"SAFE HAVEN" AT ROAD SIDES NEAR AVALANCHE PRONE SITES

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ABSTRACT: Snow avalanches cause threat to road traffic in mountainous areas in Iceland in wintertime. One or more vehicles are hit by avalanches every year but last year's no fatal accidents due to snow avalanches have been reported. In case of avalanche accidents several different respond units like police, rescue group personnel and road maintenance personnel will participate in the rescue operation. A number of rescue vehicles and a base for onsite commander will need a space near the accident site during operations. Other vehicles must be able to turn safely from the accident site. A two-lane urban road can barely serve as a location for rescue operations.
This work describes how roads in mountainous areas can be improved by adding a safe area (safe haven) at the roadside where the respond units can place their bases during operations and road users can turn back from the accident site. The criteria for the location and design of the safe area is described. Safe area at road site will help all respond units to do their job during operations at accident sites.

KEYWORDS: Road traffic, avalanches, avalanche accidents, safe area.

1. INTRODUCTION

In Iceland as well as many other mountainous countries roads are threatened by snow avalanches in wintertime and every now and then vehicles are hit. According to data from Switzerland around 18% die in vehicles which are hit by avalanches (Margreth, et al., 2003). Krister Kristensen (Kristensen, et al., 2003) has suggested that 18% is too low for Norway, 40% would be closer to the reality. No research has been done in Iceland but due to many similarities in the road infrastructure the author believes Kristers number could also be applied in Iceland.

In case of an avalanche accident on a road or highway several different respond units are involved in the rescue work such as the police, the rescue groups personnel and road maintenance personnel.

Road closures due to avalanche accidents cause usually the normal road traffic to stop until the rescue operation or avalanche danger is over. Often a space limited mountain road is not wide enough to "have room for" rescue operation base or to allow long vehicles to turn. Vehicles can be stuck on the road untill it opens. In bad weather stuck vehicles can also cause drifting snow problems and they can hinder the rescuers from travelling to and from the accident site.

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2. THE AIM OF THIS WORK

The aim of this work is to present simple methods to assess avalanche danger at sites where rescue operations can be operated from as well as to introduce a layout of a safe area ("safe haven") at road sides for the rescue operation personnel, vehicles and equipment's. Also to give a space for vehicles so they can turn safely from the area.

3. AVALANCH HAZARD ASSESSMENT FOR ROADS

Systematic avalanche hazard assessment for Icelandic roads has not yet been made, only few and relatively small sections have been studied so far.

There are several ways to assess the avalanche danger. One simple method is to use the statistical α/β-model, originally presented by the Norwegians (Lied, et al., 1980). Later this model was adapted to Icelandic avalanches (Jóhannesson, 1998) and the author has been using that model for Icelandic roads and powerlines for several years. A part of the following text refers to two of those studies i.e. one existing road section in north Iceland (Jónsson, 2007) and one proposed road section in east Iceland (Jónsson, 2008).

The α/β-model can also be presented as α/β-diagram, see Figure 1. For each avalanche profile along the road alignment the angle from the road to the potential starting zone is measured (here called α_{road}) and the β-point is also measured at the same profile.

Even though those models are derived from so called "extreme events", which for Icelandic conditions are only ~100 years, one can also use them as a guideline for smaller avalanches. The author has noticed from previous work for the Icelandic Road Authority and in work for different avalanche prone communities in Iceland that the runout of small avalanches, with return period from less than a year up to 10+ years, are close to the $\alpha+2\sigma$ which also happens to be very close to the β-point.

