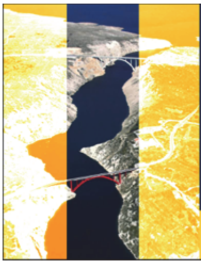

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DESIGN AND CONSTRUCTION

INTEGRAL ARCH BRIDGES

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Abstract: *Integral arch bridges are described in terms of their architectural and structural solution and a process of their erection. The described structures are formed by tied arches in which the arch horizontal force is resisted by a steel-concrete composite deck or by a prestressed concrete deck. The deck of all bridges is ended by end diaphragms that substitute traditional abutments.*

1 INTRODUCTION

Recently several tied arches have been built according design of the engineering firm Strasky, Husty and partners, Brno, Czech Republic. The deck of all bridges is ended by end diaphragms that substitute traditional abutments. These diaphragms are usually supported by concrete drilled or steel driven piles. The arches are formed by steel pipes or boxes, the decks are either composite of steel and concrete or from prestressed concrete. The bridges form following structural systems – see Figure 1:

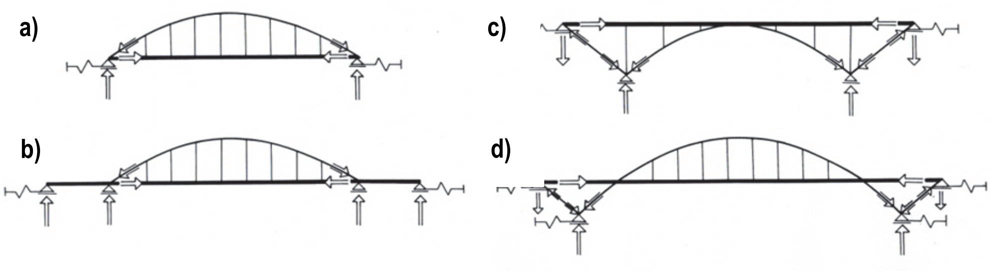

Figure 1: Structural systems

a) Langer girders.
b) Langer girders with continuous approach spans.
c) Deck arches which footings are connected with the end diaphragms by compression struts.
d) Through arches which footings are connected with the end diaphragms by compression struts.

The arches are situated either in the bridge axis, or on both deck edges or on one side of the deck. The arches situated on both deck edges are vertical, or inclined inwards or outwards. The end diaphragms that substitute classical abutments are usually supported by piles. The approach slabs are supported by short corbels anchored at the diaphragms. Since the rear ends of approach slabs are stiffened by transverse ribs preventing their horizontal movement, it is necessary to situate expansion joints between the diaphragms and slabs.

Figure 2: Vltava River Bridge

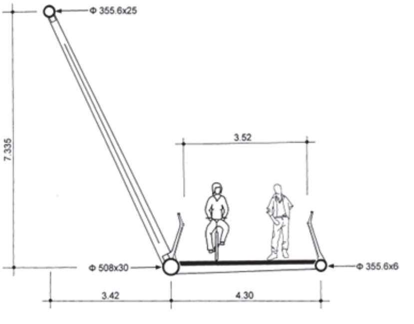

Figure 3: Cross section

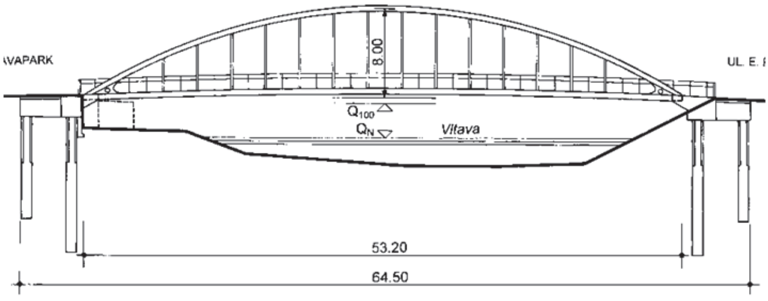

Figure 4: Elevation.

