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UHPFRC Cast-in-Situ Over-Lay of Bridge Abutments

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Abstract: Use of UHPFRC (ultra high performance fiber reinforced concrete) cast-in-situ over-lays for repairs and strengthening of bridge decks is already quite a widely used technology, while use of this method for strengthening of bridge supports is still much less often. This paper describes the first use of this technology for bridge abutments in the Czech Republic, and if we know well, also the first use of such a ribbed over-lay internationally.

Key words: Strengthening of bridges, bridge abutments, bridge supports, UHPFRC over-lay.

1. Introduction

The bridge described in this paper carries a street over Wild Creek in Meziboří at Litvínov in northern Bohemia. Originally, it had a simply supported reinforced concrete slab superstructure and plain concrete abutments with wingwalls. Due to the technical state, the bridge needed a complete reconstruction both of the deck as well as of supports. For the purpose to minimize the impact of the reconstruction to the surrounding environment especially in an urbanized area, only the deck was completely removed and replaced, while most of supports (abutments and wingwalls) were let at their place and they were strengthened by cast-in-situ UHPFRC (ultra high performance fiber reinforced concrete) over-lays.

By this way, it was possible to decrease extents of demolitions and excavations as well as volumes of transported material (old and new). Such a technique is advantageous economically as well as environmentally, including lower emissions of CO_2, and enables also a significant reduction or even elimination of relocations of underground utilities (e.g. wirings, water pipelines etc.), shortening the construction period and duration of traffic interruptions.

The bridge described in this paper is rather small, but an analogous principle and technology can be used for structures of practically any size.

2. Structural Design

During the reconstruction, the structural system of the bridge was changed into a closed frame. Firstly, the deck and upper parts of abutments and wingwalls were removed. Remaining parts of existing supports were used just as a lining of the construction pit—their function was taken by a new cast-in-situ UHPFRC over-lay. Due to the excellent properties and quite higher price of this material, it is normally used for elements with small dimensions of cross sections. Because of that, the thin vertical over-lays used here for strengthening of supports are ribbed, with stiffening ribs made in gaps prepared in the surface of existing abutments (Figs. 1-4).

Thickness of the over-lay, made in the volume of the previously removed damaged concrete surface of abutments, is 75 mm; it is increased up to 150 mm at corners with wingwalls. The width of vertical ribs is varying from 100 mm to 110 mm and their depth behind the over-lay is 225 mm so, that the complete

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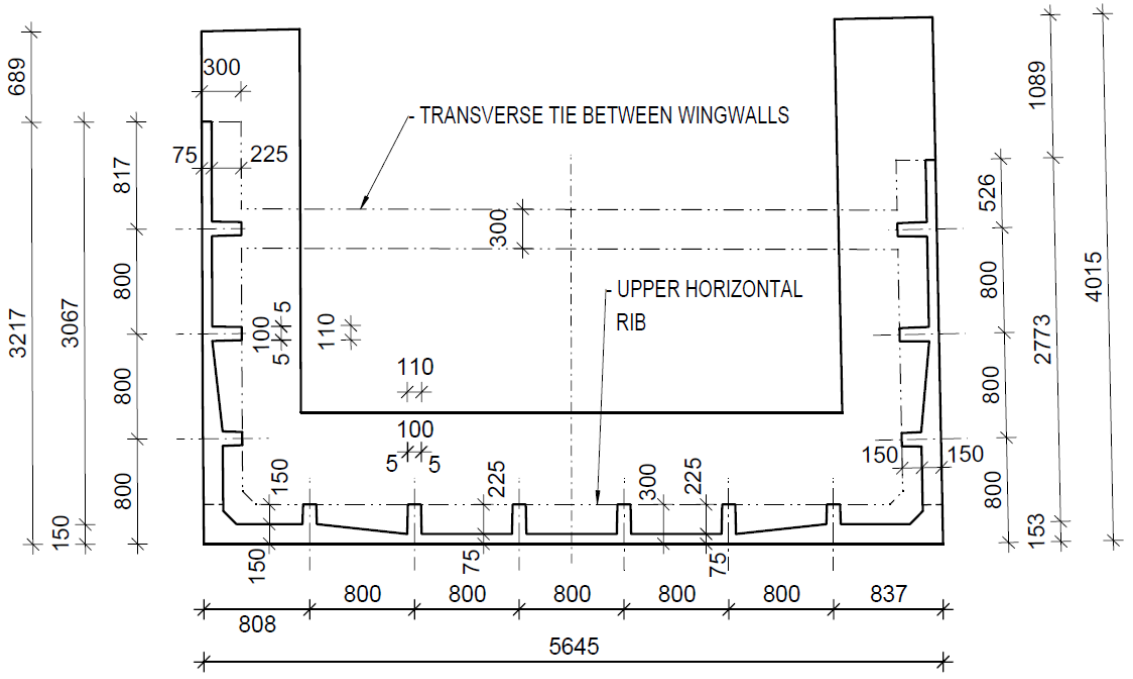

Fig. 1 Horizontal section of abutment and wingwalls with cast-in-situ UHPFRC ribbed over-lay.

