MODERNIZATION OF RAILWAY BRIDGE ON THE POLISH-GERMAN BORDER

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SUMMARY

On 02.04.2013 a railway bridge was opened on the Polish-German border between Zgorzelec (Poland) and Görlitz (Germany). The bridge, with a total length of 473.31 m, crosses the valley of the River Neisse and is used to carry rail traffic between the Polish Republic and the Federal Republic of Germany. Bridge is a historic building with architecture modelled on the Roman bridges. AECOMs` Design Team was responsible for developing a multi-sector, detailed inventory of the construction, geological research, construction design, detailed designed and the development of tender documents.

Keywords: *Modernisation, stone bridge, Zgorzelec, Görlitz, rebuild, precast, static calculations.*

1. INTRODUCTION

A historic railway bridge between Poland and Germany has reopened after being structurally restored and improved by a design team from AECOM Poland. The bridge, with a total length of 471 meters is located on the Polish-German border between Zgorzelec, Poland and Görlitz, Germany. Owned by PKP Polskie Linie Kolejowe S.A., it is part of one of the 10 Pan-European Transport Corridor (Brussels - Cologne - Dresden - Wroclaw - Krakow - Lviv - Kiev).

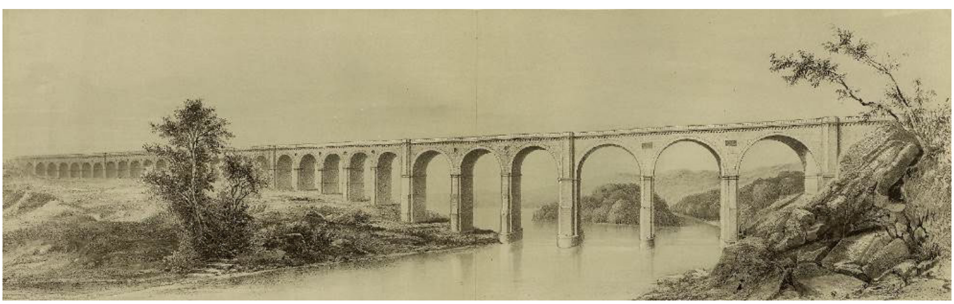

Fig. 1. *Drawing of the bridge from 19th century [1].*

The historic structure, modelled on the architectural design of Roman bridges, crosses the valley of the River Neisse. Today is used to carry rail traffic between the Republic of Poland and the Federal Republic of Germany. Drawing of the bridge from 19th century is shown in Fig. 1.

2. STRUCTURAL CONDITION BEFORE THE MODERNISATION

Originally built in 1847 as a stone bridge, it was partly destroyed in 1945 and rebuilt in 1954. The bridge consists of 30 spans arch, which spans 1 - 26 and 30 is the stone span and span 27 - 29 reinforced concrete. Supports object are 2 abutments and 29 massive pillars. General view of bridge in autumn of 2011 is shown in Fig. 2.

Fig. 2. *General view of the bridge in 2011.*

Construction of the bridge is divided into 7 sections, which are connected by massive pillars:

- section 1 – 1 span,
- section 2 – 6 spans,
- section 3 – 6 spans,
- section 4 – 6 spans,
- section 5 – 5 spans,
- section 6 – 3 spans,
- section 7 – 3 spans,

Total length measured in the axis of the structure is 473,31 m, and width is 8,65 m. Width of the object in the cornices is from 9.58 to 9.95 m. Height of bridge changes from 11,50 m on left bank (Polish side) of the river to almost 35 m on right bank (German side). Arches in stone parts are made of granite thicknesses of 0,78 m (sections 1 to 4), 0,86 m (section 5) and 1,10 m (the stone of the section 6 and 7).

On the superstructure there are 2 non-electrified railway tracks and rail signs, traffic lights and other traffic control devices. Cross section is shown on Figure 3.

For construction works it was used 27 400 m^3 of wood (piles and scaffolders) and 129 500 m^3 of stone (mainly granite). Cost of construction in 1845 was 90 thousand Tallars [3].

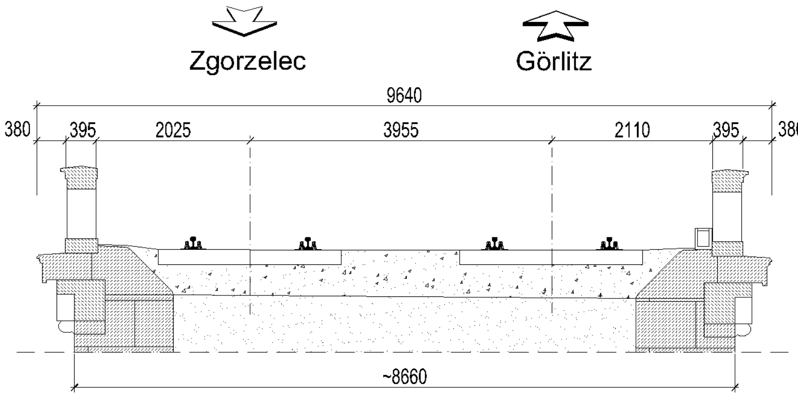

Fig. 3. *Cross section of the bridge*

On the bridge, there are the stone balustrade having a width of 0.38 m made of sandstone, wherein the handrail of a yellow and white bars. On the rebuilt part of the bridge railing were recreated as reinforced concrete with a width of 0.15 m

