

Hazard Understanding and Emergency Response Planning at Turtle Mountain, Alberta, Canada

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Abstract

Located in southwestern Alberta, Turtle Mountain is the site of one of Canada's most notorious natural disasters, the Frank Slide. The 1903 rock slide buried the Town of Frank under 30 million cubic metres of debris, killing 70 people.

A series of large cracks remains around the south peak of the mountain, prompting speculation that the cracks may widen over time and lead to another rock slide. Experts believe a failure of the South Peak could generate a slide with a volume of approximately 5 million m³. In spite of the risk, development restrictions were never placed on the areas outside the 1903 slide. As a result, numerous residential developments were built in the potential run-out zone.

In an effort to manage this risk, on April 29, 2003, the Government of Alberta committed \$1.1 million to install and commission a real-time warning system for the South Peak of Turtle Mountain. The project was administered by the Alberta Emergency Management Agency (AEMA), with technical assistance from the Alberta Geological Survey (AGS).

Although involved in a technical capacity in previous activities, as of April 1, 2005, ERCB/AGS assumed full responsibility for the monitoring and research activities at Turtle Mountain. This includes the long-term monitoring, interpretation of data and technical guidance to AEMA on the eventuality of a second large rock slide from Turtle Mountain.

The monitoring system was designed to include a number of different types of instruments communicating in near real-time to a data acquisition centre located at the base of the mountain. The design process involved defining preliminary data requirements and reviewing options for instrument types and locations, measurement frequency, and equipment requirements for data acquisition and management.

The monitoring network provides complementary types of instruments with varying sensitivities to movement and climatic influences, and also has enough redundancy built into the system to be able to distinguish real movement. At the end, this is a system capable to provide a reliable data stream 365 days per year, 24 hours per day in all weather and lighting conditions.

Hazard mapping

The design and implementation of the monitoring system assumed that the rock slide volume and kinematics were as identified by Allan in the 1930's. Sensors were installed to map movements consistent with these assumptions. The initial focus was to develop the monitoring infrastructure and provide upgrades to increase reliability of the system. However, with

developing knowledge of the hazards and an increase in financial resources, more detailed studies were undertaken to expand the understanding of the stability of the mountain as a whole. The most valuable piece of data used to characterize instabilities on the mountain was the airborne LiDAR survey collected in June 2005. By utilizing the 1 metre high resolution DEM (HRDEM) derived from interpolation of the ground returns, hill shade models were derived. These models not only highlighted the visible morphology of the mountain but also allowed for high level structural mapping of the features on the mountain. A computer based structural mapping tool, COLTOP, was applied to better understand the structural controls on the Frank Slide, South Peak and other portions of the eastern face of Turtle Mountain. These studies highlighted structural controls on instabilities on the eastern face of the mountain that differ from those previously known for the South Peak. The recently derived DEM also showed instabilities in the areas below Third Peak, which had not been identified in previous studies. The computer based structural models were later confirmed with field structural mapping. Based on these structures, various zones of potential instability were determined, their volumes estimated and preliminary kinetic analyses undertaken to determine if they are susceptible to movements.

In order to better understand the extent of the potential impact of the hazards posed by these various unstable volumes (scenarios), dynamic run-out analyses were undertaken. A three-dimensional dynamic model of Turtle Mountain was created and calibrated using the experience from the Frank Slide and other regional rock avalanches. The results from calibration back-analyses were then used to select the input parameters applied in the analyses of the potential rock avalanches. With the establishment of new zones that are potentially susceptible to run-out, management and communication of the hazard and risk is underway.

Emergency response and warning system

Although studies continue on the mountain to better understand the deformation patterns and interpretations of the slope kinematics, significant effort has been expended to develop a structure for the warning and emergency response that clearly outlines not only responsibilities and communications protocols during an emergency, but also day-to-day operational responses and procedures to ensure that the system remains operational.

From a day-to-day operational perspective, a systematic and repeatable set of procedures is required in order to ensure that not only are data trends reviewed and reported on, but that scheduled checks of system functionality are undertaken. An internal Roles and Responsibilities Manual was developed to clearly outline responsibilities for geo-engineering, IT and management staff to ensure that system checks are completed and that support is in place on a 24/7 basis should components of the system cease to operate properly or should unacceptable deformations require review. In addition to that, a clear and concise troubleshooting manual was developed. This document provides simple diagnoses of problems within the system and a clear roadmap of how to fix each component.

From a warning and emergency response perspective, a series of colour coded alert conditions were developed should unacceptable deformations be observed. At each alert level, clear responsibilities for actions and communications have been identified for geo-engineering staff, provincial emergency management authorities, municipal officials and first responders. This has been documented in the Emergency Response Protocol.

All documents described here are ‘living’ documents that are updated on a regular basis as changes to the system are made. An annual mock warning exercise was developed and run on a yearly basis in order to test responses to a hypothetical emergency.