Truss composite bridges

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Summary

Out of the variety of all possible sorts of bridge construction in composite design the truss composite bridges are viewed more closely with regard to their constructive details. The profitabiliy of such constructions in fabrication and maintenance is pointed out. By means of projects which are already carried out it is gone in the special qualitiy of such bridges. Different erection methods, in special the erection of Innbridge Königswart, are presented.

1. General

If the two materials steel and concrete are combined in a functional way, composite main structures generally can be designated as an advanced method of construction. Economic constructions with low maintenance costs too result essentially from using the material concrete for compression stressed supporting elements and the material steel for shear and tensile stressed elements of a construction.

Out of the large spectrum of all possible bridge constructions I would like to pick out the truss composite bridges described in the following. The special way of construction where the steel top chord is surrounded by concrete will be explained particularly. For the first time this principle was applied in Germany as an advanced solution in steel railway bridges construction: The bridge Nesenbach Viaduct paved the way for many following projects in this type of construction as for example the Isarbridge in Großhesselohe, the Fuldatal bridge Kragenhof in Kassel and many other bridges for railway- and road traffic. Some of these kinds of bridges are mentioned in this paper, regarding only those, with one or more special qualities as described below:

2. Special Qualities of Truss Composite Bridges:

2.1 Fully welded construction with top chord surrounded by concrete.

On the basis of designing reasons the welded construction takes priority because of the plane surfaces resulting from welded constructions (on the contrary to screwed connections). The omission of joint plates causes not only a contribution to an easy way of production but also advantages in maintenance. Figure 1 shows the lower chord with the transition to the diagonal members. The plain transition in the node area is well to be seen.

At the Nesenbach - Viaduct (1) the top chord was embedded in concrete for the first time. Figure 2 shows the principal situation that the diagonal connections are also in the concrete girder, which results from a reinforcement in the area of the steel top chord. By total embedding the steel girder no weakening of the cross section takes place. Therefore always open sections like U- and H-sections are used for steel chords.

The transfer of the shear forces happens continously by a spreaded three sided arrangement of the stud shear connectors. In order to avoid any sudden concentrated force transfer, the connection of the diagonals to the top chord embedded in concrete is done with fillets analogous to the lower chord. Figure 2 shows how the transition between steel and concrete is demarcated by a horizontal metal sheet. This simplifies the maintenance for this detail. Corrosion damages are avoided considering a possible cross bending of the diagonals at this joint.

Only secondary tensions in the steel girders are caused by a nearly total accordance of the system lines of steel top chord and the concrete system of the top chord locally stressed by bending und longitudinal forces. This important aspect leads to exceptional economic steel masses.
Besides the mentioned technical details truss composite bridges have some important advantages compared to other types of construction: Apart from the economic advantage in erection and maintenance the aspect of environment has to be mentioned. Because of the low sound emission and the attractive design of the main structure the influence of such constructions on the environment is minimized.

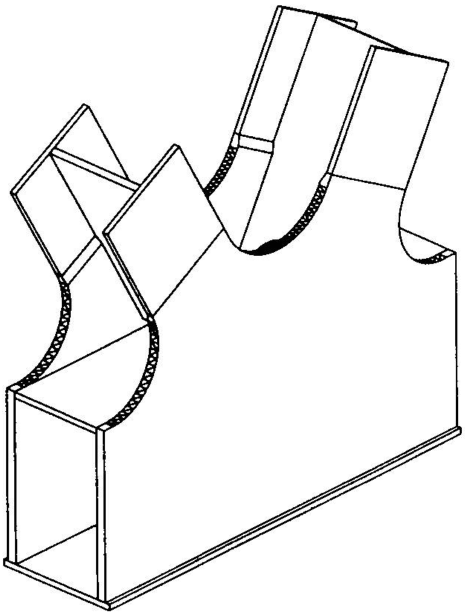

figure 1
(lower chord with the transition to the diagonal members)

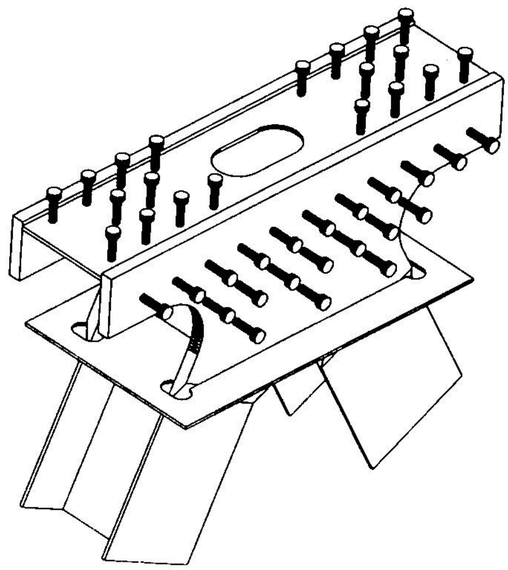

figure 2
(the principal situation that the diagonal connections are also in the concrete girder)

