DESIGN OF REINFORCED CONCRETE I GIRDER AND PRESTRESSED CONCRETE I GIRDER BRIDGE AND THEIR MATERIAL COMPARISON

Project report submitted in partial fulfillment of the degree

Bachelor in Technology

In

CIVIL ENGINEERING

Under supervision of

Mr. LAV SINGH

By

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To

Department of Civil Engineering

Jaypee University Of Information Technology

Waknaghat,Solan-173234, Himachal Pradesh

CERTIFICATE

This is to certify that project entitled "**DESIGN OF REINFORCED CONCRETE I GIRDER AND PRESTRESSED CONCRETE I GIRDER BRIDGE AND THEIR COMPARISON** ", submitted by Anmol Khanna (101612), in partial fulfillment for the award of degree of Bachelor of technology in Civil Engineering have been carried out under my supervision.

This work have not been submitted partially or fully to any other university or institute for the award of this or any other degree or diploma.

DATE :

SUPERVISOR NAME : Mr Lav Singh

DESIGNATION : Asst. Professor, JUITW

ABSTRACT

In a developing country like India every project decision is made primarily on the basis of the cost of the project which is directly proportional to the material required. It is known that construction and infra-structure play a vital role in development of a country and we all know that bridges play an extreme role in the development of infrastructure for any country. The decision to select the type and material of bridge is crucial according to the requirements should we choose a RCC I girder bridge or a RCC box girder bridge or PSC bridge or steel bridge etc..

In this project we have tried to estimate the material requirement of super structures for :

1. RCC I girder bridge
2. PSC I girder bridge

The analysis for both the bridges is done manually.

The material requirement for both the bridges is done and analysis is performed i.e. why is there a difference in the requirements of the bridge superstructure.

In this project we will be designing RCC I girder and PSC I girder bridges of span 18 meters both the bridges are considered of having same environmental conditions so that there is no other factor on which the materials cost will depend. The bridges are of 2 lanes and are having a carriage way width of 7.5 meters. The carriage way width includes only the part of the bridge where the traffic can move. More specifications about the bridges are given further in the report. Since the environmental conditions are kept constant hence the sub structure of the bridge will not play any vital role in the comparison of the materials required.

ACKNOWLEDGEMENT

We express our sincerest gratitude to our respected project supervisor Mr. Lav Singh, department of civil engineering, Jaypee University Of information Technology, Waknaghat under whose supervision and guidance this work has been carried out. His whole hearted involvement, advice, support and constant encouragement have helped us to carry out this work with confidence. We are thankful to him for showing confidence in us to take up a project of this magnitude and it was due to his guidance and planning that we are on schedule on this project and complete it in time.

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CHAPTER 1: SCOPE AND OBJECTIVE

In developing countries like India and other constant efforts are made to innovate, invent and improvise over infra structure technology ,construction materials and constant studies are done over comparisons of different project to keep a check over the construction dynamics of different projects so as to save time in future if a project of almost similar conditions is met.

One of the most influencing factor in the field of bridge construction is its cost. It is one of the very basic question that a civil engineer have to face that "Which type of bridge or bridge design to choose in order to get do the project most economically ?"

Basic technology for construction in practice is the use of reinforced cement concrete commonly known as R.C.C. which is a combination of cement, aggregate, sand that are used to make concrete along with steel hence the word "reinforced". Steel is added in order to take up tensile forces which are not taken by concrete since it is weak in tension.

In this project we will be trying to design, analyze and compare the cost of super structure for:

1. RCC I girder bridge
2. PSC I girder bridge

We are only considering the super structure since the sub structure for both the bridges will be very similar and will not make a major difference in the cost of the project if the soil conditions and other environmental factors are kept constant

We will be keeping the site conditions, designing criteria and loading same for both the bridges so that a direct relationship could be obtained between the load transfer, quantity of material and the cost of the project.

The manual analysis and design are generated and presented using excel sheets which can further be used for designing the super structure for different loading and geometric conditions. We will also be analyzing our structures over software's such as staad.pro, compare there results with each other and with the manual calculations and make comparisons of the designs generated.

CHAPTER 2: LITERATURE

2.1 Bridge: Definition

A bridge is a structure providing passage over an obstacle without closing the way beneath. The required may be a road, railway, pipeline etc. there are 6 basic forms of a bridge structure:

1. Beam Bridge
2. Truss Bridge
3. Arch Bridge
4. Cantilever Bridge
5. Suspension Bridge
6. Cable Stayed Bridge

In this project we will be designing beam bridges. Beam bridges are the oldest form of bridges being constructed and the beams can be of any shape but the usual shapes preferred are usually rectangular, symmetrical and un-symmetrical I sections. For bridges of large spans cross beams are provided which distribute the load and deflection of one main girder over the others. Beam bridges carry vertical loads by flexure i.e. by resisting the moments generated by the applied vertical loads.

2.2 Load transfer:

The load transfer on the bridges is from

1. Wearing course
2. Deck slab
3. Girders
4. Piers
5. Foundation and finally to earth

2.3 Components of bridges:

A bridge can be divided into super structure and sub structure

The major components of super structure are:

1. Deck
2. Longitudinal girders
3. Cross beams
4. Bearings
5. Approaches
6. Handrails, parapets and guard stones etc.

The major components of Sub structure are:

1. Piers
2. Abutments
3. Foundation

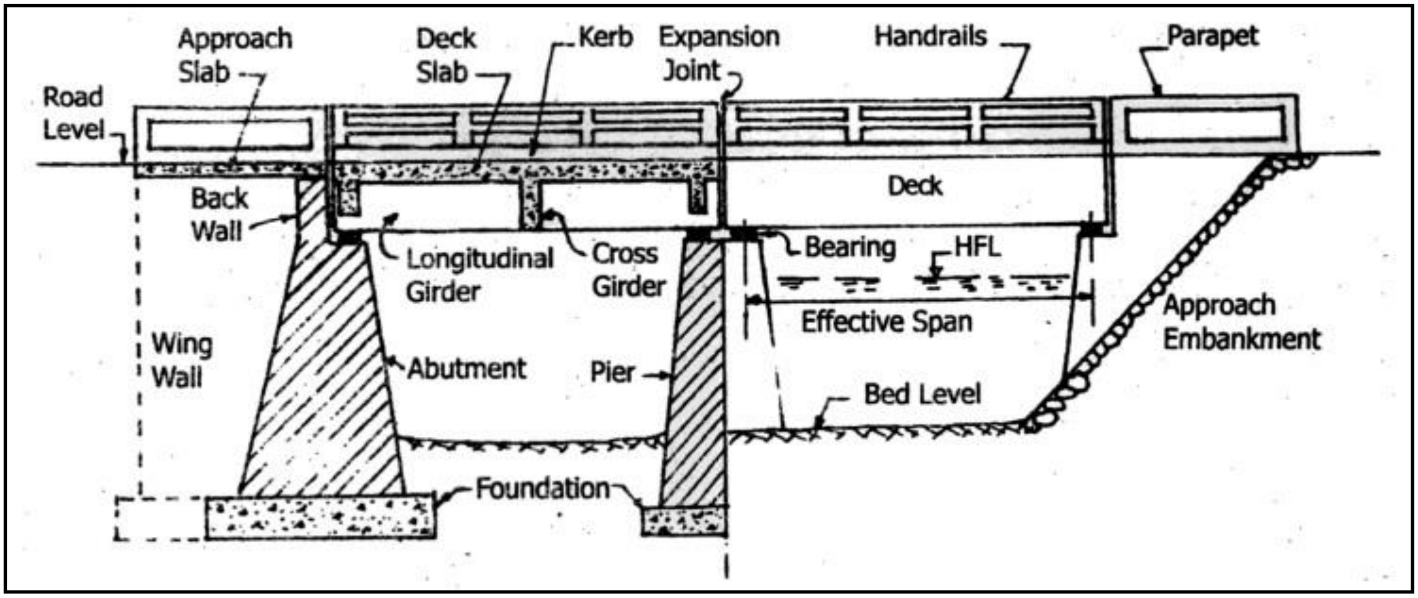


Figure 1: COMPONENTS OF BRIDGE

2.4 Reinforced concrete bridges :

The technology of Reinforced concrete has been in use in India since decades. **Reinforced concrete** is a composite material in which concrete's relatively low tensile strength and ductility are counteracted by the inclusion of reinforcement having higher tensile strength and/or ductility. The reinforcement is usually, though not necessarily, steel reinforcing bars (rebar) and is usually embedded passively in the concrete before the concrete sets.

The bridge types adopted in India are:

1. Simply supported slabs
2. Simply supported girder type
3. Cantilever bridges
4. Continuous and framed bridges

T beams have been widely used for spans 10 to 25 meters.

Standard dimensions that are considered during the design of an RCC I-Girder slab bridge are:

1. The width of the kerb should be between 475 mm to 600 mm.
2. The standard average depth of wearing course if made from asphaltic concrete is 56 mm and if it is made of M30 grade of concrete 75 mm of depth is considered.
3. If footpaths are provided they should be 1.5 m wide.(Though in our case we will not be providing foot paths)

In this project we have considered a system of girder, slab and cross beam type. The panels of the floor slab are supported along the four edges by the longitudinal and cross beams. Hence the floor slab is designed as a two way slab. This leads to more efficient use of the reinforcing steel and to reduced slab thickness and hence reduced dead load over the longitudinal girders. The provision for cross beams stiffens the structure by to a considerate extent, resulting in better distribution of concentrated loads among the longitudinal girders. With two way slab and cross beams the distance between longitudinal girders can be increased, resulting in less number of girders and lesser form work, hence enhancing the economy of the project.

2.5 Pre-stressed concrete bridges :

The application of the concept of pre-stressing to structural concrete members has opened up a wide spectrum of bridge types and has enlarged span range possible with the concrete. Pre-stressing may be defined as the application of a predetermined force to a structural member resulting from in such a manner that the combined internal stresses in the member resulting due to this force or any other external loading will be counteracted to a desired degree \. The pre-stress is usually imparted to concrete by straining the pre-stressing tendon relative to the concrete, thereby causing compressive stresses in concrete due to tension in tensioned steel

There are 3 types of members in stressed concrete according to IS:1343 definig the degree of pre-stress :

1. Type 1- Full Pre-stress
2. Type 2- Limited Pre-stress
3. Type 3- Partial Pre-stress

NOTE: For type 1 members, tensile forces are not permitted in the member under any loading condition during or after the time of construction.

Based on the method of construction pre-stresses bridges can be classifies under four categories :

1. Cast in situ bridges
2. Precast girder bridges
3. Bridges with segmental cantilever construction
4. Incrementally launched bridges

We will be doing calculations for our bridge consider cast in situ conditions.

There are two types of pre-stressing:

1. Pre-tensioning : In this method of pre-stressing the steel tendons are tensioned before the concrete has been placed in moulds. The tendons are tensioned by hydraulic jack bearing against strong abutments between which the moulds are placed and after the setting and hardening of concrete the tendons are released from tensioning device and the load in transferred to concrete by bond.

2. Post-tensioning : In this method the tendons are stressed and anchored at each end of the member after concrete has been cast and has attained sufficient strength to withstand the pre-stressing force.

2.6 Standard specifications for road bridges:

The Indian Roads Congress (IRC) has formulated Standard specifications and Codes of practice for road bridges with a view to establish a common procedure for the design and construction of of road bridges in India. These specifications are collectively known as the Bridge Code.

These codes set the minimum standards the design engineer has to keep in mind while designing the bridge and also tell us about the type of loading etc which are required for the design of bridges.

2.7 IRC standard live loads:

IRC: 6 - 1966 – Section II gives the specifications for the various loads and stresses to be considered in bridge design.There are four types of standard loading that for which road bridges are designed:

1. ***<u>IRC Class AA loading:</u>*** This loading consists of either a tracked vehicle of 700 kN or a wheeled load

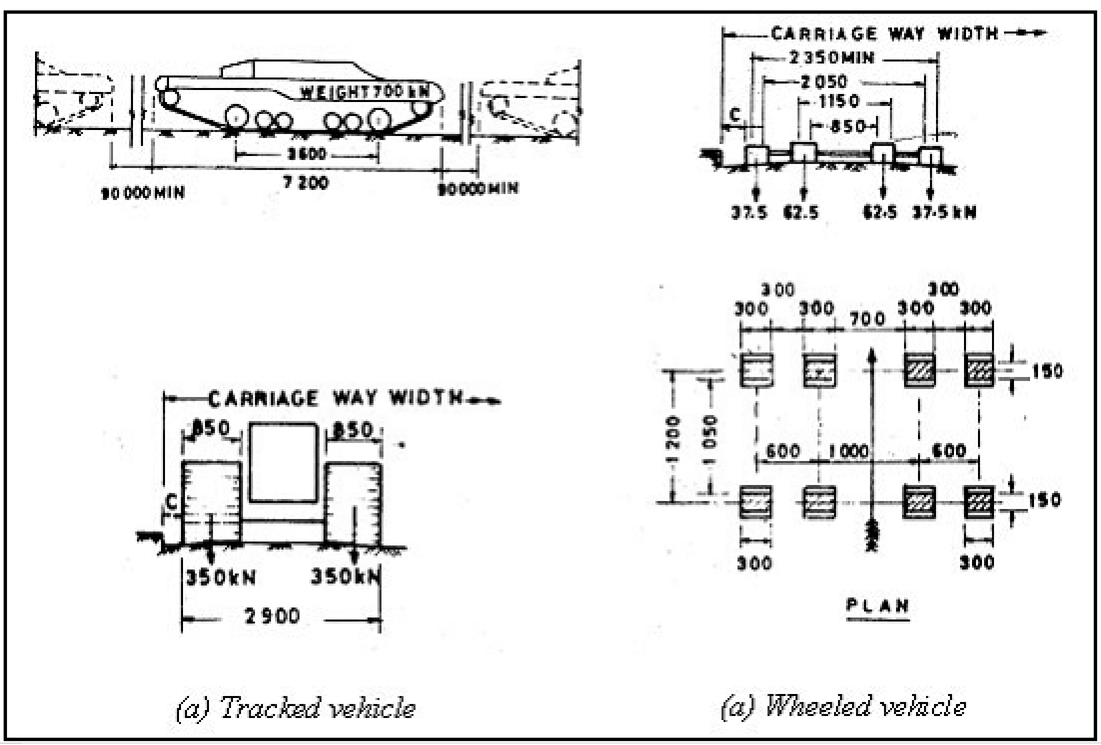


Figure 2: IRC CLASS AA LOADING

of 400 kN with the dimensions as shown in figure. The ground contact length of the track is 3.6 m and the tail to nose distance is 7.2 m. the distance between successive vehicles should not be less than 90 m . For every two lanes of bridges and culverts, one train of class AA tracked or wheeled load which ever creates severe condition is considered

2. ***IRC Classs 70 R loading***: This loading consists of a tracked vehicle of load of 700 kN or a wheeled load of 1000 kN. The tracked vehicle is similar to that of Class AA except that the contact length is 4.97 m and tail to nose distance is 7.92 m . The minimum specified spacing between successive vehicles is 30 m. The wheeled load is 15.22 m long and contains 10 axles as shown.

