

Current PhD Theses in the Field of Natural Hazards 2003

Proceedings of the 5th PhD Students' and Advisors' Meeting
5th – 7th October 2003 in Bad Schwarzsee/Fribourg



Natural Hazards Competence Centre
Kompetenzzentrum Naturgefahren
Centre de Compétence Dangers Naturels
Centro di Competenza Pericoli Naturali

5th PhD Students' and Advisors' Meeting in the Field of Natural Hazards

Preface

The 5th PhD Students' and Advisors' Meeting in the field of Natural Hazards was held in Schwarzsee/Fribourg, Switzerland, October 5-7, 2003. The major objective of the meeting was to provide a stimulating environment for both students and advisors to discuss topics in the field of natural hazards.

The 2003 meeting has been the fifth meeting of PhD students conducting research in the field of natural hazards and disaster risk management. Until 2001, the meeting took place every year at a different place in Switzerland. From now on, the meeting will be organized every two years. The former meetings were held in Berner Oberland 1998, in Davos 1999, in Crêt-Bérard (Lausanne) 2000 and in Zürich 2001. Since 1999 in Davos, many foreign students have participated.

This year's meeting took place at the Hotel Bad at Schwarzsee/Fribourg. The Institute of Geography at the University of Fribourg has been the local organizer. Special thanks are due to Prof. Dr. M. Monbaron and his assistant Dipl. Geogr. M. Stoffel. CENAT would like to thank Dr. P. Ecoffey, Direktor der Kantonalen Gebäudeversicherung Freiburg, and Dr. Bernard Loup, Service des constructions et de l'aménagement du Canton de Fribourg (SeCA), for their special presentations about the earth slide event "Falli-Hölli".

These proceedings contain the concepts or summaries of 25 current PhD theses in fields of natural hazards and disaster risk management presented at the 5th PhD Students' and Advisors' Meeting in the form of short presentations or posters.

Editor Co-ordination centre CENAT, Stefanie Dannenmann, Christine Berni, Simone Fischer

The 5th PhD Students' and Advisors' Meeting in the Field of Natural Hazards was organised by the University of Fribourg, and the Natural Hazards Competence Centre CENAT.

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CENAT is a network of the Swiss Federal Institutes of Technology and several Swiss Universities

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INHALTSVERZEICHNIS

Floods / Debris Flows / Hydrology	1
• Methodology for the assessment and mapping of the streambank erosion hazard due to flooding <i>Beck John, ISTE/HYDRAM, Swiss Federal Institute of Technology Lausanne</i>	3
• Flood forecasting: a case study of the Maggia river <i>Birsan Marius-Victor, Institute of Hydromechanics and Water Resources Management (IHW), ETH Zürich</i>	5
• Reconstruction and Comparison of Past Debris-flow Events in the Southern Valais-Valleys <i>Bollschweiler Michelle, Department of Geosciences, Geography, University of Fribourg (CH)</i>	7
• Methodologies and strategies for the analysis of possible synergies for multi-purpose run-of-river hydroelectric power plants <i>Heller Philippe, LCH, EPFL</i>	8
• Influence of laterally side weirs on bed-load transport in a prismatic channel <i>Rosier Burkhard, LCH, EPFL</i>	10
• Direct determination of rheological debris flow parameters <i>Schatzmann Markus, Laboratory of hydraulics, hydrology and glaciology, ETH Zürich</i>	12
Landslides / Rockfall	15
• Dynamic Assessment of Rainfall Triggered Shallow Soil Slips in Alpine Areas <i>Bisanti Barbara, Institute of Hydromechanics and Water Resources Management, ETH Zurich</i>	17
• Validation of a new approach to determine vegetation effects on superficial soil movements <i>Frei Martin, Swiss Federal Research Institute WSL</i>	18
• Geomechanical investigation of rock block bouncing during rockfalls <i>Heidenreich Barbara; Rock Mechanics Laboratory, EPFL</i>	20
• Analysis of Strong Ground Motion Generated by a 3-D Vertical Strike Slip Elastic Fault Model Controlled by Rate/State Friction and Fault Zone Hydraulics <i>Hillers Gregor, Institute of Geophysics, ETH Zürich</i>	23
• Mountain forests under the influence of rockfall <i>Perret Simone, Dept. of Geography University of Bern</i>	25
• Effects of the underground heterogeneities on the behaviour and the processing of landslides. Research by finite element modeling and application to the Triensenberg landslide (Liechtenstein) <i>Sierro Caroline, ENAC - GEOLEP, EPFL</i>	27
• Development of a continuous 3D-monitoring system for unstable slopes by Time Domain Reflectometry (TDR) <i>Valley Benoît, Ingenieurgeologie, ETH Zürich-Hönggerberg</i>	29
• Rockslide processes and mechanisms – Investigation of the kinematics and internal structure of complex rockslides <i>Willenberg Heike, Geological Institute – Engineering Geology, ETH Zürich</i>	31
Avalanches/ Glaciers / Permafrost	33
• Dimensioning of snow avalanche catching and deflecting dams <i>Baillifard Marc-André, Swiss Federal Institute for Snow and Avalanche Research, Davos Dorf, CH</i>	35
• Thawing of frost-susceptible soils in the foundation of roads and railways, and in mountain permafrost <i>Dysli Michel, Soil mechanics laboratory, EPF-Lausanne</i>	37
• Nowcasting nocturnal cloud cover and surface state <i>Grimbacher Tobias, Institute for Atmospheric and Climate Science (IACETH), Swiss Federal Institute of Technology, Zurich</i>	39



• Influence of avalanche loads on snow sheds	41
<i>Platzer Katharina, Swiss Federal Institute of Snow and Avalanche Research, Davos Dorf, CH</i>	
• Ice-bed coupling of sediment based glaciers	43
<i>Rousselot Marie, VAW-Glaciology, ETH Zürich</i>	
Risk Management/ Risk Evaluation	45
• “Le Management des Risques Naturels et la Gestion des Sinistres“ en Milieu Urbain	47
<i>Abdenbi Yassine, Institute of Architecture and Urban planning , University of Geneva</i>	
• Risk Management of Natural Disasters in Mexico	48
<i>Claudia Flores, Institute of Insurance, University of Karlsruhe (TH)</i>	
• Geohazard and risk: change through time and space in Wellington, New Zealand	51
<i>Hufschmidt Gabriele, Department of Geography, University of Bonn, Germany / Institute of Geography, Victoria University, Wellington, New Zealand</i>	
• Flood damage prevention by means of planning instruments	52
<i>Kipfer Andy, Institute of Geography, University of Berne</i>	
• Risk evaluation of natural hazards (with special consideration of risk aversion)	54
<i>Plattner Thomas, Chair of Forest Engineering, Dep. of Forest Sciences, ETH Zürich</i>	
Earthquakes	57
• Signature of historic and prehistoric earthquakes in lake sediments of Central Switzerland	58
<i>Monecke Katrin, Geophysical Institute, ETH Zürich</i>	

Floods / Debris Flows / Hydrology

Methodology for the assessment and mapping of the streambank erosion hazard due to flooding

Beck John, ISTE/HYDRAM, Swiss Federal Institute of Technology Lausanne

Short Description of the PhD thesis:

A methodology for estimating the streambank erosion hazard due to flooding will be developed. It will specify the important parameters influencing the hazard, the data that must be collected to describe it, the numerical modeling capable of estimating it, and the results and tools needed for the hazard mapping. Uncertainty will be assessed by interpreting the results of Monte-Carlo simulations. The developed streambank erosion model will also be useful to determine protection work efficiency.

Issues and Goals (Concept) of PhD thesis:

The first step necessary for flood protection as prescribed in the Swiss flood protection directives is to assess the flood hazard. Much attention has been given to the estimation of flood water depths and even velocities in assessing the flood hazard, although little has been said about how to estimate the streambank erosion hazard. However, streambank erosion is sometimes the flood hazard that causes the most significant damages. The Federal Office of Water and Geology (OFEG) recommends the characterization of the intensity of the streambank erosion in terms of the depth of the breach in the streambank. In the present engineering context, in which the only practical tools for analyzing erosion are riverbank stability formulas, there is a gap to be filled so that the federal directives can be followed.

A simple conceptual model for estimating the effective shear stress exerted on riverbanks has been developed at the HYDRAM laboratory. This model is an improvement over commonly used riverbank stability formulas because of its incorporation of the upstream erosion influence and the radius of curvature of the river. The model lacks a bank erosion rate formula though for estimating the depth of the erosion breach during a flood. This gap needs to be filled so that erosion breach depths during a flood event can be estimated. This estimation along with the probability of the erosion event would allow the streambank erosion danger to be calculated.

The probability of the erosion event presents another problem. How can it be estimated? Flooding frequency is most often evaluated according to the return period of the discharge. Many researchers have already shown that discharge is not always the most prominent factor in bank erosion. Many other factors such as wetness, failure mechanisms according to soil types, debris, wind effect on vegetation, sediment transport, etc. have an influence on erosion and can be quite variable. Probability density functions (PDF's) of different influential factors and their dependency/interdependency need to be estimated. Once established, these PDF's could provide the input to do Monte-Carlo simulations that will allow to take into account the uncertainties relative to the different variables. The results of these simulations will provide the indication of frequency necessary for the bank erosion danger calculation.



Application of the streambank erosion model on two or three rivers will allow the methodology for assessing and mapping the hazard to be developed and tested. This methodology will describe the required data, data treatment, modeling procedure, model results (especially those related to the erosion danger calculation), and mapping of the results.

A streambank erosion model could also have two other extremely important uses: 1) estimation of maximum channel migration, and 2) assessment of the efficiency of existing or future protection works. In relation to the second utilization, this aspect could be very beneficial for planning the replacement of riprap or concrete protection works by more natural (vegetation) protection works.

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Title of PhD Thesis: Methodology for the assessment and mapping of the streambank erosion hazard due to flooding

Date of begin and closure: July 2002 – 2005

Flood forecasting: a case study of the Maggia river

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Short Description

The EU-project MUSIC (MUlti-Sensor precipitation measurements Integration, Calibration and flood forecasting) aims at combining in an objective and optimal way different sources of precipitation estimates, such as rain-gauges, weather radar and weather satellite, in order to reduce the final bias and uncertainty associated with the precipitation estimates, which must be used as input to rainfall-runoff flood forecasting models. Accounting for uncertainty and reducing the bias allow to enhance the accuracy of flood forecasts, thus improving the identification of areas at risk of flooding and providing an aid to decision making.

One of the case studies of the MUSIC project concerns the Maggia River basin, located in Southern Switzerland. It is a typical glacial shaped basin with steep hillslopes bounding a narrow valley, having a drainage area of 926 km² with elevations ranging from 193 m. a. s. l. at the estuary, to 3274 m. a. s. l. at Monte Basodino. The torrential regime of the Maggia River is characterized by an impulsive response to heavy rainfall (mainly in autumn), which can produce a change in the discharge from few m³/s to 1000 m³/s in a couple of hours (the ratio between the historical minimum and maximum runoff is about 1:7000), hence the need of an accurate real-time flood forecast. During intense frontal precipitation, usually in the autumn season, the Maggia River contributes to endangering of the region around the city of Locarno and, jointly with the Ticino and Toce rivers, to the rapid increase of the water level of the Lake Maggiore.

