Reinforced concrete arches of the bridge "Mainland - Krk"

VIII

Reinforced Concrete Arches of the Bridge „Mainland — Krk"

Pont en arc en béton armé „Continent — Krk"

Stahlbetonbogenbrücke vom Festland zur Insel Krk

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SUMMARY
This paper deals with the description of the reinforced concrete arches of the bridge connecting the Island of Krk with the mainland which have exceptionally large spans, that is 244 m and 390 m. The arches were constructed in three portions, primarily the central boxlike portion and two lateral arch components consisting of deep I-beams. The central portion of the arches was executed applying the cantilever method including temporaty steel ties. Both the central boxlike portion and the lateral sections of the arches consist of precast elements that were assembled into a unit by means of cable-cranes.

RESUME
Il s'agit de la description des arcs en béton armé du pont reliant l'île de Krk et la côte, lesquels sont d'une portée exceptionnellement grande, 244 m et 390 m. Les arcs sont construits en trois parties, d'abord l'arc médian en caisson, ensuite, les parties latérales des arcs en forme de poutres en double té de grande hauteur. La partie centrale des arcs est exécutée par encorbellement avec des ancrages métalliques provisoires. Le caisson de la partie médiane ainsi que les parties latérales des arcs sont constitués d'éléments préfabriqués. Le montage a été réalisé par des blondins et des grues flottantes.

ZUSAMMENFASSUNG
Es werden die Bogen der Stahlbetonbrücke beschrieben, welche das Festland mit der Insel Krk verbindet. Die Brückenbogen haben eine respektable Spannweite: 224 m der kleinere und 390 m der grössere Bogen. Die Bogen wurden in drei Phasen gebaut: Zuerst wurde der zentrale, kastenförmige Teil erstellt, anschliessend wurden die Seitenteile der Bogen gebaut, welche die Form von hohen I-Trägern aufweisen. Der zentrale Teil der Bogen wurde im Freivorbauverfahren mit provisorischen, stählernen Zugseilen gebaut. Alle drei Teile, d.h. der zentrale, wie die beiden seitlichen, sind aus vorfabrizierten Elementen erstellt. Die Montage wurde einerseits durch Kabel, andererseits durch Schwimmkräne vorgenommen.

1. BRIEF DESCRIPTION OF THE ARCHES

The structure of the bridge connecting the mainland with the Island of Krk in the Adriatic Sea, consists of two large span arches, as shown in Fig. 1.

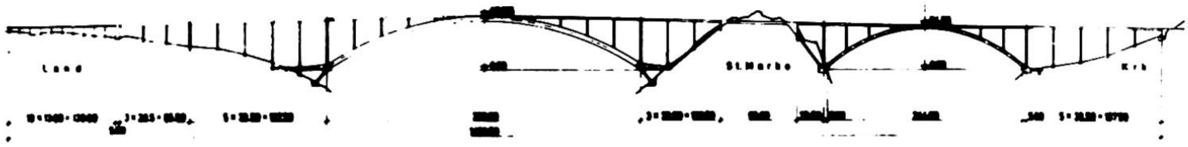

Fig. 1 - Longitudinal section of the Krk bridge

The gap between the Islands of St. Marko and Krk has been bridged with the arch of the theoretical span of 244 m, the foundations of which were established upon the sea shore line. The opening between the Island of St. Marko and the mainland has been spanned with the arch of 390 m in length. On account of fact that the breadth of water surface in this straits is much larger, over 460 m, it was necessary to have this arch footings designed to represent a type of a triangular structure consisting of nearly horizontal boxlike strut positioned above the sea level and a racking solid pier founded in the rock 19 meters beneath the sea level. The greatest part of this supporting structure consists of precast concrete elements which were definitely positioned by a floating crane of the great bearing capacity.(1)

The box section arches consist of the top and bottom slabs and four vertical ribs. The external dimensions of the section are fixed along the entire arches length - the height is equal to 1/60 of the arches span and the width to 1/30 of the span. Accordingly to the change of dimensions of the boxlike section slabs, there has been enabled the modification of the area magnitude and of the moments of inertia of the arches thus achieving nearly uniform distribution of stresses in the arch concrete throughout its length, for all types of load both in vertical and horizontal plane. For the longer arch span, the stresses in the arch concrete are somewhat greater ranging from 102 to 109 kp/cm2 for the dead load, while for the total load these stresses are oscilating through the value of 150 kp/cm2 along the entire length of the arch except immediately at the supports, where the absolute maximum of the stress occuring within the single edge point is 188 kp/cm2 although the probability of its occurance due to simultaneous action of all influences, is practically nil. All values of the extreme stresses occuring within the 244 m arch are smaller. It should be emphasized here that the tensile stresses do not even occur under the circumstance of the least favourable combination of load in concrete of both arches.

