New Bridge over Llobregat River

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ABSTRACT: Located on the road which communicates the port and the airport of Barcelona, the New Bridge over the Llobregat River is a bow-string. This road is one of the main accesses of this city and also an axis of the principal roads connecting industrial and logistic areas associated to its port and all the industrial zones of the Bajo Llobregat. Arch and deck are supported by two reversed tripods, made by a longitudinal inclinated simple pier and a both longitudinal and transversal inclinated double pier that constituted inferior part of the rhombus which is completed by the double superior arch. Bridge presents a rectangular plant and its deck is materialised by a prestressed concrete beam 304 m long and 29 m wide. Both piers and arch divide the deck in five spans; the main and the central one of 104 m long, the adjacent ones of 55 m, and the lateral ones of 42 and 48 m.

1 INTRODUCTION

The New Bridge over Llobregat River means one of the main accesses to Barcelona city from the surroundings, and also the road communication axis of the industrial areas associated to Barcelona Port (Harbour and free port) or belonged to Bajo Llobregat County, because it is situated in the road that joins the harbour and the airport of the city.

The New Bridge is close to the mouth of Llobregat river with Mediterranean Sea, and hence at a great environmental landscape. Fundamentally it is a great superior arch which clean crosses the river bed, supported by both inclined double piers; besides two single piers, one at each side, continue the structure at the same time, supporting the deck near to the wring walls.

The bridge has rectangular plant. It is solved by a continuous prestressed concrete deck 304 m long and 29 m wide, materialised by a series of five spans: main span 104 m long, adjacent spans 55 m long, and lateral spans 42 and 48 m long.

