Teror Viaduct in Gran Canaria Island, Spain

José Antonio Llombart, Civil Eng.; **Jordi Revoltós,** Civil Eng.; **Juliana Fernández,** Civil Eng.; EIPSA-SENER, Madrid, Spain.
Contact: jallombart@eipsa.net
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Abstract

Teror Viaduct is a bridge located over a difficult-to-reach gorge and was designed keeping in mind the aesthetic requirements so as to achieve the structure's full integration with the existing landscape.

The deck is rigidly fixed to piers and is supported by extra-dosed bracing. The V-shaped piers laterally 'embrace' the deck, that is the piers integrate with the deck, forming a monolithic whole as the pylons extend above.

The stays supporting the deck penetrate the pylon without friction during construction and are locked in service to withstand the effect produced by differential forces on both sides of the saddles due to the traffic load.

The deck was built using the balanced cantilever system starting from the two piers.

Following the deck's construction and prior to the two halves of the deck meeting in the centre and forming a single component, it was left open in the centre of the main span in order to partially reduce the long-term effects due to the concrete's strain (shrinkage and creep).

Keywords: extra-dosed bridge; stays; deviation saddles; cantilever system; external pre-stressing.

Fig. 1: General view of the Teror Viaduct

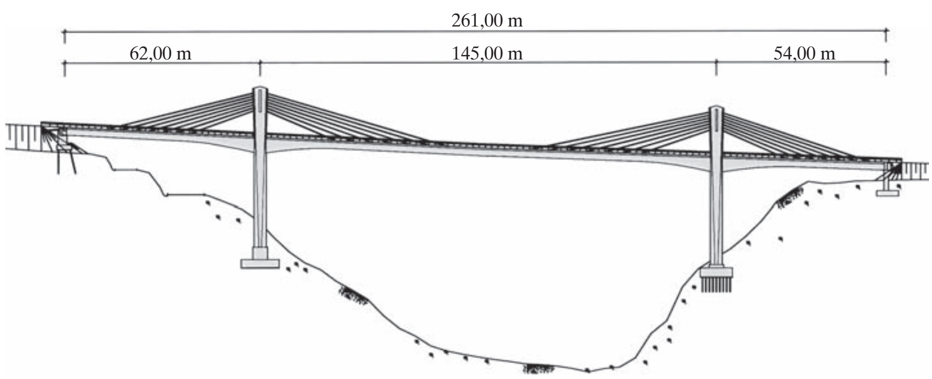

Fig. 2: Dimensions of general elevation

Introduction

The Teror Viaduct crosses a deep valley and is the gateway to one of the most beautiful regions in Gran Canaria Island. Special care was therefore taken while designing the new structure so as to achieve full integration with the surrounding landscape and environmental aspects.

The grandeur of the landscape and the valley dimensions influenced the need to build a highly diaphanous structure. A 145 m span deck was designed as being appropriate for crossing the valley without intermediate supports and the solution adopted was an extra-dosed bridge (*Fig. 1*).

A typical characteristic of the extra-dosed bridge is that, as in the case of the Teror Viaduct, it provides an advantage over the classic cable-stayed bridge with regard to the shape of the structure. Using the typical extra-dosed bridge technique, the pylon height above the deck, appropriate for a span of 145 m, is only 16 m. A classic cable-stayed bridge would have required a concrete pylon almost twice as high as the one corresponding to the extra-dosed solution.

The low height of the pylon compared to the span dimension gives an aesthetic appearance to the overall structure, which complements the valley crossing and the emerging shape of the deck does not obstruct the surrounding landscape. This way, any undesirable visual impact that would have occurred as a consequence of unwanted intrusion of artificial components into the natural environment is avoided.

The deck was built using the balanced cantilever method; use of provisional intermediate supports across the valley was avoided during the construction phases.

General Description

The viaduct crosses the Teror ravine at about 70 m above the ground level, with a 261 m long deck divided into a 145 m central span and two side spans of 62 and 54 m length (*Fig. 2*).

