Date 25.4.2020

Department of Civil Engineering

Diploma -4th SEM

01-Lecture Notes on
One way R.C.C. slab
by limit method

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MODULE-2

One-way Slabs

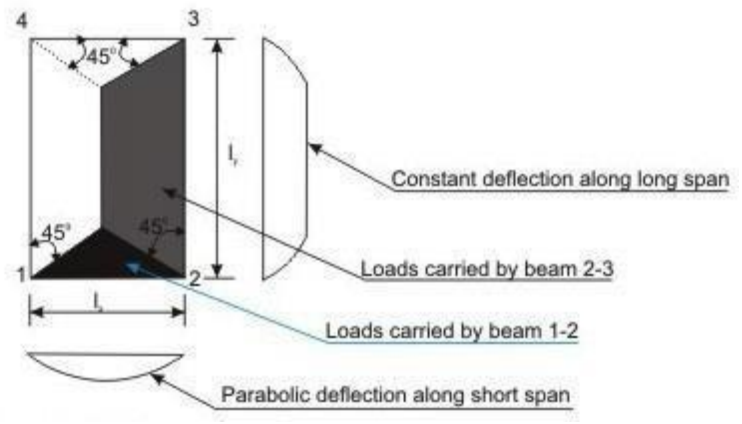


Figure 2.1(a) One-way slab (l_y/l_x>2)

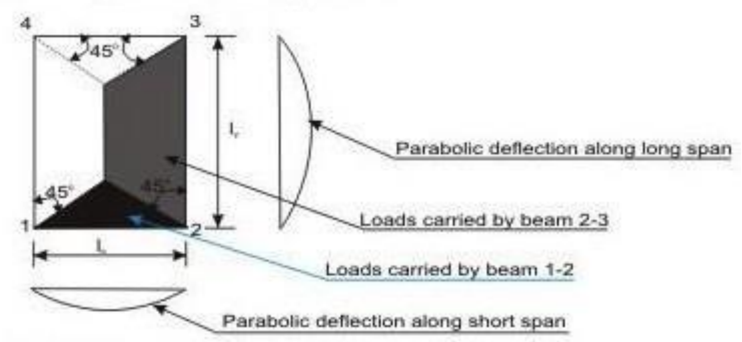


Figure 2.1(b) Two-way slab (l_y/l_x<=2)

Figures 2.1a and b explain the share of loads on beams supporting solid slabs along four edges when vertical loads are uniformly distributed. It is evident from the figures that the share of loads on beams in two perpendicular directions depends upon the aspect ratio l_y/l_x of the slab, l_x being the shorter span. For large values of l_y, the triangular area is much less than the trapezoidal area (Fig. 2.1a). Hence, the share of loads on beams along shorter span will gradually reduce with increasing ratio of l_y/l_x. In such cases, it may be said that the loads are primarily taken by beams along longer span. The deflection profiles of the slab along both directions are also shown in the figure. The deflection profile is found to be constant along the longer span except near the edges for the slab panel of Fig. 2.1a. These slabs are designated as one-way slabs as they span in one direction (shorter one) only for a large part of the slab when $l_y/l_x > 2$.

On the other hand, for square slabs of $l_y/l_x = 1$ and rectangular slabs of l_y/l_x up to 2, the deflection profiles in the two directions are parabolic (Fig. 2.1b). Thus, they are spanning in two directions and these slabs with l_y/l_x up to 2 are designated as two-way slabs, when supported on all edges.

It would be noted that an entirely one-way slab would need lack of support on short edges. Also, even for $l_y/l_x < 2$, absence of supports in two parallel edges will render the slab one-way. In Fig. 2.1b, the separating line at 45 degree is tentative serving purpose of design. Actually, this angle is a function of l_y/l_x.

Design of One-way Slabs

The procedure of the design of one-way slab is the same as that of beams. However, the amounts of reinforcing bars are for one metre width of the slab as to be determined from either the governing design moments (positive or negative) or from the requirement of minimum reinforcement. The different steps of the design are explained below.

Step 1: Selection of preliminary depth of slab

The depth of the slab shall be assumed from the span to effective depth ratios.