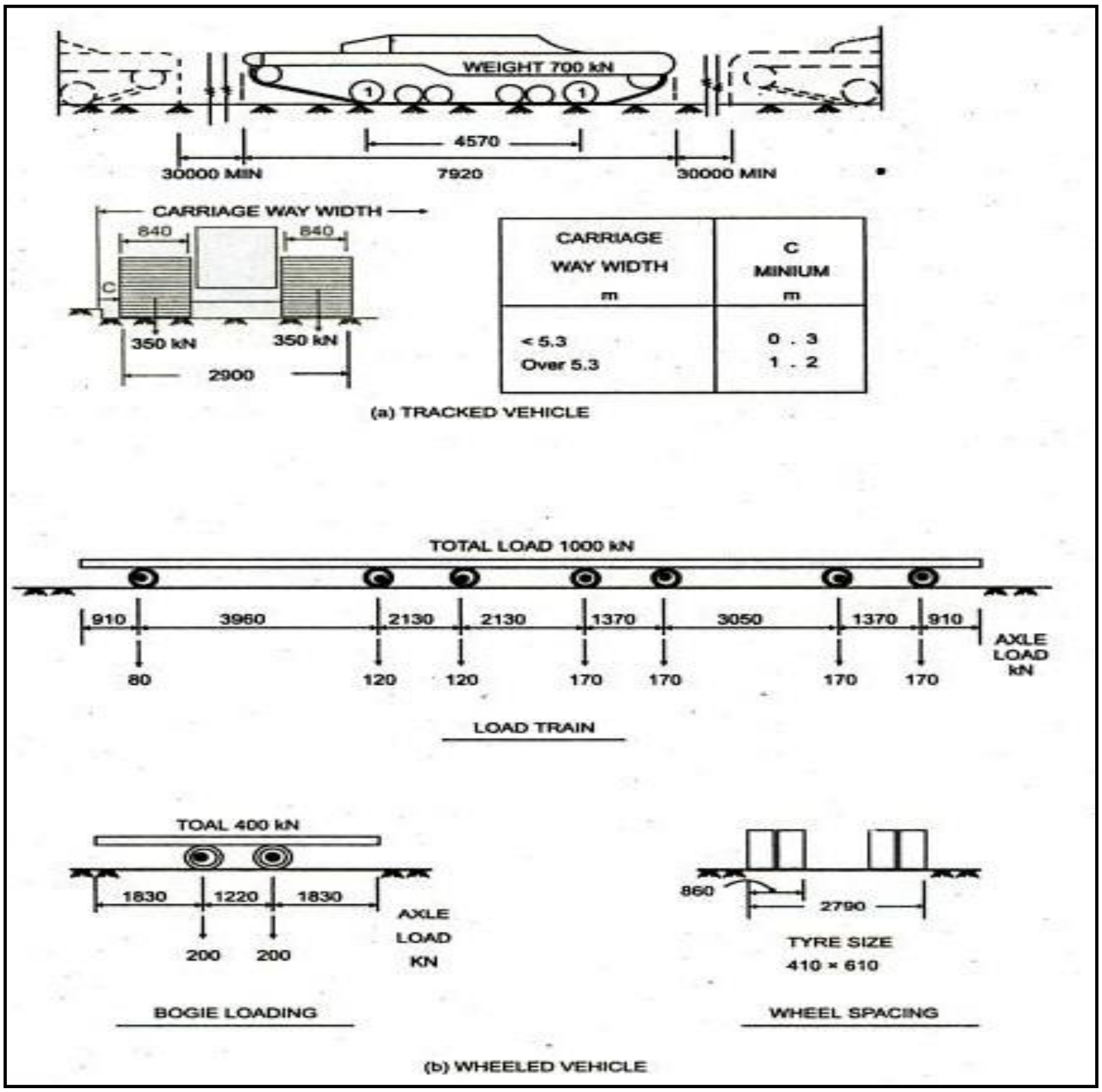
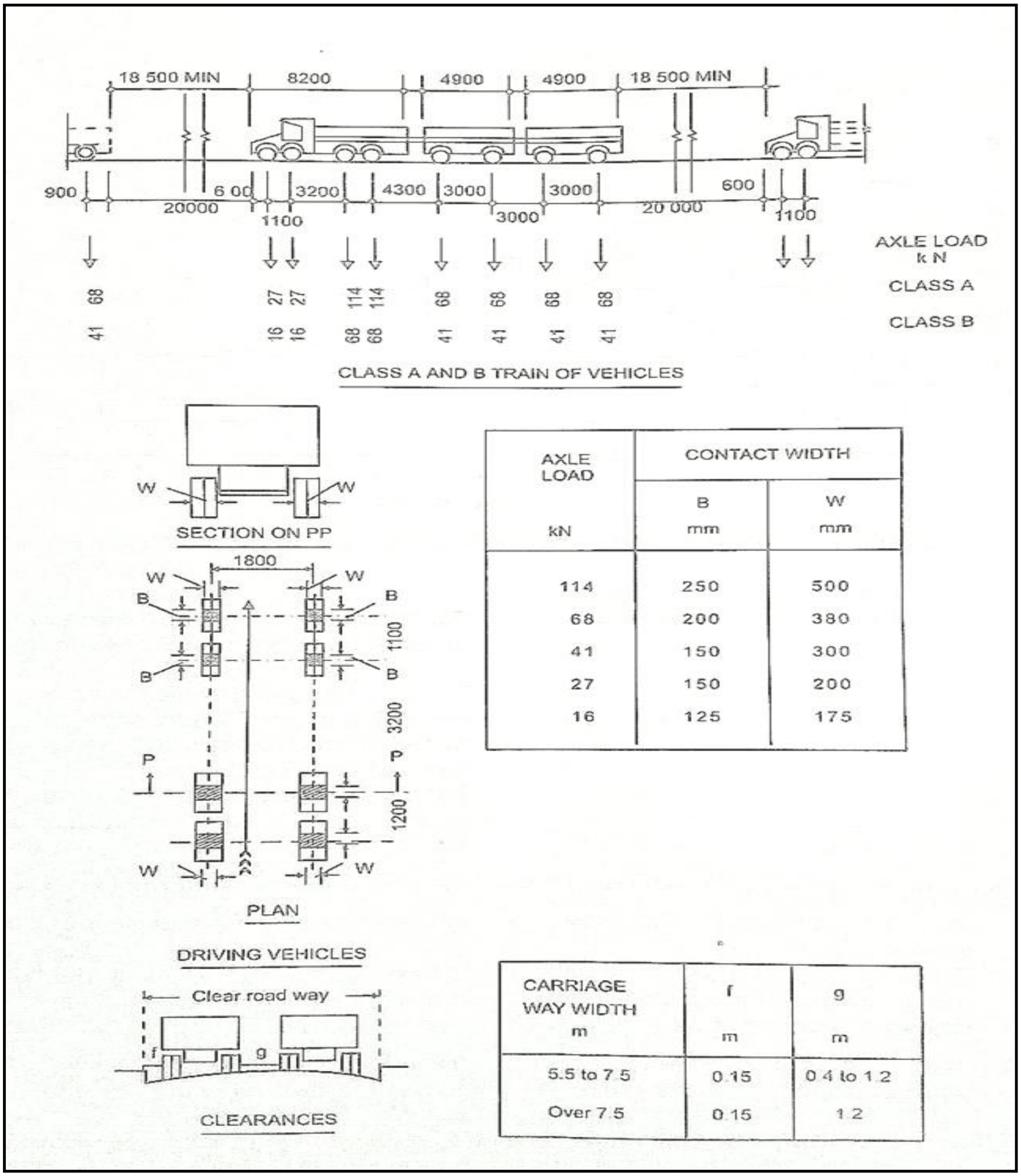


Figure 3: IRC CLASS 70R LOADING

3. ***IRC Class A loading:*** Class A loading of a wheel load train composed of a driving vehicle and trailers of specified axles spacing and loads as shown in the figure. The nose to tail spacing of



AXLE LOAD kN	CONTACT WIDTH B mm	CONTACT WIDTH W mm
114	250	500
68	200	380
41	150	300
27	150	200
16	125	175

CARRIAGE WAY WIDTH m	f m	g m
5.5 to 7.5	0.15	0.4 to 1.2
Over 7.5	0.15	1.2

Figure 4:IRC CLASS A AND CLASS B

between successive vehicles should not be less than 18.5 m.

4. ***IRC Class B loading:*** Class B loading comprises of wheeled load train similar to thar Class A loading but with smaller axle loads as shown in the figure. It is intended to be adopted for temporary structures.

2.8 Impact Factor:

Moving trains cause higher stresses than stationary vehicles. Hence to take into account there effect impact factors are considered.

1. ***For IRC Class A or B loading:*** The following relation is used:

$$I = \frac{A}{B + L}$$

I= imapact factor fraction

A= constant of value 4.5 for RCC bridges

B=constant of value 6 for RCC bridges

L= span in meters

For spans less than 3 m impact f actor of 0.5 is considered for RCC bridges

2. ***For IRC Class AA or 70 R:***

For spans greater than 9 meters : In case of tracked vehicle it is 10% upto spans 40 m then according to the figure and in case for wheeled loads it is 25% upto spans of 12 m and then the graph shown in the figure is used.

For spans less than 9 meters : In case of tracked vehicle 25% to 10% linearly varying from 5 m span to 9 m span and for wheeled load it is 25%.

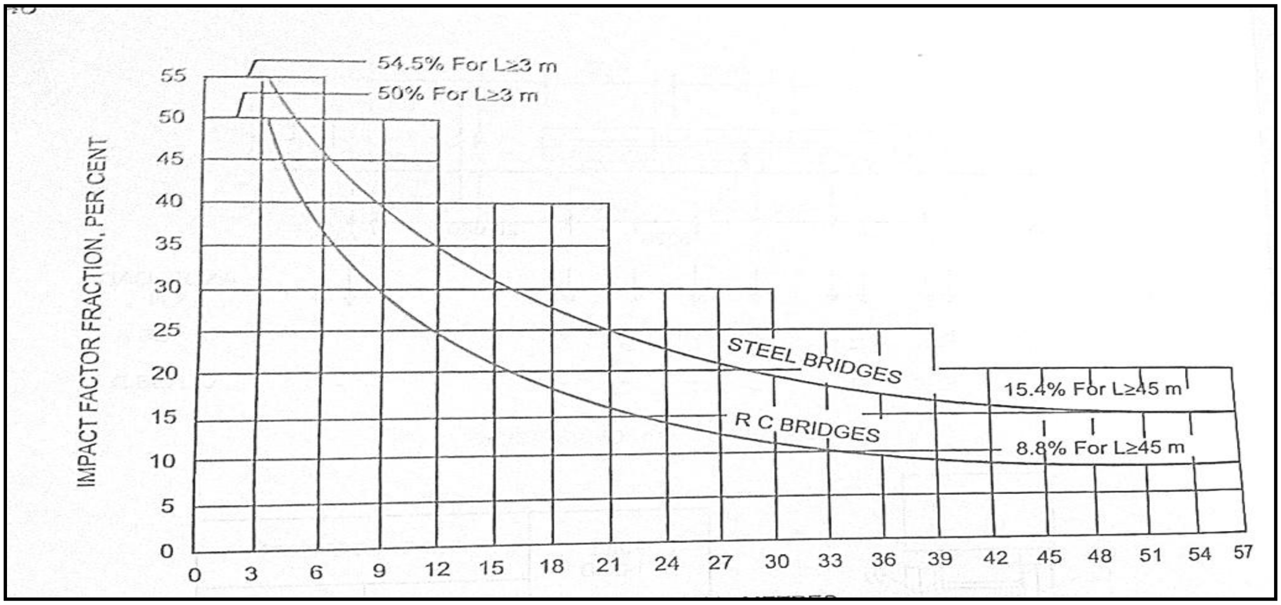


Figure 5: IMPACT FACTOR CALCULATION

2.9 Steps for design of bridge:

Step 1: Determine the Dead load and the superimposed dead load over the deck slab including the wearing course, kerbs, handrails.

Step 2: Determine the Bending Moments generated along the shorter and longer span due to dead load with the help of pigueads curve.

Step 3: Determine the bending moments generated along the shorter and longer span due to live load with the help of pigueads curve.

Step 4: Calculate the net bending moments generated over the deck slab due to dead load and the live load for different loadings of IRC.

Step 5: Calculate the reinforcement required for resisting the Bending Moments generated using the working stress method .

Step 6: Calculate the Bending Moment generated over the cantilever slab due to the dead load and the live load applied .

Step 7: Calculate the reinforcement required for resisting the Bending Moments generated over the cantilever slab using working stress method .

Step 8: Calculate the Bending Moments generated over the longitudinal girders due to the applied dead and live load .

Step 9: Calculate the reinforcement required for resisting the Bending Moments generated over the longitudinal girders using working stress method.

Step 10: Calculate the Bending Moments generated over the cross beams due to the applied dead and live load.

Step 11: Calculate the reinforcement required for resisting the Bending Moments generated over the cross beams using working stress method

NOTE: All these steps are explained in Detail further

2.10 Pigueads curve :

In bridge decks comprising slab integrally cast with longitudinal and cross girders as in the case of Tee beams and Slab Decks, the moments develop due to wheel loads on the slab both in the longitudinal and transverse directions. These moments are computed by using the design curves developed by M.Pigeaud . Pigeaud's method is applicable to rectangular slabs supported freely on all four sides and the slab should be symmetrically loaded.

CHAPTER 3: PROJECT SPECIFICATIONS

3.1 RCC I Girder

Dimensions of the bridge

Clear width of roadway	7.5	m
Span	18	m
Traffic lanes	2	
Thickness of slab	0.25	m
Thickness of wearing course	0.08	m

Considering 3 I girders run along the span

Span in transverse direction	2.5	m
Effective Span transverse direction	2.2	m

Considering 5 cross beams including diaphragm

Spacing between diaphragms	4.5	m
Effective Span in longitudinal direction	4.25	m

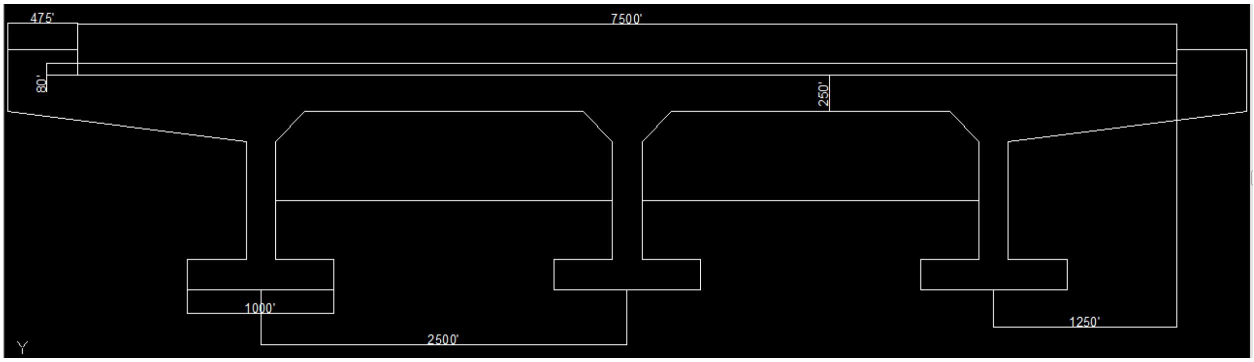


Figure 6: RCC I GIRDER TRANSVERSE SECTION

3.2 PSC I Girder

Dimensions of the bridge

Clear width of roadway	7.5	m
Span	18	m
width of bearing	0.4	m
Traffic lanes	2	
Thickness of deck slab	0.3	m
Thickness of wearing course	0.08	m

Assuming 2 I Girders run along the length

Distance between I girders	3.5	m
Cantiliver Span(excluding Kerbs)	2	m
Cantiliver Span(including Kerbs)	2.475	m

Providing 2 crossbeams

Distance between cross beams	6	m

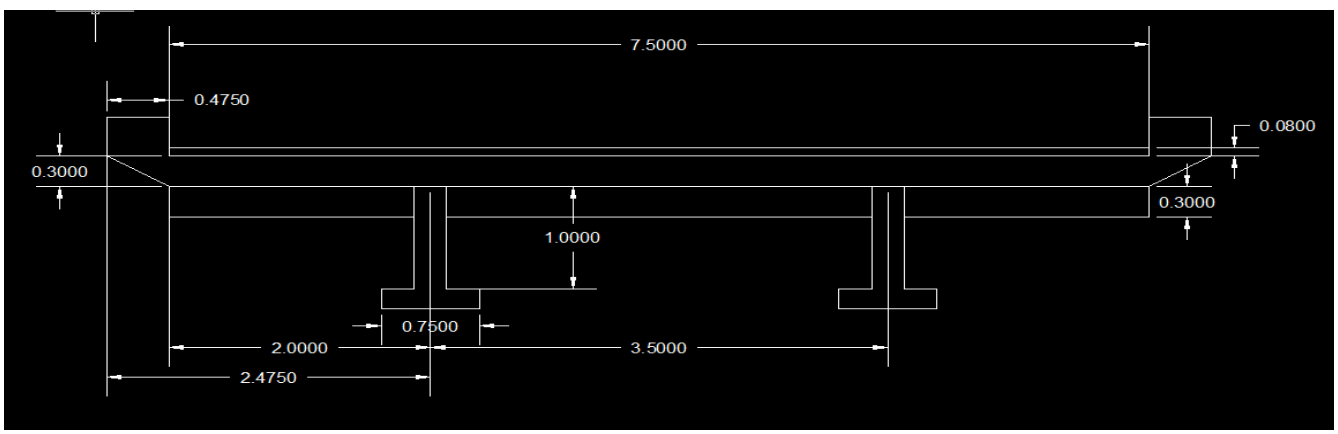


Figure 7: PSC I GIRDER BRIDGE TRANSVERSE SECTION

CHAPTER 4: BENDING MOMENTS GENERATED ON DECK SLAB

The abbreviations used in the calculations of bending moments generated on deck slab are as follows

L = Length of load

B = Breadth of load

L' = Length of dummy load

B'=Breadth of dummy load

K ratio = short span to long span ratio (used in pigueads curve)

D= depth of deck slab

Use of pigueads curve in calculating bending moment

For calculation of the bending moments along the shorter and longer span of the bridge we use pigueads curve. The two relations to calculate the bending moment are

$$M_1 = P(m_1 + \mu m_2)$$

$$M_2 = P(m_2 + \mu m_1)$$

Here M_1 is the moment along shorter span and M_2 is the moment along longer span. The coefficients m_1 and m_2 are taken from the pigueads curve and P is the total load that is applied on the slab due to which bending moment is calculated.

