Deep Foundation (Pile/Pier) Axial Capacity — Validation Report

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

Engine	Kouzouki — Deep Foundation (Pile/Pier) Axial Capacity
Basis	Single-pile static axial capacity Q_ult = Q_s + Q_p: skin friction by the alpha-method (clay, f_s=alpha·c_u) or beta-method (sand, f_s=K·tan(delta)·sigma'v); end bearing q_p=9·c_u (clay) or sigma'v,tip·N_q (sand); 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.

PC1. Clay skin & end-bearing unit values

Inputs: soil_type=Cohesive (clay), diameter=12.0, length=25.0, cohesion=1500.0, alpha=0.55, phi=32.0, gamma=120.0, K=1.0, delta=24.0, FS=3.0, applied_load=0.0

Checked quantity	Independent value	Tool output	Dev.	Verdict
f_s = alpha·c_u Tomlinson alpha	825.0 psf	825.0 psf	0.00%	**PASS**
q_p = 9·c_u Nc=9 deep clay	13,500.0 psf	13,500.0 psf	0.00%	**PASS**

PC2. Clay total capacity

Inputs: soil_type=Cohesive (clay), diameter=12.0, length=25.0, cohesion=1500.0, alpha=0.55, phi=32.0, gamma=120.0, K=1.0, delta=24.0, FS=3.0, applied_load=0.0

Checked quantity	Independent value	Tool output	Dev.	Verdict
Q_ult = Q_s + Q_p Static method	75,398.2 lb	75,398.0 lb	0.00%	**PASS**
Q_a = Q_ult/FS FS=3	25,132.7 lb	25,133.0 lb	0.00%	**PASS**

PC3. Sand beta & skin friction

Inputs: soil_type=Cohesionless (sand), diameter=16.0, length=30.0, cohesion=1500.0, alpha=0.55, phi=34.0, gamma=118.0, K=1.2, delta=25.0, FS=3.0, applied_load=50000.0

Checked quantity	Independent value	Tool output	Dev.	Verdict
beta = K·tan(delta) Burland beta	0.56	0.56	0.00%	**PASS**
Q_s = f_s·p·L (mid-depth sigma'v) beta-method	1.245e+05 lb	1.245e+05 lb	0.00%	**PASS**

PC4. Sand total capacity

Inputs: soil_type=Cohesionless (sand), diameter=16.0, length=30.0, cohesion=1500.0, alpha=0.55, phi=34.0, gamma=118.0, K=1.2, delta=25.0, FS=3.0, applied_load=50000.0

Checked quantity	Independent value	Tool output	Dev.	Verdict
Q_ult = Q_s + Q_p (N_q end bearing) Static method	2.7e+05 lb	2.7e+05 lb	0.00%	**PASS**
Q_a = Q_ult/FS FS=3	89,992.1 lb	89,992.0 lb	0.00%	**PASS**

2. Assumptions

- Single pile, homogeneous soil over the embedded length.
- Clay: Tomlinson alpha-method; sand: Burland beta-method.
- End bearing N_c=9 for deep clay; Vesic N_q for sand.

3. Limitations

- Soil parameters are geotechnical INPUTS — confirm with the soils report.
- No group effects, downdrag, negative skin friction or settlement.
- Layered profiles and submerged unit weight must be entered manually.

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

Single-pile static axial capacity Q_ult = Q_s + Q_p: skin friction by the alpha-method (clay, f_s=alpha·c_u) or beta-method (sand, f_s=K·tan(delta)·sigma'v); end bearing q_p=9·c_u (clay) or sigma'v,tip·N_q (sand); Q_a = Q_ult / FS.

Governing standards & published sources

- Tomlinson — alpha-method for pile skin friction in cohesive soil (f_s = alpha*c_u; q_p = 9*c_u).
- Burland (1973) — beta-method for pile skin friction in cohesionless soil (beta = K*tan delta).

Per-check citations (Section 1): Tomlinson alpha; Nc=9 deep clay; Static method; FS=3; Burland beta; beta-method.

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.