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The largest passable timber bridge in the world

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Abstract

The largest timber bridge is built over a strait (Vihantasalmi) along Main Road 5 , which is a part of of the European road network (TERN). The bridge is a five span king-post truss bridge and the three main spans are 42 metres (total length is 182 metres). The foundation work was started at the construction site in september 1998 and the Vihantasalmi bridge was completed in October 1999. In this report will be introduced the design and construction of the bridge.

Introduction

Since the late 1980s, the Finnish National Road Administration (Finnra) and the Helsinki University of Technology have jointly carried out Research and Development work on wooden bridges. The preliminary findings of Finnra indicated that a timber bridge could be built over Vihantasalmi by applying state-of-the-art know-how of wooden constructions. Wood would signalize the character of the area as a source for and processor of wood in many forms and also accentuate the ecological image of the area. It was also hoped that the solutions found would be usable on the other roads with high traffic volumes. Since the project was very demanding both technologically and from a scenic point of view, a design competition to find the best ideas was arranged. The main criteria which were used to choose the winner were: feasibility and costs, a scenic point of the bridge and the bridge as a port of the surroundings.The competition winner Insinööritoimisto Rantakokko & Co has also made the final design.

Photomontage of the Vihantasalmi bridge

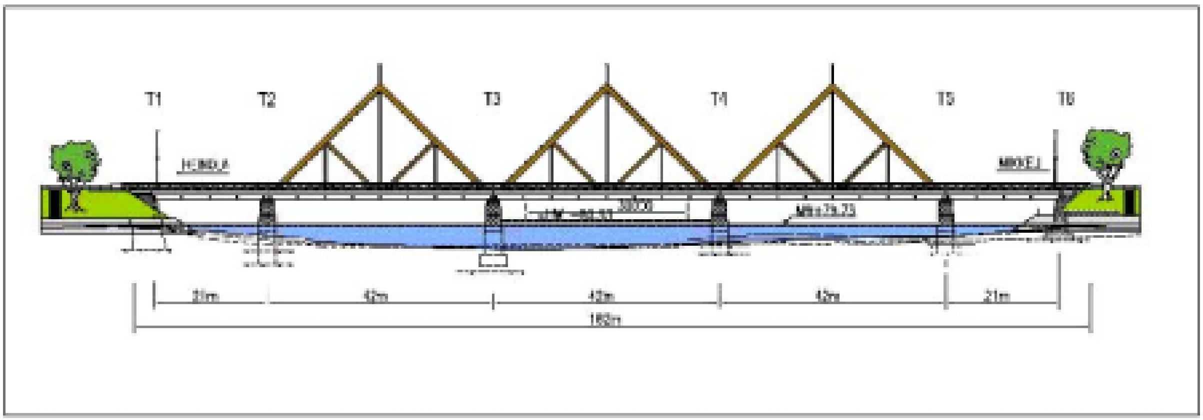
For the construction of the bridge was arranged an international competition according to the regulations of the European Union. However only the Finnish contractors were interested in the project and the contract (20,6 million FIM) was made with YIT-Yhtymä Oyj.

Planning and structural system

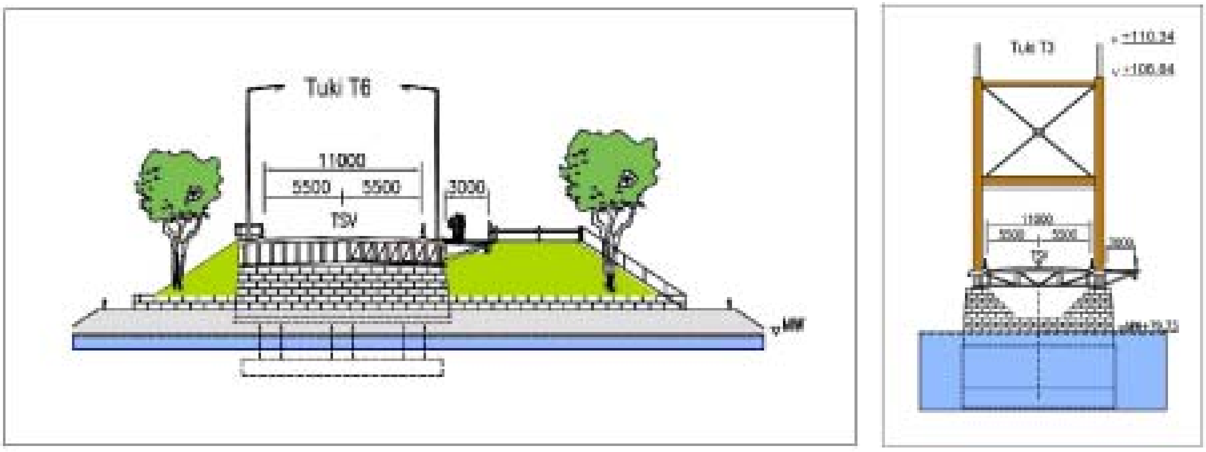
Planning

At the preliminary planning stage, both open spandrel arch bridges and girder bridges were considered. The decision was to replace the old bridge with an open spandrel arch bridge similar to old one. The distance between supports was 25,0 + 70,0 + 25,0 = 120,0 metres and the width of the carriageway 11,0 metres.

