Multi-scale simulation of elastic waves containing higher harmonics

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1. INTRODUCTION & OBJECTIVE

The huge amount of research and development has been, and continues to be, utilized in learning a more beneficial understanding in the mechanics and mathematics of wave propagation. Guided wave based non-destructive inspection techniques provide to evaluation of integrity of critical structures and to find out damage position, shape, and size [1]. Also the material nonlinearity of the structure generates higher harmonics when fundamental Raleigh surface waves or Lamb waves are used in monitoring the health of the structure. Finite element method [2, 3] is extensively used for simple wave propagation problems. Recently, some customized elements and geometric multi-scale finite element method have been developed to solve some special types of wave propagation problems [4, 5]. To simulate wave with its higher harmonics, there is a need to develop some simple and generalized multi-scale approach. For last two decades, wavelets are used to simulate wave propagation where localized region of the sharp gradient of field variable changes its locations in space with time. In the literature, some researchers have used wavelets as basis function to solve PDEs but most researchers have applied the wavelet based adaptive technique in finite difference schemes. This article will be particularly useful to applications where FEM/FDM/FVM requires a very fine mesh of uniform grid. As an example, we are presenting crack detection using guided wave in structural health monitoring problem where higher harmonics are ignored just because of computational cost. In the proposed wavelet projection method, FEM is preferred due to its capability to handle complex boundary and loading conditions instead of any other method. This multi-scale transformation hierarchically filters out the less significant frequencies and thus provides an effective framework to retain the necessary frequencies of the wave.

2. RESULTS & HIGHLIGHTS OF IMPOINTANT POINTS

This paper is presenting wavelet based nonstandard operator to improve finite element simulation of waves moving at different speeds in a large structure. This will not only useful to the structural health monitoring but it can be used where waves with higher harmonics move at different group velocities. A simple description of the nonstandard operator along with necessary algorithm and mathematical comments are provided to remove an implementation headache associated with adaptive grid techniques. The algorithm is applied to 2D plane strain problem, but it is general and independent of domain dimension. In this work, B-spline and Daubechies wavelets based multi-scale operator are applied and the results are compared with the standard finite element method. The excitation signal on a plate with a higher harmonics is shown in Fig.

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1(a). Nodal displacement response of plate received from B-spline and D4 wavelet Transform at level 1 along with FEM results are demonstrated in Fig.1(b). It can observed that the transform method is able to reduce the 50% nodes of FEM without disturbing the higher harmonics and Lamb wave.

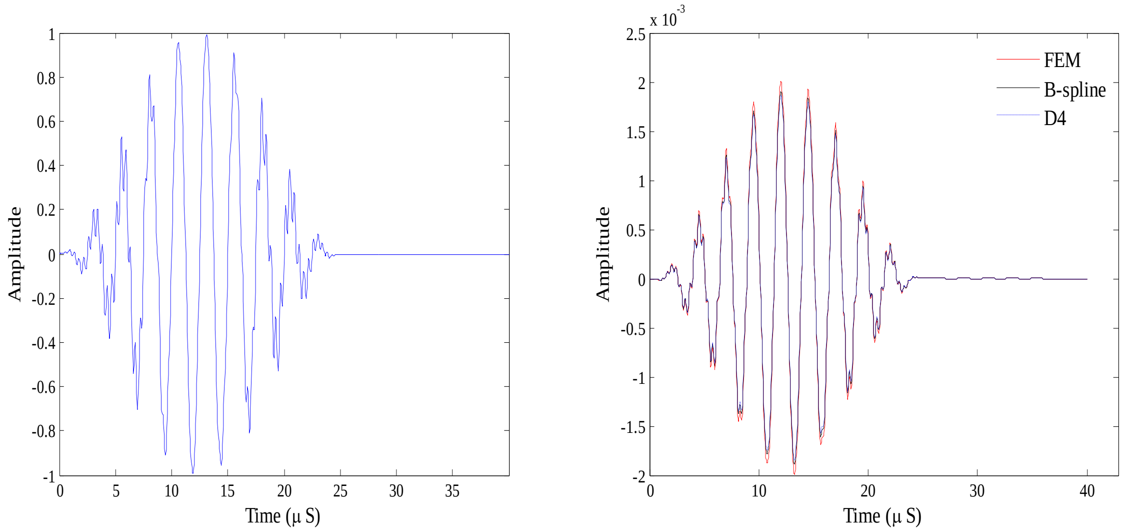

Fig.1 (a) Excitation signal for Lamb wave in plate. (b) Comparison of plate response at WT level 1

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