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A finite cyclic elasto-plastic constitutive model to improve the description of cyclic stress-strain hysteresis loops

Yilin Zhu[a], Guozheng Kang[b]*, Chao Yu[b]

[a] School of Architectural and Civil Engineering, Chengdu University, Chengdu 610106, P.R. China

[b] State Key Laboratory of Traction Power, Southwest Jiaotong University, Chengdu 610031, P.R. China

*Correspondent author: Dr. Prof. G.Z. Kang, Tel: 86-28-87603794; Fax: 86-28-87600797

E-mail address: guozhengkang@home.swjtu.edu.cn or guozhengkang@126.com

Abstract

Plenty of cyclic constitutive models have been developed to describe the cyclic hardening/softening feature and ratchetting behavior of metals and good descriptions can be obtained. The cyclic stress-strain hysteresis loops, however, cannot be well predicted by most of the existing models since the different plastic moduli between monotonic and cyclic deformations have rarely been considered. In this work, a finite cyclic elasto-plastic constitutive model is developed to improve the description of the cyclic stress-strain hysteresis loops by introducing a new proposed kinematic hardening rule and an exponential isotropic hardening rule. In the proposed kinematic hardening rule, the back stress is decomposed into long-range, middle-range and short-range components with each addressing an “Armstrong-Frederick” evolution rule consisting of a linear hardening and a dynamic recovery term (Armstrong and Frederick, 1966). For the long-range and middle-range components, the dynamic recovery coefficients are postulated to decrease with the increase of plastic deformation and each contains a ratchetting coefficient. For the short-range component, the linear hardening and dynamic recovery terms are further divided into two parts, respectively, with one part in each activating only when the reverse loading occurs. The capability of the proposed model is demonstrated by benchmarking its predictions against experimental data. It is shown that the monotonic stress-strain response, cyclic hardening with both small and large strain amplitudes, ratchetting and, particularly, the cyclic stress-strain