Explain classification of bridges.

Bridges may be classified in many ways.

i] According to function.

* Aquadict
* Viaduct
* Pedestrian
* Highway
* Railway
* Road-cum-rail or a pipeline bridge.

ii] According to the material of construction of super-structure

* Timber bridge
* Masonry bridge
* Iron bridge
* Steel bridge
* Reinforced concrete bridge
* Pre-stressed concrete bridge.
* Composite or aluminium bridge.

iii] According to the form or type of superstructure

* Slab bridge
* Beam bridge.
* Truss bridge
* Arch bridge
* cable stayed or suspension bridge.

iv] According to the inter-span relations
* simply supported bridge
* continous bridge
* cantilever bridge

v] Based on span.
* Culvert (less than 8m)
* Minor bridges (8-30m)
* Major (30-120m)
* Long span (>120m).

vi] Based on alignment
* straight
* skewed bridge.

vii] Based on position of deck.
* Deck briq
* Through
* Semi-through

viii] Based on water ways
* cause bridge
* sub-mersible
* high-level

ix] Based on usage
* Temporary
* Permanent

x] Based on connection
* Pinned joint bridges
* Riveted joint
* welded bridges.

xi] Based on grade separator
* Road over bridge
* Road under bridge
* Flyover.

xii] Based on moment

* Swing bridge.
* Bascule bridge
* Lifting bridge.

Q-1.(b) List the different loads to be considered for design of bridges.

→ (1) Dead load

(2) Live load

(3) Snow load

(4) Impact load due to vehicle

(5) Impact load due to floating bodies

(6) Vehicle collision load

(7) Wind load

(8) Earthquake load

(9) Water current

(10) centrifugal force

(11) Buoyancy

(12) Earth pressure including surcharge

(13) Temperature effects

(14) Deformation effects

(15) Wave pressure

(16) Grade effect

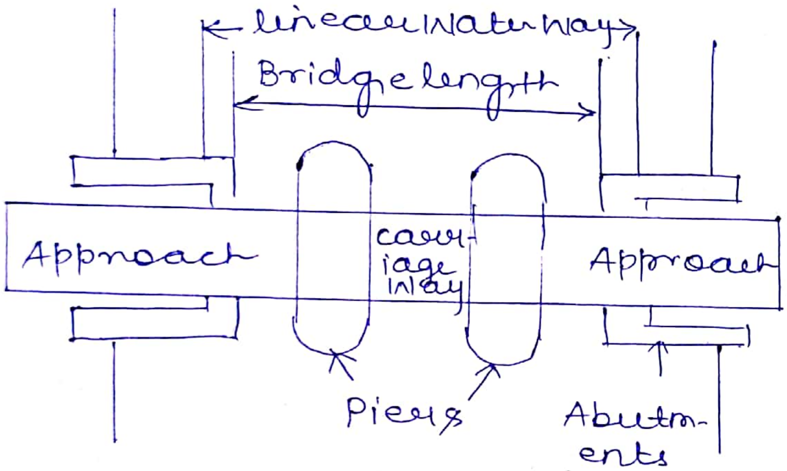
(17) Erection effect

(18) Seismic force, etc.

Q-2. Explain linear water way, economic span, afflux.

→ * **Linear water way** -

The width of water way b/w the extreme edges of water surface at highest flood level measured at right angles to the abutment face.



Plan of Bridge

* **Economic span**

$$C = A + B + (n-1)p + n \cdot K \cdot s^2 + K'L$$

where, C = Total cost of Bridge

B = cost of abutment with foundation

A = cost of approach

L = linear water way

s = length of one span

n = no. of span

p = cost of one pier including found^n

Assuming that cost of superstructure of one span is proportional to the square of span length.

Total cost of super structure to the square of span length.

Total cost of super structure $= nks^2$

where k = constant

The total cost of railing floring etc is proportional to total length of bridge $= k'L$

