A simple and effective Rigid Beam Model for studying the dynamic behaviour of freestanding columns

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ABSTRACT

In this work, a simple and effective Rigid Beam Model is proposed for studying the dynamic behaviour of ancient freestanding slender stone columns. As well known, monolithic and multi-drum freestanding columns are historical structural elements typical of ancient temples that still can be found in the Mediterranean area. These columns are particularly prone to collapse in case of seismic actions due to their freestanding condition caused by past earthquakes and other historical events, which have caused the collapse of temple rooftops and other horizontal load-bearing beams. The dynamic behaviour of freestanding columns has been studied by many authors in the past [1-3], and it is characterized by a strong nonlinearity given by sliding and rocking between the drums. The Rigid Beam Model here described assumes each drum of the column as a rigid beam element and each interface between the drums as a node of the model able to move horizontally. The small displacements hypothesis is assumed, together with the no-sliding hypothesis at the interface level, following the same assumption taken by Housner [1]. Furthermore, the material nonlinearity is considered by means of a moment-rotation constitutive law slightly modified with respect to the bilinear one introduced by Housner. Several numerical tests are performed for first by considering a monolithic column, in order to validate the results of dynamic tests with respect to existing analytic and numeric solutions. Then, further numerical tests are performed on a multi-drum column modelled with the proposed Rigid Beam Model and by means of a Discrete Element Model, which is able to consider large displacements and the possible sliding between the drums, and it has already proven its effectiveness in simulating column behaviour [2-4]. The purpose of this second comparison is to highlight the influence of different hypotheses on the numerical dynamic behaviour of the columns, with particular attention to the fields of applicability of the proposed Rigid Beam Model. Furthermore, a Discrete Element Model neglecting joints sliding is adopted for performing a better detailed validation of the Rigid Beam Model.

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