STATIC AND EIGENVALUE ANALYSIS OF CRACKED TIMOSHENKO BEAM BY NEW MACRO ELEMENT CONTAIN ARBITRARY NUMBER OF CRACKS

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ABSTRACT

In this paper the finite element of beam element with arbitrary number of transverse cracks is derived for fatigue and fracture applications. The new element is one-dimensional with arbitrary number of embedded edge cracks in arbitrary position of beam element with any depth. The cracks are not physically modeled within the element, but instead, their influences on the local flexibility of the structure are considerated by the modification of the element stiffness as a function of the cracks depth and cracks position. The derivations are based on a simplified computational model, where each crack is replaced by a corresponding linear rotational spring, connecting two adjacent elastic parts. The components of the stiffness matrix for the cracked element are derived using the superposition principle, compatibility relations, and Betti's theorem. The stiffness matrix for transversely cracked beam element is derived and all expressions are given in symbolic forms. Models using the presented stiffness matrix are shown to produce accurate results, although with significantly less computational effort than physical modeling of the crack in 2D finite element models.

INTRODUCTION

Cracks in structures present a serious threat to proper performance of structures. Most of failures of presently used structures are due to material fatigue. Experimental and computational studies have demonstrated that the presence of cracks leads to a change of the vibration properties of these structures (Cacciola et al, 2003, Dimarogonas, 1996 and Krawczuk et al, 2000). Because, due to the crack presence, the structures miss their original stiffness. Monitoring the change of these properties over time represents a widely used nondestructive method of evaluating the severity of the damage and computing the remaining life of structure.

A detailed model of the crack and its surrounding can be properly obtained with an appropriate mesh of finite elements. From a computational viewpoint, the finite element method represents a standard approach to simulate how cracked structures treat under external loading. The majority of these methods introduce the crack by physically modeling the separation of the two crack faces. A major disadvantage of these methods is that they necessitate the allocation of significant computational efforts in order to accurately model the stress singularity at the crack tip. However, such an approach is unsuitable for inverse problems where a model suitable for crack location and depth modification is required when searching for a potential crack.

For some applications, the global response of a cracked structure is of interest, while the local behavior of the material in the vicinity of the crack tip can be disregarded. In such cases there is a need for simulating the crack presence without actually modeling the crack. In this paper we present such an approach applied to a one-dimensional finite element that has arbitrary number of embedded cracks in different