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DESIGN OF COMPOSITE GIRDER DECK TYPE BRIDGE

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Abstract

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This report provides guidance on the design of steel-concrete composite bridges, which consist of steel girders and reinforced concrete slabs on top. Two common forms are considered: multi-girder and ladder deck bridges. Guidance is given on the general considerations for the preliminary and detailed design process, in addition to guidance on the verification of structural adequacy in accordance manual and relevant design and material standards.

Though few such constructions have come up in India during the last few decades there is now a sense of realization of the potential benefits of steel concrete composite construction. It is an ideal example wherein there is most effective utilization of materials i.e. concrete is in compression and steel in tension. Composite sections have higher stiffness and high ductility of steel ensures better seismic resistance.

The aim of the report is to provide guidance for both the novice and experienced bridge designer on the design of cost-effective steel-concrete composite bridges. The aim of the report is to provide guidance for both the novice and experienced bridge designer on the design Analysis and Design of Composite Bridge Structures

Keywords— ridge structures, Steel main beams, GFRP deck, pultrude GFRP material

1. Introduction

1.1 General

Steel-concrete composite bridges provide an efficient and cost-effective form of bridge construction. By utilizing the tensile strength of steel in the main girder and the compressive strength of concrete in the slab, the bending resistance of the combined materials is greatly increased and larger spans are made possible. steel bridges with a composite concrete deck is a means of circumventing this step. Indeed, the steel girder's ability to support formwork, reinforcement and the deck concrete has greatly contributed to the increasing popularity of composite bridges, along with the reduced construction time compared to concrete bridge

The guide assumes the reader is familiar with the general principles of limit state design and has some knowledge of structural steelwork. It provides advice on the general considerations for the preliminary and detailed design process, in addition to guidance on the verification of structural adequacy in accordance with the Bridge manual1 and relevant design and material standards.

1.2 Steel-concrete composite bridge girders

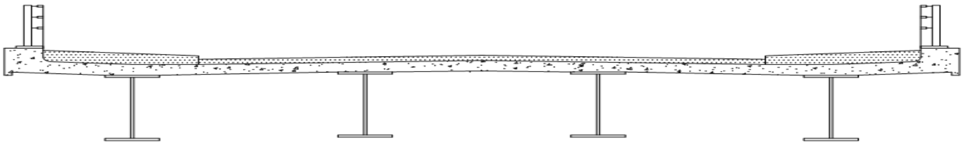
A composite steel composite girder consists of precast reinforced concrete deck slab or precast pre-stressed concrete deck slab with I steel section as beam. The steel structure of a bridge is fixed to the concrete structure of the deck so that the steel and concrete act together, so reducing deflections and increasing strength. This is done using 'shear connectors' fixed to the steel beams and then embedded in the concrete. Steel–concrete composite beams are widely used buildings and bridges due to their capability in developing high flexural strength and stiffness.

2. Objective :- Design of a composite girder of a deck type bridge

2.1 Structural Configuration

2.1.1 Multi-girder bridges

In multi-girder construction a number of similarly sized longitudinal plate girders are arranged at uniform spacing across the width of the bridge The deck slab spans transversely between the longitudinal girders and cantilevers transversely outside the outer girders. The girders are braced together at supports and at some intermediate positions. Composite action between the reinforced concrete deck slab and the longitudinal girders is achieved by means of shear connectors welded on the top flanges of the steel girders.



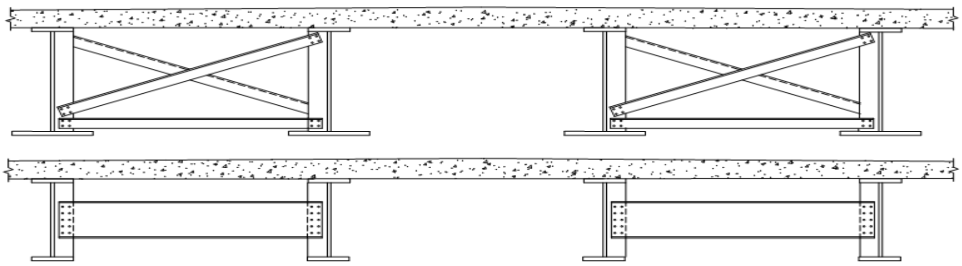
2.1.2 Longitudinal girders :-

The steel girders are usually fabricated I-section plate girders; for smaller spans, it is possible to use rolled section beams (Universal Beams) but, for reasons discussed below, rolled sections are rarely used today. Usually, girders are spaced between about 3.0 and 4.0 m apart, and thus, for an ordinary two-lane over bridge, four girders are provided. This suits the deck which has to distribute the vertical loads from the wheels.