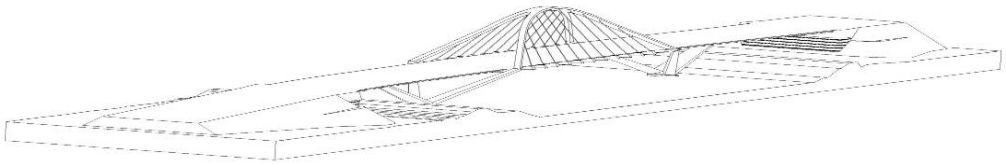

Figure 1 : Bridge perspective

Figure 2 : General view

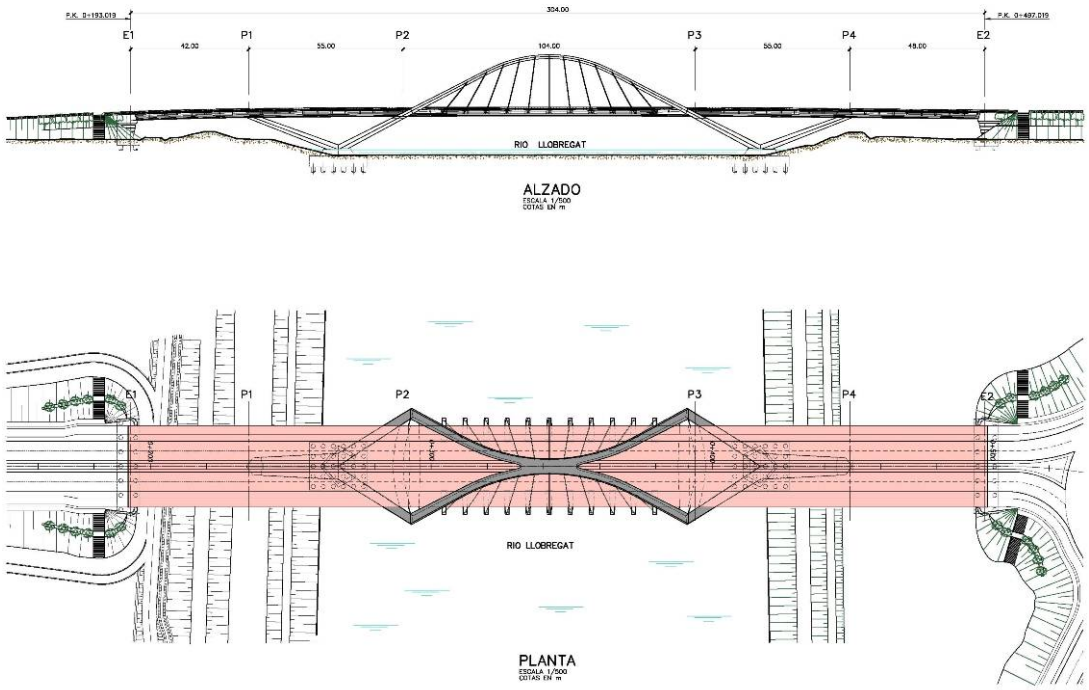

Figure 3 : Lift and plant

2 FOUNDATIONS

Bridge foundations are laid on deltaic quaternary deposits settled at the mouth of the Llobregat River laid out the pliocenic base. Those deposit of variable thickness between 75 and 100 m, are river, deltaic and marine sediments of great complexity by nature. They consist on very different sedimentary environmental materials: the river ones (sand and gravel well rounded), old river terrace buried by new alluvial deposits, and coastal sediments.

Foundations of wring walls 1 and 2 are deep and consist on pile caps which dimensions are: 8.2 m long, 33.8 m wide and 2 m high. They are supported by 14 piles 50 m long, embedded at least 3 m into the deltaic sandy gravels of Llobregat River and distributed in 7 files (longitudinal) and 2 rows (transversal).

Tripods made up of the single and the double piers are fixed to both pentagonal baseboards, as if they were big truncated pyramid reversed capitals whose maximum transversal and longitudinal widths are 14.8 m and 12.4 m, respectively.

Both baseboards are embedded to foundations of piers 1 and 2 and piers 3 and 4. Both foundations are deep and consist on pile caps with rectangular shape 20.6 m long, 17 m wide and 4 m high, supported on 30 piles of 50 m long embedded 11 m at least into river deltaic sandy gravels and distributed in 5 files (transversal) and 6 rows (longitudinal).

3 PIERS

Space rhombus, materialised by a single pier and a couple of inclined ones, make up the main elements of general view, allowing at the same time an intense structural and aesthetic unity of the whole bridge.

Double piers 2 and 3 jointly with single piers 1 and 4 are born to both truncated pyramid baseboards whose section is pentagonal; they transmit working loads to both foundations.

Double piers are solved by both solid concrete transversal sections whose biaxial trapezoidal shape has depth and width variables. Their lower parts are joined in order to geometrically

follow single pier, making up a single trapezoidal transversal section with variable depth and width.

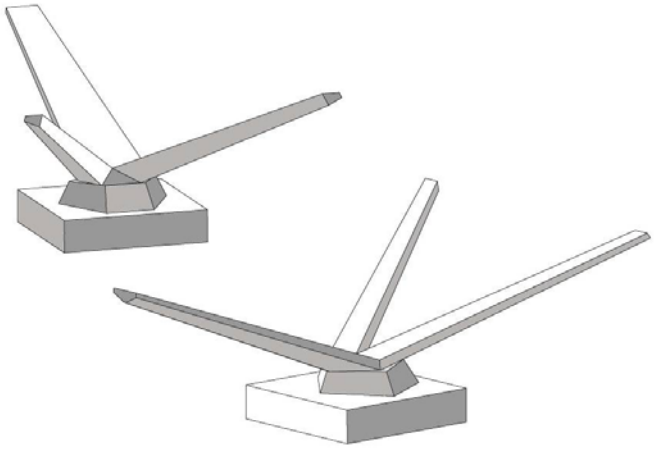

Figure 4 : Piers' Tripod perspective

Piers´ dimensions, both single and double ones, get lower from their starting at the baseboard to their joint with both arches and deck. Single pier is 2.9 m high and 9.2 m wide at the beginning and it is 1.9 m high and 5.9 m wide at the top. However, each pier which belongs to double pier is 2.8 m high and 5.2 m wide at the beginning and 1.9 m high and 3.8 m wide at its top.

