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ACCURATE MODELLING OF WAVE PROPAGATION PROBLEMS IN HOMOGENEOUS, COMPOSITE AND FUNCTIONALLY GRADED MATERIALS

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There are the following issues with existing numerical methods for elastodynamics problems: a) a large dispersion error of space-discretization methods may lead to a great error in space; b) due to spurious high-frequency oscillations, the lack of reliable numerical techniques that yield an accurate solution of wave propagation in solids; c) the treatment of the error accumulation for long-term integration; d) the increase in accuracy and the reduction of computation time for real-world dynamic problems. A new numerical approach for computer simulation of the dynamic response of linear elastic structures is suggested. The new technique is very general, and would be of equal value in such diverse applications as: earthquakes; elastic and acoustic wave propagation; crashes; dynamics testing of aerospace vehicles, airplanes, bridges and buildings; and others. The new approach, which resolves the issues listed, includes two main components: a) a new dispersion reduction technique for linear finite elements, and b) a new two-stage time-integration technique which includes a new two-stage solution strategy with the stage of basic computations and the filtering stage, a new exact analytical a-priori error estimator in time for second- and high-order methods; and a new calibration procedure for the quantification and filtering of spurious oscillations; new criteria for the selection of time-integration methods for elastodynamics. In contrast to existing approaches, the new technique does not require guesswork for the selection of numerical dissipation and does not require interaction between users and computer codes for the suppression of spurious high-frequency oscillations. Different discretization methods in space such as the low- and high-order finite elements, the spectral elements, the isogeometric elements, and others can be used with the suggested two-stage time-integration approach. The comparative study of these space-discretization methods for elastodynamics is presented. 1-D, 2-D and 3-D numerical examples show that the new approach yields an accurate non-oscillatory solution for impact and wave propagation problems and considerably reduces the number of degrees of freedom and the computation time in comparison with existing methods. Using the new approach, wave propagation and structural dynamics problems are uniformly solved. The new numerical technique is also applied to the analysis of wave propagation in the Split Hopkinson Pressure Bar (SHPB). A good agreement between the numerical and experimental results for wave propagation in the SHPB is obtained at impact loading. We have also extended and applied the new technique for wave propagation in composite and functionally graded materials under impact loading.