

Steel Structures and Bridges 2012

New Troja Bridge in Prague – Structural Solution of Steel Parts

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Abstract

The „Troja Bridge” in Prague, with the main span 200,4m is under construction now. The deck is 36m wide including the walkways. The bridge crosses the Vltava River and it will serve for tram, car and pedestrian traffic between Prague districts Troja and Holešovice. The paper introduces description of the structural solution of steel parts of the bowstring-arch type bridge with two twins of inclined network type webs. Activation and prestressing process of the tie-rods are described here.

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Keywords: Bowstring-arch type bridge; network type web; prestressed tendons; longitudinal prestressed cables; matrix of mutual interference, linear programming

1. Disposition of the bridge

The bridge with the main span 200,4m is a simply supported bowstring-arch type bridge with two longitudinal prestressed steel-concrete chords and two twins of inclined network type webs (Fig.1). The precast concrete crossbeams are fixed to longitudinal chords. The concrete slab, connected with the cross beams, is prestressed in both, longitudinal and transverse directions. The tie rods are connected with the arch and with longitudinal steel part of the chords through connection plates. Walkways are made of steel. The tram rails are inside the arch between the arch legs, the roadways and walkways are on the cantilevers outside the arch.

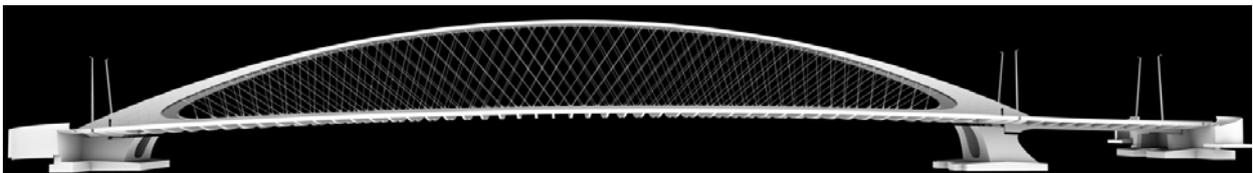


Fig. 1. Troja Bridge in Prague, lateral view

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2. Structural solution of individual parts

