The Dreirosenbridge over the Rhine at Basel

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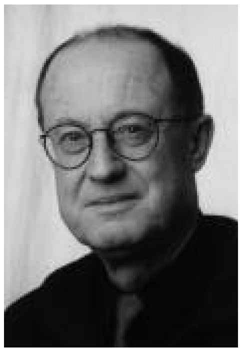

Summary

The Dreirosenbridge over the Rhine is a double decked continuous steel composite truss. It carries on the upper level the local traffic including a pedestrian promenade and on the lower deck the highway witch connects Germany with France crossing Switzerland.

Keywords: Double decked bridge, steel truss, composite bridge, Rhinebridge

1. Introduction

The Canton of Basel Stadt is presently building a new expressway the so called North-Tangent. It is closing the connection between the A2 Basle-Germany and the A35 in France. The 3.2 km long four lane dual carriage way will branch off the A2 via a set of curved viaducts which lead into a 1090 m long tunnel under the part of the city located on the right bank of the Rhine. The road will surface to cross the river on a new 266 m long double decked bridge and disappear again on the other side in a second stretch of tunnel, 1430 m long, which will end only 240 m before the Swiss-French border control post. The new link represents a total investment of about 1.1 billion Swiss francs, spent over a period of 10 years and is due for completion in 2005.

Within the scope of this paper only the marking point of the new link the crossing over the Rhine with a double decked bridge will be discussed. Due to the combination of the highway and the local traffic at the river crossing a double decked bridge was anticipated. On the lower deck is the 4-lane highway with additional 2 lanes and entries and exit ramps at both abutments. On the upper deck is the local traffic including streetcars and a promenade for the pedestrians.

The new Dreirosenbridge replaces the existing Steel bridge dated 1934, and is the result of a 3-stage competition. The stages were prequalification, idea competition and total contractor competition. For the total contractor competition 4 well renowned teams consisting of contractors, engineers and architects were selected to take part. The result of the competition is the chosen project DURCHBLICK. A solution was presented with a continuous steel truss and two concrete decks separated in two independent bridges which can be constructed and maintained separately. The other three competitors had all solutions with only one bridge.

2. The solution

Our solution DURCHBLICK has the following basic features:

- Double decked bridge
- Taking into account existing foundation
- Two independent bridges
- Use of the displaced old bridge as a temporary bridge during construction
- Use of the additional space on the upper deck to create a boulevard for the pedestrians.

From constructional, economical and esthetically points of view a composite bridge with a continuous steel truss and the roadway deck out of concrete was chosen. The slender steel diagonals which are filled with concrete inspired the name DURCHBLICK

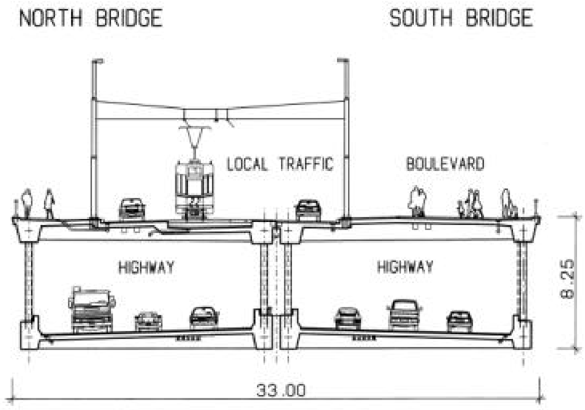

Fig. 1 Cross section

3. Description of the project

3.1 Superstructure

The superstructure is separated into two independent double decked composite bridges. Both bridges are practically identical and have the static system as a continuous girder of constant height with spans of 77+105+84 m. The longitudinal fixation is located on the pier close to Kleinbasel (Fig. 2).

The total width of both bridges is 33.0 m and the height 8.25m. The diagonals of the steel truss are welded hollow boxes 400 x 400 mm filled with concrete. The concrete decks are prestressed one way ribbed slabs with spacing of the ribs 7.0 m and a span of 14.7 m.

