Zeitschrift: IABSE reports = Rapports AIPC = IVBH Berichte

Band: 999 (1997)

Artikel: Composite bridges for high performance lines in Austria : trial calculation according to ENV 1994-2

Autor: Glatzl, Johann

DOI: https://doi.org/10.5169/seals-1033

Composite Bridges for High Performance Lines in Austria
Trial calculation according to ENV 1994-2

Johann GLATZL
Dr. tech.
HL-AG
Vienna, Austria

Johann Glatzl, born in 1957, got his civil engineering degree in 1980 and his doctor's degree in 1982 from the Technical University in Vienna. He is head of the bridge construction department at the HL-AG (railway high-performance route Plc.) and lecturer at the technical college for construction engineering in Vienna..

Summary

The application and further development of the composite construction method for railway bridges in Austria is demonstrated by some selected examples. A comparison calculation drawn up for a big railway bridge in Austria shows the differences in the results of the calculations in the comparison of the Austrian standards with the ENV 1994-2

1. Introduction

The political re-organization of Eastern Europe and the completion of the European home market have basically changed Europe at the end of the 20th century. More than ever before Austria - as a country in the heart of Europe - has become a transit country for passenger and freight traffic. A substantial part in mastering the traffic volume has to be taken over by a modern and efficient railway system.

The most important railway lines in Austria will become a part of the trans-European network (TEN). The inclusion in the trans-European railway network requires a certain standard in efficiency, capacity and velocity.

For the planning and the construction of such railway lines the "Eisenbahn-Hochleistungsstrecken-AG" (Railway high-performance route Plc.), or short "HL-AG" was founded in 1989. Our company has focused its activities on the expansion of the east-west-connection between Salzburg and Vienna.

Within the realization of these building projects, the composite method of construction became particularly significant for large bridges.

In the following pages some selected examples for composite bridges in the Austrian railway network will be briefly presented.

2. Railway Bridges in Composite Steel Construction Method

2.1 Gailitzbach Bridge

The Gailitzbach Bridge is situated at the railway line Villach - Tarvis - Pontebba - Udine, which forms one of the main thoroughfares of north-south traffic in the European railway network. Two one-track wing units were established to facilitate the maintenance and the renewal of the wing units. Apart from a reinforced concrete and a prestressed concrete solution a composite steel solution was examined as well. The latter provided for a girder bridge with a central span of 46.5 m, which was haunched in the area of the river crossing and which passed through 6 fields.

2.2 Vienna: A New Access Railway from the Western to the Eastern Railway Line

In the course of this project in Vienna also a draft for a composite bridge for the crossing of the Vienna valley was worked out. A double-tracked composite bridge was planned. The crossing of the road in the Vienna valley was planned with an arched bowstring steel bridge with orthotropic decking and a span of about 100 meters. The spans of the structures in composite steel construction were between 40 and 70 meters.

2.3 New Construction of the Railway Line Vienna - St. Pölten

For the crossing of the valley near Perschling several bridge solutions were worked out. One draft concerned a double-tracked composite bridge with an overall length of 600 meters. The bridge consists of 12 single-span structures with a span of 50 m each. Then main girders were designed as strut-braced trusses.

2.4 St. Pölten Freight Train By-Pass

The crossing of the river Traisen takes place over a three-spanned bridge construction. A draft plans a double-tracked composite steel bridge with solid beam webs, an overall span of about 150 meters and a central span of about 66 meters.

2.5 Railway Bridges over the Melk

In the course of the by-pass of the village of Melk two wing units had to be erected for being able to cross the Melk river and the federal highway B1. An approximately 150-meter-long, two-tracked railway bridge for the high-performance route and an approximately 300-meter-long, two-tracked railway bridge for the access route to the railway station in Melk had to be established. [1]

2.5.1 Bridge drafts - variants

After extensive examination of several variants a haunched -girder bridge with a monocellular box-type cross section was preferred and a composite steel and prestressed concrete version were worked out.

