REPAIR AND STRENGTHENING OF ARCH BRIDGES IN THE FRAME OF MODERNISATION OF SLOVAK RAILWAY NET

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Abstract: *Our Department of Structures and Bridges, Civil Engineering Faculty, University of Žilina, got the opportunity to co-operate on working out project documentation of various building structures in important investment plan – Modernization of railway net in Slovakia. The co-operation was with design office Reming Consult, Inc. The paper is focused on reconstruction of two similar old concrete arch bridges of small length.*

From the diagnostic there followed that the damages of structures were caused by atmospheric exposure and non-functional insulation. The structural depth was sufficient, but the bridge spatial arrangement (width of structure) was inadequate for actual Code requirements and also the load-carrying capacity was insufficient. Due to this reason, it was decided not to demolish the bridges, but to reconstruct them.

1 INTRODUCTION

The Department of Structures and Bridges, Civil Engineering Faculty, University of Žilina, got the opportunity to co-operate on working out project documentation of various building structures in important investment plan – Modernization of railway net in Slovakia. The co-operation was with design office Reming Consult, Inc. In the frame of the project, several structures, such as railway bridges, road bridges over railway, subways, etc., were designed or rehabilitated at different levels – documentation for regional planning (DUR), documentation for building permission (DSP) or documentation for building realization (DRS).

A special part of the project was to evaluate old existing arch bridges of small length at existing railway net in order to enable their further usage. The existing bridges are between the capital city of Bratislava and the town of Trnava. At that place, the new railway net interlopes the old one including old bridges. Old arch bridges were from concrete and stone masonry. The aim was to carry out bridge inspection and perform the assessment of the bridges. Following, the repair and strengthening of bridges was needed to be designed due to their low resistance.

Authors of the paper present their view on some specifics of repair and strengthening of existing arch bridges of short spans. The scope of the project documentation was dependent on the purpose to serve documentation. We have worked in processing studies existing railway net, which was necessary to assess whether the existing structure satisfies with the terms of the bridge spatial arrangements, in terms of barriers (capacity of opening in the water-course, etc.) and what is the load capacity of structure. In the case of documentation for building permission (DSP), the main accent was put on conceptual solution of design considering all boundary conditions. That design was developed in the documentation for building realization (DRS) so that the structure was realized in required quality, economical and in required time period considering input conditions.

In the paper, some designs of repair and strengthening of existing arch bridges are shown. It is needed to notice that the presented examples of design are structures realized during limited traffic (one trace was stopped and second one was in operation), what complicated the realization.

2 CODES, PROVISIONS, INSTRUCTIONS

The provision PMR3/1999 [1] is the main provision for design of Slovak railway net modernization. According to that provision, all railway crossings have to be fly-over crossing (branches, rivers, road and pedestrian communications, communications for passengers and baggage at railway stations). The geometrical form of structures considering code [2] was designed and determined together with requirements for office layout and static behavior.

The transitional area behind bridge structure (bridge spatial arrangement) was worked out according to technical code of Slovak railways [3]. Actions on bridges were considered according to old Slovak code [4].

Content and scope of single steps of documentation was depended on provision [1]. The condition of concrete or masonry structures was estimated in preliminary study, there was determined its further exploration or its demolition. In this phase, the diagnostic of real structure condition and behavior and calculation were used.

In documentation for regional planning (DUR), the base conception of design was determined, e.g. selection between reconstruction of existing structure or its demolition and design of new structure. In the case of documentation for building permission (DSP), the design of reconstruction was elaborated so that the construction solution, static behavior, volumes of basic materials, scope of works was clear to make budget. In the final documentation - documentation for building realization (DRS), the project is elaborated into details to realize the structure. Except of technical parameters design, the determination of technological production sequence was very important. It should be in accordance with production sequence of others structures (existing and also new structures – engineering nets, railway net, crossroads, railway stations, etc.) under traffic.

