

Spread (Isolated) Footing — Validation Report

Independent verification of the Kouzouki calculation engine against closed-form statics, published design-standard values and worked examples

Engine	Kouzouki — Spread (Isolated) Footing
Basis	ACI strength design: factored pressure $q_u = P_u / B^2$, one-way shear at d from the face, two-way punching at $b_o = 2(c_1 + d) + 2(c_2 + d)$, flexure $M_u = q_u B l^2 / 2$. ACI 318-14 uses $V_c = 2 \sqrt{f'c} b d$ (4 two-way); ACI 318-19 adds the size-effect factor $\lambda_s = \sqrt{2 / (1 + d / 10)}$ for members without shear reinforcement, verified separately in case SF5.
Validation type	Independent validation
Report date	2026-06-18
Result	PASS — 13/13 checks within tolerance

1. Validation cases

Each case feeds the tool a defined input set and compares its output against a value derived independently of the engine (cited per row). Tolerance is 1% unless noted.

SF1. 100k service, 6.5 ft sq, 12 in col — factored pressure

Inputs: $P_{dead} = 60000.0$, $P_{live} = 40000.0$, $col_b = 12.0$, $col_d = 12.0$, $q_{allow} = 3000.0$, $footing_size = 6.5$, $thickness = 18.0$, $fc = 3000.0$, $fy = 60000.0$, $bar_size = \#6$, $n_bars = 7$, $cover = 3.0$

Checked quantity	Independent value	Tool output	Dev.	Verdict
Factored load $P_u = 1.2D + 1.6L$ ACI 5.3.1	1.36e+05 lb	1.36e+05 lb	0.00%	PASS
Effective depth $d = h - cover - d_b$ ACI 20.5.1.3	14.25 in	14.25 in	0.00%	PASS
Net pressure $q_u = P_u / B^2$ ACI 13.3	22.354 psi	22.354 psi	0.00%	PASS

SF2. One-way (beam) shear at d

Inputs: $P_{dead} = 60000.0$, $P_{live} = 40000.0$, $col_b = 12.0$, $col_d = 12.0$, $q_{allow} = 3000.0$, $footing_size = 6.5$, $thickness = 18.0$, $fc = 3000.0$, $fy = 60000.0$, $bar_size = \#6$, $n_bars = 7$, $cover = 3.0$

Checked quantity	Independent value	Tool output	Dev.	Verdict
$V_u = q_u B (l - d)$ ACI 7.4.3.2	32,692.3 lb	32,692.3 lb	0.00%	PASS
$\phi V_c = 0.75 \cdot 2 \cdot \sqrt{f'c} \cdot B \cdot d$ ACI 22.5.5.1	91,319.0 lb	91,319.0 lb	0.00%	PASS

SF3. Two-way (punching) shear

Inputs: $P_{dead} = 60000.0$, $P_{live} = 40000.0$, $col_b = 12.0$, $col_d = 12.0$, $q_{allow} = 3000.0$, $footing_size = 6.5$, $thickness = 18.0$, $fc = 3000.0$, $fy = 60000.0$, $bar_size = \#6$, $n_bars = 7$, $cover = 3.0$

Checked quantity	Independent value	Tool output	Dev.	Verdict
Critical perimeter b_o ACI 22.6.4.1	105.0 in	105.0 in	0.00%	PASS
Punching $V_u = P_u - q_u (c + d)^2$ ACI 8.4.4.1	1.206e+05 lb	1.206e+05 lb	0.00%	PASS
$\phi V_c = 0.75 \cdot 4 \cdot \sqrt{f'c} \cdot b_o \cdot d$ ACI 22.6.5.2	2.459e+05 lb	2.459e+05 lb	0.00%	PASS

SF4. Flexure & minimum steel

Inputs: $P_{dead} = 60000.0$, $P_{live} = 40000.0$, $col_b = 12.0$, $col_d = 12.0$, $q_{allow} = 3000.0$, $footing_size = 6.5$, $thickness = 18.0$, $fc = 3000.0$, $fy = 60000.0$, $bar_size = \#6$, $n_bars = 7$, $cover = 3.0$

