

## BRIDGE OVER THE RIVER TAGUS ON THE ALCÁNTARA RESERVOIR

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**Key words:** *Solid ribbed deck arch bridge, lowering, pushing, launching.*

**Abstract:** *Currently under construction, the bridge over the Alcántara Reservoir belongs to La Plata dual carriageway. The work is being managed by the Extremadura Roads Demarcation of the Spanish Ministry for Development, with the Engineer Fernando Pedraza acting as Manager, and the OHL Company, which has developed a unique construction system, performing the work.*

*The bridge is made up of twin structures formed by a steel, solid ribbed deck arch bridge with a span of 220 metres, measured between springings, and a 42.50 m rise. The arches are fixed in springings and the profile varies from 3.20 m at the springing to 2.20 m at the crown.*

*Each of the arches is formed by two braced-together, box-sectioned pieces. The deck is formed by a continuous, composite steel-concrete structure, supported by steel piers resting on the arch and concrete piers with foundations in the sides. The steel part is formed by two box-sectioned girders, connected above to the top concrete slab. Piers provide the deck support with 26 metres between centre lines both in the area located on the arch and in the approach stretches.*

*The structural conception and design was undertaken in a manner integrated with the study and determining of a special construction process, one of whose phases consists in assembling two semi-arches in a vertical position and then lowering them until closing at the crown.*

*The deck construction system consisted in dry land assembly and subsequent pushing to its final position.*

*The paper submitted describes the details and peculiarities of the construction process and the different phases in the evolution of the structure during assembly manoeuvres.*

## 1 INTRODUCTION

Deck arch bridges are one of the classic solutions most used throughout Engineering history. The structural qualities of arches deriving from their shape have been determining factors for many years in the preferential adoption of their scheme in bridge designing and building within a certain range of spans.

However, the use of arches in bridge building commenced a gradual decline as from the mid 20<sup>th</sup> Century. The development of prestressed concrete, together with new techniques for its on-site placing, brought economic advantages and possibilities for overcoming natural obstacles which were difficult to resolve with arches, the development of whose construction systems has become stagnated.

The idea of building arches to overcome large spans has been strongly revived over the last few years. The probable main cause has been the evolution, development and modernisation of building techniques.

One representative example is the bridge over Alcántara Reservoir, which is currently under construction by OHL Company. The conception and structural design were undertaken in an integral fashion via studying and determining a building process expressly developed for this construction.

## 2 BRIDGE OVER ALCÁNTARA RESERVOIR. DESCRIPTION OF THE STRUCTURE

The bridge is formed by twin structures each of which is made up of a solid ribbed, steel deck arch with a 220 metre span measured between springings and a 42.50 m rise. The arches are fixed in springings and the profile varies from 3.20 m at the springings to 2.20 m at the crown (Figure 1).

