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Erection of Composite Bridges with Precast Deck Slabs

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Summary

This paper presents some typical erection practices of composite bridges with precast reinforced concrete deck slabs in Russia. Also it focuses on the connection details of steel to concrete, joints between reinforced concrete deck panels. Based on the obtained experience and techniques tested at construction sites, standard structural solutions have been worked out and are discussed.

1. Introduction

The first bridges utilizing the composite concept of combination the best characteristics of steel and reinforced concrete materials were constructed in Russia in the beginning of the century. The wide application of bridges of this type was begun in the 1950s. At that time the first standard designs for the spans of 21, 32.4 and 42.5m have been worked out. The tendency to shorten construction time led to more widespread use of precast deck slabs and this form of construction has become predominant in the Russian composite bridge construction practice.

The use of precast reinforced concrete deck slabs reduces additional stresses in composite structures caused by creep and shrinkage, simplifies the erection procedure, eliminates falsework and gives some advantages when an adjustment of load effects in the structure is planned.

2. Composite Highway Bridges with Precast Slabs

It is essential to consider methods of construction at an early design stage. For long-span bridges in the Russian construction practice the method of incremental launching is the most widespread. For short-span bridges, the steel girders may be erected complete using one or two cranes as necessary. The use of non-prestressed precast deck slabs is the most common practice which is now discussed.

Reinforced concrete deck slabs are normally erected when steel structure is already constructed and placed in its final position. The reinforced concrete deck panels are typically fabricated at specialized shops for reinforced concrete structures and then transported to a construction site or produced in a casting yard adjacent to the site, enabling the contractor to maintain close quality control. To minimize shrinkage and creep, the precast reinforced concrete deck panels can be stored for at least three months prior to installation in the bridge. A number of precast slab panel sizes have to be designed minimum. The choice of dimensions and weight of slab panels is generally governed by conditions of erection and transportation. Various types of cross sections of precast slabs are shown in *Fig. 1.*

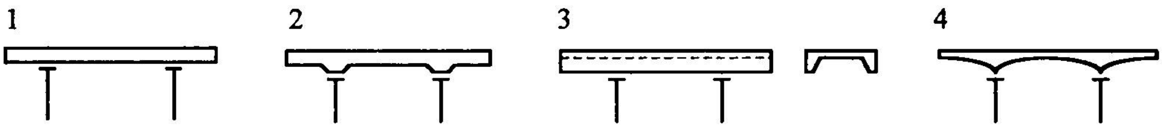

Fig. 1. Typical cross sections of precast slabs.
1 - uniform slab; 2 - haunched slab; 3 - Π - shape slab; 4 - curved soffit slab

The most usual types of precast reinforced concrete decks are slabs of uniform thickness and haunched slabs. To employ appropriate erection techniques and ensure composite action the following aspects are required to be properly considered: structural details of reinforced concrete slabs (shear connection, slab joints), hydrometeorologic effects (air temperature, wind during erection) and availability of special cranes. To achieve the required quality at the connections, an important consideration is given to a sequence and technology of works.

It was the usual practice to fabricate the precast slabs with provision of holes for shear connectors that were later filled with concrete. The disadvantages of this traditional solution for the connection of steel to concrete are the difficulties of concrete placement which, in addition, has a lack of inspection access. The concreting is distributed by small quantities over a big area of the deck. The quantity of this filling concrete may be of 10-20% of the quantity of precast deck. Filling of holes in the precast deck is required to be completed within a limited period of time. To improve the practice a new structural solution has been developed. It is based on the use of steel embeds into the precast slabs. The precast slab is connected to main girders by means of angles and high strength bolts. A typical cross section of continuous composite superstructure (84m - main span) is shown in *Fig. 2.*

Handling reasons influenced dimensions of precast slab panels which are typically taken as about 2.6 x 15 x 0.25m. The precast panels are laid with their long dimension perpendicular to a centerline of bridge carriageway and are normally erected by a crawler crane with a capacity of 25 t, working from the slab panels laid previously (*Fig.3*).

Using these techniques, the erection of precast slabs can be implemeted independent to air temperature. The only limitation is set up for the air temperature of in situ concrete placement between adjacent units. If no additional measures to assure a proper concrete hardening is planned to be implemented, the placement of concrete have to be above +5°C. Also a special concrete with additives against shrinkage may be applied for this junction between the precast slabs.