3. Bracing:-

3.1.1 Intermediate bracing:-

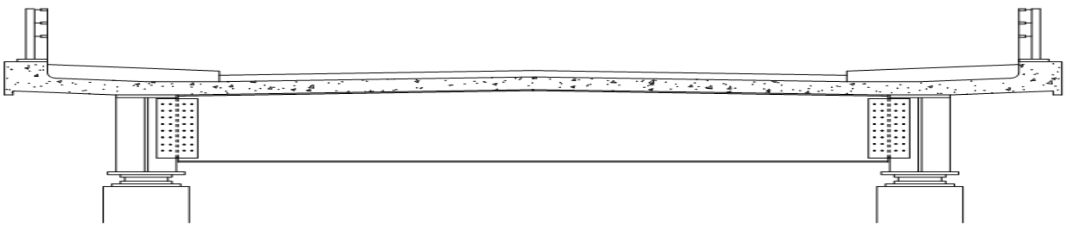
In the completed bridge, intermediate bracing is usually needed at discrete positions in the spans of multi-span bridges, to stabilise the bottom flanges adjacent to intermediate supports (where they are in compression). During construction, bracing is needed to stabilise both the bottom flanges adjacent to intermediate supports and the top flanges in mid span regions. Where the girders are curved in plan, bracing will also be needed to provide 'radial' restraint to the bottom flanges In most cases,



Typical paired bracing arrangement

3.1.2 Cross girders at internal supports (pier diaphragms)

At the internal supports of continuous spans, the cross girders are very often deeper than the intermediate cross girders, providing a stiffer and stronger 'pier diaphragm', with bolted connections that can transfer the larger restraint forces at the supports



Cross girder at an intermediate support of a ladder deck bridge

4. Methodology:-

4.1.Hydrological:-

Peak rainfall in given catchment area Q = 61.6m3 /sec

Discharge over the river Qmax =38.94m3/sec

Total discharge = Q+Qmax
=38.94+61.6
=100.54 m3/sec

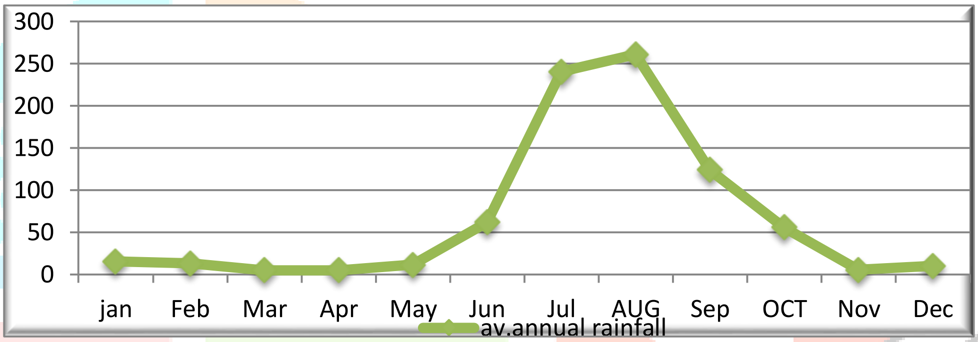
Velocity in river water in flood condition;

MANNING FORMULA = 1/N x M2/3 X √1

D = p/$_\gamma$ x (1+ sin$_\varphi$ /1- sin$_\varphi$) 2

D = (15000/ 1200) x (1+sin300 / 1-sin300) 2

D = 11 mt



Load Calculation:

Dead Load= Deck slab + Girder + side walls

W=12.2+3.64xL =740kg/m2

Live load

For wheel load: 50 tons (By according to traffic survey (A'-A') IRC loading

Impact load of live load

9/13.5+L (L=Length of span)
=9470kg/m2

Wind load :- By wind load specification at 28 m height =141kg/m2
Lateral loads:-On rolling and parapet =150kg/m2
On kerb=750kg/m2

Longitudinal force :-
Tentative effort =20% of live load
= 20/100 x5000
=10000kg/m2

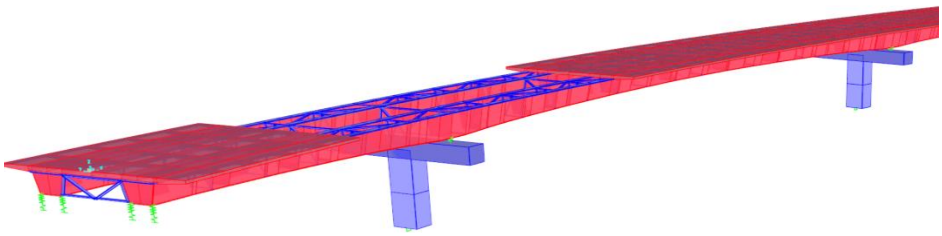
Design of RCC deck Slab

Data selected: Overall width of bridge = clear width+ (2xwidth of kerb) + drains

= 7.5+ (2x1.2) + (2x.3) mtrs.

