

Prefabrication of medium span arch bridges

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ABSTRACT: A new prestressed concrete arch bridge for the upgrading of the National Road 16 "Adriatica" near Pescara, Italy, has been just completed.

The arch, formed by five ribs with an inverted T section and spanning over 70 m, has been totally prefabricated in three segments for each rib.

The main points illustrated are the details of the connections between the precast elements and the procedure to assemble them.

1 INTRODUCTION

ANAS, the Italian National Agency for the State Roads, is carrying on a wide program to upgrade the ordinary network born more than hundred years ago, often reproducing ancient Roman roads, when it was usual to cross towns and villages. The new alternative routes to avoid these crossings are one of the main task of this program.

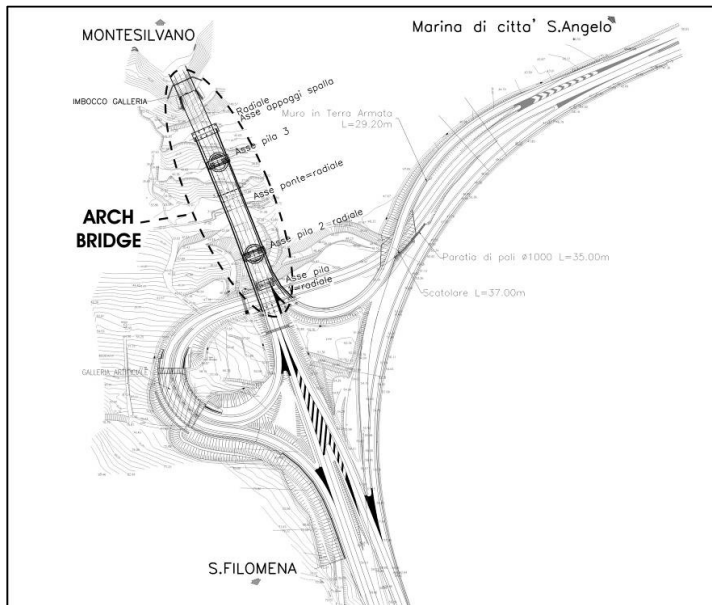


Figure 1 : General overview of the project.

The bridge here described is located in the variation of the very busy national road SS16 necessary to avoid the town of Montesilvano, along the Adriatic coast near Pescara. A 2500 m long gallery and two interchanges are comprised in this alternative route.

One of these two interchanges includes the arch bridge over the Mazzocco torrent as well as an artificial gallery and many sheetpile bulkheads necessary to limit the cuts in instable soils, see Fig. 1.

The crossing of the torrent has been made with an arch spanning over 70 m plus three approach spans, the total length resulting 145 m. The deck width, 17,2 m, includes the acceleration and deceleration lanes to enter or exit from the interchange, see Fig. 2.

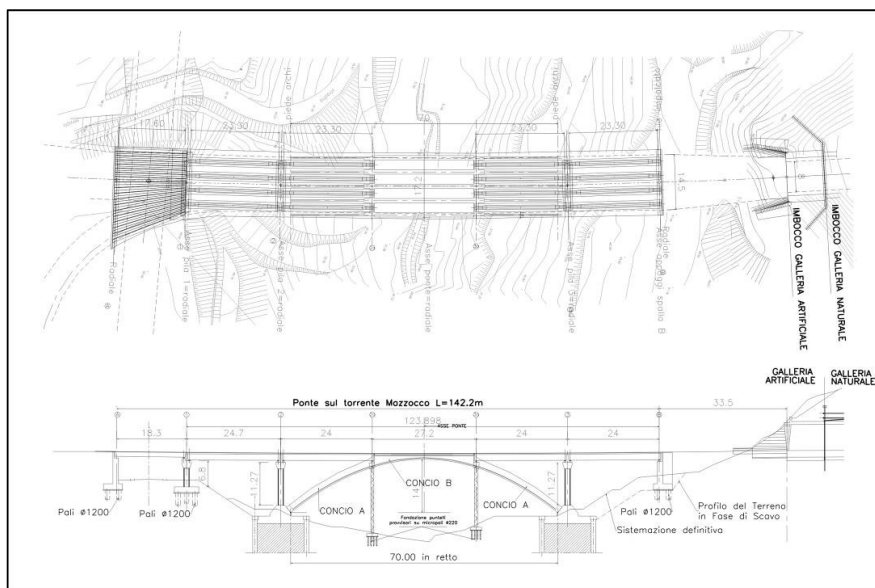


Figure 2 : Plan and side view of the Mazzocco bridge.

