The Polcevera Viaduct on the Genoa-Savona Motorway

The final stretch of the Savona-Genoa motorway, in the direction of Genoa, before it joins the Genoa-Valle del Po motorway and past a tunnel through the Coronata hill passes over the Polcevera valley and enters a stretch where the two motorways merge. Crossing the Polcevera valley and the merging system required the construction of a large and comprehensive work of art, of considerable size and technical interest because inserted into a densely built-up area of civic and industrial buildings; more importantly, it is affected by both the Polcevera River and a number of major railway structures.

All these constraints clearly impacted on the project development in terms of static concept, spans and method of execution.

As a whole, this work can be seen as an interesting example of introducing a large infrastructure into a dense urban and industrial fabric while also successfully creating a suitable composition with regard to its design and the landscape.

Furthermore, the considerable size of the main spans, bridged with low-cost structures, helps, along with other similar examples, to illustrate the potential for ever larger constructions while continuing to adopt the method and technology of reinforced and prestressed concrete, obviously with increasingly elaborate processes.

The viaduct has a total length (without the merging roads) of 1,100 metres, is 18.00 m wide and runs at an approximate height of 45 metres above the average level of the city's road system, featuring the following theoretical span sequence:

1 x 43.00 metre span
1 x 75.31 metre span
5 x 73.20 metre spans
1 x 142.65 metre span
1 x 207.88 metre span
1 x 202.50 metre span
1 x 65.10 metre span

Generally speaking, the large-span system repeats the theme previously resolved by this engineer when constructing the bridge over Lake Maracaibo (Venezuela), opened in 1962.

The crossings are resolved using special balanced systems in which the bay is formed by a continuous three-span section, on four elastic supports, with cantilevered terminal sections, at the end of which rests the tie connecting beam.

The two end supports of each bay are connected by the terminal elements of the two pretensioned steel cables passing over a tower made of four diagonal elements, rising 42.25 m above the deck.

Each large pier rests on a reinforced-concrete rafter anchored to pile foundations consisting in large-diameter bored piles. In many cases, these may be up to about 40 metres deep.

Two separate static systems, symmetrical to a shared axial plane, rise above the rafters, i.e.:

- a special V-shaped reinforced-concrete trestle composed of four parallel elements, with two arms linked to each other both at mid-height and on the deck by means of crossbeams perpendicular to the axis of the viaduct;
- a system of four-legged stiffeners, with a truncated-pyramid shape, with connecting beams longitudinal to the deck and a crossbeam at the top.

The deck consists in a continuous honeycomb beam, with an extrados slab and six vertical sides with an average thickness of 22 cm.

The ends of the beam sections have a robust crossbeam, projecting from the outer walls with shelves, to which the aforementioned stays are secured, resting on top of the pier and consisting in bundles of spring steel sheathed in concrete.

As already mentioned, a section with a span of 36.00 m was laid between the ends of the cantilevered walls of two consecutive balanced bay sections via the interposition of oscillating devices.

The three large balanced systems are thus independent of each other and so the structure is not subject to stress from any uneven settling of the foundations.

The second part of the viaduct consists in a number of special V-shaped piers each composed of four double towers having a variable section, linked at mid-height and the top by crossbeams and resting on rafters, also anchored on large-diameter pile structures. The top of the V-shaped pier supports a 20.00 metre-long beam projecting out over the piers by 7.50 metres on each side.

Resting on these cantilevers are prefabricated beams having exactly the same size and spans as those linking the large balanced systems of the large spans.

All the above structures are in normal or prestressed concrete; in particular, prestressing was adopted for some of the deck beams of the large bays and for the large support cables, as well as for all the independent beams between the piers.

The particular environmental conditions made it necessary to execute the girder sections of each balanced system with a method that, although it cannot be described as totally original, can be considered interesting and delicate.

The deck section between the two diagonal uprights of each trestle was constructed with normal shoring; two special travellers on wheels and rails, each able to support the weight of the cast of the entire bridge-deck section for a length of 5.50 m, were mounted on said section.