Issues and Goals

A reliable real-time quantitative precipitation estimate and a flood forecasting system allow to reduce the uncertainty of forecasts for a given lead-time or to extend the forecast lead-time. This turns into improved warnings and operational decisions for flood risk mitigation. In this light, one of the main targets of the present work-package of MUSIC project is to improve the reliability of rainfall estimation techniques and then to use the resulting rainfall fields in an integrated prototype of flood forecasting system.

Methods

The methods used to work out the case study consist of the coupling of an advanced methodology to estimate a rainfall field from multisensoral observations with a distributed physically oriented rainfall-runoff model.

The rainfall field driving the rainfall-runoff model is produced by means a mathematical technique which combines block Kriging and a Bayesian estimation procedure to integrate rainfall estimates from raingauges, weather radar and satellite images. Such a technique allows to minimize the variance of the estimate and to evaluate its uncertainty. The first problem to be solved for combining measurements is that point measurements, namely the rain-gauges, cannot be directly compared with the spatial estimates produced by weather radar and weather satellite. In order to consistently combine the sets of data, one has first of all to distribute the point rain-gauge measurements in space in order to make them comparable with spatial measurements. The methodology is essentially based on (1) the use of block Kriging for up-scaling the point gauge measurements to the basic sizes of the radar, (2) the computation, on the same representation

scale, of the deviations between radar estimates and block-Kriged gauge measurements using historical records, (3) the assessment of radar-gauge error statistics in order to set up a Kalman filter based algorithm and (4) the Bayesian combination of the radar estimates and the block Kriged gauges. A similar procedure is used to integrate the rainfall estimates from the satellite images.

The rainfall-runoff model used for flood forecasting is TOPKAPI (TOPographic Kinematic Approximation and Integration), a physically based distributed rainfall-runoff model deriving from the integration in space of the non-linear kinematic wave model [Todini & Ciarapica, 2002, *The TOPKAPI model*, in *Mathematical Models of Large Watershed Hydrology*]. The rainfall runoff and runoff routing processes are modelled using three non-linear reservoir differential equations, for the drainage in the soil, the overland flow on saturated or impervious soil, and the channel flow along the drainage network, respectively. The geometry of the catchment is described by a lattice of cells (the pixels of a DEM and their slope) over which the equations are integrated to lead to a cascade of non-linear reservoir. The parameterisation is done on the basis of digital thematic maps of soil, geology and landuse.

Expected results

The expected results consist essentially of (1) an improved flood forecasting system which accounts for multi-sensorial observations of rainfall; (2) a reduced uncertainty of the rainfall field estimates; and (3) an aid to the decision process of flood risk management.

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Title of research project: MUSIC (Multi-Sensor precipitation measurements Integration, Calibration and flood forecasting)

Title of PhD Thesis: to be determined

Date of begin and closure: to be determined

Reconstruction and Comparison of Past Debris-flow Events in the Southern Valais-Valleys

Bollschweiler Michelle, Department of Geosciences, Geography, University of Fribourg (CH)

Short Description of the PhD thesis:

Debris flows represent a big danger for men and infrastructure in mountainous regions as showed different events in the past few years that led to damages and even loss of life. Following the discussion about global warming, debris-flow events are said to have been more frequent in the past about fifteen years and are probably going to be more frequent in the future, too.

However, there is only little knowledge about the frequency of debris-flow events in the past century in the research area. The aim of this study is to reconstruct the history of debris flows in the Southern Valais-Valleys for approximately the past hundred years. More knowledge about debris flows in the research area will be acquired through this study.

Issues and Goals (Concept) of PhD thesis:

The study aims to reconstruct the frequency of debris-flow events in different channels in the research area. Through this reconstruction knowledge about the process in the different channels will be acquired.

The comparison of the event years in the different channels will show if the channels in a valley reacted in the same way or if they show dissimilarities. Afterwards the channels of different valleys will be compared to find similarities between the different valleys.

Finally the event years will be compared to meteorological data to find special weather situations that favour the triggering of debris flows in the research area.

Methods:

The study is mainly based on the methods of dendrogeomorphology. These methods will be used on the forested debris-flow fans. For the comparison of the event years different statistical methods will be used.

In addition aerial views will be analysed to define changes in the source area, along the channel and on the fan.

The archives of the municipalities will be searched for any information about debris flows in the region.

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Title of research project:

Title of PhD Thesis: Reconstruction and Comparison of Past Debris-flow Events in the Southern Valais-Valleys

Date of begin and closure: 05/2003 – 09/2007

Methodologies and strategies for the analysis of possible synergies for multi-purpose run-of-river hydroelectric power plants

Heller Philippe, LCH, EPFL

Short Description of the PhD thesis:

For the new available site in Switzerland, new hydroelectric powerplants can be only successfully implemented if they are designed as multi-purpose projects. The flood damages in the Alps during October 2000, especially in Canton of Valais, as well as in the central and eastern Europe in 2002, revealed the important role of hydroelectric powerplants on flood management in catchment areas.

This research project focuses on methodologies and strategies for the analysis of possible synergies of multi-purpose run-of-river powerplants. Beside electricity production such reservoir can have the following purpose: flood routing by a reserved storage volume and controlled flooding, diminution of the effect of peaking operation of powerplants situated upstream, creation of biotopes and new type of landscape as well as recreational areas for tourism activities (water sport and fishing). The behaviour of such a multi-purpose project is very complex and has to be analysed with appropriate methodologies and strategies.

Issues and Goals of the PhD thesis:

The main goal of the PhD thesis is therefore to define a methodology and a strategy, which allow quantifying the synergy and benefits of a multi-purpose run-of-river power plant. This should finally also define a key for cost distribution.

First the major parameters, which influence the complex system, have to be identified. These parameters are divided into different topics like natural and built environment, energy policy, recreational and leisure activities, influence on landscape development, flood management, river regime regulation, etc.

Then the reciprocal interactions, among all parameters, have to be defined considering their intensity and time effect, which finally allows building the complex system. Using different methods and strategies, the behaviour of this system can be analyzed. The final goal is to find a multi-purpose project with the highest economical, social and environmental benefits.

Methods:

In a first stage the network thinking method of Gomez and Probst, mainly used in the development of competitive strategies for companies, will be used to analyze the complex system of a multi-purpose project. In a further step other methods will be studied as multicriterion approaches, fuzzy logic, system operation research, artificial intelligence, etc..., in order to develop a methodology and a strategy for the analysis of complex multi-purpose run-of-river powerplant projects and to identify its critical key factors.

Expected results:

The developed methodology will be implemented in an intelligent expert system. This should not only allow to define multi-purpose projects with the best socio-economic and environmental benefits but also to generate new concepts with high synergy potential. Such a tool will be useful

for interdisciplinary designer teams, which have to deal with complex project systems influenced by a lot of non-quantifiable parameters and different interests supporting by different groups of stakeholders. The final result will be the best synergy project that every stakeholder could accept.

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Title of PhD Thesis: Methodologies and strategies for the analysis of possible synergies for multi-purpose run-of-river hydroelectric power plants

Date of begin and closure: 06.2003 – 09.2006

Influence of laterally side weirs on bed-load transport in a prismatic channel

Rosier Burkhard, LCH, EPFL

Short Description of the PhD thesis:

In the framework of the multidisciplinary flood protection research project *DIFUSE* (**D**igues **f**usibles et submersibles, Fuse plugs and overflow dams at rivers) involving governmental offices, private companies and four research institutes, the task of the involved research institutes is to establish design criteria for fuse plugs, to investigate the stability of river dykes including scouring at the toe and to study the effects of a side overflow on the sediment transport in a natural channel. The latter is the topic of the PhD thesis.

The protection against natural hazards such as floods and inundations require efficient control and management of flow processes along a river course. Lateral side weirs and fuse plugs on canalized rivers are a feasible and widely used device to cope with this challenge. They are installed at the bank along the main-channel with the purpose to divert or spill in a controlled manner water over them into flood planes when the water level exceeds a certain limit.

This lateral loss of water will reduce the sediment transport capacity in the main-channel by decreasing the bottom shear stress. This yields to the formation of sediment deposits which raise the bed level locally. As a consequence the design discharge to be diverted over the side weir is increased and consequently sediment transport capacity is further decreased. This interaction between lateral overflow and sediment transport has to be known in order to avoid such uncontrollable behaviour of the side weir as a fuse plug.

Issues and Goals (Concept) of PhD thesis:

The aim of the PhD thesis is to obtain a better understanding of the process of sediment transport in a channel with lateral overflow on one hand and to develop and provide appropriate design criteria for the engineer on the other. This regards the residual risk and optimised geometric alignment for the side weirs guaranteeing a sufficient bed-load transport capacity in the main-channel.

Methods:

By the help of an experimental setup (30 m long and 1.5 m wide flume), the physical processes in the main-channel and on the side weir were analyzed systematically to determine the influence of laterally placed side weirs on the sediment transport, erosion and deposits in the main-channel. As controlled parameters involved the main-channel discharge including flood hydrographs, the ratio between diverted discharge and main-channel discharge, channel slope, length of the lateral weir crest, number of weirs and sill height were studied. Water level and velocity field were measured using US (Ultra Sonic) and UVP (Ultrasound Doppler Velocity Profiler).

By a photogrammetrical analysis of the drained bed at the end of each test a digital terrain model (DTM) is created with the purpose to determine riverbed changes and to calculate eroded and deposited sediment volumes.

Based on a non-dimensional parameter analysis of the test results empirical relationships are developed for the main parameters of the system.

Furthermore the extensive measurements will allow to calibrate a 3D numerical model in order to analyze the influence of the parameters in detail and to widen the application range from the simplified conditions of the physical model to more general cases.

Results (or expected results):

The analysis of the first test series confirms the formation of local deposits of sediments downstream of the lateral outflow combined with an elevation of the water level resulting in an increased diverted discharge over the side weir. This process is strongly transient since at the beginning of the experiment the ratio of main-channel discharge to diverted discharge is low, then rapidly increases to a maximum before reaching almost a constant value. There is tendency towards an equilibrium state of the river bed which is also indicated by a strongly wavy water surface near the side weir at the beginning of the test which becomes smoother with elapsing experiment time.

Based on the examination of the first test series, a parametric analysis allowed to develop some design diagrams. For a given channel geometry and bottom slope as well as sill height and length of the side weir crest, the ratio main-channel discharge/ diverted discharge can be determined.

