Zeitschrift: IABSE congress report = Rapport du congrès AIPC = IVBH Kongressbericht

Band: 12 (1984)

Artikel: Two-level highway bridge in Maribor

Autor: Aanski, Vukašin / Koren, Peter

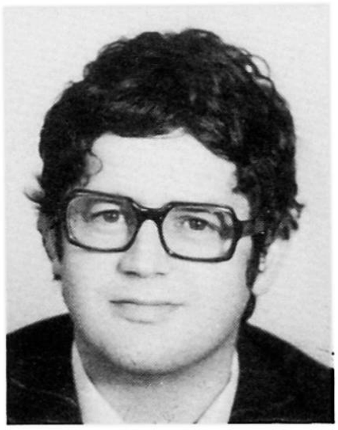
DOI: https://doi.org/10.5169/seals-12228

Two-Level Highway Bridge in Maribor

Pont autoroutier à deux niveaux à Maribor

Zwei-Etagen Brücke in Maribor

Vukašin AČANSKI
Prof. of Civil Eng.
Gip Gradis
Maribor, Yugoslavia



Mr. Ačanski was born in 1941 and awarded the Degree of Civil Engineering at University of Ljubljana. For 20 years he has been engaged in design of bridges and engineering structures. He is an adviser in the Design office of the firm, Gradis, and professor for prestressed concrete and bridge constructions at University in Maribor.

Peter KOREN
Civil Engineer
Gradis
Maribor, Yugoslavia

SUMMARY
A two-level bridge was built across the river Drava in Maribor. In the construction of the bridge, the technology of connecting the prefabricated line segments was used by grouting the elements with synthetic bonding agents (grouts) and by concreting the joints between the elements. The bridge was longitudinally prestressed and the carriageway slab was prestressed as well to obtain the continuity in the longitudinal and transverse direction.

RESUME
Un pont à deux niveaux a été construit à travers la rivière Drava à Maribor. Lors de la construction de ce pont, la technique employée pour réunir les segments linéaires préfabriqués a été éffectuée par assemblage avec des colles synthétiques (mortier) et par bétonnage des joints entre les éléments. Le pont a été longitudinalement précontraint ainsi que la dalle pour obtenir la continuité longitudinale et transversale.

ZUSAMMENFASSUNG
In Maribor wurde eine 2-Etagen-Brücke über den Fluss Drava ausgebaut. Bei der Ausführung wurde die Technologie der Verbindung von Linienfertigteilen mit den synthetischen Klebemitteln (Mörtel) verwendet. Die Fugen zwischen den Elementen wurden in Ortsbeton ausgeführt. Das Objekt wurde in Längsrichtung vorgespannt, die Fahrbahnplatte in Querrichtung. So wurde die Kontinuität in Längs- und Querrichtung erzielt.

Maribor is a typical two-banks town. All the major traffic lines cross the river Drava, as well as one of the most important traffic streams in Europe, E 93, extending from the Phyrn - highway in Austriá towards Balkan and the Near East. At the location of the European highway crossing the Drava there is also the center-point of the developing town and its traffic lines. Thus the solution to span the river for both, the transit and town traffic by means of one object, was evident by itself - that is to construct a two-level bridge. Such a solution allows the concentration of the otherwise unpleasant and expensive construction in the town area at one location, satisfying at the same time the requirements of both traffic types with only one site organization.

Maribor is a town of bridges and the new bridge has to be as well as possible incorporated into the town panorama, to serve by its function and aesthetic image the today and future generations (Fig. 1)