Checked quantity	Independent value	Tool output	Dev.	Verdict
$M_u = q_u B l^2 / 2$ ACI 13.2.7.1	9.494e+05 lb-in	9.494e+05 lb-in	0.00%	PASS

A_s,min = 0.0018 b h ACI 7.6.1.1	2.527 in ²	2.527 in ²	0.00%	PASS
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SF5. ACI 318-19 size-effect on shear (same footing)

Re-running the SF2/SF3 footing under ACI 318-19 applies $\lambda_{s} = \sqrt{2/(1+d/10)} = 0.9082$, reducing both concrete shear capacities versus ACI 318-14.

Inputs: P_dead=60000.0, P_live=40000.0, col_b=12.0, col_d=12.0, q_allow=3000.0, footing_size=6.5, thickness=18.0, fc=3000.0, fy=60000.0, bar_size=#6, n_bars=7, cover=3.0

Checked quantity	Independent value	Tool output	Dev.	Verdict
Size-effect factor λ_{s} ACI 318-19 22.5.5.1.3	0.908	0.908	0.00%	PASS
One-way $\phi V_c = 0.75 \cdot 2 \cdot \lambda_{s} \cdot \sqrt{f'c} \cdot B \cdot d$ ACI 318-19 22.5.5.1	82,931.7 lb	82,931.7 lb	0.00%	PASS
Two-way $\phi V_c = 0.75 \cdot 4 \cdot \lambda_{s} \cdot \sqrt{f'c} \cdot b_o \cdot d$ ACI 318-19 22.6.5.2	2.233e+05 lb	2.233e+05 lb	0.00%	PASS

2. Assumptions

- Concentric column on a square footing; rigid footing, uniform soil pressure; normalweight concrete ($\lambda=1.0$).
- ϕ : shear 0.75, flexure 0.90 (ACI Table 21.2.1); 3 in cover.
- Strength loads 1.2D+1.6L for concrete; service loads for soil bearing.

3. Limitations

- Allowable soil bearing is a geotechnical INPUT (not derived) — confirm with the soils report.
- Concentric load only (no moment/eccentric bearing); square footing.
- Development length / dowel detailing not checked.

4. Sources of the independent values

How the independent values are obtained. Every value in the Independent-value column of Section 1 is computed in a validation harness (validation/cases.py) written and run separately from the calculation engine. Each is an independent re-derivation of the governing closed-form equation, or a value read from a cited published worked example or design-standard table - never copied from the engine's own output. The match therefore confirms the engine reproduces the cited source within tolerance. The source beside each value (Section 1) and the references below identify the governing standard section, equation, or publication.

Basis of the independent values

ACI strength design: factored pressure $q_u = P_u / B^2$, one-way shear at d from the face, two-way punching at $b_o = 2(c1+d) + 2(c2+d)$, flexure $M_u = q_u B l^2 / 2$. ACI 318-14 uses $V_c = 2 \sqrt{f'c} b d$ (4 two-way); ACI 318-19 adds the size-effect factor $\lambda_s = \sqrt{2/(1+d/10)}$ for members without shear reinforcement, verified separately in case SF5.

Governing standards & published sources

- ACI 318 — Building Code Requirements for Structural Concrete (318-14 / 318-19), American Concrete Institute (Ch. 7, 8, 13, 20, 22).

Per-check citations (Section 1): ACI 5.3.1; ACI 20.5.1.3; ACI 13.3; ACI 7.4.3.2; ACI 22.5.5.1; ACI 22.6.4.1; ACI 8.4.4.1; ACI 22.6.5.2; ACI 13.2.7.1; ACI 7.6.1.1; ACI 318-19 22.5.5.1.3; ACI 318-19 22.5.5.1; ACI 318-19 22.6.5.2.

5. Conclusion

All 13 independent checks reproduce the reference values within tolerance. The engine correctly implements the governing equations for this tool.

Reproduce: `python scripts/run_tool_validation.py` → `python scripts/make_tool_validation_pdfs.py`. This report is for verification/demonstration; results are for preliminary design and must be confirmed by a licensed engineer against the current adopted code and project-specific conditions.