Dynamic behavior of aluminum deck-on-steel girder bridges under vehicular traffic loads considering the effect of road roughness

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Abstract

Aluminium as a structural material is known for its lightweight, which facilitates easy transportation and installation, and reduces foundation requirements. However, this lightweight characteristic makes it sensitive to excitations from vehicular traffic leading to dominating dynamic design over the static one. The dynamic design of highway bridges by the Canadian Highway Bridge Design Code (CSA S6-19) is based on the concept of equivalent dynamic amplification factors (DAF), which were derived largely based on the observations from bridges constructed with traditional materials such as concrete, wood and steel. It is prudent to evaluate whether these factors are applicable to lightweight bridges made with extruded aluminium decks. In addition, since road roughness plays an important role in the dynamic behaviour of a bridge, it is important to consider the influence of roughness on the bridge vibration response. The objective of this research is to investigate the dynamic behaviour of aluminium deck-on-steel girder bridges under vehicular loads considering the effect of road roughness, and consequently evaluate the applicability of the current design DAFs for such structures. For this purpose, numerical models have been developed in Abaqus for a range of selected bridge configurations and loading parameters and subsequently the key observations and conclusions from the numerical analysis have been presented in this paper.

Keywords: Highway bridges, Extruded aluminum decks, Bridge dynamic response, Vehicular excitations, Road roughness.

1 Introduction

Aluminum is a highly durable material with excellent corrosion resistance that could be an excellent choice either for construction of new bridges or for rehabilitation and replacement of deteriorated bridge decks. Extruded aluminum deck-on-steel girder bridges offer promising solution to the aging bridge infrastructure problem. The dynamic behavior of bridges under traffic loads is influenced by the natural frequencies of the bridge-vehicle system. Bridge decks designed with aluminum has a different mass and stiffness than traditional decks such as those constructed with concrete, wood, or steel. These properties are very decisive for the dynamic behavior of a structure. In order to take into account the dynamic effects caused by the vehicular traffic, the Canadian Highway Bridge Design Code (CSA S6-19) [1] uses a coefficient called dynamic amplification factor (DAF). The problem resides in the fact that this factor is based on the dynamic behavior of bridges made with traditional materials such as concrete. It is therefore necessary to evaluate whether these factors are applicable to lightweight bridges with extruded aluminum decks. Along this line, previous research by Petitclerc [2] focused on the development of a numerical model of the Canadian design truck CL-625 as well as dynamically analysing several aluminum deck-on-steel girder bridges under the truck load. However, this work is only limited to short span bridges. Moreover, road roughness, which plays a very important role in the

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