Evaluation of damage in structures using vibration-based analyses


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**Title**

Evaluation of damage in structures using vibration-based analyses

**Author(s)**

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**Abstract**

Composite materials are supplanting conventional metals in aerospace, automotive, civil and marine industries in recent times. This is mainly due to their high strength and light weight characteristics. But with all the advantages they have, they are prone to delamination or matrix cracking. These types of damage are often invisible and if undetected, could lead to appalling failures of structures. Although there are systems to detect such damage, the criticality assessment and prognosis of the damage is often more difficult to achieve.

The research study conducted here primarily deals with the structural health monitoring of composite materials by analysing vibration signatures acquired from a laser vibrometer. The primary aim of the project is to develop a vibration based structural health monitoring (SHM) method for detecting flaws such as delamination within the composite beams. Secondly, the project emphasises on the method's ability to recognise the location and severity of the damage within the structure. The system proposed relies on the examination of the displacement mode shapes acquired from the composite beams using the laser vibrometer and later processing them to curvature mode shapes for damage identification and characterization. Other identification techniques such as a C-scan has been applied to validate the location and size of the defects with the structures tested. The output from these plots enabled the successful identification of both the location and extent of damage within the structure with an accuracy of 96.5%.

In addition to this, this project also introduces a method to experimentally compute the critical stress intensity factor, KIC for the composite beam. Based on this, a technique for extending the defect has been proposed and validated using concepts of fatigue and fracture mechanics. A composite specimen with a 40 mm wide delamination embedded within was loaded under fatigue conditions and extension of the defect by 4mm on either side of the specimen's loading axis was achieved satisfactorily. The experimental procedure to extend the defect using fatigue was validated using the SLV system. Displacement and Curvature mode shapes were acquired post-fatigue crack extension. Upon analysing and comparing the displacement and curvature mode shapes before and after crack extension, the extended delamination was identified satisfactorily.

**Degree**

Masters by Research

**Institution**

RMIT University

**School, Department or Centre**

Aerospace, Mechanical and Manufacturing Engineering

**Keyword(s)**

Composite materials -- Testing
Materials -- Testing
evaluate different damage identification methods. 642 Structural Analysis of Historical Constructions. 2 damage identification process. 3 vibration based damage identification methods. There is not yet one methodology which gives accurate damage identification through all the presented levels of damage assessment and for all type of structural systems. stage, modal identification analysis using output-only (ambient or natural vibration) techniques. was done, where the ambient temperature and humidity were also recorded, to evaluate the envi similar structures in literature. If this observation is confirmed with real case studies, such as buildings, bridges or towers, the vibration based damage identification techniques applied to. These types of damage are often invisible and if undetected, could lead to appalling failures of structures. Although there are systems to detect such damage, the criticality assessment and prognosis of the damage is often more difficult to achieve. The research study conducted here primarily deals with the structural health monitoring of composite materials by analysing vibration signatures acquired from a laser vibrometer. Based on this, a technique for extending the defect has been proposed and validated using concepts of fatigue and fracture mechanics. A composite specimen with a 40 mm wide delamination embedded within was loaded under fatigue conditions and extension of the defect by 4mm on either side of the specimen's loading axis was achieved satisfactorily. Analysis of vibration-induced fatigue cracking in steel bridges. Master's Thesis in the Structural Engineering and Building Performance Design JASIM MOHSIN NASER. Fernando serrano toledano. Fatigue life evaluation of civil engineering structures is usually based on cyclic load considering only static effects. By adopting this approach for dynamically loaded structures it might not capture the whole picture. When the load subjected on the structure excite it with frequencies close to the structure's resonance limit, additional fatigue damage can arise. The problem with fatigue attracted attention with the use of metal in structures. One of the first to investigate the fatigue phenomenon was Wöhler 1819-1914.