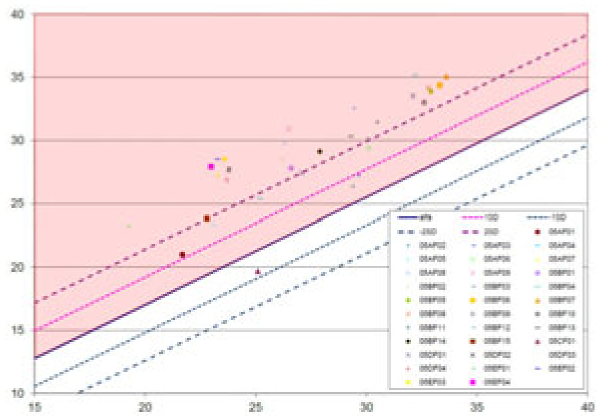

Figure 1: Icelandic α/β-diagram for a road section in Northern Iceland, see part of the road section in Figure 3. The vertical scale represents the α-value and the horizontal scale represents the β-value of the Icelandic α/β-model. The values in the diagram represent observed α-values from the road to the starting zone. All observed values below the mean α-value (the middle line) are thought to have longer return period than the mean α-value and all observed values above (in the shaded area) have shorter return period. Here most of the values are above the $\alpha+2\sigma$ line which indicates that the road can be hit by avalanches yearly. Records from this road show that the road is hit by avalanches several times pr. winter. Statistical analyze of this dataset can give an indication of the overall safety of the road. By splitting the road into sections of similar geographical or terrain conditions, see lines in Figure 3, one can indicate the safety of each section.

This method can also be applied to transmission lines and many other linear constructions endangered by avalanches.

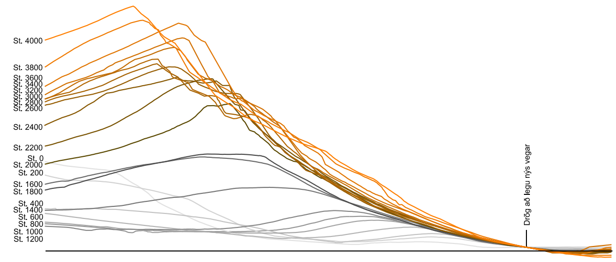

Figure 2: This figure shows cross sections to a mountainside and how they can be view a by fixing each cross section to the linear construction, in this case the road. Those cross sections are taken at 200 m interval. It can be seen how the average slope angle from the road to the top (and where the mountain is steep enough, the starting zone) increases and by measuring the angle one can have an indication of the level of avalanche danger. Station numbers are given at the left hand side of each cross section.

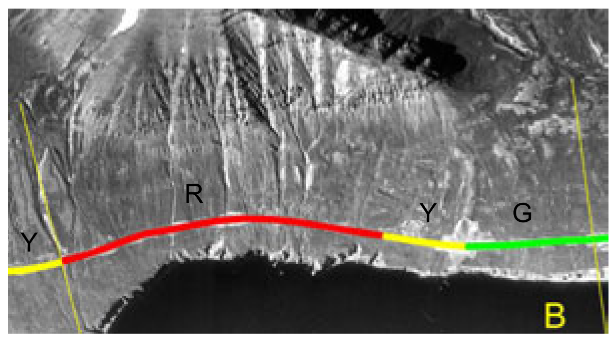

Figure 3: A road section in northern Iceland that has been divided into three levels of avalanche hazard. Lines at each end of the picture mark each section and the section shown here is B. Aerial photo: National Landsurvey of Iceland.

The above mentioned methods are simple tools which can be used to divide the road into levels of avalanche hazard which is similar to avalanche hazard zoning for villages. Below are definitions which the author has used in the mentioned work.

Safe	Moderate danger	Danger
Green (G)	Yellow (Y)	Red (R)

Green: The terrain indicates that avalanches cannot start or the frequency is very low. If green zone between two yellow zones is shorter than 100 m then the zone will be yellow.

Yellow: Avalanches are not known to reach the road. The terrain indicates that avalanches can

