RETAINING WALL STABILITY ANALYSIS

Project:	Sample Project	**Number:**	RW-2026-009
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1. INPUT PARAMETERS

Parameter	Symbol	Value	Unit
Wall type	$Type$	`Cantilever`	
Wall height	H	`5.00`	m
Base width	B	`3.00`	m
Toe length	t_{toe}	`0.30`	m
Heel length	t_{heel}	`2.10`	m
Stem thickness (top)	t_{stem_top}	`0.30`	m
Stem thickness (base)	t_{stem_base}	`0.60`	m
Base slab thickness	t_{base}	`0.60`	m
Surcharge	q_s	`10.0`	kPa
Backfill unit weight	$\gamma_{backfill}$	`18.0`	kN/m^3
Backfill friction angle	$\varphi_{backfill}$	`30.0`	deg
Concrete unit weight	$\gamma_{concrete}$	`24.0`	kN/m^3
Earth pressure theory	$Method$	`Rankine`	
Required FOS (sliding)	FOS_{s_req}	`1.5`	
Required FOS (overturning)	FOS_{ot_req}	`2.0`	

1. EARTH PRESSURE COMPUTATION

Rankine Active Earth Pressure Coefficient

$$K_a = \tan^2(45^\circ - \varphi/2)$$

$$K_a = \tan^2(45^\circ - 30.0^\circ/2)$$

$K_a = 0.3333$

Rankine (1857)

Active Pressure Height

$$H_{active} = H(nobackfillslope)$$

$$H_{active} = 5.00$$

H_{active} = **5.000** m

Total Active Horizontal Force

$$P_a = 0.5 \times K_a \times \gamma \times H^2 + K_a \times q \times H$$

$$P_a = 0.5 \times 0.3333 \times 18.0 \times 5.000^2 + 0.3333 \times 10.0 \times 5.000$$

P_a = **91.7** kN/m

Das Ch. 13

1. WALL WEIGHTS & STABILIZING MOMENTS

Wall Component Weights and Moments about Toe

Component	Weight (kN/m)	Arm from Toe (m)	Moment (kN·m/m)
Base slab	43.2	1.500	64.8
Stem (rect)	31.7	0.600	19.0
Stem (taper)	15.8	0.700	11.1
Soil on heel	166.3	1.950	324.3
Surcharge on heel	21.0	1.950	40.9
TOTAL	278.0	—	460.1

Moments computed about toe for overturning check.

1. SLIDING STABILITY CHECK

Base Friction Angle

$$\delta_b = (2/3) \times \varphi_{foundation}$$

$$\delta_b = (2/3) \times 30.0°$$

$\delta_b = \mathbf{20.00}$ deg

Das Ch. 13; typically 1/2 to 2/3 of φ

Resisting Force (Sliding)

$$R = V \times \tan(\delta_b) + c_a \times B$$

$$R = 278.0 \times \tan(20.00^\circ)$$

$R = \mathbf{101.2}$ kN/m

Factor of Safety Against Sliding

$$FOS_{sliding} = R/P_a$$

$$FOS_{sliding} = 101.2/91.7$$

$FOS_{sliding} = \mathbf{1.185}$

AASHTO 11.6.3 (min 1.5)

FAIL Sliding stability

$FOS_{required}$ = 1.5 $>$ $FOS_{sliding}$ = 1.185 (D/C = 1.27)

1. OVERTURNING STABILITY CHECK

Overturning Moment about Toe

$$M_{ot} = P_a \times z_{Pa}$$

$$M_{ot} = 91.7 \times 1.818$$

$M_{ot} = \mathbf{166.7}$ kN·m/m

Stabilizing Moment about Toe

$$M_{stab} = \Sigma(W_i \times x_i)$$

$$(see weight table above)$$

M_{stab} = **460.1** kN·m/m

Factor of Safety Against Overturning

$$FOS_{ot} = M_{stab}/M_{ot}$$

$$FOS_{ot} = 460.1/166.7$$

FOS_{ot} = **2.733**

AASHTO 11.6.3 (min 2.0)

PASS Overturning stability

$FOS_{required}$ = 2.0 $\leq$ $FOS_{overturning}$ = 2.733 (D/C = 0.73)

1. BEARING PRESSURE & ECCENTRICITY

Resultant Location from Toe

$$x_R = (M_{stab} - M_{ot})/V$$

$$x_R = (460.1 - 166.7)/278.0$$

x_R = **1.056** m

Eccentricity of Resultant

$$e = B/2 - x_R$$

$$e = 3.00/2 - 1.056$$

$e = 0.461$ m

B/6 = 0.500 m. Resultant within middle third.

Toe Bearing Pressure (Trapezoidal Distribution)

$$q_{toe} = (V/B)(1 + 6e/B)$$

$$q_{toe} = (278.0/3.00)(1 + 6 \times 0.461/3.00)$$

$q_{toe} = 178.2$ kPa

Heel Bearing Pressure

$$q_{heel} = (V/B)(1 - 6e/B)$$

$$q_{heel} = (278.0/3.00)(1 - 6 \times 0.461/3.00)$$

$q_{heel} = 7.1$ kPa

1. STABILITY SUMMARY

Stability Check Summary

Check	FOS Computed	FOS Required	Status
Sliding	1.185	1.5	FAIL
Overturning	2.733	2.0	OK
Bearing	99.900	N/A	OK

Eccentricity: e = 0.461 m (B/6 = 0.500 m) — Within middle third.