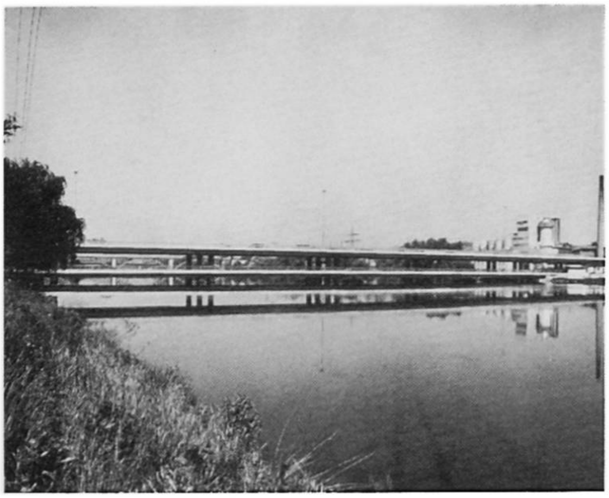


Fig. 1 : Bridge panorama

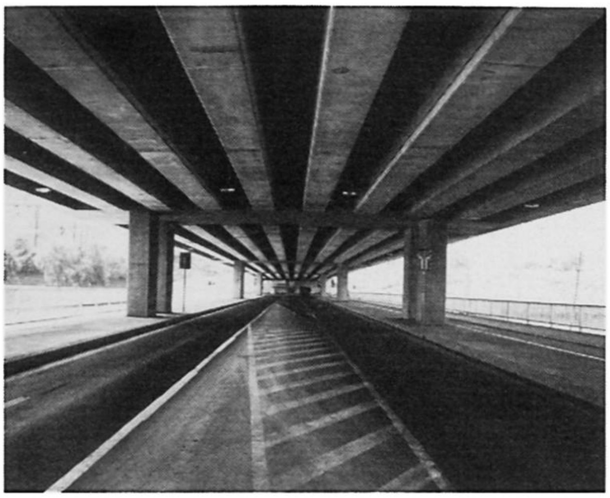


Fig. 2: The slab of the upper bridge

The grade line of the upper bridge carrying the highway is 8,0 m above the water level, and the grade line of the lower bridge serving for the local traffic is 2,0m above the water level.

The bridge is founded on bored piles. The spanning structure of both bridge levels is made of line segments - prefabricated concrete box girders connected into a ribbed slab (Fig. 2).

Such a system is frequently being used in the bridge construction. The environmental aspects of our country with a very diverse configuration, consisting of several wide and narrow valleys and rivers, as well as the need of constructing the two-level crossing for the highway and town road-network required to select a system that would satisfy all the above stated specifities. That system should be flexible enough to cover all the wide spectrum of bridging objects forms.

However, it is difficult to find the optima when looking for a system to allow a mostly industrialyzed construction using as few different elements as possible. In this endeavour, the investment possibilities force us to be even more rational.

Regarding all these facts it was decided to prefabricate the line segments. Such elements allow an industrial type construction with all the conveniences arising out of this method:

- the work conditions of the civil workers become equal as of the workers in factories,
- a high quality performance,
- permanent quality control,
- lower costs of the site organization,
- independence on the climate, season and weather conditions,
- reduced period of construction, as well as several other advantages.

Nevertheless, it is clear that the industrial type of construction has its deficiences of both, technical and organizational nature.

In their wish to design a very wide spectrum of structures, the designers are restricted by the limited number of prefabricated forms. So they have to use the methods that would increase the universality of the prefabricated elements. The system used for the construction of the bridge in Maribor tries to satisfy these requirements in the following ways:

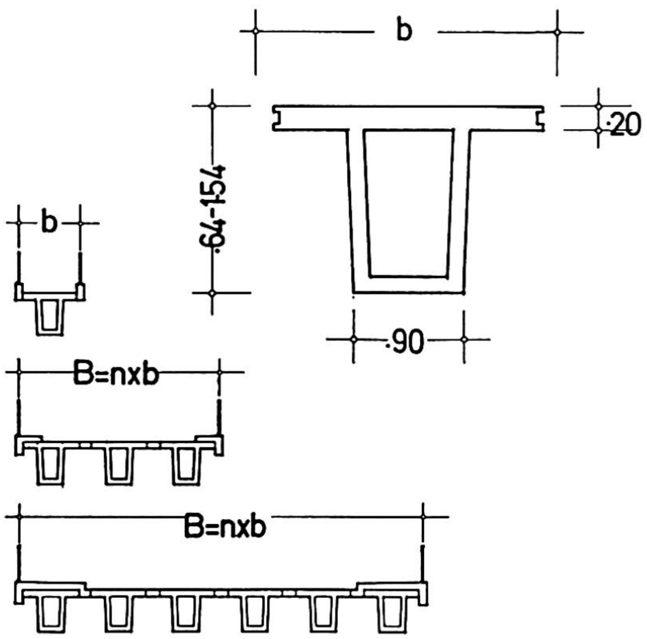


Fig. 3: Cross section of the box girder

- the selection of a line segment,that is a box girder with a wide upper flange representing the carriageway slab after in situ concreting (Fig. 3);
- the height of the beam can be modified in the same formwork, thus allowing the adaptation to various spans and permissible heights of the structure and at the same time assuring a better economy;
- the beam can be produced with a full or hollow web depending on the type of the reinforcement (prestressed or unstressed steel), the type of loading (frequency and magnitude), and on possibilities of combination with other prefabricated or in situ concreted elements. The capability of the transport and erection equipment were also considered;
- in the statical systems, the above stated beams can be used as line systems or concreted into ribbed slabs (polyhedral shells) acting as simple supported, continuous or frame systems (Fig. 4).

