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

Artikel: Maintenance facilities for the Honshu-Shikoku Bridges
Autor: Saeki, Shoichi / Eto, Takao / Tsuchiyama, Masami
DOI: https://doi.org/10.5169/seals-55218

Maintenance Facilities for the Honshu-Shikoku Bridges

Installations de maintenance pour les ponts Honshu-Shikoku

Wartungssystem für die Honshu-Shikoku-Brücken

Shoichi SAEKI
Executive Director
Honshu-Shikoku Bridge Authority
Tokyo, Japan

Masami TSUCHIYAMA
Manager, Eng. Dept
Honshu-Shikoku Bridge Authority
Tokyo, Japan

Takao ETO
Manager Maintenance Dept
Honshu-Shikoku Bridge Authority
Tokyo, Japan

Isamu ARIMA
Dep. Mgr, Maintenance Dept
Honshu-Shikoku Bridge Authority
Tokyo, Japan

SUMMARY

When all the routes of the Honshu-Shikoku Bridges are opened, the total weight of the steel in bridge sections passing over the strait will reach 800,000 tons, and the area for repair painting is expected to be as large as five million m2. The Honshu-Shikoku Bridge Authority has provided vehicles and other equipment for inspection and repair of completed sections with the goal of saving labour in bridge maintenance. The Authority is also investigating ways of saving labour through use of various types of mechanised equipment. This report outlines the characteristics of maintenance of long-span bridges, existing mechanical equipment, and mechanical equipment currently under consideration.

RÉSUMÉ

Lorsque tous les ponts entre Honshu et Shikoku auront été construits, le poids total d'acier utilisé pour les ponts en acier atteindra 800.000 tonnes environ et la surface à repeindre à des fins de maintenance est estimée à quelques 5 millions de m2. La "Honshu-Shikoku Bridge Authority" prévoit d'utiliser des véhicules spéciaux pour la vérification et l'entretien des ponts déjà construits et étudie toutes les possibilités de mécaniser ces travaux afin d'économiser la main d'oeuvre engagée dans les opérations de maintenance des ponts de grande portée. Le présent rapport rend compte des efforts pour réduire le personnel d'entretien

ZUSAMMENFASSUNG

Nach Inbetriebnahme sämtlicher Abschnitte sind die Honshu-Shikoku-Brücken ein riesiges über das Meer spannendes Gebilde aus 800.000 Tonnen Stahl und mehr als fünf Millionen Quadratmeter Anstrichsfläche. Die damit verbundenen Wartungs- und Instandsetzungsarbeiten sind beträchtlich. Die für die Honshu-Shikoku-Brücken zuständige Behörde hat deshalb Arbeitsfahrzeuge und andere Ausrüstungen für Inspektions- und Wartungsarbeiten eingeführt, um bei der Instandhaltung der Brücke möglichst viel Arbeitskräfte einzusparen. Die Behörde untersucht darüber hinaus weitere Möglichkeiten der Arbeitsplatzeinsparung durch den verstärkten Einsatz mechanischer Ausrüstungen. Der vorliegende Bericht gibt einen Überblick über die damit zusammenhängenden Punkte.

1. INTRODUCTION

The Honshu-Shikoku Bridges, carrying both the highways and railways, are composed of a group of long-span bridges passing over the strait. The total length of the bridges is approximately 178 km. At present 60% of the total, or approximately 108 km, is in service.

The main categories of long-span bridge maintenance management are bridge inspection and bridge maintenance. Repair painting task occupies a large proportion of maintenance work, and this proportion is expected to increase as the bridge ages. When all the routes of the Honshu-Shikoku Bridges are completed, the total weight of the steel used in the bridge sections passing over the strait will reach 800,000 tons, and the area for repair painting is expected to be as large as five million square meters. In Japan in recent years many laborers have been leaving the construction industry, and the average age of those remaining, just as it is among the general population, is increasing. This had led to concerns about the productivity of the labor force.

The Honshu-Shikoku Bridge Authority (HSBA) has provided vehicles and other equipment for inspection and repair of completed sections with the goal of saving labor in maintenance of the bridges. HSBA is also investigating labor saving by using various types of mechanized equipment.

