Medra Mühendislik

SOIL NAIL WALL

DESIGN REPORT

Soil nail wall

KDYY (+ TBDY 2018) — Excavation Support Structures Regulation

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Identity	Information
Project name	Smith Residence – Foundation Study
Location (province / district / quarter · sheet, block, parcel)	California / Alameda County / Oakland · Book 48, Page 3216 Sheet Block 12 Block Lot 7 (APN 048-3216-012-00) Parcel
Client	Osman Osman
Designer of record	Gökhan Demirbaş
Company	Medra Mühendislik
Wall name	Soil nail wall
Use	Temporary (excavation support)
Design code	KDYY (+ TBDY 2018) — Excavation Support Structures Regulation
Date	24.08.2026
Prepared by	
Checked by	

All numbers in this report are read from the program's calculation engine; the screen, the report and the drawing show the same results. The prepared by and checked by fields are for wet signature and stamp.

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SYMBOLS USED

Symbol	Description	Unit
H	Excavation depth	m
L	Nail length	m
S_h	Horizontal nail spacing	m
S_v	Vertical nail spacing	m
γ	Unit weight	kN/m³
c'	Effective cohesion	kPa
ϕ′	Effective angle of internal friction	°
c_u	Undrained shear strength	kPa
τ_{bu}	Ultimate bond strength	kPa
τ_{bd}	Design bond strength	kPa
FS	Factor of safety (limit equilibrium)	—
z_c	Tension crack depth	m
λ	Common scale factor of the nail forces (required nail force)	—
L_b	Effective (bond) length behind the slip surface	m
P_k	Characteristic pull-out resistance	kN
P_d	Design pull-out resistance	kN
R_{tk}	Characteristic tensile resistance of the nail bar	kN
R_{td}	Design tensile resistance of the nail bar	kN
T_d	Design force of the row = min(P_d; R_{td})	kN
T_{max}	Maximum tensile force in the nail (demand)	kN
$T_{i,max}$	Maximum tensile force along the length behind the slip surface	kN
$T_{d,max}$	Design tensile load = $T_{max} \cdot \gamma_E$	kN
γ_P	Pull-out resistance partial factor ($\gamma_k \cdot \gamma_{rb}$)	—
γ_s	Steel partial factor	—
γ_E	Action factor applied to the demand	—
γ_{Re}	Soil resistance partial factor (KDYY Table 2.1)	—
$\gamma_{G,dst}$	Permanent destabilising action factor	—
$\gamma_{Q,dst}$	Variable destabilising action factor	—
γ_{sd}	Model factor	—
A_s	Reinforcement (mesh) area	mm²/m
f_{yk}	Characteristic yield strength of reinforcement	MPa
η	Utilisation ratio (action / resistance)	—
E_d	Design effect (ULS)	—

Symbol	Description	Unit
R_d	Design resistance (ULS)	—
k_h	Horizontal seismic coefficient	—
K_a	Active earth pressure coefficient	—
P_a	Active thrust	kN/m
B_L	Base length of the sliding block	m
W	Block weight	kN/m
β_{eq}	Equivalent backslope angle	°
S_u	Undrained shear strength below the excavation base (heave)	kPa

Units are SI; forces are given per metre of wall (kN/m) or per nail (kN). Design values carry the subscript "d", characteristic values the subscript "k".

1 Use, basis and method

__Table__ 1. Use, design basis and solution method

Item	Value
Design code	KDYY (+ TBDY 2018) — Excavation Support Structures Regulation
Use	Temporary (excavation support)
Corrosion protection	Not specified
Design basis	KDYY partial factors
Lift convention	Install AFTER excavation — unsupported lift checked
Solution method	Morgenstern–Price
Tension crack	developed strength at the required FS

In a soil nail wall the nail forces enter force equilibrium; TBDY 2018 Eq. 16.30, which checks moment equilibrium only, has NOT been used in this design. Each nail force enters the slice it crosses as an external force.

2 Geometry and soil

Excavation depth H = 10.00 m, face angle 77.5°, 1 bench(es). Wall length: 10.0 m.