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Title of research project: Influence of laterally side weirs on bed-load transport in a prismatic channel

Title of PhD Thesis: Influence of laterally side weirs on bed-load transport in a prismatic channel

Date of begin and closure: 10/ 2002 – 10/ 2005

Direct determination of rheological debris flow parameters

Schatzmann Markus, Laboratory of hydraulics, hydrology and glaciology, ETH Zürich

Short Description of the PhD thesis:

Debris flows endanger human life, animals and infrastructure in hilly and mountain areas. One prior task for the risk assessment and the construction of mitigation measures is the development of numerical simulation programs which can be applied in practice and which base on scientifically founded physical models.

Issues and Goals (Concept) of PhD thesis:

Climate, Geology and Topography are the main factors, which determine the manifold appearance of debris flows as well as the very distinctive processes from initiation to deposition. These processes require differentiated physical models in order to reproduce the processes well with numerical simulation. A Coulomb mixture theory – soil mechanics based model for example seems to be appropriate to reproduce initiation, flow and deposition process of clearly two-phase, granular rich debris flows and landslides starting and moving on steep slopes (Iverson 1997). A rheological model is, for example, proper to reproduce flow and deposition process of fine material rich

(muddy) debris flows (Coussot 1997).

Methods:

In a current VAW-project the rheological model is focused. It is investigated which measuring systems and techniques permit an efficient and robust direct determination of the rheological parameters. The project includes the measurement of variably concentrated natural debris flow material as well as other sediment-water mixtures with traditional rheometric systems. These are the concentric cylinder, cone and plate as well as the parallel plate system for the flowcurve determination, and the inclined plane test, inclined channel test as well as the slump test for the yield stress determination. In addition, non traditional and recently developed systems, such as the BML viscometer (Wallevik 1991) and the BMS –Ball Measuring System- (Tyrach 2000) are tested and the measurements compared with the traditional systems. One main advantage of the latter systems is the analysis of large particle material up to 32 mm (BML) and about 8 mm (BMS) with small sample volumes of 25 liter (BML) and 0.5 liter (BMS), respectively. Compared to traditional systems good results were obtained, but these alternative systems lack of elaborated theoretical background.

Results (or expected results):

In the present project it is aimed to overcome these deficiencies and to find an efficient and robust way for the direct determination of rheological debris flow parameters with the help of an innovative combination of different measuring systems and extrapolation techniques.

Literature:

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Title of research project: Direct determination of rheological debris flow parameters

Title of PhD Thesis: Direct determination of rheological debris flow parameters – a critical examination

Date of begin and closure: 1.1.2002 to 31.12.2004

Landslides / Rockfall

Dynamic Assessment of Rainfall Triggered Shallow Soil Slips in Alpine Areas

Bisanti Barbara, Institute of Hydromechanics and Water Resources Management, ETH Zurich

Short Description of the PhD thesis:

Flood risk in mountain areas depends not only on the water dynamics, but also on processes that are connected to water and influenced by it. The occurrence of shallow soil slips on hillslopes, following a more or less intense storm precipitation, can substantially raise both the damage to infrastructures and the number of casualties during a flood event. Therefore the assessment of slope stability with regard to rainfall triggering factors proves to be of great importance.

Issues and Goals (Concept) of PhD thesis:

The majority of studies in the field of shallow landsliding risk assessment have concentrated on a static representation of the problem, mainly connecting rainfall thresholds to slope failure. The scope of this work is to address the temporal dynamics that lead to slope failure, stemming from the assumption that slope stability is influenced by repeated cycles of wetting and drying. The transition between unsaturated and saturated conditions in the soil and the consequent progressive loss of suction are fundamental issues to be tackled.

Methods:

The doctoral thesis will concentrate on the development of a physically oriented hydrological model and a slope stability model, designed to be coupled with one another. The modeling framework is intended to reproduce the physical surface and subsurface processes that contribute to slope failure, based on properties of the landscape. The hydrological model should resolve the soil water balance and therefore an appropriate soil moisture modeling scheme is required. The latter will simulate the spatial and temporal distribution of soil water content, thereby taking into account the dynamic nature of the problem. The slope stability model will feed on this input and evaluate the stability of the slope under consideration.

Results (or expected results):

Together with runoff calculation, expected results involve the determination of a temporally variable factor of safety, used as an indicator of slope stability. This will enable the creation of more realistic, time-dependent risk maps in watersheds prone to soil slips.

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Title of research project: Dynamic Assessment of Rainfall Triggered Shallow Soil Slips in Alpine Areas

Title of PhD Thesis: Dynamic Assessment of Rainfall Triggered Shallow Soil Slips in Alpine Areas

Date of begin and closure: April 2002 - April 2005

Validation of a new approach to determine vegetation effects on superficial soil movements

Frei Martin, Swiss Federal Research Institute WSL

Short Description of the PhD thesis:

Soil bioengineering methods are applied worldwide and successfully to prevent erosion and to stabilise shallow landslides. They are considered as environmentally compatible but are not included in traditional slope stability calculations. However, today's increasing requirements for risk based assessment of slope stability as well as economical aspects demands clear specifications concerning the quantitative contribution of vegetation on slope stability. At WSL, Albert Boll and Frank Graf developed a new model for quantifying vegetation effects. This model attempts to assign these effects to the shearing strength using the soil density as a temporary reference term. Three hypotheses were formulated to validate this new model, and the PhD-project focus on investigate them.

Issues and Goals (Concept) of PhD thesis:

The quantification of vegetation effects on soil stability is based on the contribution of roots and fungal hyphae to the water-stability of aggregates. First, a correlation between water-stability of aggregates and soil density was investigated. Then, the question was studied if soil specimens with vegetation have a water-stability of aggregates equivalent to specimens of higher density without vegetation. This difference of density was subsequently named "virtual density". Finally, a correlation between "virtual density" and shear strength was investigated.

Methods:

The test set-up consisted of cylindrical soil specimens. Only the fraction < 10 mm of a moraine material from a subalpine landslide area (Schwandrübi, Canton of Nidwalden) was used to produce the specimens. One third was left as control (treatment "soil"). To the remaining two thirds, alder seeds were applied (treatment "plant"). Additionally, one half of these planted specimens were inoculated with a mycorrhizal fungus (treatment "inoculation").

The water-stability of aggregates was analyzed after five months of growth in a greenhouse. Three sieves with different mesh openings (# 20 mm, # 10 mm, # 2 mm) were placed one above the other in a Plexiglas pot. A specimen was placed on the top sieve. Subsequently, the pot was filled with water covering the specimen completely. After five minutes, the water was drained and the plant roots were carefully removed. The dry unit weight of the soil material remaining on the top sieve (# 20 mm) was measured. Its proportion in terms of the mass of the entire specimen represents the water-stability of aggregates. The plant roots were scanned with a flatbed scanner and analyzed with a special soft-ware to determine the root length.

Additionally, consolidated-undrained triaxial compression tests were performed on planted and unplanted specimens.

Results :

Only a small number of specimens of the treatment "inoculation" have developed a functional plant-fungus-symbiosis, but they have the highest values for the proportion of stable aggregates > 20 mm as well as root length per volume. The other specimen of the treatments "plant" and

“inoculation” delivered lower aggregate stability. But preliminary statistical analysis with a robust regression model confirmed a positive effect of root length on soil aggregate stability, and this is particularly enhanced if the mycorrhiza has formed.

The triaxial compression tests resulted that an equivalent friction angle was between 1-2° higher for planted specimen even though they had lower dry unit weights after consolidation.

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Title of research project: Lothar und Wildbach

Title of PhD Thesis: Validation of a new approach to determine vegetation effects on superficial soil movements

Date of begin and closure: 10/2001 – 10/2004

Geomechanical investigation of rock block bouncing during rockfalls

Heidenreich Barbara; Rock Mechanics Laboratory, EPFL

Short Description of the PhD thesis:

In the framework of rockfall trajectory modelling, the bouncing phenomenon occurring when a rock block impacts with the slope surface is the most difficult to predict, owing to its complexity and its very limited understanding. Up to now, the rebound is commonly quantified by means of (one or) two coefficients of restitution expressing the amount of energy dissipated during the ground impact. These restitution coefficients commonly are evaluated from a rough description of the ground material. However, the rebound of a block is likely to be influenced not only by the characteristics of the impacted ground, but also by the characteristics of the block and the kinematics. To acquire a better knowledge of the bouncing phenomenon and to investigate the influence of the various impact parameters, a comprehensive laboratory testing campaign is undertaken on small- and half- scale models.

The small-scale testing device consists of an inclinable box filled with granular material. Spherical blocks of different masses but with the same diameter are released to impact the ground vertically or under a certain angle with an impact velocity of 4.4 m/s. The impact is filmed by a digital high-speed camera at 250 frames/second. The block motion is analysed by an image processing software to determine the normal and tangential velocities and energy of the block before and after impact. From the resulting data, the coefficients of restitution R_t , R_n and R_{TE} are calculated according to the following common formulations:

$$R_t = V_{t,r} / V_{t,i} \quad (v_t = \text{velocity component tangential to slope surface}) \quad (1)$$

$$R_n = V_{n,r} / V_{n,i} \quad (v_n = \text{velocity component normal to slope surface}) \quad (2)$$

$$R_{TE} = E_{tot,r} / E_{tot,i} \quad (E_{tot} = \text{total energy} = \text{translational} + \text{rotational energies}) \quad (3).$$

The subscripts “i” and “r” stand for “incoming” and “rebounding”, characterising the velocity or energy before and after the impact respectively.

About 150 impact tests have already been performed varying different parameters related to the ground (three granular materials with different internal friction angles, compacted or not; different slope inclinations), the block (weight) and the kinematics (impact angle, impact direction: inclined impact on horizontal ground or vertical impact on inclined ground). The influence of each varied parameter can be pointed out by a comparison of the data resulting from the different testing series.

Since the laws of similitude are not fully respected in small-scale tests, the results can only be interpreted qualitatively. In order to verify the applicability of the results for a correct quantification of the bouncing of rock blocks on natural slopes, a half-scale testing campaign is in progress. The procedure is analogous to the one adopted for the small-scale tests. Blocks weighting up to one ton are released from different heights (up to 10 m) to fall vertically on a horizontal or inclined surface of soil or rock. In addition to several parameters tested in small-scale, the impact velocity and the weight and shape of the blocks are varied.

The half-scale experiments aim at determining quantitatively the influence of the impact conditions and at putting forward mathematical expressions modelling the rebound phenomenon.

The implementation of these formulations in numerical codes should improve their prediction capacity.

Issues and Goals (Concept) of PhD thesis:

The rebound phenomenon, which occurs during rockfalls when a rock block impacts with a slope surface, is a complex and insufficiently known mechanism. It depends not only on parameters characterising the ground, but also on factors related to the kinematics and the block. Because of this lack of knowledge, a PhD thesis is undertaken at the Rock Mechanics Laboratory (LMR), EPFL. The aim is to develop mathematical expressions that model adequately the block rebound. Their subsequent implementation in rockfall computer codes should lead to a better prediction capacity for rock block trajectories and to a better delineation of areas at risk (hazard maps).

