CONTINGENCY PLANS FOR SNOW AVALANCHES FOR IMPROVED ROAD MANAGEMENT IN NORWAY

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ABSTRACT: Since 2003 the Norwegian Public Roads Administration (NPRA) has made contingency plans for snow avalanches, focusing on regions where snow avalanches make up a considerable risk for road users. This work presents the content of these plans, and explains how they can be used to improve natural hazards management. To evaluate the avalanche hazard, certain knowledge about factors that facilitate avalanches is required. Local road managers and contractors throughout the country have a variety of professional backgrounds and different experiences with avalanches, and some guidance is often needed to for them make these evaluations. The contingency plan, therefore, is a necessary tool for translating the announced regional avalanche forecast into local action, providing practical advices and guidelines on what precautions to make, which hazard signs to look for and how to act in a hazardous situation. The plan consists of a map showing all known avalanche paths in the area, together with a description on when and how often they occur, as well as a document describing the local climate, geology, and avalanche history. Recently the NPRA has begun a more extensive work on these contingency plans, also including management of other natural hazards, such as floods, landslides, blizzards and storm surges. To secure the safety of road users in Norway, the revised plan is currently being implemented throughout the country.

KEYWORDS: avalanche preparedness, emergency plan, natural hazard, civil protection

1. BACKGROUND

On the 19th of January in 2000, a snow avalanche blocked the country road 91 in Lyngen, in northern Norway. Several awaiting road users, including a bus, were parked up along the road on both sides of the avalanche. Suddenly, a second avalanche struck, and the bus and some of the parked cars were hit. This accident caused the death of five people, and served as an “eye opener” to the Norwegian Public Roads Administration (NPRA) and changed the management of avalanche exposed public roads. It became clear that in order to reduce its avalanche vulnerability, the NPRA needed to increase its knowledge about avalanches.

It became obvious that crucial knowledge about natural hazard management had to be dealt with in a more systematic way, which meant moving knowledge from an individual level to an organizational level. A more methodical work on snow avalanche mapping started, and in 2003 the first contingency plans for snow avalanches were released.

2. CONCEPT

In the period 2007 - 2010, the NPRA ran a climate adaptation program named ‘Climate and Transport’. One of the subjects dealt with in the program, was how climate change causes altered patterns of avalanche events, and how this influences road management. The program concluded with several recommendations for natural hazards preparedness and for the content of the contingency plans (Petkovic, 2013; Kosberg and Humstad, 2011).

One of the main recommendations was to achieve an even more systematic way of managing natural hazards, through locally adapted contingency plans that should not only focus on snow avalanches, but instead cover all the relevant natural hazards in a specific area. This includes presenting previous avalanches, landslides and floods. Areas especially vulnerable to other natural hazards, such as blizzards and storm surges, should be highlighted.

Another recommendation was to include extensive cartographic material in the plan. Maps are an educational and essential tool to get a quick overview of the avalanche vulnerability, and have

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become a major component in the contingency plan.

In addition, a system for stepwise, gradually increased preparedness towards unfavourable weather conditions was introduced. The way this system works is that each hazard level is determined by a set of threshold values and indicators (e.g. precipitation, snowfall and avalanche danger bulletins). Each threshold implies an associated level of preparedness, followed by a set of recommended actions.

3. METHOD

Mapping and describing the prevailing natural hazards in an area involves several procedures, including collecting natural hazards statistics, climate information, geological and topographic information, as well as fieldwork. Maps showing the Quaternary geology, hydrological regimes and climate zones come in handy. So does data series from hydrological stations in the area, together with registered events of avalanches, landslides, storm surges and floods. By merging these data, the exposed areas and road sections can be extracted. From there, recommendations can be given on how to reduce the consequences, should an avalanche or other natural hazard occur.

During field work, additional information about the local terrain, microclimate and experiences with previous hazardous events is added to the plan. Field work gives the author of the plan an opportunity to meet the local road manager and local contractors, enabling quality check of the document draft.

The NPRA has a database containing all types of data connected to public roads, e.g. information about avalanche exposed road segments and mitigation measures. The database communicates well with GIS-tools, making it easy to gather all the required data in the same software. The contingency plan contains thorough information about each registered vulnerable road segment, such as geographic location, place name, length of the road exposed by the hazard, type of natural hazard or type of avalanche and a description of the frequency and character of events.

In GIS, the different data layers have certain attributes, contained in their corresponding attribute tables. As an example, the data layer ‘avalanche exposed road segment’ contains information about the types of avalanches present, the name of the avalanche path or area, avalanche frequency and the width of the avalanche on the road (Tbl. 1).

