Zeitschrift: IABSE reports = Rapports AIPC = IVBH Berichte
Band: 60 (1990)

Artikel: Composite cable-stayed bridge: the Lumberjack's Candle
Autor: Järvenpää, Esko
DOI: https://doi.org/10.5169/seals-46525

Composite Cable-Stayed Bridge: the Lumberjack's Candle

Pont mixte haubané de Lumberjack Candle

Die Schrägkabel-Verbundbrücke in Lumberjack's Candle

Esko JÄRVENPÄÄ
Techn.Lic.
Suunnittelukortes Oy
Oulu, Finland

Esko Järvenpää, born 1946, received his Civil Eng. and Techn. Lic. degree at the University of Oulu. He is technical manager of Suunnittelukortes Oy and is also responsible for the birdge design.

SUMMARY

This paper deals with the composite cable-stayed bridge design and construction procedure. The construction has followed the process defined in the design calculations. The standard calculation method seems to give reasonably good results for the behaviour of the bridge. The beauty of the bridge has caused a great deal of interest.

RÉSUMÉ

Cet article traite du projet, du calcul et de la construction d'un pont à haubans avec poutre mixte. Le procédé de construction a suivi les directives définies par les hypothèses de base. Les méthodes de calcul usuelles semblent donner des résultats suffisamment bons pour le comportement du pont. La beauté du pont a suscité un intérêt considérable.

ZUSAMMENFASSUNG

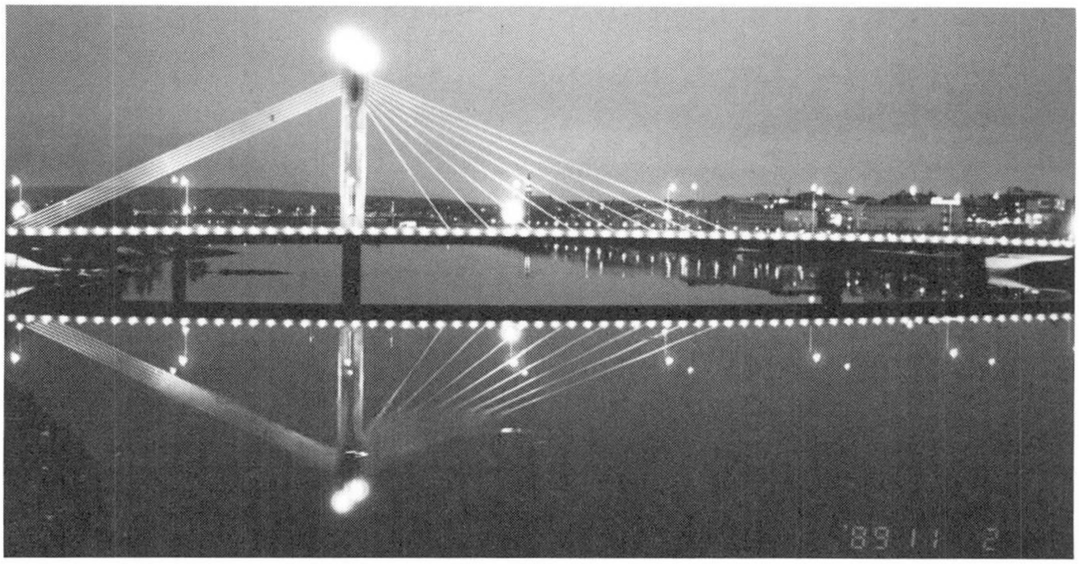
Es wird über den Entwurf, die Berechnung und den Bau einer Schrägkabelbrücke mit Verbundträgern berichtet. Der Bauvorgang folgte den Vorgaben der Entwurfsberechnung. Die üblichen Berechnungsmethoden scheinen ausreichend gute Ergebnisse für das Verhalten der Brücke zu geben. Die Schönheit der Brücke hat beträchliches Interesse geweckt.