Step 2: Design loads, bending moments and shear forces

The total factored (design) loads are to be determined adding the estimated dead load of the slab, load of the floor finish, given or assumed live loads etc. after multiplying each of them with the respective partial safety factors. Thereafter, the design positive and negative bending moments and shear forces are to be determined using the respective coefficients given in Tables 12 and 13 of IS 456.

Step 3: Determination/checking of the effective and total depths of slabs

The effective depth of the slab shall be determined employing.

$$M_{u,lim} = R_{,lim}\, bd^2$$

The total depth of the slab shall then be determined adding appropriate nominal cover (Table 16 and 16A of cl.26.4 of IS 456) and half of the diameter of the larger bar if the bars are of different sizes. Normally, the computed depth of the slab comes out to be much less than the assumed depth in Step 1. However, final selection of the depth shall be done after checking the depth for shear force.

Step 4: Depth of the slab for shear force

Theoretically, the depth of the slab can be checked for shear force if the design shear strength of concrete is known. Since this depends upon the percentage of tensile reinforcement, the design shear strength shall be assumed considering the lowest percentage of steel. The value of τ_c shall be modified after knowing the multiplying factor k from the depth tentatively selected for the slab in Step 3. If necessary, the depth of the slab shall be modified.

Step 5: Determination of areas of steel

Area of steel reinforcement along the direction of one-way slab should be determined employing the following Eq.

$M_u = 0.87 f_y A_{st} d \{1 - (A_{st})(f_y)/(f_{ck})(bd)\}$

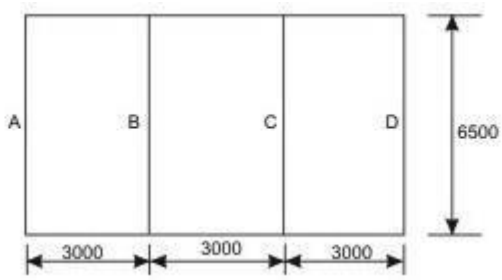
The above equation is applicable as the slab in most of the cases is under-reinforced due to the selection of depth larger than the computed value in Step 3. The area of steel so determined should be checked whether it is at least the minimum area of steel as mentioned in cl.26.5.2.1 of IS 456.

Step 6: Selection of diameters and spacings of reinforcing bars (cls.26.5.2.2 and 26.3.3 of IS 456)

The diameter and spacing of bars are to be determined as per cls.26.5.2.2 and 26.3.3 of IS 456. As mentioned in Step 5, this step may be avoided when using the tables and charts of SP-16.

Q2-

Design the ***one-way continuous slab of Fig.8.18.6 subjected to uniformly distributed imposed loads of 5 kN/m^2 using M 20 and Fe 415. The load of floor finish is 1 kN/m^2. The span dimensions shown in the figure are effective spans. The width of beams at the support = 300*** mm.



Step 1: Selection of preliminary depth of slab

The basic value of span to effective depth ratio for the slab having simple support at the end and continuous at the intermediate is (20+26)/2 = 23 (cl.23.2.1 of IS 456).

Modification factor with assumed p = 0.5 and f_s = 240 N/mm^2 is obtained as 1.18 from Fig.4 of IS 456.

Therefore, the minimum effective depth = 3000/23(1.18) = 110.54 mm. Let us take the effective depth d = 115 mm and with 25 mm cover, the total depth D = 140 mm.

Step 2: Design loads, bending moment and shear force

Dead loads of slab of 1 m width = 0.14(25) = 3.5 kN/m

Dead load of floor finish =1.0 kN/m

Factored dead load = 1.5(4.5) = 6.75 kN/m

Factored live load = 1.5(5.0) = 7.50 kN/m

Total factored load = 14.25 kN/m

Maximum moments and shear are determined from the coefficients given in Tables 12 and 13 of IS 456.

Maximum positive moment = 14.25(3)(3)/12 = 10.6875 kNm/m

Maximum negative moment = 14.25(3)(3)/10 = 12.825 kNm/m

Maximum shear V_u = 14.25(3)(0.4) = 17.1 kN

Step 3: Determination of effective and total depths of slab

From Eq. $M_{u,lim} = R_{,lim}\, bd^2$ where $R_{,lim}$ is 2.76 N/mm^2. So, d = $\{12.825(10^6)/(2.76)(1000)\}^{0.5}$ = 68.17 mm

Since, the computed depth is much less than that determined in Step 1, let us keep D = 140 mm and d = 115 mm.

