165 ft ROUND PEB — AISC 360-22 DESIGN SPECIFICATION

Fusion Developers | Governing Grade: ASTM A572 Grade 50 (Fy = 345 MPa, Fu = 450 MPa)

PRELIMINARY — NOT FOR CONSTRUCTION. *Issued for design coordination and budgeting only.*

Final member sizes subject to full 3D frame analysis (axial–flexure interaction, second-order effects).

1. GOVERNING CODE BASIS

Item	Value
Specification	ANSI/AISC 360-22 (LRFD)
ϕ flexure / axial	0.90
ϕ shear	0.75
Modulus E	200,000 MPa
Active grade	**ASTM A572 Gr. 50 — Fy = 345 MPa, Fu = 450 MPa**
Comparison grade	ASTM A36 — Fy = 250 MPa (alternative, Section 8)
Fabrication	AISC 303-22 Code of Standard Practice (COSP 2022)

2. GEOMETRY

Parameter	Value
Diameter	165 ft (50.29 m)
Eave height	18 ft (5.486 m)
Apex height	26.25 ft (8.001 m)
Roof slope	1:10 cone
Perimeter columns	20 @ perimeter
Internal columns	4 @ r = 41.25 ft (12.573 m)
Rafters	20 long + 4 short (radial)
Apex ring	8 ft dia, CHS 406.4 × 12.5
Purlin spacing	1.5 m (rafter top-flange restraint)

3. SECTION PROPERTIES

Section	Use	d (mm)	bf	tw	tf	h_clear	Ag (mm²)	Zx (cm³)	rx	ry	kg/m
ISMB 400	Columns (SHIPPED)	400	170	8.5	16.0	368	10,700	1,350	167	42	66.4
ISMB 450	Rafters (A572)	450	170	9.5	17.4	415.2	13,100	1,690	191	46	85.4

Section	Use	d (mm)	bf	tw	tf	h_clear	Ag (mm²)	Zx (cm³)	rx	ry	kg/m
CHS 406.4×12.5	Apex ring	406.4	—	12.5	—	—	15,460	—	—	—	122

4. ■ CORRECTED LATERAL-TORSIONAL BUCKLING (ISMB 450)

Correction notice. The earlier A36-based specification reported **Lp = 1.276 m** for ISMB 450. That value was **WRONG** — it was computed using **ry = 60 mm**, which is the radius of gyration of **ISMB 600**, not ISMB 450. The correct ISMB 450 value is **ry = 46 mm**.

Corrected AISC 360-22 Eq. F2-5:

$L_p = 1.76 \cdot r_y \cdot \sqrt{E / F_y}$

$= 1.76 \times 46 \text{ mm} \times \sqrt{200{,}000 / 345}$

$= 1.76 \times 46 \times 24.09$

$= 1{,}950 \text{ mm} = 1.95 \text{ m}$

Quantity	Value
Lp (corrected)	**1.95 m**
Lb (purlin spacing)	1.50 m
Lb < Lp ?	**YES — 1.50 < 1.95**
Consequence	**NO LTB.** Yielding limit state governs; full plastic moment Mp is usable.

Therefore **A572 Gr. 50 ISMB 450 rafters at 1.5 m purlin spacing are VALID** under AISC 360-22 Chapter F2.

5. FLEXURAL CHECK — LONG RAFTER (GOVERNING)

$M_p = F_y \cdot Z_x = 345 \times 1{,}690 \times 10^3 = 583.05 \text{ kN·m}$

$\phi M_n = 0.90 \times 583.05 = 524.7 \text{ kN·m}$

$M_u = 473 \text{ kN·m}$

Utilisation = 473 / 524.7 = 90.3% → PASS (marginal)

• Short rafter: Mu = 386 kN·m → 73.6% → PASS.

• **Flag:** axial thrust from the cone geometry produces combined axial–flexure interaction (Ch. H1) that may push the long rafter above 100%. **Confirm in final 3D analysis.** If H1 interaction > 1.0, upgrade the long rafters to **ISMB 500** (Zx ≈ 2,074 cm³, ϕMn ≈ 644 kN·m → ~73% flexural utilisation, ample interaction reserve).

6. AXIAL & SHEAR SUMMARY

Member	Pu / Vu	KL/r	Check	Utilisation
Perimeter column ISMB 400	Pu ≈ 307 kN	131 (Ly = 5.486 m, ry = 42)	Ch. E3, ϕPn ≈ 977 kN	≈ 31%
Internal column ISMB 400	Pu ≈ 384 kN	161 (Ly = 6.748 m, ry = 42)	Ch. E3, ϕPn ≈ 645 kN	≈ **59%** (≈ 65% with web-noncompact reduction)
Long rafter shear	Vu = 150 kN	—	Ch. G2, ϕVn = 0.75·0.6·345·d·tw	PASS
Short rafter shear	Vu = 135 kN	—	Ch. G2	PASS
Apex ring CHS	~1,500 kN distributed hoop thrust	—	Ch. E / hoop compression	PASS

6A. LOWEST-WEIGHT OPTIMIZATION (COLUMN TRADE STUDY)

Columns were driven down to the lightest ISMB section that still clears AISC 360-22 Ch. E3 with a comfortable reserve for Ch. H1 axial–flexure interaction and web-noncompact (Ch. E7) reduction. Governing case is the **internal column** (Pu ≈ 384 kN, Ly = 6.748 m).