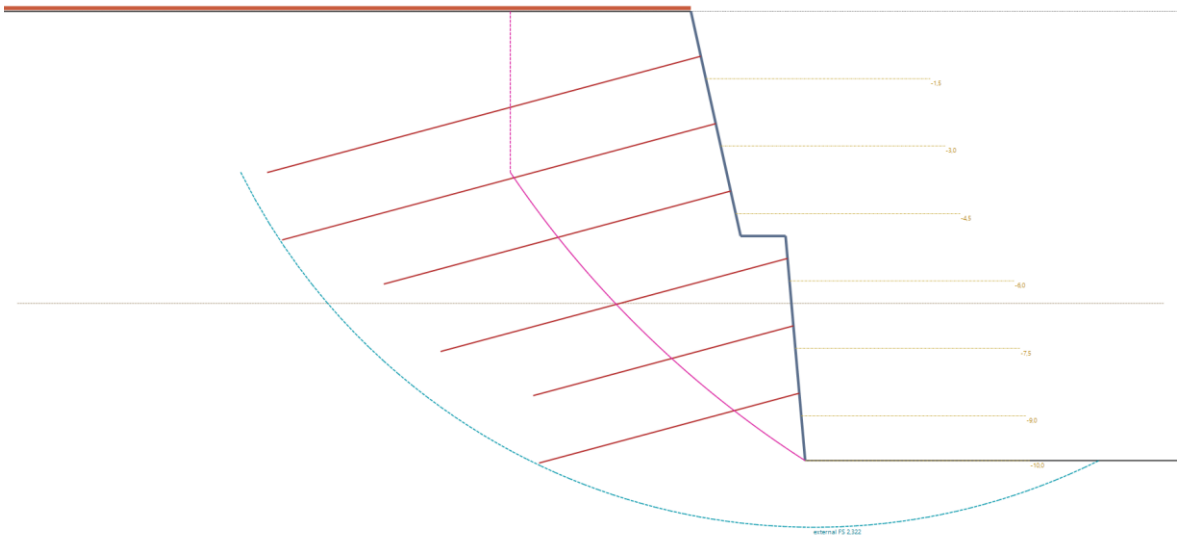


__Figure__ 1. Section — final stage, nails and governing slip surface

__Table__ 2. Soil layers and bond strength

Layer	Thickness m	γ kN/m³	c' kPa	ϕ' °	c_u kPa	τ_{bu} kPa	τ source
Rock W4	6.50	21.0	25.0	30.0	0.0	175.0	Manual
Rock W2	7.50	24.0	50.0	38.0	0.0	275.0	Manual

No groundwater assumed.

3 Nails and excavation lifts

Table 3. Nail rows

Row	Level m	L m	Incl. °	Hole mm	Bar	Sh×Sv m
1	-1.00	10.0	15	150	Ø26 / 420 MPa	1.50×1.50
2	-2.50	10.0	15	150	Ø26 / 420 MPa	1.50×1.50
3	-4.00	8.0	15	150	Ø26 / 420 MPa	1.50×1.50
4	-5.50	8.0	15	150	Ø26 / 420 MPa	1.50×1.50
5	-7.00	6.0	15	150	Ø26 / 420 MPa	1.50×1.50
6	-8.50	6.0	15	150	Ø26 / 420 MPa	1.50×1.50

