A Multilaminate Model for Overconsolidated Soils

Project Description

Numerical methods such as the finite element method are established tools in geotechnical research and in practical geotechnical engineering but there is still a need for fundamental research on constitutive modelling in geotechnics. Because of the complexity of soil behaviour, resulting from its geological history, highly advanced constitutive models are required and so far no "universal" constitutive model for soils has emerged. In this proposal the development of a constitutive model for overconsolidated, structured soils is suggested. The model will be formulated in the context of classical plasticity theory but not, as more commonly employed, in terms of stress invariants but utilizing the multilaminate framework. In multilaminate models the overall deformation behaviour of a soil body is obtained by integration of the contributions of so-called integration planes and all constitutive relations are formulated on these planes, the orientations of which depend on the integration rule employed.

In contrast to models formulated in stress invariants, multilaminate models take into account the effect of principal stress axes rotation and induced anisotropy inherently. The model developed at Graz University of Technology up to now is an elastic-plastic model which includes both deviatoric and volumetric hardening. It can account for destructuration, anisotropy in strength and strain softening employing a non-local formulation.
However, the present formulation of the model is not adequate for modelling the behaviour of overconsolidated soil due to the fact that stress states on the "dry side" of the critical state line are not permissible. Therefore a bounding surface will be introduced and it will be investigated whether a continuous function or separate parts on the dry and wet side of the critical state line are more efficient. This will require detailed investigations because the concept of a Hvorslev surface in p-q-stress space has to be transferred to the multilaminate framework. The size of the bounding surface will be a function of bonding (structure) and destructuration will be a function of damage strain. When peak strength is reached strain softening will take place and as a first stage the applicability of the (available) non-local model to simulate strain softening behaviour of highly overconsolidated clay will be evaluated. If considered necessary alternative approaches, such as a strong discontinuity formulation, will be investigated. In order to take into account small strain stiffness behaviour two possibilities will be pursued: a) implementation of the small strain stiffness model already available, ii) implementation of kinematic hardening for the deviatoric yield curve.

The main novelty of the research proposed is the introduction of a structure tensor which – in combination with the multilaminate framework – allows for considering anisotropy in strength, destructuration and stiffness in a mathematically convenient and straightforward manner. It is anticipated that the proposed model will be a significant step forward in modelling the mechanical behaviour of overconsolidated soils over the entire stress range from small strain stiffness to post peak behaviour.