Explain:-

(a) Elastometric bearing:-

* The present trend is to use elastometric bearing in preference to metalic bearing which are expensive in initial cost & Maintanence

* Chloropere rubber termed as neoprene is the most commonly used type of elastometric in bridge bearing.

* They donot freeze, corrode (or) detoriate. Bearing in earthquake the only probable causes for failure of an elastometric bearing are inferior materials in correct design (or) improper instellion.

* The elastometric bearing need no positive fixing the metalic bearings. The height of bearing is minimum and much less than roller (or) rocker bearing thus contributing reduction in cost of approches.

*

* An elastomer is any member of a class of polymeric, substancs obtained after vulcanization & prossessing characteristic similar to rubber especially, after large deformation to regain shape.

* Elastometer has better weathering resistance & is flame resistant.

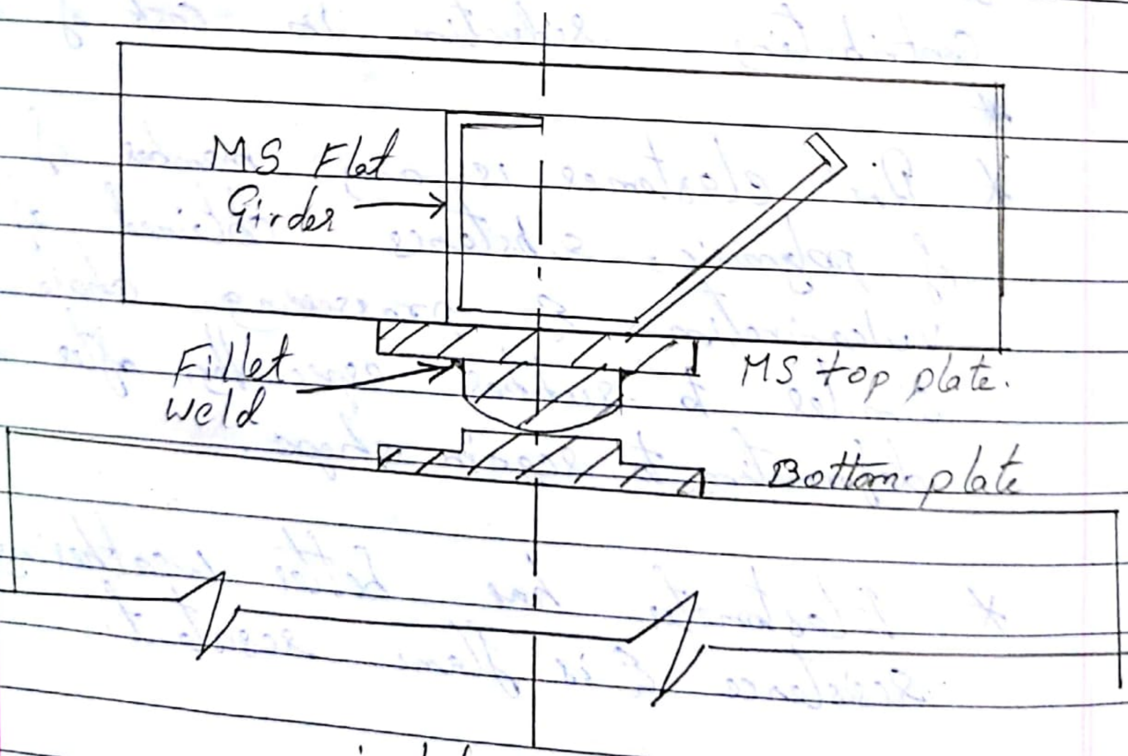
* By adding antioxidants and anti oxidants its resistance to attack by oxygen and ozone can be increased.

