LANDSLIDE TECHNOLOGY
A DIVISION OF CORNFORTH CONSULTANTS

Memo To:	Aaron Banks, C.P.G. R&M Consultants, Inc.	2925-5.2
From:	Darren Beckstrand, C.E.G. Landslide Technology	
Date:	December 29, 2021	
Subject:	**Surface Extensometer Monitoring** **Beach Road Landslide, Haines, Alaska**	

This memo presents a summary of the surface extensometer instruments at the Beach Road Landslide between installation in July 2021 and December 2021. These instruments are installed across scarp cracks, as approximately shown on Figure 1.

BACKGROUND INFORMATION

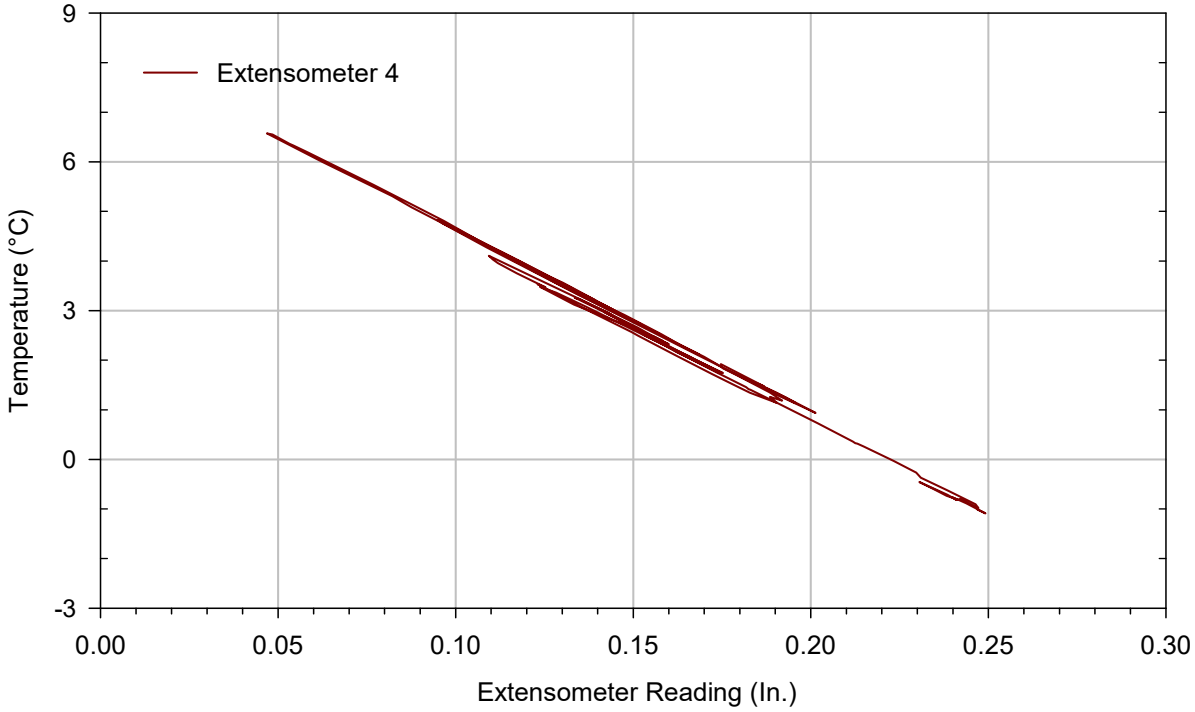
Five extensometers are located spanning a ground surface crack extending eastward from the upper landslide headscarp, ranging from a few feet wide adjacent to the headscarp then shrinking eastward and curving north until the crack is no longer visible. A sixth extensometer location is monitoring a discrete scarp and block on the upper east flank of the headscarp. Extensometers 1 through 3 cross over the tension crack with vertical offsets of about 5 feet on the west side at extensometer 1, shrinking to about 3 feet at extensometer 3. Extensometers 4 and 5 are positioned at the eastern flanks of the visible crack with vertical offsets of 1 to 3 inches. Installation details are provided in the August 26, 2021 memo.

