}{l_x}$=1.876

α_y = 0.103

α_x = 0.056

M_x = 0.103*10.77*5^2= 27.73 kN- m

M_y = 0.056*10.77*5^2=15.078 kN-m

Design of T-beams

Width of flange = $\frac{l_o}{6}$+b_w+6D_f

l_o=0.2*l=0.7 *1150 b_w=100mm*D_f=90 mm

Width of flange = $\frac{0.7\ x\ 1150}{6}$ +100 +6x90

= 774.166 mm < grid spacing

= 110 +12*90 = 1180 mm < gird spacing

B= 775 mm

Assuming neutral axis is exactly at bottom of flange

$M_u^{'}$= 0.36 f_{ck}BD_f (d-0.42D_f)

= 0.36*20*775*90(250-0.42*90) = 106.566*10^6 kN-m

$M_u^{'}$ > Design moment

M_u=0.87*f_y*A_{st}* d(1-$\frac{A_{st}f_y}{bdf_{ck}}$)

27.73*10^6 = 0.87*415*A_{st}*250 $(1 - \frac{415*Ast}{775*250*20})$

307.215=A_{st}-1.070x10^{-4} $A_{st}{}^2$

A_{st}= 318.037 mm^2

Provide 2 bars of 20 mm dia in short direction

A_{st} Provided = 628 mm^2

Area in longer direction

15.078*10^6 = 0.87*415*A_{st}*250$(1 - \frac{415*A_{st}}{775*250*20})$

167.04 = A_{st}–1.070*10^{-4} $A_{st}{}^2$

A_{st} = 170.137 mm^2

Provided 1 bar of 20mm dia

A_{st} provided = $\frac{\pi}{4}*20^2$ =314 mm^2

Design of Shear: -

Mar shear per unit width in short direction

$= q_1 \frac{l_1}{r} = \frac{qr^4}{1+x^4} \frac{l}{2} = 10.77 * \frac{1.15^4}{1+1.15^4} * \frac{5}{2} = 17.13$ kN

In longer direction

$= 10.77 * \frac{1.15^4}{1+1.15^4} * \frac{9.38}{2} = 32.136$ kN

Shear reinforcement in longer direction

V=32.136 kN

$\tau_v = \frac{32.136*1000}{100*250}$ =1.28 N/mm^2

% reinforcement P = $\frac{628}{100*250}$= 2.512

τ_v= 0.5 N/mm^2

Hence V_{ux}=32.136*1000–0.5*100*250=19636 N

Using 2 legged 8mm Stirrups

$S = \frac{0.87 f_y A_{st} d}{V_{us}} = \frac{0.87*415*2*\frac{\pi}{4}8^2*250}{19636}$ = 462.11 mm

Nominal square reinforcement is sufficient

Following code provisions, two-way, post tension, flat slab is designed. The obtained results of the two-way, flat and post tension slabs are:

Depth of slab for flat slab, two-way slab and post tension slab is 365,195 and 100 mm respectively.

The cost of slabs is estimated. A comparative study is made for depth, quantities such as cement, fine aggregate, coarse aggregate and steel along with cost.

The cost is estimated for two-way, post tension, flat and grid slabs and tabulated in Table 3.1,3.2,3.3,3.4 respectively.

Table 3.1 Cost estimation for two-way slab

TWO WAY SLAB						
particulars	**number of bar**	**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=11.04
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 aggr	3.72m^3	1240Rs/m^3			4612.8Rs	
Fine aggreg	5.66m^3	360Rs/m^3			2037.6Rs	
Cement	3676kg	6Rs/kg			22056Rs	
Steel	202.752kg	51Rs/kg			10340.352Rs	
Total					**39046.752Rs**	

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Table 3.2 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**	

