Steel strip reinforced concrete bridge (Denmark)

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Objekttyp: **Article**

Zeitschrift: **IABSE structures = Constructions AIPC = IVBH Bauwerke**

Band (Jahr): **12 (1988)**

Heft C-46: **Repair and rehabilitation of bridges: case studies I**

PDF erstellt am: **13.09.2024**

Persistenter Link: https://doi.org/10.5169/seals-20922

3. Steel Strip Reinforced Concrete Bridge (Denmark)

Owner:	*The Danish Road Directorate by County of Frederiksborg*
Design and supervision:	*Cowiconsult, Consulting Engineers and Planners AS, Copenhagen*
Contractors:	*Armton A/S, Copenhagen*
Works Duration:	*May 10 – Juny 22, 1985*
Closed for traffic:	*June 6 – July 4, 1985*

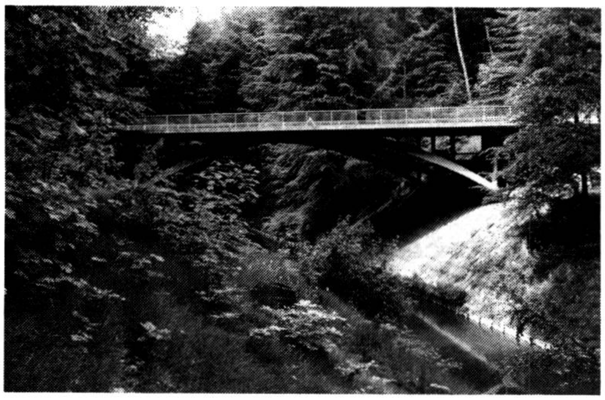
Main Quantities of Material

Steel plates st. 37	1931 kg (41 m^2)
Other Repair Works	
Water proofing membrane:	320 m^2
Wearing course:	320 m^2
Expansion joints:	30 m

Introduction

The canal bridge at Frederiksværk was reinforced in 1985 by glueing steel strips onto the underside of the bridge deck. This method is relatively unknown in Denmark, where similar cases of bridge strengthening have normally been solved by adding external prestressing cables and additional reinforced concrete.

The reinforced concrete bridge in question is an arch bridge 45 m long, 13.5 m wide, built in 1950 and designed by Cowiconsult. Above the 27.5 m span of the arch itself, the bridge deck is divided into sections. At either end of the arch there is a 7 m bay.



Canal Bridge at Frederiksværk.

Strengthening

The reinforcement was necessary in order to improve the load-bearing capacity of the bridge to meet present-day load standards. An assessment of the bearing capacity of the intact bridge had shown that the structure of the 2 side bays did not comply with these standards. By adding in these bays some local reinforcement, a higher load-bearing classification for the bridge could be obtained.

In each of the two end bays 9 steel plates (400 × 5850 × 6 mm, st. 37) were bonded to the concrete. When the bridge is subjected to the stipulated maximum load, the permissible tensile strength for the steel will only be 50% utilized. In addition, the shear force to be transferred by the glue joint is only 10% of the permissible force. In other words, reinforcement with plenty of built-in safety.

The planning of the reinforcement work began in 1984. This involved some study of experience obtained abroad and some contact with experts from other countries, particularly in regard to the choice of bonding agent. This resulted in the choice of an epoxy bonder (Sikadur 31).

Before the actual work on reinforcing commenced, tests had to be made of the tensile strength of the bridge concrete and the adhesive properties of the bonding agent on the concrete surface. Altogether, tests were made with six plates all of which were tested to breaking point.

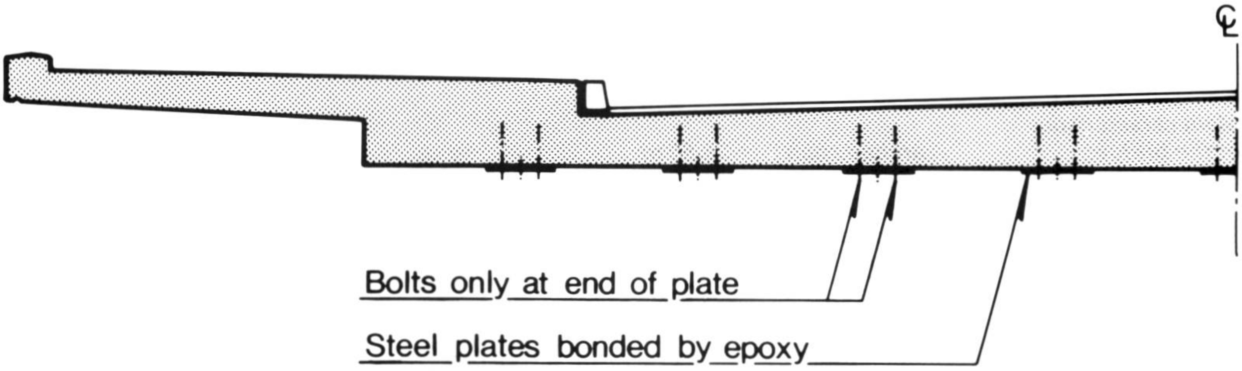
All ruptures occured either in the concrete itself or on the surface between the concrete and the bonding agent. Based on the results, the compressive strength of the concrete was assessed as minimum 25 N/mm^2.

To afford the best possible contact surface, extensive preparation of the concrete surfaces had to be carried out.

From measurements taken in connection with a load-bearing test, it was established that the bonding agent fully transferred the shear forces between the concrete and the steel plates. In addition, the distribution of stresses in the steel plates as measured was in keeping with the calculated stress-conditions for cracked and uncracked concrete cross-section.

A load-bearing test carried out one year later produced little divergence in measurements from the year before.

It is intended to repeat the load-bearing tests for some time to come, to check whether the function of the reinforcing might alter in the course of time.



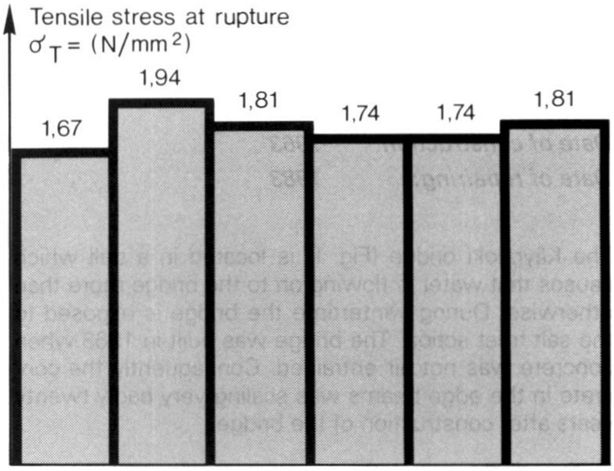
Cross section of bridge deck.

Other Repair Works

During the same period other repair works took place, such as replacement of water proofing membrane and wearing course. The new water proofing membrane consists of 2 layers of 3 mm fibre reinforced bitumen sheetings glued on top of the repaired bridge deck. A special 3 mm plastic/bitumen protection membrane then was applied. Then, a porous asphalt layer of 10–15 mm was applied as a drain layer. Finally, 2 layers of wearing course were applied.

New expansion joints at the bridge ends were also carried out (Thorma joint type). Besides, new traffic railings were installed along the carriageway in order to prevent heavy vehicles from entering the footwalks.

(Jørgen Birger Kragerup, Leif Jonsen)



Adhesion of the bonding measured by tests on 6 test slabs.

Bridge deck reinforced with bonded steel plates. The strain gauges were used to verify the efficiency of the bonding. The bolts are removed after completion.