I-90 SNOQUALMIE PASS: OPERATING A HIGHWAY AVALANCHE PROGRAM DURING A MAJOR CONSTRUCTION PROJECT

John Stimberis, Washington State Department of Transportation

ABSTRACT: Snoqualmie Pass, WA (921m) receives an average of 1100 cm of snowfall annually. Interstate 90 over Snoqualmie Pass is the major highway through the Cascade Mountains of Washington State, with traffic volumes averaging nearly 30,000 vehicles per day and peak volumes exceeding 50,000. Numerous avalanche paths affect I-90 in the vicinity of Snoqualmie Pass. Avalanche delays and closures have an economic impact that often exceeds several million dollars (USD), depending on the length of the closures. The area with the most active avalanche paths has a two-lane snow shed covering the westbound lanes; eastbound lanes are fully exposed to the avalanche hazard. Up to 40 avalanche control missions may occur at this site each winter.

The existing two-lane snow shed will be replaced as part of a $550 million (USD) highway expansion project. Construction plans include replacing the existing snow shed with a larger shed or a bridge. Approximately 1500m of snow supporting structures will be installed in adjacent avalanche zones. The construction season runs from May through October and is suspended during the winter due to snowfall and avalanche hazards. The 6-month construction season will not allow enough time for demolition of the existing snow shed and construction of the replacement structures. Thus, the affected area will be left without avalanche defensive structures for one to two winters. In this paper we will examine the challenges and possible solutions that the WSDOT Avalanche Forecasting and Control program faces. In addition we will provide a more detailed look at the proposed structures and their impacts to the future of our highway avalanche program.

KEYWORDS: snow sheds, avalanche fences, explosives tramways, avalanche forecasting, avalanche control

1. INTRODUCTION

Snoqualmie Pass, WA (921m) is the major cross mountain transportation route in WA State (Figure 1). The area is characterized by a maritime snowpack with abundant snowfall and mild temperatures (McClung and Schaerer, 2006). The WSDOT snow study plot on Snoqualmie Pass reports an average of 1100 cm of snowfall each year and 2500 mm of precipitation. Major winters can produce up to 2000 cm of snowfall. Maximum snowpack is usually reached by late March and averages 2.5 m, though peak snow cover has exceeded 4 meters on occasion. Rain on snow events are common most years at pass elevation.

*Corresponding author address: John Stimberis, WSDOT, P.O. Box 1008, Snoqualmie Pass, WA 98068, 509-577-1909, stimbej@wsdot.wa.gov

Interstate 90, the highway crossing Snoqualmie Pass, rises 300 meters over 6 km as it reaches the summit area. The final grade often crosses through the transition from rain to snow, complicating traction on the highway.

Traffic volumes on I-90 have risen steadily over the years, increasing nearly 40% in the past two decades. Current winter average daily traffic volume (ADT) exceeds 25,000 vehicles. Large trucks comprise at least 15% of the total volume, though the ratio of passenger cars to trucks varies considerable by hour of day and day of week. Winter holidays and summer
weekends often report traffic volumes exceeding 50,000 vehicles (Figure 2). Delays to traffic are common due to the large influx of vehicles; congestion and collisions are the main culprits during summer months. Winter travel volumes, though less than summer, often experience more frequent delays due to adverse weather, traction issues, and avalanche related closures. The terrain surrounding I-90 is steep and in places rises up to 900 meters above the roadway. I-90 crosses nearly 30 avalanche paths in the Snoqualmie Pass vicinity. Static avalanche defensive structures are limited to two locations. The WSDOT employs a crew of avalanche forecast and control specialists to monitor conditions and mitigate the avalanche risk.

Figure 1. Snoqualmie Pass Vicinity: A- Granite Mtn., B- Denny Mtn., C- West Shed/Airplane Curve, D- Dodge Ridge, E- WSDOT study plot, F- East Shed, G- Slide Curve. Primary weather stations are shown with asterisks.

Figure 2. Winter traffic volume on Snoqualmie Pass, WA

Avalanche return periods vary greatly from path to path with some areas having return periods on the
order of once every 5-10 years to several avalanche paths with return periods estimated to exceed 10 avalanches per winter. The areas of most significant concern are the East Shed avalanche paths (Figure 1). Here, a snow shed covers the two westbound lanes but the eastbound lanes are fully exposed to avalanches (Figure 3). The East Shed area experiences the majority of avalanche control, averaging 20 missions per winter. Traffic delays related to avalanches at the East Shed totaled 46 hours during the 2011-2012 winter, and contributed to longer pass-wide closures exceeding 80 hours. Total delays to traffic due to avalanche work exceeded 108 hours during the 2011-2012 winter, and the East Shed accounted for nearly 75% of the total.

