Assessment of a Multi-phase Formulation for the Simulation of Creep of Young Shotcrete

Peter Gamnitzer*, **Matthias Neuner and Günter Hofstetter**

Unit of Strength of Materials and Structural Analysis
University of Innsbruck
Technikerstraße 13, 6020 Innsbruck, Austria
web page: http://www.uibk.ac.at/bft/
e-mail: {Peter.Gamnitzer,Matthias.Neuner,Guenter.Hofstetter}@uibk.ac.at

ABSTRACT

The use of sprayed concrete linings, i.e. shotcrete, is a popular measure to secure excavation faces in conventional tunneling. Unlike ordinary concrete in concrete structures, shotcrete is compacted by the spraying process and applied directly on the tunnel surface, where it is loaded at a very early age during tunnel advance. Strength, stiffness and other material parameters evolve while the shotcrete is already in place and loaded. Therefore coupled hygral, thermal, and chemical processes, at early ages and beyond, are likely to be even more important for shotcrete than for ordinary concrete. Numerical data that will be shown in this contribution was obtained using a fully coupled multi-phase formulation based on the work of Gawin et al. [1, 2]. The creep parameters were calibrated and validated for several series of uniaxial compressive creep tests on shotcrete specimens documented by Müller [3]. Parameters assumed for the effective stress relation were shown to be well suited to reproduce the characteristics of separate drying shrinkage tests. Experimental data for the evolution of Young's modulus was used for a posteriori verification of the effective, time and rate dependent stiffness. Compressive creep results are investigated for concrete ages ranging from 6.5h to 28d. Loading in these tests was step-wise increased in parallel to the increase in compressive strength due to aging. Unlike in the examples shown in [2], some of the tests clearly reach the nonlinear creep regime. The multi-phase approach allows to reproduce the compressive creep curves quite accurately. Since it explicitly resolves drying shrinkage it does not require empirical shrinkage laws or the use of shape factors, like volume to drying surface ratios or effective thicknesses. This would be the case for the single-phase shotcrete models based on elastic-plastic formulations which we used for comparison. However, unfortunately, the available experimental data documented in literature is not only scattered but very sparse from the multi-phase point of view. Important input required for multi-phase modelling of shotcrete creep, like permeabilities, sorption behaviour, etc., are missing or not sufficiently documented in literature. In conclusion multi-phase modelling is a quite promising approach for modelling shotcrete loaded at young age. However, a final decision on the performance of the model will require more specific experimental data which we hope to be available in the future.

REFERENCES

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