Design of Bridges for Inspection, Maintenance and Repair

Dispositions constructives des ouvrages d'art en vue de l'inspection, de l'entretien et de la réfection

Bauliche Durchbildung von Brücken zur Besichtigung, Wartung und Instandsetzung

Hans PFOHL
Dipl. - Ing.
Fed. Highway Res. Inst.
Bergisch Gladbach, FRG

Hans Pfohl, born 1927, graduated from the Technical University of Stuttgart, FRG. For many years he worked with the Road Authority of Baden-Württemberg, FRG, in the field of design, construction and maintenance of bridges. Since 1972 he is Head of the Bridge Division at the Federal Highway Research Institute.

SUMMARY
The report stresses the importance of inspection, maintenance and repair for the long-term reliability of bridges and gives some information about requirements of structural design and the organization of bridge inspection in the Federal Republic of Germany. Guidelines for practical design for the purpose of facilitating inspection and maintenance are explained, including economic aspects.

RÉSUMÉ
Ce rapport fait ressortir l'importance que revêtent l'inspection, l'entretien et la réparation pour la fiabilité à long terme des ouvrages d'art. Il donne en même temps quelques renseignements au sujet des exigences de la construction et en matière d'organisation de l'inspection des ouvrages d'art. Des dispositions constructives visant à faciliter la gestion des ouvrages d'art sont expliquées à titre d'exemple et évaluées du point de vue économique.

ZUSAMMENFASSUNG
Der Bericht betont die Bedeutung von Prüfung, Unterhaltung und Reparatur für die Zuverlässigkeit von Brücken auf lange Sicht. Er gibt einige Hinweise zu konstruktiven Anforderungen und über die Organisation der Brückenprüfung in der Bundesrepublik Deutschland. Richtlinien für die bauliche Durchbildung zur Erleichterung der Brückenerhaltung werden erläutert und in wirtschaftlicher Hinsicht bewertet.

1. INTRODUCTION

Bridges must be properly designed, calculated and constructed. But this is not sufficient to guarantee longevity and long-term reliability. The most important causes are:

- Bridges are expected to achieve a life time of about 80 years. But nobody can predict the changes that may occur during this time, e.g. in terms of environmental conditions or service load.
- It is often not only economical but even necessary to make use of new developments in material, structural design and technique. But despite careful considerations in advance it is not possible to calculate the long-term behaviour of the structure precisely.

Therefore safety and durability of bridges can be ensured only by regular inspection and maintenance and also repair measures if necessary. From that follow particular requirements on design on the one hand and on personnel and equipment of road authorities on the other hand.

2. REQUIREMENTS OF STRUCTURAL DESIGN

It is an essential principle to be employed whenever possible to design in such a way that the structure will not suddenly collapse. Instead a possible failure should be noticeable in time by visible indications which can be detected by bridge inspection. Such indications can be extraordinary deformations or cracks whose width is increasing. In the Federal Republic of Germany it is required of prestressed concrete structures [1] that every cross section of the structure must contain several tendons. If one tendon were to fail, the others would have to be able to prevent collapse.

Usually we employ post tensioning. We have been trusting in this method, but we have also restricted the tensile stress of tendons in service to a relatively low level (55% of tensile strength). In our opinion this restriction is advantageous in order to limit the relaxation of the prestressed steel and to lessen the danger of crack corrosion. We believe that we in this way properly serve the longevity of the structure. The planned low level of the tensile stress offers also the possibility of overstressing the tendons in cases of extraordinary friction losses. These aspects should be taken into account when the allowed tensile stress is finally harmonized by the Euro Code 2.

External prestressing has been used in rare cases of strenghtening or repair of existing bridges, but not as a previously planned measure in order to facilitate future repair. Concerning new structures there are some considerations here and there to locate unbonded tendons outside the cross section so that they can be exchanged. But such solutions have not come into practice yet. We also have reservations about building in empty prestressing ducts to have the option of introducing additional tendons later on, because hollow spaces in concrete can be detrimental.