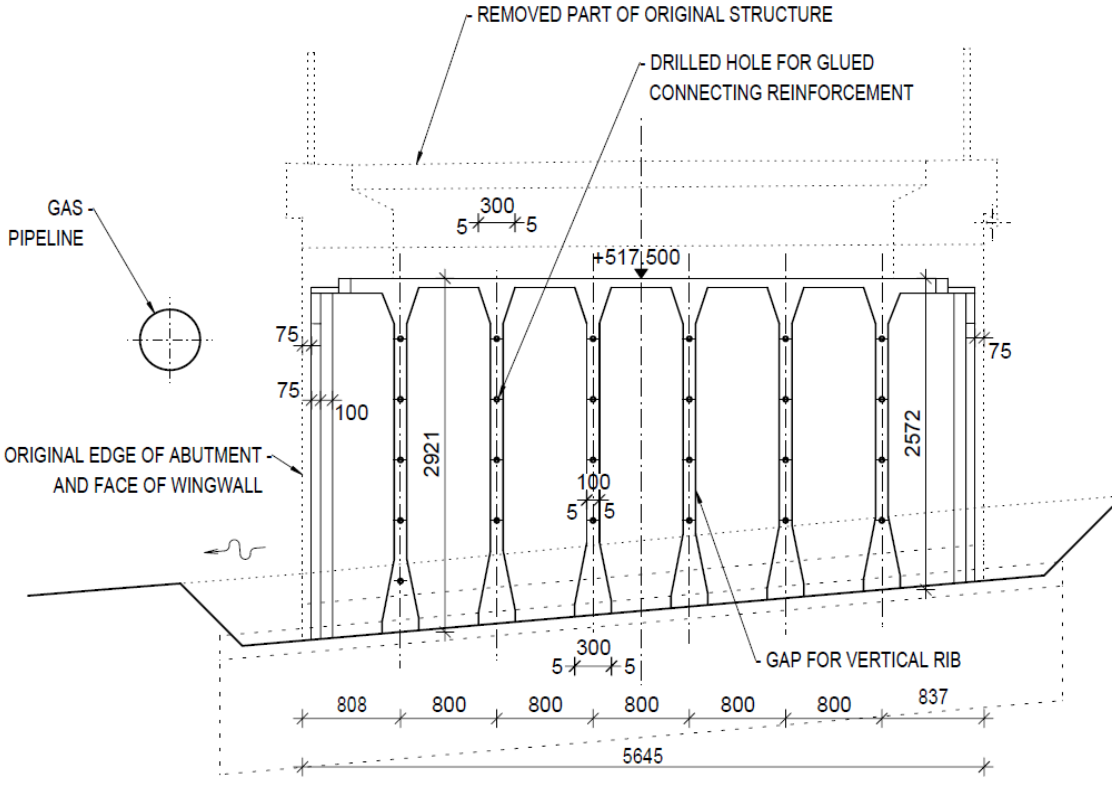

Fig. 2 Front view of abutment with removed degraded parts and with gaps prepared for vertical ribs.