M_1=Moment along shorter span

M_2=Moment along longer span

P= Total load applied over the slab

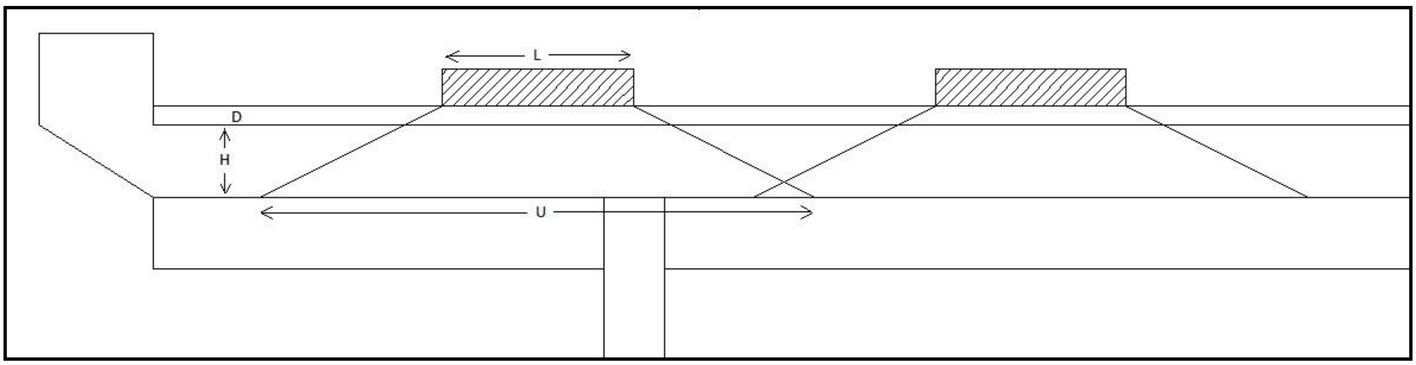
m_1 and m_2 = constants from pigueads curve

μ= poisons ratio (in case of concrete=0.15)

NOTE : For all the coefficients m_1 and m_2 in RCC slab B.M. calculations refer to appendix

Pigueads curve are only applicable when :

1. The loads applied for the bending moment moment needs to be calculated should be symmetrical. When the loads are not symmetrical some appropriate approximations are considered.
2. When the value of v/L is small the coefficients value become less accurate hence pigueads curve give best results when value of K is greater than 0.55 .



Dispersion Of Loads :

The shaded portion in the above figure shows the actual load applied over the deck slab. The net area affected by the load at the bottom of the deck slab is calculated by dispersing the load at 45 degrees either side.

4.1 RCC I Girder

Calculations of Bending Moment Generated due to DEAD LOAD

DL of deck slab	6	kN/m2
DL of wearing course	1.76	kN/m2
TOTAL DL per m2	14	kN/m2
TOTAL DL	130.9	kN

Ratio K	0.52
Ratio 1/K	1.93
Using PIGEAUDS CURVE	
Coefficient m1	0.048
Coefficient m2	0.01

Moment along short span	**6.48**	**kN.m**
moment along long span	**2.25**	**kN.m**

Calculations of Bending Moment Generated due to LIVE LOAD

Due to IRC CLASS AA TRACKED VEHICLE

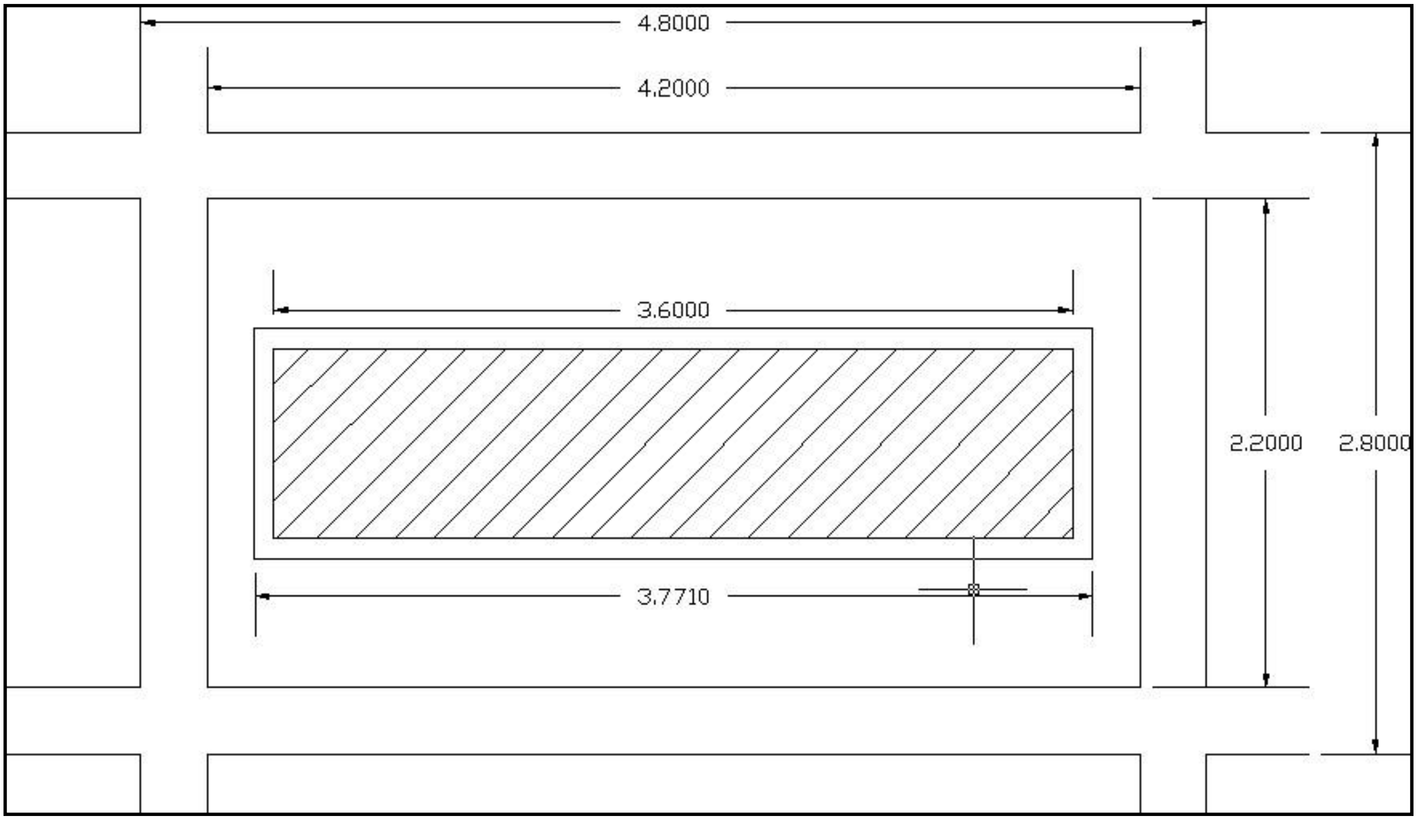


Figure 8: IRC CLASS AA LOADING ON RCC BRIDGE

Size of panel	11.25	m^2

Critical condition will arise when the track will be placed symmetrically along the central girder

Width of load spread calculation

U	1.04	m
V	3.77	m

u/B ratio	0.47	
v/L ratio	0.89	
using PIGEAUDS CURVE		
Coefficient m1	0.08	
Coefficient m2	0.02	

Total load after including impact factor is 437.5 kN

Hence, Bending moment generated

moment along shorter span	**36.42**	**kN.m**
moment along longer span	**11.88**	**kN.m**

IRC CLASS AA WHEELED LOAD

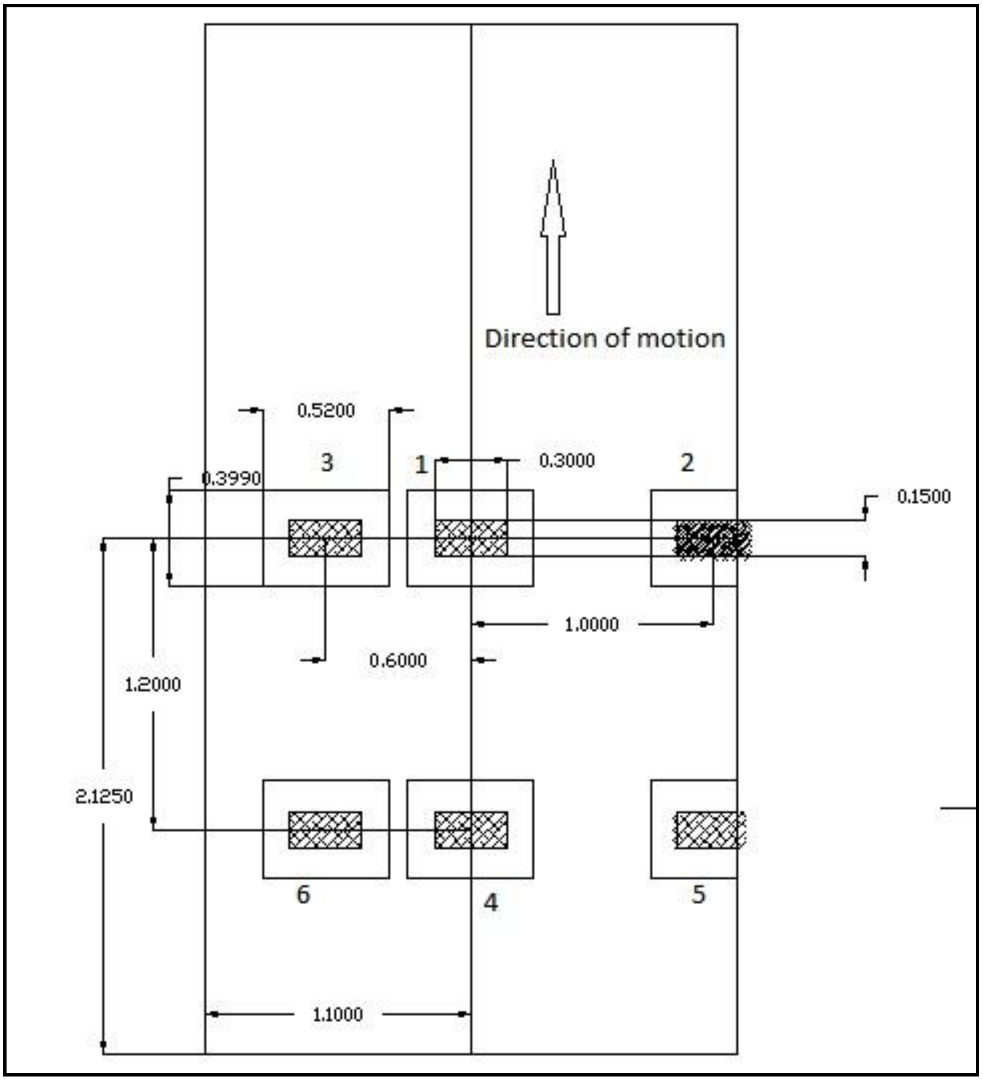


Figure 9: IRC CLASS AA EHEELED LOAD ON RCC I GIRDER BRIDGE

Critical condition when front axle is at the center of the effective length and side vehicle at the center girder

Wheel 1:

L	0.30	m
B	0.15	m

U	0.52	m
V	0.40	m

u/B ratio	0.24	
v/L ratio	0.09	
using PIGEAUDS CURVE		
Coefficient m1	0.20	
Coefficient m2	0.18	

Total load	78.13	kN

moment along shorter span	**17.58**	**kN.m**
moment along longer span	**16.38**	**kN.m**

Wheel 2 :

Since wheel 2 is unsymmetrical about XX axis hence a dummy load is considered and the moments are calculated.

total load intensity	299.76	kN/m2
loaded area	0.88	m2

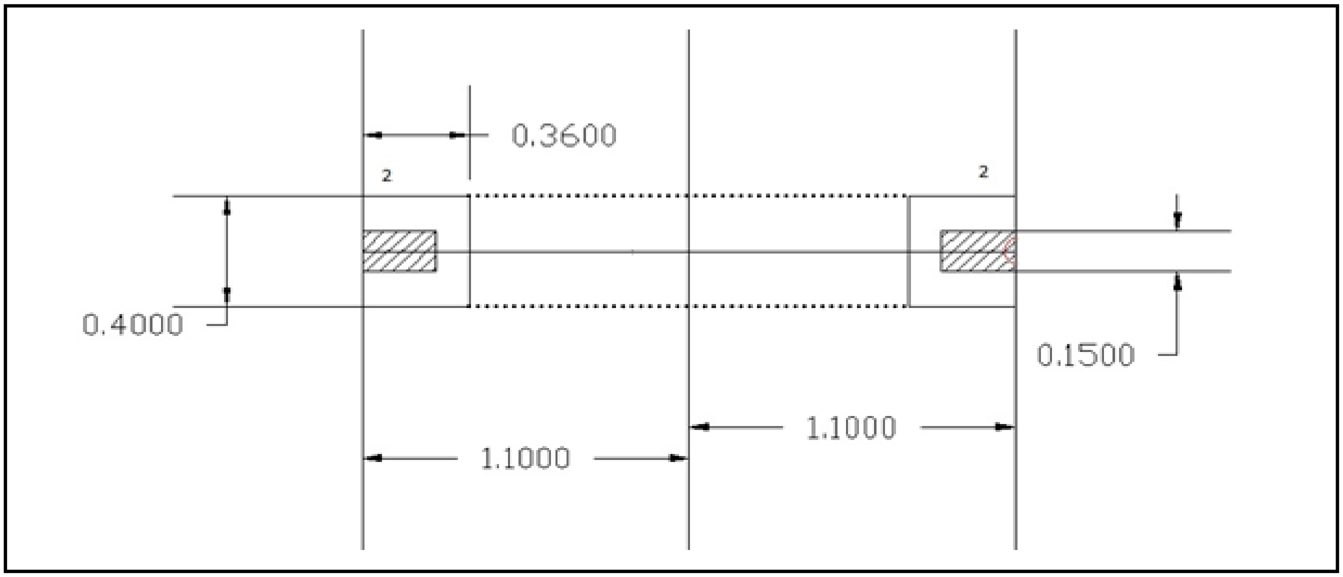
L	2.20	m
B	0.40	m

U	2.37	m
V	0.61	m

u/B ratio	1.00	
v/L ratio	0.14	
using PIGEAUDS CURVE		
Coefficient m1	0.09	
Coefficient m2	0.07	
Total load	262.63	kN
impact factor	328.29	kN

moment along shorter span	**33.80**	**kN.m**
moment along longer span	**28.50**	**kN.m**

Due to dummy load



When a dummy load is considered a udl is formed which is symmetrical about the centre of the slab since pigueads curve are applicable only for symmetrical load. Then moment generated is calculated after that moment due to extra load is again calculated and subtracted from the moment calculated due to total load and hence the net moment due to wheel is determined by halving the moment that is determined after subtraction.

