NATIONAL DATABASE FOR MITIGATIVE MEASURES AGAINST RAPID GRAVITY MASS FLOWS AND ROCK FALLS

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ABSTRACT: Mitigation measures against natural catastrophes, such as rapid gravity mass flows and rock falls, have been built in Norway for centuries. Over the last few decades the number of new constructions has been increasing due to stricter safety requirements and increased population in exposed areas.
The Norwegian Geotechnical Institute (NGI) initiated a project in early 2011 to investigate the condition of mitigation measures, and to suggest improved methods for maintaining them.
Our study revealed that most mitigation measures were left without any plans for control or maintenance. Additional field work also revealed that many of the structures required repairs. An increasing number of mitigation measures are being built every year, and there is an urgent need to establish plans for controlling and maintaining these measures in the near future.
For such plans to be established, we found that a system for maintaining information about the measures is required. The system should involve the following processes: 1) acquiring consistent information about all mitigation measures, both planned and built, 2) registering the need for maintenance for each measure and 3) making a plan for future maintenance and/or rebuilding of structures.
Based on these findings, we established a GIS-based pilot database in 2011, and started the initial registration of known measures. This pilot system was successful, and we are continuing the work throughout 2012. The results have been presented and discussed with three governmental agencies in charge of mitigation measures against different natural hazards, which has allowed the work to be continued in the NIFS project.

KEYWORDS: Mitigation measures, GIS, database

1. INTRODUCTION

Mitigation measures have been used for centuries in Norway as a protection against natural catastrophes, such as rapid gravity mass flows and rock falls. The last few decades the number of new constructions has been increasing due to higher safety requirements and increased population in exposed areas and infrastructure (SGI/ICG, 2011).

The growth in the number of mitigation measures, their increased complexity and location in more complex and steep terrain demands a plan for inspection and maintenance. As of today there is no scheme for inspection of already built mitigation measures against gravity mass flows and rock falls in Norway.

In the last 30 years NGI has been a major contributor to planning and designing of mitigation measures for local authorities, road- and railway authorities, power companies and private companies and landowners. However, each client has had the responsibility to act to the proposed plan but it has not always been done. In some cases built measures are not built according to the proposed plan or something is built without any proper design or nothing is built at all. As a result, the status of each of the measures is not known. The most likely reason for this is the lack of a centralized system for registration and management of such installations in Norway.

From the year 2011 the mandate to plan, organize and partly to finance the building of mitigation measures has been devoted to The Norwegian Water Resources and Energy Directorate (NVE). Even though this change is only one and half years old there are positive signs concerning the management of the mitigation work.

In 2011 NGI initiated a project to localize the mitigation measures and propose a plan to investigate their condition and reparation process.

The results were presented to three governmental agencies which are involved in the

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construction and maintenance of various mitigation measures against rapid gravity mass flows and rocks falls, namely The Norwegian Water Resources and Energy Directorate (NVE), Norwegian National Rail Administration (JBV) and Norwegian Public Roads Administration (SVV).

2. THE AIM OF THE WORK

The aim of our work is to investigate the possibilities of establishing a national framework with three main focus areas: 1) acquiring consistent information about all mitigation measures, planned and built, 2) registering the need for maintenance for the measure, and 3) making a plan for future maintenance, rebuilding or removal of structures.

This information system will when fully established be an asset management system for governmental agencies and local authorities.

3. THE WORK

3.1 Study of existing measures

Figure 1. The photo shows an example of a structure in bad shape. These nets have now been replaced with steel bridges.

A field work at few locations revealed that some of the structures required repairs or rebuilding. Typical remarks for these structures were damage or failure in the foundation of poles, girders or wire anchors.

Our in-house work started with compilation of old reports were mitigation measures are proposed, and interviewing colleagues at the Natural hazard division.

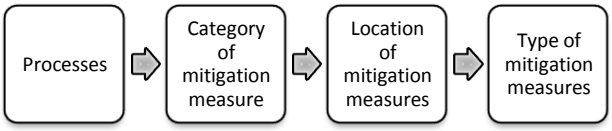
3.2 Definition of terms and of type of mitigation measures

From discussions with experts and the study of existing and proposed measures we found a number of cases of words having different meaning to different people. We also looked at definitions of terms in Norwegian and English, and we looked at previous work with definition efforts` in the Irasmos project (BOKU, 2008) and the SAME project (Brunet, 1998). Overall, we found that there is still a difference in the meaning of similar terms in different languages, and that in Norwegian different terms are still used for the same object. We found that definitions and common understanding was vital for this work to be successful.

