Lateral-Torsional Buckling Moment of an I-Beam

Elastic critical moment for lateral-torsional buckling of a doubly symmetric I-beam from its flange and web sizes, unbraced length and moment gradient factor.

Method: Elastic lateral-torsional buckling of a doubly symmetric I-beam

Input parameters

Unit system: SI

Parameter	Value	Unit
Overall depth	400.00	mm
Flange width	180.00	mm
Flange thickness	13.500	mm
Web thickness	8.6000	mm
Unbraced length	6.0000	m
Moment gradient factor (1.0 uniform moment, 1.13 UDL, 1.35 central point load)	1.1300	
Elastic modulus	200.00	GPa
Shear modulus	77.000	GPa
Yield strength	250.00	MPa

Calculated results

Parameter	Value	Unit
Minor-axis second moment	1,314.2	cm^4
Torsion constant	37.433	cm^4
Warping constant	490,048	cm^6
Elastic critical moment	226.37	kN·m
First-yield moment f_y S_x	273.46	kN·m
Plastic moment f_y Z_x	309.58	kN·m
Slenderness √(M_p/M_cr)	1.1694	

Notes for this case

• Timoshenko's elastic critical moment for a simply supported, doubly symmetric I-beam loaded at the shear centre, ends free to warp. Section constants from the plate dimensions (root fillets ignored). Design codes reduce the moment capacity from M_p using this slenderness.

Formula and method

$$M_{cr} = C_1 \frac{\pi}{L_b} \sqrt{EI_y GJ + \left(\frac{\pi E}{L_b}\right)^2 I_y C_w}$$

$$I_y = \frac{2t_f b_f^3}{12} + \frac{h_w t_w^3}{12}, \quad J = \frac{2b_f t_f^3 + h_w t_w^3}{3}, \quad C_w = \frac{I_{y,f} h_0^2}{4}$$

Variables

h	Overall depth	m
b_f	Flange width	m
t_f	Flange thickness	m

t_w	Web thickness	m
L_b	Unbraced length	m
C_1	Moment gradient factor (1.0 uniform moment, 1.13 UDL, 1.35 central point load)	-
E	Elastic modulus	Pa
G	Shear modulus	Pa
f_y	Yield strength	Pa
I_y	Minor-axis second moment	m^4
J	Torsion constant	m^4
C_w	Warping constant	m^6
M_{cr}	Elastic critical moment	N·m
M_y	First-yield moment f_y S_x	N·m
M_p	Plastic moment f_y Z_x	N·m
$\bar{\lambda}_{LT}$	Slenderness √(M_p/M_cr)	-

Method and standards

Elastic lateral-torsional buckling theory.

Assumptions and limits

- Doubly symmetric section, elastic, load at the shear centre, simple supports free to warp.

References

Elastic lateral-torsional buckling of a doubly symmetric I-beam

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/civil/steel/lateral-torsional-buckling

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Reopens the calculator with the inputs of this report.