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The consideration of the deformations in the design of reinforced retaining walls

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ABSTRACT: Today geosynthetic reinforced slopes are designed on the basis of failure behaviour. This method does not take into account the real composite behaviour and the deformation. On the basis of large-scale test results a new design method is proposed.

Soil alone is only able to carry compressive and shear forces. However through the use of synthetic reinforcing elements - so called geosynthetics - a soil structure can be built to carry tensile forces. With such soil structures steep slopes can be constructed where otherwise strutting or other support elements would be required. In the design of these slopes both the internal and external stability have to be sufficient to prevent failure.

The external stability requirement determines the length of the reinforcing elements required. The internal stability is determined using the "Tie-Back-Wedge Analysis" method. This method assumes that the soil both within and behind the reinforced soil block is in an active stress state and the internal loads within the reinforced soil block are carried by the reinforcing elements (fig. 1). The tensile strength of these elements is therefore very important for the equilibrium conditions. In these calculations the deformation of the structure is not taken into account. It is however important to seperate the questions of deformation from those of stability. The relationship betwen mobilized reinforcement force and mobilized soil shear force for the requirements of compatibility is of fundamental importance (Jewell, 1990, fig. 2).

The problem is to determine the deformations for compatibility. To study this problem a large test set up was con-

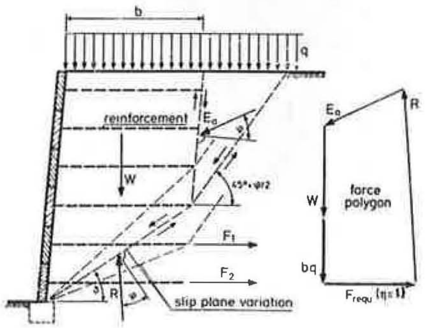

Fig. 1: Internal stability of reinforced soil (Wichter, Nimmesgern)

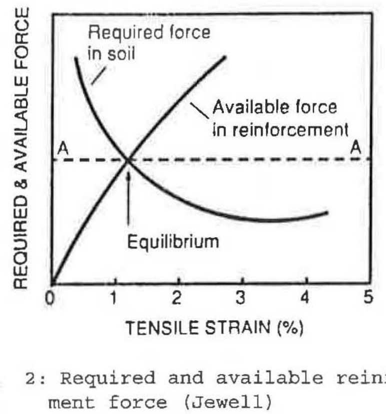

Fig. 2: Required and available reinforcement force (Jewell)