Methods:

The video registrations of the impact are analysed by means of an image processing software (WINalyze) to compute the successive positions of the block centre and of several marks on its surface. The translational and rotational velocities and energies of the block are then calculated for any moment of the impact.

To calculate the coefficients of restitution R_t , R_n and R_{TE} according to the formulations (1)-(3) shown above, the motion characteristics of the boulder before and after its impact with the slope have to be determined. The beginning of the impact is easily observed by a frame by frame analysis of the film, being the moment when the block gets in contact with the ground surface. The end of the shock, however, cannot be detected visually due to the projection of ground particles and a generally indistinct rebound of the block. The criterion adopted to solve this difficult point is inspired by the theory of shocks. In a plot of the evolution with time of the block's acceleration component normal to the slope, the end of the shock is defined as the moment when the graph reaches the value of zero.

Results (or expected results):

The results of the small-scale experimental campaign demonstrate the dependency of the rebound and the restitution coefficients not only on characteristics of the ground (compaction degree, friction angle, slope inclination), but also on factors related to the kinematics (impact angle, impact direction) and to the block (weight). Concerning the slope characteristics, the motion of the block during and after impact is found to be moderately influenced by the friction angle and significantly by the compaction degree and the slope inclination. The experiments emphasise also a clear dependency of the coefficients of restitution on parameters characterising the kinematics as the impact angle or the impact direction. They point out for instance that the more normal the impact is to the slope surface, the less the block rebounds. Finally, testing series performed with spheres of same diameter but different weight show an decrease of all restitution coefficients (corresponding to a lower rebound) for increasing block weight (or incoming energy as $E = \frac{1}{2}mv^2$).

The qualitative trends observed for the small-scale tests should be confirmed and quantified by the half-scale test results actually under examination. The development of a bouncing model and its subsequent implementation in existing trajectory codes is foreseen.



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Advisor: Dr. Vincent Labiouse

Title of research project: Rockfall trajectory analysis

Title of PhD Thesis: Geomechanical investigation of rock block bouncing during rockfalls

Date of begin and closure: May 2000 – May 2004

With the financial support of the Swiss National Science Foundation

Analysis of Strong Ground Motion Generated by a 3-D Vertical Strike Slip Elastic Fault Model Controlled by Rate/State Friction and Fault Zone Hydraulics

Hillers Gregor, Institute of Geophysics, ETH Zürich

Short Description of the PhD thesis:

The work carried out during the Ph.D. thesis will help to understand the physics of earthquake sources and the strong ground motions generated by them. Basis to these studies is a new developed, physically realistic numerical earthquake source model simulating the evolution of both elastic and hydraulic properties of the fault zone. By means of this tool I will be able to investigate rupture dynamics of a single event, the seismic wave field radiated from that source and the long-term evolution of a seismically active fault system.

Issues and Goals (Concept) of PhD thesis:

The overall goal of my studies is to investigate the role of fluids in the dynamic rupture process and their effect on strong ground motions. Since the designed source model accounts for both elastic and hydraulic properties of a vertical strike slip fault, I study effects of over-pressured fluid compartments within the seismogenic fault zone on the dynamic rupture initiation, propagation and termination. By coupling an earthquake's slipvelocity-time-function generated by the source model to a wave propagation code, I will be able to investigate the fluid effects on those radiated seismic waves responsible for the worst damage on human infrastructure. I will thus be enabled to make useful contributions in validating strong ground motion scenarios by studying their dependence on explicit rupture histories.

Methods:

The numerical earthquake source model consists of a 2-D vertical strike slip fault embedded in an elastic half space with homogeneous material properties. It is controlled by laboratory derived rate/state friction theory and an evolutionary model of the fault core's dilatancy and compaction. On the fault plane itself the evolution of elastic and hydraulic parameters are modelled, such as the surface contact state, shear stress, slip velocity, porosity of the fault zone and its pore pressure. This system of five coupled ordinary differential equations is solved by the numerical integration procedure DVODE, while the time step evolution scheme has been taken from Lapusta et al., 2000. Because of its intensive need of computational time the code will be implemented on parallel computer architectures. As Segall and Rice (1995) showed, diffusivity connecting the pore pressure state in the fault zone to the one in the elastic bulk controls the stability of the system. It turned out that undrained (sealed) and highly over-pressured fluid compartments are stable sliding in contrast to drained and unstable behaving regions of a fault system. Thus, I investigate the effect of stable sliding fault patches on the dynamic rupture propagation following the quasi-dynamic approach by Rice (1993).

Once the source time function on every fault's grid point has been generated it will be used as an input to a wave propagation code to compute strong ground motions in the vicinity of the rupturing fault. By comparing ground motions as a result of fluid affected ruptures to ground motions of smooth ruptures I want detect footprints of the sealed fault regions in the seismic wave field.

If stably sliding regions turn out to be detectable in synthetic seismograms an inversion for them in actual recorded ground motions would be a subsequent study.

Results (or expected results):

Simulations of the seismic source carried out so far show that sealed and over-pressured and thus stable sliding fluid compartments control the dynamic rupture propagation. Depending on the size of those patches, the rupture loops around them while putting stress onto them, and finally the overall system stiffness causes them to rupture as well. During that forced unstable sliding they sustain much higher stresses than the surrounding fault regions. This counterintuitive result may have an effect on strong ground motion generation, making it possible to detect those stable sliding regions. Furthermore, if the regions become large enough they behave like hydraulic barriers, i.e. they are able to arrest the rupture. This implies, that a presence of a very strong region called an asperity – which is usually considered to be responsible for rupture arrest – has to be reinterpreted for some cases, because the observed rupture termination is a result of a weak region on the fault.

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Title of research project: Large Earthquake Faulting and Implications for the Seismic Hazard Assessment in Europe (RELIEF)

Title of PhD Thesis: Analysis of Strong Ground Motion Generated by a 3-D Vertical Strike Slip Elastic Fault Model Controlled by Rate/State Friction and Fault Zone Hydraulics

Date of begin and closure: 01.09.2002 / 31.08.2005

Mountain forests under the influence of rockfall

Perret Simone, Dept. of Geography University of Bern

Short Description of the PhD thesis:

Rockfalls are major threats to settlements and traffic routes in large parts of the Alps. Therefore suitable measures have to be taken for public protection. Mountain forests might provide effective, sustainable and comparably cheap protection and their general protective function against rockfall is not questioned nowadays. However, little is known about the ideal properties of specific forest stands as far as a maximum protective effect is concerned. In order to meet this gap the European scientific project ROCKFOR, dealing with the interrelation of rockfall and forest, was established and the PhD thesis presented takes place within the framework of this project.

Issues and Goals of PhD thesis:

This PhD thesis contains two different approaches. The first approach is to develop a monitoring method for tree injuries in a selected forest stand affected by frequent rockfalls (stones < 0.5 m). Spatial patterns and temporal changes are registered and analysed. By means of dendro-geomorphological analyses rockfall frequency over the last 150 years is assessed as well. The second approach is to record trajectories of recent rockfall events (blocks > 0.5 m). The data collected are used in order to calibrate rockfall models and to make sensitivity analyses. Finally this PhD thesis should contribute to a better understanding of different factors influencing rockfall processes in mountain forests as well as of the interaction of these factors. Furthermore a method will be presented, showing how to document and interpret the current state of a protection forest.

Methods:

The test area (3000 m²) for the monitoring of rockfall injuries is located in Diemtigtal (Bernese Oberland, Switzerland), where at the foot of a high limestone cliff a subalpine Spruce forest stand grows on a steep slope. The monitoring out in the field involves two major steps: First the structure of the forest stand was assessed. For this purpose the spatial distribution of the single trees was determined by means of aerial photogrammetry and for every tree 10 general parameters such as species, diameter and height were recorded. In a second step of the monitoring, type and geometry of all externally visible injuries to every tree were registered. The injury type describes the wound – for example as “injury to the bark”, “injury to bark and wood” or “radial crack”. In order to obtain the geometry of the injury, eight parameters such as “height”, “maximal diameters”, “depth” and “azimuth angle” were measured. All data gained were stored in a database and visualised with diagrams and maps as well as analysed statistically and spatially.

After one year of monitoring activity, about one third of all trees in the test area were chopped down due to a bark beetle infestation. However, this unexpected event offered a great opportunity to have a look at the interior of some injured trees also. Therefore stem discs from 24 trees were sampled for dendro-geomorphological analyses. By means of these analyses questions about tree ages, number, type and size of the injuries and about temporal and spatial rockfall distributions are assessed. Finally the exterior and the interior view of rockfall damaged trees are compared.

Preliminary Results:

With the external monitoring for 157 trees, a total number of 1704 rockfall injuries was found, which is a mean number of 11 impacts per tree. However, the injuries show an uneven spatial

distribution. The mean injury height is about 85 cm and the mean injury diameter about 11 cm. The majority (63 %) of all injuries are located in a 90° sector around the fall line and 80 % of the injuries are totally healed over. The forest stand is characterised as a pole stage forest with a mean Diameter at Breast Height of 21 cm. Stems as well as stem diameters show an uneven spatial distribution. The highest stem density is found in the middle of the area, where mainly trees with small diameters grow, while in the upper and lower part of the forest stand, where larger diameters predominate, lower stem densities are encountered.

First results from the interior view via dendro-analyses show the following: Trees in the investigated forest stand have a mean age of about 150 years. Within 37 samples from 24 Spruce trees 119 directly visible rockfall injuries and 196 events dated via resin duct series were counted, which is a total number of 315 rockfall events. With only 27 % of all injuries wood was injured and the mean injury width is three to four centimetres. 73 % of all injuries are totally healed over and only 5 % of them are still visible from outside. Furthermore, the temporal rockfall distribution over the last 150 years shows a tendency for more events in the last 50 years, but there are also years with no events at all. Possible explanations for this trend are searched after further dendro-analyses and finally the exterior and interior view of rockfall injuries will be compared, with the aim to move on from the detailed inventory towards a more general view.

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Title of research project: ROCKFOR – Rockfall and Forest Interrelation

Title of PhD Thesis: Mountain forests under the influence of rockfall

Date of begin and closure: January 2002 – January 2005

Effects of the underground heterogeneities on the behaviour and the processing of landslides. Research by finite element modeling and application to the Triensenberg landslide (Liechtenstein)

Sierro Caroline, ENAC - GEOLEP, EPFL

Short Description of the PhD thesis:

The heterogeneities of the underground take part to the determination of hydrodynamics and geomechanics behaviour of landslides. Their spatial distribution being partially unknown, the aim of this PhD thesis is to test the uncertainty of actual numerical models (FEM) by means of different heterogeneity cases on the parameters field. It would allow to precise the efficiency of the stabilization methods.

Issues and Goals (Concept) of PhD thesis:

This study is motivated by the following fact: hydrodynamics and geomechanics models of landslides are very sensitive about the environment geometry on a small scale, that is to say the spatial distribution of parameters. These models are good and reliable at a landslide scale, but their quality may be affected by strong heterogeneities that we don't know in details.

