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Optimal Analysis of Composite Bridge without Cross Girders

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Abstract: This paper summarizes the research work on the optimal analysis of composite bridge without cross girders. Optimization techniques play an important role in structural design, the very purpose of which is to find the best ways so that a designer or a decision maker can derive a maximum benefit from the available resources. Weight optimization is becoming a priority in all civil engineering projects, and the concept of Life-Cycle Costing is penetrating design, manufacturing and construction organizations.
Keywords: Bridges, Composite Bridges, Optimization.

I. INTRODUCTION

A Composite bridge is one whose decking system consists of a concrete slab and steel girders resists moving loads on the bridge. It provides an efficient and cost-effective form of bridge construction. The steel and concrete elements of a composite bridge are connected via shear connectors that are welded to the top flange of the steel girder and are embedded in the concrete deck. The composite action is achieved through the longitudinal shear force transferred by the shear connectors, increasing the bending resistance significantly compared to that achieved by the non-composite beam. In multi-girder bridge construction a number of similarly sized longitudinal 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. Any study of bridges demonstrates the ways in which human ingenuity and resourcefulness have been applied to improve the movement of goods and people from place to place. The steel and concrete elements of a composite bridge are connected via shear connectors that are welded to the top flange of the steel girder and are embedded in the concrete deck. The composite action is achieved through the longitudinal shear force transferred by the shear connectors, increasing the bending resistance significantly compared to that achieved by the non-composite beam. Plate girders are fabricated from steel plate in accordance with the designer’s requirements. They provide the designer with the flexibility of specifying different flange sizes and web thicknesses at different positions along the span, to optimize the girder, depending on the span and applied loading on the bridge.

The combination of steel and concrete in a single composite structural element enhances the individual advantages of both materials. By utilizing the high tensile strength of steel together with the compressive strength of concrete, the resulting elements have one and a half times or even double the strength and stiffness in comparison with a non-composite element. This is the main advantage of composite bridge construction, which is recognized worldwide. Figures 1 shows the composite bridge

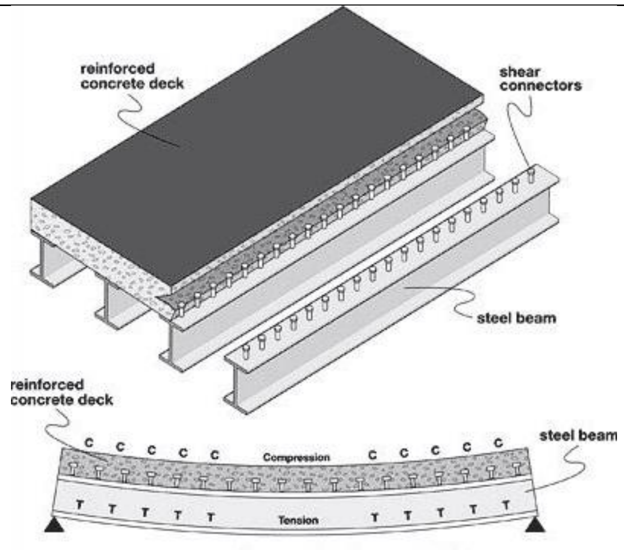

Fig. 1. Composite Bridge

II. FEATURES OF COMPOSITE BRIDGE

A. Composite Bridge without Cross Girder

The economical span of Composite bridge is in the range of 10 to 30 m. This type of bridge deck provides for speedy erection of steel girders and considerably reduces the cost of form work. The savings in overall depth of the beams leads to savings in lengths of approaches in the case of embankments. A girder bridge, in general, is a bridge that uses girders as the means of supporting the deck. Main girders of a bridge are the strong beams that carry the load from the superstructure to the substructure (columns). Cross girder of a bridge are the transverse beams (also very strong/stiff) which are provided for transverse stiffness. This transverse diaphragm will make sure that if multiple main girders are there, they share loads between them and don't behave independently.

Here I am choosed a single span roadway bridge of 25m length. It has five longitudinal girders and is without cross girders. If the main girders have the ability to take more loads from the super structure, the use of cross girder can be avoided. Deck slab is of 9.9m width and 300mm thickness. Footpath of 1.2m is provided on both side. Longitudinal girders are provided at a spacing of 2m, 2.75m & 3.75m c/c distance. Material used are M30 grade concrete and Fe415 grade steel for deck slab and Mild steel for girders. Live load is provided as per IRC-70R train of vehicles as per IRC 6-2000 and it is shown in fig. 2.

