"BATALLA" VIADUCT

(ADAPTING BRIDGES TO CHALLENGING PLACES)

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ABSTRACT

The viaduct of "La Batalla", located in Alcoy (Spain), is a hybrid solution as a result of the use of precast segmental technology in part of the deck and a steel-concrete composite section for the rest to complete the same span. Such a solution was necessary because of environmental problems that arose. The viaduct has two spans of 100 m (333 ft), one of which finishes on a slope with a high level of environmental protection. This meant that a planned access track to the site of that abutment was forbidden.

Work started from the 55 m tall central pier with a conventional cantilever construction of precast segments stretching outwards up to 60 m, with the help of a launcher. From the cantilever the launcher was able to reach the abutment and provided access for building to continue. The following step was to launch the 40 m in length steel box girder to complete the span. Precast slabs were installed to finish the composite section. Continuity prestressing was implemented in order to transfer the positive moments both in the precast and the composite sections.

Some interesting details needed to be designed such as the connection between precast and composite section.

Under a design-built scheme, innovative use of launcher led to a more efficient construction process and to optimize the preliminary design.

Keywords: Hybrid, Composite, Integral, Weathering, SCC (Self-Compacting Concrete), Segments, Wall Piers, Post-Tensioning, Cantilever.

1. INTRODUCTION: CLOSING OF THE A7 MOTORWAY AND ENVIRONMENTAL CONCERNS

The stretch of the A7 motorway between Ibi and Alcoy closes the ring around the latter city and it allows a more direct connection to Alicante from Valencia by avoiding a winding segment of N340, which runs up the ravine of “La Batalla”.

The layout of the new route avoids 3km of a mountainous path with a tunnel that crosses the massif of the "Font Roja", a protected natural park. The tunnel exits from the center of a steep slope and is perpendicular to the ravine. These connect to “La Batalla” Viaduct, which stretches over a valley 200m in width and also passes over a stream and the N340.

The Environmental Impact Statement (EIS) prevented the placement of piers and temporary works within the park. The preliminary design included the location of a support to be alongside of the N340, practically forcing a span of 150m. The structure, although technically feasible, presented a series of construction problems such as the displacement of the current N340 due to clearance problems, the construction of a temporary bracing structure, and the need of permanent anchors in the abutments.

The Technical Office of Ferrovial Agroman was commissioned to study an alternative design of the bridge.