Therefore the aims of this study are:

- Because we don't know the detail of parameters spatial distribution, we would like to test effects of heterogeneities on the parameters field by different scenarios. Thus we will be able to precise the uncertainty of our models. This can be translated in terms of stabilization methods efficiency and so in financial risks.
- By repeating this procedure on different landslides, we want to define a typology of geological context and of stabilization methods.

To complete this research, we have to answer to the following questions:

- According to the geological context and the heterogeneity degree, how will the stabilization methods be effective ?
- Which method would be the most appropriate to the case study : limited works (boreholes precisely located) or, in reason of the ground complexity, more expensive general works (gallery with multiple drains), which can be more successful because of their number ?
- Do we have lost causes for which the financial risk is too important according to the expected quality of models because of too large heterogeneities ?

The case of Triesenberg landslide (Liechtenstein) will be used as workfield for this PhD thesis. A corresponding research is dedicated to the La Frasse landslide (Vaud, Switzerland) and will allow a comparison between these two studies.

The teachings obtained from this thesis will find a direct application on various swiss cases, by choosing typical geological contexts. They will become a tool of risk and danger quantification in relation with landslides.



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Title of research project and PhD Thesis: Effects of the underground heterogeneities on the behaviour and the processing of landslides. Research by finite element modeling and application to the Triensenberg landslide (Liechtenstein)

Date of begin and closure: September 2003 - ?

Development of a continuous 3D-monitoring system for unstable slopes by Time Domain Reflectometry (TDR)

Valley Benoît, Ingenieurgeologie, ETH Zürich-Hönggerberg

Short Description of the PhD thesis:

Although in the last decade large progress has been made with the recognition, forecast, and damage reduction resulting from slope movements, they still cause high social and economic costs in Switzerland. Since landslides affect close to one tenth of the land surface in Switzerland (BWG, 1997), monitoring of unstable slopes is essential. Unfortunately, the high costs of monitoring systems limit their application.

Without exception, measurements of movements at depth don't escape to this problem. The most commonly used method utilizes inclinometric measurements, which are particularly expensive. A cheaper alternative for this type of deep measurement is the TDR (Time Domain Reflectometry) method.

This thesis, in collaboration with the drilling company Stump ForTech AG, aims to develop the TDR technique and apply it to various sites and configurations, in order to make validations for future market prospects.

Issues and Goals (Concept) of PhD thesis:

The goals of this thesis are to apply and improve the TDR measurement technique (e.g. with regards to the measurement stability, calibration, and quantification). A further goal is to implement field collected, high density temporal and spatial data, in a 3d-model, which aims to better understand the kinematics of the slope instability.

The measurement of the deformation by method TDR is comparable with the use of radar techniques (Dowding, 2001). In the TDR method, a pulse is sent via a coaxial cable installed in a borehole. The signal is propagated along the cable until it reaches a change in geometry caused by the deformation of the surrounding rock/soil. The impulse is then partially reflected and characteristic peaks are recorded. The return time of the signals make it possible to deduce the depth of the deformation and the amplitude of the signals is proportional to the intensity of the deformation.

This method was developed in the 1930's for the communication industry and was used for geotechnical measurements during the 1970's, mainly in North America for built structures and mine monitoring. In the 1990's the technique was first applied to natural slopes.

The advantage of the method lies not only in its low cost, but also in its facility of use and its flexibility. The system of measurement is well adapted for continuous and remote monitoring. A TDR measurement system can incorporate several cableprobes, which ensures a good space coverage. The TDR method offers a greater density of data than other systems available (e.g. inclinometric measurement, in-place inclinometers).

Methods:

The first phase of the project will involve laboratory work where various aspects of the method, such as exact installation procedures (type of cable, cement injection), the stability of connections and the analysis and treatment of the signal will be tested and developed. Various tests will also be carried out with the aim of calibrating the method quantitatively.

The second phase of the project will aim to calibrate the method *in-situ* by installing TDR cableprobes parallel to inclinometric borehole. It will be then possible to evaluate the quality of data with respect to different installation procedures and geological situations.

Finally the robustness and utility of the method will be demonstrated through continuous 3D Time Domain Reflectometry monitoring. The data obtained will be integrated with other available data such as topographic, geological, geodetic and surface measurements, in order to construct a 3d-model (using 3dec), which will allow a better understanding of the kinematics of the sliding slope.

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Title of research project:

Title of PhD Thesis: Development of a continuous 3D-monitoring system for unstable slopes by Time Domain Reflectometry (TDR)

Date of begin and closure: November 2003 - 2006

Rockslide processes and mechanisms – Investigation of the kinematics and internal structure of complex rockslides

Willenberg Heike, Geological Institute – Engineering Geology, ETH Zürich

Short Description of the PhD thesis:

This thesis is part of a large multidisciplinary study initiated with the aim to better understand the processes and mechanisms involved in brittle rock slope failure. Both field-based mapping and *in situ* measurements are directed towards identifying these processes. Key to any rockslide instability investigation of a natural rock slope is the knowledge of the geometry and the kinematics of slope deformation. Important geometrical parameters for the development of such a 3D-model include discontinuity orientation, spacing, persistence and connectivity, and the location of discrete surface features. More specific problems related to identifying geological structures promoting the instability and characterising likely failure processes are addressed through the combined monitoring of displacement patterns at surface and at depth, pore pressures and microseismic activity.

In summer 2001 a geotechnical and microseismic monitoring program was installed on an active rockslide within gneissic rock in the Swiss Alps (Randa, Valais) – integrating instrumentation systems designed to measure temporal and 3D spatial relationships between fracture systems, displacements, pore pressures and microseismicity. In combination with this monitoring program, geological and geophysical investigations were performed from summer 2001 to summer 2003.

Issues and Goals (Concept) of PhD thesis:

The thesis focuses on three key topics relating to the overall research project:

- i) the development of a 3D geological model to describe the internal structure of a sliding rock mass in crystalline rock and to characterise the structural features promoting the instability.
- ii) the analysis of the geotechnical measurements and integration of surface and subsurface displacement data towards a kinematical model of the unstable rock slope.
- iii) numerical modelling of kinematics and displacement patterns with respect to different geological scenarios within an unstable rock slope.

Methods:

The description of the internal structure of an unstable rock mass is obtained through a combination of geological mapping, detailed discontinuity mapping (both at surface and in boreholes), and active geophysical testing. In order to obtain 3D-information on subsurface structures and displacements, three boreholes were drilled to depths of 120, 50 and 50m. Another nine shallow boreholes (5m deep) complement the borehole array, mainly to improve the resolution of the microseismic network. After borehole drilling, caliper/borehole-trajectory and spectral gamma wireline logs were run, and then surface-to-borehole and cross-hole radar and active seismic experiments conducted. In addition, fracture-imaging logs were run in the boreholes to attempt to image the key structures. After completion of the borehole geophysics tests, the holes were cased with grooved PVC inclinometer casings cemented into place. The 120m deep casing also had outer steel rings spaced at 1m intervals for an induction coil transducer extensometer system. The casings are surveyed every spring and autumn. Coaxial cables for time domain reflectometry (TDR) measurements were also attached and cemented along the outside of

the casings to provide a secondary comparison and backup to the inclinometer measurements. To determine the detailed time-history of the displacements along active fractures during the inter-survey period, two in-place biaxial inclinometers were installed across prominent fractures in the 120m borehole. For similar reasons, two automatic continuous recording surface crackmeters were recently installed to supplement the manually-surveyed, surface benchmark array. As well, pressure sensors were installed and packed off at the bottoms of the three deep boreholes.

Results (or expected results):

Initial analyses integrating geological mapping results and surface and borehole geophysics suggest that the geological mapping results can be constrained by comparison with the geophysical investigations (and *vice versa*). The construction of a local fracture model integrating tomographic seismic and reflection georadar datasets is planned. Borehole inclinometer and extensometer data were found to be very useful in defining the 3-D displacements within the rock mass. However, it was necessary to correct the inclinometer data for two sources of error in order to resolve the relatively small displacements that are typical in instabilities in crystalline rock. Displacement vectors for surface fracture opening could be measured with a specially designed tool.

These data suggest that the rock mass can be divided into blocks delineated by several fracture sets and faults. For each block, and the “active” fractures between them, block displacement vectors could be calculated and compared to surface fracture opening directions and geodetic surface displacement monitoring results.

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Title of research project: Rockslide processes and mechanisms – Progressive Development of shear/slide surfaces in rock slopes

Title of PhD Thesis: Investigation of the kinematics and internal structure of complex rockslides

Date of begin and closure: 06/2000 – 05/2004

Avalanches/ Glaciers / Permafrost

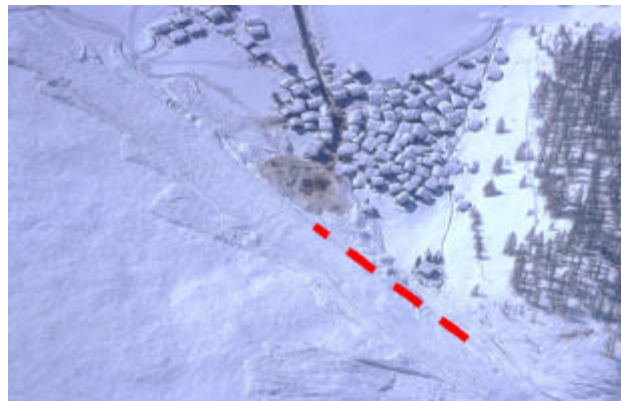
Dimensioning of snow avalanche catching and deflecting dams

Baillifard Marc-André, Swiss Federal Institute for Snow and Avalanche Research, Davos Dorf, CH

Short Description of the PhD thesis:

There is actually no way to assess the efficiency of snow avalanche catching and deflecting dams. Up to now, the dimensioning of such dams has always been done empirically.

The catastrophic 1999 avalanche winter has shown the limit of this dimensioning method: several dams have been overflowed. In some cases, this has led to the destruction of several buildings (see figure below).



To avoid such events in the future, it is essential to get a better understanding of the interaction between snow avalanches and dams, in order to give these dams the right dimension.

Issues and Goals (Concept) of PhD thesis:

The main goal of this project is to provide a guideline to civil engineers for the building of avalanche catching and deflecting dams. To do this, it is essential to get a better understanding of the interaction between snow avalanches and dams.

The main difficulty of this project lies in the fact that we actually don't know much about the dynamic of the interaction between avalanches and dams. All the models actually used to describe the movement of avalanches along a track are using the height averaging assumption, thus reducing the problem to a one or two dimensional problem. However, this assumption clearly does not apply in the case of an avalanche hitting a dam, which is clearly a 3 dimensional problem.

Methods:

At the first stage, studies of the interaction between avalanches and dams will be purely experimental. Two kinds of experiments will be conducted:

- Experiments with small glass particles simulating the snow avalanche. The glass particles, placed in a container, are released on an inclined plane, which simulates the avalanche track. A dam is placed at the lower end of the plane.

