CONSTRUCTION OF THE TROJA BRIDGE IN PRAGUE

SUMMARY

The new Troja Bridge in Prague, which is now under construction, has a main span of 200.4 m long. The steel network arch with the bridge deck made of prestressed concrete represents an advanced bridge structure. The construction combines several technologies, including incremental launching and assembly of the arch from the bridge deck supported on temporary piers in the river.

1. INTRODUCTION

The new Troja Bridge is a part of the road system which is built within the Blanka Tunnel Complex. It carries 4 lanes of road, 2 tram tracks, which connect the city centre to the northern parts of the city, and also two wide pedestrian lanes used also by cyclists. The bridge crosses the Vltava River. The bridge has two spans; the main span crossing the river is 200.4 m long and the side span on the Troja riverside, which is 40.4 m long. The bridge is about 35 m wide. There are no supports located in the river.

In 2006, the architectural competition was organized by the client (City of Prague) and the winning project submitted by J. Petrak and L. Šašek (Mott MacDonald Prague) and by R. Koucky and L. Kabrt (R. Koucky arch. office, Prague) is under construction. The bridge should be open to traffic in June 2013.

2. DESCRIPTION OF THE BRIDGE

The main span and the side span are almost independent structures; there is an expansion joint over the pier no. 2 between them. The basic theme of the elegance of the bridge lies in the ratio of the rise and span of the arch of 1/10. The slender network arch structure of the main span is tied arch (rise of the arch is only 20 m) with inclined hangers (Fig. 1 and 2). The arch is made of steel – the central part is formed by a multiple box section (Fig. 3), which is then divided into two legs on each side approaching the bridge deck at the ends of the span. The tie of the arch is located above the bridge deck and has a composite steel concrete cross-section. The longitudinal tensile force is carried mainly by 6 prestressing cables located inside the tie section. Each cable is composed of 37 strands 0.6” (15.7 mm). The bridge deck is completely made of prestressed concrete. The deck has transverse precast prestressed beams (C70/85) (Fig. 4), which are suspended on the composite tie and which support a thin prestressed concrete slab (C50/60). The concrete deck carries the tram tracks and the road lanes, the pedestrian lanes are located on steel cantilevers.

The side span is completely made of cast in situ concrete (C50/60). The two longitudinal beams form the main load carrying element. The transversal beams have the same shape as those in the main span. The slab on the top is also very similar to that in the main span. The complete structure is prestressed longitudinally and transversely.
3. CONSTRUCTION OF THE BRIDGE

The construction process of the main span was an object of many discussions. Initially the design assumed the process when first the arch with the tie and hangers would be built and then the bridge deck would be subsequently assembled and cast above the river. Due to the slenderness of the arch and very soft steel structure, the contractor saw many risks in such construction process. Also the economical evaluation was not favourable. Considering many alternatives, finally it was decided to build the deck first and then to assemble a steel arch using the deck as a fixed platform. A limited space on both sides of the river resulted in the following construction process.

The steel tie and the precast beams are assembled on the Holesovice riverside at the production yard. Since the bridge has no stiff longitudinal element, a temporary steel truss is used in order to work as a couple of stiff longitudinal beams. Top chord of the truss is definitive – the tie of the arch. The bottom chord and the diagonals are temporary and they will be removed after completion of the bridge. The 5 temporary piers were built in the river. The temporary truss with the precast transversal beams is assembled in the production yard.
and then incrementally launched across the river in steps 16 m long using the temporary supports (Fig. 5). A short launching nose was used in front of the temporary steel truss. The hydraulic system with 6 cylinders with the capacity of 60 t each was used for moving the structures forwards. The stroke of cylinders was 250 mm. The structure was suspended on 8 steel bars. A special independent braking device was used when the steel bars where moved to the next position between individual launching stages. The structure was launched initially
upwards to the slope of almost 7%, finally downwards due to the geometry of the bridge. The maximum capacity of 8 cylinders was used only for a short time. In the most of the launching process only 4 cylinders were able to push the structure. Very simple sliding bearings, where the bottom steel flange of the temporary truss moved directly on the teflon plates, were designed. No stainless steel sheets and inserted teflon plates were necessary. The friction coefficient varied between 2 and 4%.