$\therefore$ economic span $- S_e = \sqrt{\frac{P}{K}}$

If $\frac{dc}{ds} = 0$ then $P = Ks^2$

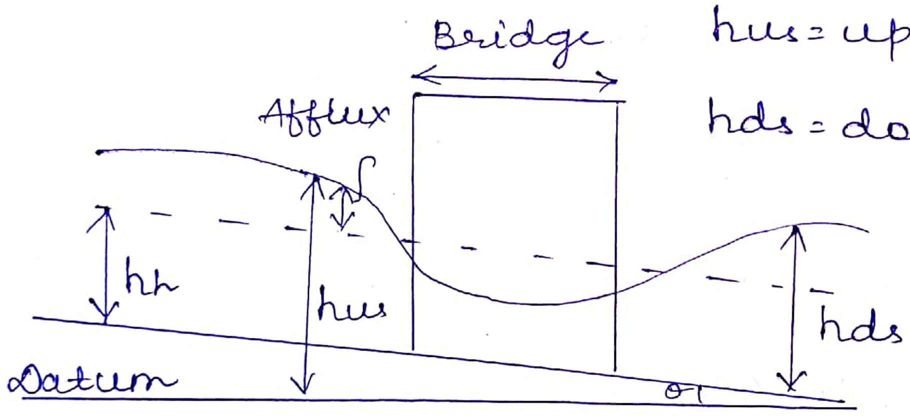
The span to satisfy this condition, is called economic span.

* Afflux

hn = normal water depth

hus = upstream surface elevation

hds = downstream surface elevation



- It is defined as heading up of water when they hit any obstruction. In bridges the water hit at u/s side when hiring the water rises.
- It is an increase in water level that can occur upstream of a bridge, that creates an obstruction in the flow.

• It is calculated as

$$X = \frac{V^2}{2g}\left[\frac{L^2}{c^2 L_1^2} - 1\right]$$

L = width of stream at High Flood level

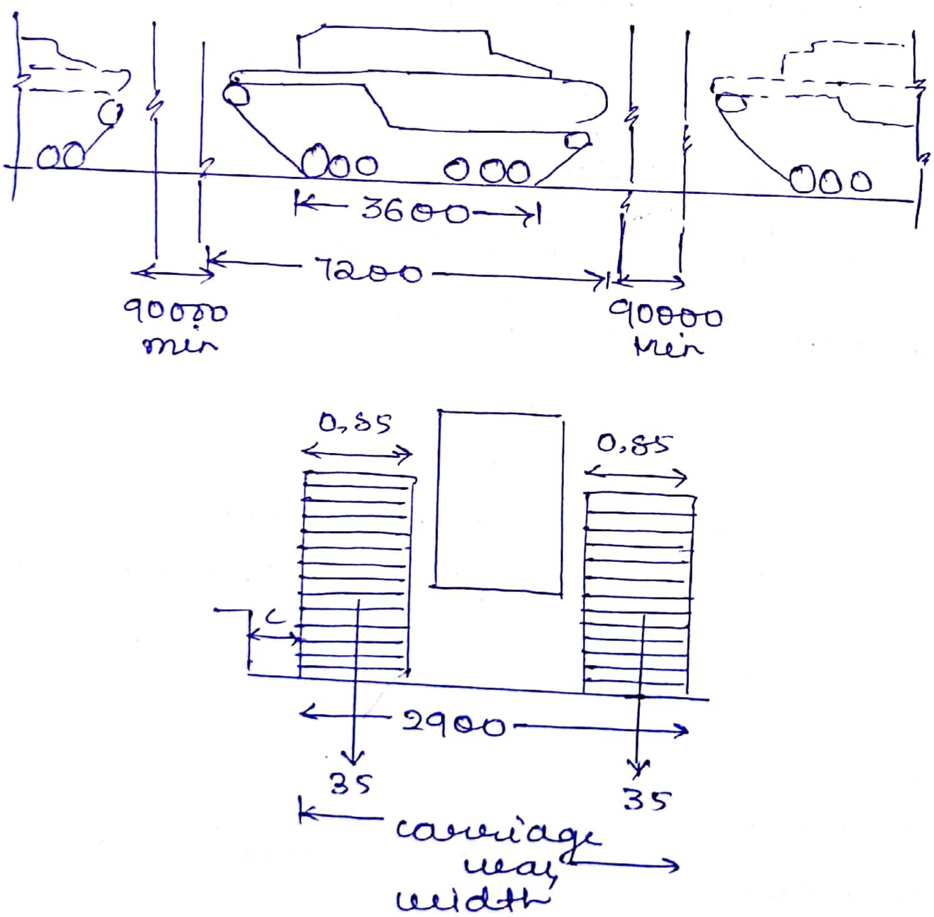
L_1 = linear water way

c = coeff of discharge

V = velocity of normal flow.

Q-3. Explain IRC class AA Tracked loading with neat sketch.

