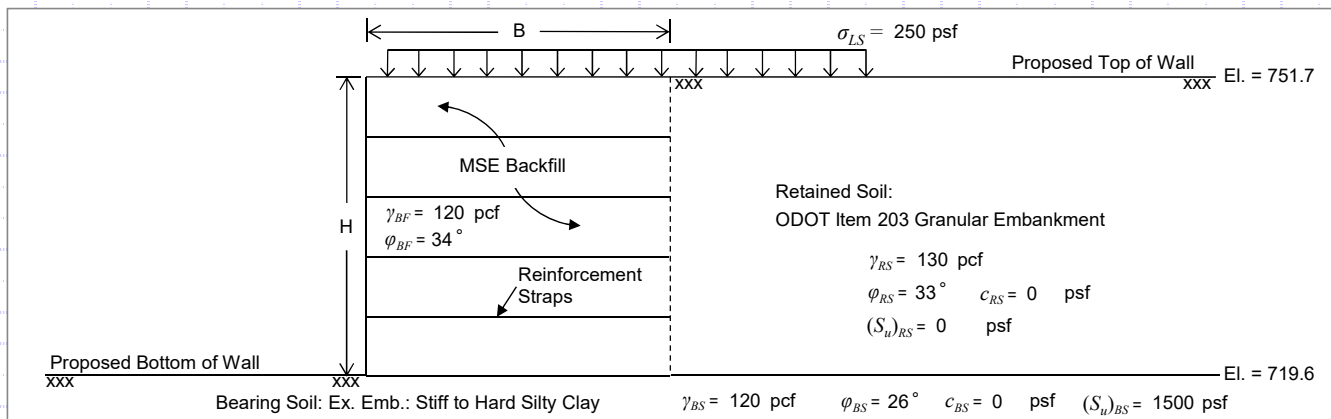




FRA-70-13.11 Project 4A - Temp Wall T3A - Sta. 0+42 to 0+72 - B-017-7-13 and B-018-4-13 - 25.4 ft. Wall Height



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	25.4 ft
MSE Wall Width (Reinforcement Length), (B) =	19.1 ft
MSE Wall Length, (L) =	30 ft
Live Surcharge Load, (σ _{LS}) =	250 psf
Retained Soil Unit Weight, (γ _{RS}) =	130 pcf
Retained Soil Friction Angle, (φ _{RS}) =	33°
Retained Soil Drained Cohesion ¹ , (c _{BS}) =	0 psf
Retained Soil Undrained Shear Strength, [(S _u) _{RS}] =	0 psf
Retained Soil Active Earth Pressure Coeff., (K _a) =	0.264
MSE Backfill Unit Weight, (γ _{BF}) =	120 pcf
MSE Backfill Friction Angle, (φ _{BF}) =	34°

Bearing Soil Properties:

Bearing Soil Unit Weight, (γ _{BS}) =	120 pcf
Bearing Soil Friction Angle, (φ _{BS}) =	26°
Bearing Soil Drained Cohesion, (c _{BS}) =	0 psf
Bearing Soil Undrained Shear Strength, [(S _u) _{BS}] =	1500 psf
Embedment Depth, (D _f) =	4.0 ft
Depth to Groundwater (Below Bot. of Wall), (D _w) =	7.6 ft

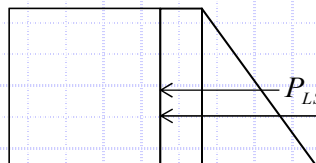
LRFD Load Factors

	EV	EH	LS
Strength Ia	1.00	1.50	1.75
Strength Ib	1.35	1.50	1.75
Service I	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

Check Sliding (Loading Case - Strength Ia) - AASHTO LRFD BDM Section 11.10.5.3

Sliding Force:



$$P_H = P_{EH} + P_{LS_h}$$

$$P_{EH} = \frac{1}{2} \gamma_{RS} H^2 K_a \gamma_{EH} = \frac{1}{2} (130 \text{ pcf}) (25.4 \text{ ft})^2 (0.264) (1.5) = 16.61 \text{ kip/ft}$$

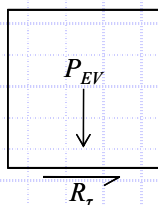
$$P_{LS_h} = \sigma_{LS} H K_a \gamma_{LS} = (250 \text{ psf}) (25.4 \text{ ft}) (0.264) (1.75) = 2.93 \text{ kip/ft}$$

$$P_H = 16.61 \text{ kip/ft} + 2.93 \text{ kip/ft} = 19.54 \text{ kip/ft}$$

Check Sliding Resistance - Drained Condition

Nominal Sliding Resistance:

$$R_r = P_{EV} \cdot \tan \delta$$



$$P_{EV} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} = (120 \text{ pcf}) (25.4 \text{ ft}) (19.1 \text{ ft}) (1.00) = 58.22 \text{ kip/ft}$$

$$\tan \delta = (\tan \phi_{BS} \leq \tan \phi_{BF})$$

$$\tan \delta = \tan(26) \leq \tan(34) \rightarrow 0.49 \leq 0.67 \rightarrow \tan \delta = 0.49$$

$$R_r = (58.22 \text{ kip/ft}) (0.49) = 28.53 \text{ kip/ft}$$

Verify Sliding Force Less Than Factored Sliding Resistance - Drained Condition

$$P_H \leq R_r \cdot \phi_r \rightarrow 19.54 \text{ kip/ft} \leq (28.53 \text{ kip/ft}) (1.0) = 28.53 \text{ kip/ft} \rightarrow 19.54 \text{ kip/ft} \leq 28.53 \text{ kip/ft}$$

OK

Use φ_r = 1.0 (Per AASHTO LRFD BDM Table 11.5.7-1)



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	25.4 ft
MSE Wall Width (Reinforcement Length), (B) =	19.1 ft
MSE Wall Length, (L) =	30 ft
Live Surcharge Load, (σ_{LS}) =	250 psf
Retained Soil Unit Weight, (γ_{RS}) =	130 pcf
Retained Soil Friction Angle, (ϕ_{RS}) =	33°
Retained Soil Drained Cohesion, (c_{BS}) =	0 psf
Retained Soil Undrained Shear Strength, [$(S_u)_{RS}$] =	0 psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.264
MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf
MSE Backfill Friction Angle, (ϕ_{BF}) =	34°

Bearing Soil Properties:

Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
Bearing Soil Friction Angle, (ϕ_{BS}) =	26°
Bearing Soil Drained Cohesion, (c_{BS}) =	0 psf
Bearing Soil Undrained Shear Strength, [$(S_u)_{BS}$] =	1500 psf
Embedment Depth, (D_f) =	4.0 ft
Depth to Groundwater (Below Bot. of Wall), (D_w) =	7.6 ft

LRFD Load Factors

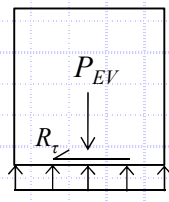
	EV	EH	LS
Strength Ia	1.00	1.50	1.75
Strength Ib	1.35	1.50	1.75
Service I	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

Check Sliding (Loading Case - Strength Ia) - AASHTO LRFD BDM Section 11.10.5.3 (Continued)

Check Sliding Resistance - Undrained Condition

Nominal Sliding Resisting:



$$R_{\tau} = ((S_u)_{BS} \leq q_s) \cdot B$$

$$(S_u)_{BS} = 1.50 \text{ ksf}$$

$$q_s = \frac{\sigma_v}{2} = (3.05 \text{ ksf}) / 2 = 1.53 \text{ ksf}$$

$$\sigma_v = \frac{P_{EV}}{B} = (58.22 \text{ kip/ft}) / (19.1 \text{ ft}) = 3.05 \text{ ksf}$$

$$R_{\tau} = (1.50 \text{ ksf} \leq 1.53 \text{ ksf})(19.1 \text{ ft}) = 28.65 \text{ kip/ft}$$

Verify Sliding Force Less Than Factored Sliding Resistance - Undrained Condition

$$P_H \leq R_{\tau} \cdot \phi_{\tau} \rightarrow 19.54 \text{ kip/ft} \leq (28.65 \text{ kip/ft})(1.0) = 28.65 \text{ kip/ft} \rightarrow 19.54 \text{ kip/ft} \leq 28.65 \text{ kip/ft}$$

OK

Use $\phi_{\tau} = 1.0$ (Per AASHTO LRFD BDM Table 11.5.7-1)



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	25.4 ft
MSE Wall Width (Reinforcement Length), (B) =	19.1 ft
MSE Wall Length, (L) =	30 ft
Live Surcharge Load, (σ_{LS}) =	250 psf
Retained Soil Unit Weight, (γ_{RS}) =	130 pcf
Retained Soil Friction Angle, (ϕ_{RS}) =	33°
Retained Soil Drained Cohesion, (c_{BS}) =	0 psf
Retained Soil Undrained Shear Strength, [$(s_u)_{RS}$] =	0 psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.264
MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf
MSE Backfill Friction Angle, (ϕ_{BF}) =	34°

Bearing Soil Properties:

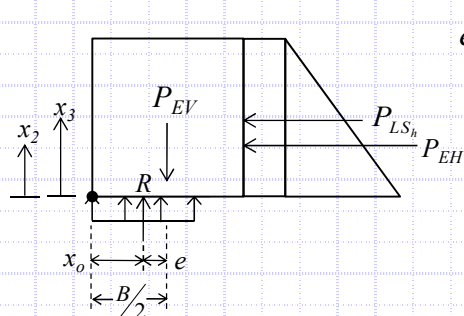
Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
Bearing Soil Friction Angle, (ϕ_{BS}) =	26°
Bearing Soil Drained Cohesion, (c_{BS}) =	0 psf
Bearing Soil Undrained Shear Strength, [$(s_u)_{BS}$] =	1500 psf
Embedment Depth, (D_f) =	4.0 ft
Depth to Groundwater (Below Bot. of Wall), (D_w) =	7.6 ft

LRFD Load Factors

	EV	EH	LS
Strength Ia	1.00	1.50	1.75
Strength Ib	1.35	1.50	1.75
Service I	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

Check Eccentricity (Loading Case - Strength Ia) - AASHTO LRFD BDM Section 11.10.5.5



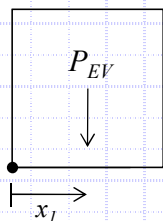
$$e = B/2 - x_o$$

$$x_o = \frac{M_{EV} - M_H}{P_{EV}} = (556 \text{ kip-ft/ft} - 177.9 \text{ kip-ft/ft}) / (58.22 \text{ kip/ft}) = 6.49 \text{ ft}$$

$$\begin{aligned} M_{EV} &= 556.00 \text{ kip-ft/ft} \\ M_H &= 177.9 \text{ kip-ft/ft} \\ P_{EV} &= 58.22 \text{ kip/ft} \end{aligned} \quad \left. \begin{array}{l} \\ \\ \end{array} \right\} \text{Defined below}$$

$$e = (19.1 \text{ ft})/2 - 6.49 \text{ ft} = 3.06 \text{ ft}$$

Resisting Moment, M_{EV} :



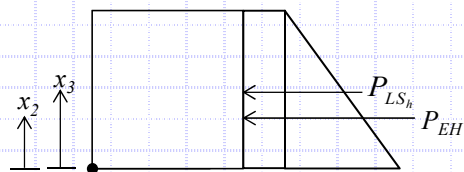
$$M_{EV} = P_{EV}(x_1)$$

$$P_{EV} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} = (120 \text{ pcf})(25.4 \text{ ft})(19.1 \text{ ft})(1.00) = 58.22 \text{ kip/ft}$$

$$x_1 = B/2 = (19.1 \text{ ft})/2 = 9.55 \text{ ft}$$

$$M_{EV} = (58.22 \text{ kip/ft})(9.55 \text{ ft}) = 556.00 \text{ kip-ft/ft}$$

Overturning Moment, M_H :



$$M_H = P_{EH}(x_2) + P_{LS_h}(x_3)$$

$$P_{EH} = \frac{1}{2} \gamma_{RS} H^2 K_a \gamma_{EH} = \frac{1}{2}(130 \text{ pcf})(25.4 \text{ ft})^2(0.264)(1.5) = 16.61 \text{ kip/ft}$$

$$P_{LS_h} = \sigma_{LS} H K_a \gamma_{LS} = (250 \text{ psf})(25.4 \text{ ft})(0.264)(1.75) = 2.93 \text{ kip/ft}$$

$$x_2 = H/3 = (25.4 \text{ ft})/3 = 8.47 \text{ ft}$$

$$x_3 = H/2 = (25.4 \text{ ft})/2 = 12.70 \text{ ft}$$

$$M_H = (16.61 \text{ kip/ft})(8.47 \text{ ft}) + (2.93 \text{ kip/ft})(12.70 \text{ ft}) = 177.9 \text{ kip-ft/ft}$$

Check Eccentricity

$$e < e_{\max} \rightarrow 3.06 \text{ ft} < 6.37 \text{ ft} \quad \text{OK}$$

$$\text{Limiting Eccentricity: } e_{\max} = B/3 \rightarrow e_{\max} = (19.1 \text{ ft})/3 = 6.37 \text{ ft}$$



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	25.4 ft
MSE Wall Width (Reinforcement Length), (B) =	19.1 ft
MSE Wall Length, (L) =	30 ft
Live Surcharge Load, (σ_{LS}) =	250 psf
Retained Soil Unit Weight, (γ_{RS}) =	130 pcf
Retained Soil Friction Angle, (ϕ_{RS}) =	33°
Retained Soil Drained Cohesion, (c_{BS}) =	0 psf
Retained Soil Undrained Shear Strength, [$(S_u)_{RS}$] =	0 psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.264
MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf
MSE Backfill Friction Angle, (ϕ_{BF}) =	34°

Bearing Soil Properties:

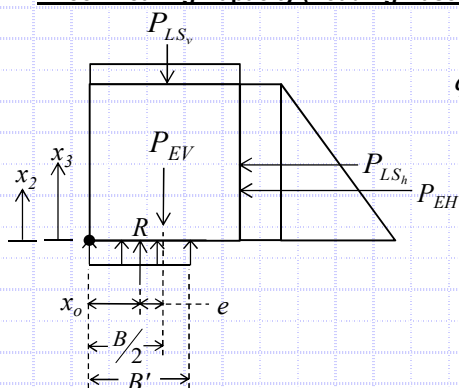
Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
Bearing Soil Friction Angle, (ϕ_{BS}) =	26°
Bearing Soil Drained Cohesion, (c_{BS}) =	0 psf
Bearing Soil Undrained Shear Strength, [$(S_u)_{BS}$] =	1500 psf
Embedment Depth, (D_f) =	4.0 ft
Depth to Grounwater (Below Bot. of Wall), (D_w) =	7.6 ft

LRFD Load Factors

	EV	EH	LS
Strength Ia	1.00	1.50	1.75
Strength Ib	1.35	1.50	1.75
Service I	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

Check Bearing Capacity (Loading Case - Strength Ib) - AASHTO LRFD BDM Section 11.10.5.4



$$q_{eq} = P_V / B'$$

$$B' = B - 2e = 19.1 \text{ ft} - 2(2.05 \text{ ft}) = 15.00 \text{ ft}$$

$$e = B/2 - x_o = (19.1 \text{ ft}) / 2 - 7.5 \text{ ft} = 2.05 \text{ ft}$$

$$x_o = \frac{M_V - M_H}{P_V} = (830.36 \text{ kip-ft/ft} - 177.91 \text{ kip-ft/ft}) / 86.95 \text{ kip/ft} = 7.5 \text{ ft}$$

$$q_{eq} = (86.95 \text{ kip/ft}) / (15 \text{ ft}) = 5.80 \text{ ksf}$$

$$M_V = P_{EV}(x_1) + P_{LS_v}(x_1) = (\gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV})(x_1) + (\sigma_{LS} \cdot B \cdot \gamma_{LS})(x_1)$$

$$M_V = [(120 \text{ pcf})(25.4 \text{ ft})(19.1 \text{ ft})(1.35)](9.55 \text{ ft}) + [(250 \text{ psf})(19.1 \text{ ft})(1.75)](9.55 \text{ ft}) = 830.36 \text{ kip-ft/ft}$$

$$M_H = P_{EH}(x_2) + P_{LSh}(x_3) = (\frac{1}{2} \gamma_{RS} H^2 K_a \gamma_{EH})(x_2) + (\sigma_{LS} H K_a \gamma_{LS})(x_3)$$

$$M_H = [\frac{1}{2}(130 \text{ pcf})(25.4 \text{ ft})^2(0.264)(1.5)](8.47 \text{ ft}) + [(250 \text{ psf})(25.4 \text{ ft})(0.264)(1.75)](12.7 \text{ ft}) = 177.91 \text{ kip-ft/ft}$$

$$P_V = P_{EV} + P_{LS} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} + \sigma_{LS} \cdot B \cdot \gamma_{LS}$$

$$P_V = (120 \text{ pcf})(25.4 \text{ ft})(19.1 \text{ ft})(1.35) + (250 \text{ psf})(19.1 \text{ ft})(1.75) = 86.95 \text{ kip/ft}$$

Check Bearing Resistance - Drained Condition

$$\text{Nominal Bearing Resistance: } q_n = cN_{cm} + \gamma D_f N_{qm} C_{wq} + \frac{1}{2} \gamma B N_{\gamma m} C_{w\gamma}$$

$$N_{cm} = N_c s_c i_c = 28.17$$

$$N_{qm} = N_q s_q d_q i_q = 15.92$$

$$N_{\gamma m} = N_{\gamma} s_{\gamma} i_{\gamma} = 10.03$$

$$N_c = 22.25$$

$$s_c = 1 + (15 \text{ ft}/30 \text{ ft})(11.85/22.25)$$

$$= 1.266$$

$$i_c = 1.000 \text{ (Assumed)}$$

$$N_q = 11.85$$

$$s_q = 1.244$$

$$d_q = 1 + 2 \tan(26^\circ) [1 - \sin(26^\circ)]^2 \tan^{-1}(4.0 \text{ ft}/15 \text{ ft})$$

$$= 1.080$$

$$i_q = 1.000 \text{ (Assumed)}$$

$$C_{wq} = 7.6 \text{ ft} > 4.0 \text{ ft} = 1.000$$

$$N_{\gamma} = 12.54$$

$$s_{\gamma} = 0.800$$

$$i_{\gamma} = 1.000 \text{ (Assumed)}$$

$$C_{w\gamma} = 7.6 \text{ ft} < 1.5(15 \text{ ft}) + 4.0 \text{ ft} = 0.669$$

$$q_n = (0 \text{ psf})(28.169) + (120 \text{ pcf})(4.0 \text{ ft})(15.921)(1.000) + \frac{1}{2}(120 \text{ pcf})(15.0 \text{ ft})(10.032)(0.669) = 13.68 \text{ ksf}$$