The segments were connected using two basic technologies:

- grouting the segments with high strength synthetic (epoxy) bonding agents, and
- concreting wet joints of bigger or smaller sections.

The grouting procedure is used mainly for joining the single elements into beams. This method is particularly suitable for prestressed beams where the necessary contact stress during grouting is obtained by partial prestressing (Fig. 5 and 6).

Such a technology allows to divide the line beam into segments of desired length, taking into account the transportation and erection requirements.

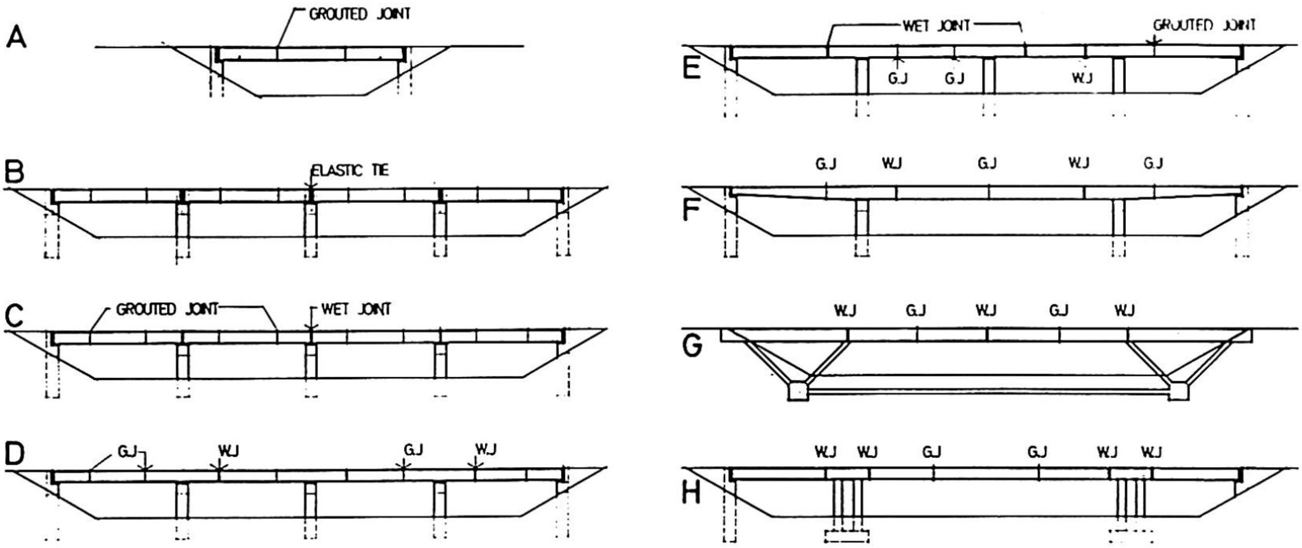


Fig. 4: Several possibilities of using the line segment in different statical systems.

