

# RISK ASSESSMENT FOR MOUNTAIN ROADS – A CASE STUDY FROM ICELAND

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## BACKGROUND AND AIM OF THE INVESTIGATION

While the management of alpine natural hazards in settlements follows highly developed operational standardised procedures in many countries, there are very few approaches for a systematic survey and assessment of these natural hazard processes and a sustainable planning of measures for roads. This is even more surprising against the background of the above average increase of traffic in Europe and its resulting importance for human living and economy. This investigation presents a regional scale assessment of the natural hazard potential and its related risks for mountain roads for a case study in Iceland.

The total length of the public road network in Iceland is ca. 13000 km ([http://vgwww.vegagerdin.is/vefur2.nsf/Files/Vegflokkar-Vegalengdir/\\$file/Vegflokkar.pdf](http://vgwww.vegagerdin.is/vefur2.nsf/Files/Vegflokkar-Vegalengdir/$file/Vegflokkar.pdf)), mostly low-volume roads outside built-up areas. Almost 10500 km of these roads are open all year. Substantial parts of the Icelandic public road network e.g. in central northern Iceland, northwestern and eastern Iceland lie in alpine mountain areas and are affected by characteristic natural hazard processes. Though the resulting road maintenance costs are considerable there is no general overview of the natural hazard situation up to now.

The aim of the investigation was to describe and assess the generalised natural hazard situation and its related risks on roads outside built-up areas following a regional scale approach. The results are documented in maps indicating the natural hazard potential for specific road sections, a report with the risk assessment and recommendations and an information system, all together providing a basis for detailed planning.

## INVESTIGATED ROAD SECTION

The regional scale approach was calibrated by a detailed investigation of the 38.7 km long section of road no 76 from Siglufjörður to Straumnes in northern Iceland. To guarantee that investigations following the developed approach are feasible and affordable for all rural roads in Iceland and reduce time-consuming and expensive fieldwork to a minimum the investigation needed to be mainly based on already existing data most of which is available at the Icelandic Road Administration (Vegagerðin) and the Icelandic Meteorological Office. Road no 76 is classified as a highway and tarred. The mean traffic densities along the investigated section of the road were between ca. 250 and 370 cars per day in the annual average, with ca. 400

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to 540 cars per day during the summer (June to September) and ca. 160 to 280 cars per day during the winter months (December to March), based on the census from 2006 ([http://vgwww.vegagerdin.is/vefur2.nsf/Files/Heildarskra-numer\\_pdf/\\$file/Landi%f0\\_nr.pdf](http://vgwww.vegagerdin.is/vefur2.nsf/Files/Heildarskra-numer_pdf/$file/Landi%f0_nr.pdf)).

## **NATURAL HAZARD ASSESSMENT**

The investigation of rockfall, sagging, flooding, debris flows and avalanches covered the main natural hazard processes for this road section. As this road lies in an essentially alpine environment these alpine natural hazard processes can be regarded as characteristic for such areas. Based on the detailed evaluation of the specific processes and the resulting natural hazards for the investigated section a comprehensive assessment of the natural hazard potential for this road was made. This assessment revealed that six road sections which are very different as to the relevant natural hazard processes and the resulting natural hazard potentials can be defined. The results of the comprehensive assessment are presented both as vertical sections for the specific road sections and as an overview map for the investigated part of the road. These figures and maps show the hazard areas of the specific natural hazard processes in comparison.

## **RISK ASSESSMENT**

For avalanche hazards, the collective risk for each process area as well as the cumulative risk for the investigated road section was calculated. The assessment of the risk by natural hazard processes for roads was based on investigations by C. Wilhelm in the Alps and adopted to comply with the data availability of the regional scale approach. While in most of the areas of avalanche hazard the collective avalanche death risk is extremely low and clearly acceptable according to international practice, road sections of a high risk level which should be given priority for possible protective measures could be identified. The calculated risks can be reduced by measures like temporary closing of parts of the road, which can bring the risk to an acceptable level almost everywhere in the investigated section of the road. This requires, however, a systematic monitoring of the development of the natural hazard situation along the road. The cumulative risk for road no 76 between Siglufjörður and Straumnes, for the case that no measures of avalanche prevention or control or temporary closing of the road are taken, agrees well with values determined for mountain roads in the Alps.

## **CONCLUSIONS**

The investigation showed that a standardised regional scale approach is practical to determine, analyse and assess the natural hazard potential and resulting risk on mountain roads and guarantees comprehensible, reproducible and comparable results, which help to assign priorities in following detailed investigations and the planning of measures. For the natural hazard management the results of this assessment need to be combined with road data (e.g. current and expected traffic volume for various timescales, road clearing and maintenance costs for problematic road sections). This allows to determine the natural hazard risk for specific road sections and cost benefit analyses as a basis for decisions on protective measures. To meet these requirements an Internet Road Information System was developed in this investigation.

**Keywords:** natural hazards, risk, mountain roads, Iceland, regional scale, hazard management, road information system