MODELING AND SIMULATION OF AN OVER-BRIDGE

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ABSTRACT

In many countries composite bridges have become a popular solution because they have many advantages over steel girders because they can carry the weight of formwork and wet concrete. The competitiveness of composite bridges has been increasing in recent years. Composite girders not only have lower deflections and economical sections but also reduce construction time, which is an added benefit to the constructor.

This project gives a brief overview of bridges that highlight composite bridges. Our work involves the design of a road overbridge with composite welded steel girder-RCC deck slab for Atvo-Laneheavy traffic road needs. A detailed design for RCC deck slab, main girders, cross girders, stiffeners, bracing, bearings, connections is displayed along with partial analysis using STAAD.VI8. Indicated codes are IRC-22, IRC-24, IRC-21, IRC-6, IRC-83 and IS-456 and steel tables for selection of steel sections. The obtained design details and results are included.

1.0 Introduction

A bridge may be a structure, engineered to span physical obstacles like water bodies, valleys, or roads to provide passage upon an obstacle. The specified passage could also be a road, a railway, pedestrian or a pipeline. Technically it's a structure carrying traffic or the other moving hundreds over associate obstruction.

First bridge everseen may be a treelying on the banks of a watercourse impressed by the power of nature, man has engineered bridges by mistreatment stones, logs, wood planks, employing a straight forward support and cross beam arrangement. Around 320 B.C, Alexander the good engineered floating bridges for the passage of his army. the amount between two hundred B.C and 260 A.D witnessed the widespread use of stone arches by Romans mistreatment large piers. Themedieval amount bridges were loaded with ornamental and defensive towers, chapels, statues, retailers and dwellings. The Arkadiko Bridge is one in every of four Mycenaeanarch bridges a part of a former network of roads, it's one in every oldest arch bridges still existing and use.

In middle nineteenth century, demand for stronger and {larger and greater} bridges over large rivers resulted within the use of forged iron and iron commutation timber and stone forbridges. Forged iron being terribly brittle wasn't found terribly appropriate for building massive span bridges. The Iron Bridge in Coal brookdale, European country in 1779 used forged iron for the primary time as arches to cross the Severn. a good combination of forged iron for compression members and iron for tension members was 1st utilized in tied bridge around 1840 particularly in railway bridges.

Many new constructions came into image by the invention of steel. Post war years saw the emergence of concrete as an appropriate material for brief and medium span bridges with the more advantage of sturdiness against aggressive

Environmental conditions as compared with steel.

The enormous leap with construction of George Washington Bridge with a span of 1060 m. Since the start of twentieth century, the employment of concrete has become in style for each road and railway bridges commutation steel primarily because of low maintenance prices and sturdiness concrete Bridge decks having varied structural configurations like block and box culverts, Tee beam and block, Continuous beam,Bowstring,Balancedcantilever,Opensurface,andRigidFramesortsare

Extensively used for medium to long spans. New era of prestressed concrete bridges started with the invention of PSC in 1950.The invention of cable stayed bridges transpire within the struggle to cut back the depth of girders of enormous span bridges.

1.2 P
ROBLEM STATEMENT

Consequently, the search for FRP capability from the above literature, in which the discussion on RCC analysis is limited, is provocative to analyze the RCC bridge. In addition, it helps to develop composite bridge by using low cost materials, i.e. concrete and steel (the addition of fibers and polymers can be expensive) which are usually available at low prices (compared to fibers), polymers etc. in the Indian market. Therefore, efforts have been expanded to develop a composite bridge with R.C.C deck slab and steel girders and to install bearings to reduce the shear force in the section.

1.3 Objectives and Scope of work

Objectives

a) To design composite I-girder bridge for two lane vehicular traffic considering class-AA loading and check its safety.

b) To know the behavior of composite bridge.

c) To know the steps involved in the design of composite steel girder bridge.

Scope of work

a) Bridge is designed for a span of 32m. which can be done for longer spans

b) The bridge is designed for class AA loading.

c) The bridge design is suitable for normal environmental conditions, where it can be done for extreme weather conditions.

d) The design is carried out for Indian conditions according to Indian Codes (IRC 24, 21, 83 etc).