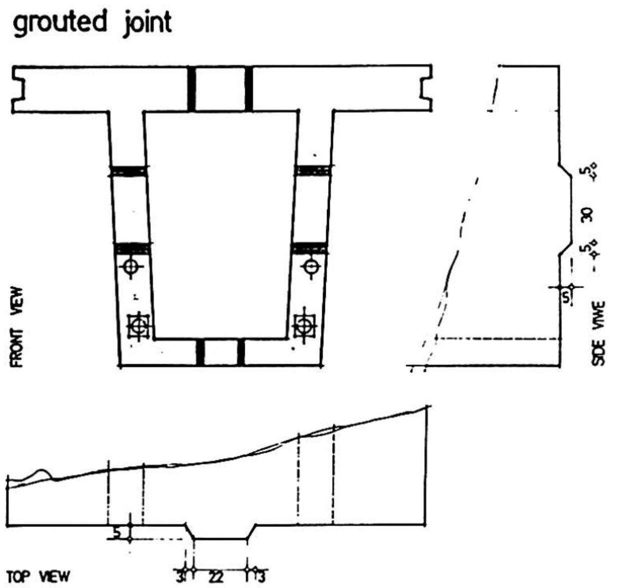


Fig. 5 : Execution of the grouted joint

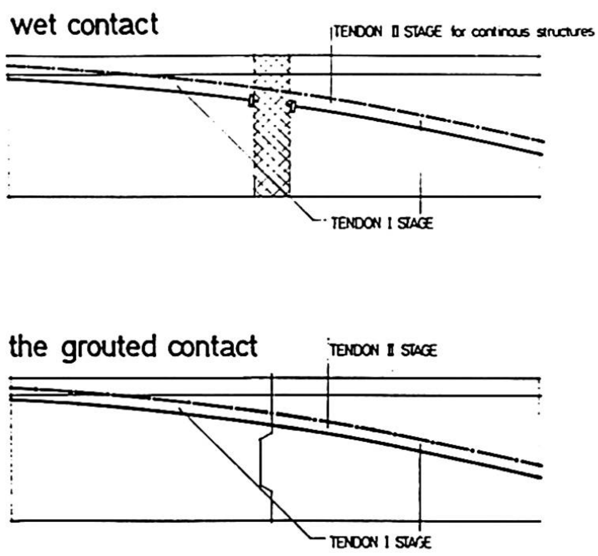
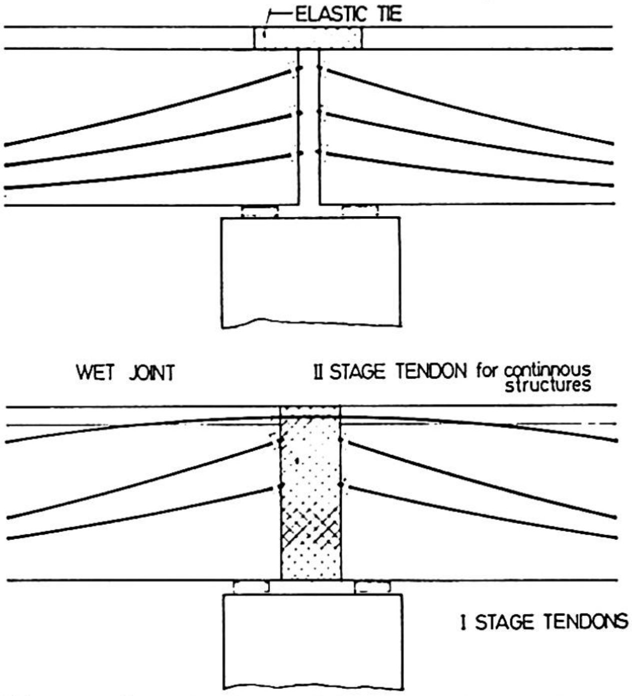


Fig. 6: Continuing of the beam with the grouted or wet joint.

Wet methods (i.e. in situ concreting) serve mainly for the longitudinal connection between beams, that means for formation of the carriageway slab with the possibility of width modification; for connection of the beams with other elements, e.c. cross elements, walls etc.; for erection of continuous elements that can be adapted to vertical curves; and for in situ casting of temporary hinges after erection (Fig. 7 and 8).



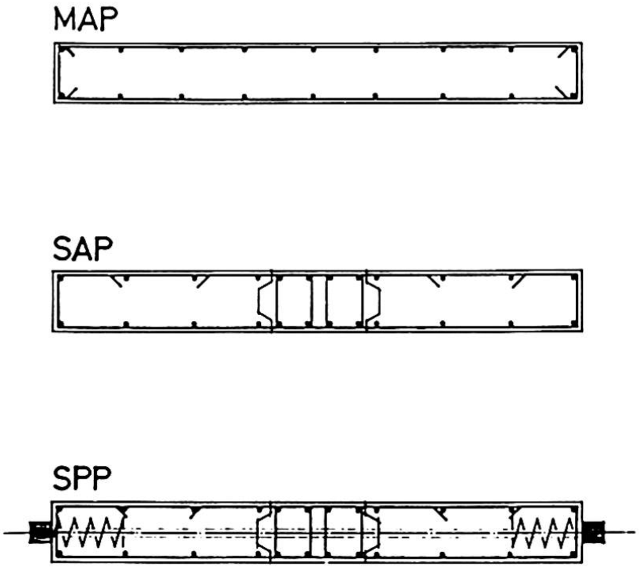


Fig.7: Continuing of beams above the support.