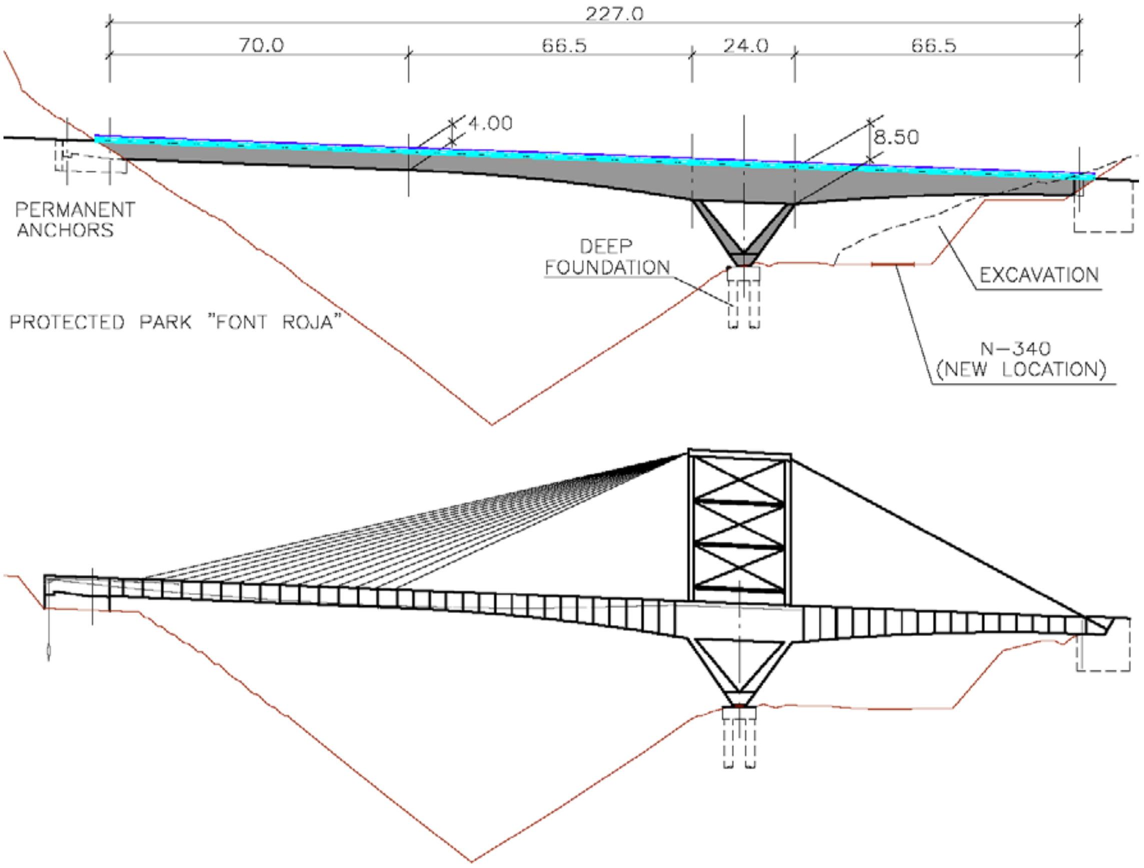


Fig. 1: Preliminary project and its construction process.

2. LA BATALLA RAVINE: STUDY OF ALTERNATIVES

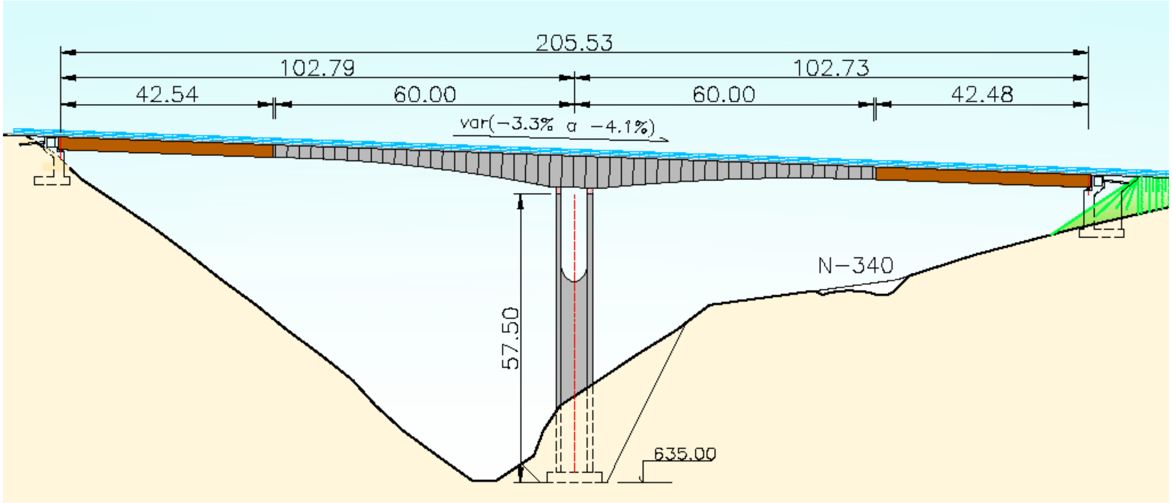
The detailed study of the EIS and the environmental protection of the area resulted in an environmentally viable location for the pier on the right bank of the stream. The protection of the park ends at the location of the stream and there was minor protection on the right-hand bank (where the N340 is), so it was possible to construct the pier there with restrictions.

The position of the permanent piers is about 100m from the tunnel exit and another 100m from the other side of the valley. Even though these spans are still of considerable length, these dimensions opened the way to more conventional solutions. A single cantilevered T bridge of 200m in length was selected as the final design.

After a detailed study of the previous experiences and the capability of the construction equipment available, it was decided to use the segmental balanced cantilever method with a launching gantry. The parameters of the gantry limited the design of the cantilever bridge. The concrete T could have a maximum total length of 120m, the segments could weigh a maximum of 80tons and the self-launching movement in cantilever of gantry could reach a maximum distance of 65m.

