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Development of Steel Plate-Concrete Composite Deck (SC Deck)

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Summary

A steel plate-concrete composite deck (SC-Deck) has been improved based on the steel-concrete composite deck girder which was developed in 1986. SC-Deck consists of bottom steel form, concrete and upper reinforcing bars, and needs no staging and scaffolding. Trial fabricating test of bottom steel form, concrete casting test and wheel trucking test of SC-Deck are conducted using real-size models. Results of those tests show that SC-Deck has no structural problems, and has required strength and durability.

1. Introduction

Commonly in Japan, cast-in-situ reinforced concrete slab (hereinafter RC slab) has been adopted as the decks of highway bridges with steel plate girders, considering its advantages on low cost and easy construction procedure. However, recently, serious damages and deterioration on RC slab have been observed due to repetitions of heavy traffic load, which were unforeseen at the time of design. And hot discussions are being made as to durability of RC slab and the method of remedial work. In addition to above, RC slab used for viaducts and overpasses in urban area has another problem that the use of enough space under the bridges for the staging and scaffolding during concrete casting, is usually not allowed. On the other hand, prestressed concrete slab, which has definitely the higher stiffness than RC slab, requires the special skill at site as to prestressing, thus results in costly deck. Comparing with above slabs, the composite deck which consists of steel plate and concrete slab has the following advantages;

- No staging and scaffolding is required during concrete casting
- High load capacity and durability is expected
- Reduction of thickness of slab is can be achieved

We have developed, as one of alternative from steel-concrete composite deck named as Robinson deck, SC Deck for the purpose of further simplification and shortening of site work. SC Deck has been used in the Kariyasuga Viaduct in Tokai-Hokuriku Motorway of Japan Highway Public Corporation. In the process of development of SC Deck, we have executed the wheel trucking test using real size models, in addition to trial fabrications of the bottom steel form and concrete casting test for the checking of deflection of bottom steel form.

2. Structural Details of SC Deck

One of the authors had modified the steel plate-concrete composite deck named as Robinson deck by welding of longitudinal and transverse ribs to the steel plate, as shown in Fig.1. This modified type deck girder was adopted to several steel bridges in Japan, refer to references [1] and [2]. The remarkable points of this type of deck girder are;

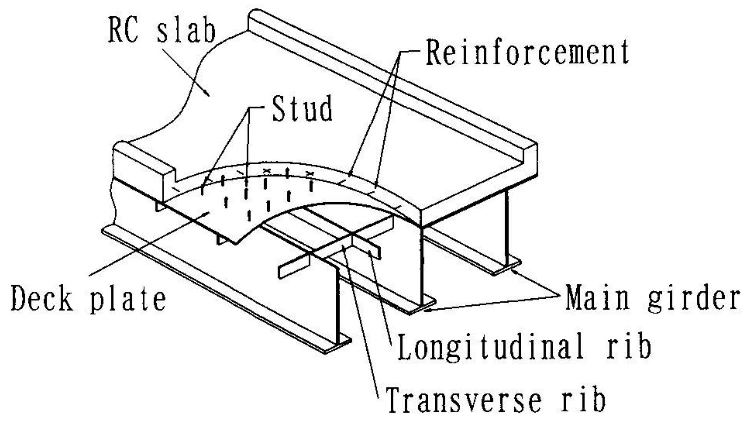

Fig.1 General view of modified composite deck girder

- Steel deck plate is designed not only as an upper flange of plate girder but also as a steel form of deck.
- The longitudinal and transverse ribs are welded to the bottom surface of steel plate.

On the contrary, SC Deck is designed such that bottom steel form is pre-fabricated separately from upper flange of girder and has only transverse ribs. Since the bottom steel form divides into small panels per span of slab, SC Deck shall be applicable to the following areas of bridges and rehabilitation works of slab;

- Repairing of slab and replacing of slab
- Viaducts and Overpasses
- Open box steel Girders

Fig.2 shows general view of SC Deck. SC Deck consists of bottom steel form, concrete slab and upper reinforcing bars. Bottom steel form is designed in 2 steps, one is as steel form during concrete casting, and the other is as lower reinforcement after hardening of concrete. Thus SC Deck requires no staging and scaffolding, and no additional lower reinforcing bars are necessary. Upper reinforcing bars are just straight bars and set on the transverse ribs. Pre-fabricated bottom steel form panel consists of steel plates, transverse ribs and studs. Each panel, which size depends on the limitation of transportation, shall be connected with High Strength Bolts after installation at site. Bottom steel form is just set on main steel girder and any bolt connection or welding is not made. For the adjustment of alignment, rubber strip is inserted between bottom steel form and main steel girder. Transverse ribs are designed to minimize deflections of bottom steel form during concrete casting, so that the safety of work and uniform concrete thickness of slab shall be ensured. Bottom steel form and concrete are to be composite by