- Experiments with real snow. The SLF (Swiss federal institute for snow and avalanche research, Davos) has built a 34 meters long chute to simulate real snow avalanches. This chute will be used to simulate the interaction between snow avalanches and dams.

In parallel, some field measurements on avalanches which have hit a dam will also be carried out, in order to compare the experimental results with real events.

A numerical DEM model simulating the interaction between small particles will also be used to simulate the interaction between snow avalanche and dam.

Results (or expected results):

The main result of this study will be a better understanding of the interaction between dams and avalanches.

A practical result of this better understanding will be a guideline for the building of avalanche deflecting and catching dams.

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Title of research project: Dimensioning of avalanche dams

Title of PhD Thesis: Dimensioning of avalanche dams

Date of begin and closure: 01.02.2003-01.02.2005

Thawing of frost-susceptible soils in the foundation of roads and railways, and in mountain permafrost

Dysli Michel, Soil mechanics laboratory, EPF-Lausanne

Short Description of the PhD thesis:

Curiously, the *thawing* of frozen soils containing ice lenses has been the subject of only a few, basic studies even though it is the cause of the greatest construction damage. The decrease in shear strength due to the thawing of such lenses is a destructive, and therefore costly, phenomenon which concerns roadway infrastructures and railway lines as well as the thawing of mountain permafrost by global warming. The thesis will seek to explain, at the thermal, hydraulic and mechanical levels, how ice lenses melt and how the water produced by thawing acts on soil strength. To accomplish this, the thesis will use freezing and thawing tests carried out in a large cell, numerical simulations of real cases with one or more coupled models (hydrothermal coupling in particular) using existing codes with little or no modification, and a more detailed interpretation of full-scale freezing and thawing tests carried out on roadway structures several years ago.

- freezing and thawing tests carried out in a large cell, if possible triaxial, including measurements of temperature, non-frozen water content (using TDR gauges) and capillary suction. This cell will be partially developed in the framework of this thesis ;
- numerical simulations of real cases with one or more coupled models (hydrothermal coupling in particular) using existing codes, with little or no modification ;
- a more detailed interpretation of full-scale freezing and thawing tests carried out on roadway structures several years ago in a large test pit.

Issues and Goals (Concept) of PhD thesis:

The first focus is the solution of unresolved questions, for instance:

- Numerous measurements on the roads show that the melting of ice lenses is very rapid. Why? This is due to the latent heat of fusion of the ice which must be entirely “consumed” for the ice to melt. However, a cube of ice in a glass of water don't melt quickly!
- Where does the water go during the thaw of ice lenses?

The second focus is to provide some basis for the new trend in design standards of the road and of railway pavements. Today almost all design methods are empirical, but the trend is to write standards based on more rational methods resulting from the rules of the continuum mechanics and stress-strain behaviour of the soil described, during the thawing, by the resilient moduli.

In addition, the research can lead to an improved understanding of the melting of mountain permafrost by global warming.

Methods:

Laboratory testing

A new sophisticated testing device was designed and manufactured at the Soil mechanics laboratory of the EPFL. New methods of measurement were developed, tested and calibrated, especially a movable micro-camera (endoscope) buried in the sample to record the process of the melting of the ice lenses continually and the measurement of the strains in the sample by X-ray

photography of lead shots. These strain measurements allow the determination of resilient moduli in each layers (frozen, unfrozen, in thawing) of the sample.

Interpretation of tests carried out several years ago

A more detailed interpretation of full-scale freezing tests carried out on roadway structures in a large test pit.

Numerical simulation

On the basis of the test results and of the detailed interpretation of full-scale tests, numerical simulation of real cases with one or more coupled models (especially hydrothermal coupling) using existing codes with little or no modification.

Results (or expected results):

Today, after many difficulties, the testing device with all the gauges and apparatus is, in part, usable and two tests have been carried out. In addition, the numerical simulation has been mastered.

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Title of research project:

Title of PhD Thesis: Thawing of frost-susceptible soils in the foundation of roads and railways, and in mountain permafrost

Date of begin and closure: 21.9.2001 – end 2004

Nowcasting nocturnal cloud cover and surface state

Grimbacher Tobias, Institute for Atmospheric and Climate Science (IACETH), Swiss Federal Institute of Technology, Zurich

Description and goals of the PhD thesis:

Road weather forecasting is one of the key topics of today's meteorology. Worst cases in road weather are those who lead to unexpected slipperiness, caused by snowfall, rain falling on supercooled ground or freezing rain water after (postfrontal) clearing. Slippery conditions often come along with cloud effects like clearing. Cloudiness, especially the advection, formation and dissipation of clouds and their interaction with surface temperatures, leads to the biggest unsolved problems for winter road weather forecasts.

The goal of this thesis is to investigate a method to calculate clouds out of surface near temperature measurements. In a spatial network this cloud information probably can be tracked together with radar precipitation data. On a scale of 1-3 hours, a forecast of clouds, clearing and precipitation is achievable. This will contribute to a better predictability of winter slipperiness and other risks connected with radiative cooling.

Methods:

Three data sets are used in the thesis: The radar composite of MeteoSwiss, the ANETZ data and a road weather measurement system operated by the road inspection office of the canton of Lucerne in central Switzerland. At six ANETZ stations several surface near temperatures, wind, etc. are measured and cloudiness is observed. In the canton of Lucerne 52 stations measure the most important road weather parameters like surface near temperatures, precipitation and wind, but no cloud information is available.

Cloudiness and the difference T_{diff} between air and surface temperature both are parameters of the radiation balance. Hence, a relationship of the type $N=c+\exp(b\cdot T_{diff}-a)$ could be developed, with N as a height-depended cloud amount and a , b , c only depending on wind speed and temperature. For nocturnal winter cases in Payerne, this relation leads to a correlation coefficient of 0.90. The use of the equations retrieved in Payerne at other ANETZ station leads to correlation coefficients between 0.74 and 0.88. An indirect comparison with the road weather stations shows similar results.

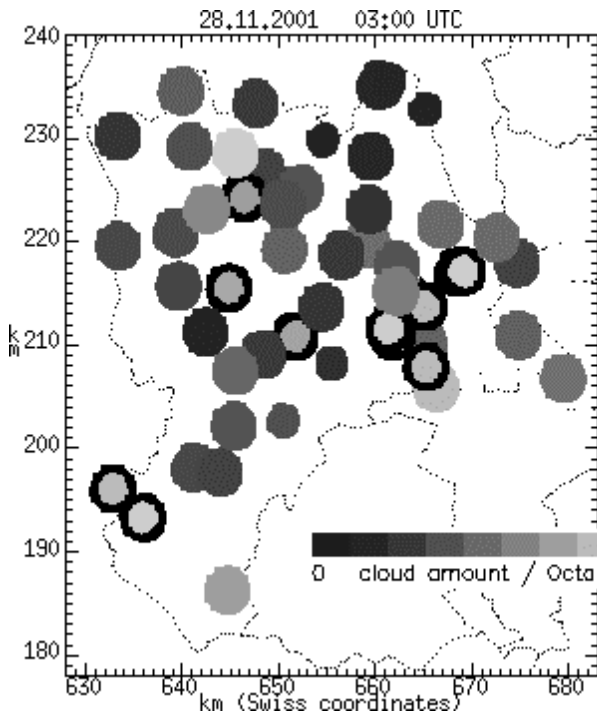
Some problems of the relationship are fog, evaporative effects after rain or snowfall, reduced sky view in mountainous regions and aftereffects of solar heating especially at the road weather stations.

Results and outlook:

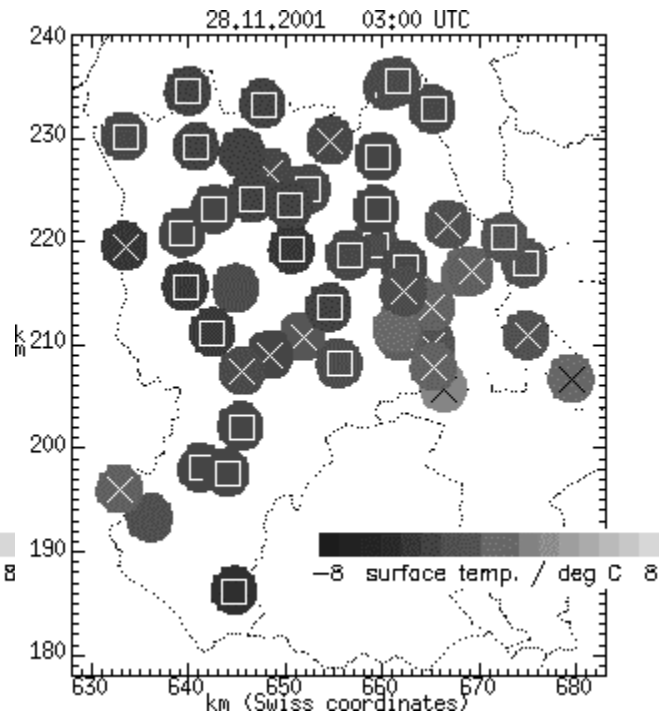
By using the developed equation at all 52 road weather stations in the canton of Lucerne, cloud maps can be calculated. Until yet, a few case studies has been done.

In the case shown below, the advective motion of a nearly cloud free area after a cold front passage is detected. The clearing was coupled with radiative cooling and followed by a decrease in surface temperature and a switch in surface state from wet to frozen. Some stations are indicated as foggy. Their calculated cloud information is overcasted but the surface temperatures decreased as well. Only few stations in the presumably cloud free north-western part of the canton rested at a high value of calculated cloud amount but without fog. This is probably due to shading by mountains. Otherwise the effects of latent heat flux and melting heat should be taken into account.

At this state of the studies the results of a station should not be used blind and exclusively, but several neighbored stations give a good idea for the real cloud situation of a region.



*Calculated cloudiness in the canton of Lucerne.
Circles around the symbols indicate fog.*



*Surface temperatures and road conditions. No
symbol: dry, cross: moist or wet road, square:
frozen or iced condition.*

In the created maps both the motion of precipitating areas and the advection, foundation and dissipation of cloud fields can be identified.

Spatial precipitation information measured by radar already can be nowcasted with tracking algorithms like COTREC. As a next step the gathered cloud information should be combined with radar precipitation fields. Prospectively it is possible to track them together and to create high resolution forecasts of cloudiness and surface state out of them.

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Title of research project: -

Title of PhD Thesis: Nowcasting nocturnal cloud cover and surface state

Date of begin and closure: October 2001- October 2004

Influence of avalanche loads on snow sheds

Platzter Katharina, Swiss Federal Institute of Snow and Avalanche Research, Davos Dorf, CH

Short Description of the PhD thesis:

Snow sheds are used in alpine regions to protect transportation routes from avalanches. They are massive structures that must withstand both the static and dynamic forces from snow avalanches. Static forces arise from the snow cover and when avalanches, or other debris, come to rest on the roofs of the shed. Dynamic forces arise from shear stresses exerted by dense avalanches as they pass over the roof. The dynamic forces are a function of flow velocities and heights as well as the coefficient of dynamic friction between the shed and the avalanche. The flow velocity of the avalanche is given by the mountain terrain of the avalanche track. It is often difficult to define the design load as well as the correct length of these structures. A series of scale experiments using granular materials in laboratory experiments and using snow in field experiments, that provide insight on the shear stress distribution exerted by flowing avalanches, will enable us to optimise the design procedures of snow sheds.

