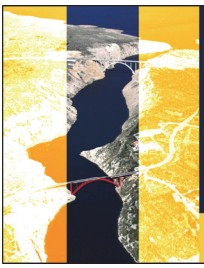

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DESIGN AND CONSTRUCTION

HIGHWAY ARCH VIADUCTS IN POLAND

Jan Biliszczuk[*], Wojciech Barcik[#], Jerzy Onysyk[+], Przemysław Prabucki[#], Mariusz Sułkowski[#], Jacek Szczepański[#], Robert Toczkiewicz[◊] & Kamil Tukendorf[#]

[*] Prof., Civ. Eng., Wrocław University of Technology,
Research & Design Office MOSTY-WROCŁAW, Wrocław, Poland
jan.biliszczuk@pwr.wroc.pl

[#] M.Sc., Civ. Eng., Research & Design Office MOSTY-WROCŁAW, Wrocław, Poland
biuro@mosty-wroclaw.com.pl

[+] PhD, Civ. Eng., Wrocław University of Technology,
Research & Design Office MOSTY-WROCŁAW, Wrocław, Poland
jerzy.onysyk@pwr.wroc.pl

[◊] PhD, Civ. Eng., Research & Design Office MOSTY-WROCŁAW, Wrocław, Poland
robert.toczkiewicz@mosty-wroclaw.com.pl

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Abstract: *For the last years an intense road network development program has been carried out in Poland. Over the past three years (2010 – 2012) 980 km of motorways and expressways have been built and more than 700 km are under construction. The total number of bridge structures along the main roads and highways, equal to 5095 in 2011, will increase by 1580 (31 %) until the end of 2013. Among the new structures dozens of arch viaducts have been built.*
The paper presents few selected arch viaducts, erected recently over highways in Poland. Bowstring arches, half through arches and true arches are presented. Design solutions and construction methods are described.

1 INTRODUCTION

During last years an intense road network development program has been carried out in Poland. The main core routes will be the A1 north-south motorway and the A2 and A4 east-west motorways. Network of expressways will connect the biggest cities and allow an easy access to the motorways. Over the past three years (2010 – 2012) 980 km of new motorways and expressways have been built and more than 700 km are under construction. At the moment (May 2013) 1370 km of motorways and 1120 km of single carriageways and dual carriageways are in service. The map of planned network of Polish highways is presented in Fig. 1. The total number of bridge structures along the main roads, equal to 5095 in 2011, will increase by 1580 (31 %) until the end of 2013.

Among the new structures dozens of arch viaducts have been built. This type of bridge has small deck depth, constant along the span, which reduces embankments of access roads. This is particularly important in flat lands, when the road grade line must cross an obstacle (highway) and the accessible area is limited. Apart from that, arch bridge may be an element interrupting monotony of driving along the highway. Mid-span arch structure also allows for the elimination of intermediate support located in central median, which is common in case of beam bridges, constructed usually over motorways.

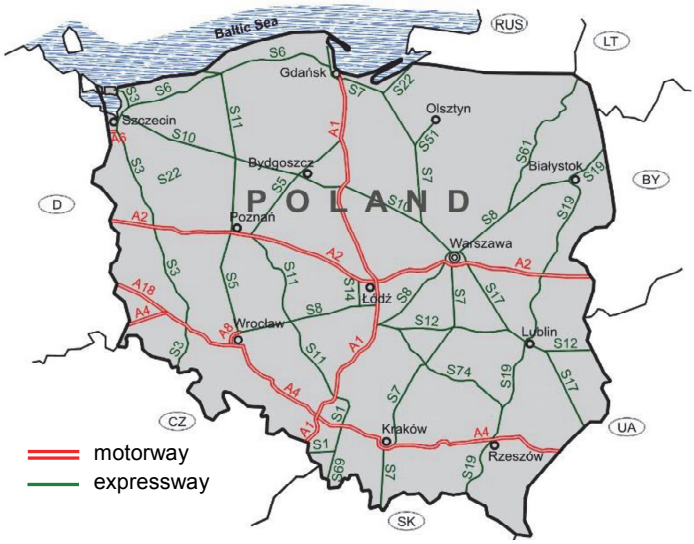

Figure 1: Map of planned network of motorways and expressways in Poland

2 VIADUCT ALONG THE BYPASS OF STRYKÓW OVER THE A1 MOTORWAY

The viaduct is located on the ring road of Stryków (part of the national road DK14) over the A1 motorway Katowice - Gdańsk [1]. It is a structure with exposed, originally shaped tied arch girders (Figure 2). Designing of an arch structure was dictated by the required low depth of the deck and the desire to create an interesting form of the viaduct. Length of the span is 50.0 m and the skew angle is 60.38º.