Table 3.3 Cost estimation for Flat slab

FLAT SLAB						
particulars	**number of bar**	**length of the**	**breadth**	**depth**	**quantity**	**explanatory note**
Negative rei	21	12.86m			21*12.86*0.78=210.64kg	9.38-21(0.005)+(21*18*0.012)=12.86m
Positive rein	46	17.016m			46*17.016*0.78=610.53kg	9.38-46(0.005)+(46*18*0.012)=17.016m
column rein	30	14.36m			30*14.36*0.78=336.024kg	9.38-30(0.005)+(30*18*0.012)=14.36m
Middle reinf	10	11.04m			10*11.04*0.78=86.024kg	9.38-10(0.005)+(10*18*0.012)=11.04m
Total					1243.306kg	
	Quantity	**Rupees**			**Total Amount**	
Coarse aggr	13.69m³	1240Rs/m³			16975.6Rs	
Fine aggrega	6.85m³	360Rs/m³			2466Rs	
Cement	6876kg	6Rs/kg			41256Rs	
Steel	1243.306kg	51Rs/kg			63408.606Rs	
Total					**124106.206Rs**	

Table 3.4 Cost estimation for Grid Slab

GRID SLAB						
particulars	number of bars	length of the each bar	breadth	depth	quantity	explanatory note
Slab reinforc	2	9.496m			2*9.496*0.78=14.81kg	9.38-2(0.005)+(18*2*0.006)=9.496m
Beams						
Long reinfor	1	9.69m			1*9.69*0.78=7.55kg	9.38-1(0.005)+(18*1*0.020)=9.69m
Short reinfo	2	10m			2*10*0.78=15.6kg	9.38-2(0.005)+(18*2*0.020)=10m
Stirrups	20	10m			20*10*0.78=156kg	
Total					**193.96kg**	
	Quantity	Rupees			Total Amount	
Coarse aggre	15.38m³	1240Rs/m³			19071.2Rs	
Fine aggrega	7.69m³	360Rs/m³			2768.4Rs	
Cement	7723kg	6Rs/kg			46330Rs	
Steel	193.96kg	51Rs/kg			2731.56Rs	
Total					**78061.56Rs**	

4. RESULTS AND DISCUSSIONS

The design values obtained from various types of slabs are analyzed which presenting the figures 4.1 and 4.2.

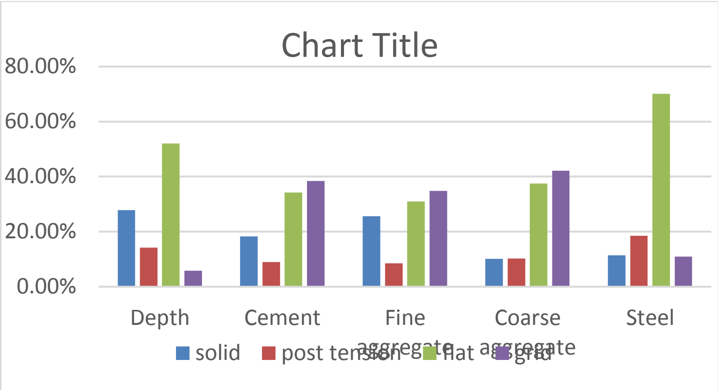

Fig.4.1 quantity analysis of slabs

The depth for various slabs are shown in the Fig.4.1. The Depth of the slab for solid slab is 195 mm, flat slab is 365 mm, post tension slab 100 mm and grid slab is 41 mm. By comparing all the above slabs, the depth of the flat slab is more when compared to post tensioned slab, solid slab, and grid slab. The depth of the grid slab is less when compared to post tensioned slab, solid slab, and flat slab. By using these values, the grid slabs are best in case of depth.

The Quantity of the cement for slab for solid slab is 3676 kg, flat slab is 6876 kg, post tension slab 1800 kg and grid slab is 7723 kg. By comparing all the above slabs, the Quantity of the cement for the grid slab is more when compared to post tensioned slab, solid slab, and flat slab. The Quantity of the cement for the post tensioned slab is less when compared to grid slab, solid slab, and flat slab. By using these values, the post tensioned slabs are best in case of Quantity of cement.