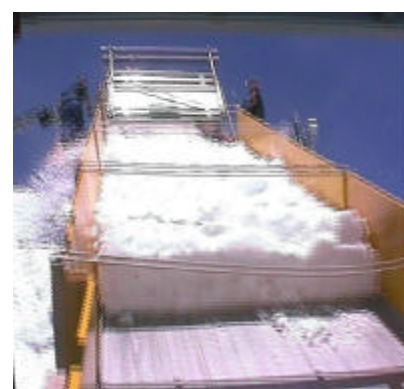
Issues and Goals (Concept) of PhD thesis:

In this project both field and laboratory experiments will be used to investigate the distribution of dynamical normal and shear forces acting on a snow shed. From these measured normal and shear forces we can deduce the coefficient of friction, considering variable surface rigidities. Our goal is to develop a law that realistically describes force distribution after a deviation of flowing avalanches and to find out the dependencies of the coefficient of friction.

Methods:

In order to reach these goals we are performing granular experiments in a laboratory chute, where normal and shear forces of granular avalanches as well as the flow velocities and flow heights in function of time before and immediately after a deviation on a snow shed can be exactly measured.

Furthermore experiments with snow on the chute situated at Weissfluhjoch will be performed with the same measurement techniques and devices equipment as the experiments in laboratory.



Additionally the study of a flowing avalanche on a snow shed will also be performed with a discrete element model.

Results (or expected results):

The aim is to optimise the Swiss directive “impacts of snow sheds” with the results from the force measurements of avalanche forces and to elaborate a friction law for dense flow avalanches.

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Title of research project: Influence of avalanche loads on snow sheds

Title of PhD Thesis: Influence of avalanche loads on snow sheds

Date of begin and closure: 15.9.2002 – 15.9.2005

Ice-bed coupling of sediment based glaciers

Rousselot Marie, VAW-Glaciology, ETH Zürich

Short Description of the PhD thesis:

Since the recognition that many glaciers and ice masses overlies soft sediment rather than hard bedrock, much research has been undertaken to investigate how mechanical and hydrological conditions of a deformable substrate control the coupling at the ice-bed interface and thus affect fast ice flow and glacier surging. A transitional state between sliding and bed deformation entitled 'ploughing' can occur when clasts that protrude into the glacier sole are dragged through the upper layer of the sediment. For rapidly sliding glaciers, excess pore-water pressures may develop downglacier from ploughing clasts such that sediment there weakens and provides little resistance to glacier motion. Thus, instead of these clasts leading to a strong coupling at the ice-bed interface, the ploughing process may help decouple the ice from the bed. A combined field and laboratory study is aimed at testing this hypothesis.

Issues and Goals (Concept) of PhD thesis:

By exploring factors that control the coupling at the ice-bed interface and the resulting distribution of motion at the base of soft-bedded glaciers, the goal of this PhD study is to identify and characterize the processes that enable rapid motion associated with ice streaming and glacier surging.

Methods:

Systematic laboratory experimentations are combined with field investigations on Unteraargletscher, Switzerland. In July 2002, newly designed ploughmeters were installed into boreholes reaching the bed. Sediment strength, pore-water pressure in front of the ploughmeters and subglacial water pressure were simultaneously measured for a period of one year. These records will be linked to high temporal resolution GPS velocity measurements, conducted during five days in July 2003, to assess the degree of sediment weakening caused by excess pore-water pressure as a function of glacier speed.

A laboratory apparatus (rotary ploughing device) is currently under construction. This device will offer the possibility to conduct ploughing experiments by dragging instrumented objects through sediment under realistic subglacial conditions. Simultaneous measurements of the drag on these objects and the pore-water pressure in the sediment can then be used to investigate systematically the influence of sliding velocity and sediment properties on ice-bed coupling.

Results (or expected results):

Diurnal variations in water pressure recorded at the base of boreholes were strongly correlated with variations in pore-water pressure recorded in the sediment underneath. Cross correlation analysis showed that the fluctuations in pore-water pressure were leading those in borehole water pressure. Furthermore, the amplitude of the pore-water pressure signal was larger than that of the borehole pressure signal.

In combination with measured diurnal variations in surface velocity, these findings suggest that temporal changes in glacier speed lead to changes in the degree of excess pore-pressure generation in front of the ploughmeter. A potential gradient may therefore exist across the water-sediment



interface at the base of the borehole, which varies temporally in accordance with fluctuations in excess pore-pressure. The resulting water pressure waves propagate through the pores of the sediment and drive pressure changes in the borehole.

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Title of research project: Flow dynamics of glaciers

Title of PhD Thesis: Ice-bed coupling of sediment based glaciers

Date of begin and closure: November 2001 – October 2004

Risk Management/ Risk Evaluation

“Le Management des Risques Naturels et la Gestion des Sinistres“ en Milieu Urbain

Abdenbi Yassine, Institute of Architecture and Urban planning, University of Geneva

Short Description of the PhD thesis:

Focus on the specific case of Algiers's flooding, November 11th 2001. Diagnostic of the events:

1/ Causes of the disaster

2/ Evaluation of the existing tools and processes

3/ Optimization of the existing tools and proposal of additional processes.

Issues and Goals (Concept) of PhD thesis:

Providing an information system of provisional and operational concepts for the management of natural hazards in third world urban areas.

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Title of research project:

Title of PhD Thesis: Management of natural hazards in urban areas

Date of begin and closure: March 2004 till March 2007 / EPFL (Lausanne)

Risk Management of Natural Disasters in Mexico

Claudia Flores-González, Institute of Insurance, University of Karlsruhe (TH)

Short Description of the PhD thesis:

In some developing countries, the government plays a fundamental role to absorb the losses of Natural Disasters. The low insurance density, the poverty and the macroeconomic problems are some causes of the low participation of private capitals in the Risk Management of Natural Disasters in these cases.

Mexico is a developing country with a large experience in natural disasters of almost all types. Furthermore, it is one of few countries that has a Natural Disasters Fund. For this reason, the case of Mexico is important to be analyzed. Some of its experience can be applied to improve the implementation and management of natural disaster funds in other countries.

As Natural Disaster we understand “the natural phenomena or phenomenon, whether concatenated or not, which occurrence within a time and space limits are cause of severe damages and whose recurrence is difficult or impossible to foresee” (cf. FONDEN’s Mandate (2003)). The main goal of Mexico’s Fund for Natural Disasters (FONDEN) is to mitigate the effects of natural disasters whose magnitude surpass the capacity of answer of local governments and public federal entities. FONDEN can provide economic resources for

- the reestablishment of the normal functioning of governmental entities,
- the reconstruction of non-insurable infrastructure,
- the help for the low-income victims
- the acquisition of specialized equipment and
- the restoration of cultural and historical patrimony.

FONDEN's assistance should be provided within a budget established at the beginning of every fiscal year. Almost every year since its creation, FONDEN's resources have been insufficient to meet all the government obligations established in FONDEN's Mandate. The process of budgetary planning of such a fund is complex and often politically difficult (cf. Freeman (2002)). In 1998, for example, six changes to the budget were required to provide additional funds for natural disasters. The same year, 2558.6 millions of pesos (of the year 2000) were authorized and 4175 millions of pesos (of the year 2000) were required (cf. SHCP (1999)).

The responsible of managing FONDEN is the Ministry of Finance and Public Credit (SHCP), but the Ministry of the Interior (SEGOB) manages the resources to attend emergencies. In case of imminent danger or high probability of disaster, SEGOB can declare a situation of emergency and provide resources to attenuate the effects of the possible disaster. For the fiscal year 2001, for example, 20 millions of pesos for emergencies were approved. The resources administrated by SHCP are divided into two parts: budget and trusteeship. FONDEN's trusteeship acts as a reserve and it is constituted with the annual surpluses of FONDEN's budget.

As we mentioned above, FONDEN's rules of operation establish that in case of high probability of natural disaster or imminent danger, the local governments can ask for a declaration of emergency to get resources faster from FONDEN. So, they can take measures in order to attenuate the effects of the possible disaster. For this reason, it becomes desirable the development of a mathematical model considering this type of outcome. Starting from FONDEN 's example, we develop a dynamic strategy to optimize the management of a natural disasters fund with similar

characteristics by controlling the level of the fund's cash for the year $T((R_t^{(T)})_{T-1 \leq t \leq T})$, where $T=1,2,\dots, n$. The optimality is in the sense of

$$\min\{E[(c - R_T^{(T)})_+^2] - \ln(F_T)\}, \quad (1)$$

where the constant c is the objective value for $R_T^{(T)}$ and $(F_t)_{0 \leq t < \infty}$ is the level of reserves, which in our case study corresponds to FONDEN's trusteeship. The control variable is the amount taken from the reserves (\tilde{u}_t) . We assume that the payments for risk transfer are made at $t = 0$. We determine the constant $c > 0$ at $t = 0$ and then we try to pull at every moment the process to this objective, considering the necessity of building reserves.

Issues and Goals (Concept) of PhD thesis:

The aim of the project is the development of a dynamic strategy using stochastic control to optimize the management of a fund for natural disasters in the framework of a risk-averse government, which is the case of Mexico. The optimality is meant in the sense of minimizing the risk measure (1). The problem of budgetary planning is also considered for the modeling.

Methods:

Risk Theory, Stochastic Control, Multifractal Measures, Extremal Events Statistics

Results (or expected results)

An analysis of the functioning of FONDEN was made as well as a comparison between the current and the past rules of operation. Starting from this study, we make the mathematical modeling from a governmental perspective.

Given the difficult economic situation in developing countries, it is not possible to ask for a large amount of money without a very well founded explanation about the estimation of the initial budget. We should estimate its minimum value.

In the private industry, it is theoretically allowed to allocate funds to the reserve at every moment. In the case of our governmental fund it is not so. The moment and the amount of the contributions are restricted. Our fund is linked to a trusteeship that has the function of reserve. If at the end of the fiscal year not all the money was disbursed, this residual will be transferred to the reserve. This is the only valid way to build it. This restrictions explain why we didn't consider the problem of minimizing ruin. In our case, to improve the budget planning in order to hedge a predetermined contribution to the reserve is more important than avoiding ruin along the year. Thus, we identify the deficit with respect to a scheme of annual contributions for the reserve as the main risk.

We distinguish in our model the warned from the not-warned natural disasters and we assign costs for the false warnings and we consider the positive effect of a good warning. The quality of the warning system is not a central point for the modeling, but its impact and the modelation of outcome's moments.