LITERATURE REVIEW

2.0 Introduction

Theories are developed by practical experiences and practices are the implementations of theories. Therefore, the records of these experiences and theories which form a literature, plays a vital role in researches. Further, literature review can save lot of time for researchers by eliminating the redundancy. In view of this an attempt is made to review the literature in this filed to check the work carried out in the contemporary period. In addition, since, the literature review can also help finding the research gaps, this chapter becomes a pathfinder for this project.

2. Dr. Sabeeh Z. Al-Sarraf, Dr. Ammar A.Ali & Rana A.Al-Dujaili, on a whole described the Analysis of Composite Bridge Superstructures Using Modified Grillage Methodto analyze anisotropic plates (having various elastic properties and geometries in various directions), the model has four side beams with only flexural rigidity. The substitute grid framework is studied to provide the same deformations and deflections of the orthotropic plate elements of the modeled bridge. Application of the procedure suggested in the study of actual bridge decks is checked out using STAAD Pro.V8i program. The results supported the suggested procedure and admissible to adaptto this kind of bridge deck. It is found that the modified grillage method gives simpler method and adequate results when compared with the Finite Element Method or orthotropic plate theory solved using Finite Difference Method for this type of bridges.

3. Y. Okui(2014) has written on Design Issues for Steel-Concrete Composite Girders, which deals with the 2-I steel concrete composite girder bridge design. Also states the time dependent behavior of the composite girder, crack-width control design procedure and flexural strength of composite sections.

2.1.2Literature from papers published

1.PeterCollin,AndersStoltz,MikaelMoller(2002)explained on Innovative Pre fabricated Composite Bridges, how the composite girder bridge is best alternative to conventional RCC Bridge based on there action time, quality ,working environment and deck surface in the paper.

2. **Hu Zhendong Wang Hualin, focused** on the effect of bridge vibration on vertical acceleration of the vehicles and presenting the Analysis of Comfort Properties for high-speed Vehicle Moving Over Bridgebased on the model of simply supported beam on moving load. Also, the maximal accelerations of the vehicles at both the ends and at critical states were analyzed.

3. ZHONG Ming-quan, YANG Guang, WANG Xu-jun, SHIShangwei,LU Ya-nidiscussed on the high amounts of creeping camber of simply supported prestressed concrete plate girder bridge which influences the travel comfort of the vehicle and the Analysis of Influence of Creeping Camber of PC Plate Girder Bridge on Riding Comfort of High-Speed Traveling Vehicle was given. The model of vehicles and relation between plate girder bridge deck and the mathematical relations between the vehicle vertical vibration response and creep, span and vehicle speed on the bridge are determined using half-sine curve and ¼ sine curve simulations.

4. TomaszSiwowski, Damiankaleta(2018)investigated on Structural behaviour of an all-composite road bridge, developed a super structure of U-shaped girders and sandwich deck slab were fabricated using vacuum infusion, the bridge configuration was given in Finite Element Model for design and the results were discussed. The changes in the structural behavior of the bridge were assessed using fiber-optic sensors to understand the long-term performance of FRP and the paper states that an all-composite bridge can meet the relevant strength, deflection design criteria.

5. Kvamme, Jeffrey David(2018) gathered information over about 1500 studied to examine time domain trends on bridge decks in service that undergo treatments. They studied the average improvement on decks post-treatment and pre-treatment condition.

6. J Prakash Arul Jose, P Rajesh Prasanna, Fleming Prakash (2018)investigated on the bridges made of timber-concrete (deck and pile foundations of massive timber and vertical supports of fibre reinforced concrete)and conducted several tests on stability and durability.

3. METHODOLOGY

3.0.Specifications

The specification of the required bridge are to be considered as follows

Clear span available =26m

Number of main girders=6

Number of cross girders = 7

Total length of main girders=32m

Total length of cross girders = 10m

Spacing between main girders =2m

Spacing between cross girders= 4m

3.1. Methods of analysis

3.1.1. Working stressmethod

This is conventionally employed method to RCC design with an assumption that concrete is elastic, and therefore steel and concrete act together elastically. The loads are linearly related to stresses up to the structural collapse. The fundamental point of this method is that the maximum allowable stress for concrete and steel do not exceedthroughout the structure though subjected to the undesirable combination of working loads. The sections are so designed according to the elastic theory of bending presuming obeyance of Hooke's law by both materials. The elastic theory specifies a linear variation of strain and stress from basic (zero) at the neutral axis to a maximum at the extreme fibre. Typical stress and strain distributions in a rectangular section are shown in fig.

