DESIGN PRINCIPLES OF BRIDGES

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BRIDGE DEFINITION

A BRIDGE IS A STRUCTURE THAT IS BUILT OVER A CANAL, DRAIN, RIVER, VALLEY, ROAD, RAILWAY/RAIL ROAD TRAFFIC ETC SO THAT PEOPLE OR VEHICLES CAN CROSS FROM ONE SIDE TO THE OTHER SIDE.
CLASSIFICATION OF BRIDGES:

Bridges can be classified from various considerations, such as:

A. Carriage way of the bridge
B. Span of the bridge
C. Load carrying capacity of the bridge
D. Material of construction of the bridge
E. Span arrangement of the bridge
F. Structural arrangement of the bridge
## A. CARRIAGE WAY WIDTHS

<table>
<thead>
<tr>
<th>TYPE OF BRIDGE</th>
<th>CARRIAGE WAY</th>
<th>TYPE OF ROADS</th>
</tr>
</thead>
<tbody>
<tr>
<td>FOOT BRIDGE</td>
<td>1.50 M</td>
<td>PEDESTRAINS &amp; ANIMALS</td>
</tr>
<tr>
<td>SINGLE LANE ROAD BRIDGE</td>
<td>4.25 M</td>
<td>CART TRACKS VILLAGE ROADS</td>
</tr>
<tr>
<td>DOUBLE LANE ROAD BRIDGE</td>
<td>7.50 M</td>
<td>ZP ROADS MAJOR DISTRICT ROADS</td>
</tr>
<tr>
<td>DOUBLE LANE ROAD BRIDGE</td>
<td>10.90 M</td>
<td>NATIONAL HIGHWAYS STATE HIGHWAYS</td>
</tr>
</tbody>
</table>
B. Span of the bridge

1) Minor bridge ( < 30 m )
2) Major bridge ( > 30m )
3) Long span bridge (> 120 m )

C. Load carrying capacity of the bridge

1) Class B bridge
2) Class A bridge
3) Class AA bridge
4) 70R bridge
D. Material of construction of the bridge

1) Timber bridge
2) Masonry bridge
3) Reinforced concrete bridge
4) Prestressed concrete bridge
5) Steel bridge
6) Composite bridge
E. Span arrangement of the bridge

1) Simply supported bridge
2) Continuous bridge
3) Cantilever bridge
4) Balanced cantilever bridge
F. STRUCTURAL ARRANGEMENT OF THE BRIDGE

- SLAB BRIDGE
- SLAB AND GIRDER BRIDGE
- BOX CELL BRIDGE
- HOLLOW BOX GIRDER BRIDGE
- PORTAL FRAME BRIDGE
- ARCH BRIDGE
- PLATE GIRDER BRIDGE
- BOX GIRDER BRIDGE
- TRUSSED GIRDER BRIDGE
- CABLE STAYED BRIDGE
- SUSPENSION BRIDGE
VERTICAL CLEARENCES
(CI 106.2.1 0F IRC: 5-1998)

<table>
<thead>
<tr>
<th>DISCHARGE IN CUMECS</th>
<th>MIN. VERTICAL CLEARENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>UPTO 0.30</td>
<td>150 MM</td>
</tr>
<tr>
<td>&gt; 0.30 AND &lt; 3.00</td>
<td>450 MM</td>
</tr>
<tr>
<td>&gt; 3.00 AND &lt; 30</td>
<td>600 MM</td>
</tr>
<tr>
<td>&gt; 30 AND &lt; 300</td>
<td>900 MM</td>
</tr>
<tr>
<td>&gt; 300 AND &lt; 3000</td>
<td>1200 MM</td>
</tr>
<tr>
<td>&gt; 3000</td>
<td>1500 MM</td>
</tr>
</tbody>
</table>
NORMAL SCOUR DEPTH  =  \( d_{sm} = 1.34 \left( \frac{q^2}{f} \right)^{1/3} \)

where  
\[ f = \text{silt factor} = 1.76 \ (m)^{1/2} \]
\[ m = \text{weighted mean diameter in mm} \]

MAXIMUM DEPTH OF SCOUR

Near Piers  = 2.00 \( d_{sm} \)
Near Abutments  = 1.27 \( d_{sm} \) (when approaches retained )  
= 2.00 \( d_{sm} \) (when scouring allround )

For Rafts/ shallow footings  = 1.27 \( d_{sm} \) (In straight reach )  
= 1.50 \( d_{sm} \) (At moderate bend )  
= 1.75 \( d_{sm} \) (At severe bend)  
= 2.00 \( d_{sm} \) (At right angled bend)
Open Foundations as per cl. 705.2 IRC:78-2000

- **In soil**
  The minimum depth of open foundations shall be up to stratum having safe bearing capacity but not less than 2.0 m below the scour level or the protected bed level.

- **On rocks**
  (a) For hard rocks, with an ultimate crushing strength of 1.0 MPa or above arrived at after considering the overall characteristics of the rock, such as, fissures, bedding planes, etc. : 0.6 m
  (b) All other cases : 1.5 m
AFFLUX

Afflux is the rise/heading up of water over the normal water level on u/s of a bridge caused by constriction of water way at the bridge site.

Afflux as per Molesworth formula:

\[ h = \left\{ \frac{(V^2)}{17.85} \right\} + 0.015 \left\{ \frac{(A^2)}{a^2} - 1 \right\} \]

Where

\[ V = \text{Average velocity prior to obstruction in m/sec} \]

\[ A = \text{Un obstructed sectional area of canal/drain in Sq.m} \]

\[ a = \text{Sectional area of canal/drain at obstruction in Sq.m} \]
CLASSIFICATION OF IRC LOADING

(Ch. 207.1 of IRC: 6-2000)

IRC class ‘AA’
loading
1) Tracked vehicle of 70 t
2) Wheeled vehicle of 40 t
   1) On National Highways
   2) On State Highways
   3) On Major District Roads

IRC class ‘A’
loading
1) On other District roads
2) Village roads
3) Cart tracks on main canal

IRC class ‘B’
loading
on Temporary structures like Timber bridges

MAIN COMPONENTS OF BRIDGE STRUCTURE

1. Super structure
2. Substructure
3. Foundation
4. Protective works
SUPER STRUCTURE


SUB STRUCTURE


BRIDGE FOUNDATIONS

1. SHALLOW FOUNDATIONS
   - Isolated, combined
   - Raft foundation
   - Strip foundations

2. DEEP FOUNDATIONS
   - WELL FOUNDATIONS
     - Open sinking
     - Pneumatic sinking
   - PILE FOUNDATIONS
     - Pre-cast driven piles
     - Driven cast-in-situ piles
     - Boxed cast-in-situ piles
     - Boxed precast piles
     - Driven steel piles

PROTECTIVE WORKS

(INC: 89-1985)

## LIMITATIONS OF SPAN LENGTH

(As per general practice based on experience)

<table>
<thead>
<tr>
<th>Type of bridge</th>
<th>Span in mts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simply supported RCC slab</td>
<td>3 – 10</td>
</tr>
<tr>
<td>Simply supported RCC girder</td>
<td>10 – 24</td>
</tr>
<tr>
<td>RCC box girder</td>
<td></td>
</tr>
<tr>
<td>RCC balanced cantilever</td>
<td>25 – 40</td>
</tr>
<tr>
<td>Prestressed concrete girder</td>
<td></td>
</tr>
<tr>
<td>Prestressed concrete box girder</td>
<td>35 – 75</td>
</tr>
<tr>
<td>Prestressed concrete cantilever</td>
<td>75 – 150</td>
</tr>
<tr>
<td>Cable stayed bridge</td>
<td>100 – 800</td>
</tr>
<tr>
<td>Suspension bridge</td>
<td>300 - 1500</td>
</tr>
</tbody>
</table>
Loads, Forces and Stresses to be considered in the design

