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A methodology based on temperature monitoring to reduce fire risk in tunnels

Paula Rinaudo, Ignacio Paya-Zaforteza, Pedro A. Calderon

Universitat Politècnica de València, Valencia, Spain

Contact: pauri@posgrado.upv.es

Abstract

The monitoring of temperatures during a tunnel fire is of major importance for both, the fire-fighters and the engineers in charge of undertaking the repair works. However, current methods commonly used in assessing fire damage have limitations when applied to tunnels, and only provide an estimation of the maximum temperatures caused by the fire. The temperature-time curves associated to the fire event should be used to properly assess the residual strength of the structure of the tunnel which is the key parameter to define the repair works, the time the tunnel will be closed and, therefore, the socio-economic cost of the fire. In addition the availability of temperature-time curves on real-time would provide very valuable information for the fire-fighters in charge of the fire extinction works. This paper presents a new general methodology for the optimal placement of sensors in a tunnel to obtain the evolution of the temperatures with time at any point of the tunnel linings.

Keywords: Fire; tunnel; Structural Health Monitoring; multi-objective optimization; temperature-time curve.

1 Introduction

Disasters such as the fires in the St. Gotthard tunnel (2001), the Twin Towers in New York (2001) or the Windsor Building in Madrid (2005) show the importance and the necessity of a monitoring strategy for fire vulnerable structures. Through this strategy, the assessment of fire damaged structures would be possible and if necessary, the demolition operation could be guided.

Tunnels are usually key infrastructures within the transportation network of a country or region. In tunnels, there is no damage scenario in which the construction of a new tunnel would be preferable as to repair the existing one, since building a new tunnel requires more time and a higher investment than repairing it [1] .

As a consequence, it is always necessary to repair tunnels affected by fires. Therefore, after a tunnel-fire event there are two main tasks to do: (a) to design a repair method to reopen the tunnel as soon as possible and (b) to evaluate and understand the causes of the fire.

Concrete is the typical material used in tunnel linings. After a fire, concrete assessment is usually done through the evaluation of their residual capacity using non-destructive or minor destructive techniques and/or by deducing the temperature-time curves associated to the fire event and then by using these curves to calculate the residual strength of the structure [2]. However, the application of non-destructive techniques in tunnels is limited due to the non-verticality of walls and roughness of the surfaces. Furthermore difficulties in defining the temperature-time curves were reported by several authors [3-4].

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