Cantilever Retaining Wall — Validation Report

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

Engine	Kouzouki — Cantilever Retaining Wall
Basis	Rankine earth pressure (K_a=tan^2(45-phi/2), K_p=tan^2(45+phi/2)) with active+surcharge thrust driving and passive+base friction resisting; overturning/sliding factors of safety and bearing pressure by statics (IBC 1807.2.3).
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.

RW1. Rankine pressure coefficients (phi=30deg)

Inputs: stem_height=8.0, stem_thickness=12.0, footing_thickness=12.0, toe_length=2.0, heel_length=4.0, embedment_front=2.0, gamma_soil=120.0, phi=30.0, friction_coef=0.45, surcharge=100.0, q_allow=3000.0, include_passive=True, passive_factor=1.0, fc=3000.0, fy=60000.0, cover=3.0, stem_bar=#6, stem_spacing=12.0, footing_bar=#6, footing_spacing=12.0

Checked quantity	Independent value	Tool output	Dev.	Verdict
Active K_a = tan^2(45-phi/2) Rankine	0.333	0.333	0.00%	**PASS**
Passive K_p = tan^2(45+phi/2) Rankine	3	3	0.00%	**PASS**

RW2. Lateral thrusts (active, passive)

Inputs: stem_height=8.0, stem_thickness=12.0, footing_thickness=12.0, toe_length=2.0, heel_length=4.0, embedment_front=2.0, gamma_soil=120.0, phi=30.0, friction_coef=0.45, surcharge=100.0, q_allow=3000.0, include_passive=True, passive_factor=1.0, fc=3000.0, fy=60000.0, cover=3.0, stem_bar=#6, stem_spacing=12.0, footing_bar=#6, footing_spacing=12.0

Checked quantity	Independent value	Tool output	Dev.	Verdict
Active P_a = 1/2 K_a gamma H^2 Rankine; H=9 ft	1,620.0 lb/ft	1,620.0 lb/ft	0.00%	**PASS**
Passive P_p = 1/2 K_p gamma D^2 Rankine; D=2 ft	720.0 lb/ft	720.0 lb/ft	0.00%	**PASS**

RW3. Overturning stability

Inputs: stem_height=8.0, stem_thickness=12.0, footing_thickness=12.0, toe_length=2.0, heel_length=4.0, embedment_front=2.0, gamma_soil=120.0, phi=30.0, friction_coef=0.45, surcharge=100.0, q_allow=3000.0, include_passive=True, passive_factor=1.0, fc=3000.0, fy=60000.0, cover=3.0, stem_bar=#6, stem_spacing=12.0, footing_bar=#6, footing_spacing=12.0

Checked quantity	Independent value	Tool output	Dev.	Verdict
Overturning M_OT = P_a(H/3)+P_q(H/2) Statics about toe	6,210.0 lb-ft/ft	6,210.0 lb-ft/ft	0.00%	**PASS**
FS overturning = M_res/M_OT IBC 1807.2.3	4.283	4.28	0.06%	**PASS**

RW4. Sliding & bearing (passive included)

Inputs: stem_height=8.0, stem_thickness=12.0, footing_thickness=12.0, toe_length=2.0, heel_length=4.0, embedment_front=2.0, gamma_soil=120.0, phi=30.0, friction_coef=0.45, surcharge=100.0, q_allow=3000.0, include_passive=True, passive_factor=1.0, fc=3000.0, fy=60000.0, cover=3.0, stem_bar=#6, stem_spacing=12.0, footing_bar=#6, footing_spacing=12.0

Checked quantity	Independent value	Tool output	Dev.	Verdict
FS sliding = (mu·SumW + P_p)/(P_a+P_q) IBC 1807.2.3	1.859	1.86	0.08%	**PASS**

Max soil pressure q_max Statics; e<B/6	1,179.8 psf	1,180.0 psf	0.02%	**PASS**

2. Assumptions

- Level granular backfill; Rankine theory; vertical stem back.
- Stability at service loads (FS basis); concrete members at factored loads.
- Passive pressure included with a mobilisation factor (default 1.0).

3. Limitations

- Soil friction angle, unit weight, base-friction coefficient and allowable bearing are geotechnical INPUTS — confirm with the soils report.
- Passive resistance requires wall movement; reduce or neglect it where movement is unacceptable (set the passive factor to 0).
- Level backfill, no seismic increment, no water table / hydrostatic load.

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 earth pressure (K_a=tan^2(45-phi/2), K_p=tan^2(45+phi/2)) with active+surcharge thrust driving and passive+base friction resisting; overturning/sliding factors of safety and bearing pressure by statics (IBC 1807.2.3).

Governing standards & published sources

- International Building Code (2018 / 2021 / 2024), ICC — Ch. 18 (soils & foundations, Table 1806.2, Sec. 1807) and Sec. 1604.3 (deflection).
- Rankine (1857) — active/passive lateral earth-pressure coefficients K_a = tan^2(45-phi/2), K_p = tan^2(45+phi/2).
- 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=9 ft; Rankine; D=2 ft; Statics about toe; IBC 1807.2.3; Statics; e<B/6.

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.