A COMPOSITE CABLE STAYED BRIDGE, THE LUMBERJACK'S CANDLE

1.GENERAL

In Autumn 1989 at the Artic Circle town of Rovaniemi Finland's first cable stayed bridge for motor traffic was opened. The composite beam bridge has been, for many years, competitive compaired with concrete bridges. The reason has been the optimal construction timing between the cold winter period and the warm summer. The manufacturing of steel structures in Finland is also a highly automated industry.

The bridge design was selected as the result of the result of the invitation design competition. The aim was to provide an attractive bridge, which would enhance the image of Rovaniemi town. The bridge was not selected on the basis of the lowest price. The tender contract was for two deck alternatives. A concrete,prestresed box carried out by the incremental launching method and a composite box beam bridge. The contract itself was awarded on the basis of the lowest tender.



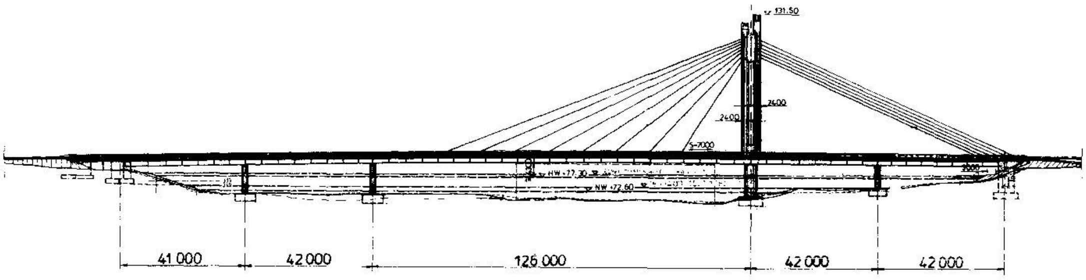
Picture 1. The bridge illuminated at night, complete reflection

2.EXTERNAL APPEARANCE

An assymetrical cable arrangement was selected for the bridge to balance the construction mass of the town and the high opposite bank. At the top of the pylon a "Lumberjack's Candle" was designed to symbolize the locking tradition. The pylon was split into twin round pillars, which are combined to one joint wall at the cable fixing position.

The subructures were designed to be narrow so that the river landscape, as seemed from the bank, would be as free as possible. The edge cantilevers of the bridge were supported with diagonal elements.

The edge beams of the bridge which have a side surface height of 700 mm were inclined. The inclined position lightenes the side surface. The bridge and its reflection in the water present an increadibly beautiful and impressive spectical.



Picture 2. The Lumberjack's Candle

3. BRIDGE TECHNICAL DETAILS

The main span of the bridge is 126 m long and the side spans 42 m. The effective width of the bridge is 25,5 m. Box width is 8,8 m.

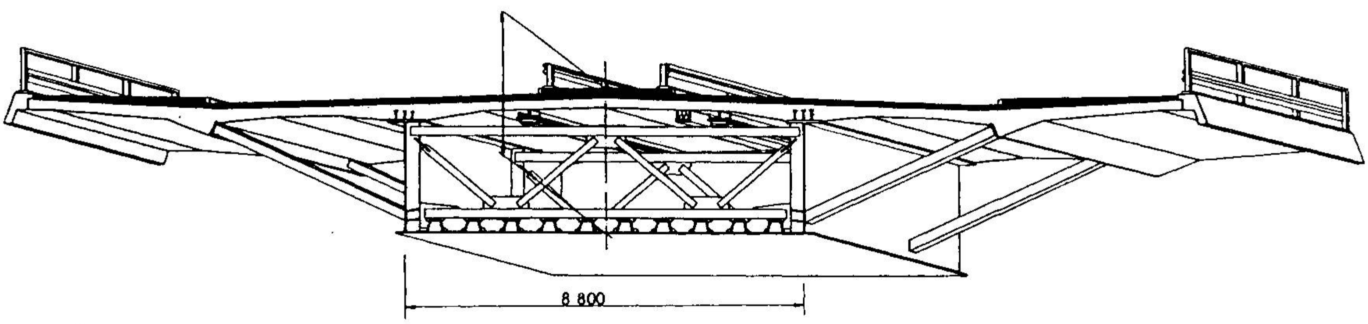
The cables are located along the center line of the bridge. At the main span the cables arranged in eight pairs with a fan shape. The back stay cables are arranged parallel and the cable group is formed of six cable pairs. The abutment operates as a counterweight due to its own mass and is not anchored to the rock bed. The deck structure is fixed to the abutment without bearings or expansion joints.

