ECCS TC 6

Fatigue and Fracture

From Assessment to Best Practice

A Collection of Historical Fatigue Damage Cases in Steel and Composite Bridges

1st Edition, 2020

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PREFACE

During more than 150 years, steel has been playing an important role as a construction material for structures, including rail and road bridges. In spite of all the experience acquired with the structural use of this material, different pathologies including fatigue, a time-dependent one can develop, often because of improper detailing and/or inadequate idealization of the behaviour of structural details.

Just as in medicine, understanding structural pathologies needs observing, collecting cases, analysing them in order to understand the origins of the phenomena in order to properly cure and/or prevent them. As a step forward concerning the pathology of fatigue, this book collects and analyses more than 100 historical fatigue damage cases in steel and composite bridges, aiming at appropriate assessment and/or design methods to ensure that steel will allow us to build structures like bridges for another 150 years or more.

The publication of this collection was made possible within the framework of Working Group 6.1 “Assessment of Existing Steel Structures”, part of ECCS Technical Committee 6 “Fatigue and Fracture”. Active members of the committee were involved in drafting, reviewing and commenting the collection.

Special thanks go to Mohamad Al-Emrani, who did a pioneer work on collecting all the available information on fatigue damage cases, and then in categorising and summarising them. This publication, unique on an all-European level, gives the possibility to all involved in designing steel structures to base the design of fatigue prone details on the cases of real pathology of fatigue. Furthermore, those involved in maintenance will find information where to look for fatigue damage in order to assess the state of a structure and decide about its future.

With such assets, this collection represents another step forward towards an optimal use of steel in structures, both existing and new ones, subject to variable loading and with it a long and healthy life of the European steel construction industry.

June 2020

Mladen Lukić, ECCS TC6 Chairman
Bertram Kühn, ECCS TC6 WG6.1 Chairman

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INTRODUCTION

Fatigue is often the limit state that determines the design of steel and composite bridges. The residual life of existing bridges is also regularly governed by the fatigue performance of critical details in these bridges. The survey of fatigue-prone details presented in this report shows clearly that the majority of fatigue damage cases reported for steel and composite bridges are caused by secondary effects (the so called deformation-induced fatigue cracking) which are usually not considered in design. This type of fatigue damage is often the result of secondary restraint forces generated by some kind of unintentional or overlooked interaction between different members in the bridge. Poor detailing, with unstiffened gaps and abrupt changes in stiffness at the connections between different members, also contributed to fatigue cracking in most details.

Design codes and evaluation specifications generally provide very little guidance on the way this kind of fatigue damage should be accounted for or prevented. It is the responsibility of the bridge designer to ensure – through good detailing – that these secondary effects and the kind of fatigue damage associated with them are avoided. Therefore, information feedback to bridge engineers on the real performance of various bridge details that are frequently used in bridge design is essential to promote good design practice and avoid details that have shown unsatisfactory fatigue performance.

In addition, a correct identification of fatigue-prone details in a bridge, along with well-planned inspection routines and successful strengthening and repair schedules, can contribute to the continuous satisfactory performance of the bridge during its service life.

In this report, more than 100 fatigue damage cases were studied and categorized according to the type of detail and/or the mechanism behind the observed fatigue cracking. It is clear that more than 90% of all reported cases are of the kind caused by secondary effects, so-called deformation-induced cracking.

Figure 1 shows the collected damage cases categorized according to detail type. The most common types of deformation-induced fatigue damage can be found in the connections between stringers and floor beams, between the latter and the main load-carrying elements in the bridge and at the connections of diaphragms and cross-bracings. Moreover, fatigue damage in details in orthotropic decks and in bridge elements with coped ends or cut-short flanges at their connections to other elements are fairly common.

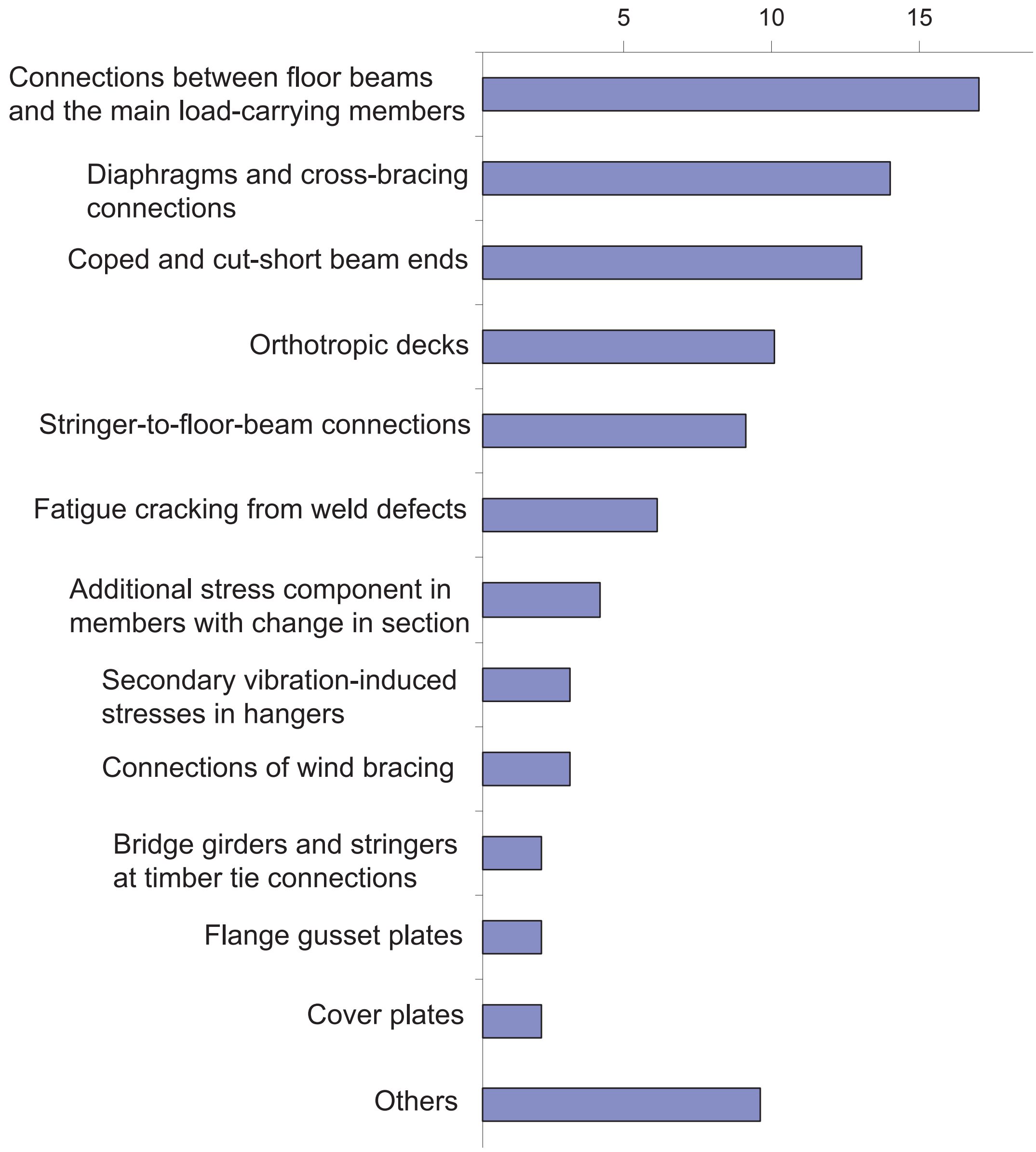

Fig. 1: Collected fatigue damage cases listed according to the type of detail in which they were encountered