UTC Project Information	
Project Title	**Hammer Time: Using the Schmidt Hammer to Improve the Rockfall Activity Index (RAI) Forecasting Accuracy**
University	University of Alaska Fairbanks
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Funding Source(s) and Amounts Provided (by each agency or organization)	University of Washington PacTrans $60,000 University of Alaska Fairbanks $ 60,000
Total Project Cost	$120,000
Agency ID or Contract Number	69A3551747110
Start and End Dates	Mar 16, 2022- June 30, 2023
Brief Description of Research Project	The Schmidt hammer is a widely-used and inexpensive instrument used to estimate rock strength either in the lab or in the field. This indirect testing method can provide rock strength information without destroying the sample like other testing procedures (e.g., unconfined compressive strength (UCS) testing). In collaboration with another PacTrans-funded project (Darrow et al. *In Review*), our research team tested the accuracy and repeatability of the Schmidt hammer to estimate rock strength for six Alaskan rock slopes and four Washington/Oregon rock slopes, all sites of long-term data collection and rockfall analysis. For this project, we: 1) determined *in situ* rock hardness and weathering conditions at field sites using two different Schmidt hammers (Types L and N); 2) conducted a comprehensive literature review of up-to-date analyses of strength testing using the Schmidt hammer; 3) conducted UCS testing for select Alaskan rock samples; 4) performed a preliminary statistical analysis of Schmidt hammer results as they relate to varying lithology; and 5) summarized the pros and cons of using the Schmidt hammer in the field. *Answering these questions is critical for transportation agencies to plan for and allocate resources optimally to address maintenance needs for rock debris removal and slope mitigation, thus ensuring efficient mobility of the transportation network*.

Describe Implementation of Research Outcomes (or why not implemented)
 	
Place Any Photos Here
	• Our literature review identified several parameters that potentially affect Schmidt hammer results, including: testing methodology, sample testing conditions, and data reduction. All of these parameters effect the rebound values' correlation to UCS values. Our results indicate that major structures within a rock unit (such as bedding or foliation), variation in mineralogy, and moisture content will significantly impact Schmidt hammer results. After data collection, several correction methods can be used to process the Schmidt hammer results. Choice of method depends on the intent of the measurements (i.e., strength of the intact rock or the rock mass), and the application of any method can alter the final results.
	• At the Alaska sites, we collected large rock samples representative of each major lithology from each slope for strength testing. Here we present the UCS results of six of the rock types. The UCS results generally correlate to the Schmidt hammer rebound values (e.g., rock types with high rebound values also had high UCS values).
	• Based on this research, we suggest considering the following before using the Schmidt hammer:
	  • The selection of Schmidt hammer type is up to the user. The N-Type is potentially a better candidate for general use due lower scatter in its results.
	  • Determine the final goal before using the Schmidt hammer and selecting a testing methodology (i.e., acquiring results representative of the rock mass or the intact rock).
	  • Before recording any values, identify the rock type and determine potential bedding, foliation, persistent jointing, faults, etc. that can influence results at the testing location.
	  • Differences in testing environments, for example in the field on in situ rock versus in the lab on large samples, may impact results due to the bias of sample selection.
	  • Select the most applicable data reduction method for the Schmidt hammer results. The method used will change the final averaged rebound results.

Impacts/Benefits of Implementation (actual, or anticipated)	• Based on this research, we suggest considering the following before using the Schmidt hammer:
	  • The selection of Schmidt hammer type is up to the user. The N-Type is potentially a better candidate for general use due lower scatter in its results.
	  • Determine the final goal before using the Schmidt hammer and selecting a testing methodology (i.e., acquiring results representative of the rock mass or the intact rock).
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	 Acquisition of Schmidt Hammer (SH) readings at sites in (a) Alaska and (b) Oregon (photographs by M. Darrow).
Web Links • Reports • Project Website	