New constitutive modelling approach for shape memory alloys vibration control devices

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ABSTRACT

Shape memory alloys (SMA) belongs to the family of smart materials being comprehensively studied in recent decades. One of the main fields of its application in civil engineering is oriented on mitigation of earthquakes' effects on structures. Vibration isolators that incorporate elements made of SMA take advantage of its characteristic phenomenon of nonlinear hysteretic response, also known as superelasticity [1]. Such devices are especially promising for retrofitting and protection of architectural heritage what was verified in such of applications as in the bell tower of San Giorgio church in Trignano [2] or in the Basilic of San Francisco in Assisi and the Cathedral of San Feliciano in Foligno [3].

For modelling of SMA materials one of leading approaches is used – constitutive models based on thermomechanical material parameters or models based on system identifications. In this work, authors presents an approach to modelling of SMA by using rheological schemes [4–7]. One of the advantages of this phenomenological modelling approach is a possibility of formulation of constitutive relationships as a set of explicit differential equations. Such system of equations can be easily implemented in mathematical software or in the commercial FEM codes as user's subroutines.

As an illustration of validity of the formulation, authors present the response of single degree of freedom oscillator that incorporates SMA elements modelled by different existing SMA models. The response obtained based on the model that uses rheological schemes is compared with thermodynamic constitutive SMA model [8,9] and simplified material model [10]. All of the compered models are found to match well and show important reduction in displacement transmissibility.

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