2 GENERAL DESIGN CRITERIA

Both ANAS and the local Authorities considered the arch bridge to be an essential feature to get a correct environmental integration from an architectural point of view. Other more economical solutions were possible, the soil conditions not being ideal to support horizontal forces, but the aesthetical reasons prevailed.

The preliminary design prepared by ANAS indicated the arch to be cast “in situ” on temporary scaffolding; the same construction method was prefigured for the upper deck, made by small spans connected to the arch by a number of columns.

This solution, very usual in the past, has many inconvenient: **(i)** the high cost for assembling both the scaffolding and the reinforcing bars, as well as for casting the concrete; **(ii)** the obstruction, for a long time, of the slope of the valley that in the past had already given problems of floods; **(iii)** the need of guarantee the absence of different settlements between the foundations of the scaffolding.

The last of these requirements resulted to be very severe since the geotechnical survey pointed out the presence in the valley of a layer of loose soil coming from the excavation of an ancient gallery.

All these considerations suggested to study a solution based on the prefabrication of the arch in the yard, the transport of heavy elements from a factory to the site being very difficult in the zone.

3 BRIDGE'S MAIN FEATURES

The crossing of the Mazzocco torrent is obtained with four spans of 140 m total length, 70 m being spanned by the arch whose foundations are made by 15 m dia caissons supporting also the pier n. 2 and 3.

The caissons have been built with the aid of a ring of piles, 1,2 m dia, that allowed the soil excavation until 25 m below the ground level. The abutments and the pier n. 1 have foundations resting on piles, 1,2 m dia.

The piers are composed by two vertical columns connected at the top, their maximum height being of about 14 m.

The deck is currently 17,2 m wide, up to 26,23 m near the south abutment to receive the auxiliaries lanes of the interchange already mentioned. The deck is made by four p.c. beams spanning over 24,7 m with a V shaped, 1,6 m high, section. Eighteen p.c. beams, with double T section, spanning over 19 m, form the first span where the width must vary from 17,2 to 26,23 m (Fig. 3).

The four beams are supported on one side directly by the arch that is composed by 5 ribs, each one made by three precast elements connected in situ. The two side elements were built with ordinary concrete while only the central one is prestressed with two post tensioned cables, each composed by 10 strands of 0,6" nominal dia.

The ribs have an inverted double T sections varying regularly from the base to the crown section of the arch: the bottom slab width varies from 200 to 50 cm., the total height from 180 to 120 cm (Fig. 4).

The three precast elements forming each rib are connected by short straight prestressing bars anchored in a widening of their web. This enlargement is missing on the lateral ribs (the ones visible in the frontal view) for aesthetical reasons and the bars are curved to be anchored in the upper part instead of the lateral face.

