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OPEN PARTIAL AGREEMENT ON THE PREVENTION OF, PROTECTION AGAINST, AND ORGANISATION OF RELIEF IN MAJOR NATURAL AND TECHNOLOGICAL DISASTERS

# ACTIVITIES 2005 - REPORT


## CERG –

**European Centre on Geomorphological Hazards**
3, rue de l'Argonne
F–67083 STRASBOURG Cedex
Tel: 00 33 (0)3 90 24 09 11 Fax: 00 33 (0)3 90 24 09 00
E mail : cerg@equinoxe.u-strasbg.fr
http://cerg.u-strasbg.fr

# 1. Research activities in 2005

## 1.1 Programme earthquake-induced landslides in the NW Apennines

**University of Modena e Reggio Emilia (UNIMORE Team),** *D. Castaldini, M. Panizza, G. Tossati*

As concern the topic on earthquake-induced landslides in the NW Apennines the research was concluded in 2005. The first investigation phase (realized in the former years) was based on bibliographic records on earthquakes and landslides. This step has led to the collection of 18 well documented landslides induced by seismic shocks. Up to 11 landslides were set in motion by a strong (10 MCS degrees and 6.5 magnitude) earthquake which struck the Tyrrhenian side of the Northern Apennines on September 7$^{th}$ 1920. Other landslides were triggered by earthquakes occurring in 1779, 1832, 1952, 1965, 1996 and 2003. The landslides were triggered by earthquakes ranging from 4.5 to 10 MCS degrees (3.3 to 6.5 magnitude) with epicentres as far as 20÷40 km. The earthquake-induced landslides studied are mainly complex or slide-type movements. The rock types involved are mainly calcareous flysch, clay shales and debris.

In order to understand the complexity of the relationships between all the parameters affecting slope stability in static and dynamic conditions, for each landslide area detailed studies (scale 1:5,000÷1:10,000) were carried out. In detail, this part of the research was carried out according to the following studies for the area surrounding the most significant landslides triggered in 20th and 21$^{st}$ centuries: 1) study of geological characteristics. Elaboration of geological map; 2) study of geomorphological characteristics. Elaboration of geomorphological map; 3) study of hydrogeological characteristics. Elaboration of a hydrogeological map; 4) geomechanic-geotechnic characterization of the area with possible elaboration of a soil/rock mechanics map; 5) analysis of pluviometric data; 6) digital elevation model (DTM); 7) back analysis.

The final research remarks are that earthquakes are the triggering cause for a great number of landslides even if the intrinsic causes are connected to the amount of rainfall in the preceding periods (soil saturation conditions and build-up of pore-water pressures). In fact, in the 18 study cases only in three landslides did the earthquake undoubtedly play a decisive role. Also lithological characteristics and weathering conditions of the bedrock appear to be extremely important since the two cases previously mentioned affected loose debris materials or weak rocks.
The final results of the research have been illustrated at the CERG General Assembly carried out in occasion of the 6$^{th}$ IAG (International Association of Geomorphologists) Conference held in Zaragoza in September 2005.

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## 1.2 Debris flow modelling

**University of Utrecht (UU Team),** *Th.W.J. van Asch, J.-P. Malet, S. Begueria, R. Van Beek*

This programme was a new activity launched by the CERG in 2004, has continued in 2005 and will stop in 2006. The development of this activity has been motivated by the fact that the mechanism of debris-flow is not fully understood and the prediction of failure, runout and stoppage is practically impossible at the present time. None previous activity of the CERG was directed towards the study of this type of geomorphological hazard, although debris flows are dangerous and their occurrence is recognized as becoming high in mountain watersheds for different kind of climate change scenarios.