b) Plate bearing:-

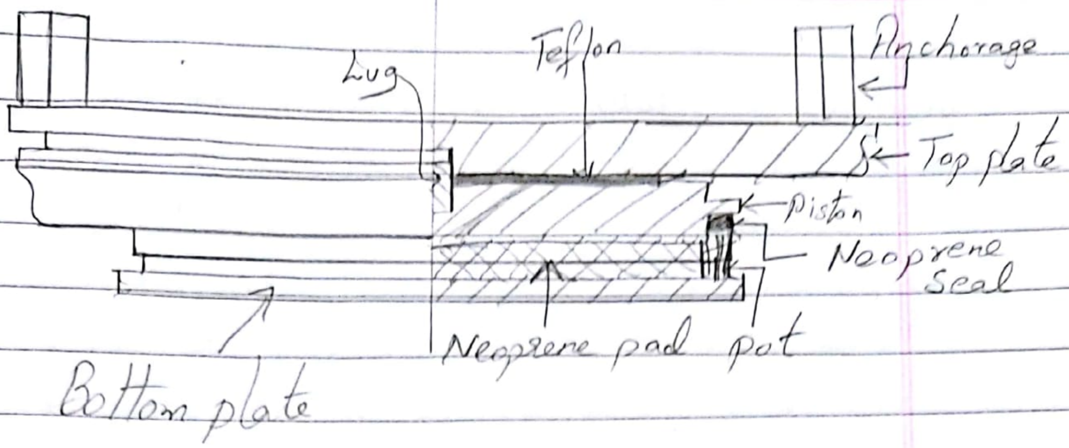
* The slide plate bearing is the simplest form of expansion bearings. This type is useful for girder bridge of span up to 15M.

* When the contact surfaces are flat, teflon coating should be used to prevent the development of frictional resistance & to facilitate smooth movement due to expansion.

* The current practice is to provide a curved shape to the top plate to reduce contact and frictional resistance



- plate bearing :-



Elastomeric pot bearing.

c) Rocker Roller bearing:-

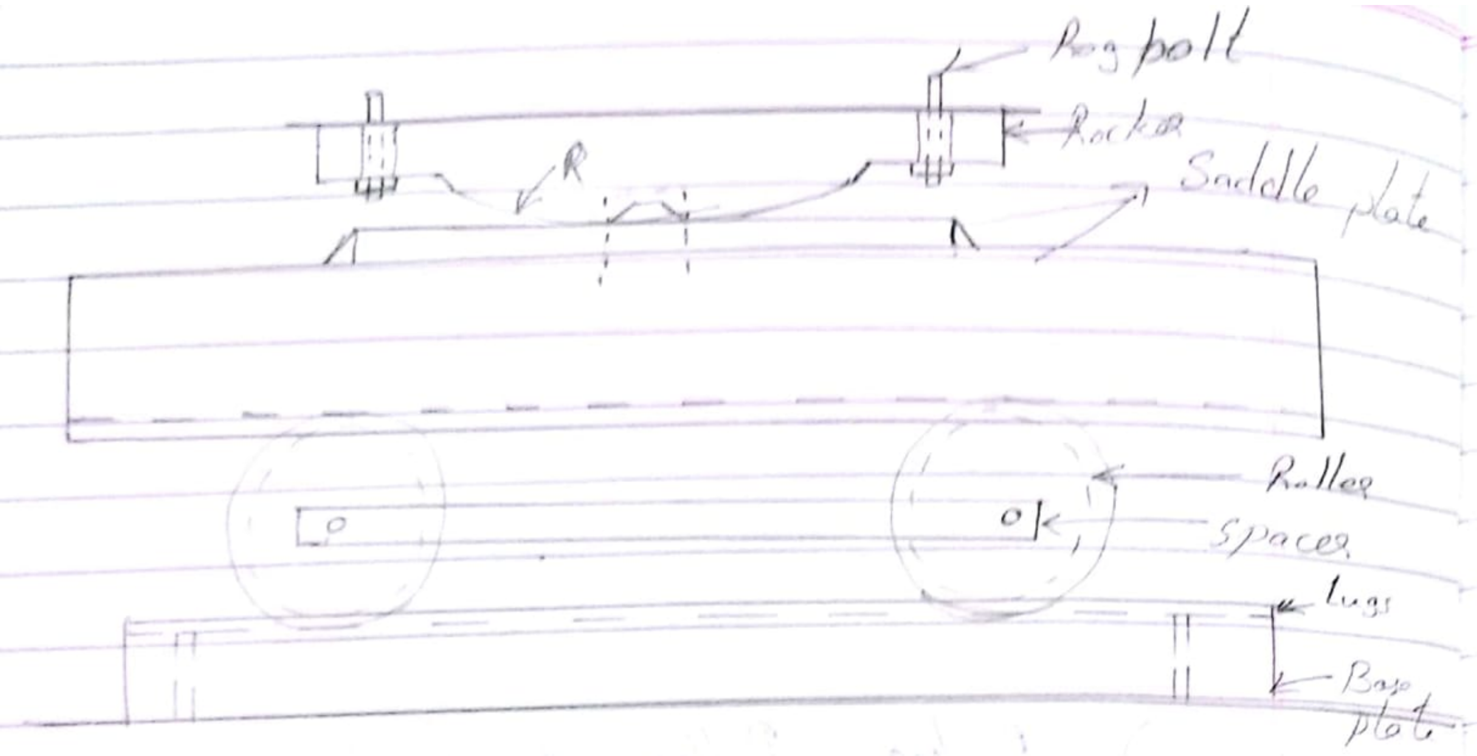
* Roller cum rocker bearing permits longitudinal movement by rolling & simultaneously allows rotation Movement.