3. ORGANIZATION OF BRIDGE INSPECTION

Facing the significance of maintenance of existing bridges the road authorities of the FRG have been setting up a well thought out system of bridge inspection. Each federal state employs well trained inspection groups. The staff must meet high requirements, because the correct interpretation of observations, possibly indicative of dangers, needs expert knowledge and wide experience.

The general rules of bridge inspection are laid down in DIN 1076 [2]. There are three basic types of bridge inspection:

- Superficial inspection
- Principal inspection
- Special inspection

Superficial inspections are carried out at least four times a year in connection with the normal observation of the road by road maintenance personnel without special training. The purpose is to report obvious deficiencies which can be found without special means.

Intervals of principal inspections are three years. Every six years even hardly accessible areas have to be inspected by means of special equipment or scaffolding. Principal inspections are made by inspection groups led by a trained inspector under the general supervision of a bridge engineer.

Special inspections are required after particular events like extraordinary traffic accidents, high water or fire.

4. PRACTICAL DESIGN FOR FACILITATING BRIDGE INSPECTION AND MAINTENANCE

The inspection groups have all equipment needed to reach the critical zones of the structures. They are even equipped with snoopers (investigation cars) working from the ground or from the surface of the bridge grasping at the soffit. But this kind of equipment is costly. Snoopers can not carry heavy loads and are susceptible to dirt arising from repair work. Therefore it is economical and efficient to design in such a way that inspection and maintenance can be done without special equipment as far as possible.

In the Federal Republic of Germany guidelines [3] in this field were elaborated. We have learnt that they must be respected at all stages of the design process. These guidelines are to ensure that inspection as well as foreseeable repair work can be performed whenever necessary, as easily as possible, with due regard to the safety of the staff and without significant hindrance of traffic. The objective is a design which enables the bridge inspector to reach every point of the surface of the structure with his own hands using means as simple as possible.

Special value is attached to accessibility of bridge bearings, transition joints, drainage pipes and other components which are particularly exposed to wear and tear. According to our experience an inspection tunnel should be provided below transition joints. Drainage pipes along the web of a T-beam need to be accompanied by a foot-bridge for the inspecting crew. All hollow spaces must be accessible.

Necessary repairs must not be delayed because of lacking infrastructure. Therefore driveways to the ground below the bridge and also basic installations for electrical lighting in the hollow spaces must be taken care of when the bridge is built.

As an example of practical design fig. 1 reveals the access to the head of a high hollow pier from the box girder and within the pier. The box girder is accessible from each abutment, the pier from the ground by a door. Within the pier platforms (at intervals of 5 m) and ladders are installed. This is especially significant in case of drainage pipes within the pier. All steel parts are hot-galvanized. The platforms can carry loads usually occurring during repair work. Material can be lifted by a winch through openings in the platforms. All arrangements are made to install jacks on the pier head so as to lift the superstructure and to exchange bridge bearings if necessary.