3 EXAMPLES OF ARCH BRIDGES

3.1 Reconstruction of object SO 12.33.06

In first case, existing arch bridge has clearance 6.0 m and it is over cart-road and spring (Figure 1, 2). The existing bridge was just in condition that it was possible to improve its parameters on required level given by current codes and provisions. The arch is from concrete and the massive concrete abutments of the arch are on square foundation and the structure was built in 1941.

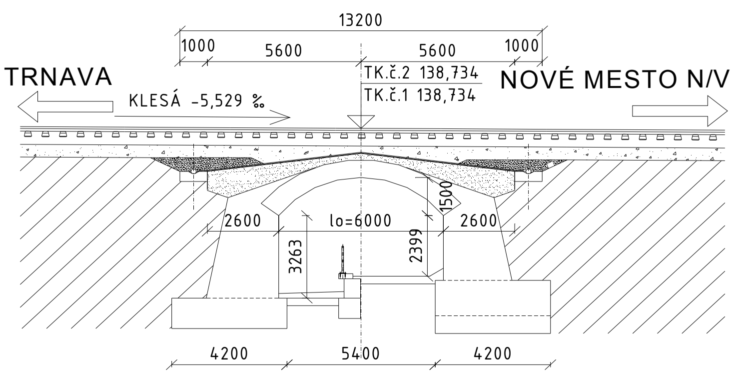

Figure 1: Reconstruction of arch bridge – longitudinal section

From the diagnostic followed that the failures on structure were caused by atmospheric exposure (environmental loads) and non-functional insulation. The building depth was sufficient, but the bridge spatial arrangement (width of structure) was unfit and also the load-carrying capacity was insufficient. From this reason, it was decided not to demolish the bridge, but to reconstruct the object. The reconstruction included elimination of failures, strengthening of superstructure (arch) and substructure (abutments), modification (expansion) of bridge spatial arrangement and creation of new transitional areas. These rescue work were carried out: cleaning the surfaces of the bridge from weathered parts by water jet, surface leveling, grouting of supports and arches. The reinforced concrete slab-layer in gradient 12.46 % coupled with an original arch was built up on arch reverse due to strengthening of the arch. The insulation was laid on the reinforced concrete slab. The cross drainage draining the rainwater out of bridge was created at both ends. The ballast bed is closed along sides by cornice beams and walls. Finally, all the visible surfaces were furnished by unifying gray paint.

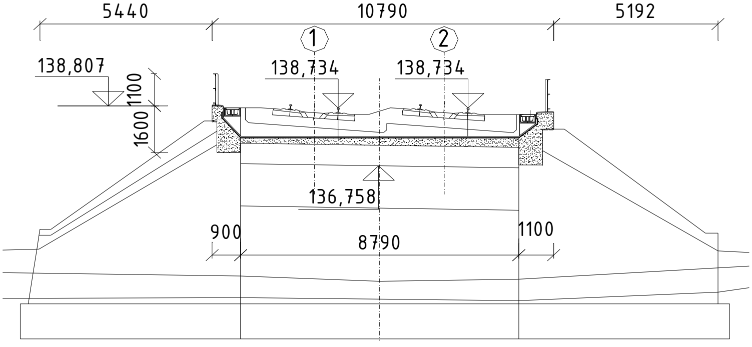

Figure 2: Reconstruction of arch bridge – cross-section

The theoretical model was created so that best describes the structure state after reconstruction. The 2D model "area tightness" in software [5] with depth 1.0 m was used. The ballast bed with subgrade, the transition wedge in front of and beyond bridge, the concrete arch and coupled reinforced slab were included in the model. The result of the strengthening was new load-carrying capacities, which fulfill criterions given in [4].
The arch reconstruction was carried out in three phases:
- phase 0 without traffic lock-out included works, which were not depending on arch traffic,
- phase I included the traffic lock-out on trace 1 and traffic on trace 2,
- phase II included the traffic lock-out on trace 2 and traffic on trace 1.

All needed works were carried out under traffic lock-out trace. The ballast bed at railway track in service was bounded by rider bracing. The trains speed on the railway track in service was limited to 40 km.h^{-1}. The cornice beams along arch sides closed the ballast bed are independent to arch and they are supported on abutments.

