US HIGHWAY 550 AVALANCHE REDUCTION PROJECT SAN JUAN MOUNTAINS OF COLORADO

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INTRODUCTION

In September 1992, the Colorado Department of Transportation (CDOT) contracted the Colorado Department of Natural Resources, Avalanche Information Center (CAIC) to provide avalanche condition evaluations, forecasts and recommendations for avalanche control and road closure, and other related services for U.S. Highway #550 in the San Juan Mountains of southwestern Colorado. Two CAIC forecasters are based midway along the 37mi/54Km avalanche-prone route, in the town of Silverton (Pop. 400; 9320'/2830m asl), from November 1 through May 1. This paper will describe project elements and forecasting methodology and will summarize weather, avalanche events and forecasting results for two winter seasons.

Setting

The discovery of gold and silver in the late 19th century dictated the need for access into the highly active avalanche terrain of the San Juans. US Highway #550, which follows an historic wagon road, is now an important transportation corridor, linking Farmington, New Mexico and Durango, Colorado with the Montrose/Delta/Grand Junction region to the north. Three Passes (Coal Bank, 10580'/3216m; Molas, 10910'/3316m and Red Mountain, 11090'/3370m) are traversed by about 400 vehicles/day during the winter, passing under or across 101 identified avalanche paths.

The area of greatest concern on the highway is the East Riverside Slide, scene of 5 fatalities through 1987. In 1985, a 185' wide avalanche shed, costing $2.7 million was constructed at the main gully intersection of this path. In March, 1992, a sixth fatality resulted from an avalanche on an adjacent path, just north of the shed. This incident prompted the development of the avalanche reduction program. The East Riverside area accounts for no more than 20% of the highway hazard, and dozens of other incidents involving the public and CDOT personnel have occurred over the length of the highway, some with injuries.

The town of Silverton is totally dependent upon US #550 for access beyond the mountain valley. No other populated community in the conterminous United States has such a potential for isolation due to avalanche related road closure, which disrupts daily delivery of mail, goods and services and access to medical services.

Snow climate

The project area is characterized by relatively low snowfall, cold temperatures, and location considerably inland from coastal areas, factors which define a continental snow climate. Weather systems most commonly produce orographic precipitation, which is dependent upon the position of terrain features in relation to the regional setting. Thus precipitation events will generally favor one portion of the highway over others during much of a storm period. Snow cover is often shallow (60" - 120" in the starting zones) and develops in a pattern of frequent storms having <12" per 24 hr. period. This condition leads to persistent structural weakness in the snow pack from large temperature gradients, and development of faceted grains at basal and mid-pack layers. (Higher intensity snowfall, >12"/24 hr. produce most natural avalanche events.) Average winter water equivalent at Red Mountain Pass is around 25", while extremes can range from 12" to 40". Temperatures generally range from -25°C to +5°C. These elements, coupled with frequent ridge top winds >15 mph, will result in both hard and soft slab avalanches, during the winter season. Spring temperature warm-up periods will often produce wet avalanches across the road.

Avalanche Inventory

Avalanche paths which cross the highway range in vertical fall dimension from 60' to 3200' with starting zones of <1 acre to 150 acres or greater in a few cases. Based upon frequency estimates of return period, the project lists 25 paths that run one or more times annually, 35 paths at 1-5 years and 16 paths at 5-10 years. The remaining paths release erratically, but most have reached the highway in the past 25 years. Eighty-three avalanche paths can produce damaging events, while 19 of these would destroy a heavy vehicle. Frequency estimates are based upon 40 years of record (of varying quality) from CDOT, the US Forest Service and the Institute of Arctic and Alpine Research (INSTAAR).

AVALANCHE FORECASTING

Methods

Avalanche forecasting methods utilize conventional observations and subjective analysis by experienced forecasters. Each forecaster has more than 20 years avalanche related experience in the continental snow climate, including 12 years of specific forecasting responsibilities for the lead forecaster. Snowpack measurements are made at four sites along the highway corridor. Total depth and snowfall totals are recorded. Frequent ramsonde and snowpit investigations were made. Daily observations of highway avalanche paths and back country indicator samples helped forecasters develop pattern recognition skills. Each observed avalanche occurrence was recorded in detail and entered, along with weather and snowpack observations, onto a data base. Continuous monitoring of storm periods by traveling the highway verified forecasted potential. Radio communication and contact between forecasters and CDOT maintenance personnel helped develop immediate response to changing conditions.

During the 1993-94 season two remote instrument packages providing wind speed and direction, and temperature information were installed on a ridge above the north segment of the highway at 12000'/3660m and at 12900'/3,930m adjacent to Red Mountain Pass. Five Soil Conservation Service SNOTEL sites, located along the highway corridor for water yield and management purposes, provided daily precipitation and temperature information.

