REAL BRIDGE, ORIZABA, MEXICO

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The Real Bridge in Orizaba, Mexico, is a small cable-stayed bridge with significant challenges in the design and construction due to restrictions in its geometry, which were overcome mainly through the use of post-tensioning techniques.

As a background, the bridge is located in an aggressively seismic area—that of Eastern Sierra Madre—on the skirts of 20,000+ ft (6100 m) high Orizaba Volcano.

The structure had to cross a skewed double railway track for double-deck trains as well as two vehicle lanes (Fig. 1). It also had a limited total length to allow for crossing street traffic, which forced the deck depth to a minimum. Fitting in the maximum allowable grades in the access posed an additional challenge.

Altogether, the defining geometrical figures were 232 ft (70.8 m) for the span, 24.6 ft (7.50 m) for the clearance, and 7.40/8.85% for the access grades, which resulted in only 2.7 ft (0.82 m) available for deck depth. A rigidized, cable-supported deck was required, which was only achievable in concrete with cable stays and massive post-tensioning (Fig. 2).

The cable stays are composed of parallel epoxy-coated strands covered with high-density polyethylene (HDPE) pipe and transfer the vertical forces to the pylons by means of saddles. This allowed for solid pylons with a thickness consistent with the deck dimensions: their base is only 6.2 ft (1.90 m) long increasing upwards to take the increasing vertical forces.

Saddles transfer 125% of differential loads to the pylons by means of bond stay-cable anchorages and consist of very low friction individual tubes embedded in a cementitious blend within rolled steel tubes.

The anchorages connect to a straight extension of one end of the general tubes by means of nuts, which would ease an eventually required stay substitution (Fig. 3 and 4).

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Fig. 1—Real Bridge aerial view.

Installation of the stays was also challenging, requiring limited stressing equipment sizes to allow for the tall train passages during the cast-in-place balanced cantilever construction (Fig. 5).

In turn, inserting the strands through the saddle tubes was a comfortable and mistake-free operation. Concerns about corrosion protection separation, both during strand placing and stressing, were low due to the low-friction saddles.

The deck post-tensioning consisted of a congested set of longitudinal cables, required to give it rigidity, regardless of the low eccentricity. By using couplers, many cables served dual purposes: for construction and after closing the cantilevers, for service, which helped to reduce their total number in such a small place (Fig. 6).

Stressing of the construction cables was done at the front of the segments, while some service cables had to be stressed at deck recesses, limited in size to avoid excessive concrete compression (Fig. 7).

Transverse deck post-tensioning was used to ensure the pylon-to-deck moment link, which had to be left free during construction to ease the geometry versus stay-tension control (Fig. 8).

