ENGINEERING RESOURCES · MECHANICAL DESIGN SERIES

Beam Formula Sheet

Reactions, maximum moment and maximum deflection for four standard beam cases, with the assumptions and unit notes used in the Beam Analysis Workbook.

DOCUMENT
ER-BEAM-S1 · Sample

FORMAT
A4 PDF · 2 pages

PREPARED FOR
Mechanical and structural engineers

UNITS
SI: m, kN, GPa, cm⁴, mm

Four standard cases

L span · P point load · w uniform load · E elastic modulus · I second moment of area. Maximum values occur at the stated position.

Case	Reaction	Maximum moment	Maximum deflection
Simply supported, central point load	$R = P / 2$	$M = P L / 4$	$\delta = P L^3 / (48 E I)$
Simply supported, uniform load	$R = w L / 2$	$M = w L^2 / 8$	$\delta = 5 w L^4 / (384 E I)$
Cantilever, end point load	$R = P$	$M = P L$	$\delta = P L^3 / (3 E I)$
Cantilever, uniform load	$R = w L$	$M = w L^2 / 2$	$\delta = w L^4 / (8 E I)$

Bending stress and serviceability

$$\sigma = M / S \quad \cdot \quad \delta \text{ ratio} = \delta / L$$

With M in kN·m and S in cm³, $\sigma = M \times 10^3 / S$ gives N/mm² (MPa). A deflection ratio of 1/250 corresponds to 0.004 and is a common serviceability guide, not a code requirement for every project.

Worked check — case 1

L = 6 m, P = 25 kN, E = 210 GPa, I = 4,500 cm⁴.

$$E I = 210 \times 4500 \times 0.01 = 9{,}450 \text{ kN·m}^2 \quad R = 25 / 2 = 12.5 \text{ kN} \quad M = 25 \times 6 / 4 = 37.5 \text{ kN·m} \quad \delta = 25 \times 6^3 / (48 \times 9450) = 0.0119 \text{ m} = 11.9 \text{ mm}$$

Unit handling

- E enters in GPa and is multiplied by 10^6 to give kN/m².
- I enters in cm⁴ and is multiplied by 10^{-8} to give m⁴.
- Together, E × I in GPa·cm⁴ becomes kN·m² when multiplied by 0.01.
- Deflection is reported in millimetres; stress in N/mm².

Assumptions

- Linear elastic, isotropic, homogeneous material.
- Euler–Bernoulli bending with small deflections.
- Prismatic section with constant E and I.
- Loads applied in the plane of bending; no axial load or torsion.
- Shear deformation, self-weight and support settlement ignored.

> **Scope.** This sheet supports preliminary sizing and checking. It is not a substitute for frame analysis, a code check or independent review of safety-related work.

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