2.2 Sound emission and characteristic vibration

By means of ballast and the underlying concrete slab, thickness 40 - 60 cm, the bridges have a far bigger mass concentration under the rails in comparison to orthotropic steel slabs. Exactly this mass concentration in the sector of stimulating forces (wheel-rail-system) causes a convenient transfer of vibration energy to the remaining construction. The ballast und the concrete slab affect the resonance attidude in a positive way by means of their high damping property. Additional big slab fields, which maybe could respond inconveniently to the vibration transfer, are not caused by the truss girder construction. A convenient vibration attidude relating to the sound emission is caused by continous interruption of the stereoscopic fields and by the comparatively stiff nodes of the truss composite construction.

Such bridges can justly be named „whisper bridges“ as the sound emission on the bridge is not bigger than between stations.

2.3 Visual pollution controll

On the contrary to solid girder constructions the truss girder construction does not form such a strong optical barrier by means of a higher transparency. Demonstrated in many examples such bridges fit harmoniously in our landscape. The method of truss composite construction fulfills the demands of clients for utmost design preservation when replacing an old steel bridge by a new truss girder.

3. Selected bridges with different special qualities.

3.1 Innbridge Königswart.

In 1874 a truss composite bridge was erected in Königswart over the river Inn with the participation of the famous Bavarian bridge engineer Dr. Heinrich Gerber. The building owner, the Deutsche Bahn AG, decided for a new construction including the revamping of the piers. For the new construction a continous beam system built up as a truss deck bridge in the way of steel composite construction was chosen. This way of design pays attention to the visual pollution control because the truss fits harmoniously in the wonderful landscape. The span of the three fielded continous beam is 89,7m, 69m and 89,7m with a total length of 248,4 m (figure 3) between the abutment axes. The steel construction of the jambless strut frame has a constant hight of 6630mm (figure 4).

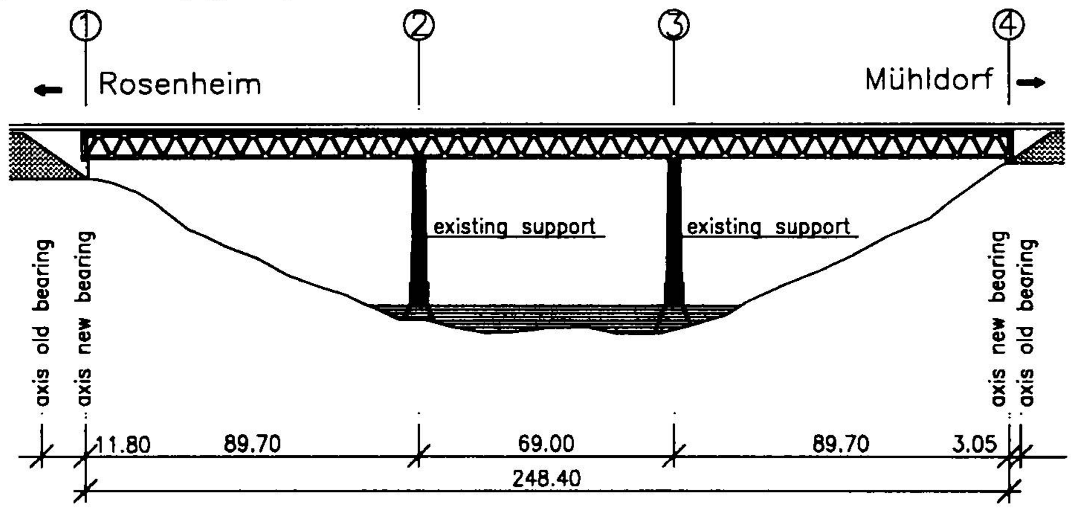

figure 3 (longitudinal view of Innbridge Königswart)

The system hight of the complete main structure is aprox. 6,3m. Therefore the relation of span to systemhight is calculated with aprox. 14 or 11 respectively. The center to center distance of the one truss girder structure is 4m. The steel mass is aprox. 810 to, that is equivalent to aprox. 3,3 to/m. At this bridge the top chord passes outside the concretee slab on the contrary to the bridges described in here. The bridge is also a completely welded construction. Above all in this project the erection plan is very remarkable. This will be discussed in a few words because of the special quality and the given construction situation.