The possibilities of the integral arch bridges are demonstrated on the following examples of bridges.

2 PEDESTRIAN BRIDGE ACROSS THE VLTAVA RIVER

The pedestrian bridge built in the city of Ceske Budejovice connects its historic center with new residential area - see Figure 2. The bridge is formed by an one side inclined tied arch anchored at a composite deck - see Figure 3. The arch of a span length of 53.20 m and rise of 8.00 m is formed by a steel pipe; the suspenders are from I-shaped steel members - see Fig 4. The deck is formed by two edge pipes mutually connected by a truss floor beam and a composite deck slab. The steel structure is supported by short cantilever protruding from the end diaphragm. To resist the bending moments, the diaphragms are supported by a couple of piles. The steel structure was assembled on temporary towers. When the towers were removed, the composite deck slab was cast.

3 PEDESTRIAN BRIDGE ACROSS THE SVRATKA RIVER

The bridge that is currently under construction ? in a city of Brno connects new sport facilities situated on both banks of the river – see Fig. 5. The prestressed concrete deck formed by a spine girder with

Figure 5: Svratka River Bridge

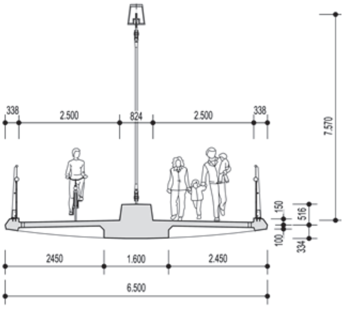

Figure 6: Cross section

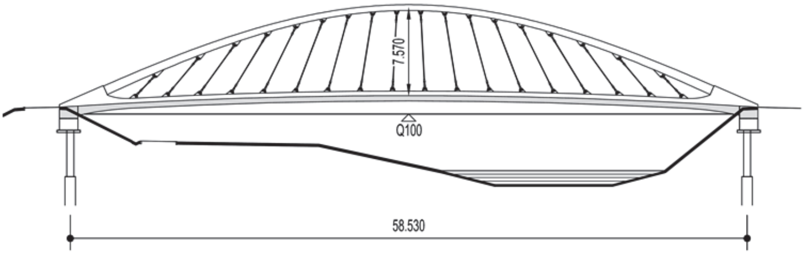

Figure 7: Elevation

overhangs – (see Figure 6) is suspended on a single steel arch of a trapezoidal cross section of a span length of 58.5 m - see Figure 7. The spine girder that protrudes above the deck slab naturally divides pedestrian and cyclist lanes (or pathways). The arch is filled with concrete.

4 PEDESTRIAN BRIDGE ACROSS THE BORDER RIVER OLSE

Figure 8: Olse River Bridge

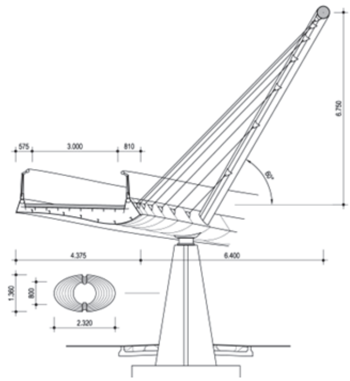

Figure 9: Cross section

Pedestrian bridge crossing the border River Olse connects two cities: Czech and Polish Tesin – see Figure 8. The bridge of a total length of 95.40 m is in a plan curvature with a radius of 100 m and in a crest elevation. The bridge has four spans of lengths from 13 to 45 m – see Figure 10. The deck is formed of a slender box girder of a non-symmetrical streamline cross section that is stiffened by one side inclined arch in the main span – see Figure 9. The deck is fixed into the end abutments and is supported by elastomer pads on intermediate piers. To balance the torsional moment due to the dead load, the deck is prestressed by radial cables situated at edge curbs. Both the girder and the arch are composite of steel and concrete. The piers and abutments are supported by drilled piles.
The structure was erected on temporary towers that were supported by a temporary truss bridge in the span crossing the river. After casting the deck slab and end diaphragms, the structure was prestressed by external cables. Then the elastomer bearings were placed.