2.1. The arch

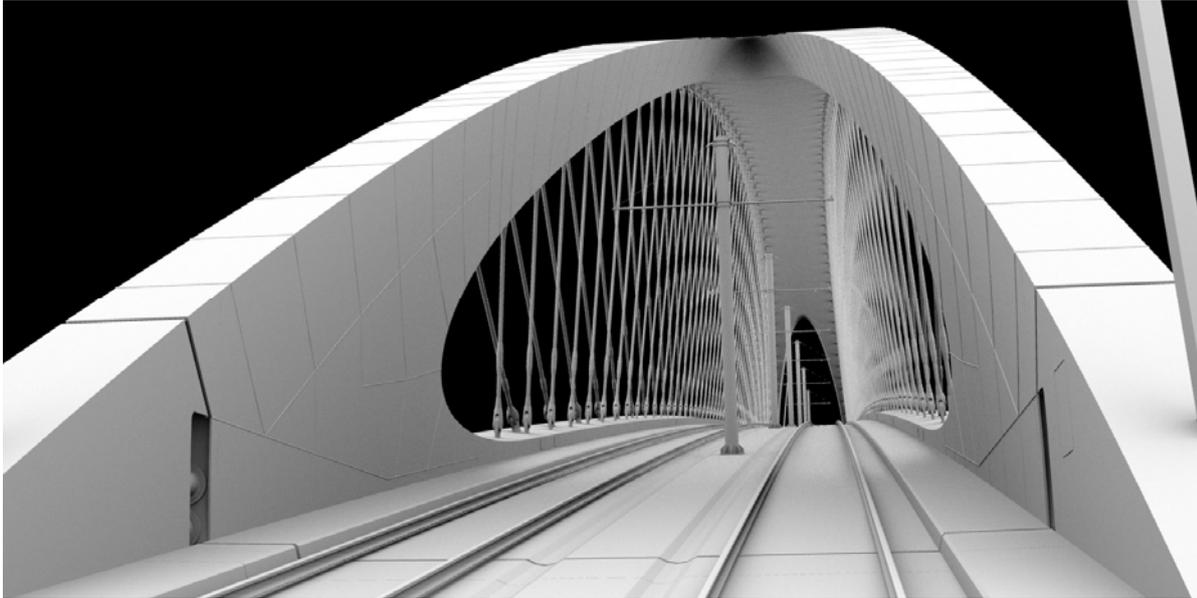


Fig. 2. The arch, entrance view

The steel arch (Fig. 2) spanning approx. 200m with the rise of 20m has flat pentagonal box cross section with varying width and height (Fig. 3). The upper and bottom flange of the arch is from the plate 60mm thick and the side walls are from the plate 50 mm thick. The bottom flange is divided into two parts of cylindrical shape connected each to other creating the arrow shape. Inside of the pentagonal arch cross-section, there are another six longitudinal walls (webs). Four longitudinal walls of thickness 40mm are welded with the connecting plates for hangers through bottom flange plate. There are cross stiffeners of thickness 25 mm situated each 1,8m inside the arch sections.

