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# RECONSTRUCTION OF THE BRIDGE OVER THE HRON RIVER IN VILLAGE HRONOVCE

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**Abstract**

The paper deals with the reconstruction of four-span bridge carrying the third-class road over the Hron river nearby village Hronovce. The need of immediate reconstruction of the bridge object was evocated by an accident of the middle pier. The reconstruction consisted of two phases: the sanitation of the substructure and the replacement of the original superstructure, which was in bad technical condition. This paper deals mainly with the second stage, e.g., the design of new superstructure, which was suggested as a continuous, three-span steel and concrete composite structure.

**Keywords:**

Bridge reconstruction;
Bridge superstructure;
Composite steel and concrete structure;
Method of reconstruction;
Bridge substructure.

## 1 Introduction

Bridges are important and critical elements of the transport infrastructure not only from the viewpoint of the purpose, which they ensure, but especially due to safety, durability and usability of the roads, as well as from the economic aspects, as they are the most financially demanding elements of the roads. Therefore, it is necessary to pay extra attention to their design, erection technology and maintenance to fulfill the required functions during their design life, i.e. implementation of safe and fluent transport over bridged obstacles.

Currently, when bridges built mainly after the Second World War as a result of the reconstruction of the war-damaged transport infrastructure reach the limits of their service life and operability, there is more and more discussion about the need for their rehabilitation. This discussion was also supported by the recent serious accidents of bridges in our country and abroad [1-3]. A common feature of these disasters is mainly insufficient maintenance of the transport infrastructure, overestimation of the properties and quality of materials, bad or unmanaged construction technologies, including imperfect and faulty projects, as well as ever-increasing traffic intensity together with increasing axle loads.

The given examples deal with crashes of prestressed concrete bridges and their reconstructions, which is currently a crucial problem of road infrastructure. However, there are also problems with old steel bridges requiring rehabilitation. Different rehabilitation and strengthening methods are developed and used, which are described by many authors [e.g. 4-8]. General approaches to the rehabilitation of steel structures and bridges are summarized and described in the book [9].

## 2 Description of the original bridge

The original bridge was situated on the third-class road near the village Hronovce in south Slovakia. The substructure of the original bridge consisted of three inner piers and two outer abutments. Both the abutments and the piers consisted of pairs of columns with circular cross-sections, on which the pier caps formed by a concreted welded IP 600 girders were placed.

The superstructure of the original bridge was made up of two systems. Four IP 1000 steel welded girders of length 18.0 m made of steel grade S235 were placed on the substructure in each field, which were connected above the piers by bolted connections of the webs using double-sided backing plates. The axial distance of the IP girders in the bridge transverse direction was 1 670 mm. The theoretical spans of individual fields were 17.4 + 18.0 + 18.0 + 17.25 m. The load-bearing steel structure of the temporary single-story three-webs Bailey Bridge (BB), made of steel S355, consisting of truss main girders, open bridge deck and wooden carriageway, was installed on the IP girders and supported near the IP girders supports (considering the location of the verticals of the truss main girders of the temporary bridge in the 3 048 mm module). Detailed cross-section of the original bridge is shown in Fig. 1.

During the extensive flood, there was significant damage of the middle inner pier, so it was necessary to close the bridge and to proceed with the reconstruction of the bridge.

## 3 Diagnostic inspection and structural analysis of original bridge superstructure

Detailed diagnostic inspection of the bridge and a detailed static analysis of the original bridge superstructure was performed before decision related to the method of reconstruction. Due to the accident of the middle pier of the bridge, the restoration of which was abandoned for several reasons, the originally four-span bridge structure became a three-span structure with double size of span in the middle field. The 3D computational model of the bridge superstructure was created in the software environment of SCIA Engineer (see Fig. 2) using beam elements only.

The results of the static analysis clearly showed that the relatively markedly damaged upper part of the bridge superstructure, formed by the temporary bridge BB, limited very significantly the normal load-carrying capacity (LCC) of the bridge superstructure to $V_n$ = 9.2 t. The lower part of the superstructure, formed by steel welded IP girders, was in relatively good technical condition and even after the middle pier was excluded, it proved a much higher load- carrying capacity than upper part of the bridge superstructure.

