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Initial study of permeability in bed of snow using x-ray microtomography and CFD

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Flow in porous media is occurring in a large number of industrial applications such as internal erosion in embankment dams, drying of iron ore pellets, composites manufacturing and paper-making, to mention a few. However, it is also occurring in a number of naturally formed materials, for instance snow. To know the flow through the snow is important when investigating the ageing of fresh snow. The ageing is an important parameter when investigating mechanical properties of snow. When modelling and simulating the flow in these contexts the choice of computational domain is often dependent on the field of application. Still there might be some common issues between the different fields. To exemplify, when performing measurements or simulations of porous media flow it is usually difficult to determine a representative volume of the material. This is also true when mapping the porous media with x-ray microtomography.

A snow sample that represents fresh snow, acquired only minutes after snowfall, was scanned at the x-ray microtomography lab at Luleå University of Technology, using a Zeiss Xradia Versa 510 (Carl Zeiss X-ray Microscopy, Pleasanton, CA, USA). The in situ loading was carried out using a Deben CT5000TEC temperature controlled load stage with a 500 N load cell. Four XMT scans were acquired along the load cycle 0N-10N-18N-25N, at a constant temperature of -15℃ (± 0.1℃). The porous network within each volume was isolated, meshed, and imported into a commercial CFD code Ansys CFX.

When performing CFD-simulations on any volume of a porous media it is of highest importance that the discretization of the pore space geometry is fine enough both from a geometrical point of view as from a grid resolution point of view. Hence, we here discretise the volumes obtained with x-ray microtomography with increasing number of computational cells in order to capture the main flow features of interest; such as the velocity distribution, the pressure drop over the geometry and also, of course, from a porous media viewport the permeability of the material.

Preliminary results indicate that this method finds the velocity and pressure “hot spots”, where the risk of erosion is highest, and also that the other main flow features show potential to be resolved in a qualitative way.

References

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