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Large-Scale Experimental and Numerical Studies on the Temperature Response of Main Cables and Suspenders in Bridge Fires

Authors : Shaokun Ge, Bart Merci, Fubao Zhou, Gao Liu, Ya Ni

Abstract : This study investigates the thermal response of main cables and suspenders in suspension bridges subjected to vehicle fires, integrating large-scale gasoline pool fire experiments with numerical simulations. Focusing on a suspension bridge in China, the research examines the impact of wind speed, pool size, and lane position on flame dynamics and temperature distribution along the cables. The results indicate that higher wind speeds and larger pool sizes markedly increase the mass burning rate, causing flame deflection and non-uniform temperature distribution along the cables. Under a wind speed of 1.56 m/s, maximum temperatures reached approximately 960 ℃ near the base in emergency lane fires and 909 ℃ at 1.6 m height for slow lane fires, underscoring the heightened thermal risk from emergency lane fires. The study recommends a zoning strategy for cable fire protection, suggesting a 0-12.8 m protection zone with a target temperature of 1000 ℃ and a 12.8-20.8 m zone with a target temperature of 700 ℃, both with a 90-minute fire resistance. This approach, based on precise temperature distribution data from experimental and simulation results, provides a vital reference for the fire protection design of suspension bridge cables. Understanding cable temperature response during vehicle fires is crucial for developing fire protection systems, as it dictates necessary structural protection, fire resistance duration, and maximum temperatures for mitigation. Challenges of controlling environmental wind in large-scale fire tests are also addressed, along with a call for further research on fire behavior mechanisms and structural temperature response in cable-supported bridges under varying wind conditions. Conclusively, the proposed zoning strategy enhances the theoretical understanding of near-field temperature response in bridge fires, contributing significantly to the field by supporting the design of passive fire protection systems for bridge cables, safeguarding their integrity under extreme fire conditions.

Keywords : bridge fire, temperature response, large-scale experiment, numerical simulations, fire protection
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