3. LA BATALLA VIADUCT: DESCRIPTION OF THE SOLUTION

The viaduct is a box girder with two spans of 102.5m fixed at the pier and supported at the abutments. It consists of the central T, 120m long, post-tensioned precast concrete segments (50 units, each 2.4m long), and two composite segments at the ends, each with a length of about 42.5m. The concrete sections are of varying depths (6.25m over the pier and 2.5m at the 25th concrete segment) and the width of the box is 6.5m. The bottom slab of the box section has a varied thickness of 0.60m-0.25m and the width of the webs are 0.40m. The width of the roadway on the south-bound side is 13.3m with cantilevered overhangs of 3.4m and the north-bound side has a roadway width of 11.3m with cantilevered overhangs of 2.4m. The top slab has a varied thickness from 0.21m to 0.59m.



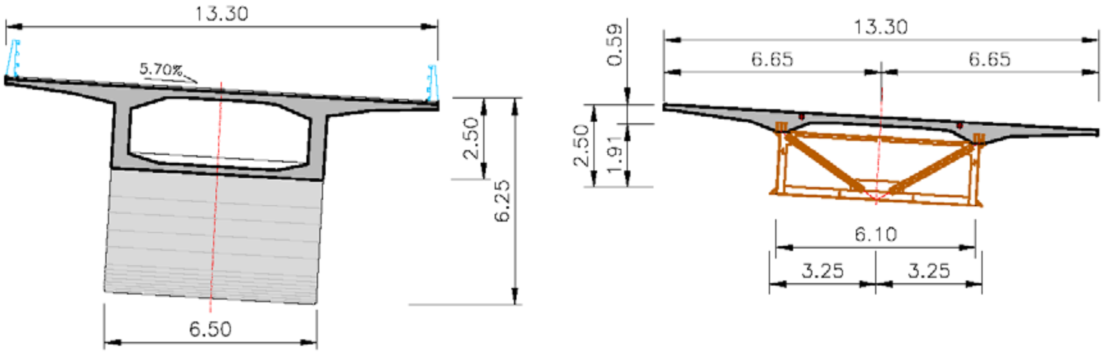


Fig. 2: Elevation of the solution & cross sections of the south-bound carriageway.

The composite cross section consists of a steel box and an upper, precast concrete slab. It has an external geometry equal to the 25th segment, except for the webs, which are spaced at 6.1m (central axis of the concrete segmental webs). The lower and upper flanges are reinforced with triangular cells made with steel plates. Diaphragms have a separation of 2.4m, which coincides with the length of the concrete segments. The beams of each span have different plate thicknesses due to the different structural needs (construction processes in both cases are quite different).

The permanent pier is 58m high and consists of 2 pier walls that are 1.1m thick, with a separation of 5.4m. The width of each pier wall varies along its height (from 6.5m at the top to 9.3m at the bottom). The first 38m high from the ground, the 2 pier walls are connected with another 2 perpendicular thin walls (0.4m thick, separated 5.75m) between them, creating a hollow box cross section. The pier is supported by a footing foundation directly into limestone rock, with dimensions of 15.0m x 14.0m x 2.2m.

The plan view of the viaduct shows a constant curve of radius 1200m with a camber of 5.7% and a median strip that widens in order to adjust to the tunnels separation, resulting in divergent carriageways. The elevation slope varies from -3.3% to -4.1%. As stated previously, the south-bound carriageway is wider than the north-bound because of an extra lane for slow vehicles climbing.

Fig. 3: View of the viaduct under construction (placing south steel beam).

4. LA BATALLA VIADUCT: CONSTRUCTION PROCESS

The construction process consisted of the following phases:

- The concrete segments and the upper concrete slabs of composite segments are cast in a casting yard close to the site.

- While the segments were being prepared, the permanent pier was constructed on the right-hand bank at the bottom of the ravine.

- The construction of the provisional concrete pier needed to support one end of the composite section of the northern span is carried out.

Fig. 4: Provisional pier.

Fig. 5: Permanent pier.

- The steel box beam of the northern span is assembled in 2 pieces by mobile cranes while supported by the abutment, an intermediate prop and the provisional pier.

- The precast slabs are placed on the steel box sections of the northern span.

- The joints of connection are concreted to form the complete composite beam (40m long).