The structural scheme adopted consists of a spatial frame with a prestressed concrete deck embedded into the piers and is partially sustained by extra-dosed bracing.[1]

The 13,00 m wide deck is formed by a continuous, hollow box-girder varying in depth from 2,57 m at the centre of the main span to 5,07 m at the area closer to the connection with the piers (*Fig. 3*).

The deck was built with pre-stressed concrete grade of 40MPa, using 5,20 m long segments near the piers and 6,00 m long segments in the stay area, in line with the spacing between the stay anchors in the main span. Prior to concreting the 4,80 m long central mid-span stitch, a jacking manoeuvre was carried out in order to lock the structure in the longitudinal direction. The cross section was partially filled with poor concrete at the side spans, where the distance between the cables is 4,50 m, in order to counteract the ascending forces produced by the stays.

The deck is vertically anchored to the abutments in order to prevent uplift of bearings following span imbalance.

Deck Pre-stressing

The pre-stressing system of the deck can be classified into three families:

1. Tendons located at the top slab of the box-girder forming the deck, with the characteristic layout of cantilever built bridges.
2. The second is formed by straight continuity tendons located at the bottom slab of the central span.
3. Polygonal exterior pre-stressing covering the 145 m span.

Stays

The Teror Viaduct is braced by seven pairs of stays per pier. These stays pass through the pylons via steel deviation pipes (*Fig. 4*). This solution allows for very slender pylons, providing the entire structure with an aesthetic appearance.

During the deck construction phases, the tendons were allowed free sliding movement, and once the tensioning processes were concluded, they were locked in during the service phase.

The stays enjoy three levels of protection:

1. They are formed by wax-wrapped galvanised steel strands surrounded by individual high-density polyethylene casings.
2. The strands forming each stay are grouped into continuous high-density polyethylene sheaths, between the pylon and the anchor.
3. Once the tensioning was completed, the deviation pipes embedded in the pylons were injected with wax.