Verify Equivalent Pressure Less Than Factored Bearing Resistance

$$\text{Use } \phi_b = 0.65 \text{ (Per AASHTO LRFD BDM Table 11.5.7-1)}$$

$$q_{eq} \leq q_n \cdot \phi_b \rightarrow$$

$$5.80 \text{ ksf} \leq (13.68 \text{ ksf})(0.65) = 8.89 \text{ ksf}$$

$$\rightarrow 5.80 \text{ ksf} \leq 8.89 \text{ ksf}$$

OK



RESOURCE INTERNATIONAL, INC.
6350 PRESIDENTIAL GATEWAY
COLUMBUS, OHIO 43231
PHONE: (614) 823-4949
FAX: (614) 823-4990

WWW.RESOURCEINTERNATIONAL.COM

JOB	FRA-70-13.11 Project 4A	NO.	W-13-045
SHEET NO.	5	OF	6
CALCULATED BY	BRT	DATE	6/29/2020
CHECKED BY	JPS	DATE	6/29/2020
Temp Wall T3A - Sta. 0+42 to 0+72			

MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	25.4 ft
MSE Wall Width (Reinforcement Length), (B) =	19.1 ft
MSE Wall Length, (L) =	30 ft
Live Surcharge Load, (σ_{LS}) =	250 psf
Retained Soil Unit Weight, (γ_{RS}) =	130 pcf
Retained Soil Friction Angle, (ϕ_{RS}) =	33°
Retained Soil Drained Cohesion, (c_{BS}) =	0 psf
Retained Soil Undrained Shear Strength, [$(s_u)_{RS}$] =	0 psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.264
MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf
MSE Backfill Friction Angle, (ϕ_{BF}) =	34°

Bearing Soil Properties:

Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
Bearing Soil Friction Angle, (ϕ_{BS}) =	26°
Bearing Soil Drained Cohesion, (c_{BS}) =	0 psf
Bearing Soil Undrained Shear Strength, [$(s_u)_{BS}$] =	1500 psf
Embedment Depth, (D_f) =	4.0 ft
Depth to Groundwater (Below Bot. of Wall), (D_w) =	7.6 ft

LRFD Load Factors

	EV	EH	LS
Strength Ia	1.00	1.50	1.75
Strength Ib	1.35	1.50	1.75
Service I	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

Check Bearing Capacity (Loading Case - Strength Ib) - AASHTO LRFD BDM Section 11.10.5.4 (Continued)

Check Bearing Resistance - Undrained Condition

$$\text{Nominal Bearing Resistance: } q_n = cN_{cm} + \gamma D_f N_{qm} C_{wq} + \frac{1}{2} \gamma B N_{\gamma m} C_{w\gamma}$$

$$N_{cm} = N_c s_c i_c = 5.650$$

$$N_{qm} = N_q s_q d_q i_q = 1.000$$

$$N_{\gamma m} = N_{\gamma} s_{\gamma} i_{\gamma} = 0.000$$

$$N_c = 5.140$$

$$s_c = 1 + \frac{(15 \text{ ft})[(5)(30 \text{ ft})]}{1000} = 1.100$$

$$i_c = 1.000 \text{ (Assumed)}$$

$$N_q = 1.000$$

$$s_q = 1.000$$

$$d_q = \frac{1 + 2 \tan(0^\circ) [1 - \sin(0^\circ)]^2 \tan^{-1}(4.0 \text{ ft}/15 \text{ ft})}{1.000}$$

$$1.000$$

$$i_q = 1.000 \text{ (Assumed)}$$

$$C_{wq} = 7.6 \text{ ft} > 4.0 \text{ ft} = 1.000$$

$$N_{\gamma} = 0.000$$

$$s_{\gamma} = 1.000$$

$$i_{\gamma} = 1.000 \text{ (Assumed)}$$

$$C_{w\gamma} = 7.6 \text{ ft} < 1.5(15 \text{ ft}) + 4.0 \text{ ft} = 0.669$$

$$q_n = (1500 \text{ psf})(5.650) + (120 \text{ pcf})(4.0 \text{ ft})(1.000)(1.000) + \frac{1}{2}(120 \text{ pcf})(15.0 \text{ ft})(0.000)(0.669) = 8.96 \text{ ksf}$$

Verify Equivalent Pressure Less Than Factored Bearing Resistance

$$q_{eq} \leq q_n \cdot \phi_b \rightarrow 5.80 \text{ ksf} \leq (8.96 \text{ ksf})(0.65) = 5.82 \text{ ksf} \rightarrow 5.80 \text{ ksf} \leq 5.82 \text{ ksf} \quad \text{OK}$$

Use $\phi_b = 0.65$ (Per AASHTO LRFD BDM Table 11.5.7-1)



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	25.4 ft
MSE Wall Width (Reinforcement Length), (B) =	19.1 ft
MSE Wall Length, (L) =	30 ft
Live Surcharge Load, (σ_{LS}) =	250 psf
Retained Soil Unit Weight, (γ_{RS}) =	130 pcf
Retained Soil Friction Angle, (ϕ_{RS}) =	33°
Retained Soil Drained Cohesion, (c_{BS}) =	0 psf
Retained Soil Undrained Shear Strength, [$(S_u)_{RS}$] =	0 psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.264
MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf
MSE Backfill Friction Angle, (ϕ_{BF}) =	34°

Bearing Soil Properties:

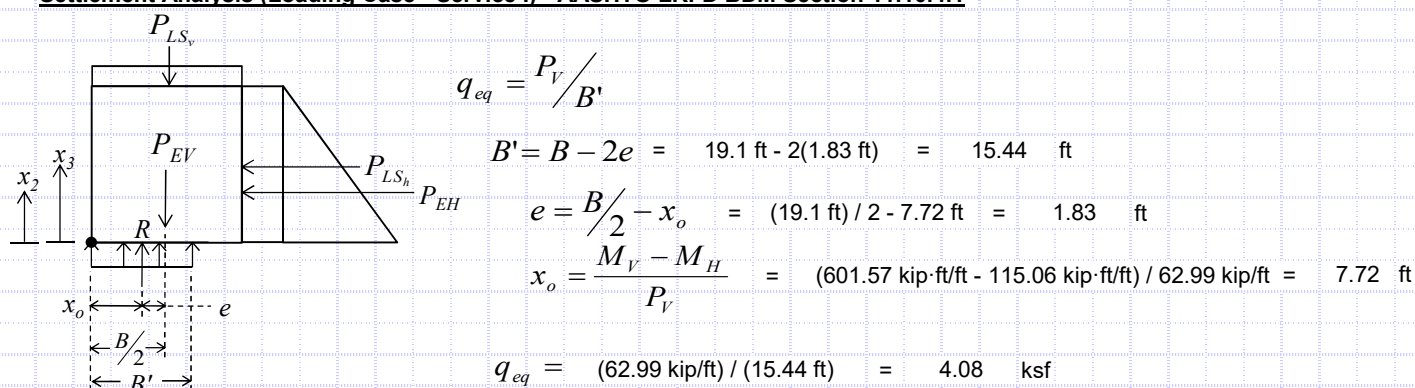
Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
Bearing Soil Friction Angle, (ϕ_{BS}) =	26°
Bearing Soil Drained Cohesion, (c_{BS}) =	0 psf
Bearing Soil Undrained Shear Strength, [$(S_u)_{BS}$] =	1500 psf
Embedment Depth, (D_f) =	4.0 ft
Depth to Groundwater (Below Bot. of Wall), (D_w) =	7.6 ft

LRFD Load Factors

	EV	EH	LS
Strength Ia	1.00	1.50	1.75
Strength Ib	1.35	1.50	1.75
Service I	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

Settlement Analysis (Loading Case - Service I) - AASHTO LRFD BDM Section 11.10.4.1



$$M_V = P_{EV}(x_1) + P_{LS}(x_1) = (\gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV})(x_1) + (\sigma_{LS} \cdot B \cdot \gamma_{LS})(x_1)$$

$$M_V = [(120 \text{ pcf})(25.4 \text{ ft})(19.1 \text{ ft})(1.00)](9.6 \text{ ft}) + [(250 \text{ psf})(19.1 \text{ ft})(1.00)](9.6 \text{ ft}) = 601.57 \text{ kip}\cdot\text{ft/ft}$$

$$M_H = P_{EH}(x_2) + P_{LS_h}(x_3) = \left(\frac{1}{2} \gamma_{RS} H^2 K_a \gamma_{EH}\right)(x_2) + (\sigma_{LS} H K_a \gamma_{LS})(x_3)$$

$$M_H = \left[\frac{1}{2}(130 \text{ pcf})(25.4 \text{ ft})^2(0.264)(1.00)\right](8.47 \text{ ft}) + [(250 \text{ psf})(25.4 \text{ ft})(0.264)(1.00)](12.7 \text{ ft}) = 115.06 \text{ kip}\cdot\text{ft/ft}$$

$$P_V = P_{EV} + P_{LS} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} + \sigma_{LS} \cdot B \cdot \gamma_{LS}$$