This report outlines the characteristics of maintenance management of long-span bridges, existing mechanical equipment, and mechanical equipment currently under consideration.

2. CHARACTERISTICS OF MAINTENANCE OF THE HONSHU-SHIKOKU BRIDGES

Table 1 shows the elements of bridges over the strait that comprise the Honshu-Shikoku Bridges and that are in use. The characteristics of maintenance services of the Honshu-Shikoku Bridges are as follows:

① The Honshu-Shikoku Bridges are a large bridge system whose construction required the overcoming of severe natural obstacles. Therefor, total replacement of the bridges is extremely unfeasible, and maintenance services that will last over the bridge s life for more than 100 years must be established.

② Most long-span bridges of the Honshu-Shikoku Bridges are on or near the sea. Maintenance services must deal with a highly corrosive environment.

③ Most of the bridges are large, complicated structures that incorporate both the road and railway transportation passing high above the sea, therefor, the inspection and repair work becomes difficult.

④ Alternative means of transportation are limited, so the bridges must offer a safe and dependable transportation corridor at all times.

Given the above characteristics, there are various design, construction, and maintenance considerations. Maintenance considerations are as follows:

① Maintenance facilities, including passageways and work vehicles for inspection and repair, are provided

② Inspection work is categorized as daily, periodic, and extraordinary, and the goals and contents of each job are clarified. To gather information for inspections, measurement devices such as wind direction and wind speed detectors, displacement gauges, and accelerographs, all of which also provides data for the traffic management and design verification, are installed on the main bridges. The bridges are in salty environments and are thus vulnerable to corrosion; they are also long and tall, which makes them difficult and expensive to repaint and maintain. Therefore, to reduce maintenance work highly anti-corrosive paints and coating specifications (long-term anti-corrosive paint system) are used.

The characteristics of the painting management system are as follows:

① The effectiveness of the long-term anti-corrosive paint system has not been studied over a long period of time, therefore, corrosion formation and deterioration patterns are not well understood. However, observations indicate that the rust tends to penetrate materials and not to spread out over the paint system. It thus necessitates to repair damaged areas as soon as possible. A scaffolding system that provides good access to all parts of the bridge is required.

② The painting of an entire bridge is a burdensome job that must be done efficiently in a difficult work environment. Therefore, safe and rational methods that minimize the impact of the work on the other environments are required.

Bridge Name	Bridge Type	Bridge Length (m)	Center Span (m)	Tower Height (m)
Ohnaruto Bridge	Suspension	1,629	876	144 *1
Tozaki Viaduct	Steel Box	1,009	190 *2	-
Muya Bridge	Steel Box	535	160 *2	-
Shimotsui Seto Bridge	Suspension	1,400	940	149 *1
Hitsuishijima Bridge	Cable-stayed	790	420	152 *1
Iwakurojima Bridge	Cable-stayed	790	420	152 *1
Yoshima Bridge	Truss	850	245 *2	-
Kita Bisan-Seto Bridge	Suspension	1,538	990	184 *1
Minami Bisan-Seto Bridge	Suspension	1,648	1,100	194 *1
Onomichi Bridge	Cable-stayed	385	215	77 *1
Innoshima Bridge	Suspension	1,270	770	145 *1
Ikuchi Bridge	Cable-stayed with Composite Box Girder	790	490	127 *1
Ohmishima Bridge	Two-hinged Steel Arch	328	297	-
Hakata Bridge	Steel Box	325	145	-
Ohshima Bridge	Suspension	840	560	97 *1

*1 Indicates the height of the tower from T.P. (mid-point in the Tokyo Bay tidal range)
*2 Indicates the length of the longest span.

Table 1 Elements of Bridges In Use

3. EXISTING MAINTENANCE FACILITIES

The Honshu-Shikoku Bridges in use have the maintenance and management facilities as the following.