Fig. 8: Execution of the joint in the slab between the beams

All these joints are conventionally reinforced, and in prestressed systems also fully or partially prestressed.

The objects constructed according to the described system are conventionally reinforced or prestressed using a various percentage of the prestressing steel. Generally, the longitudinally prestressed beams are used, thus increasing the quality of jointing.

In the transverse direction - in slabs - the internal forces are carried by the reinforcement or by secondary transverse prestressing, using the tendons of smaller diameters.

Due to the specific form of the bridge in Maribor, several of the above described methods were used. Inspite of their heterogeneity, these methods have caused no truobles to the constructors; on the contrary, in some aspects they even helped to accelerate the construction and make it cheaper.

The beams used for the bridge were 154 cm high, with the 20 cm wide flange - slab, and 33, 25 m long (Fig. 9 and 10).

The upper bridge consists of 10 beams with the axial spacing of 2,0 m, and the lower one of 8 beams having the axial spacing 2,50 m. The slab of the prefabricated segment is 1,70 m wide; so the in situ concreted longitudinal joint in the upper level is 30 cm wide and in the lower level 50 cm wide.

In the longitudinal direction, the bridge crosses the river in 6 spans as a continuous two-level frame; the upper bridge is extended into the viaduct with three spans of the same length as in the bridge.

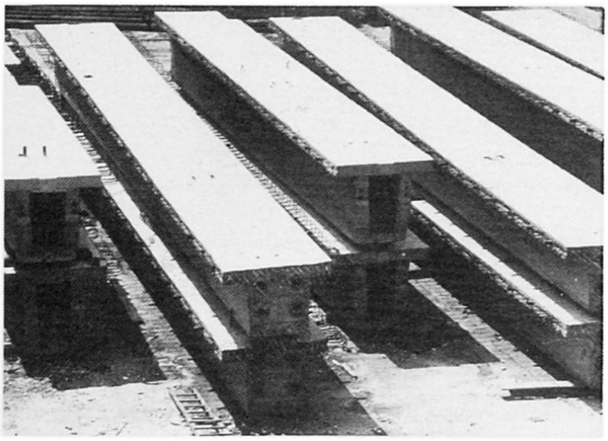


Fig. 9: Beams at the storage area.

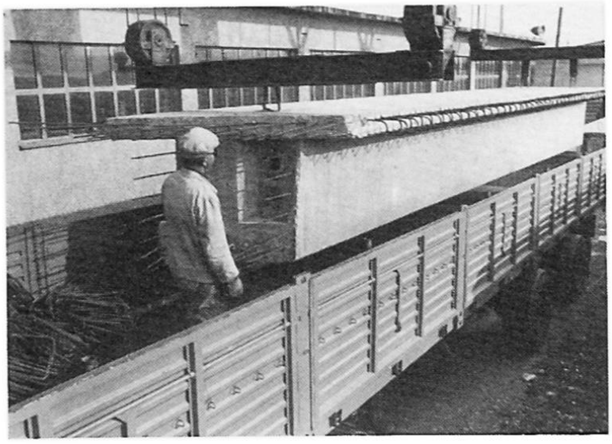


Fig. 10: Transportation to the site of construction.

The first phase of construction, foundations, were carried out using 8 bored piles of Benotto system for each support. The piles extended by round river piers carry the cross members of the lower bridge; on the piers there are coloumns carrying the cross members of the upper bridge. On the cross members there are suitable short brackets supporting the prefabricated beams. The beams were transported from the central fabrication shop, divided into three segments to be connected at the site with two-pack bonding agent (Fig. 11). Simply supported beams were prestressed using four tendons consisting of 24 parallel wires Ø 7 mm.

Fig. 11: Beams during grouting at the construction site.