L'	1.32	m
B'	0.40	m

U	1.50	m
V	0.61	m
u/B ratio	0.68	
v/L ratio	0.14	
using PIGEAUDS CURVE		
Coefficient m1	0.12	
Coefficient m2	0.10	

Total load	157.99	kN
impact factor	197.48	kN

moment along shorter span	**26.66**	**kN.m**
moment along longer span	**23.30**	**kN.m**

NET MOMENT SHORT SPAN	**3.57**	**kN.m**
NET MOMENT LONG SPAN	**2.60**	**kN.m**

Wheel 3 :

total load intensity	179.86	kN/m^2
loaded area	0.68	m^2

L	1.70	m
B	0.40	m

U	1.88	m
V	0.61	m

u/B ratio	0.85	
v/L ratio	0.14	
using PIGEAUDS CURVE		
Coefficient m1	0.10	
Coefficient m2	0.09	

Total load	122.05	kN
impact factor	152.57	kN

moment along shorter span	**17.68**	**kN.m**
moment along longer span	**15.48**	**kN.m**

Due to dummy load

L'	0.66	m
B'	0.40	m

U	0.85	m
V	0.61	m

u/B ratio	0.39	
v/L ratio	0.14	
using PIGEAUDS CURVE		
Coefficient m1	0.17	
Coefficient m2	0.19	

Total load	47.05	kN
impact factor	58.82	kN

moment along shorter span	**11.44**	**kN.m**
moment along longer span	**12.64**	**kN.m**

NET MOMENT SHORT SPAN	**3.12**	**kN.m**
NET MOMENT LONG SPAN	**1.42**	**kN.m**

Wheel 4 :

L	1.40	m
B	0.52	m

U	1.58	m
V	0.73	m

u/B ratio	0.37	
v/L ratio	0.33	
using PIGEAUDS CURVE		
Coefficient m1	0.15	
Coefficient m2	0.06	

Total load	219.58	kN
impact factor	274.47	kN

moment along shorter span	**42.35**	**kN.m**
moment along longer span	**22.99**	**kN.m**

Due to dummy load

L'	0.60	m
B'	0.52	m

U	0.80	m
V	0.73	m

u/B ratio	0.19	
v/L ratio	0.33	
using PIGEAUDS CURVE		
Coefficient m1	0.17	
Coefficient m2	0.06	

Total load	94.58	kN
impact factor	118.22	kN

moment along shorter span	**21.21**	**kN.m**
moment along longer span	**10.46**	**kN.m**

NET MOMENT SHORT SPAN	**10.57**	**kN.m**
NET MOMENT LONG SPAN	**6.26**	**kN.m**

Wheel 5 :

total load intensity	299.76	kN/m2
loaded area	0.73	m2

L	1.40	m
B	0.52	m

U	1.58	m
V	0.73	m

u/B ratio	0.37	
v/L ratio	0.33	
using PIGEAUDS CURVE		
Coefficient m1	0.15	
Coefficient m2	0.06	

Total load	219.58	kN
impact factor	274.47	kN

moment along shorter span	**42.35**	**kN.m**
moment along longer span	**22.99**	**kN.m**

Due to dummy load

L'	0.60	m
B'	0.61	m

U	0.80	m
V	0.81	m

u/B ratio	0.19	
v/L ratio	0.37	
using PIGEAUDS CURVE		
Coefficient m1	0.14	
Coefficient m2	0.05	

Total load	110.49	kN
impact factor	138.12	kN

moment along shorter span	**20.43**	**kN.m**
moment along longer span	**10.22**	**kN.m**

NET MOMENT SHORT SPAN	**10.96**	**kN.m**
NET MOMENT LONG SPAN	**6.38**	**kN.m**

Wheel 6 :

L	1.40	m
B	0.52	m

U	1.58	m
V	0.73	m

u/B ratio	0.37	
v/L ratio	0.33	
using PIGEAUDS CURVE		
Coefficient m1	0.15	
Coefficient m2	0.06	

Total load	52.57	kN
impact factor	65.71	kN

moment along shorter span	**10.14**	**kN.m**
moment along longer span	**5.50**	**kN.m**

Due to dummy load

L'	0.18	m
B'	0.52	m

U	0.42	m
V	0.73	m

u/B ratio	0.10	
v/L ratio	0.33	
using PIGEAUDS CURVE		

Coefficient m1	0.19	
Coefficient m2	0.06	

Total load	6.60	kN
impact factor	8.26	kN

moment along shorter span	**1.65**	**kN.m**
moment along longer span	**0.75**	**kN.m**

NET MOMENT SHORT SPAN	**4.25**	**kN.m**
NET MOMENT LONG SPAN	**2.38**	**kN.m**

FINAL BENDING MOMENTS THAT ARE GENERATED :

Due to dead load

Moment along short span	**6.48**	**kN.m**
Moment along long span	**2.25**	**kN.m**

Due to class AA tracked vehicle

Moment along short span	**36.42**	**kN.m**
Moment along long span	**11.88**	**kN.m**

Due to class AA wheeled load

wheel 1

Moment along short span	**17.58**	**kN.m**
Moment along long span	**16.38**	**kN.m**

wheel 2

Moment along short span	**3.57**	**kN.m**
Moment along long span	**2.60**	**kN.m**

wheel 3

Moment along short span	**3.12**	**kN.m**
Moment along long span	**1.42**	**kN.m**

wheel 4

Moment along short span	**10.57**	**kN.m**
Moment along long span	**6.26**	**kN.m**

wheel 5

Moment along short span	**10.96**	**kN.m**
Moment along long span	**6.38**	**kN.m**

wheel 6

Moment along short span	**4.25**	**kN.m**
Moment along long span	**2.38**	**kN.m**

TOTAL MOMENTS DUE TO WHEELED LOAD		
along short span	**50.04**	**kN.m**
along longer span	**35.42**	**kN.m**

NET MOMENTS APPLIED ON SLAB		
SHORT SPAN	**56.52**	**kN.m**
LONG SPAN	**37.67**	**kN.m**

4.2 PSC I Girder

Bending Moment generated due to dead laod

Dead load of slab	7.2	kN/m^2
Dead load of wearing course	1.76	kN/m^2

Total Dead load	8.96	kN/m^2

Total dead load	188.16	kN

B	3.5	m
L	6	m
k ratio	0.583333	
1/k ratio	1.714286	
From pigueads curve		
m1	0.048	
m2	0.015	
Moment along shorter span	9.45504	kN.m
Moment along longer span	4.177152	kN.m

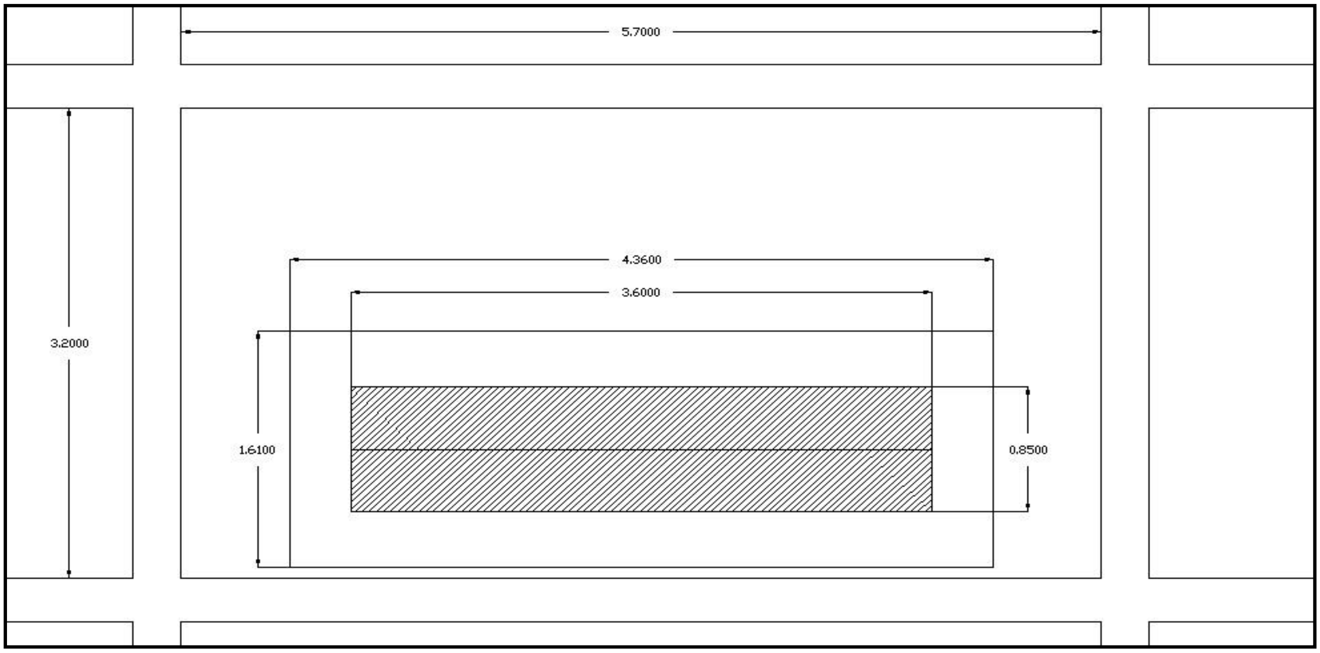


Figure 10: IRC CLASS AA LOADING ON PSC I GIRDER BRIDGE

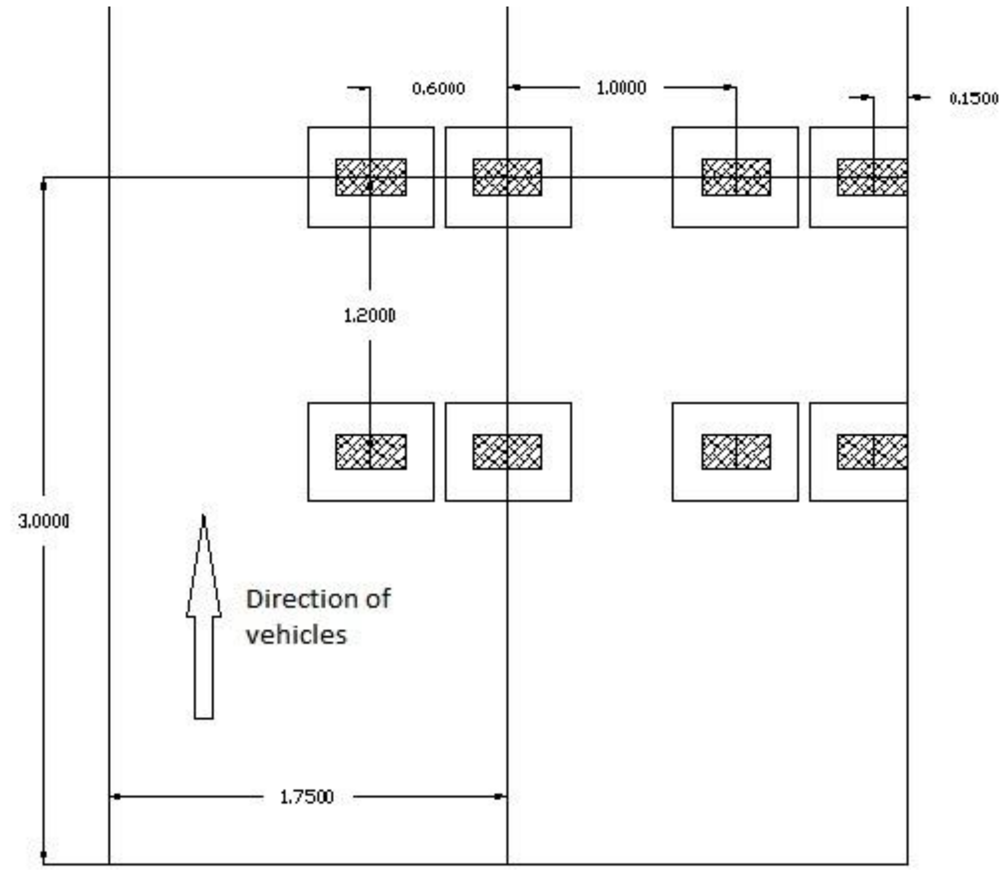
Bending Moment generated due to IRC Class AA tracked load

size of one panel	21.00	m^2

U	1.61	m
V	4.36	m
u/B ratio	0.46	
v/L ratio	0.73	
using PIGEAUDS CURVE		
Coefficient m_1	0.11	
Coefficient m_2	0.04	

Total load per track including impact factor of 0.25 is 437.50 kN

moment along shorter span	**48.67**	**kN.m**
moment along longer span	**22.27**	**kN.m**


0.6000
1.0000
0.1500
1.2000
3.0000
Direction of vehicles
1.7500

Bending Moment generated due to IRC Class AA wheeled load

Critical condition will arise when the track will be placed symmetrically along the central girder

Wheel 1 :

L	0.30	m
B	0.15	m

U	0.55	m
V	0.43	m
u/B ratio	0.16	
v/L ratio	0.07	
using PIGEAUDS CURVE		
Coefficient m_1	0.24	
Coefficient m_2	0.22	

Total load	78.13	kN

Figure 11: IRC CLASS AA WHEELED LOAD ON PSC I GIRDER BRIDGE

moment along shorter span	**21.33**	**kN.m**
moment along longer span	**20.00**	**kN.m**

Wheel 2:

total load intensity	263.81	kN/m^2
loaded area	1.51	m^2

L	1.50	m
B	0.15	m

U	1.69	m
V	0.43	m

u/B ratio	0.48	
v/L ratio	0.07	
using PIGEAUDS CURVE		
Coefficient m_1	0.16	
Coefficient m_2	0.15	

Total load	398.32	kN
impact factor	497.90	kN

moment along shorter span	**90.87**	**kN.m**
moment along longer span	**86.63**	**kN.m**

Bending moment due to dummy laod

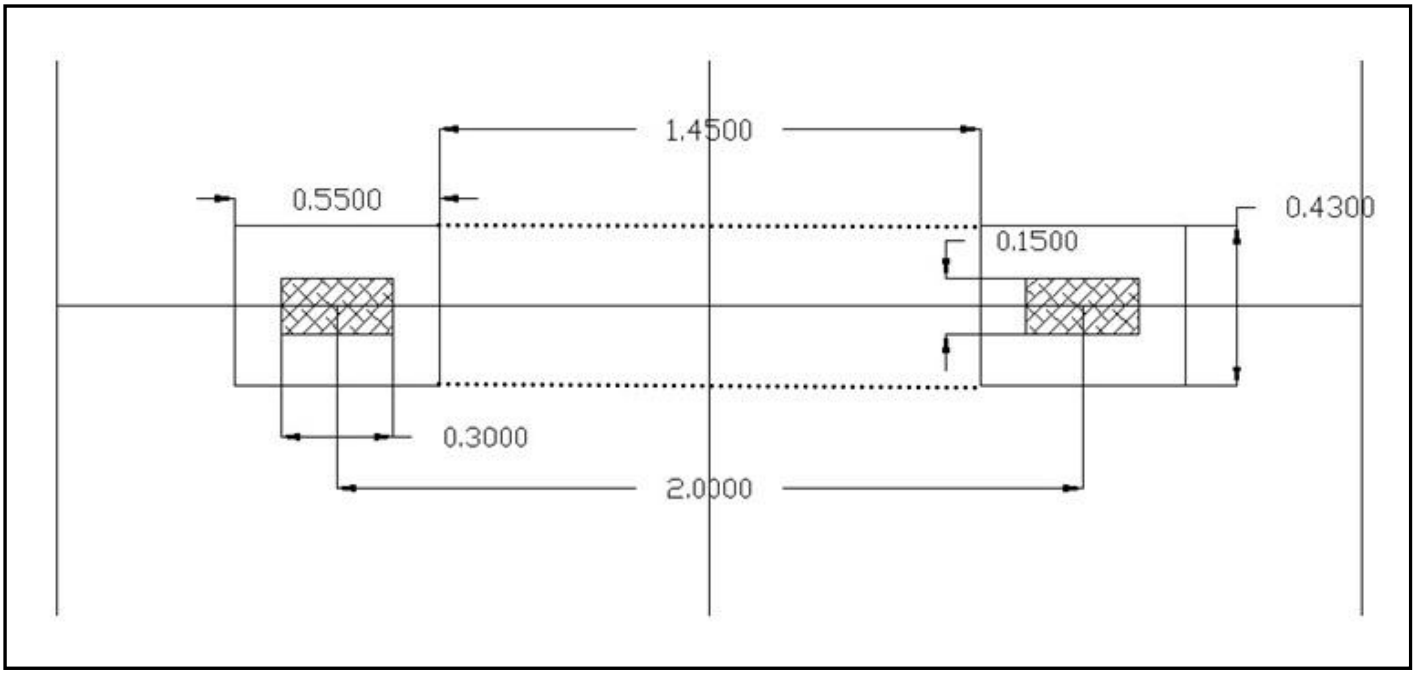


Figure 12 : DUMMY LOAD REPRESENTATION FOR PSC BRIDGE SLAB

When a dummy load is considered a udl is formed which is symmetrical about the centre of the slab since pigueads curve are applicable only for symmetrical load. Then moment generated is calculated after that moment due to extra load is again calculated and subtracted from the moment calculated due to total load and hence the net moment due to wheel is determined by halving the moment that is determined after subtraction.

