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A suitability analysis of precast components for standardized bridge construction in the United Kingdom

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Abstract

This paper presents the suitability of precast components for standardized UK bridges. The conventional design and construction of UK bridges is often criticized for being inefficient and unsafe as the majority of the work is carried out on-site, which requires lots of time and temporary works. The concept of Design for Manufacture and Assembly (DfMA) is employed in this study to overcome the limitations of the current bridge construction practice. First, underlying DfMA criteria for bridge construction are identified and a suitability analysis of precast components based on the identified DfMA criteria identified is conducted via an interview. Second, a case study on a bridge recently built for a highway bridge project is conducted to identify the feasibility of the potential precast components selected from the suitability analysis. The result of the case study demonstrates that the recommended precast components can be successfully used for future standardized bridges of the UK.

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Keywords: Design for manufacture and assembly, precast components, standardised bridges, suitability analysis

1. Introduction

The traditional bridge construction process is often criticized as being inefficient and unsafe [1]. The underlying reason for this is the nature of the construction where the majority of the work is carried out on-site. In fact, the design

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and construction of bridges in the UK has not been standardized or commoditized, resulting in costly and time-consuming construction practices. To address this problem, trials of off-site manufactured precast components for standardized bridge construction have increasingly been explored, inspired by the US Accelerated Bridge Construction (ABC) program [2] which utilizes a variety of precast components including piles, piers and full-depth deck slabs. However, the use of precast components in the UK is limited to a few types such as precast beams and precast piers/columns. Hence, there is a need to investigate and identify the suitability of all types of precast components for the standardization of bridge components. The concept of Design for Manufacture and Assembly (DfMA) is employed in this study to meet the needs and requirements of the bridge standardization. The objectives of this study are two-fold: (1) Identify specific DfMA criteria to be used for the evaluation of precast components for the standardization of bridge construction; and (2) Analyze the suitability of precast components based on the criteria identified. The rest of the paper is as follows. A brief review of DfMA is presented along with a classification of current and future UK highway bridges in Section 2, followed by the identification of detailed criteria for future standardized bridge components in Section 3. Section 4 analyses the suitability of precast components based on the identified DfMA criteria. Section 5 presents a case study on a bridge project adopting the DfMA approach to investigate the feasibility of the potential precast elements. Finally, Section 6 concludes with a summary of the paper.

2. Research background

2.1 Design for Manufacture and Assembly (DfMA)

DfMA is an approach to design that focuses on ease and efficiency of manufacture and assembly [3] as illustrated in Fig. 1. This approach is driven by the need to produce large numbers of high-quality products, so widely adopted in sectors such as the automotive and consumer-products industries. DfMA is the combination of two methodologies: (1) Design for Manufacture (DfM), which means parts are designed to make their manufacturing processes easier, and (2) Design for Assembly (DfA), which means the product is designed to allow easy on-site assembly. These two main blocks of DfMA are important milestones of a product development process and allocate increased percentage of time on the conceptual design phase of the product development. DfM and DfA are used in the earlier realization of technical criteria to be fulfilled for successful manufacturing and assembly of parts. There are a number of benefits of using DfMA approaches: (1) *Reduced Manufacture & Assembly Cost* - DfM seeks to reduce manufacturing costs by using fewer standardized parts and by eliminating unique parts wherever possible. This has follow-on benefits during the bridge assembly stage, because the use of standardized parts and the creation of a repetitive and familiar construction sequence can improve both the construction program and quality performance; (2) *Shorter assembly time and increased reliability* - DfMA has the potential to reduce assembly time by utilizing standardized components and rapid assembly practices. The use of digital modelling and visualization tools also allows for the simulation of assembly sequences prior to work commencing on site. This enables construction teams to become familiar with the erection sequence and methodology before setting foot on site. DfMA also increases quality and reliability by reducing variation in components and associated assembly processes, thus decreasing the chance of error on site; (3) *Shorter total time-to-market* - The development of a standardized kit of bridge parts/components with established manufacturing and assembly techniques allows designers to choose appropriate components from a library of components with well-defined design and detailing rules. This approach can create an opportunity for fast and efficient option selection during the conceptual design phase of a bridge project.

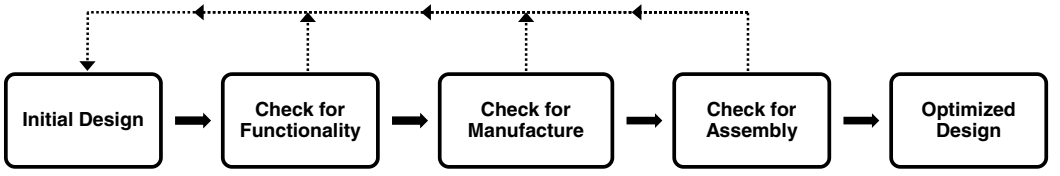

Fig. 1. DfMA procedure for a new product.