→



Tracked vehicle

- This type of loading is considered for the design of new bridge especially heavy loading bridges like bridge on highways, in cities, industrial areas etc.
- generally two types of vehicle are considered in this class.
  - (i) Tracked vehicle
  - (ii) Wheeled vehicle
- This loading is to be adopted with certain municipal limits, in certain existing or contemplated areas, in other specified areas and along certain specified highways
- Bridges designed for class AA loading should be checked for class A loading also, as under certain conditions, heavier stress may occur under class A loading.

Part B

Q-4. A RCC Deck slab bridge is to be constructed over a trapezoidal channel. The following details are available.

clear span 5 m

Road width 7.5 m

Wearing coat thickness 80mm

Footpath either side 0.8 m

M25 & Fe 415

IRC class AA Tracked loading.

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Sol:- (1) Design of deck slab

• preliminary dimensions

(i) Effective depth-

Assume 80mm depth thick for every 1m length slab

∴ overall depth = 80 × 5 = 400mm

Assume clear cover of 50mm thick and dia of bar = 20mm

∴ eff. depth (d) = $400 - 50 - \frac{20}{2} = 340mm$

$\simeq 350mm$

(ii) effective span-

• clear span + $\frac{Bearing}{2} \times 2 = 5 + \frac{0.35}{2} \times 2 = 5.35m$

• clear span + eff. depth = 5 + 0.35 = 5.35m

∴ $L_{eff} = 5.35m$

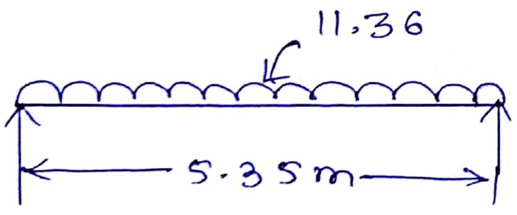
(2) load calculation

• Dead loads

(i) self wt of slabs = 0.4 × 24 = 9.6 KN/m^2

(ii) self wt of W.C = 22 × 0.08 = 1.76 KN/m^2

11.36 KN/m^2



BM due to dead load = $\frac{Wl^2}{8} = \frac{11.36 \times 5.35^2}{8} = 40.64 KNm$

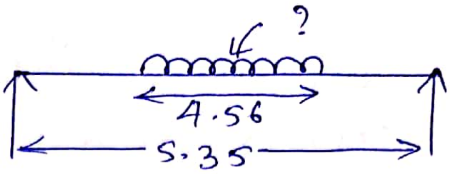
SF due to dead load = $\frac{Wl}{2} = \frac{11.36 \times 5.35}{2} = 30.38 KN$

• live load

(i) $\ell_L = 3.6 + (D+t_w) \times 2$

$= 3.6 + (0.40 * 0.08) \times 2$

$= 4.56\ m$



(ii) $b_{eff} = \alpha a \left(1 - \frac{a}{L}\right) + b_1$ [IRC-21, Pg-52]

$L = 5.35\ m$

$a = \frac{L}{2} = 2.675\ m$

$b_1 = 0.85 + (2 \times 0.08) = 1.01$

$\alpha = \frac{B}{L} = \frac{7.5 + 0.8 + 0.8}{5.35} = 1.7$

$\alpha = 2.92$

$b_{eff} = 2.92 \times 2.675 \left(1 - \frac{2.675}{5.35}\right) + 1.01 = 4.915\ m$

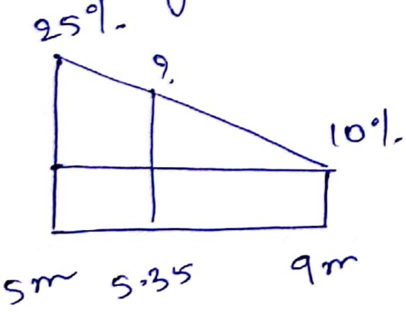
(iii) $\ell_W =$ (i) $2.45 + 2.05 + 2.45 = 6.95\ m$ ✓ } least value

(ii) $2.825 + 2.05 + 2.45 = 7.32\ m$

$\therefore \ell_W = 6.95\ m$

(iv) Impact factor for the live load

Pg-21, IRC-6

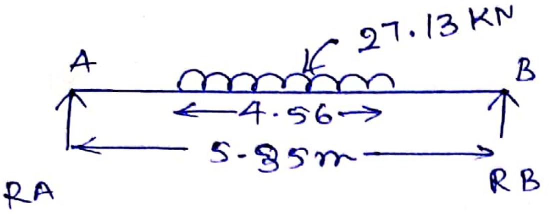


$\frac{x}{0.35} = \frac{15}{4} \Rightarrow x = 23.68\%$

live loading including IF

$= 700 \left(1 + \frac{23.68}{100}\right) = 865.76\ KN$

Total live load $= \frac{865.76}{6.95 \times 4.56} = 27.31\ KN$



$RA = RB = \frac{27.13 \times 4.56}{2}$

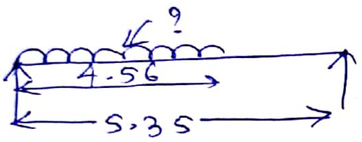
$= 61.85\ KN$

BM due to live load @ Midpoint.