3.1 Inspection passageways

The main inspection passageways are primarily located alongside the bridge girders. In addition, fixed scaffoldings are installed at tower entrances, bearings, and near navigation lights. Secondary maintenance passageways are installed to connect the main passageways, and the elevators are also installed in towers of suspension bridges and cable-stayed bridges .

3.2 Work vehicles for inspections and repairs

As shown on the Table 1, the types of bridges under discussion are suspension bridges, cable-stayed bridges, truss bridges, and box bridges. Therefore, work vehicles for inspections and repairs are of the following types:

① Work vehicles for inspections and repairs installed on the girders (suspension bridges, cable-stayed bridges, and truss bridges)
② Work vehicles for inspections and repairs installed on the towers (cable-stayed bridges)
③ Work vehicles for inspections and repairs installed on the main cables (suspension bridges)

Photographs 1 to 4 show some examples of these vehicles.

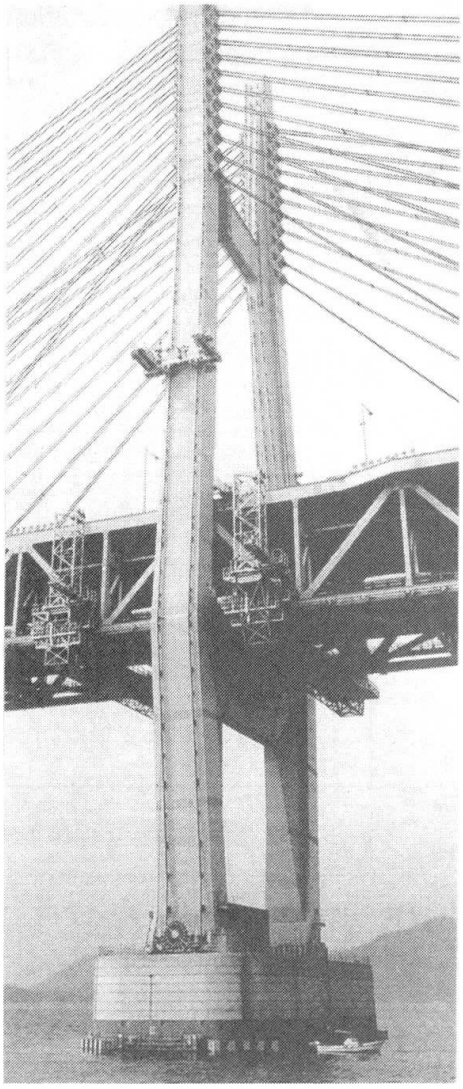

Photo 1 Work vehicle for inspecting girder and tower exteriors

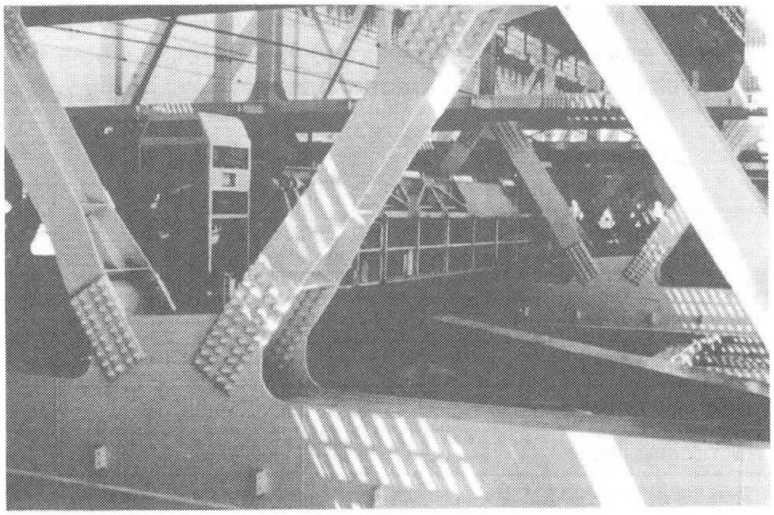

Photo 2 Work vehicle for inspecting girder interiors

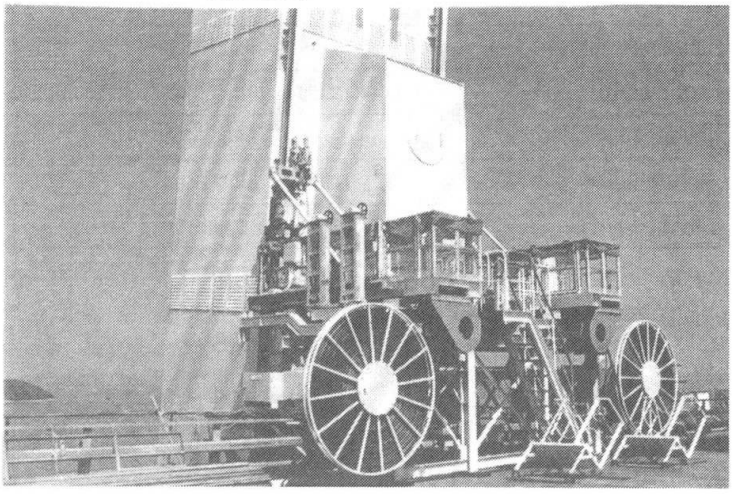

Photo 3 Work vehicle for inspecting roadside walls of the tower

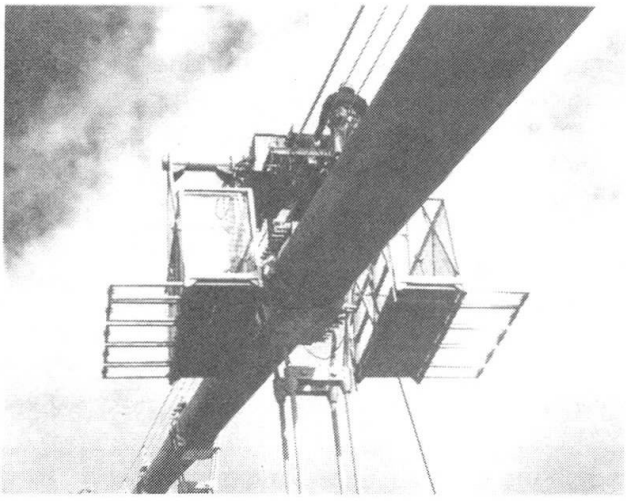

Photo 4 Work vehicle for inspecting cables

4. MECHANICAL FACILITIES UNDER DEVELOPMENT

4.1 Mechanical facilities for repair painting

4.1.1 Development goals

It is anticipated that the repair painting will comprise a large proportion of maintenance work. As described above, when the three routes are completed, the total area of sections that will need repair painting will be tremendously large, requiring a large number of painters. The following two problems are accompanied with this labor problem:

