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Application of the time-strain superposition – Part II: Prediction of the frequency-dependent behaviour of brain tissue

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Abstract

Knowing the real material properties of brain tissue is of great importance when it comes to the precise prediction of its mechanical response. The efficiency of these procedures depends on the adequacy of experimental data and the analytical and numerical tools utilized.

In this study, we combine existing approaches within the theory of viscoelasticity in order to predict the frequency-dependent behaviour of the porcine brain from the known stress relaxation data. Time-strain superposition is applied to the brain shear relaxation segments for the construction of the long-term master curve in the linear viscoelastic range. A widely-used and well-established numerical procedure is then utilized for the prediction of the frequency-dependent modulus based on the constructed master curve. The demonstrated methodology is evaluated using the porcine brain experimental data available from the literature.

The results show reasonably good agreement between the predicted and the previously measured and published storage modulus data in the whole frequency range investigated. On the other hand, prediction of the loss modulus is only possible within certain frequency ranges related to the time frame of experimentally known relaxation behaviour. Nevertheless, the outcomes of the paper speak in favour of the validity of the linear viscoelastic interconversion relations between the time- and frequency-dependent material functions of the porcine brain tissue exposed to strain up to the tissue's linear viscoelastic limit.