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Prestressed Concrete Slab Deck of the Fadalto Bridge

Tablier à dalle précontrainte du viaduc de Fadalto

Die uorgespannte Plattenbrücke des Fadalto-Viadukts

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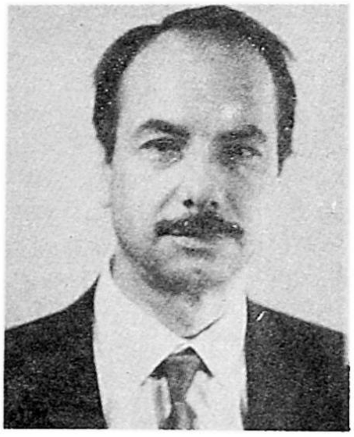

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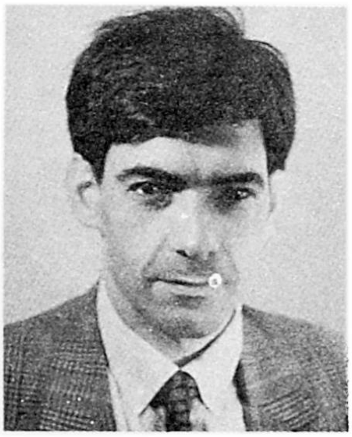

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SUMMARY
The Fadalto Viaduct superstructure consists of a series of thin slabs, 55 m long, in prestressed concrete. The thickness, at centre line of span, is reduced to 1.10 m. The project work is mainly concerned with the reduction of environmental impact. Its main structural and technical features are highlighted.

RÉSUMÉ
Le tablier du viaduc de Fadalto est constitué par une série de dalles minces en béton précontraint, d'une portée de 55 m. Leur épaisseur est limitée à 1,10 m au milieu de la travée du pont. L'article fournit les raisons du choix de ce projet et notamment de son intégration dans l'environnement. Il met aussi en évidence les caractéristiques principales de l'ouvrage, du point de vue structural et technique.

ZUSAMMENFASSUNG
Der Überbau der Talbrücke Fadalto besteht aus einer Reihe dünner Spannbetonplatten von 55 m Spannweite. Die Bauhöhe ist nur 1,10 m in der Mitte des Brückenfelds. Man beschreibt die Auswahl des Entwurfs und besonders die Einpassung des Bauwerks, in die Umgebung. Die wichtigsten konstruktiven und technologischen Besonderheiten des Bauwerks werden hervorgehoben.

1. GENERAL FEATURES

The viaduct is 3,550 m long and runs half-way up the hill. This presentation is concerned with the structural solution adopted for 6/7 of the whole length (the remaining part was carried out by means of a cantilever structure with spans of 115 m).
From the point of view of the construction technologies adopted, the greatest interest is given by the basic solution of the deck made of 55 m long continuous spans. The choice of this structure was the result of considerations both technical-economical and environmental. In fact the surrounding area is highly attractive. First of all foundation work had to be reduced as much as possible in order to avoid serious damages to the landscape. This is the reason for the choice of a single foundation for the couple of adjoining piers corresponding to the two carriageways. The result is a rectangular foundation having a reduced longitudinal size, wich stands, crosswise, at two different ground levels (following the natural slope). Excavation is hold up by a cap of jet grouting.
The choice of span was also the result of a series of factors: the height of piers between 15 and 65 m, the necessity to reduce the number of foundations whose heavy costs due to the morphology of ground were a burden to the whole work, the difficulty of entrance to work site with heavy machines and finally the speed of construction.
Nevertheless, technical solutions had to respect criteria of resistance and easy maintenance of the work. The Client (AUTOSTRADE S.p.A.), on a proposal of ITALSTRADE Design office, chose the type of superstructure made in pre-stressed concrete slabs, cast on site, continuous on four spans and connected with the piers, built by means of a mobile truss system running beneath the beams.
The interesting feature of the structure is provided by its architectural slenderness and trasparency as well as by the spans of the bridge (55 m). Actually the working out of such an agile and light structure was essential for a correct environmental fitting.