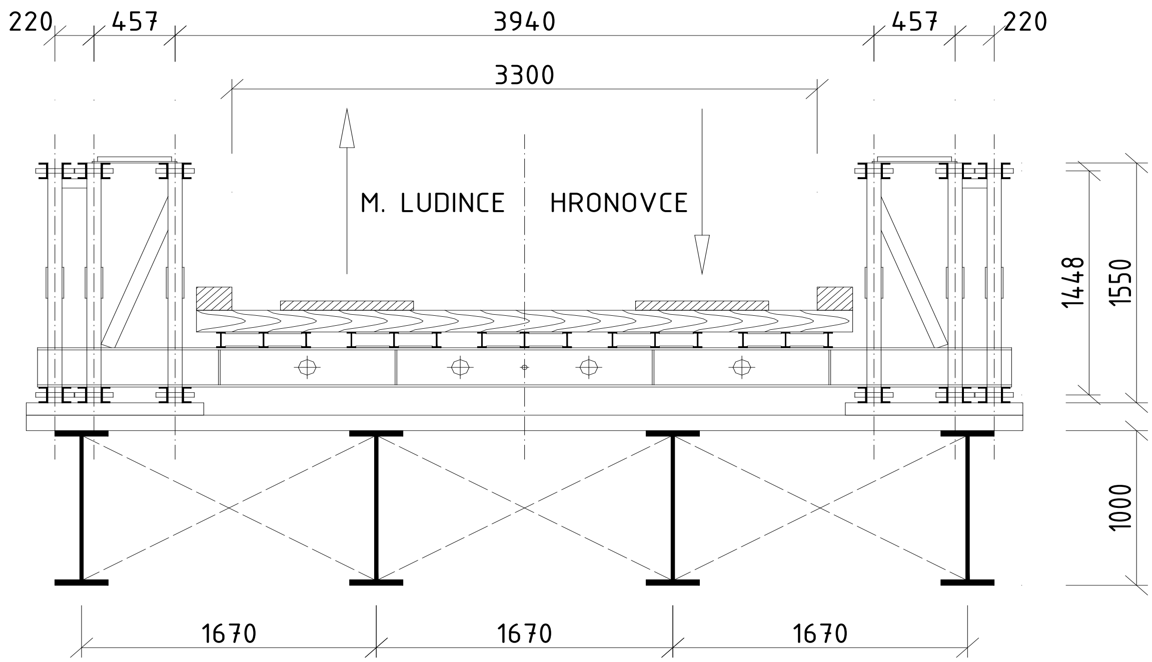


Fig. 1: Cross-section of the original bridge.

