Experimental Validation of Numerical Ice Accretion Prediction on Stay Cables due to Freezing Rain

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Ice accretion is a complex phenomenon involving three-dimensional multi-phase flow, heat transfer, and gravitational, viscous and shear forces. Predicting how ice accretes on engineering structures is essential to forecasting its occurrence and mitigating its undesirable consequences. The shape of ice accretions may alter the aerodynamics of bridge cables and transmission lines, causing large amplitude vibrations called galloping. In addition, pieces of ice falling from structures such as stay bridge cables, overhead transmission lines, wind turbines and telecommunication masts can cause serious injuries and property damage.

The objective of this work is to partially validate a numerical morphogenetic ice accretion model that predicts realistic ice accretion shapes under freezing rain conditions. The morphogenetic model is a discrete element, random walk model that emulates the motion and freezing of individual fluid elements arriving at the accretion surface. The focus of the analysis is ice formation on a simple but common, three-dimensional cylindrical geometry. Such a geometry can be found in a variety of engineered structures, such as bridge cables, transmission lines and telecommunication masts.

Experimental results obtained in the NRC Climatic Testing Facility will be used to validate the morphogenetic model prediction. The facility is 6 m wide, 6 m high and 30 m long and can generate a range of precipitation conditions. Four stay cable models have been subjected to 4 hours of freezing rain at a precipitation rate of 2.5 mm/h at two different air temperatures. The forming ice accretion was scanned and digitized using a handheld laser scanner. The resulting three-dimensional experimental ice shape will be used to validate our numerical prediction model.

Ice accretion on four stay cable models inclined at 30° and 45°. The inset shows the ice surface at -10°C and the locating dots for the handheld ice accretion shape scanner.