In 2005, the 2-dimensional debris flow model developed by our team in 2004 has been tested at the field scale on several catchments affected by debris flow events. A modified version of the model has also been tested to simulate the displacement of continuously slow-moving mudslides developed in clay-shales of Southeast France. Their mechanism of movement, influenced by slope morphology, rock mass fabric and pore pressures variation, associates a relatively thin viscous shear band with a high water content at the bottom and a more or less rigid body on top. A dynamic hydrological coupled to a mechanical model has been developed to simulate the velocity pattern of these complex landslides. The hydrological model assumes transient Darcian saturated flow to represent the small observed groundwater fluctuations; to compute the velocity field, the mechanical model assumes shear stress variations and an intrinsic constant velocity. A simple visco-plastic model (Bingham constitutive equation) is used to represent the rheology of the shear band. Landslide movement is computed in two dimensions, and the mass is allowed to travel along a local drainage direction map derived from a DEM. The long-term (30 years) evolution of the Super-Sauze mudslide has been simulated. Performance of the model has been evaluated against field observations and long-term monitoring of the landslide.

More important in 2005 has been the scientific activity dedicated to the analysis of the triggering mechanism of debris flows, and especially to the possibility of fluidization of static and cohesive soils. In many cases debris flows originates from slope material which initially failed as a sliding block. In this view, the transformation from a slide into a debris flow is depicted in three stages: (a) failure localized along a surface within a soil, generally described by the Mohr-Coulomb plastic criterion, (b) partial or complete liquefaction of the bulk as a result of high pore-fluid pressure, (c) initiation and acceleration of the debris flow. Great effort has been devoted in this failure process by studying the generation of excess fluid pressure and possible liquefaction within the initial rigid sliding block for several types of material. For coarse-grained, loosely-packed low density soils (typically coarse sands or volcanic ashes), the most well known liquefaction mechanism is the collapse of the soil structure during shearing. Several flume experiments have confirmed this mechanism of contraction of the soil skeleton for saturated materials under poorly drained conditions. Soil texture and initial pore volume are important factors for the amount of contraction of the material and a maximum pore pressure build-up during failure. Also after failure net excess forces may generate an increase in kinetic energy, which partly can be conversed in vibration energy agitating soil particles and enhancing the liquefaction process.

However less attention has been given to the potential liquefaction of more fine-grained and densely-packed soils. The aim of our research was to get a better insight why more compacted and thus potential dilative soils may show also liquefaction. A conceptual model has been developed which described the principle of undrained loading caused by a changing stress field during initial failure. The geometry of the slip surface determines the rate of change in the stress field of the failing mass and hence the potential for liquefaction. The model describes the initial state of failure, solving forces for each slice with the Bishop finite equilibrium method. After failure the difference in movement for each slice is calculated assuming a viscous shear band and using the Coulomb viscous theory. The differential movement leads to differential strain which is transferred to excess pore pressure. In slides with a curved slip surface the lower part showed compaction and increase in pore pressure during displacement, while the upper part showed dilatation and a decrease in pressure. The potential liquefaction is evaluated for each slice in relation to the displacement. Investigation with the model on the liquefaction potential in relation to the geometry of curved slip surfaces reveals that the liquefied volume increases with steeper slopes and more curved slip surfaces. It is discussed also how planar slides, which in theory show small differential movement of the individual slices and hence no large compaction can completely liquefy through deformation at the toe.

Another theory, which is under investigation, is the possibility that a geometrical change at the toe of the landslide may increase the effective stress so that the material may pass the critical state line and transfer from a dilative into a contractive state, which brings the material in a potentially liquefying state.

In 2006, the different concepts for liquefaction will be tested in a laboratory flume where controlled slump failures are generated in material with different densities. Several geometries of the failure plane will also be tested. During failure, pore pressure in 12 points, total heads and strain deformation are monitored continuously.

**References:**

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Van Asch, Th.W.J., Malet, J.-P., van Beek, L.P.H. (submitted). Generation of excess pore pressure and possible liquefaction in compacted soils. Impact for debris flow triggering. 4th International Conference on Debris Flow Hazard Mitigation, Chengdu, China, 2007.

## 1.3 Implementation of didactic materials on geomorphological hazards

A new activity carried in 2005, to be continued in 2006, has been the implementation of didactic materials on geomorphological hazards (Power Points presentations, Thematic maps, etc……). This material has been used by D. Castaldini, A. Pasuto and M. Soldati (CERG members) for the following Courses.