Excavation lift levels: -1.50 · -3.00 · -4.50 · -6.00 · -7.50 · -9.00 · -10.00 m

4 Staged analysis

Table 4. Excavation stages — factors of safety

Case	Type	Level	Rows	GS	z_c m	Required	Result
1	unsupported lift	-1.50	0	3.955	3.58	1.00	ADEQUATE
2	nails installed	-1.50	1	6.079	3.58	1.00	ADEQUATE
3	unsupported lift	-3.00	1	3.657	3.58	1.00	ADEQUATE
4	nails installed	-3.00	2	3.880	3.58	1.00	ADEQUATE
5	unsupported lift	-4.50	2	2.576	3.58	1.00	ADEQUATE
6	nails installed	-4.50	3	2.833	3.58	1.00	ADEQUATE
7	unsupported lift	-6.00	3	2.218	3.58	1.00	ADEQUATE
8	nails installed	-6.00	4	2.493	3.58	1.00	ADEQUATE
9	unsupported lift	-7.50	4	2.226	3.58	1.00	ADEQUATE
10	nails installed	-7.50	5	2.217	3.58	1.00	ADEQUATE
11	unsupported lift	-9.00	5	1.940	3.58	1.00	ADEQUATE
12	nails installed	-9.00	6	1.959	3.58	1.00	ADEQUATE
13	unsupported lift	-10.00	6	1.756	3.58	1.00	ADEQUATE
14	nails installed	-10.00	6	1.756	3.58	1.00	ADEQUATE

External stability (KDYY 3.3.3.4 — deep circles A, B and forward sliding J; FHWA 6.5.2): separate search without nail contribution, only surfaces enclosing all nails (cutting no nail, entry behind the farthest nail end, exit at or in front of the toe).

Table 5. External stability — separate search (no nail contribution)

Case	Level	GS	Required	Surface	Result
2	-1.50	8.031	1.00	A/B — deep circular	ADEQUATE
3	-3.00	4.880	1.00	J — forward sliding (flat base)	ADEQUATE

Case	Level	GS	Required	Surface	Result
4	-3.00	4.880	1.00	J — forward sliding (flat base)	ADEQUATE
5	-4.50	3.764	1.00	J — forward sliding (flat base)	ADEQUATE
6	-4.50	3.764	1.00	J — forward sliding (flat base)	ADEQUATE
7	-6.00	3.647	1.00	A/B — deep circular	ADEQUATE
8	-6.00	3.647	1.00	A/B — deep circular	ADEQUATE
9	-7.50	3.001	1.00	A/B — deep circular	ADEQUATE
10	-7.50	3.001	1.00	A/B — deep circular	ADEQUATE
11	-9.00	2.548	1.00	A/B — deep circular	ADEQUATE
12	-9.00	2.602	1.00	A/B — deep circular	ADEQUATE
13	-10.00	2.322	1.00	A/B — deep circular	ADEQUATE
14	-10.00	2.322	1.00	A/B — deep circular	ADEQUATE

Solution method: Morgenstern–Price (moment and force equilibrium together). Because nail forces enter force equilibrium in a soil nail wall, TBDY 2018 Eq. 16.30, which checks moment equilibrium only, has not been used.

Each nail force enters the slice it crosses as an external force (vertical component into the base normal, horizontal component into interslice equilibrium, its moment into moment equilibrium). Acceptance criteria: interslice forces must be admissible (Morgenstern and Price 1967); the result must lie within [0.5 ; 2.0] times the Bishop / Janbu value of the same surface. A surface that does not converge is discarded without falling back to another method.

Soil resistance factor: KDYY Table 2.1 → γ_{Re} = 1.10. Stage actions: $\gamma_{G,dst}$ = 1.35, $\gamma_{Q,dst}$ = 1.50; model factor γ_{sd} = 1.00 (B.3.16, on driving actions).

Governing case: 7-E unsupported excavation (elev. -10.00) — factor of safety 1.756.

THE GOVERNING CASE IS AN UNSUPPORTED EXCAVATION LIFT. Not the final stage but a moment during construction governs the design: improve it by reducing the lift height or installing that lift's nails earlier.

External stability (KDYY 3.3.3.4, FHWA 6.5.2 — no nail contribution, surface behind/below all nails): 7-E unsupported excavation (elev. -10.00) — FS 2.322 (required 1.00), A/B — deep circular, adequate.

