Cable-Stayed Pedestrian Bridge, Spain

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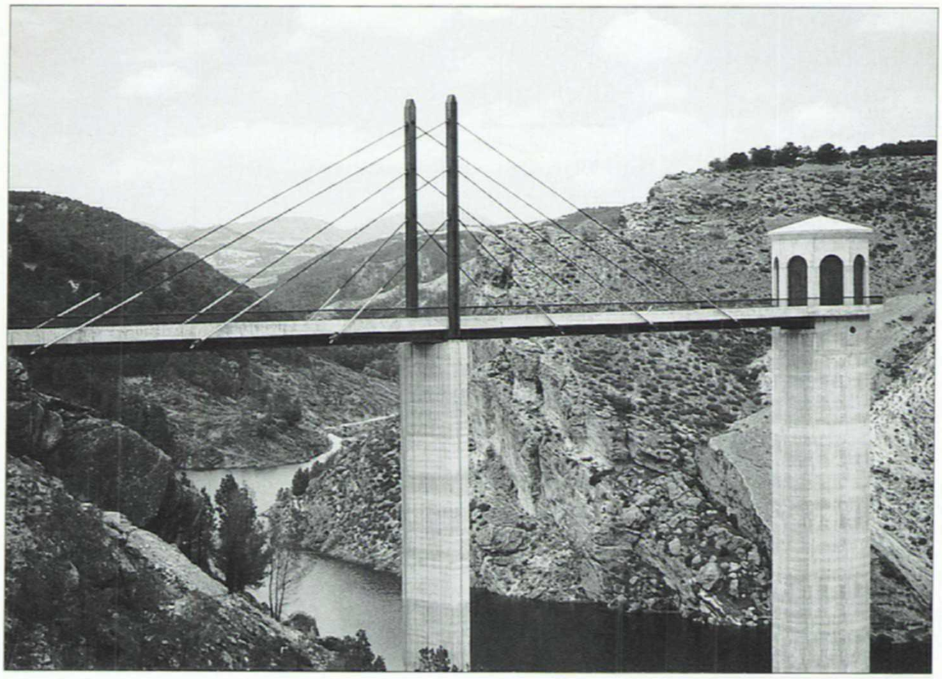

Fig. 1: General view

General Description

To provide access to an intake tower at a reservoir in the province of Granada, Spain, a pedestrian bridge with capacity to carry a 17 t truck was needed. The beauty of the landscape at the site made aesthetics especially important in the design of the bridge *(Fig. 1)*. Priority was also given to using simplified construction techniques because of the difficult working conditions on the steep hillside and the 80 m height of the intake tower. The solution that was finally developed consists of a slender cable-stayed structure built with a construction system of considerable simplicity.

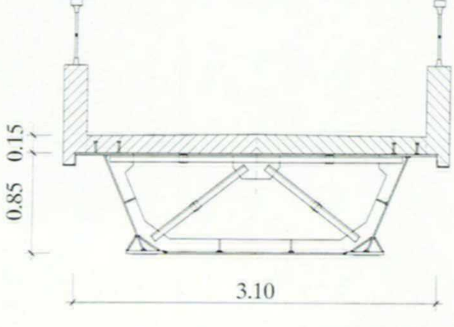

Fig 2: Deck cross section

The deck is a composite steel-concrete cable-stayed structure with two symmetrical 45 m spans. The steel pylons are rigidly connected to the deck, which is constructed with unpainted weathering steel to contrast in texture and coloration with the predominantly concrete structure.

Construction

The steel deck is a box beam consisting of steel plates with internal struts, open at the top, with a horizontal truss is formed from profiles *(Fig. 2)*. The superstructure was fully assembled on temporary supports on the ground. After assembly and checking, the stay cables were installed and the first tensioning was applied. This tensioning was suitable for transferring 90% of the load due to the self-weight of the deck to the zone located in the centre, at the intersection of the two pylons.

The tensioning forces in this phase were relatively low compared to the final forces. Therefore, adjustment and control were carefully carried out in order to prevent deviations deriving from the variation in the apparent modulus of deformation of the stay cables.

