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Summary

This work describes the results of experiments conducted to examine the load and deformation characteristics of geosynthetic reinforced soil structures (GRSS). The load carrying system of GRSS is characterised by numerous economical and ecological advantages compared to classical slope stability by gravity or angular retaining walls. Especially constructions on weak ground or constructions that do not fulfil stability analysis without additional reinforcing elements can be stabilised effectively by geosynthetics. GRSS are distinguished by high durability, small deformations under serviceability loads and a very high load carrying capacity. Stability of possible sliding mechanisms has to be ensured in the design. Soil shearing resistance as well as tensile strength are used as resisting elements in the stability calculation. The load carrying capacity of the GRSS is explicitly calculated by this method, while serviceability of the ductile and creep susceptible geosynthetics cannot be proven based on mechanical behaviour. Numerous GRSS, of which a few are presented in chapter 2, confirm that the multifunctional and flexible applicability leads to safe and durable constructions. Several GRSS constructed with a low factor of safety for research purposes show significantly higher load carrying capacity than calculated by the design method. Even under loads leading to failure according to the design only small geosynthetics strains and deformations of the structure have been measured. Loads determined from the geosynthetic strains are much smaller than the ones calculated in failure state according to the design method. The significant discrepancies between calculated and measured geosynthetic forces in stable geosynthetic reinforced soil structures were the reason for this research. Aim of the work is the investigation of the load transfer mechanism inside the compound material. Previous results indicate that parametric studies on the influencing factors on the load transfer mechanism under comparable defined boundary conditions are necessary. To determine the load carrying principle and the geosynthetic strains inside the GRSS experiments under a state of stress comparable to field conditions as well as equal boundary conditions have been accomplished. To exclude any size effects a biaxial apparatus with dimensions of 1,0 x 1,0 x 1,5 (length x width x height) has been used. Layer spacing, grain size and geosynthetics with comparable strength can be defined in it as used in the field. Under constant vertical loading a horizontal movement is forced by a movable side wall. Analogue to a GRSS that can only deform transverse to the slope axis deformations in the test are only possible under plane strain conditions with stress formation transverse to the deformation direction.

Stresses acting on the movable and rigid side walls have been measured depending on the movement of the side wall. The stresses absorbed by the GRSS can be calculated based on the induced movement from the difference of earth pressure at rest to the pressure induced by the compound material. By comparing the pressure acting on the movable side wall the influence of varying geosynthetic and soil parameter on the compound material can be identified. Already after small strains the compound material is fully activated. When fully activated the compound material is characterised by significant smaller effective horizontal stress than the unreinforced soil. If the parameter for the compound material are chosen ideally, all acting horizontal stresses from the at rest conditions are absorbed inside the reinforced soil. Additional horizontal movement after activation of the compound material does not lead to a lower load carrying capacity. Higher vertical pressures on the compound material after full activation are absorbed after small secondary horizontal movement. The properties of the compound material are controlled by geosynthetic parameters and soil properties. Soil deformations in the geosynthetic layer are restricted by the geosynthetic properties. The compound effect mainly depends on the geosynthetic layer spacing, soil grain size, geosynthetic aperture size as well as strength of shape and extensional stiffness of the geosynthetic. Deformation can be restricted effectively by sufficient bond between geosynthetic and soil and the stress reduction inside the compound material is increased significantly. Changes in the stressstrain behaviour of the soil surrounding the geosynthetics have been verified in the tests. The load carrying capacity is significantly increased when layer spacing is reduced (< 0,6 m). If the influenced areas around the geosynthetics are overlapping each other the properties of the unreinforced soil will be completely replaced by the properties of the compound material. With increasing layer spacing, if the influenced areas are not overlapping, stress carrying capacity of the compound material mainly depends on the compound effect. Opposite to the design method no correlation between geosynthetic tensile strength and serviceability of the GRSS can be accomplished. Without sufficient bond, soil parameters like the unreinforced soil are present in the structure as well as the geosynthetic strength that can be activated by shearing resistance. The increase in load carrying capacity as well as the deformation reduction of the compound material cannot be activated under these conditions. Due to this discrepancy only smaller load carrying capacity can be calculated by the design method. Complementary to the model tests in the laboratory the transferability of the results has been proven by 7,8 m high trial test wall. Influences of the compaction induced stresses and strains in the geosynthetics were measured and the applicability of the serviceability design was tested. The results of the field tests indicate that serviceability of GRSS can be based on allowable geosynthetic strains and lower geosynthetic strength than calculated by the classical design method. To optimise current design a new design concept based on allowable deformation properties of the compound material is suggested. From the test results loss of serviceability of the GRSS is defined as the point when maximum shearing resistance of the soil is reached. To encounter for varying soil stressstrain properties, maximum potential in serviceability state is defined when the compound material reaches a strain of 2%. Every compound material can absorb a special amount of energy that is calculated as the integral of the area under the activation curve of the compound material. To obtain an equilibrium state in the construction, the energy absorbed by the compound

material has to be equal to the energy that is activated by the GRSS. Dependent on the compound effect, the resulting horizontal pressure in the GRSS can be calculated by the compound material properties. The strain to obtain equilibrium between acting and resisting pressure is calculated based on the laboratory tests. A factor of safety of the actual design (can be) is calculated by comparing the activated energy to the energy that can be absorbed by the compound material at 2% strain. The derived calculation model is leading to a more economical dimensioning of GRSS. Material parameters of the compound material are used to describe the stress strain behaviour of the material instead of using independent ascertained material parameters for geosynthetics and soil.