STANDING INTERNATIONAL ROAD WEATHER COMMISSION -S-I-R-W-E-C-

Surface prediction modelling, the effect of a changing snow layer on the thermal balance

A.D.W. Nuijten[1], K.V. Høyland[1,2]

[1] Department of Civil and Transport Engineering, Norwegian University of Science and Technology, Trondheim, Norway
[2] Sustainable Arctic Marine and Coastal Technology (SAMCoT), Centre for Research-based Innovation (CRI), Norwegian University of Science and Technology, Trondheim, Norway

Corresponding author's E-mail: anne.nuijten@ntnu.no

A snow layer largely affects the energy balance at the pavement surface. Its physical properties are a function of the thermal properties and snow microstructure and can vary greatly during the melting process. The thermal balance depends on the height and properties of the snow layer. The density, specific heat capacity and thermal conductivity all change in time. The thermal conductivity of a snow layer can vary from 0.025 W $m^{-1}K^{-1}$ to 0.56 W $m^{-1}K^{-1}$ for densities varying from 10 to 550 kg m^{-3}. This study looks into the change of the thermal properties of a melting snow layer.

The different mass and heat fluxes during the melting process of snow on a heated pavement system are calculated based on measured temperatures, weather data and estimated pavement properties. An experiment was conducted in the cold lab at the NTNU. On the bottom side of the 5cm thick asphalt plate heating films were connected to the slabs. The setup was equipped with sensors measuring the pavement, snow and air temperatures, the humidity, incoming longwave radiation and wind speed. Additionally the height of the snow layer was measured and the surface condition was registered.

The height of the snow layer changed from 40 till 4 mm during the melting process. As soon as the snow started to melt the height of the snow layer decreased with a constant rate till it was changed into slush and reached a height of 4 mm. The density changes from 66 till 999.8 kg m^3 during the melting process. The specific heat capacity is calculated based on the specific heat capacity, density and volume fractions of ice, water and air. It changes from 2.1 till 4.2 kJ $kg^{-1}K^{-1}$. The thermal conductivity depends mostly on the density and snow microstructure. It can be described as a function of density or as a function of the thermal conductivity and volume fractions of ice, water and air. During the melting process the thermal conductivity changes from $2.6\cdot10^{-2}$ W $m^{-1}K^{-1}$ for dry snow till 0.58 W $m^{-1}K^{-1}$ for water.

The surface layer changes from a dry well insulated layer of snow into a much thinner layer and a better conductor when it is melted. Measured temperature differences within a 4 cm snow layer were up to 6°C. As soon as the melting process started the snow surface temperature started to rise and the temperature difference started to decrease until it was transformed into slush after which the temperatures of the surface layer and the top of the asphalt layer were almost the same. During the melting process the surface flux increases, mostly due to the changes in the radiative and convective heat fluxes. The results clearly show that even a thin snow layer on a pavement can significantly affect the surface temperature and thermal balance.