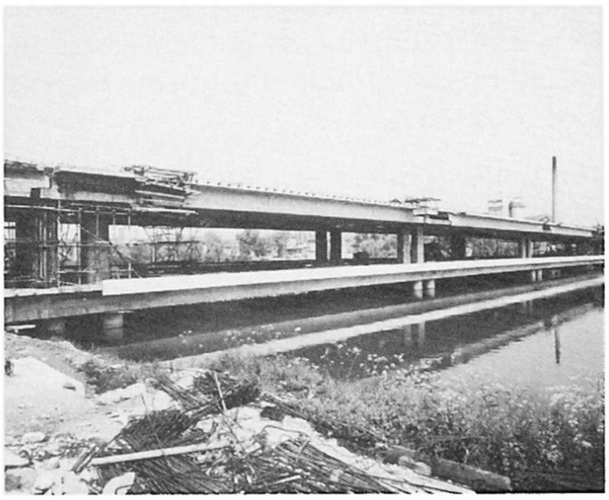


Fig. 12: The joint between the beam and the cross member before concreting.

The beams formed in this way have been put on the short cross member brackets and joined with the cross girders by in situ concreting. After that the longitudinal joints between the beams were concreted (Fig. 13).

This phase of construction was followed by second-phase prestressing, that is prestressing of continuous tendons consisting of 36 parallel wires Ø 7 mm. Each beam contains two such tendons. In the cross member of the central river pier the continuous tendons are lapped.

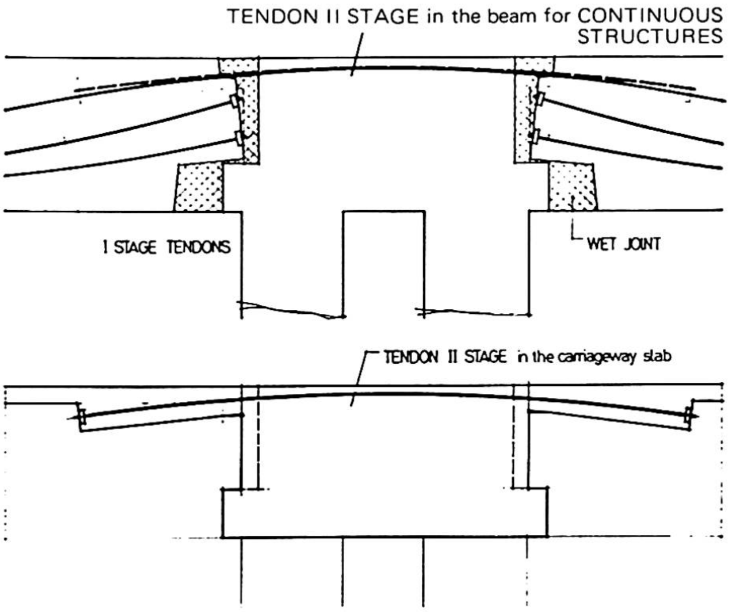


Fig.13: Connecting of the beam with the cross member.

The negative bending moments above the supports are additionally carried by two tendons consisting of 16 Ø 7 mm wires; the anchorage of the tendons was successfully effected in the longitudinal joints between the beams (Fig. 13).

Taking into account the rather large spacings between the webs (boxes) of the beams, especially in the lower bridge where several ducts have to be drawn between the webs, the bridge slab carries large loadings arising out of the local wheel loads as well as of the load distribution from single beams to other beams.

Reinforcing of the slab and the slab joint would require a large percent of reinforcing, therefore the slab was prestressed with tendons consisting of 16 paralles wires Ø 7 mm, spaced for 80 cm (Fig. 15).

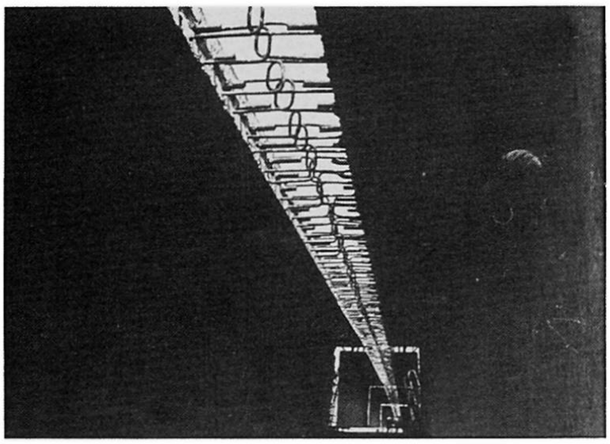


Fig. 14: The longitudinal joint before concreting.

