

Steel Shapes - Reading the Property Table

What a shape designation tells you, which tabulated property answers which check, and how W-shape and round pipe values come out of their dimensions. Area (A) · Moment of Inertia (I) · Elastic Modulus (S) · Plastic Modulus (Z) · Radius of Gyration (r)

SHAPE DESIGNATIONS

DESIGNATION	READS AS
W12×30	W-shape, nominal 12 in deep, 30 lb/ft
C10×20	Channel, nominal 10 in deep, 20 lb/ft
HP12×53	HP pile, nominal 12 in deep, 53 lb/ft
L4×4×½	Equal-leg angle, legs × thickness
L6×4×½	Unequal-leg angle, long leg first
S12×35	S-shape, nominal 12 in deep, 35 lb/ft
WT6×15	Tee split from a W12×30, 15 lb/ft
HSS6×6×⅜	HSS, nominal outside size × wall

Designations are nominal. Take actual dimensions from the shape table.

WHICH PROPERTY MATTERS

CHECK	LOOK AT	UNITS
Axial	A	in ²
Flexure	S, Z, I	in ³ , in ³ , in ⁴
Deflection	I	in ⁴
Buckling	r, KL/r	in, unitless
Torsion	J, C _w	in ⁴ , in ⁶
Local buckling	b/t, h/t _w	unitless
Weight	W	lb/ft

J = torsional constant · C_w = warping constant · K = effective length factor · L = unbraced length
c = distance to extreme fiber · S elastic, Z plastic · Δ: simple span, uniform load, E = 29,000 ksi

EQUATIONS

$$S = I / c$$

$$f_b = M / S$$

$$M_p = F_y \cdot Z$$

$$\Delta = 5wL^4 / (384 \cdot E \cdot I)$$

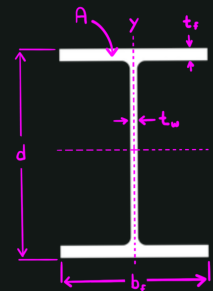
$$r = \sqrt{I / A}$$

$$\text{Slenderness} = KL / r$$

$$W = 490 \cdot A, A \text{ in ft}^2$$

WORKED EXAMPLE: W12×30 FROM ITS DIMENSIONS

Given: d = 12.3 in · b_f = 6.52 in · t_w = 0.260 in · t_f = 0.440 in · x strong, y weak



EQUATION

$$A = 2b_f t_f + (d - 2t_f) t_w$$

$$I_x = [b_f d^3 - (b_f - t_w)(d - 2t_f)^3] / 12$$

$$S_x = I_x / (d / 2)$$

$$Z_x = b_f t_f (d - t_f) + t_w (d - 2t_f)^2 / 4$$

$$r_x = \sqrt{I_x / A}$$

$$I_y = [2t_f b_f^3 + (d - 2t_f) t_w^3] / 12$$

$$S_y = I_y / (b_f / 2)$$

$$r_y = \sqrt{I_y / A}$$

$$W = 490 \cdot A, A \text{ in ft}^2 = \text{in}^2 / 144$$

$$W \approx 3.403 \cdot A, A \text{ in in}^2 (490 / 144 = 3.403)$$

HAND CALC

$$A = 8.71 \text{ in}^2$$

$$I_x = 234 \text{ in}^4$$

$$S_x = 38.1 \text{ in}^3$$

$$Z_x = 42.5 \text{ in}^3$$

$$r_x = 5.19 \text{ in}$$

$$I_y = 20.3 \text{ in}^4$$

$$S_y = 6.24 \text{ in}^3$$

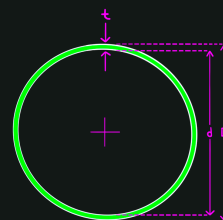
$$r_y = 1.53 \text{ in}$$

$$W = 29.6 \text{ lb/ft}$$

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ROUND PIPE FROM OD AND WALL

Given: D = 12 in · t = 0.5 in · d = D - 2t = 11 in



D = outer diameter (OD)
d = inner diameter (ID)
t = wall thickness

EQUATION

$$A = (\pi / 4)(D^2 - d^2)$$

$$I = (\pi / 64)(D^4 - d^4)$$

$$S = I / (D / 2)$$

$$Z = (I / 6)(D^3 - d^3)$$

$$W = A \times 490 / 144 \approx 3.403 \cdot A$$

RESULT

$$A = 18.1 \text{ in}^2$$

$$I = 299 \text{ in}^4$$

$$S = 49.9 \text{ in}^3$$

$$Z = 66.2 \text{ in}^3$$

$$W = 61.5 \text{ lb/ft}$$

SHAPE APPLICATIONS

- **W-shapes.** Beams, girders, temporary works, crane supports and excavation support.
- **HP-shapes.** Driven piles. The uniform cross section gives consistent resistance during driving.
- **Pipe.** Piles, bracing, columns, caissons, casing. Longitudinal seams run parallel to the pipe axis; spiral seams wrap the pipe and can accommodate large diameters.
- **HSS.** Bracing, columns, frames, casing. Closed section gives strength about multiple axes and torsional resistance.
- **Angles (L).** Bracing, connections, stiffeners, frames and miscellaneous supports.
- **Channels (C).** Framing, bracing, stiffeners, temporary works.
- **Tees (WT/MT/ST).** Stiffeners, bracing, framing, connections.
- **Plates.** Cover, connection, base and bearing plates, stiffeners, diaphragms and member reinforcement.

FIELD NOTES

- **Nominal is not actual.** A W12×30 is 12.3 in deep; a W12×336 is 16.8 in. Detail to the tabulated d.
- **Gross section, as rolled.** Holes, copes and notches are not in the table. Hand calcs ignore fillets and run 1 to 2% low.
- **Substitutions.** Compare I_x and r_x, not lb/ft.
- **Shape is not grade.** W14×48 is geometry, ASTM A992 is material. Grade changes F_y and F_u, not A, I, S, Z or r.
- **Modified members.** Stiffeners, doublers and cover plates change the section. Evaluate the modified geometry and load path.
- **Strong vs. weak axis.** Confirm the member is oriented the way the properties assume. Pipe has the same I about every axis.