- 1. Dead Load
- 2. Live Load
- 3. Impact of Live load
- 4. Water currents
- 5. Longitudinal forces:
  - a. Tractive or Braking force
  - b. frictional resistance to bearings
- 6. Centrifugal forces
- 7. Buoyancy
- 8. Earth pressure incl. Live load surcharge
- 9. Temperature effects
- 10. Deformation effects
- 11. Secondary effects
- 12. Wind loads
- 13. Wave pressures
- 14. Impact due to floating bodies
- 15. Errection effects
- 16. Sesmic forces
DEAD LOAD

DEAD LOAD CONSISTS OF LOADS OF ALL COMPONENTS OF SUPER STRUCTURE:

- DECK SLAB AND GIRDERS
- FOOT PATHS
- WEARING COAT
- KERB
- HAND RAILING
LIVE LOAD

ALL BRIDGES SHALL BE DESIGNED AS PER THE FOLLOWING INDIAN ROAD CONGRESS LOADINGS:

<table>
<thead>
<tr>
<th>Carriageway width</th>
<th>Number of Lanes for Design purposes</th>
<th>Load combination</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Less than 5.3m</td>
<td>1</td>
<td>One lane of Class A considered to occupy 2.3m. The remaining width of carriageway shall be loaded with 500 Kg/m²</td>
</tr>
<tr>
<td>2. 5.3m and above but less than 9.6m</td>
<td>2</td>
<td>One lane of Class 70R OR two lanes of Class A</td>
</tr>
<tr>
<td>3. 9.6m and above but less than 13.1m</td>
<td>3</td>
<td>One lane of Class 70R with one lane of Class A OR 3 lanes of Class A</td>
</tr>
<tr>
<td>4. 13.1m and above but less than 16.6m</td>
<td>4</td>
<td>One lane of Class 70R for every two lanes with one lane of Class A for the remaining lanes, if any, or one lane of Class A for each lane</td>
</tr>
<tr>
<td>5. 16.6m and above but less than 20.1m</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>6. 20.1 m and above but less than 23.6m</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>
IRC CLASS A

Class A train of vehicles

Notes:
1. The nose to tail distance between successive trains shall not be less than 18.4 m.
2. No other live load shall cover any part of the carriageway when a train of vehicles (or trains of vehicles in multi-lane bridge) is crossing the bridge.
3. The ground contact area of the wheels shall be as under:

<table>
<thead>
<tr>
<th>Axle load (tonne)</th>
<th>Ground contact area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B mm</td>
</tr>
<tr>
<td>11.4</td>
<td>250</td>
</tr>
<tr>
<td>6.8</td>
<td>200</td>
</tr>
<tr>
<td>2.7</td>
<td>150</td>
</tr>
</tbody>
</table>

4. The minimum clearance, $f$, between outer edge of the wheel and the roadway face of the kerb, and the minimum clearance, $g$, between the outer edges of passing or crossing vehicles on multi-lane bridges shall be as given below:

<table>
<thead>
<tr>
<th>Clear carriageway width</th>
<th>$g$</th>
<th>$f$</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.5 m to 7.5 m</td>
<td>150 mm for all carriageway widths</td>
<td></td>
</tr>
<tr>
<td>Above 7.5 m</td>
<td>Uniformly increasing from 0.4 m to 1.2 m</td>
<td></td>
</tr>
</tbody>
</table>

5. Axle loads in tonne linear dimensions in metre.
## IRC 70 R LOADING

### TRACKED VEHICLES

<table>
<thead>
<tr>
<th>Class</th>
<th>Width of track</th>
<th>Width over track</th>
<th>Four wheelers</th>
<th>Max. single axle load</th>
<th>Six wheelers</th>
<th>Max. single axle load</th>
<th>Max. bogie load</th>
</tr>
</thead>
<tbody>
<tr>
<td>70R</td>
<td>840</td>
<td>2900</td>
<td>100 t</td>
<td>3000</td>
<td>20 t</td>
<td>40 t</td>
<td></td>
</tr>
</tbody>
</table>

Nose to tail Length 7920

### WHEELED VEHICLES

<table>
<thead>
<tr>
<th>Axle wheelers</th>
<th>Max. single axle load</th>
<th>Max. bogie load</th>
<th>Minimum wheel spacing and tyre sizes of critical (Heaviest) axles</th>
<th>Max. tyre load on min. tyre size</th>
<th>Max. tyre pressure</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20 t</td>
<td>40 t</td>
<td></td>
<td></td>
<td>5.273 kg/cm²</td>
<td>Actual max. tyre load 5.0 t on 410x610</td>
</tr>
</tbody>
</table>
**IMPACT**

Impact allowance is a percentage of the applied live load and is for the dynamic action of live load as listed in table.

<table>
<thead>
<tr>
<th>Type of bridge</th>
<th>Class A and Class B loading</th>
<th>Class AA and 70 R loading</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>For spans 3.0 to 45 m</td>
<td>For Spans less 9.0m</td>
</tr>
<tr>
<td></td>
<td>Tracked vehicle</td>
<td>Wheeled vehicle</td>
</tr>
<tr>
<td>RCC concrete bridges</td>
<td>4.5/ (6+span length)</td>
<td>25% upto 5m reducing linearly to 10% for 9m</td>
</tr>
<tr>
<td>Steel bridges</td>
<td>9/ (13.5+ span length)</td>
<td>10% for all spans</td>
</tr>
</tbody>
</table>
For spans ≥ 9 m:

a) R.C. bridges:
   i) Tracked: 10% up to 40 m span & as per curve in Fig: for spans > 40 m.
   ii) Wheeled: 25% up to 12 m span &

(b) Steel bridges:
   i) Tracked: 10% for all spans.
   ii) Wheeled: 25% up to 23 m span & as per curve in Fig: for spans > 23 m.

For design of piers & abutments below bed block, the impact of the following proportions shall be allowed:

i) Pressure on bearings & top of bed block: Full value
ii) Bottom of bed block: Half value
iii) From bottom of bed block up to 3 m below: Half to zero decreasing uniformly.
iv) 3 m below bottom of bed block: zero

4. Wind load: Act horizontally on any exposed portion of the bridge structure.

a) For deck structure: Area of structure seen in elevation including the floor system & railing less area of perforation in handrails/parapet
WIND LOAD

WIND PRESSURE & VELOCITY (Cl. 212.3 of IRC: 6-2000)

