Geophysical Research Abstracts, Vol. 8, 08977, 2006
SRef-ID: 1607-7962/gra/EGU06-A-08977

Mechanical contribution of vegetation to erosion control and slope stability: an overview of experimental studies carried out on different types of plants

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The paper will present an overview of experimental studies developed by CESI S.p.A. and particularly focused on the evaluation of roots tensile strength related to nine kinds of plants commonly used for slope stabilisation in different Italian regions: i.e. respectively, green alder, willow-tree (on the Alps), cordata alder, turkey oak (on the Apennines) and five kinds of perennial "graminae" plants (Eragrass, Elygrass, Pangrass, Cold Vetiver and Vetiver), imported from abroad and under experimentation in Italy.

In the studies, roots were drawn from the site using hydraulic excavation methods; a water jet pressure of about 4 bars had permitted to remove progressively and smoothly the entire soil around the plant. In some particular cases, with presence of large size rock blocks on site, plant systems were removed by hands in order to avoid breaking of fine roots.

A tensile testing machine with deformation control was used in order to check the roots mechanical properties: roots fastened to the clamps were tested at a strain of 10 mm/min; strain was determined by an infrared extensimeter with two gauges fixed on the roots.

The results obtained from these experimental activities emphasise that small diameters correspond to high strength.

In order to know the mechanical properties of the soil and then estimate the contribution of roots tensile strength to the slope stabilization, some geotechnical tests, both in laboratory and in situ, were executed; the results were used as an input to a model that calculated the increase of shear strength (and so the increase of safety factor) due

to the plant roots. The results demonstrate the effective reinforcement capability of tested plant roots, particularly in the superficial soil layers of slopes.

Moreover, it was foreseen to realise a laboratory tests program both on undisturbed soil samples and on undisturbed rooted soil samples. The site interested by the drawing was located in the Southern part of Italy, where a new power plant is under construction. The construction caused a huge soil movement that brought to the realisation of new excavated slopes, on average inclined of 18°. In order to protect soil from erosion action of rainfall and runoff and also in order to prevent superficial soil instability, it was foreseen to install four different kinds of perennial "graminae" plants (Eragrass, Elygrass, Pangrass and Vetiver) characterised by deep and very resistant roots, able to grow in very different environments, even with scarce quantity of water and in difficult climatic conditions.

The first step of the research consisted in drawing three undisturbed samples of soil containing roots for each of the four different kind of perennial "gramineae" plants and three undisturbed samples of only soil, all samples taken from the surface to a depth of 1 m. Afterwards, direct shear tests were planned to be carried out in laboratory in order to evaluate the shear strength of both rooted soil samples and of soil samples without roots . The tests are ongoing and are carried in a modified large direct shear apparatus directly on specimens of 200 mm in diameter, allowing the roots resistance mechanism to fully develop. Therefore, the obtained results will not be influenced by the scale effect and they will allow to quantify the increase of soil shear strength due to the presence of the root matrix, comparing the results of the tests performed on mass soil only. In fact, cohesion and friction angle will be evaluated, considering the Mohr-Coulomb approach, carrying out the shear tests at three different depths both for the soil specimens and for each of the rooted soil specimens.