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Titolo articolo: A 3D CFD modeling for assessing the effects of both longitudinal slope and traffic volume on user safety within a naturally ventilated road tunnel in the event of a fire accident.

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Abstract: A 3D Computational Fluid Dynamics (CFD) model was set up to investigate the effects of the longitudinal slope on the risk level of users in naturally ventilated unidirectional road tunnels in the event of a fire accident. These tunnels, which in general do not require any mechanical ventilation system, have a length <1 km and their natural ventilation is due to the difference of pressure at the portals and/or the piston effect of the unidirectional traffic flow. Fire accidents related to vehicles characterized by different maximum Heat Release Rates ($HRRs_{max}$), situated at different locations from the entrance portal of the tunnel, were simulated by varying the longitudinal slope (i), as well as by applying both a positive and negative pressure difference (ΔP) between the entrance and exit portals to also consider any adverse wind conditions, or neglecting that (i.e., ΔP = 0). The combined effects of Peak Hourly Volumes (PHVs) were also investigated in the Quantitative Risk Analysis (QRA), which based on a probabilistic approach, considered as a risk indicator the annual cumulative frequency (F) of having a certain number of potential fatalities (N). The longitudinal profiles of temperature, radiant heat flux, toxic gases concentrations, and visibility distance upstream of the burning vehicle along the escape route (i.e., sidewalks) are reported and compared with the acceptability limits to verify if the environmental conditions are tolerable for user safety while escaping from the tunnel towards the entrance portal or the emergency exit located in the middle of the tunnel length. The results showed that the number of dangerous scenarios for user safety increased in the event of adverse wind (i.e., ΔP < 0) and/or negative gradients (i.e., i < 0). The QRA indicated the combinations of i, ΔP, and PHV for which the annual cumulative frequency (F) of having a given number of potential fatalities (N) was not acceptable. By providing additional points of knowledge in the field of fire safety engineering, this paper might serve in the design of the vertical alignment of naturally ventilated tunnels with a length <1 km, as well as in the strategies of management and traffic control.

Keywords: Computational fluid dynamics; Road tunnels; Natural ventilation; Longitudinal slope; Traffic volume; User safety.

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