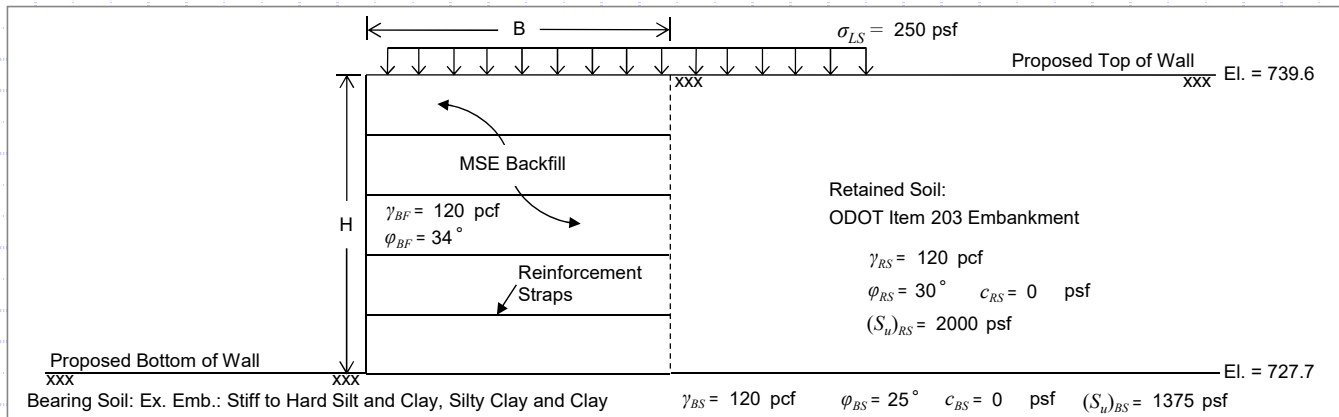




FRA-70-13.11 Project 4A - Temp Wall T1 - Begin to Sta. 6+85 - B-016-0-08, B-017-0-08 and B-017-3-13 - 11.9 ft. Wall Height



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	11.9 ft
MSE Wall Width (Reinforcement Length), (B) =	8.3 ft
MSE Wall Length, (L) =	715 ft
Live Surcharge Load, (σ_{LS}) =	250 psf
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf
Retained Soil Friction Angle, (ϕ_{RS}) =	30°
Retained Soil Drained Cohesion ¹ , (c_{BS}) =	0 psf
Retained Soil Undrained Shear Strength, [$(S_u)_{RS}$] =	2000 psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.297
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}) =	25°
Bearing Soil Drained Cohesion, (c_{BS}) =	0 psf
Bearing Soil Undrained Shear Strength, [$(S_u)_{BS}$] =	1375 psf
Embedment Depth, (D_f) =	3.0 ft
Depth to Groundwater (Below Bot. of Wall), (D_w) =	15.7 ft

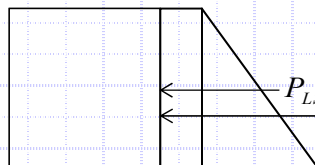
LRFD Load Factors

	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:



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

$$P_{EH} = \frac{1}{2} \gamma_{RS} H^2 K_a \gamma_{EH} = \frac{1}{2} (120 \text{ pcf}) (11.9 \text{ ft})^2 (0.297) (1.5) = 3.79 \text{ kip/ft}$$

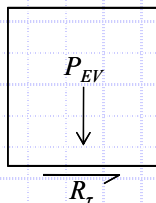
$$P_{LS_h} = \sigma_{LS} H K_a \gamma_{LS} = (250 \text{ psf}) (11.9 \text{ ft}) (0.297) (1.75) = 1.55 \text{ kip/ft}$$

$$P_H = 3.79 \text{ kip/ft} + 1.55 \text{ kip/ft} = 5.34 \text{ kip/ft}$$

Check Sliding Resistance - Drained Condition

Nominal Sliding Resistance:

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



$$P_{EV} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} = (120 \text{ pcf}) (11.9 \text{ ft}) (8.3 \text{ ft}) (1.00) = 11.85 \text{ kip/ft}$$

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

$$\tan \delta = \tan(25) \leq \tan(34) \rightarrow 0.47 \leq 0.67 \rightarrow \tan \delta = 0.47$$

$$R_r = (11.85 \text{ kip/ft}) (0.47) = 5.57 \text{ kip/ft}$$

Verify Sliding Force Less Than Factored Sliding Resistance - Drained Condition

$$P_H \leq R_r \cdot \phi_r \rightarrow 5.34 \text{ kip/ft} \leq (5.57 \text{ kip/ft}) (1.0) = 5.57 \text{ kip/ft} \rightarrow 5.34 \text{ kip/ft} \leq 5.57 \text{ kip/ft}$$

OK

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



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JOB	FRA-70-13.11 Project 4A	NO.	W-13-045
SHEET NO.	2	OF	6
CALCULATED BY	BRT	DATE	6/29/2020
CHECKED BY	JPS	DATE	6/29/2020
Temp Wall T1 - Begin to Sta. 6+85			

MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	11.9 ft
MSE Wall Width (Reinforcement Length), (B) =	8.3 ft
MSE Wall Length, (L) =	715 ft
Live Surcharge Load, (σ_{LS}) =	250 psf
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf
Retained Soil Friction Angle, (ϕ_{RS}) =	30°
Retained Soil Drained Cohesion, (c_{BS}) =	0 psf
Retained Soil Undrained Shear Strength, [$(S_u)_{RS}$] =	2000 psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.297
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}) =	25°
Bearing Soil Drained Cohesion, (c_{BS}) =	0 psf
Bearing Soil Undrained Shear Strength, [$(S_u)_{BS}$] =	1375 psf
Embedment Depth, (D_f) =	3.0 ft
Depth to Groundwater (Below Bot. of Wall), (D_w) =	15.7 ft

LRFD Load Factors

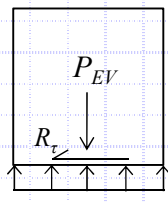
	EV	EH	LS
Strength Ia	1.00	1.50	1.75
Strength Ib	1.35	1.50	1.75
Service I	1.00	1.00	1.00

(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:



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

$$(S_u)_{BS} = 1.38 \text{ ksf}$$

$$q_s = \frac{\sigma_v}{2} = (1.43 \text{ ksf}) / 2 = 0.72 \text{ ksf}$$

$$\sigma_v = \frac{P_{EV}}{B} = (11.85 \text{ kip/ft}) / (8.3 \text{ ft}) = 1.43 \text{ ksf}$$

$$R_{\tau} = (1.38 \text{ ksf} \leq 0.72 \text{ ksf})(8.3 \text{ ft}) = 5.98 \text{ kip/ft}$$

Verify Sliding Force Less Than Factored Sliding Resistance - Undrained Condition

$$P_H \leq R_{\tau} \cdot \phi_{\tau} \rightarrow 5.34 \text{ kip/ft} \leq (5.98 \text{ kip/ft})(1.0) = 5.98 \text{ kip/ft} \rightarrow 5.34 \text{ kip/ft} \leq 5.98 \text{ kip/ft} \quad \text{OK}$$

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) =	11.9 ft
MSE Wall Width (Reinforcement Length), (B) =	8.3 ft
MSE Wall Length, (L) =	715 ft
Live Surcharge Load, (σ_{LS}) =	250 psf
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf
Retained Soil Friction Angle, (ϕ_{RS}) =	30°
Retained Soil Drained Cohesion, (c_{BS}) =	0 psf
Retained Soil Undrained Shear Strength, [$(s_u)_{RS}$] =	2000 psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.297
MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf
MSE Backfill Friction Angle, (ϕ_{BF}) =	34°

Bearing Soil Properties:

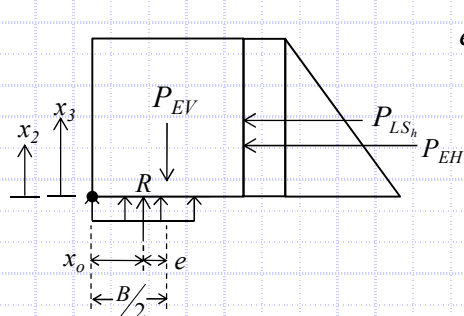
Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
Bearing Soil Friction Angle, (ϕ_{BS}) =	25°
Bearing Soil Drained Cohesion, (c_{BS}) =	0 psf
Bearing Soil Undrained Shear Strength, [$(s_u)_{BS}$] =	1375 psf
Embedment Depth, (D_f) =	3.0 ft
Depth to Groundwater (Below Bot. of Wall), (D_w) =	15.7 ft

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



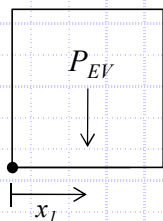
$$e = B/2 - x_o$$

$$x_o = \frac{M_{EV} - M_H}{P_{EV}} = (49.18 \text{ kip-ft/ft} - 24.27 \text{ kip-ft/ft}) / (11.85 \text{ kip/ft}) = 2.10 \text{ ft}$$

$$\begin{aligned} M_{EV} &= 49.18 \text{ kip-ft/ft} \\ M_H &= 24.27 \text{ kip-ft/ft} \\ P_{EV} &= 11.85 \text{ kip/ft} \end{aligned} \quad \left. \begin{array}{l} \\ \\ \end{array} \right\} \text{Defined below}$$

$$e = (8.3 \text{ ft})/2 - 2.1 \text{ ft} = 2.05 \text{ ft}$$

Resisting Moment, M_{EV} :



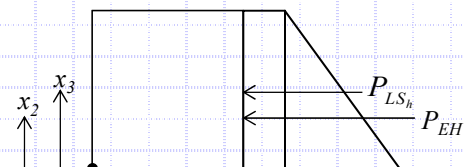
$$M_{EV} = P_{EV}(x_1)$$

$$P_{EV} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} = (120 \text{ pcf})(11.9 \text{ ft})(8.3 \text{ ft})(1.00) = 11.85 \text{ kip/ft}$$

$$x_1 = B/2 = (8.3 \text{ ft})/2 = 4.15 \text{ ft}$$

$$M_{EV} = (11.85 \text{ kip/ft})(4.15 \text{ ft}) = 49.18 \text{ kip-ft/ft}$$

Overturning Moment, M_H :



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

$$P_{EH} = \frac{1}{2} \gamma_{RS} H^2 K_a \gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(11.9 \text{ ft})^2(0.297)(1.5) = 3.79 \text{ kip/ft}$$

$$P_{LS_h} = \sigma_{LS} H K_a \gamma_{LS} = (250 \text{ psf})(11.9 \text{ ft})(0.297)(1.75) = 1.55 \text{ kip/ft}$$

$$x_2 = H/3 = (11.9 \text{ ft})/3 = 3.97 \text{ ft}$$

$$x_3 = H/2 = (11.9 \text{ ft})/2 = 5.95 \text{ ft}$$

$$M_H = (3.79 \text{ kip/ft})(3.97 \text{ ft}) + (1.55 \text{ kip/ft})(5.95 \text{ ft}) = 24.27 \text{ kip-ft/ft}$$

Check Eccentricity

$$e < e_{\max} \rightarrow 2.05 \text{ ft} < 2.77 \text{ ft} \quad \text{OK}$$

$$\text{Limiting Eccentricity: } e_{\max} = B/3 \rightarrow e_{\max} = (8.3 \text{ ft})/3 = 2.77 \text{ ft}$$