Figure 3: View on arch bridge after reconstruction

3.2 Reconstruction of object SO 12.33.05

In second case, existing arch bridge has also clearance 6.0 m and it is just over cart-road (Figure 4, 5). Both arch bridges are very similar. The arch is from concrete and the massive concrete abutments of the arch are on square foundation and the structure was also built in 1941. At this part of the railway, a lot of bridge structures were made at the same time.

The failures on structure were similar to previous bridge structure and they were caused mainly by atmospheric exposure and non-functional insulation. Due to same type of bridge with similar problems, again it was decided not to demolish the bridge, but to reconstruct the object. The reconstruction included elimination of failures, strengthening of superstructure (arch) and substructure (abutments), modification (expansion) of bridge spatial arrangement and creation of new transitional areas. In this case, the reinforced concrete slab was connected to cornice beams along sides and create the box (tank). The gradient of the reinforced concrete slab-layer is 2.0 %. The concrete box if over the arch embedded on the arch top, but it is not coupled (Figure 4). The insulation was laid on the reinforced concrete slab. The cross drainage draining the rainwater out of bridge was created at both ends. The ballast bed was made inside the box (tank). Finally, all the visible surfaces were again furnished by unifying gray paint.

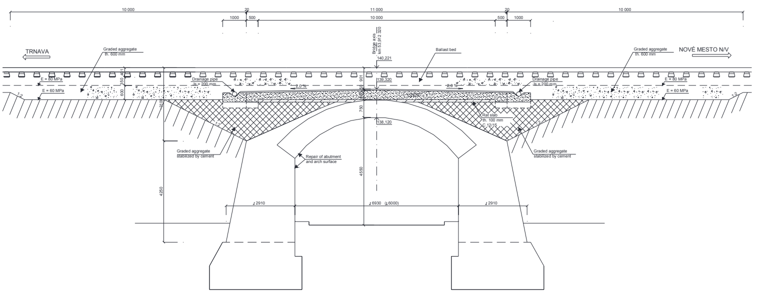

Figure 4: Reconstruction of arch bridge – longitudinal section

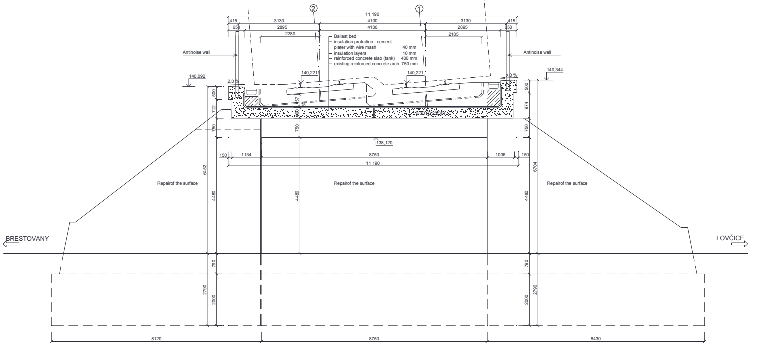

Figure 5: Reconstruction of arch bridge – cross-section

As well, the 2D model “area tightness” in software [5] with depth 1.0 m was used. This type of model is very easy, practical and sufficient accurate for that structure. The ballast bed with subgrade, the transition wedge in front of and beyond bridge, the concrete arch and reinforced slab over arch were included in the model. The result of the strengthening was new load-carrying capacities, which fulfill criterions given in [4].

Figure 6: View on arch bridge after reconstruction

4 CONCLUSIONS

The presented paper shows two ways of reconstruction of concrete arch bridges on modernized railway net in Slovakia. Our knowledge from design of strengthening and realization of concrete structures on Slovak railways is able to summarize:
- design of strengthening was markedly influenced by fact that the reconstruction of railway was performed in the same railway track (without side-track),
- it was also influenced the choice of the technological processes of concrete structure construction (cast-in-place or precast members), separation of structure into expansion parts, time schedule of realization, using the auxiliary structures, etc.,
- time schedule of reconstruction is subjected to the traffic lock-out on traces

ACKNOWLEDGEMENT

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