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Free vibration analysis of cracked beams by using rigid segment method

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ABSTRACT

This paper deals with the analysis of influence of crack parameters to the modal characteristics of beams at various boundary conditions by using rigid segment method. The beam was discretized by a number of rigid segments which were connected by elastic joints with three degrees of freedom, while the crack was described by cracked element based on fracture mechanics. This model allows detection of coupling between the axial and transverse vibrations under the special boundary conditions. The proposed approach covers both the Euler–Bernoulli and Timoshenko beam model. The efficiency of the method was shown through the few numerical examples.

1. Introduction

The cracked beam model is essential for the health monitoring of the many complex engineering structures like as bridges, tall buildings, turbine blades, etc. The existence of a cracks in the structure leads to the change in its modal characteristics. Today, it is possible to easily monitor the modal characteristics of the structure by setting the accelerometers anywhere on the structure. For this reason, it is clear the interest of many researchers for the model of a cracked beam that has been going on since the fifties of the last century to date. Although the literature on this topic is plenty, it is beyond the scope of this paper to make a review. A detailed literature review is given in Ref. [1]. Generally speaking, two types of cracked beam models can be found in literature [1,2]: the notched beam and the beam with cracked element. The notched beam model consist the saw cuts that describe the crack. A significant number of papers [3–7] deal with this model, although in Ref. [1] was emphasized that it is not applicable to real cracks. As pointed out therein, the reason for this is an insufficiently precise description of the crack. The second, more realistic crack model is based on the fracture mechanics [8] where the local flexibility of the cracked beam region is determined by using the stress intensity factors. After defining all the parameters of a cracked beam, different methods can be used for its modal analysis. Some of the methods used are analytical methods [9–15], Rayleigh Ritz method [16], perturbation method [17], modified Fourier series method [18], transfer matrix method [19], Galerkin method [20], finite element method [21], discrete element method [22], etc.

The coupling between the axial and transverse vibration modes may occur due to certain boundary conditions or structural characteristics of the beam. The causes of the mentioned coupling can be twofold.

The first cause of coupling over the crack model was discussed in Refs. [9,13,23] where the Euler–Bernoulli beam model was considered. In Ref. [13] was concluded that there is a small influence of the coupling between the axial and transverse

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