5 Row checks at the governing case

***Table** 6. Row checks at the governing case*

Row	Level	L_b m	P_d kN	R_{td} kN	T_d kN	Governs	KDYY check
1	-1.00	5.600	233.2	193.9	193.9	steel rupture	adequate
2	-2.50	5.350	222.8	193.9	193.9	steel rupture	adequate
3	-4.00	4.000	166.6	193.9	166.6	pullout	adequate
4	-5.50	4.040	218.3	193.9	193.9	steel rupture	adequate
5	-7.00	3.180	208.1	193.9	193.9	steel rupture	adequate
6	-8.50	4.500	294.5	193.9	193.9	steel rupture	adequate

Calculation steps of the row checks

Row 1 (level -1.00 m, L_b = 5.60 m)

$P_d = P_k / \gamma_P = 461.8 / 1.98 = 233.2$ kN
$R_{td} = R_{tk} / \gamma_s = 223.0 / 1.15 = 193.9$ kN
$T_d = \min(P_d; R_{td}) = \min(233.2; 193.9) = 193.9$ kN
$T_{d,max} = T_{max} \cdot \gamma_E = 0.0 \cdot 1.00 = 0.0$ kN
$\eta_{rupture} = T_{d,max} / R_{td} = 0.0 / 193.9 = 0.000$
$\eta_{pull\text{-}out} = T_{i,max} \cdot \gamma_E / P_d = 0.0 \cdot 1.00 / 233.2 = 0.000 \rightarrow$ adequate

Row 2 (level -2.50 m, L_b = 5.35 m)

$P_d = P_k / \gamma_P = 441.2 / 1.98 = 222.8$ kN
$R_{td} = R_{tk} / \gamma_s = 223.0 / 1.15 = 193.9$ kN
$T_d = \min(P_d; R_{td}) = \min(222.8; 193.9) = 193.9$ kN
$T_{d,max} = T_{max} \cdot \gamma_E = 0.0 \cdot 1.00 = 0.0$ kN
$\eta_{rupture} = T_{d,max} / R_{td} = 0.0 / 193.9 = 0.000$
$\eta_{pull\text{-}out} = T_{i,max} \cdot \gamma_E / P_d = 0.0 \cdot 1.00 / 222.8 = 0.000 \rightarrow$ adequate

Row 3 (level -4.00 m, L_b = 4.00 m)

$P_d = P_k / \gamma_P = 329.9 / 1.98 = 166.6$ kN
$R_{td} = R_{tk} / \gamma_s = 223.0 / 1.15 = 193.9$ kN
$T_d = \min(P_d; R_{td}) = \min(166.6; 193.9) = 166.6$ kN
$T_{d,max} = T_{max} \cdot \gamma_E = 0.0 \cdot 1.00 = 0.0$ kN
$\eta_{rupture} = T_{d,max} / R_{td} = 0.0 / 193.9 = 0.000$
$\eta_{pull\text{-}out} = T_{i,max} \cdot \gamma_E / P_d = 0.0 \cdot 1.00 / 166.6 = 0.000 \rightarrow$ adequate

Row 4 (level -5.50 m, L_b = 4.04 m)

$P_d = P_k / \gamma_P = 432.2 / 1.98 = 218.3$ kN
$R_{td} = R_{tk} / \gamma_s = 223.0 / 1.15 = 193.9$ kN
$T_d = \min(P_d; R_{td}) = \min(218.3; 193.9) = 193.9$ kN
$T_{d,max} = T_{max} \cdot \gamma_E = 0.0 \cdot 1.00 = 0.0$ kN
$\eta_{rupture} = T_{d,max} / R_{td} = 0.0 / 193.9 = 0.000$
$\eta_{pull\text{-}out} = T_{i,max} \cdot \gamma_E / P_d = 0.0 \cdot 1.00 / 218.3 = 0.000 \rightarrow$ adequate

Row 5 (level -7.00 m, L_b = 3.18 m)

$P_d = P_k / \gamma_P = 412.1 / 1.98 = 208.1$ kN
$R_{td} = R_{tk} / \gamma_s = 223.0 / 1.15 = 193.9$ kN
$T_d = \min(P_d; R_{td}) = \min(208.1; 193.9) = 193.9$ kN
$T_{d,max} = T_{max} \cdot \gamma_E = 0.0 \cdot 1.00 = 0.0$ kN
$\eta_{rupture} = T_{d,max} / R_{td} = 0.0 / 193.9 = 0.000$
$\eta_{pull\text{-}out} = T_{i,max} \cdot \gamma_E / P_d = 0.0 \cdot 1.00 / 208.1 = 0.000 \rightarrow$ adequate