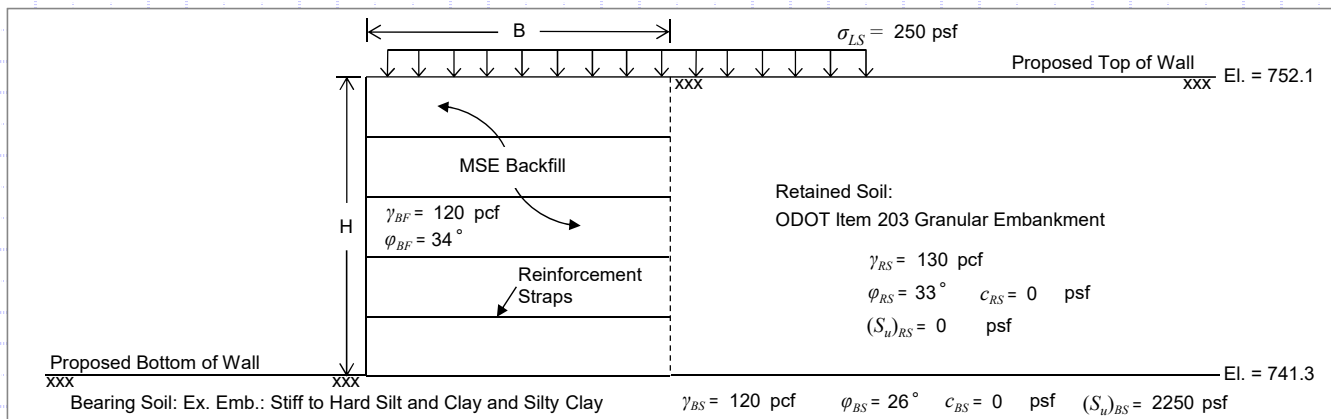
$$P_V = (120 \text{ pcf})(25.4 \text{ ft})(19.1 \text{ ft})(1.00) + (250 \text{ psf})(19.1 \text{ ft})(1.00) = 62.99 \text{ kip/ft}$$

Settlement, Time Rate of Consolidation and Differential Settlement:

Boring	Total Settlement at Center of Reinforced Soil Mass	Total Settlement at Wall Facing	Time for 90% Consolidation	Distance Between Borings Along Wall Facing	Differential Settlement Along Wall Facing



FRA-70-13.11 Project 4A - Temp Wall T3A - Sta. 0+72 to End - B-017-7-13, B-018-4-13 and B-018-5-13 - 10.8 ft. Wall Height



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	10.8 ft
MSE Wall Width (Reinforcement Length), (B) =	8.0 ft
MSE Wall Length, (L) =	434 ft
Live Surcharge Load, (sigma_LS) =	250 psf
Retained Soil Unit Weight, (gamma_RS) =	130 pcf
Retained Soil Friction Angle, (phi_RS) =	33 degrees
Retained Soil Drained Cohesion, (c_BS) =	0 psf
Retained Soil Undrained Shear Strength, [(S_u)_RS] =	0 psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.264
MSE Backfill Unit Weight, (gamma_BF) =	120 pcf
MSE Backfill Friction Angle, (phi_BF) =	34 degrees

Bearing Soil Properties:

Bearing Soil Unit Weight, (gamma_BS) =	120 pcf
Bearing Soil Friction Angle, (phi_BS) =	26 degrees
Bearing Soil Drained Cohesion, (c_BS) =	0 psf
Bearing Soil Undrained Shear Strength, [(S_u)_BS] =	2250 psf
Embedment Depth, (D_f) =	3.0 ft
Depth to Groundwater (Below Bot. of Wall), (D_W) =	29.3 ft

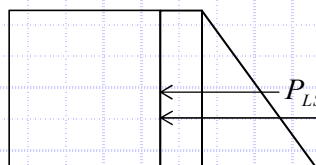
LRFD Load Factors

	EV	EH	LS
Strength Ia	1.00	1.50	1.75
Strength Ib	1.35	1.50	1.75
Service I	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

Check Sliding (Loading Case - Strength Ia) - AASHTO LRFD BDM Section 11.10.5.3

Sliding Force:



$$P_H = P_{EH} + P_{LS_h}$$

$$P_{EH} = \frac{1}{2} \gamma_{RS} H^2 K_a \gamma_{EH} = \frac{1}{2} (130 \text{ pcf}) (10.8 \text{ ft})^2 (0.264) (1.5) = 3 \text{ kip/ft}$$

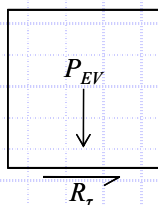
$$P_{LS_h} = \sigma_{LS} H K_a \gamma_{LS} = (250 \text{ psf}) (10.8 \text{ ft}) (0.264) (1.75) = 1.25 \text{ kip/ft}$$

$$P_H = 3 \text{ kip/ft} + 1.25 \text{ kip/ft} = 4.25 \text{ kip/ft}$$

Check Sliding Resistance - Drained Condition

Nominal Sliding Resistance:

$$R_r = P_{EV} \cdot \tan \delta$$



$$P_{EV} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} = (120 \text{ pcf}) (10.8 \text{ ft}) (8.0 \text{ ft}) (1.00) = 10.37 \text{ kip/ft}$$

$$\tan \delta = (\tan \phi_{BS} \leq \tan \phi_{BF})$$

$$\tan \delta = \tan(26) \leq \tan(34) \rightarrow 0.49 \leq 0.67 \rightarrow \tan \delta = 0.49$$

$$R_r = (10.37 \text{ kip/ft}) (0.49) = 5.08 \text{ kip/ft}$$

Verify Sliding Force Less Than Factored Sliding Resistance - Drained Condition

$$P_H \leq R_r \cdot \phi_r \rightarrow 4.25 \text{ kip/ft} \leq (5.08 \text{ kip/ft}) (1.0) = 5.08 \text{ kip/ft} \rightarrow 4.25 \text{ kip/ft} \leq 5.08 \text{ kip/ft}$$

OK

Use $\phi_r = 1.0$ (Per AASHTO LRFD BDM Table 11.5.7-1)



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	10.8 ft
MSE Wall Width (Reinforcement Length), (B) =	8.0 ft
MSE Wall Length, (L) =	434 ft
Live Surcharge Load, (σ_{LS}) =	250 psf
Retained Soil Unit Weight, (γ_{RS}) =	130 pcf
Retained Soil Friction Angle, (ϕ_{RS}) =	33°
Retained Soil Drained Cohesion, (c_{BS}) =	0 psf
Retained Soil Undrained Shear Strength, [$(S_u)_{RS}$] =	0 psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.264
MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf
MSE Backfill Friction Angle, (ϕ_{BF}) =	34°

Bearing Soil Properties:

Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
Bearing Soil Friction Angle, (ϕ_{BS}) =	26°
Bearing Soil Drained Cohesion, (c_{BS}) =	0 psf
Bearing Soil Undrained Shear Strength, [$(S_u)_{BS}$] =	2250 psf
Embedment Depth, (D_f) =	3.0 ft
Depth to Groundwater (Below Bot. of Wall), (D_w) =	29.3 ft

LRFD Load Factors

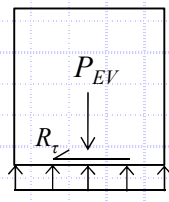
	EV	EH	LS
Strength Ia	1.00	1.50	1.75
Strength Ib	1.35	1.50	1.75
Service I	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

Check Sliding (Loading Case - Strength Ia) - AASHTO LRFD BDM Section 11.10.5.3 (Continued)

Check Sliding Resistance - Undrained Condition

Nominal Sliding Resisting:



$$R_{\tau} = ((S_u)_{BS} \leq q_s) \cdot B$$

$$(S_u)_{BS} = 2.25 \text{ ksf}$$

$$q_s = \frac{\sigma_v}{2} = (1.30 \text{ ksf}) / 2 = 0.65 \text{ ksf}$$

$$\sigma_v = \frac{P_{EV}}{B} = (10.37 \text{ kip/ft}) / (8 \text{ ft}) = 1.30 \text{ ksf}$$

$$R_{\tau} = (2.25 \text{ ksf} \leq 0.65 \text{ ksf})(8.0 \text{ ft}) = 5.20 \text{ kip/ft}$$

Verify Sliding Force Less Than Factored Sliding Resistance - Undrained Condition

$$P_H \leq R_{\tau} \cdot \phi_{\tau} \rightarrow 4.25 \text{ kip/ft} \leq (5.20 \text{ kip/ft})(1.0) = 5.20 \text{ kip/ft} \rightarrow 4.25 \text{ kip/ft} \leq 5.20 \text{ kip/ft}$$

OK

Use $\phi_{\tau} = 1.0$ (Per AASHTO LRFD BDM Table 11.5.7-1)



