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Crack identification in functionally graded material framed structures using stationary wavelet transform and neural network

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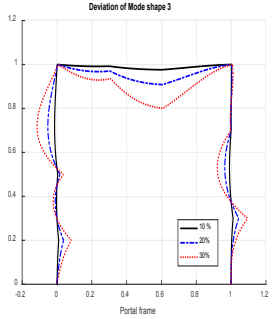
Key words: Crack identification; Functionally graded material; Neural network; Stationary wavelet transform; Dynamic stiffness method

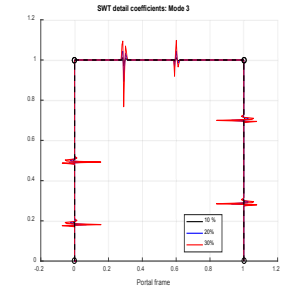
- Functionally graded material (FGM) has been proved to be an advanced material by its advantaged properties compared to the laminate composites and by the wide application in the high-tech industries such as aerospace, automobile, electronics, optics, chemistry, biomedical engineering etc. The presence of a crack in a structure usually leads to the reduction of stiffness and changes the dynamic characteristics, therefore, the crack problem in FGM is extremely important to evaluate the structure's serviceability and integrity. Crack identification in FGM structures is receiving increased attention from both structural engineers and scientists.

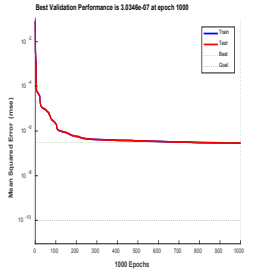
- The Wavelet Transform (WT) and neural networks (NNs) are common tools in structural damage identification but both of them have their disadvantages. To overcome these problems, many researchers developed new approaches to combine WT and NN to detect damage on structures. To the best of the authors' knowledge, the NN and the stationary wavelet transform (SWT) based approach to the crack identification of multiple cracked FGM frame structures is a gap that has to be fulfilled.

- In this paper, an integrated procedure to identify cracks in a portal framed structure made of FGM using SWT of mode shapes and NN is proposed.

- Cracks are assumed to be open and are modeled by double massless springs with stiffness calculated from their depth. Material properties of the structure vary along the thickness of beam elements by the power law of volumn distribution
- Firstly, the Dynamic Stiffness Method (DSM) is developed to calculate the mode shapes of a cracked frame structure based on shape functions obtained as a general solution of vibration in multiple cracked FGM Timoshenko beams. DSM is well-known as the most exact tool for vibration analysis to date. DSM allows examination of the arbitrary high-frequency vibration modes of elastic structures including the FGM ones
- Then, the stationary wavelet transform (SWT) of mode shapes is used to detect locations of cracks based on the positions related to the wavelet maxima coefficients.
- The neural networks (NNs) are properly established to provide a relationship between crack location, depths and wavelet maxima coefficients. Inputs of crack identification method proposed can be not only mode shapes but also static, dynamic deflections of multiple cracked FGM beams







RESULTS AND CONLUSIONS

1. The DSM developed herein for multiple cracked FGM frames provides an exact and powerful tool for modal analysis of multiple cracked FGM structures in an arbitrary high frequency band.
2. It was demonstrated that the stationary wavelet transform as a filtered wavelet transform applied for mode shapes is an efficient technique in localizing cracks in frame FGM structures. The numerical example shows also that for accurate localization of cracks it is enough to use only the fundamental mode shape.
3. The neural network technique in combination with the stationary wavelet transform of the mode shape is shown to be very effective for accurately assessing crack depth in composite structures such as one made of functionally graded material, even with noisy measured mode shapes.
4. The integrated procedure proposed for multi-crack identification of FGM frame in this study is useful also in the case of a limited amount of measured data not only of the mode shape but also of static or dynamic deflection of the structures.