SNOW DRIFT CHALLENGES AT KLETTSHÁLS MOUNTAIN ROAD PASS IN ICELAND

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ABSTRACT: Snow fences are usually used to control snowdrift problems on a relatively flat and open terrain. Snowdrift problems on mountain roads and passes are normally more challenging. The terrain is often more complex, winds can be stronger and other problems related to road construction have to be solved in joint action with snowdrift problems.

In 2004 a road section across Klettsháls in southern part of Westfjords Iceland was reopened after major reconstruction. Before the road was only open and passable in periods of good weather during wintertime. The road section is known for the heavy snowdrift problem and some previous attempts to solve the problem did not proof successful. The challenge was that one side of the road has a steep slope downhill and the opposite side is an excavated rock wall 4 to 5 m high. In 2007, an alternative method of solving the snowdrift problem was tested along a short section of the road. The result was acceptable and the year after a new permanent and robust snow fence was built. The structure functions not only as a snow fence but also as a guardrail for the road. The road is now passable in one lane closest to the fence during most weather conditions. Future plans are extension of the invented snow fence and the road authorities are considering building similar fences in eastern Iceland.

KEYWORDS: Klettsháls, snowdrift, snow fences, mitigation

1. INTRODUCTION

The state highway no. 60 on the southern part of Westfjords Iceland is the main highway to Patreksfjordur and several other small fishing towns on the west coast of Westfjords. Keeping the road connection to these villages open during wintertime has always been a problem. The roads were old and long sections were laying very low in the terrain causing heavy snow problems. A passenger and car ferry across the fjord Breidafjörður has compensated for the problems on the southern part of Westfjords.

The road section across Klettsháls pass has been one of the most difficult sections due to weather conditions and snowdrift. In wintertime the pass has only open every now and then.

During the last decade, long sections have been reconstructed almost every year. Between 2001 and 2002 the section from Kollafjörður across the mountain pass Klettsháls was reconstructed, se blue ellipse on Fig. 1. The section from bottom of

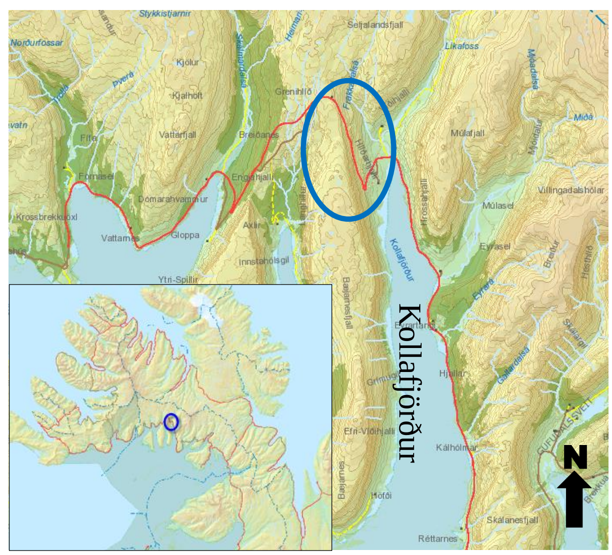

Fig. 1. Map of the area. Blue ellipse shows the Klettsháls area. Map: National Land Survey of Iceland.

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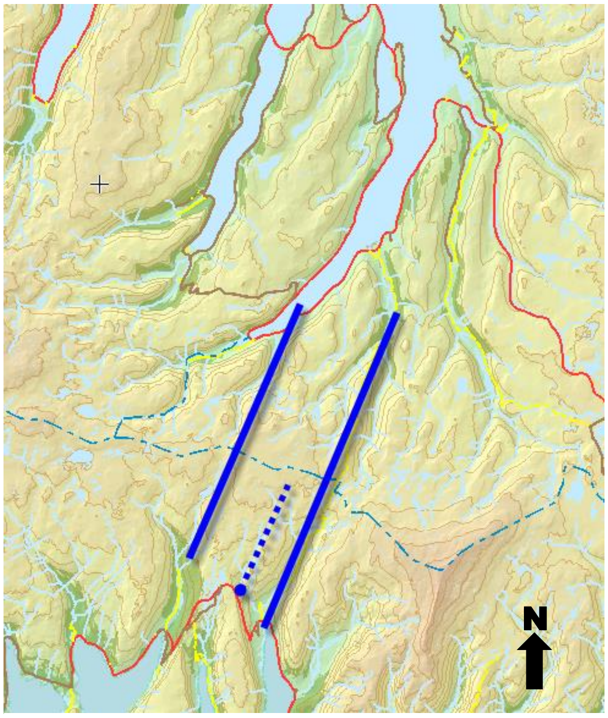