<table>
<thead>
<tr>
<th>H</th>
<th>V</th>
<th>P</th>
<th>H</th>
<th>P</th>
<th>V</th>
<th>H</th>
<th>P</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>80</td>
<td>40</td>
<td>15</td>
<td>128</td>
<td>107</td>
<td>60</td>
<td>168</td>
<td>183</td>
</tr>
<tr>
<td>2</td>
<td>91</td>
<td>52</td>
<td>20</td>
<td>136</td>
<td>119</td>
<td>70</td>
<td>173</td>
<td>193</td>
</tr>
<tr>
<td>4</td>
<td>100</td>
<td>63</td>
<td>25</td>
<td>142</td>
<td>130</td>
<td>80</td>
<td>177</td>
<td>202</td>
</tr>
<tr>
<td>6</td>
<td>107</td>
<td>73</td>
<td>30</td>
<td>147</td>
<td>141</td>
<td>90</td>
<td>180</td>
<td>210</td>
</tr>
<tr>
<td>8</td>
<td>113</td>
<td>82</td>
<td>40</td>
<td>155</td>
<td>157</td>
<td>100</td>
<td>183</td>
<td>217</td>
</tr>
<tr>
<td>10</td>
<td>118</td>
<td>91</td>
<td>50</td>
<td>162</td>
<td>171</td>
<td>110</td>
<td>186</td>
<td>224</td>
</tr>
</tbody>
</table>

Where H = Ave. height in m of the exposed surface above
       Ground level/ bed level/ water level
V = horizontal velocity of wind at height H in Km/ hr
P = horizontal wind pressure at height H in Kg/ m²
Lateral wind force against moving live load:

- Ordinary bridges \( \ldots 300 \, \text{kg/linear m} \) \{ acting at 1.5m above the roadway. \}
- Bridges carrying tramway \( \ldots 450 \, \text{kg/linear m} \)

The total assumed wind force \( \leq 450 \, \text{kg/linear m} \) in the plane of loaded chord.

- \( 225 \, \text{kg/linear m} \) in the plane of unloaded chord
- \( 450 \, \text{kg/linear m} \) on deck spans.

5. Horizontal forces due to water currents (cl 213 of IRC:6-2000)

Intensity of wind pressure on piers

//cl 213 to direction of water current \( P = 52 \, \text{K.V}^2 \)

Where \( V = \) velocity of current at the point under consideration in \( \text{m/sec} \).

\( K = \) a constant having values for different shapes of pier illustrated in Fig. (cl 213.2 & Fig 7 of IRC:6-2000)
<table>
<thead>
<tr>
<th>Shape of Bridge Pier</th>
<th>Description</th>
<th>Value of $K$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Square ends</strong></td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td><strong>Circular/semi-circle</strong></td>
<td>0.66</td>
</tr>
<tr>
<td>$&gt;30^\circ$</td>
<td><strong>Triangular, $\leq 30^\circ$</strong></td>
<td>0.50</td>
</tr>
<tr>
<td>$&gt;60^\circ$</td>
<td><strong>Triangular, $&gt; 60^\circ$, $\leq 90^\circ$</strong></td>
<td>0.7 to 0.9</td>
</tr>
<tr>
<td>$&gt;90^\circ$</td>
<td><strong>Equilateral arcs</strong></td>
<td>0.45</td>
</tr>
<tr>
<td></td>
<td><strong>Arcs intersecting @ 90^\circ</strong></td>
<td>0.50</td>
</tr>
</tbody>
</table>

*Fig. 7
IRC:6-2000
cl: 213.2
6. **LONGITUDINAL FORCES**: Due to tractive or braking effect & frictional resistance offered by bearing.

- **Horizontal force due to braking** = act @ 1.2 m above roadway, along roadway.

- **For s. s. spans, up to 10 m where no bearings (except bitumen layer),**
  
  \[ \text{Hor. force @ bearing level} = \frac{F_h}{2} \text{ or } \mu R_g \]  
  
  where \( F_h \) = applied hor. force.

  \( \mu = \text{Coe. of friction as given in Table} \)

  \( R_g = \text{Reaction due to Dead load} \)

- **Longitudinal force at any free bearing** (sliding or roller) for a s. s. bridge

  \[ \{ \} = \mu R \]

  where \( R = \text{Sum of Dead & live load reaction} \)
• The magnitude of braking effect: (Cl 21A.2 of IRC: 6-2000)
  a) For single/two lane bridge: (i) 20% for 1st train of vehicle +
     10% for succeeding trains.
     (ii) 20% of the load actually on the span
          where the entire 1st train is not on span.
  b) For > Two lane bridges: value given in (a) above for Two lanes +
     5% of the loads on the lanes in excess of 2.

   Due to buoyancy, a reduction is made in gross weight of member.
   a) In shallow pier/abutment pier
      founded at/near bed level
      \{ reduction equal to displaced water \}
   b) In deep foundations which displaces
      water & soil
      \{ reduction as made up of 2 factors
      (i) Wt of volume of water displaced
      (ii) Upward pressure
           due to submerged
           Wt of soil \}
Some design aspects of super & sub structures:

Super Structure:

Deck Slab: Designed as one way slab to carry dead load & prescribed live load with impact.

For S.L. Bridges: The max BM & SF due to live load of IRC class 'A' loading for the critical position of loading.

For D.L. Bridges: Worst effect of one lane of IRC class 'AA' t.v. or one lane of class 'AA' wheeled loading or two lanes of class 'A' load trains.

• Checked for max B.M; shear & bond.
SLAB & GIRDER BRIDGES:

- For D-L Bridge, three beams deck is found economical in general.
- The girder spacings in such cases are usually bet 2.25 to 2.75m.
- To distribute loads bet main girders.
- Cross beams to offer resistance to torsion of main girder.
- To stiffen the girders laterally.
- For proper functioning, at least 2 cross beams @ 2 ends + 1 @ centre are essential.

- A spacing of about 4.5 to 6.0m is generally found satisfactory for cross beams.
- In two-way slab, the live load moments due to a concentrated or locally distributed load may be worked out by 'Pigcaud's Method'.

- For T beam SL bridges: IRC class 'A' loading.
- DL Bridges: IRC class 'AA' kN/m² or W.V.
- Checked for max BM, shear & bond.
- Estimation of load distribution by Courbon's theory or Morice & Little's theory.
SUB-STRUCTURE:

PIERS


LOADS & FORCES for Piers:
1) Self wt.  2) D.L. from adjacent spans & live load reactions either from one or both spans.  3) Buoyancy  4) Long-force due to braking effect  5) L.F. due to frictional resistance @ bearings  6) HF due to water currents acting @ C.G. of water pressure diagram  7) HF due to wind acting on moving loads, superstructure & pier @ the C.G.  8) CF (when the bridge is on a curve)  9) HF due to seismic effect/wave action etc. if applicable.

The loads & moments on A/C of above forces (which are applicable) are calculated @ bottom of pier & bottom of foundation concrete.
Stress $p = \frac{P}{A} \pm \frac{M_{xx}}{Z_{xx}} \pm \frac{M_{yy}}{Z_{yy}}$

where $P$ = stress in masonry/concrete or on soil.

$A$ = Area of section @ base of pier/f.c. base

(considering equivalent length of cut & ease waters).

$M_{xx}/M_{yy}$ = Moment in roadway/canal flow directions.

$Z_{xx}/Z_{yy}$ = Modulus of section of pier

NO TENSION IS ALLOWED ON FOUNDATION SOIL.

Some tension in pier masonry/concrete is being allowed in some projects.

PIERS WITH CUT & EASE WATERS: To ensure ease, smooth & streamline flow:

Equilateral Arches/Semi circular arc mostly in use.

ABUTMENTS

1. Brick masonry
2. Stone Masonry
3. Mass concrete
4. R.C.C.

- Length of Abutment = Normally equal to the formation width of Road or more.
**Loads & Forces: for Abutments**

1) Self wt of Abutment including wt of back fill
2) DL & LL from S.S.
3) LF due to braking effect
4) LF due to frictional force
5) Active earth pressure from earth fill including L.L. Surchage
6) C.F & seismic force if applicable

- For computing earth pressure, T V A Procedure is in practice treating the rear face as stepped back.
- Approach slab is invariably provided if embankment ht is > 3m.
- Where the canal slopes cut the formation line beyond Abutments, short wings/returns are required to retain the earth.
OTHER PROVISIONS:

BED BLOCKS: R.C.C. in M 15 grade to distribute the load evenly.

