Nonlinear vibration analysis of specially orthotropic tapered plate with arbitrarily oriented crack: An analytical approach

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Abstract. The current work aims to investigate nonlinear vibrations in a partially cracked orthotropic plate with linearly varying thickness. The orientation of this crack is arbitrary and can vary from 0° to 90°. The equilibrium principle is used, and the governing equation of a tapered orthotropic plate is derived using classical plate theory. The simplified line spring model, which incorporates in-plane forces and bending moments, is used to consider the impact of a partial crack on plate dynamics. The inclusion of Berger's formulation introduces nonlinearity into the model in terms of in-plane forces. For converting the governing equation into time-dependent modal coordinates, Galerkin's method was chosen, which employs an approximate solution technique to solve the non-linear Duffing equation. The effects of the taper constants, crack orientation, and crack length on the fundamental frequency are investigated for SSSS and CCSS boundary conditions.

Introduction

Studies suggest that orthotropic plates have significant applications in modern engineering structures. A high-strength and low-weight structure is always a priority while designing any complex structure. To achieve such mechanical properties, plates with non-uniform thickness are used significantly. In many cases, these plates are operated in extreme dynamic conditions, resulting in the generation of flaws in the form of cracks that affect the complete system's performance. Rice and Levy [1] developed the Line Spring Model (LSM) based on the classical plate theory. The crack is signified as a continuously distributed line spring for stretching and bending compliance coefficients. LSM gave the relation between stresses at the crack tip to the stresses at the far end of the plate. Using LSM, an analytical model for vibration analysis of a partially cracked rectangular isotropic plate with a centrally located is presented by Israr et al. [2]. Ismail and Cartmell [3] extended the model of Israr et al. [2] and presented an analytical method for determining the natural frequencies of the isotropic plate with an arbitrarily oriented crack. Chandrakar et al. [4] developed an analytical model to investigate the nonlinear vibration analysis of a specially orthotropic tapered micro-plate. To the best of the author's knowledge, the literature lacks the results for vibration analysis of the specially orthotropic tapered plate containing an arbitrarily oriented crack.

Results and Discussion

Results are presented for a specially orthotropic cracked plate with linearly varying thickness. The effects of the variations of crack orientation, taper constant and crack length are obtained for two boundary conditions. It has been found that the vibration characteristics are affected by the taper parameters, cracks lengths, crack orientation, fibre direction & boundary conditions.

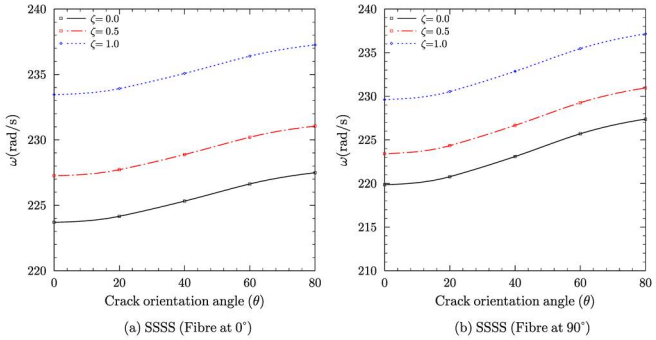

Figure 1: Fundamental frequency as affected by taper parameter & crack orientation for specially orthotropic SSSS cracked plate

References

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