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Linking static and dynamic NDT through fractional derivatives

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Static testing of mechanical properties of materials is widely used and well documented. Several extensively employed NDT techniques relying on induced mechanic wave motion (dynamic strain) exist. Comparing results obtained with dynamic NDT techniques to each other and to certified static tests is problematic especially for polymer materials whose absolute mechanical moduli depend on loading frequency. We present a study performed on 102 block-shaped dry samples of Norwegian spruce wood (Picea Abies [L.] Karst., a complex natural polymer) using ultrasound propagated in the longitudinal wood direction with frequencies ranging from 50 kHz to 8 MHz. The samples were also tested using a standardized three-point bending test providing longitudinal elasticity estimates at near-zero frequency (static MOE). We validate experimentally the Pritz[1] five-parameter fractional derivative model and we link together the static test and the ultrasonic NDT technique. Our results allow predicting the static MOE from the dynamic MOE obtained with ultrasonic test equipment, and permit comparison of data obtained with ultrasonic methods applying different frequencies.

[1] T. Pritz, Five-parameter fractional derivative model for polymeric damping materials, Journal of Sound and Vibration, 265(5), pp. 935-952, 2003