As a result of acoustic examinations the box-type cross section in the composite version was dismissed and an open cross section with two I-beam girders was followed up. According to practical experience and observations composite steel bridges are very suitable for meeting the requirements of modern railway infrastructure in connection with sound radiation because the mass of the wing unit is bigger than in the case of pure steel bridges and the inherent frequency differences of concrete plate and steel structure are so big that coupling effects and regenerative amplification resulting from this can be avoided.

The bridge objects concerned were constructed in such a way that the inherent frequencies of the concrete track plate, of the web plates and the main girder chords show a sufficiently big distance to the critical stimulating frequencies from the railway traffic.

The prevailing experience in railway bridge construction showed that in the case of the present dimensions and span ratios it cannot be said ad hoc whether the cheapest tender result can be reached by a composite steel or rather by a prestressed concrete version. As the tender prices are strongly dependent on the respective market situation, tenders for both composite steel and prestressed concrete versions were invited to reach an optimum economic tender result, and in the comparison of the tenders the maintenance costs were evaluated from the monetary point of view.

This led to the result that the composite steel version, which was more expensive than the prestressed concrete version seen from the tender result, was finally cheaper all in all considering the maintenance and dismantling costs and was therefore further developed.

2.5.2 Description of the structure

The wing unit of the bridge for the high-performance route is a haunched four-field girder with spans of 33 m - 48 m - 33 m and 41 m. The cross section of the wing unit is formed by two haunched web girders of the steel quality S355 JO and thermo-mechanically rolled steel of the quality DIMC-355B with singly reinforced composite plate made of B400 with overhead track. The height of the steel girders varies between 2.60 m at the abutments and 3.90 m at the pillars.

The wing unit of the bridge for the access route to the railway station of Melk is a haunched five-field girder with spans of 53 m - 53 m - 79 m - 53m - 36 m. The cross section of the wing unit is formed by two I-beam girders of the steel quality S355 Jo, thermo-mechanically rolled steel of the quality DIMC-355B and a singly reinforced composite plate made of B500. The height of the structure varies between 3.30 m at the abutments and 5.80 m at the pillars.

