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REPORT

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Innovative Method for the Production of Deck Slabs of Steel-concrete-Composite Bridges

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Abstract

Different methods have been developed for the production of deck slabs of large steel-concrete-composite bridges. Often such deck slabs are cast with in-situ concrete with the aid of a formwork carriage. In order to speed up the construction, construction methods with pre-past partial-depth or full-depth elements have been employed. Usually a crane is needed for the placing of the pre-fabricated elements.

A patent for a new construction method for deck slabs of steel-concrete-composite bridges was recently granted to TU Wien. The innovative feature of this novel method consists in the combination of the advantages of in-situ construction using a formwork carriage with partial-depth elements. First, pre-fabricated elements for a section of the deck slab with a chosen length of for example 25m are placed at the assembly area. Reinforcement is placed on top of the pre-fabricated elements and a first concrete layer is cast on top of the pre-fabricated elements. Then a carriage, which can travel along the whole length of the bridge like in the case of a formwork carriage, moves the precast elements to their final location by lifting them approximately 400 mm and then transporting them where ever they need to go. Finally an in-situ concrete layer is added on top of the elements. When the in-situ concrete has gained enough strength, the prefabricated elements, which serve as a lost formwork but also become a load carrying part of the deck slab, are detached from the carriage. This construction process is repeated until the entire bridge carriageway is constructed.

The essential advantage of this innovative construction method for the production of slabs for bridges is the reduction of construction time and the production of a deck slab with the same quality as an in-situ concrete slab.

Keywords: Deck slab; Steel-concrete-composite bridge; Precast element; installation carriage.

1 Introduction

Deck slabs of steel-concrete-composite bridges can either be produced using cast in-situ concrete or by placing precast concrete elements. An example where the deck slab is cast directly on site is shown in Figure 1, with a formwork carriage being used. The formwork of the deck slab is supported by a formwork carriage, which can be moved longitudinally along the bridge. Placing of the reinforcement takes place at the installation site resulting in a construction progress of 20m to 25m
of deck slab a week. Transverse construction joints are created between the slab sections.

Figure 1. Production of a deck slab using a formwork carriage (© Doka)

A faster construction of the deck slab is possible, if full depth precast elements are used, as shown in Figure 2, where full depth precast elements are placed on transverse steel girders. In this example [1] a crawler crane was used to install the precast elements. If the bridge deck is located high above the ground or if the ground conditions do not permit the utilization of a crane, installation machines can be used to place the precast elements. Examples of the production of the deck slab with installation machines are shown in [2]. A big disadvantage of the construction with full depth precast deck elements is the fact that a supporting structure has to be provided. The cantilevering transverse steel girders of the bridge deck, whose sole purpose is to support the precast elements, can clearly be seen in Figure 2. On one hand a reinforced concrete deck slab without these transverse girders would presumably contribute to a reduction of the erection costs of the deck slab on the other hand the construction time would increase in comparison to a precast solution if an in-situ concrete deck would be produced. A further issue of full depth precast construction is the large amount of transverse and longitudinal joints with cracks occurring at the joints between the precast elements and the in-situ concrete, which is placed between the precast elements. Although these cracks will often only have widths of about 0.1 mm and a waterproofing layer is applied on top of the concrete slab, some bridge owners chose to not use full depth precast elements in bridge decks due to the crack predisposition.

Figure 2. Assembling full depth precast elements (© LAP Dresden) [1]
The focus point of the TU Wien proposal for the erection of deck slabs for steel-concrete-composite bridges was the search for a construction method combining the erecting speed of precast element constructions with the quality of a monolithic concrete slab, which is obtained with in-situ construction methods.

2 TU Wien proposal for the erection of deck slabs

The construction steps of the presented method [3, 4] to produce a bridge deck for steel-concrete-composite bridges are shown in Figure 3 through Figure 7. The figures are partly taken form the patent documents and show the erection process in a simplified and schematic manner.

