Zeitschrift: IABSE reports = Rapports AIPC = IVBH Berichte

Band: 999 (1997)

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Autor: Unterholzner, Peter / Stiebellehner, Werner

DOI: https://doi.org/10.5169/seals-1053

Renewal of Bridge Superstructures under traffic at the A13 Brenner Motorway

Peter UNTERHOLZNER
Ingenieur
Alpen Strassen AG
Innsbruck, Austria

Peter Unterholzner, born 1940, received his civil engineering degree 1959 at the Technical College of Innsbruck.
Since 1973 chairman and since 1988 president of the Alpen Strassen AG.

Werner STIEBELLEHNER
Diplomingenieur
Wito-Konstruktionen Ges.m.b.H
Lienz, Austria

Werner Stiebellehner, born 1940, received his engineering degree 1966 at the Technical University of Vienna.
Since 1973 managing director of Wito-Konstruktionen Ges.m.b.H.

Summary

A number of bridge superstructures have been and will be repaired and renewed along the route of the A 13 Brenner Motorway in Tyrol, Austria. Hereby composites proved widely and advantageous. After a review on widening and repair work of various composite bridge decks it will be reported especially on the renewal of so-called 'Mushroom Bridge' deck slab by composite superstructures. The advantage of their construction, in particular, being accomplished under flowing traffic - even in winter - will be described.

1. Review:

In the course of widening works at the A 13 Brenner Motorway positive experiences were made with some composite bridges built more than 30 years ago.
A typical example was the widening of the two 'Gschnitztal Bridges' both situated side by side. There concrete deck slabs were dismantled and completely renewed one after the other. With the steel construction only the lower positioned windbracing had to be strengthened by welded straps.
A number of aspects led to this success: higher concrete quality in connection with transverse prestressing (less weight), segmental concrete puring sections in artful sequence (higher grade of compound) and new calculation methods with meanwhile lowered prescriptions of traffic loads.
Since both superstructures were widened one by one, traffic could flow during wintertime too. It was only restricted to one lane in each direction on one bridge. In the main travelling season both bridges were available, anyhow, with two lanes in each direction.

2. Disassembling and re-erection of so-called 'Mushroom Bridge' superstructures

These constructions are worth mentioning because of the very special solution and design work, which are required for the exchange of a superstructure carrying both traffic directions (full size bridge), without interruption of traffic.
It was an unavoidable condition that traffic could be restricted to one lane in each direction only between September and June. During the main season, however, two lanes in each direction have to be available.

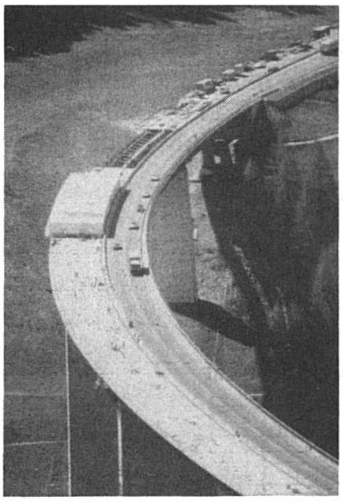

Fig. 1 Gschnitztal Bridges

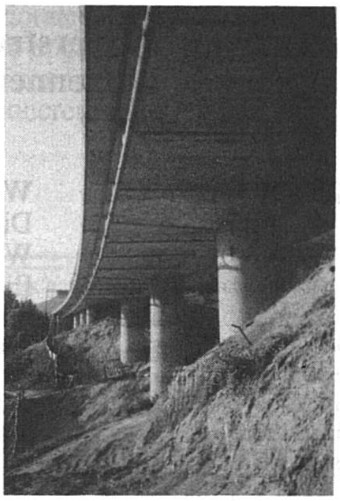

Fig. 2 Mushroom bridges (full size bridge)

2.1 The existing structures

The 'Mushroom Bridges' along the route of the A 13 were built thirty years ago. They are ten prestressed concrete bridges with a total area of 56.000 m². This variable bridge system was chosen at that time because of the difficult terrain situation, expected soil problems with the foundation as well as economic aspects. The full size bridges carrying both directions on one 'mushroom' have a typical span of 30 m. The half size bridges with only one traffic direction on a mushroom have one of 15 m. Each mushroom consists of a round, stiff bridge pier, which is fixed deap in the ground, and a very thin top slab being vouted towards the pier. Concrete hinges are connecting and supporting the mushroom structures.
During the time of existence, the influence of traffic loads and winter maintenance caused defects in all the system-required joints. Therefore an overall repair became necessary.
The repair work done at one mushroom bridge, by way of coupling together all the mushrooms to one single superstructure, proved almost as expensive as new bridge decks.

