Fatigue Design of Van Brienenoord Bridge Deck

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Abstract

The remaining life of steel bridges is often governed by fatigue cracking in the orthotropic steel deck (OSD). Since the design and construction of many of the steel bridges in Europe's motorway system, the number and weight of the trucks they must carry has significantly increased. This has led to many bridges being deemed understrength, compared to contemporary design guidance, and experiencing local fatigue damage. This is a problem facing the Dutch national bridge authority, Rijkswaterstaat (RWS), and many other governments globally as decades old steel bridges need renewing, strengthening or sometimes, in the case of OSD, an inspection and repair program.

Rotterdam's Van Brienenoord bridge [1] is the busiest in the Netherlands, and renewing the twin-tied arch bridge requires a newly designed OSD. The key challenges were to sustainably extend the life of the bridge to its 100-year design life whilst minimising hindrance to traffic and maintaining the aesthetic of what is a national icon. Given the extreme sensitivity of fatigue calculations to stress magnitude, the aim of the work was to develop a state-of-the-art accurate method for predicting the design, or remaining, life of OSD. Traditional methods tend to underestimate fatigue demand.

Keywords: sustainable design; steel bridges; local fatigue; orthotropic steel deck; renovation; 100-year life.

1 Introduction

The design of a new OSD for Van Brienenoord Bridge (VBB), see Figure 1, used state-of-the-art fatigue calculations developed by Arup over the past 15 years with input from RWS and TNO (Toegepast Natuurwetenschappelijk Onderzoek). Over this time Arup have assessed and renovated several bridges, developing an in-depth knowledge of a range deck types and configurations.

The aim of the work was to develop an accurate method for predicting either the remaining or design life of OSD. Traditional methods tend to underestimate fatigue demand as they fail to capture all the local effects that contribute to the build-up of stress in the weld. Hence, one of the main aspects of the modern approach to local fatigue assessments is the detailed finite element (FE) model with hot-spot stress extraction. Fatigue calculations are

https://doi.org/10.2749/manchester.2024.0268