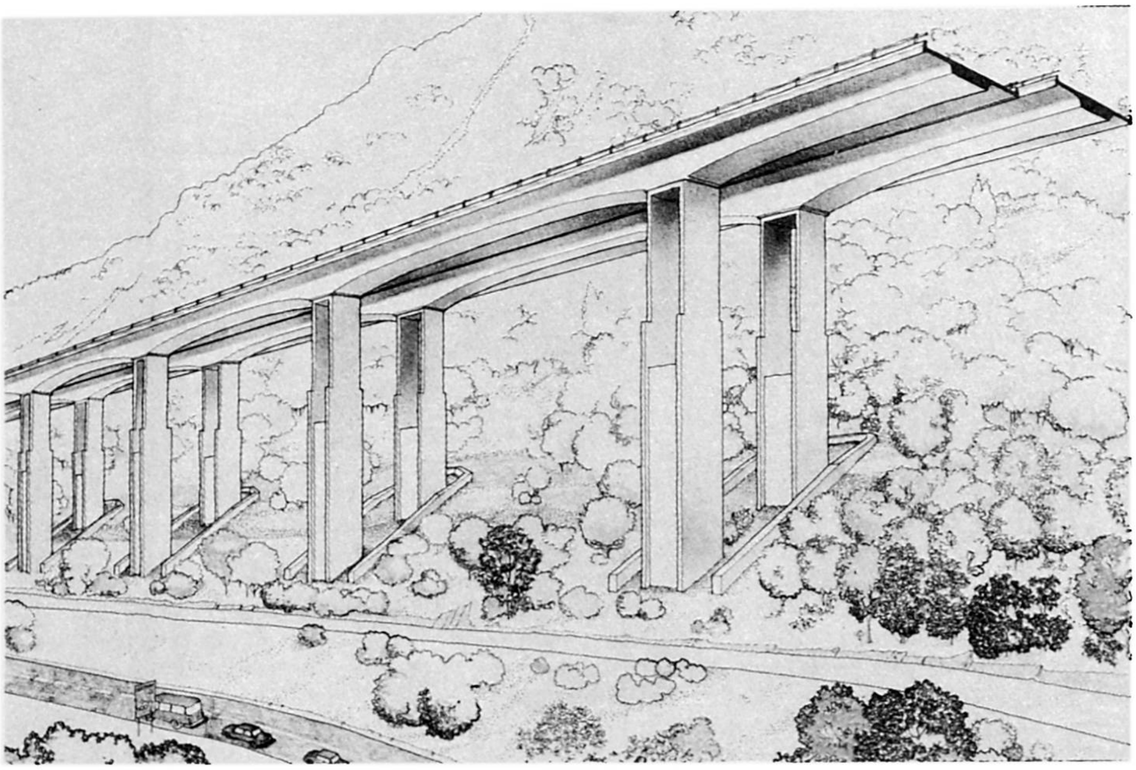

Fig. 1 Perspective view

Studies had to be carried out in order to find out the principal conditions the project had to meet according to the above mentioned factors.
The construction system was meant to be completely free from the ground level in order to proceed easily in the slope section where in fact the ground is very rough.
In such environment, difficulties and cost of excavations drove to the decision to reduce them, as much as possible, bringing structural spans to maximum expectation with the adopted construction system.
The nature of foundation ground made of miscellaneous materials from the "Fadalto ancient landslide", whose chaotic texture confirs a discontinuous geomechanical setting and consequent problems of anisotropy for bearing capacity and differential settlements between piers. Such risk expanded more and more with the horizontal thrust due to the topographic acclivity of the area with a peak of 40° in the slope angle. The deck structure had, therefore, to be flexible enough to absorb any possible subsiding with no consequences.
The construction system adopted had to guarantee an adequate speed in order to complete the 6 km viaduct (slab deck only) as provided for by the contract.
The number of expansion joints and bearing devices of the structure had to be considerably reduced in order to contain inspection and replacement costs and any inconvenience for users. At the same time the structure had to guarantee high duration .
These considerations contributed to the definition of the construction system and structure typology as described in the following paragraphs.