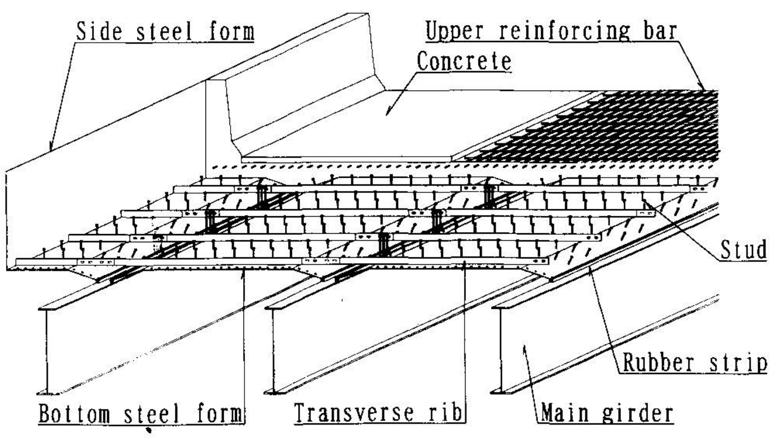

Fig.2 General view of SC Deck

studs. Bottom steel form shall be hot-dip galvanized or painted, and if the condition of atmosphere is not severe, atmospheric corrosion resisting steel shall be used. If side steel form is to be welded or to be bolt jointed to bottom steel form, no additional work for installation of form is required for concrete barrier and curb.

3. Design of SC Deck

SC Deck is to be designed in accordance with references [3] and [4]. A concept of design is that bottom steel form itself resists to dead load of weights of bottom steel form, fresh concrete and reinforcing bars, while composite section of bottom steel form and concrete slab resists to dead load of pavement, concrete barrier and curb, etc. and live load. Calculation of stress shall be made as follows ;

- For pre-composite load : To superimpose the membrane stress of bottom steel form onto the stress of T-section beam consisting of bottom plate and transverse rib.
- For post-composite load : To calculate the stress as a composite section of bottom plate and concrete. Table 1 shows basic design criteria of SC Deck.

Table 2 shows outline of real-size model utilized for wheel trucking test, and Fig.3 shows its section.

Design strength of concrete	$\sigma ck = 30$ N/mm² (Approx.)
Raito of Young's modulus	n = 10 or 15 *
Thickness of concrete slab	Minimum thicknes of RC slab by reference [3]
Thickness of bottom steel form	ts = 9 mm (Approx.)
Height of transverse rib	Approx. half of thickness of concrete slab
Span of slab	L = 2.0～6.0 m

* : under severe load condition

Table 1 Basic designe criteria

Design strength of concrete	$\sigma ck = 30$ N/mm²
Raito of Young's modulus	n = 15
Span of slab	L = 3.0 m
Thickness of concrete slab	tc = 20 cm
Upper reinforcing bar	Main upper bar : D19(SD345) Distributing bar : D16(SD345)
Thickness of bottom steel plate	ts = 9 mm
Interval of transverse rib	dr = 750 mm
Height of transverse rib	hr = 100mm
Thickness of transverse rib	tr = 16mm
Diameter of stud	ϕ16
Interval of stud	ds = 250mm or less
Height of stud	hs = 120mm

Table 2 Outline of real-size model

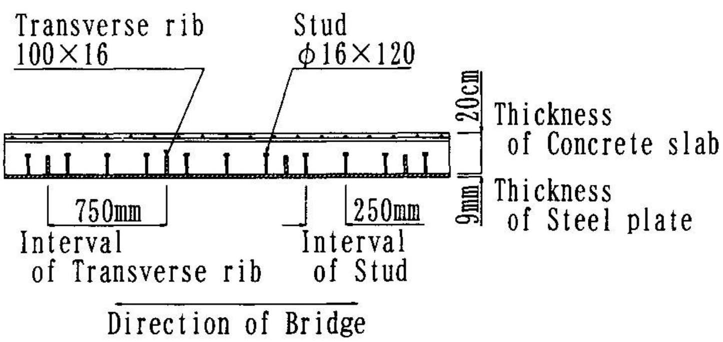

Fig.3 Section of real-size model

4. Tests of SC Deck using real-size model

4.1 Trial fabrications of bottom steel form

We have made trial fabrications in order to obtain the following data;

- Amount of deformation of bottom steel form due to hot-dip galvanizing

· Checking of details at joints of bottom steel form

In order to obtain the amount of deformation of bottom steel form due to hot-dip galvanizing, we have fabricated 2 types of panel for test, one is that the transverse ribs are continuously welded to bottom plate and the other one is intermittently welded. Thickness of bottom steel plate in both panels was 9 mm. Amounts of deformation for each panel were only about 10 mm, and we have confirmed that such amounts would cause no problem for installation of bottom steel form panel to steel girders at site. Since deformation by intermittent weld were slightly smaller than that of continuous weld, we have decided that transverse rib are to be intermittently welded to bottom steel form. And also we have confirmed that there would be no problem as regard to joint details of bottom steel form pannel for the installation at site.

