AVALANCHE PROTECTION ON HIGHWAY E8 TO THE CITY OF TROMSO, NORTHERN NORWAY.

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Ole-André Helgaas*, Oevind Skeie Hellum and Dag T. Andreassen,
Norwegian Public Roads Administration,
Tromso/Bodo, Norway

ABSTRACT: The highway network in the northern part of Norway is mostly located in alpine terrain. Every winter snow avalanches affect some of these roads and give challenges for road traffic and the Norwegian Public Roads Administration (NPRA). The last winters we have had a discussion on the level of acceptable avalanche risk. In this presentation we want to present some of the main aspects from our discussion in Norway.

So far we are working on two solutions. First: to improve the avalanche forecasting and warning system. And second: to improve and build more efficient avalanche protection measures for the public roads and highways.

As an illustration we want to present a case:

Avalanche protection on the main highway E8 to the city of Tromso in Northern Norway, through the alpine Lavangsdalen valley. Especially the avalanche path "Hestvollan" has been challenging with discussions on different suggestions for protection, such as dams, cones, galleries and artificial avalanche release. The avalanche mapping in the valley will be illustrated on slope angle ArcGIS-maps, and supplemented with results from computer simulations with the quite new RAMMS program.

1 INTRODUCTION

1.1 Norwegian Public Roads Administration - NPRA

The Norwegian Public Roads Administration is responsible for the planning, construction and operation of the national and county road networks. The public road network of Norway counts 92500 km in total (2010).

On matter pertaining to national roads, the Public Road Administration is under the direction of the Ministry of Transport and Communications. On those related to county roads, the Regional Director is subordinated the county legislature.

The Public Roads Administration is under the leadership of the Directorate of Public Roads, which is an autonomous agency subordinated the Ministry of Transport and Communication. The Public Roads Administration encompasses five regional offices. In Region North responsible for N-Norway this office is located in the city of Bodo.

* *Corresponding author address:* Ole-André Helgaas, Norwegian Public Roads Administration, NO-9291 Tromso, Norway
tel: +47 97570737;
email: ole-andre.helgaas@vegvesen.no

Vision:
On the road to a better society

Figure 1: Overview Europe with Norway in black

The objective of the Norwegian Public Roads Administration:
To develop and maintain a safe, eco-friendly and efficient transport system. This is being done on a sound, professional basis by interacting with politicians, users and other interested parties.

1.2 Avalanches in Northern Norway

Snow avalanches are common incidents wintertime (November - May) in Northern Norway. Here far north the period with snow in the mountains may last 7 - 8 months from October/November until May. The mountains here are alpine and rise direct up from the fjord, typically up to 1000 – 1800 m.a.s.l. The highway network in this region is located over, under, in between and through this alpine terrain.

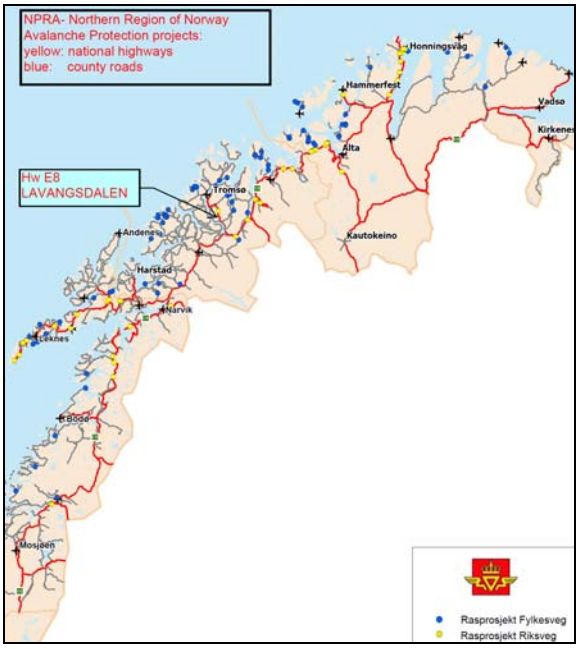

Figure 2: Avalanche protection projects for public roads in Northern Norway, priority high - medium in the National Transport Plan 2014 - 2023

Every winter snow avalanches affect some of these roads and give challenges for road traffic and the Norwegian Public Roads Administration (NPRA). The coastal climate gives quite a lot of precipitation coming in from the Atlantic Ocean. With unstable snowy winter weather, avalanches are common in this region. Our avalanche data base shows approximately 500 different avalanche sites along the public roads in this long-stretched northern region.