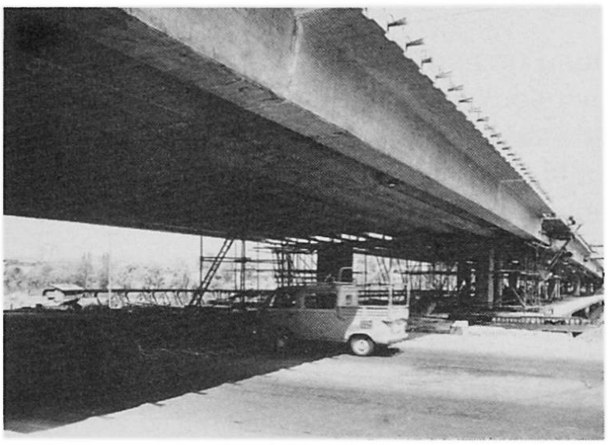


Fig. 15: The tendons in the slab after anchoring.

In this way a better economy was achieved and at the same time also better quality and durability by eliminating some cracks; in our climate conditions the upper surface of the structure is namely much exposed.

Using all the methods that can be satisfactorily rationalized through their frequency we obtained an object that is well connected in the transverse and longitudinal direction; thus increasing our confidence in a longer serviceability of the structure.

In the statical analysis the bridge was treated as space frame, taking into account that the slab acts as a polyhedral shell. In the static calculation this treatment was simplified into the model of the plain grid with the elements of a corresponding rigidity assuring a similar acting of both statical systems; the costs of the computerized calculation are lower. In general, several computerized investigations were made for the above described system of prefabrication; their correctness was proved by investigations on prototypes as well as by measurements on the completed objects.

Such investigations are reasonable as they make possible to simplify the statical analysis and to increase the economy in dimensioning the concrete sections and their reinforcement with bars and tendons.

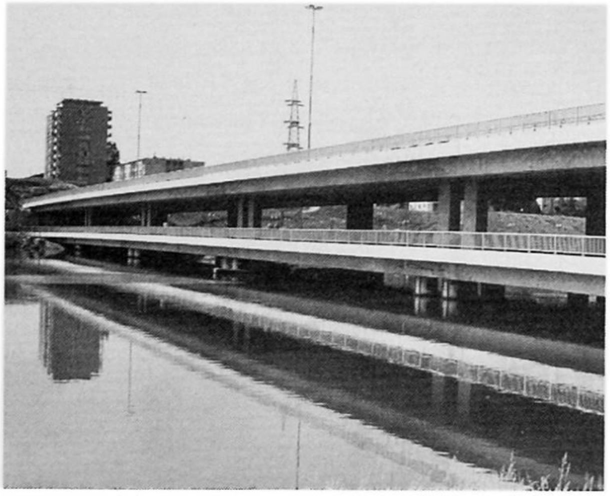


Fig. 16: View of the completed bridge

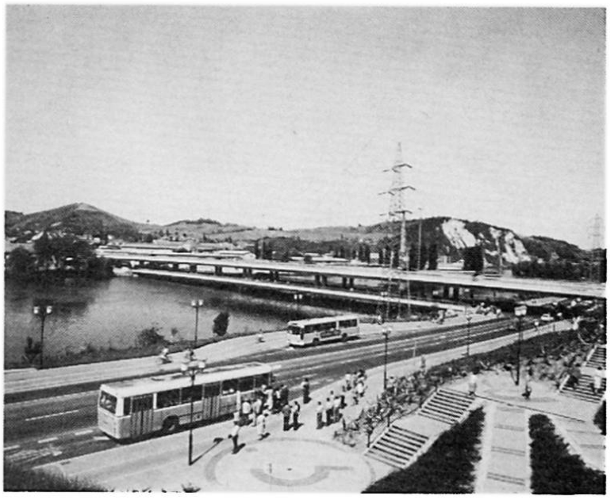


Fig. 17: The lower bridge has already been opened for the local traffic.

These investigations are still going on as the line segment system proved to be very convenient in our conditions of construction. New perceptions will be included into future explorations as well as the dimensioning methods existing in the world, yet taking into account the specific local conditions with the intention to construct the best objects in the most economic way.