IRC SPECIFICATION AND LOADING - RC SOLID SLAB BRIDGE

2.4 Design Of Reinforced Concrete Solid Slab Bridge

Example 4

Design and draw the RC solid slab bridge for a national highway with the consideration of following data

Design for two lane (7.5m wide) and with 1m foot paths on both side.

Clear span = 5m

Wearing coat = 70mm

Width of bearing = 0.4m

Use M25 grade concrete, Fe415 grade steel and loading IRC class AA tracked vehicle.

Given data

Two lane = 7.5m

clear span = 5m

wearing coat = 70mm

width of bearing = 0.4m

Solution:

Step 1 : Determine of slab depth and effective span

Permissible stresses (from IRC:21 – 1987 cl 303.1)

σ_{cb} = 8.3 N/mm^2

σ_{st} = 200 N/mm^2

m = 10

j = 0.90

Q = 1.1

Assume thickness of solid slab highway bridge at 80mm/meter of span.

overall slab thickness = 80 x 5

= 400mm

Let thickness of slab as 400mm. Assume using 25mm ϕ rebar with clear cover of 25mm.

effective depth = 400 – (25/2) – 25

= 362.5mm

width of bearing = 400mm

Effective span

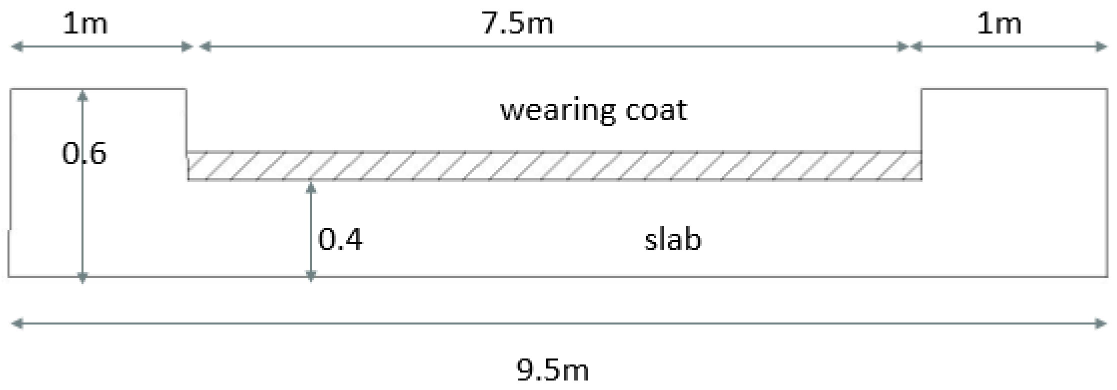
Clear span + effective depth = 5 + 0.3625

= 5.3625m

Center to center of bearing = 5 + 0.4

= 5.4m

Effective span = 5.3625 m



Step 4: Dead load calculation

self weight of slab = 0.4x25

= 10kN/m^2

Load due to wearing coat = 0.07x22

= 1.54 kN/m^2

= 11.54 kN/m^2

Bending moment due to D.L = $(11.54 \text{ X } 5.3625^2)/8$

= 41.5kNm

Step 5: Bending moment due to live load

Impact factor = [25 – 15/4(5.3625 – 5)]

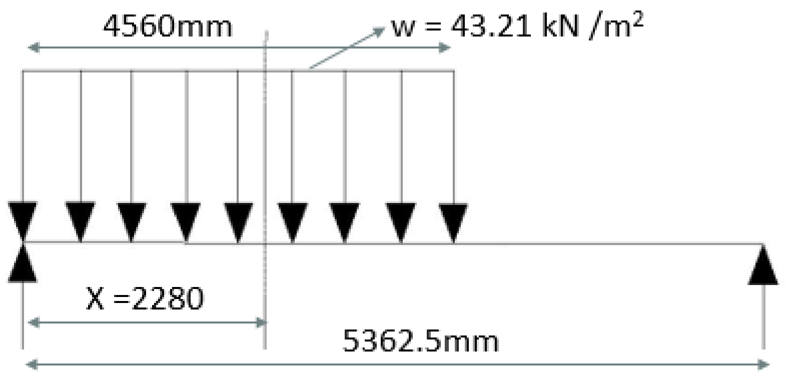
= 23.64%

Assume vehicle is placed symmetrically on the span.