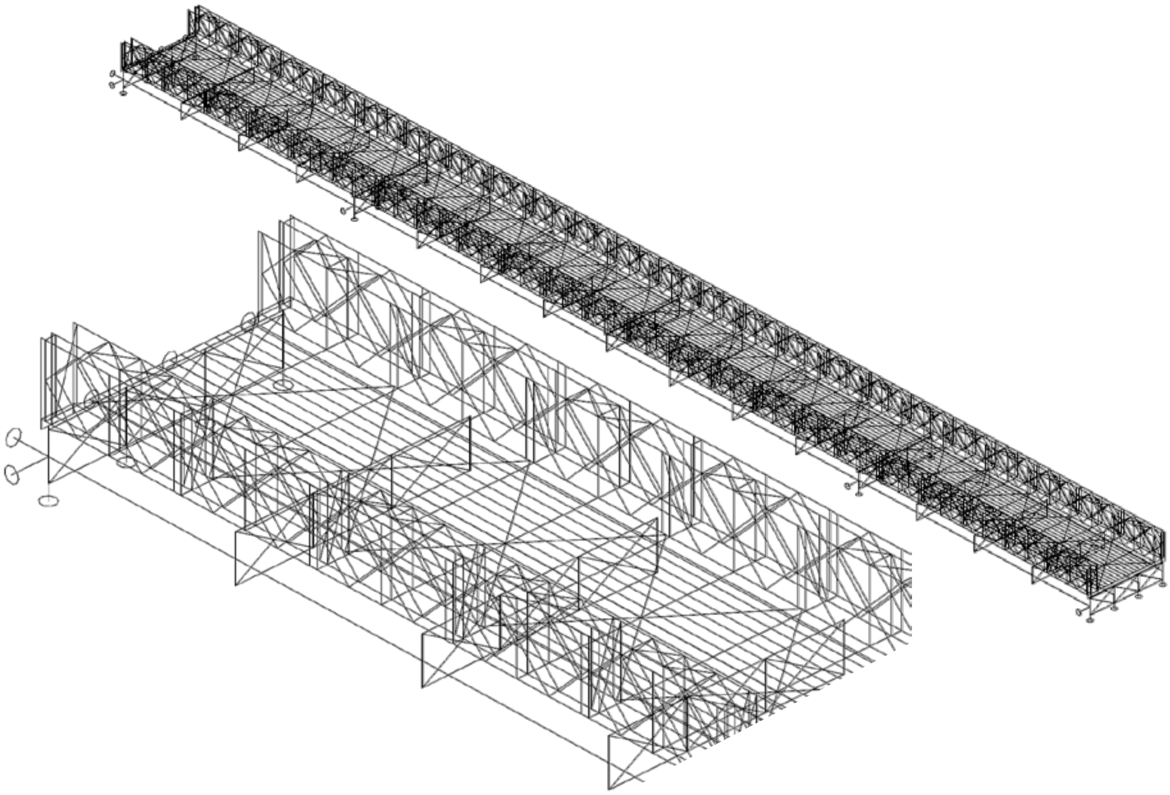

Fig. 2: Computational model of the original bridge superstructure - a view of the entire model and a detailed view of the part at the edge support.

**4 Technical solution of bridge reconstruction**

In frame of the first stage of reconstruction, the piers were reinforced with micro piles and reinforced with stone backfill. The pier caps made of the IP 600 girders were reinforced by concreting. The abutments were adjusted and supplemented with parallel wing walls.

Based on the results of the static analysis as well as the diagnostic inspection, it was decided to proceed with the reconstruction of the bridge superstructure. Preliminary static assessments using computational model shown in Fig. 2 indicated the possibility of using IP girders to create a new type of superstructure excluding the temporary BB bridge. The choice of a composite steel and concrete system showed up as the optimal structural solution, in which the original welded IP girders would be used for the steel part of the composite structure connected to a newly built reinforced concrete slab concreted on the girders.

The composite steel and concrete superstructure was designed as a continuous three-span grid system with spans of 17.25 + 36.0 + 17.40 m. The bridge longitudinal arrangement is shown in Fig. 5. The design of the superstructure was processed for load class B of road traffic action according to standard [10], as far as the bridge was situated on the local communications. To calculate the internal forces and moments, the computational model shown in Fig. 4 was created in the software SCIA Engineer. The bridge slab was modelled using shell elements and the steel girders and transversal bridge bracings were approximated by means of beam elements (see Fig. 3).

Reliability assessments of individual members of the system respected the principles of standards [10], [11], [12], [13], [14], guideline [15] and considering the essential rules of the approach to the evaluation of existing bridges according to [16]. The slab concreting was considered on IP girders placed on supports. The effects of shrinkage and creep of concrete have been taken into account according to standard [11]. Due to the statically indeterminate bridge superstructure, it was also necessary to take into account the secondary effects of the concrete creep influences, which was carried out using the so called ω-method [17].

The arrangement of the girders in the bridge cross-section was also kept at the original distances, i.e., 1 670 mm (see Fig. 4). Due to the non-functionality of the reinforced concrete slab in the support areas, when the slab is stressed by tension and is ineffective from the viewpoint of the resistance of the support cross-section, its coupling with the steel part was not realized in this part, as well as in the end fields of the bridge due to hogging bending area. For this reason, static analysis proved the need to strengthen all IP girders above the piers in a length of 4 400 mm. The strengthening was realized by widening both flanges with 50 × 20 mm profiles welded using butt welds of 1/2 V. The welding connection of the strengthened part was performed as notch-less with a fluent transition of the strengthening part in the length of 200 mm to the original dimensions of the flanges of 300 mm. In the end fields, the need for additional strengthening was not proved.