2. SLAB DECK

2.1 General Considerations and Design

The deck structure is made up of a reinforced concrete slab of variable section, longitudinally pre-stressed (Fig. 2). Piers are formed by two reinforced concrete baffles, right angled with the viaduct direction; they run free up to a height of 15.5 m from the bottom deck and downwards are connected by two walls so as to form a box-shaped section. The deck is fixed to the baffles: neither relative displacements nor reletive rotations are allowed. The longitudinal movements due to the thermal variations, creep and shrinkage of concrete, are absorbed by expansion joints located every 4 spans in a section 16 m from pier centre line where the structural continuity is interrupted. In such a way, the structural configuration is given by several frames formed by four decks and their piers which are completely integrated between them. By the Gerber type expansion joints the transmission of vertical loads is allowed through four bearing sliding devices. The comb joint is contained in the pavement thickness. By the expansion joint a space is obtained in the centre of the lower cantilever slab in order to allow entrance to the two bearing devices located inside for periodical inspection.

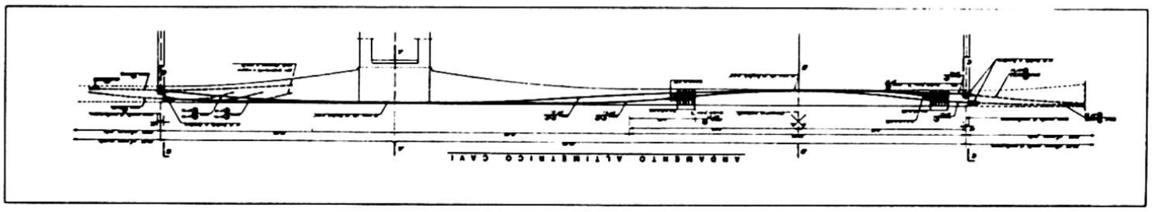

Fig. 2 Tendons profile

Furthermore room is provided to input a couple of jacks to enable the bearing devices to be uplifted if replacement is necessary. Thanks to the flexibility of the deck central section such work can be easily done without overcoming the acceptable strains.
The geometrical balance of baffles make the upper section of piers flexible

enough in relation to horizontal shifting and yet it reacts to deflections due to vertical loads. Piers are therefore able to absorb, with a slight increase in stress, longitudinal shiftings due to changes in the length of deck stemming from temperature, creep and shrinkage. At the same time the two baffles give a considerable flexural reaction under the action of vertical loads. They operate like a tight and stressed connecting rod located at a distance of 4.8 m between centres. It has been, thus, possible to get rid of all bearing devices overhead of piers and place one expansion joint only every 220 m.
The deck cross-section (Fig. 3) consists of a trapezium-shaped central part, 5.8 m maximum width and thickness ranging from 2.5 m at bearing to 1.1 in the span central area, as well as by side cantilever slabs of variable thickness.

