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6

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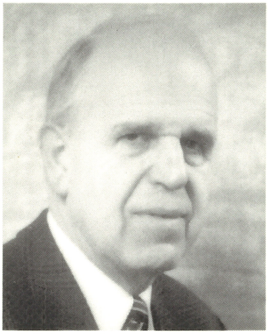
Structural Bearings and Expansion Joints for Bridges

International Association for Bridge and Structural Engineering IABSE
Association Internationale des Ponts et Charpentes AIPC
Internationale Vereinigung für Brückenbau und Hochbau IVBH

About the Author



Günter RAMBERGER

Born 1942 in Aspang, Austria, Günter Ramberger received his civil engineering degree from the Technical University, Vienna, in 1966. He worked as an assistant to Prof. Dr.-Ing. Peter Stein, Institute for Steel Structures, from 1967 to 1969 and received his doctor's degree in 1970 with a thesis on orthotropic plates. In 1970 he joined Hein, Lehmann AG, Düsseldorf, Germany, where he worked in the field of steel bridges, finally, as head of this department. He was involved in design, fabrication and erection of the following steel bridges: Oberkasseler Brücke, Düsseldorf, Franklinbrücke, Düsseldorf, Süderelbebrücke, Hamburg, Hammerbrookbrücke, Hamburg, Hochbrücke, Brunsbüttel, and many others. Since 1981 he has been professor of Steel Structures at the Technical University, Vienna, and was Dean of the Faculty for Civil Engineering from 1984 to 1987. He has been a member of the Working Commission 2 of IABSE

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Dedicated to the commemoration of the late Prof. Dr. techn. Ferdinand Tschemmernegg, University of Innsbruck.

Preface

It is my hope that this treatise will serve as a textbook for students and as information for civil engineers involved in bridge construction. My intent was to give a short guideline on bearings and expansion joints for bridge designers and not to mention all the requirements for the manufacturers of such products. These requirements are usually covered by product guidelines, which vary between different countries.

Not all the references are related to the content of this document. They are more or less a collection of relevant papers sometimes dealing with special problems.

I express many thanks to Prof. Dr.-Ing. Ulrike Kuhlmann, University of Stuttgart, chairperson of Working Commission 2 of IABSE, who gave the impetus for this work; to her predecessor of the IABSE Commission, Prof. Dr. David A. Nethercot, Imperial College of Science, Technology and Medicine, London, for reviewing the manuscript, and Prof. Dr. Manfred Hirt, Swiss Federal Institute of Technology, Lausanne, for his contributions and comments.

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Vienna, April 2002 Günter Ramberger

Table of Contents

1 Bearings

1.1 Introduction

All bridges are subjected to movements due to temperature expansion and elastic strains induced by various forces, especially due to traffic loads. In former times our bridges were built of stones, bricks or timber. Obviously, elongation and shortening occurred in those bridges, but the temperature gradients were small due to the high mass of the stone bridges. Timber bridges were small or had natural joints, so that the full elongation values were subdivided into the elongation of each part. On the other hand, the elongation and shortening of timber bridges due to change of moisture is often higher than that due to thermal actions. With the use of constructional steel and, later on, of reinforced and prestressed concrete, bridge bearings had to be used. The first bearings were rocker and roller bearings made of steel. Numerous rocker and roller bearings have operated effectively for more than a century. With the development of ageing-, ozone- and UV-radiation-resistant elastomers and plastics, new materials for bearings became available. Various types of bearings were developed with the advantage of an area load transmission in contrast to steel bearings with linear or point load transmission, where elastic analysis leads theoretically to infinite compression stresses. For the bearings the problems of motion in every direction and of load transmission were solved, but the problem of insufficient durability still exists. Whilst it is reasonable to assume the life of steel bearings to be the same as that of the bridge, the life of a bearing with elastomer or plastic parts can be shorter.

1.2 The role of bearings

The role of bearings is to transfer the bearing reaction from the superstructure to the substructure, fulfilling the design requirements concerning forces, displacements and rotations. The bearings should allow the displacements and rotations as required by the structural analysis with very low resistance during the whole lifetime. Thus, the bearings should withstand all external forces, thermal actions, air moisture changes and weather conditions of the region.