L'	0.90	m
B'	0.15	m

U	1.10	m
V	0.43	m
u/B ratio	0.31	
v/L ratio	0.07	
using PIGEAUDS CURVE		
Coefficient m_1	0.19	
Coefficient m_2	0.18	

Total load	35.61	kN
impact factor	44.52	kN

moment along shorter span	**9.40**	**kN.m**
moment along longer span	**9.03**	**kN.m**

NET MOMENT SHORT SPAN	**40.73**	**kN.m**
NET MOMENT LONG SPAN	**38.80**	**kN.m**

Wheel 3:

L	2.30	m
B	0.15	m

U	2.48	m
V	0.43	m

u/B ratio	0.71	
v/L ratio	0.07	
using PIGEAUDS CURVE		
Coefficient m_1	0.11	
Coefficient m_2	0.11	

Total load	205.12	kN
impact factor	256.40	kN

moment along shorter span	**32.44**	**kN.m**
moment along longer span	**32.44**	**kN.m**

Due to dummy load

L'	1.70	m
B'	0.15	m

U	1.88	m
V	0.43	m

u/B ratio	0.54	
v/L ratio	0.07	
using PIGEAUDS CURVE		
Coefficient m_1	0.14	
Coefficient m_2	0.16	

Total load	40.36	kN
impact factor	50.45	kN

moment along shorter span	**8.27**	**kN.m**
moment along longer span	**9.13**	**kN.m**

NET MOMENT SHORT SPAN	**12.08**	**kN.m**
NET MOMENT LONG SPAN	**11.65**	**kN.m**

Wheel 4 :

L	3.50	m
B	0.15	m

U	3.67	m
V	0.43	m

u/B ratio	1.00	
v/L ratio	0.07	
using PIGEAUDS CURVE		
Coefficient m_1	0.09	
Coefficient m_2	0.08	

Total load	138.50	kN
impact factor	173.13	kN

moment along shorter span	**17.14**	**kN.m**
moment along longer span	**16.11**	**kN.m**

Due to dummy load :

L'	2.90	m
B'	0.15	m

U	3.07	m
V	0.43	m

u/B ratio	0.88	
v/L ratio	0.07	
using PIGEAUDS CURVE		
Coefficient m_1	0.09	
Coefficient m_2	0.10	
Total load	114.76	kN
impact factor	143.45	kN

moment along shorter span	**14.95**	**kN.m**
moment along longer span	**15.56**	**kN.m**

NET MOMENT SHORT SPAN	**1.09**	**kN.m**
NET MOMENT LONG SPAN	**0.27**	**kN.m**

Wheel 5 :

L	0.30	m
B	2.55	m

U	0.55	m
V	2.73	m

u/B ratio	0.16	
v/L ratio	0.45	
using PIGEAUDS CURVE		
Coefficient m_1	0.17	
Coefficient m_2	0.06	

Total load	201.81	kN
impact factor	252.27	kN

moment along shorter span	**44.97**	**kN.m**
moment along longer span	**20.31**	**kN.m**

Due to dummy load

L'	0.30	m
B'	2.25	m

U	0.55	m
V	2.43	m

u/B ratio	0.16	
v/L ratio	0.40	
using PIGEAUDS CURVE		
Coefficient m_1	0.18	
Coefficient m_2	0.06	

Total load	178.07	kN
impact factor	222.59	kN

moment along shorter span	**40.96**	**kN.m**
moment along longer span	**19.20**	**kN.m**

NET MOMENT SHORT SPAN	**2.01**	**kN.m**
NET MOMENT LONG SPAN	**0.55**	**kN.m**

Wheel 6 :

total load intensity	158.29	kN/m^2
loaded area	0.77	m2

L	0.30	m
B	2.55	m

U	0.55	m
V	2.73	m

u/B ratio	0.16	
v/L ratio	0.45	
using PIGEAUDS CURVE		
Coefficient m_1	0.17	
Coefficient m_2	0.06	

Total load	121.09	kN
impact factor	151.36	kN

moment along shorter span	**26.98**	**kN.m**
moment along longer span	**12.18**	**kN.m**

Due to Dummy Load :

L'	0.30	m
B'	2.25	m

U	0.55	m
V	2.43	m

u/B ratio	0.16	
v/L ratio	0.40	
using PIGEAUDS CURVE		
Coefficient m_1	0.18	
Coefficient m_2	0.06	

Total load	106.84	kN
impact factor	133.55	kN

moment along shorter span	**24.57**	**kN.m**
moment along longer span	**11.52**	**kN.m**

NET MOMENT SHORT SPAN	**1.20**	**kN.m**
NET MOMENT LONG SPAN	**0.33**	**kN.m**

Wheel 7 :

total load intensity	158.29	kN/m^2
loaded area	0.77	m^2

L	0.30	m
B	2.55	m

U	0.55	m
V	2.73	m

u/B ratio	0.16	
v/L ratio	0.45	
using PIGEAUDS CURVE		
Coefficient m_1	0.17	
Coefficient m_2	0.06	

Total load	121.09	kN
impact factor	151.36	kN

moment along shorter span	**26.98**	**kN.m**
moment along longer span	**12.18**	**kN.m**

Due to Dummy load :

L'	0.30	m
B'	2.25	m

U	0.55	m
V	2.43	m

u/B ratio	0.16	
v/L ratio	0.40	
using PIGEAUDS CURVE		
Coefficient m_1	0.18	
Coefficient m_2	0.06	

Total load	106.84	kN
impact factor	133.55	kN

moment along shorter span	**24.57**	**kN.m**
moment along longer span	**11.52**	**kN.m**

NET MOMENT SHORT SPAN	**1.20**	**kN.m**
NET MOMENT LONG SPAN	**0.33**	**kN.m**

Wheel 8 :

L	0.30	m
B	2.55	m

U	0.55	m
V	2.73	m

u/B ratio	0.16	
v/L ratio	0.45	
using PIGEAUDS CURVE		
Coefficient m_1	0.17	
Coefficient m_2	0.06	

Total load	121.09	kN
impact factor	151.36	kN

moment along shorter span	**26.98**	**kN.m**
moment along longer span	**12.18**	**kN.m**

Due to dummy load :

L'	0.30	m
B'	2.25	m

U	0.55	m
V	2.43	m

u/B ratio	0.16	
v/L ratio	0.40	
using PIGEAUDS CURVE		
Coefficient m_1	0.18	
Coefficient m_2	0.06	

Total load	106.84	kN
impact factor	133.55	kN

moment along shorter span	**24.57**	**kN.m**
moment along longer span	**11.52**	**kN.m**

NET MOMENT SHORT SPAN	**1.20**	**kN.m**
NET MOMENT LONG SPAN	**0.33**	**kN.m**

4.3 FINAL BENDING MOMENTS THAT ARE GENERATED :

Due to dead load

Moment along short span	9.46	kN.m
Moment along long span	4.18	kN.m

Due to class AA tracked vehicle

Moment along short span	48.67	kN.m
Moment along long span	22.27	kN.m

Due to class AA wheeled load
wheel 1

Moment along short span	21.33	kN.m
Moment along long span	20.00	kN.m

wheel 2

Moment along short span	40.73	kN.m
Moment along long span	38.80	kN.m

wheel 3

Moment along short span	12.08	kN.m
Moment along long span	11.65	kN.m

wheel 4

Moment along short span	1.09	kN.m
Moment along long span	0.27	kN.m

wheel 5

Moment along short span	2.01	kN.m
Moment along long span	0.55	kN.m

wheel 6

Moment along short span	1.20	kN.m
Moment along long span	2.38	kN.m

wheel 7

Moment along short span	1.20	kN.m
Moment along long span	0.33	kN.m

wheel 8

Moment along short span	1.20	kN.m
Moment along long span	0.33	kN.m

TOTAL MOMENTS DUE TO WHEELED LOAD		
Along short span	80.85	kN.m
Along long span	74.33	kN.m

NET MOMENTS APPLIED ON DECK SLAB		
SHORT SPAN	**90.30**	**kN.m**
LONG SPAN	**78.50**	**kN.m**

CHAPTER 5: REINFORCEMENT CALCULATION IN DECK SLAB

For the designing of RCC slab design coefficients are calculated whose relations are as shown

$$k_c = \frac{m.c}{mc + t}$$

$$j_c = 1 - k_c/3$$

$$R_c = 0.5 c j_c k_c$$

Here ,

m is the modular ratio

c is the strength of concrete, whose are values are taken from IS codes.

The relations given below are then used in calculating the minimum depth that is required to take the moment which should be less than the depth provided and also the area of steel required to take the bending moments.

$$d = \sqrt{\frac{M}{R_c b}}$$

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

Here

D = effective depth of deck slab

M = Bending Moment applied

b = breadth of the deck slab considered (1000 mm)

A_{st} = Area of steel required

σ_{st} = strength of steel

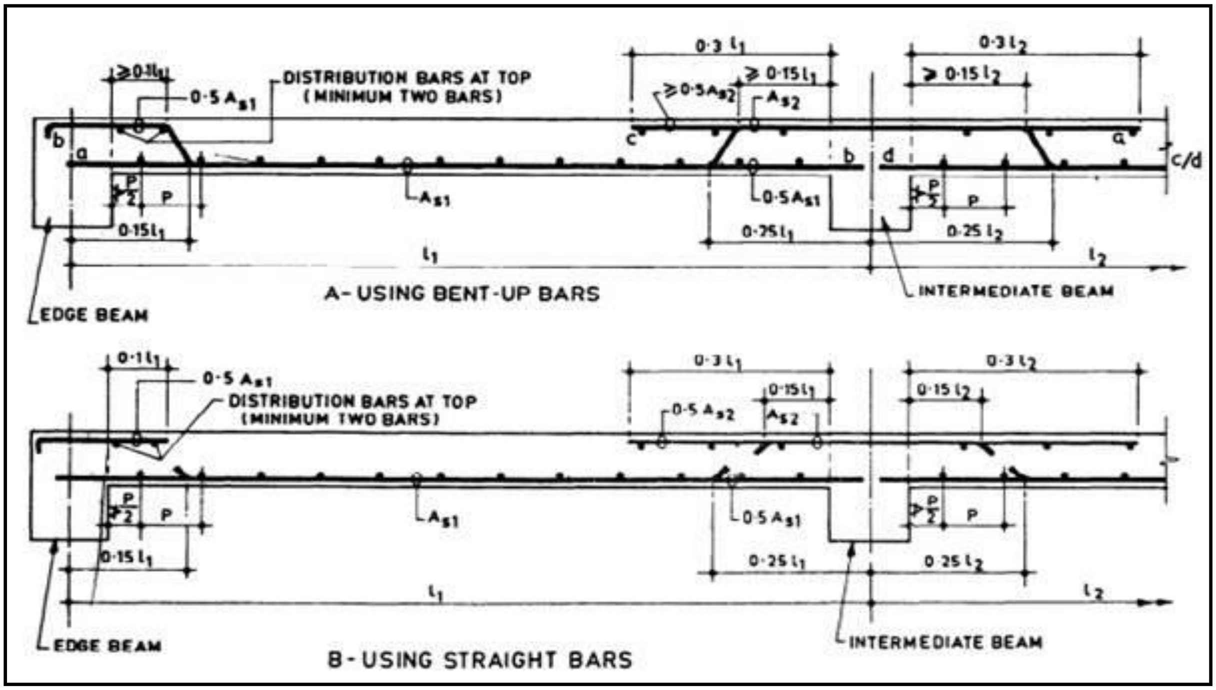


Figure 13: TYPICAL REINFORCEMENT FOR DECK SLAB OF BRIDGE

5.1 RCC I Girder

Permissible compressive stress in concrete for M30 grade	10	N/mm^2
Permissible shear stress in steel	200	N/mm^2

m,modular ratio	9.3

Design constants

K	0.32
lever arm,j	0.89
R	1.42

Bending Moments generated

MAX bending moment	56520461.40	N.mm
	37672913.23	N.mm

Effective depth calculations

effective depth required	199	mm
Assumed diameter of bars	20	mm

MAIN REINFORCEMENT

Area of steel required	1581	mm^2
Spacing provided	199	mm

hence 20 mm dia bars provided at 195 mm c/c spacing

LONGITUDINAL REINFORCEMENT

Area of steel required	1171	mm^2
Spacing provided	268	mm

hence 20 mm dia bars provided at 260 mm c/c spacing

5.2 PSC I Girder

Permissible compressive stress in concrete for M30 grade	10	N/mm^2
permissible shear stress in steel	200	N/mm^2

modular ratio	9.3

Design Constants

K	0.32
lever arm,j	0.89
R	1.42

Bending Moments generated

MAX bending moment	90301741.32	N.mm
Secondary bending moment	76125834.78	N.mm

Effective depth calculations

effective depth required	252	mm
Assumed diameter of bars	20	mm

Effective depth provided for main reinforcement	250	mm

MAIN REINFORCEMENT

Area of steel required	2020	mm^2
spacing provided	155	mm

hence 20 mm dia bars provided at 150 mm c/c spacing

LONGITUDINAL REINFORCEMENT

Area of steel required	1909	mm^2
spacing provided	164	mm

hence 20 mm dia bars provided at 160 mm c/c spacing

CHAPTER 6: BENDING MOMENTS GENERATED ON CANTILEVER SLAB

6.1 RCC I Girder

DEAD LOAD

Hand rails	load	1.74	kN
	lever arm	1.34	m
	moment	2.33	kN.m
Kerb	load	3.14	kN
	lever arm	1.34	m
	moment	4.19	kN.m
Wearing course	load	2.20	kN
	lever arm	0.55	m
	moment	1.21	kN.m
Slab	load	9.05	kN
	lever arm	0.55	m
	moment	4.97	kN.m

TOTAL MOMENT	**12.71**	**kN.m**

LIVE LOAD

Due to clearance conditions the bridge will be taking class A loading
effective width calculation "be"

A	0.7	m
Bw	0.41	m
Be	1.25	m

LIVE LOAD including impact factor is 68.4 kN

Maximum bending moment	**47.88**	**kN.m**

6.2 PSC I Girder

DEAD LOAD

Hand rails	Load	1.74	kN
	lever arm	2.24	m
	Moment	3.89	kN.m
Kerb	Load	3.14	kN
	lever arm	2.24	m
	Moment	7.01	kN.m
Wearing course	Load	1.76	kN
	lever arm	1.00	m
	Moment	1.76	kN.m
Slab	Load	18.00	kN
	lever arm	1.00	m
	Moment	18.00	kN.m

