Uncertainties in wave characteristic of one-dimensional periodic media using the fuzzy wave finite element method

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ABSTRACT

The design of periodic media is generally based on deterministic models without considering the effect of intrinsic uncertainties existing in these media. In general, the design is aimed at controlling as much as possible the mechanical waves; however, inherent uncertainty may affect their characteristics. Periodic media are diffused in all the trasporation engineering and demand a high level of robustness, which can be ensured with the careful consideration of the presence of uncertainty in the numerical models. The uncertainties, in terms of material properties and geometrical parameters, are mostly exhibited in both the manufacturing and assembly processes. The exact sources of the uncertainty are rarely found since their identification represents a difficult task. When facing with incomplete information about the uncertainties, the adoption of the probabilistic approach can result in very challenging evaluations [1]. In this scenario, the fuzzy set theory offers a way to approximating the uncertainty distribution in the form of the confidence interval through fuzzy membership functions. These are equivalent representations for the characterization of the linguistic, vague and missing data uncertainties [2].

To predict the wave characteristics of the periodic media in presence of uncertainties, the wave finite element method in conjunction with fuzzy logic and algebra has been applied. For one-dimensional wave propagation, firstly, the most significant input parameters such as Young's modulus and mass density are identified and then *fuzzified* using the membership functions. Then, fuzzy variable is propagated through the numerical model as a sort of interval analysis.

The dispersion curves for flexural and longitudinal waves with fuzzy parameters has been used to illustrate the generality of the proposed approach also looking at the possibility to have frequency region in which those waves cannot propagate (frequency band gaps). The triangular membership functions have been used in the numerical examples and the obtained results are compared against the classical Monte Carlo simulations (MSC). The approach was presented for very simplified test-cases but it is found to be more efficient when compared with the conventional MCS approach in terms of computational cost.

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