**Zeitschrift:** IABSE reports = Rapports AIPC = IVBH Berichte
**Band:** 73/1/73/2 (1995)

**Artikel:** Rational and environmentally compatible maintenance of old steel bridges
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**DOI:** https://doi.org/10.5169/seals-55219

# Rational and Environmentally Compatible Maintenance of Old Steel Bridges

## Entretien rationnel et écologique de vieux ponts métalliques

## Rationeller und umweltverträglicher Unterhalt von alten Stahlbrücken

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**SUMMARY**

During the last couple of years there has been strong focus on environmental aspects of surface treatment and maintenance of steel structures in Denmark. This article deals with a solution in which environmental, economic and quality assurance elements are taken into consideration when planning and carrying out the maintenance of two of the biggest bridges in Denmark.

**RÉSUMÉ**

Au cours des dernières années, le Danemark a été sensibilisé sur l'environnement et ses aspects en ce qui concerne le traitement de surface et l'entretien des constructions métalliques. L'article présente une solution prenant en considération les aspects de l'environnement, l'économie et l'assurance de qualité. C'est la solution qui a été retenue pour le projet et l'exécution de l'entretien de deux grands ponts au Danemark.

**ZUSAMMENFASSUNG**

In den letzten Jahren wurden die Umweltaspekte der Oberflächenbehandlung und der Unterhaltung von Stahlkonstruktionen immer mehr in den Mittelpunkt gestellt. Dieser Artikel zeigt eine Losung, die sowohl Umweltaspekte als auch Wirtschaftlichkeit und Qualitätssicherung berücksichtigt bei der Planung und Durchführung von Unterhaltungsarbeiten an den beiden grössten Brücken Dänemarks berücksichtigt.

## 1. HISTORY

Most of the bigger bridges in Denmark were built during the nineteen-thirties. All the bridges were of rivetted construction, as that was the technology best known at that time.

This type of construction is certainly not optimal for maintenance as the surface area is big, there are hollow spaces in several members and there are a lot of joints with more or less open gaps.

Two of the big bridges are the Old Lillebælt Bridge (length 850 meters) and the Storstrøm Bridge, which with its 3,200 meters is the longest combined railway/road steel bridge in Europe.

Both bridges have been under continuous maintenance since construction. It takes about 20 to 25 years to actually do the surface treatment of the steel structures from one end to the other, and after this it is necessary to begin again.

In the nineteen-thirties the bridges were painted with two layers of leaded alkyd, two layers of ordinary alkyd and one layer of bitumen. During the years up to now there have been added more and more layers of alkyd and bitumen. Since the beginning of the nineteen-eighties there have been brought into use totally new systems utilizing epoxy resin and also chlorinated rubber.

The total thickness and the condition of the existing paint, makes it today impossible to add more paint without first removing the old paint completely.

It was necessary to find a solution, where the renovation of the surface treatment could be carried out without dumping the lead-rich waste into the sea. This was partly due to ethical reasons and partly due to the strong focus on environmental aspects there is today in Denmark.

Another big problem with the maintenance of the bridges concerned the difficulty of actually carrying out the surface treatment. The persons doing the job until now have been like mountaineers, as they where erecting the scaffolding themselves. This was not only time consuming, but it was also not optimal for labour safety reasons.

## 2. PLANNING THE FUTURE MAINTENANCE OF THE STORSTRØM BRIDGE

The owner of this bridge, Danish State Railways, decided in 1991 that it was time for a total reconsideration of the philosophy for the maintenance of the bridge.

RH&H Consult was asked to start the planning for the future maintenance with a total inspection of every single steel element. The results of the inspection were put into a database, where among other things were registered the type of paint, the condition and the expected lifetime of the existing surface treatment.

It became clear during the registration that not only should the new maintenance philosophy take care of environmental aspects, it should also bring the renewal period for the surface treatment down from 25 years to 15 years, to avoid costly removal of a large number of elements in poor condition.

