THE USE OF COMMERCIAL CAD SOFTWARE IN SNOW AVALANCHE RUN-OUT ESTIMATION

Árni Jónsson, ORION Consulting, Iceland (now at Norwegian Geotechnical Institute)
Sigurjón Hauksson, Verkfræðistofa Austurlands, Iceland.

ABSTRACT: Linear infrastructures like highways and transmission lines often pass avalanche terrain both in remote and urban areas. In some cases these areas are quite wide, measured along the lines, and the number of avalanche paths can be counted in dozens or even hundreds. Avalanche hazard assessment can be quite tedious in such areas when conventional methods like α/β are used.
In 2009 the state owned Icelandic Landsnet (Icegrid) was working on a 107 km long transmission line running from the power station in Blanda river northwest Iceland to the capital of North Iceland, Akureyri. Most of the line runs along valleys with high and steep mountains.
Our work was a preliminary estimation of the avalanche hazard along the route. Due to a limited timeframe set for the work it was important to find a method to deal with all these avalanche paths in an efficient way. No previous work had been carried out for this transmission line but avalanche records were known in some areas, as the transmission line partly follows the state highway.
A solution based on long experience in designing roads and highways using Bentley Microstation and GEOPAK software in Iceland was chosen. The GEOPAK design software has a very flexible cross section module that allows the user to write macro programs to solve specific problems. In snow avalanche context this would be to estimate avalanche run-out at given locations.
This article describes how the commercial cad software can be used in estimating multiple avalanche run-outs along transmission lines, using the α/β-method. This method can speed up the tedious work at the initial stage of avalanche hazard assessment along linear structures.

KEYWORDS: CAD software, avalanches, run-out calculations.

1. INTRODUCTION

Linear infrastructures like highways and transmission lines do often pass snow avalanche terrain in remote and urban areas. The number of potential avalanche paths can be counted in dozens or even hundreds of paths for long stretches of highways or transmission lines. An avalanche hazard assessment can be quite tedious for such long linear infrastructures when conventional methods are used.

In 2009 the state owned Icelandic Landsnet (Icegrid) was planning for a new 220 kV transmission line (here named BL3) from the power station in Blanda river northwest Iceland to the capital of North Iceland, Akureyri, to strengthen existing power supply. A large part of this planned ca. 107 km transmission line is located in narrow valleys with steep mountains and known avalanche activity (Sveinsson, 2009). Planned transmission line route is mostly alongside existing 132 kV transmission line, which has been hit by avalanches several times in over 40 years lifetime. Long stretches of the transmission line follows also the main highway to Akureyri over the pass Öxnadalsheiði.

Landsnet invited ORION Consulting and Verkfræðistofa Austurlands consulting to perform a preliminary snow avalanche assessment for the transmission line. The timeframe for the work was rather limited compared to the extent of the work. It was therefore important to find ways to perform the assessment in efficient way.

A solution based on long experience in designing roads and highways using Bentley Microstation and GEOPAK software in Iceland were chosen to speed the work. The GEOPAK design software has a very flexible cross section module that allows the user to write macro programs to solve specific problems. In snow avalanche context this would be to estimate avalanche run-out at given locations.

This article describes how the commercial cad software, used for road- and highway design, can be used in estimating multiple avalanche run-outs along transmission lines, using the α/β-method (Jóhannesson, 1998, Lied, 1980).

* *Corresponding author address:* Arni Jonsson, Norwegian Geotechnical Institute, Sognsveien 72, NO-0608 Oslo, Norway; tel: +47 469 32 640; email: arni.jonsson@ngi.no

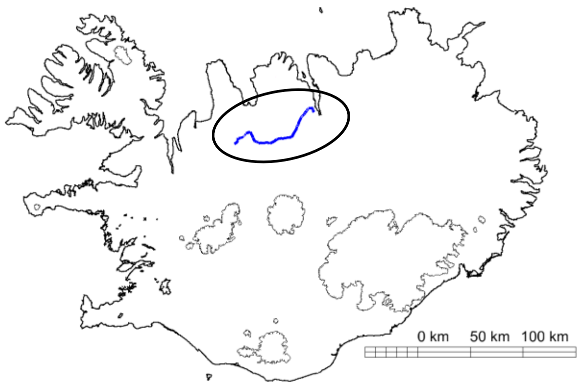

Figure 1. The figure shows the transmission line route inside the ellipse, in northern Iceland.