The nonlinearity of the cables reflected in the Ernst modulus is more evident when the tension of the stay cables is small. Although the corrections deriving from the apparent variation in the modulus of deformation of the stay cables are usually only necessary in the analysis of large cable-stayed bridges, in this particular case these corrections were significant, due to the low tension of the stay cables in the first phase of construction.

The light weight of the slender deck, without its upper concrete slab, together with the stiffness of the stay system as a whole, allowed launching to be performed with the front part fully in cantilever action *(Fig. 3)*. This was maintained until deck reached the intake tower, following the recovery of a 19 cm elastic deflection by using two small hand-operated hydraulic jacks.

Pushing virtually the entire steel structure into position required approximately 10 hours in the course of one day. Bearings for the deck are elastomeric pads *(Fig. 4)*. At the abutment and intake tower, the deck was vertically anchored by 25 mm diameter alloy bars before the final tensioning of the stay cables.

The tensioning of the stay cables was carried out in such a way that once the slab had been concreted and the permanent load (railings) positioned, the deck was free of deflections and the stay cables had the forces planned in the service phase. Therefore, the total vertical component of the force given to the stay cables was greater than the self-weight of the deck, making it necessary to secure the girder vertically to the abutment and the intake tower. The maximum upward deflections at the end of this phase were 7 cm in each span.

Concreting the 20 cm thick slab on top of the box beam, structurally attached by bolt-type connections, created the final composite structure. The sequence for concreting the slab was the same for both spans, starting from the base of the pylon simultaneously in order to avoid any asymmetric deformation of the structure from the setting of the concrete.

In a later phase, the side railings – relatively heavy compared to the dimensions of the deck and now acting on the composite section – were erected. The deflection due to the action of the self-weight of the concrete neutralized the elastic deformation produced earlier during the final tensioning of the stay cables. When this operation was completed, the final geometry of the deck was as planned in the design, with a final upward deflection of 1 cm in both spans.

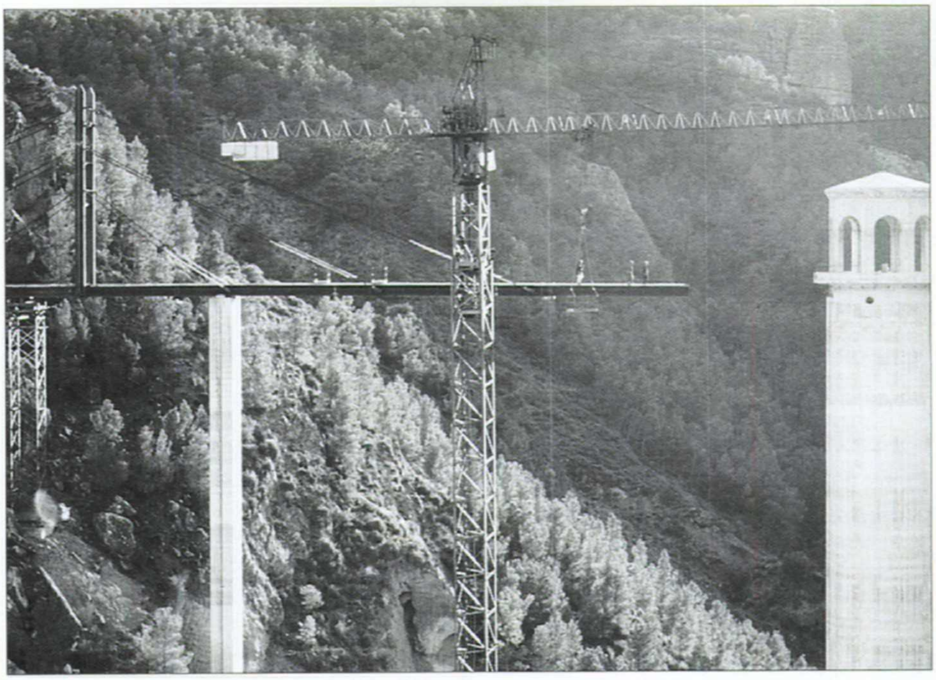

Fig 3: Launching process

Structural Details and Launching System

Each stay cable is made from an alloy bar 40 mm in diameter with an ultimate load of 1.32 MN. The cables are enclosed by a polyethylene sheath with an internal diameter of 90 mm, which was injected with cement grout after final tensioning was concluded.