1. FIGURES

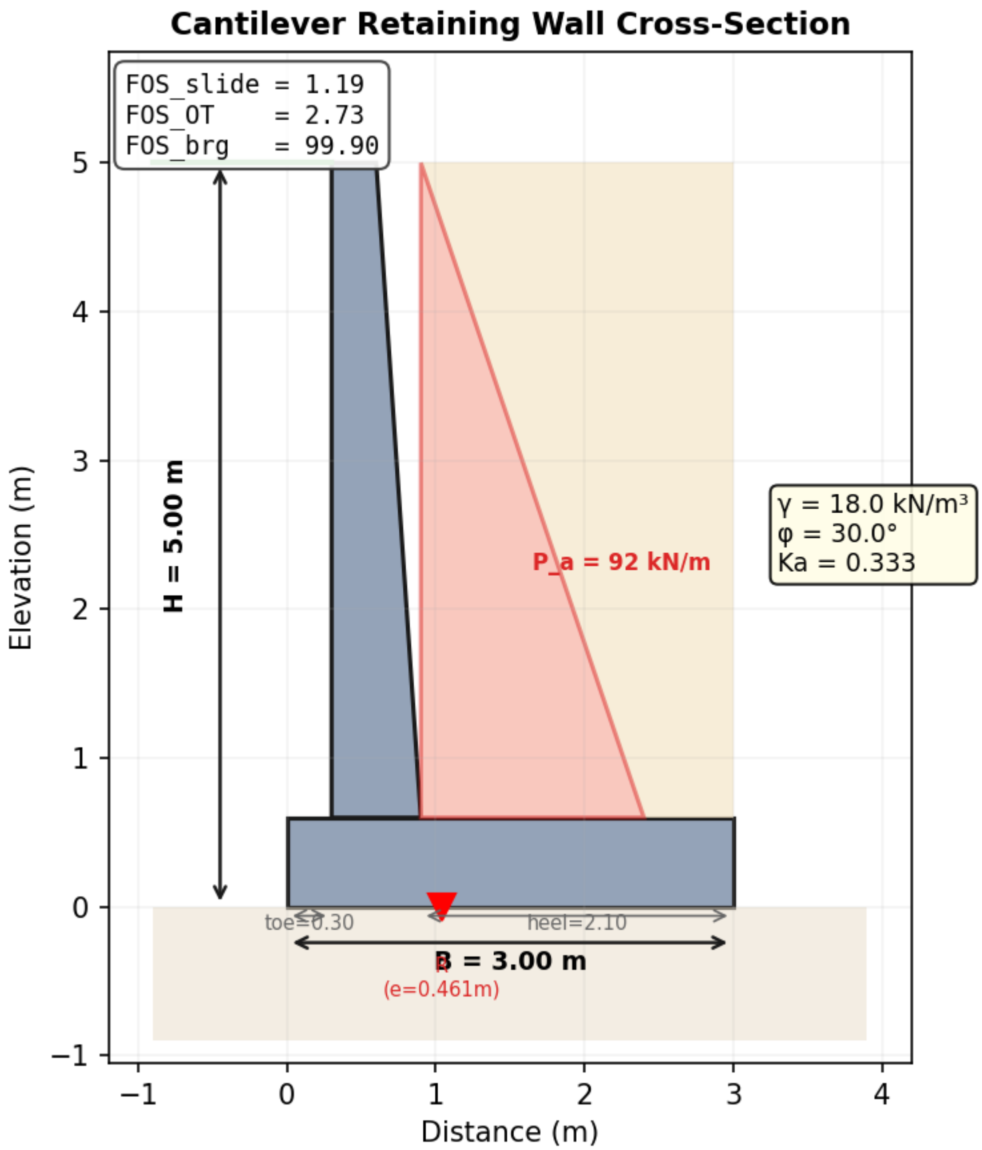

Figure 1: *
Figure 1: Cantilever wall cross-section. H = 5.00 m, B = 3.00 m.

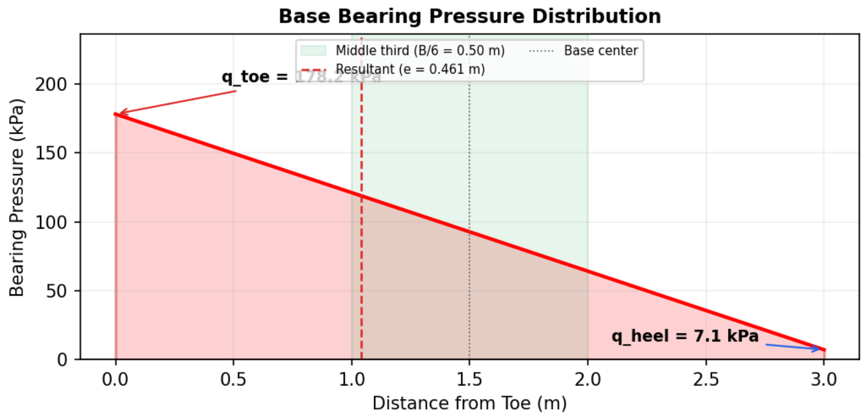

Figure 2: *
Figure 2: Bearing pressure distribution along base. q_toe = 178.2 kPa, q_heel = 7.1 kPa.

1. REFERENCES

1. FHWA GEC-11 (FHWA-NHI-10-024): Design of Mechanically Stabilized Earth Walls and Reinforced Slopes. FHWA, 2009.
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3. Das, B.M. Principles of Foundation Engineering, 9th Ed., Ch. 13.
4. Coulomb, C.A. (1776). "Essai sur une application des regles de maximis et minimis a quelques problemes de statique." Memoires de Mathematique et de Physique, Academie Royale des Sciences.
5. Rankine, W.J.M. (1857). "On the Stability of Loose Earth." Philosophical Transactions of the Royal Society, 147.