Preliminary Results on the Simulation of Pressurized Sand Dampers by the Vaiana-Rosati Model

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Abstract. This work briefly illustrates the potentialities of the brand-new Vaiana-Rosati model of hysteresis to reproduce the symmetric and pinched hysteresis loops characterizing the rate-independent hysteretic behavior exhibited by a pressurized sand damper. It represents a novel promising energy dissipation device to be adopted for structural vibration control.

Introduction

Passive energy dissipation devices typically exhibit a complex hysteretic behavior that is referred to as rate-independent (rate-dependent) if the device restoring force depends on the device displacement (velocity). Makris et al. [1] have recently proposed an innovative, low-cost, eco-friendly, long-stroke, fail-safe rate-independent hysteretic device denominated *Pressurized Sand Damper*. The main aim of this work is to show that a recently formulated hysteresis model [2], denominated *Vaiana-Rosati Model*, is sufficiently general to simulate the complex hysteresis loops typically exhibited by such a novel device.

Results and Discussion

Figure 1a illustrates the damper prototype that has been tested at the Structures Laboratory of the University of Patras, Greece. Such a device is made up of a steel cylinder, having a diameter of 18.9 cm and length of 62 cm, that is filled with dry sand pressured by adopting four external post-tensioned steel rods. A sphere with radius of 3 cm, attached to a piston rod having radius of 2 cm, is able to move along the damper axial direction.
Figure 1b shows the typical rate-independent hysteretic behavior exhibited by the above-described device when subjected to a sinusoidal axial displacement having amplitude of 40 mm and frequency of 0.1 Hz under the effect of a pressure of 1 MPa. The experimentally derived symmetric and pinched hysteresis loops demonstrate the capability of the device to dissipate a large amount of mechanical energy.
To accurately simulate the complex force-displacement hysteresis loops characterizing the response of the tested device, we adopt the Vaiana-Rosati Model (VRM) [2].
Compared to other models available in the literature, the VRM offers some advantages such as: (i) evaluation of both force and related work in closed form, (ii) simulation of complex hysteresis loop shapes, (iii) modeling of the loading and unloading phases by employing two different sets of parameters; (iv) adoption of parameters having a clear theoretical and/or experimental interpretation, (v) straightforward computer implementation.
Figure 1c illustrates a comparison between the experimental hysteresis loops and those simulated by using the VRM. The very good agreement between such results demonstrates the capability of the VRM to accurately predict the experimental hysteresis loops exhibited by the tested device.

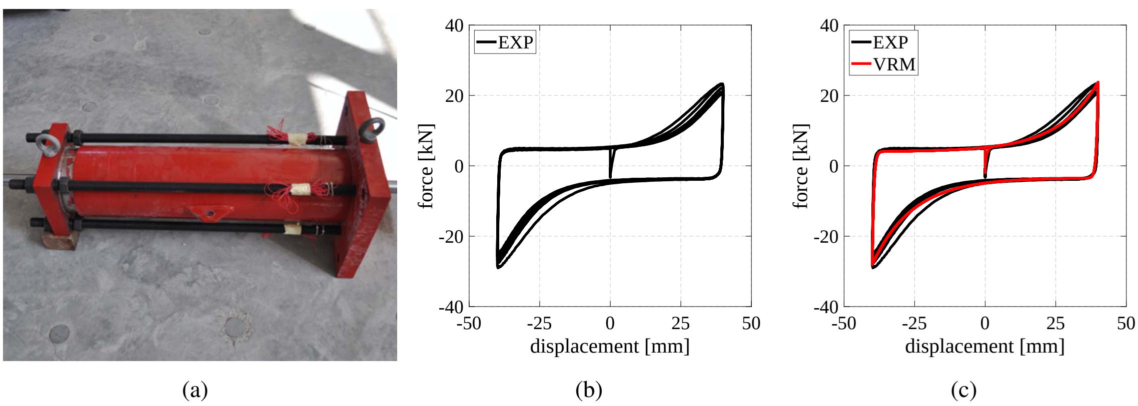

Figure 1: Tested pressured sand damper: picture (a), experimental (b) and simulated (c) force-displacement hysteresis loops.

References

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[2] Vaiana N., Rosati L. (2023) Classification and Unified Phenomenological Modeling of Complex Uniaxial Rate-Independent Hysteretic Responses. *Mech. Syst. Signal Pr.* **182**:109539.