Row 6 (level -8.50 m, L_b = 4.50 m)

$P_d = P_k / \gamma_P = 583.2 / 1.98 = 294.5$ kN
$R_{td} = R_{tk} / \gamma_s = 223.0 / 1.15 = 193.9$ kN
$T_d = \min(P_d; R_{td}) = \min(294.5; 193.9) = 193.9$ kN
$T_{d,max} = T_{max} \cdot \gamma_E = 0.0 \cdot 1.00 = 0.0$ kN
$\eta_{rupture} = T_{d,max} / R_{td} = 0.0 / 193.9 = 0.000$
$\eta_{pull\text{-}out} = T_{i,max} \cdot \gamma_E / P_d = 0.0 \cdot 1.00 / 294.5 = 0.000 \rightarrow$ adequate

$\gamma_P = \gamma_k \cdot \gamma_{rb}$: equivalent pull-out factor from the Table 3.17 chain of the layers the row crosses (factor list in section 7). Rows not crossing the slip surface or whose head lies outside the sliding mass are not shown (T_d = 0).

6 Required nail force (from the solver)

Required nail force: the critical surface of each stage is held fixed, all nail forces entering it are scaled by the same factor λ, and the λ giving FS(λ) = required FS is found. $T_{required} = \lambda \cdot T_d$. This is not KDYY's T_{max} / $T_{i,max}$ and does not enter the KDYY check; it shows how much the nails are utilised.

***Table** 7. Required nail force factor λ at each stage*

Stage	λ	GS(λ=0)	GS(λ=1)	Required	Note
1-E unsupported excavation (elev. -1.50)	—	—	—	1.00	[K1]
1-N nail installed (elev. -1.50)	0.000	6.249	6.079	1.00	adequate even without nails
2-E unsupported excavation (elev. -3.00)	0.000	3.569	3.657	1.00	adequate even without nails
2-N nail installed (elev. -3.00)	0.000	3.569	3.880	1.00	adequate even without nails
3-E unsupported excavation (elev. -4.50)	0.000	2.284	2.576	1.00	adequate even without nails
3-N nail installed (elev. -4.50)	0.000	2.362	2.833	1.00	adequate even without nails
4-E unsupported excavation (elev. -6.00)	0.000	1.799	2.218	1.00	adequate even without nails
4-N nail installed (elev. -6.00)	0.000	1.666	2.493	1.00	adequate even without nails
5-E unsupported excavation (elev. -7.50)	0.000	1.565	2.226	1.00	adequate even without nails
5-N nail installed (elev. -7.50)	0.000	1.550	2.217	1.00	adequate even without nails
6-E unsupported excavation (elev. -9.00)	0.000	1.296	1.940	1.00	adequate even without nails
6-N nail installed (elev. -9.00)	0.000	1.048	1.959	1.00	adequate even without nails
7-E unsupported excavation (elev. -10.00)	0.000	1.108	1.756	1.00	adequate even without nails
7-N nail installed (elev. -10.00)	0.000	1.108	1.756	1.00	adequate even without nails

***Table** 8. Required nail force envelope per row*

Row	T_d kN	$T_{required}$ kN	Utilisation	Governing stage
1	193.9	0.0	0.00	1-N nail installed (elev. -1.50)
2	193.9	0.0	0.00	2-N nail installed (elev. -3.00)
3	193.9	0.0	0.00	3-N nail installed (elev. -4.50)
4	193.9	0.0	0.00	4-N nail installed (elev. -6.00)
5	0.0	0.0	—	5-N nail installed (elev. -7.50)
6	193.9	0.0	0.00	6-N nail installed (elev. -9.00)

7 Facing, nail demand, factors and quantities

⚠ Facing check not made: nail force $T_{max} = 0$ at the governing case (the design resistance of the cut rows is zero) — $T_o = 0$.