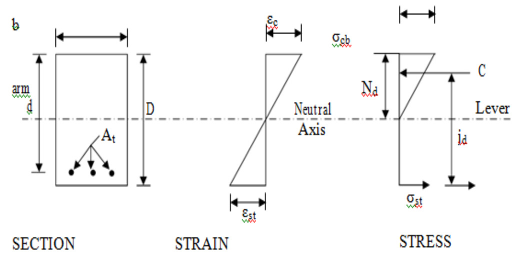

Figure 3.2.1.1 Stress-strain curve in working stress design

4.1. Design of deck slab

Adopting working stress method for shorter span, Depth oftheslab d= $\sqrt{\frac{M}{R_b}}$

$\sqrt{\frac{28.809\times10^6}{2.104\times1000}}$=117.015 mm

Hence provide an overall depth D=200 mm and d=160 mm (assuming 40mm cover)

Area of steel A_st=M/(σ_st×d)

=28.809x106/200x0.857x16

=1050.503 mm2

Provide 16mmφ bars @ 200 mm c/c for main reinforcement

For longer span,

Effective depth d =160 – 16/2 = 152

Depth of the slab $d=\sqrt{\frac{M}{Rb}}$

$=\sqrt{\frac{8.625*10^6}{2.104*1000}}$ =64.025 mm

Hence 200mm depth provided is ok

Area of steel $A_{st}=\frac{M}{\sigma_{st}\times d}$

$=\frac{28.809\times10^6}{200\times0.857\times160}$ =331.058 m

Minimum area of steel = 0.85bd / f_y

=327.711 mm^2

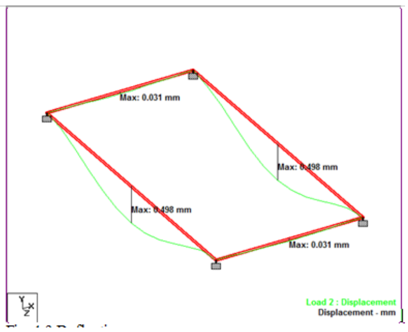

Fig. 4.3 Deflection

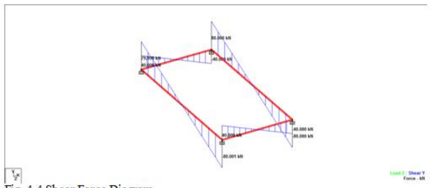

Fig. 4.4 Shear Force Diagram

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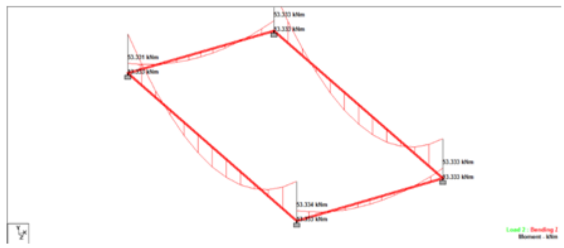
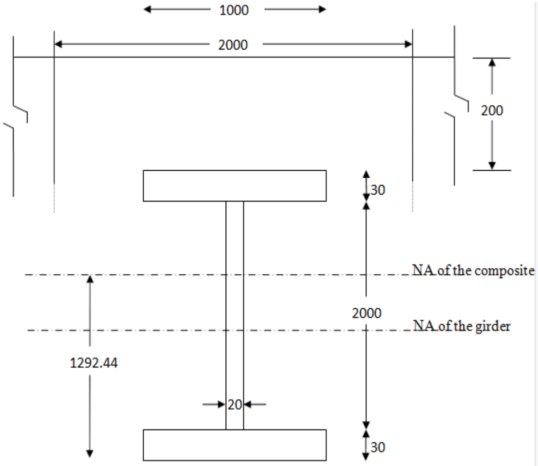


