Design Fire Scenarios for Railway Tunnel Fires

Nan HUA
Ph.D. Candidate
University at Buffalo
Buffalo/NY, United States
nanhua@buffalo.edu

Nan received her Master's degree from Tongji University and is now a Ph.D. candidate with a research interest in tunnel fires.

Anthony F. TESSARI
Ph.D., P.E.
University at Buffalo
Buffalo/NY, United States
atessari@buffalo.edu

Dr. Tessari holds a PhD from Rensselaer Polytechnic Institute and focuses on research in extreme event response of geotechnical systems.

Negar ELHAMI-KHORASANI
Ph.D.
University at Buffalo
Buffalo/NY, United States
negarkho@buffalo.edu

Dr. Elhami-Khorasani holds a PhD from Princeton University, and her area of research focuses on fire engineering and community resilience.

Contact: atessari@buffalo.edu

1 Abstract

Extreme fire events in tunnels may have catastrophic consequences, which include loss of lives, structural damage, and major socioeconomic impacts. One of the primary factors that influences the level of damage is the demand fire scenario in a tunnel. A few standard hydrocarbon fire temperature-time curves exist, but they are idealized and do not consider the actual fire duration and fire spread inside the tunnel. Risk-based decision-making frameworks and performance-based design of tunnel linings require a more realistic set of fire scenarios compared to the standard fire curves. This paper focuses on a traveling fire model for a railway tunnel to evaluate temperature evolution considering fire spread between train cars. In this study, a series of numerical simulations are conducted in Fire Dynamics Simulator (FDS), a computational fluid dynamics software package. A parametric study with varying ventilation velocity, amount of fuel, tunnel slope, ignition point and criteria for fire spread is performed. The outcome of this work can be used in future to establish guidelines for design temperature demands within risk-based frameworks to minimize economic losses in railway tunnels in case of fire.

Keywords: Railway tunnel fire; temperature evolution; traveling fire; probabilistic methods; performance-based approach.

2 Introduction

In the last few decades, a number of extreme tunnel fires have occurred around the world, leading to rising interest in this research area. Compared to their roadway counterparts, railway tunnel fires are less frequent but could have more severe consequences, including far more fatalities, injuries, longer service disruption and economic losses due to tunnel lining damage. Table 1 provides details of four historic railway tunnel fire events [1-4], including a metro fire. Observations from these real events show that fire spreading between railcars occurred in most cases and exacerbated the damage.

Meanwhile, there are still unanswered questions related to a performance-based design framework for tunnel linings subjected to fire, primarily due to the involved mechanical complexity and material uncertainties. One of the primary factors that influences the level of damage is temperature demand. Standard fire curves have been developed for simulating tunnel fires, however, they are idealized curves and do not consider the actual fire duration for various tunnel fire scenarios. Risk-based decision-making frameworks and performance-based design of tunnel linings require a more realistic set of fire scenarios.

https://doi.org/10.2749/newyork.2019.0082
Distributed by Structurae