BEARINGS: In practice no bearings are provided upto 8m deep slab except kraft paper after rendering the top of bearing surface smooth asphaltic.

EXPANSION JOINTS: 12mm Exp. Joints filled with mastic filler.

WEARING COAT: Asphaltic concrete w/c or R.C. Wearing coat 50 - 110 - 50mm

50 - 100 - 50mm.

• To protect slab from the damage by moving vehicles or by rain water.

DRAINAGE SPOUTS: 100 ø @ centre of each span on both sides.

To serve as outlet for rain water; Spacing > 10m.

HAND RAILING & ORNAMENTAL PILASTERS: For protection of Traffic.

Ht 4 (1.1m - ½ hor. width of top rail) (cf. 115.12 of IRC: 5-1998).

Ornamental pilasters in masonry - supported on rear face of Abutment.

APPROACHES & BRIDGES:

1. Min. Straight length - 15m. With Hamlet.

2. 1 in 30 HAMP.

3. Guide stones / Guard stones (20 x 15 x 12 cm)

© 3m c/c h/r. of embankment to > 3.8m.
NOTES AND SPECIFICATIONS

1. All the dimensions are in millimetres and the levels are in metres.

2. The single lane road bridge is designed for a carriage way width of 4.25 m and for one lane of IRC Class 'A' loading.

3. The approach slab shall be designed as per IRC: 6-2000 as per IS:383

REFERENCE DRAWINGS:

1. DISCHARGE DESIGNED VALUE OF SOIL NOT LESS THAN 28°.

APPROACHES SHALL BE PROPOSED AS PER SITE CONDITIONS.

1/2
1. GENERAL PLAN AND SECTIONAL ELEVATION - SLRB/101/001/2009

SINGLE LANE ROAD BRIDGE

500
10 Ø @ 200 C/C

1000
300

NOTES AND SPECIFICATIONS

1. ALL THE DIMENSIONS ARE IN MILLIMETRES AND LEVELS ARE IN METRES.
2. DO NOT SCALE THE DRAWING. WRITTEN DIMENSIONS ONLY SHALL BE FOLLOWED.
4. MINIMUM COVER TO ALL REINFORCEMENT INCLUDING STIRRUPS SHALL BE 40MM UNLESS OTHERWISE SPECIFIED TO ENSURE PROPER COVER TO REINFORCEMENT.
5. ALL REINFORCEMENT STEEL SHALL BE OF HIGH YIELD STRENGTH DEFORMED BARS (Fe 415) CONFORMING TO IS 1786 - 1985.
6. JOINTS OR LAPPING OF BARS IN MAIN REINFORCEMENT SHALL BE AVOIDED AS FAR AS POSSIBLE. HOWEVER IF LAPS ARE INEVITABLE THE PROVISION IN CLAUSE 304.6.6 OF IRC 21 - 2000 SHALL BE STRICTLY FOLLOWED.
7. BENDING OF REINFORCEMENT BARS SHALL BE AS PER IS -2502. SUPPORTING CHAIRS OF 12 Ø F SHALL BE STRICTLY FOLLOWED.
8. CONCRETE SHALL BE PREPARED IN THE MECHANICAL MIXERS OF CAPACITY NOT LESS THAN 200 LITRES. PROPER COMPACTION OF CONCRETE SHALL BE ENSURED BY USE OF FORM AND NEEDLE VIBRATORS.
9. WEEP HOLES OF 100 MMØ SHALL BE PROVIDED IN THE ABUTMENT AT 1.0 M INTERVAL BOTH VERTICALLY AND HORIZONTALLY AND STAGGERED.
10. 2.5 KG/SQ.M SKIN REINFORCEMENT SHALL BE PROVIDED FOR PIER ON EACH FACE.

GOVERNMENT OF ANDHRA PRADESH
IRRIGATION & CAD DEPARTMENT

REFERENCE DRAWING

M15
2125 500
50
4250
KRAFT PAPER
## Structural Details

**Bed Block:**
- Location: Under Slab, Longitudinal and Cross Girder

**Pier Footing:**
- Location: Under Slab, Longitudinal and Cross Girder

**Leveling Course for Pier:**
- Location: Under Slab, Longitudinal and Cross Girder

**Stress Table:**

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Description of Items</th>
<th>Stress (T/Sq.M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bed Block</td>
<td>Max. 70.870</td>
</tr>
<tr>
<td>2</td>
<td>Pier Footing</td>
<td>Min. -96.70</td>
</tr>
<tr>
<td>3</td>
<td>Pier, FLY WING</td>
<td>Max. 2.180</td>
</tr>
<tr>
<td>4</td>
<td>Approach Slab</td>
<td>-71.300</td>
</tr>
</tbody>
</table>

**Hydraulic Particulars:**

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Description of Items</th>
<th>Discharge Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Canal</td>
<td>0.018</td>
</tr>
<tr>
<td>2</td>
<td>Approach Slab</td>
<td>0.018</td>
</tr>
<tr>
<td>3</td>
<td>Pier, FLY WING</td>
<td>0.018</td>
</tr>
<tr>
<td>4</td>
<td>Approach Slab</td>
<td>0.018</td>
</tr>
</tbody>
</table>

**Reference Drawings:**

- General Plan and Sectional Elevation
- 1/3 SCALE BLUEPRINT OF SLAB, LONGITUDINAL AND CROSS GIRDER
- 1/3 SCALE SECTION OF SLAB, LONGITUDINAL AND CROSS GIRDER

**Notes and Specifications:**

1. All dimensions are given in millimeters and are accurate within 0.5 mm.
2. All structural steel reinforcements are as per IS 456-2000.
3. The single lane road bridge is designed adopting the following IRC and codes:
   - IRC 5-1998
   - IRC 6-2000
   - IRC 21-2000
   - IRC 78-2000
   - IRC 83-2000

4. The bridge is designed following the following IS standards:
   - IS 383

5. The use of RCC and M25 concrete is as per IRC 6-2000 for structural members.

6. The abutment foundation shall be designed for a horizontal load of 1.0 kN/m.

7. The pier foundations shall be designed for a horizontal load of 1.0 kN/m.

8. The pier footings shall be designed for a horizontal load of 1.0 kN/m.

9. The approach slabs shall be designed for a horizontal load of 1.0 kN/m.

10. The cross girders shall be designed for a horizontal load of 1.0 kN/m.
3/3

REFERENCE DRAWINGS

Sl.No | Description | DRAWING NO |
--- | --- | --- |
1 | GENERAL PLAN AND SECTIONS | AS INDICATED |
2 | DETAILS OF BEARINGS AND PEDESTALS | AS INDICATED |