Step 4: Depth of slab for shear force

Table 19 of IS 456 gives τ_c = 0.28 N/mm^2 for the lowest percentage of steel in the slab. Further for the total depth of 140 mm, let us use the coefficient k of cl. 40.2.1.1 of IS 456 as 1.3 to get $\tau_c = k\,\tau_c$ = 1.3(0.28) = 0.364 N/mm^2.

Table 20 of IS 456 gives $\tau_{c,\max}$ = 2.8 N/mm^2. For this problem $\tau_v = \dfrac{V_u}{bd}$ = 17.1/115 = 0.148 N/mm^2. Since, $\tau_v < \tau_c < \tau_{c,\max}$, the effective depth d = 115 mm is acceptable.

Step 5: Determination of areas of steel

It is known that

$M_u = 0.87 f_y A_{st} d \{1 - (A_{st})(f_y)/(f_{ck})(bd)\}$

(i) For the maximum negative bending moment

$12825000 = 0.87(415)(A_{st})(115)\{1 - (A_{st})(415)/(1000)(115)(20)\}$

or $- 5542.16 A^2_{st} A_{st} + 1711871.646 = 0$

Solving the quadratic equation, we have the negative $A_{st} = 328.34$ mm^2

(ii) For the maximum positive bending moment

$10687500 = 0.87(415) A_{st} (115) \{1 - (A_{st})(415)/(1000)(115)(20)\}$

or $- 5542.16 A^2_{st} A_{st} + 1426559.705 = 0$

Solving the quadratic equation, we have the positive $A_{st} = 270.615$ mm^2

Distribution steel bars along longer span l_y

Distribution steel area = Minimum steel area = 0.12(1000)(140)/100 = 168 mm^2. Since, both positive and negative areas of steel are higher than the minimum area, we provide:

(a) For negative steel: 10 mm diameter bars @ 230 mm c/c for which $A_{st} = 341$ mm^2 giving $p_s = 0.2965$.

(b) For positive steel: 8 mm diameter bars @ 180 mm c/c for which $A_{st} = 279$ mm^2 giving $p_s = 0.2426$

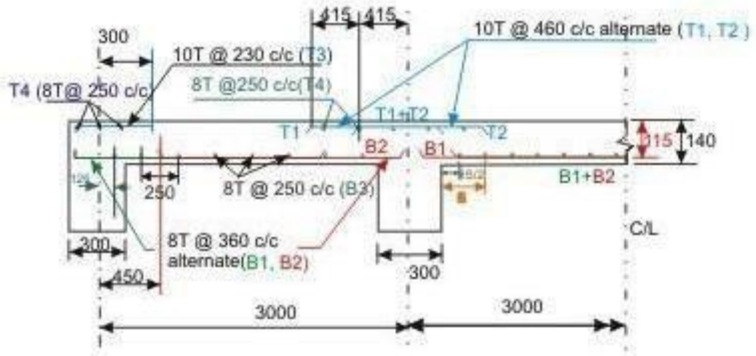
(c) For distribution steel: Provide 8 mm diameter bars @ 250 mm c/c for which A_{st} (minimum) = 201 mm^2.

Step 6: Selection of diameter and spacing of reinforcing bars

The diameter and spacing already selected in step 5 for main and distribution bars are checked below:

For main bars (cl. 26.3.3.b.1 of IS 456), the maximum spacing is the lesser of 3*d* and 300 mm i.e., 300 mm. For distribution bars (cl. 26.3.3.b.2 of IS 456), the maximum spacing is the lesser of 5*d* or 450 mm i.e., 450 mm. Provided spacings, therefore, satisfy the requirements.

Maximum diameter of the bars (cl. 26.5.2.2 of IS 456) shall not exceed 140/8 = 17 mm is also satisfied with the bar diameters selected here.



300
415
415
10T @ 460 c/c alternate (T1, T2)
10T @ 230 c/c (T3)
T4 (8T@ 250 c/c
8T @250 c/c(T4)
T1
T1+T2
T2
115
140
B2
B1
B1+B2
250
8T @ 250 c/c (B3)
300
8T @ 360 c/c
alternate(B1, B2)
C/L
450
300
3000
3000