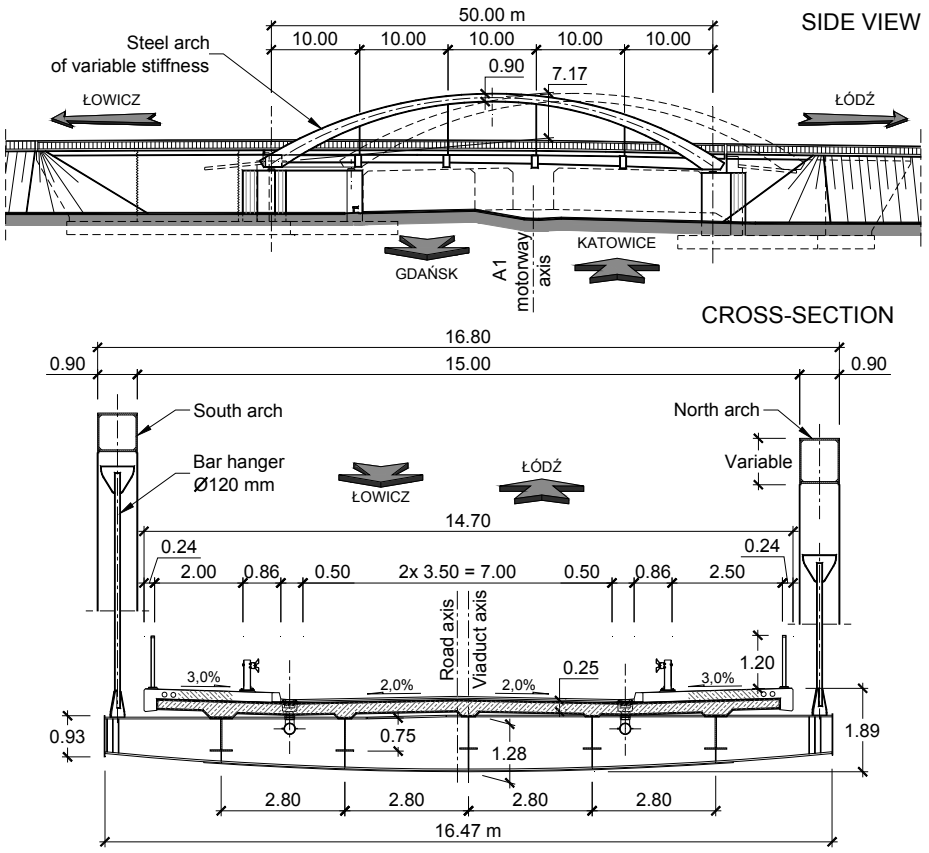

Figure 2: Side view of the viaduct in Stryków and cross-section of the span in the middle of the southern arch

The deck is a steel grid composite with a reinforced concrete slab (Figure 2). It consists of longitudinal I-beams, acting as a tie, spaced every 2.80 m and crossbeams spaced every 10.0 m (spacing of bar hangers). Crossbeams in the span are plate girders of variable height, with curved bottom flange, as in Figure 2. Crossbeams over the supports are stiff box girders. In side spans of the steel grid diagonal I-beam struts have been added.

Two vertical steel, welded arch girders with a rise of 7.85 m are situated on both sides, outside the outline of the deck slab (Figure 2) and fixed in the side crossbeams. Due to the large skew angle of the viaduct, both arches are offset along each other by 9.11 m. The arches have a circular shape and different radii of top and bottom flanges, hence the depth of their cross-section changes from 0.90 m at the crown to 1.91 m at the level of bearings.

Main construction stages of the viaduct included [1]:

- erection of abutments and temporary supports, located under crossbeams (in the axis of hangers);
- placing of the span crossbeams on the auxiliary supports and side crossbeams on the abutments;

- assembly of longitudinal beams of the deck and side segments of the arches;
- assembly of top segments of the arches with use of heightened temporary supports;
- installation of hangers, replacement of bearings and removal of auxiliary supports;
- deck slab concrete casting.

Photos of the viaduct during construction and after completion in 2008 are shown in Figure 3. The viaduct was designed by Research & Design Office Mosty-Wrocław.

Figure 3: Views of the viaduct in Stryków during construction (photo: P. Pilczuk, VISTAL Gdynia S.A.) and view of completed structure

3 VIADUCT IN JELENIA GÓRA

The viaduct in Jelenia Góra is a part of reconstructed level intersection [2]. It crosses a dual carriageway national road DK3, section Legnica - Jelenia Góra, which is a part of international route E65, leading to the border with the Czech Republic in Jakuszyce/Harrachov.

The viaduct is a single-span through arch viaduct with a span of 42.0 m. The deck is suspended by six inclined bar hangers anchored to a single arch with a span of 38.14 m, located in the longitudinal axis of the viaduct, fixed in massive abutments (Fig. 4). The span consists of two parallel decks, each of 11.41 m width. Each of them is a steel-concrete composite structure, consisting of two steel box girders with inclined webs (trapezoidal cross-section). All girders are braced by six cantilevered crossbeams, common to both decks, suspended in the middle to the arch (Figure 4).

