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Reducing Uncertainties in Snow Fence Design: Development of Methods for Estimation of Snow Drifting and the Snow Relocation Coefficient

(IHRB RESEARCH PROJECT TR-760)

Sponsor
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About
IIHR-HYDROSCIENCE & ENGINEERING

IIHR's mission is to advance science and technology, providing innovative solutions for fluids-related problems while building upon its long tradition of excellence in laboratory, field, and simulation-based research and education.

BACKGROUND

Blowing and drifting of snow is a major concern for safety, transportation efficiency, and road maintenance in regions subject to intense snowfalls and winds during the winter season. Snow moving across the roadway leads to reduced driver visibility and ice formation on roads leading to increased number of accidents.


The most often-used snowdrift mitigation measure is the deployment of temporary or permanent snow fences. They are deployed in areas prone to snow-drifting as either structural barriers (constructed using lightweight materials) or as living fences (combination of planted shrubs, trees and tall grasses that act as a windbreak).


The design of snow fences relies on empirical relations that do not necessarily apply to the U.S. Midwest. Major issues are related to the estimation of the snow relocation coefficient (SRC). Currently, Iowa DOT snow fence designers use default SRC values suggested by snow fence design software despite that these empirical estimates are widely different from those where they were determined.

OBJECTIVES

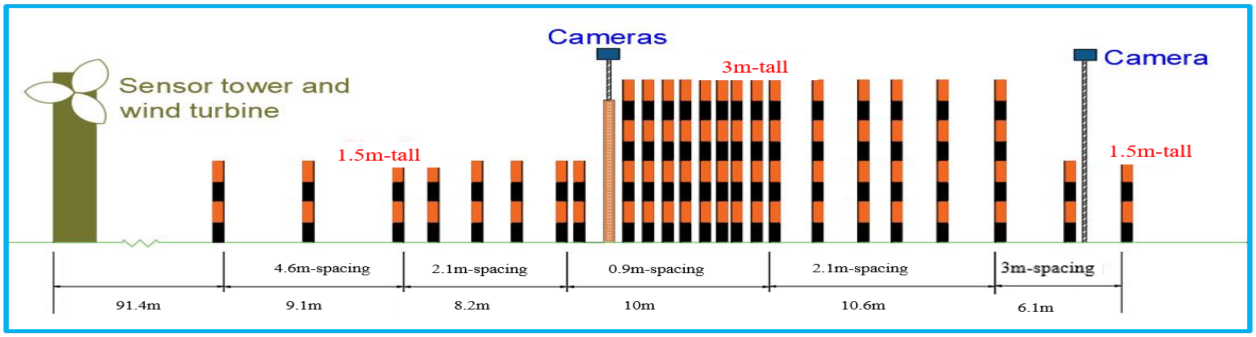
This research addresses two critical questions related to snow fence design:

1) **What is the seasonal snow relocation coefficient for Iowa?**
2) **What is the seasonal storage capacity of the snow fences when accounting for successive storms and ablation between snow events?**

Estimation of the SRC in the field is a challenging problem as it requires accurate quantification of snowfall and snowdrift fluxes at the site where the snow fence is installed. There are no established protocols for in-situ determination of the SRC in the presence or absence of snow fences. Therefore, we first needed to develop accurate methods for estimation of snowfall and snow drifting fluxes, building on prior research efforts.

RESEARCH APPROACH & MONITORING METHODS

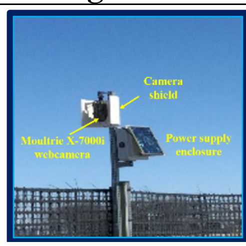
Three experimental sites, located in open areas regularly exposed to high-severity snow drifting, were selected in consultation with Iowa DOT design engineers and the project Technical Advisory Committee. Seven types of direct and close-range measurements were deployed at the experimental sites to measure local meteorological variables and for tracking the accumulated snow, due to drifting. Complementary meteorological data were accessed from public sources for validation and verification purposes.



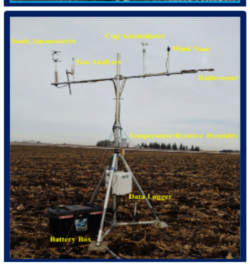
Sample schematic showing the arrangement of the monitoring equipment at the experimental sites

Continuous monitoring

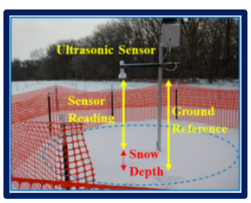
Real-Time web cameras for snow deposits tracking (self-powered and remote communication over the internet)



Meteorological tower for measuring local weather conditions (self-powered and remote communication)



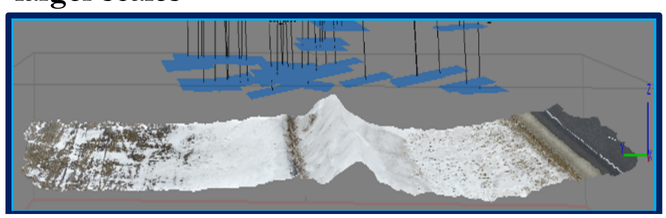
Ultrasonic sensors for snowfall measurements (self-powered and remote communication)



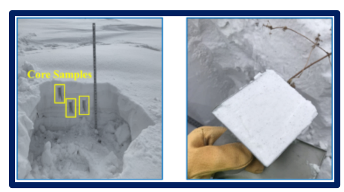
Synoptic measurements

Real-Time Kinetic GPS for quantification of snow depths at critical points at experimental sites, used for validation of image-based methods

Drone surveys & photogrammetry for quantification of the snow deposited at fence at larger scales



Snow core sampling for estimation of snow density in fresh snow and in accumulated deposits



KEY FINDINGS & CONTRIBUTIONS

The most important research outcomes are the first-of-the-kind quantitative estimates for the Snow Relocation Coefficient (SRC), based on direct measurements, acquired on an individual event basis. The values are considerably smaller for individual events and vary between 0.2 to 0.3 for the winter season average, which is considerably lower than the default value SRC = 0.5 currently used by the Iowa DOT Design office. The study also shows that fences often recover storage capacity between snowstorms allowing for additional drift accumulation, an important factor that is currently not considered in snow fence design. Estimated additional storage was between 10% and 90 % for the two sites investigated during the winter of 2019-20. Further investigations are needed to generalize the results to be applicable across the various landscapes in Iowa. Additional contributions of this research include: a) methods and protocols for local measurement of snowfall and snowdrift fluxes, and b) methods for continuous mapping of snow accumulated at snow fences. The above listed methods represent a solid basis for a rebust estimation of SRC and charactersization of snow transport and accumulations over the winter season for Iowa-specific sites and may be applicable more broadly in the U.S. Midwest.