Currently, readings are programmed to be taken every 15 minutes, 24 hours per day. The readings are averaged and compiled each hour and stored until data management systems obtain the data at scheduled intervals. Additional subsurface instrumentation, including inclinometer strings and vibrating wire piezometers, have been installed since our last October 2021 memo. Subsurface instrumentation was installed in the 12 borings and is also being monitored regularly (the installation and data will be presented in a separate report). The gateway datalogger is currently programmed to turn on its radio and modem at 12:00 pm and turn it off at 14:00 pm (Alaska local time) to conserve power. This power management has worked well in the low light months of fall and early winter with minimal threat of dead or low batteries. While the modem is on and connected, the cloud-based data processing and plotting service 'Konect' communicates with the datalogger and obtains all readings since its last communication. Landslide Technology's servers also connect daily to download and archive hourly readings. Configured websites allow our geotechnical staff to view data as it is collected.

DATA

Extensometer data has successfully been obtained daily since installation. Since July 21, data has been populating the project's Konect data portal. Temperature affects the length of the measurement cable

(expands as the temperature increases), causing changes in the extensometer readings deviating from the actual distance between the two anchor posts. Plot 1 below exhibits this generally linear relationship between displacement readings and temperature. Plotting a 24-hour running average helps mute the daily temperature effects.



Plot 1: Temperature versus apparent displacement for Extensometer 4 between November 1 and 7, 2021.

Plots have been configured to illustrate the 24-hour running average over the latest 7-day time history (Plot 2), and a 24-hour running average over the latest 28-day time history (Plot 3). The 24-hour running average over a 90-day time history is shown as Plot 4. This data shows that three extensometers (Extensometers 2, 3, and 6) began exhibiting apparent change between December 8 and 12, coinciding with the onset of heavy snowfall.

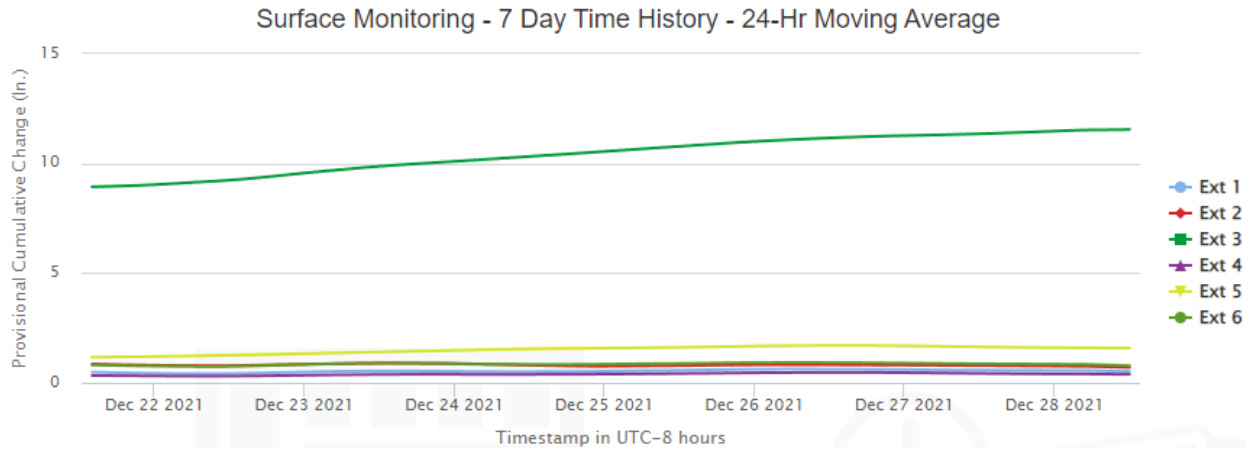
Snow depths measured at the Mt. Riley weather station measured about 40 inches at the onset of increasing readings, reaching a maximum depth of about 48 inches by December 11. Extensometer 6 returned to prior reading trends once snow depths decreased to 36 inches and lower. A gradual increase in readings in Extensometer 5 is present between December 13 and 26, possibly attributed to densification and/or creep of the snowpack. To account for the effects of temperature on the readings, linear relationships were calculated for each extensometer and those effects removed from the dataset and a 24-rolling average plotted to reduce data noise (Plot 5).

