Cantilever Beam: Moment, Deflection, Stress

Fixed-end reaction and moment, tip deflection and bending stress of a cantilever under a uniform load and a point load at the free end.

Method: Euler–Bernoulli beam theory

Input parameters

Unit system: SI

Parameter	Value	Unit
Length from the fixed end	2.0000	m
Uniformly distributed load (including self weight)	2.0000	kN/m
Point load at the free end	5.0000	kN
Modulus of elasticity	200.00	GPa
Second moment of area	1,943.0	cm^4
Elastic section modulus	194.00	cm^3

Calculated results

Parameter	Value	Unit
Bending moment at the fixed end	14.000	kN·m
Tip deflection	4.4605	mm
Maximum bending stress	72.165	MPa
Reaction at the fixed end	9.0000	kN
Length over deflection	448.38	

Notes for this case

- Fully fixed support assumed; a real support that rotates adds deflection. Check shear and buckling separately.

Formula and method

$$R = wL + P \qquad M_{max} = \frac{wL^2}{2} + PL \qquad \delta_{max} = \frac{wL^4}{8EI} + \frac{PL^3}{3EI} \qquad \sigma_b = \frac{M_{max}}{Z}$$

Variables

L	length	m
w	distributed load	N/m
P	tip load	N
E	modulus of elasticity	Pa
I	second moment of area	m^4
Z	section modulus	m^3
M_{max}	fixed-end moment	N·m
δ_{max}	tip deflection	m
σ_b	bending stress	Pa
R	fixed-end reaction	N
L/δ	length over deflection	–

Method and standards

Euler–Bernoulli small-deflection theory for a cantilever, superposing the two load cases.

Assumptions and limits

- Linear elastic; fully fixed support.

- The stress is not compared with an allowable. I and Z are entered separately: take both from the same section, as an inconsistent pair is not detected.

References

- Euler–Bernoulli beam theory

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/cantilever-beam

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Reopens the calculator with the inputs of this report.