4 ARCHES

Central bridge span is supported by two upper arches which are born to two pairs of inclined piers making up two great expressive space rhombuses. Both arches softly meet at their upper part by a joint piece, achieving a very special image, as it was a large access door to the bridge inside.

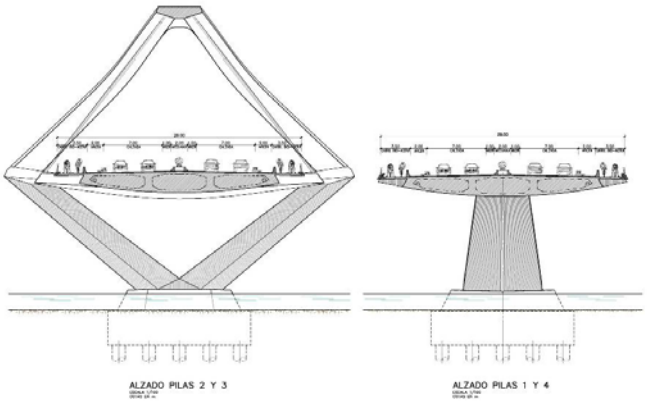

Figure 5 : Double and single piers' Lifts

Arch lift's axis is defined by a second grade parabola 104 m long and 18.9 m string. Both arches' axis measure feel obliged to their auto maximum height sign; it must be enough to allow traffic crossing under arches and lifting cables. Arches are double curve pieces with variable section all along them until their central part were they made up of a single arch. It presents a trapezoidal biaxial section. Its upper measures are 2.5 m minimum wide and 3.5 m the maximum one. The down ones are 2.22 m minimum wide and 3.11 m maximum wide. Besides, its depth varies from 1.4 m to 1.9 m.

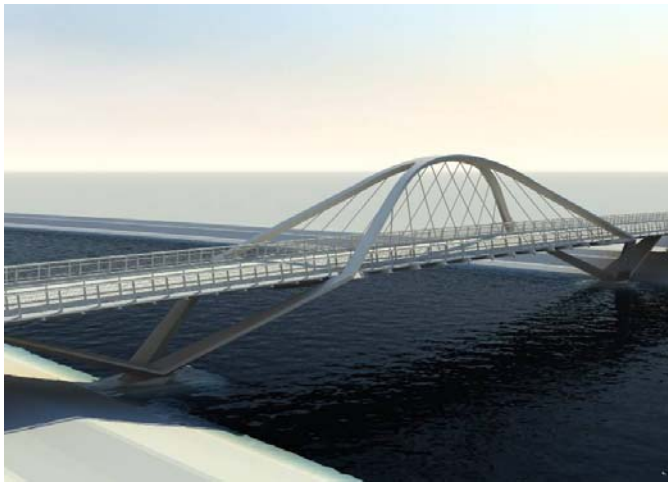

Figure 6 : Space rhombus perspective

Chosen section is also appropriate to anchor pairs of inclined strained cables; anchorage points are situated close arches` centre of gravity, avoiding excessive transversal bending in the stresses transmission to both arches.

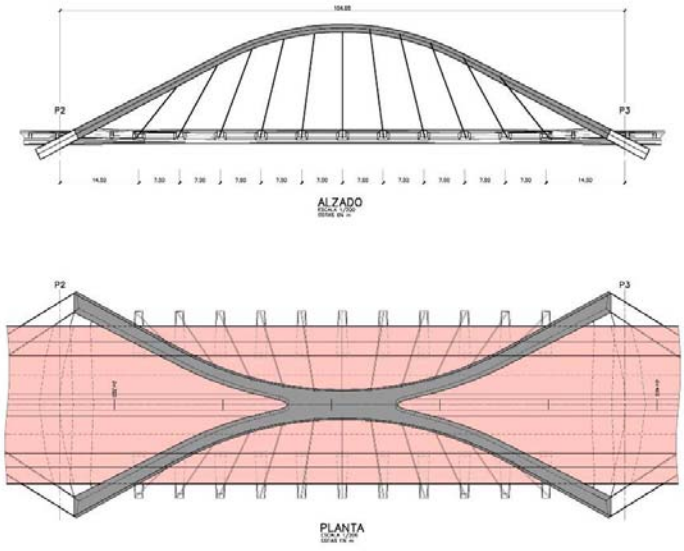

Figure 7 : Central superior arch's Lift and plant

Strained cables are distributed in pairs shaping an "A", going down from both arches to deck lateral sides. Therefore they made up plane triangulations which contribute to deck torsional strength.