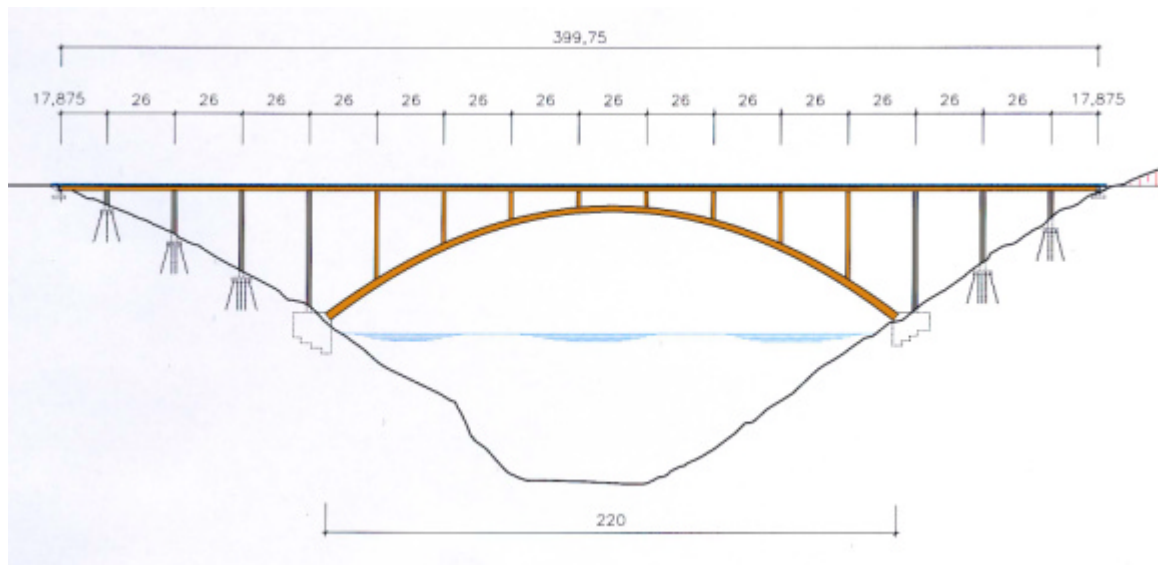


Figure 1. General elevation

Each of the arches is formed by two longitudinal, braced-together, box sectioned pieces (Figure 2).



Figure 2. General Overview (Virtual)

The deck is supported by piers with 26 metres between centres both in the area located on the arch and in the approach stretches.

The arch springings have direct foundations provided by large concrete blocks. The approach viaduct's piers have their foundations in the reservoir cliffs using micropiles with their pertinent cappings. The abutments have direct foundations, being anchored into the rock to withstand the stresses deriving from the arch building process.

The deck is formed by a continuous composite steel/concrete stretch supported by the metal piers resting on the arch and concrete piers with foundations in the sides. The metal part is formed by two box section girders connected at the top to the concrete slab with a thickness varying from 0.25 to 0.365 m (Figure 3). Each of the metal girders is 1.60 m thick.

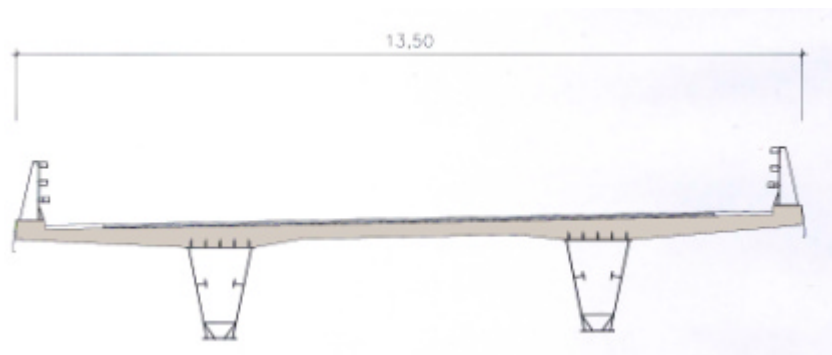


Figure 3. Deck cross section

The piers located on the arch are metal and are rectangular box sectioned. The remaining piers in the approach areas are reinforced concrete.

The steel making up the whole of the metal structure (arches, deck girders and piers on arches) is the CORTEN type.

### 3 GENERAL DESCRIPTION OF THE CONSTRUCTION PHASES

Figures (4 to 9) graphically defining the most significant peculiarities of the construction system developed in an overall fashion are shown hereafter:

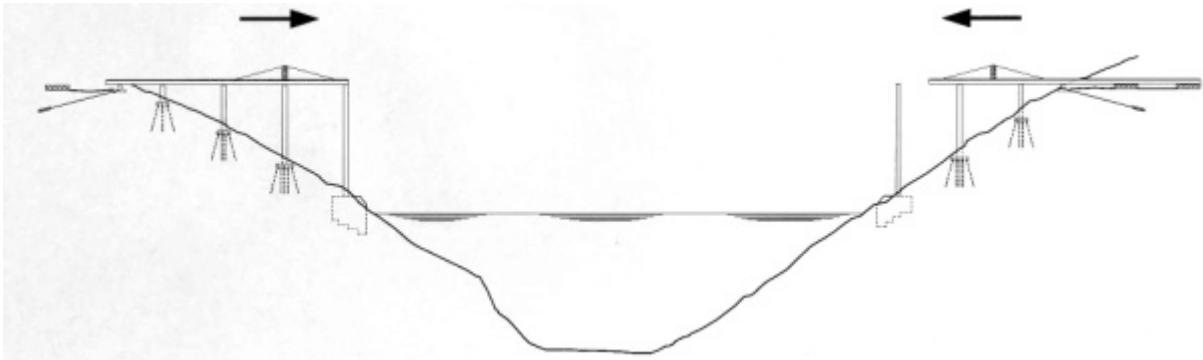


Figure 4. Construction of a fraction of the deck on dry land and pushing it to reach the piers located on both sides of the reservoir.

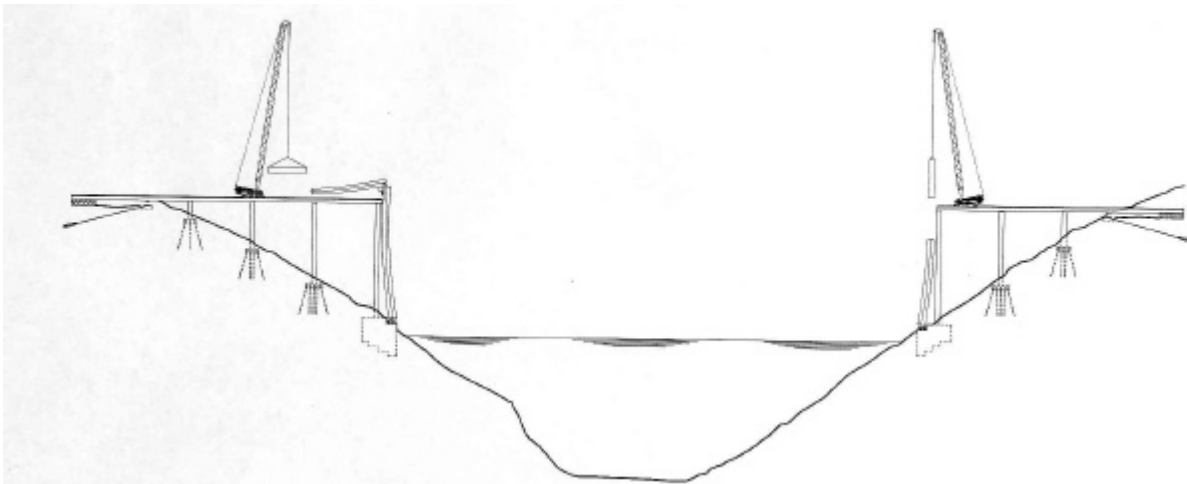


Figure 5. Assembling the parts of the two metal semi-arches with a crane.