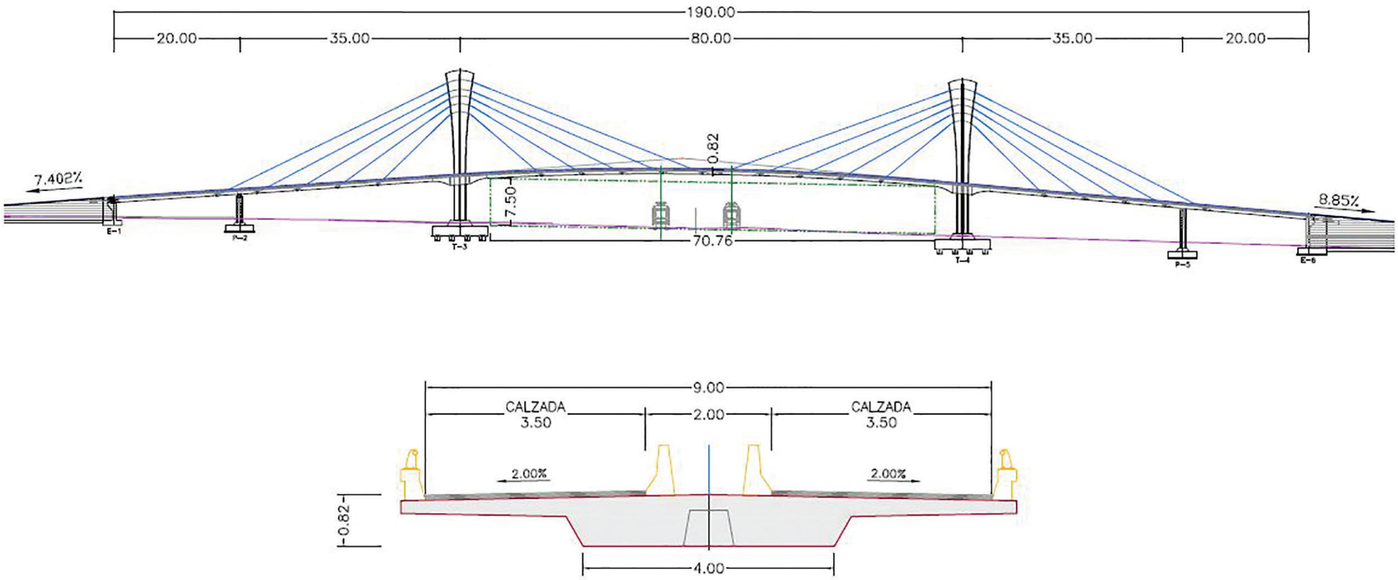

Fig. 2—Bridge geometry.