Fig. 2. The blue lines show the wind direction from north, approx. 22° (NNE-SSW). The dotted line shows wind direction to the observation site. The direction coincides with the direction of the fjords on the northern side of the mountain plateau. Map: National Land Survey of Iceland.

the fjord to the pass has a one sharp turn. The part from the U-turn to the top is exposed to strong northerly winds and snowdrift. The terrain below the road is open and it has a long fetching area for drifting snow on a relatively flat mountain plateau to the northeast (Fig. 2).

The aim of the reconstruction was to build a modern road with two 4 m wide lanes, which could be kept open the whole year round.

The wind force and snowdrift problem proved to be much higher than expected and in late 2005 the road authority engaged ORION Consulting to study the problem and propose solution.

This article describes the work by ORION Consulting (Jónsson 2007) and the experience during and after the work was completed.

2. THE STUDY

The aim of the project was to study wind, snowdrift and snow accumulation on the road from the U-turn to the top, with main focus on the topmost part where the main problem was, and to propose mitigation measures which kept at least one lane open during most of the winter.

2.1 Weather

The road authority has been running an automatic weather station at Klettsháls (approx. 330 m a.s.l.) just above the observation area since 2000. The station registers temperature, wind, wind direction and dew point. Precipitation data was available from the nearest weather station at Kvígindisdalur some 65 km west of Klettsháls until 2004 when the Icelandic Meteorological Office (IMO) closed the station. So, there was only four years of direct comparison between observations at Klettsháls and the IMO station.

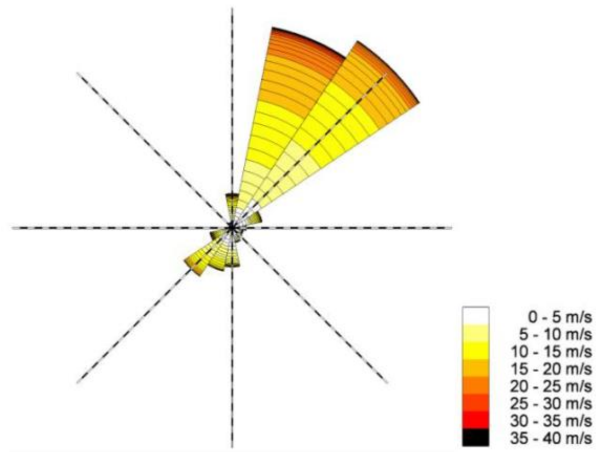

Fig. 3. The figure shows a wind rose with wind speed at Klettsháls for the period 2000 to 2006 from the beginning of November to the end of April (181 day), when temperature equal to or lower than 0 deg. C.

A comparison of the temperature at Kvígindisdalur and Kletthals showed that the temperature was about 2.8 deg. C lower at Klettsháls for the period 2000 to 2004. This helped estimating when the precipitation was rain or snow at the Klettsháls site. From the wind rose in figure 3 we see that wind from NNE to NE is the dominant wind direction and it indicates the snow drift problem. The frequency of wind speed larger than 20 m/s for the sector N to NE is approx. 6% for this period of time which means on the average 11 days pr. winter or approx. once every second week. Wind gust is expected to be at least 1.5 times the average 10 minutes wind speeds so the wind problem is obvious.

Fig. 4. This aerial photo is draped on a digital terrain model (DTM). The observation site is between the red vertical lines. Above the road is a rock wall, steep scree and cliffs; below is the road fill. Wind direction lines of 22° (NNE) are draped on the terrain model. The distance between the lines is 50 m.

