An Algebraic Model for Hysteretic Responses exhibiting Cyclic Hardening and Softening Phenomena: Preliminary Results

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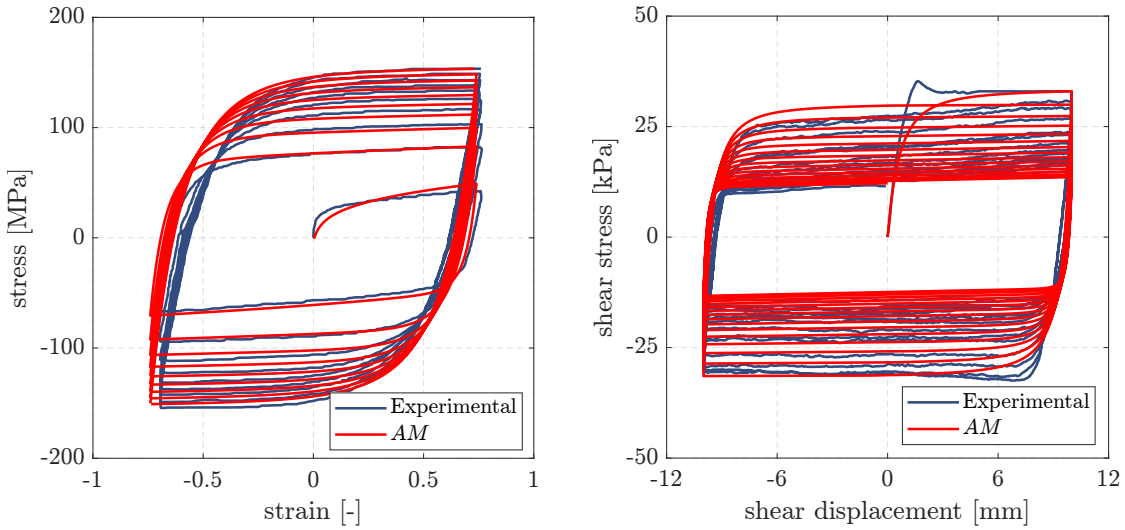
Abstract. We provide closed-form expressions to evaluate the generalized work done by a generalized hysteretic force, simulated by using a recently formulated model denominated Algebraic Model. Such expressions are valid over a generic generalized displacement interval and are used to simulate the cyclic hardening and softening phenomena observed in many mechanical systems and materials. In addition, we also provide closed-form expressions for evaluating the work done by the generalized hysteretic force when a full cycle of generalized displacement is assigned.

Introduction

Modeling of cyclic hardening or softening phenomena affecting the hysteretic response of mechanical systems and materials needs to take into account several complex aspects; consequently, it is quite difficult to formulate a single model adopting few parameters. Over the years, many authors presented different models to reproduce such complex responses, as those characterized by cyclic degradation phenomena [1] and nonlinear kinematic hardening [2]. In this regard, we present an extension of the Algebraic Model (AM) described in [3] in order to accurately simulate cyclical hardening/softening phenomena. Such a model is computationally efficient, being based on closed-form expressions, and adopts parameters having a clear mechanical meaning.

Results and Discussion

Figure 1 shows the comparison between the analytical and experimental results obtained by using the proposed AM in two different cases. In particular, Figure 1a shows the results obtained by modeling the cyclic hardening hysteretic behavior exhibited by an annealed OFHC (oxygen free high conductivity) copper material when an axial sinusoidal strain is applied with a frequency of 0.008 Hz and an amplitude of 0.74. [4]. Moreover, Figure 1b illustrates the results obtained by modeling the cyclic softening hysteretic behavior exhibited by the Fujian standard sand when a transverse (shear) sinusoidal displacement is imposed with a frequency of 0.002 Hz, an amplitude of 10 mm, under the effect of a normal stress of 90 kPa [5].



(a) (b)

Figure 1: Comparisons of analytical and experimental results obtained for an annealed OFHC copper [4] (a) and a Fujian standard sand [5] (b) under cyclic loading.

References

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