Elastic Waves from Localized Sources in Multilayered Composite Plates: A New Wavenumber Integral Method

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This study is motivated by the need for an efficient and accurate tool to analyze the wavefield produced by localized dynamic sources on the surface or the interior of anisotropic composite laminates. A semi-analytical method based on the wavenumber integral representation of the elastodynamic field is described that reduces the overall computational effort significantly over other available methods. This method is used to calculate the guided wavefield produced in a thin unidirectional graphite/epoxy composite laminate by dynamic surface loads. The results from the Mindlin plate theory and a finite element analysis are used for model verification. A periodic reversal in the phase of the signal with propagation distance is observed and explained using steepest descent calculations. The calculated wavefields in a thick aluminum plate as well as a thick $[90/0/90/0]_{4s}$ graphite/epoxy cross-ply composite plate due to a pencil lead break source are then compared with the experimental results. In addition, the acoustic emission (AE) waveforms from the initiation of shear delamination are calculated in both thin and thick multilayered graphite/epoxy composite plates. An approximate laminate theory with shear correction factor and "moment tensor" representation of the source is used to compare the results. The differences in the characteristics of the signals and their potential for AE source characterization are discussed. The present work is expected to be helpful in developing impact damage monitoring systems in defect-critical structural components through real time analysis of acoustic emission waveforms.

Keywords: guided waves, multilayerd composite plates, wavenumber integral, acoustic emission