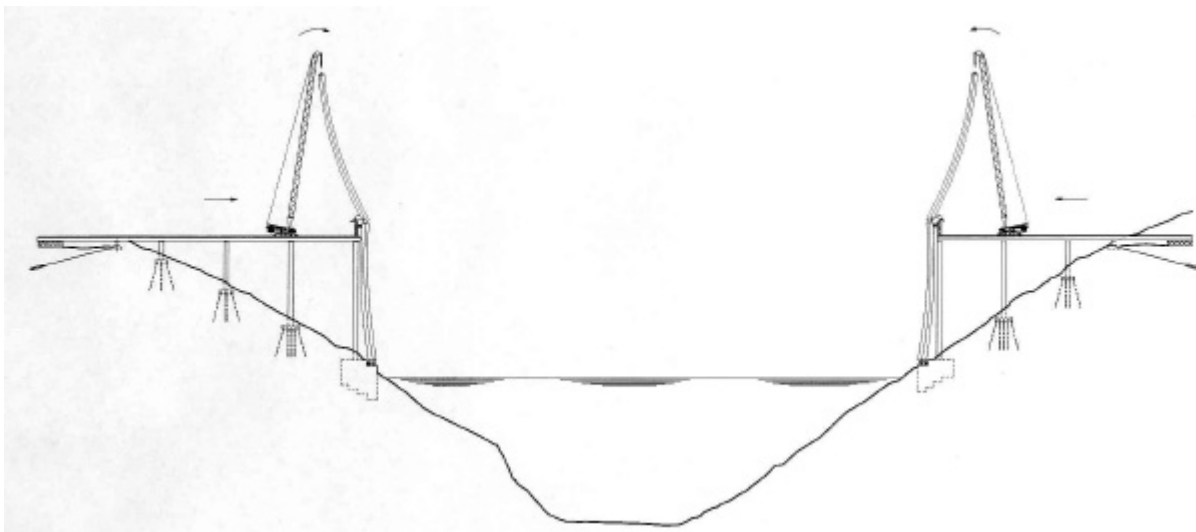


Figure 6. Crane hoisting the arch's top fraction, pivoting the base on an intermediate hinge.

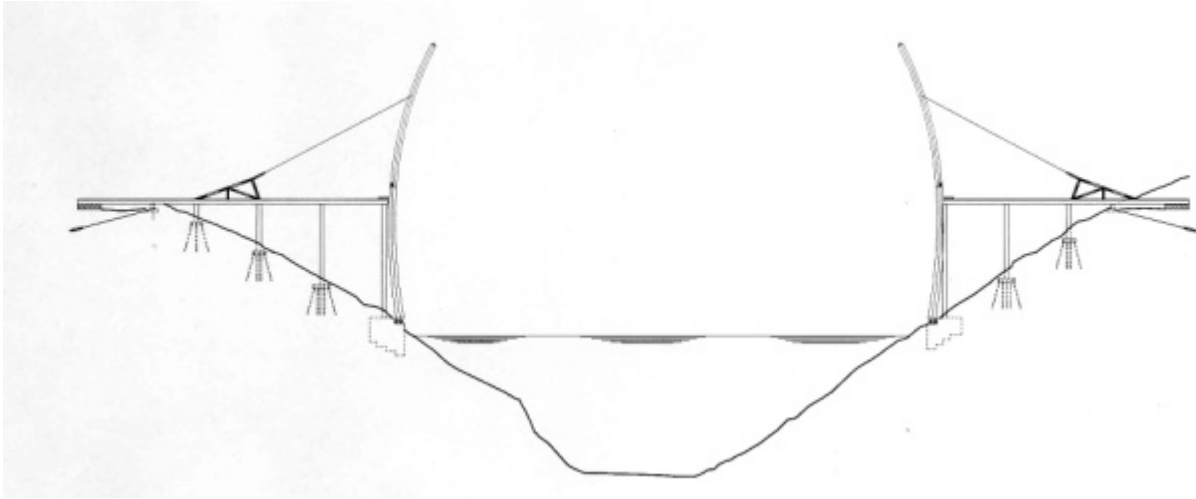


Figure 7. Setting up a holding and lowering system

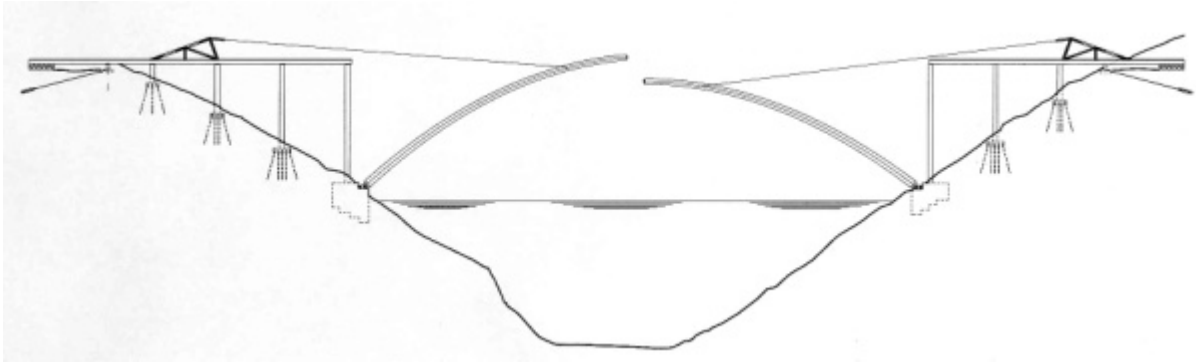


Figure 8. Lowering semi-arches and crown closing of the arch formed. Hinge locking

