Digital Bridge Schwindegg: Ab initio bridge monitoring for a sustainable lifecycle management

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Abstract

Bridges worldwide are facing challenges of aging, increasing traffic, and heavier vehicles, for which they were not originally designed. Lack of funds and skilled labour to strengthen and maintain existing structures have further intensified the need for bridge rehabilitation. Intelligent lifecycle management is proposed as a countermeasure to these problems. Many are researching the conceptual design of digital twins, exploring their potential, and investigating implementation approaches. Building Information Modelling platforms and other databases have been developed for this purpose. We demonstrate the Digital Bridge in Schwindegg (Germany) as an Industry 4.0 based prototype to monitor new bridges from opening to traffic. This paper presents the conceptual design of this unique monitoring project, and the intelligent data collection in the asset administration shell BBox. The objective is to achieve sustainable life cycle management of bridges through the creation of Digital Twins with extended lifetimes beyond the typical 50-100 years.

Keywords: Bridge Construction; Sensors; Structural Health Monitoring; Lifecycle management; Digital Twin; Data Model; Degradation of Bridges

1 Introduction

The degradation of a bridges condition is a problem which is dealt with by most governments. The German Federal Highway Research Institute (BASt) publishes therefore periodically condition grades of the German highway bridges in a bridges statistics document on their homepage [1]. The raw data is also given in [2]. The condition grades reach from 1,0 (best) to 4,0 (worst). An overview of the grade distribution is shown in Figure 1a). Figure 1b) depicts the distribution of the superstructure's material of German highway bridges. With 68,9 % of the bridges area, most German highway bridges are made out of prestressed concrete [1]. The United States Department of Transportation also provides statistics of the US bridges conditions. They differ between the conditions of their bridge areas in "good area", "fair area" and "poor area" [3]. The proportional areas of the bridges conditions in 2021 are summarized in table 1.

Table 1. Proportional conditions of US bridges (Database: [3])

	good area	fair area	poor area
ratio	43,4%	51,5%	5,1%

As bridges contribute to the functioning of a society, the development and maintenance of the structures is of high importance. Poorer countries often do not have the financial capacity to maintain their bridge structures. This is referred to as a financing gap, which needs to be closed (e.g. [4]).

https://doi.org/10.2749/newdelhi.2023.0817