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Traffic parameter sensitivity in the development of site-specific load models

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Abstract

In the context of an aging infrastructure in a highly developed country like Germany and the resulting increased importance of reassessment of existing bridge structures, a need for more realistic and precise descriptions of traffic load impact (road traffic) on bridges arises. To address this necessity, a research project has been initiated in cooperation with the Highways Authority of Southern Bavaria, aiming at developing site-specific traffic load models and evaluating their potential of application within the scope of reassessment for an exemplary route, the federal highway BAB A92 in Germany.
Based on large sets of recorded traffic data provided from permanent measurement stations, extensive numerical traffic simulations are performed. By evaluation of the structural response for selected bridge systems due to this simulated traffic and subsequent statistical extrapolation to extreme load effects, characteristic values of traffic load effects with defined return periods in accordance with requirements from the Eurocode are obtained, serving as base for calibration of site-specific load models.
Extensive numeric parameter studies estimating extreme load effects on a set of different structures and traffic constellations are performed, to gain a better understanding of the underlying correlations, and hence support the development of strategies to identify those sections of the highway network promising the highest potential for the application of site-specific load models in bridge reassessment. This paper presents a general approach for developing site-specific load models based on recorded traffic data, and discusses first findings and results gained from the above described parameter study.

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Keywords: bridge reassessment, road traffic, load model, parameter sensitivity, simulation, extreme load effect, aging infrastructure, traffic parameter, statistical extrapolation, parameter study, remaining lifetime

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1. Introduction

For a country like Germany – being a major player in Europe's economy and situated in the center of the continent experiencing extensive transit traffic by several main cross European routes – the traffic infrastructure, and especially the network of federal highways, is of outstanding significance. It not just ensures economic performance and efficiency, but also provides mobility and quality of life to the population, hence decisively contributing to the country's wealth. As one of the key elements, bridge structures pose critical points for the functionality and performance of this network. Correspondingly, restrictions or even deficiencies of their utilization might result in severe and extensive consequences.

Considering the age pattern of the bridge inventory of the German federal highway network, it gets obvious that our country has to face increasingly the challenges of an extensive but aging infrastructure. With a main period of construction of new bridges from the 1960s to the 1980s, at present about two thirds of the structures are older than 30 years [1]. While bridge design generally aims at providing safe, reliable and functional structures for a long lifetime (generally 100 years), consequences from shortcomings in past structural design, structural deterioration, and increased heavy traffic volumes can lead to noticeable decline in structural performance already throughout service life, entailing that at present, road bridges not even 50 years in service face considerable difficulties to fulfill all requirements in terms of structural reliability, functionality and durability under current conditions. Within this context, an inevitable necessity arises for structural reassessment and development of sustainable strategies for dealing with an aging infrastructure in the face of limited resources and high demand for its utilization.

A first step has been made by the introduction of a special guideline ("Nachrechnungsrichtlinie", [2]), providing a wide and consistent framework for reassessment of existing road bridges. The findings from reanalysis of a large set of bridge structures applying this guideline yet show that in many cases calculative deficiencies could still be identified when assessing the structures under current conditions [3]. In the face of these a bit unsatisfactory results, and the awareness of the existence of several reserves in reassessment due to simplifications in the description of load impact and structural resistance, multiple research efforts have been undertaken, mainly aimed at describing the actual structural behavior in a more precise and realistic manner.

Within this context, a research project has been initiated in cooperation with the Highways Authority of Southern Bavaria. The main objective of this project is the investigation of the potential of more realistic and precise descriptions of the load impact due to actual road traffic on bridge structures. Based on recorded traffic data from already existing and operating measurement stations along an exemplary section of the federal highway network of Bavaria (federal highway BAB A92), site-specific load models shall be developed, and their potential for application in bridge reassessment evaluated. Additionally, the results from this research and the knowledge about the significance of the different traffic parameters shall allow for evaluation of the consequences of future traffic developments (e.g. increasing traffic volumes, higher permissible gross vehicle weights, etc.), and thus contribute to the development of efficient and sustainable strategies for dealing with an aging infrastructure.

2. Methodology

One common approach to develop site-specific load models follows the principle of obtaining an estimate for extreme load effects on the bridge at site due to the traffic at site. These extreme load effects are defined by a certain probability of occurrence during the lifetime of the structure, in accordance with specifications stated in the Eurocodes [4]. Denoted as "characteristic values" of the structural demand, they serve for subsequent calibration of the site-specific load models, by adapting the α–values from the Eurocode load model such that an evaluation of the structure with this "modified" model leads to the same load effects as stated by the respective characteristic values. Figure 1 shows a principle scheme for the development of site-specific load models. Similar approaches have been already applied for the development of the load models in the Eurocode [5], and in other related research works, such as [6] and [7], to name just a few.