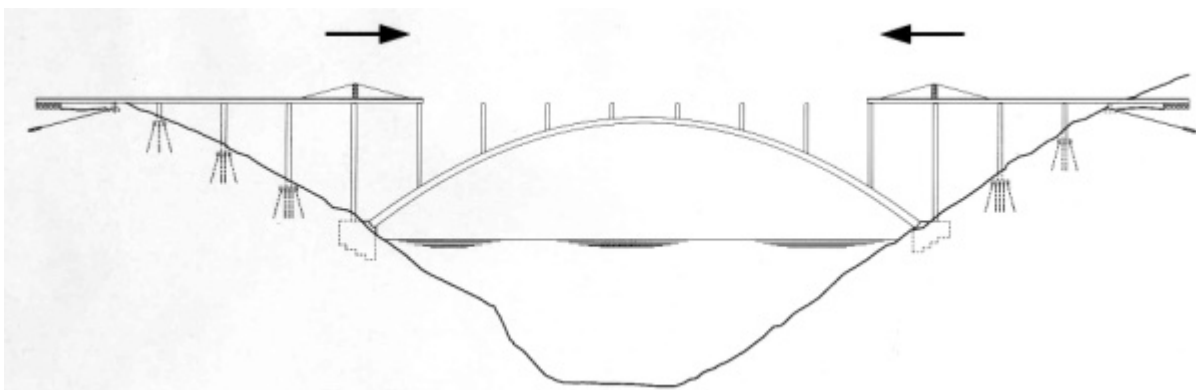


Figure 9. Deck launching to complete closing at the centre.

## **4 SPECIAL ITEMS IN THE CONSTRUCTION SYSTEM**

### **4.1. - Deck launching**

Formed by a composite structure, the deck is built in its entirety on dry land, including the top slab's concreting, and is pushed with the complete cross section.

During pushing, the deck is provided with a bracing system at the front so a launch nose does not have to be erected. The tower is provided with jacks to regulate the stress in the stays during the different launch stages.

### **4.2. - Lowering. Hinge system and regulating jacks.**

The system allowing each of the semi-arches to rotate at the bottom is formed by four hinges, each located on the centre line of the two box girders' webs, so that no local bending conditions occur in the structure. The hinges are spherical so as to avoid the effects of a possible misalignment of the rotating centre line in the erection process.

Each of the semi-arches rests on a base allowing them to move in the bridge's longitudinal centre line direction. Movement is controlled by two horizontally arranged hydraulic jacks supported against the abutment's vertical facing so that, once the lowering process has ended, the position may be regulated not only in a longitudinal direction by means of synchronised operation of the jacks but also causing a lateral movement in the crown area by a differential action in the aforesaid jacks' stroke. It is thus possible to regulate the position of the end of each of the semi-arches in the crown area in all possible directions in order to achieve assembly in the position provided for.

### **4.3. - Wind effect holding system**

Consideration of the side wind effect proves critical with regard to safety as to the assembly's overturning and sliding during the semi-arch lowering process in the position prior to meeting in the crown area.

The vertical support reactions in the arch base may be likened to a couple of forces, each applied at the base of the two metal box girders. Calculated according to the consideration of an exceptional wind worked out from the IAP Standard's specifications, the magnitude of the reaction in an upward direction is higher than the reaction due to the arch's dead weight. A powerful vertical support mechanism compatible with the horizontal sliding movement in a longitudinal direction is provided in order to prevent any risk of the supports' lifting up and the consequent instability of the unit from an overturning effect.

The horizontal component of the support reactions produced by the side wind effect may also be likened to a couple of forces, the magnitude of which is also higher than the dead weight reaction, materialising in a force applied on the jacks. A horizontal holding system formed by adjustable stops which may be unlocked during manoeuvres for adjusting the semi-arches' positions in the phase prior to the crown closing was provided to prevent the uncontrolled sliding of one of the two supports in a reservoir bound direction.