2. THE SOFTWARE

CAD software used in road- and highway design is designed to run cross sections for long stretches of roads and highways in complex terrain. The cross sections show the designed road structure in relation to the existing ground and the substrata.

Cross sections do not need to be perpendicular to the road alignment, or to be straight lines. In snow avalanche context cross sections represent the avalanche profile.

Snow avalanche run-out estimation study is not a standard solution in road- and highway design software but the cross section module of GEOPAK has a programming possibility which was ideal for our work.

3. THE TRANSMISSION LINE SITE

The transmission line route is 107 km long from the power house in Blanda river to the transformer station in Akureyri. The first ca. 40 km of the transmission line route are through relatively flat area with few potential avalanche activities. For the next 50 km of the transmission line route the line it is located in relatively narrow valleys or at the root of the mountains in open valleys. In some places the transmission line could be hit by avalanches from both sides of the valley.

4. THE PROCEDURES

The basic information for digital study of the avalanche problem is a digital terrain model (DTM with coordinates in x,y,z) for the whole area. The total number of points was over 6.4 million and the point density varies from valley bottom to top of mountain. The average density is ca. 0,004 pr. m² or 10 to 20 m distance between points. At

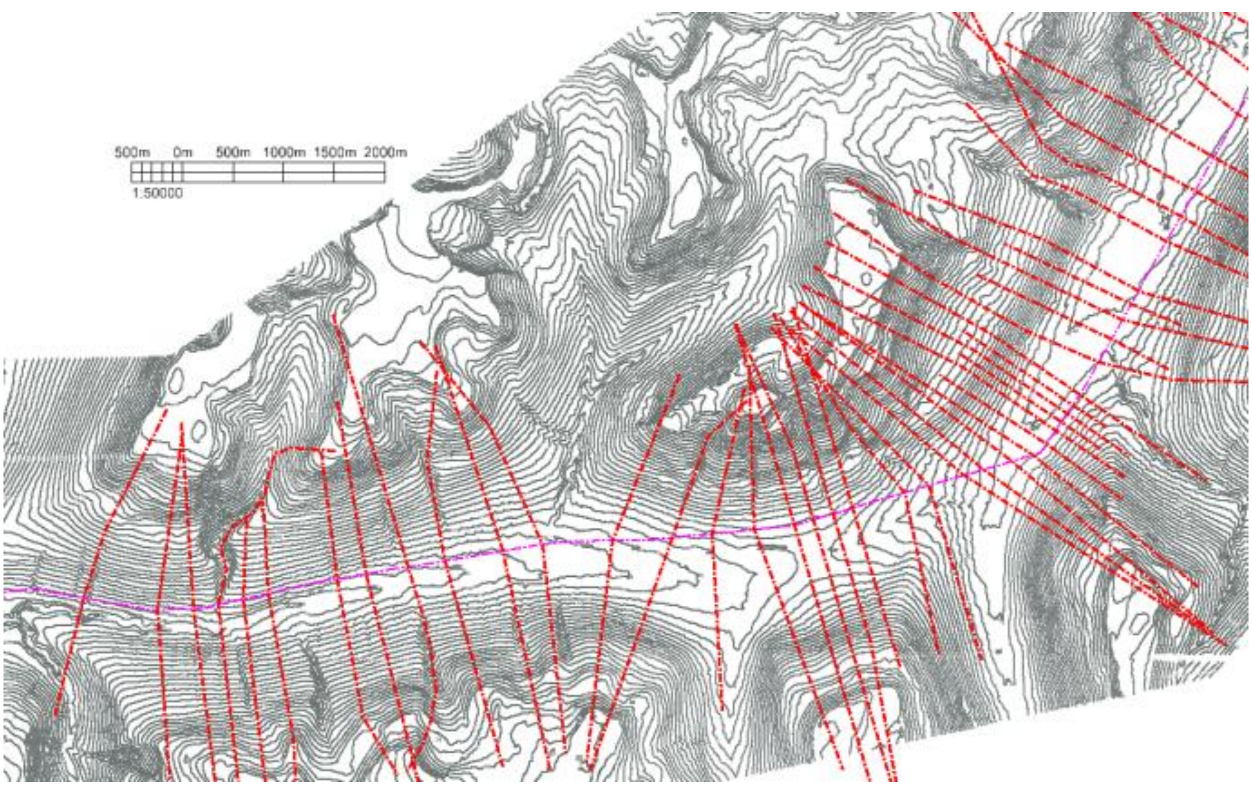

Figure 2. The figure shows the transmission line over Öxnadalsheiði pass. Pattern lines (cross sections) cross the transmission line, from mountain top to mountain top.

valley bottom the elevation accuracy is between 0.5 m and 1 m and event better at the transmission line route. Due to large amount of data the transmission line route was split into four subareas to make work easier and faster.