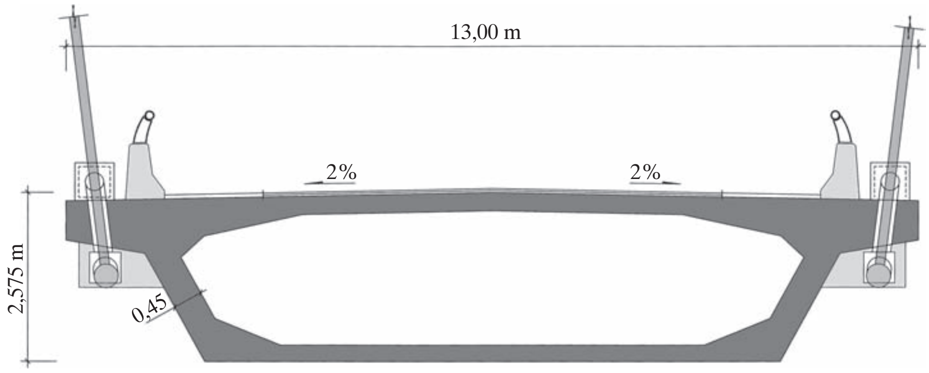

Fig. 3: Cross section of the deck in the stay supported area

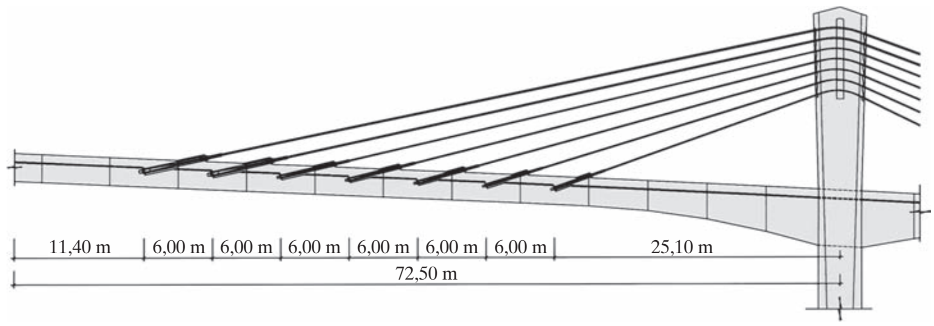

Fig. 4: Scheme of stays and support in the deviation saddles

For practical design reasons, stays were dimensioned for working at 50% of the ultimate load, well below the limits for fatigue set by current design codes (around 65% of the ultimate strength of strands). Thus in the Teror Bridge stays, the maximum variation of tension stress caused by the traffic load is approximately 100 N/mm^2.

Deviation Saddles

Each saddle is formed by two metal pipes, one inside the other, allowing for the tendon's continuity through the pylon with a locking capability to absorb the overload caused by tension differences in the stay on either side of the pylon.

Once the viaduct's construction was completed, the inside of the saddles was conventionally injected with cement grout. Wax was injected into the anchor area inside the bare strands. The layout adopted allowed provision for the stays to be completely replaced in the future if required.

The remaining areas were left uninjected because the tendons had three levels of protection: galvanising, wax and individual high-density polyethylene sheath. The high-density polyethylene sheath is continuous between the pylon and the anchor and its end joints are watertight.

Deck Construction

The deck was built using the balanced cantilever system starting from the piers (*Fig. 5*). The extra-dosed deck type with its interior pre-stressing allowed advance operations to be undertaken without having to fit the stays, whose anchorings were located in the segments under construction.

Once the lateral cantilever reached 52 m, the remaining side spans were built on false formwork.

During the construction process, each pair of stays was stressed in a single stage as a result of the deck's strength capacity.

The length of the segments (6,00 m) is the same as the distance between the anchorings of the stays in the main span.

Deck Jacking at the Centre of the Main Span

Prior to the construction of the 4,80 m long closure segment, located in the centre of the main span, a jacking operation was performed in order to lock the relative horizontal displacement between the front ends of the two cantilever ends. This manoeuvre helped to partially offset the concrete's creep and shrinkage effects and improve the

Fig. 5: Deck construction with the balanced cantilever system

long-term structural performance of the piers.

The operation included applying a horizontal force using hydraulic jacks against the vertical surfaces of the rear ends of the deck, balancing the cantilevers as well as horizontally blocking the relative movement caused by placing of metal struts. Once the jacks were removed, the remaining compression force in the struts was 2000 kN.

The relative movement between the two ends of the deck was 55 mm in the longitudinal direction and 37 mm in the vertical direction.

Conclusions

The extra-dosed bridge solution adopted has the longest span (145 m) built in Spain and is the first where the deck erection procedure involved the cantilever system.

Adopting 6,00 m long segments coinciding with the distance separating stay anchorings led to a special design of the form traveller.

The extra-dosed bridge solution combined the advantages of cantilever construction and cable staying while the sizing of the latter was not affected by fatigue problems.

The viaduct perfectly integrates with the Teror gorge by virtue of the slender deck and relatively low pylons that do not obstruct the beauty and size of the ravine. The bottom of the gorge was not at any time affected during the balanced cantilever construction operations.

The viaduct was designed in a very modern, highly aesthetic fashion as seen in the accompanying photographs.

And last but not least, the balanced cantilever construction method allowed an efficient construction rate of one pair of segments per week.

Reference

[1] Leonhardt F, Zellner W. *Cable-Stayed Bridges*. IABSE Surveys. S-13/80; 1980.

SEI Data Block	
Owner: Canary Islands Government	
Contractor: COMSA – OAC	
Design and technical assistance during construction: EIPSA-SENER (Madrid)	
Steel (t):	1040
Concrete (m^3):	7300
Cable stay steel (t):	73
Pre-stressing steel (t):	117
Estimated cost (EUR million):	6
Service date:	February 2011