These trends are being closely observed. The absence of a trend through all the extensometers supports an interpretation that snow, debris, and/or support posts becoming misaligned and displacing the extensometer wire as a likely cause behind the reading changes. Sensor temperatures

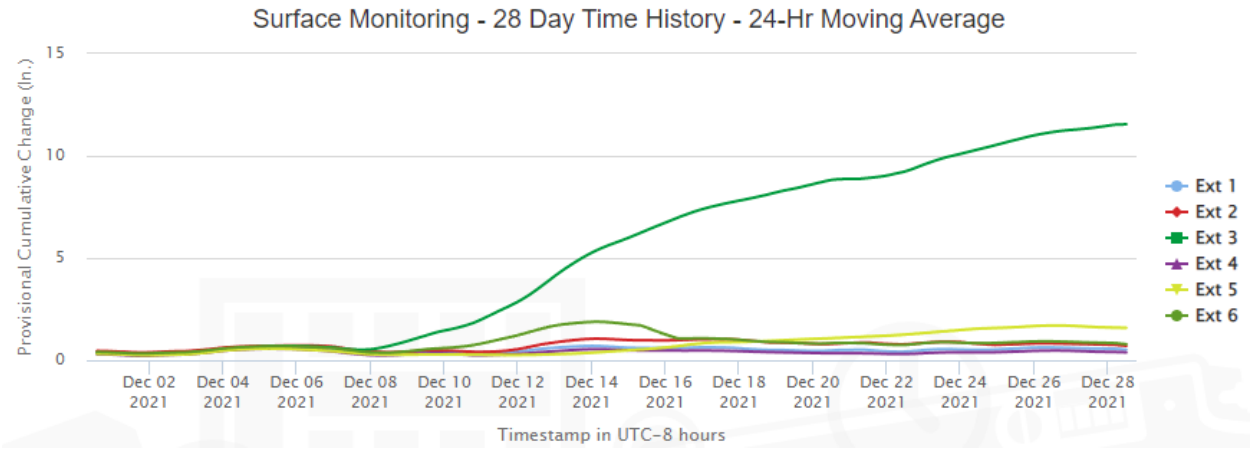
(Plot 6) indicate that extensometers 5 and to a lesser extent, 4, have been insulated by a snow blanket. These two installations are the furthest in the trees and closest to the ground surface.

The apparent displacement trends in the extensometers were compared with the subsurface instrumentation data from the borings, where little to no subsurface displacement is indicated. Therefore, the magnitudes of apparent displacement measured by the surface extensometers are related to surface environmental conditions and possibly near-surface ground disturbance.

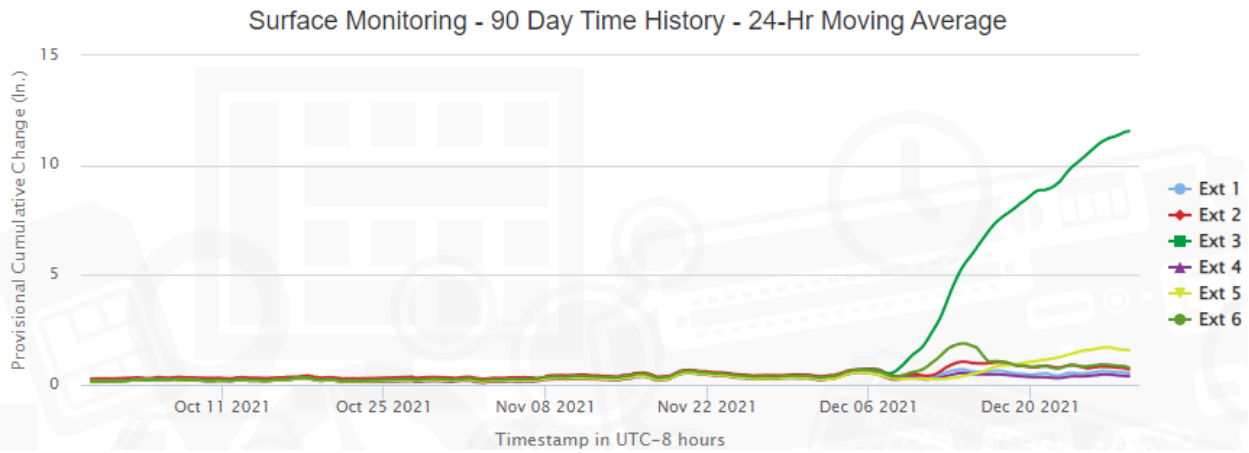
Battery voltage over time is shown on Plot 7. The data is frequently reviewed to verify that there is no significant loss of power and that the solar panel is sufficiently recharging the batteries. The power management programming, 200W solar panels, and 150 amp-hrs of battery capacity have overcome traditional challenges of communications, very cold temperatures, and winter's short daylight hours. Monitoring battery charge of the other 11 datalogging stations indicate that this original base station experiences the most demand, indicating that if the base station maintains voltage, so will the others.



