

Best Practices for Road Weather Management

Version 2.0

Wyoming DOT Avalanche Warning System

US Highway 189 near Jackson, Wyoming is a steep, mountain road that winds through Hoback Canyon. Along the highway, there is an avalanche path with a 35-degree slope that poses a threat to the traveling public and to Wyoming Department of Transportation (DOT) personnel engaged in snow and ice control activities. In the past, maintenance personnel have been caught in avalanches while clearing snow and debris from a prior slide. The DOT has deployed a warning system on the highway to detect avalanches, warn approaching motorists, and alert maintenance personnel working in the area.

System Components: The avalanche warning system is comprised of a sensor assembly, a radio communication system, a controller, two static warning signs equipped with flashing beacons, and audible alarms in maintenance vehicles. The sensor assembly includes tilt switch sensors enclosed in galvanized steel pipes. The pipes are hung on weighted wire ropes attached to a 3/4-inch (19-mm) diameter cable, which is strung across the slide path. The cable is suspended roughly 8 feet (2.5 meters) above the ground and anchored to steel posts embedded in concrete. The sensor assembly is installed 980 feet (298.7 meters) above the roadway.



**Wyoming DOT
Avalanche Warning System Location**

The controller monitors sensor status, records sensor data, and activates warning systems via radio when the onset of an avalanche is detected. The roadside warning signs are located 1,300 feet (396.2 meters) in advance of the affected highway segment. Batteries with solar panel chargers supply power to all field sensors, control devices, and communications hardware. Portable alarm devices are placed in maintenance vehicles—primarily rotary snowplows and front-end loaders—operating in the area.

System Operations: Controller software is programmed to continuously monitor the sensor assembly and detect switch closure based upon established threshold values. When an avalanche is detected, warning devices are instantly activated. Tilt switches within the steel pipes pivot from vertical to horizontal positions when impacted by a slide causing a circuit to close. The controller automatically prompts a radio to transmit a modulated tone to activate beacons atop motorists warning signs and to sound 97-decibel sirens in maintenance vehicles. The audible alert gives maintenance personnel about ten seconds to move out of the slide path.

Transportation Outcome: The avalanche warning system improves roadway safety by minimizing risks to drivers and to maintenance personnel. The system also facilitates timely inspection of the roadway after an avalanche, snow and debris removal activities, and road closure or rescue operations.

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Implementation Issues: The warning system project was initiated as a multi-state, pooled fund study involving Colorado, Idaho, Utah, Washington State, and Wyoming. After developing equipment requirements, designers of the Wyoming system decided where the sensor assembly should be installed based upon starting zones and slide speeds of prior avalanches. If sensors were located too far above the highway, the system could initiate warnings for avalanches that did not reach the road. If placed too close to the road, there would not be sufficient time for the system to warn those in danger.

Designers considered system expandability through the integration of new components. A preliminary test of non-invasive avalanche sensors is underway. Two geophones, which measure ground motion, were installed adjacent to the slide path roughly 98 and 197 feet (30 and 60 meters) below the tilt switch sensor assembly. When the tilt switch sensors are activated, the controller simultaneously samples the geophones. By detecting the time lag in the arrival of an avalanche waveform, the controller can distinguish avalanches from other events and determine slide velocity. Further experimentation is necessary to establish criteria for warning system activation.

In a coordinated effort, local winter maintenance managers and emergency managers plan to examine hardware and communication interface reliability, document system operation, and assess roadway impacts. Evaluation results will be used to optimize the system and supplement training.

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