Subject
Thermo-fluid dynamic modelling of fire development and smoke propagation in underground transportation systems finalized to the determination of optimal control strategy

List of proponents (with e-mail address of the responsible person)

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Description of the international background of the proposal

The use of underground ways for transportation constitutes a solution even more adopted for solving traffic problems in large urban centres and in the connections between areas trough mountains or hills.

In most of these systems the possibility of controlling the indoor environment and managing dangerous conditions are related to the presence of control and safety plants, especially the ventilation system. In fact its intervention is determinant, in case of accident, in order to improve the air quality inside the tunnel as much as possible, to keep safe the evacuation routes and to control the smoke propagation.

The search for the optimal control algorithm to be used in case of fire passes through the use of reliable simulation tools. In order to take the effect of all these factors into account, it is necessary to consider the whole system in the analysis and not simply a part of it. Often a tridimensional detailed thermo-fluid-dynamic analysis of such system is not possible, due to the computational efforts that would require. In this case, models with lower detail must be used for the analysis of the complete system. It is also possible to consider a smaller part of the system, which can include the zone where flames develop and the adjacent parts of tunnel, and perform a tridimensional computation by using the results provided by the one-dimensional model as boundary conditions. This is the main objective of this thesis.

These considerations are particularly important when the analysis of many different scenarios is required. This case occurs when the analysis purpose consists in checking the emergency procedures or determining the optimal ventilation system algorithm. In all these cases, the time simulation must cover all the event, from its beginning until the complete restoring of safe conditions. Thus, the simulation requires even more resources.

As widely documented in the scientific literature, several applications of the one-dimensional, three-dimensional and zone models have been proposed by Institutions, such as CETU and U.S. Department of Transportation, and Universities, such as University of Dundee, University of Leeds and University of Maryland.

Research program objectives (intermediate and final) and expected results

The main result expected from this program is constituted by the development of a thermo-fluid-dynamic code able to simulate the smoke propagation in a complex underground system. In the first part of the research, a zone model will be developed in order to simulate the behaviour of the volume close to the fire, which include the fire and the smoke layers. This model should interact with a one-dimensional model, representing the remaining part of the system, including the
The complete model will be applied to a large tunnel with a semi-transversal ventilation system, such as the tunnels through the Alps. This tool will be used in order to determine the optimal ventilation procedures to be used in case of fire, by considering a wide range of atmospheric conditions, traffic conditions and fire positions. These results will be used to build a control algorithm to be used in case of fire with the objective of allowing the tunnel personnel to intervene in the most effective way in order to obtain the smoke confinement at the shortest possible distance from the fire location.

Some tests in a real tunnel will be conducted in order to determine the required fluid-dynamic parameters as well as the reaction and operation time. These tests will be designed in order to validate both the model and the control algorithm, with particular attention to the effects of ambient conditions and traffic.

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**List of publications of the proponents and/or specific references (with titles)**


2) Borchiellini R., Calì M., Giaretto V., Vannelli G., Verda V. Reflection on the importance of monitoring and control after the Mont Blanc tunnel fire event' Proceeding of Fifth International Conference "Safety in Road and Rail Tunnels", Marseille, 6-10 Ottobre 2003, pp. 39-48


