Synopsis

Thesis Title : STRUCTURAL HEALTH MONITORING USING WAVE PROPAGATION TECHNIQUES.

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The thesis deals with axial wave propagation in concrete beam with dis-continuities. Dis-continuity (impedance mismatch) is induced in the beam by varying its cross section area along its length. Numerical simulations are performed using the spectral finite element method (SFEM) and compared with experimental studies conducted on four different concrete beams under (1) Pulse echo and (2) Pitch catch configurations. It is noted that numerical simulations are in good agreement with the experimental data. The effect of reduction of area (or increase of area) causes reduction in stiffness as well as mass and hence axial impedance is not altered to a great extent. How a wave propagation based technique is able to identify the location and magnitude of defect is brought out. Towards simulating the damage scenario in a sagged conductor made of wire rope, a prismatic steel rod is taken up for experimentation. The sag of the rod at the center is varied by varying its un-supported span. An initial axial wave, tangential to the curve of the arc manifests as both axial and flexural waves as it propagates along the length of the rod. This interaction effect between axial and flexure wave propagation is also studied in this experiment. Dis-continuity (impedance mismatch) is also induced in the rod by welding two steel rods which in turn indicated the variation of its cross section area along its length. Numerical simulations are performed using spectral finite element method (SFEM) with combined axial and flexure effect and compared with experimental studies conducted under pitch-catch configuration. It is noted that numerical simulations are in good agreement with the experimental data.

The guided wave propagation experiment is conducted in the same steel rod with varying sag conditions, along with structural discontinuities. The contribution of this work is conducting an experimental investigation of guided wave generation with Lead Zirconate Titanate (PZT) patches using function generator. Responses are collected through other PZT patches through condition amplifier the output of which is fed to an oscilloscope. It is proposed that the location of damage can be easily identified. General ultra-sonic experiments are conducted using piezo crystal oscillator resonating in its natural mode with higher vibrational energy. Piezo patch with which the excitation is carried out shall have the flexibility of varying the frequency of excitation, though the energy levels of vibrations are small. However, using another piezo with conditioning amplifier, adequate reflected responses are able to be recorded. The guided wave propagating under near ultra-sonic frequencies are found to be better matched if the elemental rod theory is replaced with higher-order rod theory, proposed as Love theory. Numerical simulations are performed using higher order Love theory as implemented in spectral finite element library and compared with experimental studies conducted on steel rod using instrumentation for Pitch catch configuration.

Application of wave propagation for damage detection in an aluminum plate, which represent a two dimensional structural element is also presented in this thesis. The experimental investigation had been conducted on an aluminum plate through generating the wave with PZT patches using function

generator. Normal responses (out of plane flexural response) are measured with the Laser Scanning Doppler Vibrometer (LSDV). The obtained results are presented in the form of scatter plots and contour maps. It is envisioned that the proposed approach enables damage localization in a relatively fast and precise manner.