Shallow Foundation Bearing Capacity — Validation Report

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

Engine	Kouzouki — Shallow Foundation Bearing Capacity
Basis	Vesic general bearing-capacity equation q_ult = c·N_c·s_c·d_c + q·N_q·s_q·d_q + 0.5·gamma·B·N_gamma·s_gamma with Vesic shape and Hansen depth factors; allowable q_a = q_ult / FS.
Validation type	Independent validation
Report date	2026-06-18
Result	**PASS** — 8/8 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.

BC1. Vesic factors (phi=30deg)

Inputs: width=5.0, length=5.0, depth=3.0, cohesion=0.0, phi=30.0, gamma=120.0, water_depth=50.0, FS=3.0, applied_pressure=0.0

Checked quantity	Independent value	Tool output	Dev.	Verdict
N_c = (N_q-1)/tan phi Vesic/Prandtl	30.14	30.14	0.00%	**PASS**
N_q = e^(pi tan phi) tan^2(45+phi/2) Reissner	18.401	18.401	0.00%	**PASS**

BC2. Shape & depth factors

Inputs: width=5.0, length=5.0, depth=3.0, cohesion=0.0, phi=30.0, gamma=120.0, water_depth=50.0, FS=3.0, applied_pressure=0.0

Checked quantity	Independent value	Tool output	Dev.	Verdict
s_c = 1+(B/L)(N_q/N_c) Vesic	1.611	1.611	0.00%	**PASS**
d_q = 1+2 tan phi(1-sin phi)^2(Df/B) Hansen	1.173	1.173	0.00%	**PASS**

BC3. Ultimate & allowable (sand, square)

Inputs: width=5.0, length=5.0, depth=3.0, cohesion=0.0, phi=30.0, gamma=120.0, water_depth=50.0, FS=3.0, applied_pressure=0.0

Checked quantity	Independent value	Tool output	Dev.	Verdict
q_ult (Vesic sum) Vesic 1973	16,291.3 psf	16,291.0 psf	0.00%	**PASS**
q_a = q_ult/FS FS=3	5,430.4 psf	5,430.0 psf	0.01%	**PASS**

BC4. Cohesive (phi=0) with high water table

Inputs: width=6.0, length=10.0, depth=4.0, cohesion=1200.0, phi=0.0, gamma=115.0, water_depth=2.0, FS=3.0, applied_pressure=2500.0

Checked quantity	Independent value	Tool output	Dev.	Verdict
N_c = 5.14 (phi=0) Prandtl pi+2	5.14	5.14	0.00%	**PASS**
q_ult (c term + surcharge) Vesic, buoyant q	9,060.0 psf	9,060.0 psf	0.00%	**PASS**

2. Assumptions

- Level ground, concentric vertical load, drained strength parameters.
- Vesic bearing factors with shape (Vesic) and depth (Hansen) factors.

- Water table adjusts the surcharge and base unit weight (buoyant).

3. Limitations

- Soil c, phi and gamma are geotechnical INPUTS — confirm with the soils report. No load inclination, eccentricity or sloping ground.
- Settlement is not checked; allowable bearing may be settlement-governed.
- Single homogeneous layer within the influence zone.

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

Vesic general bearing-capacity equation q_ult = c·N_c·s_c·d_c + q·N_q·s_q·d_q + 0.5·gamma·B·N_gamma·s_gamma with Vesic shape and Hansen depth factors; allowable q_a = q_ult / FS.

Governing standards & published sources

- Vesic, A.S. (1973), 'Analysis of Ultimate Loads of Shallow Foundations,' ASCE JSMFD 99(SM1) — bearing-capacity factors and shape terms.
- Prandtl (1921) / Reissner (1924) — plasticity solutions underlying N_c (pi+2 for phi=0) and N_q.
- Reissner (1924) — surcharge bearing-capacity factor N_q.
- Brinch Hansen (1970) — depth factors used with the Vesic bearing equation.

Per-check citations (Section 1): Vesic/Prandtl; Reissner; Vesic; Hansen; Vesic 1973; FS=3; Prandtl pi+2; Vesic, buoyant q.

5. Conclusion

All 8 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.