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	10.8 ft
MSE Wall Width (Reinforcement Length), (B) =	8.0 ft
MSE Wall Length, (L) =	434 ft
Live Surcharge Load, (σ_{LS}) =	250 psf
Retained Soil Unit Weight, (γ_{RS}) =	130 pcf
Retained Soil Friction Angle, (ϕ_{RS}) =	33°
Retained Soil Drained Cohesion, (c_{BS}) =	0 psf
Retained Soil Undrained Shear Strength, [$(s_u)_{RS}$] =	0 psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.264
MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf
MSE Backfill Friction Angle, (ϕ_{BF}) =	34°

Bearing Soil Properties:

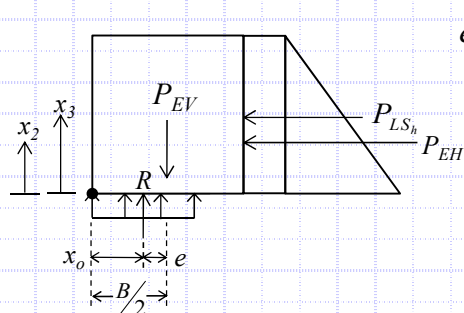
Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
Bearing Soil Friction Angle, (ϕ_{BS}) =	26°
Bearing Soil Drained Cohesion, (c_{BS}) =	0 psf
Bearing Soil Undrained Shear Strength, [$(s_u)_{BS}$] =	2250 psf
Embedment Depth, (D_f) =	3.0 ft
Depth to Groundwater (Below Bot. of Wall), (D_w) =	29.3 ft

LRFD Load Factors

	EV	EH	LS
Strength Ia	1.00	1.50	1.75
Strength Ib	1.35	1.50	1.75
Service I	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

Check Eccentricity (Loading Case - Strength Ia) - AASHTO LRFD BDM Section 11.10.5.5



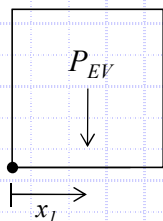
$$e = B/2 - x_o$$

$$x_o = \frac{M_{EV} - M_H}{P_{EV}} = (41.48 \text{ kip}\cdot\text{ft}/\text{ft} - 17.55 \text{ kip}\cdot\text{ft}/\text{ft}) / (10.37 \text{ kip}/\text{ft}) = 2.31 \text{ ft}$$

$$\begin{aligned} M_{EV} &= 41.48 \text{ kip}\cdot\text{ft}/\text{ft} \\ M_H &= 17.55 \text{ kip}\cdot\text{ft}/\text{ft} \\ P_{EV} &= 10.37 \text{ kip}/\text{ft} \end{aligned} \quad \left. \begin{array}{l} \\ \\ \end{array} \right\} \text{Defined below}$$

$$e = (8 \text{ ft})/2 - 2.31 \text{ ft} = 1.69 \text{ ft}$$

Resisting Moment, M_{EV} :



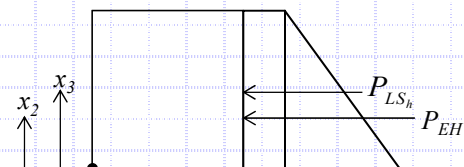
$$M_{EV} = P_{EV}(x_1)$$

$$P_{EV} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} = (120 \text{ pcf})(10.8 \text{ ft})(8.0 \text{ ft})(1.00) = 10.37 \text{ kip}/\text{ft}$$

$$x_1 = B/2 = (8.0 \text{ ft})/2 = 4.00 \text{ ft}$$

$$M_{EV} = (10.37 \text{ kip}/\text{ft})(4.00 \text{ ft}) = 41.48 \text{ kip}\cdot\text{ft}/\text{ft}$$

Overturning Moment, M_H :



$$M_H = P_{EH}(x_2) + P_{LS_h}(x_3)$$

$$P_{EH} = \frac{1}{2} \gamma_{RS} H^2 K_a \gamma_{EH} = \frac{1}{2} (130 \text{ pcf})(10.8 \text{ ft})^2 (0.264)(1.5) = 3.00 \text{ kip}/\text{ft}$$

$$P_{LS_h} = \sigma_{LS} H K_a \gamma_{LS} = (250 \text{ psf})(10.8 \text{ ft})(0.264)(1.75) = 1.25 \text{ kip}/\text{ft}$$

$$x_2 = H/3 = (10.8 \text{ ft})/3 = 3.60 \text{ ft}$$

$$x_3 = H/2 = (10.8 \text{ ft})/2 = 5.40 \text{ ft}$$

$$M_H = (3 \text{ kip}/\text{ft})(3.6 \text{ ft}) + (1.25 \text{ kip}/\text{ft})(5.4 \text{ ft}) = 17.55 \text{ kip}\cdot\text{ft}/\text{ft}$$

Check Eccentricity

$$e < e_{\max} \rightarrow 1.69 \text{ ft} < 2.67 \text{ ft} \quad \text{OK}$$

$$\text{Limiting Eccentricity: } e_{\max} = B/3 \rightarrow e_{\max} = (8.0 \text{ ft})/3 = 2.67 \text{ ft}$$



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	10.8 ft
MSE Wall Width (Reinforcement Length), (B) =	8.0 ft
MSE Wall Length, (L) =	434 ft
Live Surcharge Load, (σ_{LS}) =	250 psf
Retained Soil Unit Weight, (γ_{RS}) =	130 pcf
Retained Soil Friction Angle, (ϕ_{RS}) =	33°
Retained Soil Drained Cohesion, (c_{BS}) =	0 psf
Retained Soil Undrained Shear Strength, [$(S_u)_{RS}$] =	0 psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.264
MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf
MSE Backfill Friction Angle, (ϕ_{BF}) =	34°

Bearing Soil Properties:

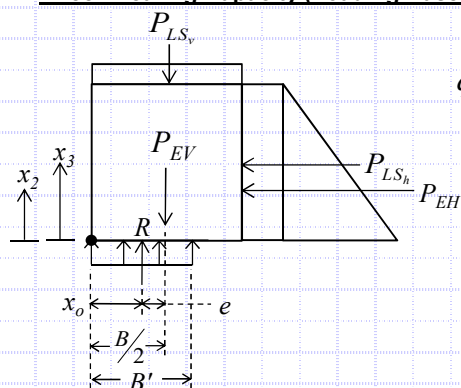
Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
Bearing Soil Friction Angle, (ϕ_{BS}) =	26°
Bearing Soil Drained Cohesion, (c_{BS}) =	0 psf
Bearing Soil Undrained Shear Strength, [$(S_u)_{BS}$] =	2250 psf
Embedment Depth, (D_f) =	3.0 ft
Depth to Groundwater (Below Bot. of Wall), (D_w) =	29.3 ft

LRFD Load Factors

	EV	EH	LS
Strength Ia	1.00	1.50	1.75
Strength Ib	1.35	1.50	1.75
Service I	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

Check Bearing Capacity (Loading Case - Strength Ib) - AASHTO LRFD BDM Section 11.10.5.4



$$q_{eq} = \frac{P_V}{B'}$$

$$B' = B - 2e = 8.0 \text{ ft} - 2(1 \text{ ft}) = 6.00 \text{ ft}$$

$$e = \frac{B}{2} - x_o = (8.0 \text{ ft}) / 2 - 3 \text{ ft} = 1.00 \text{ ft}$$

$$x_o = \frac{M_V - M_H}{P_V} = (69.99 \text{ kip-ft/ft} - 17.54 \text{ kip-ft/ft}) / 17.5 \text{ kip/ft} = 3 \text{ ft}$$

$$q_{eq} = (17.5 \text{ kip/ft}) / (6 \text{ ft}) = 2.92 \text{ ksf}$$

$$M_V = P_{EV}(x_1) + P_{LS_v}(x_1) = (\gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV})(x_1) + (\sigma_{LS} \cdot B \cdot \gamma_{LS})(x_1)$$

$$M_V = [(120 \text{ pcf})(10.8 \text{ ft})(8.0 \text{ ft})(1.35)](4 \text{ ft}) + [(250 \text{ psf})(8.0 \text{ ft})(1.75)](4 \text{ ft}) = 69.99 \text{ kip-ft/ft}$$

$$M_H = P_{EH}(x_2) + P_{LS_h}(x_3) = \left(\frac{1}{2} \gamma_{RS} H^2 K_a \gamma_{EH}\right)(x_2) + (\sigma_{LS} H K_a \gamma_{LS})(x_3)$$

$$M_H = \left[\frac{1}{2}(130 \text{ pcf})(10.8 \text{ ft})^2(0.264)(1.5)\right](3.6 \text{ ft}) + [(250 \text{ psf})(10.8 \text{ ft})(0.264)(1.75)](5.4 \text{ ft}) = 17.54 \text{ kip-ft/ft}$$

$$P_V = P_{EV} + P_{LS} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} + \sigma_{LS} \cdot B \cdot \gamma_{LS}$$

$$P_V = (120 \text{ pcf})(10.8 \text{ ft})(8.0 \text{ ft})(1.35) + (250 \text{ psf})(8.0 \text{ ft})(1.75) = 17.5 \text{ kip/ft}$$