#### 4.4. - Crown closing.

There are two guiding elements to facilitate the assembly of the two semi-arches in the crown area, with facings formed by sloping steel sheets such that regulation up to the final position is automatic once the two ends have made contact. The front contact between the two semi-arches occurs through a spherical axial hinge located in each of the two box girders.

Once the lowering process has ended, with the semi-arches in contact, a small vertical safety locking system is fitted and the holding cables are released of load. The structure responds at that moment to a three-hinged arch scheme which, in view of its isostatic condition, allows the crown area to be height regulated by operating the horizontal jacks located at the springing. A variation in the piston stroke of these jacks causes the crown area to move vertically with no variation in the arch stresses, and neither in the support's reactions.

#### 4.5. - Hinge locking

The hinges are locked in a subsequent phase in order to form a fixed arch.

The crown area is locked by adding steel closing sheets and then welding, thus establishing structural continuity.

The springing area is locked by filling with concrete underneath the box girder steel closing sheets and then prestressing with anchoring bars. This prestressing was sized by laying down the condition of the non-existence of concrete decompression states as against compound bending situations in the base of the arch during future stages of the bridge in service (Figure 10).

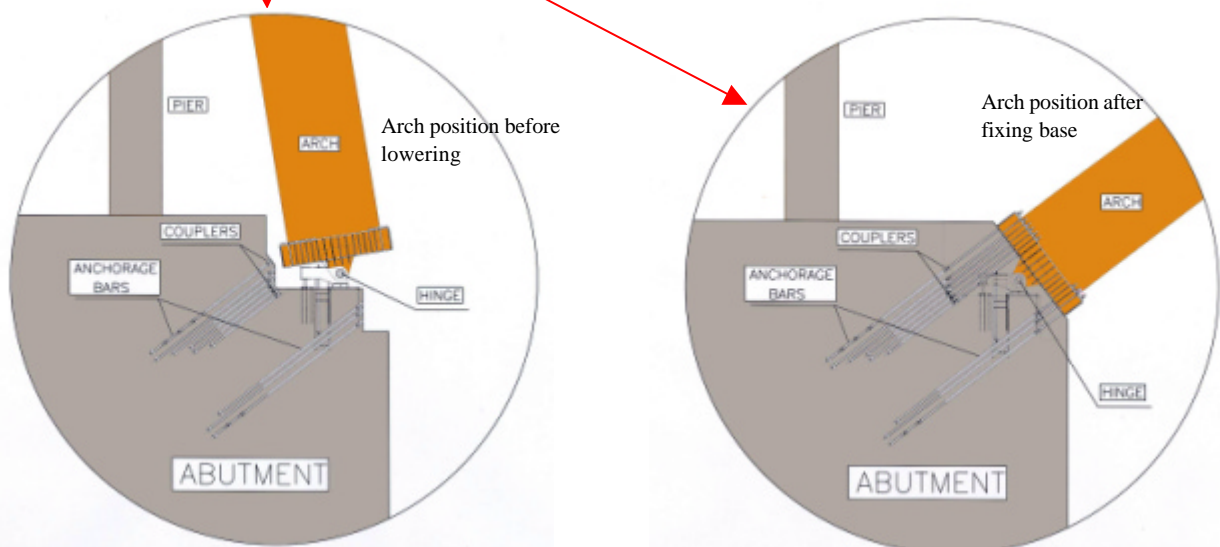


Figure 10. - Fixing arch on its base

## 5 CONCLUSIONS

- The construction system developed provides the possibility of quick performance under much more favourable conditions than those resulting from other conventional systems.
- The deck's launch construction provides the advantages of discarding the need for full dry land assembly, facilitating the auxiliary items and allowing for easy quality control.
- The fact of mounting the arches by means of the possibility of assembling large sized elements is an advantage deriving from the reduction in the number of construction phases and the time necessary for the overall work.
- Applying the process developed calls for intense engineering work integrating the general design of the structure, shapes, construction system and detail design of special items.
- The solution developed provides considerable environmental benefits, safety in the construction phase and final quality.