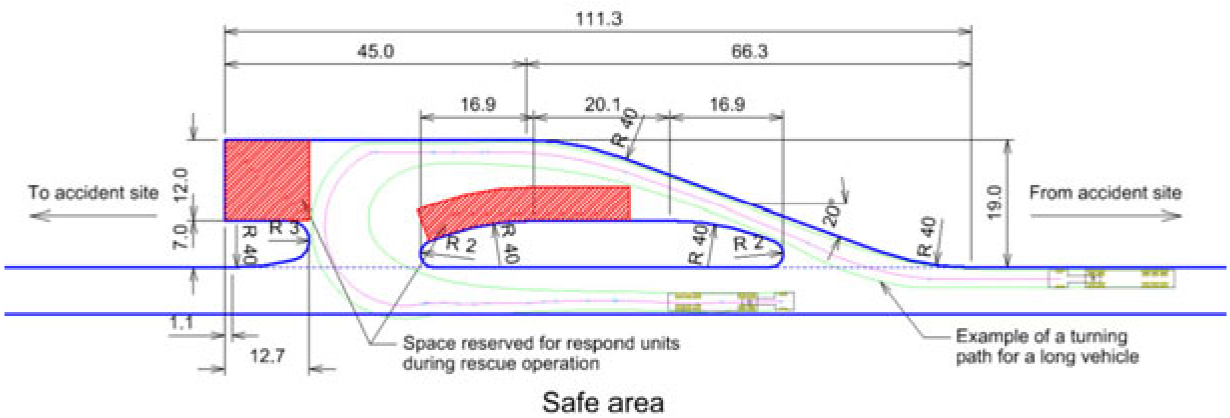

Figure 4: Principal layout of safe area.

reach the road in extreme conditions. The length of yellow zone is not shorter than 100 m. Yellow zone is always between red and green zone.

Red: Avalanches are known to hit the road and the frequency is higher than or equal to the reference frequency set by the Road Authority. If the width of a yellow area between red areas is shorter than 100 m then the area is also defined as red. The length of a red zone shall not be shorter than 50 m and it shall reach min. 50 m out of known avalanche path.

4. LOCATION OF SAFE AREAS

The location of the safe area should be on each side of an avalanche prone area so rescue personnel can advance from both sides if necessary and the road traffic from both sides can turn back safely. This is the ideal case but it is not always easy to accomplish this. In some cases the road section can have short safe areas and endangered areas for many kilometers which make it difficult to position only two safe areas for rescue operations. It is not easy to give guidelines for the number of safe areas or the location of them in such cases but their location must be related to the terrain, the road geometry and the traffic volume.

The general rule should be to build safe areas in green zones. If it is necessary to build safe area inside the yellow zone a detailed hazard evalu-ation should be worked out prior to rescue operations. It should also be born in mind that a safe area located in a yellow zone can be used by road travellers in wintertime when avalanche danger is persistent. Safe areas should never be built inside red zones!

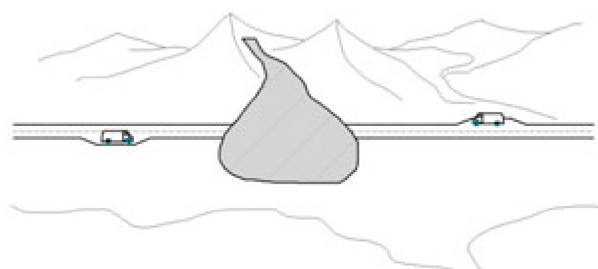

Figure 5: Principal sketch of location of safe areas on each side of avalanche area.

It is extremely important, when rescue personnel arrive at accident site, that they are aware of potential avalanche sites on the way to the accident site as well as possible avalanche danger on site.

5. DESIGN OF SAFE AREA

The design of safe area introduced here is partly based on a design of a vehicle inspection area for urban roads in Iceland (Jóhannesson,et.al., 2007). One of the main feature about the design of a safe area is that it has reserved areas for the rescue personnel and it gives drivers of long vehicles an opportunity to turn from the avalanche site instead of lineing up in long queues and wait till the closure is ended. Most avalanche prone road sections in Iceland are along low traffic urban roads where traffic volume can range from less than a hundred to several hundred vehicles pr. day.
The form of the safe area has two designated areas for rescue operation; an area of ~150 square meters located at the site facing the accident site for the onsite commander and an area for rescue vehicles and equipment in the

middle (see hatched area in Figure 4). If necessary the total length and the width of the safe area can be extended, this applies also to the area for the onsite commander. Due to the importance of being able to turn long vehicles the two areas are separated which can be a disadvantage for the safety of rescuers who have to cross the turning lane.

STANDARDS FOR SAFE AREA

Winter maintenance

The same maintenance protocol should be applied to safe areas as to the road it serves which means, if the road is cleared in wintertime the safe area has also to be cleared at the same time. One can reason that the safe area should be cleared before the road through the avalanche prone area in case something would happen to the maintenance personnel during the clearance. It should be a part of the winter maintenance protocol.

Communication

The location of safety area should take into account the quality of mobile phone connection, VHF, Tetra and/or other communication alternatives rescue personnel use. If it is not possible a thought must be given to a suitable location for beacons which is necessary for the onsite commander to communicate with rescue headquarters, hospitals or police stations.

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