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MANUAL DESIGN OF PIER CAP AND PIER

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ABSTRACT The pier cap(deck beam) is designed as a cantilever on a pier and cap looks like a hammer. The Pier is designed for the axial dead load and live load from the slab, girders, deck beam. The pier is designed for two lane bridge loaded with IRC Class AA tracked vehicle. Foundation designed as footing for the safe load bearing in thesoil.All the elements are designed by using M25 grade concrete and Fe415grade steel. Designs are based on Working stress and Limit state method as per IRC: 21-2000 and IS: 456-2000.

KEYWORDS :

Design Procedure

Design of hammer head portion over circular pier for the following details

Live load: IRC Class AA Tracked vehicle

Materials: M20 grade concrete and Fe 415 steel.

1: Data

Clear projection of cantilever slab = 3750+2250-1000 = 5000 mm

R.C.C posts 150 mm×150 mm×1 m are provided at every 1.5 m intervals.

Thickness of wearing coat =75 mm

Materials: M_{20} grade concrete and Fe 415 steel.

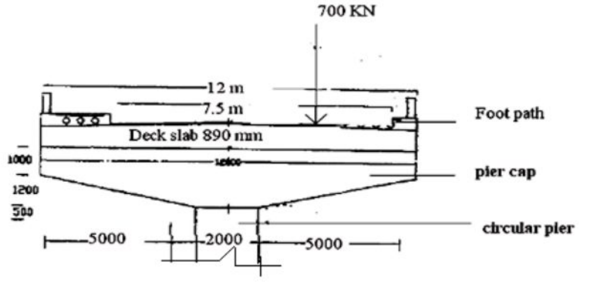
Live load is IRC class AA tracked vehicle.

2: Permissible stresses (IRC: 21):

For M_{20} grade concrete and Fe 415 steel.

$\sigma cb = 6.7\ N/mm^2$, $m = 10$, $\sigma st = 200 N/mm^2$, $j = 0.91$, $Q = 0.762$.

3:Deadloadmoment



Considering one meter width of cantilever slab the dead load moment at the fixed end of the cantilever is computed considering the self weight of slab, kerb, parapet and railings.

TABLE 7.1 CALCULATIONS OF MOMENTS

S.NO	Dimensions of structural element	Load (KN)	Lever arm (m)	Moment (KN-m)
1	Hand rails (lumps 4 m)	2	2.75+(2.25-0.075) = 4.925	9.85
2	R.c.c posts = (0.15×0.15×1×24)	0.54	4.925	2.6595
3	Kerb = (2.25×0.3×24)	16.2	+2.75 =3.875	62.775
4	wearing coat = (2.75×0.075×24)	4.5375	=1.375	6.23
5	R.C.C deck slab = (0.89×5×24)	106.8	5/2 = 2.5	267
6	Triangular portion of hammer head (pier cap) =×1.2×5×24	72	5/3 = 1.67	120.24
7	Rectangular portion of hammer head (pier cap) = 1×5×24	120	5/2=2.5	300

Total dead load moment (Mg) = 9.85+ 2.6595+ 62.775+6.23+ 267+120.24+300 = 768.7795 KN-m.

4: Live load moment

The live load is IRC class AA tracked vehicle. This is placed with its edge 1200 mm from the kerb.

Effective width of dispersion perpendicular to span is given by

be= 1.2x +bw x is the distance of center to gravity of the concent rated load from the face of the cantilever support.

bw = The breadth of the concentration area of the load i.e; the dimension of the track contact area over the road surface of the slab in the direction parallel to the supporting edge of the cantilever plus twice the thickness of the wearing coat or surface finish above the structural slab.

be= 1.2×x+bw

X= 0.1m

bw = [0.85+2×0.075]=1m.

Therefore be= (1.2×0.1)+1 = 1.12m.

Live load per meter width including impact =(770×2)/1.12=1375KN.

Design live load moment (Mq) = 1375×0.1 = 137.5 KN-m.

5: Design moment

Design moment =M=(M+M) =768.7795+137.5 =906.2795 KN-m.

Factored moment = 906.2795×2.1=1903.18 KN-m.

6: Reinforcements

Effective depth required

Qbd^2 =maximum bending moment

$$d = \sqrt{\frac{\max b.m}{Q \times b}} = \sqrt{\frac{1903.18\times10^6}{0.762\times1000}} = 1580.38 \text{ mm.}$$

Effective depth required =2200-50 = 2150 mm > 1580.38 mm

Hence adopted depth is adequate.

$$A_{st} = \frac{maximum\ bending\ moment}{\sigma st \times j \times d} = \frac{1580.38\times10^6}{200\times0.91\times2150} = 4038.79\ mm^2 = 4039\ mm^2$$

Use 25mm ø bars

$$a_{st} = \frac{\pi \times d^2}{4} = 490.87\ mm^2$$

$$\text{Number of bars} = \frac{4039}{490.87} = 8.22 \cong 9 \text{ no.s}$$

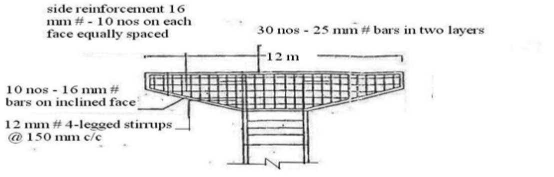
However provided more effective more reinforcement than required.

