Calibration of the viscoelastic behavior of polypropylene fiber reinforced concrete with the extended Lattice Discrete Particle Model approach

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Abstract:

Fiber reinforced concrete (FRC) is a composite material whose adoption is becoming widespread. The ability of exhibiting remarkable residual capacity after cracking of the cementitious matrix represents its characteristic feature.

At present, studies dealing with the mechanical characterization of this material are mainly focused on the analysis of the mechanical behavior under short-term conditions. On the other hand, a comprehensive identification of FRC performance requires also the investigation of the rheological properties and the long-term behavior. To this purpose, some researches are making first steps towards the standardization of the creep testing methodologies for FRCs, together with the study of the relevant aspects influencing their time-dependent behavior.

On the other side, the numerical simulation of the FRCs behavior is another challenging topic, due to the composite nature of the material. In particular, the reliability of the model is often driven by the method of introducing the concrete heterogeneity and the fiber distribution. Among the others, the extended lattice discrete particle model (LDPM-F) approach is able to describe the instantaneous composite material behavior through the inclusion of fibers and the simulation of the crack-bridging effect responsible for the FRCs residual strength. At the same time, conventional LPDM model can be coupled with the HTC model and the microprestress solidification theory to fully reproduces the concrete viscoelasticity and aging properties.

In the present paper, a new version of LPDM model has been proposed, where both a concrete viscosity and a fiber viscosity are utilize to describe the long-term behavior of FRC. In the case of plastic fibers (MS), the contribution of fibers to the creep deformation is remarkable. The numerical predictive model has been calibrated with respect to experimental results obtained from instantaneous and creep tests on macro-synthetic fiber reinforced concrete (MSFRC) with polypropylene fibers. In particular, fiber viscoelasticity has been calibrated against tensile creep tests for a single fiber. The validated model has been then used to predict the long-term elongation of pre-cracked notched MSFRC cylinders under the uniaxial tensile stress. Results show that the presented numerical scheme is able to capture this complex behavior.