Analysis of several strategies for the monitoring of bridges under fire

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Abstract

Bridge fires are a major concern because of the consequences that these kind of events have and because they are a real threat. This paper explains how temperature monitoring can be used to estimate the temperatures and mechanical response of a composite I-girder bridge affected by a fire. To reach this goal, the paper studies where high temperature sensors should be placed in a three spans bridge with a main span of 37,2 m which is affected by a tanker truck fire under its main span. The study combines the use of Computational Fluid Dynamics (CFD) to create the fire model, and finite element software to obtain the thermo-mechanical response of the bridge. Results show that accurate predictions can be obtained by locating the temperature sensors at the mid-height of the I-gider web with a maximum separation along the longitudinal axis of the bridge of 3 m.

Keywords: fire, bridge, multi-girder, monitoring strategies, guidelines, CFD, FEM, 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 by Garlock et al. [1] and Peris Sayol et al. [2]. However, this topic has got very little attention [1] as fire safety engineering and structural fire engineering have mainly been concerned with building and tunnel fires (see e.g.[3, 4]).

Previous studies on bridge fires focused on obtaining the response of bridges to different fire loads (see e.g. Payá-Zaforteza and Garlock [5], Alós-Moya et al. [6], Wright et al. [7], Peris-Sayol et al. [8, 9], Gong and Agraval [10]) and on the development of risk analysis methodologies (Gil et al. [11]). This paper opens a new path, as it analyses how temperature monitoring can help to identify the damage suffered by a bridge during a fire and, therefore, to mitigate the consequences of bridge fires. The paper focuses on a particular composite I-girder bridge because this structural system is very common and has been involved in many fire events [1, 2].

2. Methodology

The proposed methodology follows the next five steps:

- Step 1. Collection of data on the bridge under study.
- Step 2. Definition of possible fire scenarios. Defining fire scenarios involves determining the fire load characterized by its location, size and Heat Release Rate (HRR) as a function of time. The HRR is the rate at which heat is generated by fire.
- Step 3. Numerical modelling of the fire scenarios using Computational Fluid Dynamics (CFD) techniques. In this study the software Fire Dynamic Simulator (FDS henceforth) [12] is used.
- Step 4. Proposal of monitoring strategies, i.e., proposal of location of the temperature sensors.

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