# Use of Smart Rock Sensors to Improve Rock Slope Design

**Technical Brief** **March 2022**

***Report Title***

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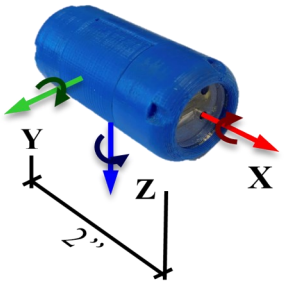


***Principal Investigators***

*Jean Benoît, Project Investigator*

*Bruma Souza, Graduate Student*

*University of New Hampshire*

***Report Link***

*https://www.nh.gov/dot/org/projectdevelopment/materials/research/projects/26962z.htm*

***NHDOT Research Unit***

*Bureau of Materials and Research*
*5 Hazen Drive*
*Concord, NH 03302*
*(603) 271-3151*

## Why was it studied?

Rockfall events attract significant attention and adverse reaction from the public, especially near highways and residential areas. Risk assessments in rockfall mitigation are critical but unfortunately public and private resources to minimize natural hazards are limited. Reliable hazard mapping and territory management require reliable predictions of rockfall trajectories, velocities, bounce heights, and kinetic energies. However, the unpredictability of falling blocks turns this task significantly difficult, given their intrinsic randomness and currently available field instrumentation techniques. Extensive research conducted at the University of New Hampshire developed a Smart Rock (SR) sensor. These sensors consist of 3D printed capsules, 2” in length and 1” in diameter, capable of instrumenting field and laboratory rockfall experiments to better understand rockfall mechanics.

## What was done?

Rockfall assessments were performed with the aid of Smart Rock sensors to obtain acceleration, rotation, and altitude data from the perspective of the falling rocks. More than 85 field experiments were conducted in NH provided data at 10 different sites with a wide range of topographies, geologies and hazard ratings, with field measurements and video analysis. Laboratory and modeling assessments were also undertaken to compare experimental trajectories with rockfall simulations.

## What did we learn?

The findings show that acceleration and rotational velocity data from the rock perspective provide a high potential to expand rockfall understanding and improve model simulations. The Smart Rock data outputs were used to distinguish rockfall movement over time (free fall, bouncing, rolling, sliding). Predominant rockfall modes of motion were identified at different ranges of slope angles. The modes of motion of a rockfall and the slope characteristics have a significant effect on the distances traveled by falling blocks. Shallower slopes and slope irregularities often increased runout distances and lateral displacements. It was also demonstrated that rockfall motion is strongly influenced by the characteristics of the falling block and its fall kinematics.

## How can we use it?

The protective design against rockfall events must primarily account for the slope conditions and expected rockfall modes of motion, verified for different slope configurations typically encountered in NH. The SR measurements can be used to estimate impact forces and block rotational kinetic energies leading to safer design for motorists across the state.