NOTES AND SPECIFICATIONS

1. ALL THE DIMENSIONS ARE IN MILLIMETRES AND LEVELS ARE IN METRES.
2. DO NOT SCALE THE DRAWINGS. WRITTEN DIMENSIONS ONLY SHALL BE FOLLOWED.
4. MINIMUM COVER TO ALL REINFORCEMENT INCLUDING STIRRUPS SHALL BE 40MM UNLESS OTHER WISE SPECIFIED TO ENSURE PROPER OF CONCRETE TO REINFORCEMENT.
5. ALL REINFORCEMENT STEEL SHALL BE OF HIGH YIELD STRENGTH DEFOR MED BARS (Fe 415) CONFORMING TO IS 1786 - 1985.
6. JOINTS OR LAPPING OF BARS IN MAIN REINFORCEMENT SHALL BE AVOIDED AS FAR AS POSSIBLE. HOWEVER IF LAPS ARE INEVITABLE THE PROVISION IN CLAUSE 304.6.6 OF IRC 21 - 2000 SHALL BE STRICTLY FOLLOWED.
7. BENDING OF REINFORCEMENT BARS SHALL BE AS PER IS -2502. SUPPORTING CHAIRS OF 12 Ø  SHALL BE STRICTLY FOLLOWED.
8. CONCRETE SHALL BE PREPARED IN THE MECHANICAL MIXERS OF CAPACITY NOT LESS THAN 200 LITRES. PROPER COMPACTION OF CONCRETE SHALL BE ENSURED BY USE OF FORM AND NEEDLE VIBRATORS.
NOTES AND SPECIFICATIONS

1. All the dimensions are in millimetres and levels are in metres.

2. Do not scale the drawings. Written dimensions only shall be followed.

3. The design is according to the following bridge and S. codes:
   1) IRC 5 - 1998
   2) IRC 6 - 2000
   3) IRC 21 - 2000
   4) IS 456 - 2000.

4. Minimum cover to all reinforcement including stirrups shall be 40 mm unless otherwise specified to ensure proper cover to reinforcement.

5. All reinforcement steel shall be of high yield strength deformed bars (Fe 415) conforming to IS 1786 - 1985.

6. Bending of reinforcement bars shall be as per IS - 2502. Supporting chairs of 120 mm shall be provided in the pier/abutment at 1.0 m interval both vertically and horizontally and staggered.

7. Support of abutment shall be provided in the abutment.

8. Weep holes of 75 mmØ shall be provided in the abutment at 1.0 m interval both vertically and horizontally and staggered.

9. Proper compaction of concrete shall be ensured by use of form and needle vibrators.

IF LAPS ARE INEVITABLE THE PROVISION IN CLAUSE 304.6.6 OF IRC 21 - 2000 SHALL BE STRICTLY FOLLOWED.
GENERAL PLAN AND SECTIONAL ELEVATION

AS INDICATED

BOX CULVERT

GOVERNMENT OF ANDHRA PRADESH
IRRIGATION & CAD DEPARTMENT

HYDRAULIC PARTICULARS OF DRAIN:
1. ALL THE DIMENSIONS ARE IN MILLIMETRES AND THE LEVELS ARE IN METRES.
2. DO NOT SCALE THE DRAWING. ONLY FIGURED DIMENSIONS SHALL BE FOLLOWED.
3. THE CULVERT IS DESIGNED ADOPTING THE FOLLOWING IRC AND IS CODES.
   i. IRC - 5 - 1998
   ii. IRC - 6 - 2000
   iii. IRC - 21 - 2000
   iv. IRC - 78 - 2000
   v. IS 456 - 2000
   vi. IS 383 - 1999
   vii. IS 3370 (Part-I) & (Part-II).
4. 15.0 M STRAIGHT APPROACH SHALL BE PROVIDED ON EITHER SIDE OF THE STRUCTURE.
5. 300 THICK SIDE REVETMENT SHALL BE PROVIDED UPTO MFL Touches THE GROUND LEVEL ON EITHER SIDE OF THE STRUCTURE.
6. 15 MM THICK EXPANSION JOINT WITH 300 WIDE PVC WATER STOP SHALL BE PROVIDED AS SHOWN IN THE DRAWING.
7. ALL ROUND CUT-OFF BELOW THE BOX SHALL BE PROVIDED AS SHOWN IN THE DRAWING.
8. THE SPECIFICATIONS PROPOSED FOR THE VARIOUS COMPONENTS OF THE STRUCTURE ARE AS FOLLOWS:

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>DESCRIPTION</th>
<th>GRADE OF CONCRETE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>HEAD WALL</td>
<td>CC M15</td>
</tr>
<tr>
<td>2</td>
<td>BOX</td>
<td>RCC M20</td>
</tr>
<tr>
<td>3</td>
<td>20 MM</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>CUT-OFF</td>
<td>CC M15 40 MM</td>
</tr>
<tr>
<td>5</td>
<td>WEARING COAT IN THE BOX</td>
<td>CC M25 20 MM</td>
</tr>
</tbody>
</table>

NOTES AND SPECIFICATIONS

<table>
<thead>
<tr>
<th>NO. OF VENTS</th>
<th>SIDE OF VENT</th>
<th>DISCHARGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.50 M X 2.40 M</td>
<td>8.150 CUMECS</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>0.3125 SQ. KM.</td>
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</table>

REFERENCE DRAWINGS

<table>
<thead>
<tr>
<th>DRAWING NO</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>R.C.C. DETAILS OF BOX &amp; SECTIONS 1</td>
<td></td>
</tr>
</tbody>
</table>

SIDE SLOPE 2:1
SIDE SLOPE 1.5:1
SIDE SLOPE 1.5:1
SIDE SLOPE 1.5:1

GL +238.120
DBL +238.120
DRAIN FLOW
ASIFABAD
UTNOOR

<table>
<thead>
<tr>
<th>QUANTITY &amp; UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>10900</td>
</tr>
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</table>

1000 | | 2000 | | 3000 | | 4000 | | 5000 | | 6000 | | 7000 | | 8000 |

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>75 TH. WEARING COAT</td>
</tr>
<tr>
<td>IN CC M20 GRADE</td>
</tr>
<tr>
<td>5000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>300 TH. LEVELLING COURSE</td>
</tr>
<tr>
<td>IN CC M10 GRADE</td>
</tr>
<tr>
<td>2500</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>40 TH. SEALING COAT</td>
</tr>
<tr>
<td>IN CC M25 GRADE</td>
</tr>
<tr>
<td>1000</td>
</tr>
</tbody>
</table>

DRAIN FLOW
RL +245.000
RL +245.000
RL +245.000
1. DETAILS OF SECTIONS

2. DO NOT SCALE THE DRAWING. ONLY FIGURED DIMENSIONS SHALL BE FOLLOWED.

3. THE DOUBLE LANE ROAD BRIDGE IS ADOPTED FOR A CARRIAGE WAY WIDTH OF 7.50 M WITH OUT FOOT PATHS AS PER M O S T.

4. THE BRIDGE IS DESIGNED ADOPTING THE FOLLOWING IRC AND IS CODES.
   - IRC - 5 - 1998
   - IRC - 6 - 2000
   - IRC - 21 - 2000
   - IRC - 78 - 2000
   - IS 456 - 2000
   - IS 383 - 1999

5. 100 THICK LINING IN C.C. M10 GRADE SHALL BE PROVIDED FOR BED AND SIDES OF THE CANAL FOR A LENGTH OF 10.0 M ON EITHER SIDE OF THE CANAL. THE SECTION NEEDS TO BE REDESIGNED.

6. THE ROAD BRIDGE IS PROPOSED TO CROSS RIGHT ANGLE TO THE CANAL FLOW AND SUITABLE 180° CURVATURE HAS BEEN CONSIDERED IN THE DESIGN (SHOWN IN THE STRESS TABLE), THE SECTION NEEDS TO BE REDESIGNED.

