Cost -effectiveness of balanced cantilever girder bridges versus cable supported bridges

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Summary

The paper presents a technical comparison of two different bridge types that can be competitive for spans ranging from 100 m to 250 m. Through different case studies in which the author has been involved, the paper illustrates the different approaches on the design of both bridge types.

Keywords: Bridge, Extradosed, Balanced Cantilever, Design, Construction, Cost

1. Introduction

There is a clear interaction between design and construction of bridges. The selection of the structural type, span arrangement and materials should consider the method of construction at the design stage since the beginning. Intermediate construction stages such as changing structural systems, temporary supports, erection equipment on the structure, movements of form traveler, sequence of post-tensioning tendons and stays, among others, might govern the design of the structure. The following sections summarize the main features of both concrete continuous girders and extradosed bridges built in balanced cantilever and a comparison of cost-effectiveness.

2. Conceptual design of girder bridges built in balanced cantilever

Balanced cantilever construction is widely used worldwide being cost-effective for medium and long-span post-tensioned concrete girders (200 to 200 m). Either cast-in-place or precast construction might be used depending on site conditions. This erection method reduces environmental impact and does not interrupt existing traffic on the infrastructures below, does not required heavy construction equipment (in particular structures cast-in-place) and result in a safe and rapid construction, particularly in areas with difficult access.

2.1. Case study: Huasco bridge

Huasco Bridge is part of the new concessionary road “Ruta Norte 5” in the stretch between Vallenar and Caldera in the North of Chile. The bridge crosses Huasco valley, a semi-arid valley located in Chile’s Atacama Region surrounded by the Atacama Desert. To minimize the new road impact in the valley, bridge piers should be located outside the irrigation area, not interfering with the existing canals. This led to a continuous girder bridge with an overall length of 200 m and three spans, 42+116+42 m long. The deck is very wide, 22.3 m, and it consists of a post-tensioned concrete single cell box (Figure 1), whose depth varies between 2.5 m (L/46.4) at mid span and 6.5 m (L/17.4)) at piers. The platform accommodates four road traffic lanes, a central median and two lateral shoulders. The deck is a tapered post tensioned concrete single box cell with inclined webs. The bridge has been designed to be erected by balanced cantilever cast-in-place due to the significant height over the ground profile, up to 24 m and to meet the site restrictions. The bridge is the first application of this construction technology in Chile.

https://doi.org/10.2749/222137813808627695
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Fig.1: View of Huasco Bridge.

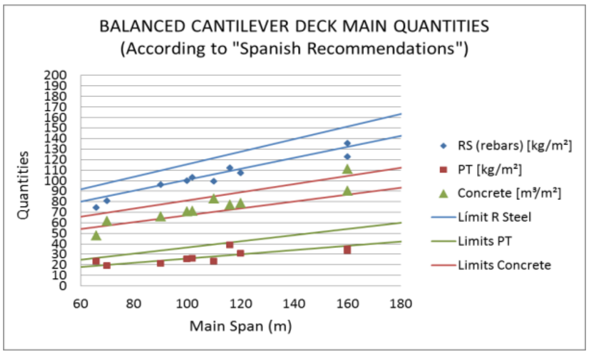
Fig. 2: The Triplets in La Paz (Bolivia).

3. Conceptual design of extradosed bridges built in balanced cantilever

An extradosed bridge has its deck partially supported by a system of stays which are connected to a pylon of small height. The pylon's height measured above the bridge deck level is in between 7 and 13% of the main span length (unlike to the classic cable-stayed bridge where the pylon has a height between 20 to 25% of the span length). Having this geometrical arrangement, extradosed bridge stays have a small inclination with respect to the roadway and therefore provide less vertical stiffness to the deck in comparison to a cable-stayed bridge. The stays partially compensate a fraction of the dead load effects (60 to 80% of the segment dead load) and a small part of the live loads. Due to that, the deck is subjected to significant longitudinal bending. Under traffic loads, stays do not experience large fatigue stresses. Extradosed bridges are suitable for spans between 100 and 250 m depending on specific site constrains (Figures 2). For medium spans they compete with continuous pre-stressed concrete or steel girders. For larger spans (more than 250m) cable-stayed structures are more economical than extradosed bridges depending on site constrains.

4. Cost comparison of girder bridges versus extradosed bridges

Continuous girder bridges built in balanced cantilever consume more concrete, reinforcing steel and post-tensioning than extradosed bridges built with the same erection process but the cost of the stays and a longer cycle for the erection of a typical segment can offset the savings on the rest of the materials. Also, maintenance and inspection cost should be considered. Figures 3 and 4 summarize the material quantities of 10 balanced cantilever bridges cast-in-place designed with the AASTHO Code and 5 extradosed concrete bridges (designs made by Pedelta).



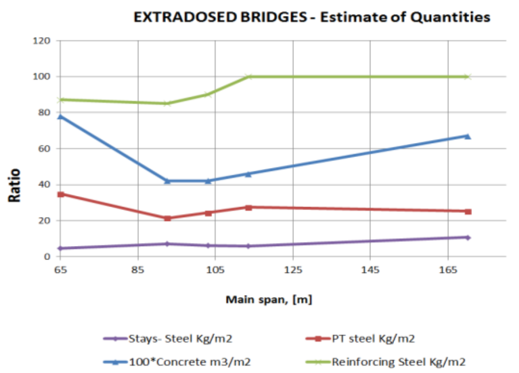


Fig. 3 and 4: Quantities estimate for continuous 3-span girder bridges built in balanced cantilever and extradosed bridges.

Balanced cantilever construction is a competitive and efficient construction method for spans ranging from 75 to 200 m. Balanced cantilever construction minimizes impact over existing traffic below and allows industrialization and rapid construction. Extradosed bridges built in balanced cantilever might be more economical than continuous girders cast in place for spans over 110 m.