The individual essential phases of erection are shown by means of dias. At the pre erection site behind the abutment in the bridge axis the delivered elements were assembled to large elements sized 90m, 70m and 90m. Afterwards this elements were moved and taken over from the transporter using temporary frames and launching beams. Now the three bridge elements were transported over the existing old bridge, moved to the final position and were welded together to the three field continous girder system. The new main structure was lifted and fixed in the bearing axis over the old bridge with so called „equipment towers" with cross beams making use of hydraulic lower jacks. Afterwards the existing old main structure was removed with transport units running on the top chord of the new main structure. Then the new main structure was lowered to the final position by lower jacks and put on the bearings. The concrete plate was produced in 18 concrete units.

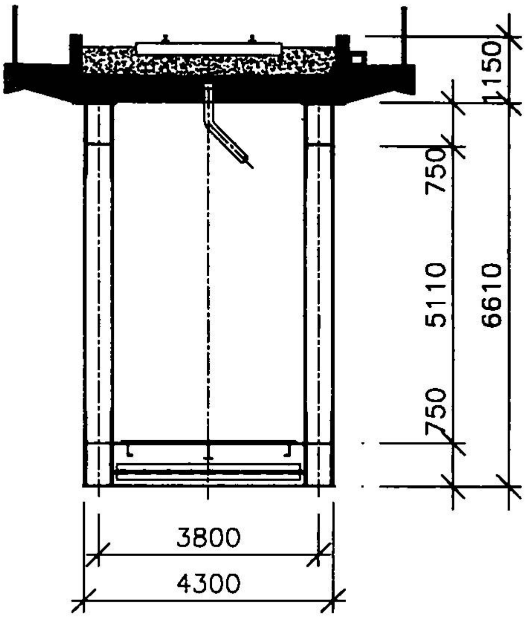

figure 4 (cross section of Innbridge Königswart)

Through this fast method of construction the environment was not much bothered with dust and sound. This interrupted the traffic only short. Through a high mass concentration in the ballast and through the composite slab the sound emission is reduced. Therefore the bridge can be called whisper bridge .

3.2 Railway bridge across the river ATTEL

This bridge, located close to the Königswarter Bridge is mentioned because the design of the composite slab is different to the one described before. The existing old main structure, built in 1873, fails to meet today's requirements and had to be renewed together with the substructure. The new main structure, a truss composite construction, is constructed with a concrete deck (figure 5). The span of the one fielded main structure is 60m. The height of the system is 4,3 m, with a distance of 2,7 between the truss levels. The mass allocation, 2,5to/m, is calculated from a weight of 152to.The cross section of the bridge is a two flanged T beam.

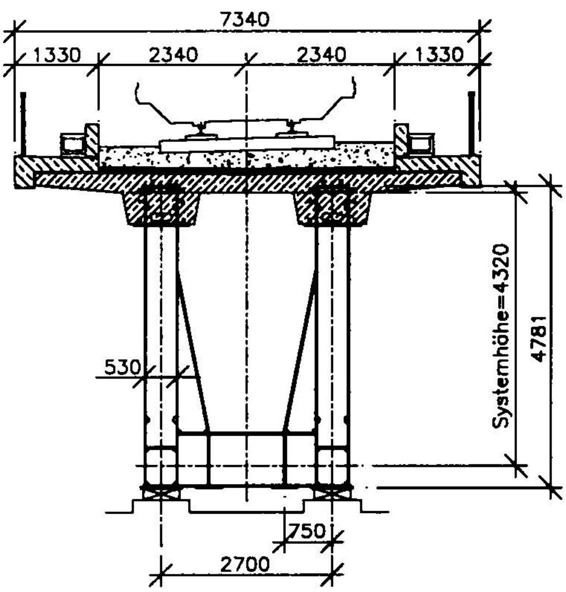

figure 5 (cross section of Attel Bridge)

The flanges are formed out of total welded jambless truss girders. The cross section of the 30cm sized concrete slab is constructed in such a way that the centre of the steel top chord is identical with the concrete slab. Welded open sections were used for top chords and diagonals, whereas the lower chord was constructed as an airproof welded box section.It is remarkable that it was possible to avoid a strenghtening of the joint plates in the initiation sector due to an appropriate selection of the plate thicknesses of the lower chords. This results in a functional and also visual pleasing detail solution because of the plane surfaces. Both in longitudinal-and cross direction the concrete slab is singly reinforced. In the sector of the truss top chords 50 cm high and 120 cm wide beams are planned which surround the steel chords totally.

In the following the method of erection and a rarely used method of dismantling are mentioned.

Parallel to the old main structure the new bridge is erected on cross adjustment ways. The truss walls are supported horizontally to the old wing unit, therefore it was possible to omit the very complicated additional bracing. After completion of concreting the couplings to the old main structure were removed. Following unusual dismantling of the old bridge was selected after finishing the parallel situated new main structure: The old bridge including abutments was removed by use of directed blastings. Afterwards the new bridge was traversed in the final position and put on the bearings. For erection of this bridge the old main structure was used as an important part in the erection concept.