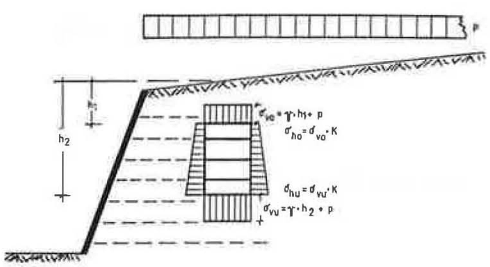

Fig. 3: Stress-state in a steep slope

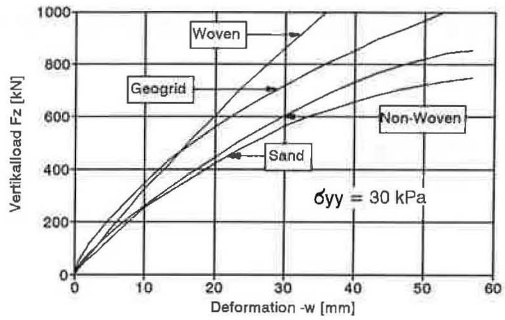

Fig. 5: Load deformation curves

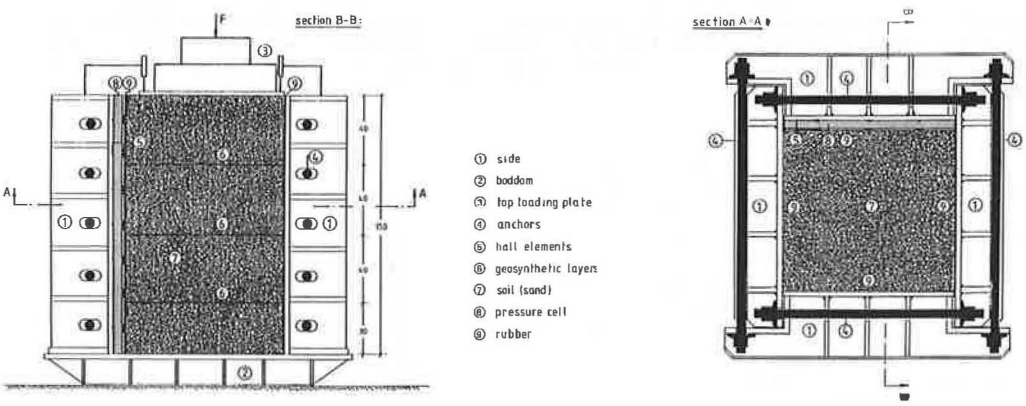

Fig. 4 Biaxial test equipment

structed in order to study the behaviour of reinforced soils under plane strain conditions similar to the actual conditions in steep slopes (fig. 3 and fig. 4).

Several tests using sand with and without geosynthetic reinforcing materials in three layers were carried out under various conditions. The reinforcing materials used were a non-woven one (polyester 300 g/m^2), a woven one (polyester 200 kN/m) and a biaxial stretched grid (polypropylene 35 kN/m). The results of the tests showed that the behaviour of the composite material is not dependant on the tensile strength. Fig. 5 shows the load deformation curves for sand and the reinforced sand with a horizontal pressure of 30 kPa.

The main aim of the tests was to study the behaviour of the reinforcement under working loads. In this stress region the non woven reinforcement did not affect the mechanical proporties of the sand appreciably. The shape of the curves are similar but higher normal stresses are reached in the reinforced sand. The curves for the woven and grid reinforcement however have a very different shape to that of sand alone. The grid is stiff and the effect of the reinforcing occur immediately. The woven reinforcement requires some deformation to develop its stiffness. Thereafter the woven reinforcement showed a quasi-linear load-deformation behaviour.

Using a mechanical model the behaviour is described as a macroscopic composite material with differential elastic properties. In the first step two material-parameter - a modul D and a Poisson coefficient - were determined. Fig. 6 shows the dependance of the parameter from the deformation of the top plate of the test equipment.

The next step will be to compare with the load deformation behaviour of several full scale tests in order to calibrate the results of the above investigations.

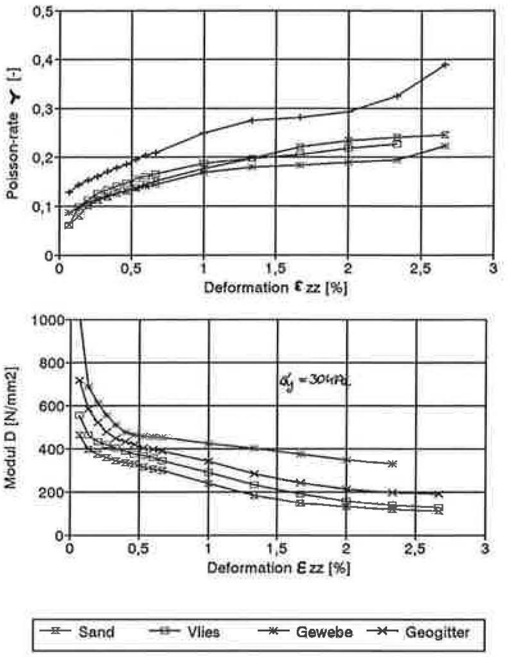

Fig. 6: Parameters of the composite material

References:

Jewell, R.A. (1990): Strength and deformation in reinforced soil design. 4th Intern. Conf. on Geotextiles Geomembranes and related Products, The Hague

Sawicki, A.; Kulczykowski, M. (1994): Pre-failure behaviour of reinforced soil Geotextiles and Geomembranes 13, p. 213-230

Wichter, L.; Nimmesgern, M. (1990): Stützbauwerke aus Kunststoffen und Erde - Bemessung und Ausführung Bautechnik 67, H. 4