

**Macrocategoria:** Geometria e Sicurezza.

**Titolo articolo:** A simultaneous analysis of the user safety and resilience of a twin-tube road tunnel.

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**Abstract:** This study complements our previous work with a simultaneous analysis of user safety and road tunnel resilience. We developed a computational fluid dynamics (CFD) model and simulated the corresponding egress process to evaluate the risk level of users exposed to different types of fire, such those which might occur on the undisrupted lane of a partially closed tube tunnel due to a traffic accident, or in the adjacent tube when used for two-way traffic in the case of the complete closure of the tube involved in the accident. The CFD results showed that: (i) better environmental conditions were found with the partial closure of the tube rather than the complete one; (ii) additional benefits can be achieved by activating variable message signs (VMSs) that suggest an alternative itinerary for heavy good vehicles (HGVs) only; (iii) safety issues for human health may arise only in the case of a 100 MW fire, occurring during the complete closure of the tube and the use of the parallel one for two-way traffic. The findings of the CFD simulations were subsequently used to perform a quantitative risk analysis (QRA) based on a probabilistic approach. The findings of the QRA were found to be consistent with those obtained by the tunnel resilience analysis. In particular, the lowest risk level for user safety was found with the partial closure of the tube instead of the complete one, and by activating the VMSs to redirect HGVs only towards an alternative itinerary. This finding was found to correspond to a higher resilience index of the tunnel (i.e., a lower resilience loss due to a traffic accident occurring in a tube). This study increases our knowledge on certain relevant aspects of the operating conditions of tunnels and can serve as a possible reference for tunnel management agencies (TMAs) in their choice of the most appropriate arrangement to recover the functionality of a tunnel taking into account both user safety and resilience at the same time.

**Keywords:** Road tunnels; User safety; Resilience Index; Recovery strategies; Computational fluid dynamics; Quantitative risk analysis.

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