3. MITIGATION ALTERNATIVES

3.1 Preliminary snow fences

The road authority decided to build a test snow fence on the shoulder of the road at the most exposed part of the section as a start of the project in late 2005.

The fence was built of 3" diameter steel tube posts, spaced 2.5 m, and Tenax plastic nets of different heights and qualities. The ground opening was set from 0.4 to 0.6 m. The test fence was heavily damaged the winter 2005/2006 due to the strong winds. The fence was partly rebuilt in 2006 with stronger plastic material.

The results from the test period gave valuable information for further evaluation of mitigation measures (Fig. 4).

3.2 New road cross section

The cross section of the road is important when considering drifting snow on the actual location in a steep mountainside, partly in steep cut area and partly on a fill with steep slope. In many places, the steepness of the terrain is close to the friction angle of the local material. This in turn means that the fill-slope must be as close as possible to the friction angle of the fill material to limit the volume and reach.

By flattening the top of fill to approx. 1:5 (rise:run) over a distance of approx. 5 m from the shoulder the direction of the wind would be roughly parallel to the pavement surface and thus no lee effect. Outside the 5 m width the steepness of the fill slope would be stable by 1:1.4.

Likewise the cut/excavation area should be modified. By extending the width of the ditch to 5 - 7 m and reduce the steepness of the rock wall, the wind would deposit less on the road, preferably only on the lane closest to the rock side.

This idea was rejected as it was thought it would cost too much.

3.3 Roadside structure – Jet roof

A jet roof was considered for a while but there were several uncertainties that led to the conclusion of not build it. The main reasons were the uncertainty about the wind force and the fear that small cars could be blown of the road towards the rock wall. In addition, windblown gravel from the shoulder could damage the cars and possibly hurt drivers and passengers.

3.4 Roadside structure – Non-porous snow barrier

Tabler (2003) discusses non-porous snow barriers which were built along a touristic highway near Nakayama Pass, Hokkaido Japan (Fig. 5). The main feature of this structure is that most of the snow is deposited on the slope below the barrier while remaining particles are diffused vertically by the turbulent flow over it.

This type of barrier was considered but after discussion the idea was dropped mainly because of uncertainties in performance.

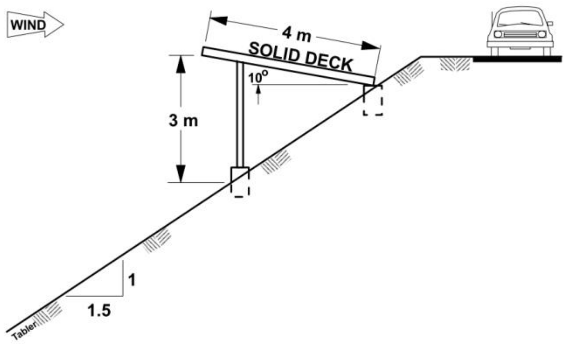

Fig. 5 A schematic figure of solid snow barrier on Nakayama Pass, Hokkaido, Japan. From (Tabler 2003).

3.5 <u>Roadside structure – Porous snow fence</u>

As mentioned in chapter 3.1 the test with a simple and inexpensive snow fence on the shoulder of the road indicated that a "conventional" snow fence would improve the visibility and the lane closest to the fence was almost clear of snow after periods with snowdrift. The road authority decided to go for the alternative described in the following chapter.

4. THE SNOW FENCE AT ROAD SIDE

The test of snow fence showed that it might be possible to keep at least one lane open during heavy snowdrift, but the tested material proved too weak for the winter conditions at the site. Therefore it was important to choose stronger material and larger dimensions to withstand the heavy wind load.

The chosen material is steel profiles for the posts and the fencing material is a synthetic HDPE-fabric.

Due to the steep slope of the road fill it is not possible to support the fence with slats as is the usual method. Instead it is necessary to excavate for the posts deep into the fill.