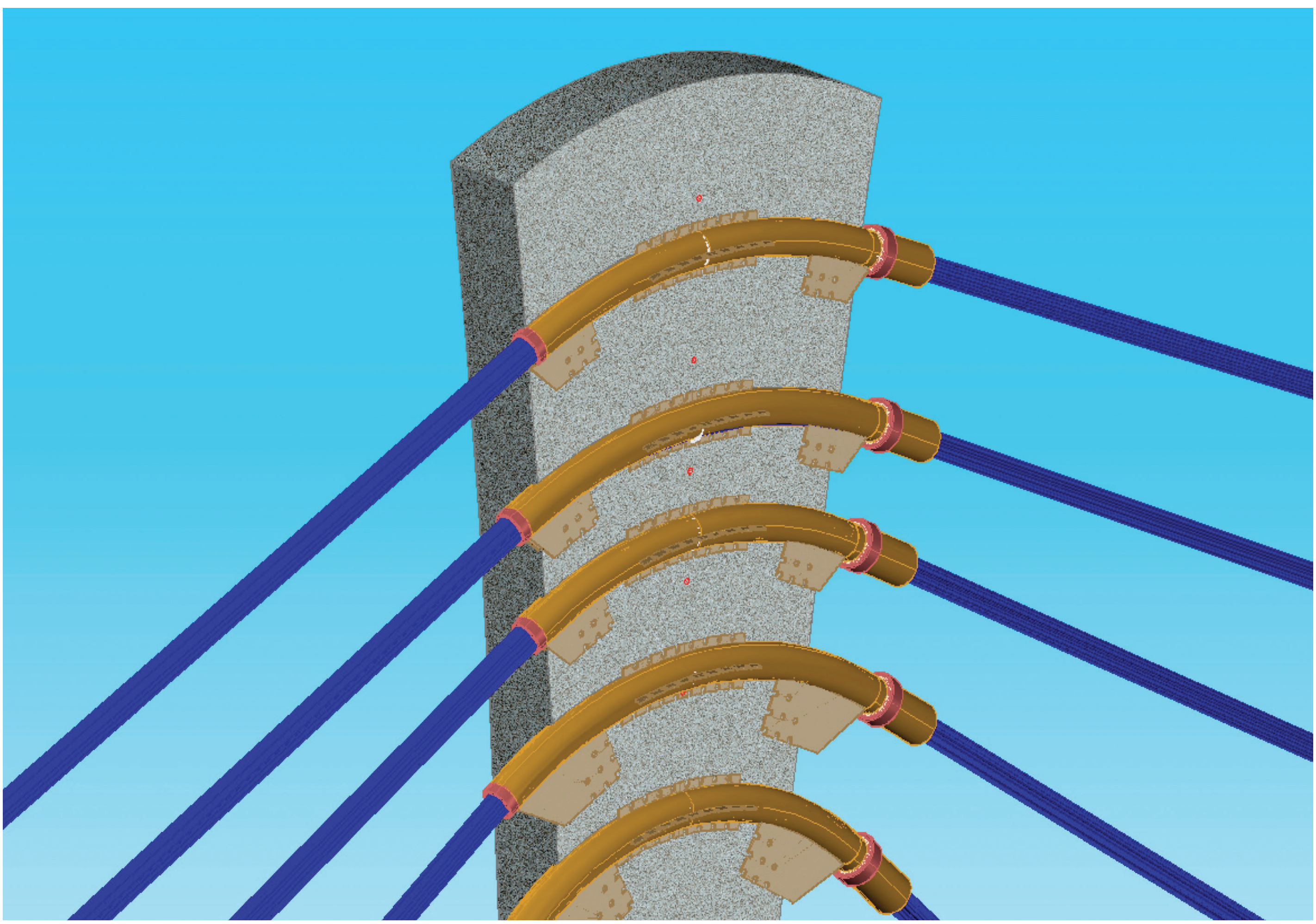

Fig. 3—Anchorage connection at pylon.

Fig. 4—Stay anchorage installation.

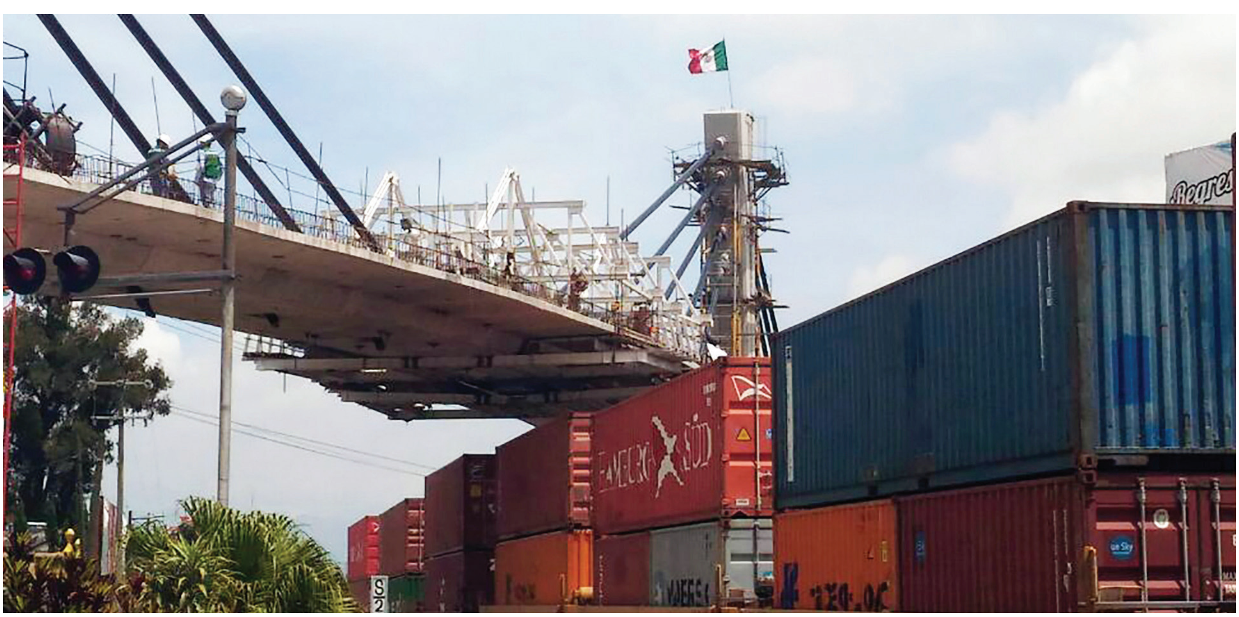

Fig. 5—Installation of stays.