A. Pasuto and M. Soldati. Course for student of Degree in Geography on “Geomorphology and slope instability” (24 hours). University of Malta (Malta), 3 – 7 January 2005

D. Castaldini: Post-graduates Course on "Geomorphological Hazards: studies and mapping methodologies" (20 hours). University of Baja California Sur (La Paz, Mexico), 1-6 February 2005

D. Castaldini: Master Course on "Geomorphology and seismik risk" (8 hours). University of Lisbon (Portugal), 26-27 April, 2005

Based also on CERG research activity two chapters of a recently published "Manual on applied Geomorphology" have been written by CERG members (BORGATTI & SOLDATI, 2005; CASTALDINI & PANIZZA, 2005)

References:

BORGATTI L. & SOLDATI M. (2005) - *Fenomeni franosi*. In: M. Panizza (ed.), Manuale di Geomorfologia Applicata. Franco Angeli s.r.l, Milano, 88-123.

CASTALDINI D. & PANIZZA M. (2005) – *Geomorfologia e rischio sismico*. In: PANIZZA M. (a cura di) – Manuale di Geomorfologia Applicata. Franco Angeli s.r.l., 250-301, Milano.

### 1.4 Support to preparation answer to 6th FP

A specific budget has been allocated in 2005 to answer to the 3rd call of the Marie Curie Action 'Research Training Network'. The project is called "*Mountain-Risks: from prediction to management and governance*" and is built around the core group of the Cerg. The consortium associates 12 teams (9 European Universities from France, Germany, The Netherlands, Italy, Spain and Switzerland; 2 private companies from Spain and Switzerland; 1 local government Agency from UK). Two meetings have been held prepare the proposal (the first in March 2005 in Paris, the second in September 2005 in Zaragoza). The outline proposal has been submitted in October 2005, and we are invited to submit the full proposal for February 2006.

### 1.5 Programme risk management

The activity for 2005 have been focused on:

1. Completion of NATO- and ISTC-funded projects in Caucasus;
2. Preparation and submission of a follow-up proposal to NATO Science for Peace Programme;
3. Development of earthquake hazard project in Central Asia.

## 2. Training activities in 2005

#### 2.1. Regular training activities

No training activities have been organized in 2005.

#### 2.2. Participation to the implementation of the BeSafeNet web portal

Since November, the Cerg is involved, as a new partner, in the Website on Disaster Awareness with the use of the internet "BE-SAFE-NET", in the framework of the FORM-OSE programme (European Training Programme for South, East and West) of the EUR-OPA Major Hazards Agreement.

Prof. O. Maquaire has participated to a meeting at the European Centre for Disaster Awareness With The Use of the Internet, Nicosia, Cyprus: (1) from 30-31 May for the training of local administrators who will be in charge to implement their national language content; and (2) from 2-3 June 2005, for the meeting of the Steering Committee (two people from the APO secretary and people from four collaborating APO Specialized Centres) to examine the version of the website (available on line since January 2005) and the additional information provided by collaborating Centres.

#### 2.3. Participation to the Master of Sciences 'Natural and Technological Risks' in the framework of the Bologne agreement.

In 2005, as Director of the Cerg, Oliver Maquaire has participated to the implementation and the finalization of a Master of Sciences 'Natural and Technological Risks' hosted University Louis Pasteur, Strasbourg. Several members of the Cerg are involved in this new formation and have given several courses since September.

## 3. Other activities in 2005

Cerg members have:

- participated to several international scientific meetings and sometimes organize specific CERG session such as in the 6th IAG (International Association of Geomorphologists) Conference held in Zaragoza in September 2005, or

- participated to the Programme Leonardo Da Vinci (Community Vocational Training Action Programme): “Debris: Development of innovative forms of learning and teaching oriented towards Building a family of new curricula in the field of natural Risks”. Second Phase: 2000-2006.

- most of the Italian CERG members participated in the International Conference “Mountains and Plains” held from 15 to 17 February 2005 in Padova (Italy).