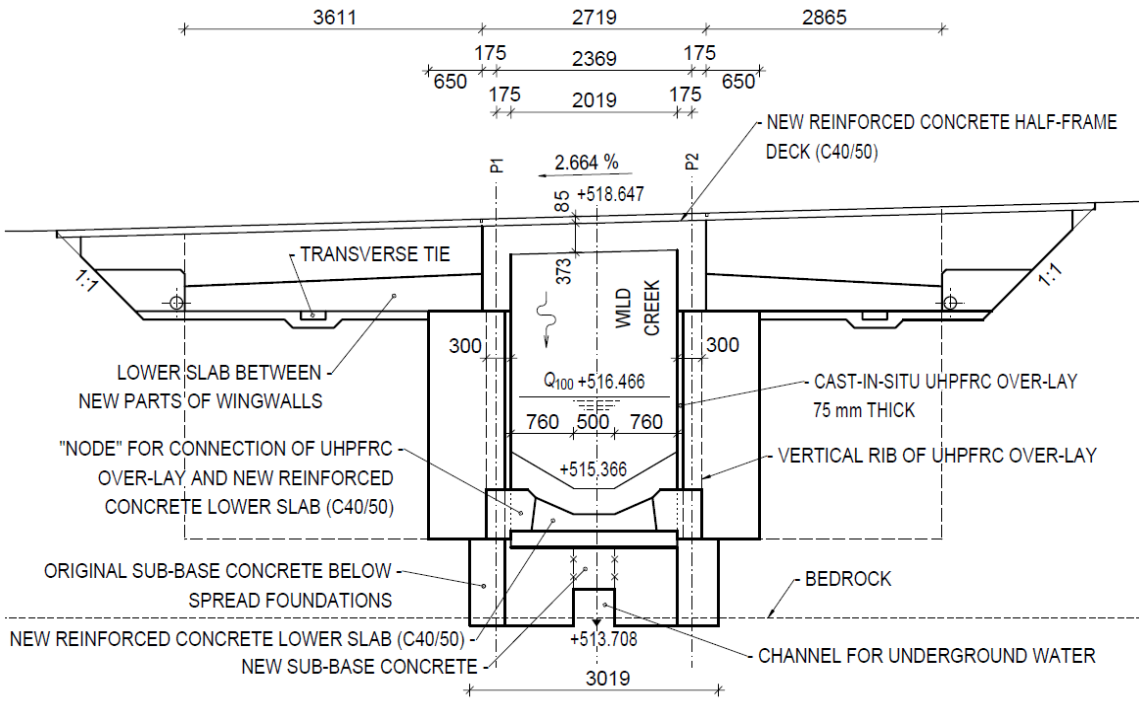

Fig. 3 Longitudinal section of the bridge after reconstruction.

depth of the rib cross section is 300 mm. At the top of the over-lay, there is a horizontal stiffening rib 300 mm wide. Wingwalls are at their ends connected together by a transverse horizontal tie. All parts of the over-lay are made of UHPFRC with a characteristic cylindric strength of 130 MPa and are reinforced also by bars of reinforcing steel. The over-lays are connected to the existing substructure by reinforcing bars glued into drilled holes.

The structural design was made under the assumption that the main load-bearing reinforcement would be made of reinforcing bars, while the "transverse" reinforcement would be made of steel fibres distributed in the concrete.

A new reinforced concrete (made of C40/50) half-frame superstructure was fixed to the top of these UHPFRC over-lays and a new reinforced concrete slab (made of C40/50 too) was fixed between lower parts of abutments. This lower slab enlarges also the spread foundations and works as a strut between the feet of abutments. Parts made of UHPFRC and made of C40/50 are connected together by bars of reinforcing steel.

Fig. 4 Face of abutment with removed degraded concrete, gaps prepared for ribs and their reinforcement.

Fig. 5 Testing specimen made of UHPFRC before casting the over-lays.

Fig. 6 Casting UHPFRC over-lays; transverse ties between wingwalls are also visible.

Fig. 7 View of the bridge after reconstruction; calculations proved that hydraulic capacity is sufficient even with the gas pipeline in front of the bridge.

3. Material for UHPFRC Over-Lays

For this project, self-compacting UHPFRC mix with a characteristic cylindric compressive strength of 130 MPa, volume content of steel micro-fibres of 2% (160 kg/m^3) and tensile strength of 15 MPa (corresponding to a crack width of 0.5 mm) was prepared. The fresh material was transported by truck mixers to the distance of 110 km between the producing factory and the construction site. It had to remain fresh for 6 h. Before casting the actual over-lays, a testing specimen was cast, which included a rib and an adjacent part of the over-lay and which is shown in Fig. 5.

Two types of steel fibres were compared for this project—one with a diameter of 0.3 mm and a slenderness of 57, the other one with a diameter of 0.2 mm and a slenderness of 65. Material tests proved that properties of the mix with the both types of fibres were very similar, only the material with more slender fibres (diameter of 0.2 mm) had a wavier shape of a stress-crack diagram due to the progressive pulling-out of fibres from concrete.

4. Conclusions

Abutments of the described bridge in Meziboří were strengthened with use of thin cast-in-situ ribbed UHPFRC over-lays. This technology enabled to significantly decrease quantity of demolitions, excavations and construction works in an urbanized area, as well as volume of the waste and also of new material, which had to be transported. Although the bridge is in a place with lots of underground utilities, no one had to be replaced. The UHPFRC was successfully transported to quite a long distance of 110 km and was kept fresh for a processing for 6 h (Figs. 6 and 7).

The client and the owner of the bridge is the city of Meziboří. Project manager was Miloslav Kovač from Projektyss Ltd., designer of the bridge was Roman Šafář, the reconstruction was made by a construction company JCA stavebn í(JCA construction) Ltd. and the UHPFRC was prepared and manufactured by Robert Coufal from TBG Metrostav Ltd.

Acknowledgments

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