# Bridge over the IJssel

SSF Ingenieure

Picture credits: SSF Ingenieure AG / Florian Schreiber Fotografie

The new IJssel Bridge is part of the 50 km long new railway line Hanzelijn from Zwolle to Lelystad. The double-tracked structure spans the IJssel with a length of 930 m including the foreland areas, and connects the communities Zwolle and Hattem. The span widths are 33.34 + 4x40.00 + 75.00 + 150.00 + 75.00 + 10x40.00 + 33.13 m. The clearance height is 9.1 m above the river, enabling unrestricted ship navigation also during high tide.

The contract for construction of the railway bridge was awarded to the construction consortium Welling-Züblin-Donges together with Quist Wintermans Architekten, SSF Ingenieure and Grontmij, wining the two-stage design competition.
Five prequalified entrants each consisting of construction enterprises, architects and designers had been invited to the competition, organized as design-cost-built optimisation process. The design was established in close dialogue with the client ProRail/ Utrecht, who had only set in advance the boundary conditions and not the bridge's design.

In contrast to public award procedures in Germany, where preliminary design including the call for tenders is distinguished from contract award on the basis of clearly described construction services, in this project the competition winner was not only draft designer but also structural engineer and constructor of the bridge.

**Western foreshore bridge** seen from abutment Hattem

Not the offered price, but the design of the load-bearing structure was decisive for the award decision. Railway bridges are in general rather massive structures because of the high load and high stiffness requirements they have to meet. Contrary to usually bulky appearing bridge types, a modest design has been successfully implemented, integrating itself into the flat landscape. After contract award, the design joint venture SSF Ingenieure / ABT adviseurs in bouwtechniek has been charged with structural engineering of the bridge, and the company Max Bögl with execution of steelworks.

The superstructure of the bridge is a composite load-bearing structure with external air-tightly welded steel box girders, continuous over the whole bridge length. Above the spans, widening in the areas over the IJssel, the girders merge into an arch-shaped truss. The continuous effect of the arch leads to a relatively low arch height with a maximum rise of only around 15 m at a span width of 150 m. The concrete track slab between the main girders with the ballast bed is supported on cross girders at distances of 3.3 to 3.5 m.

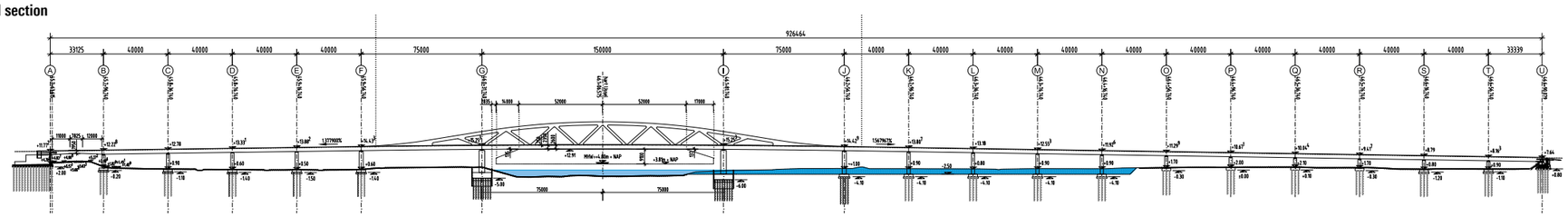
In addition to rail traffic, a pedestrian sidewalk with cyclist lane had to be installed over the whole bridge. For architectonic reasons it is separated from the main cross section and connected by cantilever arms to the main cross section on one bridge side, so

| **Data** | |
|---|---|
| Project | Railway bridge over the IJssel<br>part of new railway line Hanzelijn between Lelystad and Zwolle, Netherlands |
| Client | ProRail, Utrecht, Netherlands |
| Construction type | 2-tracked steel composite superstructure with truss arch over river, and laterally suspended sidewalk |
| Span widths in m | 33.34 + 4 x 40.00 + 75.00 + 150.00 + 75.00 + 10 x 40.00 + 33.13 = 926.47 |
| Particularities | wining design in a design-build award process 927 m long structure without expansion joints – composite superstructure connected to abutment at Hattem |
| Superstructure railway bridge | ballasted |
| Construction costs | approx. 50 m Euro |
| Services SSF | basic evaluation, preliminary and draft design, approval and final design, preparation of tenders for both project planning and structural engineering |
| Planning period | final design 2008 to 2010 |

