DEVELOPMENT OF THE AVALANCHE MANAGEMENT PROGRAM FOR THE COQUIHALLA HIGHWAY

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This paper discusses the evolution of the avalanche management program for the Coquihalla Highway, a freeway opened in 1986, which transects a mountain pass in the Cascade Range of British Columbia. Standard and innovative avalanche management applications used throughout design, construction, and in the current operation provide a safe and efficient highway.

The Coquihalla Highway is a new freeway which passes through an avalanche prone mountain pass in the southwestern section of British Columbia. The area consists of steep granitic 2000 meter peaks with vertical relief of 600 to 900 meters. This highway has effectively become the Trans-Canada Highway as it is the shortest route from Vancouver and the Lower Mainland to the interior.

The area is dominated by a southwesterly maritime flow and often experiences large winter storms. Heavy snowfalls are often accompanied by large and rapid fluctuations in freezing levels. Occasionally the area is affected by periods of high pressure from the continental climate of the bordering interior plateau. This creates a deep, primarily stable, snowpack with some weaknesses caused by kinetic growth development. Avalanches are usually the result of overloading due to the heavy precipitation and are triggered by rapid warming. These warm temperatures also cause rapid post cycle stabilization.

Avalanche considerations were a prime concern in the development of the highway and the Snow Avalanche Section was heavily involved in its design. For ten years prior to construction, snowpack, weather and avalanche paths were monitored and recorded. An avalanche atlas was created providing a detailed inventory of the snow avalanche paths in the form of photographs, maps and written technical descriptions. Avalanche terminus information became essential and was recorded relative to permanent landmarks.

The most effective method of control, avoidance, became our primary design criteria. Final route alignment was projected based on many considerations; however, every effort was made to avoid avalanche paths. Where paths could not be avoided and where terrain allowed, other passive methods were used including raising the highway grade, construction of berms, mounds, diversion and catchment dams, and a snowshed. This

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significantly reduced the number of avalanches which could affect the highway. The remaining avalanche hazard would have to be controlled using active methods. Various explosive options were considered based on several factors including range, accuracy, cost, availability, and effectiveness relative to the terrain and snowpack. Avalanche control ropeways and long range weapons were recommended.

In 1984 the government decided to complete the highway by May 1986. Construction was accelerated and continued through the following two winters. Three continuously occupied construction trailer camps were located within the hazard area. Avalanche forecasting and control was required for the contractors and Ministry employees living and working in the area. Hazard forecasts were made daily and updated as required using weather forecasts and snowpack and weather data gathered in the field. These hazard forecasts dictated work habits and locations. Full work stoppages were enforced when the hazard warranted. Explosive control was done using helicopters and avalaunchers.

The avalanche path which threatened the snowshed construction site required more intensive monitoring and control since more than sixty workers were constantly on the site. All workers took a short avalanche awareness training session and were required to wear rescue beacons at all times. Numbers of workers and planned work locations were reported to the avalanche forecaster daily. Snow study sites were set up near the starting zone and track. Control included hand charge routes, ski cutting of small cut slopes above the shed site, and a "clothesline bomb tram". All of these options had specific deficiencies, mainly lack of access during poor weather and/or dangerous access during hazardous periods. However, the combination of these methods provided a safe working area for the short construction period. A more efficient means of control would be provided when the highway was opened to continuous traffic.

The construction period allowed the avalanche staff to attain increased familiarity with the avalanche phenomena in the area, providing more detailed information for future program requirements.

Efficient operation of the highway, once open with the expected high traffic volumes, required minimum closure periods. A more precise avalanche forecast was facilitated by installation of four additional remote weather stations, in conjunction with the two manual weather stations. Standard as well as starting zone profile sites were established throughout the pass. Two avalanche control ropeways, the first of their type and magnitude in North America, were designed, located and installed. Eleven fixed gun positions were built for artillery control during all winter weather conditions. This would ensure efficient control of the avalanche hazards.

The current operation uses computers to facilitate retrieval of on-line weather forecasts, maps and data. Snowpack information is gathered as required from standard and other locations in the field and is recorded using internationally recognized standards. An avalanche hazard forecast is produced daily and updated as required using the above information. The forecasts are then disseminated via computer to a central dispatch center and to affected maintenance areas.

Avalanche awareness training is given to all maintenance staff with rescue practices conducted throughout the winter season. All staff are made aware of avalanche safe areas. Work habits and plowing procedures are conducted accordingly with respect to the forecast hazard.

When hazard dictates road closures and avalanche control, road crews close off the hazard area as designated by the avalanche technician. Snow clearing operations continue throughout the closure in safe areas only, again under the direction of the avalanche technician, to ensure the highway is in good condition when it is re-opened. Throughout the closure, ropeway and artillery control are conducted simultaneously to maintain minimum road closure times and to take full advantage of the typically short term instabilities.

In the winter of 1987-1988 a snow glide study was begun in conjunction with the National Research Council of Canada. Observations taken indicate that many avalanches off of rock slabs are snow glide initiated. These have been difficult to forecast as isolated occurrences have been recorded, some of these during long periods of cold, clear weather. With time and more study a glide triggered avalanche indicator may be determined. This would be a great asset toward forecasting these difficult to predict avalanches.

Many criteria are used to determine the avalanche management applications required to achieve an efficient operation in a specific area. This program has developed to a point where a safe and economically efficient traffic corridor is being maintained throughout the winter season. Similar studies and avalanche management programs should be an integral part of any development which may affect the safety and economic concerns of the public.