The diameter of the twin pillars of the pylon is 2,3 m and the free space width between the pylons is 1,5 m. The pylon pearcers the deck.

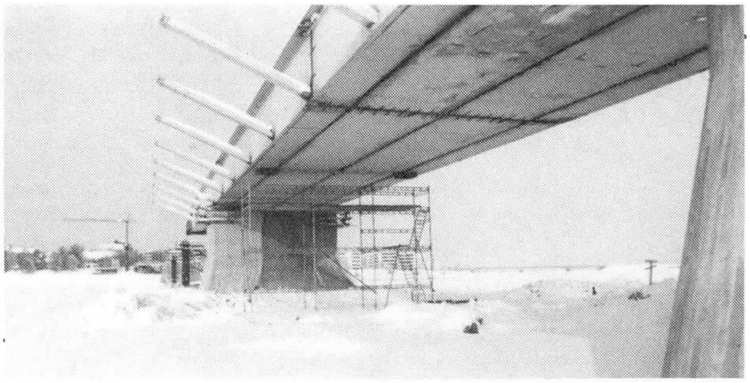
4. DESIGN OF COMPOSITE STRUCTURE

The bridge was designed so that the steel girders, without the deck slab, was launched over the river. Temporary auxilliary supports were constructed for the main span. During the construction phase, the bridge was a seven span beam bridge and each span length was 42 m

The bottom plate stiffners of the steel beam are trapetsidal in shape. The intermediate trusses are formed of tubular steel structures and are at intervals of about 5,6 m.



Picture 3. Cross sections of bridge



Picture 4. Launching work in progress

In the main direction the box was analyzed with a grid model describing the box structure. The torque loads were also analyzed in accordance with source /1/ to solve the truss forces.

The superposing of the stresses was done by following the various static phases of the structure. The following list describes the calculation chain in the main direction:

- A simple steel structure supported on auxilliary supports with a span interval of 7 x 42 m.
- Casting of the deck slab in sections, a total of 23 different structures supported on temporary supports. A separate computer programme was made for this casting stage which took into account shrinking and creep in accordance with source /2/.
- Calculation of the magnitudes of the stresses caused by post-tensioning in the longitudinal direction over the support areas.
- Removal of temporary supports and cable stressing. The magnitude of the forces in the cable stressing were calculated by brid-ecing the complete structure in reverse order to the cable stressing programme. Stressing was done in principle with two stressing cycles.
- The loading of the surface layers on the asymmetric cable structure.
- The fixing cast of the deck structure to the abutment and inclusion of the creep caused by this structural change.
- Calculation of traffic loads and other natural loads on the entire structural system.

5. DECK SLAB CONSTRUCTION AND DESIGN

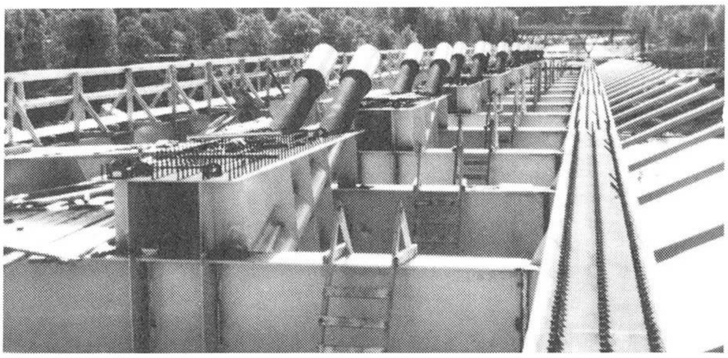
In the structure an effort was made to have as cracked-free structure as possible. In the construction phase the schedule was also aimed at this.

