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Performance-Based Assessment and Mitigation of Fire Hazard for Bridges

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Abstract

Several recent incidents have demonstrated vulnerability of bridges to fire hazard. Fire-induced damage or collapse of bridges can disrupt the functioning of infrastructure networks, leading to significant costs to public including business interruption from route closures as well as potential casualties. While application of fire protection in a selective manner might be necessary to achieve a resilient bridge design for bridges, an across the board fire-rating approach similar to what is used in building design practice is unrealistic and uneconomical. A performance-based approach can provide a better hazard assessment for each individual bridge, thus leading to a cost-effective fire protection scheme.

Although the benefits of a performance-based approach are well-known, attempts in practice face an efficiency challenge to go through the steps of hazard analysis and identification of realistic scenarios, fire simulation and determination of design variables while keeping the process repeatable. This paper presents an innovative computational approach that allows the engineer to evaluate a bridge for several possible fire scenarios in a generalized scheme to determine if there exists a scenario that can potentially threaten the integrity of the structure. If such a case is identified, advanced detailed computational methods can be used for a more accurate evaluation. An example study is conducted on fire retrofit of a highway interchange with interconnected bridges to showcase this approach. Various fire scenarios caused by tanker truck accidents are initially analysed using simple computational tools that account for direct radiative heat transfer and lumped mass heat conduction while the bridge is subjected to realistic temperature curves. Necessity of advanced Finite Element analysis is determined based on the results of initial evaluation.

Keywords: Performance-based fire engineering, bridges, fire hazard mitigation, fire protection

1 Introduction

The recent increase in number of incidents on bridges has evidenced bridge vulnerability to fire hazards. The total collapse of the MacArthur Maze I-80/I-880/U-580 interchange overpass in Oakland, CA, USA in 2007 and that of the I-75 overpass, Hazel Park, MI, USA in 2009 are instances of recent severe accidents provoked by the ignition of flammable material spilled by tanker trucks. Tanker truck accidents are particularly treacherous as the

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