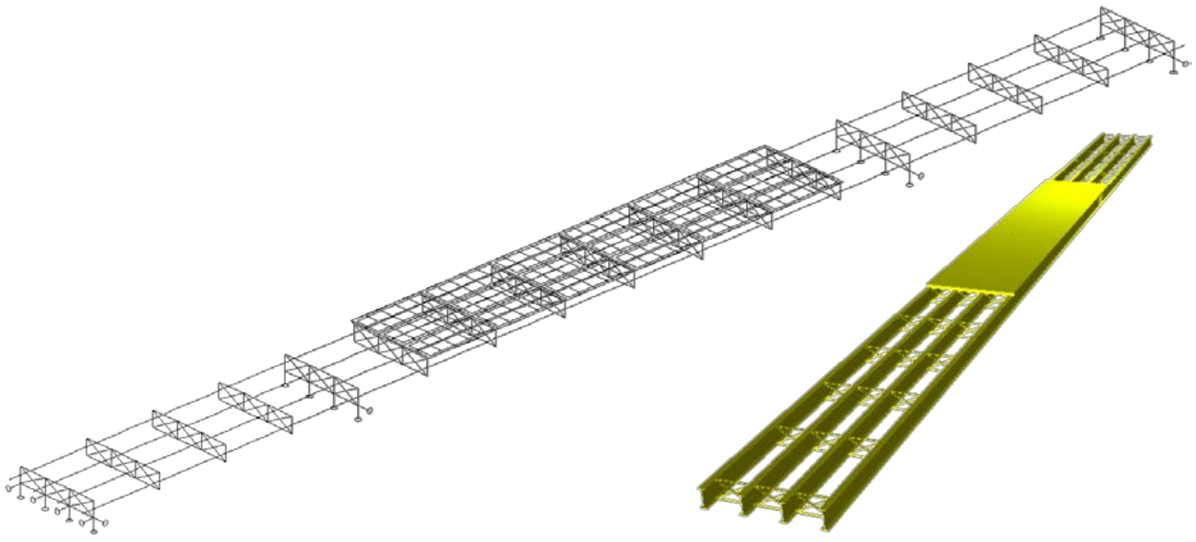

Fig. 3: Computational model of new bridge superstructure.

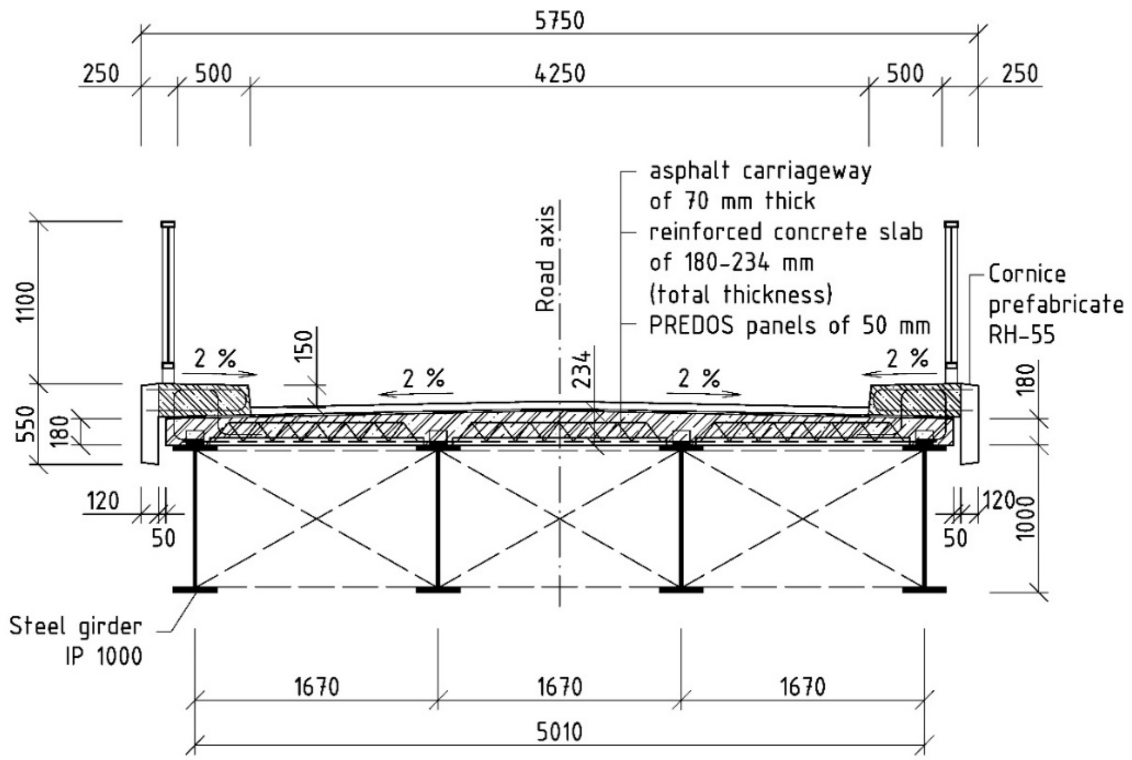


Fig.4: Cross-section of reconstructed bridge superstructure.