2. ARCHES ERECTION OPERATION

Both of these arches have been executed applying the so called cantilever method. Back in 1963, the people from the Designing Bureau of Mostogradnja of Belgrade elaborated a special technique for concreting of the large span arches, applied for the first time in construction of the arch spanning the 246.40 m broad straits near Šibenik in Yugoslavia (2). The same technique was applied again in 1967. in construction of the 193.20 m arch span for the reinforced concrete bridge connecting the mainland with the Island of Pag in the Adriatic Sea (Fig. 2).

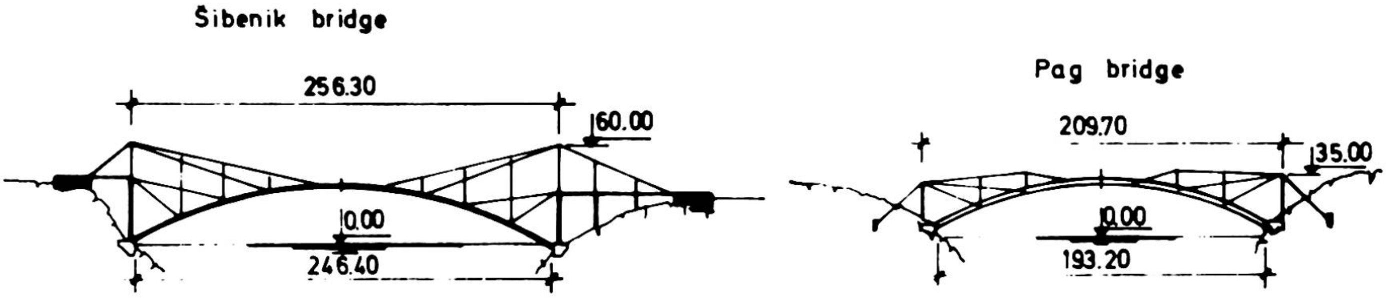

Fig. 2 - Erection of the arches for the bridges "Šibenik" and "Pag"

The method of concrete placement in the arch is exercised in the manner of immediate casting in its full section, in several segments, by longitudinal displacement of the steel lattice platform. This steel structure, upon which the arch was being cast, as well as the accomplished arch segments were suspended upon the U-section steel ties strengthened with prestressing cables.

In case of the bridge in Šibenik, the temporary steel ties were guided from two centres, including the auxiliary pylon erected above the pavement at the innundation. The intermediate piers were constructed of the light concrete elements to exclusively serve for the installation of the ties which were composed of several extensions. As regards Pag bridge, all ties were guided from a single centre and, in addition, the intermediate piers were receiving the refracting forces existing in the latticelike tie network.

The technique of arch construction for the bridge connecting the Island of Krk with the mainland is similar to that applied formerly, as shown in Fig 3. The principal difference is to be seen in the fact that the arches here were not concreted throughout the section, but instead, the diminished central portion of the arch, applying the cantilever technique, was constructed first and its lateral sections thereafter, in the form of high I-beams. Likewise, the arches were not concreted into the sections of 27 m and supported by a steel lattice platform, but they were concreted to form the assembly sections of 5 m in length instead. The large arch is composed of 40 segments at both sides, and the small one of 26 each.

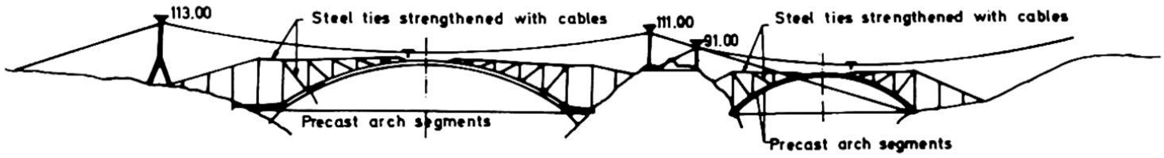

Fig. 3 - Erection of the arches for the Krk bridge

3. ERECTION OF THE CENTRAL PORTIONS OF THE ARCHES

The central portion of the arches consists of prefabricated elements, two vertical ribs, and identical bottom and top slabs. They were erected on the light cantileverlike latticework fixed to the end of the previously completed segment (Fig. 4). The erection was completed by cable-cranes.

