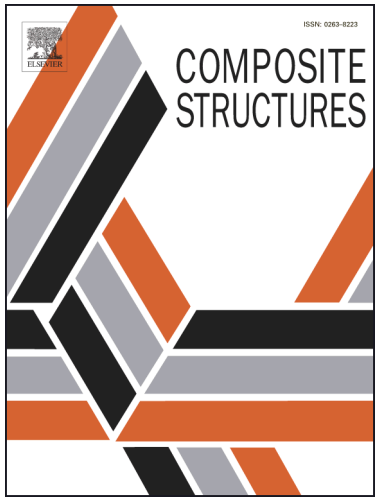

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Multiple damage detection in laminated composite beams by data fusion of Teager energy operator-wavelet transform mode shapes

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Abstract

Mode shapes have been widely used for structural damage detection. The basic premise of this method is that damage occurring in a structure causes singularities in mode shapes, which in turn reveal damage. However, singularities induced by small damage are insignificant and susceptible to noise. To address these deficiencies, the Teager energy operator (TEO) together with wavelet transform (WT) is introduced to process mode shapes, producing TEO-WT mode shapes. It is noted that each TEO-WT mode shape has its specific sensitivity to damage at a certain location, which means that multiple damage may not be identified simultaneously from a single TEO-WT mode shape. Thus data fusion of multiple TEO-WT mode shapes is used to create an overall TEO-WT mode shape. A damage indicator (DI) is then obtained by integrating the overall TEO-WT mode shape in the scale domain. The DI features distinctive capability to suppress noise, intensify singularities caused by damage, and improve the reliability of damage detection. The efficacy of the method is verified numerically and then validated experimentally on cracked laminated composite beams. The numerical and experimental results demonstrate the capability of the method to detect multiple damage in laminated composite beams under noisy conditions.

Keywords: Multiple damage detection, Laminated composite beam, Mode shape, Wavelet transform, Teager energy operator, Data fusion

1. Introduction

Composite laminates have been extensively utilized in civil, mechanical, military, and aerospace industries owing to their high specific stiffness and strength, low weight, corrosion resistance, and non-conductivity [1]. These composite laminates are exposed to various types of damage. Damage detection in composite laminates is important to avoid structural failure and has been a research focus during the last few decades [2–5]. Vibration-based methods have been widely studied, as they are non-destructive, inexpensive, and expedient [6–8]. In particular, mode shapes have been widely used for damage detection as they carry local information about the damage and have high

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