Characterizing the Ultra-Slow Creep in Concrete Based on the Non-Local Structural Derivative Maxwell Model

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Abstract: Creep of concrete can last for decades, which displays the ultra-slow rheological phenomena. As an empirical formula, the logarithmic law is usually used to describe the ultra-slow creep. However, the logarithmic law does not always work well especially for the long-term creep. And its corresponding relaxation response cannot be obtained analytically. It is known that the Mittag-Leffler and the inverse Mittag-Leffler functions are generalized from the exponential and the logarithmic functions, respectively. And the inverse Mittag-Leffler function is much slower and generalized than the logarithmic function. In this paper, we use the non-local structural derivative to establish a new Maxwell-type viscoelastic model, in which the inverse Mittag-Leffler function is employed as the structural function to capture the ultra-slow rheology. The viscoelastic responses of the generalized Maxwell model are analytically derived, including creep and relaxation. Moreover, the proposed model is tested by three long-term creep experimental data of concrete. Compared with the standard linear solid model, the Lomnitz logarithmic creep model and the fractional Maxwell model, the proposed generalized Maxwell model agrees better with the experimental data. Numerical results indicate that the non-local structural derivative involving the inverse Mittag-Leffler function is feasible to capture the ultra-slow creep in concrete.

Keywords: Ultra-slow creep; concrete; structural derivative; inverse Mittag-Leffler function; structural function