Check Bearing Resistance - Drained Condition

$$\text{Nominal Bearing Resistance: } q_n = cN_{cm} + \gamma D_f N_{qm} C_{wq} + \frac{1}{2} \gamma B N_{\gamma m} C_{w\gamma}$$

$$N_{cm} = N_c s_c i_c = 22.41$$

$$N_{qm} = N_q s_q d_q i_q = 13.64$$

$$N_{\gamma m} = N_\gamma s_\gamma i_\gamma = 12.46$$

$$N_c = 22.25$$

$$s_c = 1 + (6 \text{ ft}/434 \text{ ft})(11.85/22.25)$$

$$= 1.007$$

$$i_c = 1.000 \text{ (Assumed)}$$

$$N_q = 11.85$$

$$s_q = 1.007$$

$$d_q = 1 + 2 \tan(26^\circ) [1 - \sin(26^\circ)]^2 \tan^{-1}(3.0 \text{ ft}/6 \text{ ft})$$

$$= 1.143$$

$$i_q = 1.000 \text{ (Assumed)}$$

$$C_{wq} = 29.3 \text{ ft} > 3.0 \text{ ft} = 1.000$$

$$N_\gamma = 12.54$$

$$s_\gamma = 0.994$$

$$i_\gamma = 1.000 \text{ (Assumed)}$$

$$C_{w\gamma} = 29.3 \text{ ft} > 1.5(6 \text{ ft}) + 29.3 \text{ ft} = 1.000$$

$$q_n = (0 \text{ psf})(22.406) + (120 \text{ pcf})(3.0 \text{ ft})(13.639)(1.000) + \frac{1}{2}(120 \text{ pcf})(6.0 \text{ ft})(12.465)(1.000) = 9.4 \text{ ksf}$$

Verify Equivalent Pressure Less Than Factored Bearing Resistance

$$\text{Use } \phi_b = 0.65 \text{ (Per AASHTO LRFD BDM Table 11.5.7-1)}$$

$$q_{eq} \leq q_n \cdot \phi_b \rightarrow 2.92 \text{ ksf} \leq (9.40 \text{ ksf})(0.65) = 6.11 \text{ ksf}$$

$$\rightarrow 2.92 \text{ ksf} \leq 6.11 \text{ ksf} \quad \text{OK}$$



RESOURCE INTERNATIONAL, INC.
6350 PRESIDENTIAL GATEWAY
COLUMBUS, OHIO 43231
PHONE: (614) 823-4949
FAX: (614) 823-4990

WWW.RESOURCEINTERNATIONAL.COM

JOB	FRA-70-13.11 Project 4A	NO.	W-13-045
SHEET NO.	5	OF	6
CALCULATED BY	BRT	DATE	6/29/2020
CHECKED BY	JPS	DATE	6/29/2020
Temp Wall T3A - 0+72 to End			

MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	10.8 ft
MSE Wall Width (Reinforcement Length), (B) =	8.0 ft
MSE Wall Length, (L) =	434 ft
Live Surcharge Load, (σ_{LS}) =	250 psf
Retained Soil Unit Weight, (γ_{RS}) =	130 pcf
Retained Soil Friction Angle, (ϕ_{RS}) =	33 °
Retained Soil Drained Cohesion, (c_{BS}) =	0 psf
Retained Soil Undrained Shear Strength, [$(S_u)_{RS}$] =	0 psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.264
MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf
MSE Backfill Friction Angle, (ϕ_{BF}) =	34 °

Bearing Soil Properties:

Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
Bearing Soil Friction Angle, (ϕ_{BS}) =	26 °
Bearing Soil Drained Cohesion, (c_{BS}) =	0 psf
Bearing Soil Undrained Shear Strength, [$(S_u)_{BS}$] =	2250 psf
Embedment Depth, (D_f) =	3.0 ft
Depth to Groundwater (Below Bot. of Wall), (D_w) =	29.3 ft

LRFD Load Factors

	EV	EH	LS
Strength Ia	1.00	1.50	1.75
Strength Ib	1.35	1.50	1.75
Service I	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

Check Bearing Capacity (Loading Case - Strength Ib) - AASHTO LRFD BDM Section 11.10.5.4 (Continued)

Check Bearing Resistance - Undrained Condition

$$\text{Nominal Bearing Resistance: } q_n = cN_{cm} + \gamma D_f N_{qm} C_{wq} + \frac{1}{2} \gamma B N_{\gamma m} C_{w\gamma}$$

$$N_{cm} = N_c s_c i_c = 5.160$$

$$N_{qm} = N_q s_q d_q i_q = 1.000$$

$$N_{\gamma m} = N_{\gamma} s_{\gamma} i_{\gamma} = 0.000$$

$$N_c = 5.140$$

$$s_c = 1 + \frac{6 \text{ ft}}{[(5)(434 \text{ ft})]} = 1.003$$

$$i_c = 1.000 \text{ (Assumed)}$$

$$N_q = 1.000$$

$$s_q = 1.000$$

$$d_q = \frac{1 + 2 \tan(0^\circ) [1 - \sin(0^\circ)] \tan^{-1}(3.0 \text{ ft}/6 \text{ ft})}{1.000}$$

$$1.000$$

$$i_q = 1.000 \text{ (Assumed)}$$

$$C_{wq} = 29.3 \text{ ft} > 3.0 \text{ ft} = 1.000$$

$$N_{\gamma} = 0.000$$

$$s_{\gamma} = 1.000$$

$$i_{\gamma} = 1.000 \text{ (Assumed)}$$

$$C_{w\gamma} = 29.3 \text{ ft} > 1.5(6 \text{ ft}) + 29.3 \text{ ft} = 1.000$$

$$q_n = (2250 \text{ psf})(5.160) + (120 \text{ pcf})(3.0 \text{ ft})(1.000)(1.000) + \frac{1}{2}(120 \text{ pcf})(6.0 \text{ ft})(0.000)(1.000) = 11.97 \text{ ksf}$$

Verify Equivalent Pressure Less Than Factored Bearing Resistance

$$q_{eq} \leq q_n \cdot \phi_b \rightarrow 2.92 \text{ ksf} \leq (11.97 \text{ ksf})(0.65) = 7.78 \text{ ksf} \rightarrow 2.92 \text{ ksf} \leq 7.78 \text{ ksf} \quad \text{OK}$$

Use $\phi_b = 0.65$ (Per AASHTO LRFD BDM Table 11.5.7-1)



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	10.8 ft
MSE Wall Width (Reinforcement Length), (B) =	8.0 ft
MSE Wall Length, (L) =	434 ft
Live Surcharge Load, (σ_{LS}) =	250 psf
Retained Soil Unit Weight, (γ_{RS}) =	130 pcf
Retained Soil Friction Angle, (ϕ_{RS}) =	33°
Retained Soil Drained Cohesion, (c_{BS}) =	0 psf
Retained Soil Undrained Shear Strength, [$(S_u)_{RS}$] =	0 psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.264
MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf
MSE Backfill Friction Angle, (ϕ_{BF}) =	34°

Bearing Soil Properties:

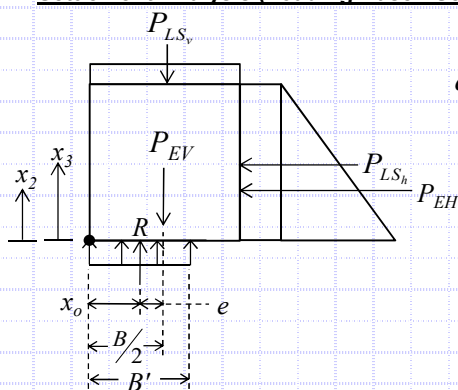
Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
Bearing Soil Friction Angle, (ϕ_{BS}) =	26°
Bearing Soil Drained Cohesion, (c_{BS}) =	0 psf
Bearing Soil Undrained Shear Strength, [$(S_u)_{BS}$] =	2250 psf
Embedment Depth, (D_f) =	3.0 ft
Depth to Groundwater (Below Bot. of Wall), (D_w) =	29.3 ft

LRFD Load Factors

	EV	EH	LS
Strength Ia	1.00	1.50	1.75
Strength Ib	1.35	1.50	1.75
Service I	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

Settlement Analysis (Loading Case - Service I) - AASHTO LRFD BDM Section 11.10.4.1



$$q_{eq} = P_V / B'$$

$$B' = B - 2e = 8.0 \text{ ft} - 2(0.89 \text{ ft}) = 6.22 \text{ ft}$$

$$e = \frac{B}{2} - x_0 = (8.0 \text{ ft}) / 2 - 3.11 \text{ ft} = 0.89 \text{ ft}$$

$$x_0 = \frac{M_V - M_H}{P_V} = (49.47 \text{ kip-ft/ft} - 11.05 \text{ kip-ft/ft}) / 12.37 \text{ kip/ft} = 3.11 \text{ ft}$$

$$q_{eq} = (12.37 \text{ kip/ft}) / (6.22 \text{ ft}) = 1.99 \text{ ksf}$$

$$M_V = P_{EV}(x_1) + P_{LS}(x_1) = (\gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV})(x_1) + (\sigma_{LS} \cdot B \cdot \gamma_{LS})(x_1)$$

$$M_V = [(120 \text{ pcf})(10.8 \text{ ft})(8.0 \text{ ft})(1.00)](4.0 \text{ ft}) + [(250 \text{ psf})(8.0 \text{ ft})(1.00)](4.0 \text{ ft}) = 49.47 \text{ kip-ft/ft}$$

$$M_H = P_{EH}(x_2) + P_{LS}(x_3) = (\frac{1}{2} \gamma_{RS} H^2 K_a \gamma_{EH})(x_2) + (\sigma_{LS} H K_a \gamma_{LS})(x_3)$$