The upper deck is used by the local traffic, the streetcars, bicycles and pedestrians. In the middle of both bridges is a movement joint longitudinally which allows crossing of the traffic from one bridge to the other. A boulevard of 8.5 m was created due to the asymmetric position of the traffic. On the lower deck is the highway symmetrically with 3 lanes in each direction. To reduce the emission of noise and pollution the south side and ½ of the north side of the bridge are covered by a barrier made out of glass.

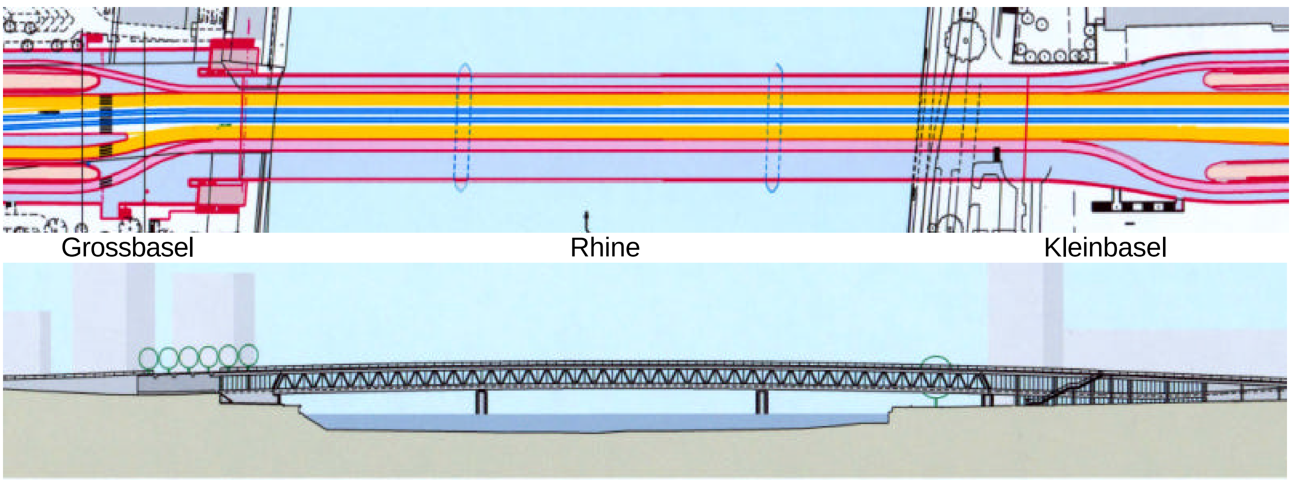

Fig. 2 Plan and elevation

3.2 Pier and abutment

The piers consist of massive concrete structures which are 40 m long and 4 m wide. They incorporate the old foundation and uses additionally bored piles ∅150 cm (Fig. 13). The construction of the piers was done within the protection sheet piles, which had to take a ship impact of 9.0 MN in direction of the river and 6.0 MN transverse to the stream. The piers are dimensioned for a ship impact of 19 MN longitudinal and 6.0 MN transverse.

The abutments are also resting on pile foundations, and are completely new constructed.

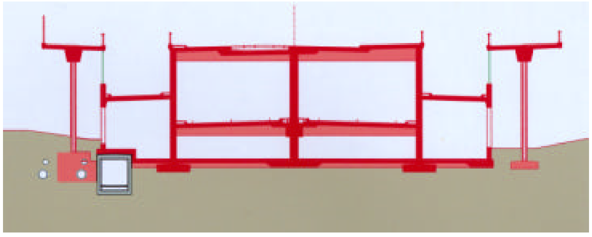

Fig. 3 Approach Kleinbasel

3.3 Approaches

The approaches are mainly jointless frame constructions resting on flat foundation with length of 126 m in Grossbasel and 132 m in Kleinbasel (Fig. 3 and 4).
The concrete deck slabs are similar to the one in the bridge are resting on a central concrete wall and two sidewalls (Fig. 4). In the transition from the bridge to the approaches the sidewalls develop in longitudinal ribs which are supported by columns in a 14.0 m spacing (Fig 3).