After launching, the end elements (footings) of the arch will be connected to the tie and the end transversal beams will be cast in situ. The ends of the steel arch will be embedded into the end transversal beams. Their steel structure is extremely complex. The anchorage of 6 prestressing cables (each composed of 37 strands) represents a large force which has to be transferred to the steel arch. A number of stiffeners in the steel structure of the arch footing would be too high. Therefore the footing will be filled with high strength self-compacting concrete (C80/95). The self-compacting concrete will be pumped into the steel structure in several layers approximately 2 m thick. The concrete will distribute the forces from the anchorage into the entire steel section. The welded studs and steel reinforcement are used for connection of steel and concrete.

A complete deck slab will be subsequently cast from the ends to the centre of the main span in the sections again 16 m long. The formwork will be transported on ships, lifted and finally anchored to the transversal precast beams. The transversal prestressing will be activated immediately when the appropriate strength of concrete is achieved. When the slab is completed, approximately 1/3 of the longitudinal prestressing force will be activated. The slab supported on the temporary truss and on the 5 temporary supports in the river will form a platform with sufficient load carrying capacity for the assembly of the arch.

The steel parts of the arch will be delivered to the bridge deck and welded together into 3 parts of the arch. The temporary towers will be built on the deck. The three parts will be then lifted to the position and welded together in order to complete the arch (Fig.6). All the manipulations with steel elements on the arch will be carried out using hydraulic systems without any heavy crane. The hangers then may be installed and slightly prestressed to the stress level about 10% of their strength in order to avoid their excessive deflection. Very small deformations of the arch are expected in this stage which allows for a relatively precise specification of forces in hangers. All these activities will be executed in stable temperature conditions, preferably during the night. An extensive monitoring system will be used for detailed check of forces in individual hangers.

Then it will be possible to activate the second level of the prestressing in the longitudinal direction, interrupt the bottom chord of the temporary truss and release the supports in the river. The bridge will deform and all the hangers become activated simultaneously. After that it will be possible to remove the temporary truss, finalize the prestressing (level 3) in the longitudinal direction and complete the works on the bridge (pavements, lighting, tram rails, etc.).

The side span will be cast in situ on the fixed scaffolding and then prestressed. The side span will be cast in three stages after the completion of the launching process and will be used for delivery of steel parts of the arch to the main span.
4. CONCLUSIONS

The structure of the new Troja bridge is rather complex. On the other hand the bridge is elegant and fits well into the environment of the recreation area of the city, which will be further developed and in some years it becomes a central areas. The city representatives decided to build this bridge because the arrangement and shaping of the bridge, with a span of 200.4 m, form an internationally unique structure. Taking into account the tradition of architectural development of the historical city of Prague it is certainly the right decision.
As of now (June 2011) the launching process has been completed. The steel elements of the arch are produced in two factories – in Metrostav and in MCE. The short construction time requires excellent organisation of all activities on the site and in factories. The structural performance is monitored using many strain and temperature gauges installed on the main parts of the structure. Additionally the detailed surveying provides information on deformations and movements of the structure. Execution of complex details is verified on models or trial structures in the scale 1:1. The executing team believes that it is able to finalize this sophisticated project on time and in adequate quality.

5. MAIN PARTICIPANTS OF THE CONSTRUCTION

Client: City of Prague
Client represented by: IDS – Engineering of transport structures
General consulting office: Mott MacDonald Prague, R.Koucky, arch. office
Consulting office – steel structure: Excon, j.s.c.
Supervision and construction process analysis: Novak and Partner, Ltd.
Contractor: Metrostav j.s.c.
Steel production: Metrostav j.s.c., MCE Czech branch in Slany
Concrete production: TBG Metrostav, Ltd.
Other partners: VSL-CZ, Ltd., SMP CZ, j.s.c., SM7, Ltd.
MTEK, Ltd., CCE, Ltd. PONTEX, Ltd.

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