Figure 3. Eastbound lanes of I-90 are exposed to avalanches at the East Shed

2. TRANSPORTATION CONCERNS

The avalanche-hazard index (AHI) is a weighted numeric expression determined by multiplying the frequencies of vehicles being hit by various types of avalanches (Schaerer, 1989). The AHI for an active avalanche area with high traffic volumes is anticipated to be quite high. We are currently calculating the AHI for the East Shed area without the snow shed in place. We anticipate a very high AHI even with an active avalanche forecast and control program. Although trained and experienced forecasters go to great lengths to eliminate avalanche risk natural avalanches are still encountered; it is estimated that explosive control reduces natural avalanches by 90% (Schaerer, 1989). The biggest contributors to a high avalanche risk at the East Shed paths are a frequently producing avalanche path and in particular an ADT that often exceeds 25,000. I-90 over Snoqualmie Pass has a variable speed limit to allow for changing weather conditions, but when the road is free of snow and ice the speed limit is usually raised to 95 km/h for trucks and 105 km/h for autos (60 and 65 mph respectively). High rates of speed increase the consequences if a vehicle encounters an avalanche blocking the highway.

Traffic volumes, snow and ice issues, and avalanches cause avoidable delays to traffic and commerce on Snoqualmie Pass. The WSDOT has designed a highway expansion project to resolve a number of these issues by increasing travel lanes, improving the highway design, allowing for additional snow storage, and mitigating avalanches. The total cost of improvements for the 8 km project area exceeds $550 million USD, with the avalanche mitigation accounting for $45-50 million USD (Scott Golbeck WSDOT Project Engineer, personal communications). The original plans called for the removal of the current two-lane snow shed and replacing it with a larger six-lane structure. A proposal to construct a bridge in lieu of the snow shed was proposed and is currently under review. Additionally, over 1500 meters of snow fences will be installed throughout this section of highway, mainly in the Slide Curve location (Figure 4). The snow fences anchor the snowpack preventing avalanche release.

The final result of the I-90 construction project is improved traffic flow and reduced avalanche risk. Total avalanche control may be reduced by up to 85% on Snoqualmie Pass. Avalanche control within the project area will mostly be eliminated. The construction project is expected to be completed by 2016. Construction and reconfiguration of the highway presents a challenge to WSDOT during the summer construction season and the winter snow and ice maintenance season. Most winter issues are related to traffic and snow removal due to lane and shoulder restrictions created during the construction season.
Figure 4. Slide Curve Avalanche Paths will receive the majority the proposed snow fences

The existing snow shed will be removed during the summer of 2014 and there will not be enough time to complete the replacement, thus during the winter of 2014-2015 the WSDOT will operate I-90 without any snow shed for the first time in more than 70 years. The highway configuration and absence of the snow shed will complicate highway operations in several ways; most notable will be avalanche debris removal and the presence of a center divider within the active avalanche areas. Both issues will likely increase the delay times, again complicating highway operations as traffic will need to be stopped in the outlying communities 20-50 km away.

3. OUTCOME

Presently the construction plans for 2014-2015 will leave our avalanche program with a 10-12 meter wide catchment between the cut slope and the highway where the snow shed once stood. Four lanes of travel, two west bound and two east bound, will be maintained with limited shoulders. There will be a 15-18 m drop from the most active avalanche track to the bottom of the catchment. The catchment may prove effective at stopping small avalanches, or sluffs. Size 2+ avalanches (destructive force, SWAG 2010) will most certainly affect the travel lanes of I-90.

Highway standards require a center barrier to be in place for travel division. The center barrier commonly used is known as “Jersey Barrier”, a reinforced concrete barrier 82 cm high by 385 cm length with a 3000 kg mass. It is expected that the barriers will be easily displaced by flowing avalanches (Figure 5). It's also expected that size 2 and larger avalanches will deposit debris on all four travel lanes requiring more extensive clean up than is currently encountered. Debris cleanup and realignment of the concrete barrier will extend delays to traffic.

