Structural and mechanical rehabilitation of old bascule bridges

Structural and Mechanical Rehabilitation of Old Bascule Bridges

Rénovation structurale et mécanique de vieux ponts basculants

Bauliche und mechanische Erneuerung alter Klappbrücken

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SUMMARY

Rehabilitation of old bascule bridges usually makes good economic sense. Carrying capacity, traffic capacity and machinery and control systems can be improved by structural and mechanical rehabilitation. Often, the work has to be staged and traffic maintained on one half of the bridge deck. The paper is illustrated by case histories.

RESUME

La rénovation de vieux ponts basculants est rentable. La capacité portante, la capacité du trafic ainsi que la machinerie et les systèmes de contrôle peuvent être améliorés par une rénovation structurale et mécanique des ouvrages. Souvent, il faut entreprendre les travaux par étapes tout en maintenant le trafic sur l'autre moitié du tablier du pont. L'article est illustré par des exemples.

ZUSAMMENFASSUNG

Die Erneuerung alter Klappbrücken ist im allgemeinen wirtschaftlich. Tragfähigkeit, Leistungsfähigkeit für den Verkehr, Maschinerie und Kontrollsysteme können durch bauliche und mechanische Erneuerung verbessert werden. Meist sind die Arbeiten in Abschnitten auszuführen, um den Verkehr auf einer Brückenhälfte aufrecht zu erhalten. Der Beitrag wird durch Beispiele erläutert.

1. GENERAL

Many bascule bridges, mainly constructed in the period of 1920 to 1950, have insufficient carrying capacity (only vehicles of 30 to 50 t max.). The traffic capacity is not satisfactory either, due to a narrow carriageway width of 5.5 to 6 m. Furthermore, in many cases they are in poor condition.

Therefore, a replacement with a new high level bridge without a movable span to disturb the traffic is very often considered. However, calculations very often show that this is a very expensive solution, especially inside a town where the long bridge ramps require a lot of land.

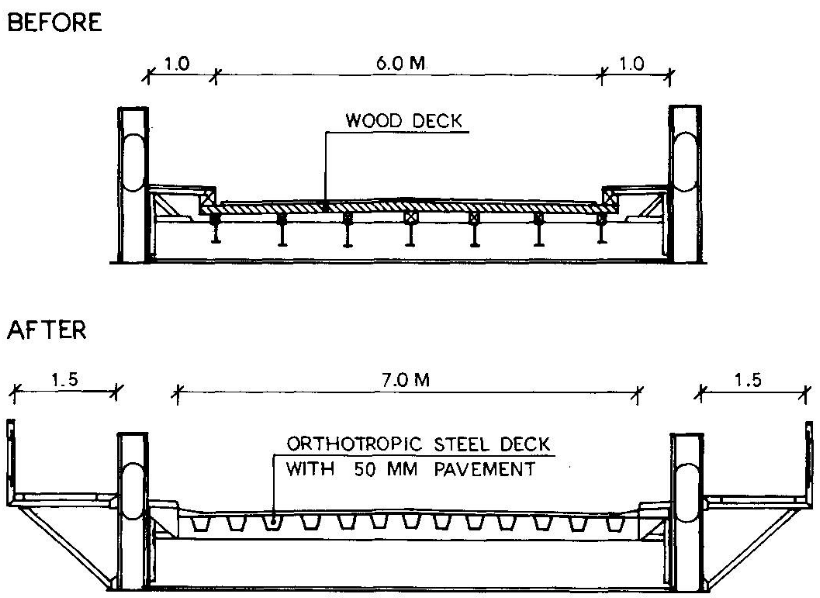
A new bascule bridge to replace the old one is then the next solution considered. However, it might be difficult to change the final alignment of the new bridge in relation to that of the old bridge. An interim bridge could then be constructed and the new bridge be positioned in the same alignment as the old one.

All the above solutions are quite expensive, and therefore in many cases it makes good economic sense to repair, strengthen and widen the old bridge.