TOTAL MOMENT	**30.67**	**kN.m**

LIVE LOAD

Due to clearance conditions the bridge will be taking class A loading
effective width calculation "be"

A	1.65	m
Bw	0.41	m
Be	2.39	m

Live load including impact factor 35.7 kN

Maximum bending moment	**59.02719665**	**kN.m**

CHAPTER 7: REINFORCEMENT CALCULATION FOR CANTILEVER SLAB

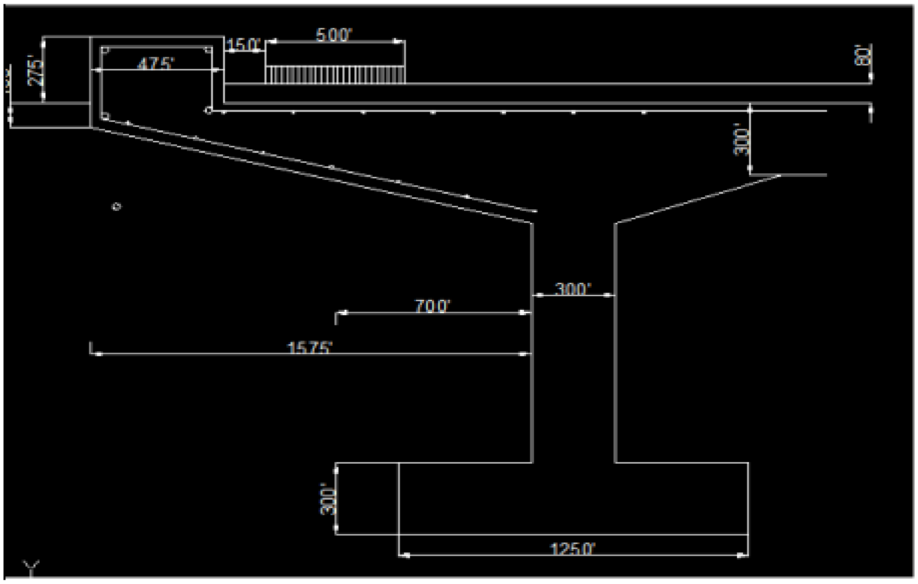


Figure 14: TYPICAL REINFORCEMENT FOR CANTILEVER SLAB

7.1 RCC I Girder

Main reinforcement

total bending moment	60.59	kN.m

Area required	1114.69	mm^2
diameter of bars assumed	16.00	mm
Spacing provided	180.28	mm

provide 16 dia bars at c/c spacing of 180 mm

Distribution steel

total bending moment	16.91	kN.m

Area required	311.03	mm^2
diameter of bars assumed	10.00	mm
Spacing provided	252.39	mm

provide 10 dia bars at c/c spacing of 250 mm

7.2 PSC I Girder

Main reinforcement

total bending moment	89.70	kN.m

Area required	1650.28	mm^2
diameter of bars assumed	18.00	mm
Spacing provided	154.12	mm

provide 18 dia bars at c/c spacing of 150 mm

Distribution steel

total bending moment	16.91	kN.m

Area required	311.03	mm^2
diameter of bars assumed	10.00	mm
Spacing provided	252.39	mm

provide 10 dia bars at c/c spacing of 250 mm

CHAPTER 8: BENDING MOMENT GENERATED ON LONGITUDINAL GIRDER

In order to compute the bending moment in the longitudinal girders its distribution over each girder have to be determined. There are various rational methods that can be used to determine the reactions over the longitudinal girders.

1. Courbon's method
2. Hendry-jaegar method
3. Morrice and little version of guyon and massonet method

In our project we have considered courbons method to determine the reactions coefficients of the girders and hence the bending moment.

Courbons method:

According to this method the reaction R_i of the cross beams on any girder of a typical bridge consisting of parallel beams is computed assuming a linear variation of deflection in the transverse direction. This deflection will be max on the exterior girders and minimum on the central girder.

The reaction R_i is given by,

$$R_i = \frac{PI_i}{\sum I_i}\left[1 + \frac{\sum I_i}{\sum I_i\, {d_i}^2}.ed_i\right]$$

Here

P = Total live load

I_i = Moment of inertia of longitudinal girder

e = eccentricity of live load

d_i = distance of girder from the axis of the bridge

Courbons method is only applicable in the following conditions

1. The ratio of span to width should lie between 2 and 4
2. The longitudinal beams are interconnected by symmetrically spaced cross girders
3. The cross girders extend to a depth of 0.75 times the depth of longitudinal girder.

8.1 RCC I Girder

Dimension Of Longitudinal Girder

Effecive span	18.00	m
Slab Thickness	0.25	m
width of rib	0.30	m
spacing of longitudnal beams	2.50	m
overall depth	1.55	m
length of I girder	1.25	m

Elastic Modulus	27386.13	N/mm^2

Moment Of Inertia for I girder

about NA rect 1	0.02143437500	m^4
about NA rect 2	0.00281250000	m^4
area rect 1	0.30000000000	m^4
area rect 2	0.37500000000	m^4
Distance	0.62500000000	m^4

Moment of inertia	320028125000.00	mm^2

Bending Moment Due to DEAD LOAD

Wearing Course	4.40	kN/m
Deck Slab	15.00	kN/m
I Rib	11.52	kN/m
Cross beams	3.67	kN/m

Total load	**34.59**	**kN/m**

Max. Bending Moment due to dead load	**1400.76**	**kN.m**

Bending Moment Due to LIVE LOAD

Reaction Factors for beam A,B and C

Ra	1.89
Rb	1.33
Rc	0.77

Max. Bending Moment	**455.286**	**kN.m**

Net Bending Moment On Beams

A	1023.63	kN.m
B	720.87	kN.m
C	418.10	kN.m

8.2 PSC I Girder

Dimension Of Longitudinal Girder

Effecive span	18.00	m
Slab Thickness	0.30	m
width of rib	0.30	m
spacing of longitudnal beams	6.00	m
overall depth	1.60	m
flange length of I girder	1.00	m

Elastic Modulus	27386.13	N/mm^2

Moment Of Inertia for I girder

about NA rect 1	0.01822500000	m^4
about NA rect 2	0.00225000000	m^4
area rect 1	0.30000000000	m^4
area rect 2	0.30000000000	m^4
Distance	0.60000000000	m^4

Moment of inertia	238725000000.00	mm^4

Bending Moment Due to DEAD LOAD

Wearing Course	10.56	kN/m
Deck Slab	43.20	kN/m
I Rib	10.80	kN/m
Cross beams	5.83	kN/m

Total load	**70.39**	**kN/m**

Max. Bending Moment	**2850.93**	**kN.m**

Bending Moment Due to LIVE LOAD

Reaction Factors for beam A and B

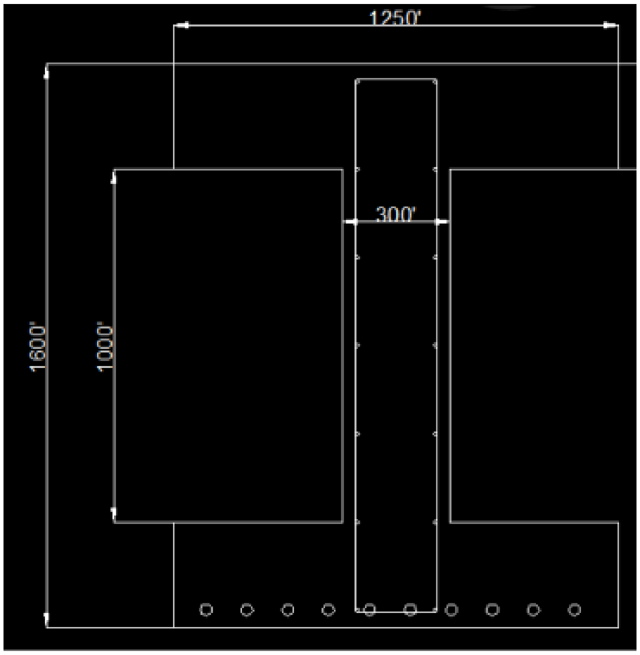
Ra	3.21
Rb	0.79

Max. Bending Moment	**455.286**	**kN.m**

Net Bending Moment On Beams

A	1737.59	kN.m
B	425.02	kN.m

CHAPTER 9: REINFORCEMENT FOR LONGITUDINAL GIRDER



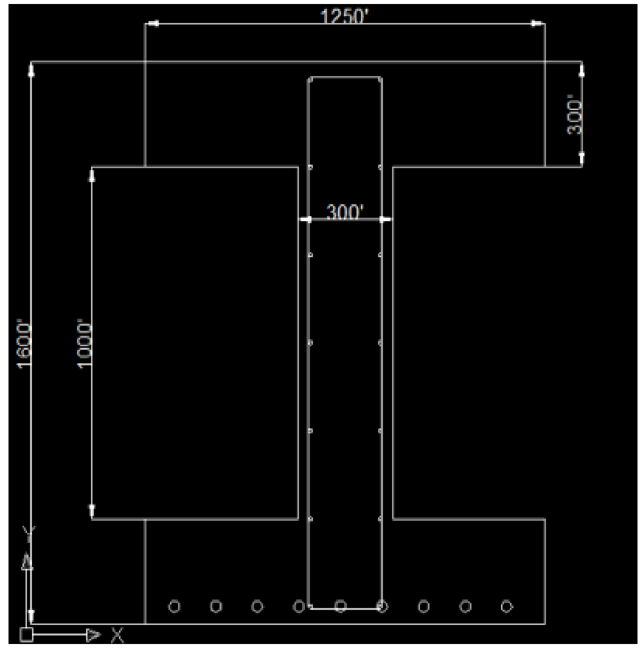


Figure 15: REINFORCEMENT DETAILS FOR RCC I GIRDER

In RCC I Girders reinforcement is provided as shown in the above figure. The reinforcement provided in the web is for additional stiffness since it a deep beam as per the norms of IS 456. The vertical reinforcement in the web is for the resisting the shear force that will be generated in the girders. Since no tension is generated in the above portion of the beam no steel reinforcement is provided additionally.

The calculations for the reinforcement in the longitudinal girders are shown below for RCC as well as PSC girders in sub-chapters 8.1 and 8.2 respectively and the method used to calculate the reinforcement is explained earlier

9.1 RCC I Girder

CENTRAL GIRDER

Desgning bending moment	2121.63	kN.m

Area of main steel r/f required	7857.89	mm^2
diameter of bars used	32.00	mm
spacing	127.87	mm

Providing 32 dia bars c/c spacing of 125 mm

END GIRDER

Desgning bending moment	2424.39	kN.m

Area of main steel r/f required	8979.24	mm^2
diameter of bars used	32.00	mm
spacing	111.90	mm

Providing 32 dia bars c/c spacing of 110 mm

SIDE FACE REINFORCEMENT

area of steel required	300	mm^2
using dia bars	10	mm
Spacing	261.6666667	mm

providing 10 mm dia bars c/c spacing of 250 mm

9.2 PSC I Girder :

Designing as type 1

Lever Arm	0.78	m
Total Moment	3247.896	kN.m

Final prestressing force	4163.969	kN
Initial prestressing force	4898.787	kN

Calculation are performed for Zone 1

Check for area

Σcbci	18.5	N/mm^2
Σcbc	21	N/mm^2

Grade of Concrete	60
Fci	50

Area should be less than 600000 mm^2

A1 i.e. due to initial force	529598.6	mm^2
A2 i.e. due to final force	396568.5	mm^2

Hence area is safe

Check for section modulus

Zt	250884615.4	Should be greater than	95340860.15	ok
Zb	250884615.4	Should be greater than	134176615.9	ok

Location of cable line

k2, Radius of gyration	271791.67	
ecl1	169.06	mm
ecl2	339.74	mm
ecu1	567.67	mm
ecu2	339.74	mm

Ecl	169.06	mm
Ecu	339.74	mm

C3C5	570.061489	mm
C1C4	1087.951645	mm

min position of prestress wire	748.21	mm
max positon of prestress wire	739.12	mm

Assuming wire dia	5	mm
area of one strand	39.25	mm
Area of wire required	4082.322775	mm^2
No. of strands required	104	
No. of strand in one wire	5	
No. of wires	21	
No. of wire in one tendon	7	
No. of tendons	3	

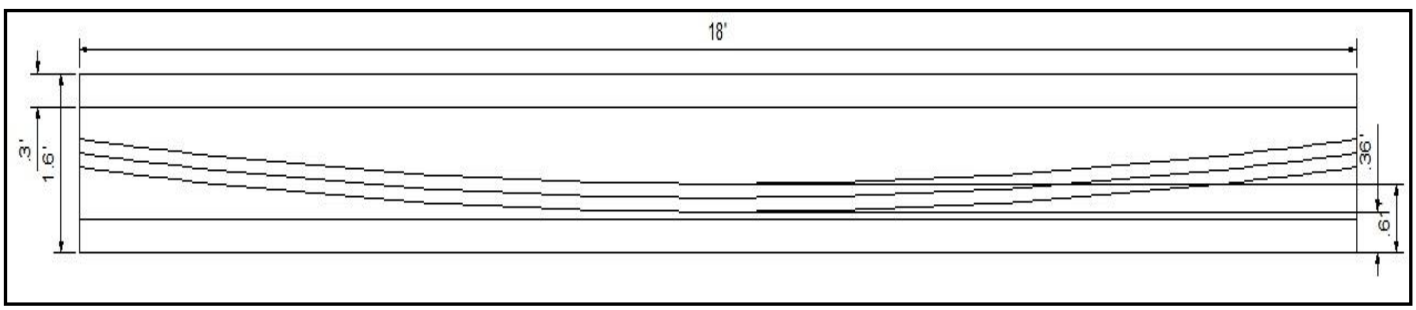


Figure 16: CABLE PROFILE FOR PSC GIRDER

Detailed sections and eccentricity at extremes and at mid span are given on the next page

LOCATION	ECCENTRICITY OF WIRE 1	ECCENTRICITY OF WIRE 2	ECCENTRICITY OF WIRE 3
MID SPAN	190	310	430
AT L/4	80	200	320
AT EXTREMES	-200	-80	40

