Modeling of the axial hysteretic behavior of Wire Rope Isolators using a novel asymmetric rate-independent model

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Abstract. We present a uniaxial asymmetric rate-independent model to accurately predict the complex hysteretic behavior typically exhibited by Wire Rope Isolators along their axial direction. The proposed model, that is based on a set of only six parameters, is validated by comparing the results predicted analytically with some experimental results obtained during several experimental tests recently performed at the Department of Structures for Engineering and Architecture of the University of Naples Federico II.

Introduction

Wire Rope Isolators (WRIs) are metal devices made up of a stainless steel cable and two aluminum alloy or steel retainer bars where the cable is embedded. The hysteretic behavior displayed by a WRI deforming along its axial direction is characterized by asymmetric restoring force-displacement hysteresis loops [1].
Several differential models have been proposed in the literature for simulating the complex axial hysteretic behavior occurring in WRIs [1, 2]. Unfortunately, such models are not computationally efficient since they require the numerical solution of a differential equation for each time step of a nonlinear time history analysis; moreover, they adopt parameters having no clear mechanical significance.
Conversely, we present an Asymmetric Exponential Model (AEM), belonging to the class formulated by Vaiana et al. [3, 4], that not only offers the advantage of accurately simulating the WRIs axial response, but also allows for a considerable reduction of the computational burden of nonlinear time history analyses and for the use of six parameters directly associated with the experimentally measured properties of the hysteresis loop.

Results and discussion

Figure 1b (1c) shows the comparison of the analytical and experimental results obtained in the axial direction by imposing ten cycles of sinusoidal axial displacement to the tested WRI (Figure 1a), at three different amplitude levels, with a frequency of 0.1 Hz, and without (under) the effect of an axial compressive preload, f_v, of 2 kN. It can be observed that the agreement between the experimental force-displacement hysteresis loops and the ones simulated by means of the proposed model, whose parameters have been calibrated through a simple analytical fitting of the experimental data, is satisfactory. In particular, it is proved that the proposed asymmetric model is capable of well predicting the increase of the tangent stiffness that occurs in the tested WRI, for positive values of the applied displacement, when it is about to reach its limit of deformation.

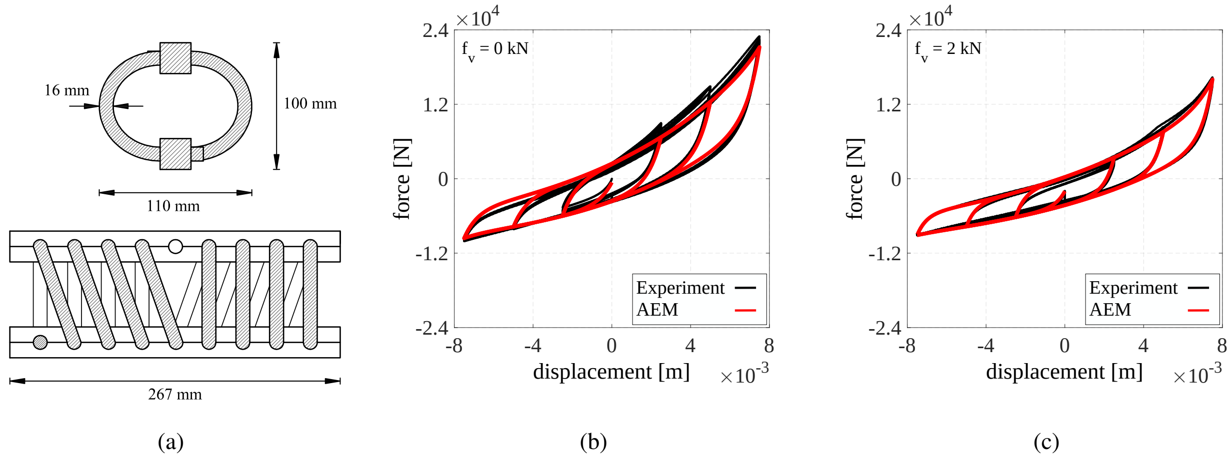

Figure 1: Comparisons of analytical and experimental results obtained for the tested WRI (a) in axial direction without (b) and under (c) the effect of an axial compressive preload f_v = 2 kN

References

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