Viaduct over the Alcántara Reservoir: Walking over the Tagus

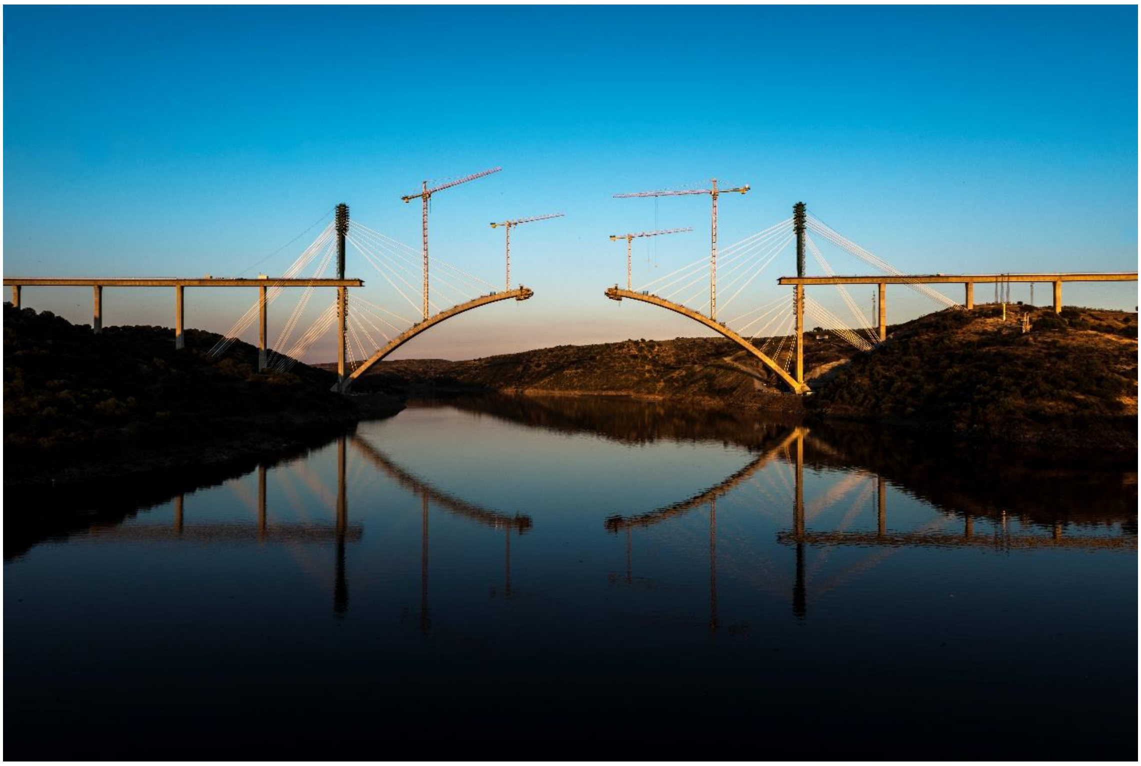

Fig. 1: Current status of the project. (Photo by Carlos Manterola Jara).

The progress of the arch has already accomplished four fifths of the total length at present. A second pair of tower cranes were installed over the arch in mid-June, thus the structure has all the auxiliary elements necessary for its finalization.

This article is focused on the required auxiliary means to carry out the works, looking at both their technical characteristics and the effects of these means over the arch.

<u>Tower cranes over the basement:</u>

Like in other outstanding infrastructure projects, this project relies on relevant auxiliary structures that allow its construction. The project counts on a complete system of tower cranes together with the thousands of meters of access stairs to visit the 70 m high piers and the 54 m high temporary pylon, tensioning platforms, and inner and external stairs of the arch. To understand the necessity of the aforementioned means, this articles explains bellow the material supply process of the construction of the arch. To perform the first 21 segments, a tower crane with cab from where the operator can operate was needed. Initially, it was enough with a 85 m high crane, but, as planned, it was required to lengthen it to more than 134 m to avoid the overlapping with the temporary pylon in a second phase. It was placed next to the pier where the arch begins. This crane was settled on a micropiled foundation. It required a brace at the upper part of the pier, to exceed its maximum freestanding height. Once the 21 segment (out of the total 47 that makes up each one of the semiarchs) is accomplished, the crane was put down with the help of another crane, being moved to its next position over the arch.

Fig. 2: The crane is put down to be moved to the position 2 (over the arch).