- The intermediate support is eliminated and then, the composite box beam rest on neoprene bearings at the abutments and supported by jacks over the provisional pier.

Fig. 6: Assembly of the north steel beam.

- The launching gantry, which is mounted at the northern side of the abutment, advances and places one of its movable supports (“binario”) at the end of the north composite box beam (at the vertical axis of the provisional pier). Then, rest on this “binario”, the gantry continues advancing the 65m in cantilever towards the permanent pier (“self-launching movement”). Finally, it places its own frontal support on the permanent pier.

Fig. 7: Launching to the permanent pier.

- The launching gantry then takes the first segments (one by one) and places them upon the permanent pier, connecting them to the previous segments with post-tension cables and bars.

Fig. 8: Placing “cero” segment.

- Once a gantry support is placed over the first segments, the usual balanced cantilever sequence starts from the permanent pier (fed from the composite beam) until the 25th and last concrete segment is in place. The complete T120-section is then mounted onto the supporting jacks at the top of the permanent pier.

- The final stage of the mounting process of the T-sections is the alignment of the north end of the concrete segmental T120 with the end of the north composite beam and, at the same time, get the best adjustment of the free south end of T120 to its theoretical position (for the future connection with the south beam).

Fig. 9: Orientation of the T120 and the north composite beam.

- This orientation of the solid T120 is carried out by means of the 2x2 supporting jacks situated at the pier (where the whole T120 rest), and the 2 supporting jacks on the provisional pier (where one side of the composite beam rest). Each pair of jacks permits vertical and horizontal (transversely to bridge alignment) movements.

- The deck is in turn fixed to the permanent pier before the composite section is joined to the T120-section (concreting key segment).

Fig. 10: Advance of south box beam over the deck.

- The launching gantry is then repositioned at the north abutment, taking the south steel box beam and advancing over the deck with it, in a complex sequence of steps (ones to move the gantry itself, and others to advance the steel beam).

- While this is taking place, the tunnel exits from the hillside, and the south abutment is constructed from the tunnel.

Fig. 11: Launching the south box beam to the abutment.

Fig. 12: 25th concrete segment, south side of T120 section.

- After the self-launching process to the south abutment, the gantry places the steel south beam.

- The precast slabs are launched and installed on the south steel box beam and the joints and bottom slab to anchor the tendons are poured. The south span is then completely post-tensioned and the launching gantry leaves the bridge.

- Finishes are completed over the bridge.

Fig. 13: Load test.

5. LA BATALLA VIADUCT: CONNECTING COMPOSITE TO CONCRETE SECTION

The union of the T120-section to the composite beams was completed by means of a cast in place concrete key segment 0.50m long. This is the current process used in other precast segmental balanced cantilever bridges to connect adjacent T sections. It has the advantage of requiring the same tolerances and equipment (e.g. no critical welding is needed during construction). The steel box girders have the following configuration:

- In the last 2.5m of the length of box girder the webs are reinforced with two additional lateral webs that are separated by 0.4m. These three "webs" support a frontal plate that will be in contact with the future key segment. This generates the same external geometry of the web of the concrete segment (included the shear keys at the front). Its interior cavity is then injected with concrete in order to provide rigidity and strength.

- The bottom flange plate of the box girder is aligned with the lower face of the concrete segment, and the bottom concrete slab extends 15m to the bottom of the box girder so as anchor the continuity pre-stress tendons.

- Precast concrete slab of the composite box has the same geometry as the top slab of the T120 segments, and hosts a pair of upper continuity pre-stress tendons.

