

Numerical simulation of soil creep with a visco-hypoplastic constitutive model

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Slow-moving landslides make up a great part of geohazards in the Three Gorges reservoir (TGR) in China. Most of them move at speed of several centimeters per year (or even less) and show evidence of creep behaviour. It has been suggested that motion of creep landslides is mainly governed by the viscous properties of sheared materials forming the rupture zone, as these zones are where most of the slope deformation localizes. Understanding of creep behaviour of slipping material calls for laboratory tests as well as advanced constitutive models. For this purpose, a high order visco-hypoplastic constitutive model has been introduced.

Unlike some of the visco-hypoplastic models, which consider the total strain rate as a combination of reversible strain rate and viscous strain rate respectively, such as $\dot{\epsilon} = \dot{\epsilon}^e + \dot{\epsilon}^{vis}$ (where $\dot{\epsilon}$, $\dot{\epsilon}^e$ and $\dot{\epsilon}^{vis}$ are the total strain rate, reversible strain rate and viscous strain rate respectively), the proposed visco-hypoplastic constitutive model decompose the Cauchy stress into a statical part and a dynamical part, $s = \hat{s} + \check{s}$ (where s , \hat{s} and \check{s} are total stress, statical stress and dynamical stress respectively), whereas the strain rate has been considered as a whole. Within in this framework, stress change induced by strain acceleration can be taken into account. Moreover, compared with some special creep models, which may only valid for one or two stages of the three-state creep, i.e. primary creep, secondary creep and tertiary creep, this novel scheme is able to describe creep test with the whole three stages.

This model has been also implemented into FEM code to evaluate some boundary-value problems. An explicit adaptive Rung-Kutta-Fehlberg algorithm is applied for stress-point integration. For verification of this model, numerical triaxial tests compared with laboratory tests have been conducted. Then a homogenous slope has been taken as an example to demonstrate the gravity induced-creep. It turns out that the proposed visco-hypoplastic constitutive not only is able to model the response of geomaterials to loading rate, but it is also useful for modeling the response of geomaterials to long-term loading for creep analysis.