Propagating Snow Measurement Uncertainty to Structural Reliability by Statistical and Interval-Based Approaches

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Abstract

Observations are inevitably contaminated by measurement uncertainty, which is a predominant source of uncertainty in some cases. In reliability analysis, probabilistic models are typically fitted to measurements without considering this uncertainty. This paper intends to explore the effect of this simplification on structural reliability and to provide recommendations on its treatment.

Statistical and interval-based approaches are used to quantify and propagate measurement uncertainty. They are critically compared by analysing ground snow measurements which are often affected by large measurement uncertainty. Measurement uncertainty is propagated through the mechanical model of a generic structure to investigate its effect on reliability. Parametric studies facilitate to analyse the effect of key parameters, such as measurement uncertainty, coefficient of variation of ground snow load and load ratio. The interval analysis is performed as a hybrid interval-probabilistic analysis. Measurements are represented as intervals and probabilistic model is then fitted to them. Hence, snow parameters and the reliability index are also interval variables; other random variables are described by standard probabilistic distributions. Implementation of the statistical approach is based on the Bayesian paradigm where the measurements are represented as random variables. This approach offers a powerful tool to combine epistemic and aleatory uncertainties and to decouple measurement uncertainty from a variable of interest.

The results indicate, that measurement uncertainty can have significant effect on structural reliability and should be taken into account in reliability analysis. If more information than interval endpoints is available, a statistical Bayesian approach is recommended. Ranges of the key parameters are identified, where measurement uncertainty should be considered. For practical applications, the lower bound and predictive reliability index are recommended as point estimates using interval and Bayesian analysis, respectively. These should be accompanied by uncertainty intervals, which convey valuable information about the credibility of results.