shearcheck

Verification Report

v1.0

Verification of AISC 360-22 Single-Plate Shear Connection Calculations — V1 Product Scope

Foundry Core Labs

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1. Executive summary

This document records the verification of shearcheck's steel connection calculations against independent authorities. shearcheck is a free web tool at `https://shearcheck.foundrycorelabs.com` that checks conventional single-plate shear connections per ANSI/AISC 360-22 and produces a printable report and editable `.docx` calculation document.

Verification verdict:

- Against **two independent blind derivations** produced from a frozen, self-contained prompt (no access to the engine or to any worked example), shearcheck's engine agrees to ≤ **0.001%** on every limit state, every per-bolt strength, and the eccentric-bolt-group coefficient. The two derivations agreed with each other exactly (six significant figures on every quantity).
- Against the **printed values of AISC Design Examples v16.0, Example II.A-17A** (the published conventional single-plate example), shearcheck agrees to ≤ **0.59% on every quantity — within 1%** — with the same governing limit state at published precision (see the governing-tie note in §6).
- The instantaneous-center-of-rotation (ICR) bolt-group solver independently reproduces the two fully-worked coefficients published in Brandt (1982) and the Design Example's tabulated coefficient (§5).

2. Scope

2.1 V1 product scope

Parameter	V1 range
Configuration	Conventional single-plate shear connection: single vertical bolt row, plate fillet-welded both sides to a rigid support, beam-to-column-flange
Beam	Any W-shape (AISC Shapes Database v16.0, 289 sections); uncoped
Bolts	5/8, 3/4, 7/8, 1 in.; Group 120 / Group 150; threads N or X; bearing-type; STANDARD holes; n = 2–9
Plate	ASTM A36 or A572 Gr 50
Weld	E70 fillet, both sides; size ≥ (5/8)·t_p (hard floor)
Loading	Vertical shear only; LRFD and ASD
Geometry	a ≤ 3.5 in. (V1 scope restriction — the conventional range as used in the Design Examples; not a claimed code rule); e = a/2

2.2 Out of V1 scope

Coped beams; slip-critical connections; oversized/slotted holes; the extended configuration; axial or combined loading; seismic provisions; metric units; non-standard welds; electrodes other than E70.

2.3 Witnessed point vs computed envelope

The independent verification below is at the published example's configuration (n = 4, 3/4-in. Group 120 N bolts). The engine's limit-state equations and the ICR solver are fully general within the V1 envelope; the distinction between the witnessed point and the computed envelope is stated on the methodology page.

3. Methodology

Two independent computational witnesses each derived the complete check from a frozen, self-contained prompt (`witness_prompt_shear_tab_v1.md`, archived) that restates the cited AISC 360-22 provisions and the Brandt (1982) ICR procedure. Neither witness had access to the engine, to the other witness, or to any worked example. The engine was built separately, from the same pinned clause equations. Acceptance thresholds were committed before comparison: engine vs witnesses < 0.5% (publish-clean); engine vs the printed Design Example ±1% and the same governing limit state.

4. Provisions verified (ANSI/AISC 360-22)

Clause	What it provides
Eq. J3-1, Table J3.2	Bolt shear rupture (Group 120/150, N/X)
Table J3.3, B4.3b	Hole dimensions; net-area hole allowance (+1/16 in.)
Table J3.4, §J3.4	Minimum edge distance (pinned for all four supported diameters); minimum spacing 2-2/3·d
Eq. J3-6a / J3-6c (§J3.11a)	Bearing and tearout at bolt holes (deformation considered)
Eq. J4-3 / J4-4 (§J4.2)	Shear yielding / shear rupture of the plate
Eq. J4-5 (§J4.3)	Block shear rupture of the plate
Table J2.5	Fillet weld strength (direct-shear model, no directional bonus — conservative)
—	Eccentric bolt group: ICR method per Brandt, AISC Engineering Journal, Q2 1982 (open access) with $R = R_{ult}(1 - e^{(-10\Delta)})^{0.55}$, $\Delta_{max} = 0.34$ in.

Conventional-configuration rules ($e = a/2$; $t \le d_b/2 + 1/16$; weld = $5/8 \cdot t_p$) are applied as illustrated in AISC Design Examples v16.0 Example II.A-17A and cited accordingly; the AISC Manual's tabulated per-n rules are not reproduced.

5. ICR solver verification

Case	Published C	shearcheck C	Δ
Brandt (1982) Example 1 — 3 bolts, s = 3 in., vertical load, e = 4 in.	1.40 (stabilized; iterations 1.435 ⟶ 1.410 ⟶ 1.402)	1.40	within stated precision
Brandt (1982) Example 2 — 6 bolts (2 × 3, gauge 6 in., pitch 3 in.), inclined load, 20 in. arm	1.10 (extrapolated 1.100)	1.10	within stated precision
DE II.A-17A — 4 bolts, s = 3 in., vertical, e = 1.50 in.	3.54 (Manual Table 7-6, interpolated)	3.5564 (exact iteration)	0.46% (interpolation vs exact)

6. Verification case — AISC Design Examples v16.0, Example II.A-17A

W16×50 (A992) beam to W14×90 column flange; PL 1/4 × 4 1/2 × 11 1/2 (A572 Gr 50); four 3/4-in. Group 120 N bolts, STD holes, s = 3, l_ev = 1 1/4, l_eh = 1 1/2, a = 3 (e = 1.50); 3/16-in. E70 fillets both sides; R_u = 49.6 kips / R_a = 33.0 kips.

