Postprint: Study on Rheological Damage Constitutive Model of Red-Bed Mudstone Considering Water Saturation Time

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Abstract

Red beds primarily refer to continental clastic rocks formed during the Jurassic, Cretaceous, Paleogene, and Neogene periods, dominated by lacustrine, alternating lacustrine-fluvial, or piedmont alluvial-proluvial facies, which are widely exposed globally. For red bed slopes composed of interbedded sandstone and mudstone, the critical causative factor for landslide initiation is the damage and deterioration of mudstone layers. Owing to the water-induced deterioration and disintegration characteristics of red bed mudstone upon water loss, sampling and specimen preparation present considerable challenges, resulting in limited research by scholars. Consequently, investigating the time-dependent deformation behavior of red bed mudstone under water-rock interaction holds significant importance for elucidating the creep deformation behavior of slopes. This study focuses on red bed mudstone from southwestern China, conducting triaxial creep tests under varying water saturation durations to analyze the creep deformation, creep rate, and long-term strength of the material. Building upon traditional creep models, a nonlinear viscoplastic element is proposed to establish a one-dimensional creep constitutive model. By incorporating both initial and process damage from water-rock interaction into this model, a damage creep constitutive model for red bed mudstone is developed, with model parameters calibrated, and subsequently extended from one-dimensional to three-dimensional formulation. The proposed constitutive model effectively captures the creep characteristics of red bed mudstone during water saturation processes.

Full Text

Preamble

Study on Rheological Damage Constitutive Model of Red Bed Mudstone Considering Water Saturation Time

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Abstract

Red beds primarily refer to continental clastic rocks formed during the Jurassic, Cretaceous, Paleogene, and Neogene periods, dominated by lacustrine, fluvial-lacustrine alternating, or piedmont alluvial facies, and are widely exposed across the globe. For red bed slopes with interbedded sandstone and mudstone, the critical triggering factor for landslides is the damage deterioration of mudstone layers. Due to the water-induced weakening and disintegration upon drying properties of red bed mudstone, sampling and specimen preparation are extremely challenging, resulting in limited research attention. Therefore, investigating the time-dependent deformation behavior of red bed mudstone under water-rock interaction is crucial for revealing the creep deformation mechanisms of slopes.

This study focuses on red bed mudstone from Southwest China and conducts triaxial creep tests under various water saturation durations to analyze creep deformation, creep rate, and long-term strength. Based on traditional creep models, a nonlinear viscoplastic element is proposed to establish a one-dimensional creep constitutive model. By incorporating both initial damage and process damage from water-rock interaction into this model, a damage creep constitutive model for red bed mudstone is constructed. Model parameters are calibrated, and the model is further extended from one-dimensional to three-dimensional formulation. The new constitutive model can effectively capture the creep characteristics of red bed mudstone during the water saturation process.

Keywords: red beds; water-rock interaction; constitutive model; creep

Note: Figure translations are in progress. See original paper for figures.