8 ULS summary table (KDYY 3.3.3.1-h/j, Figure 3.20)

__Table__ 9. ULS failure modes — $E_d \le R_d$ summary

No.	Failure mode (Figure 3.20)	E_d	R_d	Ratio	Unit	Verdict	Clause	Note
1	Internal stability	1.000	1.756	0.569	GS	adequate	3.3.3.3, B.3.16	[K2]
2	External stability (deep / translational)	1.000	2.322	0.431	GS	adequate	3.3.3.4, FHWA 6.5.2	[K3]
3	Basal heave	—	—	—		not applicable	Figure 3.20-3, FHWA 5.6.6	[K4]
4	Base sliding	473.9	2248.4	0.211	kN/m	adequate	3.3.3.5, FHWA 5.17	FS = 4.744 (required 1.00)
5	Nail pullout	0.000	199.9	0.000	kN	adequate	3.3.3.6-m, B.3.17	row 1, 1-N nail installed (elev. -1.50)
6	Nail tensile rupture	0.000	193.9	0.000	kN	adequate	3.3.3.7-d, B.3.19	row 1, 1-N nail installed (elev. -1.50)
7	Facing flexure (initial)	—	—	—		not computed — $T_o = 0$	3.3.3.8-b/c	[K5]
8	Punching (initial)	—	—	—		not computed — $T_o = 0$	3.3.3.8-d	[K5]
S	SLS deformation	—	—	—		not checked	3.3.3.9	[K6]

· g.2 — ULS + stress-deformation analysis (PLAXIS) MANDATORY (KDYY 3.3.3.1-g.2): excavation category not specified — the g.1 condition (Category 2) cannot be shown.

· WARNING: in a g.2 wall the nail loads must also be checked with stress-deformation analyses (KDYY 3.3.3.7-c); the T_{max} source is not the PLAXIS import.

· KDYY 3.3.3.1-j / B.3.15: each ULS case is shown separately, $E_d \le R_d$. In the stability rows E_d = required FS, R_d = computed FS; in base sliding on the characteristic basis E_d = required FS × driving.

9 SLS displacement and design approach (KDYY 3.3.3.9, 3.3.3.1-g)

g.2 — ULS + stress-deformation analysis (PLAXIS) MANDATORY (KDYY 3.3.3.1-g.2): excavation category not specified — the g.1 condition (Category 2) cannot be shown.

· WARNING: in a g.2 wall the nail loads must also be checked with stress-deformation analyses (KDYY 3.3.3.7-c); the T_{max} source is not the PLAXIS import.

__Table__ 10. SLS displacement estimate and design approach

Item	Value
Design approach (3.3.3.1-g)	g.2
SLS estimate	SLS displacement estimate not produced: KDYY Table 3.20 soil class not selected (the program does not guess).
Limit 0.005·H (3.3.3.9-f)	50.0 mm

· SLS displacement estimate not produced: KDYY Table 3.20 soil class not selected (the program does not guess).

10 Basal heave (FHWA 5.6.6, Figure 3.20-3)

__Table__ 11. Basal heave intermediate values

Item	Value
Check	not applicable — the layer below the excavation base (Rock W2) is not defined as undrained (S_u); no soft fine-grained soil

· Basal heave NOT APPLICABLE: the layer below the excavation base (Rock W2) is not defined as undrained (S_u); no soft fine-grained soil (FHWA 5.6.6a: evaluated only for soft fine-grained soils).

11 Base sliding (KDYY 3.3.3.5, FHWA 5.7.3)

__Table__ 12. Base sliding intermediate values

Item	Value	Source
Block base length B_L	11.98 m	FHWA Figure 5.12
Block weight W	2398.7 kN/m	FHWA 5.17
Face batter α (from vertical)	5.0°	input
β_{eq}	0.0°	[K7]
H1	10.00 m	FHWA 5.20
δ	0.0°	= β_{eq} (FHWA)
K_a	0.265	Coulomb, FHWA 5.21
$P_a = ½·\gamma·H1^2·K_a$	292.1 kN/m	FHWA 5.19
Surcharge thrust ES	53.0 kN/m	variable q_v
Block inertia $k_h·W$	0.0 kN/m	K4 seismic mode
Vertical contribution of permanent surcharge	0.0 kN/m	Table 3.16: favourable q_p 1.0, q_v 0
$R_s = c·B_L + (W + P·\sin\delta)·\tan\phi$	2473.2 kN/m	FHWA 5.18
γ_{Re}	1.10	C1 (settings)
Driving (design)	473.9 kN/m	
Resisting (design)	2248.4 kN/m	
FS / required	4.744 / 1.00	adequate