7. IF THE STRATA METWITH AT FOUNDATION LEVEL DURING EXECUTION IS DIFFERENT FROM WHAT HAS BEEN CONSIDERED IN THE DESIGN (SHOWN IN THE STRESS TABLE), THE SECTION NEEDS TO BE REDESIGNED.

8. THE ROAD BRIDGE IS PROPOSED TO CROSS RIGHT ANGLE TO THE CANAL FLOW AND SUITABLE 180° CURVATURE HAS BEEN CONSIDERED IN THE DESIGN (SHOWN IN THE STRESS TABLE), THE SECTION NEEDS TO BE REDESIGNED.

9. THE ROAD BRIDGE IS PROPOSED TO CROSS RIGHT ANGLE TO THE CANAL FLOW AND SUITABLE 180° CURVATURE HAS BEEN CONSIDERED IN THE DESIGN (SHOWN IN THE STRESS TABLE), THE SECTION NEEDS TO BE REDESIGNED.

Notes and specifications:

- All the dimensions and coordinates are to the lining in metres.
- The levels are in metres.
- The double lane road bridge is designed for a maximum speed of 80 kmph at 1.5:1 slope.
- All the materials and specifications are as per IRC: 6-2000 AS PER IS: 383 GRADE OF CONCRETE MAX. SIZE OF C.A.
- Table of stresses in T / SQ.M.

- Reference drawings:
  - Graphs/sections
  - Details of sections
  - Section of bridge

- Approval of plans:
  - Graphs/sections
  - Details of sections
  - Section of bridge

- Double lane road bridge general plan and sectional elevations
  - Graphs/sections
  - Details of sections
  - Section of bridge

- Government of Andhra Pradesh Irrigation & CAD Department
  - Graphs/sections
  - Details of sections
  - Section of bridge

- Approved:
  - Graphs/sections
  - Details of sections
  - Section of bridge
1. CE/CDO/CD2/VSP/DLRB/3.350/    /2010 - DETAILS OF SECTIONS

2. EXPANSION JOINTS, RAILING, DRAINAGE SPOUTS SHALL BE PROVIDED AS PER M.O.S.T DRAWINGS.

3. THE SPECIFICATIONS PROPOSED FOR THE VARIOUS COMPONENTS OF THE STRUCTURE ARE AS FOLLOWS:

4. THE ROAD BRIDGE IS PROPOSED TO CROSS RIGHT ANGLE TO THE CANAL FLOW AND SUITABLE APPROACHES SHALL BE PROPOSED AS PER SITE CONDITIONS.

5. 100 THICK LINING IN C.C. M15 GRADE SHALL BE PROVIDED FOR BED AND SIDES OF THE CANAL FOR A MINIMUM OF 7.00 M / 7.00 M.

6. BACK FILLING SHALL BE DONE SIMULTANEOUSLY WITH THE RAISING OF THE STRUCTURE WITH Ø 150 Ø CASURINA BALLIES AT 1500 C/C AND 6000 DEEP SHALL BE PROVIDED BELOW THE RAFT. CASURINA BALLIES BELOW THE RAFT SHALL BE STAGGERED AT 1500 C/C AND 6000 DEEP.

7. 200TH LEVELLING COURSE IN CC M15 GRADE OF 7500 X 1000 MILLIMETERS THICKNESS SHALL BE PROVIDED TO SATISFY THE ROAD LEVEL +5.500.

8. THE ROAD BRIDGE IS PROPOSED TO CROSS RIGHT ANGLE TO THE CANAL FLOW AND SUITABLE APPROACHES SHALL BE PROPOSED AS PER SITE CONDITIONS.

9. THE BANK CONNECTIONS SHALL BE FORMED TO SUIT THE SITE CONDITIONS.

10. EXPANSION JOINTS, RAILING, DRAINAGE SPOUTS SHALL BE PROVIDED AS PER M.O.S.T DRAWINGS.

11. THE SPECIFICATIONS PROPOSED FOR THE VARIOUS COMPONENTS OF THE STRUCTURE ARE AS FOLLOWS:

**HYDRAULIC PARTICULARS**

<table>
<thead>
<tr>
<th>DESCRIPTION OF ITEM</th>
<th>QUANTITY &amp; UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**INFRASTRUCTURAL PARTICULARS**

<table>
<thead>
<tr>
<th>CODE</th>
<th>DESCRIPTION OF ITEM</th>
<th>QUANTITY &amp; UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

**STRESS TABLE**

<table>
<thead>
<tr>
<th>CODE</th>
<th>DESCRIPTION OF ITEM</th>
<th>QUANTITY &amp; UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**SPECIAL NOTES:**

1. THE DESIGN AND CONSTRUCTION OF THE STRUCTURE IS BASED ON THE APPLICABLE IRC CODES.

2. THE EFFECTIVENESS OF THE STRUCTURE TO THE LOCATED CANAL AND CANAL ARE SATISFACTORY.

3. 100 Ø CASURINA BALLIES HAVE BEEN PROVIDED AT THE FOUNDATION LEVEL.


5. THE SPECIFICATIONS PROPOSED FOR THE VARIOUS COMPONENTS OF THE STRUCTURE ARE AS FOLLOWS:

6. THE ROAD BRIDGE IS PROPOSED TO CROSS RIGHT ANGLE TO THE CANAL FLOW AND SUITABLE APPROACHES SHALL BE PROPOSED AS PER SITE CONDITIONS.

7. 200TH LEVELLING COURSE IN CC M15 GRADE OF 7500 X 1000 MILLIMETERS THICKNESS SHALL BE PROVIDED TO SATISFY THE ROAD LEVEL +5.500.

8. THE ROAD BRIDGE IS PROPOSED TO CROSS RIGHT ANGLE TO THE CANAL FLOW AND SUITABLE APPROACHES SHALL BE PROPOSED AS PER SITE CONDITIONS.

9. THE BANK CONNECTIONS SHALL BE FORMED TO SUIT THE SITE CONDITIONS.

10. EXPANSION JOINTS, RAILING, DRAINAGE SPOUTS SHALL BE PROVIDED AS PER M.O.S.T DRAWINGS.

11. THE SPECIFICATIONS PROPOSED FOR THE VARIOUS COMPONENTS OF THE STRUCTURE ARE AS FOLLOWS:

**NOTES AND SPECIFICATIONS**

1. All the dimensions on the drawings are in meters.

2. Constructing the bridge on firmly compacted soil is a must.

3. All the materials used in the construction of the bridge shall be approved by the competent authorities.

4. The bridge shall be constructed in such a way that it is not affected by any future scouring.

5. The bridge shall be designed and constructed to withstand the expected traffic loads.

6. All the components of the bridge shall be designed and constructed to ensure the safety of the users.


8. The bridge shall be designed and constructed to ensure the safety of the users.


10. The bridge shall be designed and constructed to ensure the safety of the users.

DLR BRIDGE
SLAB REINFORCEMENT
DESIGN OF DECKSLAB

Clear Span = 6.00 m
Thickness of slab = 53 cm
(assumed)
Thickness of w.c = 75 mm
Clear cover = 4.00 cm
(as per clause 303.1 and table 9 of IRC bridge code 21-2000, section III)

Main reinforcement = 20 mm dia. HYSD bars conforming to IS-1786
(Deformed bars)
Concrete Mix is M20 grade
Bearing(assumed) = 50 cm