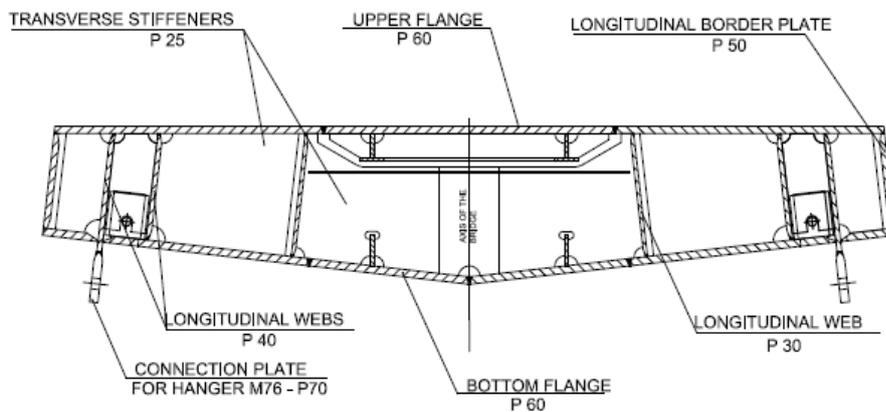


Fig. 3. Typical cross section of the arch

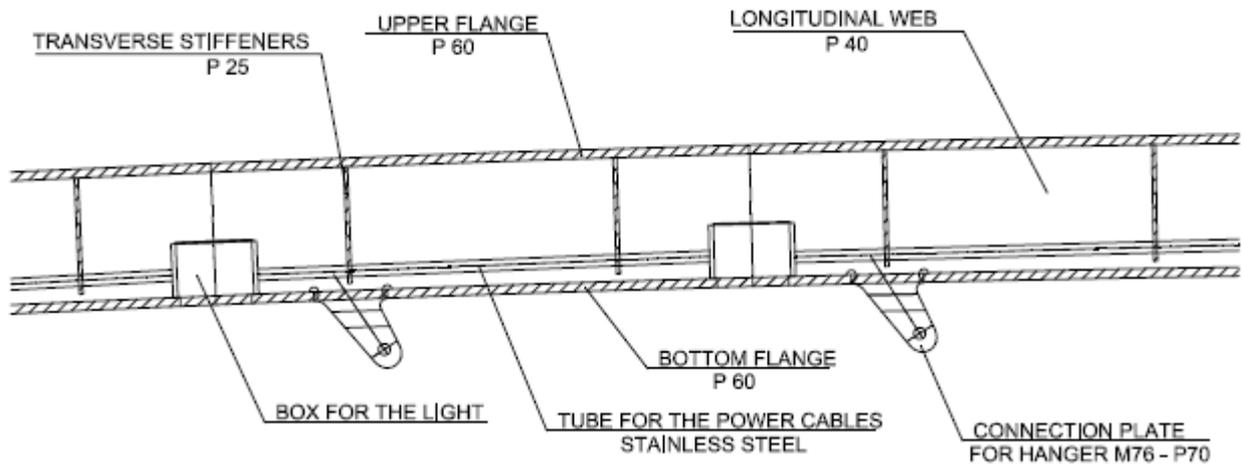


Fig. 4. Longitudinal section of the arch

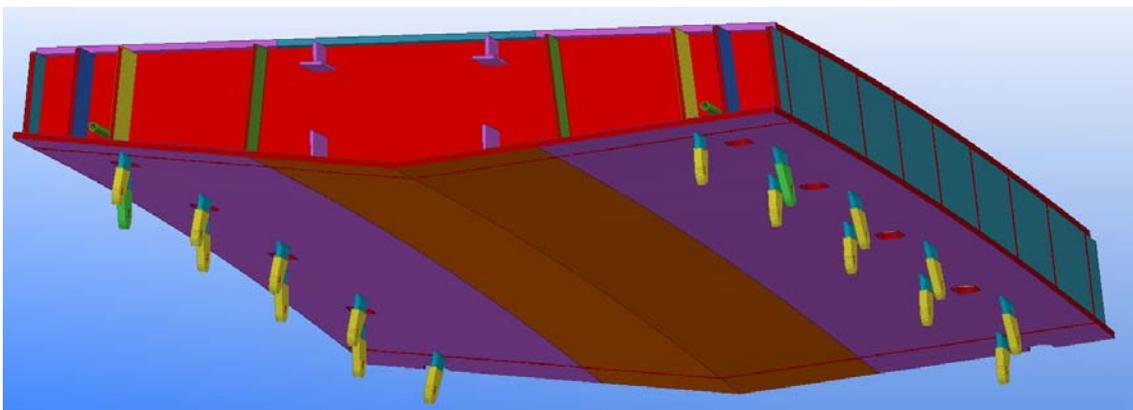


Fig. 5. Section of the arch

The arch body divides in the transitional part into two sections called „legs” (Fig. 7) having tetragonal box cross-section. The section where pentagonal arch is divided through the „crotch” of parabolic shape to the „legs”, is called „trousers” (Fig. 6). The „legs”, are connected to steel horizontal tendons through four base sections.

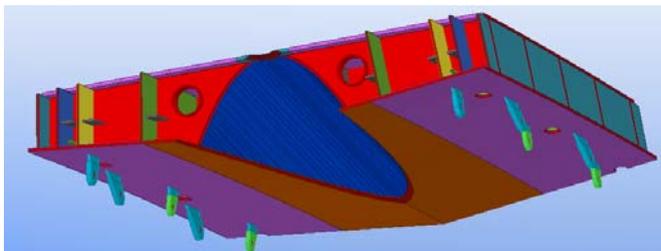


Fig. 6. Dividing section called „trousers”

The narrowest dimension in the central part of the arch is 6,957m with the height 900mm of the border plate. From the midpoint of the arch towards the “trousers” the section becomes wider. From the trousers towards the supports the legs become higher and narrower. Inner wall of the trousers is of the parabolic shape. The four base sections are filled by the concrete with which are connected by shear studs and connected trough reinforced concrete with the monolithic terminal crossbeams. The arch body is all welded, air locked. The welds are visible (not grinded). The openers for the lights are in the bottom flange.

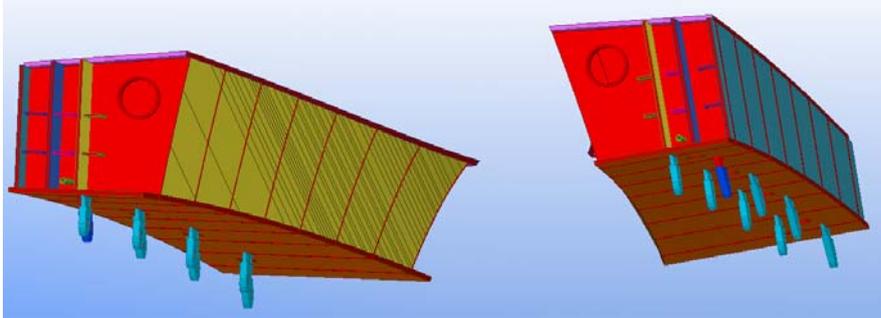


Fig. 7. Arch divided into two „legs”

2.2. The deck tendon

Two deck chords (Fig. 8) connecting the base sections (Fig. 9) of the arch consist of steel welded tie with cross section similar to omega letter with connecting plates to hangers at the top, which are finally filled by concrete. Chords serve also to connect the hangers at their top part with the precast concrete transversal beams at the lower part and to lead 6 main longitudinal prestressing cables inside of each of them. The deck chords are welded with the base section on site of erection.