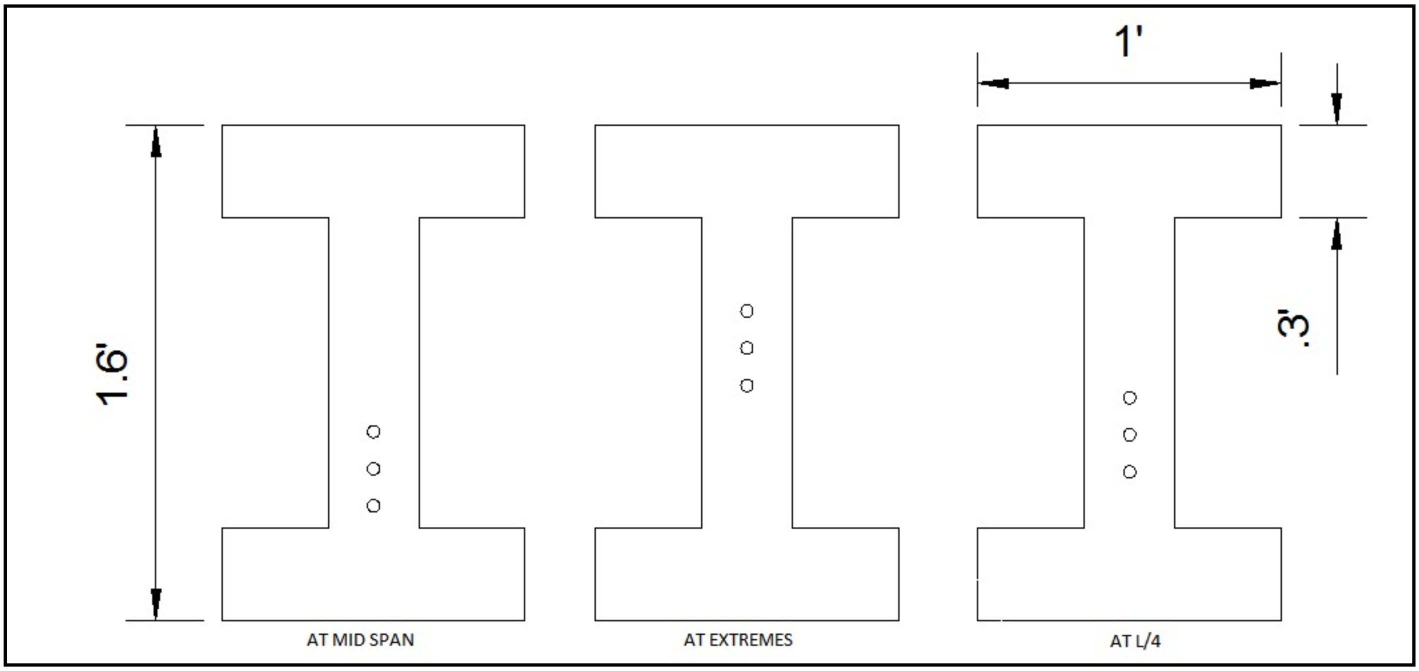


Figure 17: ECCENTRICITY OF WIRE AT VARIOUS SECTIONS

CHAPTER 10: BENDING MOMENT GENERATED ON CROSS BEAMS

10.1 RCC I Girder

Bending Moment due to DEAD LOAD

Total dead load from slab	18.7792	kN
DL of cross beam	14.784	kN
TOTAL DEAD LOAD	33.5632	kN

BENDING MOMENT			
	Positive	3.84	kN.m
	Negative	7.16	kN.m

Bending Moment due to LIVE LOAD

TOTAL LIVE LOAD	**350**	**kN**
Effective Load on cross beams	**285.92**	**kN/m**

BENDING MOMENT			
	Positive	118.73	kN.m
	Negative	114.80	kN.m

10.2 PSC I Girder

Bending Moment due to DEAD LOAD

total load from slab	54.88	kN
DL of cross beam	17.64	kN
TOTAL DEAD LOAD	72.52	kN

BENDING MOMENT			
	Positive	13.20	kN.m
	Negative	24.62	kN.m

Bending Moment Due to LIVE LOAD

TOTAL LIVE LOAD	**350**	**kN**
Effective Load on cross beams	**302.5872**	**kN/m**

BENDING MOMENT CALCULATIONS

BENDING MOMENT			
	Positive	**199.90**	kN.m
	Negative	**193.28**	kN.m

CHAPTER 11: REINFORCEMENT CALCULATION FOR CROSS BEAMS

11.1 RCC I Girder

Permissible shear stress in concrete for M30 grade	10.00	N/mm^2
permissible shear stress in steel	200.00	N/mm^2

modular ratio	9.33

Design constants

K	0.32
lever arm,j	0.89
R	1.42

Positive moment	122.57	kN.m
effective depth	0.725	m

Area of steel required	945.5971096	mm^2

Area of steel provided	761.25	mm^2

Area of steel required	1706.84711	mm^2
Dia of bars assumed	18	mm
No. of bars required	6.710887432	

Provide 7 bars of 18 dia

Negative moment	121.96	kN.m
effective depth	0.725	m

Area of steel required	940.9011654	mm^2
Dia of bars assumed	18	mm
No. of bars required	3.699383366	

Provide 4 bars of 18 dia

11.2 PSC I Girder

Permissible shear sstress in concrete for M30 grade	10.00	N/mm^2
permissible shear stress in steel	200.00	N/mm^2

modular ratio	9.33

Design constants

K	0.32
lever arm,j	0.89
R	1.42

Positive moment	213.10	kN.m
effective depth	0.625	m

Area of steel required	1907.02	mm^2

Area of steel provided	562.5	mm^2

Area of steel required	2469.5	mm^2
Dia of bars assumed	20	mm
No. of bars required	7.8	

Provide 8 bars of 20 dia

Negative moment	217.9	kN.m
effective depth	0.625	m

Area of steel required	1950	mm^2
Dia of bars assumed	18	mm
No. of bars required	7.66	

Provide 8 bars of 18 dia

CHAPTER 12: MATERIALS REQUIRED

Material used	Steel required		Concrete required	
	mm^3	m^3	mm^3	m^3
RCC	442866415.97	0.443	90030038584.03	90.03
PSC	291125603.9	0.292	40024779396.34	40.024

As we can see the material requirement for PSC is much less than the material requirement for RCC hence PSC is much more economical than RCC bridges for span of 18 meters. The major difference in the demands of concrete and steel is due to the removal of I girder. As we have seen in the above report the bridge which is designed using RCC had 3 longitudinal girders spanning along the length of 18 meters where as in case of PSC we have only 2 I girders. The requirement of steel is also affected since one I girder is reduced hence the steel provided in it is also reduced also the steel used in designing is of very high strength and hence the area requirement in the section reduces hence reducing the volume of steel required in the bridge.

CHAPTER 13: CONCLUSION

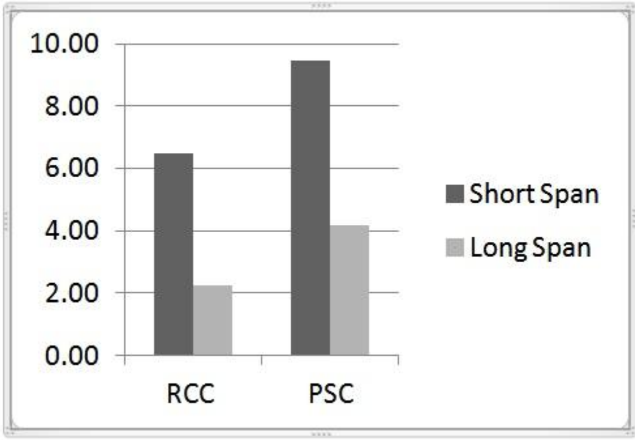


Figure 1: B.M. over deck slab due to dead load

The above graph relationship between the bending moments generated in RCC and PSC bridges due to dead as we can see higher bending moments are generated in PSC this is because the depth of deck slab is higher and the need for increasing the depth is since there is larger distance between the main girders

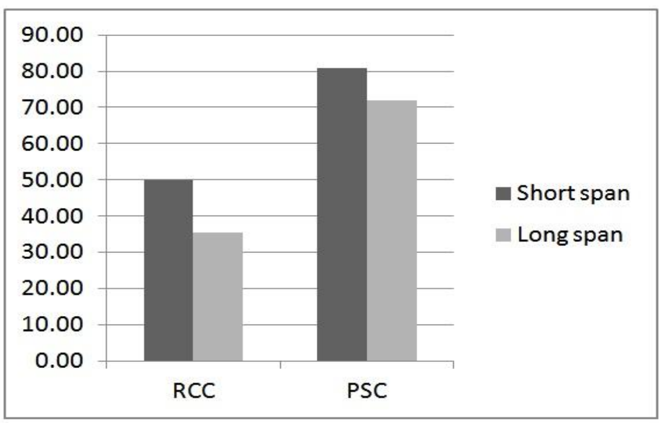


Figure 2 :B.M. over deck slab due to live load

The above graph shows relationship between the live load bending moments generated in the deck slab along the short and the long span as we can see higher moments are generated in the PSC deck slab this is because a larger lever arm is generated since the dimensions of the slab are large.

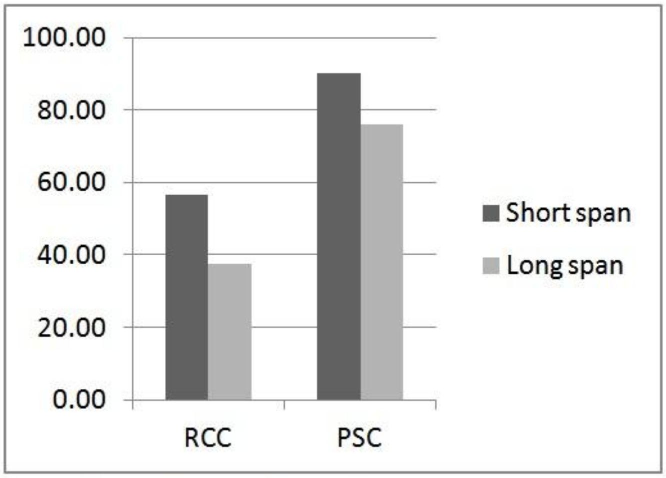


Figure 3 : Net B.M. over deck slab

The above graph shows relationship between the net bending moments generated in the deck slab along the short and the long span as we can see higher moments are generated in the PSC deck slab this is because since moments due to both dead load and live load are increased.

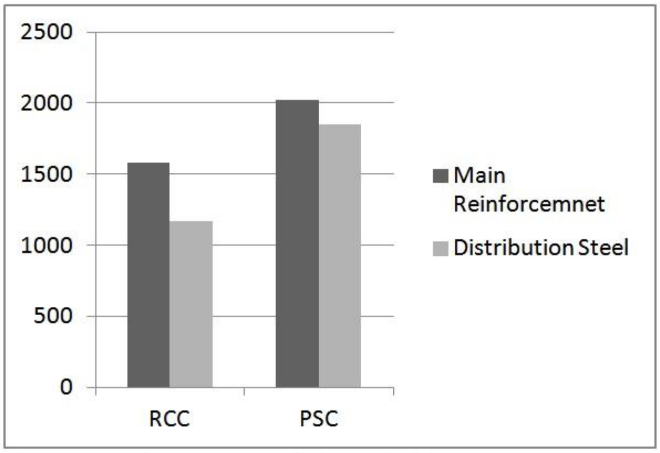


Figure 4 : Reinforcement provided in deck slab

The above graph shows relationship between the reinforcement provided along the short and the long span since higher moments are generated in the deck slab hence more reinforcement is provided in the deck slab of PSC bridge.

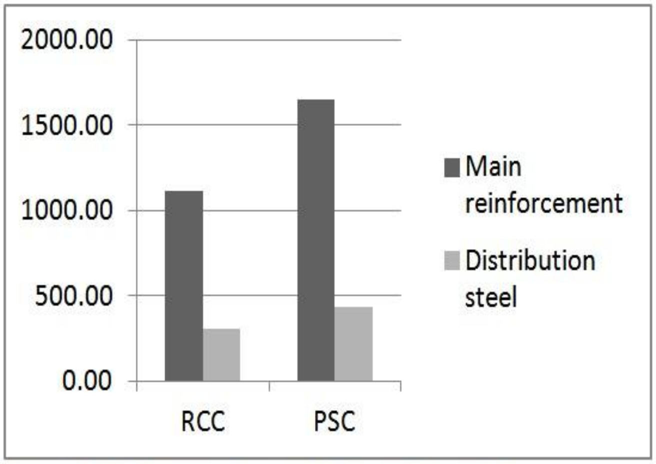


Figure 5 : Reinforcement provided in cantilever slab

The above graph shows relationship between the main reinforcement and the distribution steel provided in the cantilever portion of the slab of RCC and PSC bridges since the bending moment generated in PSC is higher therefore the steel requirements are also high. We can also note that the amount of increase in the main reinforcement is much higher than that of distribution steel this is because the bending moment is majorly changed along the direction of cantilever.

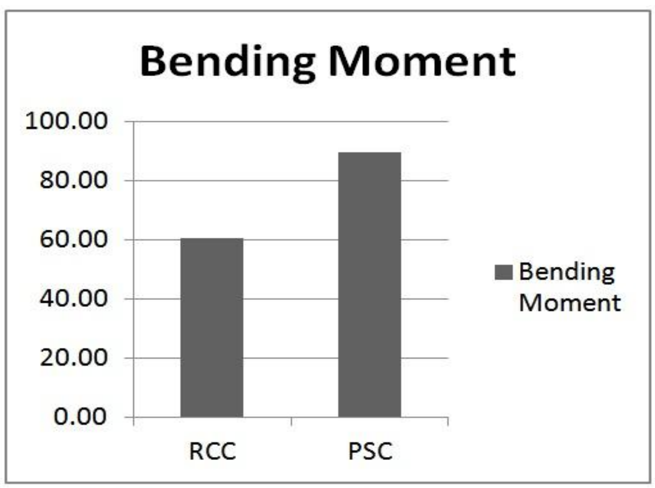


Figure 6 : B.M. generated in cantilever

The above graph shows relationship between the bending moments generated in the cantilever portion of the slab of RCC and PSC bridges depth is higher in case of PSC and also the lever arm generated in PSC is higher hence larger bending moments are generated in PSC.

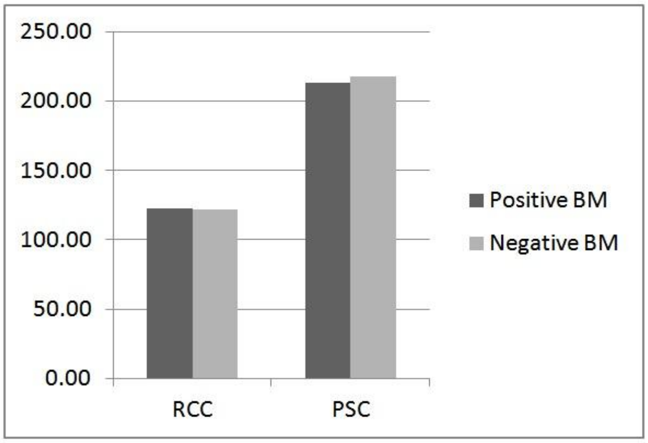


Figure 7 : B.M. generated in cross beams

The above graph shows relationship between the bending moments generated in the cross beam of RCC and PSC bridges as the loas is calculated over the beam by trapezoidal rule hence the net force acting on the cross beams of PSC bridge is higher because the slab sixe is large,since the load acting on the cross beams is higher it generated a greater Bending Moment

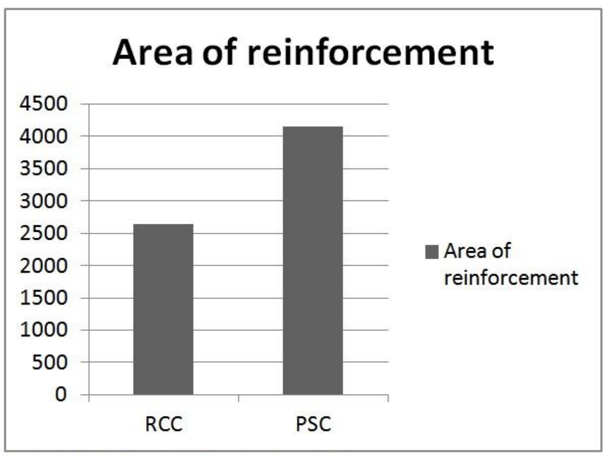


Figure 9 : Reinforcement in cross beams

The above graph shows relationship between the reinforcements provided in the cross beam of RCC and PSC bridges as the net Bending Moment is higher in case of cross beams provided in PSC bridge hence more reinforcement is provided.