1.3 General types of bearings and their movements

Normally, reaction forces and the corresponding movements follow a dual principle – a non zero bearing force corresponds to a zero movement and vice versa. An exception is given only by friction forces which are nearly constant during the movement, and by elastic restraint forces which are generally proportional to the displacement.
Usually, the bearing forces are divided into vertical and horizontal components.
Bearings for vertical forces normally allow rotations in one direction, some types in all directions. If they also transmit horizontal forces, usually vertical forces are combined.

2 Expansion Joints

2.1 Introduction

As mentioned in chapter 1.1, movements in old stone and timber bridges were small and no additional devices were necessary to close the gaps between bridges and abutments due to bridge movements. The first expansion joints were built for steel railway bridges because their movements were not negligible. With the increase of road traffic and of its speed, closing the gaps became necessary for safety reasons, especially at the moveable bearings. Initially, cover plates were used for expansion joints. For longer bridges these cover plates were not sufficient, so that finger joints and sliding plate joints were used. All these types of expansion joints were not watertight and so the water ran down to the bearings and to the abutments. The first watertight expansion joints were built using steel rails between rubber tubes to absorb the movements. This principle led to a lot of different multisealed expansion joints which differed in the means of supporting the steel rails, in the rubber profiles and in controlling the gap widths. Another type of watertight expansion joint is the cushion joint, consisting of a rubber cushion with vulcanised steel plates which transfer the traffic loads. In spite of continuous amendments of all constructions for expansion joints, these still remain wearing parts, especially in bridges with high traffic density and high traffic loads. The following chapters give a short survey of expansion joints for different movements used in the construction of bridges.

2.2 The role of expansion joints

The role of expansion joints is to carry loads and to provide safety to the traffic over the gap between bridge and abutment or between two bridges in a way that all bridge displacements can take place with very low resistance or with no resistance at all. A further requirement is a low noise level especially in an urban environment. The expansion joints should provide a smooth transition from the bridge to the adjacent areas. The replacement of an expansion joint is always combined with a traffic interruption – at least of the affected lane. Therefore expansion joints should be robust and suitable for all loads and local actions under all weather conditions, moisture and deicing agents. The replacement of all wearing parts should be possible in a simple way.

2.3 Calculation of movements of expansion joints

Movements of expansion joints depend on the size of the bridge and the arrangement of the bearings. Normally the form of construction depends on the horizontal translation orthogonal to the joint. But it is necessary to consider all translations and rotations to ensure that the displacements will not reach the limits of the joint construction.
To describe the movements of an expansion joint in detail we have to consider three translations and three rotations (fig. 2.3-1).

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The International Association for Bridge and Structural Engineering (IABSE) was founded as a non-profit scientific association in 1929. Today, it has more than 4200 members in over 100 countries. IABSE's mission is to promote the exchange of knowledge and to advance the practice of structural engineering worldwide. IABSE organizes conferences and publishes the quarterly journal *Structural Engineering International,* as well as conference reports and other monographs, including the SED series. IABSE also presents annual awards for achievements in structural engineering.

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Structural Bearings and Expansion Joints for Bridges

Bridge superstructures have to be designed to permit thermal and live load strains to occur without unintended restraints. Bridge bearings have to transfer forces from the superstructure to the substructure, allowing all movements in directions defined by the designer. The two functions – transfer the loads and allow movements only in the required directions for a long service time with little maintenance – are not so easy to fulfil. Different bearings for different purposes and requirements have been developed so, that the bridge designer can choose the most suitable bearing.

By the movement of a bridge, gaps are necessary between superstructure and substructure. Expansion joints fill the gaps, allowing traffic loads to be carried and allowing all expected displacements with low resistance. Expansion joints should provide a smooth transition, avoid noise emission as far as possible and withstand all mechanical actions and chemical attacks (de-icing) for a long time. A simple exchange of all wearing parts and of the entire expansion joint should be possible.

The present volume provides a comprehensive survey of arrangement, construction and installation of bearings and expansion joints for bridges including calculation of bearing reactions and movements, analysis and design, inspection and maintenance. A long list of references deals with the subjects but also with aspects in the vicinity of bearings and expansion joints.

This book is aimed at both students and practising engineers, working in the field of bridge design, construction, analysis, inspection, maintenance and repair.