Cranes over the arch:

Subsequently, this same crane, in its 85 m high configuration, it is assembled on the previously fabricated 20th segment of each semi-arch (position 2 of the cranes 1 and 2). For this, it was necessary to design a docking structure that allows the connection between the crane feet and the segment inclined surface, at 65 m over the water surface. In this case, because of the height where the jib is placed, there is no overlapping problem with the temporary pylon, enabling the complete rotation. Due to the huge punctual loads transmitted by the crane feet with compressions over 510 tons and tractions over 420 tons unfactored, it was necessary to introduce some modifications in the segments where the cranes are placed to assure the correct dissipation of strains.

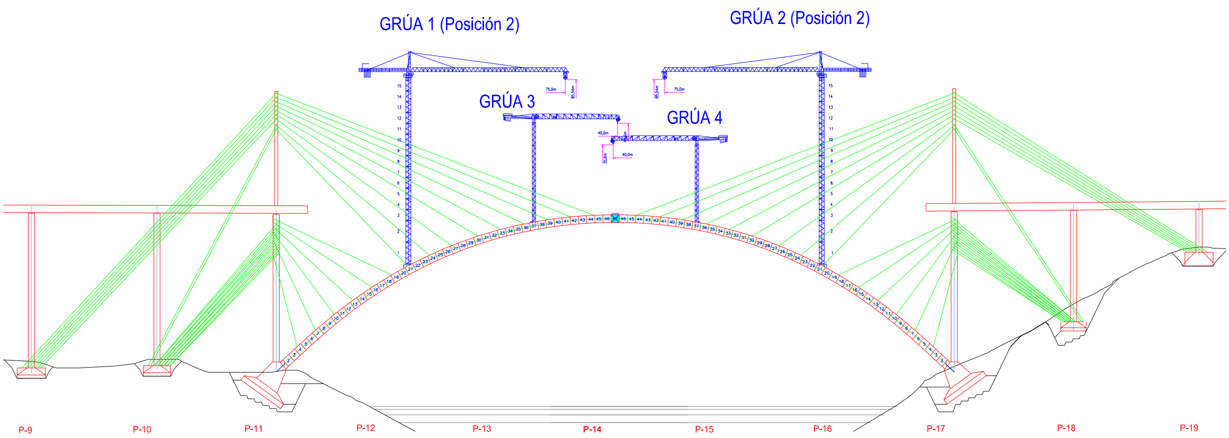

Fig. 3: Schematic of the cranes needed in the arch construction.

Fig. 4: Crane over the segment number 20 in its position number 2. The 7th stays pair is next to the crane. The first sixth couples are anchored to the pile.

Once the segment number 38 is completed, the cranes 3 and 4 are assembled over the arch, these cranes are 45 and 35 m high, that is into the radius of action of the first crane, with a reach of 45 m. These cranes, without a cab, have its anchor at 85 m over the water surface. For these cranes, it is equally necessary to reinforce the segment where it is placed, as well as to implement the docking structure between the feet and the segment surface.

Fig. 5: Cranes 3 and 4. The left crane is placing loads in the material exchange platform. There are some operators on the platform.

The performance of the cranes is possible by a material exchange platform, placed in the segments 31th and 32th. The first crane provides the platform of the elements that the arch requires to its construction, the second crane takes these materials to the phase front.

The concrete feeding is undertaken by two concrete skips with a volume of 2 m^3, so that while the crane number 2 is draining one in the phase front, the other crane is refilling the other one directly from the concrete bucket placed in the plinth.

The aeroelastic effects have been deeply studied in order to check the behavior of the cranes and the arch under adverse wind conditions.

<u>Adjustment of the base inclination:</u>

Due to the rotations experienced by the segments during the construction process, the docking structures of the cranes base to the segments are required to be adjustable in their inclination, to meet the restricted margins of flatness established by the manufacturer of the auxiliary element.

This structure, adjustable in all directions, was designed thanks to the remarkable work of both the team in the central office in Madrid, and the engineers placed on site. The use of a 250-t capacity hydraulic jack allows the regulation of the inclination in its base, introducing gauges prepared for this purpose.

Fig. 6: Docking structure of the crane 1 on the arch.

