CADFEM CONFERENCE 2024
EMPOWERING DIGITAL ENGINEERING

The influence of air pore pressure on the snow cover entrainment mechanisms and dynamics of snow avalanches

Alpine mass movements pose a significant threat to both people and infrastructure in mountainous regions. The erosion and incorporation of bed material within the flow, a process referred to as entrainment, may lead to a significant increase of the flow volume thus increasing the danger . In debris-flows, the role of water pore pressure during fast and undrained loading of saturated bed sediments may cause liquefaction of the bed material, thereby enhancing the flow mobility. However, the potential effect of interstitial and ambient air on snow cover entrainment and on the suspension mechanisms of snow into a light fluidized avalanche layer remains debated and requires further investigation. To gain a better understanding of air pore pressure mechanisms in dry-snow avalanches, we propose to use a coupled CFD-DEM numerical method, through Ansys Rocky and Ansys Fluent, respectively. This approach allows us to unravel crucial micro and mesoscale interactions between fluid particles and interstitial/ambient air and will provide a quantitative assessment of the entrainment and suspension processes. Our ongoing research covers several key aspects related to granular flows and fluid-sediment interactions. To enable fast and automatic sensitivity analyses, we have developed a versatile Python tool named “RockySweep” which is based on the API of Ansys Rocky 2023 R2. This tool allows us to extract YAML configurations from existing Rocky projects, set up new projects based on pre-existing configurations, run comprehensive simulations, and log data to Weights and Biases for simultaneous cloud-based simulations. Therefore, we are generating a range of porous bed snow materials, spanning from densely packed
(50% porosity) to fresh snow (80% porosity) using ballistic deposition. Using the Parallel-Bond Contact model, we aim to simulate the elastic-brittle mechanical behaviour of snow. In a first step, we perform simulations without modelling air to establish a reference scenario. Our current focus is on setting up a granular flow over an erodible porous, air-saturated snow bed and quantifying the influence of air-pore pressure on entrainment and therefore on flow mobility. This work aims at better understanding the formation of mixed snow avalanches and could help in refining entrainment formulations in depth-averaged geophysical mass flow models which are used in engineering for hazard assessment, thereby contributing to improved mitigation measures. In the future, we plan to extend this research to water-saturated sediments to study debris flow entrainment.

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