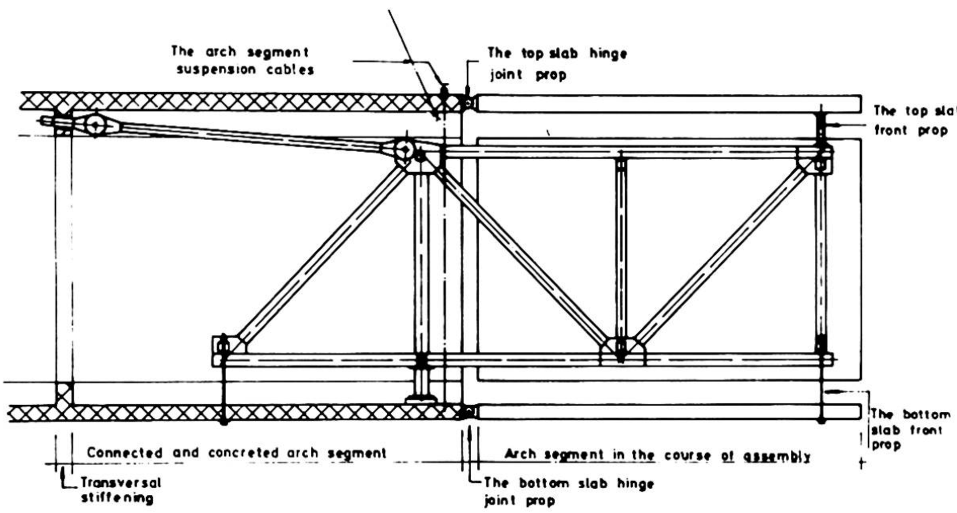

Fig. 4 - Longitudinal section of the arches` assembly portion

The erection of the arch segment and the adjustment of its elevation and position were followed by the placement of reinforcement and concrete for the longitudinal edge beams connecting all arch elements, and for the joint to the previous arch segment in the form of a transverse stiffener throughout the cross section, as shown in Fig. 5.

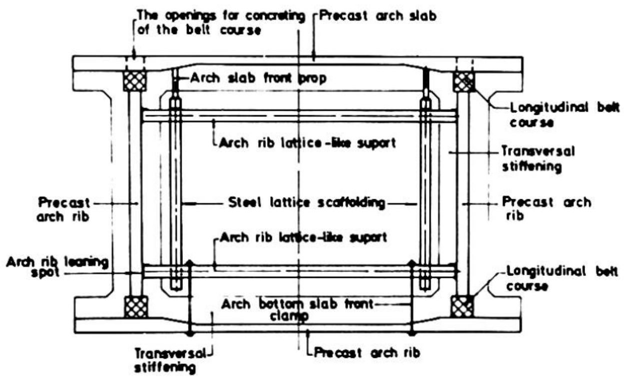

Fig. 5 - Cross section of the arches` assembly portion

Finally, the temporary cables which made possible the cantilevered construction of the arch in several segments from one to the next bearing tie, were tensioned. Upon the erecetion of several segments, the central part of the arch was suspended and held by the bearing steel tiework made of rigid sections and which are provided with hydraulic jacks for control of the forces in the ties. The temporary cables were released immediately after the bearing steel tie was actuated (Fig. 6).

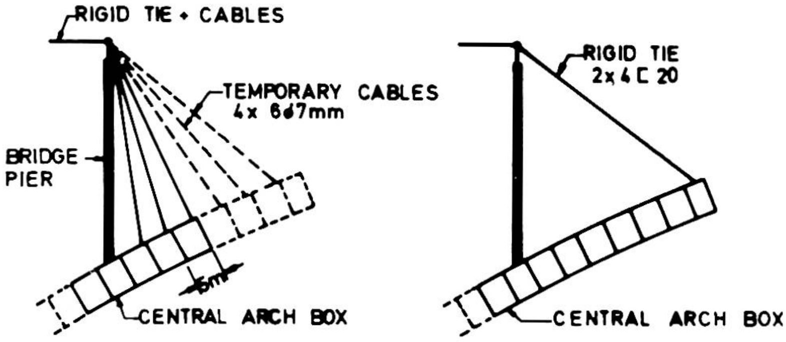

Fig. 6 - Erection by means of temporary cables

Exercising such continuous work, which was scheduled in all details, all other segments of the arch designed in the form of box, were erected up to the arch crown.

Completion of the central portion of the arch consisting of the precast members was done in the exceptionally short period, that is, in less than 13 months required for the erection of the arch of the span of 390 m, and the small one of 244 m in span, was completed in 5 months and 12 days (fig. 7).