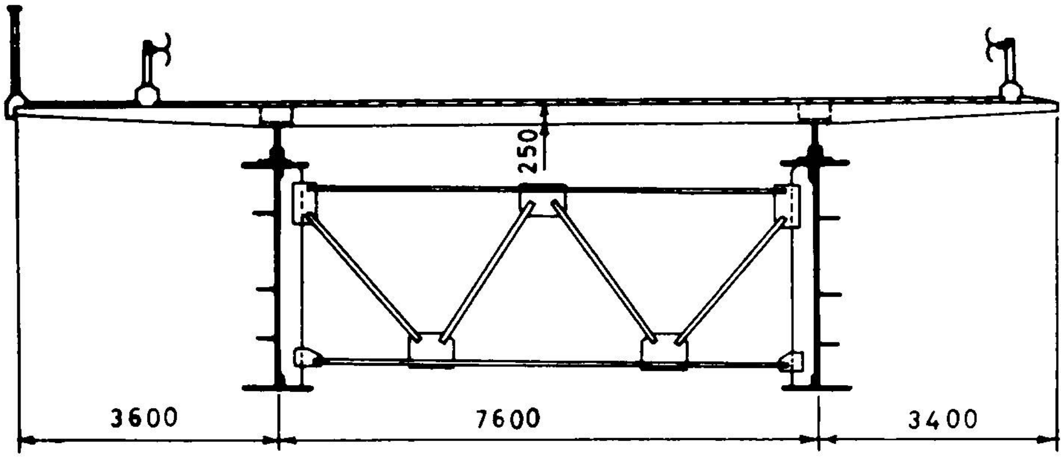

Fig.2. Typical cross section of superstructure using steel embeds for connection of steel to concrete.

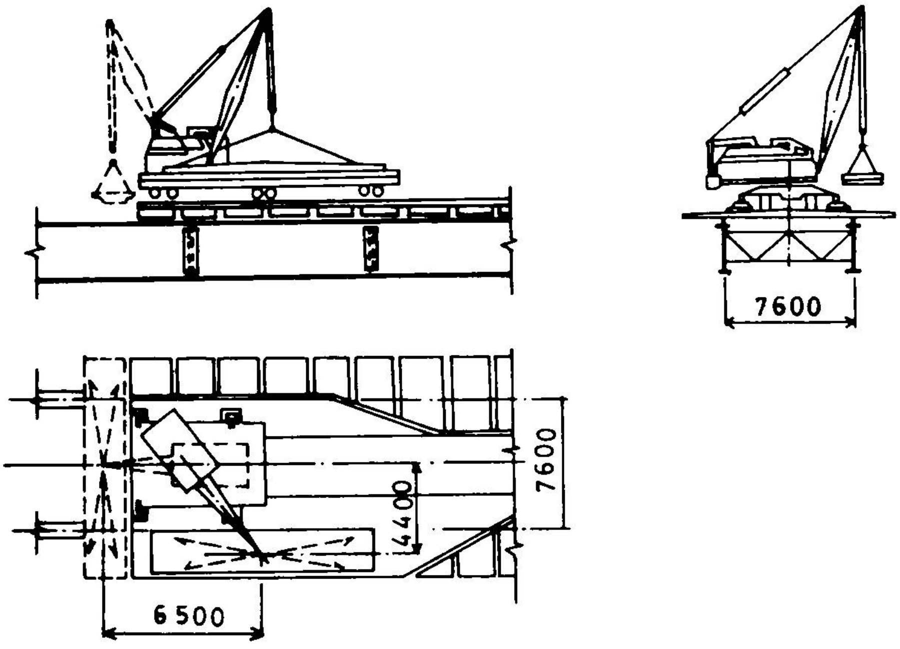

Fig. 3. Scheme of precast slab erection.

3. Composite Railway Bridges with Precast Slabs

3.1. Precast Slabs for Ballastless Track

In the Russian bridge railway construction practice steel superstructures of a through and deck truss types are widely used. Standard designs of these bridge types cover the range of spans from

33 to 154m.The application of ballastless track over precast reinforced concrete slab panel is a typical practice. This type of slab has a longer lifespan, prevents top flanges of girders against corrosion and deterioration, allows to replace wooden ties with no lifting or lowering the track line at approaches, provides safety in case of derailing. A typical section of precast reinforced concrete slab panel is shown in Fig.4.