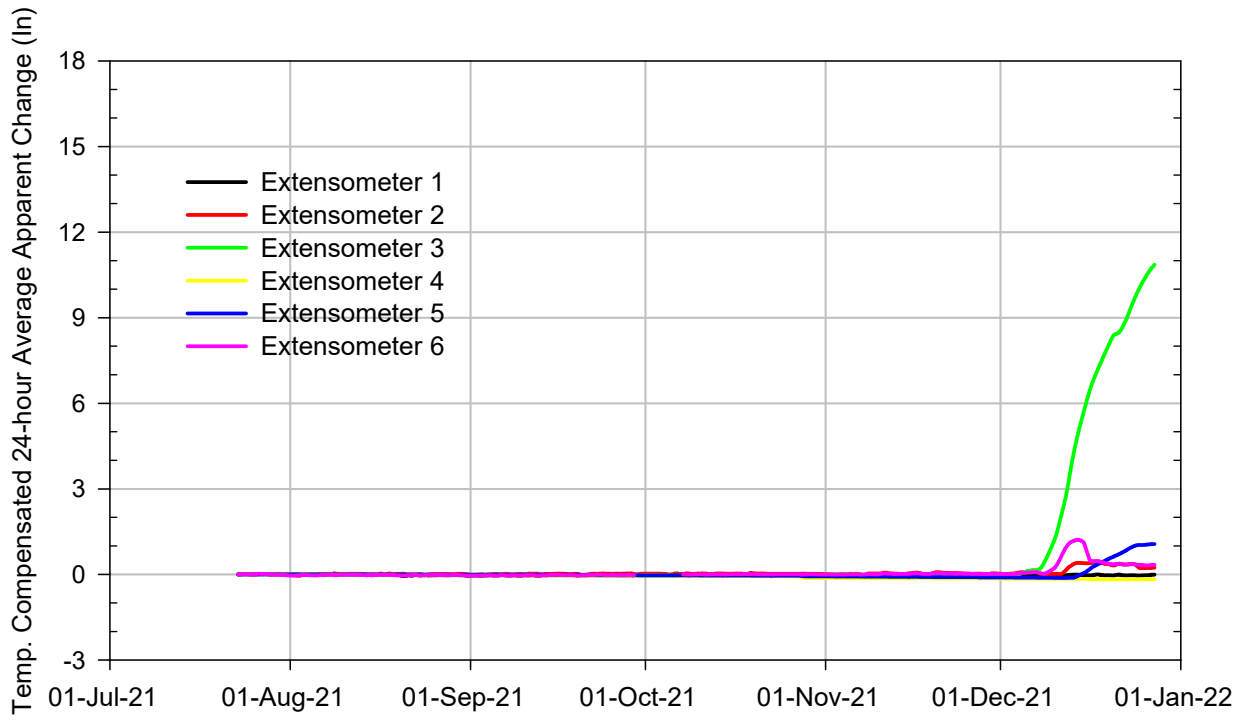
Plot 2: Extensometer data, 7-day time history, automatically scaled range.



