ACID TEST OF JOINT TECHNICAL AND BIOLOGICAL MEASURES IN SLOPE STABILISATION AND GULLY CONTROL – IMPACT ANALYSIS OF THE HEAVY RAINSTORM EVENT IN AUGUST 2005

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INTRODUCTION

The persisting and heavy rainstorms from 20th to 22nd August in 2005 resulted in loss of human lives and tremendous damage on infrastructure all over Switzerland. Many of the measures taken hitherto to protect against such natural hazards were stressed to their limits or even beyond due to water saturation of the soils and extreme discharges of the torrents. This particular configuration offered the possibility to investigate the reliability of technical and biological measures taken within the scope of slope stabilisation, torrent and gully control.
In the context of a joint project financed by the Federal Office for the Environment (FOEN) the ancient sliding area "Schwandrübi" in Dallenwil (Central Switzerland) providing joint technical and biological measures (Fig.1) was chosen to address the following aspects:

- Reliability of technical supporting structures in respect of their spatial arrangement as basis for biological measures as well as concerning their bearing capacity under limit stress
- Development of biological measures in the course of time and their performance under the extreme impact
- Effects of biological measures on the stability of slopes with inclinations partially above the critical angle from a soil mechanical point of view

Fig. 1: The "Schwandrübi" area. left: in 1974 prior to the application of joint technical (gabions) and biological (*Alnus incana*, *Salix purpurea*, hydroseeding) measures conducted during 1981 and 1982 and
right: in 2005 after the heavy rainstorm event in August

INVESTIGATION AREA AND CONCEPT OF MEASURES

The "Schwandrübi" is a steep and amphitheatre-like gully on moraine material and part of a larger catchment. Until 1980 it was a steady source of bed load of the outlet channel and, therefore, a potential danger for the ski resort "Wirzweli" above (Fig. 1) as well as the subjacent villages.

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During 1981 and 1982 joint technical and biological measures had been taken on a large scale with minor follow-ups shortly after. The underlying strategy was based on several pilot surveys as thorough soil analysis, e.g. grain size distribution and determination of the angle of internal friction (Φ') related to the porosity (n) and the dry unit weight (γ), respectively. Furthermore, it was considered that the moraine material compacted by the glacial cap is in fact stable, however, loses solidity through weathering and the (pre-) existing inclination is not to be reached by biological measures, entailing lack of erosion control. The technical constructions (gabions) are necessary to reduce the inclination in the way plants are able to establish and guarantee the surface protection in the long term. The critical angle relevant for the spatial arrangement of the gabions was based on the angle of internal friction (Φ') determined on the loose moraine soil material.

TECHNICAL SUPPORTING STRUCTURES

Basically, the spatial arrangement of the gabions was in accordance with the theoretical guidelines. However, it was not possible to meet the soil mechanical criterion of inclination between the constructions in all cases. Additionally, some steep ridges as well as the precipitous zone of the failure edge could not been flattened (Fig. 1). Regardless of the extreme impact during the rainstorm (~100-year event), no serious damage occurred neither on the roughly 25-year old gabions nor on the torrent control structures. The recalculated peak discharge in the outlet channel was ~60 m^3s^{-1} superimposed by high bed load transport.

DEVELOPMENT AND RELIABILITY OF PLANTS

The development of the biological measures that consisted of cuttings of *Salix purpurea* and rooted plantlets of *Alnus incana* combined with a conventional seed mixture (hydro-seeding) was most satisfactory (Fig. 1 right). The natural re-establishment of *Salix appendiculata* – rarely used in eco-engineering due to the low vegetative reproduction – reveals the underestimated potential of this species. The rainstorm left hardly any destructive marks neither on the vegetation nor on the soil surface. Root excavations in the field and laboratory investigations confirm a high rooting degree. Furthermore, plant association analysis yielded in considerable diversity and a species composition close to natural succession stages.

QUANTIFICATION OF BIOLOGICAL EFFECTS ON SOIL STABILITY

The stability of the "Schwandrübi" was not affected during the heavy rainstorm although some of the sections between the technical structures were too steep compared to the proposed tolerable inclination. A new approach based on the experience of the "Schwandrübi-project" offers the first time to explain this phenomenon with biological effects on soil stability. Previously conducted laboratory experiments were validated with field based investigations conducted in 2006 and confirmed the higher soil stability due to mycorrhizal fungi and better rooting; in terms of an increase of the angle of internal friction (Φ') of up to 5°.

CONCLUSIONS

The joint technical and biological measures in "Schwandrübi" are vitally important concerning practical as well as scientific aspects. The concept applied has proven suitable to protect the ski resort above and the subjacent villages. It was and still is the starting point of new findings and perspectives in view of environmentally compatible slope stabilisation. There is evidence that the eco-engineering approach of WSL shapes up as a successful strategy in the long-term, although the complex interactions of the processes that control soil stability do not adjust within 25 years to a steady-state.

Keywords: eco-engineering, slope stabilisation, long-term reliability