Fig. 4. *Openwork balustrade, decorative cornice and arcaded frieze.*

3. AIM OF TH MODERNISATION

The main aim of the project was to ensure the strength of the structure in accordance with the requirements of EN 1991-2, for models loads 71 (k+2) and SW/2, the velocity V = 80 km/h. As a result of the design object adapted to the axle load 25 tonnes, achieved UIC B gauge structure and compliance with the requirements of the Technical Specifications for interoperability. Thanks to these treatments the railway line located on the property has been adapted to the parameters described in international agreements AGC and AGTC. All the technical solutions were agreed with the other user of the bridge - Deutsch Bahn, so all documentation was completed in two languages-in Polish and German.

4. ELEMENTS OF MODERNIZATION

AECOM Poland was responsible for developing a multi-sector, detailed inventory of the construction, geological research, construction design, detailed design and the development of tender documents. Services included geological research and construction design which required taking into account the historic significance of the bridge.

The primary task was to modernize the structure so that it corresponded to modern requirements and standards of railroads, especially in the areas of gauge, loads and the safety of railway traffic. At the same time, it was necessary to minimize the changes in order to preserve the historic nature of the building. It was also essential that the design be performed to allow rail traffic to continue on at least one track throughout the duration of the modernization works.

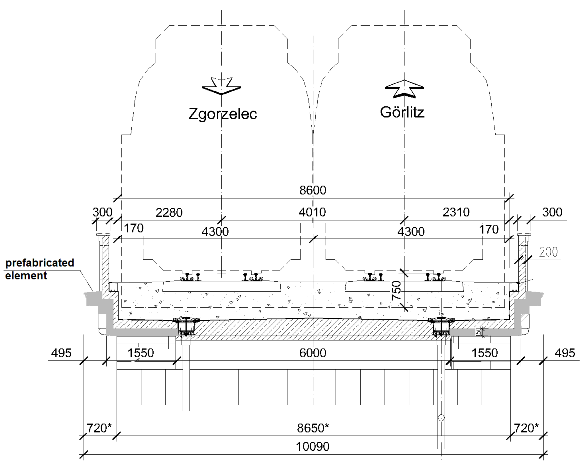

Fig. 5. *Cross section of bridge after modernisation.*

The entire design process and its subsequent execution were conducted within strict time constraints because the completion of work on the bridge in Zgorzelec were prerequisites for modernization of another railway bridge in Horka, also district on the Polish-German border .

Prior to the renovation, the distance between the tracks and the gauge dimensions were not compatible with modern rail regulations. This was true of both the dimensions of the horizontal gauge-distance from the axis of the track to the railings and vertical below the railhead.

All of these factors cause that the bridge had to be extended in the upper and the decision was made to remove the rails, ballast, and stone balustrades, cutting out the upper portion of the side walls. Unfortunately, part of the structure that had to be demolished included characteristic architectural elements such as openwork balustrade, decorative cornice and arcaded frieze. In order to minimize the changes to the appearance of the bridge, the elements involved were designed as close to the original form as possible. Cross section of modernised bridge is shown in Figure 5.

The new construction of the ballasted deck was made from prefabricated elements and monolithic reinforced concrete slabs. AECOM designed 80 types of precast elements. Some of them, especially on the oriels, were made only as a single element. Others, like precasts between the oriels were standardized and fabricated in a number of pieces.

Fig. 6. *Prefabricated elements during installation on bridge [4].*

A total of 642 prefabricated elements were laid out. Their dimensions were chosen in such a way so they can be transported by rail line as well as on public roads without additional authorization. The facade of precast elements included a restored arcaded frieze and a decorative cornice. The use of prefabrication allowed architectural elements to be installed with due diligence. During construction precast elements were redesigned to fit the requirements of construction company Firesta – Fiser from Bratyslava. In Figure 6 and 7 are shown precast elements.

***Fig.** 7. Prefabricated elements after installation.*

The chosen technology of the fabrication simplified reconstruction (there was no need to use formwork) and shortened the time required to achieve it, which was a critical factor.

This type of modernisation, using precast elements, was also used in modernisation of other monumental bridge in Bolesławiec [2].

The ballasted deck was designed in the form of a monolithic reinforced concrete construction consisting of the lower part of the prefabricated elements that were connected. The ballasted deck was thus covered with impact-resistant epoxy-polyurethane resin.