* Cast iron roller bearing have been in general use for major bridges with above 20M span.

* The bearing consists of single roller, 2 rollers (or) Nest of rollers.

* When 2 large diameter roller are used, sometimes only the central segment for a certain width is used instead of full cylinder

* When roller bearing are provided over abutment the base plate should have sufficient length to cater for the large movement over abutment.



Roller Rocker Bearing.

d) Expansion joint:-

* Expansion joints are important structural elements in any type of road bridges, elements. They accomodate the relative movements of bridge elements, especially those due to concrete shrinkage, change in temp & long term creep.

* The expansion joint should be robust, durable, watertight & replaceable besides facitilating good riding quality.

* Satisfactory long term performance and durability of expansion joint system requires diligent design, quality fabrication, competent construction, adequate inspection and meticulous maintanance.

* The expansion joint and the bearings should be designed togather to be compatible.

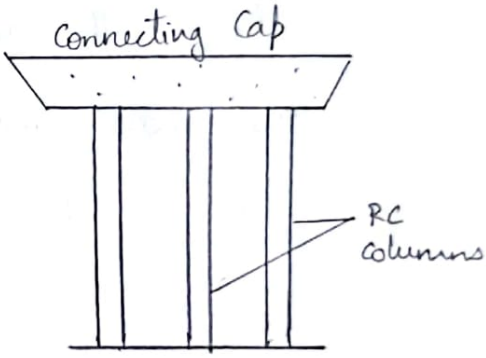
* located at the road level, the expansion joints are subject to impact and vibration due to wheel loads and are exposed to the effects of water, dust, petroleum derivatives and salt solutions.

* Different types joints.
    * Buried joint.
    * Filler joint.
    * Single strip seal joint.
    * Finger joint.
    * Box seal joint.

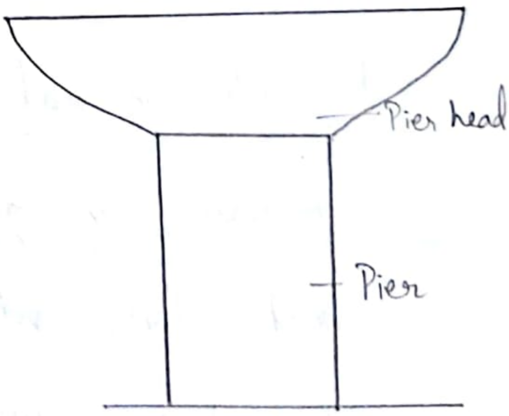
Types of Piers

(i) **Solid pier** = These piers are made of brick masonry, stone masonry or concrete. They are used in bridges where water flow underneath the bridge is present.

(ii) **Trestle pier** – It consists of ~~RC~~ ~~columns~~ a set of RC columns connected at the top by a connecting cap.
~~Generally used in flyovers~~

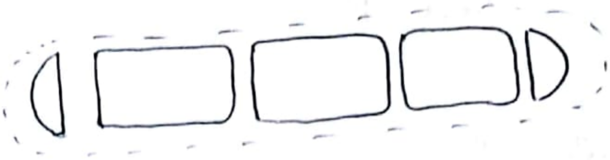


(iii) **Hammer head pier** – The head of pier is in the form of a hammer, consisting of cantilever projection on either side of pier. These are generally used in flyovers.

