Influence of variability in geometric and material parameters on the damping properties of multilayer structures

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Abstract. In this work, we present finite element models based on the solid–shell approach, which have been specifically designed for the modeling of multilayer structures. The originality in the current study lies in the analysis of variability in the design parameters, which could be of geometric or material type. The first type of imperfections generally results from the manufacturing of such structures [1], while the second source of variability arises from the mechanical parameters of the same material, as identified in the literature (e.g., Aluminum Young modulus equal to 70.3 GPa in [2], while estimated as 69 GPa in [3]). Therefore, it is of importance to assess the influence of these uncertainties on the design of actual structures. To this end, several studies have been proposed in the literature, among which in reference [4], the MSP (Modal Stability Procedure) was combined with the MCS (Monte Carlo Simulation). The approach we propose is rather simple and is based on the uncertainty on the actual values of several parameters in some well-defined intervals. The developed method is applied to modeling the vibrations of multilayer shell structures made of elastic layers, viscoelastic and piezoelectric materials. The resulting problem is discretized by linear and quadratic solid–shell finite elements developed in [5, 6] and extended to viscoelastic sandwich structures in [7]. To solve the associated nonlinear equations, we adopt the method that couples the homotopy to ANM (Asymptotic Numerical Method) and AD (Automatic Differentiation) proposed in [8]. The obtained results provide information on the tolerance margin of error that can be committed without compromising structural integrity.

Keywords: Variability, Solid–shell finite elements, Multilayer structures, Vibrations, Viscoelasticity, Piezoelectricity, Asymptotic numerical method.

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