Advisories

The core of the project is the development and dissemination of daily avalanche potential evaluation and forecast advisories for three highway segments. Evaluations are made for the time of the advisory, and forecasts are routinely issued for a 25 hour period. Updates are issued in response to changing conditions. Avalanche forecasts are based upon quantitative weather forecasts provided by the CAIC Forecast Office in Denver and real time stability evaluations.

Avalanche release potential is characterized as low, moderate, high and extreme which are defined in terms ranging from very unlikely to certain. Travel and maintenance restrictions vary from none, to total road closure. The advisories are distributed to CDOT personnel, law enforcement officials and other interests through personal contact and FAX line.

Control & closure recommendations

Contracted obligations with CDOT extend to recommendations for control and closure of the highway when necessary. These recommendations are included in the advisory and specify which highway segments and groups of paths require control work and by what methods. Closure recommendations may be made prior to control efforts when potential for natural release renders highway unsafe for travel. The highway is then swept and the gates shut until safe travel can resume. CDOT then responds with explosive control methods which may include helicopter bombing and avalauncher delivery of high explosives. The avalanche forecasters accompany control teams to help direct the efforts and record results.

OUTCOME

Weather summary

The 1992-93 winter was characterized by a series of strong storm systems which entered the San Juans on a southern fetch with comparatively mild temperatures and abundant moisture. Snowfall water equivalent on Red Mountain Pass was 36.50", well above the mean of 25.50" established over a 12 yr. period of accurate data gathered by INSTAAR from 1971-1983.

The 1993-94 winter was much lighter with a snowfall water equivalent of 17.00" on Red Mountain Pass at the 3rd week in April.

Avalanche summary

A total of 142 avalanches crossed the highway during the 1992-93 winter. Explosive control accounted for 65, while 87 released naturally. Of the 87, 25 small events crossed the road while it was open and the remainder after road closure. Debris dimensions at centerline ranged from about 2'X 30' to 4' x 1300' to 20' x 250'. During an extraordinary storm period from 2/19 through 2/24, 42 avalanches crossed the road, covering the centerline for a total distance of 3.9mi/6.3Km, with average dimensions of 6.8' x 500'. All but a few of these events were natural while the road was closed. Total road closure days south of Silverton were 7 days and north of Silverton (Red Mountain Pass) 17 days. Numerous other short closures were made for control work. Two incidents were noted. An avalanche struck the mail truck, with no damage, and a fully loaded semi-tractor-trailer plowed into debris in another avalanche and had to be abandoned for 3 days.

A total of 94 avalanches crossed the highway during the 1993-94 winter. Average dimensions were about 4' x 220'. Total road closures were 2 days for the entire highway. A few closure periods were for control work. No avalanche incidents involved the public, though two plows inadvertently got stuck in avalanche debris.

Forecasting summary

During the 1992-93 season 172 advisories provided forecasts and recommendations for the three separate highway segments. A total of 517 forecast decisions were made: 420 "LOW"; 69 "MODERATE"; 20 "HIGH" and 8 "EXTREME". Forecast decisions are scored against the next advisory's evaluation, based upon rating definitions. Results showed that rating periods of "moderate" or above, were under forecast in 21% of the cases, while 34% of those rating decisions were over forecast. Over forecasting reflects a conservative bias for the operational project. Forecast accuracy for the entire decision sample was 91.2%.

Forecast decisions for 1993-94 were 422, of which 390 were for low, 24 for moderate and 8 for high. Forecasts were under estimated for 7 low periods and 2 moderate. There were 3 over forecasts at moderate. Overall forecast accuracy for the season was 97%.

DISCUSSION

This project marks the first systematic on-site forecasting effort undertaken for Colorado mountain highways. Institutional constraints resulted from the newness of interagency advisory and decision-making roles, however, cooperation between forecasters and local maintenance personnel was instrumental in the success of the project. Frequent discussion of weather forecasts, avalanche conditions and logistics at the maintenance barn level resulted in increasing trust and appropriate mutual response to potentially dangerous situations. Public interest was high and frequent media coverage and personal contact with community leaders, law enforcement personnel and citizens, helped interpret this somewhat controversial program.

Some factors leading to forecasting error were:

- 1. Uncertain meso-scale weather forecasts;
- 2. Lack of real-time weather data at starting zone elevations;
- 3. Difficulty in accurately assessing contributory factors.
- 4. Inability to expeditiously perform explosive testing.

Future Program

The Avalanche Reduction Project is now a state-wide line item program. Full time forecasters went on duty for the 1993-94 season on the I-70 and mountain pass corridors west of Denver and on Wolf Creek Pass. The Silverton Forecast Office added Lizard Head Pass, south of Telluride, and CO #110 to the Gladstone mine to their forecast responsibilities. A comprehensive CDOT statewide avalanche atlas is nearing completion. An Avalanche Hazard Index is in preparation as an inventory and decision-making tool. Future sophistication of the operational forecasting programs will include additional remote and direct instrumentation, a blending of analytical modeling into the conventional forecasting techniques, and improved communication with Colorado Department of Transportation personnel.

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