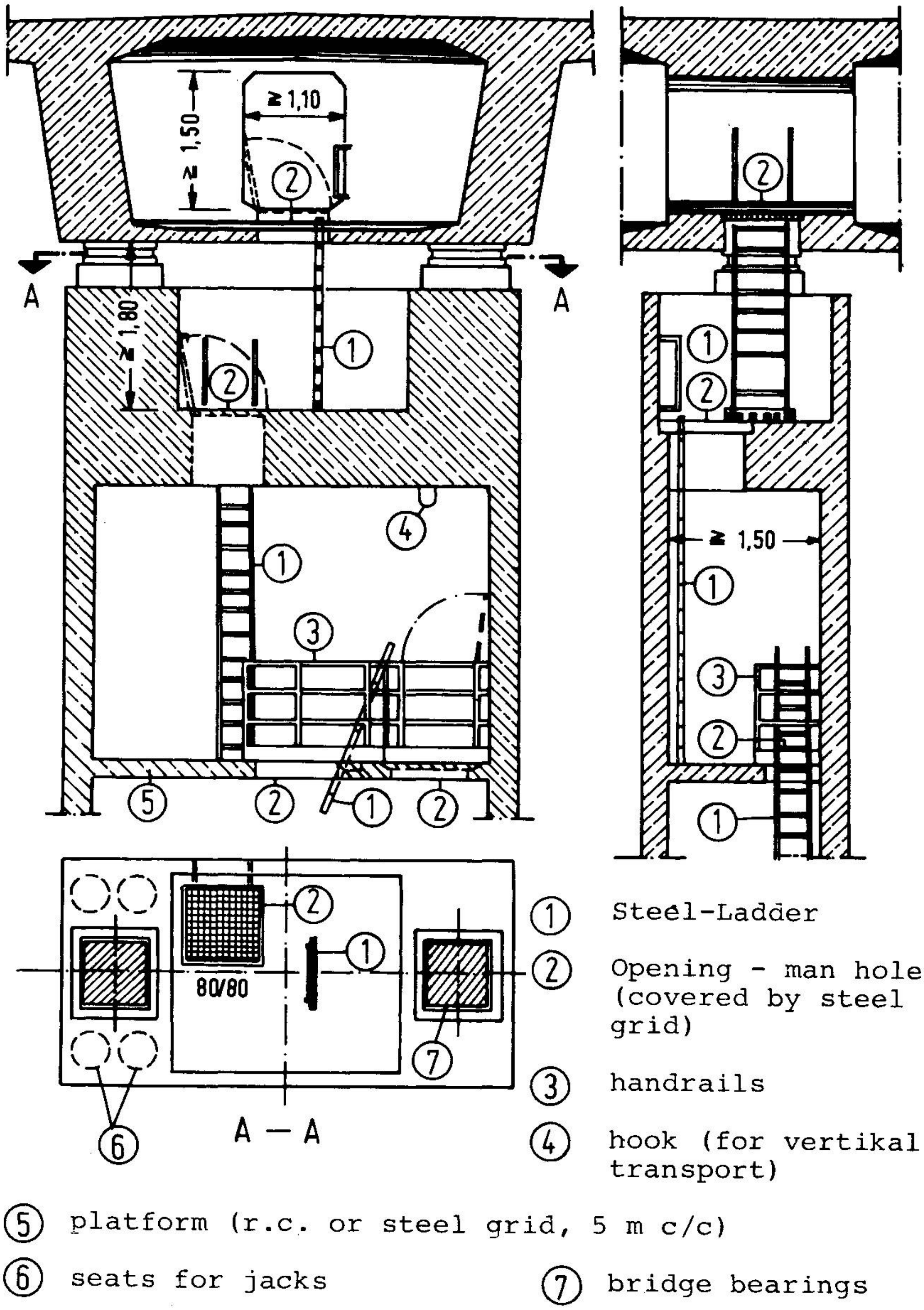

Fig. 1 Access within pier and from box girder to pier head.

5. ECONOMIC CONSIDERATIONS

Appropriate practical design to facilitate bridge inspection, maintenance and repair undoubtedly requires special care and to some extent extra costs. On the occasion of the erection of the bridge over the Kiel Channel near Brunsbüttel (2831 m long, 21 m wide, up to 45 m high, structure partly of steel, partly of prestressed concrete, completed in 1983) these extra costs were figured up. The costs of the structure amounted to 150 million DM, the additional costs of the measures derived from the principles explained in chapter 4 amounted to 4.4 million DM, which is 3%. Considering the importance of all these measures for reliable and durable bridges we are convinced that an expenditure of this order, with respect also to smaller bridges, is worth-while.

BIBLIOGRAPHY

[1] DIN 4227, Teil 1 Spannbeton; Bauteile aus Normalbeton mit beschränkter oder voller Vorspannung. Published 1979 by Beuth Verlag GmbH Berlin, FRG

[2] DIN 1076 Ingenieurbauwerke im Zuge von Straßen und Wegen, Überwachung und Prüfung. Published 1983 by Beuth Verlag GmbH, Berlin, FRG

[3] Richtlinie für die bauliche Durchbildung und Ausstattung von Brücken zur Besichtigung, Wartung und Instandsetzung. Issued 1982 by Federal Ministry of Transport, Bonn, FRG

Leere Seite
Blank page
Page vide