2. STRUCTURAL REHABILITATION

2.1 Bascule Span

Double leaf bascule bridges very often consist of two main girders, each of a double web steel girder (hollow section), with I-profiled cross beams with a distance of 4 to 5 m and I-profiled secondary longitudinal steel girders wearing a wooden deck. Figure 1. shows a typical section of the original deck on a bascule bridge at Frederikssund in Denmark.



In order to save load and carrying capacity the deck including the secondary longitudinal girders was replaced by a modern orthotropic steel deck as shown in the figure. Normally the deck plate has a thickness of 12 mm and is supported by trapezoid formed ribs with a centre line distance of 30 cm.

Fig. 1. Frederikssund Bridge. Rehabilitation of Bascule Span.

The width of the carriageway was at the same time increased from 6.0 to 7.0 m by constructing new sidewalks outside the main girders by means of steel supports bolted to the side of the main girders and covered by a deck of aluminium profiles.

Due to the new sidewalks it was necessary to move the control tower. When removing the new control tower it was completely rebuilt and equipped with a modern control system, see below.

At the above mentioned bridge the 12 mm steel deck plate was paved with 50 mm asphaltic mastic. The steel deck was sandblasted to SA 3 and primed with a bostic adhesive. A 4 mm layer of softer mastic was applied as a waterproofing membrane. Two layers of asphaltic mastic of 20 and 25 mm were applied and friction stones rolled into the surface of the upper layer before cooling down.

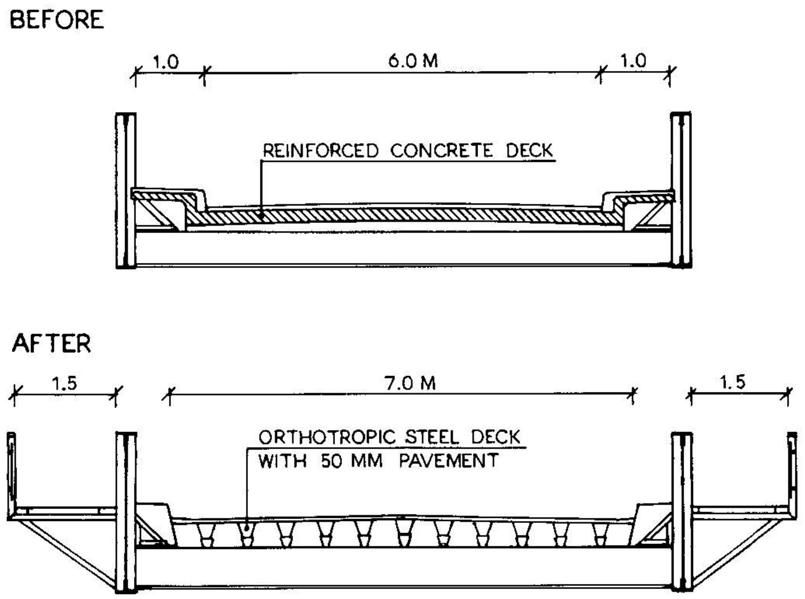
However, a greater reduction of weight is necessary, the steel deck can be paved with 5 to 6 mm thin resin pavement of acrylic or epoxy basis. This has been done at the rehabilitation of other bascule bridges in Denmark (Guldborg Bridge and Sønderborg Bridge). The resin pavement is applied after sandblasting of the steel deck, normally in two layers, and the upper surface applied with corns of bausit which gives an excellent surface friction.

The service life of the asphaltic mastic is about 20 to 25 years, whereas the resin pavement has a service life of 15 to 17 years.

The orthotropic steel deck is normally connected to the existing cross beams in a flexible way to adapt the different levels, and a careful level survey has to be carried out. In many cases the connections must be made by friction bolting, as the old steel of the cross beams is not weldable.

2.2 Side Spans

Side spans are normally rehabilitated in accordance with the same principles as the bascule spans.



As dead load often is an dominating factor for the main girders of longer side spans it is important to reduce weight. In many cases, as shown on the typical section, figure 2, the old deck consists of a reinforced concrete slab, supported by secondary longitudinal steel beams.

Fig. 2. Frederikssund Bridge. Rehabilitation of Side Spans.