① Due to the strong winds and work heights, it is difficult to create safe working environments for painters.

② It is impossible to provide access by work vehicles for inspections and repairs to all members requiring repair painting.

Hopefully, all repair painting should have a good quality and consistency comparable to those achieved in a factory. Therefore, to minimize labor costs for painting while maintaining those quality requirements, an entire bridge mechanical facilities are being developed for repair painting.

4.1.2 Requirements

The requirements of the mechanical facilities for repair painting are as follows:

① For the time being, semi-automatic man-machine system with use of servo-assisted machines should be developed, and the fully automated system will be facilitated in the future.

② Existing work vehicles for inspection and repair should be used efficiently.

③ Devices on the vehicles should be suitable for general purposes and as light as possible.

④ The first and the second coating works should be focused for an entire bridge repainting, and the quality of such coating works should be as equal as that of the painting in the factory.

⑤ The systems should prevent from dispersion of dust of paint mist during surface treatment or painting.

4.1.3 Current situation of development

Development of mechanical facilities for repair painting began in 1990. By the end of 1992, those studies had been carried out such as collection of reference materials, and investigation on labor-saving equipment, applicability to the structures, the latest equipment for painting and surface treatment, and the main structures of mechanical facilities. At present, being studied are the latest system to prevent from the paint dispersion.

