Extended fractional models in the evaluation of dynamic characteristics of plates with viscoelastic layers

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Laminate plates are frequently used structural elements in many branches of engineering. The understanding of their dynamic behaviour under various service conditions is of great importance. This paper is devoted to the free vibration analysis of such plates containing viscoelastic layers, which are useful in reducing excessive vibrations. This is the continuation of authors' earlier research, e.g. [1].

The viscoelasticity is modelled using four different material descriptions based on the fractional derivatives and including the separation of volumetric and deviatoric parts of deformation. The standard linear solid (or Zener) material model, the 5-parameter model proposed by Pritz [2], the 6-parameter model by Heymans [3] and the most elaborate 10-parameter model proposed by Arikoglu [4] are considered.

Arikoglu showed in [4] that the simpler models containing even 5 or 6-parameter, despite the theoretical possibility to depict the non-symmetric inverted-U-curve relation in the Wicket plot and the limitless storage modulus behaviour in high-frequency limit, are still not capable of sufficiently good representation of real VE materials. Basing on six tested particular materials he proposed the further generalisation of the VE description and introduced the model consisting of two nested 5-parameters segments, showed that its performance is very much superior to the simpler models and proposed an effective identification procedure for the material parameters, based on genetic algorithms and provided the material parameters for those VE materials. In the presented paper these results are effectively embedded into the solution procedure for the layered plates.

The time-temperature superposition is used to include the effect of the ambient temperature. Three methods of thermal shift computation are considered, i.e. the Arrhenius formula based on the activation energy, the Williams-Landel-Ferry proposal and the modified Kaelble method.

The plate kinematics is described with the refined zig-zag theory and the free vibration problem of layered plates is formulated using the principle of virtual work and the finite element discretisation. The solution of the resulting non-linear eigenvalue problem is obtained using the homotopy method.

The results and discussion of several numerical examples solved using the proposed approach will be presented at the conference. Especially, the comparison of the damping performance of six different viscoelastic materials described by four models of viscoelasticity for various sandwich plates will be addressed. The influence of the ambient temperature will be analysed, too.

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[1] R. Lewandowski, P. Litewka, P. Wielentejczyk, *Compos. Struct.* **2021**, 278, 114547

[2] T. Pritz, *J. Sound Vib.*, **2003**, 265, 935-952

[3] N. Heymans, *Rheol. Acta* **1996**, 35, 508-519

[4] A. Arikoglu, *Rheol Acta*, **2014**, 53, 219-233