$= \left(61.85 \times \frac{5.35}{2}\right) - \left(\frac{27.13 \times 4.56}{2} \times \frac{4.56}{4}\right)$

$= 94.93\ KNm$

SF due to live load -



$b_{eff} = \alpha a\left(1 - \frac{a}{L}\right) + b_1$

$= 2.92 \times \frac{~~2.675~~}{2.28}\left(1 - \frac{2.28}{5.35}\right) + 1.01$

$= 4.83$

1. $DW = \frac{b_{eff}}{2} + 2.05 + \frac{b_{eff}}{2} = 6.88\ m$ ✓

2. $DW = 2.825 + 2.05 + \frac{b_{eff}}{2} = 7.29\ m$

$\therefore DW = 6.88\ m$

$Load/m^2\ slab = \frac{865.76}{6.88 \times 4.56} = 27.59\ KN$

$RA = \frac{27.59 \times 4.56 \times (5.35 - 4.56/2)}{5.35}$

RA = 72.19 KN

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(3) Structural design

(i) Check for depth -

$d = \sqrt{\frac{M}{Qb}}$ where $M = (40.64 + 94.93) \times 10^6$

$= 135.57 \times 10^6$ Nmm

$b = 1000$ mm

$Q = 0.5 n j \sigma_{cb} = 1.104$

$j = 1 - n/3 = 1 - 0.294/3 = 0.902$

$n = \frac{1}{1 + \frac{\sigma_{st}}{m \sigma_{cb}}} = \frac{1}{1 + \frac{200}{10 \times 8.33}} = 0.294$

IRC-21 Pg-18, 19 σ_{cb}, σ_{st} value

$d = \sqrt{\frac{135.57 \times 10^6}{1.104 \times 10^3}} = 341.57 < 350$

Hence safe

(ii) Main reinforcement -

$A_{st} = \frac{M}{\sigma_{st} j d} = \frac{135.57 \times 10^6}{200 \times 0.902 \times 350} = 2147.13 \text{ mm}^2$

$\text{spacing} = \frac{a_{st}}{A_{st}} \times 1000 = \frac{\frac{\pi}{4} \times 20^2}{2147.13} \times 1000 = 146.31$

≈ 150 mm

$A_{st\,prov} = 2100 \text{ mm}^2$

(iii) Distribution reinf.

$M = 0.3 DL + 0.2 DL$

$= 0.3 \times 40.64 + 0.2 \times 94.93$

$= 31.17 \times 10^6$

$A_{st} = \frac{M}{\sigma_{st} j d} = \frac{31.17 \times 10^6}{200 \times 0.902 \times 334} = 517.31 \text{ mm}^2$

$S_v = 218.62 \approx 200$ mm

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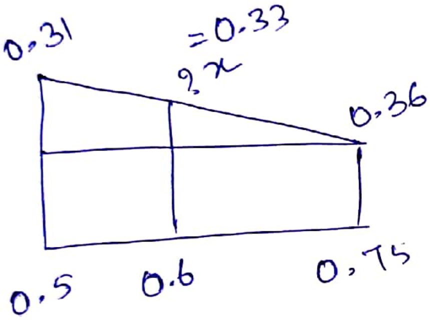
(IV) <u>check for shear</u>

IRC-21, Pg-35, 36, 37

$$\tau_v = \frac{V}{bd} = \frac{(30.38+72.19)\times 10^3}{1000\times 350} = 0.293$$

$$\frac{100A_{st}}{bd} = \frac{100\times 2100}{1000\times 350} = 0.6$$

τ_c = ~~0.29~~ 0.33 [from Table-12B Pg-37]



$$\frac{x}{0.1} = \frac{0.05}{0.25}$$

$x = 0.02$

$= 0.31 + 0.02$

$=$ ~~0.29~~ 0.33

$\therefore$ $\tau_c > \tau_v$

Hence safe