Photo 1: Snow avalanches affect many North-Norwegian roads every winter (Photo: O.A.Helgaas)

2 ACCEPTABLE LEVEL OF AVALANCHE RISK ON PUBLIC ROADS?

In the last years we have had a discussion on the level of acceptable avalanche risk for the traffic. The NPRA and the authorities are working on two main solutions:

1. To improve the avalanche forecasting and warning systems. A new national forecasting system is now under pilot testing, and will be further developed during the next few years.
2. To improve and build more efficient avalanche protection measures for the public roads and highways. Steep and challenging topography demands smart solutions. But high costs for such projects gives also reasons for a discussion on protection safety and what rest-risk is possible to accept in the future for Norwegian public roads.

In Norway traditionally we have spent much effort and rather high budgets on building permanent avalanche protection measures and less focus on avalanche forecasting.

An important tool to help to decide between different solutions for avalanche safety measures for public roads is 2012 - 2013 to test out and conclude to a national standard for acceptable avalanche risk. A proposal for this is coming up these days (Dahle et al May 2012). This is an important step and will hopefully contribute to gain the goal soon.

As an illustration in this paper and on our poster presentation at ISSW2012 we want to present a case: Avalanche protection on the main highway E8 to the city of Tromso in Northern Norway, through the alpine Lavangsdalen valley.

3 CASE: THE HIGHWAY E8 LAVANGSDALEN AVALANCHE PROTECTION PROJECT

3.1 Highway E8 – an important route to the city of Tromso

The national highway E8 through the 18 km long Lavangsdalen valley is an important "gate" to the biggest city and main regional centre of Northern Norway. The city of Tromso has approximately 70000 inhabitants, and is only 30 km beyond this valley to the north. E8 gives also connections to Finland and EU, and to the main highway E6 through Norway. If E8 is closed in the valley due to avalanches or other reasons it is only one possible detour on a low standard narrow and 25 km long road, with rather high risk of traffic accidents and traffic jam.

As an illustration on this narrow and long - stretched country, the driving distance for example from Tromso to Oslo is about 1700 km. In the other direction highway E6 north-east to Kirkenes and the Russian border is almost 1000 km.

3.2 The avalanches in the valley

The U-shaped valley Lavangsdalen from Ramfjord in the north to Kantornes in Balsfjord to the south has alpine mountains on both sides. From the rather flat bottom at about 70 meters above sea level (m.a.s.l.), the valley sides rise up to the mountain peaks at 1200 - 1300 m.a.s.l. The upper sides of the mountains have typical slope gradient around 30-50 degrees. Here the terrain with lot of bowl-shaped areas is also optimal releasing zones for snow avalanches. In a normal winter from October/November to April/May, the snow depth is 1.5 - 2 m at valley bottom.

Historically the highway E8 through the valley has been affected by many avalanches. Along some of the courses of streams or gullies also slush avalanches are quite common. The most frequent snow avalanches are visualised and drawn on an ArcGIS-map where light orange shows slopes with an angle of 30 – 45 degrees. Most common avalanche paths are drawn where blue lines stand for typical limitations for start zone, the track and some of the run out zones to the highway. See the avalanche map with 12 avalanche paths.

The forest is shown in green colour. Because the treeline is not higher than about 300 m.a.s.l. the small tree forest in this tough arctic climate will not give any contribution to avalanche protection. Of course we also have no good conditions for planting new forest in the avalanche releasing zones – this method may e.g. the Swiss and Austrians keep for themselves…

Photo 2: Overview Lavangsdalen valley and still some snow in avalanche paths on the east side June 29 2012. Nearest to the right the Sarasteinen avalanche from the 1300 m high Tverrbotnfjellet. (Photo: Andreas Persson, NPRA)

From the 1980's the location of the highway has been adjusted step by step to avoid the most frequent avalanche run out zones. At the same time building of avalanche protection measures have been important to improve the safety for the rising traffic volume through the valley and the gate to the city of Tromso.

3.3 The level of acceptable avalanche risk on highway E8 in Lavangsdalen valley

The 2012 proposal for a new NPRA-system (Dahle et al May 2012) gives an advice on what acceptance avalanche risk level we should reach for planning more avalanche protection for highway E8. The traffic volume is 3450 units/day in 2010 places it in the next highest group 3000-7999. Since this is a main road we go up one step – and from a list we get:

Max 1/100

as an acceptable avalanche risk level of the route in the valley = one avalanche per 100 years may hit the highway.
For single paths under these circumstances it may be possible to accept that one avalanche may hit the highway every 50 years (1/50).

3.4 The avalanche protection for highway E8 in the valley

See the overview in the list in the figure 3, and at the map in figure 8.