The precast slab elements, with a thickness of 60mm to 70mm, are produced under industrial conditions in manufacturing plants before being transported to the construction site. The slab elements already contain a part of the reinforcement needed for the final deck slab. The bonding surface of the elements are produced with a predefined roughness and are equipped with lattice girders to further enhance the bond between the element surface and in-situ concrete.

The assembly area on the construction site consists of a working platform with an adjustable surface in order to match the geometry of the top surface of the main girders of the bridge and the position of the deck slabs at the installation site.

![Figure 3. Precast slab elements placed on working platform at assembly area](image1)

Figure 3 shows how the precast slab elements are placed on the working platform. In the following construction process a distinction will be made between joints between precast elements (section A-A in Figure 3) and joints between sections of the deck slab (section B-B in Figure 3), which cause...
transverse construction joints in the in-situ part of the deck slab. At the assembly area reinforcement is placed on the precast elements and a first concrete layer with a thickness of 50 mm is cast (Figure 4). The precast slab elements are connected by reinforcement, which is not shown in the figures for the sake of keeping the drawings simple, and the first concrete layer. Three plates are formed by the process of connecting the individual precast slab elements. These plates are designated as cantilever plates and a center plate in Figure 4.

An installation carriage is needed for the transport of the plates form the assembly area to the installation site. A very basic example of an installation carriage, which is very similar to a formwork carriage [5, 6], is shown in Figure 5. Supports are fixed to the top flanges of the main girders with roller bearing installed on top of these supports. A movement of the installation carriage in the longitudinal direction of the bridge is achieved by a rolling action of the longitudinal beams of the installation carriage on the roller bearings.

![Diagram](attachment:transverse_beam.png)

*Figure 5. Installation carriage*

![Diagram](attachment:transport_of_prefabricated_slab_elements_with_first_concrete_layer_using_the_installation_carriage.png)

*Figure 6. Transport of prefabricated slab elements with first concrete layer using the installation carriage*
After moving the installation carriage to the assembly area the plates are fixed to the installation carriage using tension bars. Hydraulic jacks, which are not shown in Figure 6, are positioned on top of the transverse beams at the location of the tension bars. Lifting and lowering of the plates can be easily achieved by activating the hydraulic jacks. In the next construction step the plates are moved from the assembly area to the installation site. During the longitudinal transport the plates are in an elevated position, which is required in order to avoid a contact with the top flanges of the main girders and to pass over finished sections of the deck slab. At the installation site the plates are lowered into the final position and placed on elastomeric strips, which are fixed to the upper side of the top flanges of the main girders. Additional transverse reinforcement, which cannot be present during the transport of the plates, has to be installed in the deck over the main girders. A second concrete layer is cast at the installation site creating a monolithic carriageway once the concrete is hardened out of the cast in-situ concrete, the centre plate and the two cantilever plates (Figure 7).

A section through a joint between two precast slab elements is shown in Figure 8. The thickness of the precast slab elements is equal to 70mm, with a formed pocket at the connecting edge, in order to obtain the required concrete cover for the reinforcement, which is placed across the joint in the first concrete layer. After hardening of the first concrete layer the precast slab elements are connected with each other forming a plate with a thickness of 120 mm. The deck slab is completed by casting a second concrete layer at the installation site.

The situation is different for a joint between precast slab elements at the end of the slab section, as is shown in Figure 9. The first concrete layer cannot be cast in a strip parallel to the edge. The width of this strip corresponds approximately to the splice length of the transverse reinforcement. Continuity of the deck slab is achieved by the reinforcement and the in-situ concrete of the second layer. Because the in-situ concrete is cast at different times for two sections of the deck slab, a construction joint exists in the second concrete layer.

Figure 7. Second concrete layer at installation site

![Diagram showing installation site with second concrete layer](image)

Figure 8. Section A-A of figures 3, 4 and 7 showing the joint between precast elements

![Diagram showing section A-A](image)
3 Conclusions

A new method for the production of deck slabs for steel-concrete-composite bridges is presented in this paper. The innovative feature of this new method consists in the combination of the advantages of in-situ construction using a formwork carriage with partial-depth elements.

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5 References