Effective depth = 53 - 4.00 - 1.00 = 48 cm
Effective Span

As per clause 305.4 of IRC code 21-2000
Effective span shall be the least of the following

i) Effective span \( = l_1 + d \)

where

- \( l_1 = \) clear span
- \( = 6.00 \) m
- \( d = \) effective depth
- \( = 0.48 \) m

Effective span

\( = 6.00 + 0.48 \)

\( = 6.48 \) m

ii) \( l = \) distance from centre of supports

\( = 6.00 + 2 \times 0.5 \times \frac{0.5}{2} \)

\( = 6.5 \) m

Effective span shall be least of (i) and (ii)

\'. Effective span \( = 6.48 \) m

Carriage way \( = 4.25 \) m

Width

(width)

(clause 112 of IRC 5-1998)

Kerb width \( = 0.225 \) m

Width of slab \( = 4.25 + 0.225 \times 2 \)

\( = 4.70 \) m
As per clause 303.1 and Table 9 of IRC code 21-2000
Permissible flexural compressive stresses for M20 grade is
\[ s_c \text{ allowable} = 6.67 \text{ M.Pa} \]
\[ = 66.7 \text{ kg/cm}^2 \]
Modular ratio \[ \frac{E_s}{E_c} = 10 \]

As per clause 303.2.1 of IRC code 21-2000(Table 10)
Permissible tensile stress in steel for combined bending
For steel Fe 415 \[ = 200 \text{ M.Pa} \]
\[ m = 10 \]
\[ n = mc/mc+t \]
\[ n = \frac{10 \times 67}{10 \times 66.7 + 2000} = 0.250 \]
\[ j = 1 - \frac{n}{3} \]
\[ = 1 - \frac{0.2501}{3} = 0.917 \]
\[ Q = \frac{1}{2} c n j \]
\[ = 7.645 \]
As per clause 211.2 of IRC code 6-2000

Impact factor \( \frac{4.5}{6+L} \)

where \( L \) is Effective span = 6.48 m

Impact factor \( \frac{4.5}{6+6.48} \) = 0.361

**Dead Load Bending Moment**

Weight of slab = 0.53 * 2500 = 1325 kg/m

Weight of w.c = 0.075 * 2400 = 180 kg/m

Total dead load = 1505 kg/m

Bending Moment \( \frac{wl^2}{8} \) = 1505 * \( \frac{6.48^2}{8} \)

due to dead load

\( \frac{8}{8} \) = 7899 kg-m

\( \frac{8E+05}{8} \) kg-cm

**Live Load Bending Moment**

As per clause 305.16.2(1) of IRC code 21-2000

Ratio \( \frac{b}{l_o} \)

where

\( b \) = width of slab = 4.70 m

\( l_o \) = Effective span = 6.48 m

\[ \text{Ratio} = \frac{4.70}{6.48} = 0.725 \]

<table>
<thead>
<tr>
<th>( \frac{b}{l_o} )</th>
<th>( a ) for simply supported slab</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.7</td>
<td>2.12</td>
</tr>
<tr>
<td>0.8</td>
<td>2.24</td>
</tr>
</tbody>
</table>
For \( \frac{b}{l_0} a \) = \( 2.12 + \frac{0.12 \times 0.025}{0.1} \)

= 2.150

As per clause 305.16.2.(1) IRC 21-2000

Solid slabs spanning in one direction

For a single concentrated load, the effective width may be calculated in accordance with the following equation

\[
b_{ef} = a (1 - \frac{a}{l_0}) + b_1
\]

where

- \( b_{ef} \) = The effective width of slab on which the load acts.
- \( l_0 \) = The effective span as indicated in clause 305.1
- \( a \) = The distance of the centre of gravity of the concentrated load from the nearer support
- \( b_1 \) = The breadth of concentration area of the load, i.e. the dimension of the tyre or track contact area over the road surface of the slab in a direction at right angles to the span plus twice the thickness of the wearing coat or surface finish above the structural slab.
- \( a \) = a constant having the following values depending upon the ratio \( \frac{b}{l_0} \), where \( b \) is the width of the slab

\[
\begin{align*}
2.7t & \quad 11.40t & \quad 11.40t & \quad 6.80t & \quad 6.80t \\
3.2 & \quad 1.2 & \quad 4.8 & \quad 3
\end{align*}
\]

Class 'A' Train
For maximum bending moment, the two loads of 11.40 t should be kept such that the resultant of the load system and the load under consideration should be equidistant from the centre of span.

Dispersion Width Under 'C'

\[
b_{ef} = a a (1 - a/l_o) + b_1
\]

- \(a = 2.15\)
- \(a = 2.94\)
- \(l_o = 6.48\)
- \(b_1 = 0.65\) m
- \(b_{ef} = 4.104\) m \(> 1.80\) m

Dispersion Widths overlap
Combined dispersion width
= 0.225+ 0.15+ 0.5/2+ 1.8+ 4.104 /2
= 4.477 m

Intensity of load under 'C' = 11.4 (1.00+0.36)
= 3.463 t

Dispersion Width Under 'D'

\[ b_{ef} = a \cdot a \cdot (1 - \frac{a}{l_0}) + b_1 \]

\[ a = 2.15 \]
\[ a = 2.34 \]
\[ l_0 = 6.48 \]
\[ b_1 = 0.65 \text{ m} \]
\[ b_{ef} = 3.865 \text{ m} > 1.80 \text{ m} \]

Dispersion Widths overlap

Combined dispersion width
= 0.225+ 0.15+ 0.5/2+ 1.8+ 3.865 /2
= 4.357 m

Intensity of load under 'C' = 11.4 (1.00+0.36)
= 3.558 t
Taking moments about 'B'

\[
\begin{align*}
Ra \times 6.48 &= 3.558 \times 2.34 + 3.463 \times 3.54 \\
Ra &= 3.177 \text{ t} \\
Rb &= 3.463 + 3.558 - 3.177 \\
Rb &= 3.844 \text{ t}
\end{align*}
\]

Maximum live load Bending Moment

\[
\begin{align*}
\text{Total B.M} &= \text{Dead load B.M} + \text{Live Load B.M} \\
&= 789944 + 933968 \\
&= 1723912 \text{ kg-cm}
\end{align*}
\]

Effective depth

\[
\begin{align*}
\text{Effective depth required} &= \sqrt{\frac{M}{Q*b}} = \sqrt{\frac{1723912}{7.645 \times 100}} \\
&= 47.485 \text{ cm} < 48 \text{ cm} \\
&\text{Hence O.K.}
\end{align*}
\]
Steel

Steel at bottom

Main steel reinforcement required = \( M = \frac{s_{st} j d 2000 \times 0.917 \times 48}{2000 \times 0.917 \times 48} = 19.59 \text{ cm}^2 \)

As per clause 305.19 of IRC code 21-2000
Minimum area of tension in slab for Fe 415 steel is 0.12% total cross sectional area

\[ \text{reinforcement} = \frac{0.12 \% \text{ of } b \times d}{100} = \frac{0.12}{100} \times 100 \times 53 \]

\[ = 6.36 \text{ cm}^2 < 19.59 \text{ cm}^2 \]

provide 20 mm dia. HYSD bars at \( 160 \text{ mm c/c} \)

\( A_{st, \text{provided}} = 19.63 \text{ cm}^2 \)

Distribution Steel

As per clause 305.18.1 of IRC code 21-2000

Resisting moment = 0.3 times the moment due to concentrated live loads plus 0.2 times due to other loads such as dead load, shrinkage, temperature etc.