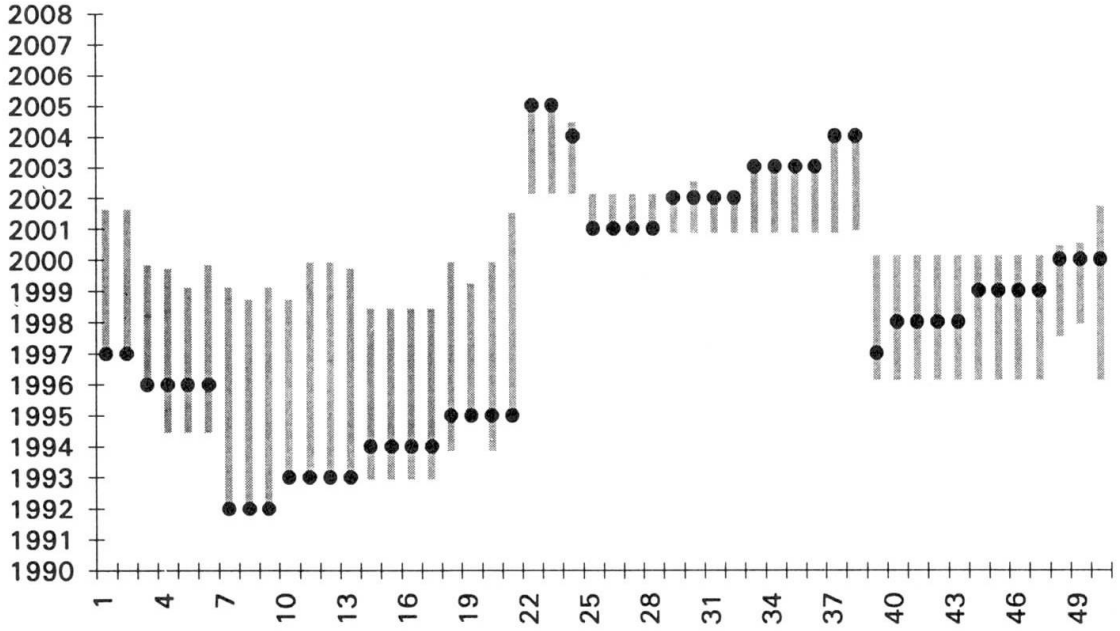



Figure 1 shows one of the results from the database. On the abscissa is shown the bridge span number from 1 to 50, on the ordinate is shown the weighted lifetime of the steel members in the spans. There are three different types of information: *Minimum* which shows the minimum lifetime of the existing surface treatment on the members, *Maximum* which shows the maximum lifetime, and *Dots* showing the planned maintenance. In an optimal case the dots should be somewhere between the Minimum and the Maximum points.

Now the task was divided into three main goals:

1) To find a solution where the waste from the surface treatment can be handled in a safe way.

2) To find a solution where the period for the surface treatment can be reduced from 25 years to 15 years, without significant extra annual cost.

3) To find a solution where the work with the surface treatment can be improved in a way which is safe for the labour force and economic.

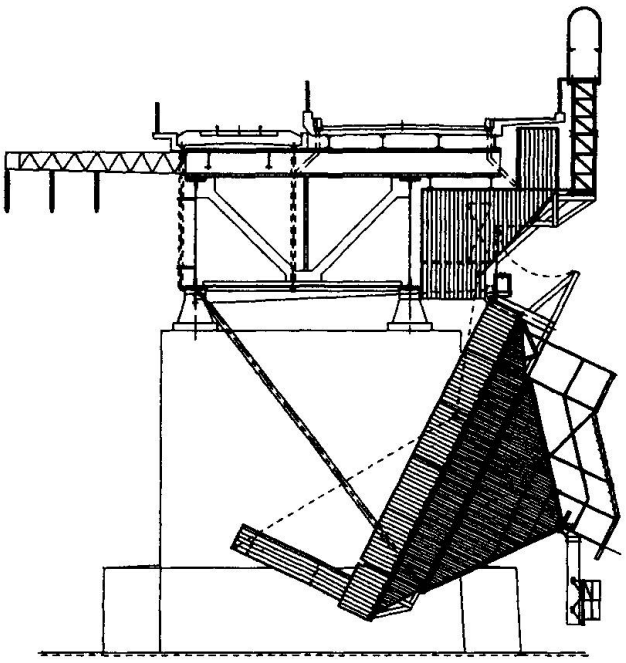
## 3. THE MOBILE PLATFORMS

During the investigation of the condition of the existing paint, it soon became clear that complete removal of the old paint was necessary (by sand blasting).

From that point it was also clear that the only solution was to have an easily movable scaffolding platform which should be enclosed so that the waste products would not disappear in an uncontrolled way.

In Denmark it is only possible to do outdoors surface treatment work about 6 months of the year. One of the positive side effects of having the whole working platform enclosed, is that the time available for surface treatment can be extended, as the climate inside the platform can be controlled.

There is already an existing market offering some standard solutions for mobile platforms. However such platforms were not found optimal for a number of reasons, mainly because the standard mobile platforms were not able to meet the geometric requirements, as it was impossible to maintain the whole 7 m high cross section of the bridge in one operation. Neither are they able to pass the 49 bridge pillars in a non- time-consuming way. Furthermore the standard mobile platforms were not designed to be mounted on a bridge for a period of 15 years, without maintenance of the platform itself.



RH&H Consult were asked to investigate the possibility of designing a mobile platform. The platform was to be able to meet all the special requirements for the actual bridge and was not to be significantly more expensive than the standard mobile platforms on the market.

Figure 2 shows the cross section of the designed platform in a situation just before passing one of the bridge pillars. The platform deck is lowered to a vertical position and the facade is folded also to a vertical position, the whole operation passing a pillar takes approximately one day.

It was decided to have hot-dip galvanized steel elements for the main structure of the platforms and all secondary elements such as the grid plates etc. were in aluminium to save weight. The covering of the platform sides was made of glass-fibre reinforced polyester to allow as much light as possible to enter the working area on the platform. Sand blasting tests were done both for the grid plates and for the covering. The tests showed that they could withstand direct sand blasting at a distance of 30 centimeters for more than 20 minutes, which was decided to be sufficient.

