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PAPER AND PENCIL IN THE AGE OF *BIM*. DESIGN AND CONSTRUCTION OF THE *BUTARQUE* FOOTBRIDGE

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Summary

Many key aspects of a bridge project are governed by construction site-related, geometric, functional and constructional constraints. Furthermore, economy is a decisive factor in public works and, with respect to bridge aesthetics, there is an increasing demand for more than just utilitarian structures. Such exacting boundary conditions often spur careful and indeed even innovative structural design. Since the successful translation of numerous constraints into a reliable, functional, cost-effective and aesthetically attractive structure is primarily a question of consistent conceptual design, the importance of this step in the design process as a whole cannot be overstated. A suitable choice of structural system, foundations, deck cross-section and constitutive materials on the one hand, and manufacturing and assembly procedures on the other, usually yields a cost-effective solution that meets structural safety and serviceability requirements. In addition, an appropriate balance needs to be reached between economy and aesthetics.

Keywords: site constraints; conceptual design; integral bridge; torsion; composite girder; detailing; ductility; innovation; economy; aesthetics

1. Context

The fundamental objectives of bridge design are structural safety, service performance, economy and elegance. All four goals must be attained, although their relative importance varies from case to case depending on the consequences of failing to do so [1]. Structural safety is clearly the most important of the four, since unsafe bridges may lead to a loss of life or property. By definition, structural safety and serviceability are achieved through the correct application of codes and standards. Consequently, the accomplishment of these objectives depends chiefly on the engineer's analytical skills. Economy and elegance, by contrast, are not subject to hard-and-fast rules. Although some guidelines for improving bridge cost-effectiveness and aesthetics exist, fortunately such criteria cannot be standardized. Economy and elegance in bridge design therefore depend mainly on the designer's creative talent.

In recent years, increasing importance seems to be given by the public to the aesthetic aspects of bridges and other types of infrastructure. A feedback may therefore arise between such a social demand, apparent or real, and the decisions taken by authorities when commissioning new public works. Such a *Zeitgeist*, or spirit of the times, involves an obvious threat to subordinate structural considerations to passing fashions, where cost-effective solutions are no longer possible. Inasmuch as infrastructures are financed with public funds and that good governance entails spending the available resources cost-effectively, substantial extra costs can be justified in very few bridges only. An optimal balance is therefore needed between cost and structural grace. In such a context, careful conceptual design based on an ingenious or inspiring structural idea, which must be compatible with the numerous construction site-related, geometric, functional and constructional constraints, is of paramount importance.

2. Design procedure

The conceptual design of any load bearing system must be based on a structural idea, in keeping with the case specific constraints. Demanding boundary conditions may be perceived as inhibitive. However, often they spur innovative structural design. Building on the original structural idea, the solution is further developed with a series of consecutive sketches, while viability is substantiated through simplified structural analysis. The most important details should be developed at this early stage. In addition to overall design and structural detailing, the main dimensions of the key members defined in the solution adopted should be established at the conceptual stage.

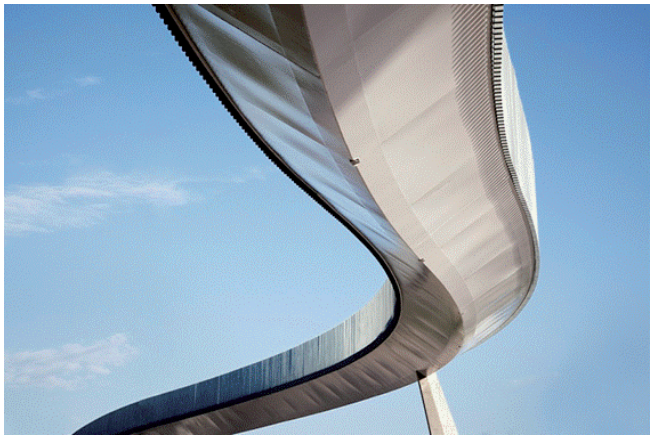
3. *Butarque* footbridge

For purpose of illustration, the ideas underlying the conceptual design for the *Butarque* footbridge are explained in the paper, particularly as regards the specific boundary conditions involved, along with the actual layout including a few comments on detailing, as well as the realization of the structure.

The *Butarque* and *Canalejas* park is located within walking distance of a number of commuter developments on the outskirts of the city of *Leganés*. Promenades and bicycle paths along the *Butarque* brook are heavily trafficked on weekends. This, in conjunction with a general lack of maintenance, contributed to the deterioration of the park, whose facilities were in sore need of an upgrade. Motorway M-411 intersects *Butarque* park at the same point where it is crossed over by radial expressway R-5, an access road to Madrid. A footbridge was to be built to enable pedestrians and cyclists to cross safely from one side to the other (Figure 1).

The example shows that a modern, technologically advanced design may be compatible with a solution whose elegance meets the most exacting aesthetic standards. It also shows that when the conceptual approach is well thought out, the solution will undergo only minor changes in subsequent design stages.

a)



b)

Fig. 1. Footbridge in the Butarque and Canalejas Park after completion: a) aerial view; b) meandering layout (Photos: Paco Gómez)

4. Reference

[1] MENN C., Prestressed concrete bridges, Birkhäuser, Basel – Boston – Berlin, 1990, ISBN 3-7643-2414-7 (Basel), 535 pp.