



TECHNICAL WHITE PAPER

Structural Steel vs. Aluminum Carport Canopies

Engineering calculations, flexural strength comparison and cost-benefit breakdown for commercial solar carport framing

Summary. For the same 27-ft canopy beam and the same design loads, a 6061-T6 aluminum beam can carry the bending moment with a lighter section, but aluminum's elastic modulus is about one-third of steel's, so **deflection, not strength, governs the aluminum design**. Sized for equal stiffness, the aluminum beam in our example weighs about 58% of the steel beam (not the one-third suggested by density alone), and its material cost per beam is roughly 1.4-1.5 times higher. Welding 6061-T6 also cuts its yield strength near the weld by more than half. Hot-dip galvanized structural steel remains the lower-cost, stiffer choice for most commercial solar carports; aluminum earns its premium in severe coastal exposure, where weight drives the foundation or logistics cost, or for small bolted structures.

This white paper is general technical information for planning and comparison. It is not a sealed design. Every carport must be designed for its site loads by a licensed professional engineer under the governing building code (IBC / ASCE 7), and prices must be confirmed with current supplier quotes.

1. Materials compared

The comparison uses the materials most often specified for commercial carport framing in the United States: ASTM A500 Grade C hollow structural sections (HSS) and ASTM A992 wide-flange beams on the steel side, and extruded 6061-T6 aluminum on the aluminum side, designed to the Aluminum Association's *Aluminum Design Manual* (ADM).

Property	Structural steel (A500 Gr C / A992)	Aluminum 6061-T6 (extruded)	Ratio Al / steel
Minimum yield strength, F_y	50 ksi (A992; rectangular A500 Gr C HSS)	35 ksi	0.70
Minimum tensile strength, F_u	62-65 ksi	38 ksi	~0.60
Yield in weld heat-affected zone	No significant loss	~15 ksi as-welded (5356 filler, ADM)	0.30
Elastic modulus, E	29,000 ksi	10,100 ksi	0.35
Density	0.284 lb/in ³ (490 lb/ft ³)	0.098 lb/in ³ (169 lb/ft ³)	0.35
Coefficient of thermal expansion	6.5×10^{-6} /°F	13.1×10^{-6} /°F	2.0
Design specification	AISC 360	ADM (Aluminum Association)	-
Corrosion protection	Hot-dip galvanizing (ASTM A123)	Natural oxide film; anodize or paint optional	-

Two numbers drive everything that follows: aluminum is about one-third the weight of steel *and* about one-third as stiff. Specific strength favors aluminum; specific stiffness is roughly equal. A carport beam is usually limited by how far it may sag under snow or wind, so aluminum's weight advantage shrinks once the section is deepened to control deflection.

2. Design example: a 27-ft canopy beam

To compare like with like, both materials are sized for the same primary canopy beam, simply supported between columns. The loads are typical of a light-snow commercial site; actual projects must use site-specific ASCE 7 loads, including wind uplift and load reversal, which this example does not cover.

Input	Value	Note
Span, L	27 ft (324 in)	Typical structural-steel column spacing
Tributary width	9 ft	Beam spacing
Dead load (PV modules, purlins, misc.)	6 psf -> 54 plf	Self-weight added in margin
Snow / roof live load	30 psf -> 270 plf	Illustrative; use site ground snow load
LRFD factored load, $1.2D + 1.6S$	$w_u = 496.8$ plf	
Factored moment, $M_u = w_u L^2 / 8$	45.3 kip-ft (543 kip-in)	
Deflection limit (snow)	$L/240 = 1.35$ in	Common limit for canopies supporting PV

2.1 Required section properties

Flexural strength (braced, compact sections): $\phi M_n = \phi F_y Z$ with $\phi = 0.90$ for both AISC 360 and the ADM yielding limit state. Required plastic modulus $Z_{req} = M_u / (\phi F_y)$.

Stiffness: $\Delta = 5wL^4 / (384EI) \leq L/240$, so $I_{req} = 5wL^3(240) / (384E)$ with $w = 270$ plf (22.5 lb/in) unfactored snow.

Requirement	Steel (F_y 50 ksi, E 29,000 ksi)	Al 6061-T6 unwelded (35 ksi)	Al 6061-T6 at a weld (15 ksi)
Z_{req} for strength	12.1 in ³	17.2 in ³	40.2 in ³
I_{req} for L/240	82.5 in ⁴	236.8 in ⁴	236.8 in ⁴
Ratio to steel	1.0	1.43 (Z), 2.87 (I)	3.33 (Z), 2.87 (I)

Aluminum needs 2.87 times the moment of inertia of steel for the same sag - the ratio of the two moduli. If the maximum moment falls at a weld (a welded splice or bracket at midspan), the as-welded aluminum needs 3.3 times steel's plastic modulus as well. Good aluminum detailing keeps welds away from high-moment regions or uses bolted connections.

2.2 Candidate sections and flexural check

Rectangular tubes were sized for both materials. Properties below were computed from the nominal dimensions (steel HSS with the AISC design wall thickness of 0.93t and square corners; AISC Manual tabulated values, which include corner radii, are a few percent lower - confirm against AISC Manual Table 1-11). The aluminum tubes are computed shapes for comparison - confirm a stock or custom profile with an extruder.