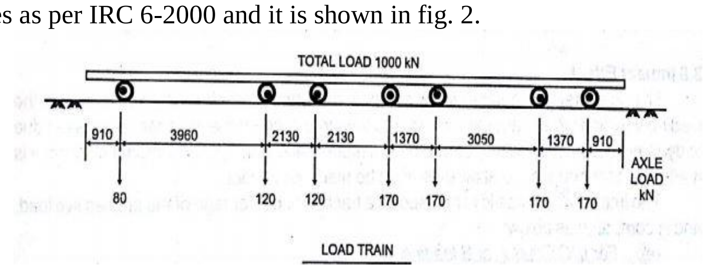

Fig. 2. 70R Loading Pattern

Shear Connectors are the most important structural element in a composite bridge deck and its main function is to prevent the separation between the steel girder and the in-situ concrete slab by transferring the horizontal shear force along the contact surface without any slip. Shear studs and Channel Connectors are the examples of shear connectors.

III. STRUCTURAL DESIGN OF COMPOSITE BRIDGES

A. Composite Bridge with 5 Girders

In this case, the longitudinal girders are spaced at a distance of 2m. The reinforcement details and Size of Steel Beam are

- Longitudinal Reinforcement provided is 20mm dia. bar @ 300mm c/c.
- Distribution Reinforcement provided is 12mm dia. bar @ 300mm c/c.
- Size of the web is 1000 x 10 mm

- Size of the flange is 580 x 40 mm

B. **Composite Bridge with 4 Girders**

In this case, the longitudinal girders are spaced at a distance of 2.75m. The reinforcement details and Size of Steel Beam are

- Longitudinal Reinforcement provided is 20mm dia. bar @ 300mm c/c.
- Distribution Reinforcement provided is 12mm dia. bar @ 300mm c/c.
- Size of the web is 1000 x 20 mm
- Size of the flange is 625 x 40 mm

C. **Composite Bridge with 3 Girders**

In this case, the longitudinal girders are spaced at a distance of 3.75m. The reinforcement details and Size of Steel Beam are

- Longitudinal Reinforcement provided is 20mm dia. bar @ 190mm c/c.
- Distribution Reinforcement provided is 12mm dia. bar @ 230mm c/c.
- Size of the web is 1200 x 30 mm
- Size of the flange is 600 x 40 mm

IV. WEIGHT OPTIMIZATION OF COMPOSITE BRIDGES

In the first case the total no. of girder is 5. Then it is reduced to 4 and 3. Here in each cases what are the changes occurred are studied. Table 1 to 3 shows the weight estimation details of each bridges.

TABLE 1. Estimation of Bridge with 5 Girder

Weight of Steel		**Weight of Concrete**		**Weight of Wearing Coat(T)**
Girder(T)	61.71	Slab(T)	185.625	43.56
Bar(T)	3.37	Kerb(T)	45.75	
Total(T)	65.08	Total(T)	231.375	

TABLE 2. Estimation of Bridge with 4 Girder

Weight of Steel		**Weight of Concrete**		**Weight of Wearing Coat(T)**
Girder(T)	58.52	Slab(T)	185.625	43.56
Bar(T)	3.37	Kerb(T)	45.75	
Total(T)	61.89	Total(T)	231.375	

TABLE 3. Estimation of Bridge with 3 Girder

Weight of Steel		**Weight of Concrete**		**Weight of Wearing Coat(T)**
Girder(T)	52.23	Slab(T)	185.625	43.56
Bar(T)	3.39	Kerb(T)	45.75	
Total(T)	55.62	Total(T)	231.375	

Figure 3 shows the graphical representation of weight of steel vs. no. of girders

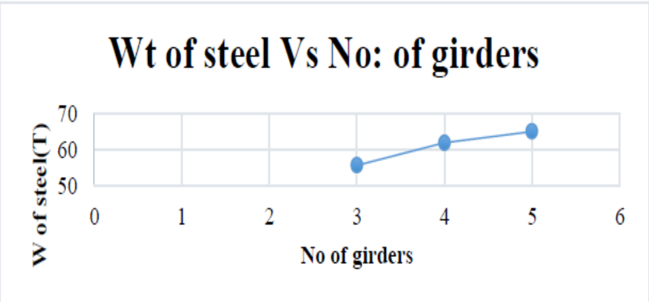

Fig.3. Weight of steel vs. no.of girders

V. CONCLUSIONS

From the optimal analysis, it can states that if we reduce composite bridge without cross girder having 25m span and 9.9m width having 5 longitudinal girder to 3 girder within the safe limit, the amount of steel can be save up to 14.5%.

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