Fig 4.5 Bending Moment Diagram

4.1. Design of the composite section



Equivalent Area of concrete = actual area of concrete slab/modular ratio

$$= \frac{2000x200}{13} = 30769.23\ mm^2$$

Total horizontal shear force on the width = 159.648 x 1000

= 159648 N ≈ 159.648 kN

4.2. Loading details

Using class AA loading,

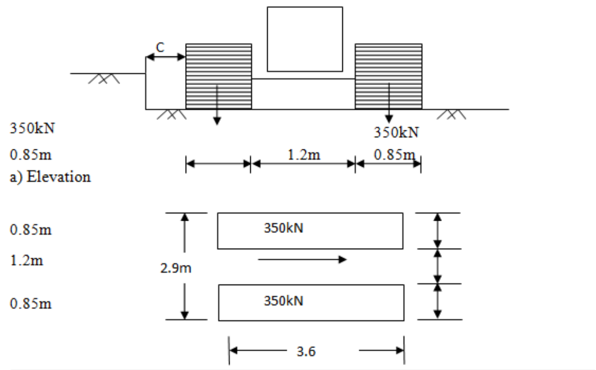
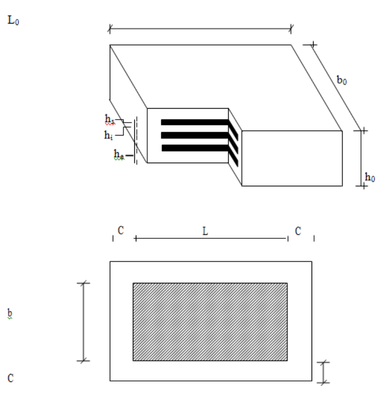


Figure 4.1 for tracked vehicle



SELECTION OF BEARING PAD DIMENSIONS

Maxvertical Loadonbearing

N_{max}=338.8+330.312=669.112 k N

Min vertical load N min = 330.312 k N

Table ref IRC- 83-1987(part II) clause 916.2 (ref APPENDIX A-

Adopt plan dimensions of bearing pad as 320 x 630mm

B_o =400 mm;

l_o = 800mm;

Loaded area $A_2 = 30.6 \times 10^4$ mm^2

From IRC-21, clause 307.1, (ref APPENDIX A-II)

Allowablecontactpressure = $0.25\ f_c \sqrt{\frac{A_1}{A_2}}$

Where,

A_1 – concrete bed block area over pier

A_2 - elastomeric pad area

But, A_1/A_2 =2

Allowable contact pressure σ_{ac}= 0.25*20*$\sqrt{2}$

= 7.07 MPa

Effective bearing area required = $\frac{N_{max}}{\sigma_{ac}} = \frac{669.112 \times 10^3}{7.07}$

= 9.461×10^4 mm^2< 23.9×10^4 mm^2

Hence safe.

Bearingstressσ_m=$\frac{669.112 \times 10^3}{9.5 \times 10^5}$

= 3.435 MPa

FRAME STRUCTURE

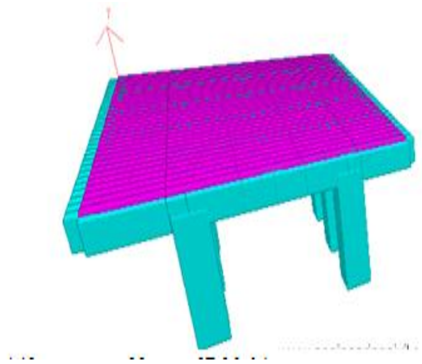


Fig. 4.13, structure of frame – 3D Model

RESULTS AND DISCUSSION

One step further from the conventional bridge, a detailed design of the composite girder bridge is proposed for the given load and traffic conditions as specified in the project detail data.

R The bridge is designed by referring to IRC codes, which are safe in all respects.

Considering all the amps and obstacles on the site at a clear interval of 26 m, the 32-meter-long steel bridge girder composite bridge adopts a 200mm thick RCC deck slab as well as the cross girders, stiffeners, bracing and design requirements.

While the bridge is a well-established alternative to the concrete bridge, one can expect many benefits such as faster erection time, higher quality, reduced deflections and longer life if the deck is made faster.

In addition to this, FRPs used in developed countries are not economical in the Indian market and this composite bridge has been adopted for economic purposes as concrete and steel are also readily available in the region.

Composite bridges have many advantages over steel girders because they can carry the weight of formwork and wet concrete.

The competitiveness of composite bridges has been increasing in recent years. Composite girders not only have lower deflections, but also reduce construction time, which is an added benefit to the structure.

Elastomeric use reduces shear stress due to longitudinal force, creep and shrinkage in La section.

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