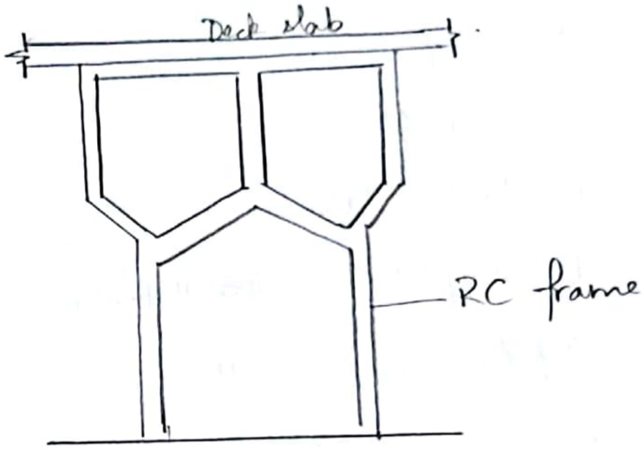


Hammer head pier

(iv) Cellular piers – Prove to be economical when used in bridges which accomodate multilane traffic.



(v) RC frame piers – Used to reduce span of bridge, thereby reducing the cost & hence proving economical.



• loads on pier

- load of superstructure
- self weight of pier
- longitudinal loads due to vehicles
- Force due to buoyancy
- Force due to wave action of water
- Force due to water current
- Wind loads
- Seismic loads

Part - B

(1) Given.

(a) Trapezoidal channel:

base width: 12.5m

side slope = 1:1

$Q = 30\ m^3/s$

Bed level : 100m

Full supply level : 101.25m

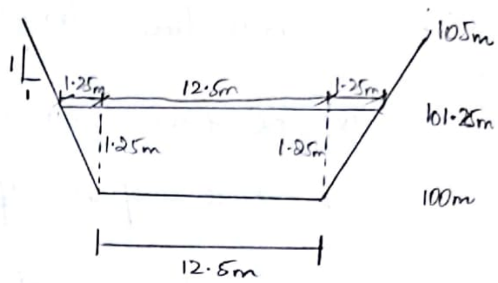
Top level of slab : 105m

M25, Fe415

Road width = 7.5m

footpath = 750mm

Bell mouthed wing wall : C = 0.9



(i) To find span of bridge

Area of trapezoid $= (a+b)\frac{h}{2}$

$= (12.5 + 15) \times \frac{1.25}{2}$

$A = 17.19\ m^2.$

vel. of flow, $v = \frac{Q}{A} = \frac{30}{17.19} = 1.745\ m/s.$

Width at FSL,

$b = 12.5 + 1.25 + 1.25$

$b = 15m$

$h = FSL - BL$

$= 101.25 - 100$

$= 1.25m$

Taking afflux, X = 15 mm

$$x = \frac{v^2}{2g}\left[\frac{L^2}{C^2 L_1^2} - 1\right]$$

$v = 1.745\ m/s$
$x = 15/1000\ m$
$g = 9.81\ m/s^2$
$L = 15m$
$C = 0.9$
$L_1 = ?$ = span of bridge

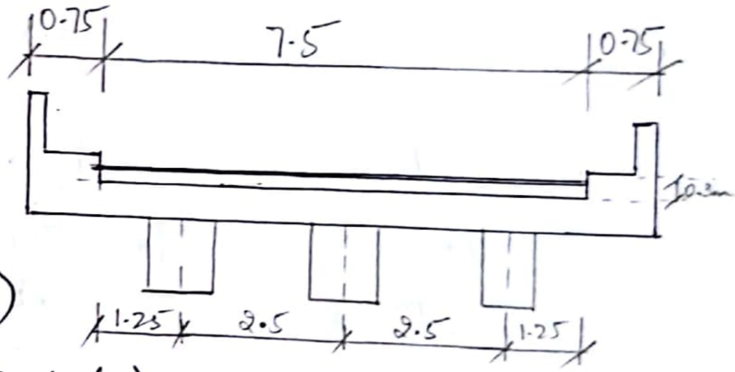
$$\frac{15}{1000} = \frac{1.745^2}{2\times9.81}\left[\frac{15^2}{0.9^2 \times L_1^2} - 1\right]$$

$L_1 = 15.92\ m \approx 16m.$

∴ Span of bridge = 16m.

(ii) Cross section of bridge.

~~No. of cross girders = 3 (assumed)~~



(All dim. in m)

Let :

- No. of longitudinal girders = 3 (say)
- Spacing of longi. girders = 2.5 m c/c (say)
- Depth of slab = 200mm (say)
- Depth of wearing coat : 80mm bitumen (say)

Width of girder = 1.5 × Depth of slab = 1.5 × 200 = 300mm.

Depth of girder = 100mm depth per metre length of span (including slab)

= 100 × 16

= 1600mm.

∴ Actual depth of girder = 1600 − 200 = 1400mm.