Road- and highway software need “design alignments”. Here the alignment was the transmission line which was built up of straight elements between transmission line towers.

Automatic placement of the avalanche profiles (pattern lines for cross sections) is possible by using even or incremental stationing but it would give wrong location of the avalanche profile in too many places. Therefore it was decided to do the job manually and adjust the profile roughly to proposed avalanche path. The timeframe set for the work did not allow detailed location of avalanche paths. A filed trip was used to verify the location of most of the avalanche paths. An example of avalanche paths is shown in Figure 2.

Road- or highway cross sections are usually up to 100 m to each side of the road alignment but when running cross sections for snow avalanches cross sections have to be 1000 m to 2000 m to each side of the centerline, i.e. to the potential starting zone, usually near the top of the mountain. To get a better view of the area on the top of the mountains few hundreds of meters were added to the section.

Extracting cross sections/avalanche path profile is an easy task when the profiles/pattern lines have been placed.

4.1 *α/β run-out estimation*

Prior to running the cross section module with the α/β-method the starting zone and β point must be defined for every path. To program all possible locations of the β-point and the starting point in complex terrain would have taken to long time. Therefore the thematic module of GEOPAK was used to locate areas around the β-point (10° ± 1°) and areas steeper than 27°. Simple algorithm was then programmed for both locations and they were verified and location changed manually if necessary.

Execution of ca. 120 cross sections took less than a minute. The result was a graphical presentation of the profile as well as different lines representing β point, mean α and one and two standard deviations (se Figure 3), and text files with variable data (all angles, horizontal and vertical distances, coordinates etc.) were generated. The text data can be used for statistical evaluation if necessary.

The location of the construction in relation to expected avalanche run-out is important. α-value for the construction is calculated and plotted to α/β-diagram as show in Figure 5.

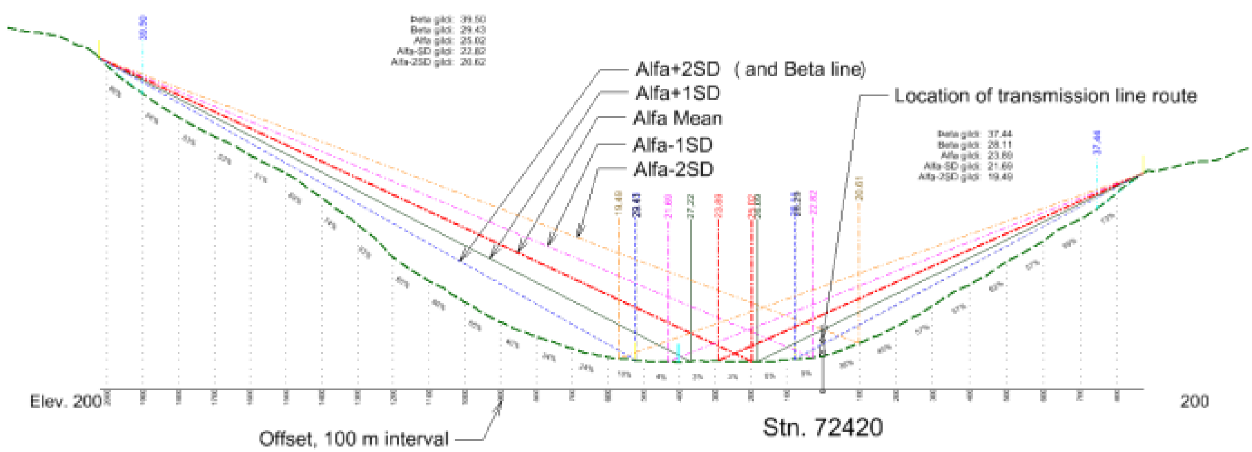

Figure 3. The figure shows one of the cross sections and calculated values/lines.

