Torsion of Thin-Walled Open Sections: Angles, Channels and I-Beams

Torsion constant, maximum shear stress and angle of twist of a thin-walled open section made of up to three rectangular plates, such as an angle, channel or I-beam.

Method: Saint-Venant torsion of thin-walled open sections (membrane analogy)

Input parameters

Unit system: SI

Parameter	Value	Unit
Length of plate 1 (e.g. web)	300.00	mm
Thickness of plate 1	8.0000	mm
Length of plate 2 (e.g. one flange)	150.00	mm
Thickness of plate 2	12.000	mm
Number of plates like plate 2	2.0000	
Length of plate 3 (0 if none)	0	mm
Thickness of plate 3	0	mm
Torque	2,000.0	N·m
Member length	3.0000	m
Shear modulus	79.300	GPa

Calculated results

Parameter	Value	Unit
Torsion constant Σ bt³/3	22.400	cm^4
Maximum shear stress (thickest plate)	107.14	MPa
Angle of twist	19.353	°
Section area	60.000	cm^2
Stiffness gain if closed into a square tube of the same area and thickness t_1	235.42	

Notes for this case

- Thin-walled open section: K = Σ bt³/3, stress τ = T t/K in each plate, largest in the thickest. Warping restraint at the ends is ignored (free warping).

Formula and method

$$K = \sum \frac{b_i t_i^3}{3}, \quad \tau_{max} = \frac{T t_{max}}{K}, \quad \theta = \frac{TL}{KG}$$

Variables

b_1	Length of plate 1 (e.g. web)	m
t_1	Thickness of plate 1	m
b_2	Length of plate 2 (e.g. one flange)	m
t_2	Thickness of plate 2	m
n_2	Number of plates like plate 2	-
b_3	Length of plate 3 (0 if none)	m
t_3	Thickness of plate 3	m

T	Torque	N·m
L	Member length	m
G	Shear modulus	Pa
K	Torsion constant Σ bt³/3	m^4
τ_{max}	Maximum shear stress (thickest plate)	Pa
θ	Angle of twist	rad
A	Section area	m^2
K_{tube}/K	Stiffness gain if closed into a square tube of the same area and thickness t_1	-

Method and standards

Membrane-analogy torsion of thin open sections.

Assumptions and limits

- Thin walls (b/t above about 10), free warping, elastic.

References

Saint-Venant torsion of thin-walled open sections (membrane analogy)

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/thin-open-section-torsion

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Reopens the calculator with the inputs of this report.