

Section Properties Tool (I-section) — Validation Report

Disclaimer: This report documents validation of the section properties engine against the cases presented. Results are provided for educational purposes and should be independently reviewed and verified by a qualified professional before use in design or construction.

Generated 2026-10-12 15:42:01 | Engine: section_properties.py v1.0.0 (sha256: c9f03c24053c...) | References: textbook closed form + sectionproperties (finite element, no fillets)

Engine vs textbook: maximum difference 0.0000% across all checks | Accuracy of the J / Cw approximations vs finite element: J 1.3-4.7%, Cw 0.06-1.10%

How this report works: each built-up I-section (flanges bf x tf, web tw, overall depth d; weld fillets not included) is solved by the engine and by textbook closed-form formulas written independently of the engine (e.g. $I_x = [bf d^3 - (bf - tw) hw^3] / 12$). The reviewer verifies Engine against Textbook; all values should agree to rounding. J and Cw use the thin-walled formulas of AISC Design Guide 9 ($J = [2 bf tf^3 + (d - tf) tw^3] / 3$, $Cw = I_y (d - tf)^2 / 4$), which are approximations. The grey columns show, for information only, an exact finite-element solution (sectionproperties package, no fillets; element area $0.05 \times \min(tf, tw)^2$, converged to < 0.2 %) and how far the engine is from it -- i.e. the accuracy of those approximations. Geometric and plastic properties agree with it exactly.

Quantity	Unit	Textbook	Engine	Diff %	Verified	Finite element	Engine vs FE
11. Typical welded beam				Date verified:	2026-10-12		
d = 400 mm, bf = 200 mm, tf = 20 mm, tw = 10 mm							
Area A	mm^2	11,600.00	11,600.00	0.0000%	✓	11,600.00	0.00%
Centroid from bottom	mm	200.0000	200.0000	0.0000%	✓	200.0000	0.00%
Ix	x10^6 mm^4	327.9467	327.9467	0.0000%	✓	327.9467	0.00%
Iy	x10^6 mm^4	26.6967	26.6967	0.0000%	✓	26.6967	0.00%
Sx (elastic)	x10^3 mm^3	1,639.73	1,639.73	0.0000%	✓	1,639.73	0.00%
Sy (elastic)	x10^3 mm^3	266.9667	266.9667	0.0000%	✓	266.9667	0.00%
rx	mm	168.1406	168.1406	0.0000%	✓	168.1406	0.00%
ry	mm	47.9733	47.9733	0.0000%	✓	47.9733	0.00%
Zx (plastic)	x10^3 mm^3	1,844.00	1,844.00	0.0000%	✓	1,844.00	0.00%
Zy (plastic)	x10^3 mm^3	409.0000	409.0000	0.0000%	✓	409.0000	0.00%
J (torsion) -- approximate	x10^3 mm^4	1,193.33	1,193.33	0.0000%	✓	1,139.58	+4.72%
Cw (warping) -- approximate	x10^9 mm^6	963.7497	963.7497	0.0000%	✓	962.2198	+0.16%
12. Deep plate girder				Date verified:	2026-10-12		
d = 1200 mm, bf = 300 mm, tf = 25 mm, tw = 12 mm							
Area A	mm^2	28,800.00	28,800.00	0.0000%	✓	28,800.00	0.00%
Centroid from bottom	mm	600.0000	600.0000	0.0000%	✓	600.0000	0.00%
Ix	x10^6 mm^4	6,699.00	6,699.00	0.0000%	✓	6,699.00	0.00%
Iy	x10^6 mm^4	112.6656	112.6656	0.0000%	✓	112.6656	0.00%
Sx (elastic)	x10^3 mm^3	11,165.00	11,165.00	0.0000%	✓	11,165.00	0.00%
Sy (elastic)	x10^3 mm^3	751.1040	751.1040	0.0000%	✓	751.1040	0.00%
rx	mm	482.2905	482.2905	0.0000%	✓	482.2905	0.00%
ry	mm	62.5460	62.5460	0.0000%	✓	62.5460	0.00%
Zx (plastic)	x10^3 mm^3	12,780.00	12,780.00	0.0000%	✓	12,780.00	0.00%
Zy (plastic)	x10^3 mm^3	1,166.40	1,166.40	0.0000%	✓	1,166.40	0.00%
J (torsion) -- approximate	x10^3 mm^4	3,801.80	3,801.80	0.0000%	✓	3,668.30	+3.64%
Cw (warping) -- approximate	x10^9 mm^6	38,887.24	38,887.24	0.0000%	✓	38,833.76	+0.14%

Section Properties Tool (I-section) — Validation Report (continued)