<table>
<thead>
<tr>
<th>ID</th>
<th>Name</th>
<th>Avalanche type(s)</th>
<th>Avalanche frequency</th>
<th>Width of avalanche on road (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Kapervatn I</td>
<td>Snow avalanche, debris flow</td>
<td>0,05</td>
<td>50</td>
</tr>
<tr>
<td>2</td>
<td>Svartholatunnelen, øst</td>
<td>Snow avalanche</td>
<td>1,5</td>
<td>30</td>
</tr>
<tr>
<td>3</td>
<td>Bløtkakesvingen</td>
<td>Snow avalanche, slush flow, rock fall</td>
<td>2</td>
<td>30</td>
</tr>
<tr>
<td>4</td>
<td>Kvalvika II</td>
<td>Snow avalanche</td>
<td>0,3</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td>Brathesten tunnel, øst</td>
<td>Snow avalanche, slush flow</td>
<td>4,85</td>
<td>50</td>
</tr>
</tbody>
</table>

Depending on what type of information that is the most prominent in an area, it is possible to put together maps that highlight exactly what the author finds to be the most important data. Using a GIS application as the main designing instrument also allows for frequent and easy data updates.

4. RESULTS

In the following, we will present example maps from two contingency plans. Case 1 is Senja and case 2 is Indre Nordmøre (Fig. 1). These maps illustrate how the graphical content in a contingency plan might look like.
4.1 Case 1: Senja – a snow avalanche exposed island in Northern Norway

With its location at the outermost coast of Northern Norway, the Senja Island is exposed to a wet, snowy and windy climate. Snow avalanches are especially frequent along the western and northern parts of the island. During winter, it is not unusual to have several snow avalanches threatening or blocking a number of roads at the same time.

An example area from the plan is Mefjorden (Fig. 2). The registered snow avalanches are highlighted in white and grey. Terrain steepness, ranging from 0° to 90°, is indicated with a colour bar.

Such cartographic material is of great help for the local road managers, when deciding when and where to intensify the preparedness for avalanches throughout the winter season. A combination of hazard maps, the prevalent weather conditions (e.g. precipitation and dominating wind direction), as well as the announced regional avalanche forecast allows the local road managers to point out vulnerable road segments on a daily basis.

4.2 Case 2: Sunndalen – a divert area with a complex hazard situation

Sunndalen is a valley on the north-western coast of southern Norway, and is covered by the contingency plan 1505 for Indre Nordmøre. With its coastal location and alpine terrain, Sunndalen has a complex natural hazard situation (Fig. 3). The area is exposed to several natural hazards, such as snow avalanches, slush flows, debris floods, ice falls and rock falls. This requires great avalanche awareness from the local road managers and contractors, all year round.
Fig. 2: Detailed map of Mefjorden, from the contingency plan for Senja (Kristensen, 2014).

Fig. 3: Map of Sunnfjorden, from the contingency plan for Indre Nordmøre (Orset, 2014).
5. DISCUSSION

A certain amount of avalanche registrations are needed for the professional to know something about the avalanche hazard in an area. There are some regional differences throughout the country when it comes to “registration awareness”, meaning how important people think it is to report an avalanche. Some regions have registered avalanches thoroughly throughout many years, whereas other regions do not have the same attention on avalanche registration. The latter leaves the professional with little or no avalanche statistics to work with, and is, of course, a challenging situation.

However, since the beginning of the 21st century, the mean annual number of avalanche registrations within the NPRA has increased remarkably, from somewhat 500 annual registrations in the 1990s, and up to today’s level of approximately 2000 annual registrations. The recent increase in the number of registrations shows that resident engineers and local contractors have started to pay more attention to natural hazards and risk management.

The next step would be to implement this “registration awareness” onto other natural hazards as well, such as floods, storm surges and strong wind events, to improve the data basis of such events. In the years to come, a major task for the NPRA will be to continue organizing the registration of avalanches and other natural hazards, as well as encouraging more locals to register events.

Going out in the field, observing the terrain and talking to local contractors and other people acquainted with the area, are of great importance for the quality of the final contingency plan. The local contractors always have supplementary information about the natural hazards in the area, and our experience is that they are, on the whole, more than willing to share their knowledge. Field work gives a quality assurance of the information gathered in the office beforehand, and one should always aspire to carry it out.

The NPRA has a responsibility to reduce the consequences of natural hazards on Norwegian roads. Thorough contingency plans for natural hazards are a necessity to reach the required level of traffic safety. The plan’s content and design should accommodate the way local road managers work with natural hazards, and reflect their need for information. The template for the contingency plan is continuously being revised, to make sure the content is appropriate and up to date, and presented in an understandable way. For this reason, we recommend that, during revisions of the plan, representatives of local road management and maintenance are invited to participate in hearings and meetings. Following this approach, it is our hope that the upcoming contingency plans will be educational and communicate well with both fellow employees and local contractors.

The aim must be that the plan gives the resident engineer a quick overview of the most exposed locations in an area, as well as more detailed information on what precautions to make, which hazard signs to look for and how to act when an avalanche or other natural hazard occurs.

6. CONCLUSIONS AND RECOMMENDATIONS

The NPRA should request both local contractors and internal employees to register avalanches and other natural hazards, especially floods, storm surges and strong wind events. Emphasis should be put on the importance of having a comprehensive database of events and vulnerable road sections, to ensure efficient natural hazard preparedness.

Field work gives a quality assurance of the information gathered, and we recommend that one always carry it out as part of the preparation of the contingency plan.

The plan should meet the information requirements of both road managers within the NPRA, as well as external contractors. Achieving this could improve local cooperation on managing natural hazards.

REFERENCES