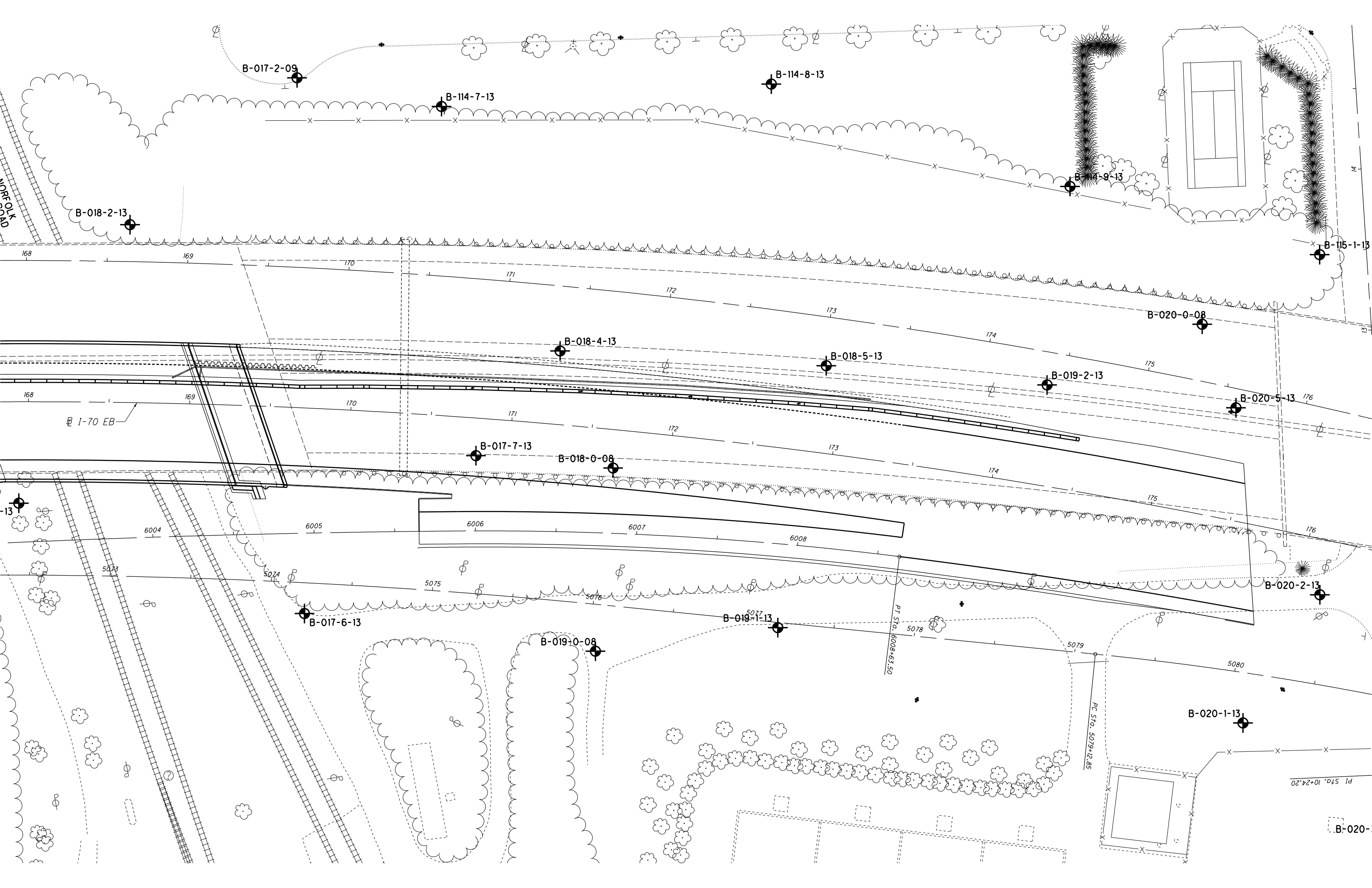
$$M_H = [\frac{1}{2}(130 \text{ pcf})(10.8 \text{ ft})^2(0.264)(1.00)](3.6 \text{ ft}) + [(250 \text{ psf})(10.8 \text{ ft})(0.264)(1.00)](5.4 \text{ ft}) = 11.05 \text{ kip-ft/ft}$$


$$P_V = P_{EV} + P_{LS} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} + \sigma_{LS} \cdot B \cdot \gamma_{LS}$$

$$P_V = (120 \text{ pcf})(10.8 \text{ ft})(8.0 \text{ ft})(1.00) + (250 \text{ psf})(8.0 \text{ ft})(1.00) = 12.37 \text{ kip/ft}$$

Settlement, Time Rate of Consolidation and Differential Settlement:

Boring	Total Settlement at Center of Reinforced Soil Mass	Total Settlement at Wall Facing	Time for 90% Consolidation	Distance Between Borings Along Wall Facing	Differential Settlement Along Wall Facing



	PROJECT: FRA-70-12.68 - PHASE 4A		DRILLING FIRM / OPERATOR: RII / J.B.		DRILL RIG: MOBILE B-53 (SN 624400)		STATION / OFFSET: 170+79.36 / 23.3' RT		EXPLORATION ID B-017-7-13														
	TYPE: STRUCTURE		SAMPLING FIRM / LOGGER: RII / S.B.		HAMMER: AUTOMATIC		ALIGNMENT: BL I-70 EB																
	PID: 77372 BR ID: FRA-70-1358R		DRILLING METHOD: 4.25" HSA / RC		CALIBRATION DATE: 4/26/13		ELEVATION: 743.1 (MSL) EOB: 96.7 ft.		PAGE 1 OF 4														
	START: 8/4/13 END: 8/7/13		SAMPLING METHOD: SPT / HQ		ENERGY RATIO (%): 77.7		LAT / LONG: 39.953200568, -83.006425064																
MATERIAL DESCRIPTION AND NOTES			ELEV.	DEPTHS		SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG				ODOT CLASS (GI)	BACK FILL		
			743.1									GR	CS	FS	SI	CL	LL	PL	PI	WC			
0.9' - ASPHALT (11.0")			742.2																				
0.5' - AGGREGATE BASE (6.0")			741.7	1																			
FILL: MEDIUM DENSE, GRAY GRAVEL, LITTLE FINE TO COARSE SAND, TRACE SILT, TRACE CLAY, MOIST.				2		4																	
				3		5	14	67	SS-1	-	69	13	5	10	3	NP	NP	NP	7	A-1-a (0)			
				4		6																	
FILL: STIFF TO VERY STIFF, BROWNISH GRAY TO BROWN SILT AND CLAY, LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, DAMP.			739.1	3		3																	
				4		5	10	50	SS-2	-	-	-	-	-	-	-	-	9	A-1-a (V)				
				5		5																	
FILL: VERY DENSE, BROWN GRAVEL, TRACE SILT, DAMP.				6		6																	
				7		8	26	50	SS-3	2.00	-	-	-	-	-	-	-	12	A-6a (V)				
				8		12																	
FILL: STIFF TO HARD, BROWN TO DARK BROWNISH GRAY SILTY CLAY, SOME FINE GRAVEL, LITTLE COARSE TO FINE SAND, DRY TO MOIST.			735.1	9		18																	
				10		25	65	44	SS-4	-	-	-	-	-	-	-	-	5	A-1-a (V)				
				11		25																	
FILL: STIFF TO HARD, BROWN TO DARK BROWNISH GRAY SILTY CLAY, SOME FINE GRAVEL, LITTLE COARSE TO FINE SAND, DRY TO MOIST.			732.6	12		3																	
				13		9	25	50	SS-5	2.00	-	-	-	-	-	-	-	12	A-6b (V)				
				14		10																	
				15		1																	
				16		2	9	56	SS-6	1.50	31	11	8	30	20	37	18	19	19	A-6b (6)			
				17		5																	
				18		15	39	39	SS-7	2.00	-	-	-	-	-	-	-	-	9	A-6b (V)			
				19		15																	
				20		50	101	39	SS-8	2.00	-	-	-	-	-	-	-	-	19	A-6b (V)			
				21		28																	
				22		6	27	56	SS-9	1.75	-	-	-	-	-	-	-	-	20	A-6b (V)			
				23		12																	
				24		21	18	56	SS-10	4.50	24	10	9	33	24	40	20	20	18	A-6b (8)			
				25		6																	
				26		7	23	83	SS-11	2.50	-	-	-	-	-	-	-	-	16	A-6b (V)			
				27		8																	
				28		10																	
29		WOH	16	72	SS-12	2.75	-	-	-	-	-	-	-	-	18	A-6b (V)							
		2																					
		10																					

[illegible]

[illegible]



PROJECT: FRA-70-13.10 - PHASE 6A
 TYPE: STRUCTURE
 PID: 89464 BR ID: N/A
 START: 3/26/14 END: 3/27/14

DRILLING FIRM / OPERATOR: RII / J.K.
 SAMPLING FIRM / LOGGER: RII / S.B.
 DRILLING METHOD: 3.25" HSA
 SAMPLING METHOD: SPT