**Completed and planned bridge** in comparison

Picture credits (above): SSF Ingenieure AG / Florian Schreiber Fotografie / Visualisation (below): Quist Wintermans Architekten

**Longitudinal section**



**Side view**

that the load-bearing effect of the supported cross section areas was a structurally difficult design task to be solved. The cross section of the sidewalk is, just like the main bridge, a composite structure with concrete slab. Advantages of low icing potential in the winter and low noise pollution led to the choice of a concrete slab instead of an orthotropic slab. The geometry of the load-bearing structure with variable cross sections due to the arch's incline and with curved outline on the side of Zwolle as well as the widening rail bed on the side of Hattem offered a challenge to design and construction execution. An economic structural and workshop design, delivered in the given time frame, was only possible by 3D modelling. There are no joints in the continuous bridge superstructure so as to eliminate damage-susceptible transitions as well as quick wear of the track superstructure in these areas.

**View of the new bridge** over the IJssel; in the background the old one, which will be demolished

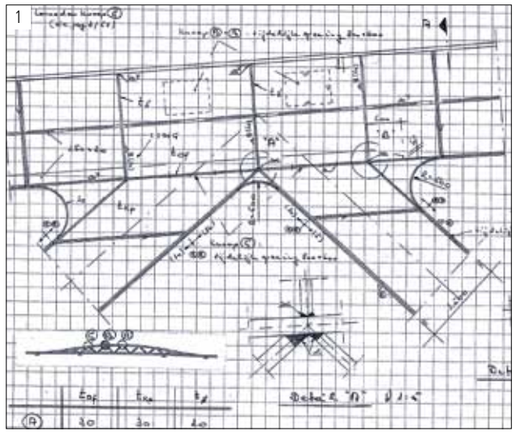
Picture credit: SSF ingenieure AG / Florian Schreiber Fotografie

Moreover, the switches on the superstructure made spacious rail interruptions impracticable. Rail fasteners have only been planned on one side, that is the abutment in Zwolle, in the radially curved track. In Hattem the superstructure is connected bending-stiff to the abutment, entailing a much easier distribution of high horizontal forces of about 2600 t of the long load-bearing structure than it is the case with bearings.

The substructures consist of architecturally designed piers expanding from bottom to top with opening angle of 73°. The modest forms and the discrete gray of the concrete emphasise the superstructure painted in red, optically highlighting the function of the railway bridge. The abutments and piers are founded on prefabricated concrete piles (□ 450 mm, l = between 11 mm and 22 mm) by pile driving method. A total of 764 piles with a

**1** **Drawing** of a truss node
**2** **Lifting and assembly** of the closed-cell steel boxes

1



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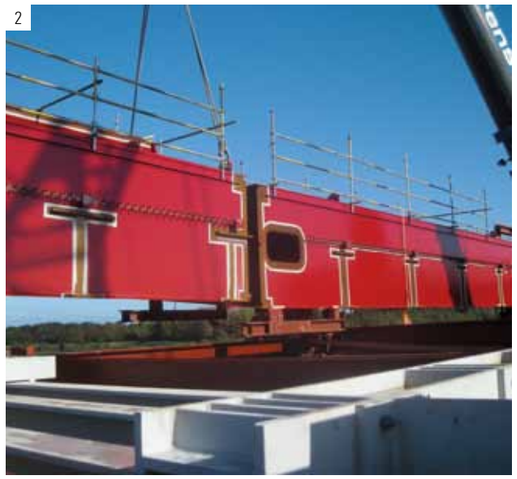


**3** **Prefabrication** of arch ends at the plant
**4** **Strand jacking** of 2,500 ton heavy arch truss over the river span