Effective length of load = 3.6 + 2(0.4 + 0.07)

= 4.56m

Effective width of slab (from IRC 21 – 1987 cl.305.13)



$b_e = k_x (1 - x/L) + b_w$

Where

x = 2.68125m,

L = 5.3625m,

B = 9.5m,

B/L = 1.77

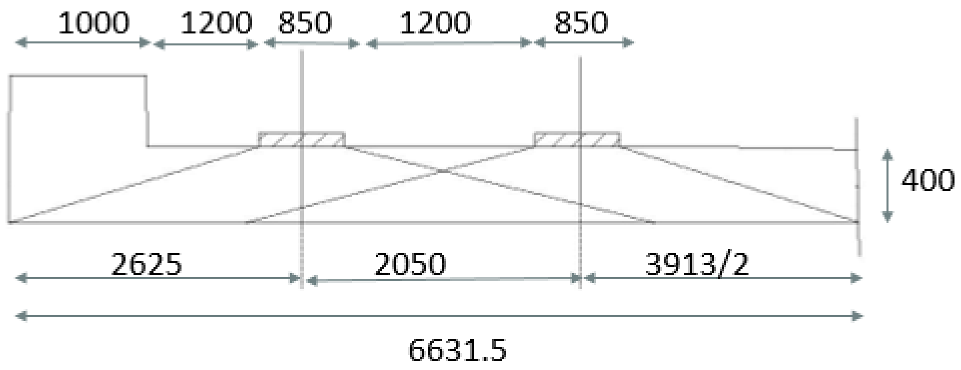
b_w = (0.85 + 2 x 0.07)

= 0.99m

K value for B/L = 1.77 for Simply supported slab is equal to 2.948

b_e = 2.984x2.68125[1-(2.68125/5.3625)] + 0.99

= 3.913m



Net effective width of dispersion = 6.6315m

Total factored load 2 track with impact

= 1.5 [1 + 23.64/100]x700

= 1298.22Kn

Average factored load intensity = 1298.22/(4.56x6.6315)

= 42.93kN/m^2

Maximum bending moment for factored live load

M_{max} = [(42.93x4.56)/2 x 2.68125] – [(42.93x4.56)/2 x 4.56/4]

M_L = 150.85 kNm/m

Total bending moment (L.L + D.L)

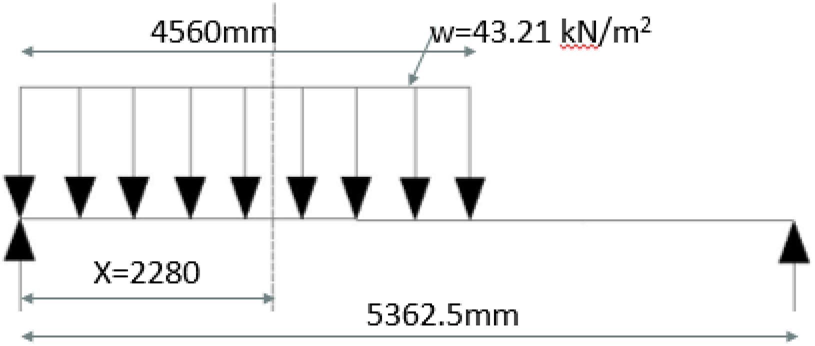
= M_L + M_d

= 150.85 + 41.5

= 192.35kNm

Step 6 : Shear force due to IRC class AA loading

The maximum shear while occurs while load subjects towards the support



Effective width of dispersion

b_e = k_x [1 – x/L]+b_w

Where,

x =2.28m

B = 9.5m

b_w = 0.99m

L = 5.3625m

B/L = 1.77

K = 2.948

b_e = 2.948x2.28[1-(2.28/5.3625)]+0.99

= 3.825m

Width of dispersion = 2625 + 2050 + 3825/2

= 6587.5mm

Average factored load intensity

w = [1298.22/(4.56x6.5875)]

= 43.21 kN/m^2

factored shear force V_A = [43.21x4.56x(5.3625 – 2.28)]/5.3625

= 113.25kN/m

shear due to dead load = 11.54x5.3625/2

= 30.94

Total shear force = 113.26 + 30.94

= 144.2 KN/m

Step 7: Design of check slab

$$\text{required depth, } d = \sqrt{\frac{M}{Qb}}$$

= [(150.85 x 10^6)/(1.1x1000)]$^{0.5}$

= 370.319 mm

Depth provided 400mm. Hence it is ok.

A_{st} = (150.85x10^6)/(200x0.9x362.5)

= 2311.8mm2

Assume 25mmϕ bars,

$$\text{spacing} = \frac{\pi\, 25^\wedge 2}{4} \times \frac{1000}{2311.8}$$

= 212.33mm

Let provide 25mm ϕ @ 200mm c/c spacing as main reinforcement and 10mm ϕ @300mm c/c at top on both side.

Bending moment for distribution reinforcement

= 0.3 M_L + 0.2M_d

= 0.2(150.85)+0.2(41.5)

= 53.55kNm

Let use 16mm ϕ bars,

effective depth = [362.5-(12.5+16/2)]

= 342mm

A_{st} = (53.55x10^6)/(200x0.9x342)

= 870mm^2

16mm ϕ bar spacing = 16^2 x π/4 x1000/870

= 231.1

Provide 16mm ϕ @ 220mm c/c as distribution reinforcement.

