Design of Structures –II

Lecture – 27

In the previous lecture we have seen a one way continuous slab required for a room of size 8m and 3.5m. In this lecture we are going to design a corridor floor slab for a building. And in this one we are also going to calculate total load on the slab, effective span of the slab, bending moment and then we are going to find out the effective depth of the slab. And then we are going to find out what is the main reinforcement which is required for corridor floor slab and finally we are going to check the depth against the deflection as well as we are going to see the reinforcement detailing for the one way slab corridor slab. This is similar to the previous problem any way the previous problem we have discussed about the one-way simply supported slab for a room by finding whether that slab is one way slab or two way slab.

Here it is somewhat different and it is the lengthy corridor slab. The width of the corridor slab here it is 3m and that same design can be adopt for the any length of corridor. The width of the corridor is taken as the effective span.

One Way Simply Supported Corridor Floor Slab

Design a one way simply supported corridor floor slab over an effective span of 3.0m required for an institutional building. It carries a live load of $3kN/m^2$. Consider other dead loads also. Adopt M20 concrete and Fe415 steel. Draw the section of slab showing reinforcement details also.

Solution:

Here the effective span of the slab is 3.0m and then it carries a live load of 3kN/m^2.

Load Calculations:

Dead load:

Dead load is which includes the self weight of the structure itself and the weight of partition and weight of floor finish. Since it is the floor slab and it is the corridor slab it is not having partition wall. In the case of the simply supported slab which is constructed over a room that is which we have seen in the last problem. We planned to construct a partition over the slab. So that's why we have included the partition wall. But here since it is a corridor floor slab we are not going to construct a partition wall on the corridor. That's why the load due to the partition wall is completely avoided.

$$\frac{l}{d} = 20; d = \frac{3000}{20} = 150mm;$$

$$D = 150 + 15 + 10/2 = 170mm$$

Here I am adapting or I am going to keep based on my experience I am going to keep D is equal to 125mm. And finally we will check whether my assumption is correct or not. Now here the self weight of the slab is equal to 0.125 x 25 that is equal to 3.125kN/m^2. We have only the weight of floor finish which is normally provided as concrete which is equal to 0.025 x 24 that is 0.60kN/m^2. The total dead load on the give slab W_d is 3.725kN/m^2.

Live load on slab:

The live load provided in the problem that is equal to $W_l = 3.00 kN/m^2$. Now the total load on the slab is,

$$W = w_d + w_l = 6.725 kN/m^2.$$

This is the way of calculating the load over the corridor slab. So next to the load acting on the slab we are going to find out the bending moment.

<u>Bending moment calculation:</u>

The ultimate bending moment is equal to,

$$M_u = 1.5 \times wl^2 / 8$$

$$= \frac{1.5 \times 6.725 \times 3^2}{8}$$

$$= 11.35 kN/m$$

<u>Effective depth of the slab:</u>

The effective depth of the slab is from equating the bending moment to the limiting value of the bending moment that are by assuming over section is the balanced section. So assuming a balanced section and equating M_u to $M_{u\lim}$. So $M_{u\lim}$ for the given grade of slab is $0.138 f_{ck} bd^2$. Where d is equal to

$$d = \sqrt{\frac{M_u}{0.138 f_{ck} b}}$$

$$= \sqrt{\frac{11.35 \times 10^6}{0.138 \times 20 \times 1000}}$$

$$= 64.13m$$

$$D = 64.13 + 15 + 10/2 = 84.13mm$$

Hence it is safe against flexure. We have satisfied the thickness of the slab against flexure.

To find the area of reinforcement:

Main Steel:

Here in this case the slab is normally designed as the simply reinforced structure since we have used the depth of the slab somewhat more than the depth then the bending which is 84.13mm which is very less than 125mm. Again in order to check the depth in deflection I am keeping the depth of the slab as 125mm. So I'm keeping somewhat more than the depth which is required for the flexure.

$$d = 125 - 15 - 10/2 = 105mm$$

Here this slab is need to be designed as the singly reinforced slab. So we have to find out the A_{st} I am going to use the expressions,

$$M_u = 0.87 f_y A_{st} (d.0.416 x_u)$$

$$x_u = \frac{0.87 f_y A_{st}}{0.36 f_{ck} b}$$

$$= \frac{0.87 \times 415 \times A_{st}}{0.36 \times 20 \times 1000} = 0.05 A_{st}$$

Now this has to be substituted in the expression to calculate the value of A_{st}.

$$11.35 \times 10^6 = 0.87 \times 415 \times A_{st} (105 - 0.416 \times 0.05 A_{st})$$

$$A_{st}^{\,2} - 5047.92A_{st} + 1.51 \times 10^{6} = 0$$

$$A_{st(req)} = 319.33mm^{2}.$$

By using 8mm diameter bar corridor slab and from that I am finding the spacing of reinforcement. The spacing of reinforcement is normally we designed for 1m width. The spacing should also be found for 1m width of the slab that is,

$$= \frac{1000 \times {}^{\pi}\!/_{4} \times 8^{2}}{319.33} = 157.40mm$$

Check for Minimum Steel:

Before finding the spacing of reinforcement we need to check this A_{st} with the minimum A_{st}. That is minimum A_{st} is equal to 0.12% of cross sectional area of concrete.

$$= \frac{0.12}{100} \times 1000 \times 105 = 126mm^{2} < 319.33mm^{2}$$

Hence we can adapt A_{st} required as 319.33mm^2. From that we can assume 8mm diameter bar and the spacing we have already found as 157.4mm. This spacing again has to be checked with maximum spacing. This should not exceed the maximum spacing. To avoid the tensile force we must place a tensile force which is very close and that spacing that should not exceed the maximum spacing which prescribes in IS456:2000.