Section	Weight (lb/ft)	I (in ⁴)	Z (in ³)	ϕM_n (kip-in)	Strength use $M_u / \phi M_n$	Snow deflection	Result
Steel HSS 10x4x1/4	21.5	78.1	19.7	886	0.61	1.43 in (L/227)	Fails L/240
Steel HSS 10x6x1/4	24.6	100.3	24.2	1,089	0.50	1.11 in (L/292)	OK
Al tube 12x4x0.25	9.1	132.4	28.3	891	0.61	2.41 in (L/134)	Fails L/240 badly
Al tube 12x6x0.375	15.2	241.1	49.9	1,571	0.35	1.33 in (L/244)	OK, marginal
Al tube 14x6x0.312	14.2	299.8	53.5	1,686	0.32	1.07 in (L/304)	OK

Flexural comparison. Note the 12x4 aluminum tube: it has the same flexural strength as the 10x4 steel tube (891 vs. 886 kip-in) at 42% of the weight, yet it sags 2.4 in - nearly twice the limit. Once both beams are sized to the same stiffness (steel 10x6, aluminum 14x6), the aluminum beam is 4 in deeper and weighs 14.2 vs. 24.6 lb/ft: **58% of the steel weight**, and it uses only a third of its strength. The extra strength is the price of the stiffness.

3. Other engineering considerations

- **Welding.** Welding 6061-T6 locally anneals the metal; the ADM requires reduced (weld-affected) strengths within about 1 in of a weld. Steel has no comparable loss. Aluminum carports are therefore usually bolted, with welds placed in low-stress zones.
- **Thermal movement.** Over a 27-ft span and a 100 °F temperature swing, steel moves 0.21 in and aluminum 0.42 in. Long aluminum canopies need slotted connections or expansion joints, and the movement acts on the PV racking and module clamps.
- **Fatigue and wind.** Aluminum has no fatigue endurance limit and a lower fatigue strength than steel; canopies with repeated wind-induced vibration need a fatigue check, particularly at welded details.
- **Dead load and foundations.** Lighter framing lowers gravity load on footings, but carport foundations are usually sized for wind overturning and uplift, where a lighter structure gives less resisting weight. The foundation savings are often small.

- **Fire.** Aluminum loses strength at a much lower temperature than steel - the strength of 6061-T6 drops quickly above about 300 °F (150 °C) and approaches zero near 750 °F (400 °C). This matters for parking structures where a vehicle fire is the design fire scenario.
- **Mixed metals.** Aluminum in contact with galvanized steel bolts is generally compatible because zinc and aluminum sit close together galvanically; contact with bare carbon steel or copper needs isolation, especially in marine air.
- **Corrosion.** Aluminum's oxide film needs no coating in most atmospheres and is the stronger choice in severe coastal sites. Galvanized steel needs no maintenance for decades in most U.S. environments (see the companion ASTM galvanizing guide), and a duplex paint system extends that in marine exposure.

4. Cost-benefit breakdown

Material cost per beam is estimated from the section weights above and planning price ranges for 2026. Aluminum prices follow the LME primary aluminum benchmark (around \$1.50/lb in fall 2026; confirm current price at lme.com) plus extrusion and alloy premiums; the range used for mill-finish 6061 extrusion is \$2.20-\$3.20/lb. Steel uses \$0.50-\$0.70/lb for fabricated-grade HSS plus \$0.35-\$0.55/lb for hot-dip galvanizing. These are unsourced budgeting assumptions, not quotes - replace them with fabricator and galvanizer quotes.

Per 27-ft beam	Steel HSS 10x6x1/4, galvanized	Aluminum 14x6x0.312, mill finish
Weight	665 lb	384 lb
Material + coating rate	\$0.85-\$1.25 / lb	\$2.20-\$3.20 / lb
Material cost per beam	\$565-\$830	\$845-\$1,230
Relative material cost	1.0	~1.5
Freight and handling	Baseline	~40% lighter
Erection	Crane picks; heavier members	Lighter picks; more bolted joints
Maintenance to first touch-up	Decades in most U.S. atmospheres (HDG)	Minimal; inspect fasteners and isolation
End-of-life scrap value	Low per lb	High (clean extrusion ~\$1.0-\$1.3/lb)

Framing material is only part of the installed cost of a carport; labor, foundations, engineering and PV integration change little between the two metals. The premium on the finished structure is therefore smaller than the ~50% material premium, and is partly offset by lower freight and handling. Price both options with your fabricator before deciding.

5. Selection guidance

Choose galvanized structural steel when...	Consider aluminum when...
Spans exceed about 20 ft, or there are long cantilevers over drive aisles	Spans are short and the structure is small or modular
Snow, wind or seismic loads are significant	The site is coastal or severely corrosive (ISO C5 / CX)
The budget is the main driver	Weight drives cost: remote sites, rooftop or deck mounting, portable or rental units
A clean, welded architectural finish is wanted	Bolted, kit-style assembly is acceptable or preferred
Vehicle-fire resistance matters (garages, dense lots)	High residual scrap value matters to the owner

References

- AISC 360-22, *Specification for Structural Steel Buildings*; ASTM A500/A500M (Grade C HSS); ASTM A992/A992M.
- Aluminum Association, *Aluminum Design Manual* 2020, Specification for Aluminum Structures (incl. weld-affected strengths). Summary: STRUCTURE magazine, "The 2020 Aluminum Design Manual", structuremag.org.
- ASCE/SEI 7, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*.
- London Metal Exchange (lme.com), primary aluminum price; scrap ranges from metalcharts.org (September 2026), indicative only.

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