= 10.5 mt.

Thickness of slab be selected as 80 mm per meter of span
D = 80x40 = 3200 mm
Effective depth d = 3200-50 = 3150mm.

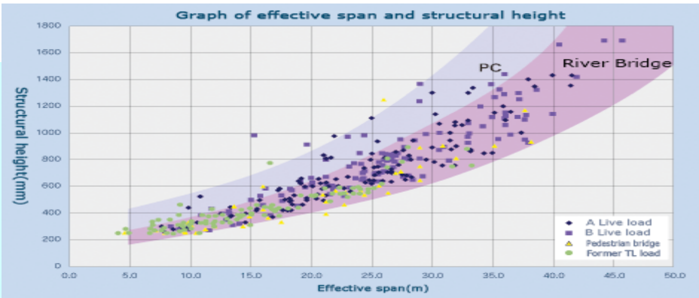


Effective Span

Clear span + effective depth = 7.5 + 3.15 = 10.65 m

Centre to center of supports = 7.5 + 3.2 = 10.7

Therefore Effective span = 10



Dead Load Bending Moment per Meter Width

Dead load of slab = 3.200 x 24 = 76.8 KN/m2
Dead load of wearing coat = .080 x 22 = 1.76 KN/m2
Total = 78.56 KN/m2
=$(Wl^2)/8$ =(78.56 X10.65)/8 **= 103.7 KN/m**

Live load BM

W = 500mm = .5 m
Therefore Distance between centers of two vehicles = 1.2 + .5 = 1.42 m

Minimum distance of wheel from the kerbs = 0.15 + (0.50/2)
= 0.4 m

moment which occurs at centre of span =28.35X – 23.25xs = 58.74 kN/m

Impact factor = 0.35

= 158.45 kn-m = 158.45 x 106 N-m

Distribution Reinforcement : As per the recommendation of IRC, distribution steel is to be provided to resist 0.3 times the live load moment including impact contribution and 0.2 times the dead load moment. M = 0.3x 58.74 + 0.2X (40.29 + 23.5)

= 30.38 kN-m = 30.38 x 106 N-mm

Effective depth for distribution steel

= 350 - x thickness of distribution steel

= 350 - x12 = 344mm = 350 mm take (if 12 mm bars are used)

Ast = = 522 mm2 = 550 mm2

Take Spacing of 12 mm bars

S = x (122) x1000/522
= 216 Provide 12 mm bars at 200 mm c/c.

Design of flange

Flange area req. = m/ Ωbct xd

Af = 160400x106 /165x 2500

Af = 18501.8mm2
Flange outstand =500-8/2 = 246mm

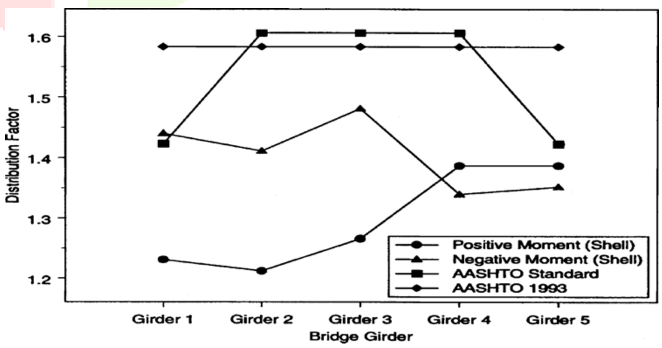
Flange are provide by plate = 500 x t
= 500x 40
= 20000 mm2
Check = moment of inertia of the plate girder
Ixx = 8x 25003/12+ 2x (500x403 /12+ 500x40 x (2500/2+20)2
Ixx = 7493800x104mm4
.Moment of resistance = Ωbct x I/ y
M g = 165 x 7493800 x 104/ (2500/2+30)
= 7531.42x106 N/mm.