\[ = 0.3 \times L.L \text{ B. Mom.} + 0.2 \times D.L \text{ B. Mom.} \]

\[ = 0.3 \times 933968 + 0.2 \times 789944 \]

\[ = 438179 \text{ kg-cm} \]

Assuming the dia. Of distribution bar = 12 mm HYSD

Effective depth = 46.4 cm

\( A_{st, \text{required}} = \frac{M}{s_{st} j d} = \frac{438179}{2000 \times 0.917 \times 46.4} = 5.15 \text{ cm}^2 \)
As per clause 305.19 of IRC code 21-2000

Minimum distribution reinforcement = \( \frac{0.12}{2} \times \frac{100 \times 53}{100^2} \)
\( \approx \frac{3.18}{2} \text{ cm}^2 < 5.15 \text{ cm}^2 \)

Hence provide minimum distribution reinforcement of 5.15 cm²

provide 12 mm dia. HYSD bars at 210 mm c/c

Ast provided = 5.383 cm²

Top Reinforcement

Shrinkage & Temperature reinforcement = 250 mm² of steel area per metre in each direction (vide cl. 305.10 of IRC:21-2000)

Provide 10mm dia. HYSD bars at 250 mm c/c at top to take care of temperature and shrinkage in either direction

Also provide distribution steel of 10 mm dia. HYSD bars at 250 mm c/c on top

Check for shear

As per clause 305.13.3 of IRC code 21-2000

Dispersion of loads along the span

Longitudinal dispersion = The effect of contact of wheel or track load in the direction of span length shall be taken as equal to the dimension of the tyre contact area over the wearing surface of the slab in the direction of the span plus twice the overall depth of the slab inclusive of the thickness of the wearing surface.

Longitudinal dispersion = \( 0.25 + 2 \times (0.53 + 0.075) \)
\( = 1.46 \text{ m} \)
Case I

The load of 11.40 t may be kept at $1.46/2 = 0.73$ m from the support to get max. shear

Dispersion Width Under 'D'

$\alpha = 2.15$

$a = 1.35$

$lo = 6.48$

$b1 = 0.35$ m

$bef = 2.648$ m $> 1.80$ m

Dispersion Widths overlaps

nos. of 8Φ & 10Φ @ 300 c/c stirrups
Combined dispersion width
\[ = 0.225 + 0.15 + 0.2 + 1.8 + \frac{2.648}{2} \]
\[ = 3.599 \text{ m} \]
Intensity of load under 'D'
\[ = \frac{2.7 \times (1.00 + 0.36)}{3.599} \]
\[ = 1.020 \text{ t} \]

Dispersion Width Under 'E'
\[ \text{bef} = a \times (1 - a/lo) + b1 \]
\[ \text{bef} = 2.15 \]
\[ a = 1.93 \]
\[ lo = 6.48 \]
\[ b1 = 0.35 \text{ m} \]
\[ \text{bef} = 3.264 \text{ m} > 1.80 \text{ m} \]

Dispersion Widths overlap

Combined dispersion width
\[ = 0.225 + 0.15 + 0.2 + 1.8 + \frac{3.264}{2} \]
\[ = 3.907 \text{ m} \]
Intensity of load under 'E'
\[ = \frac{11.4 \times (1.00 + 0.36)}{3.907} \]
\[ = 0.940 \text{ t} \]

Dispersion Width Under 'F'
\[ \text{bef} = a \times (1 - a/lo) + b1 \]
\[ \text{bef} = 2.15 \]
\[ a = 0.73 \]
\[ lo = 6.48 \]
\[ b1 = 0.65 \text{ m} \]
\[ \text{bef} = 2.043 \text{ m} > 1.80 \text{ m} \]
Dispersion Widths overlap

Combined dispersion width
= 0.225 + 0.15 + 0.5/2 + 1.8 + 2.043 /2
= 3.446 m

Intensity of load under 'F' = 11.4 \times \left(1.00 + 0.36\right) / 3.446
= 4.499 t

Taking moments about 'B'

Ra \times 6.48 = 4.499 \times 0.73 + 0.940 \times 1.93 + 1.020 \times 5.13 +
Ra = 1.594 t
Rb = 4.864 t
Case II

Dispersion Width Under 'C'

\[ \text{bef} = a \left(1 - \frac{a}{l_0}\right) + b_1 \]

\[ \begin{align*}
\text{bef} & = 2.15 \\
\alpha & = 2.15 \\
a & = 0.73 \\
l_0 & = 6.48 \\
b_1 & = 0.65 \text{ m} \\
\text{bef} & = 2.043 \text{ m} > 1.80 \text{m}
\end{align*} \]

Dispersion Widths overlap
Combined dispersion width

\[\begin{align*}
&= 0.225 + 0.15 + 0.5/2 + 1.8 + 2.043/2 \\
&= 3.446 \text{ m}
\end{align*}\]

Intensity of load under 'C'

\[\begin{align*}
&= 11.4 \times (1.00 + 0.36)/3.446 \\
&= 4.499 \text{ t}
\end{align*}\]

Dispersion Width Under 'D'

\[
\text{bef} = \alpha(1 - \alpha/lo) + b1
\]

\[
\begin{align*}
\alpha &= 2.15 \\
a &= 1.93 \\
lo &= 6.48 \\
b1 &= 0.65 \text{ m}
\end{align*}
\]

\[
\text{bef} = 3.564 \text{ m} > 1.80 \text{ m}
\]

Dispersion Widths overlap

Combined dispersion width

\[\begin{align*}
&= 0.225 + 0.15 + 0.5/2 + 1.8 + 3.564/2 \\
&= 4.207 \text{ m}
\end{align*}\]

Intensity of load under 'D'

\[\begin{align*}
&= 11.4 \times (1.00 + 0.36)/4.207 \\
&= 3.685 \text{ t}
\end{align*}\]
Taking moments about 'B'

\[ Ra \times 6.48 = 3.685 \times 4.55 + 4.499 \times 5.75 \]

\[ Ra \times 6.48 = 42.634 \]

\[ Ra = 6.579 \, t \]

\[ Rb = 1.604 \, t \]

The shear force in case (I) and case (II) are calculated and case (II) gives max. shear and hence it is considered in the shear calculation.

Max. shear due to live load = 6.579 \, t

Shear due to dead load = \( \frac{wl}{2} \)

\[ = \frac{1505 \times 6.48}{2} \]

\[ = 4876.2 \, kgs \]

Total shear due to dead load = 6579 + 4876.2

\[ = 11455.2 \, kgs \]

Nominal shear stress \( t_v \) = \( \frac{V}{bd} \)

\[ = \frac{11455}{100 \times 48} \]

\[ = 2.3865 \, Kg/cm^2 \]
Permissible shear stress = $t_c$

$A_{st}$ provided = 19.63 cm$^2$

$\frac{100 \ A_{st}}{bd} = \frac{100 \times 19.625}{100 \times 48} = 0.409$

from table of 12B of IRC:21-2000

$t_c = 0.271$ N/mm$^2$

$= 2.74$ Kg/cm$^2$

For solid slabs the permissible shear in concrete = $kt_c$

(vide cl. 304.7.1.3.2 of IRC:21-2000)

For solid slab of more than 300 mm thick, $k = 1.0$ (Table 12C of IRC:21-2000)

$\therefore \ kt_c = 1 \times 2.74 = 2.74$ Kg/cm$^2$

$t_c > t_v$

Hence safe against shear.

**Kerb**

Provide 7 nos. of 8Φ & 10Φ @ 300 c/c stirrups