The viaduct, designed by Research & Design Office Mosty-Wroclaw, was opened to traffic in 2011 (Figure 5).

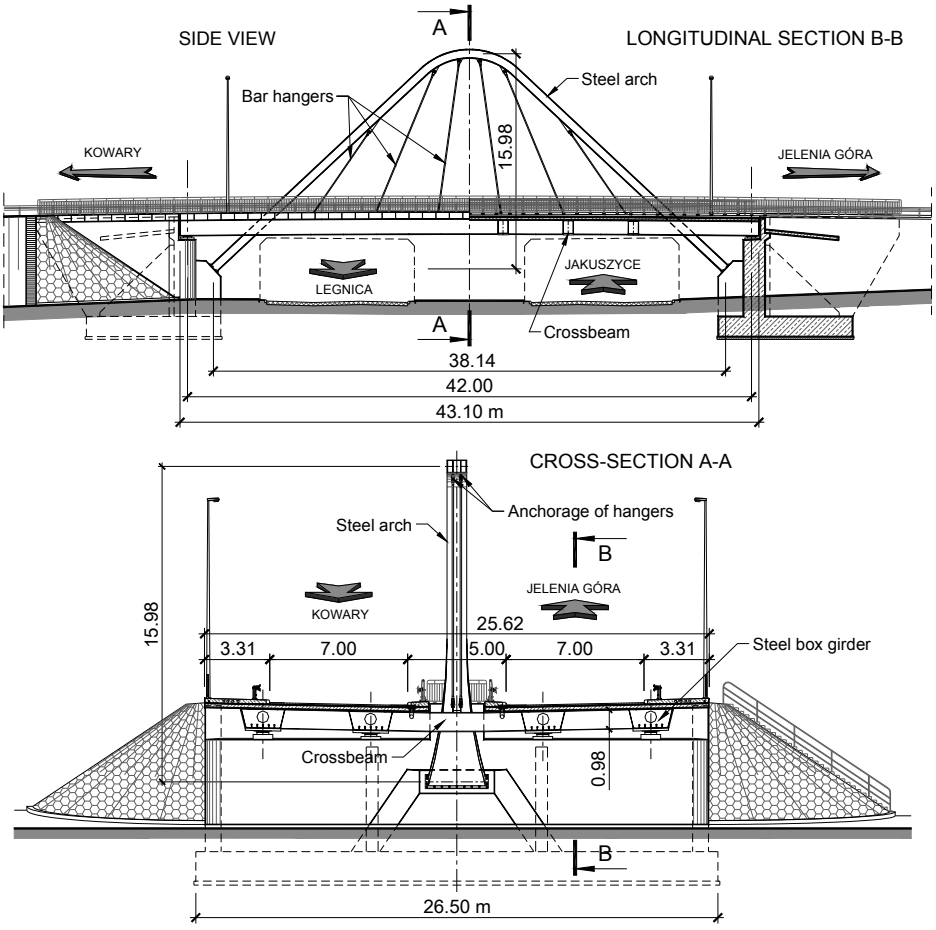

Figure 4: Side view and cross-section of the viaduct in Jelenia Góra

Figure 5: Assembly of the arch and view of completed viaduct in Jelenia Góra

4 GREEN VIADUCT OVER JUNCTION ROAD OF THE MOTORWAY RING ROAD OF WROCŁAW

Described animal crossing (green viaduct) was constructed over dual carriageway junction road, connecting motorway ring road of Wrocław [3] with the national road DK8 Wrocław - Warsaw.

The viaduct is a reinforced concrete fixed barrel arch structure of a complex geometry [2], variable in plan view and cross-section (Figure 6). Minimum thickness of the arched shell in the crown is 0.90 m. The clearance length of the span is 35.55 m. The whole structure is divided into three segments, separated by expansion joints. The minimum width of the structure (in the crown) is 37.16 m and the maximum width at the level of the foundations is 60.42 m.

In order to transfer large horizontal forces (thrust of the arch), both pile foundations are connected by tie-beams situated below the road level (Figure 6). The tie consists of six concrete beams (two in each segment) with a cross-section of 1.00 × 1.20 m, prestressed by six 19L15.7 mm type tendons [2].

Concrete arched shells were cast on scaffolding, segment by segment (Figure 7). Insulated concrete structure was covered with sand and gravel backfill of variable thickness and two layers of soil: fertile soil (humus) with a thickness of 0.40 m and a layer of turf (grass and vegetation). Trees and shrubs guiding animals to the viaduct, continue natural forest stand in the area of the crossing.