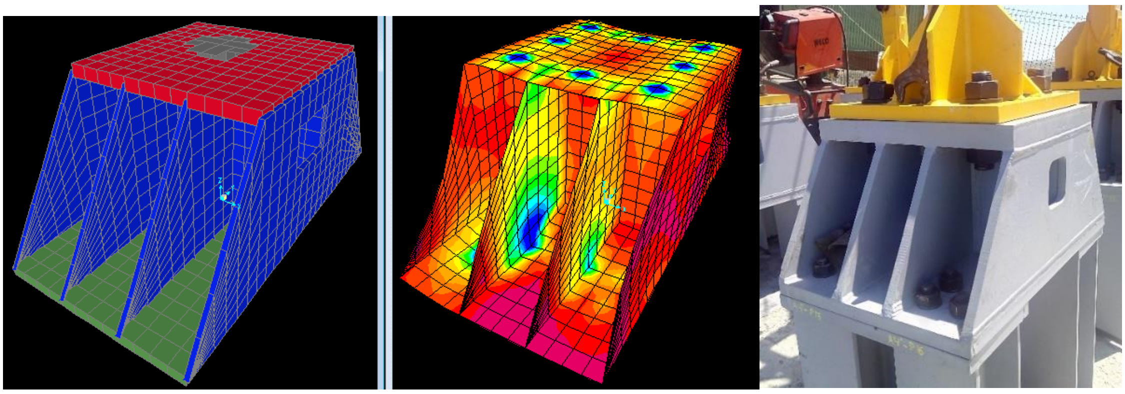

Fig. 7: Finite Element Model (FEM) used in the design of the connection structure of the cranes in the position 2 on the arch and the structure actually manufactured.

<u>Interior reinforcement of the segments:</u>

The segments have been reinforced to receive the loads transmitted by the cranes. Pi-shaped diaphragms are placed in the 20th segment concreted at the same time than the segment thanks to the partial elimination of the internal cast of the form traveler, without the use of steel connectors. The form travelers have the restriction of the maximum volume allowed of concrete per concreting, because of the limitation of load that the auxiliary structure can afford. Therefore, it was necessary to perform this segment in two phases, getting the connection between concretes with overlap splices, without needing mechanical splices, which are more expensive for big diameters. This was one of the most challenging goals achieved by the team.

Likewise, the diaphragms have ducts where the Ø26.5 mm Dywidags go in, which bear the tractions transmitted by the connection structures.

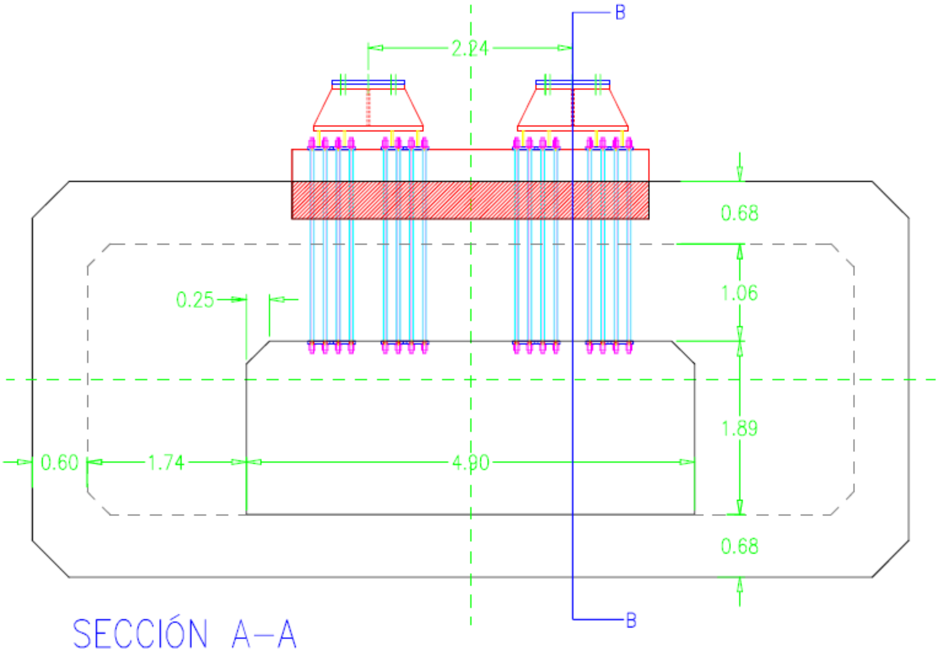

Fig. 8: Cross section of the segment where the 85 m high cranes are placed. It is possible to see the Dywidag that connect the docking structure to the Pi-shaped diaphragms.

