Analysis of the Structural Response of a Mid-span Multi-girder Composite Bridge submitted to different Fire Scenarios

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Summary

Bridge fires are a major concern because of the consequences that these kind of events have and because they are a real threat. However, bridge fire response is an under researched topic not covered in the codes. This paper presents an approach which is used to evaluate the influence of the fire scenario in the response of the most exposed girder of a composite girder bridge with a span close to 25 m. The analyses use computational fluid dynamics (CFD) to create the fire model, and finite element (FE) software for obtaining the thermo-mechanical response of the girder. Results show that bridge failure times, when the fire load is close to the bridge supports, are between 35 and 65% lower than when the fire load is under the bridge midspan. Additionally results show that the main factors that influence the temperatures are: the heat release rate (HRR) of the fire load and the size and the HRR of the spilled fuel.

Keywords: fire, bridge, CFD, steel concrete composite girder bridge, performance-based design, adiabatic surface temperature

1. Introduction

As bridges are a critical component of the transportation system a lot of effort has been paid to understand and predict the effects on bridges of accidental extreme load events such as earthquakes, winds, scour, and ship collisions. Fire is an additional major hazard as proved, e.g., by a bridge failure survey carried out in 2011 which collected data related to 1746 bridge failures from the departments of transportation of 18 US states [1]. This survey showed that fire had caused more bridge collapses than earthquakes and that fire had been the fifth cause of bridge collapses.

Despite its importance, bridge fires have got very little attention in the past as described by Garlock et al. [2]. In fact, fire safety engineering and structural fire engineering have mainly been concerned with building and tunnel fires [3], but bridge fires are different to those and deserve a particular approach. This is due to several reasons such as the cause of fire, the fire loads, the fire ventilation conditions, the use of fire protection, and the type of connections among structural members [4]. A comprehensive review about fire effects in bridges, past incidents and previous studies may be found in Garlock et al. [2] and Payá-Zaforteza et al. [5].

Within this general context, this paper develops a three step approach to analyze the effects of fires on bridges. The approach comprises: (1) a fire model of the fire event using CFD techniques, (2) a thermal model using FE and (3) a study of the mechanical response using FE and considering the non-linear response of the structure with temperature dependent material properties. The paper focuses in the analysis of the fire response of a particular composite girder bridge because this type

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