BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI
DEPARTMENT OF CIVIL ENGINEERING
FIRST SEMESTER 2022-23
CE G616: BRIDGE ENGINEERING
COMPREHENSIVE EXAMINATION
PART-A (CLOSED BOOK)

Duration: 1 Hrs. **Max. Marks: 25**

Q1. In a composite bridge the *cube* compressive strength of concrete in the slab is found 35 MPa. Determine the static shear strength of the following shear connectors embedded in the slab.

(i) Stud (Diameter 18 mm and height 80 mm),

(ii) Channel ISMC 125 (Flange width 65 mm, Depth = 125 mm) of length 200 mm

[5]

Q2. An elastomeric pad bearing has overall dimensions 225 mm x 420 mm. (a) Determine the range of vertical load reactions for which this bearing pad may be used, (b) if the thickness of internal elastomer layers is 12 mm, check the suitability of the bearing for lateral bulging.

[5]

Q3. Derive an expression for determining the economic span of bridges. Mention the steps involved in evaluating the economical span for a proposed bridge.

[5]

Q4. What do you understand by 'Fixed bearing' and 'Free bearing'? How many fixed and free bearings will be needed in a three-span continuous bridge? Can an elastomeric pad bearing may be used at the 'Fixed bearing' location, justify your answer?

[5]

Q5. Read the following statements and mention whether they are True or False? Justify your answer.

(a) High-strength steel Channel-type shear connectors perform better than mild-steel study-type shear connectors.

(b) The heads on stud-type shear connectors are provided to improve the horizontal shear resistance of the shear connectors.

(c) For a simply supported 'shear span' is taken equal to the effective span of the composite bridge.

(d) For a composite bridge if the spacing of shear connectors is to be considered variable along the span to make the design economical, then the spacing of shear connectors near support is kept small compared to that near mid-span.

(e) A composite bridge designed for the ultimate loads may be considered safe at the service load stage also.

[5]

Static Strength of Shear Connectors

1. Stud Connectors

The design resistance, Q_u of stud shears connectors shall be as given below:

$$Q_u = \frac{0.8 f_u \pi d2/4}{\gamma_v} \leq \frac{0.29 \alpha d^2 \sqrt{f_{ck(cy)} E_{cm}}}{\gamma_v} \qquad \text{... 6.1}$$

where,

$$\alpha = 0.2\left\{\frac{h_s}{d} + 1\right\} \text{ for } 3 < \frac{h_s}{d} < 4 \quad \text{and} \quad \alpha = 1.0 \text{ for } \frac{h_s}{d} \geq 4$$

Q_u = design strength of stud in newton (N)

γ_v = partial safety factor for stud connector = 1.25

d = diameter of the shank of the stud in millimeters (mm)

f_u = ultimate tensile strength of the stud material $\leq$ 500 N/mm²

$f_{ck(cy)}$ = Characteristic cylindrical compressive strength of concrete = 0.8 f_{ck}

h_s = nominal height of stud in millimeters (mm)

E_{cm} = Secant modulus of elasticity of concrete (Refer: **Table–III.1** of **Annexure-III)**

2. Channel Connectors

Assuming that the web of the channel is vertical with the shear applied nominally perpendicular to the web, the design resistance of a channel connector shall be determined as given below:

$$Q_n = \left[20b.(h)^{3/4}.(f_{ck(cy)})^{1/3}\right] / \gamma_v \qquad \text{... 6.2}$$

where,

Q_u = design strength of channel in newton (N)

b = length of the channel in millimeters (mm)

h = height of the channel in millimeters (mm)

While using channel shear connectors the following recommendation need to be followed.

1. The height h of the channel should not exceed 20 times web thickness or 150 mm whichever is less.
2. The width b of the channel should not exceed 300 mm.
3. The underside of the top flange of the channel should not be less than 30 mm clear above the bottom reinforcement.
4. The leg length of the weld connecting the channel to the plate should not exceed half the plate thickness.

Table - III - 1: Properties of Concrete

Strength Class of Concrete																
Strength Class	**M 15**	**M 20**	**M 25**	**M 30**	**M 35**	**M 40**	**M 45**	**M 50**	**M 55**	**M 60**	**M 65**	**M 70**	**M 75**	**M 80**	**M 85**	**M 90**
$(f_{ck})_{cu}$ (MPa)	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
$(f_{ck})_{cy}$ (MPa)	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72
f_{cm} (MPa)	1.6	1.9	2.2	2.5	2.8	3.0	3.3	3.5	3.7	4.0	4.4	4.5	4.7	4.8	4.9	5.0
E_{cm} (GPa)	27	29	30	31	32	33	34	35	36	37	38	38	39	40	40	41

Note:-

$(f_{ck})_{cu}$ ---- characteristic compressive (cube) strength of concrete

$(f_{ck})_{cy}$ ---- characteristic compressive (cylinder) strength of concrete, given by 0.8 times 28 days cube crushing strength of concrete

f_{cm} ---- mean tensile strength of concrete

E_{cm} ---- Secant Modulus of elasticity of concrete.