The weight of the concrete slab is normally quite essential and a replacement with an orthotropic steel deck - especially with a thin resin pavement - will normally save so much weight that the live load can be increased by 50% resulting in a satisfactory load-carrying capacity.

At the same time the composition of the orthotropic steel deck and the existing cross beams will often increase the moment of resistance of the new cross beam to the double.

The connection between the cross beam and the main girders is then often the weak point. However, supplemental friction bolting will normally solve this problem.

3. MECHANICAL REHABILITATION

3.1 Machinery

In some cases the old machinery is in good shape and only a few changes are necessary, such as new electric motors.

A replacement of the steel machine parts (such as gear, wheels and racks) is normally an expensive affair. In some cases an application of an electric hydraulic machinery to replace the old machinery can be a more economic solution.

A typical hydraulic machinery is shown in figure 3.

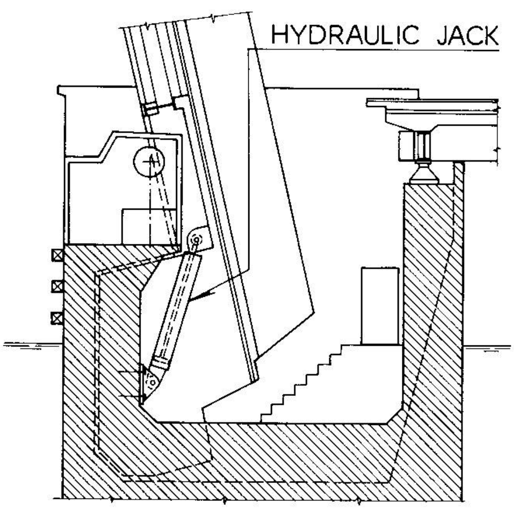


Fig. 3. Typical Hydraulic Machinery

An advantage of such replacements is that the hydraulic machinery can be installed while the old machinery is still functioning. Thus, the bridge can be operated nearly without interruptions.

3.2 Control System

To operate an old bridge a lot of individual actions have to be taken: Start machinery, sea signals, road traffic signals and lifting barriers, release brakes and locking arrangement, sea signals, raise bascule spans, etc. etc.

By automatic electric operation this can be done by touching a few buttons. The correct succession of activities can also be insured.

During the last years all these operations have been computer controlled, so the raising speed of the bascule spans can be regulated in the correct way.

All this means that a bascule bridge can be operated by a less skilled personnel and a saving is hereby obtained.

It therefore makes good economic sense, when rehabilitating the bridge to modernize the electric control. Furthermore, it is often difficult to get spare parts for the old steering system.

4. DESIGN PHASES

Design phases can be divided into:

1) Special investigation of the old bascule bridge (condition and load-carrying capacity)
2) Economy study of bridge type (high level or bascule bridge)
3) Preliminary design and budget (preliminary design of chosen type and corresponding economic estimate)
4) Detailed design and tender documents
5) Tender (orientation and evaluation of bids (tender report))
6) Supervision (site supervision during construction with home office back-up)
7) Daily running and maintenance

Re 1) Also the substructure shall be carefully investigated, e.g. underwater piers and scour protection by diver and sea-bed levelling by echo soundings.

Dubious steel parts of machinery shall be carefully examined by ultra sound or magnetoflux. Samples for chemical testing of weldability shall be taken.

Re 6) During the rehabilitation works it is important that the site supervision is in close contact with the design engineer ("home office back-up"), as the actual conditions often differ from the design assumptions.

Re 7) Manuals shall be made to describe how to operate the renovated bridge, sea/road traffic regulations, how to repair the new machinery, how to service machinery and how to maintain the structures (length of interval for painting), etc.

Instructions for regular routine inspections shall also be made.

5. TRAFFIC PROBLEMS

In many cases it is not possible to find a deviation route when rehabilitating the bridge. Then, the rehabilitation has to be made in two phases (only one half of the carriageway can be rehabilitated at a time). Therefore, a new orthotropic steel deck panel for a bascule span has to be made in two parts, which must later be connected by in situ welding.