2.2 Project

An entirely new static system provides continuous beams supported by newly erected transverse pierheads which are attached to every old pier. This concept made it possible to support the superstructure as usual, but avoided a number of sensitive hinges and joints.
The first two bridges designed in this manner were put out for tender.The best bid was an alternative design which used composite instead of prestressed slab and beam construction. According to the good experiences with composites mentioned before, this variant design was applied by the authority to full and half size bridges.
Since the construction work under traffic is more remarkable in the case of full size bridges, this proceeding will be illustrated in detail.

2.3 Loads and design of composite superstructure

In addition to the standard loads, a 100 ton heavy vehicle load was taken into account with the static calculations. The final system of a full size bridge is a continuous superstructure of 1,8 m height. It consists of six steel main girders in longitudinal direction, a transverse steel truss every 6 m and a concrete deck slab, which is typical 22 cm thick.

2.4 Construction

Boundary conditions caused by the influence of traffic led to the following construction sequence within 3 working seasons – allways from September to June

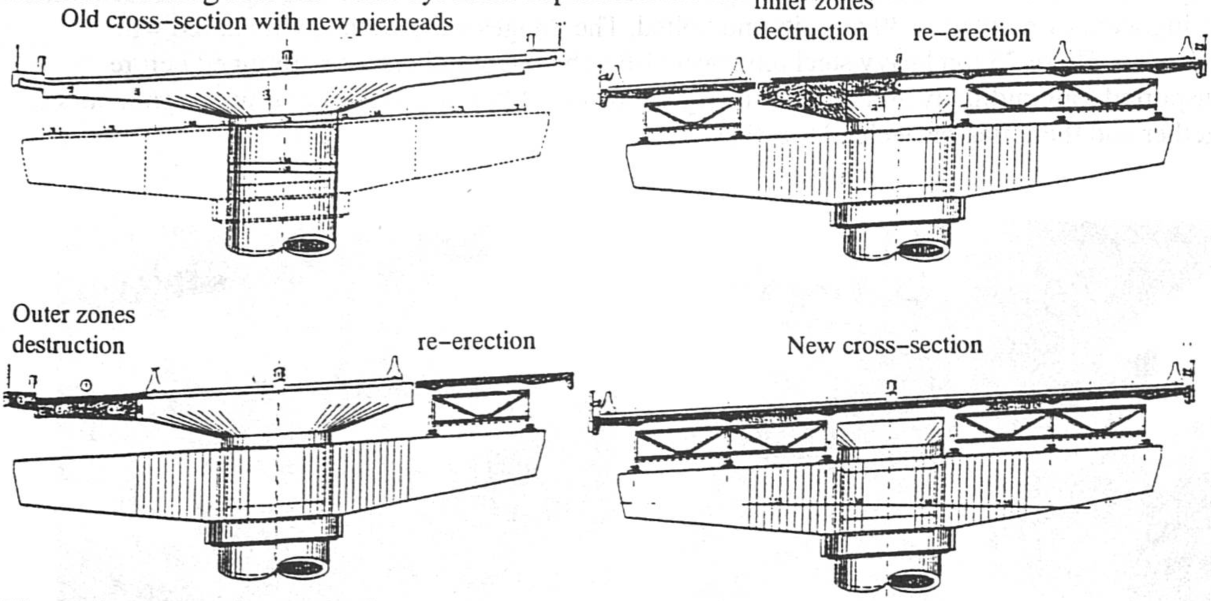

Fig. 3 Sequence of construction

From October 1992 to June 1993 the first half size mushroom bridge decks were reconstructed and new transverse pierheads for the full size bridge installed. In fall, winter and spring of 1993/94 the outer deck slab region and within the same period in 1994/95 the inner deck slab region were dismantled and re-erected. Two traffic lanes were always available, first at the inner and then at the new auter region. During each summer, traffic was flowing on both parts using four lanes. Speed was reduced to 80 km/h.

2.4.1 Destruction

The destruction of the bridge deck from out- to inside was exactly prepared. The concrete was machine cut by large diamond saw blades or in case of bigger volume by rope saws. For transportation two portal cranes were used being moved on longitudinally situated rails. The shipping weight of the concrete blocks lay between 6 and 18 tons.

