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Two dimensional numerical analysis of snow avalanche interaction with structures

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The purpose of this work, within the Project "DynAval - Dynamique des avalanches: départ et interactions écoulement/obstacles" - European Territorial Cooperation objective Italy - France (Alps), is to analyse the snow avalanche and structure interaction, through a numerical analysis. The avalanche behaviour, considered as an incompressible fluid, is described by a two-dimensional, in the avalanche slope, Navier-Stokes equations to which an advection equation is coupled to take into account the shape variation. The model allows to describe the velocity and the pressure at every point, representing important features for the structural design. The simulations are carried using a FEM Multiphysics software.

For a such problem different analysis can be carried. Firstly, changing the obstacle shape (circle, square, triangle) and its dimension in relation to the avalanche size, the drag coefficient Cd can be evaluated. The obtained results are then compared with the values indicated by the procedures, concerning the avalanches, available in the literature. This study is realized for different Froude numbers too.

Secondarily the pressure acting on the different parts of the obstacle (up-wind, down-wind, lateral) is studied. The first investigation concerns the evaluation of the Cp coefficient and on its comparison with the wind effects. The second analysis allows to evaluates, by an integration process, the total load exerted by the avalanche on the obstacle. A practical example of a building design is presented, taking into account the results of the simulations.

Thirdly the study is focused on the characterization of the two dead zones created up-wind and down-wind the obstacle. The dependence of the dead zone on the obstacle characteristics, such as dimension and shape, and on the avalanche features, such as density and velocity, is analysed. The results obtained are compared with the data available in the literature concerning snow or granular material interaction with obstacle. In addition the dead zone is studied using a two dimensional model in the avalanche section too. In this way, in fact, the jet length created in the impact, for instance with a dam, can be measured and compared with the laws proposed in the literature.

Fourthly the evolution in time of the pressure during the impact is investigated, showing a peak in the first times steps of the interaction. The time and the intensity of this maximum value is related with the flow and the obstacle characteristics.

In conclusion, the fan of the analysis carried recovers different and very important features that represent the starting point for reliable design of the structures in avalanche-risk zones. In addition it shows the capabilities and the deficiencies of the model proposed and, finally, it introduces some aspects that will should be furtherer experimentally studied and validated.