SAIL BRIDGES VERSUS CABLE-STAYED BRIDGES

By

JOSÉ-LUIS QUINTANA

Authorized reprint from: December 2017 issue of the PTI Journal

SAIL BRIDGES VERSUS CABLE-STAYED BRIDGES

BY JOSÉ-LUIS QUINTANA

INTRODUCTION

The recent construction of the Barra Vieja Bridge near Acapulco, Mexico, has brought an opportunity to compare figures and experiences between cable-stayed or extradosed techniques (CS), and the sail bridge (SB) concept that was adopted for this structure.

SAIL BRIDGE DEFINITION

The name refers to a superstructure where the deck is supported by prestressed post-tensioned concrete elements connected to pylon heads, which by nature take a sail shape. The technique was initiated in the 1970s—the Ganter Bridge (Fig. 2) in Switzerland (designed by Christian Menn) being a beautiful example. The concept is a PT option to support a large span by means of precompressed concrete elements versus the widely used CS with tension elements. One could distinguish the two by saying that a conventional CS bridge has the stays exposed in the air (thus tensile elements) versus the sail bridge has the "stays" cast in concrete (thus creating a precompressed concrete element with the tensile elements hidden in it and precompressing it).

The super structure of a sail bridge typically consists of a deck integrated with edge beams, ribs and slab, towers, and sails connected to the edge beams.

Post-tensioning is used in practically all the elements, as shown in Fig. 3.

PTI JOURNAL, V. 13, No. 2, December 2017. Received and reviewed under Institute journal publication policies. Pertinent discussion will be published in the next issue of *PTI JOURNAL* if received within 3 months of the publication.

Fig. 1—Barra Vieja Bridge.

Fig. 2—Ganter Bridge.

COMPARATIVE ISSUES

Table 1 shows various design considerations and provides a comparison between the features of a cable stay bridge and a sail bridge.

CONCLUSIONS

While all of the aforementioned issues should be assessed for each specific bridge to define whether sails could be recommended over cable stays, as a summary, basic concepts could be extracted: Sails are a good option on issues such as:

- Fatigue;
- Corrosion;
- Wind/rain; and
- Fire/temperature changes.

However, sails could represent increasing difficulties when dealing with increasingly large bridge spans.

Table 1: Comparison of features of cable stay and sail bridges.

Construction factor/ construction method	Cable stay	Sail
Superstructure		Superstructure is more solid than the deck + pylons + cable stays group, allowing for full seismic isolation concepts such as the one used in Barra Vieja Bridge, where the "girder" formed by deck + pylons + sails was vertically supported by pendular bearings and horizontally controlled by dampers.
Bridge span	Relatively light and can be installed with normal cranes.	To use sails for very large-span bridges could increase costs and make the technique difficult to apply due to the height.
		Forming and pouring concrete in sails may become complicated for large-span bridges. Additional weight and material costs for the concrete sails.
Construction	Balanced cantilever must be used.	Balanced cantilever typical, other options possible (Fig. 4 to 6).
	Complex installation of stays	
Wind/rain	Need special cover	No extra rain protection or damping considerations needed
	Generally need damping consideration	
	Lateral resistance of the structure must be considered	Lateral resistance normally taken by the rigidity and shape of the sails.
Fire/temperature change	Need protection against fire and temperature change – can be costly.	Sails naturally protect against fire and temperature change hazards.
Corrosion	Main tension element must be protected by two nested anti-corrosion barriers	Grout in the corrugated sheaths does the coverage
	Lower anchorages require special treatment for the waterproofing	No special waterproofing needed.
Durability	Elements are in tension, which is always a complication factor, and are subject to corrosion and damage, which implies monitoring, repair, and substitution	On the other side, sails bring back a timeless concept, basic for durability: elements are in compression.
Fatigue	Prestressing steel strands must not work over 45% MUTS	Normal post-tensioning limits are used: 75% MUTS initial force. This indicates savings in SB.
	Anchorages must also be special to accommodate fatigue stresses.	Typical anchorages used, resulting in additional savings.

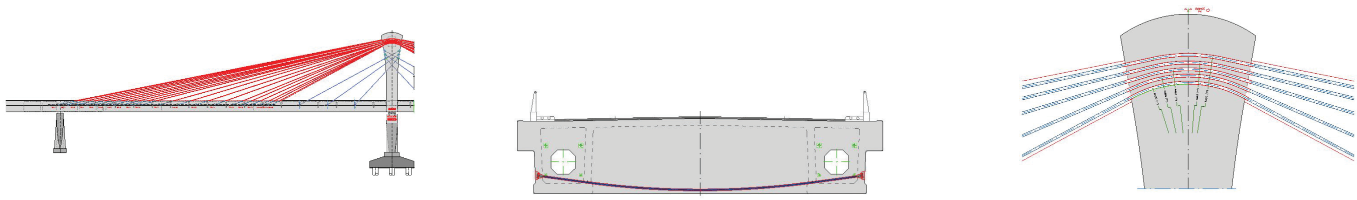

Fig. 3—PT (indicated in red) used in practically all the elements of the sail bridge.

Fig. 4—Barra Vieja Bridge.

Fig. 5—Barra Vieja Bridge shows how deck was incrementally launched over temporary bents, including the preparations for the connection of the sails to the edge beams, which meant all the PT installation work could be done comfortably in the casting yard.

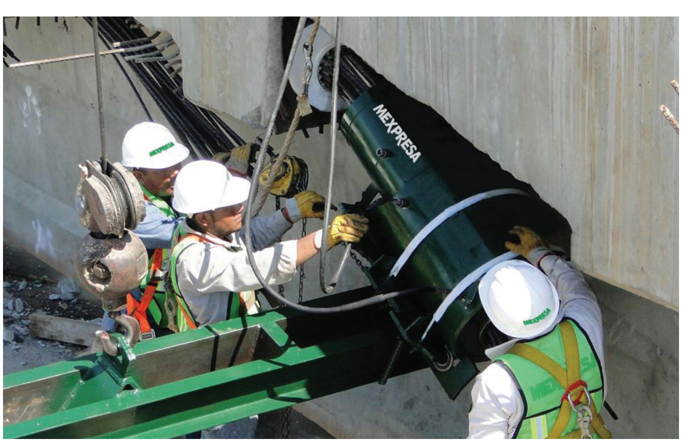

Fig. 6—Stressing the sails.

José-Luis Quintana *has been the president of Mexpresa, since 1996. Mexpresa is a Mexico City based company devoted to the development and site implementation of bridge post-tensioning and erection systems. He has a Masters in civil engineering and 30 years' experience in structures.*