To overcome this problem, we started categorizing the measures, partly based on the definitions used in the Irasmos project. Irasmos project attempted to define and categorize mitigation measures but as the report states "…the use of these terms is not universal but depends on the culture, on the practice and on the experience of each region" (BOKU, 2008). However the basic idea from the Irasmos project will be used in our project with some changes.

The Irasmos project categorizes the measures into active, passive, structural, non-structural, permanent and temporary measures. We will first and foremost concentrate on structural and permanent measures and then on temporary measures and in the long run afforestation.

We will not go into the discussion about active and passive measures as it seems as these terms differ most between countries or regions in Europe.



First of all we defined the type of processes the measures are meant to mitigate for. At this stage we have defined snow avalanches, slush flows, debris flows and rock falls as the initial processes, but other processes will be included at a later stage as the work progresses.

The Irasmos project defines several types of categories for the mitigation measures. Most of them are used in our project.

In addition to categories, we also specified

how to describe the geographic location of the measures. The location is especially important in snow avalanches and, to some extent, in slush flows as these processes can be prevented from starting.

Thereafter we defined according to the actual type of measure. The type of mitigation measures is for instance steel bridges, snow nets, catching dams, deflecting dams, snow sheds and rock fall nets.

3.3 The geographical database – GIS system

Over the last years NGI has built up a GIS based system for the analysis and evaluation of snow avalanche hazards. All data is registered in a central database. This includes information about terrain, hazard zones, run-out distances and mitigation measures. In addition, the system contains historical records from previous projects. This central database is used for the pilot database, which allows for an easy integration with the GIS used by the avalanche experts.

3.4 Definition of the geo-referenced object

For the pilot database, the location of a measure was defined by its centerline. For later versions, more complex ways of specifying locations will be added. Different structures have different location of centerlines, and we have proposed a system which caters for the most common structures used in Norway today. The list is not finite, and will be extended with new centerline/ alignment definitions as new structure types are added.

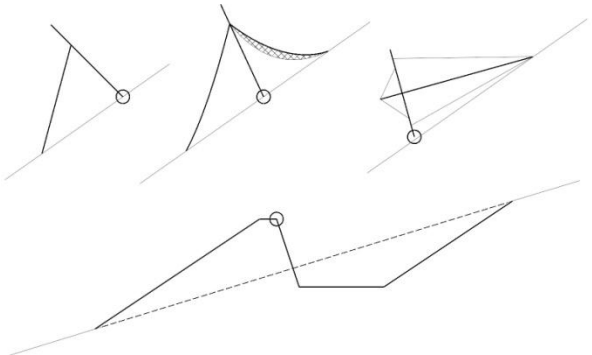


Figure 2. The circles in the figure shows an example of the location of centerline for supporting structures, upper most structures (from left: steel bridges, snow nets, umbrella structures) and at bottom, dams and mounds which form rows in the run-out zone.

3.5 Objects in the database

There are four types of objects defined in the database: 1) the boundary of the mitigation area, 2) the centerline of the measures if available, 3) boundary of the structures area and 4) the area below the structures which is protected.
Each of the objects has a set of attributes to describe the object, see Figure 3. The list is now under revision and may change based on feedback and requirements from other stakeholders.

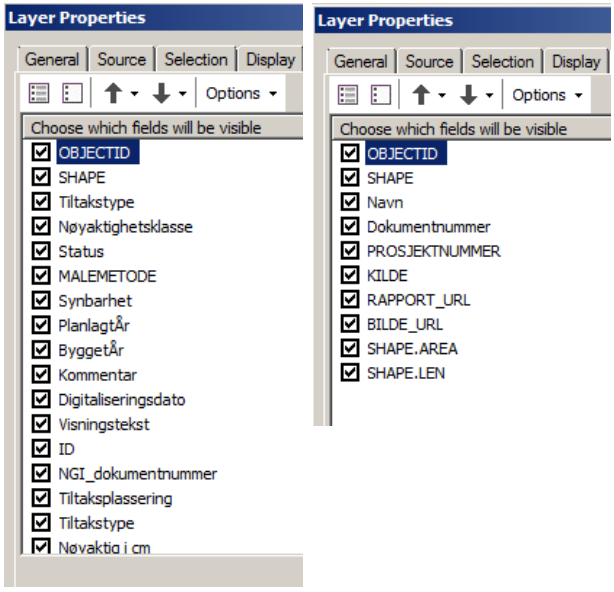


Figure 3. The list to the left shows part of the properties for centerline of mitigation measures and the list to the right show boundary properties.