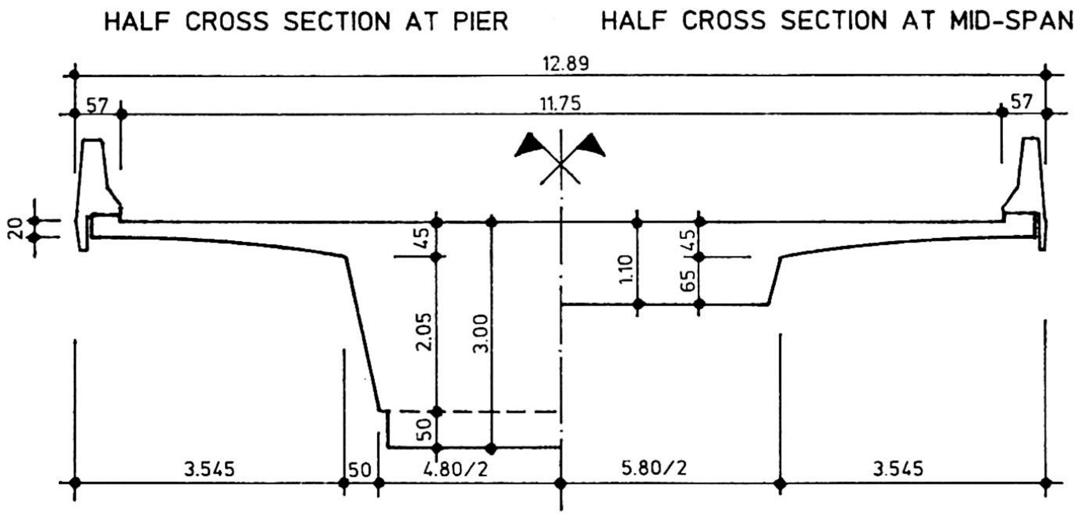

Fig. 3

The large structural thickness is a further guarantee of durability of the work. Thanks to the cooperating piers and to the favourable stiffness ratio between the sections at the supports and at midspan, 55 m span is reached, which is quite noticeable for this bridge type and this construction system, especially considering the low height of the midspan cross section. It is therefore solved the clashing necessity to guarantee a reduced deflection under live loads (3 cm) and to stand settling of foundation in order of 10 cm without overcoming acceptable strains of materials.
As to the rules in force the bridge is located in an area which has been classified as a 2nd range seismic zone (with 9 degrees of seismicity).

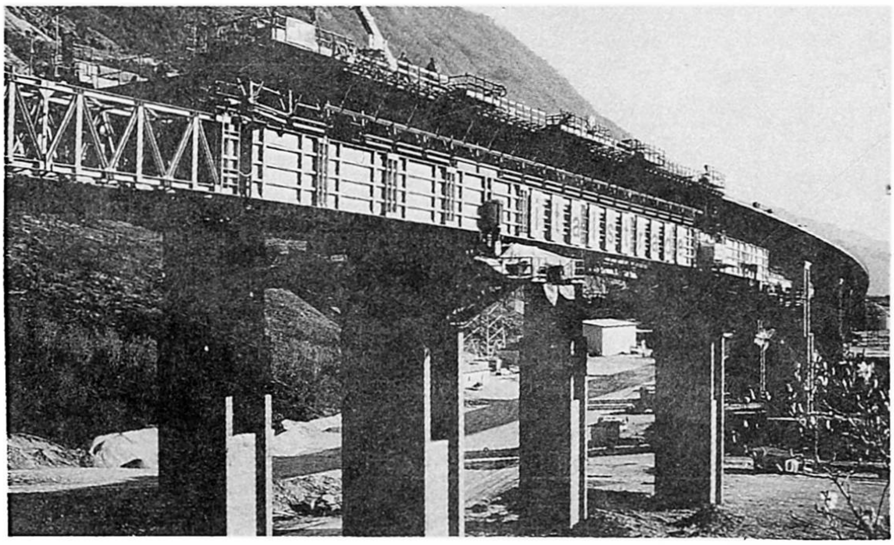

Fig. 4

Dynamic analysis carried out have proved that the flexibility of the end section of piers makes the main period of the structure higher than 1.3 seconds for lower piers and therefore outside the most dangerous seismic frequency range.
The deck unit and the piers enable the structure to withstand seismic stresses assuring adequate safety resources without the need of special devices for seismic isolation.

