Strain Energy, Resilience and Suddenly Applied Load

Strain energy stored in a bar under axial load, the modulus of resilience and proof resilience, and the stress under a suddenly applied load.

Method: Textbook mechanics (strain energy, Timoshenko, Strength of Materials)

Input parameters

Unit system: SI

Parameter	Value	Unit
Axial load (gradually applied)	50.000	kN
Cross-sectional area	500.00	mm²
Length	2.0000	m
Young's modulus	200.00	GPa
Yield (elastic limit) stress	250.00	MPa

Calculated results

Parameter	Value	Unit
Stress P/A	100.00	MPa
Strain energy σ² A L/(2E)	25.000	J
Modulus of resilience S_y²/(2E)	156.25	kJ/m³
Proof resilience of the bar	156.25	J
Stress if the load is applied suddenly 2P/A	200.00	MPa

Formula and method

$$U = \frac{\sigma^2}{2E} AL, \quad u_r = \frac{S_y^2}{2E}, \quad \sigma_{sudden} = \frac{2P}{A}$$

Variables

P	Axial load (gradually applied)	N
A	Cross-sectional area	m²
L	Length	m
E	Young's modulus	Pa
S_y	Yield (elastic limit) stress	Pa
σ	Stress P/A	Pa
U	Strain energy σ² A L/(2E)	J
u_r	Modulus of resilience S_y²/(2E)	J/m³
U_p	Proof resilience of the bar	J
σ_s	Stress if the load is applied suddenly 2P/A	Pa

Method and standards

Elastic energy of an axially loaded bar.

Assumptions and limits

- Elastic, uniform bar: the page warns when P/A, or 2P/A for a sudden load, exceeds the yield stress.
- The modulus of resilience is shown in kJ/m³ in every unit system.

References

- Textbook mechanics (strain energy, Timoshenko, Strength of Materials)

Report details

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

This calculator online

https://calc.firecad.com/mechanical/strength-of-materials/strain-energy-resilience

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.