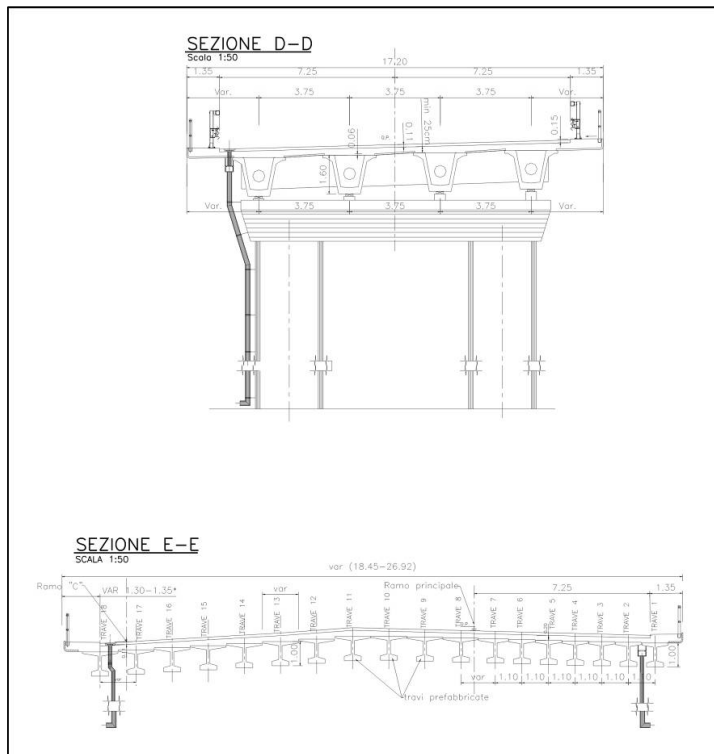


Figure 3 : Transversal sections of the V shaped beams and double T beams decks.

The foundations of an arch must guarantee, in addition to the bearing capacity, a very limited deformability not to reduce the thrust, it is well known.

This constraint addressed the choice towards deep caissons, a classical solution for situation like that here described.

Particular attention has been reserved to the design of the foundations devoted to absorb the relevant horizontal forces transmitted by the arch. The soils interested are clay and silty clay of marine origin, overlaid by sand and soft material coming from previous excavations, as already said.

4 CONSTRUCTION METHODS

Fifteen precast elements, necessary to compose the five ribs of the arch, were built in a prefabrication yard located very close to the bridge site, see Fig. 6. The industrial production in a factory was excluded because of: (i) the length of the elements, 24,6-26m, (ii) their weight up to 1100 KN, (iii) the difficulties to move in the area and (iv) the small number of pieces to produce.



Figure 6 : Precast arch segments brought to the building site.

Wooden formworks placed over a concrete basement, appropriately shaped to reproduce the bottom of the arch, have been utilised (Fig. 7). The central elements have been prestressed, as already said, before launching them.

Two provisional piers, 15 m high, have been prepared to assemble the precast elements. Each pier was formed by five towers realized with small steel pipes and connected by braces. The foundations of these piers rested on piles 80 cm dia, 15-21 m long.

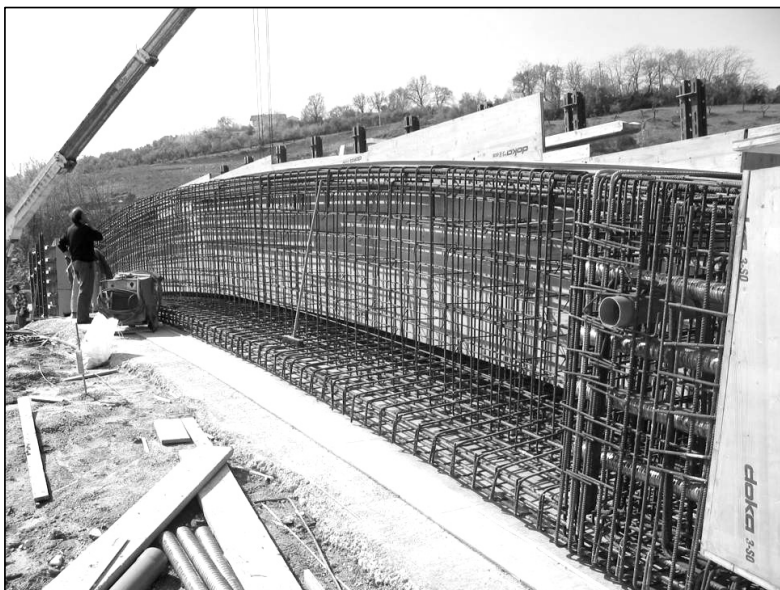


Figure 7 : Arch wooden formwork

In a first stage all the 5+5 lower elements have put in place over the foundations and the provisional piers; appropriate bearing devices have been requested to be sure that the strong inclination of the precast elements did not originate horizontal forces stressing the provisional piers (Fig. 8).

The five central elements have been placed on site in a second stage by mean of 300 ton cranes operating in the very narrow space available (Fig. 9).

Once all the concrete ribs were in place, the prestressing bars have been inserted and jointed in the connection zone.