Let no. of cross girders = 5

∴ Spacing of cross girders = $\frac{16}{(5-1)} = \frac{16}{4} = 4m\ c/c$.

Kerb = 0.3 × 0.75m.

(iii) <u>Permissible stresses</u>

~~$n = \frac{1}{1+\frac{\sigma_{st}}{m\sigma_{cbc}}}$~~

From IRC: 21 Pg. 18, 19, table 9, 10:

For M25 & Fe415

$\sigma_{cbc} = 8.33 MPa$

$\sigma_{st} = 200 MPa$

Modular ratio (for bridge design), $m = 10$

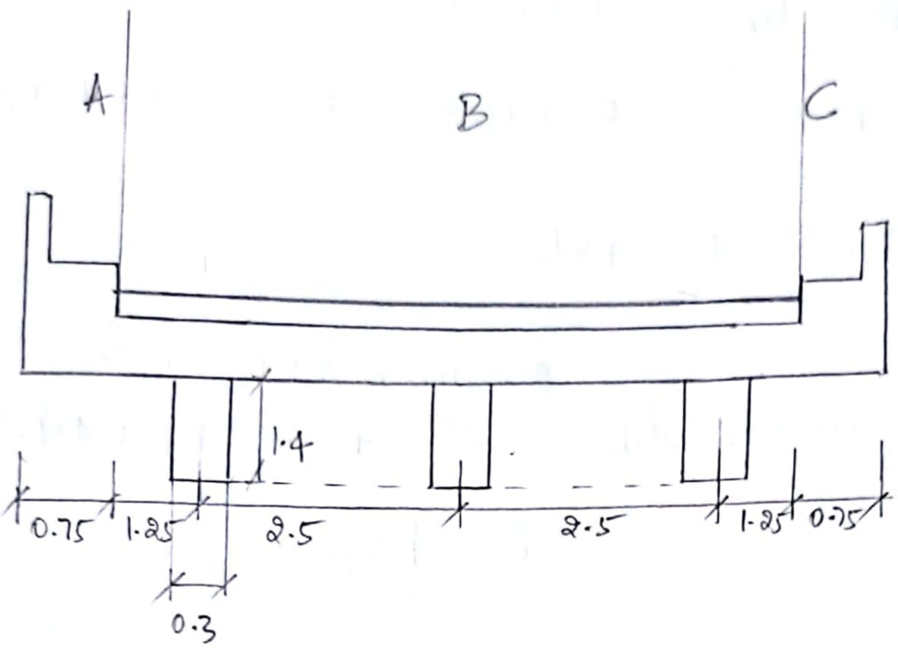
$$n = \frac{1}{1+\frac{\sigma_{st}}{m\sigma_{cbc}}} = \frac{1}{1+\frac{200}{10\times 8.33}}$$

$n = 0.294$.

$$j = 1 - \frac{n}{3} = 1 - \frac{0.294}{3} = 0.9$$

$$Q = 0.5\,\sigma_{cbc}\,j\,n = 0.5\times 8.33\times 0.9\times 0.294 = 1.1.$$

(iv) Design of longitudinal girder



• DL

(Portion A = Portion C)

Loading :

SW of slab = 1×1 × 0.2× 24 = 4.8 kN/m

SW of W.C. = 1×1× 0.08× 22 = 1.76 kN/m

Parapet / Guard rail = 0.8 kN/m

Kerb load = 0.3×0.75×1×24 = 5.4 kN/m

Portion A :

Parapet = 0.8 kN/m

Kerb = 5.4 kN/m

~~Deck load = 4.8 × 0.75 = 3.6 kN/m~~ Deck slab load = 4.8×0.75 = 3.6 kN/m

Total = 6.2 kN/m + 3.6 = 9.8 kN/m

Portion B :

SW of slab = 4.8 × (1.25 + 2.5 + 2.5 + 1.25) = 36 kN/m

SW of W.C. = 1.76 × (1.25 + 2.5 × 2 + 1.25) = 13.2 kN/m

Total load = 49.2 kN/m.

Total load on deck slab = 2× Portion A + Portion B = ~~2×6.2+~~ = 2×9.8 + 49.2

= 68.8 kN/m.

