Rankine Active and Passive Earth Pressure on a Wall

Active and passive earth pressure coefficients, pressure at the base and resultant thrust per metre of a vertical wall with level backfill by Rankine's theory.

Method: W.J.M. Rankine (1857); Bell (1915) for cohesive soil

Input parameters

Unit system: SI

Parameter	Value	Unit
Bulk density of the soil	1,800.0	kg/m³
Angle of internal friction	30.000	°
Cohesion	0	kPa
Height of the wall	4.0000	m
Uniform surcharge on the backfill	10.000	kPa

Calculated results

Parameter	Value	Unit
Active earth pressure coefficient	0.33333	
Passive earth pressure coefficient	3.0000	
Active pressure at the base	26.869	kPa
Depth of the tension crack	0	m
Active thrust per metre of wall	60.405	kN/m
Height of the active thrust above the base	1.4805	m
Passive resistance over depth H, no surcharge (per metre)	423.65	kN/m

Notes for this case

- Smooth vertical wall, level drained backfill, no water pressure; tension in cohesive soil is ignored down to the crack depth. Add water pressure where the backfill can be wet.

Formula and method

$$K_a = \tan^2\left(45° - \frac{\varphi}{2}\right), \quad K_p = \tan^2\left(45° + \frac{\varphi}{2}\right)$$

$$\sigma_a(z) = K_a(\rho g z + q) - 2c\sqrt{K_a}, \quad z_c : \sigma_a(z_c) = 0$$

$$P_a = \int_{z_c}^{H} \sigma_a \, dz, \quad P_p = \frac{1}{2} K_p \rho g H^2 + 2c\sqrt{K_p}\, H$$

Variables

ρ	Bulk density of the soil	kg/m³
φ	Angle of internal friction	rad
c	Cohesion	Pa
H	Height of the wall	m
q	Uniform surcharge on the backfill	Pa
K_a	Active earth pressure coefficient	-
K_p	Passive earth pressure coefficient	-
σ_a	Active pressure at the base	Pa

z_c	Depth of the tension crack	m
P_a	Active thrust per metre of wall	N/m
$\bar{y}$	Height of the active thrust above the base	m
P_p	Passive resistance over depth H, no surcharge (per metre)	N/m
g	Standard gravity	m/s²
$\sigma_a(z)$	Active pressure at depth z	Pa

Method and standards

Rankine's limiting stress states for a smooth vertical wall and level backfill, with Bell's cohesion term; the active thrust integrates only the compressive part of the pressure.

Assumptions and limits

- Smooth vertical wall; level, drained backfill.
- No wall friction, seismic or compaction loads.

References

• W.J.M. Rankine (1857); Bell (1915) for cohesive soil

Report details

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Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

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