Snowflake by Snowflake

Simulation provides insight about snow safety.

A cubic µSnow model sample from CRREL, 25 millimeters on edge with a 2-D cross-sectional plane; the particle diameter is about 1 millimeter and the density is 30 percent

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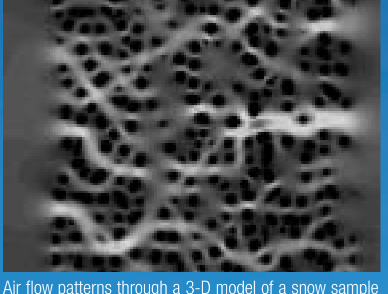
For many, the romantic dream of winter weather is sitting beside a roaring fire with a hot drink while snow drifts gently to the ground outside. However, the reality can be more of a nightmare. According to the National Snow and Ice Data Center in Colorado, U.S.A., seasonal snow affects up to 33 percent of the earth's total land surface, 98 percent of which occurs in the Northern Hemisphere. With snow accumulation come transportation challenges, natural events such as avalanches, and increased demands related to maintaining our human support infrastructure, including electricity and fuel supply. To better address these challenges, researchers are taking a closer look at snow deformation — a factor that is related to each of these scenarios.



Air flow patterns through a 3-D model of a snow sample

Snow, which is actually an aggregate of ice grains, can be considered at three scales: the micro-scale (10^{-3} meters), the local scale (1 meter), and the landscape scale (10^{4} meters). Landscape-scale snow properties can be derived from local-scale snow data using distributed or statistical models. Local-scale snow properties, however, depend strongly on heterogeneities and layering at the micro-scale. Representative elemental volumes (REVs) are able to model local-scale snow; however, they do not take into account micro-mechanical factors that are fundamental in explaining deformation.

To account for the micro-scale factors, researchers at the Cold Regions Research and Engineering Lab (CRREL) use a discrete element method (DEM) to explicitly model the dynamics of snow particle assemblies and the micro-mechanical interaction processes between the grains. DEM was selected for its ability to model materials that undergo large-scale discontinuous deformations that depend on micro-scale contact processes, internal breakage of contact bonds and compaction of broken fragments.

CRREL's DEM model, called µSnow, stores the particle shapes, velocities and locations; finds contacts; calculates contact forces and moments; calculates conditions for contact bond formation, growth and rupture; and calculates movement for each particle within the aggregate. This explicit representation provides a way to identify the important processes that control snow deformation and directly compare physical experiments to simulation.

Recently, CRREL began combining a fluid flow model with µSnow to account for the flow and diffusion of air and water vapor in snow. Researchers simulated pressure-driven air flow through 3-D models of snow samples and found that modeled results closely matched measured values.

In the future, this methodology for addressing the complexity of the problem by providing a way to incorporate individual mechanisms into the larger snow model can lead to better predictions and understanding for a whole range of snow-related scenarios. So as you sit having happy thoughts while snow gently falls outside your home, think of the science that lies behind the safety of snow tires, avalanche best practices and making sure that your home stays warm through those winter months. ■

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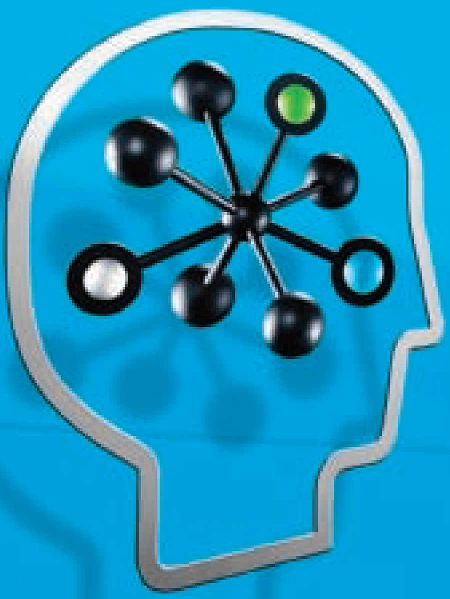

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