DRILLED SHAFT CAPACITY ANALYSIS (GEC-10)

Project: Sample Project **Number:** DS-2026-006
Prepared By: S. OConnell, PE **Date:** 2026-02-17
Company: Geotech Associates

1. INPUT PARAMETERS

Parameter	Symbol	Value	Unit
Shaft diameter	D	1.2	m
Shaft length	L	20.0	m
Shaft perimeter	P	3.770	m
Tip area	A_{tip}	1.1310	m^2
Concrete strength	$f'c$	28.0	MPa
Number of soil layers	*Layers*	3	
Soft to medium clay (0.0-8.0 m)	*Layer*1	γ = 17.5 kN/m^3, c_u = 50 kPa	
Stiff clay (8.0-15.0 m)	*Layer*2	γ = 18.5 kN/m^3, c_u = 100 kPa	
Dense sand (15.0-25.0 m)	*Layer*3	γ = 19.0 kN/m^3, φ = 35°, N_60 = 30	
Groundwater depth	*GWT*	3.0	m
Factor of safety	*FS*	2.5	
Analysis method	*Method*	GEC-10	

1. SHAFT GEOMETRY & EXCLUSION ZONES

Shaft Perimeter

$$P = \pi \times D$$

$$P = \pi \times 1.200$$

$P = 3.770$ m

Shaft Tip Area

$$A_{tip} = \pi \times D^2/4$$

$$A_{tip} = \pi \times 1.200^2/4$$

$A_{tip} = \mathbf{1.1310}\ \text{m}^2$

Length-to-Diameter Ratio

$$L/D = L/D$$

$$L/D = 20.00/1.200$$

$L/D = \mathbf{16.7}$

Top Exclusion Zone

$$z_{excl_top} = \max(1.5m, casingdepth)$$

$$z_{excl_top} = \max(1.5, 0.00)$$

$z_{excl_top} = \mathbf{1.50}\ \text{m}$

GEC-10 Section 13.3.3: top 1.5 m excluded from side resistance

Bottom Exclusion Zone (cohesive only)

$$z_{excl_bot} = L - D(bottom1 \times Dexcludedforcohesivelayers)$$

$$z_{excl_bot} = 20.00 - 1.200$$

$z_{excl_bot} = \mathbf{18.80}\ \text{m}$

GEC-10 Section 13.3.3: bottom 1D excluded for cohesive soils

1. SIDE RESISTANCE METHODS

Alpha Method (Cohesive Soils)

$$\alpha = 0.55 for c_u / p_a \leq 1.5 \alpha = 0.55 - 0.1 \times (c_u / p_a - 1.5) for c_u / p_a > 1.5 (minimum \alpha = 0.35) f_s = \alpha \times c_u Q_s = f_s \times P$$

$$=$$

GEC-10 Section 13.3.3.2; O'Neill & Reese (1999)

Beta Method (Cohesionless Soils)

$$\beta = 1.5 - 0.245 \times \sqrt{z \times 3.281}, clamped to [0.25, 1.2] f_s = \beta \times \sigma'_{v,} capped at 200 kPa Q_s = f_s \times P \times \Delta z$$

$$=$$

GEC-10 Section 13.3.3.3; Brown et al. (2010)

1. PER-LAYER SIDE RESISTANCE

Layer 1: Soft to medium clay (0.0-8.0 m) – Alpha Method

$$f_s = \alpha \times c_u = alpha = 0.550 Q_s = f_s \times P \times \Delta z$$

$$f_s = 27.5 kPa Q_s = 27.5 \times 3.770 \times 6.50$$

$Q_s = \mathbf{673.9}$ kN

Effective zone: 1.5-8.0 m, σ'_v = 66.0 kPa

Layer 2: Stiff clay (8.0-15.0 m) – Alpha Method

$$f_s = \alpha \times c_u = alpha = 0.550 Q_s = f_s \times P \times \Delta z$$

$$f_s = 55.0 kPa Q_s = 55.0 \times 3.770 \times 7.00$$

$Q_s = \mathbf{1,451.4}$ kN

Effective zone: 8.0-15.0 m, σ'_v = 121.4 kPa

Layer 3: Dense sand (15.0-20.0 m) – Beta Method

$$f_s = \beta \times \sigma'_{v,} beta = 0.250 Q_s = f_s \times P \times \Delta z$$

$$f_s = 43.7 kPa (\sigma'_v = 174.8 kPa) Q_s = 43.7 \times 3.770 \times 5.00$$

$Q_s = \mathbf{823.5}$ kN

Effective zone: 15.0-20.0 m

Per-Layer Side Resistance Summary

Layer	Depth (m)	Description	Soil Type	Method	f_s (kPa)	Q_s (kN)
1	0.0-8.0	Soft to medium clay	cohesive	alpha=0.550	27.5	673.9
2	8.0-15.0	Stiff clay	cohesive	alpha=0.550	55.0	1,451.4
3	15.0-20.0	Dense sand	cohesionless	beta=0.250	43.7	823.5

Total Side Resistance

$$Q_{skin} = \Sigma Q_{s,i}$$

$$Q_{skin} = 673.9 + 1,451.4 + 823.5$$

$Q_{skin} = \mathbf{2,948.8}$ kN

Side Resistance by Soil Type

Soil Type	Q_s (kN)	% of Q_skin
Cohesive (clay/silt)	2,125.3	72%
Cohesionless (sand/gravel)	823.5	28%
Total Q_skin	2,948.8	100%

1. END BEARING

Unit End Bearing (Cohesionless Tip)

$$q_b = 57.5 \times N_{60} (N_{60} cappedat 50)$$

$$q_b = 57.5 \times 30$$

$q_b = \mathbf{1,725.0}$ kPa

GEC-10 Section 13.3.4.3; O'Neill & Reese (1999)