Anchoring the stay cables at both ends is by means of a conventional nut system. At the lower end, prepared for conducting the tensioning operations, a metal diaphragm crosses the deck and projects on both sides in order to receive the anchoring elements for each stay cable. At the upper ends, inside the pylon, there is a small space for the bearing plates for the nuts formed from a metal reinforcement ring positioned prior to assembly of the plates forming the pylon *(Fig. 5)*. With this system, anchorage inside the pylon has been solved without any increase in pylon size, which is usually necessary in cable-stayed pedestrian bridges.

The launching was been carried out with simple elements. Two auxiliary towers provided additional support for the deck during launching. Two stainless steel plates, 4 mm thick and 220 mm wide, were welded to the bottom of the box beam along its entire length to act as slippage skates.

The temporary supports used neoprene pads with a sheet of teflon on the upper faces. Guides assured that the movement was only in the direction of the launching. With the launching system consisting of two longitudinal stainless steel skates, teflon supports and guide plates, the cushions that are usual in most launched bridges were not needed, nor was it necessary for any personnel to be present in the support zones during the launching.

The horizontal launching force was transmitted by means of two strands 15 mm in diameter with an ultimate load of 0.27 MN, anchored at one end to the abutment and passing through post-tensioning jacks located on the rear of the box beam. The jacks were operated by means of a hydraulic unit located on the box beam itself so that launching was continuous, since all tensioning of the jacks was performed from the hydraulic unit itself.

The longitudinal stainless steel skates were not removed when the launching was completed. Instead, they have been left in place, permanently visible as a decorative element.

Owner:
Spanish Ministry of Public Works

Engineers:
J. A. Llombart and J. Revoltós

Main contractor:
Agroman

Service date:
April 1996

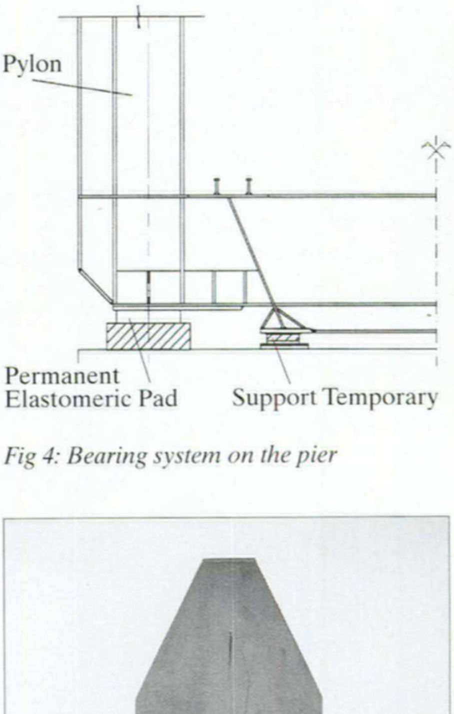

Fig 4: Bearing system on the pier

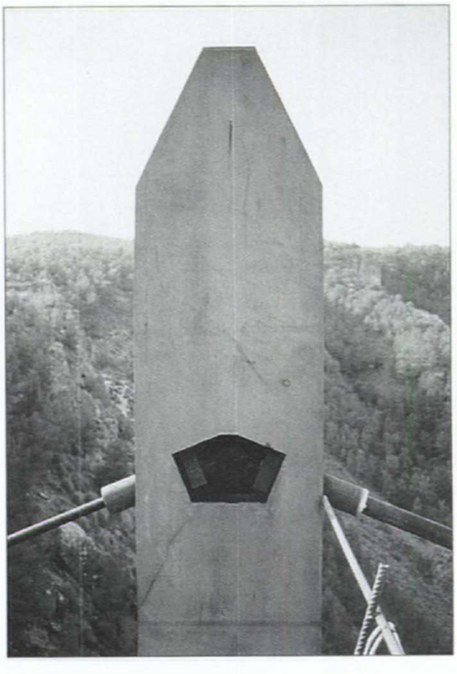

Fig 5: Pylon anchorages