3.5 The Hestvollan avalanche protection

In Lavangsdalen valley especially the avalanche path "Hestvollan" from the mountain “Henrikstind” (1270 m.a.s.l.) has been challenging with discussions on different protection concepts, such as dams, cones, galleries and artificial avalanche release.

Photo 3: Hestvollan avalanche path with a leading dam. But still better protection needed for highway E8 crossing the run out zone. (Photo June 29 2012: O.A. Helgaas)

No	Avalanche name	Type & frequency	Protec-tion?	Planned ?
1	Hestvollan	Dry snow aval., every 3-5 yrs	Partly with leading dam – not enough	Gallery or huge catching dam
2	Skavskogen	Wet and slush aval., 10 yrs	OK, Catch-ing dam 2010	
3	Sarasteinen	Big dry snow aval. , 10-15 yrs	Nothing	Catching dam up to 14 m high
4	Lav.dalen midtre 1 (Smalak nord)	Big dry snow aval. , 10-15 yrs	OK, cones and catching dam	
5	Lav.dalen midtre 2	Big dry snow aval. , 20 yrs	Partly OK, catching dam 6 m high	(A me-ander river stop longer dams)
6	Andersdalstind	Wet and slush aval., no reg. on the hwy	Nothing, level app. 100 yrs	
7	Storskreda	Big dry snow aval. , 20 yrs	OK, catching dam	Improve 2013
8	Blåtind/ Lav.dal sør	Several small aval. paths	OK, roadline moved out from the moun-tain side	Maybe if new highway project.

Figure 3: An overview of 12 different avalanche paths, with comments on avalanche protection measures for highway E8. (Listed from north to south).

At Hestvollan in 1990 a leading dam was built as a first attempt for avalanche protection in connection with construction of a new highway E8. After the year 2000 several avalanches flew over the dam and hit the road three winters in a row. The dam was enlarged 2004 up to 15-18 m high – but still not with satisfying protection effect.

Especially after the great January 29 Hestvollan avalanche in 2008 the focus has been on improved avalanche protection. This “greatest snow avalanche ever seen by any man” locally said, swept about 50 meter further down of the highway. A big rescue operation was organized, but luckily no vehicle hit and no person involved. But the consequences are serious

Photo 4: The avalanche at Hestvollan January 29 in 2008. In backgrund the 1238 m high Tromsdalstind, the city mountain of Tromso (Photo O.A. Helgaas)

The challenge at Hestvollan is that area just east of und up from highway E8 where it is possible to locate e.g. protection dams, is in a too steep track an early run out zone for the avalanche. Here it seems that the velocity of the dry sliding snow is too high for the dam build so far, approximately 15-20 m/s.

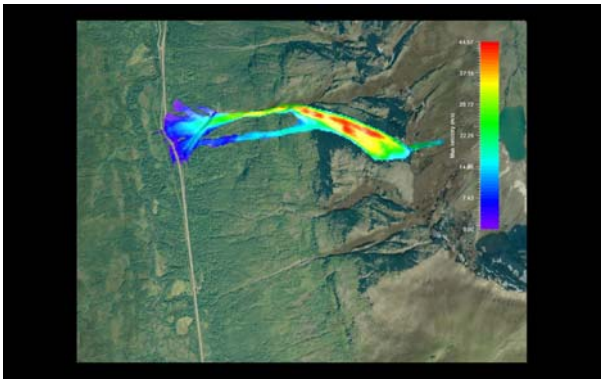

Figure 4: Hestvollan with existing dams, max velocity from RAMMS simulation. Dark red = max 45 m/s (by Oe.S.Hellum).

Therefore we now have a plan for improved protection:
- dig out a huge catching dam - in connection with a plan for modernising E8 in the valley
- improve the leading dam, higher angle to the direction of the avalanche track (from about 35 degrees today to max 15 degrees)
- build steeper sides on the avalanche side if the dam
- build a new catching dam along E8.

If this not gives a high enough avalanche protection effect, the only way is to put hwy E8 in a tunnel or gallery, minimum 250 m long.

3.6 The Sarasteinen avalanche protection

For protection E8 against the avalanche path "Sarasteinen" (“The Sara stone”) an up to 14 m high and 400 m long catching dam is this year planned. Due to the fact that the avalanche has an approximately 350 m long run out zone from the foot of the steep mountain side, crossing the rather flat valley bottom before it reach the highway E8, a catching dam gives a reasonable avalanche protection.
RAMMS-simulation are done for avalanches released from the 1300 m high mountain ”Tverrbotnfjellet”. The simulations are sensitive on the choice and size of the starting zone. A snow depth of 2 m is used in starting zone. The results are valuable for the detailed planning of the avalanche protection dams, see figure 5-6 under.