End Bearing Capacity

$$Q_{tip} = q_b \times A_{tip}$$

$$Q_{tip} = 1,725.0 \times 1.1310$$

$Q_{tip} = \mathbf{1,950.9}$ kN

Effective Stress at Shaft Tip

$$\sigma'_{v,tip} = \Sigma(\gamma'_i \times \Delta z_i)$$

$\sigma'_{v,tip} = \mathbf{197.7}$ kPa

1. ULTIMATE & ALLOWABLE CAPACITY

Ultimate Axial Capacity

$$Q_{ult} = Q_{skin} + Q_{tip}$$

$$Q_{ult} = 2,948.8 + 1,950.9$$

$Q_{ult} = \mathbf{4,899.7}$ kN

GEC-10 Eq. 13-1

Capacity Breakdown

Component	Value (kN)	% of Q_ult
Side resistance (Q_skin)	2,948.8	60%
Clay	2,125.3	43%
Sand	823.5	17%
Rock	0.0	0%
End bearing (Q_tip)	1,950.9	40%
Total Q_ult	4,899.7	100%

Allowable Capacity

$$Q_{all} = Q_{ult} / FS$$

$$Q_{all} = 4,899.7 / 2.5$$

$Q_{all} = \mathbf{1,959.9}$ kN

1. FIGURES

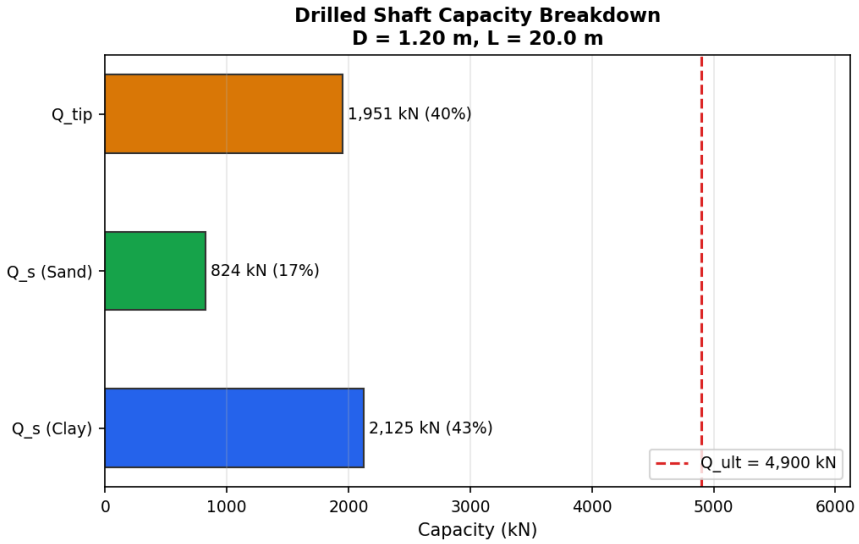

Figure 1: *

Figure 1: Capacity components – Q_skin = 2,948.8 kN, Q_tip = 1,950.9 kN, Q_ult = 4,899.7 kN.

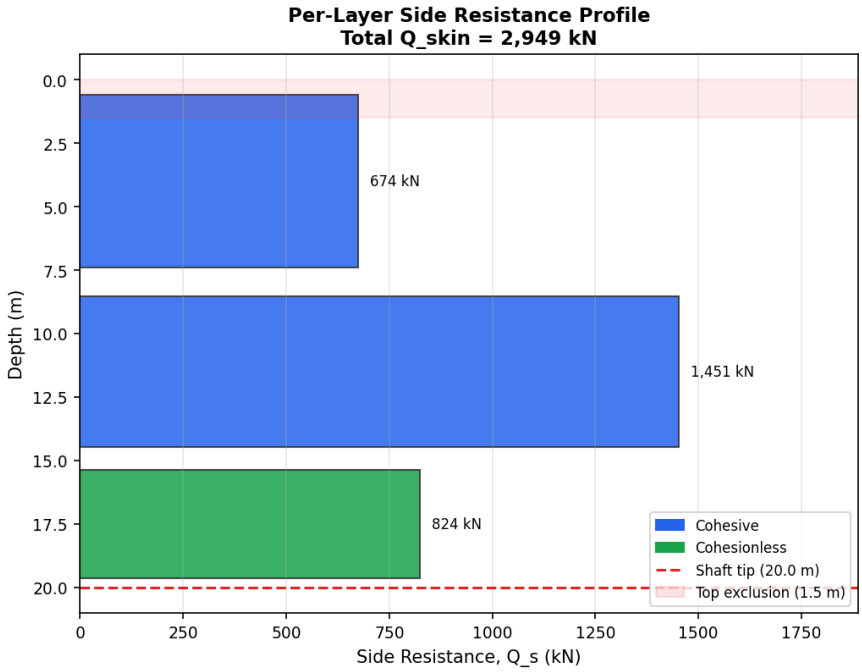

Figure 2: *

Figure 2: Per-layer side resistance profile – total Q_skin = 2,948.8 kN across 3 layer(s).

1. REFERENCES

1. Brown, D.A., Turner, J.P. & Castelli, R.J. (2010). "Drilled Shafts: Construction Procedures and LRFD Design Methods." FHWA-NHI-10-016, GEC-10.
2. O'Neill, M.W. & Reese, L.C. (1999). "Drilled Shafts: Construction Procedures and Design Methods." FHWA-RD-99-049.
3. Horvath, R.G. & Kenney, T.C. (1979). "Shaft Resistance of Rock-Socketed Drilled Piers." Symposium on Deep Foundations, ASCE, pp. 182-214.
4. FHWA GEC-10, Chapters 12-14: Drilled Shaft Design and Construction.