VISCOELASTIC BEHAVIOR OF SOFT MATERIALS AT LOW FREQUENCY: THEORETICAL CHARACTERIZATION AND CONSTITUTIVE MODELING

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In many practical applications viscoelastic solids endure small-amplitude harmonic deformation on top of the static load caused, for instance, by the self-weight of the target structures. This is indeed the case for a rolling car tire or for a human artery under tension, pressure, and pulsating blood flow. If the deformation amplitude is small, then the resulting stress field can be assumed to be periodic and there is phase shift between the applied deformation and the load. This phase shift depends on the frequency w of the harmonic strain.

In this context, the material mechanical properties are usually expressed in terms of the storage , G', and loss, G", moduli: they measure the amplitude of the stress in-phase and in-quadrature with the applied deformation, respectively.

Experimental evidence from the literature on different materials (rubber, polyurethane and mozzarella cheese) show a similar functional dependence on the frequency of the dynamic moduli; in particular, when assessed at the lowest frequencies, both the storage and loss moduli show a high sensitivity with respect to frequency variations. Attempting to fit this experimental data with the commonly employed linear and nonlinear viscoelastic models results in significant errors at low frequency. This is essentially due to the fact that, for most of the models used, the resulting frequency sensitivity of the storage modulus is always zero as $w \to 0$. This should be considered an important drawback as the frequencies up to 10-15 Hz are often the most significant in many applications, e.g., rolling tire at 100 km/h or the human heart rate!

After having identified the crucial property of the viscoelastic kernel responsible for the vanishing sensitivity of the storage modulus, some preliminary solutions are proposed: two models with the proper memory's rate of decay are introduced and their ability to match the experimental data analysed.

References

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