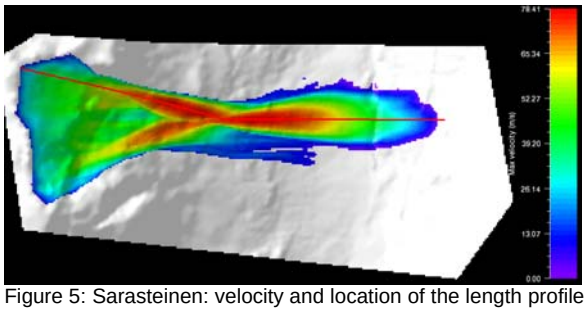

Figure 5: Sarasteinen: velocity and location of the length profile with avalanche velocity from RAMMS. (O.S.Hellum)

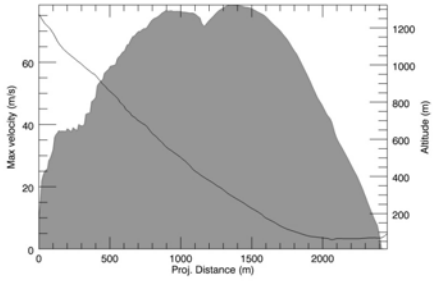

Figure 6: Sarasteinen: max velocity up to 67 m/s in the length profile, location shown in figure 5 above. (O.S.Hellum)

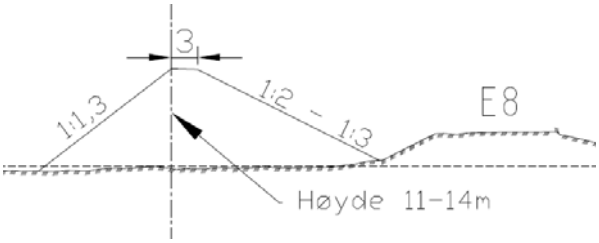

Figure 7: Sarasteinen: cross section of the plan for a catching dam up to 14 m high.

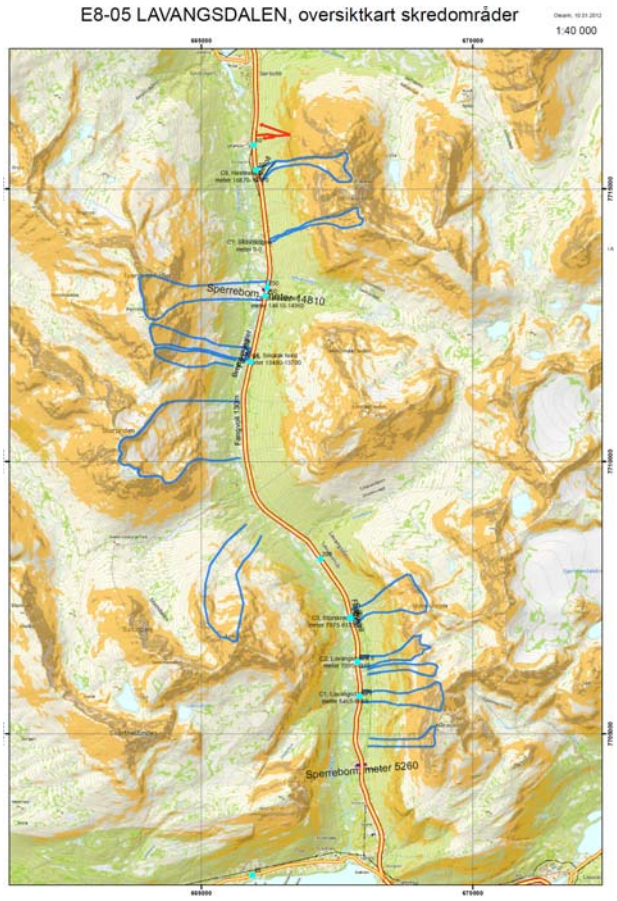

Figure 8: The avalanches along highway E8 in the Lavangsdalen valley drawn on an ArcGIS-map.

Photo 5: Snow avalanches are common from the steep mountains surrounding E8 in Lavangsdalen valley (Photo April 29 2003: O.A.Helgaas).

4 REFERENCES

NPRA 2011; Planbeskrivelse –reguleringsplan for E8 Lavangsdalen (Storskreda – Sørbotn) i Balsfjord og Tromsø kommune., September 2011 (In norwegian. A plan for new steel step barrier along the centerline of the highway), Norway.

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