Laminated (Leaf) Spring: Stress and Deflection

Bending stress and deflection of a semi-elliptic laminated leaf spring from load, span, leaf width and thickness and the number of full-length and graduated leaves.

Method: Bhandari; Design of Machine Elements; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Load at the centre	20.000	kN
Span (eye to eye)	1,000.0	mm
Leaf width	60.000	mm
Leaf thickness	10.000	mm
Full-length leaves	2.0000	
Graduated leaves	8.0000	
Elastic modulus	207.00	GPa

Calculated results

Parameter	Value	Unit
Bending stress (pre-stressed, equalised)	500.00	MPa
Deflection at the centre	54.897	mm
Spring rate	364.32	kN/m

Notes for this case

- Semi-elliptic spring treated as two cantilevers of length L each carrying W/2, with full-length leaves pre-stressed (nipped) so all leaves reach the same stress. Ignores leaf friction.

Formula and method

$$\sigma = \frac{6(W/2)L}{nbt^2} = \frac{3WL}{nbt^2}, \quad \delta = \frac{12(W/2)L^3}{Ebt^3(2n_g + 3n_f)} = \frac{6WL^3}{Ebt^3(2n_g + 3n_f)} \quad (W \text{ centre load},\ L \text{ half span}, n = n_f + n_g)$$

Variables

W	Load at the centre	N
$2L$	Span (eye to eye)	m
b	Leaf width	m
t	Leaf thickness	m
n_f	Full-length leaves	-
n_g	Graduated leaves	-
E	Elastic modulus	Pa
σ	Bending stress (pre-stressed, equalised)	Pa
δ	Deflection at the centre	m
k	Spring rate	N/m

Method and standards

Multi-leaf spring theory.

Assumptions and limits

- Equal width and thickness leaves; pre-stressed.
- The stress is not compared with an allowable, and no ineffective length is deducted for the centre clip or band (deduct it from the span yourself).

References

• Bhandari
• Design of Machine Elements
• 4th ed.
• ch. 10 (multi-leaf springs: $\sigma = 6WL/(nbt^2)$, $\delta = 12WL^3/(Ebt^3(2n_g + 3n_f))$)

Report details

Report reference	FCC-1PZ3-SR49 (the same inputs always give the same reference)
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Release checks	2 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/mechanical/machine-design/leaf-spring-stress-deflection

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.