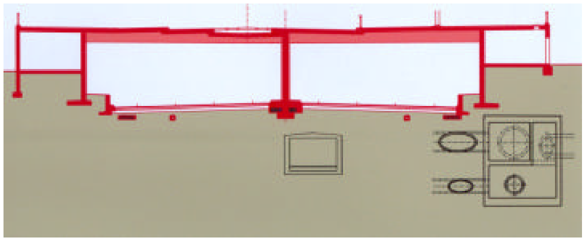

Fig. 4 Approach Grossbasel

4. Main elements

4.1 Truss nodes

The truss nodes are the key elements of the bridge. The steel diagonals, the steel chords, the conrete chords and the transverse ribs are all coming together in these nodes. The connection between the steel diagonals is done conventionally with gusset plates. The connection between the steel diagonals and the concrete chords is very important. Here two different materials meet, and the forces have to be transferred from one material to the other. Constructability and durability had also to be considered in the design of the nodes. Additionally the loads from the transverse concrete ribs are also introduced into the node.
The load transfer in transverse direction is done by prestressed tendons and shear ribs, and the load transfer in longitudinal direction is done by shear stud which are concentrated at the side plates of the node.

4.2 Frame

The steel nodes are also the key element for the frame action of the cross section. The frame consist of steel diagonals and the concrete deck with it post tensioned ribs spaced at 7.0 m. The concrete deck and the smeared steel diagonals build a stiff tube section wherein the nodes have to take the forces from the frame action. The stiff tube (cross section) has to take all horizontal forces due to wind action, earthquake the unintentional skewnwess of the top deck, and to transfer it down to the lower deck and from there down to the piers. No additional endframes are therefore necessary.

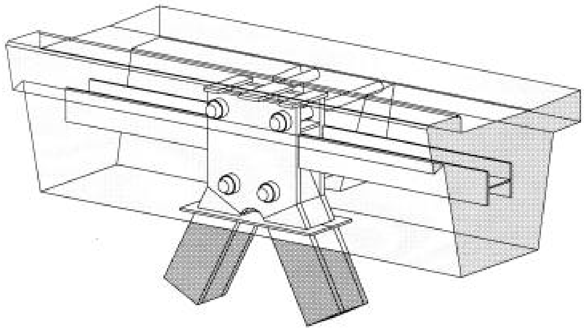

Fig. 5 Upper chord

4.3 Chords

The upper and lower chord consist from steel and concrete (Fig. 5 and 6). The steel chords are mainly used during construction and have a minor contribution at the final stage. The chords have to fulfill besides the static function the following :

- Encapsulation of the steel nodes for corrosion protection and aesthetics. Only the steel diagonals are seen.
- Room for the longitudinal post tensioning
- Room for the anchor heads of the transversal post tensioning.

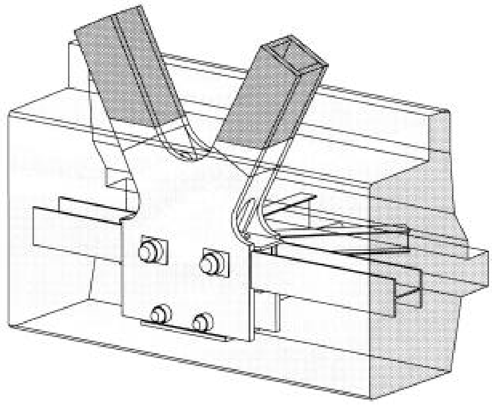

Fig. 6 Lower chord

In addition the cross section of the top chord allows the transition into the cross section of the two curved pedestrian viaducts which will branch of from the bridge on to the right bank of the Rhine.

The lower chord (Fig. 6) is formed at the inner surface as a “New Jersey” concrete barrier. The top part allows the fixation of the noise barrier made out of glass.

Fig. 7. Isometrie

5. Steel truss

The steel truss was originally designed from round tube sections diameter 500 mm welded together on the tip. After an economic and detailed construction evaluation it was decided to change to a quadratic section 400 by 400 mm welded together from steel plates and connected in the nodes by gusset plates. The steel quality of the diagonals are normal FeE 355 and thermo mechanic FeE 460 to ease the welding procedures of the steel plates witch have a thickness of up to 80 mm and the wells are full penetration V-welds. The location of the weld diagonals nodes are chosen as to allow at any time to control the fully penetrated welds by ultrasonic measurements.