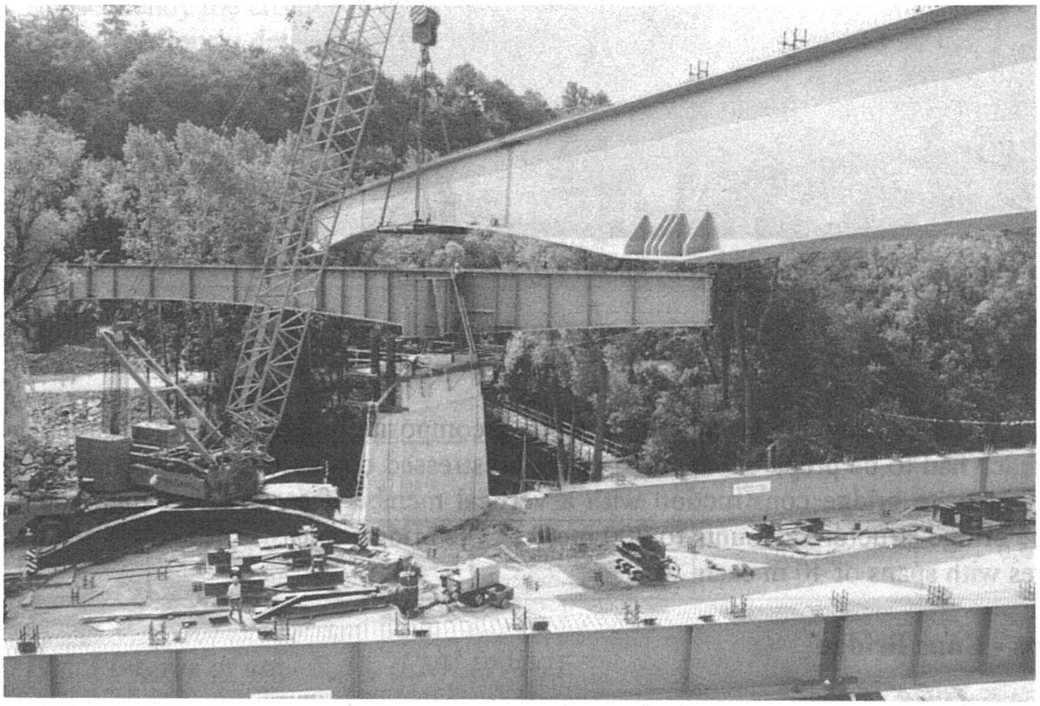

Fig. 1 Hoisting in a span crossing the river

2.5.3 Construction implementation

The approx. 1540-ton-heavy bridge parts were produced from October 1994 to May 1995 in Vienna. The essential parts were established from material with the quality DIMC-355B. Materials up to 90 mm thick were used. The strongest chords consisted of two 90 mm sheets that were up to 1400 mm wide. In the variation of material thickness particular importance was attached to fatigue-resistant construction. In the factory the individual feed scaffoldings with a height of up to 5.20 m, a length of approx. 25 m and a weight of up to 40 tons per piece were welded together. Three feed scaffoldings each, which spanned the river, were welded together to form one unit. The bigger parts with a length of approx. 70 m and weight of approx. 170 tons were mounted by means of mobile cranes. The composite plate of the main bridge was established in the concrete quality B400, that of the access bridge in B500.

The concrete plate is connected to the steel wing unit with setbolts. After completion and age-hardening of the composite plate the wing units were lowered to their final position. During the lowering procedure constructional prestressing of the composite plate was obtained through well-aimed lowering of the pillars.

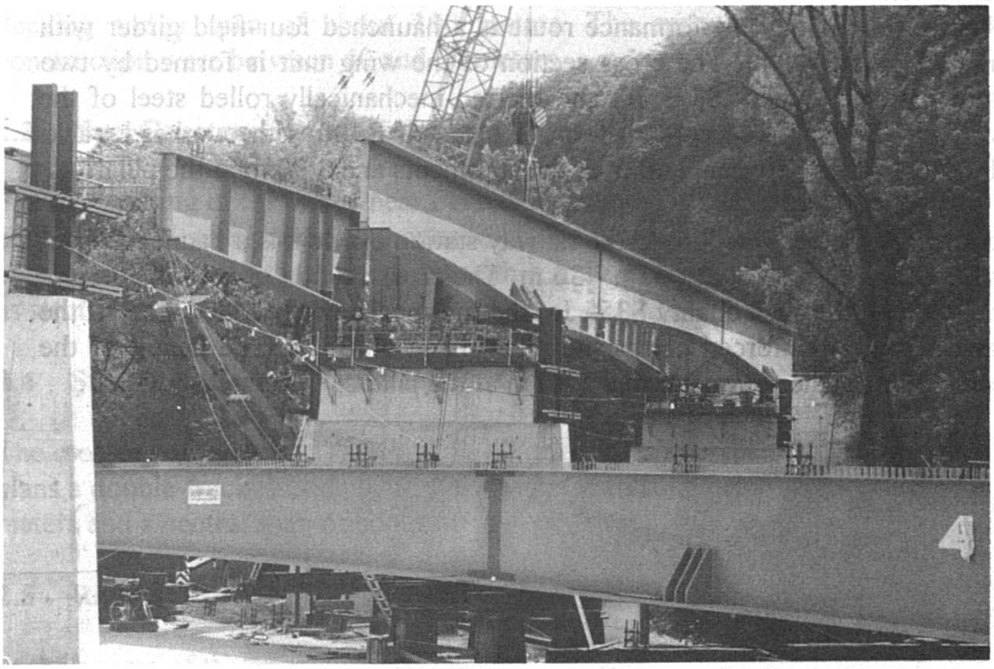

Fig. 2 Establishing and connecting the two main girders of the span crossing the river

2.6 Section Haag - St. Valentin

For the new building of the railway line Haag - St. Valentin a composite bridge draft for crossing the section Haagerbach had to be prepared, apart from the prestressed concrete draft. It concerns a double-tracked composite bridge construction with a vertical member-free strut bracing. The overall length of the bridge structure amounts to 200 meters. The bridge consists of 5 single-span composite structures with spans of 40 m each.

2.7 Enns By-Pass - Enns Bridge

For the bridging of the river Enns two pre-drafts for bridges were worked out, a composite bridge over the main supports and a prestressed concrete bridge solution. The overall span of this bridge project amounts to 413 m; the longest span is 120 m.