4.2 Mechanical facilities for inspecting the main towers of suspension bridges

4.2.1 Development goals

The main towers of the suspension bridges are over 100 meters above the sea level. To provide access to the towers for inspection, there is no other means than temporary facilities, such as gondolas. However, considerable manpower is required to set up such facilities, and the workmanship to conduct an inspection can be required in the great heights. These problems are particularly critical on the Akashi Kaikyo Bridge under construction, which is 300 meters above the sea level.

Meanwhile, visual inspection can be done from a distance with a small, light ITV. In addition, multi-joint manipulator systems have been developed for removing deteriorated paint and measuring coat thickness. By applying these systems, it should be possible to inspect the bridges from a distance.

Robots that can move along and inspect the walls of buildings are presently being developed. By using these robots as well as with the other technologies outlined above, development of the

mechanical facilities for the main towers can be feasible, and thus the safety of inspection work can be improved, and manpower requirements can be reduced. In addition, through the use of interchangeable attachments, light repair work such as localized repair painting should also be possible.

4.2.2 Requirements

The requirements of the mechanical facilities for inspecting the main towers of suspension bridges are as follows:

① Access to discretional points on a main tower s wall.
② To provide workspace for inspection and recording the data on the coats
③ To provide workspace to remove eteriorated coats.
④ To provide workspace to perform simple tasks such as partial repair painting.

4.2.3 Current situation of development

Development of mechanical facilities for inspecting the main towers of suspension bridges began in 1989. Following this, in the same year the basic concepts were established for the facilities. Based on these concepts, in 1990 the basic design was developed to list up technical issues to be dealt with. In 1991 tests were conducted to solve various technical problems, and in 1992 the overall feasibility design was completed, which includes design of carriage system and inspection devices. At present, preparations are being made for conducting tests on the actual bridges. Figure 1 outlines the concepts being examined.

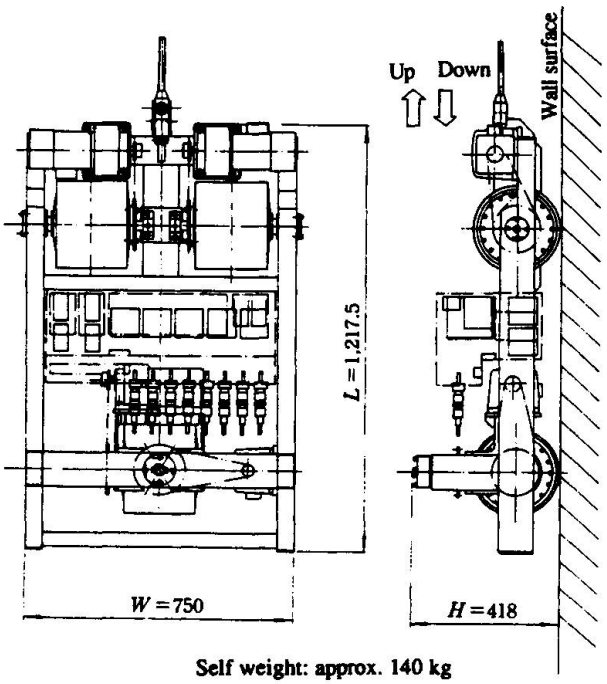

Fig. 1 Outline of the concept of the mechanical facilities for repair painting

5. CONCLUSION

The authors outlined the existing mechanical facilities and facilities being developed to save labor in the maintenance of the Honshu-Shikoku Bridges. It seems to need more time to complete development of the facilities and put them into practical use. Meanwhile, there also seems to need the other mechanical system to be used for the partial repair painting work and the inspection of the foundations 60 meters deep from the sea level. This will require the latest technologies of not only the civil and mechanical engineering but also the other fields concerned.

To maintain the nation's infrastructure in a good manner for as long as possible, corresponding to the needs of upcoming the aged society of Japan, a new technology for maintenance services shall be developed by the end of this century. Towards this goal, a technical committee has been established for development of mechanical facilities for repair painting. This committee has provided HSBA with invaluable guidance regarding development tasks. Finally, the authors would like to encourage the readers of this paper to provide us with valuable information regarding our goals.