The two temporary wind bracing used for erection form with the two steel trusses a space frame as shown in figure 7.

5.1 Static calculations

The static analysis was done on a space truss incorporating second order effects and the tolerances during construction.

The construction engineering was very complicated due to the different materials involved and the construction stages. First the steel truss alone was transported in two halves on the Rhine an welded together to form a continuous girder. Then the concrete was poured with the aid of two form traveler with the balanced cantilever method. The integral over all construction stages gives the superelevation for the steel truss.

5.2 Fabrication

The steel contractors fabricated in their workshops parts of the truss which consist in the tension diagonal and two nodes. These parts are transported to the field shop and assembled into the big truss by implementing the compression diagonals. With the wind bracing which is bolted to the trusses for multiple use the steel bridge is completed. For transportation on the Rhine the bridge is separated into two halves.

Fig.8 Node at pier

Fig. 9 Typical node

Fig. 10 Node at abutment

5.3 Construction

The two halves 133 m long and weighting 470 t will be transported on the Rhine with the help of pontoons and moored to the piers sidewards. After lifting the two bridge half to the required height the pontoons will be displaced along the piers and positioned. After lowering the two bridge half at the abutments the last connection piece can be placed in the center. Lifting the now connected steel bridge at the abutments for about 500 mm favorable secondary moments are introduced in the now continuous girder.

