

# **Impact of Large Landslides in the Mountain Environment: Identification and Mitigation of Risk**



**Contract n° EVG1-CT-2000-00035**

**Deliverable D11**

**Report/guidelines on the improved computation procedures for the run out areas**

## Critical Remarks to the use of run-out models for the definition of the hazard

Dealing with mass movements and evaluating their risks requires:

- a topographic model (“a map is not the territory”, Korzibski 1933)
- a geological and hydrogeological model
- a model of the material behaviour
- a model of the development of the mass movement over time (historical analysis)
- a model of deformation and failure mechanisms (considering monitoring data if available)
- a numerical model of the triggering mechanism and the runout with appropriate boundary conditions

Each of these models can only be a simplification of reality and can therefore take into consideration only a limited number of factors of influence and aspects.

The main objectives of the models are:

- finding the most important factors of influence
- definition of the influenced area
- detection of the mechanisms proceeding in reality
- evaluating of the physical, economical, environmental and social impacts
- assessment of the risks

The numerical models (especially for the failure mechanism and of the run out) and their results can only be as good as the models they are based on (e.g. topographic, geologic, etc.). In particular:

- the choice of the most suitable code (e.g. FLAC provides a continuum mechanical model and therefore can model only heavily fractured or intensively stratified or foliated rock resulting in a sagging process; only a limited number of interfaces allowing discrete shear displacements and joint openings can be included) premises good knowledge of deformation and failure mechanism in situ,
- strength parameters have to be back calculated from observations in nature and cannot be taken from laboratory tests on small examples because dimensions of laboratory specimens cannot include properties of large scale structures such as mass movements and
- PFC-parameters for the contacts ball-wall and ball-ball (absorption, friction, damping etc.) making a realistic calculation of the run out possible have to be calibrated using experience from rock fall cases.

Generally PFC is not yet able to model the influence of water (e.g. pore pressure) on the runout, whereas DAN needs an estimate of the detached rock mass and of the runout direction. An estimation of the detached rock mass is also needed for the PFC Ball Wall model, which was provided by a FLAC3D investigation (input of WP3). Thus the methods described should be used in combination, which makes a comprehensive assessment of the runout close to reality possible.

Moreover uncertainties may result from:

- the number of elements, which is limited by calculation speed (e.g. FLAC<sup>3D</sup> can solve models containing up to 140.000 elements of Mohr-Coulomb material in almost one day on a standard PC; at present the calculation speed of PFC is limiting the number of balls (maximum 100.000) included. Therefore only coarse blocky runout material can be modelled).
- large deformations occurring in reality which can be considered only partly, because they can produce new fractures and can change material behaviour of the rock mass and the mechanisms. Thus FLAC<sup>3D</sup> can model only the triggering mechanism.

Consequently, the following are essential.

- interpretations of the results of numerical models from the geological–geotechnical engineering point of view
- continuous adjustment of the models on monitoring data.