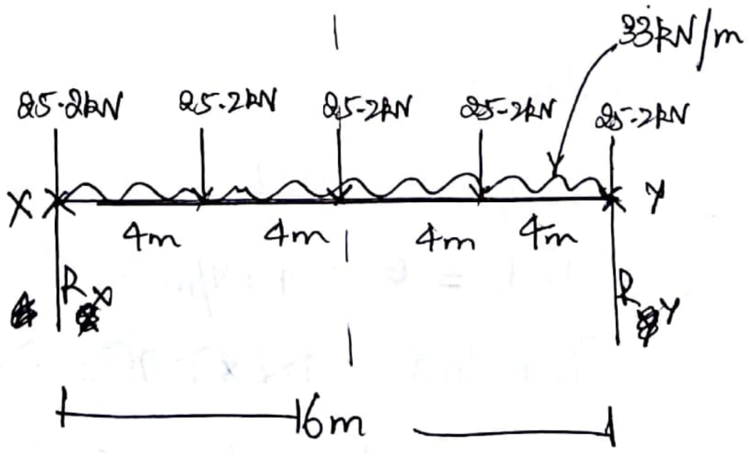
load on each girder = $\frac{68.8}{3}$ = 22.93 kN/m.

SW of longi. girder = (0.3 × 1.4 × 1) × 24 = 10.08 kN/m.

Total UDL on girder = 22.93 + 10.08 = 33 kN/m.

SW of Cross girder = (0.3 × 1.4 × 2.5) × 24 = 25.2 kN.

BM_{DL} and SF_{DL}



Reactions :

$R_X = R_Y = \frac{(25.2 \times 5 + 33 \times 16)}{2}$

R_X = 327 kN.

BM_{DL} = BM at centre

$= R_x \times 8 - 25.2\times8 - 25.2\times4 - 33\times\frac{8^2}{2}$

$= 327\times8 - 25.2\times8 - 25.2\times4 - 33\times\frac{8^2}{2}$

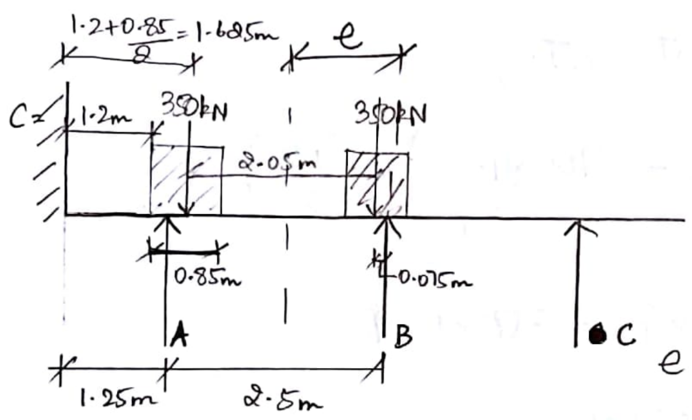
$BM_{DL} = 1257.6\,kNm$

SF_{DL} = SF at support

$= \frac{(25.2\times3 + 33\times16)}{2}$

$SF_{DL} = 301.8\,kN$

• LL



C = 1.2m, for span > 5.3m multilane (IRC 6 Pg 10)

$e = \frac{2.05}{2} + 0.075$

$e = 1.1m$

Reaction constant, $R = \frac{2}{3}W_1\left[1 + \frac{nex}{\Sigma x^2}\right]$, where $W_1 = \frac{W}{2}$

$\therefore R = \frac{W}{3}\left[1 + \frac{nex}{\Sigma x^2}\right]$

$$R_A = \frac{W}{3}\left[1 + \frac{3 \times 1.1 \times 2.5}{2.5^2 + 2.5^2}\right]$$

$n = 3$
$e = 1.1m$
$x = 2.5m$

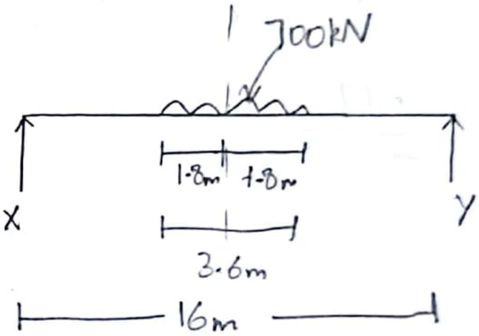
$$R_A = 0.553\,W.$$

$$R_B = \frac{W}{3}\left[1 + 0\right]$$, as $e = 0$, as C.O.G. of girder & wheels coincide