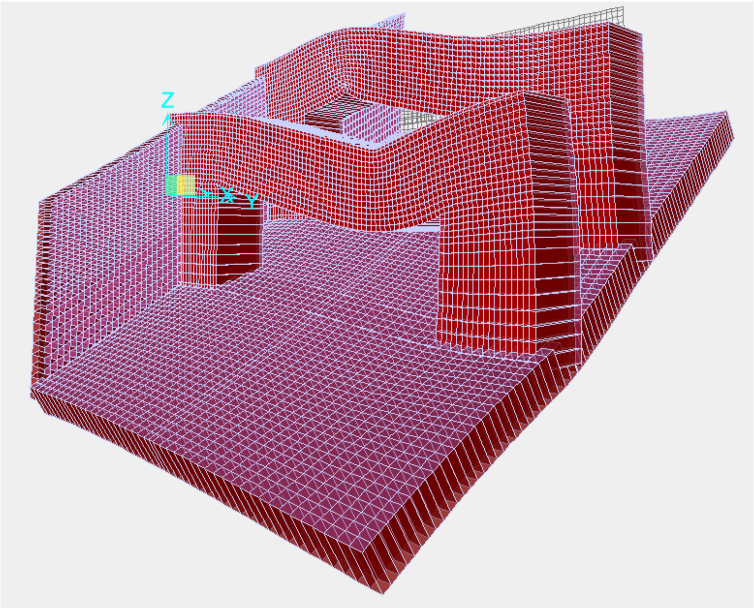

Fig. 9: FEM used to verify the traction strains on one foot and the compression strains on the other (jib in diagonal position) on the diaphragm. In this view the right wall and the superior slab are hidden

Regarding the cranes in positions 3 and 4 over the arch, they are placed in the 36th segment. Due to the smaller transmitted loads and width of the segment, which lead to smaller bending moments and shear efforts, it was enough to increase the thickness of the superior slab and to reinforce with extra rebars, embedding steel plates. These plates have improved resistance to the deformation in the perpendicular direction to the plate surface (Z25). The connection structures are welded to these plates, obtaining a solution really simple to develop.

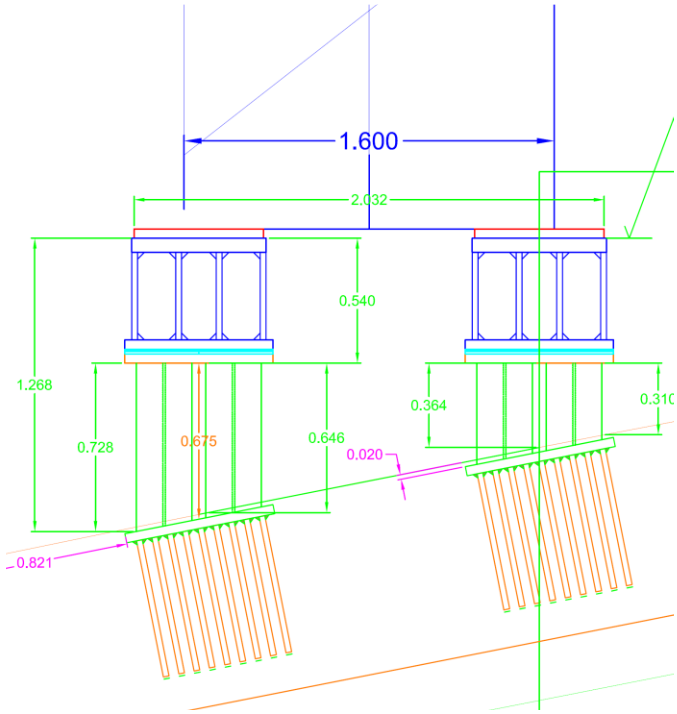

Fig. 10: Superior slab section, where the anchor plates' connectors are placed. Once the segment is concreted, the docking structures are welded to this plate.

In summary, to design both the reinforcement of the segments where the cranes are settled and the docking structures, it was necessary the collaboration between the drafting team of the Project with the technicians working on site. It was necessary the collaboration of the departments of production, surveying, quality, safety, purchasing and the rest of the people that undertake the works, achieving the best solution in terms of technical considerations, safety, deadline, simplicity of the implementation and economic criteria. The teamwork is extremely important in this kind of projects.

Author: Luis Miguel Salazar Martín.

Structural Engineer.

Carlos Fernández Casado, S.L.