Section	Mass kg/m	Internal col util (360-22)	Total steel	Verdict
ISMB 600	133	7%	58.49 t	heavy, not optimized
ISMB 500	106	~38%	53.7 t	heavier than needed
ISMB 400	**66.4**	**59% (≈65% w/ web noncompact)**	**48.40 t**	**SHIPPED — lightest safe**
ISMB 350	52.6	88.7% (≈95% w/ web noncompact)	46.6 t	absolute lightest, **MARGINAL**

Shipped selection: ISMB 400, ASTM A572 Gr. 50 — the lightest section retaining a comfortable margin once Chapter H1 axial–flexure interaction and the Chapter E7 web-noncompact reduction are applied. Steel tonnage drops from **58.49 t** → **48.40 t (–10.09 t, –17.2%)**.

ISMB 350 (not recommended). It saves a further **1.9 t**, but internal-column utilisation reaches ≈ **95%** after the noncompact-web reduction — no reserve for interaction, erection tolerance, or second-order effects. **Not to be released for construction without a full 3D second-order analysis.**

Rafters remain ISMB 450. This is the minimum section for Mu = 473 kN·m at L = 12.637 m (ϕMn = 524.7 kN·m → 90.3%). ISMB 400 gives ϕMn ≈ 338 kN·m → **FAILS** (140%). Any further rafter weight reduction requires a **geometry change** (additional internal columns or tie rods to shorten the rafter span) — **offered as an option, not applied** in this revision.

7. WIND UPLIFT

Item	Value
Basic wind speed	110 mph, Exposure C
Velocity pressure qz	≈ 26 psf
Cone suction Cp	≈ –0.9
Net uplift	≈ 23 psf
Net gravity load	63 psf
Result	63 psf > 23 psf → **members remain in net downward flexure**. Uplift does **not** reverse rafter bending, but **governs anchor-bolt tension** at column bases.

8. THE 16 DESIGN PARAMETERS

#	Parameter	A572 Gr. 50 Value	AISC 360-22 Ref	Limit / Result
1	Member depth	ISMB400 d=400 (col); ISMB450 d=450 (rafter)	Ch. B4 / F	Adequate for span/depth
2	Flange width	170 mm (col); 170 mm (rafter)	Ch. B4.1	Compact
3	Clear web depth	368 mm (col); 415.2 mm (rafter)	Ch. B4.1b	Compact
4	Unsupported length	Rafters Lu = 1.5 m; Cols Ly = 5.486 / 6.748 m	Ch. F2 / E3	Within limits
5	Purlin spacing	1.5 m	Ch. F2	< Lp = 1.95 m ✔
6	Bracing	Purlins at 1.5 m + roof plan bracing + eave strut ring	App. 6	Stability satisfied
7	Yield strength Fy	**345 MPa** (A36 alt: 250 MPa)	Ch. A3	ASTM A572 Gr. 50
8	Axial capacity	ISMB 400: Perim 31%, Internal **59%**	Ch. E3	PASS — lightest safe section
9	Bending capacity	Long rafter **90.3%** (473 / 524.7 kN·m)	Ch. F2	PASS (marginal)
10	Shear capacity	Vu 150 kN (long) / 135 kN (short)	Ch. G2	PASS
11	Wind uplift	23 psf uplift < 63 psf gravity	ASCE 7 + Ch. J	No reversal; anchors govern
12	Local buckling	Flange λ = bf/2tf = 4.88 < λp = 8.6; Web h/tw = 43.7 < λp = 90 (flex), < λr = 33.7·√ ✔	Ch. B4 Table B4.1	**Fully compact**
13	**LTB**	**Lp = 1.95 m > Lb = 1.5 m → NO LTB (CORRECTED)**	Ch. F2, Eq. F2-5	Full Mp usable
14	Connection forces	Eave gusset plate; M25 ASTM F1554 anchor bolts in tension from uplift	Ch. J	Design per Ch. J3
15	Fabrication tolerances	AISC 303-22 (COSP 2022)	COSP 2022	Mill + erection tolerances
16	Corrosion protection	Hot-dip galvanising (ASTM A123) or 3-coat epoxy/PU system	Ch. M	Per exposure category

9. ALTERNATIVE GRADE — ASTM A36 COMPARISON

Quantity	A572 Gr. 50	A36
F_y	345 MPa	250 MPa
ISMB450 $L_p = 1.76 \cdot r_y \cdot \sqrt{(E/F_y)}$	1.95 m	2.29 m
L_b = 1.5 m vs L_p	No LTB	No LTB
ϕM_n (ISMB450)	524.7 kN·m	380.3 kN·m
M_u = 473 kN·m	90.3% → PASS	**124.4% → FAIL**
Verdict	**GOVERNING / ACTIVE**	Requires ISMB 550/600 rafters

Conclusion: A36 is not viable with ISMB 450 rafters at the stated demand. **A572 Grade 50 is adopted as the governing grade.**

10. CAVEAT

This document is **PRELIMINARY**. Utilisations are based on hand calculations using the stated demands. Final issue requires:

- Full 3D second-order frame analysis (AISC 360-22 Ch. C direct analysis method).
- Chapter H1 combined axial–flexure interaction on all rafters.
- Base-plate and anchor-bolt design for uplift tension.
- Connection design per Chapter J.

Fusion Developers — AISC 360-22 Design Specification, Rev. A572-02 (lowest-weight column optimization)