The composite structure was casted so that in areas in which prestressing was not used in the longitudinal direction, the cast in the support region was done only after the middle span area had been casted. Thus it was necessary to move the forms frequency. This succeeded very well in the work arrangements. The area built in this way is that between the bridge cables. The compressive force from the cables caused a compressive force of about 60 MN on the composite structure. In the support areas outside the cable areas, prestressing in the longitudinal direction was used to prevent cracking. Approximately 0,5 MN tendon units were used. Transversal prestressing in the deck slab was approximately 0,5 m intervals.

The superelevation of the steel structure was defined also in accordance with the development of the composite action according the casting order of the deck slab.

After the deck cast it could be confirmed that work had succeeded in producing almost totally uncracked concrete. No water ligide has been, up till now, observed in the deck slab.

Cracks were eliminated at the cable anchoring locations by distributing the anchoring horizontal force of the cable both trough the steel structure and concrete clab. Bult studs were used.

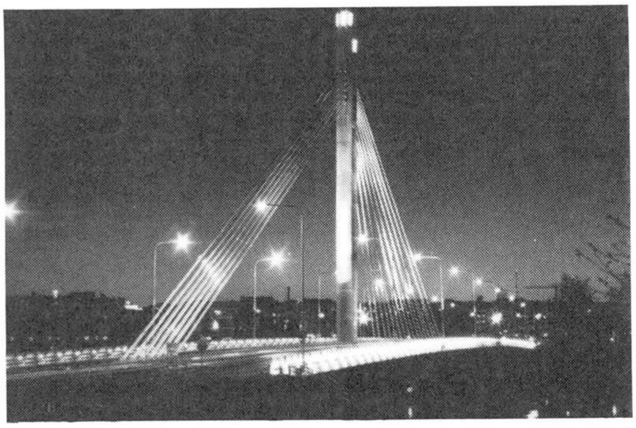


Picture 5. Cable anchoring structures, studs

6. CABLES AND PYLON

The cables were formed of unbonded, greased and coated strands. The anchoring area was injected with grease and other cable parts were injected with a cement grout. The cable grease was tested to $\pm$ 50 ^{o} C. The behaviour of the grease made it necessary to arrange separate expansion cylinders in the anchors due to the pressure changes caused by the changes in temperature /3/.

The cables were wrapped with white tape to minimize temperature differencies and make possible /4/. The lower regions of the cables were protected against mechanical damage by white painted steel tubes. At the head of the pylon there is the anchoring chamber designed as composite structure. The steel structure was analyzed as plate elements with a FEM programme.



Picture 6. The tower and the cables

7. MEASUREMENT OF STRUCTURAL BEHAVIOUR

The behaviour of the structure was measured with trial loads in autumn 1989. The main interest was to confirm the difference between the calculated and actual magnitudes in the stiffness of the bridge both in bending and twisting and also in the dynamic behaviour.

In the design phase the lowest nominal frequency was achieved with a sideways movement of the pylon and cable system 0.45 Hz.

In longitudional bending the first frequency was 0.67 Hz. The same value was registred during tests. The displace of the girder during testloading was 45 mm and calculated value was 48 mm.

The position of the bridge deck in the completed bridge and the cable forces correspond well to the theoretically calculated values.

On the basis of this project, it can been assumed that the functioning of composite structures can be handled with normal calculation assumption for practical design.

/1/ ISOKSELA ERKKI:
Torsional moment in Thin-Walled Box Girder
(not publiced)

/2/ GHALI A. AND FAVRE R.
Concrete Structures: Stresses and deformations
1986 London

/3/ VSL INTERNATIONAL, BUERGI P. AND SCHNEITER T.
Method statement for the stay cable injection
1989

/4/ LEONHARDT FRITZ
Cable stayed bridges, FIB-congress 1986,
New delhi 16. February

/5/ WALTHER RENE
Ponts Haubanes
1985 Lausanne