Thus, static movements and deck vibrations are meaningfully reduced as moving loads are crossing. Therefore, each 7.5 horizontal meters two strained cables are disposed in a vertical plane, whose aim is to carry deck loads at the end of each transversal diaphragm and lift them to the anchorage points at the arch, in order to change them in a compressive effort basically. In this way, strained cables' vertical projection increases as arch axis elevation, as crown is nearer. Strain cables' beginning points at the deck are 16.10 m far from bridge axis, on anchorage's plugs.

Figure 8 : Central span Perspective

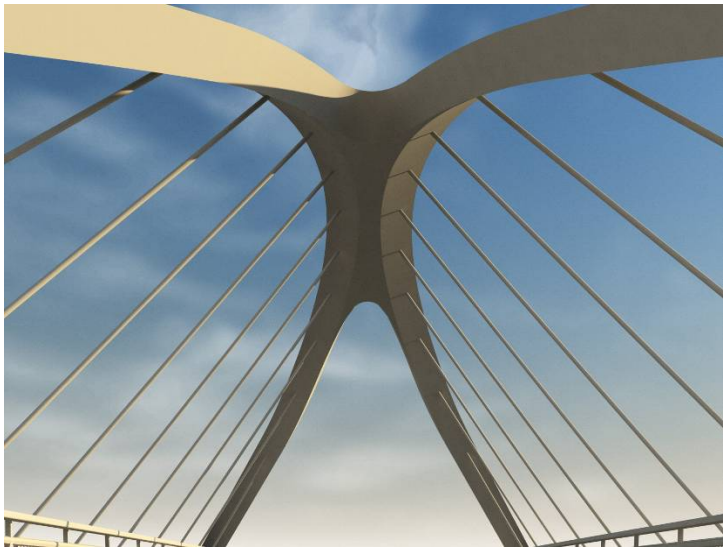

Figure 9 : Central upper arch's Perspective.

5 DECK

Deck transversal section is solved by a light lenticular prestressed concrete section whose depth is constant. A set of transversal and lateral crosspieces 5 m repeated apart from each other join and support lateral slabs 20 cm thick which made up bridge sidewalks. Deck's depth is maximum at section's centre (2.5 m) and minimum at both sides (1.09 m). It is 29 m wide measured between outer edges and 23.76 m wide measured between bottom ones. The inner section's profile is a circular arch 63.54 m radius. Side walks` ribs lateral planes made up of an angle of 28º and 11º with vertical and horizontal planes.

Bridge holds four lanes, two cycle paths and two sidewalks. Due to strained cables at both deck sides bending stiff crosspieces are disposed not only outside the deck but inside it.

6 CONSTRUCTIVE PROCEDURE

Owing to the appearance of clayey consolidated soils at the wring walls, a foundation treatment consisted on vertical drains and terrain pre-charge is designed in order to remove consolidations after its construction, so, lateral thrusts and negative friction on piles are avoided. Besides, a

temporary island will be built at bridge beginning in order to develop piles and pile cap of piers 1 and 2, and temporary piles (beginning side) of central part as well.