4.2 Concrete casting tests using real-size model

We have made concrete casting tests to confirm the following points;

· Leakage of water under concrete casting
· Deflection of bottom steel form under concrete casting
· Propagation of cracks due to shrinkage

In order to ensure safety of concrete-casting work and ensure the designed thickness of slab, max. 5 mm was to be considered as an allowable deflection of bottom steel form during concrete casting. And also we have confirmed that there would be no problem as regard to leakage of water and propagation of cracks.

4.3 Wheel trucking test

Wheel trucking test of SC Deck has been executed using real-size model at Osaka Institute of Technology. Fig.4 shows phtograph of wheel trucking test. The purpose of this test is as follows;

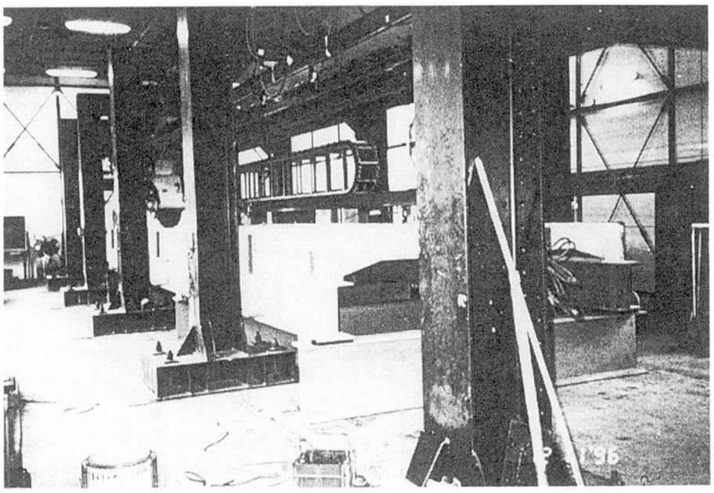

Fig.4 Photograph of wheel trucking test

· Evaluation of load capacity and durability of SC Deck in compared with ordinary RC slab
· Determination of most suitable type of transverse rib
· Checking for the behavior of joints of bottom steel form pannel

Since the transverse ribs are to be embedded into concrete, it was anticipated that cracks would be propagated from top of rib plate to upper surface of concrete, thus resulting in serious damages to composite slab. So we have made comparison for details of transverse rib, using 3 different types of specimens A, C, and D as shown in Table 3. In addition ,we have also made comparison for propagation of cracks between ordinary concrete and expansive concrete (specimens A and B).

It was observed for all types of specimen that the behavior as to deflection and strain remained within the range of elasticity and the propagation of cracks did not occur. Test results for joint details of bottom steel form were also satisfactory, and we have decided to select specimen A from the economical point of view. Water proofing agent shall be applied to the surface of concrete. Another wheel trucking test using real-size model with slab span of 2.5 m for various types of slab including SC Deck has been executed at Public Works Research Institute, Ministry of Construction. In this test, wheel loading, initially starting from 156.8 kN, was increased by 19.6 kN every 40 thousands of cycle wheel loading up to 392 kN. The result of this test showed that deformation of SC Deck remained within the range of elasticity up to 392 kN (520 thousands cycles), while the ordinary RC slab was destroyed at the load stage of 254.8 kN (220 thousands cycles).

Type	Note	Concrete	Sketch
A	Steel plate only	Ordinary Concrete	Steel plate; Bottom steel form
B	Steel plate only	Expansive Concrete	
C	Combination of Steel plate and Welded Wire Net	Ordinary Concrete	Welded Wire Net (3.2×150×150)
D	Combination of Steel plate and Deformend bar	Ordinary Concrete	Deformend bars are to be welded (D16)

Table 3 Types of specimen

5. Construction of SC Deck

Results of several tests mentioned above had verified that SC Deck had enough load capacity and durability, and also had good workability at site. Thus, finally, SC Deck had been adopted to the Kariyasuga Viaduct in Tokai-Hokuriku Motorway of Japan Highway Public Corporation, with structural outline as follows;

