Elastic Moduli from Ultrasonic Wave Velocities

Young's modulus, shear modulus, bulk modulus and Poisson's ratio of an isotropic solid from its longitudinal and shear sound velocities and density.

Method: Elastic wave velocities in isotropic solids

Input parameters

Unit system: SI

Parameter	Value	Unit
Longitudinal wave velocity	5,920.0	m/s
Shear (transverse) wave velocity	3,230.0	m/s
Density	7,850.0	kg/m³

Calculated results

Parameter	Value	Unit
Shear modulus	81.898	GPa
Poisson's ratio	0.28807	
Young's modulus	210.98	GPa
Bulk modulus	165.92	GPa
Rayleigh wave velocity (approximate)	2,985.1	m/s

Notes for this case

• In an isotropic elastic solid the shear wave velocity is √(G/ρ) and the longitudinal (bulk) wave velocity √[(K + 4G/3)/ρ], so two velocities and the density give all the elastic constants. These dynamic (adiabatic, small-strain) moduli are slightly higher than static test values, by up to a few per cent for metals and more for concrete or polymers. The Rayleigh velocity uses Viktorov's approximation.

Formula and method

$$G = \rho v_S^2, \quad \nu = \frac{v_L^2 - 2v_S^2}{2(v_L^2 - v_S^2)}, \quad E = 2G(1+\nu), \quad K = \rho\left(v_L^2 - \frac{4}{3}v_S^2\right)$$

Variables

v_L	Longitudinal wave velocity	m/s
v_S	Shear (transverse) wave velocity	m/s
ρ	Density	kg/m³
G	Shear modulus	Pa
ν	Poisson's ratio	-
E	Young's modulus	Pa
K	Bulk modulus	Pa
v_R	Rayleigh wave velocity (approximate)	m/s

Method and standards

Ultrasonic moduli.

Assumptions and limits

- Isotropic, homogeneous, linear elastic solid.

References

Elastic wave velocities in isotropic solids

Report details

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Release checks	3 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/materials/properties/ultrasonic-elastic-moduli

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.