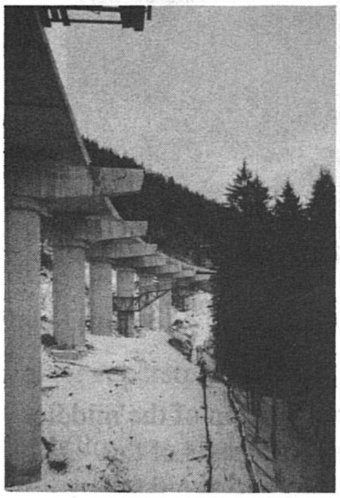

Fig. 4 Destruction outer deck slab

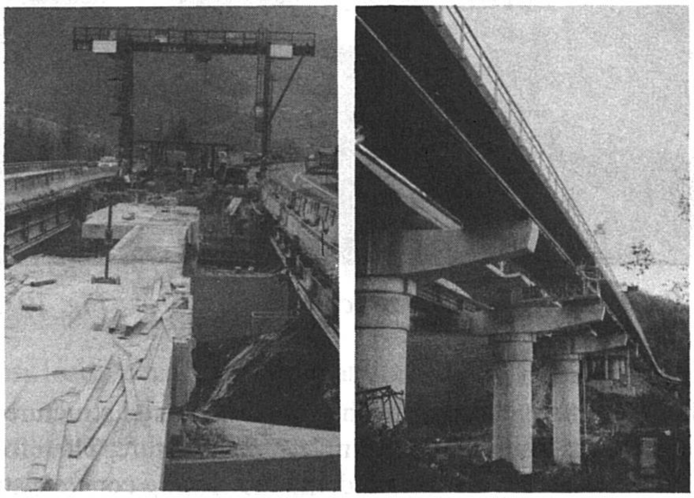

Fig. 5 and 6 Destruction inner deck slab

2.4.2 Steel Construction
The steel structure was produced in factory, derusted by sandblasting and coated with the first layer or with a rub resistant coating in the region of friction–type connections. Out side the actual bridge area (before or behind) four main girders, the transverse trusses belonging to them and the bracing were assembled in 30 m units and bolted. The flanges were welded with cored wire electrodes. These 23 ton heavy steel units were lifted by the portal cranes mentioned before, transported longitudinally and set into the right position. After that unit by unit were again bolted together and there flanges welded together.

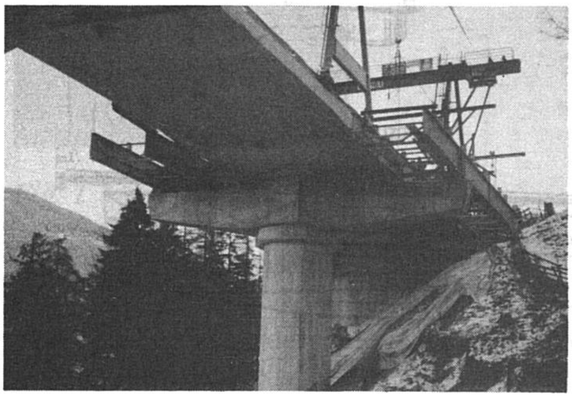

Fig. 7 Setting of steel units at outer structure

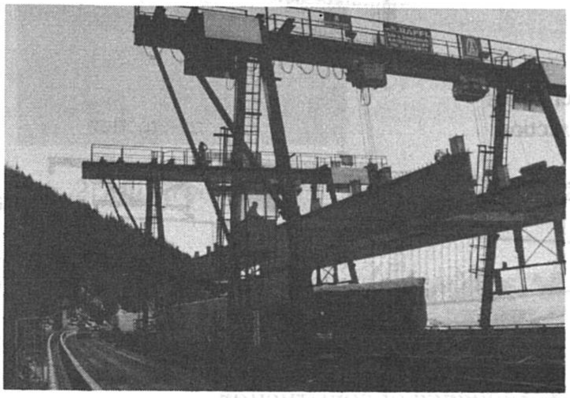

Fig. 8 Setting of steel units at inner structure

The assembling work and job site welding were done in wintertime, from December until March.

2.4.3 Top slab
The concreting of the top slab was done in 15 m units within five days. Gaps were left between in order to reduce the tensile stresses. Form carriages were moved on rails installed above and supported by lost concrete pads. By encasing and heating the form carriages, a continuous working cycle was possible even in wintertime.