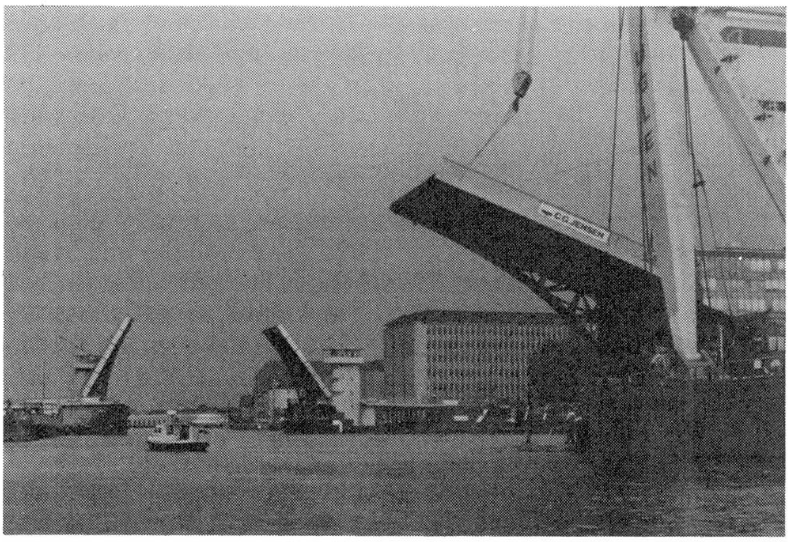
Traffic light regulation is necessary when the original carriageway only has two lanes. Traffic queue lengths must be calculated and local population advised accordingly. Some activities require a full traffic stop and should take place during night hours. Ship traffic restriction should be announced in due time.

Special attention shall be paid to secure that the bascule equilibrium is maintained and a comprehensive planning for changing the weight of the structural elements of the bascule span is necessary.

6. KNIPPELS BRIDGE

In the centre of Copenhagen city, the northern harbour bridge between Copenhagen and Christianshavn was in a poor condition.

The bridge is owned by Copenhagen Harbour Authorities and Copenhagen Municipality.



The bridge is a double leaf bascule bridge from 1939 with a bascule span of 35 m (free navigation clearance) and a deck width of 27 m.

The main pier concrete was deteriorated to a large extent. Some of the main trusses of the bascule span were badly corroded and the side span concrete needed repairing, etc.

Fig. 4. Knippels Bridge. Bascule Span Moved by Floating Crane.

An economy study indicated that the most feasible solution was to rehabilitate the old bridge under the condition that traffic on one half carriageway was maintained.

As the bascule span steel structures needed repair at a workshop, a special solution was found: The bascule span structures were divided (cut) at the bridge centre line into two halves which could be operated separately, see figure 5.. Hereby, one half could be taken by a huge floating crane to the nearby situated workshop. This is possible because the bascule span structures consists of four steel truss main girders.

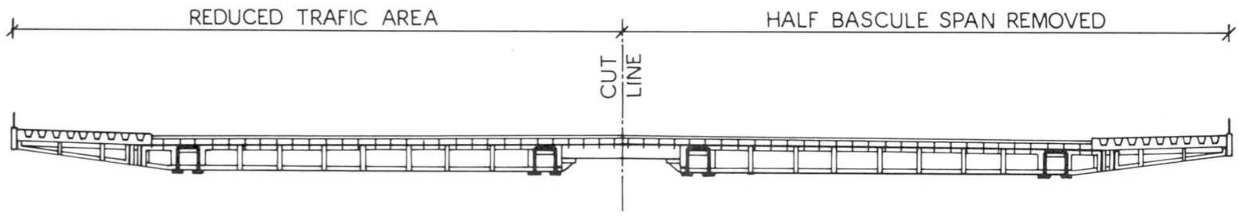


Fig. 5. Knippels Bridge. Cross Section of Bascule Span.

At the workshop the steel main trusses are rehabilitated by additional friction bolted profiles when needed. All steel is sandblasted and painted. The halves of the bascule spans are replaced and put in service. Hereafter the other side of the bridge can be rehabilitated.

In the meantime piers and side spans are repaired.

The old mechanical machinery is replaced by new hydraulic machinery controlled by a modern electronic system, operated by one man (instead of two men).