Step 8**:** shear check

Maximum factored stress force,

V_u = 144.2 kN/m

Nominal shear stress,

τ_v = V_u/bd

= 144.2x10^3/1000x362.5

= 0.397 N/mm^2

τ_c = 0.4 N/mm^2

Hence safe.

Step 9 : check for development length @ support

M1 = ½ X M_u

= ½ x 150.85

= 75.425

Development length for 25 ϕ rebars

L_d = 56ϕ

Anchorage length of 90̊ bend

L_o = 8ϕ

= 8x25

= 200mm

$L_d \leq 1.3M_1/V_u + L_o$

56ϕ ≤ (1.3x75.425x10^6 /144.2 x 10^3) + 200

ϕ ≤ 880/56 mm

ϕ ≤ 15.7

we provide 25mm . Hence ok.

0.08L = 0.08(5362.5)

= 429mm

Provide 25 ϕ of 50% of curtailment @ 429mm for support.

Step 10: Design of footpath

width of footpath = 1m

depth of footpath = 0.6m

dead load = 0.6x1x24

= 14.4 kN/m

assumed parapet load (railing) = 5kN/m

live load = 3x1

= 3kN/m

total load = 22.4kN/m

Maximum factored bending moment

= (1.5x22.5x2.3625^2) /8

= 120.77kNm

BM due to vehicle loading = 0.6x150.85

= 90.51kNm

Total BM, M_u = 120.77+90.51

= 211.3 kNm

Effective depth = 600 – [25+25 /2]

= 562.5mm

A_{st} = 211.3x10^6 / 200x0.9x562.5

= 2087mm^2

Provide 4nos of 25mm ϕ bars @ bottom and 4nos of 12mm ϕ bars @ top with 10mm ϕ stirrups @ 300mm c/c spacing.

Reinforcement details

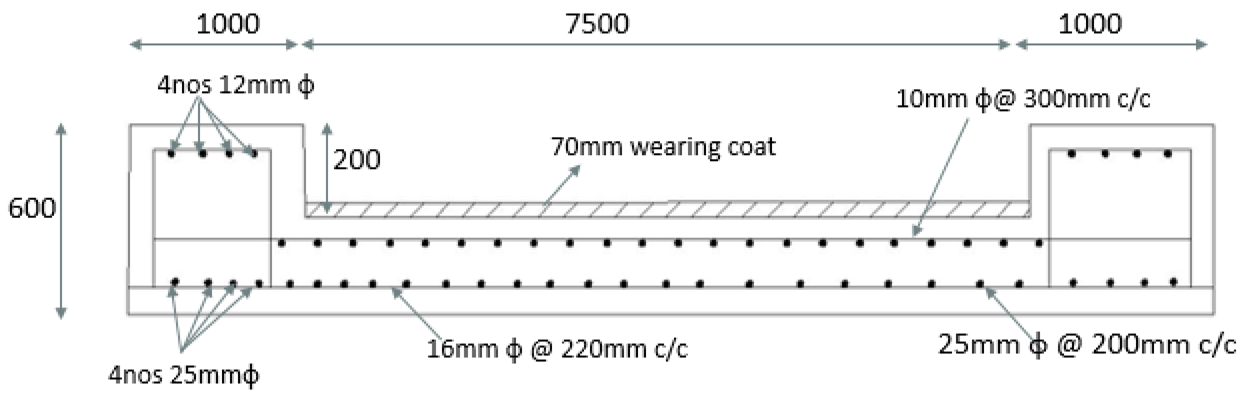


Fig. 2.1 Cross section

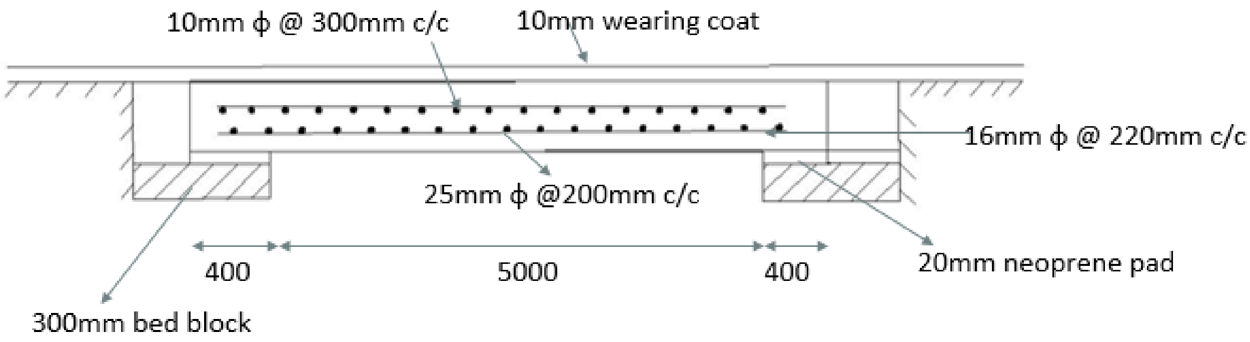


Fig. 2.2 Cross section