Workshop Numerik in der Geotechnik

Constitutive Modelling of Soil Viscous Behavior

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Extended abstract

In the lecture, predicting viscous soil behaviour using hypoplasticity is presented. The general model is represented using equation

$$\mathring{\boldsymbol{\sigma}} = f_s(\boldsymbol{\mathcal{L}} : \dot{\boldsymbol{\epsilon}} + f_d \mathbf{N} \|\dot{\boldsymbol{\epsilon}}\|) \qquad (1)$$

where $\mathring{\boldsymbol{\sigma}}$ and $\dot{\boldsymbol{\epsilon}}$ represent the objective (Zaremba-Jaumann) stress rate and the Euler stretching tensor respectively, $\boldsymbol{\mathcal{L}}$ and $\mathbf{N}$ are fourth- and second-order constitutive tensors, and f_s and f_d are two scalar factors. In hypoplasticity, stiffness predicted by the model is controlled by the tensor $\boldsymbol{\mathcal{L}}$, while strength (and asymptotic response in general), is governed by a combination of $\boldsymbol{\mathcal{L}}$ and $\mathbf{N}$. Earlier hypoplastic models (such as the model by von Wolffersdorff 1996) did not allow to change the $\boldsymbol{\mathcal{L}}$ formulation arbitrarily, as any modification of the tensor $\boldsymbol{\mathcal{L}}$ undesirably influenced the predicted asymptotic states. This hypoplasticity limitation was overcome by Mašín (2012, 2014). He developed an approach enabling to specify the asymptotic state boundary surface independently of the tensor $\boldsymbol{\mathcal{L}}$.

In the lecture, new hypoplastic model is presented, with anisotropic asymptotic state boundary surface. Additionally, the tensor L was made bilinear in D to more realistically predict the stress path. The apparent rotation of state boundary surface is done by skewing the stress space. Viscous behaviour is introduced using approach similar to the one proposed by Niemunis et al. (2009). Figure 1 shows predicted asymptotic state boundary surface and normalised stress path due to in proportional loading. Figure 2 shows predictions of oedometric relaxation test, compared with predictions by the Niemunis et al. (2009) model. Figure shows predictions of settlement of embankment with time on creeping peat (Czech Republic, D3 motorway) which were calculated with the proposed model.