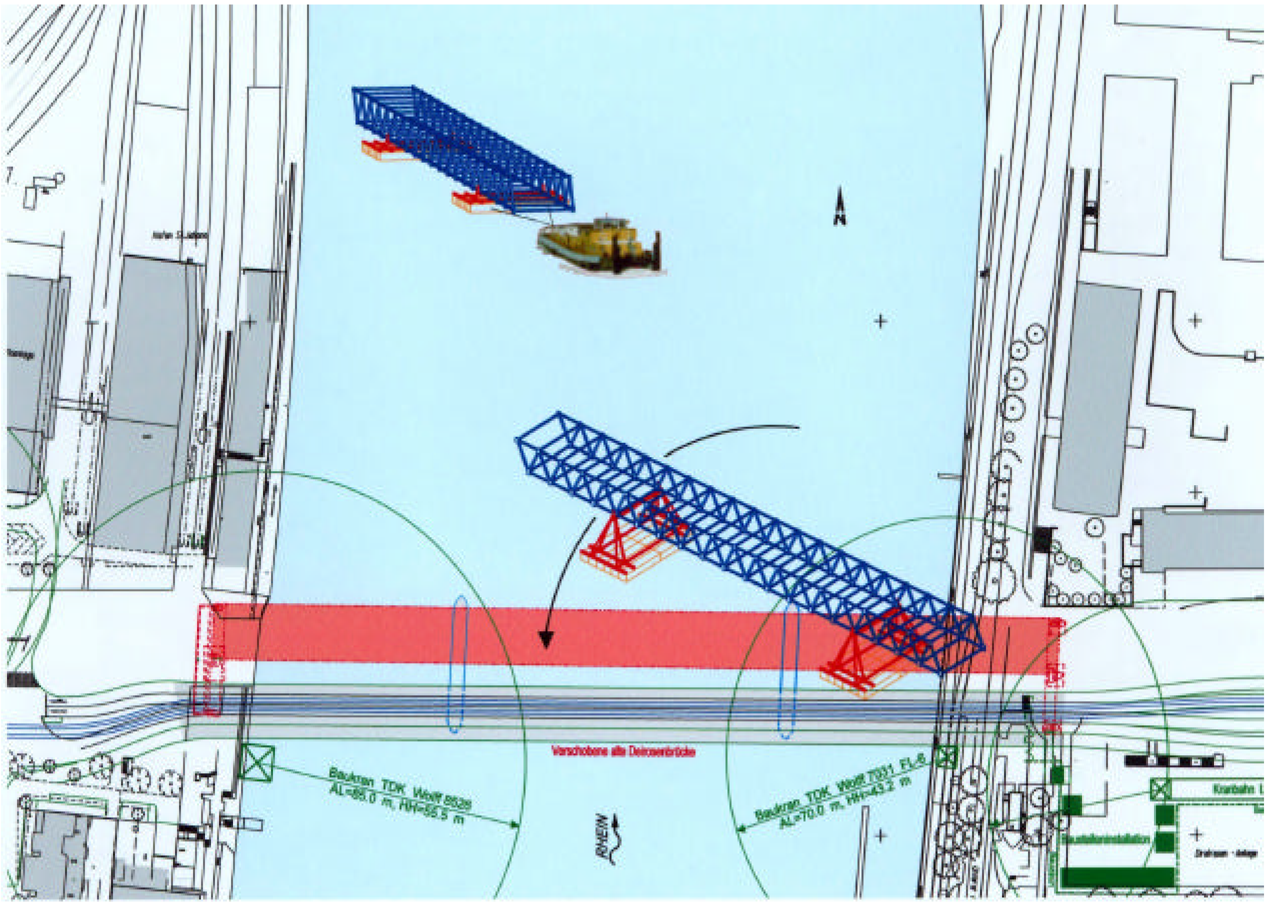

Fig. 11 Construction of the steel truss

6. Form traveler

For the concreting of the two decks, two form travelers are installed. The length of one pour is 7.0 m which is also the distance between two nodes. The casting is done from the pier symmetrically to the center of the span in a cycle of one week.
Each form traveler is built up from 3 transverse steel trusses and 2 longitudinal steel trusses, which form together a space frame. The formwork is hung from the transverse trusses on tension rods.

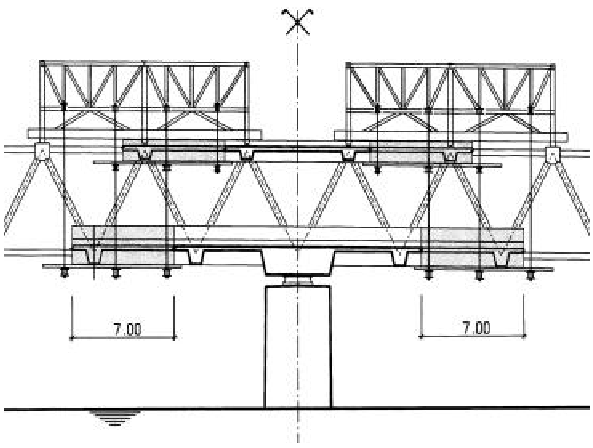

Fig. 12 Form traveler

7. Construction sequences

The construction of the bridge is separated into 5 different phases. During all construction phases the public traffic has to be maintained. Only short interruptions are allowed.
The total construction time is 48 month.

- Phase 1
  - Build temporary ramps at the abutments
  - Build new piers within the protection of the from sheet pile casing
  - Preparation of the rails for transversal

- Phase 2 (Figure 13)
  - Translation of the old bridge

- Phase 3 (Figure 14)
  - Build abutments
  - Erection of the steel truss.
  - Build the fist bridge (north bridge)
  - After completion of the steel bridge, the cross beams at the abutment and over the piers are cast on conventional formwork and set on the definitive bearings. Construction of the concrete decks by balanced cantilever method in a weekly cycle.
  - Demolition of the old adjoining ramps

- Phase 4
  - Demolition of the old bridge and removal
  - Demolition of the temporary ramps
  - Construction of the south bridge and the adjoining ramps

- Phase 5 (Figure 15)
  - Transversal displacement of the south bridge to the north bridge
  - Finishing works

