

DAMAGE IDENTIFICATION IN POLYMER COMPOSITE BEAMS USING SPATIAL CONTINUOUS WAVELET TRANSFORM

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INTRODUCTION

In this paper, a method based on Continuous Wavelet Transform (CWT) technique is applied to beam structures in order to localize the area of damage. CWT coefficients are extremely sensitive to any signal discontinuities and singularities, therefore location of damage due to a sudden loss of stiffness can be detected in those operational deflection shapes (ODS), that yield large amplitude wavelet coefficients.

Damage index (DI) for ODS is depicted as follows

$$DI_{i\ CWT}^{n} = W_{i\ s,b}^{n} = \int_{L} w_{i}^{n} \cdot \psi_{s,b}(x) dx$$

where *n* is a mode number, *i* is number of grid point in *x* direction, *w* is a transverse displacement, $\psi_{s,b}(x)$ is a translated and dilated wavelet function in spatial domain and DI is damage index.

In order to minimize the measurement noise, DI results for ODS are normalized with respect to largest DI value as follows

 $DI_i = \frac{1}{N} \cdot \sum_{i=1}^{N} \frac{DI_i^n}{i}$ where N is a total number

To quantify the reliability of wavelets to identify the location of damage, a new parameter, called *"damage estimate reliability"* (DER) is introduced

$$DER_{i} = \frac{SDI_{i}(b)}{\overline{SDI_{i}}(a) + \overline{SDI_{i}}(b) + \overline{SDI_{i}}(c)} \times 100\%$$

zone a – before damage, zone b – damage, zone c – after damage.

Most of the mode shape curvature (MSC) damage detection methods require the baseline data of the healthy structure. Often these baseline modal parameters are not available.

In this paper, an interpolation technique with a Fourier series approximation is applied on a MSC data of the damaged structure, generating smooth MSC surfaces that are estimates of the healthy structure.

$$\kappa(x) = a_0 + \sum_{i=1}^n a_i \cdot \cos(n\omega x) + b_i \cdot \sin(n\omega x) \qquad \frac{1 \le n \le 8}{(F1 - F8)}$$

The DI is defined as the absolute difference between squares of the measured curvature of the damaged structure and reconstruction of MSC approximation with Fourier series representing the healthy structure.

$$\sum_{n=1}^{i} DI_{i,\max}^{n}$$
 of modes.

These damage indices are then standardized according to statistical hypothesis and standardized damage indices (SDI) are obtained

$$SDI_i = \frac{DI_i - \mu_{DI}}{\sigma_{DI}}$$

where $\mu_{\rm DI}$ and $\sigma_{\rm DI}$ are mean value and standard deviation of damage indices.

$$DI_{i\ MSCS}^{n} = \left| \left(\frac{\partial^2 w^n}{\partial x^2} \right)_i^2 - \left(\kappa_x^n \right)_i^2 \right| = \left| \left(\frac{\left(w_{i+1}^n - 2w_i^n + w_{i-1}^n \right)}{h^2} \right)^2 - \left(\kappa_x^n \right)_i^2 \right|$$

SDI and DER values are calculated for MSCS method aswell.



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