Each post is split into two; the ground section and the surface section (Fig. 6). The ground section has a 120x120 mm 3 m long profile of steel with top 0.76 m above the pavement/shoulder top and approx. 2.2 m in compacted gravel. Due to too small surface area of the profile in the gravel two steel plates were welded to the profile to increase the surface area; one close to the surface and one close to the bottom. The ground section is located 1.25 m from the edge of the pavement and is equipped with a guardrail for safety for the traffic. The spacing of the posts is 2 m.

The surface section has a 100x100 mm profile of steel, 2.3 m long of which 0.2 m are placed into the ground section and fastened with bolts.

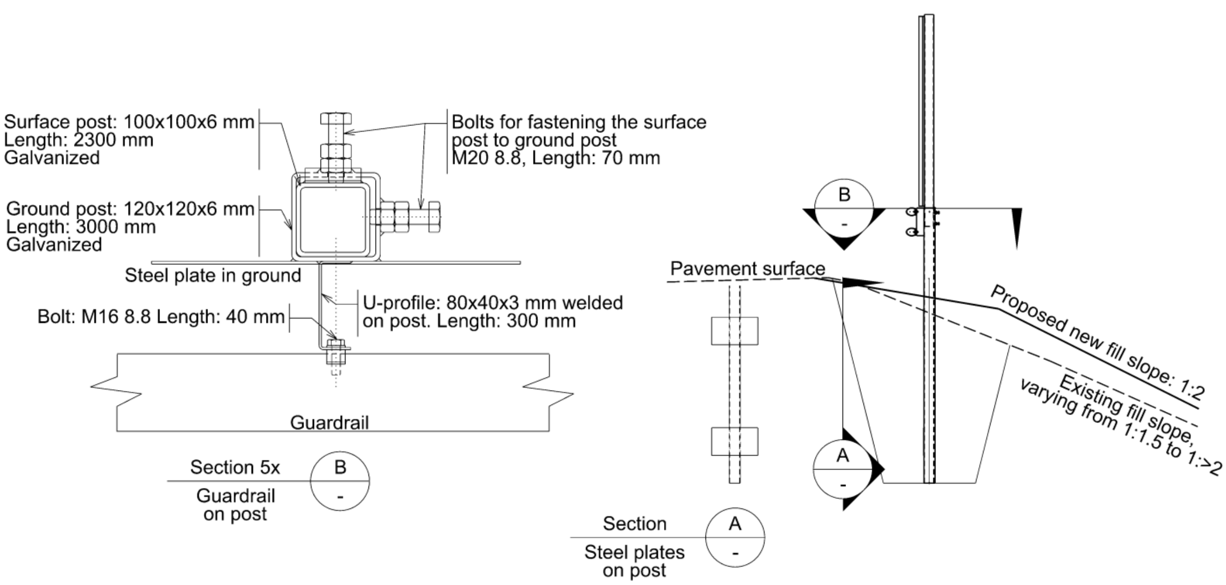

Fig. 6. The figure shows some of the details of the snow fence.

Fig. 7 The photo shows two sections of snow fences at the road side in summer time.

Fig. 8 This photo shows the Tenax fencing and the wood fastening system. Behind the net is the surface steel post.

The fence is built of two rows of 1 m wide synthetic Tenax “Residence” material. This synthetic material has been tested at other sites in Iceland and has proved to be the only mass produced material that has been able to withstand the wind forces. The material is made of HDPE and has 30 kN/m longitudinal tensile strength and yield point elongation of about 13%.

The fencing material is fastened between two wooden braces and bolted to the steel posts (Fig. 8).

In 2009 an approx. 180 m long section was built at the top most part of the site (Fig. 7-9). Experience during the two first winters was very promising so a second section of similar length was built in 2011. A third section is now planned.

Even though we have not succeeded in keeping the road permanently open the whole winter the improvement is significant. The number of closure days has been drastically reduced and the road safety has been improved considerably. Drivers have also responded and told that it is much easier to pass the secured sections as the wind force is significantly less than before during bad weather periods.

Fig. 9 A close up of one of the end posts. The guardrail end is bent down from the post into the ground.

CONFLICT OF INTERESTS

This study was not supported financially or materially by Tenax, the manufacturers of Tenax Residence nets. None of the authors are involved financially in the production or sale of Tenax Residence nets nor have they received any related grants or patents.

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