# Flexural Behaviour of Orthotropic Composite Bridge Deck

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## Summary

A new type of steel and concrete composite bridge deck comprised of an orthotropic steel plate with deep corrugation and a concrete slab is proposed in this paper. In the new composite deck, many parameters, such as concrete slab thickness, corrugated steel plate height and width, etc., will affect the section property. The reasonable detail size of composite cross section was optimized to improve the flexural capacity and decrease the structural weight. Based on the size optimization of the composite section, a full scale composite deck slab was designed and its flexural bearing capacity was tested by loading experiment. The test proves that the bending capacity of the composite bridge deck is 5.67 times that of the designing capacity according to specification, and the load behaviour of the composite bridge deck in the serviceability limit state can be calculated according to the plane cross section assumption.

**Keywords:** Composite deck; corrugated steel plate; load test; optimization; cross section.

## 1. Introduction

There are usually two kinds of bridge decks, the concrete deck and the orthotropic steel deck. The use of concrete bridge deck in the large-span bridge is limited by the shortage of heavy self-weight. Further, the concrete has a weak tensile strength, so the cracking is the main problem of the concrete deck. The use of orthotropic steel deck in small and medium span is limited by its high cost. What's more, the steel bridge deck has a complicated configuration, with many longitudinal and transverse ribs and welds, therefore liable to cause fatigue failures. In addition, the common damages of the pavement in orthotropic steel bridge deck such as longitudinal cracking, pushing and local packing in the lane have not been solved well. In the medium span bridge, neither the steel deck nor the concrete deck has an apparent advantage, thereby giving room for the application of the composite bridge deck. A new type of steel and concrete composite bridge deck comprised of an orthotropic steel plate with deep corrugation and a concrete slab is proposed in this paper.

## 2. Dimension determination

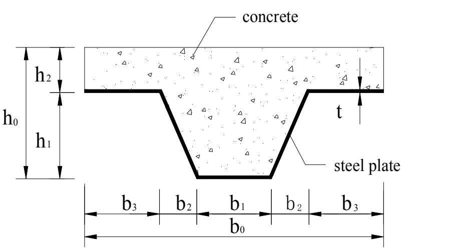


*Fig.1 Cross section of the composite bridge*

A standard unit cross section of the composite deck illustrated in Fig.1 is adopted to analyse the bending resistance behaviour revolving the strong axis under the positive bending moment. First of all, the reasonable dimension of the composite bridge deck needs to be determined.

In the serviceability state, assume that the combination of concrete and steel is intact, the material is in elastic state, and the bridge deck is simple-supported, on the precondition that the structure complies with the demand of load-carrying in serviceabilty state, and the design is controlled by the demand of the ultimate load-carrying state. A program using optimization toolbox of MATLAB is designed, determining the optimal section which make the target function smallest while conforming to all the constraint condition.

Parameters $h_1$ , $b_1$ , $h_2$ and $b_0$ (shown in Fig.1) are selected as the control variables. The target function is to achieve the the smallest area $A$ and the biggest load-carrying capacity $M$ , i.e., $A/M$ as less as possible.

Based on the calculation result, the optimal sections under calculation in different scenarios have some common traits: the ratio of $h_1$ to $h_2$ is about 2.0; the neutral axis is around the top steel plate when the section reaches ultimate load-carrying state; $b_1$ needs to be increased as the span increases.

## 3. Full-scale test

To test the bearing capacity of the composite bridge deck with orthotropic steel plate and concrete proposed in this paper, static load full scale test has been carried out. The loading setup schematic is illustrated in Fig.2 and the cross section of the specimen is illustrated in Fig. 3.

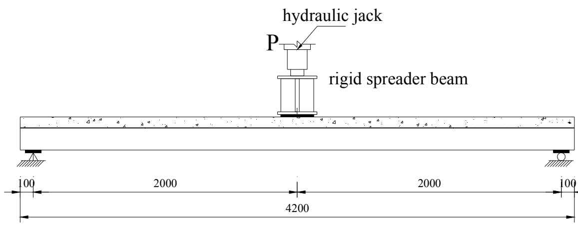


*Fig.2 Loading setup schematic（Unit：mm）*

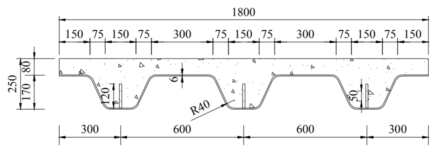


*Fig.3 Dimension of the cross section (Unit: mm)*

In the experiment, the load-deflection relation, the load-slip relation, concrete strains and steel strains were tested. The failure mode of the specimen is to form plastic hinge at mid-span section where the top concrete is crushed and the steel plate yields. The ultimate vertical load is 575.4kN. The ultimate load-bearing capacity of a unit width of the composite deck in the test is 479.5 kNm, which is 5.67 times that of the calculation result according to the current China code, which indicate that the composite deck in this paper can meet the requirement of load-carrying capacity.

## 4. Conclusions

This paper has proposed a new kind of composite bridge deck based on the summary of characteristics of structure and mechanical behaviour of common decks. Through the determination of size and experimental analysis, the conclusions are drawn as follows:

(1) The composite bridge deck with orthotropic steel plate and concrete has the competitive merits of high load-carrying capacity and convenience for construction

(2) The optimal cross section through calculation under different circumstances: the ratio of $h_1$ to $h_2$ is around 2.0; the neutral axis is around the top steel plate when the section reaches ultimate load-carrying state; $b_1$ increases as the span increases.

(3) Test results show the load-carrying capacity of the composite deck is far bigger than the value produced by design load stipulated in the current code, and no end-slip between steel and concrete happens in the serviceability state, therefore the cross section conforms to plane section assumption.

## 5. Acknowledgement

This research is sponsored by Key Project of Chinese National Programs for Fundamental Research and Development (973 Program, Grant No: 2013CB036303). This support is gratefully acknowledged.