The travellers were then simultaneously and symmetrically moved outside the vertical transversal plane of the bridge, passing via the axis of the pier and the first 5.50 m segment was cast on both sides.

Once the cast had hardened and was joined to the previous structure using normal steel reinforcements, it was seen to withstand the bending and shear stress ensuing from the cantilever construction method by temporary spring steel wires, anchored to the symmetrical end sections and placed in tension on both sides.

These wires, not protected by concrete sheaths, were placed above the extrados plane of the deck and diverted by two vertical walls in reinforced concrete 2.10 metres high, set in line with the top sections of the stiffeners.

Once the executed section was detached from the traveller, this was moved forward for the casting of the second 5.50 metre section, after which the hook-up to a number of temporary cables and their tensioning were repeated.

A series of nine operations was executed in this way to reach the section with the anchoring of the permanent tie rods. The last section was cast without including the total volume of the large crossbeam anchoring the tie rods to the deck but only that of a smaller layer 1.00 metre high. This was to avoid loading the end of the shelf with a 50.00+ metre span with the heavy weight of the large crossbeam.

At this point, temporary tie beams formed of bundles of spring-steel wire were introduced in a position similar to that of the permanent stays (therefore crossing the pier) but anchored, at deck level, not to the ends of the large crossbeam but in line with the six independent ribs. Once the one-metre base layer of the large crossbeam had hardened, the temporary tie beams were placed in tension and the casting of the large crossbeam completed. Next the cables of the permanent stays were installed and placed in slight tension after partially tensioning the prestressing cables of the large crossbeam. Having eliminated the cables of the temporary tie beams, the tension in the permanent stays of the cantilevers was increased automatically past the stay anchoring point, partly as a result of the casting in two sections and again using a traveller.

After partially tensioning the permanent prestressing cables of the bay section, the temporary tie beams supporting the bay section were eliminated, section by section all along its length. The tensioning of the cables of the girder section was then completed and the traveller dismantled and removed.

After fully tensioning the prestressing rods of the large crossbeam and the stay cables, auxiliary ones were installed around the stays already in tension for the prestressing of the stay sheaths.

The sheaths were then cast, again in sections as already mentioned, making sure to leave a certain interval at the deck attachment point free. Once the casts had hardened and the join sealings had subsequently been cast between each section, the sheaths were restrained by tensioning the auxiliary stays of the temporary heads, level with the free end above deck level.

The remaining part of the sheath was then cast and, after the auxiliary stays had been lengthened using a special sleeve joining them to the permanent headpiece at the large crossbeam, it was prestressed.

With all the stays tensioned, the structure was ready to receive first the installation of the prefabricated ribbing of the 36.00 metre girders, then the subsequent casts to complete them, the laying of the surface and the addition of the other road superstructures and finally the imposed loads.

Throughout the process of building the bay sections, the strains on the structure were constantly checked, particularly any lowering of the ends with the due corrections being made by acting on the stays so that, by the end of all operations and with the effect of each one having been duly taken into account, the vertical position reached by these sections was strictly that required for the working conditions of the bridge.

Finally, to highlight the financial aspects of the solution adopted for the large spans, please note the following:

For a 208.00 metre span, the deck area is 3,742.00 m^2.

For the deck system, the piers and stays (excluding the trestles, assimilated with the piers in all other solutions), we have the following quantities:

- Concrete: 5,530.00 m^3
- Deformed steel: 348.50 tons
- Steel R/nO kg/mm^2: 191.60 tons

These quantities, related to a square metre of deck, produce the following figures:

- Concrete: 1.48 m^3/m^2
- Deformed steel: 93.00 kg/m^2
- Steel R/170 kg/mm^2: 51.00 kg/m^2

The work designed by Prof. Ing. Riccardo Morandi with the collaboration of Ing. Claudio Cherubini was executed by Società Italiana per Condotte d’Acqua di Roma under the direction and control of the Ufficio Speciale Autostrade della Azienda Autonoma delle Strade Statali.

Dott. Ing. Luigi De Sanctis managed the construction on the company’s behalf.