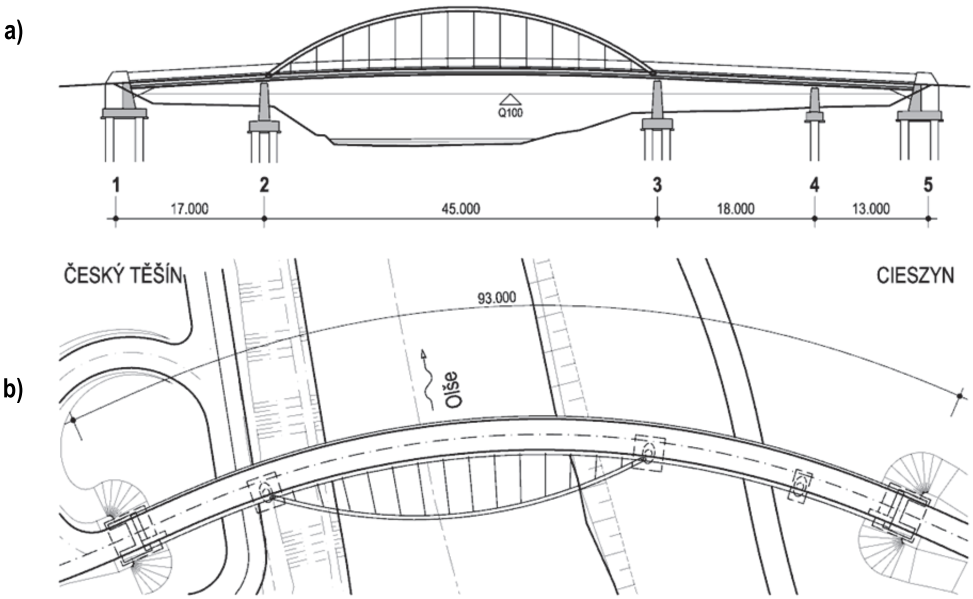

Figure 10: a) elevation, b) plan

5 MINTO ISLAND BRIDGE, SALEM, OREGON, USA

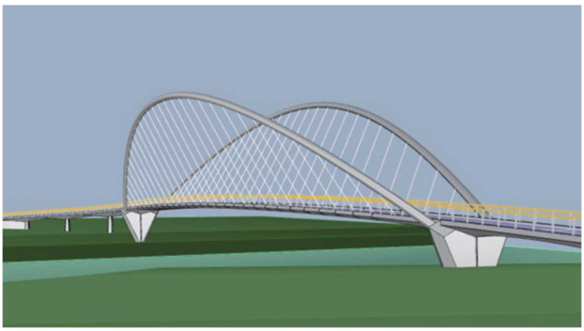

Figure 11: Minto Island Bridge

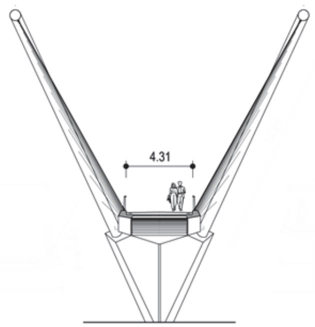

Figure 12: Cross section

The Minto Island Pedestrian Bridge that is under design for a city of Salem crosses the Willamette River - see Figure 11. The bridge is formed by a continuous girder of 5 spans of length from 15.24 to 93.88 m – see Figure 13. The main span is formed by a stress-ribbon deck that is suspended on two inclined arches - see Figure 12. The arches are formed by steel pipes of 750 mm diameter. They are inclined outwards and therefore the bridge has a butterfly shape. The stress-ribbon deck is assembled from precast segments and a composite deck slab. The deck tension due to dead load is resisted by bearing tendons. The tension due to live load is resisted by the stress-ribbon deck that is prestressed by prestressing tendons. Both bearing and prestressing tendons are situated in the composite slab.