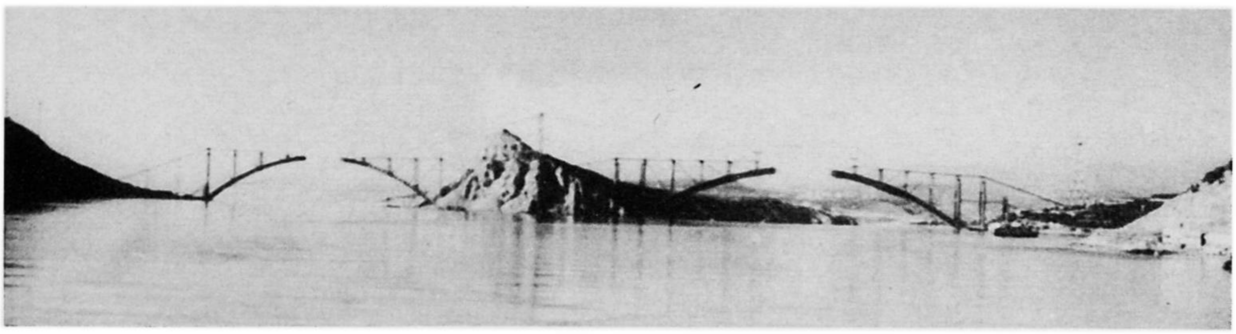

Fig. 7 - Erection of the central portion of the bridge arches

4. ERECTION OF THE ARCH LATERAL SECTIONS

Upon completion of erection of the basic, central portion of the arch in its entire length, the hydraulic jacks, positioned at its crown, were actuated and steel auxiliary ties were removed. Upon removal of ties, the lateral parts of the arch were erected, too.

In case of the smaller arch of the cross sectional height of 4.0 m, these additional parts were erected immediately in their entire section, as shown in Fig. 8.

The relevant precast units were fabricated rather long, even up to 32 m in length and of 35 to 93 ton in weight. They were brought and erected by means of a floating crane.

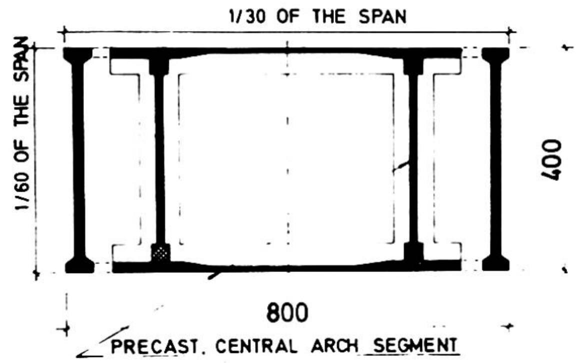

Fig. 8 - Cross section of the 244 meters arch

As regards the large span arch of the sectional height of 6.5 m, the erection of the lateral arch sections was completed of segments of rather small weight. The top and bottom parts were completed of the precast elements of the weight of 10 ton each and the intermediate part was concreted in-situ (fig. 9).

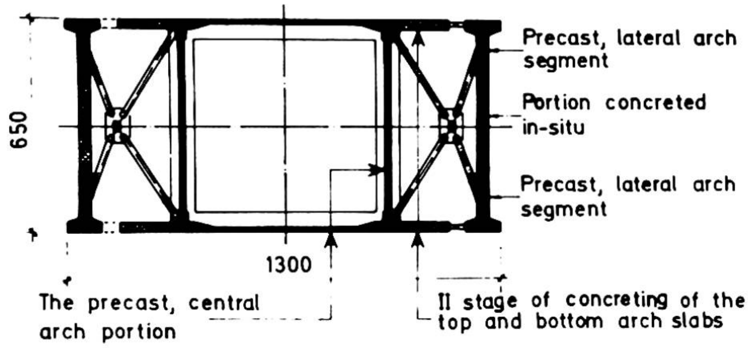

Fig. 9 - Cross section of the 390 meters arch

The erection of these lateral arch elements was quick and simple, and was accomplished by cable-cranes and having the elements held by light steel scaffolding tied to the arch central portion.

After the arch lateral elements were leaned against the hydraulic jacks in the crown, their longitudinal joints to the arch central portion, and the transverse stiffeners at the spot of piers, were concreted as these are required to participate in receiving further load. Finally, required cross prestressing operation was carried out, whereby the entire cross section of the arch turned into a monolithic structure.

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