Design of welding:-
Horizontal shear/ mm. = Vay /Ixx
V = 16040kN
Ay = 500x16x (2500/2 + 16/2)
Ay = 1006.4 x104mm4
Ixx = 7943800 x 104mm4
Horizontal shear= 160400 x103x1006.4 x104 / 7493800x104
= 349.20 N/mm
Size of weld = welding is done on both side
349.20 = 2 x (.7xSx108) **41 |** R G P M S

= 2.47 mm.

Permissible pitch = 96 + 40 =136mm

Provide 40 mm long fillet weld at pitch of 80mm.the 40mm, 30mm , 16mm



Design of bearing stiffeners:

Max. Shear force V = 16040 kN.

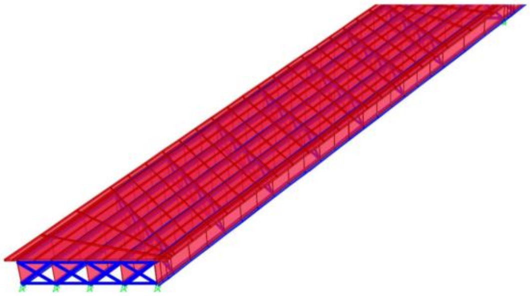
Allowable bearing stress = .75 FY
Bearing area req. = 160400 x103 /187.5
= 8577 mm2
Let's try two plate 200 mm wide as stiffeners.
Thickness of pates = (8577 /2) x 200
Out stand = 200 mm
Bearing area provide = 2 x200 x20
= 10560mm2
IXX = 2 x (20 x 2003 /12 + 20 x200 (100+8)2/2)

Ixx = 11319.46 x 104mm4
Radius of gyration r = Ixx /A
= 11319.46 x104 /10560
= 103.5 mm
Effective length = .7 x 2500 = 1750 mm
λ = l/r , λ = 1750/103.5

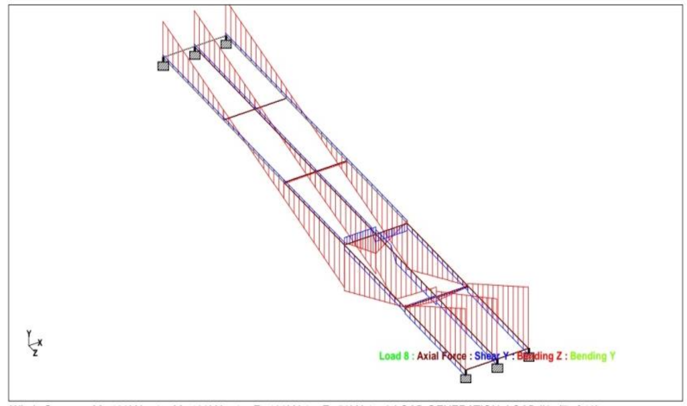
λ = 16.90 mm

By I.S. 800- 1984 l/r =16.90, FY =250N/mm2
Ωac = 148.67 N/mm2
Safe load = 148.62 x10560
= 15694.4 kN <16040 Hence Safe.
So that provides 400mmx20mm plates as stiffeners

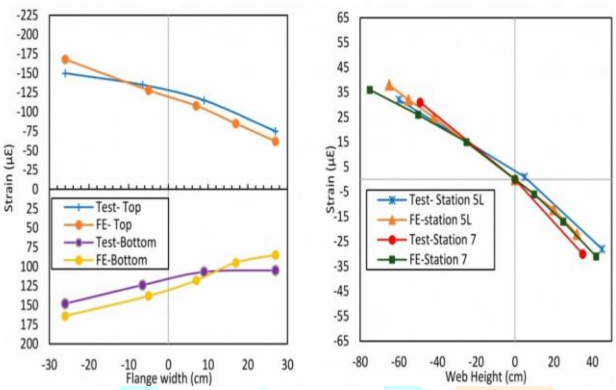
So that spacing is provide = 300 mm.