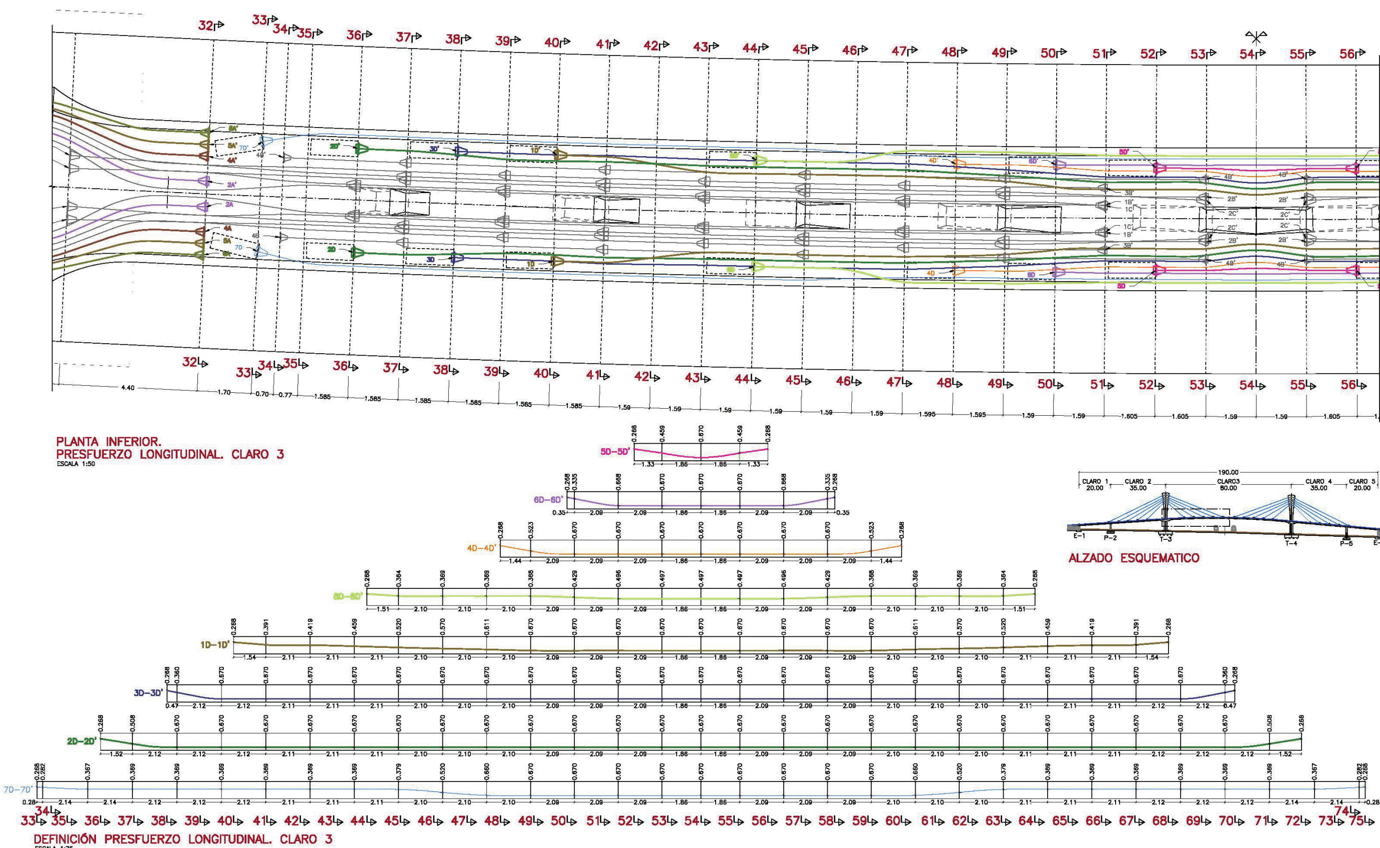

Fig. 6—Deck post-tensioning plan.

Fig. 7—Stressing of tendons from deck recesses.

Fig. 8—Transverse deck post-tensioning.

Fig. 9—Completed bridge.

In summary, the design and construction challenges presented to this bridge project were met by using creative post-tensioned concrete and cable stay bridge techniques and solutions. The project team leveraged this post-tensioning technology to successfully address the geometric, seismic and construction phase challenges, while ultimately delivering an aesthetically pleasing bridge, highly beneficial to the infrastructure of Orizaba, Mexico (Fig 9).

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