Ultrasonic Determination of Elastic Properties

Procedure

- Time of flight measurements together with a known material thickness allow the determination of the sound velocity of longitudinal (c_L) and transverse (c_T) waves.
- The elastic modulus E and the shear modulus G can be determined out of c_L und c_T knowing the density (ρ):

$$E = 4\rho c_T^2 \frac{3/4 - (c_T/c_L)^2}{1 - (c_T/c_L)^2} \qquad G = \rho c_T^2$$

Example: Contact Technique

- Determination of c_L with a longitudinal probe
- Determination of c_T with a transverse probe

Example: Immersion Technique

- Water transmits only longitudinal waves
- Determination of c_L out of the time of flight between the entrance echo and the backwall echo (perpendicular insonification).
- There are certain experimental conditions (dependent on probe and material) where partial wave mode conversions longitudinal ↔ transverse occur. Out of the corresponding LT echo one can determine c_T.

Example: Transmission with Air-Coupling

- Out of the temporal difference Δt between transmission signals with and without the sample one can determine it's longitudinal sound velocity c_L:

$$c_L = \frac{1}{1/c_{Air} - \Delta t/d}$$

- d = Thickness of the sample
- c_{Air} = Sound velocity of air (temperature dependent!)

Example: Surface Waves

- Oblique insonification in immersion: Creation of surface waves in sample
- Reception of leaky waves by oblique probe
- Time of flight measurements at different receiver positions allow the determination of the propagation velocity of the surface wave.
- Reference: J. Neuenschwander, T. Schmidt, T. Lüthi, and M. Romer, Leaky Rayleigh wave investigation on mortar samples, Ultrasonics, 45 (2006) 50-55.