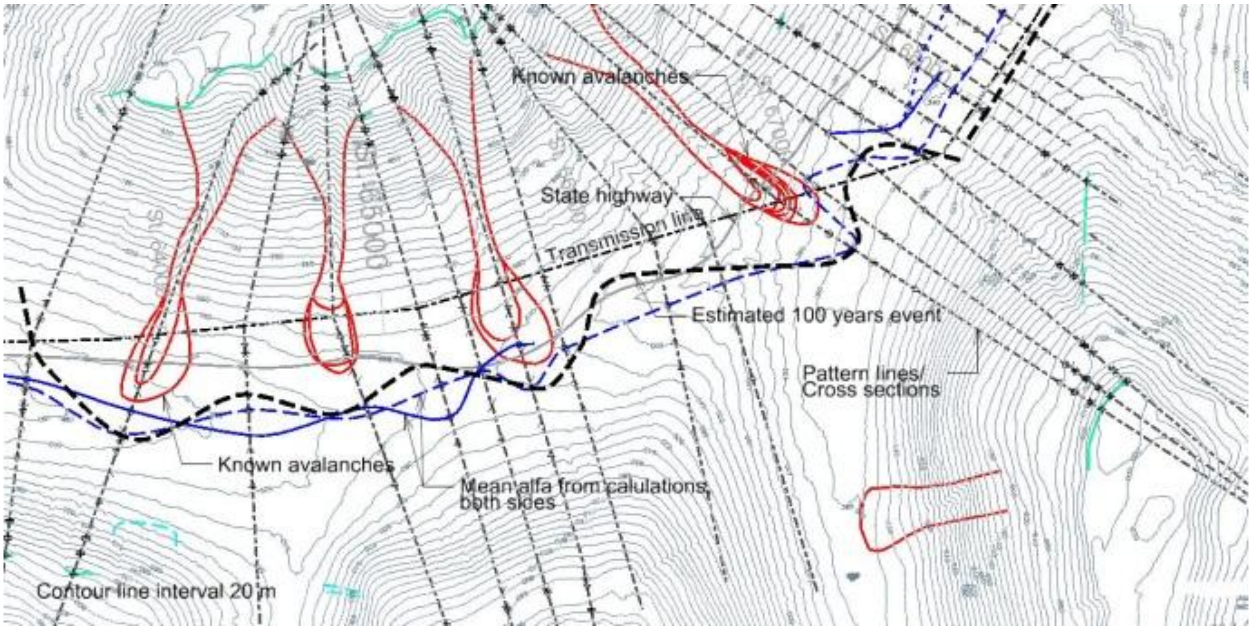

Figure 4. The figure shows the proposed hazard zone in Öxnadalsheiði pass.

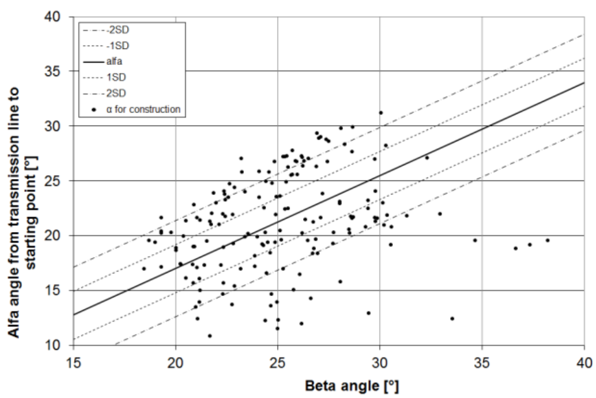

Figure 5. α/β-diagram. The diagram shows the location of the transmission line in accordance to the Icelandic α/β-model. The lines represent mean α-value and ± standard deviations, one and two. All values (points) above the mean α-line (the bold and black line) show the transmission line inside the mean α-run-out. Points around the upper most dashed line (+ two standard deviations which is also almost the β-point) indicates high exposure of the transmission line. Values in the diagram are from both valley sides.

5. CONCLUSION

The conclusion of this work is that commercial CAD software like Microstation and GEOPAK can be used for snow avalanche run-out estimation in the preliminary phase of hazard assessment. The ability of this software to execute large number of cross sections/avalanche paths in short time revealed that this method can speed up the tedious work at the initial stage of avalanche hazard assessment along linear structures and assist the designers to choose alternative routes if possible.

Basic knowledge in macro programming is important to be able to program simple one dimensional avalanche run-out methods.

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