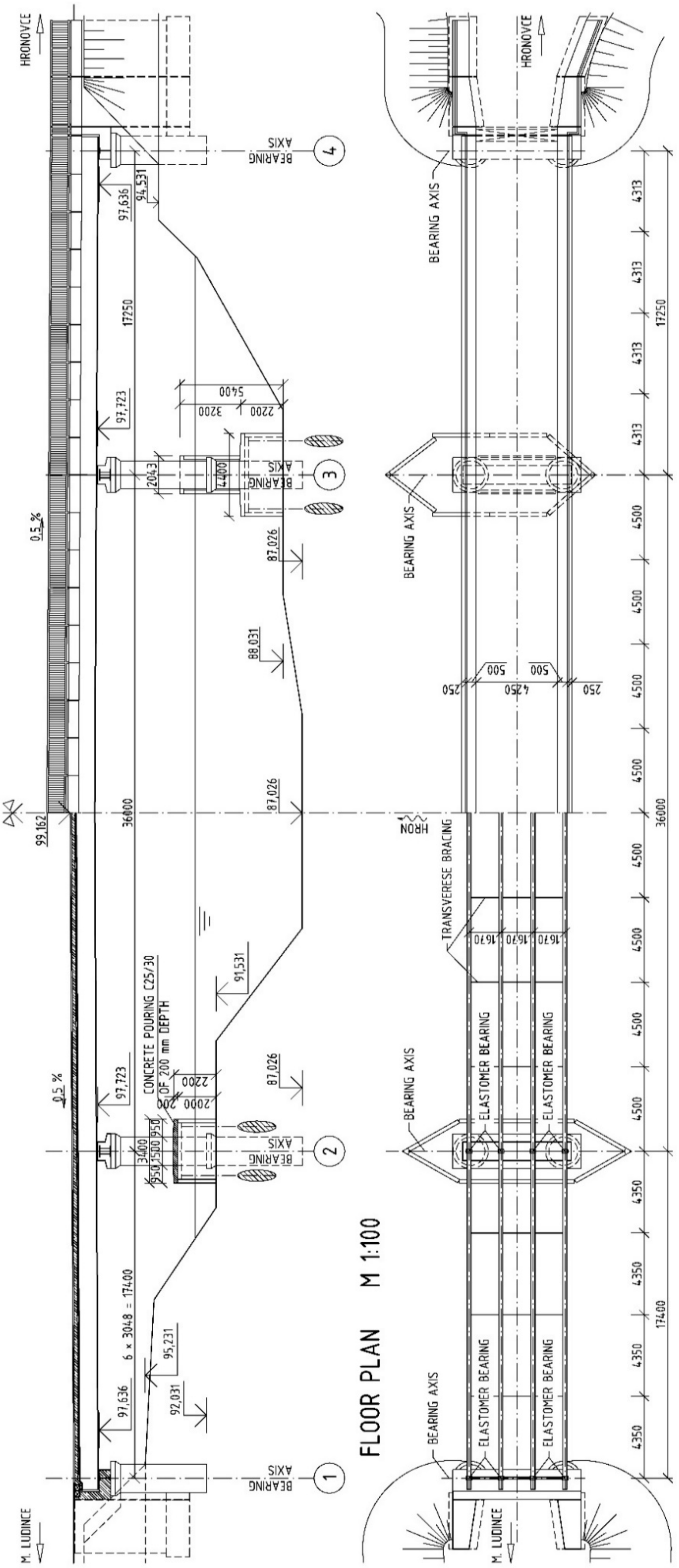


Fig. 5: Bridge longitudinal arrangement.

The steel girders of IP 1000 were connected to the reinforced concrete slab in the central part of the inner field in the length of 26.0 m, i.e. 13.0 m to each side from the centre of the span. The coupling was realized using block connectors made of 100 × 150 × 12 mm angles with a length of 120 mm, which were welded to the upper flanges of the IP girders with fillet welds with the effective thickness of 6 mm (see Fig. 6). The distance of the block connectors was graded depending on the size of the shear flow. The lifting of the concrete slab and its separation from the steel part is prevented by the reinforcement welded to the upper surface of the block connectors in the longitudinal direction of the girders.