The Quantity of the fine aggregates for slab for solid slab is 5.66 m^3, flat slab is 6.85 m^3, post tension slab 1.88 m^3 and grid slab is 7.69 m^3. By comparing all the above slabs, the Quantity of the fine aggregates for the grid slab is more when compared to post tensioned slab, solid slab, and flat slab. The Quantity of the fine aggregates for the post tensioned slab is less when compared to grid slab, solid slab, and flat slab. By using these values, the post tensioned slabs are best in case of Quantity of fine aggregates.

The Quantity of the coarse aggregates for slab for solid slab is 3.72 m^3, flat slab is 13.69 m^3, post tension slab 3.75 m^3 and grid slab is 15.38 m^3. By comparing all the above slabs, the Quantity of the coarse aggregates for the grid slab is more when compared to post tensioned slab, solid slab, and flat slab. The Quantity of the coarse aggregates for the solid slab is less when compared to grid slab, post tensioned slab, and flat slab. By using these values, the solid slabs are best in case of Quantity of coarse aggregates.

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The Quantity of the steel for slab for solid slab is 202.752 kg, flat slab is 1243.306 kg, post tension slab 329.238 kg and grid slab is 53.56 kg. By comparing all the above slabs, the Quantity of the steel for the flat slab is more when compared to post tensioned slab, solid slab, and grid slab. The Quantity of the steel for the grid slab is less when compared to solid slab, post tensioned slab, and flat slab. By using these values, the grid slabs are best in case of Quantity of steel.

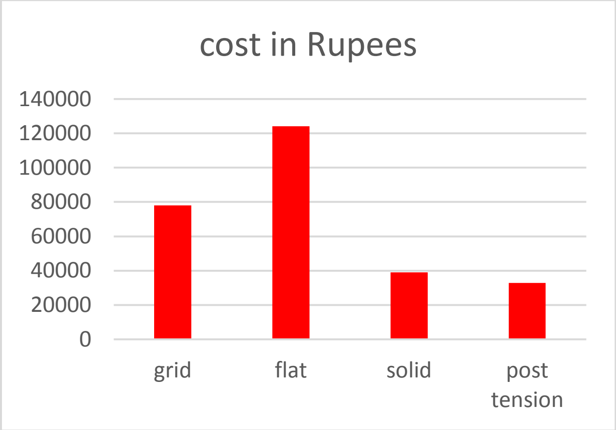

Fig.4.2 cost comparison of slabs

The overall cost of the slabs are Rs. 39,046/- for the construction of solid slab, Rs.1,24,106/- for the construction of flat slab, Rs. 32,917/- for the construction of post tension slab and Rs. 70,901/- for the construction of grid slab. By using the overall costs, the flat slab requires more cost for the construction of slab and post tensioned slab requires less amount for the construction. So post tension slabs are best in case of the cost of construction.

5. CONCLUSIONS

From the limited study conducted

- Grid slab requires less depth with 41mm and flat slab has high depth of slab with 365mm.
- Post tension slab requires less cement of 1800 kg and grid slab requires more cement with an amount of 7723 kg.
- Post tension slab requires less fine aggregates of 1.88 m^3 and grid slab requires high amount of fine aggregates with 7.69 m^3
- Solid slab requires less coarse aggregate of 3.72 m^3 and grid slab requires high amount of coarse aggregate with 15.38 m^3
- Grid slab requires less steel of 53.26 kg and flat slab requires high amount of steel with 1,243.306 kg.
- Considering the factors like depth of the slab, cement, fine aggregate, coarse aggregate and steel requirements, it is concluded that post tensioned slab requires less amount of Rs. 32,917/- for the construction and Flat slab requires high amount of Rs.1,24,106/-.

REFERENCES

[01]. Boskey Vishal Bahoria and Dhananjay K. Parbat "Analysis and Design of RCC and Post-Tensioned Flat Slabs Considering Seismic Effect" IACSIT International Journal of Engineering and Technology, Volume 5, No. 1, February 2013.

[02]. Cost comparasion between flat slabs with drop and without drop in four storey lateral load resisting building by Vikunj k. Tilva and Prof.B.A. Vyas, May 2011.

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

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

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