DRILL RIG: MOBILE B-53 (SN 624400)
 HAMMER: AUTOMATIC
 CALIBRATION DATE: 4/26/13
 ENERGY RATIO (%): 77.7

STATION / OFFSET: 171+35.06 / 40.2' RT
 ALIGNMENT: BL I-70 WB
 ELEVATION: 743.1 (MSL) EOB: 50.0 ft.
 LAT / LONG: 39.953396, -83.006271

EXPLORATION ID
B-018-4-13

PAGE
 1 OF 2

MATERIAL DESCRIPTION AND NOTES	ELEV. 743.1	DEPTHS	SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	HOLE SEALED
								GR	CS	FS	SI	CL	LL	PL	PI			
0.9' - ASPHALT (11.0")	742.2	1																
0.8' - CONCRETE (9.0")	741.4	2	5	16	67	SS-1	4.25	-	-	-	-	-	-	-	-	21	A-6b (V)	
FILL: VERY STIFF TO HARD, DARK GRAY AND BROWN SILTY CLAY , LITTLE TO SOME FINE GRAVEL, LITTLE TO SOME COARSE TO FINE SAND, DAMP TO MOIST. -ROCK FRAGMENTS PRESENT THROUGHOUT		3	5 7															
		4	11 11 12	30	67	SS-2	4.00	27	15	8	26	24	38	18	20	7	A-6b (7)	
		5																
		6	8															
		7	8 8	21	44	SS-3	2.25	-	-	-	-	-	-	-	-	17	A-6b (V)	
		8																
		9	15 14 10	31	67	SS-4	4.5+	12	6	10	41	31	34	17	17	14	A-6b (10)	
		10																
		11	15 12 10	28	44	SS-5	3.00	-	-	-	-	-	-	-	-	12	A-6b (V)	
	730.1	12																
LIMESTONE FRAGMENTS.		13																
	727.6	14	8 11 14	32	6	SS-6	-	-	-	-	-	-	-	-	-	-	A-1-a (V)	
		15		-	0	2S-6A	-	-	-	-	-	-	-	-	-	-		
FILL: VERY STIFF TO HARD, DARK GRAY AND BROWN SILTY CLAY , SOME FINE GRAVEL, LITTLE COARSE TO FINE SAND, DAMP. -ROCK FRAGMENTS PRESENT THROUGHOUT		16	10 15 10	32	56	SS-7	-	-	-	-	-	-	-	-	-	12	A-6b (V)	
		17																
		18																
	723.1	19	8 11 8	25	67	SS-8	3.00	21	10	6	29	34	38	18	20	17	A-6b (10)	
FILL: DARK BROWN GRAVEL WITH SAND , TRACE SILT, TRACE CLAY, MOIST.		20																
		21			29	ST-9	-	-	-	-	-	-	-	-	-	7	A-1-b (V)	
		22																
	720.1	23																
FILL: VERY STIFF TO HARD, DARK GRAY AND BROWN SILTY CLAY , SOME FINE GRAVEL, LITTLE COARSE TO FINE SAND, DAMP. -ROCK FRAGMENTS PRESENT THROUGHOUT		24	7 11 12	30	33	SS-10	4.00	-	-	-	-	-	-	-	-	15	A-6b (V)	
		25																
		26																
		27																
		28																
		29	10 8 15	30	67	SS-11	4.5+	29	10	9	20	32	38	18	20	12	A-6b (7)	

[illegible]



PROJECT: FRA-70-13.10 - PHASE 6A
 TYPE: STRUCTURE
 PID: 89464 BR ID: N/A
 START: 3/25/14 END: 3/26/14

DRILLING FIRM / OPERATOR: RII / J.K.
 SAMPLING FIRM / LOGGER: RII / S.B.
 DRILLING METHOD: 3.25" HSA
 SAMPLING METHOD: SPT

DRILL RIG: MOBILE B-53 (SN 624400)
 HAMMER: AUTOMATIC
 CALIBRATION DATE: 4/26/13
 ENERGY RATIO (%): 77.7

STATION / OFFSET: 173+01.62 / 30.1' RT
 ALIGNMENT: BL I-70 WB
 ELEVATION: 739.1 (MSL) EOB: 50.0 ft.
 LAT / LONG: 39.953431, -83.005683

EXPLORATION ID
B-018-5-13

PAGE
 1 OF 2

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	HOLE SEALED
								GR	CS	FS	SI	CL	LL	PL	PI			
1.0' - ASPHALT (12.0")	739.1																	
1.0' - CONCRETE (12.0")	738.1	1																
FILL: VERY STIFF, DARK BROWN SILTY CLAY , SOME COARSE TO FINE SAND, LITTLE FINE GRAVEL, MOIST.	737.1	2	6	14	83	SS-1	3.75	-	-	-	-	-	-	-	-	21	A-6b (V)	
FILL: MEDIUM DENSE TO DENSE, BROWN TO DARK GRAY GRAVEL WITH SAND, SILT, AND CLAY , DAMP TO WET. -CONCRETE FRAGMENTS PRESENT IN SS-2 -ROCK FRAGMENTS PRESENT THROUGHOUT -COBBLES ENCOUNTERED @ 8.5'	735.6	3	6 5	26	33	SS-2	-	36	20	9	22	13	30	17	13	12	A-2-6 (1)	
		4	6 8 12															
		5																
		6	13 8 11	25	78	SS-3	-	-	-	-	-	-	-	-	-	20	A-2-6 (V)	
FILL: STIFF TO HARD, BROWN SILTY CLAY , LITTLE TO SOME COARSE TO FINE SAND, LITTLE FINE GRAVEL, DAMP TO MOIST. -BRICK FRAGMENTS PRESENT IN SS-5 -ROCK FRAGMENTS PRESENT THROUGHOUT	728.6	7																
		8																
		9	20 15 13	36	67	SS-4	-	45	11	9	21	14	30	17	13	7	A-2-6 (1)	
		10																
		11	10 12 14	34	89	SS-5	4.5+	-	-	-	-	-	-	-	-	17	A-6b (V)	
		12																
		13																
		14	6 8 14	28	44	SS-6	4.5+	-	-	-	-	-	-	-	-	17	A-6b (V)	
		15																
		16	7 11 14	32	56	SS-7	4.00	14	9	15	31	31	36	16	20	17	A-6b (9)	
FILL: MEDIUM DENSE TO VERY DENSE, BLACK AND BROWN TO BROWN GRAVEL WITH SAND AND SILT , TRACE CLAY, MOIST.	712.1	17																
		18																
		19	5 6 5	14	67	SS-8	1.75	-	-	-	-	-	-	-	-	20	A-6b (V)	
		20																
		21			38	ST-9	2.00	19	8	6	35	32	38	19	19	19	A-6b (10)	
		22																
		23																
		24	6 5 4	12	50	SS-10	-	-	-	-	-	-	-	-	-	12	A-6b (V)	
		25																
		26																
		27																
		28																
		29	43 35 24	76	100	SS-11	-	32	19	18	21	10	NP	NP	NP	16	A-2-4 (0)	

PID: 89464	BR ID: N/A	PROJECT: FRA-70-13.10 - PHASE 6A	STATION / OFFSET: 173+01.62 / 30.1 RT						START: 3/25/14		END: 3/26/14		PG 2 OF 2		B-018-5-13																																																																																																																																																																
MATERIAL DESCRIPTION AND NOTES			ELEV. 709.1	DEPTHS		SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG				ODOT CLASS (GI)	HOLE SEALED																																																																																																																																																										
FILL: MEDIUM DENSE TO VERY DENSE, BLACK AND BROWN TO BROWN GRAVEL WITH SAND AND SILT, TRACE CLAY, MOIST. (same as above) -BRICK, CINDER, AND LIMESTONE FRAGMENTS PRESENT THROUGHOUT			709.1	31																																																																																																																																																																											
																							32																																																																																																																																																								
																																											33																																																																																																																																				
																																																														34	7	14	32	33	SS-12	-	-	-	-	-	-	-	-	-	11	A-2-4 (V)																																																																																																	
																																																																																	35	11																																																																																													
																																																																																																				36																																																																											
																																																																																																																							37																																																								
																																																																																																																																										38																																					
																																																																																																																																																													39	4	30	65	56	SS-13	-	46	19	11	16	8	32	25	7	13	A-2-4 (0)		
41																																																																																																																																																																															
																			42																																																																																																																																																												
																																						43																																																																																																																																									
																																																									44	5	7	18	61	SS-14	-	-	-	-	-	-	-	-	-	11	A-2-4 (V)																																																																																																						
																																																																												45	7	7																																																																																																	
																																																																																															46																																																																																
																																																																																																																		47																																																													
																																																																																																																																					48																																										
																																																																																																																																																								49	10	16	43	100	SS-15	-	63	16	7	11	3	23	19	4	21	A-1-a (0)							
																																																																																																																																																																											50	17			

Notes:

GROUNDWATER ENCOUNTERED INITIALLY @ 43.5' AND AT COMPLETION @ 40.0'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 188 LBS CEMENT / 50 LBS BENTONITE POWDER / 40 GALLONS WATER