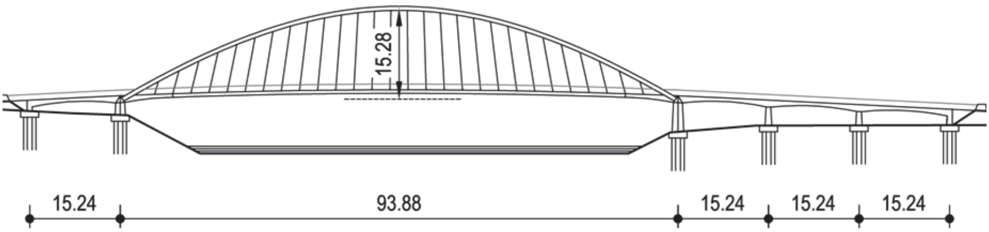

Figure 13: Elevation.

6 OVERPASS ACROSS THE MOTORWAY D1 NEAR STUDENKA

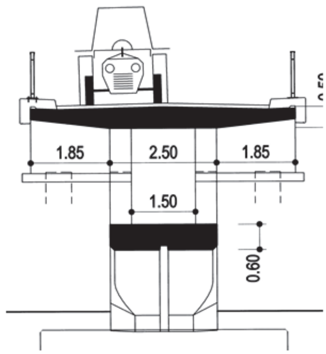

Figure 14: Overpass near Studenka

Figure 15: Cross section

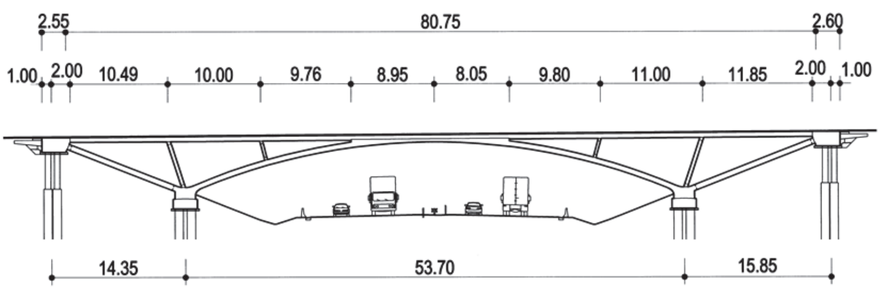

Figure 16: Elevation

Since the local road crosses the motorway at the height of 9 m, it was evident that from the aesthetic point of view an arch structure would represent the most suitable solution - see Figure 14. The deck of the bridge is formed by a slender solid deck of depth of only 0.50 m – (see Figure 15) that is supported by a flat arch of the span of 53.70 m and rise of 6.157 m (see Figure 16). The prestressed concrete deck is fixed into the end diaphragms that also serve as abutments. The bridge that was cast on a stationary falsework was completed in fall 2009.

7 McLOUGHLIN BRIDGE, PORTLAND, OREGON, USA

The McLoughlin Boulevard Pedestrian Bridge (see Figure 17) is a part of a regional trail in the Portland, Oregon metropolitan area. The bridge is formed by a stress-ribbon deck that is suspended on two inclined arches of span 73.8 m (see Figure 18). Because the deck anchor blocks are connected to the arch footings by struts, the structure forms a self-anchored system - see Figure 19. Since the deck is suspended on arches via suspenders of a radial arrangement, the steel arches have a funicular/circular shape. The arches are formed by 457 mm-diameter pipes that are braced by two wall diaphragms. The stress-ribbon deck is assembled from precast segments and a composite deck slab.