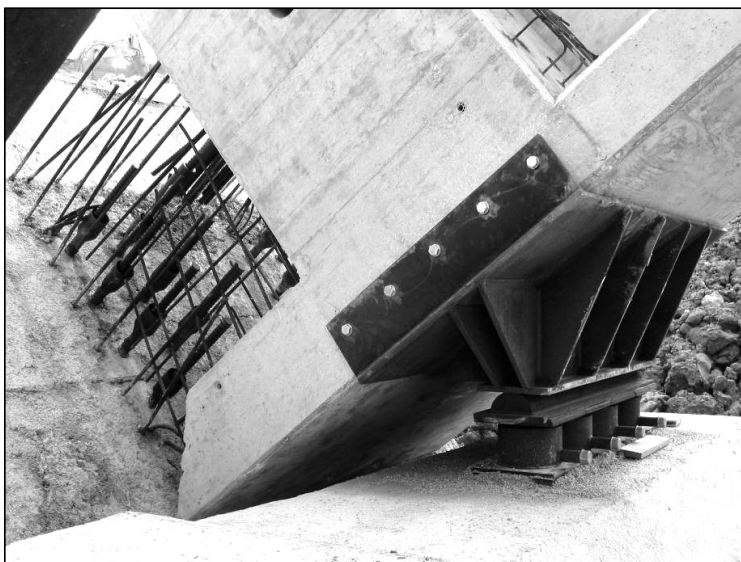


Figure 8 : Detail view of the lower arch with temporary bearing device



Figure 9 : Crane operated placement of the arch central elements

Sixteen bars, 36 mm dia, connect each rib to the foundation: these bars were initially embedded in the concrete and therefore coupling threaded sleeves were necessary to joint them; twelve bars of the same dia were sufficient for the upper joint but while the straight bars have been easily inserted in the interior ribs, coupling threaded sleeves were necessary for the bended bars connecting the elements of the side ribs were no widening of the web was adopted for aesthetical reason, see Fig. 10.

In the upper joint the concrete cast in situ forms a transverse beam both connecting the ribs and offering the support to the four V beams that form the deck. Also this transverse beam is prestressed by twelve 32 mm dia bars.

After having completed all the connections the provisional supports have been disengaged by lowering the jack screws and the sand boxes on which the precast element were rested (Fig. 11).

The launching of the precast deck beams and the cast in place of the upper slab ended the construction of the bridge, expected to be opened to the traffic during this year.

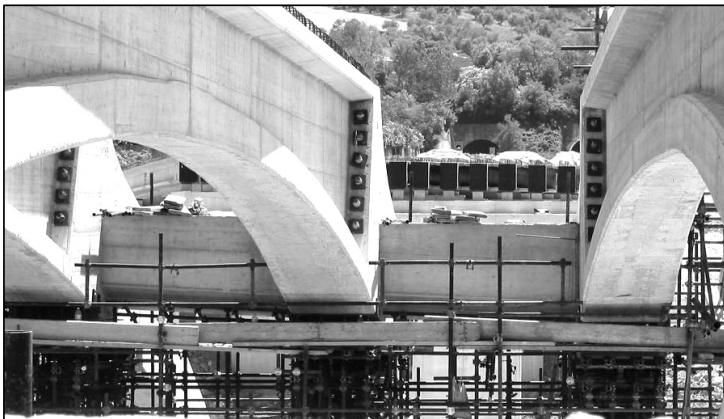


Figure 10 : View of the precast elements joints



Figure 11 : View of the bridge nearing its completion

5 CONCLUSIONS

The fascination of the arch bridges is unquestionable and derives from their elegance as well as from their capability to utilise in the best way the materials, like the concrete, not able to suffer tensile stress. Moreover they represent the archetype of the bridge since thousands of years.

Their popularity has been dramatically reduced since the end of the '60 because of the “new entries” like the segmental bridges built by cantilever method and, more recently, the cable stayed bridges. In addition to that the cost of the provisional centring to build them had reached an unacceptable level: more than 30 % of the total cost for large arch bridges built in Italy between 1960 and 1980.

Recently this type of r.c. structure is considered again a valid solution for span larger than 100 m thanks to the new procedure combining the cantilever construction with the use of provisional stays. This procedure, rather sophisticated, does not seem to be competitive for medium spans, i.e. 50-100m.

The prefabrication of the arch in a number of segments to assembly on the site, like the example here shown, seems to be a valid alternative when, for environmental matters, a bridge more elegant than the ordinary p.c. or steel girder is requested.