3.3 Taggenbrunner Viaduct

Tenders for a new building were invited including technical and economic aspects, caused by the age of the bridges (built in 1905 and 1911) and the resulting efforts in repair. Attention was payed to the integration of the new main structures into the landscape. The old appearence of the bridge was to change only slightly. Therefore it was decided to leave the position and design of piers, of abutments and of parts built with bricks, to revamp them and to replace only the superstructure. (2)

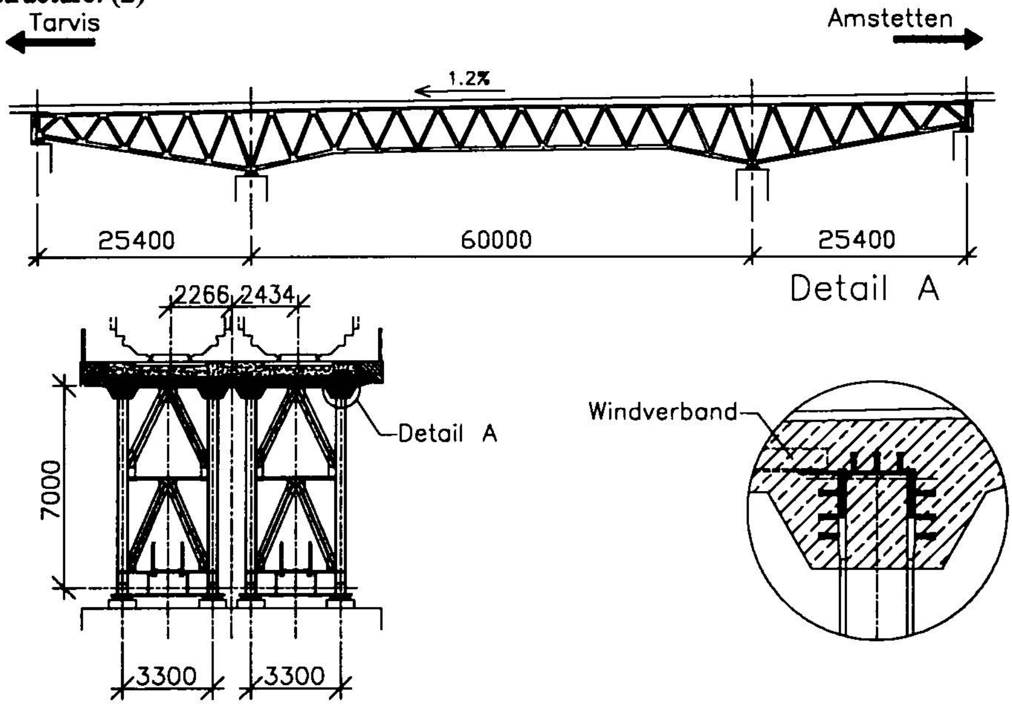

figure 6 (longitudinal and cross section of Taggenbrunner Viaduct, detail of upper chord)

In several intermediate stages in the competitive procurement procedure, in close cooperation with the client, the Austrian Railway company, a solution for the construction was found, which was applied for Austrian railway bridges for the first time. A system of contious beams was designed in the way of truss composite construction. For this double rail track again two single rail main structures were erected with the prescribed spans of 25,4 m, 60, and 25,4m caused by the old piers (figure 6).Therefore the total lenght between the abutments is 110,8m. The truss girders are arranged in a distance of 3,3m. The system height of the composite main structure varies from 5m in the middle of the span to 7m at the supports. The weight of both main structures amounts to 465 to. The mass allocation of the steel structure results in 2,1to/m per rail As a structural special quality I would like to remark, that welded U-sections were used for top and lower chords and rolled sections were used for diagonals. Therefore the members outside the concretee slab are open sections without exception. The site connections of top chord and lower chord are welded. Secondary truss elements were screwed to the main construction. For simplification of the erection, the chords of the diagonals were welded, whereas the webs were screwed. The top chord is completely embedded in the concrete slab and therefore it is placed in the system line of the composite slab. This way of construction practiced in other european countries was used in Austria for railway bridges for the first time. This construction leads to an economical steel mass possible despite of the unfavourable proportion of spans caused by the existing piers.For maintaining the traffic in this line at least on one rail it was necessary to dismantle respectively assemble the main structures one after the other. The new bridge was assembled on the ground parallel to the old bridge, afterwards the new bridge was lifted with jacks and traversed in the final position. After this the formwork was produced for the whole length of the bridge and the composite slab was concreted. After transferring the traffic to the new main structure the second main structure was erected in the same way. By selecting a bridge system with two separate main structures per rail it was possible to reduce the interruption of traffic to a minimum.

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