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Refined zig-zag theory for dynamic characteristics of laminate plates with viscoelastic layers

Przemysław Litewka and Roman Lewandowski

Institute of Structural Analysis, Poznan University of Technology, Poland

The laminate structural elements – beams, plates and shells, including viscoelastic (VE) layers attached to or inserted between elastic panels, are very often used in various engineering applications, like aerospace, machine or car industry. Such structures possess very desirable mechanical properties combining light weight with high load capacity. The VE layers are applied to dissipate significant amounts of energy and thus vibrations and noise can be significantly mitigated also allowing to avoid fatigue failure.

In this paper the refined zig-zag theory (RZT) is used to carry out the dynamic analysis of composite sandwich plates including the VE layers. RZT allows to introduce the different physical properties of layers while preserving the stress continuity on the layer interfaces. The application of RZT to such type of problem leads to the frequency-dependent complex-valued character of the zig-zag function unlike in the case of static analysis.

The linear constitutive relations written down separately for volumetric and deviatoric strains are used to model the material. It is worth to note that such an approach allows for a clear physical interpretation whereas the corresponding relaxation and creep functions can be determined from experiments. It also introduces naturally the frequency-dependence of the Poisson's ratio postulated in some recent papers on viscoelasticity.

The fractional Zener model is used in the formulation of VE material. It is already well known that the application of fractional calculus is a very efficient tool allowing for description of all important rheological phenomena while utilizing a few material parameters. The Laplace transformation and the finite element method are used to derive the discretized nonlinear eigenvalue problem.

The fundamental properties of the plates required for design of structural elements in many fields of engineering, i.e. their dynamic characteristics – the frequency and the damping ratio, can be obtained using the specially developed numerical procedure. It is based on the continuation method. In the iterative part of each continuation step either the full Newton or the quasi-Newton iterative procedure is used.

Several numerical examples are solved to verify accuracy, efficiency and versatility of the proposed formulation. Numerous parametric studies were carried out to determine the influence of various variants of solution methods, combinations of material parameters and layers layout onto the damping properties of plates. These results will be presented and discussed at the conference.

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