The data is registered in the snow avalanche evaluation system using ArcGIS. Once registered, the data is available to NGI through a web map and in ArcGIS through NGI's avalanche evaluation system.

3.6 Data exchange form

The project currently involves several participants, and will affect even more parties as it progresses. As each party has its own methods for handling geographic information, we looked at ways of exchanging mitigation measure data without interfering with each party's internal handling of data.

Figure 4. The figure shows the area boundaries (dashed lines) in several places in Hammerfest Norway. Individual rows of mitigation measures are shown inside the area boundaries.

One way of achieving this is through the use of standards for data exchange. We proposed that data about mitigation measures are to be included in existing standards.

In Norway, all governmental and local authorities are to exchange geographic data using the SOSI data exchange format. This format is continuously being revised and extended to include new subjects. As the current version of the format does not include enough information for our purposes, the SOSI workgroup was informed about our needs. Their response was positive, and a plan for adding the new features into the SOSI data exchange format is being established.

It is also our plan to be able to import design data directly into the database after completion of the design work. Most often the designs of mitigation measures are done in CAD. The CAD systems produces detailed and feature rich datasets. All this information is not necessary in the GIS system. The project will look into which of the CAD elements shall be exchanged with the GIS system and how to translate CAD objects into GIS objects.

3.7 The registration work

A geographic database (a pilot database) was established at an early stage of the project for registration of mitigation measures. This database has been expanded and improved as new types of mitigation measures are added. A new version of the database is now under development and it will be available this fall.

We have now added over 200 areas of mitigation measures and over 600 individual mitigation measures. Attributes are registered for each of the measures. Even though the total number of measures is not known we believe this represents more than half of all measures built in Norway.

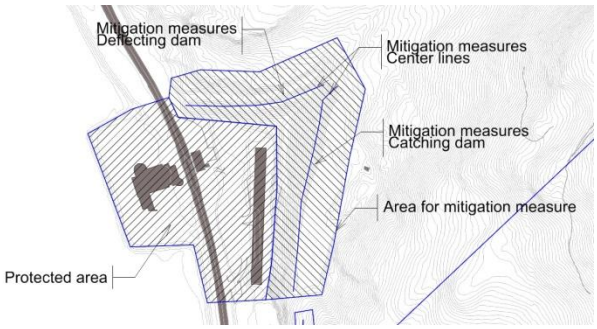


Figure 5. The figure shows an area for deflecting dam and catching dam, which connect at the end, and protected area below the structures.

3.8 Control of existing mitigation measures

A central part of the project is to suggest structured methods for controlling existing structures. Similar to the registration of the measures, this will involve definitions of terms to ensure a common understanding of the terms used in the control. A plan is being worked out on how to proceed, and work will start in 2013.

3.9 Maintenance work

A control of mitigation measure may reveal a need for maintenance work. A requirement for the maintenance is an agreement on how to handle the need for maintenance in a database. At the moment the idea is to categorize the need for maintenance work into urgency: 1) critical, 2) moderate, and 3) on occasion. Cost estimates are essential in this phase.

4. FUTURE DEVELOPMENT

Based on the results from the project so far, the work will continue as a part of the NIFS framework. NIFS (NATURAL HAZARD - infrastructure - flooding – avalanches) is a framework, where all the previously mentioned governmental agencies are main partners.

The future revisions of the database structure will take into account specific requests or information from the governmental agencies. Registration will continue and the agencies will supply us with information on their mitigation

measures and tight cooperation will be with them in the control- and maintenance phase.

In the coming weeks NGI will set up a project plan for the remaining of 2012 and for 2013. Our intention is to start the formal use of this asset management system in the fall 2013.

It is the nature of such systems that they are never completed, they are constantly under development. Already today we see possible extensions and we believe that once the asset management system is implemented more and more usability will be observed which adds value to it.

In the near future the workgroup at NGI plans to contact other institutions who work with similar databases for mitigation measures against rapid gravity mass flows and rocks falls, to find out if we can share information, experience and knowledge.

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