Fig. 8. Deck chords before concrete casting

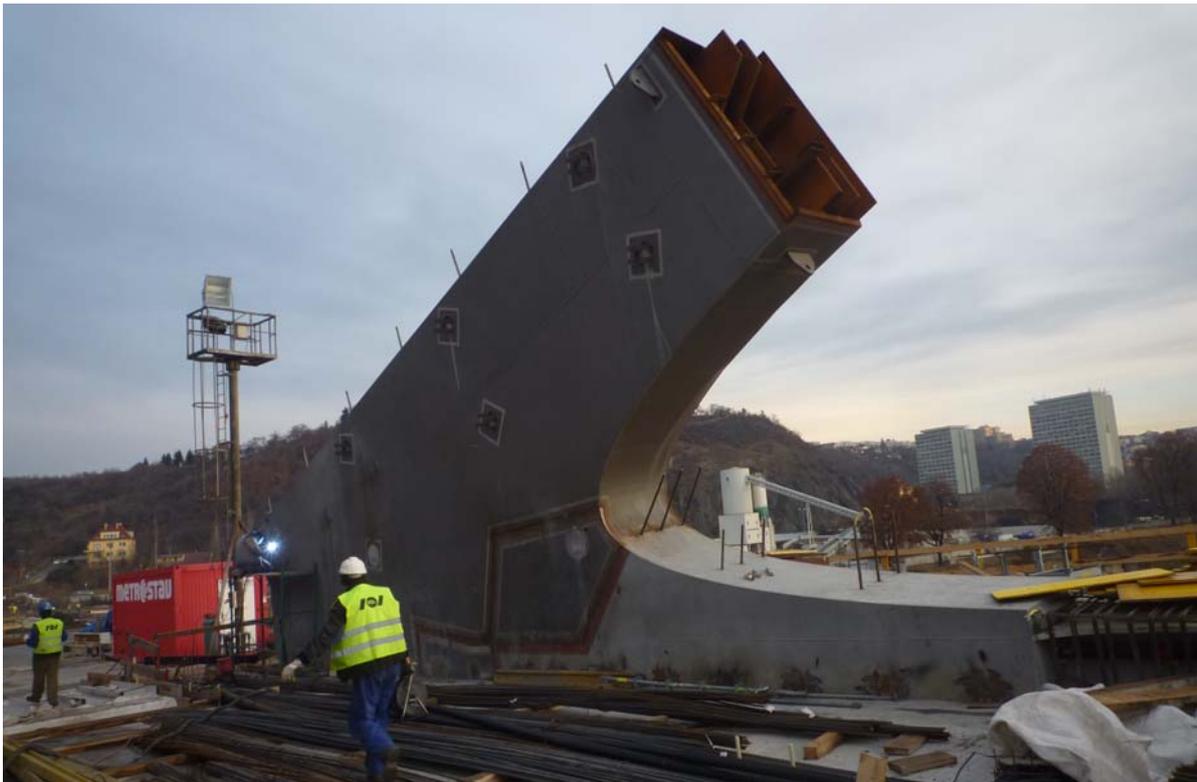


Fig. 9. Base section after inside concreting

Material of the longitudinal parts of arch and deck tendons is mostly S420 ML. Base section is mostly made of S355NL steel as well as the transversal stiffeners of the arch and the attachment plates for the hangers. The structural solution enables non-destructive testing of all main structural welds.

