

Analytical Solutions and Experiments in Wave Propagation Problems

Thesis report submitted to
Indian Institute of Technology Mandi
in partial fulfilment for the award of the degree of
Master of Science
in
Design

by
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Under the supervision of
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School of Engineering
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Spring Semester, 2017-18
October, 2018

DECLARATION

I certify that

- (a) The work contained in this report has been done by me under the guidance of my supervisor.
- (b) The work has not been submitted to any other Institute for any degree or diploma.
- (c) I have conformed to the norms and guidelines given in the Ethical Code of Conduct of the Institute.
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Date: October, 2018

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CERTIFICATE

This is to certify that the project report entitled “Analytical Solutions and Experiments in Wave Propagation Problems” submitted by Gaurav Sharma (Roll No. S16006) to Indian Institute of Technology Mandi towards partial fulfilment of requirements for the award of degree of Master of Science in Design is a record of bona fide work carried out by him under my supervision and guidance during Spring Semester, 2017-18.

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Abstract

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Every disturbance in a continuum media generates a wave, which propagates through the space-time domain. Therefore, the study of waves and its propagation is of the utmost importance for all engineering problems. Various studies have been performed in this domain. Analytical solutions exist for the simple cases and can be applied to most of the complex scenarios by using the superposition principle. A more complex problem can be solved using computational methods. But, each of them pertains to their own drawbacks. The response through a computational method needs the whole space and time domain to be analyzed. This approach provides good results but becomes inefficient when the solution is required at only a very distant time step. Also, some complex excitation become very cumbersome to be decomposed into superimposing components. Novel analytical methods are proposed for wave propagation problems to overcome the above mentioned limitations.

A modified Laplace Transform approach is proposed to investigate the wave propagation/ vibration response of a stretched string. The vibration response is demonstrated using the proposed method for various initial and boundary conditions. The method is capable of calculating the vibration response of a moving impulse loading on the string. The method is compared with other methods such as Fourier analysis and finite difference method for accuracy and computational efficiency.

A Dirac Delta function approximation is proposed to analyze the acoustic wave propagation through panel. Governing wave equation is modified to include the Dirac Delta function which represents the discontinuity in the wave propagation medium (air to panel). The expression for wave transmission, reflection, and absorption coefficients are evaluated for a single panel in terms of strength of the Dirac Delta. The obtained results are compared with Finite Element simulation results for a single-layered and multilayered panel materials.

Finally, one-dimensional acoustic transmission line has been constructed to experimentally measure the strength of Dirac Delta function for various test materials of panel. For this purpose, a Two Microphone Impedance Tube experimental setup is designed and constructed. A statistical study has been performed on the developed setup to minimize the errors in measurements. The sample calculations has been demonstrated for acoustic testing of different materials using the developed experimental setup.

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