2.2 Construction Technique

Casting is carried out on site by means of a mobile steel truss running beneath the beams, completely independent from the ground level, as it is equipped with self-launching panels (Fig. 4).
The whole reinforcement steel cage and sheaths for pre-stressing tendons are assembled off-site and then moved into position within the truss by a motorized steel transport device. The same device is equipped with a double-conveyor belt casting system which enables pouring of the whole span (approx. 530 sq.m.) in 6-7 hours time (Fig. 5).
This equipment was carried out by the Building Contractor just for this project. Actually, thanks to the length of the bridge, has been considered the opportunity to get a better span than the ones carried out with already available systems, bearing in mind, at the same time, the possibility to pay off opening and erection costs. In this connection it is to be remembered that the whole weight of the equipment (self-launching steel truss and motorized steel transport device) is approximately 14 MN.
The mobile steel truss is equipped with a speed-up steam curing plant which allows one span to be built every 4 days. Manpower incidence stands on levels that can compete with the most sophisticated execution systems.
The slab deck is used along the western carriageway up to pier 42. The remaining section consists of different structure and construction techniques. A special system of steel truss movement has thus been worked out for the change of carriageway which includes the lift on the deck with proper equipment, the transport with special multiple axle trolleys up to the abutment and the new placement on the first span of the east carriageway.

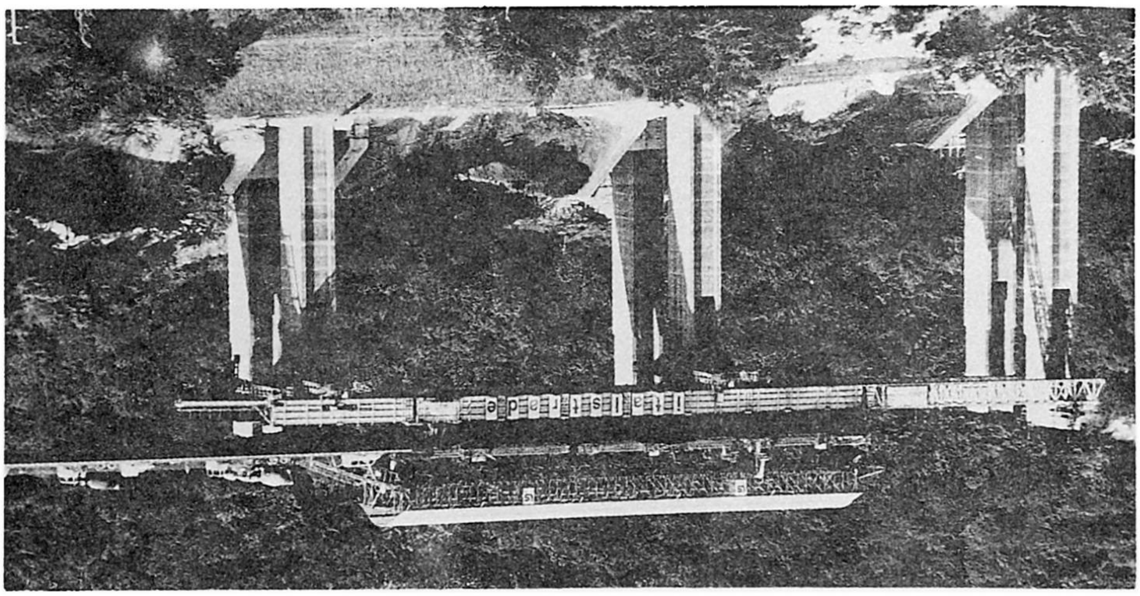

Fig. 5

2.3. Innovative Pre-Stressing Techniques

Longitudinal pre-stressing of the deck is executed with tendons composed of 27 0.6" strands and with a maximum starting tensioning of 5040 kN. The number of tendons has therefore been reduced as much as possible.
One of the most important innovations introduced with this structure is the coupling of cables at the construction joints between one span and the next one.

Instead of the usual coupling of anchorages, continuity of spans is obtained by overlapping pre-stressing tendons. The cables of each span enter the previously cast concrete structure taking a "U-turn". In such a way it was possible to distribute pre-stressing on more than one section avoiding the using of coupling anchorages and risks of sliding of anchorages wedges that would have very negative effects on duration of the structure (Fig. 6).