The possibility of using return periods for extreme rainfall events from a multifractal model for rainfall is being considered as an alternative to extreme-events statistics.

Finally, we wish to remark that, according to our study, the temporary unavailability of emergency resources, as well as the positive effect of a good warning, are of relevant influence for budgetary planning, transferring risks and determining an optimal management strategy.



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Title of research project: Risk Management of a Governmental Fund for Natural Disasters

Title of PhD Thesis: Risk Management of Natural Disasters in Mexico

Date of begin and closure: 1/5/2001-31/4/2004

Geohazard and risk: change through time and space in Wellington, New Zealand

Hufschmidt Gabriele, Department of Geography, University of Bonn, Germany / Institute of Geography, Victoria University, Wellington, New Zealand

Short Description of the PhD thesis:

The study will analyse the temporal and spatial variability of risk as a result of landsliding. Wellington city, New Zealand, is suggested as an urban study location; the considered time span encompasses several decades. Causes, correlations and interaction between the factors determining risk will be identified and assessed. The temporal and spatial variability of these factors will not only be a basis for understanding the actual risk level, but also to estimate future trends, which will be modelled in scenarios. Developing a methodology of a dynamic risk level analysis, i.e. regarding temporal and spatial variability, and its implementation is a crucial aspect of the study. Emphasis is placed on the transferability to other regions. The results of the project will support risk-management and serve as a tool to optimise future strategies of damage reduction. Moreover, the study will answer the question if an increased level of risk is caused by changes of natural processes or human activities.

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Title of research project:

Title of PhD Thesis: Geohazard and risk: change through time and space in Wellington, New Zealand

Date of begin and closure: Feb 2004 - 2007

Flood damage prevention by means of planning instruments

Kipfer Andy, Institute of Geography, University of Berne

Short Description of the PhD thesis:

Flood events during the last years in Switzerland (1987, 1993, 1999, 2000, 2002) have shown that a complete protection from floods by using technical measures only is unrealistic and cannot be afforded. “Weak” planning measures – like taking into account of hazard zones in local planning and reducing the damage potential, but also an optimised event-management or an improved information of the endangered population – have to be included. These instruments are all part of an integral risk management system.

On the one hand, the study describes within the framework of an IRMA-Project (Interreg Rhine-Meuse Activities), possibilities to improve the use and implementation of “weak” flood protection instruments. On the other hand, two case studies compare risk management systems according to “theory” with concrete cases in practice.

Issues and Goals (Concept) of PhD thesis:

A first goal of the study is to provide, based on the analysis of existing planning instruments, procedures and recommendations to make the implementation of new protection measures easier – e.g. in the field of hazard zoning.

During a flood event reasons for problems are often not based on the lack of instruments, but rather on an insufficient implementation, co-ordination or communication of decisions. A second goal is therefore, again with taking into account existing instruments, to work out guidelines and fact-sheets for flows of information and communication techniques – for the periods before, during and after a flood event. This should also help to improve public awareness of flood danger, which is a third goal of this study.

In theory, various risk management concepts exist. A fourth goal is to analyse their practical implementation with the aid of two case studies (City of Thun and Schwarzenburg (both Canton of Berne)). This should also contribute to a better understanding of possible problems associated with the realisation of flood protection concepts.

This should contribute to draw a clearer picture of the possibilities and limits of “weak factors” in flood protection and – as far as possible – enable to calculate their benefits.

Methods:

The research is based on the analysis of existing planning instruments and on carrying out case studies in different regions of Switzerland. The case studies are mainly held in regions which have been affected by the flood event of May 1999 (e.g. City of Basel, City of Thun and Lake of Constance). Interviews with authorities, insurance companies and inhabitants help to investigate the knowledge and awareness of flood danger. Discussions with experts should make it possible to identify today's problems with the implementation of planning instruments in practice.

Results (or expected results):

The thesis concludes with recommendations, guidelines and checklists to assist actors in flood risk prevention and in preparing for event management. This should help to improve the use and implementation of existing planning instruments.



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Title of research project: IRMA – SPONGE: Development of spatial planning instruments to improve river flood prevention and awareness

Title of PhD Thesis: Flood damage prevention by means of planning instruments

Date of begin and closure: 06/2000 – 11/2004

Risk evaluation of natural hazards (with special consideration of risk aversion)

Plattner Thomas, Chair of Forest Engineering, Dep. of Forest Sciences, ETH Zürich

Short Description of the PhD thesis:

The theoretical understanding and modelling of the evaluation of risk is most advanced in the domain of technical risks, and only little is known about the evaluation of risks due to natural hazards. On behalf of three federal offices (BWG, BZS, BUWAL) and PLANAT (National Platform on Natural Hazards), the present research project aims at investigating the socioeconomic and psychological basis of natural hazard risk evaluation and its implication for risk management activities by local and especially federal authorities. Based on a survey of the literature on risk perception and risk evaluation, the fundamentals of risk evaluation of natural hazards are determined.

Among the factors affecting risk evaluation, a special focus is placed on risk aversion. Risk aversion is the increasing reluctance to accept risks with increasing expected extent of consequences even if the risk itself (defined as the product of frequency and extent of consequences) remains constant. Currently, risk aversion is incorporated using two different approaches. The implicit consideration, often used in regulatory applications (e.g. in the Swiss ordinance on Technical Hazards [Störfallverordnung], BUWAL 1991), is based on an acceptance or boundary line presenting constant risk in a double-logarithmic *F-E-diagram* (F = frequency, E = extent of consequences). To take into account the risk aversion, the gradient g of the boundary line B has to be $g(B) < -1$.

Introducing aversion terms, usually either as factors or as exponents, is the explicit way of considering risk aversion, resulting in a perceived risk R_{perc} . As a lot of the important risk perception affecting factors are not included in such an aversion term, the resulting risk should be called an aversion-corrected risk R_{AC} . This can be calculated as either

$$R_{AC} = F \cdot E \cdot a(E)$$

or as

$$R_{AC} = F \cdot E^{a(E)}$$

using a multiplicative or an exponential aversion term $a(E)$, which depends on the extent E of consequences. For both the multiplicative and the exponential risk aversion terms, the relations $a(E) > 1$ and $da/dE > 0$ generally hold, i.e. risks with a greater extent are artificially and progressively increased (while the acceptance criteria are assumed constant).

Issues and Goals (Concept) of PhD thesis:

For supporting those active in risk management, an improved definition and understanding of the phenomenon risk aversion should be provided. Such an approach must not be limited to the extent of expected consequences, but it must also consider what those affected and the society think about the relevance of the consequences of an event. To adequately consider risk aversion in the risk management process, it is thus essential to know what the criteria are for deriving a value of the risk aversion term $a(E)$.

A preliminary set of factors for defining and estimating risk aversion contains the following elements:

- Objective risk, particularly the expected extent of consequences.
- Tolerance criteria. Since the magnitude of the potential consequences is relevant, the scale for judging this magnitude is also important (e.g. the potential difference between events resulting from an involuntary and from a voluntary activity).
- Effects for the stability of the system considered.
- Speciality of a risk (extraordinary vs. normal events).

Using this theoretical framework, the project aims at developing a scientific, yet practically usable method for modelling the risk evaluation by the affected population. Such a model can then be used by the authorities to get a more accurate estimate of the public's risk evaluation should risk management measures be planned.

Methods:

The model is developed in a multiphase procedure. After the derivation of the determinants of risk evaluation and risk aversion, based on the current state of knowledge about risk perception (literature survey, empirical data), the official handling of risk evaluation and the determination of theoretical models of risk evaluation is studied. In a next phase, the correlation between the survivability of systems and the risk aversion is investigated. This includes the relevance of the identified weighting factors and the correlation between perceived and actual devastation. Based on this input, a model for estimating the risk evaluation (including, but not limited to, risk aversion) is then developed using standard modeling techniques. In a final phase, the model is tested, calibrated, and evaluated and subsequently revised (if necessary).

Results (or expected results):

The research shows that the current approach of considering aversion in the risk management process uses it as a substitute for a whole set of factors affecting risk perception *PAF*. In this concept, the aversion is reduced to a simple function of the extent of expected consequences C_{exp} according to

$$a(E) = f(C_{exp})$$

and consequently, other aspects of risk aversion and the other perception factors remain unaccounted for. The result of the explicit consideration of aversion, often referred to as perceived risk R_{perc} , is thus really an aversion corrected risk R_{AC} . For an adequate consideration of the risk evaluation process, the perceived risk R_{perc} has to be calculated according to

$$R_{perc} = f(PAF, R_{obj})$$

so that all the perception affecting factors (*PAF*) are included, not only the risk aversion as one of them.

The survey of previous research resulted in a list of *PAF* factors and a compilation of aspects that have to be taken into account for the redefinition of risk aversion. Both the list of *PAFs* and the aspects of risk aversion currently are reviewed in a Delphi-procedure involving experts from various fields. The results will provide a basis for redefining risk aversion and reassessing risk evaluation.



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Title of research project: Risk evaluation of natural hazards

Title of PhD Thesis: Risk evaluation of natural hazards

Date of begin and closure: Februar/August 2002 – Februar 2005

Earthquakes

Signature of historic and prehistoric earthquakes in lake sediments of Central Switzerland

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Short Description of the PhD thesis:

In Central Switzerland the historic record since AD 1300 show significant levels of seismicity, including five earthquakes with intensities of VII to VIII (European Macroseismic Scale, EMS). The strong earthquakes are considered to have recurrence intervals of several hundreds to thousands of years. In order to obtain reliable data about seismic hazard and risk the earthquake history of Central Switzerland has to be extended further back into the Holocene. Lake deposits in particular are regarded as most suitable for the study of seismically induced deformations. Different lake deposits in Central Switzerland were studied in order to find traces of historic as well as prehistoric earthquakes.

Issues and Goals (Concept) of PhD thesis:

The aim of the present study is the reconstruction of the Holocene earthquake history of Central Switzerland using deformation structures in recent lake deposits. Four lakes in Central Switzerland with different sedimentary processes distributed within an area of 2000 km² were investigated using high-resolution seismic data and sediment cores. Deformation structures identified both in the seismic lines and in the sediment cores are described and dated. Special emphasis has been placed on small-scale in-situ deformation structures.

Methods:

High resolution seismic and study of sediment cores.

Results (or expected results):

Deformation structures in lake deposits occur within distinct zones and include large-scale slumps and rockfalls, as well as small-scale structures like disturbed and contorted lamination and liquefaction structures. The deformed horizons are dated by historic environmental changes and climate data, ¹³⁷Cs activity and radiocarbon ages. They can partly be attributed to historic earthquakes. This allows the recognition and calibration of earthquake-induced deformation structures also in prehistoric lake sediments and can be used to extent historic earthquake records further back into the Holocene.

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Title of research project: Paleoseismology in Switzerland

Title of PhD Thesis: Signature of historic and prehistoric earthquakes in lake sediments of Central Switzerland

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