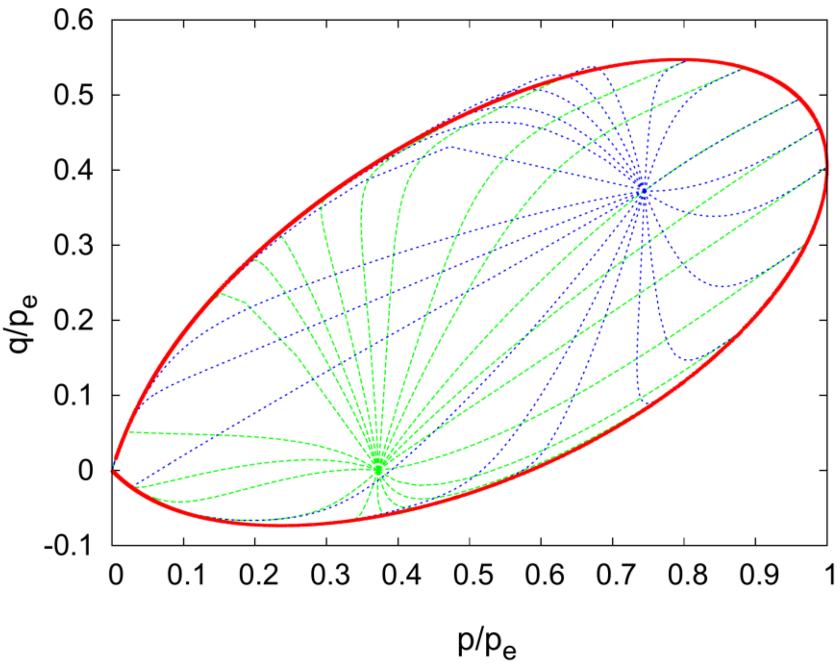
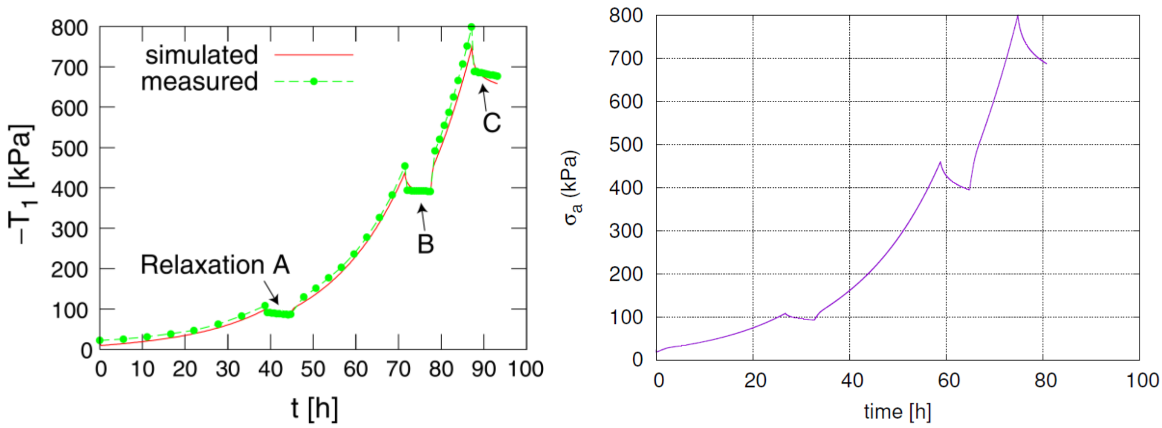


Figure 1: Predicted anisotropic ASBS and normalised stress paths associated with proportional loading of a newly developed model.



(a) (b)

Figure 2: Predicted results of oedometric creep test (b) compared with predictions of the model by Niemunis et al. (2009) and with experimental data (a)

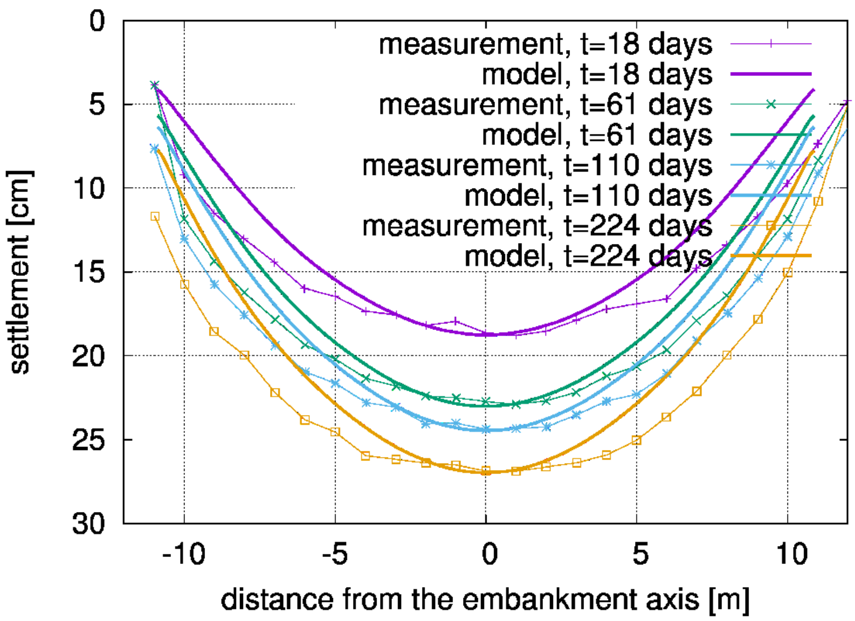


Figure 3: Predictions of settlement of embankment with time on creeping peat.

References

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