2.3. The hangers

There are 200 hangers of S520 steel grade with dimension of the thread M76 – M105 in the bridge network (Fig. 10). Hangers are created by tension system, which consists of solid bars with rolled thread, turnbuckles, forks, pins, and lock covers. The used system Macalloy was successfully tested to fulfill requirements of Eurocode [1] for fatigue properties of tension components. Two million cycles of stress range 130 MPa were applied to the whole system. The turnbuckles were innovated for this purpose. Material, dimension, internal shape and the shape of the thread were optimized to withstand heavy fatigue loading. The network of hangers will be prestressed in two phases. First the hangers will be activated on structure on temporary supports to approx. force 200 kN. The hangers will be supported by temporary hangers on free length to avoid the non-linear behavior before they reach full load. Then the hangers will be prestressed by the own weight of the structure when the bridge will be released from the temporary supports. Then the forces and geometry of the bridge will be “tuned” using hydraulic device techno-tensioner. Hydraulic device is fixed to threads of the bars on the both sides of the turnbuckles. Prestressing procedure with respect to matrix of mutual interference of the hangers and optimal procedure of prestressing from actual situation to projected one will be found by method based on linear programming. The forces in the hangers will be measured by strain gauges (full bridge). The actual forces of all hangers will be available on-line via internet or wifi connection of the site of erection. At the

end, after installing of all permanent loads, the frequency measurements of all tendons will be carried out. The measured frequencies will be compared with ones measured in future in terms of regular inspection of the bridge.

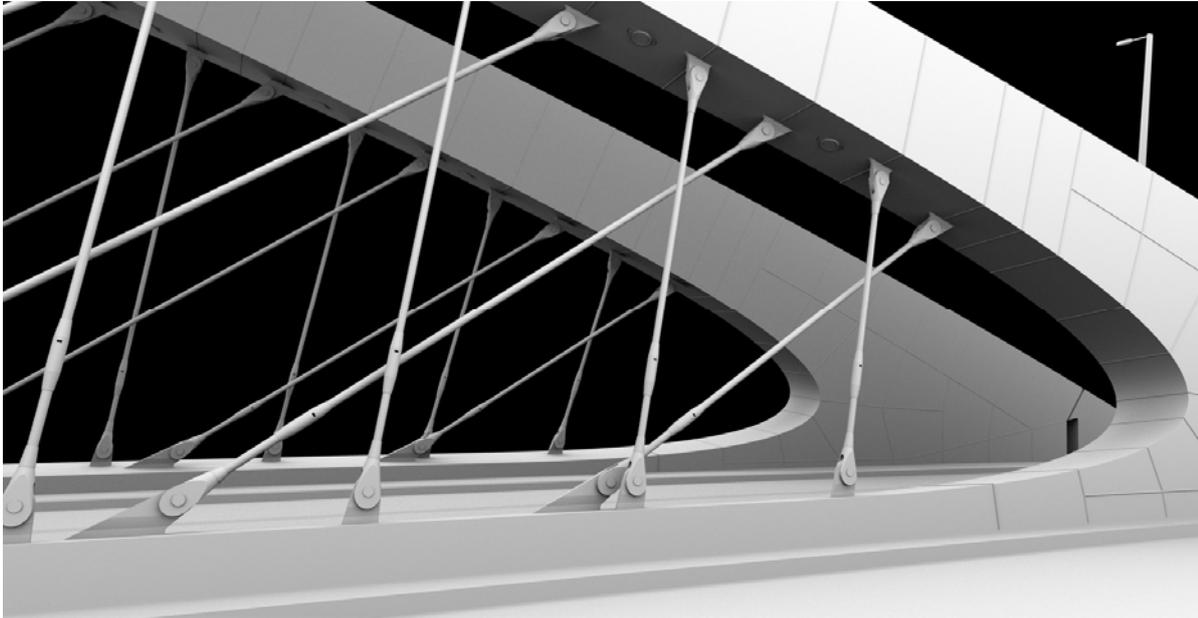


Fig. 10. Network of hangers

3. Document management

The detail design of the bridge (all professions) and erection procedure and workshop drawings are carried out using system of document management Alex which enable to follow via internet on-line design procedure to all subjects concerned in the project respecting the user rights to upload, revise, or download the documents. This system helps to avoid any mistakes due to incorrect documentation in workshop and on site of erection and ensures actual information to design team in real time.

References

- [1] EN 1993-1-11 Eurocode 3: Design of Steel Structures, Part 1.11: "Design of structures with tension components", European Committee for Standardisation, 2008