The values of E_{cm} given above are for quartzite/granite aggregates. They should be multiplied by the following factors as given below: Limestone = 0.9; Sandstone = 0.7; Basalt = 1.2

The values have been taken from Table - 6.5 of IRC:112-2011

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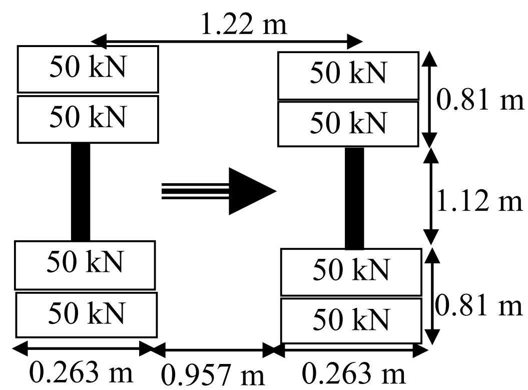
COMPREHENSIVE EXAMINATION
PART-B (OPEN BOOK)

Duration: 2 Hrs. **Max. Marks: 50**

Q1. An 8 m wide and 5.0 m span simply supported slab culvert is to be designed for IRC Class 70R bogie loading (total wt. 400 kN as shown in Figure). (a) treating the wheel loads as concentrated loads, determine the longitudinal position of vehicle for producing the absolute maximum moment in the bridge (b) placing the vehicle at the location determined in part (a), and considering the appropriate dispersions of loads, determine the magnitude of maximum live load moment in the slab culvert. Thickness of slab is 360 mm and thickness of wearing coat is 56 mm.



[15]

Q2. A square slab bridge has Effective span = overall width = 8.24 m. The thickness of the slab is 500 mm and the thickness of wearing coat may be ignored. The width of the kerb is 440 mm. Treating the wheel loads of IRC Class 70R tracked/ wheeled vehicle as *concentrated* loads and using the *Morrice-Little method* :

(i) Determine the absolute Maximum longitudinal moment along the central line of bridge due to IRC Class 70R *wheeled* vehicle and compare the magnitude moment with that calculated using simple hand calculation, and

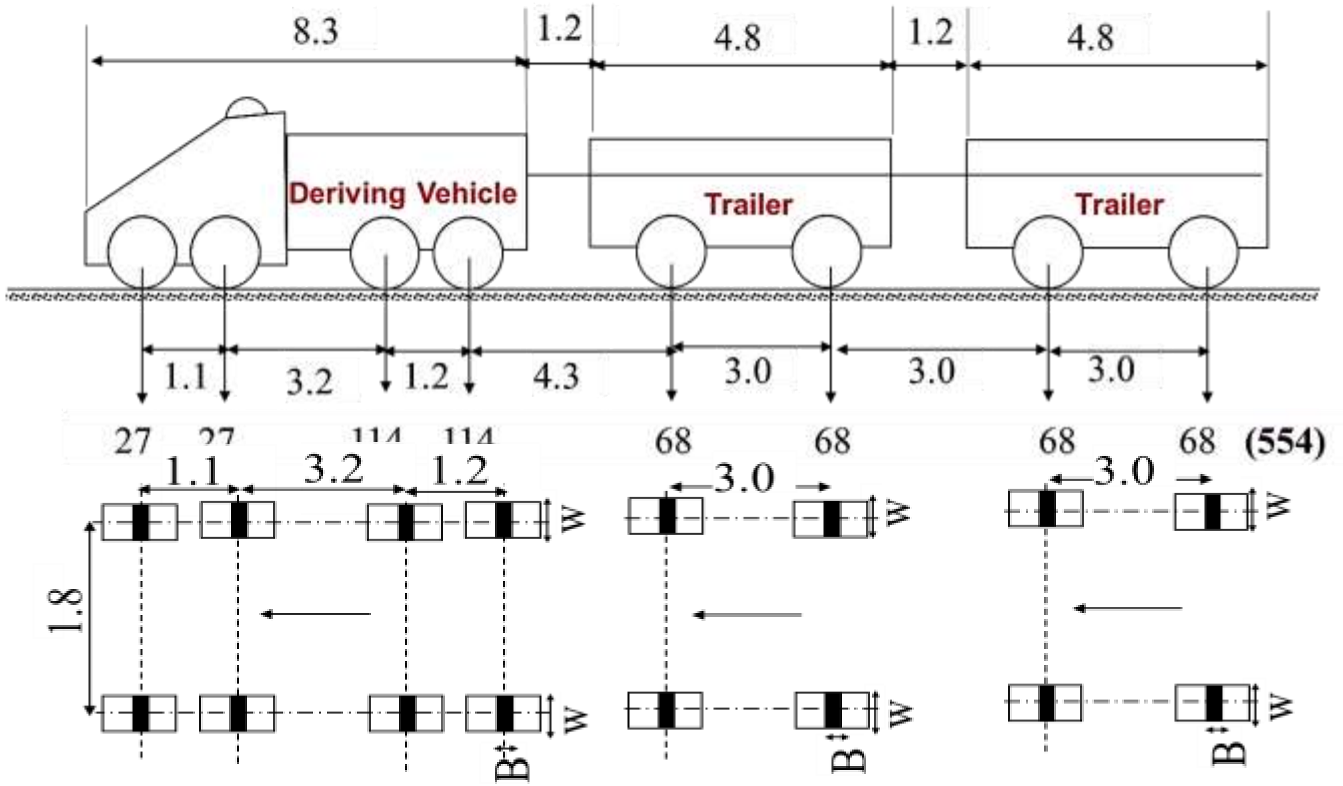
(ii) Calculate the maximum Transverse moment in the bridge at mid-span section due to IRC Class 70R *Tracked* vehicle.