The arches were assembled from two arch segments supported at footings and a midspan erection tower. After that the bearing tendons were erected and tensioned. Then the segments were progressively suspended on the arch and the tension in bearing tendons was adjusted. When the deck slab was cast, the deck was prestressed by prestressing tendons. The bridge was completed in 2006.

Figure 17: McLoughlin Bridge

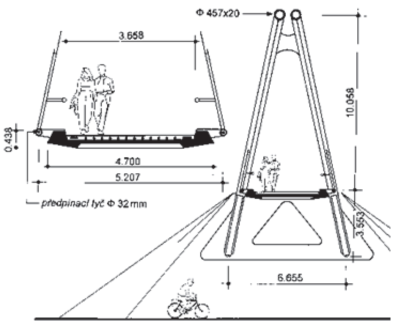

Figure 18: Cross section

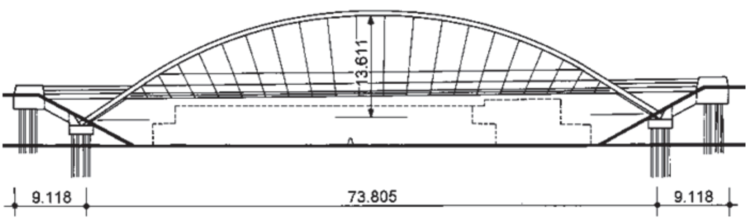

Figure 19: Elevation

8 BRIDGE ACROSS THE EXPRESWAY R1, NITRA, SLOVAKIA

Figure 20: Bridge across Expressway R1

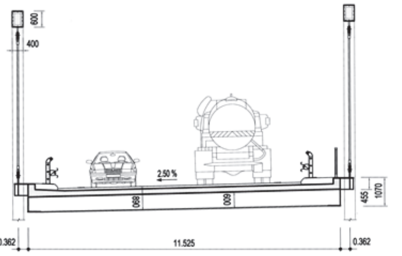

Figure 21: Cross section

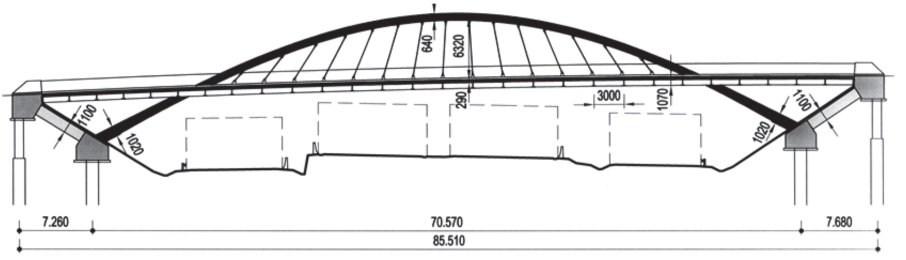

Figure 22: Elevation

Similar static system was used in construction of the overpass across the expressway R1 near Nitra - see Figure 20. The composite deck formed by edge plate girders, floor beams and a deck slab (see Figure 21) is suspended on edges on slender arches of span of 70.57 m (see Figure 22). The arches that are formed by steel boxes filled with concrete are not braced; their stability is given by tension stiffness of the suspenders. The arch footings are connected with the end diaphragms by concrete compression struts. The steel structure was erected on temporary towers. After that the deck slab and end diaphragms were cast. By tensioning the suspenders the designed state of stresses was obtained. The bridge was completed in 2010.

9 CONCLUSIONS

The structural arrangement and technology of their erection used in construction of described bridges proved to be very efficient and cost effective. The bridges formed aesthetically pleasing structures that require minimum maintenance.

The architectural and structural solution of bridges built in the Czech Republic was developed by the design office Strasky, Husty and Partners, Brno, who also worked out the final designs. The bridges built in Oregon, USA were designed by OBEC, Consulting Engineer, Eugene, OR, USA with a collaboration of Jiri Strasky, Consulting Engineer, Greenbrae, CA, USA.