The structure, designed by Research & Design Office Mosty-Wroclaw, was completed in 2011 (Figure 7).

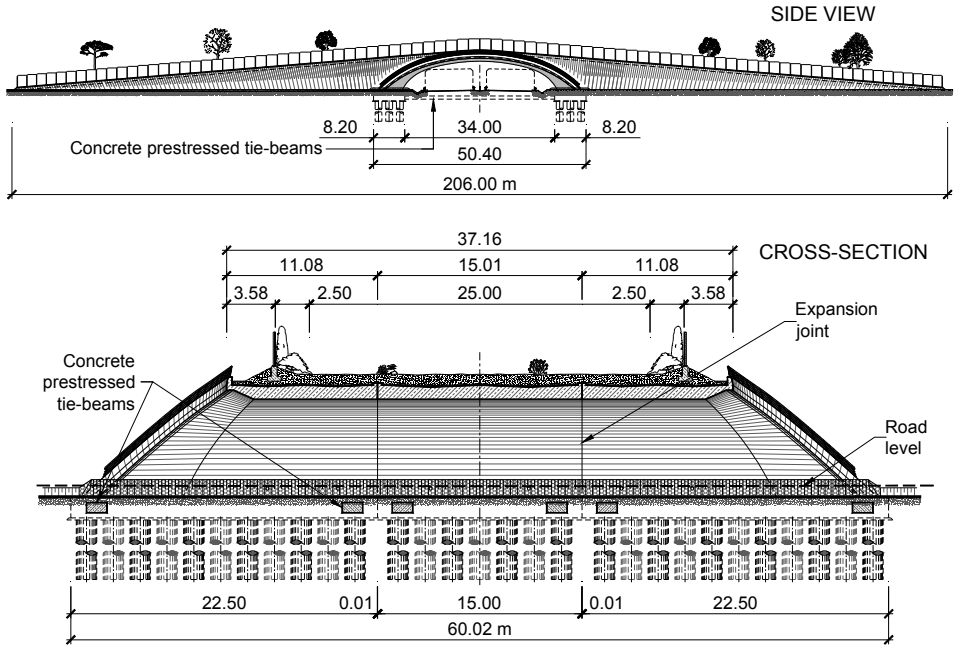

Figure 6: Side view and cross-section of the green viaduct

Figure 7: Green viaduct – photos of construction stages and views of completed structure

5 VIADUCTS OVER THE A4 MOTORWAY IN THE MURCKOWSKA INTERCHANGE IN KATOWICE

The twin arch viaducts were built in Katowice during reconstruction of one of the most intensively used road interchanges in Poland - the "Murckowska" interchange of the A4 motorway and the national road DK86. New viaducts carry the traffic along the completely rebuilt junctions on the directions Katowice-Warsaw and Warsaw-Cracow over the A4 motorway [4].

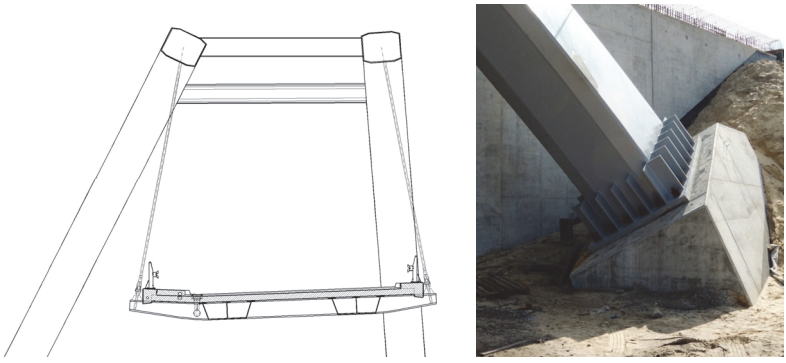

Figure 8: Cross-section and fixing of the arch in the abutment [4]

Each of the viaducts is a through arch structure (Figure 9). Steel-concrete composite deck is suspended by inclined, radially arranged bar hangers to two side steel box arch girders with spans of 68.2 m and 62.0 m and rise of 15.7 m. The girders are fixed in massive abutments and braced by three tubular struts. Untypical structural solution is inclination of inner arches to the road axis due to a large horizontal curvature of the deck (Figure 8).
The viaducts were designed by Mosty Katowice.

Figure 9: Overall view of one of the arch viaducts in the "Murckowska" interchange in Katowice during construction [4]

6 CONCLUSIONS

Highway arch viaducts described in the paper are only examples of many structures of such type, built recently as a part of a road network development program that has been carried out in Poland for the last ten years. They prove that mid-span arch bridges can be an attractive alternative to beam bridges, constructed usually over dual carriageway roads. Apart from structural advantages (elimination of pier located in central median, small height of the deck) arch viaducts may be also landmarks - elements interrupting monotony of driving along highways located in lowland countries, such as Poland.

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