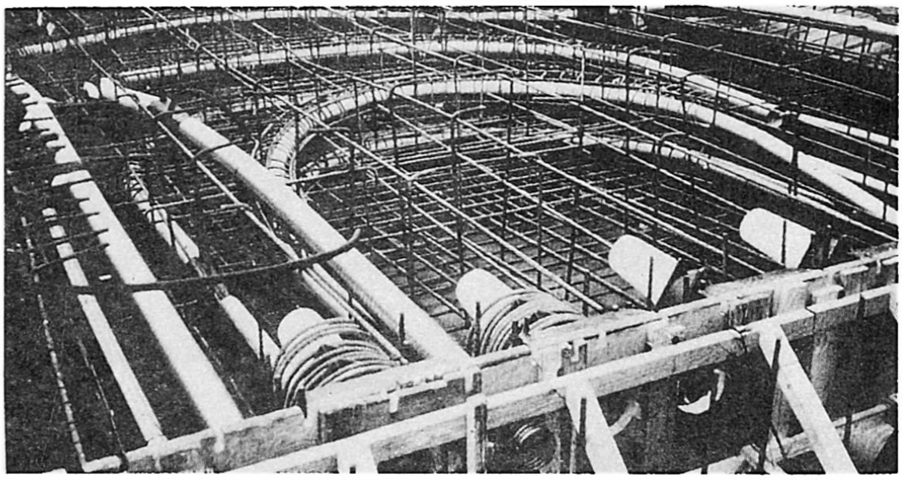

Fig. 6

Thorough studies were made on this matter to establish the minimum radius of curvature of anchor loops in relation to their diametre and the type of duct. In order to guarantee an even distribution of pre-stressing pressure and before the real stretching, every single tendon is lightly tensioned. Operations of inserting and stretching of cables placed in the first spans are controlled by endoscopes which allow to check the relation between theorical forecast and real attitude.

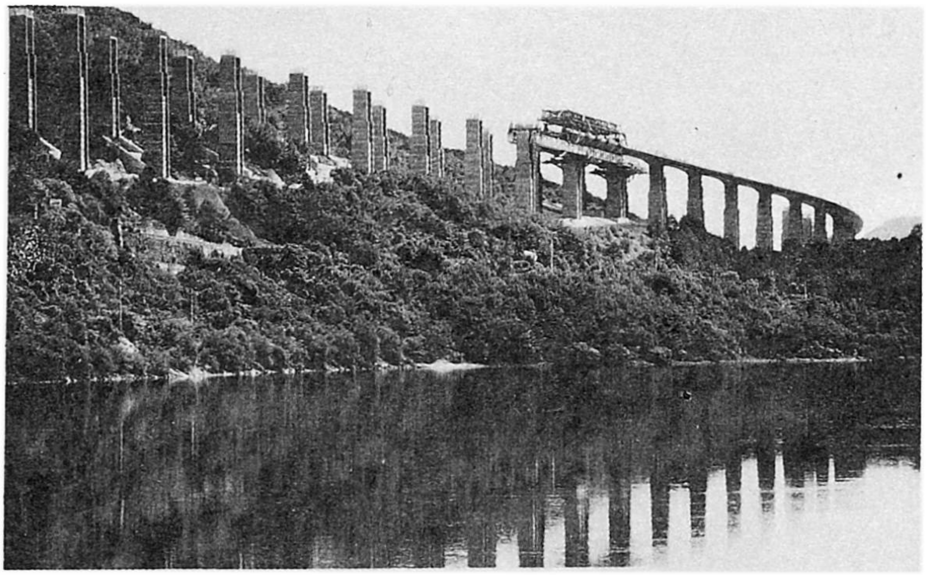

Fig. 7

3.CONCLUSION

The designing engineers' concern for geographical and morphological aspects of the area has enabled the realization of this civil work necessary to solve viability problems. Even though considerably long, it towers above the surrounding environment with the lightness of its geometric proportions (Fig. 7). For instance the outstretched and clear line of the viaduct, at the bottom of the valley, seems to underline, on purpose, the lake borders and the Millifret Mountain lower slopes.
This is a further confirmation that nowadays skillful builders must not give up experiment on big civil works nevertheless sucessfully defending the surrounding countryside.