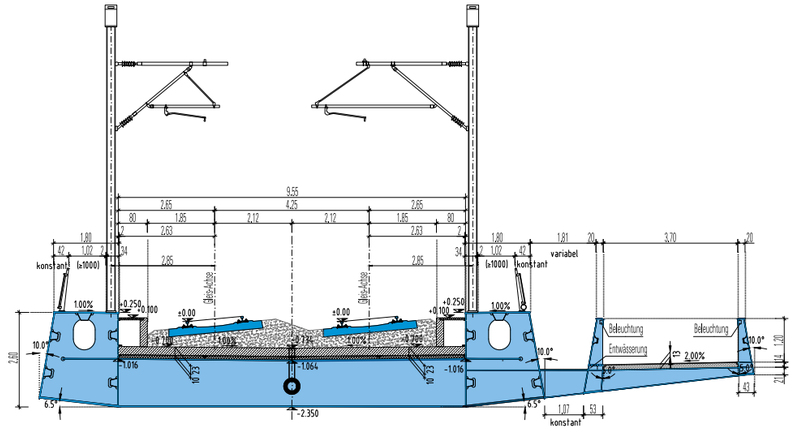
3

4

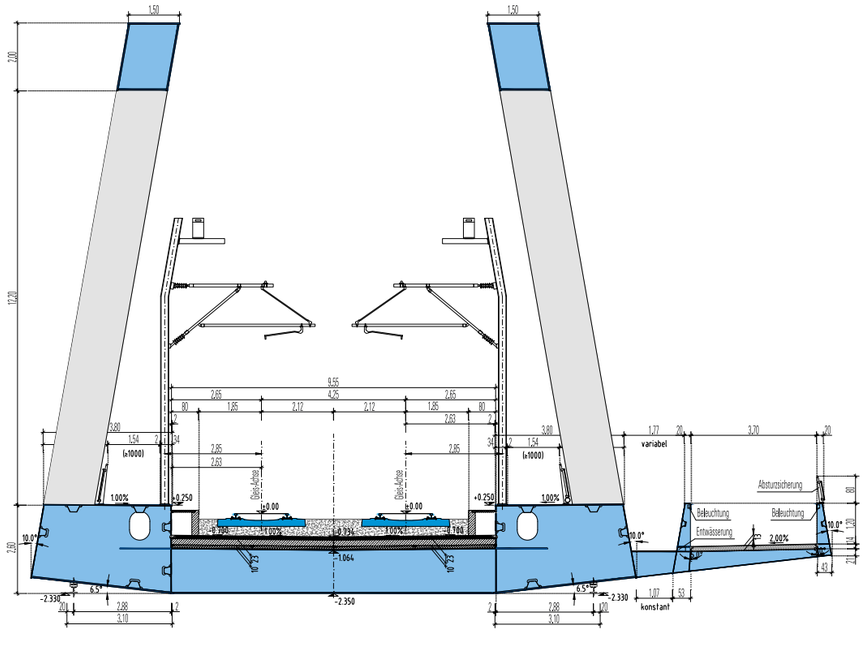
Picture credits: **1+3** SSF Ingenieure AG / **2** Bouwcombinatie Welling/Züblin / **4** Firmengruppe Max Bögl

Picture credits: SSF Ingenieure AG

**Cross-section** of the foreshore bridge




**Cross section** of the steel truss arch bridge



total length of about 13.6 km were installed. The superstructure was assembled starting at both abutments, advancing to the river span. The steel girders were placed span by span and the track slab was built subsequently. To accelerate the construction process, prefabricated concrete slab elements were used, completed with shear-resistant cast in-situ supplements. The entire steel truss of the span over the IJssel was floated into position by pontoons and lifted into its final position by strand jack into the steel structure projecting beyond the river piles.

Another challenge to design and construction have been the required highly accurate connections of the steel components; despite numerous spatial constraint points at the arches and stiffening girders, the thick sheets of the large cross sections made corrections after strand jacking nearly impossible. The constructive collaboration of all project participants beyond borders, led to a successful implementation of a technically very demanding and architecturally ground-breaking railway bridge, implemented in the given time frame and meeting the required quality.

| **Bridge deck / superstructure** | |
|---|---|
| Structural steel | approx. 9,200 t |
| Concrete bridge deck | approx. 3,100 m³ |
| Reinforcing steel | approx. 850 t |

| **Parties involved in the project** | |
|---|---|
| Client | ProRail Netherlands |
| Design & build team | |
| Construction company | Bouwcombinatie Welling/Züblin,<br>Brug over de IJssel, Netherlands |
| Steelwork | Max Bögl Stahl- und Anlagenbau GmbH<br>& Co. KG, Germany |
| Architects | Quist Wintermans Architekten BV<br>Netherlands |
| Joint venture engineering | SSF Ingenieure AG<br>Consulting engineers, Germany<br>ABT adviseurs in bouwtechniek<br>Netherlands |

**Above: detail of the bridge** at the abutment Hattem
**Below: detail** of a pier

Selected by the German Chamber of Architects Berlin as one of 20 German contributions at the International Architecture Biennial in São Paulo, Brazil 2011.

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