EFFICIENCY AND AESTHETICS

THREE FOOTBRIDGES AT VALENCIA DE DON JUAN, SPAIN

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Summary

The fundamental objectives of bridge design form the backdrop for a discussion of the parameters that determine the success of a project. Inasmuch as economic and aesthetic criteria cannot be standardized, successful design depends almost entirely on the talent and creativity of the engineer. The practical application of these general principles is illustrated with a description of three footbridges built as part of an enhancement project for the left bank of the Esla River at Valencia de Don Juan, Spain. The ideas underlying the conceptual design for the bridges over the river and its canal, in particular as regards the specific boundary conditions, are explained, along with the actual layout and a few comments on construction procedures.

Keywords: Site constraints; conceptual design; safety; serviceability; design codes; economy; elegance; creativity; steel; glued laminated timber.

1. Introduction

1.1 Context

The town of Valencia de Don Juan, León, Spain, recently undertook to upgrade the left bank of the Esla River, an area of great natural beauty located within walking distance of its historic quarter and Medieval castle. The riverscape enhancement project called for a 110-m footbridge to connect the two parts of the future park that was to flank both sides of the Esla. It also included the construction of a new canal spanned by two footbridges to provide access to the town's historic quarter from the park.

The design for the three footbridges was subject to numerous constraints in connection with the construction site and geometric, functional, constructional and economic requirements. These complexities were heightened by community demands, in keeping with a growing trend, for the works to fulfil more than a mere utilitarian purpose. In the present case the three footbridges were expected to meet high aesthetic standards in light of the natural beauty of the surrounding landscape and because the enhancement of the left bank of the Esla river was also intended to attract more visitors to the town. The challenge was therefore to design footbridges that would blend into without being wholly camouflaged by the landscape. In short, the project required a sober design based on modern structural concepts and construction materials and methods respectful of the environment.

1.2 Purpose of the contribution

Difficult boundary conditions may 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 for the design process as a whole cannot be overstated. The relevant ideas behind the structural concept for the three footbridges are described in the framework of the complex interactions between geometry, functionality, construction materials, manufacturing, erection, overall structural concept, detailing, structural reliability and aesthetic considerations.

2. Esla River footbridge

This footbridge project was chiefly governed by the unfavourable geotechnical conditions prevailing, characterised by very low soil resistance. Therefore a bow string – in which the horizontal thrust is resisted by the tension member, in this case the bridge deck – was found to constitute the most efficient structural system. To accommodate the geotechnical restrictions, the design envisaged transferring only vertical loads to the ground, by means of piles.

The only cost-effective material for manufacturing the bow string arches was structural steel. The bow string consists of two inward-leaning arches with a rise-to-span ratio of 1/12 (Figure 1). The twin arches are inter-braced with transverse members spaced at 12 m from centreline to centreline for greater buckling strength. The 4.75-m wide bridge deck is positioned between the arch ties, which are 5.45 m apart. The arch inclination determines the rhomboid shape of both the arch and the tie cross-sections. The ties, in turn, are interconnected by composite transverse beams spaced at 3-m intervals that support the composite bridge deck. The deck is attached to rigid transverse beams at both abutments to contribute to horizontal thrust resistance. Vertical loads are transferred to the arches by a suite of hollow-section steel tube hangers, set 6 m apart.

Not only all the structural details but also the finishes were designed with great care: the wood sheathing laid on cladding rails for proper ventilation; enhanced pedestrian and cyclist safety thanks to the inward slant of the horizontal tube handrails running parallel to the plane of the arches; and spotlight illumination to afford a handsome night-time view of the bridge.

Fig. 1 Esla River footbridge

Fig. 2 Esla canal footbridge

3. Esla canal footbridges

In addition to aesthetic considerations, economic criteria were particularly important in the design of the two canal footbridges due to the limited budget available for enhancing the left bank of the Esla River.

The 2.8-m wide decks on the two footbridges, each spanning a length of 15 m, consist in two twin arches made of glued laminated timber with underlying tension members (Figure 2). The two twin arches, separated by 1.8 m, are connected by transverse beams positioned at 2.5 m from centreline to centreline. The 94-m radius of the arches is mandated by the maximum allowable slope in pedestrian bridges, while the vertical clearance required over the canal determines the position of the horizontal tension members – high-performance galfan coated cables. The arches and cables are connected by vertical structural steel posts spaced at 2.5-m intervals and aligned with the transverse beams. The slenderness of the system, with a rise-to-span ratio of 1/25, subjects the timber arches to substantial bending moments which are partially offset by the eccentric connection between tension members and arches at the abutments. The cables were slightly pre-stressed to improve system performance, and more specifically to increase the fundamental natural frequency and reduce deformation as a result of the reduction of slip in mechanical joints.

Timber member durability was ensured by appropriate conceptual design and detailing for proper ventilation. Great care also went into all the details and finishes, while transparent handrails were chosen, to enhance the bridge's slender airiness.