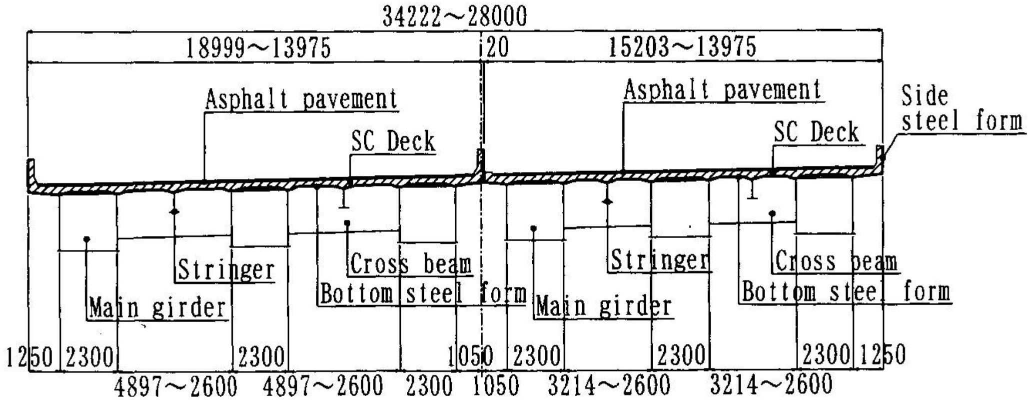

Fig.5 Typical cross section of the Kariyasuga Viaduct

· Type of Bridge : 2 Nos. of 3-spans·continuous steel box girder
· Length of Bridge : 140m + 160m
· Total width of Bridge : 43.352m to 34.222m and 34.222m to 28.000m (variable)

Typical cross section is shown on Fig.5 and photographs of construction scene are shown in Fig.6 to Fig.7

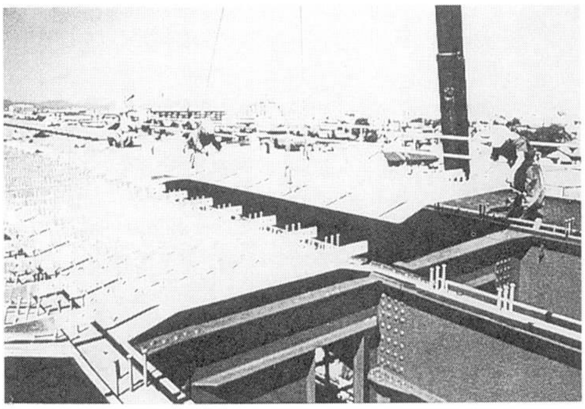

Fig.6 Erection of Bottom form

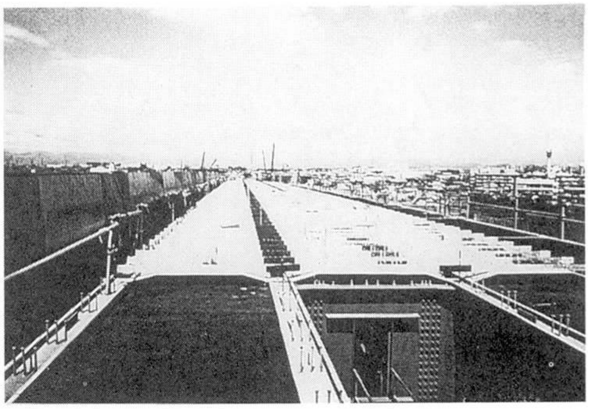

Fig.7 Setting of Bottom form on girders

6. Conclusions

We are still investigating further improvement on SC Deck as below;
· Reduction of Nos. of stud by clarifying distribution of horizontal shear force
· Simplification of joint detail for bottom steel form

If SC Deck is to be planned to adopt in case that there would be the limitation for usage of underbridge space during slab work, or in case that the span of slab in excess of 3.0 m would be required, we believe that SC Deck could demonstrate its cost advantages to RC slab and PC slab .Therefore, we expect that SC Deck would be used for many of steel bridges.

Finally, we take this opportunity to express our thanks to the staffs of Japan Highway Public Corporation concerned, Prof. and Dr. S.Matsui of Osaka Univ. and Prof. and Dr. T.Horikawa of Osaka Institute of Technology for giving us kinds advices as for the development of SC Deck.

References

[1] S.Matsui , T.Akiyama , H.Watanabe , Y.takeda : Steel-concrete composite deck girder The design and construction of The Tanaka Bridge, Bridge Engineering, pp.31~39, No.11,1986. (in Japanese)

[2] S.Matsui , H.Sasaki , Y.Fukumoto , H.Watanabe : Fatigue character of composite slab under repetitions of traffic load, The 42th Annual Conference of JSCE, I-164, pp.362~363, Sep.1987. (in Japanese)

[3] Japan Road Association : Specifications for Highway Bridges、 Part I : Common Specifications、 Part II : Steel Bridges, 1996-12. (in Japanese)

[4] JSCE : Design Code for Steel Structures PART B : Composite Structures, 1997 (in Japanese)