Factor of safety against base sliding (KDYY 3.3.3.5, FHWA 5.17)

> $FS = R_d / E_d \geq$ required FS
> $= 2248.4 / 473.9$
> **$= 4.744 \geq 1.00 \rightarrow$ adequate**

· Partial factor basis (KDYY Table 3.16): earth thrust ×1.35, surcharge thrust (variable q_v) ×1.50; on the resisting side W, P·sin δ favourable ×1.00; variable surcharge favourable 0 (not counted as resistance); soil resistance divided by γ_{Re} = 1.10 (the wall's C1 choice); expected FS ≥ 1.00.

· Block: B_L = 11.98 m, H = 10.00 m, α = 5° (from vertical), W = γ·A (A = 108.78 m², from the face geometry; top width 9.44 m) = 2398.7 kN/m. K_a = 0.265 (Coulomb (FHWA 5.21), ϕ_f = 32.8°, θ = α + 90° = 95°, δ = β_{eq} = 0°, β = 0°).

· β_{eq} = 0° (no break within 2H = 20.00 m: infinite slope, β_{eq} = β); H1 = H + (B_L − H·tan α)·tan β_{eq} = 10.00 m (FHWA 5.20); δ = β_{eq} (FHWA 5.7.3a simplification: thrust parallel to the ground slope).

· Driving (unfactored): P·cos δ 292.1 + surcharge ES = K·q·H1 53.0 + inertia 0.0 kN/m → design 473.9 kN/m.

· Resisting (FHWA 5.18): $c_b \cdot B_L$ 599.2 + (W 2398.7 + P·sin δ 0.0 + permanent surcharge 0.0)·tan ϕ_b = 1874.0 → R_s = 2473.2 kN/m; design 2248.4 kN/m.

· The variable surcharge on the block was NOT COUNTED AS RESISTANCE (KDYY Table 3.16: q_v favourable 0; FHWA 5.7.3a: vertical Q_{ES} not added). Before 24.09.2026 q·B·tan ϕ was counted — error corrected.

· The weight of the backslope wedge above the block was not added to W (safe side); the horizontal surcharge thrust was not reduced by cos δ (safe side).

· Method: FHWA GEC-7 (2015) 5.7.3, Eq. 5.17–5.23 — gravity retaining wall approach (KDYY 3.3.3.1-h.2, 3.3.3.5).

12 Nail test programme (KDYY 3.3.4, Table 3.21 / 3.22)

***Table** 13. Number of tests (KDYY Table 3.21)*

Item	Value
Excavation category	not specified — counts not produced
Number of soil types	2
Number of nailed excavation stages	6
Minimum KBD	0
KD ratio / lower bound	— / 0
Total nails	40
Number of KD	—

***Table** 14. Nail test programme — test loads per row*

Type	Row	Soil	$T_{d,max}$ kN	P_{test} kN	τ_{bd} kPa	$L_{b,t}$ m	Structural limit kN	$\delta_{n,min}$ mm

Reading times 0–1–2–5–10–15–20–60 min; hold 10 min at the maximum load, 1 min at intermediate stages; Δ ≤ 0.5 mm; creep v = $(s_2 - s_1)/\log(t_2/t_1)$ < 2 mm (KDYY 3.3.4.2).

· KBD: $P_{test} = T_{d,max}$. gamma_d . ksi = $T_{d,max}$. 2.0 . 1.1; $L_{b,t} = P_{test}$/(tau_bd.pi.d).

· KD: $P_{test} = T_{d,max}$. k = $T_{d,max}$. 1.25.

