

Lateral Earth Pressure — Validation Report

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

Engine	Kouzouki — Lateral Earth Pressure
Basis	Rankine lateral earth pressure for level backfill. $K_0=1-\sin \phi$ (Jaky), $K_a=\tan^2(45-\phi/2)$, $K_p=\tan^2(45+\phi/2)$. Resultants $P = 1/2 \cdot K \cdot \gamma \cdot H^2$ (soil) + $K \cdot q \cdot H$ (surcharge) + $1/2 \cdot \gamma_w \cdot H_w^2$ (hydrostatic) located by statics.
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.

LE1. Active coefficient & thrust ($\phi=30\text{deg}$)

Inputs: condition=Active, height=10.0, $\phi=30.0$, $\gamma=120.0$, surcharge=0.0, water_depth=50.0

Checked quantity	Independent value	Tool output	Dev.	Verdict
$K_a = \tan^2(45-\phi/2)$ Rankine	0.333	0.333	0.00%	PASS
$P_{\text{total}} = 1/2 K_a \gamma H^2$ Rankine; H=10 ft	2,000.0 lb/ft	2,000.0 lb/ft	0.00%	PASS

LE2. Active resultant location

Inputs: condition=Active, height=10.0, $\phi=30.0$, $\gamma=120.0$, surcharge=0.0, water_depth=50.0

Checked quantity	Independent value	Tool output	Dev.	Verdict
Soil resultant P_{soil} Rankine	2,000.0 lb/ft	2,000.0 lb/ft	0.00%	PASS
Resultant height $y_{\text{bar}} = H/3$ Triangular pressure	3.333 ft	3.333 ft	0.00%	PASS

LE3. At-rest with surcharge & water table

Inputs: condition=At-rest, height=12.0, $\phi=32.0$, $\gamma=125.0$, surcharge=250.0, water_depth=6.0

Checked quantity	Independent value	Tool output	Dev.	Verdict
$K_0 = 1 - \sin \phi$ Jaky	0.47	0.47	0.00%	PASS
Total resultant (soil+surcharge+water) Rankine + hydrostatic	6,236.2 lb/ft	6,236.0 lb/ft	0.00%	PASS

LE4. Hydrostatic & base pressure

Inputs: condition=At-rest, height=12.0, $\phi=32.0$, $\gamma=125.0$, surcharge=250.0, water_depth=6.0

Checked quantity	Independent value	Tool output	Dev.	Verdict
$P_w = 1/2 \gamma_w H_w^2$ Water; $H_w=6$ ft	1,123.2 lb/ft	1,123.2 lb/ft	0.00%	PASS
Base pressure $K \gamma H + K q$ Rankine	822.6 psf	823.0 psf	0.04%	PASS

2. Assumptions

- Level backfill, vertical wall face, cohesionless soil ($c=0$).
- Soil triangle acts at $H/3$, surcharge rectangle at $H/2$ above base.
- Below the water table the buoyant unit weight is used for soil.

3. Limitations

- Soil phi and gamma are geotechnical INPUTS — confirm with the soils report.
- No cohesion, sloping backfill, wall friction or seismic increment.
- Rankine (not Coulomb); passive assumes full mobilisation.

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

Rankine lateral earth pressure for level backfill. $K_0=1-\sin \phi$ (Jaky), $K_a=\tan^2(45-\phi/2)$, $K_p=\tan^2(45+\phi/2)$. Resultants $P = 1/2 \cdot K \cdot \gamma \cdot H^2$ (soil) + $K \cdot q \cdot H$ (surcharge) + $1/2 \cdot \gamma_w \cdot H_w^2$ (hydrostatic) located by statics.

Governing standards & published sources

- Rankine (1857) — active/passive lateral earth-pressure coefficients $K_a = \tan^2(45-\phi/2)$, $K_p = \tan^2(45+\phi/2)$.
- Jaky (1944) — at-rest earth-pressure coefficient $K_0 = 1 - \sin \phi$.
- 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): Rankine; Rankine; $H=10$ ft; Triangular pressure; Jaky; Rankine + hydrostatic; Water; $H_w=6$ ft.

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.