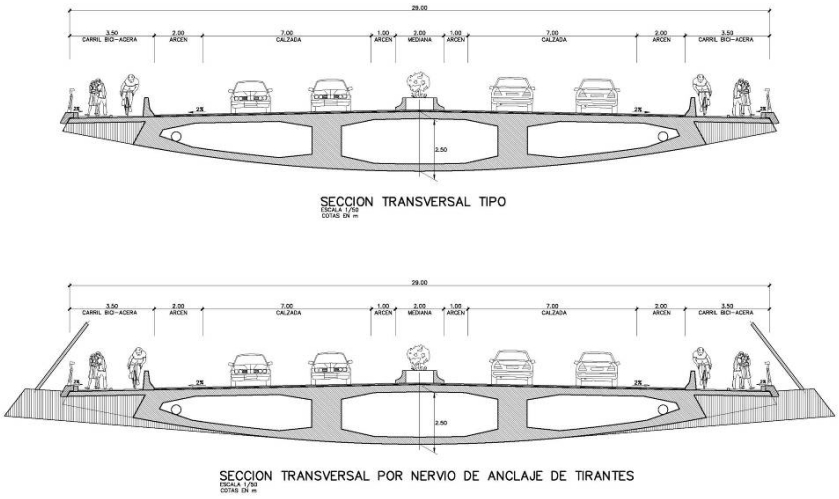

Figure 10 : Deck's transversal section

Figure 11 : Longitudinal lift

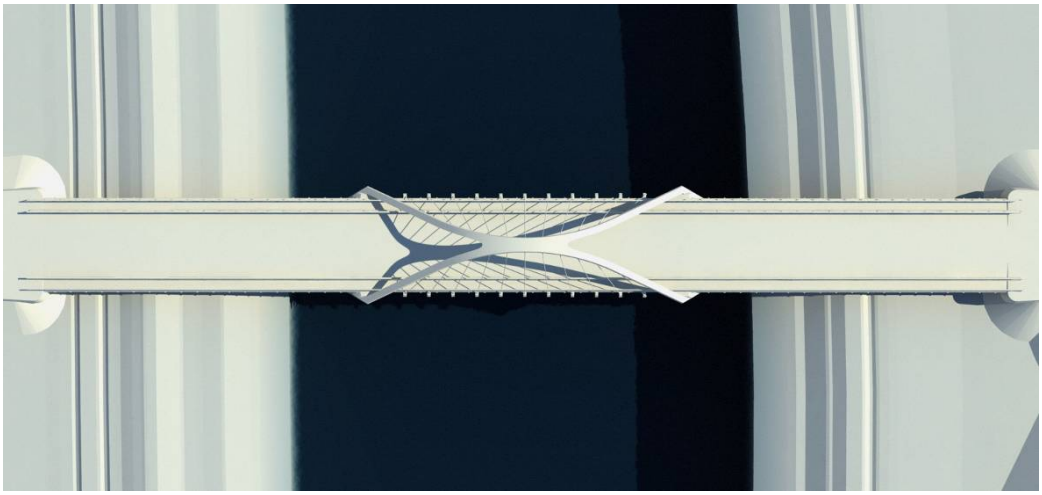

Figure 12 : Plant

Once piers 1 and 2 are built, lateral phase of the deck at wring wall 1 will be carried out; this phase belongs with 42 m of first span, 55 m of second span and first 12.4 m of central span. Subsequently, temporary island at the beginning will be removed and another temporary island will de carried out but at the end of the structure. Once this second island is finished piles and pile cap of piers 3 and 4 will be built and temporary piles (ending side) of central part will be carried out as well.

Later on, pre-charge terrain at wring wall 2 will be removed, and piles, pile cap and lift of this wring wall will be done, as well as piers 3 and 4 lifts. As soon as wring wall is finished its access embankment will be carried out and breakwater's protection at piers 3 and 4 foundation will be laid.

Once piers 3 and 4 are built, lateral phase of the deck at wring wall 2 will be carried out; this phase belongs with 48 m of span number five, 55 m of span number four and last 12.4 m of central span. Subsequently, central span's centering will be laid in order to build the 79.2 m left.

Once deck is finished, arch's centering will be laid. After this last one is completed strained cables will be laid and tight. Finally, pavement and retaining barriers will be placed.

7 CONCLUSIONS

New Bridge over Llobregat river is nowadays under construction. It will communicate the harbour and the airport of Barcelona by means of a bow string and becoming one of the main accesses to this city from its surroundings, and a communication road axis of industrial areas associated to Barcelona port area (Harbour and free port).

Figure 13 : New Bridge's Perspective

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