Under the platform is mounted a funnel (9x9 meters), so the sand can be collected in a controlled way on a barge anchored under the platform. The funnel is made of stain-less

steel thin plate shaped in a trapeze. The funnel was designed as flat as possible with built-in vibrators, to minimize the bending moments, when the platform is turned into a vertical position for passing the bridge pillars.

The total working area on the mobile platform is approximately 325 square meters and the total weight is about 40 tons.

In order to optimize the work it was decided that two platforms were needed. The procedure for the work is that the platforms are placed at a distance of half a bridge span between the centre lines. At all times during the working period sand blasting is being carried out on one of the platforms and paint is being applied on the other platform.

A very similar mobile platform was designed for the Old Lillebælt Bridge.

Photo 2 shows the mounting of the mobile platforms under the Storstrøm Bridge.

While the platforms are passing the pillars, the barge with all the waste (sand grains mixed with leaded paint waste) is towed to shore. The capacity of the barge is designed to be able to carry all the sand needed to treat one whole bridge span together with all the equipment needed to undertake the surface treatment.

The traffic on the bridge is not disturbed at all while work proceeds on the surface treatment as all the equipment and containers are placed on the barge - and not on the bridge.

Two possibilities were investigated for further handling of the waste product: Either to

deposit it in a special dumping area, were it could be controlled that the lead would not get into the groundwater, or as a new possibility to reuse the lead-rich sand in a constructive way in industry.

The investigation showed it possible to implement a new solution, that the lead-rich sand could be used in the brick industry. The sand is added to the clay needed for the bricks before the firing process, and thus sealed, will not give any negative environ-mental consequences in the future.

## 4. CONCLUSION

Now that the mobile platforms on both the Old Lillebælt Bridge and the Storstrøm Bridge have been in use for more than two years, it has been shown that not only is it possible to collect more than 90 per cent of the waste products, but it is also possible to speed up the work in a safe and an economic way.

For bigger bridges where one or more of the following requirements shall be met:

* Handling the waste problems with a minimum of environmental impact,
* having a more rational work procedure for the surface treatment,
* controlling the climate (extending the time available for surface treatment),
* improving the working conditions for the labour force,

the solution with a specially designed mobile platform is worth considering.

For the time being we are investigating a project, where similar mobile platforms can be used for maintenance of a big concrete bridge abroad.

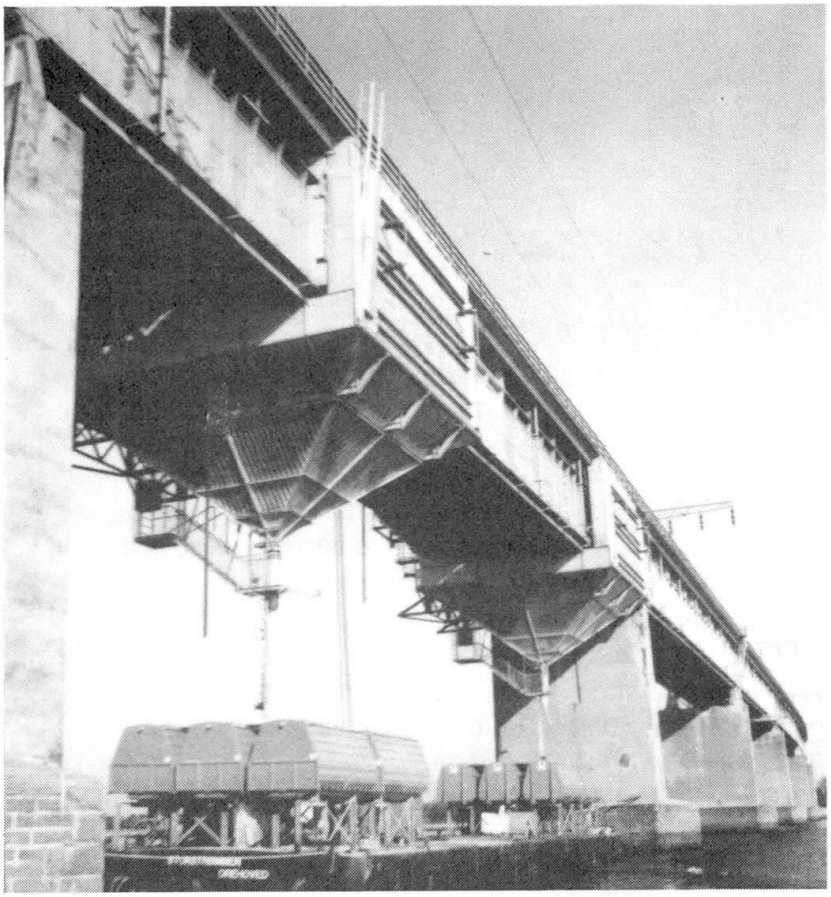


Photo 3 shows the entire system with the two mobile platforms at work on a span of the bridge. The barge with all the new and used sand is placed under the platform and can be accessed directly from the platforms.