In this manner, the stone elements were protected from the destructive influence of rainwater, which penetrated to the inside of the construction through the ballast.

In the axis of the ballasted deck, a sewage drain was designed which funnelled water to the existing sewage wells. The drainage facility is designed for two rainwater sewerage systems in gravity with an outlet to the river Lusatian Neisse.

Several architectural elements of the existing bridge were aesthetically significant, particularly an openwork balustrade. Designed architectural elements included the existing railings which were made of reinforced concrete. The outer surfaces of railings were covered with white (bars) and yellow sandstone (handrail and cap).

5. CALCULATIONS

Use of static calculation was another issue that had to be confronted. Both Poland and Germany apply the same set of standards of construction design - Eurocodes. Therefore, all models of loads are the same in both countries.

Static calculations of various complexities were made in the two models, depending on the stage of the project. At the stage of conceptual design, it was decided to model only single span, using simple beam elements. Results from this model made it possible to determine how to strengthen the superstructure of the bridge. The final calculations model was made with 2D plain-strain elements, which fully reflect the construction`s work. The use of this element allowed the modelling of stone arches, backfill and concrete slab of ballasted bed, and the interaction between them. 2D model, which was used to calculate of 2 last spans is shown in Fig. 8, green colour – sand backfill, violet – existing concrete elements, azure - existing stone elements, dark blue – new concrete slab. All static calculation were made in Robot Structural Analysis Professional.

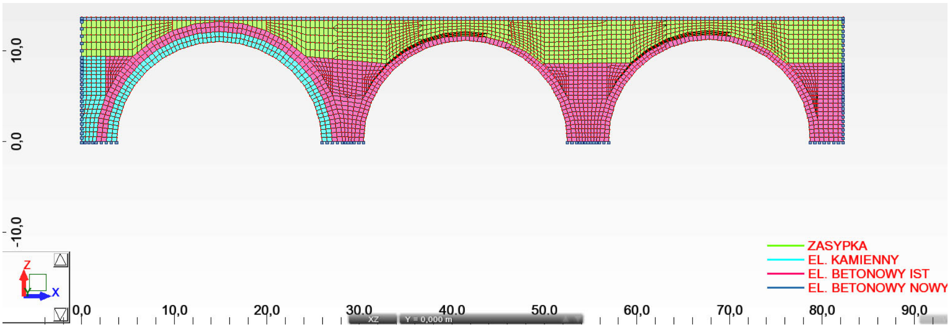

Fig. 8. *2D model of construction.*

While an inventory of the bridge was being performed, it was uncertain what kind of material would be used as backfill on the arches. As a matter of due diligence, the decision was made to make two submodels of the construction. Two most popular materials were chosen – well compacted sand (first model) and concrete (second model). Model witch well compacted sand is shown in Fig. 8. This approach reduced the risk of unpredictable situations that could occur after the demolition of existing elements as well as possible delays. Results of static calculations showed that the designed concrete slab allowed the use of relief stone arches and the arches did not require any additional strengthening.

6. ELEMENTS OF MODERNIZATION

Renovation of the stone superstructure and substructure consisted of the cleaning surface, refilling deteriorated joints between stone units, injections, and replacing deteriorated elements. At the conclusion, construction was covered with a layer of anti-graffiti paint. After the completion of the modernization, load tests were conducted which confirmed the correctness of adopted technical solutions.

New tracks were laid on the bridge and across the whole length of the bridge 14 new lamps were installed, connected directly to railing. The construction of the bridge was also adapted to future electrification. Prefabricated elements can be easily rebuilt and have sufficient carrying capacity to install masts of railway electric traction.

7. SUMMARY

The investment cost almost 28 million zł (6,6 milion euro), what gives ~ 5,900 zł/m^2 (1,400 euro/m^2).

The newly restored bridge was both technically and aesthetically successful, securing the structure while maintaining its historical integrity. General view of the bridge after modernisation is shown in Fig. 9.

Fig. 9. *General view of the bridge after modernisation – view on German side.*

REFERENCES

[1] Neisse – Viaduct bei Görlitz, *Zetschtift fur Bauwesen*, Ernst und Korn, Berlin, 1855.

[2] BUDKA E., GRUBA Sz., LEWANDOWSKI G., ŚMIERTKA D., Rewitalizacja i modernizacja kolejowych obiektów inżynieryjnych, *Infrastruktura Transportu*, Warszawa, 2011.

[3] BILISZCZUK J., BUDYCH L., RABIEGA J., Mosty kamienne na kolei dolnośląsko-marchijskiej, *Transport i Logistyka*, Wrocław, 2007.

[4] http://www.pw-comfort.com.pl/modernizacja-mostu-linii-kolejowej-wroclaw-swiebodzki-zgorzelec/.