Figure 5. Example of small wet-loose avalanche impact on concrete barriers

3.1 Highway Operations

Standard operating procedures on I-90, Snoqualmie Pass are to minimize local traffic delays to less than 90 minutes. Thus, under normal avalanche control operations at the East Shed the WSDOT Maintenance crews stop traffic several kilometers from the avalanche zone. Traffic remains in these locations while avalanche control and cleanup is performed. As the duration of the traffic delay increases so does the length of the traffic queue. These longer delays further impact traffic and road conditions by increasing the amount of time that it takes for traffic to clear following an avalanche closure and by limiting the amount of road maintenance that can be completed during the delay. Furthermore the mountainous terrain limits the amount of acceptable locations where traffic can be stopped. Stopping traffic on a steeper gradient often complicates the closure; collisions may occur when vehicles attempt to stop on a downhill
gradient, or they may lose traction when attempting to restart on an uphill gradient. As the length of the traffic queue increases the Maintenance crews will often stop traffic at further location below a major grade. Additional closures require more personnel to staff the closures and the waiting traffic have limited access to facilities or provisions.

When delays or closures are expected to extend beyond 90 minutes the Maintenance crews will choose to stop traffic in the outlying communities of North Bend, WA 30 km to the west and several locations east of Snoqualmie Pass ranging from 25 to 80 km away, depending on the anticipated delay and volume of traffic. These types of closures allow motorists access to facilities and the ability to reroute their travel. Closures in the outlying communities also allow the maintenance crews to continue with snow removal on the highway in anticipation of reopening. The drawback to these extended closures is the cost to commerce from delayed shipments or the added cost of fuel from a lengthy detour. Delays to commerce and the risk of avalanches are two of the primary reasons for the Hyak East Construction project.

3.2 Avalanche Operations

WSDOT Avalanche crews determine when to perform avalanche control based on when snow pack instability will be most receptive to explosives. The forecasting dilemma extends beyond instability and into traffic management as well. Peak instability may coincide with peak traffic flow; therefore a careful decision must be made. These challenges will be more complicated with the removal of the snow shed due to extended closures for avalanche debris removal. Avalanche impacts to the Jersey barrier and the volume of snow on the highway will be important considerations regarding how long the highway will remain closed. The forecaster will need to look beyond instability and forecast how much snow is likely to reach the highway and thus where traffic will be stopped. Greater impacts to the highway will require traffic to be stopped in the outlying communities. Socio-political pressures will increase as the avalanche delays lengthen and become more frequent, further complicating the decision making process.

One way to reduce the impacts to the highway is to reduce the amount of snow reaching the highway from avalanche control missions. More frequent control work has the potential to reduce the volume of avalanche debris. The WSDOT already employs this concept and regularly performs more frequent control on the East Shed 3 and 4 avalanches paths. Quite often delays will be minimal due to a limited amount of avalanche debris cleanup. Removal of the snow shed will mean more snow to remove as the westbound lanes will be exposed. Overall though more frequent control is likely to reduce avalanche volumes.

A possible drawback to more frequent control is the risk of performing avalanche control too frequently and creating a false sense of security. WSDOT utilizes a series of explosive deliver trams to perform avalanche control in the East Shed area. Each of these trams delivers 12 Kg of explosives into fixed positions within the avalanche paths. The explosives are very effective at removing snow from the starting zones due to the size of the charge and location relative to starting zone geometry. With more frequent control snow will undoubtedly be removed from the upper starting zones. Additional snow and instabilities may remain in the upper track and some of the smaller feeder paths; snow that is often removed when moderate or larger avalanches are released. An additional explosive delivery tram will be added to the East Shed 4 path to deliver explosives deeper into the upper track.

The WSDOT will plan and prepare for the 2014-2015 winter internally from an operational standpoint and externally to their customers. Ultimately the outcome will depend on the weather and snowfall. Weather patterns and specific snow events are important factors driving instability, particularly for an avalanche control program. Timing is essential to getting the best results from avalanche control. Heavily controlled avalanche
paths exhibit different snow structure characteristics than neighboring areas where less or no avalanche control is performed. Specific attention must be made to these differences. Additionally there are the logistical considerations regarding how long a closure may last based on the estimated impact of the avalanche debris and the volume of snow to be removed. These additional considerations are sure to test the abilities of the avalanche forecasting crew and the patience of travelers during this potentially trying winter season.

REFERENCES