[20]

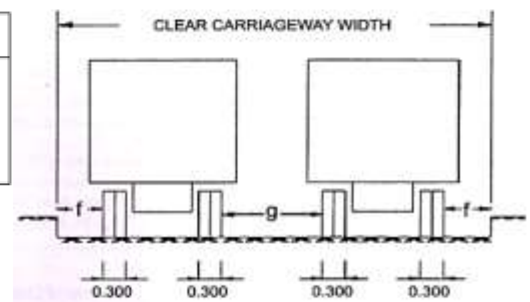
Q3. Considering appropriate dispersion of live load, determine the design moment in the cantilever slab of a 16 m span T-beam bridge to be designed for a national highway. The overall width of the bridge is 7.8 m and there are three longitudinal girders which are symmetrically provided at c/c spacing of 2.6 m. The width and thickness of kerbs on each side are 300 mm and 200 mm respectively. There are five transverse girders, one girder at each support and remaining three are provided at equal spacing. The thickness of the cantilever slab at the face of the longitudinal girder is 300 mm at it reduces linearly to 100 mm at the free end. The thickness of wearing coat is 56 mm. The dead load of railing on each side may be considered as 2.0 kN/m span.

[15]

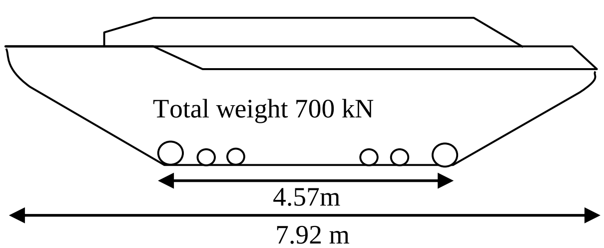
IRC Class-A Loading

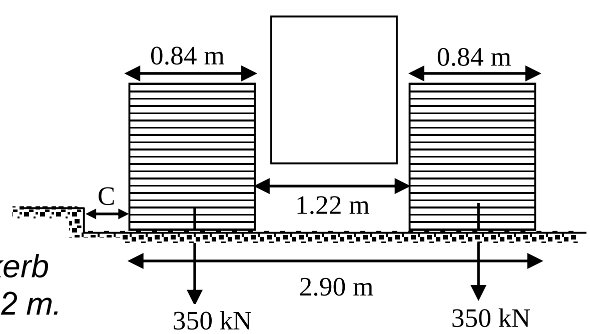


Clear Carriage Width	g	f
5.3 m (*) to 6.1 m (**)	Varying between 0.4 m to 1.2 m	150 mm for all carriage way widths
Above 6.1 m	1.2 m	

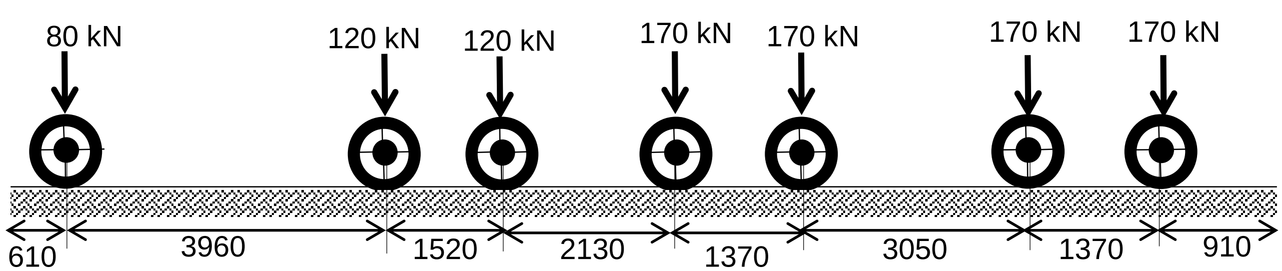


IRC Class 70-R Loadings





The minimum clearance between the road face of the kerb and the outer edge of the wheel or track, 'C, shall be 1.2 m.



Axel Loads for IRC Class 70 Wheeled Vehicle