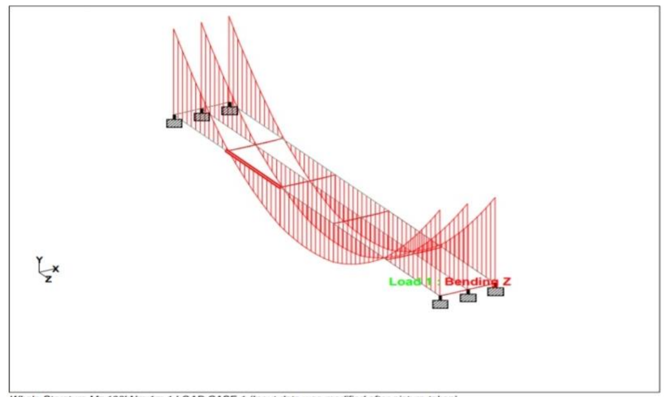


Model of a composite I girder bridge



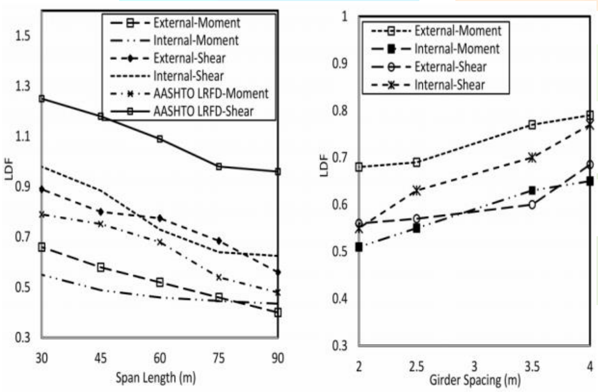
Whole Structure My 100kNm:1m Mz 100kNm:1m Fy 100kN:1m Fx 50kN:1m 8 LOAD GENERATION, LOAD #8, (7 of 10)

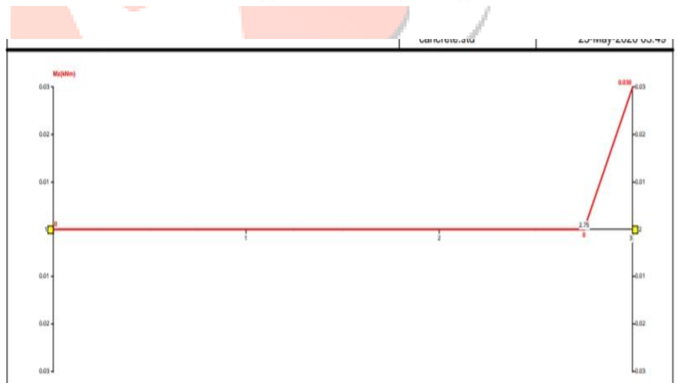




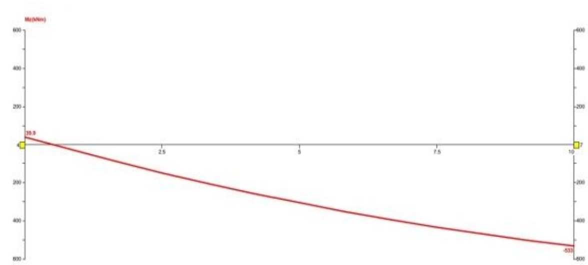
Whole Structure Mz 100kNm:1m 1 LOAD CASE 1 (Input data was modified after picture taken)

Bridge Load Distribution Factors

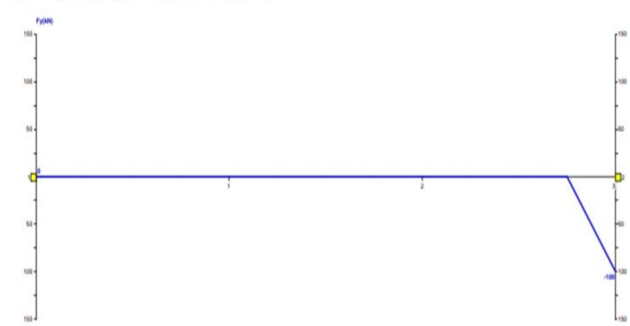




Beam 1, Mz, 2 LOAD GENERATION, LOAD #2, (1 of 10)



Beam 8, Mz, 1 LOAD CASE 1 (Input data was modified after picture taken)



Beam 1, Fy, 2 LOAD GENERATION, LOAD #2, (1 of 10)

5.Conclusions

A detailed numerical investigation of the behavior of skew composite bridges with steel girders under truck loads was conducted for this study. The numerical approach applied included an extensive study of continuous bridges to determine the effect of various key parameters of bridges on the live load distribution factors for both shear and bending moment. Empirical expressions for the shear and bending moment distribution factors were derived that are suitable for use with current bridge design codes. The proposed expressions are a function of the girder spacing, number of lanes loaded, and span length of bridges

Analytical procedures for determining the residual shear capacity of damaged web panels, which were based on an assumed plastic collapse mechanism, were found to be unrepresentative of the fracture failures exhibited by the maraging steel test girders. Further development of the analytical procedures will probably require consideration of material fracture. Areas of particular interest include the magnitude of the applied stress field in the web panel (accounting for damage) and appropriate stress intensity factors due to the approximate size and type of crack.

6 .REFERENCES

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