Third Millennium Bridge over the Ebro River. Zaragoza. Spain

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Summary

The way followed from conception to construction of this high strength white concrete arch bridge, an urban 216 m span bow-string arch bridge, is described in this paper. The approach to the city needs, the choice of type and material, the geometric design, the structural solution, the specific studies developed, and the bridge construction, are all explained to show how this outstanding and challenging structure takes bridge design and engineering one step beyond.

Keywords: bow-string arch bridge; white self-compactable high resistance concrete; bridge design; external post-tensioning, bridge aesthetics, structural art.

1. Introduction

The Third Millennium Bridge is a white concrete bowstring arch, with 43 m of typical deck width and a main span of 216 m, becoming the bowstring bridge with the biggest span built to date using this material.

The design of the central arch with final open "A" frames, where the main arch divides itself into two leaning legs linked by a crossbeam, is an evolution of the 168 m span and 30 m width steel made Barqueta Bridge, designed by the same author and built for Sevilla Universal Exposition of 1992. This bridge can be considered a test model for the design and construction of the much wider and longer post-tensioned high strength concrete made Third Millennium Bridge.

Fig. 1: Render image of the Third Millennium Bridge

2. The bridge challenge

This new challenging bridge is destined to have a great importance due to many factors:

1) Its urban function and location in the city of Zaragoza, over the Ebro River (which gives name to

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the Iberian Peninsula), the highest water flow river in Spain, closing the third ring road of the city, giving the left bank of the city fast access to the recently built high speed train and bus station, and becoming the main road entrance to the International Exposition of 2008 to be celebrated in Zaragoza between June and September.

2) Its dimensions: with 270 m length, 216 m main span, 36 m height of arch over deck, and 43 m deck width, it will become the largest concrete bowstring arch built to date.

3) The quality of its aesthetical design, becoming an icon for the city and the Expo 2008 event.

4) The use of a new material, the high strength, self-compacting white concrete, used to build almost the whole bridge, and with theoretical compression resistance of 75 N/mm^2 for the arch and 60 N/mm^2 for the deck, but over 85 N/mm^2 real values due to early pre-stressing construction needs.

5) The quality of its structural design, taking its slenderness to the limit and using a great number of external and internal post-tensioning tendons disposed in a highly complex way to reduce the thickness of the different concrete elements to the minimum, enabling the slender shell arch to hold up the bridge's own weight.

6) The complex erection procedures needed for its construction, including the launching from one bank of a 34 m wide and up to 200.000 kN heavy deck with longitudinal curvature and a curved bottom cross section, and the introduction of a 120.000 kN horizontal load in the top of the arch using hydraulic jacks for putting its final forces into play.

The concept, detailed design and site construction management of the bridge was all provided by the Arenas & Associates team, led by Dr. J.J. Arenas.

Fig. 2: Image of the bridge near the end of its construction

The Third Millennium Bridge is an example of structural art, a field where the seen elements are a response for the structural needs, being its aesthetically pleasing design an expression of its internal forces. As size and slenderness were taken to their limits, the bridge required exhaustive design, calculation and site control effort, the development of a new material and highly complex erection methods, leading bridge design and engineering one step beyond.