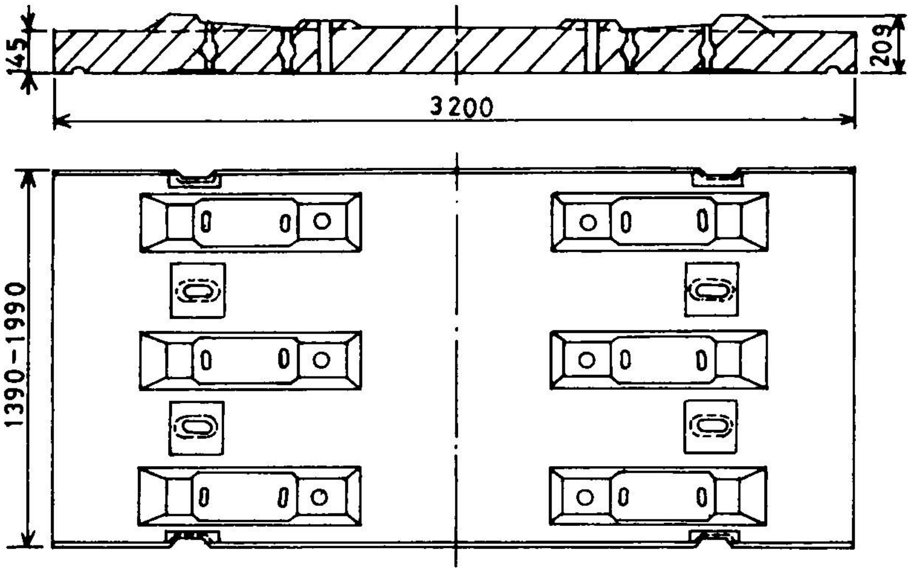

Fig.4. Typical cross section of precast reinforced concrete panel.

Erection of precast panels may be easily implemented with a cantilever locomotive crane or special cranes for track installation. For the connection of panels to steel structure stud bolts are normally employed. Gaps between the precast slab panels and bearing pads are not allowed. The connection between the panels and superstructure are filled with mortar or concrete under a thorough control. These works have to be implemented only in a warm weather period. Within a period of 5 days while concrete hardening, the force of stressing the stud bolts have to be controlled by a value of up to 80kN. When concrete strength of at least 980 kPa is obtained, the stud bolts are tightened to the design value of 200kN.

3.2. Composite Superstructures of Deck Plate Girder Type

In nowadays railway bridge construction practice composite superstructures of deck plate girder type are mainly employed. This type of single track ballasted deck superstructures was designed in 1970s for the spans of 18.2, 23.0, 33.6, 45.0 and 55m.

Steel portion of each superstructure comprises 2 welded main beams of I non-symmetrical section (Fig.5). Steel main girders for 18.2 - 33.6m spans have no erection connections. The main beam of 45m span consists of 2 segments of 22.5m length each. The main beam of 55m span consists of 3 segments of the following lengths 17.4, 21, 17.4m. To form a complete superstructure cross section, main beams are connected between each other by cross-bracings. Stability of top flange at erection is assured by cross-bracings and at operation condition by deck slab.

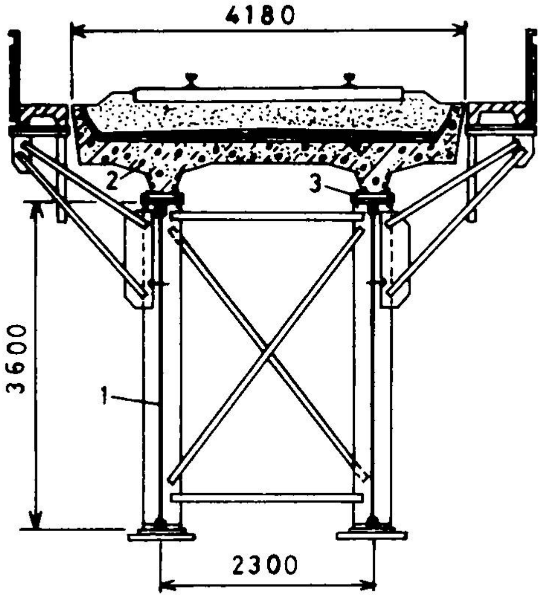

Fig. 5. Typical superstructure cross section with ballasted deck.
1 - steel girder; 2 - reinforced concrete slab; 3 - embedded item.

The slab consists of panels, length of which are taken from 2.5 to 3.2m (weight of one panel up to 11t). The position of embeds has very strict tolerances. The slab has relatively high haunches, contributing to a working capacity of the structure. To reduce cast-in-place concrete processes, high strength bolts are used for connection of precast reinforced deck panels to steel structure. Cast-in-place concrete only implemented at the connections between deck panels.

