Design for Manufacturing and Assembly-Oriented Parametric Modelling of Prefabricated Bridges

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Abstract

Design for manufacture and assembly (DfMA) has become the efficient design method for prefabricated bridge construction which is being popular at present. However, the current design systems are not well suited for combining the parametric design of Building Information Modeling (BIM) with DfMA. In order to solve the problem, this paper introduces the novel concept of DfMA-oriented parametric modelling of prefabricated bridge structures. The new modelling method is the integration of DfMA principles with BIM model parameters to control the process of manufacturing and assembling. Essential considerations for the manufacturing and the assembly should be included in the model definition as rules and geometry authoring algorithm. The primary outcomes are the digital manufacturing model and digital assembly model of bridge members. Digital manufacturing model is required to guarantee the allowable manufacturing tolerance before delivery to the construction site. Preassembly is used to check the allowable tolerances of bridge components and connections. Finally, the DfMA-oriented parametric modelling of a full prefabricated bridge is presented.

Keywords: Design for manufacture and assembly (DfMA), BIM, prefabricated bridge, parametric bridge modeling.

1 Introduction

Prefabricated bridge construction is the process of fabricating bridge members in the off-site factory with better conditions, then transported to the construction site for assembly. As a result, the prefabrication construction industry expects the benefits of better quality control, mitigating labor shortage, cost-effectiveness, time-saving, lower environmental impact, better safety, and security. In order to accelerate the effort of prefabrication, Building Information Modeling (BIM) technology for bridge fabrication has been implemented [1]–[3]. Through the BIM process, Information Delivery Manualy (IDM) uses digital parametric models and data models to improve the accuracy of the information exchange between the stakeholders [1]. 3D digital models are used to shorten the learning time of workers in construction site [2]. Preconstruction includes digital preassembly by the virtual simulation to minimize errors during the construction phase [3]. Geometry quality of the members is crucial for the assembly of the prefabricated members. Checking fabrication tolerances plays a critical factor in the process of prefabricated bridge assembly [4].

Design for manufacturing and assembly (DfMA) improves design quality for ease of manufacturing and assembling of bridge components [5]. The primary purpose of DfMA method provides the ease of component prefabrication and assembly tolerance control through data model of design, modeling, fabrication and assembly (shown in Figure 1). DfMA provides the potential to ensure maximum integration of knowledge from design, manufacturing and assembly. It requires highly standardized and customizable prefabricated elements. Current practices in fabricated bridge