Performance of Simply-Supported Steel Bridge in Realistic Fires

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Abstract

This paper investigated the thermomechanical performance of a simply-supported steel girder bridge above a tanker fire by coupling the computational fluid dynamics (CFD) method and finite element method (FEM). Numerical results show that the presented method was able to replicate the inhomogeneous thermomechanical response of box bridges exposed to real fires. The girder failed due to the buckling of a central diaphragm after the ignition of the investigated tanker fire in no more than 10 min. The framework presented in this study is programmatic and friendly to researchers and can be applied to estimate bridges in different fire conditions.

Keywords: steel bridge; fire; thermomechanical performance; CFD; FEM.

1 Introduction

Fire-induced damages to bridges appear as an increasing concern as more bridges fail due to vehicle fires [1-3]. The fire threat to bridges can worsen along with the prominent development of transport of inflammable products. By reducing the material strength dramatically, fires can result in partial or total collapses of bridges. Famous examples include MacArthur Maze, the I-65 overpass, and the more recent railway bridge in Tempe town in the USA.

Exposed to fires, steel bridges deflect seriously and can reach the ultimate state at high temperatures. Previous studies simplified the fire condition as the temperatures increased over time for building structures, such as the ISO834 curve and ASTM119 fire. However, bridge fires usually have no air limitations. Therefore, adopting prescriptive curves for bridges can underestimate surrounding temperatures and make the safety estimation unconvinced.

Comparatively, coupling the computational fluid dynamics (CFD) model of the fire scenario and the finite element (FE) model of the exposed structural portion can provide a more realistic insight into the thermomechanical behavior of the bridges in fire conditions [4]. However, the

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