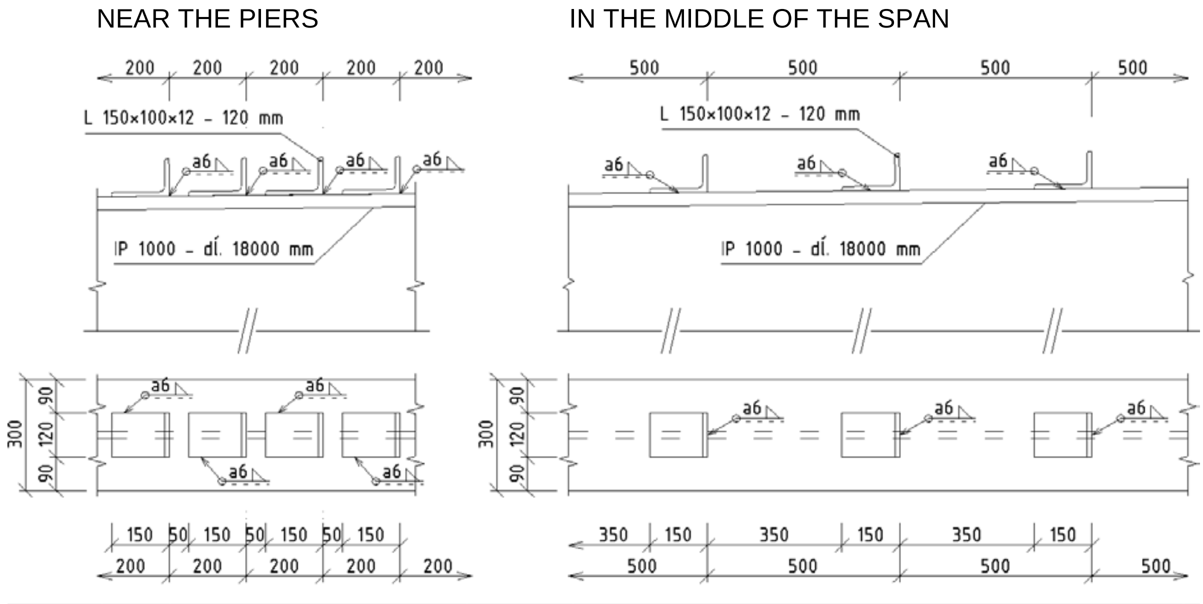


Fig. 6: Arrangement of shear connectors.

The reinforced concrete slab was made using prefabricated PREDOS panels, which performed the function of lost formwork in the first phase of assembly. PREDOS panels with a thickness of 50 mm, a width of 1 480 mm and a length of 1 470 mm were placed on the upper flanges of the steel IP girders by means of a crane. The panels were reinforced by spatial truss beam ZC 13. The overhanging ends of the reinforcement were connected to each other by welding in the places above the IP girders in the length of 160 mm. A monolithic part of the reinforced concrete slab was concreted onto the laid PREDOS panels. Its total minimum thickness is 180 mm including prefabricated panel, the greatest thickness in the longitudinal axis of the bridge is 234 mm, which ensures a transversal slope of the roadway of 2% towards the cornices. The slab is made of concrete C 25/30 and reinforced by the main reinforcement ϕ 10, B500B and structural reinforcement ϕ 6, B325B.

The bridge superstructure was installed on ELV 4 elastomeric bearings with dimensions of 200 × 300 mm on all bridge supports. On the end supports, the elastomeric bearings had to be secured against displacement due to the small reaction of the end field. Shifting was prevented by welding of 20 mm high steel strips to the flanges of the IP 600 beams, which form the pier caps.

Fig. 7: Views of the reconstructed bridge.

**5 Conclusion**

The article presents interesting method of the bridge rehabilitation by means of the application of a composite steel and concrete bridge superstructure for the reconstruction of the road bridge over the Hron river in Slovakia. It is a very effective type of bridge structure, combining the good properties of two of the most widely used building materials.

• The use of composite steel and concrete type of bridge was all the more advantageous in this case, because it was possible to use the original steel superstructure, requiring only minimal structural modifications and the necessary surface treatment.

• The coupling of the reinforced concrete slab with steel girders made it possible to preserve the original arrangement of the substructure with minimal costs for its rehabilitation after the crash of one of the piers, and thus to bridge fields with a disadvantageous span ratio of the outer and inner fields without significant intervention in the steel structure.

• During the concreting of the monolithic reinforced concrete slab, a system of lost formwork from light prefabricated panels was used, which form part of the reinforced concrete slab after the concrete hardens, and thus participate in the load transfer. This system is well-known and commonly used primarily in the field of civil engineering, however, the mentioned contribution proves the possibility of its effective use in bridge construction as well.

• After presented way of bridge reconstruction, new values of load-carrying capacities (LCC) were achieved – normal LCC, $V_n$ = 22,0 t and exclusive LCC, $V_r$ = 40,0 t, which are sufficient values for road class of B.

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