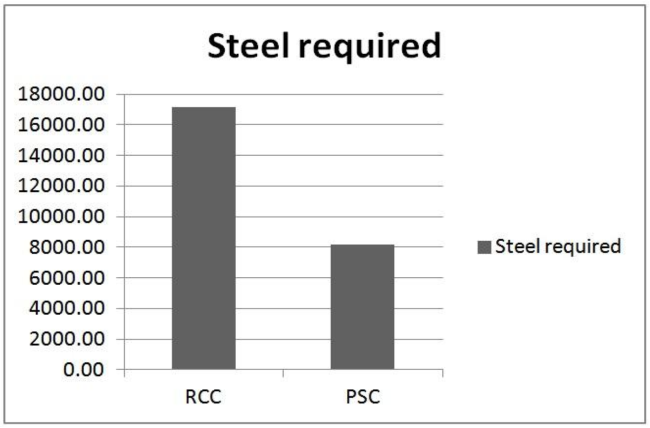


Figure 8 : Reinforcement provided in longitudinal girders

The above graph shows relationship between the reinforcements provided in the main beam of RCC and PSC bridges and we can see the requirement of PSC bridge is very less it is because pre tensioned wires of very high strength are used

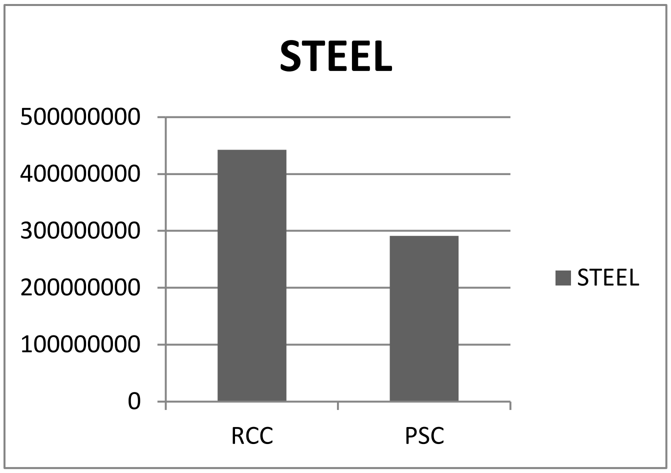


Figure 10: Total Steel provided in bridge

The above graph shows relationship between the total steel required in the construction of RCC and PSC bridges and we can see the total steel requirement of PSC bridge is very less, it is primarily because of the reduction of one longitudinal girder

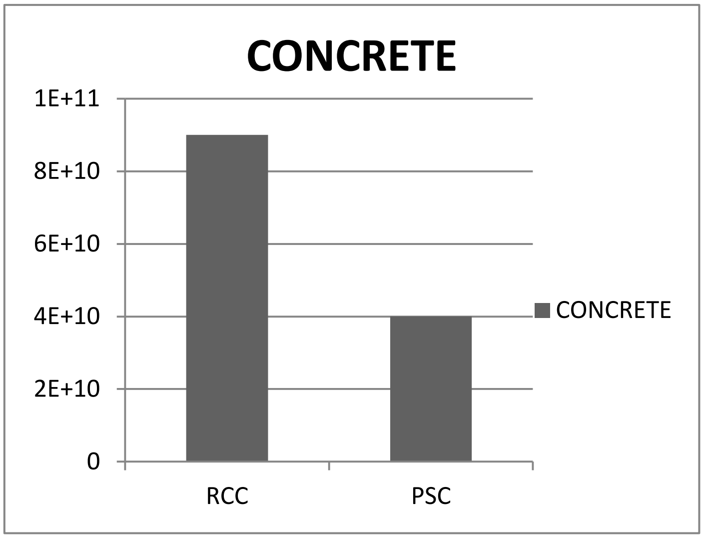


Figure 11: Total Concrete provided in Bridge

The above graph shows relationship between the total concrete required in the construction of RCC and PSC bridges and we can see the total concrete requirement of PSC bridge is very less, it is primarily because of the reduction of one longitudinal girder and instead of 5 cross beams in we are only using 3 cross beams.

RESEARCH SCOPE

In this project we have compared the material requirement for an RCC I girder bridge and PSC I girder bridge and established why is there a difference between the two bridges requirement. There is a wide scope for research and to learn more about bridges and determine new ways to reduce the material requirement in either or both of the bridges. Following are just a few:

1. Cost Variation in bridges with increase in span.
2. Cost Variation in bridges with increase in no. of lanes.
3. Simply Supported Girders vs. Continuous Girders over a pier.
4. Economizing the section with number of Girders and depth.
5. Rehabilitation Cost comparison.
6. Maintenance Cost comparison.
7. Comparison in Cost of Construction.
8. Designing the bridges for other types of loading and comparing them.
9. Comparison in Limit State Design of Bridges and AASHTO LRFD.
10. Comparison of I Girders with Box Girders in PSC & Steel.

APPENDIX

Sl. No.	Materials	Weight per m³ kN
1.	Ashlar (granite)	27
2.	Ashlar (sandstone)	24
3.	Stone setts: (a) Granite	26
	(b) Basalt	27
4.	Ballast (stone screened, broken 2.5 cm to 7.5 cm gauge, loose): (a) Granite	14
	(b) Basalt	16
5.	Brickwork (pressed) in cement mortar	22
6.	Brickwork (common) in cement mortar	19
7.	Brickwork (common) in lime mortar	18
8.	Concrete (asphalt)	22
9.	Concrete (breeze)	14
10.	Concrete (cement-plain)	22
11.	Concrete (cement-plain with plums)	23
12.	Concrete (cement-reinforced)	24
13.	Concrete (cement-prestressed)	25
14.	Concrete (lime-brick aggregate)	19
15.	Concrete (lime-stone aggregate)	21
16.	Earth (compacted)	18
17.	Gravel	18
18.	Macadam (binder premix)	22
19.	Macadam (rolled)	26
20.	Sand (loose)	14
21.	Sand (wet compressed)	19
22.	Coursed rubble stone masonry (cement mortar)	26
23.	Stone masonry (lime mortar)	24
24.	Water	10
25.	Wood	8
26.	Cast iron	78
27.	Wrought iron	77
28.	Steel (rolled or cast)	78

FIGURE 1: List of density for different materials

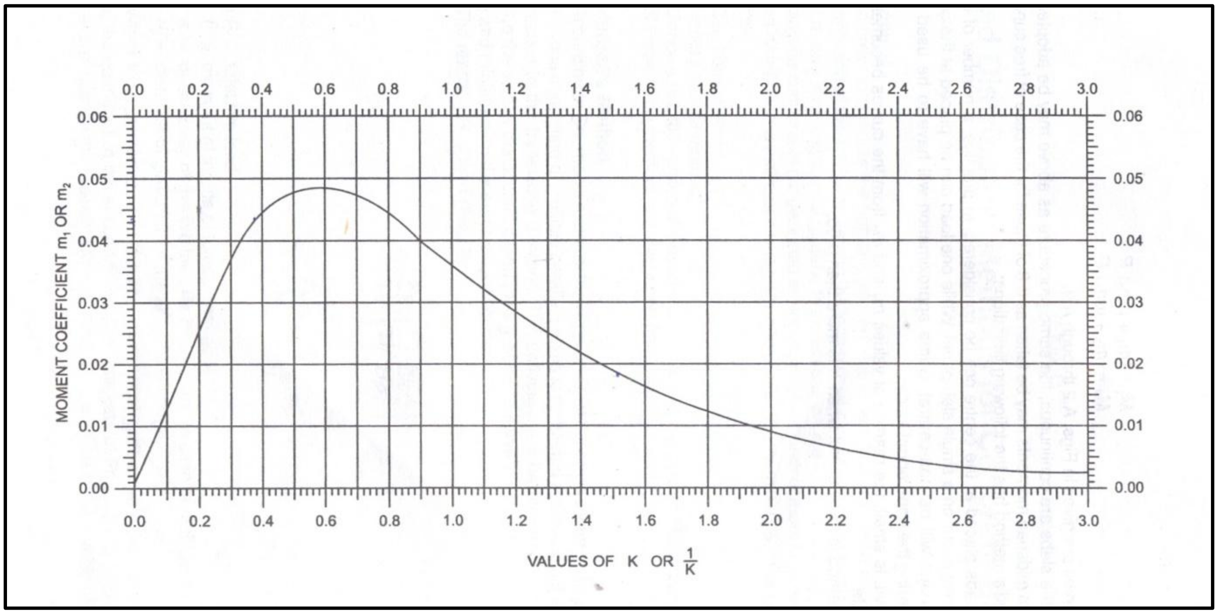


Figure 2: Pigueads Curve for Dead Load Bending Moment

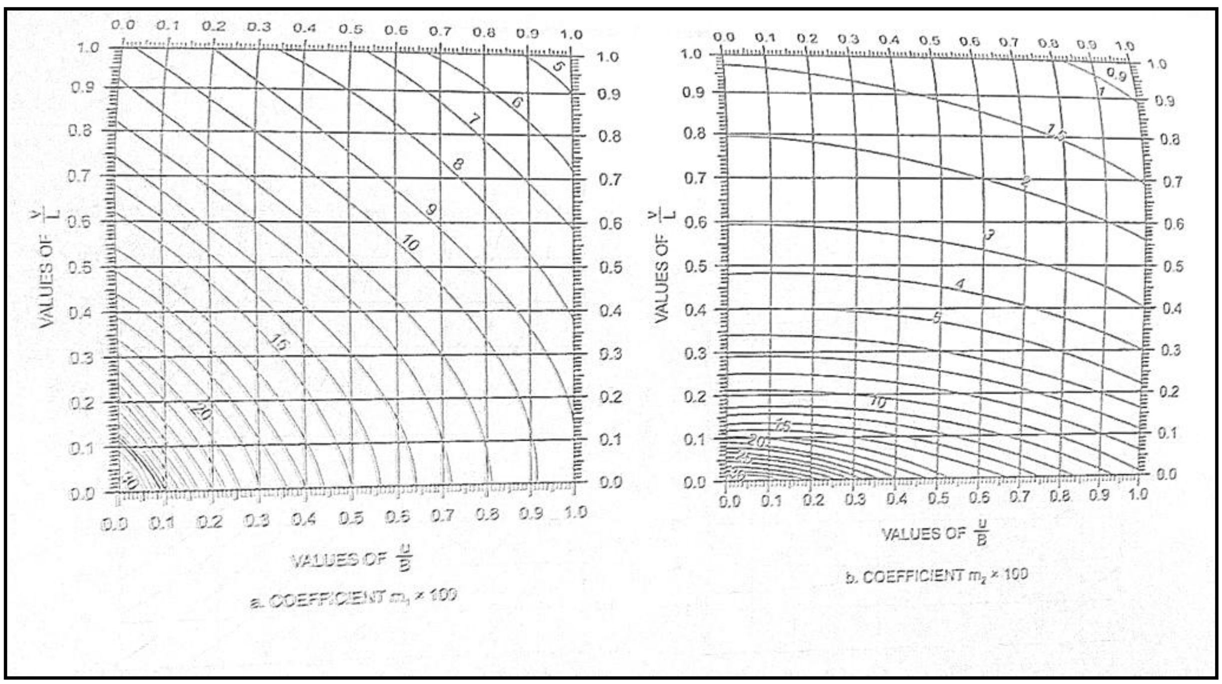


Figure 3: Pigueads Curve for k = 0.5

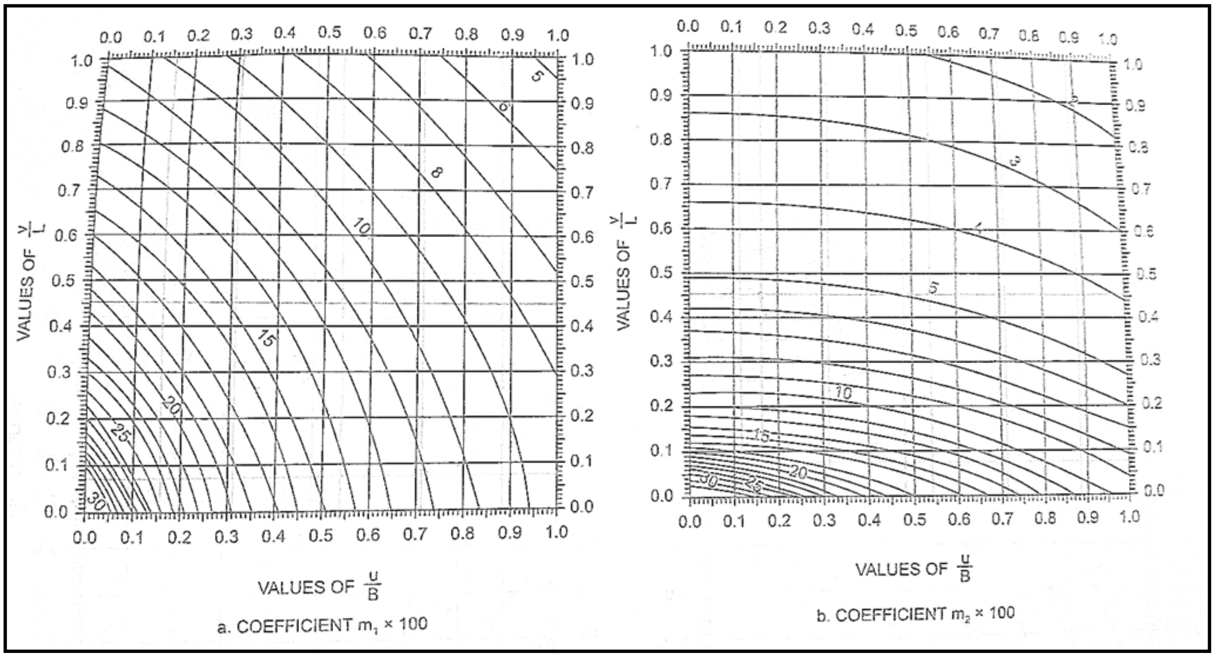


Figure 4: Pigueads Curve for k = 0.6

Table 19 Design Shear Strength of Concrete, τ_c, N/mm²

(*Clauses* 40.2.1, 40.2.2, 40.3, 40.4, 40.5.3, 41.3.2, 41.3.3 *and* 41.4.3)

$100\frac{A_s}{bd}$	Concrete Grade					
	M 15	M 20	M 25	M 30	M 35	M 40 and above
(1)	(2)	(3)	(4)	(5)	(6)	(7)
≤ 0.15	0.28	0.28	0.29	0.29	0.29	0.30
0.25	0.35	0.36	0.36	0.37	0.37	0.38
0.50	0.46	0.48	0.49	0.50	0.50	0.51
0.75	0.54	0.56	0.57	0.59	0.59	0.60
1.00	0.60	0.62	0.64	0.66	0.67	0.68
1.25	0.64	0.67	0.70	0.71	0.73	0.74
1.50	0.68	0.72	0.74	0.76	0.78	0.79
1.75	0.71	0.75	0.78	0.80	0.82	0.84
2.00	0.71	0.79	0.82	0.84	0.86	0.88
2.25	0.71	0.81	0.85	0.88	0.90	0.92
2.50	0.71	0.82	0.88	0.91	0.93	0.95
2.75	0.71	0.82	0.90	0.94	0.96	0.98
3.00 and above	0.71	0.82	0.92	0.96	0.99	1.01

NOTE — The term A_s is the area of longitudinal tension reinforcement which continues at least one effective depth beyond the section being considered except at support where the full area of tension reinforcement may be used provided the detailing conforms to **26.2.2** and **26.2.3**

Fugure 5: Design Shear Streangth Of Concrete

Table 20 Maximum Shear Stress, $\tau_{c\,max}$, N/mm²

(*Clauses* 40.2.3, 40.2.3.1, 40.5.1 *and* 41.3.1)

Concrete Grade	M 15	M 20	M 25	M 30	M 35	M 40 and above
$\tau_{c\,max}$, N/mm²	2.5	2.8	3.1	3.5	3.7	4.0

Figure 6: Max Shear Stress of Concrete

Table 21 Permissible Stresses in Concrete **IS 456 : 2000**

(*Clauses* B-1.3, B-2.1, B-2.1.2, B-2.3 *and* B-4.2)

All values in N/mm².

Grade of Concrete	Permissible Stress in Compression		Permissible Stress in Bond (Average) for Plain Bars in Tension
	Bending	Direct	
(1)	(2)	(3)	(4)
	σ_{cbc}	σ_{cc}	τ_{bd}
M 10	3.0	2.5	—
M 15	5.0	4.0	0.6
M 20	7.0	5.0	0.8
M 25	8.5	6.0	0.9
M 30	10.0	8.0	1.0
M 35	11.5	9.0	1.1
M 40	13.0	10.0	1.2
M 45	14.5	11.0	1.3
M 50	16.0	12.0	1.4

NOTES

1 The values of permissible shear stress in concrete are given in Table 23.

2 The bond stress given in col 4 shall be increased by 25 percent for bars in compression.

Figure 7: Permissible stresses in Concrete

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