Before the final plans were made, the idea of the wooden bridge came up as an alternative. The final design is mainly based on the winning entry of the design competition. The bridge is a five spans glulam king-post truss bridge, with king posts in the three middle spans and the side spans having laminated wood beams as main girders. Spans are 21,0 + 42,0 + 42,0 + 42,0 + 21,0 = 168,0 metres and the overall length of the bridge is 182,0 metres. The width of the carriageway is 11,0 metres and that of the pedestrian and bicycle lane is 3,0 metres. The navigable clearence is 4,05 metres in height.



Side elevation



Cross sections

The basic idea of the bridge is traditional, but the dimensions made it a very difficult project. The distance between the surface of the water and highest point of the bridge is comparable to an 11-story building. The design life of the bridge has been set at 100 years, the same as for other major bridges.

As regards the total surface area, the Vihantasalmi bridge will be the largest timber bridge in the world (at least in the main roads). The spans are twice the length of the longest earlier existing wooden road bridges in Finland.

Structural system

Substructure

The other abutment is founded on the rammed piles of the reinforced concrete and the other on the broken stone. All the other supports are founded on bedrock. The visible portions of the supports are cladded by granite. The central part of supports is built open for ”lightening” those.

Support

Superstructure

The three middle spans have suspended laminated beam truss frames in so called king-post form. The diagonals (inclined members) are made of double glulam beams connected by plywood sheets. Also the horizontal truss members are made of double glulam beams. The hangers of the frame is of steel. The deck structure utilizes state-of-the-art wood construction technology, where the reinforced concrete deck slab and the laminated beams are joined into a composite structure with steel dowels. Furthermore, the secondary beams in the main spans are supported crosswise by steel trusses, making the deck structure a three material combination. Reinforced concrete deck slabs and laminated beams joined in a composite structure are used in the side spans also.
The weather exposed diagonals of the king-posts are structurally protected against ultra violet radiation and moisture changes.
All wooden parts are preservative treated against decay.

Gross section

Dowels

Some structure details

The deck of the bridge is designed as wooden-concrete-composite structure, where as joints are functioning the dowels. The joints are made more effective by notchis.The surface of the glulams is treated by epoxy because these are left partly inside the concrete.

The Helsinki University of Technology made a lot of tests to investigate the endurance of the dowels and what is the best glue to join the dowels into the glulams.

The joints of truss diagonals and main beams were fittid with steel mountings. The holes of the bolts were injected with epoxy glue. The pair of the main beams were fasten together by welding on site and laying with concrete between the two steel mountings.

Coupled basic piece

Construction

The contractor used their own alternative way of fitting, where all three truss bridges were mounted on the places using temporary supports. Because the project was a somekind pioneerwork according to timber bridge there appeared also some problems. The biggest was manufacturing and joining together – and also with glulamstructures – the quite large steel parts in very cramped spaces. This caused that a lot of the steel parts must be cutted up and then afterwards welded and having the surface treating. Also connecting the plywood cheets by special nails to the diagonals was a big job (about 200 000 nails was needed). A lot of working by means of hands was to do when about 10 000 bolts were fitted up the joints of steel and timber. The implementation schedule of the project was about one year.

Bill of quantities

Substructures:

Reinforced concrete piles	300	m
Concrete	2 400	m^3
Reinforced steel	71	ton
Natural stone cladding	840	m^2

Superstructure:

Wooden structures	1 050	m^3
Structural steel	270	ton
Concrete	780	m^3
Reinforced steel	160	ton

To learn for the future

When the project is such a kind of pioneerwork you must have the design finished before you ask for the invitation of bids. We had at this stage only about 50 % of design ready. Partly that is why the costs of the bridge are increasing up to 23,5 million FIM (the contract was 20,6 million).
It was the clients idea that while calculating their tenders, the contractors would also find new innovations for the final bridge design, but it did´nt happen.
The live span maintenance of the bridge must be a remarkable basis even at the preliminary planning stage. Now we are making, not until the maintenance plan.
As mentioned earlier we hope that the solutions found for designing Vihantasalmi bridge would be usable, even developed further on other roads with high traffic volumes.

The Vihantasalmi bridge