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INTEGRATING 1D AND 3D MODELING FOR THE ANALYSIS OF VENTILATION CONTROL IN TUNNELS

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ABSTRACT Computational fluid dynamics is widely used for the design and analysis of tunnel ventilation systems, both in sanitary and emergency conditions. Nevertheless, complex physical models present a drawback related to the large computational resources that are often necessary, especially when multiple scenarios or long tunnels are investigated. A multi-level approach for the thermo-fluid dynamic simulation of long tunnels was proposed as a possible technique for evaluating the effectiveness of ventilation systems in long tunnels basically for longitudinal ventilation flows. An open tool for the multi-level analysis has been created by modifying the open source CFD package Fire Dynamic Simulator (FDS). A 1D formulation of continuity, momentum energy and mass transport equations has been integrated in the 3D code. The advantage is given by the reduction of the computational resources of the multi-level model with respect to a fully 3D model, but without significant reduction of information gathered from the simulations.
The new open tool, as obtained, has been used for modeling the ventilation system of the Monte Cuneo road tunnel in case of fire. A parametric analysis has been performed in order to investigate the optimal configuration of the ventilation system that ensures a correct smoke control. In particular, possible effects obtaining by installation of larger extraction dumpers, the installation of proper deflectors on the jet fans located in the lay-bys and the modification of blade angles of the axial fans. Results show that in the case of the current configuration of the ventilation system, depending on the traffic and atmospheric conditions at portals, smoke might not be fully confined. Significant improvement in terms of safety conditions can be achieved through increase in smoke extraction, which requires the installation of large dumpers and proper changes in the operating point of the axial fans. In addition, an increase effectiveness of jet fans is required in order to obtain a zero velocity in the fire area and converging velocities on both sides.