Geophysical Research Abstracts, Vol. 9, 10512, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-10512
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Experimental investigations for the determination of soil-plant parameters

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The ability of vegetation to stabilise soils is frequently employed in water resource management and slope stabilisation projects, but up to now there exists no standardised calculation methods including the soil-plant parameters. The main effects of vegetation on slope stability are generally considered to be:

- mechanical stabilisation due to the presence of roots
- soil moisture depletion as a result of transpiration and interception
- surcharge from the weight of trees
- wind-breaking

This paper evaluates the mechanical stabilisation of soil slopes by means of trees or shrubs depending on the strength properties of the roots and their growth pattern within the soil. Root fibres increase the shear strength of soil primarily by transferring shear stresses that develop in the soil matrix into tensile resistance in the fibres via interface friction along the imbedded fibres.

This paper presents results of experimental studies focused on the quantitative determination of the root tensile strength and the increase in soil shear strength due to root systems in the laboratory and in-situ. In the research we focus on soil materials consisting of fine-grained material. In order to quantify the contribution of roots to soil mechanical properties, direct shear tests on undisturbed samples of rootless soil and soil with roots, respectively, were carried out. For the investigation in the laboratory one, two and three years before testing there are planted up to 5 birch (Betula pendula) and maple (Acer platanoides) saplings. A large direct shear apparatus (25 cm × 25 cm) was adapted to perform shear tests on the soil blocks. Load (stress) and displacement (strain) were plotted throughout the duration of the test procedure. The testing methodology followed DIN 18137. After the completion of the test, photographs of the sheared surface were taken, and the roots were removed to measure the biomass and root area ratio (RAR). The maximum cohesion achieved in the rootless soil was about 2.4 kN/m^2 depending on the water content and density of the soil sample. For the root permeated soil the "root"cohesion was found between 3.6 kN/m^2 and 6.3 kN/m^2. The angle of friction ranges between 32° and 34.7° for all tests.

The roots provide a reinforcing effect in the soil through their tensile resistance and frictional or adhesion properties. In laboratory tensile tests the tensile strength was measured where up to 15 cm long specimens with a maximum diameter of 11 mm were tensioned. For the species tested the root tensile strength decreased with root diameter.

To map root systems of trees in situ e.g. in slopes we tested the ground-penetrating radar (GPR) technique at our plant test site at the university. By this technique the roots are detected by an electromagnetic signal, as anomalies in the soil, and this information is transmitted in the form of time impulses to a computer.