

## Abstract

The dissertation presents a comprehensive approach to problems of concrete pavements design in reference to complex, non-linear behaviour of soils, taking into account soil mechanics phenomena, e.g., primary and secondary consolidation or failure.

A co-authored procedure of rigid pavement design was proposed in which maximum stresses in concrete slabs were estimated using finite element method (FEM). A FEM model of a pavement concrete slab resting on a layered elastic half-space with contact conditions allowing for separation between the slab and the subgrade was used in order to realistically simulate the behaviour of an individual slab. Such approach serves as an effective and safe way of maximum stress estimation. FEM calculations carried out in Abaqus software were automated using a Python script. The proposed method was compared to existing analytical methods for estimation of stresses and fatigue strength of concrete pavements.

An overview of elastoplastic constitutive models of soil was presented with special attention put into the differences related to various implementations in FEM software. In case of the widely used in soil mechanics calculations, Hardening Soil model, evolution of the yield surface was shown based on calculations performed in Mathematica software. A new method of modelling soil hysteresis behaviour observed in triaxial compression tests on the stress deviator – strain plane using both classical and non-classical rheological elements was presented. Parameters of the proposed rheological structure were determined based on triaxial compression tests with unloading.

In the study, the description of one-dimensional transient consolidation process (rate dependent) was generalized to any rheological schemes, taking into account primary and secondary settlement. In particular, the viscoelastic Burgers rheological structure was used in order to find the constitutive equation for the soil skeleton. Long term oedometric IL-type laboratory tests of organic soils were carried out in order to validate the proposed soil transient consolidation model. The results of the analysis were compared with possible modifications of the evolution of the cap yield surface of Modified Drucker-Prager/Cap model available in Abaqus. Additionally, a novel rheological structure using the non-classical Kepes element was proposed to model the steady-state one-dimensional consolidation (drained conditions).

Finally, a numerical analysis of a problem in which it is important to combine advanced constitutive modelling of soil and problems related to the design of concrete pavements was carried out. Consolidation of an organic soil layer loaded by a road embankment and layers of plain joined concrete pavement structure was analysed. Transient coupled pore pressure – stress analysis was carried out taking into account secondary settlement in the organic soil layer. The impact of soil subgrade deformation on stress state in concrete slabs was evaluated.

**Keywords:** soil mechanics, geotechnics, concrete pavements, finite element method, constitutive modelling, soil consolidation