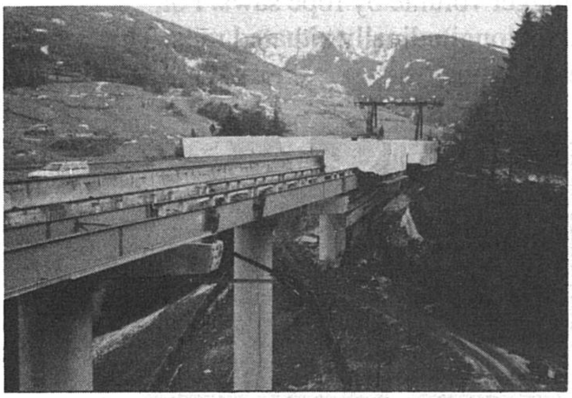

Fig. 9 Concreting at outer structure

Fig. 10 Concreting at inner structure

2.4.4 Completion
In the last construction phase the completed outer structure and the raw construction of the middle structure were unified to one single superstructure. Therefore the remaining steel parts of the transverse trusses were installed and the closing concrete stripes casted. In order to avoid strong vibrations this was done on the weekends when no trucks were going.

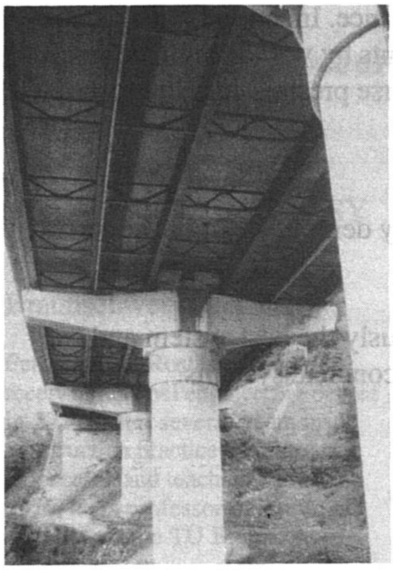

Fig. 11 Completed bridge

Both bridges were completed in time.

3. Preview

Because of its success the described method of renewing the bridges described before was also applied to further objects. 3 bridges are in reconstruction at the moment. They are expected to be completed by the summer of 1998.

4. Conclusion

Only because of the advantages of composites, the short schedules could be met, despite the narrow space situation beside traffic and the seasonal weather conditions.

The following advantages of the composite construction system were essential:

Labour and supervision intensive work on site are reduced by a far–reaching preproduction of the steel structure in the workshop and simple assembling on site.

Composite construction is a simple system which manages without heavy and costly scaffolding.

Overlapping steel and concrete work is possible by way of concreting the top slabs in segments one by one.

Continuous construction without delay can be done even in winter. Steel erection and welding with cored wire electrodes too is possible without any problem at minus degrees.

Only concreting in segments allows encasement and heating.

Lighter superstructures are possible with less load on piers and foundation.

The following advantages of composites will be useful in the future:

The composite deck is a wearing part with less lifetime than the rest of the structure. It can be removed and renewed in a simple way.

Composites can be changed easily, strengthened and widened for instance. Increased traffic loads and/or wider decks can be achieved in accordance to static requirements by way of higher rate of compound, higher concrete quality and reinforcement ratio or transverse prestressing. In most cases the steel part can be strengthened slightly and easily.

Maintenance is less expensive than with solid concrete structures.

And last but not least: in case of a pulling down of the bridge, the easy demolition of the concrete part and the easy recycling of the steel part are worth mentioning.

In view of economy and ecology the composite construction is obviously the best system and can compete – especially under certain circumstances – with prestressed concrete systems.

Involved Parties

Owner:
Austrian Federal Ministry for Economic Affairs
Bundesstrassenverwaltung Abt.VI/7
Stubenring 1
A-1011 Wien

Alpen Strassen AG
A-6020 Innsbruck, Austria

Design:
Tender project, design substructure and dismantling sequence
Kirsch – Muchitsch and partners, Consulting Engineers
Linz, Austria

Composite superstructure
Baumann – Obholzer, Consulting Engineers
Innsbruck, Austria

Supervising engineer:
Prof.Dipl.-Ing.Dr.techn.Manfred Wicke
Innsbruck, Austria

Contractor:
Concrete Joint Venture 'Mayreder-Innerebner-Stuag'
Steel Joint Venture 'Raffl-Wito-Hamberger'

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