Combined Footing (two columns) — Validation Report

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

Engine	Kouzouki — Combined Footing (two columns)
Basis	ACI 318-14 (simplified shear). Resultant location x_bar=(P1 x1+P2 x2)/R; uniform factored soil reaction w_u=R_u/L; longitudinal beam moment minimised at x=P1_u/w_u for the negative (between-column) moment. ACI 318-19 adds size-effect lambda_s.
Validation type	Independent validation
Report date	2026-06-18
Result	**PASS** — 7/7 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.

KF1. Resultant location & factored load

Inputs: P1_dead=50000.0, P1_live=30000.0, P2_dead=70000.0, P2_live=50000.0, col_spacing=16.0, edge_to_col1=1.5, col_size=18.0, q_allow=3000.0, length=22.0, width=7.0, thickness=30.0, fc=3000.0, fy=60000.0, bar_size=#8, cover=3.0

Checked quantity	Independent value	Tool output	Dev.	Verdict
Service resultant location x_bar Statics	11.1 ft	11.1 ft	0.00%	**PASS**
Factored resultant R_u ACI 5.3.1	2.72e+05 lb	2.72e+05 lb	0.00%	**PASS**
Uniform soil reaction w_u = R_u/L Soil reaction	12,363.6 plf	12,363.6 plf	0.00%	**PASS**

KF2. Max negative moment (between columns)

Inputs: P1_dead=50000.0, P1_live=30000.0, P2_dead=70000.0, P2_live=50000.0, col_spacing=16.0, edge_to_col1=1.5, col_size=18.0, q_allow=3000.0, length=22.0, width=7.0, thickness=30.0, fc=3000.0, fy=60000.0, bar_size=#8, cover=3.0

Checked quantity	Independent value	Tool output	Dev.	Verdict
M_neg at x=P1_u/w_u Beam diagram (dM/dx=0)	-3.097e+05 lb-ft	-3.097e+05 lb-ft	0.00%	**PASS**

KF3. Effective depth & beam-shear capacity

Inputs: P1_dead=50000.0, P1_live=30000.0, P2_dead=70000.0, P2_live=50000.0, col_spacing=16.0, edge_to_col1=1.5, col_size=18.0, q_allow=3000.0, length=22.0, width=7.0, thickness=30.0, fc=3000.0, fy=60000.0, bar_size=#8, cover=3.0

Checked quantity	Independent value	Tool output	Dev.	Verdict
d = h-cover-d_b ACI 20.5.1.3	26 in	26 in	0.00%	**PASS**
phi V_c = 0.75·2·sqrt(f'c)·B·d ACI 22.5.5.1	1.794e+05 lb	1.794e+05 lb	0.00%	**PASS**

KF4. Soil bearing eccentricity (near-concentric)

Inputs: P1_dead=50000.0, P1_live=30000.0, P2_dead=70000.0, P2_live=50000.0, col_spacing=16.0, edge_to_col1=1.5, col_size=18.0, q_allow=3000.0, length=22.0, width=7.0, thickness=30.0, fc=3000.0, fy=60000.0, bar_size=#8, cover=3.0

Checked quantity	Independent value	Tool output	Dev.	Verdict
Eccentricity e = x_bar - L/2 Statics	0.1 ft	0.1 ft	0.00%	**PASS**

2. Assumptions

- Rectangular footing; uniform soil pressure (size for e->0).
- Analysed as a longitudinal beam (uniform up, two column point loads).

- Strength loads for concrete; service for soil bearing.

3. Limitations

- Allowable soil bearing is a geotechnical input.
- Uniform-pressure idealisation (trapezoidal only via q_max check).
- Transverse 'beam strips' under each column not separately designed here.

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 318-14 (simplified shear). Resultant location x_bar=(P1 x1+P2 x2)/R; uniform factored soil reaction w_u=R_u/L; longitudinal beam moment minimised at x=P1_u/w_u for the negative (between-column) moment. ACI 318-19 adds size-effect lambda_s.

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).
- Classical statics & Euler-Bernoulli beam theory (equilibrium, M=wL^2/8, V=wL/2, deflection=5wL^4/384EI) — independently re-derived in the validation harness.

Per-check citations (Section 1): Statics; ACI 5.3.1; Soil reaction; Beam diagram (dM/dx=0); ACI 20.5.1.3; ACI 22.5.5.1.

5. Conclusion

All 7 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.