The composite superstructures of 18.2, 23.0 and 27m spans are normally erected by cantilever locomotive cranes GEK-80 and GEPK-130 with deck slabs already connected to the steel beams. The composite superstructure of 33.6m span may be erected by the cantilever locomotive crane GEPK-130 with no 4 deck panels in its final position. Assembled steel beams of 45m span may be erected by crane GEPK-130 or by crane GEK-80 but in the latter case a temporary pier in the middle of span is required. Steel structures of 55m span may be erected by the same cranes but additionally using a temporary pier in 1/3 of the span. Alternatively the erection may be implemented by the method of longitudinal launching using a nose and in this case temporary bracings at top flanges of steel beams are required. The prefabricated slab panels are supplied to erection site with the applied waterproofing and protective layer.

3.3. Composite Superstructures of Large Shop Fabricated Units

The aim of efficient construction schedules, economy and safety may be achieved by the use of large prefabricated units. To meet this aim in the construction of railway bridges a concept of composite superstructure comprising two large shop fabricated units have been worked out. Although the superstructures of various span length have been designed for a single track railway the application for a double or more track railway bridge is also possible using a common ballasted deck. The designed box girders with a ballasted deck cover standard span lengths of 18.2, 23.0, 27.0, 33.6, 45.0m. A typical cross section of superstructure comprising two shop fabricated units is shown in Fig. 6. Each composite superstructure unit comprises a sealed steel box girder

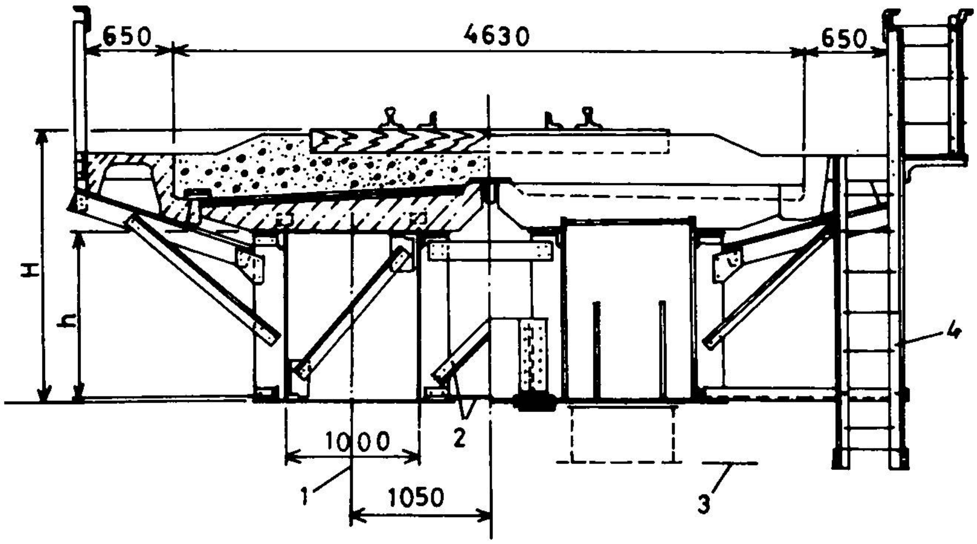

Fig.6. Typical cross section of superstructure comprising two shop fabricated units.
1 - axis of box girder; 2 - only for superstructures of 27m span and over; 3 - top of bearing upstand; 4 - ladder for pier access.

(full span) and reinforced concrete deck for ballast. Waterproofing and protective layer are applied at shop. The connection of reinforced concrete deck to steel is provided by means of stiff shear connectors.

Two composite superstructure segments are jointed at erection by cross bracings using high strength bolts. Weights of composite superstructure segments for standard span lengths are given in the Table below.

Span length, m	18.2	23	27	33.6	45
Weight of composite superstructure segments, t	34.6	45.4	54.2	74.0	110.7

Table.

The erection is normally implemented by special cantilever locomotive cranes GEK-80 or GEPK-130y with capacities of 80 and 130 t consequently.

4. Conclusion

The erection techniques and structural details described has been implemented for a large number of bridges in Russia. The wide application was started about 20 years ago, and over the years the techniques has been steadily refined. The abovediscussed structural details and erection techniques reflect the standard designs used for current construction practice.