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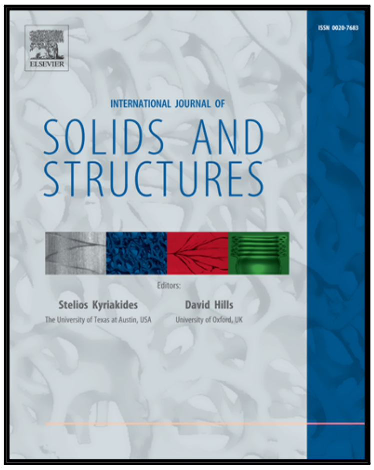

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Abstract. In the present paper, the problem of detecting unknown number of cracks is solved in a closed form for a multistep beam. First, general Rayleigh quotient is established for a multistep beam with an arbitrary number of cracks and boundary conditions. Then, it is used for obtaining an explicit expression of natural frequencies through crack parameters for cantilever multistep beams. The obtained expression is straightforward for calculating natural frequencies of a multistep beam with an arbitrary number of transverse cracks and enables to develop an efficient procedure for detecting unknown number of cracks in the beam structure. Numerical examples show that the Rayleigh quotient is really a useful tool for modal analysis and identification of cracked multistep beams. An experimental study is accomplished for a two-step cracked cantilever beam to validate the theoretical development.

Keywords: *Multistep beam*; *crack detection*; *natural frequencies*; *Rayleigh quotient.*

1. **Introduction**

A stepped beam structure is frequently used in the practice of robotics, mechanical engineering, and structural engineering. It is also an appropriate model for studying beams of nonuniform profiles. Vibrations of such structures and benefits of the structure model were investigated in the widespread literature, some examples of which are studies by Jang and Bert (1989), Jaworski and Dowell (2008), Subramanian and Balasubramanian (1987), Koplow et al. (2006), and Yang (2010). Numerous methods were also developed for the vibration analysis of multistep beams such as transfer matrix method (TMM) (Sato 1983, Patil and Maiti 2003, Attar 2012), finite difference method (Sarigul and Aksu 1986), finite element method (FEM) (Ju et al. 1994), Green's function method (Kukla and Zamojska 2007), composite element method (CEM) (Lu et al. 2009), adomian decomposition method (Mao 2012), and differential quadrature element method (Wang and Wang 2013).

The problem of vibration in stepped beams becomes more appealing when a damage such as crack is present in the structures and need to be detected. Namely, using the Green's function method, Kukla (2009) demonstrated that the nonuniformity of a column and the location and depth of a crack