· Excavation category (KDYY Table 1.1) NOT SPECIFIED: Table 3.21 test NUMBERS were not produced. Category 2: KBD ≥ 3 (≥ 1 per soil type), KD 2% (≥ 3; ≥ 1 per excavation stage and per soil type). Category 3: KBD ≥ 5 (≥ 2 per soil type), KD 3% (≥ 5; ≥ 1 per excavation stage).

· If KBD tests are performed, the number of KD tests may be reduced (KDYY 3.3.4.1-d). Tests are distributed evenly along the wall (3.3.4.1-a).

· Structural limit (KDYY 3.3.4.2-f): $P_{test} \le 0.80 \cdot R_{tk}$ (KBD) / $0.90 \cdot R_{tk}$ (KD); $R_{tk} = A_{s,nom} \cdot f_{yk}$, γ_s = 1.0 (3.3.3.7-d, field tests); no corrosion allowance since the test nail is newly installed.

· KBD elastic length criterion (Table 3.22): $\delta_n \ge 0.80 \cdot P \cdot L_{df}/(E \cdot A_{s,nom})$, E = 200 GPa. Free length L_{df} NOT ENTERED; no numerical value produced. In KD the free length is zero (Figure 3.23).

· Loading (KDYY 3.3.4.2, Table 3.22): reference load $P_0 = 0.10 \cdot P_{test}$ at the start. KBD at least 2 cycles, T_d not exceeded in the first cycle, stages within a cycle not above 20% of that cycle's maximum load. KD 1 cycle, at least 5 stages.

· Readings: t = 0, 1, 2, 5, 10, 15, 20, 60 min; next stage if the difference of consecutive readings Δ ≤ 0.5 mm. Hold: 10 min at the maximum test load, 1 min at intermediate stages. If Δ ≤ 0.5 mm is not met the next stage is not applied (P_{res}). Creep v = (s1 − s2)/log(t2/t1) < 2 mm (≥ 2 mm → P_{cr}).

· Nails for KBD tests are NOT PRODUCTION NAILS; when the excavation reaches the relevant row they are installed SEPARATELY as test nails between the production nails.

13 Design notes and drainage (KDYY 3.3.3.1, FHWA 6.3.3)

· WARNING: the last row is 1.50 m above the base > 0.9 m (FHWA 6.3.3b: ≈ 2–3 ft).

· Info: longest nail L/H = 1.00 (FHWA 6.3.3d preliminary sizing ≈ 0.7H = 7.00 m).

· Drainage (KDYY 3.3.3.1-e): drainage conditions must be considered in the design; failure to drain the soil immediately behind the facing may cause serious problems during / after construction.

· Pressure grouting methods used for prestressed anchors cannot be applied to nails and the bond values recommended for anchors cannot be used for nails (KDYY 3.3.3.6-b).

14 Conclusion

None of the ULS failure modes checked is inadequate; however, the design is NOT FINAL because the checks below could not be made.

Not checked (input missing): Facing flexure (initial), Punching (initial) — the design is not final until these checks are completed.

SLS: the wall is in class g.2 (KDYY 3.3.3.1-g.2) and no PLAXIS (SSA) displacement has been entered — a STRESS-DEFORMATION ANALYSIS (SSA) IS REQUIRED; the SLS verdict is to be given with the SSA result.

Section, elevation and head detail are in the attached drawing: Soil nail wall.dxf

15 References and clauses

***Table** 15. References and clauses*

No.	Source / clause text
[K1]	no installed nail crosses the critical surface
[K2]	minimum FS: 7-E unsupported excavation (elev. -10.00) (14 stages; unsupported lifts included)
[K3]	separate search, no nail contribution, surface behind/below all nails: 7-E unsupported excavation (elev. -10.00); A/B — deep circular; Morgenstern–Price; FS 2.322
[K4]	the layer below the excavation base (Rock W2) is not defined as undrained (S_u); no soft fine-grained soil
[K5]	nail force T_{max} = 0 at the governing case (the design resistance of the cut rows is zero) — T_o = 0
[K6]	SLS displacement estimate not produced: KDYY Table 3.20 soil class not selected (the program does not guess).
[K7]	FHWA 5.20 — no break within 2H = 20.00 m: infinite slope, $\beta_{eq} = \beta$