A 3D Structural Model for Nonlinear Dynamic Analyses of Rigid Blocks Supported by Wire Rope Isolators

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Abstract. In this study we propose a 3D structural model to perform nonlinear dynamic analyses of rigid blocks mounted on Wire Rope Isolators. The complex hysteretic behavior of such devices is simulated by using the recently formulated Vaiana-Rosati model since it is capable of reproducing both symmetric and asymmetric force-displacement hysteresis loops. The dynamic of the base-isolated system under both harmonic and seismic excitation will be addressed.

Introduction

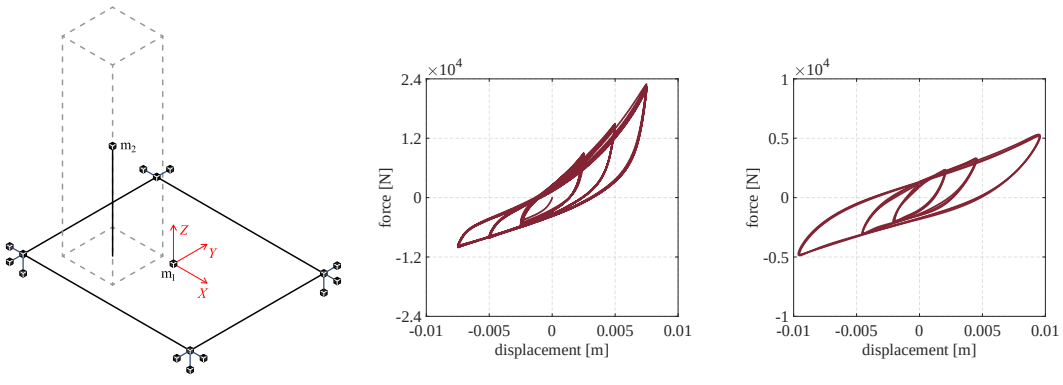
Wire Rope Isolators (WRIs) are metal devices made up of a stainless steel cable and two aluminum alloy or steel retainer bars where the cable is embedded. They can be effectively adopted for the vibration control of museum artifacts, hospital equipment, electrical transformers, supercomputers, and intermodal containers.
To allow for an accurate assessment of their performance when they are employed in the above-mentioned applications, we derive the nonlinear equilibrium equations of the three dimensional (3D) structural model shown in Figure 1a. Notably, the rigid block is mounted on a rigid plate supported by four WRIs and is located eccentrically with respect to the center of gravity of the isolation base. To reproduce the typical asymmetric (symmetric) hysteresis loops, as those in Figure 1b (1c), characterizing the WRIs response along their axial direction (transverse directions), we use a recently formulated hysteresis model [1]. The 3D model can be used to perform nonlinear dynamic analyses of the base-isolated system subjected to earthquake excitation.

3D Structural Model

The proposed 3D structural model (Figure 1a) consists of a first rigid body having mass m_1 and a second rigid body of mass m_2 rigidly linked to the first one; it is assumed to have an eccentricity between the two mass centers. Three rate-independent hysteretic elements are attached to each corner of the first rigid body in order to simulate the hysteretic behavior of WRIs along their axial, roll and shear directions.

Vaiana-Rosati Model of Hysteresis

The vertical (horizontal) rate-independent hysteretic elements are adopted to simulate asymmetric (symmetric) restoring force-displacement hysteresis loops. In particular, such responses are reproduced by adopting the Vaiana-Rosati Model (VRM) since it offers a series of advantages with respect to other models available in the literature [2, 3], such as: (i) the evaluation of the output variable in closed form, (ii) the simulation of complex hysteresis loops, (iii) the modeling of the loading and unloading phases by employing two different sets of parameters, (iv) the adoption of parameters having a clear theoretical and/or experimental interpretation, and (v) a straightforward computer implementation.



(a) (b) (c)

Figure 1: 3D structural model (a) and typical hysteresis loops exhibited by WRIs along their axial (b) and transverse (c) directions.

References

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