



## ■ Bridges



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### Reference Details:

**Owner** SETEC, Paris, France; SNCF, Paris, France +++ **General Contractor** Eiffage du Viaduc de Millau, Issy Les Moulineaux, France +++ **Executing Company** Eiffage TP, Neuilly sur Marne, France; Eiffel, Lauterbourg, France +++ **Design** Greisch, Belgien; Stoa/Eiffage, France; EEG Simecsol, France; Thales, France; SERF, France

**DSI Units** DSI France, Villeurbanne, France

**DSI Services** Supply of 200 t of post-tensioning tendons as well as 224 anchorages MA 19x0,6"; Rental of equipment for installation, tensioning and injecting



## "Viaduc de Millau": Technically Challenging Bridge Reached Record Breaking Height

### The Millau Viaduct, Millau (Aveyron), France

Designed by the English architect Sir Norman Foster, the Millau Viaduct is an EUR 310 million building project, financed and constructed by the Eiffage Group within the scope of a concession agreement. Its subsidiary Eiffage du Viaduc de Millau built the structure and subsequently has the commercial right to operate and maintain the bridge for 75 years. The viaduct is 2,460m long and 343m high at the highest pier measured at the top of the pylon. The bridge is the last section of the A75 freeway between Clermont-Ferrand and Béziers in the French Massif Central. The strive for an aesthetically appealing solution led to the concept of an eight span stay cable bridge with a very light deck, with a single plane of stays in the main load axis and a cross section which encompasses both directions of carriageway. The bridge deck rests on seven extremely slim piers which appear only to touch the valley flanks. A toll will be collected for driving on the bridge which was completed by the end of the year 2004.

### High strength concrete for abutments and piers

A special feature of the 7 extremely tall piers is their geometric shape: The hexagonal cross section in the shape of a rhombus with cut-off edges extends from the foundations up to a height of 90 m beneath the bridge deck where it splits into two slim half piers. This gives the impression of a delicate tuning fork, with the deck and the 90m high bridge pylons, which have the shape of an inverted Y, being located on its tips. For each new pour section, the Eiffage jump forming systems were adapted to the minimally changed angles to the vertical line and the minimally detectable adjusted outer surfaces. The pier cross section continuously decreases from a maximum 200m<sup>2</sup> at the foundation to only 30m<sup>2</sup> at the top of both pier arms. Two locally installed concrete plants supplied the high-strength concrete for abutments and piers.

### Steel Superstructure and pylons

Steel offered the following advantages for the superstructure and pylons:

- The low unit weight minimized the number of stay cables; in addition, using steel for the pylons reduced the total weight of the bridge.
- The prefabrication of large high quality units in the Eiffage fabrication shops in Lauterbourg and Fos-sur-Mer, and subsequent rapid assembly and positioning of the sections under construction from the existing freeway.
- Of the total number of man hours required for fabrication and assembly, only about 4% were expended in the air. Lowering the deck into position using intermediate supports

After completion of the abutments and piers, deck segments were launched into position in lengths of 171m (1/2 span width) from working platforms on both banks of the river Tarn. The deck included the first pylon and auxiliary stays at the front end. To facilitate launching, into position, the bridge spans (204+6 x 342+204m) temporary intermediate supports were constructed at the center of each span. The two bridge halves were joined across the Tarn. Subsequently, the remaining 5 pylons were transported from the prefabrication yard to the installation site and erected using a rig normally used by oil refineries when erecting distillation towers. After installation, stressing and adjusting the stay cables, the temporary intermediate supports were removed.

### **In focus: post-tensioning of the piers**

The height of the piers reaches up to 245m above the top edge of the foundation. Each pier shaft is post-tensioned with 8 DYWIDAG Bonded Post-Tensioning tendons type MA 19-0.62" placed in Ø101.6 mm ducts. Four of the tendons, anchored in the top crossbeam, reach to level -98 m and four to a level 60 m below the deck. The lower anchorages are located on a beam that was later cast inside the piers.

Post-tensioning of the piers provides stabilization against wind forces as well as eliminating cracks due to differences in temperature changes and fatigue resulting from dynamic loads.

A total of 200t of prestressing steel and 224 MA 19-0.6" anchorages were supplied. The construction time per pier was about 3 weeks. The strands were directly installed from the top anchorage through the anchor plate and held in place by wedges after the lowering into position. The lower anchorage includes a tubular cap to accommodate the tendon tail.

### **All post-tensioning tendons were stressed from the top only.**

Grouting of the vertical 60 and 98 m long tendons required great care. The suitability of the envisaged method and the equipment to be used was demonstrated in a preliminary test in a similarly high pier on the nearby Verrières Viaduct. The grouting with "Superstresscem" grout cement was carried out in 3 stages.

For safety reasons, the lower anchorage of each tendon was closed with a "grouting plug" to avoid possible leakage and loss of cement grout loss from the 98m high tendons. After hardening of the plug, the tendon was grouted up to its top anchorage. To displace any bleed water accumulating at the high points or to grout existing interstices there, re-grouting takes place from the top anchorages approximately 24 hours later.

For logistic reasons, the grout is mixed at the pier base, while grouting is carried out from working platforms located -98 m or -60 m near the lower anchorages. A "rotation" of 3 grout containers by crane made it possible to continuously feed the grouting stations.

For safety reasons, lock-up intermediate openings of the ducts were installed at heights of -60 and -30 m in the pier shafts. This made it possible to properly grout the tendons in sections later, even if the crane broke down.

These works were carried out by Eiffage with DSI special equipment.



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