$$R_B = 0.333W.$$

<u>To find BM, W</u>

$$R_x = R_y = \frac{700}{2} = 350kN.$$



∴ BM at centre,

$$W = R_x \times 8 - \left(700 \times \frac{1.8}{3.6}\right) \times \left(\frac{1.8}{2}\right)$$

$$= 350 \times 8 - 350 \times 0.9$$

$$W = 2485\ kNm.$$

∴ Outer girder BM $= BM_{OG_{LL}} = R_A = 0.553 \times 2485 = 1374.21\,kNm.$

Inner girder BM $= BM_{IG_{LL}} = R_B = 0.333 \times 2485 = 827.51\,kNm.$

Design $BM_{LL} = 1374.21\,kNm \times If$

$If = 10\%$, for span $> 9m$ tracked vehicle RC bridge,

~~IF~~ as per IRC: 6-2010 Pg 21.

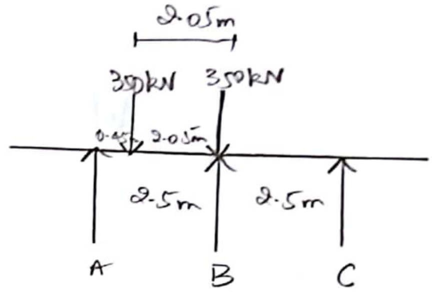
∴ Design ~~SF~~ $BM_{LL} = 1374.21 \times 1.1 = 1511.63$ kNm.

Design BM = $BM_{DL} + BM_{LL} = 1257.6 + 1511.63$

BM = 2769.23 kNm

SF_{LL} =>

Reactions:



$R_A = \frac{350 \times 2.05}{2.5} = 287$ kN

$R_B = 350 + \frac{0.45}{2.5} = 413$ kN.

SF_{LL} = Max. SF = $SF_B = 413 \times \frac{(16 - 1.8)}{16}$

$SF_{LL} = 366.54$ kN.

Design $SF_{LL} = 366.54 \times I_f = 366.54 \times 1.1$

$= 403.19$ kN.

∴ Design SF $= SF_{DL} + SF_{LL}$

$= 301.8 + 403.19$

SF = 705 kN.

(v) Ast.

$$A_{st} = \frac{M}{\sigma_{st}\, j d}$$

$d = 1450$ mm

Providing lever arm, $d = 1450 - \frac{1}{2} \times 200 = 1350$ mm

$$\therefore A_{st} = \frac{2769.23 \times 10^6}{200 \times 0.9 \times 1350} = 11396 \text{ mm}^2.$$

Providing 32mmφ bar (Max. as per IRC : 21)

$$\text{No. of bars} = \frac{11396}{\left(\frac{\pi}{4} \times 32^2\right)}$$

$$= 14.17 \approx 16\#.$$

Provide 16# – 32mmφ as main steel rft.

(vi) Check for shear.

Nominal shear stress, $\tau = \frac{V_u}{bd}$ (IRC 21 Pg 35 Cl. 304.7.1.1.1.)

$$\tau = \frac{705 \times 10^3}{300 \times 1450}$$

$$\tau = 1.62 \text{ MPa}.$$

~~Design shear stress, τ_v =>~~

~~$\frac{100 A_{st}}{bd} = 100 \times 1130$~~

Design shear stress => τ_v =>

$$\frac{100 A_{st}}{bd} = \frac{100 \times 11396}{300 \times 1450} = 2.62 \text{MPa}$$

Factor, k = 1.2 for 200mm slab

$$\therefore \tau_v = 2.62 \times 1.2 = 3.14 \text{ MPa}.$$

As $\tau < \tau_v$, provide shear rft.

Assuming ~~Providing~~ 2#-32ϕ to be bent up,

$$V = \sigma_{sv} A_{sv} \sin\alpha$$

$$V = 200 \times \frac{2 \times \pi}{4} \times 32^2 \times \sin 45$$

$V = 227.48 kN.$

$\therefore$ Rft. SF, $V_{us} = V_u - V$

$= 705 - 227.48$

$V_{us} = 477.52 kN.$

Providing 4LVS - 8mmϕ,

$$Spacing = \frac{A_{sv}\, \sigma_{sv}\, d}{V_{us}}$$

$$= \frac{4 \times \frac{\pi}{4} \times 8^2 \times 200 \times 1450}{477.52 \times 10^3}$$

$= 122.1mm \approx 120mm\, c/c.$

$\therefore$ Provide 4LVS - 8mmϕ @ 120mm c/c as shear rft.