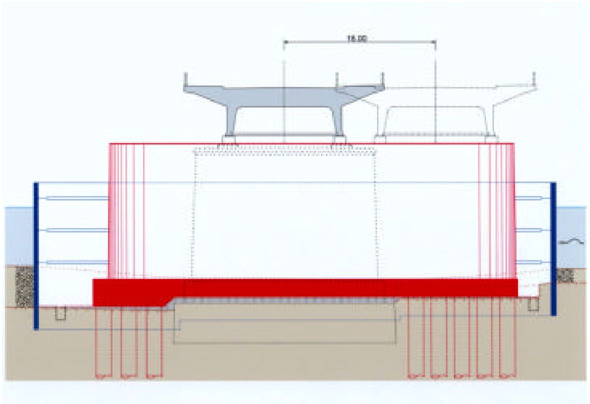

Fig. 13 Displacement of the old bridge

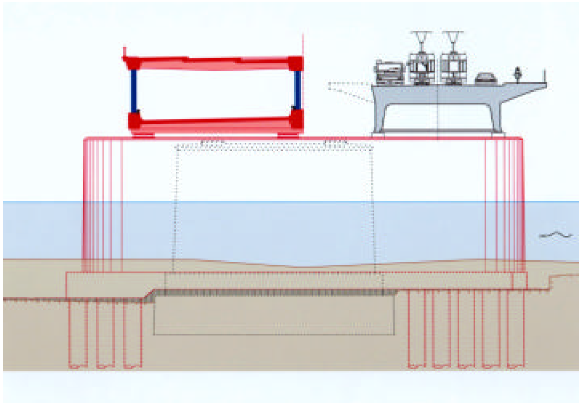

Fig. 14 Construction of the north bridge

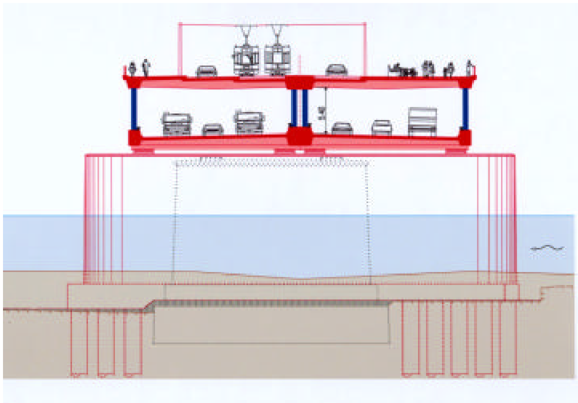

Fig. 15 After completion

7. Technical data

Concrete	15'000 m3
Mild steel	1900 to
Prestressing steel	400 to
Steel	2 x 800 to
Highway	2 x 3 lanes
Local traffic	2 x 1 lane
Streetcar traffic	2 x 1 lane
Bicycle (North/South)	2.15 m/3.15 m
Pedestrians (Boulevard)	2.50 m/8.50 m

Fig. 16 Photomontage

8. Intervening parties

Owner:

Kanton Basel-Stadt, Baudepartement, Tiefbauamt

Contractors Dreirosenbrücke:

Spaltenstein Hoch + Tiefbau AG, Lead
Batigroup AG Basel
Frutiger AG
Jean Cron AG
Straumann-Hipp AG

Engineers:

Bänziger+Bacchetta+Partner, Lead
ACS-Partner AG
Cyril Burger & Partner AG
Dauner Ingeneiuers Conseils SA
Steib W. u. K. Architekten

Steel Contractors:

Preiswerk+Esser AG, Federführung
Giovanola Frères SA
Tuchschmid Engineering AG

9. Final Comment

All the details and difficulties encountered in building the above described bridge could only be solved by a good team work and a good bases of experience by contractors and engineers.

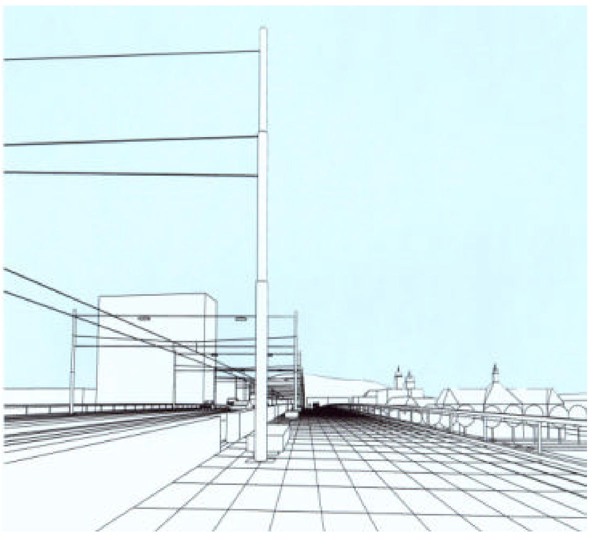

Fig. 16: *Boulevard*