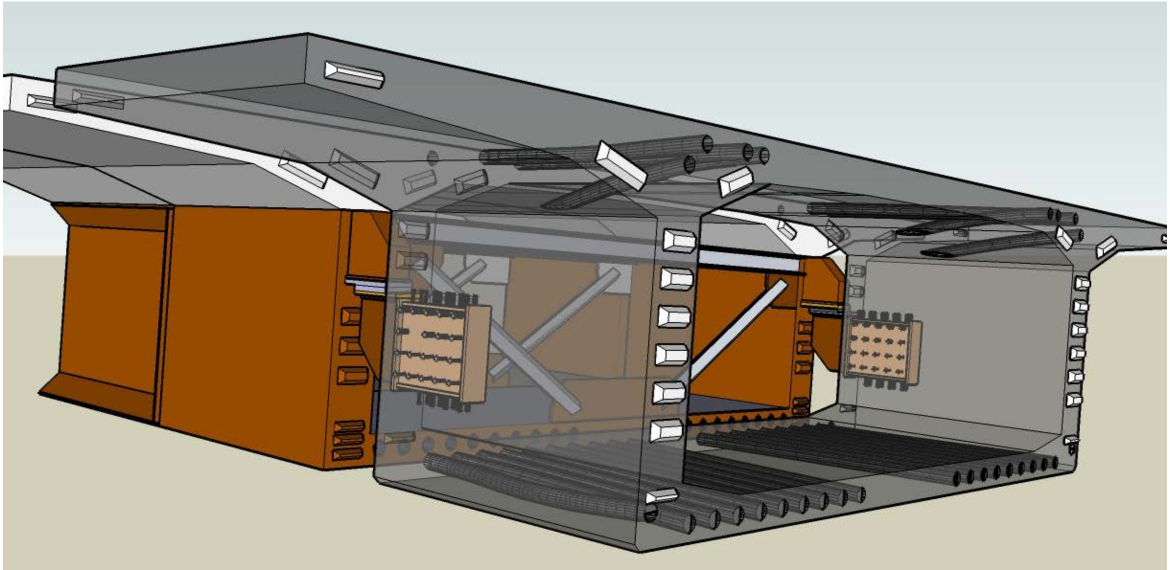


Fig. 14: General view of the connection of T120 section & composite box beam.

The proper positioning of the ends to be joined is achieved by a couple of metal brackets ("noses"), embedded in the width of webs; the upper bracket is welded to the head of the frontal plate of the composite box web previously mentioned, and the bottom bracket is anchored in the web of the 25th concrete segment, which is reinforced to resist the local force.

The definition of these brackets (“noses”) includes inclined plates to correct camber and ensure horizontal support; a sliding neoprene bearing that permits rotation and longitudinal movement when the weight of composite beam is transferred from its end (upper “nose”) to the extreme of the cantilever arm of the T120-section (lower “nose”).

Fig. 15: Connecting the T120-section and north box beam.

The unions of both composite beams and the T-section are constructed using the same system; however, the circumstances for each joint are quite different:

- In the north span, the composite box girder and the T-section are supported by jacks that allow movement on both the permanent and provisional piers, so that the position may be adjusted as needed. The ends are correctly positioned before the concrete deck is fixed to the permanent pier. The jacks on the provisional pier are lowered until half of the cantilevered reaction is transferred to the extreme of the cantilever arm of T120. Finally, the key segment is cast, the continuity pre-stress of deck is partially tensioned, and the jacks are lowered completely introducing the remaining reaction as a point load in the span, working as a beam (fixed support at permanent pier and free support at abutment).

The reason for this maneuver is to ensure compression at all times in the T-section and minimize the moment on the pier due to the construction process. Although the structure is symmetrical, there is no symmetry during the construction process.

- In the south span, the steel beam hanging from the gantry is deposited directly onto the "nose" brackets of the 25th segment and the abutment. Then, the bottom slab of the composite girder is poured, the first upper prefabricated deck slab is positioned and the closing key segment is poured. Once completed, the continuity pre-stress of the deck is partially tensed, and the remaining slabs are put in place to complete the composite girder.

6. CONCLUSIONS

The A7 motorway project between Ibi and Alcoy led to the following conclusions:

- The study of the project by the Technical Department of Ferrovial-Agroman allowed technically complex structural adjustments using the powerful resources available, and led to constructive improvements, as well as functional and aesthetic improvements from the original designs.

- The design of precast segmental cantilever bridges may extend beyond the normal boundaries by means of building hybrid solutions, taking advantage of the capabilities of the launching gantry.

- In general, the optimal structural solutions to the most demanding projects go through the eclectic and inventive use of materials, forms and structural layouts, while not necessarily compromising the economic optimization with the aesthetic requirements. The optimal solution comes from an evolutionary process that critically analyses the key aspects of a problem and the relationships between them.

Fig. 16: Bridge finished (before demolishing the provisional piers).