2.8 Innsbruck By-Pass

As the last bridge project the Inntal bridge is to be presented. It was erected in the course of the Innsbruck by-pass for which also a composite bridge draft was submitted. The design, however, was carried out as a curved, prestressed, open concrete trough bridge with an overall length of 488 meters. The structures consist of single-span beams with a length of 50 m. This bridge structure is located quite near the town of Innsbruck and spans the river Inn and the Inntal motorway.

3. Consequences of ENV 1994-2 Demonstrated by the Example of the Melk Railway Bridge

For composite steel railway bridges no Austrian standards were available. Therefore a separate calculation basis had to be created for every individual case on the basis of the Austrian norms regulating steel, concrete, composite and railway bridge construction.

In order to be able to study the consequences of the ENV 1994-2 (second draft - 1996), which was in the stage of development a calculation for comparison [4] for the bridge wing unit of the high-performance route in Melk on the basis of ENV 1994-2, was drawn up.

The measurements and material distribution for steel, concrete and reinforcement were taken out from the implementation documents. Then the static analyses for the first compression strut of the bridge construction were carried out according to ENV 1994-2 independently of the implementation statics. The load was calculated according to ENV 1991-3 and then the relevant loading condition combinations for the ultimate limit state (ULS), the serviceability limit state (SLS) and the fatigue limit state (FLS) were determined.

Subsequently the cross section resistance was calculated according to ENV 1994-2 and compared to the previously determined stresses, taking also into consideration the tension stiffening effects above the pillar. The degree of use = S_d/R_d can be seen in the table below for the ultimate limit state (ULS), the serviceability limit state (SLS) and the fatigue limit state (FLS).

	ULS	**SLS**	**FLS**
concrete	0,35	1,12	0,58
reinforcement	0,90	0,72	1,29
structure steel top flange	1,12	0,57	0,16(ts) 1,97
studs	0,69	0,67	0,69

Fig. 3 Degree of use - S_d/R_d (ENV 1994-2)

From the table the following can be seen:

- the ultimate limit state (ULS) and the serviceability limit state (SLS) show transgressions of approx. 12% for the structure steel and the concrete, which can be absolutely considered within the range of dispersion of the calculation codes.
- the fatigue limit state (FLS) shows a transgression of approx. 29% in the reinforcement, which leads to an increase of the single reinforcement if determined according to ENV 1994-2 compared to the Austrian norms.
- all three states show that in the case of design of the studs there is a reserve of 30% when calculated according to ENV 1994-2 compared to the Austrian norms, which leads to a significant reduction of the composite means.

All in all it can be ascertained that by calculating according to ENV 1994-2 and by taking into consideration the tension stiffening effects there is an increase in the single reinforcement above the pillar on the one hand and a clear reduction of the composite means on the other.

Thereby the composite action between the concrete track and the main steel girder becomes more elastic, which has a positive effect on the formation of cracks due to the setting heat flowing off and the shrinkage during the setting process of the concrete.

4. Conclusion

As the above statements show today solutions in modern railway bridge construction can be offered with the help of the composite steel construction method, which can optimally meet the requirements from the following points of view:

- efficiency for a modern rail infrastructure
- maintenance and utilization
- preservation of the environment and integration into the landscape
- economic efficiency.

5. References

[1] Glatzl, J.; Pommer, H.: "Neue Eisenbahnbrücken Melk in Stahl-Verbundbauweise" (New Railway Bridges in Melk in Composite Steel Construction Method) Stahlbau-Rundschau (survey on steel construction) 85/1995, p. 24-31

[2] ENV 1991-3 "Eurocode 1: Basis of design actions on structures. Part 3: Traffic loads on bridges" (1994)

[3] ENV 1994-2 (Second draft) "Eurocode 4: Design of composite steel and concrete structures. Part 2: Bridges" (1996)

[4] Tschemmernegg, F., Pattis, A.: "Vergleichsstatistik Eisenbahnbrücken Melk" (Comparison of Statics of the Railway Bridges in Melk), TU (Technical University) in Innsbruck