Top reinforcement:
Provide 30 numbers of 25mmø bars in 2 layers

Side reinforcement:
Provide 10 numbers of 16mm ø bars on each face equally spaced.

Inclined reinforcement:
Provide 10 numbers of 16mm øbars on each face equally spaced.

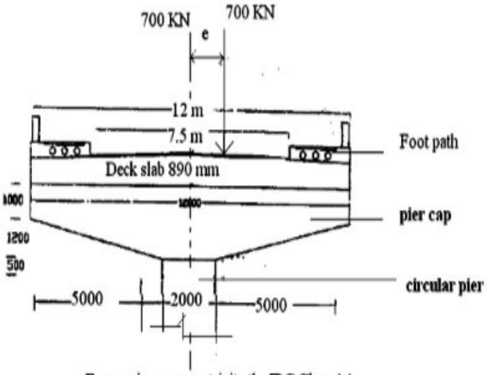
Shear reinforcement:
Provide reinforcement 12mm ø 4-legged stirrups @ 150 mm\cc.



REINFORCEMENT DETAILS IN HAMMER BED BLOCK

Live load: IRC Class AA tracked vehicle
Materials: M20 grade concrete and Fe 415 steel

1. Calculation of loads



For maximum eccentricity the IRC Class AA Tracked vehicle is placed away from the centre

Weight of
1. Parapet railing = (2×0.7) = 1.4 KN/m
2. Wearing coat = (0.075×7.5×22) = 12.375 KN-m
3. Deck slab = (0.89×12×24) = 256.32 KN-m
4. Krebs = (2×0.3×2.25×1×24) = 32.4 KN-m
5. Dead load of pier cap

The pier cap is divided into two cantilevers and one rectangular section Weight of two trapezoidal sections = area × unit weight of concrete

$$= 2\times\frac{(1+2.2)}{2}\times 5 \times (25) = 400 \text{ KN-m}$$

Weight of rectangular portion = (2×2.2) × 25 = 110 KN-m
Therefore total weight of pier cap = 400+110 = 510 KN-m

$$\text{Dead load of circular pier} = \frac{\pi\times 2^2}{4}\times 8.062\times 25 = 633.18 \text{ KN-m}$$

Weight of IRC Class AA tracked vehicle is 700 KN
Total load = dead load + live load = 1445.675+700 = 2145.675 KN
Total load with impact = 2145.675×2= 4291.35 KN

By considering dynamic effects such as wind load, longitudinal forces due to tractive effort of vehicles and longitudinal forces due to braking of vehicles a suitable factor of safety is made
Factor of safety = 2
Factored load = 4291.35×2 = 8582.7 KN
Factored load Pu=8582.7 KN

If vehicle is moving away the center of the bridge moment is induced.

e is the eccentricity of the wheel load from center.
e = 1.1m

Live lsoad = 700×2 = 1400 KN
Maximum moment = 1400×1.1 = 1540 KN
Moment with impact = 700×1.1= 1400 KN
Factored moment = 1540×2.2 = 3388 KN-m
Therefore factored moment = Mu = 3388 KN-m

2. Non dimensional parameters

$$\frac{P_u}{f_{ck}D^2} = \frac{8582.7*10^3}{20*2000^2} = 0.1$$

$$\frac{M_u}{f_{ck}D^3} = \frac{3388*10^6}{20*2000^3} = 0.02$$

$$\text{Ratio } \left(\frac{d}{D}\right) = \frac{60}{2000} = 0.03$$

Where D is the diameter of the circular pier = 2000 mm
d is the clear cover = 60 mm

By referring chart number of 55 of SP 16

Where P is the percentage of steel reinforcement

P = 0.01*20 = 0.2

$$\text{Area of steel} = \frac{P*\pi*D^2}{400} = \frac{0.2*\pi*2000^2}{400} = 6283.18 \text{ mm}^2$$

Use 25 mm φ bars

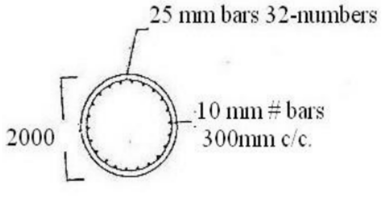
$$a_{st} = \frac{\pi*25^2}{4} = 490.87 \text{ mm}^2$$

$$\text{Number of numbers} = \frac{6283.18}{490.87} = 12.8\text{mm}^2$$

However provide 32 numbers of 25φ mm bars around the circular pier.

Using 10 mm φ lateral ties
Spacing is the least of the following
1. Least lateral dimension = 2000 mm
2. 16×25 = 400 mm
3. 300 mm

Hence provide 10 mm ø bars of lateral ties @ 300 mm c/c.



PLAN OF CIRCULAR PIER