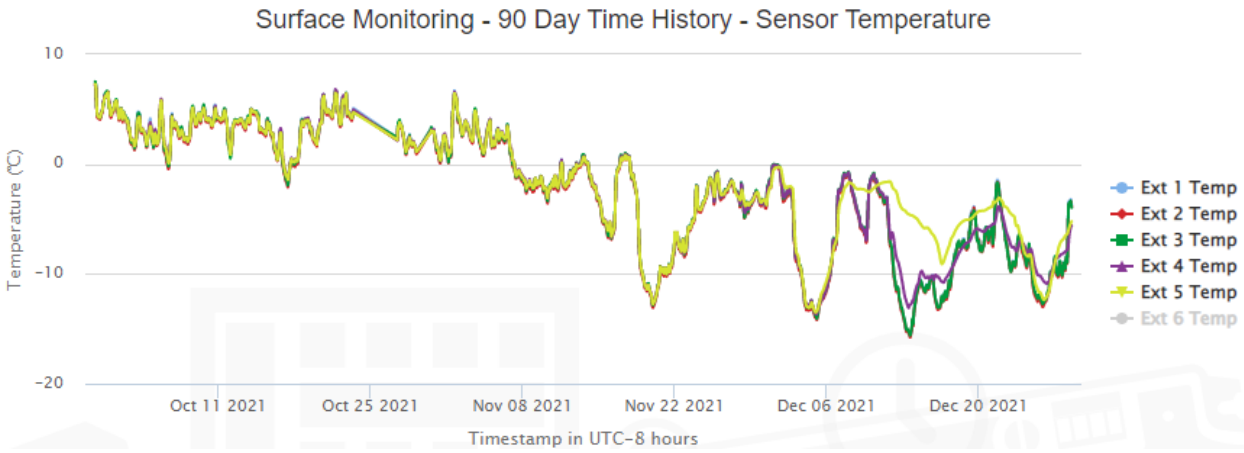
Plot 3: Extensometer data, 28-day time history.



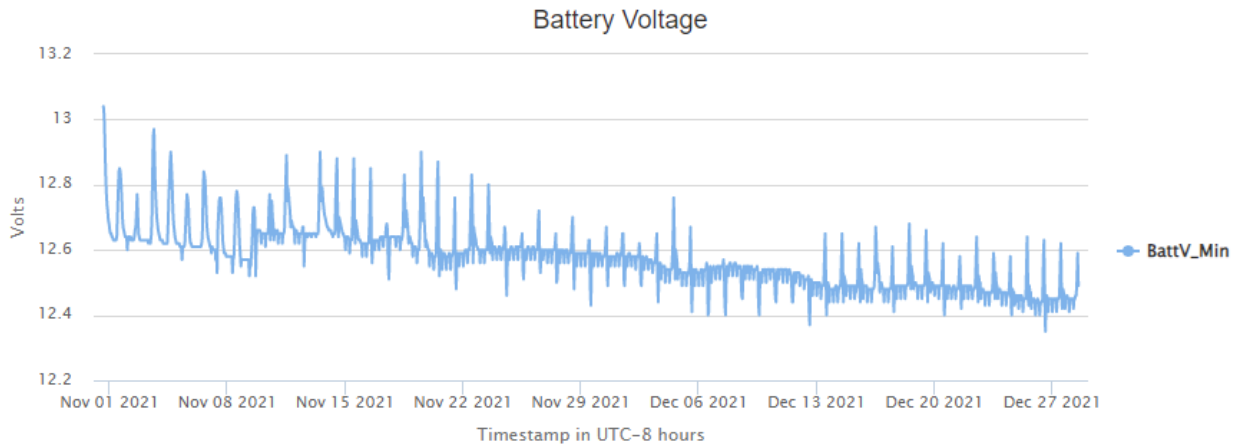
Plot 4: Extensometer, 90-day time history.



Plot 5: Complete Time History of Temperature Compensated 24-hour Rolling Average of Apparent Change.



Plot 6: Senor temperature data, 90-day time history with automatic y-axis scaling.



Plot 7: Base station battery voltage.