Check for maximum spacing:

The main reinforcement is 3 into depth of the reinforcement and 300mm whichever is placed. The value of depth of the slab is 105. So the reinforcement is 3 x 105 which is equal to 315mm that is closer to 300mm. Hence I adopt the spacing is 157.4mm. Here when I am reducing the spacing I am finding what is the actual Ast I have provided for one meter width of the slab it will be,

$$A_{st(pro)} = \frac{1000 \times \pi/4 \times 8^2}{125} = 402.12mm^2$$

Next reinforcement is distribution reinforcement and here I am providing 6mm diameter bar. Ast required for this will be 0.15% of cross sectional area of the concrete. Cross sectional area of the concrete here it is equal to,

$$= \frac{0.15}{100} \times 1000 \times 105 = 225mm^2$$

So here I am using 6mm diameter bar and spacing of bar is equal to

$$= \frac{1000 \times \pi/4 \times 6^2}{225} = 175mm$$

I am also going to check with the maximum spacing. In the case of bar which is provided perpendicular to the direction of main reinforcement then that bar is called as the distribution reinforcement. For the distribution reinforcement the maximum spacing should not exceed 5d or 400mm whichever is less. That is 5 x 105 which is equal to 525mm. So I am adopting 6mm ϕ ms bar at 150mm c/c. this is the distribution reinforcement I have provided.

Check the depth of the section for deflection:

Here the depth of the section that is l/d ration which is normally equal to 20 for simply supported slab that factor again has to be modified by multiplying with the modification factor. That modification factor has to be again found from figure 4.

$$\frac{l}{d} = 20 \times M.F$$

$$p_t = \frac{100 A_{st}(pro)}{bd}$$

$$= \frac{100 \times 402.12}{1000 \times 105} = 0.38\%$$

But in the case of this graph there are different curve that shows it depends on the stress in the reinforcement. I need to also identify the curves which corresponding to my design I need to first find out what is the stress in steel.

$$f_s = \frac{0.58 f_{yx} A_{st}(req)}{A_{st}(pro)} = \frac{0.58 \times 415 \times 319.33}{402.12}$$

$$= 191.14 N/mm^2$$

For this stress the modification factor found from the graph is 1.7, so the effective depth of the slab that is needed to satisfy the deflection here it is,

$$d = \frac{l}{20 \times M.F} = \frac{3000}{20 \times 1.7}$$

$$= 88.23 mm < 105 mm$$

Hence these say that this is safer section as well as the economical section. The different between these two values are less so it is most economical section. So here the depth of the section need is 125mm and the main steel it need is 8mm diameter bar at 125mm c/c. And distribution steel is 6mm ϕ at 150mm c/c.

Reinforcement detail:

The cross section of the slab or it may be called as the longitudinal section that is the section which is parallel to the width or the length of the slab. The center to center distance of the support which is equal to 3000mm and here the 50% of the reinforcement has to be cranked over the support from the distance 0.1l from the face of the support that is 300mm from the face of the support. This is the straight bar and it has to be placed at uniformly spacing. A perpendicular reinforcement has to be provided there is called as distribution reinforcement. And this one is the distribution reinforcement 6mm ϕ at 150mm c/c. So the arrangement of the reinforcement in the plan view will be this is the support and this is the crack and the bottom reinforcement. And these are all the distribution reinforcement the spacing of distribution reinforcement throughout the entire width of the slab is 6mm ϕ at 150mm c/c.

Summary:

In this lecture we have seen the design of one way corridor slab. So in the previous lecture we have seen the one way simply supported slab in the room. In this we have consider the load due to the support. Since here we have designed a corridor slab. And here worked example was carried to design the slab and also detailing of reinforcement had been drawn.

Questions:

To design the section,

1. Design a one way simply supported floor slab for a residential building of effective span 3.5m. It carries a live load of 1.5kkN/M^2, floor finish of 1.0kN/m^2 and also partition wall of 1.96 kN/m^2. Adopt M20 concrete and Fe415 steel. Draw the reinforcement details also.
2. Design a one way simply supported roof slab over an effective span of 4.0m required for an institutional building. It carries a live load of 3kN/m^2 and floor finish 0f 1.0kN/m^2 . Adopt M20 concrete and Fe415 steel. Draw the section of slab showing reinforcement details also.

References:

- IS 456:2000 Plain and reinforcement concrete – Code of practice.
- IS 875 (1-5):1987 Code of practice for design loads (other than earthquake) for buildings and structures.
- SP34:1987 Handbook of concrete reinforcement and detailing.
- S.N. Sinha, "Reinforced concrete Design", Tata McGraw hill publishing Co. Ltd, New Delhii, 1998.
- Ashok Kk. Jain, "Reinforced concrete: Limit State Design" Nem Chand & Bros., Roorkee (Vol 6th Ed) year: 2006.