Quantity	Unit	Textbook	Engine	Diff %	Verified	Finite element	Engine vs FE
I3. Shallow, wide flanges					Date verified:	2026-10-12	
d = 200 mm, bf = 250 mm, tf = 16 mm, tw = 10 mm							
Area A	mm^2	9,680.00	9,680.00	0.0000%	☒	9,680.00	0.00%
Centroid from bottom	mm	100.0000	100.0000	0.0000%	☒	100.0000	0.00%
Ix	x10^6 mm^4	71.8340	71.8340	0.0000%	☒	71.8340	0.00%
Iy	x10^6 mm^4	41.6807	41.6807	0.0000%	☒	41.6807	0.00%
Sx (elastic)	x10^3 mm^3	718.3403	718.3403	0.0000%	☒	718.3403	0.00%
Sy (elastic)	x10^3 mm^3	333.4453	333.4453	0.0000%	☒	333.4453	0.00%
rx	mm	86.1445	86.1445	0.0000%	☒	86.1445	0.00%
ry	mm	65.6190	65.6190	0.0000%	☒	65.6190	0.00%
Zx (plastic)	x10^3 mm^3	806.5600	806.5600	0.0000%	☒	806.5600	0.00%
Zy (plastic)	x10^3 mm^3	504.2000	504.2000	0.0000%	☒	504.2000	0.00%
J (torsion) -- approximate	x10^3 mm^4	744.0000	744.0000	0.0000%	☒	724.9109	+2.63%
Cw (warping) -- approximate	x10^9 mm^6	352.7852	352.7852	0.0000%	☒	352.5374	+0.07%
I4. Thin plates					Date verified:	2026-10-12	
d = 600 mm, bf = 200 mm, tf = 8 mm, tw = 5 mm							
Area A	mm^2	6,120.00	6,120.00	0.0000%	☒	6,120.00	0.00%
Centroid from bottom	mm	300.0000	300.0000	0.0000%	☒	300.0000	0.00%
Ix	x10^6 mm^4	363.3786	363.3786	0.0000%	☒	363.3786	0.00%
Iy	x10^6 mm^4	10.6728	10.6728	0.0000%	☒	10.6727	0.00%
Sx (elastic)	x10^3 mm^3	1,211.26	1,211.26	0.0000%	☒	1,211.26	0.00%
Sy (elastic)	x10^3 mm^3	106.7275	106.7275	0.0000%	☒	106.7275	0.00%
rx	mm	243.6711	243.6711	0.0000%	☒	243.6711	0.00%
ry	mm	41.7602	41.7602	0.0000%	☒	41.7602	0.00%
Zx (plastic)	x10^3 mm^3	1,373.52	1,373.52	0.0000%	☒	1,373.52	0.00%
Zy (plastic)	x10^3 mm^3	163.6500	163.6500	0.0000%	☒	163.6500	0.00%
J (torsion) -- approximate	x10^3 mm^4	92.9333	92.9333	0.0000%	☒	91.7398	+1.30%
Cw (warping) -- approximate	x10^9 mm^6	935.1037	935.1037	0.0000%	☒	934.5333	+0.06%

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Quantity	Unit	Textbook	Engine	Diff %	Verified	Finite element	Engine vs FE
I5. Stocky (thick plates)				Date verified:	2026-10-12		
<i>d = 300 mm, bf = 300 mm, tf = 40 mm, tw = 30 mm</i>							
Area A	mm^2	30,600.00	30,600.00	0.0000%	☒	30,600.00	0.00%
Centroid from bottom	mm	150.0000	150.0000	0.0000%	☒	150.0000	0.00%
Ix	x10^6 mm^4	435.4200	435.4200	0.0000%	☒	435.4200	0.00%
Iy	x10^6 mm^4	180.4950	180.4950	0.0000%	☒	180.4950	0.00%
Sx (elastic)	x10^3 mm^3	2,902.80	2,902.80	0.0000%	☒	2,902.80	0.00%
Sy (elastic)	x10^3 mm^3	1,203.30	1,203.30	0.0000%	☒	1,203.30	0.00%
rx	mm	119.2871	119.2871	0.0000%	☒	119.2871	0.00%
ry	mm	76.8019	76.8019	0.0000%	☒	76.8019	0.00%
Zx (plastic)	x10^3 mm^3	3,483.00	3,483.00	0.0000%	☒	3,483.00	0.00%
Zy (plastic)	x10^3 mm^3	1,849.50	1,849.50	0.0000%	☒	1,849.50	0.00%
J (torsion) -- approximate	x10^3 mm^4	15,140.00	15,140.00	0.0000%	☒	14,518.97	+4.28%
Cw (warping) -- approximate	x10^9 mm^6	3,050.37	3,050.37	0.0000%	☒	3,017.07	+1.10%