6.1 Witness cross-agreement

Witness A ≡ Witness B on every quantity to six significant figures, including the ICR coefficient (C = 3.556378) and its converged instantaneous center. Requirement (≥ 4 significant figures): exceeded — exact.

6.2 Engine vs witness consensus (nominal strengths, kips)

Quantity	Witnesses	Engine	Δ
Bolt shear (per bolt)	23.8565	23.8565	0
Plate bearing (per bolt)	29.2500	29.2500	0
Plate tearout, edge / interior	16.4531 / 42.6563	16.4531 / 42.6562	~0
Web bearing / tearout	44.4600 / 64.8375	44.4600 / 64.8375	0
ICR C	3.556378	3.556382	1×10^{-4} %
Bolt group R_n	78.2603	78.2604	~0
Shear yield / rupture / block shear R_n	86.2500 / 78.0000 / 87.3438	identical	0
Weld R_n	128.0747	128.0747	0
Design φR_n / R_n/Ω	58.5000 / 39.0000	58.5000 / 39.0000	0

6.3 Engine vs printed example (available strengths, kips)

Quantity	DE printed	shearcheck	Δ	Note
Shear yield φR_n	86.4	86.25	0.17%	DE rounds A_gv to 2.88 in²
Shear rupture φR_n	58.5	58.500	0.00%	exact
Block shear φR_n / R_n/Ω	65.3 / 43.6	65.508 / 43.672	0.32% / 0.17%	DE rounds areas
Bolt shear φr_n	17.9	17.892	0.04%	
Plate tearout edge φr_n	12.4	12.340	0.49%	DE per-inch table rounding
C	3.54 (interpolated)	3.5564 (exact)	0.46%	
Bolt group φR_n / R_n/Ω	58.5 / 38.9	58.695 / 39.130	0.33% / 0.59%	via exact C
Connection φR_n / R_n/Ω	58.5 / 38.9	58.5 / 39.0	0% / 0.26%	

Governing-limit-state note (disclosed). The Design Example concludes the connection is controlled by shear transfer at the bolt holes at φR_n = 58.5 kips; at the example's printed precision this ties plate shear rupture (also 58.5 kips). With the exact ICR coefficient, the bolt group rises to 58.7 kips and plate shear rupture (58.500 kips) governs. The connection's available strength is identical either way. shearcheck reports the exact-computation governing state; this note appears on the methodology page.

7. Independent audit trail

An adversarial audit of the engine (two rounds) identified and closed, before release: (1) a block-shear shear-path formula that would have been unconservative for plates deeper than the minimum (corrected to the load-path form l_ev + (n−1)·s, with a regression test); (2) a missing plate-depth ≤ T check (added, with the beam's workable-flat T from the Shapes Database); (3) an uncapped a dimension (V1 scope cap a ≤ 3.5 in. added). Test suite at release: 46+ passing, including the golden assertions of every printed value in §6.3 and the three ICR cases in §5.

8. What this verification does and does not establish

Establishes: the engine's limit-state implementations agree with independent first-principles derivations of the cited AISC 360-22 provisions at the verified configuration, and reproduce the published Design Example within the stated tolerances. Does NOT establish: a precision claim for every input combination in the envelope; the suitability of any connection for a particular structure; compliance of the design as a whole. shearcheck output is a calculation aid, not a sealed design. Connection design responsibility follows AISC 303-22 Section 3.1.2 as assigned in the contract documents; the engineer of record or connection design engineer must review and seal. Not affiliated with AISC.

9. References

- ANSI/AISC 360-22, *Specification for Structural Steel Buildings*, AISC, 2022 (free download; clauses cited by number, text not reproduced).
- *Companion to the AISC Steel Construction Manual, v16.0, Vol. 1: Design Examples*, AISC (free download); Example II.A-17A.
- Brandt, G. D., "Rapid Determination of Ultimate Strength of Eccentrically Loaded Bolt Groups," *AISC Engineering Journal*, Q2 1982, pp. 94–100 (open access).
- AISC Shapes Database v16.0 (dimensional data reproduced with attribution).
- Crawford, S. F., and Kulak, G. L., "Eccentrically Loaded Bolted Connections," *Journal of the Structural Division*, ASCE, Vol. 97 ST3, 1971 (cited via Brandt).

10. Revision history

Date	Version	Change
2026-09-01	v1.0	Initial publication. One verified configuration (II.A-17A) with 2-witness protocol; ICR solver verified against Brandt (1982) Examples 1–2 and the DE coefficient; audit trail §7.

End of report. Witness derivations and the frozen prompt are archived with the application's verification documents.