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	11.9 ft
MSE Wall Width (Reinforcement Length), (B) =	8.3 ft
MSE Wall Length, (L) =	715 ft
Live Surcharge Load, (σ_{LS}) =	250 psf
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf
Retained Soil Friction Angle, (ϕ_{RS}) =	30°
Retained Soil Drained Cohesion, (c_{BS}) =	0 psf
Retained Soil Undrained Shear Strength, [$(S_u)_{RS}$] =	2000 psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.297
MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf
MSE Backfill Friction Angle, (ϕ_{BF}) =	34°

Bearing Soil Properties:

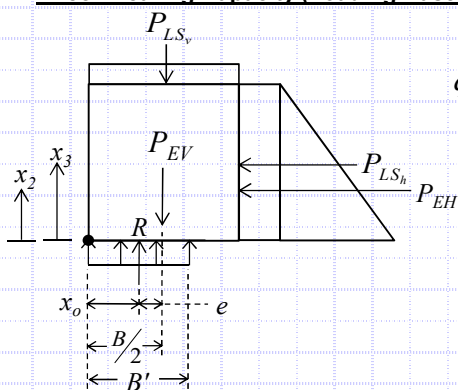
Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
Bearing Soil Friction Angle, (ϕ_{BS}) =	25°
Bearing Soil Drained Cohesion, (c_{BS}) =	0 psf
Bearing Soil Undrained Shear Strength, [$(S_u)_{BS}$] =	1375 psf
Embedment Depth, (D_f) =	3.0 ft
Depth to Groundwater (Below Bot. of Wall), (D_w) =	15.7 ft

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



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

$$B' = B - 2e = 8.3 \text{ ft} - 2(1.23 \text{ ft}) = 5.84 \text{ ft}$$

$$e = \frac{B}{2} - x_o = (8.3 \text{ ft}) / 2 - 2.92 \text{ ft} = 1.23 \text{ ft}$$

$$x_o = \frac{M_V - M_H}{P_V} = (81.47 \text{ kip-ft/ft} - 24.23 \text{ kip-ft/ft}) / 19.63 \text{ kip/ft} = 2.92 \text{ ft}$$

$$q_{eq} = (19.63 \text{ kip/ft}) / (5.84 \text{ ft}) = 3.36 \text{ ksf}$$

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

$$M_V = [(120 \text{ pcf})(11.9 \text{ ft})(8.3 \text{ ft})(1.35)](4.15 \text{ ft}) + [(250 \text{ psf})(8.3 \text{ ft})(1.75)](4.15 \text{ ft}) = 81.47 \text{ kip-ft/ft}$$

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

$$M_H = \left[\frac{1}{2}(120 \text{ pcf})(11.9 \text{ ft})^2(0.297)(1.5)\right](3.97 \text{ ft}) + [(250 \text{ psf})(11.9 \text{ ft})(0.297)(1.75)](5.95 \text{ ft}) = 24.23 \text{ kip-ft/ft}$$

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

$$P_V = (120 \text{ pcf})(11.9 \text{ ft})(8.3 \text{ ft})(1.35) + (250 \text{ psf})(8.3 \text{ ft})(1.75) = 19.63 \text{ kip/ft}$$

Check Bearing Resistance - Drained Condition

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

$$N_{cm} = N_c s_c i_c = 20.80$$

$$N_{qm} = N_q s_q d_q i_q = 12.29$$

$$N_{\gamma m} = N_\gamma s_\gamma i_\gamma = 10.85$$

$$N_c = 20.72$$

$$s_c = 1 + (5.84 \text{ ft} / 715 \text{ ft})(10.66 / 20.72)$$

$$= 1.004$$

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

$$N_q = 10.66$$

$$s_q = 1.004$$

$$d_q = 1 + 2 \tan(25^\circ) [1 - \sin(25^\circ)]^2 \tan^{-1}(3.0 \text{ ft} / 5.84 \text{ ft})$$

$$= 1.148$$

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

$$C_{wq} = 15.7 \text{ ft} > 3.0 \text{ ft} = 1.000$$

$$N_\gamma = 10.88$$

$$s_\gamma = 0.997$$

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

$$C_{w\gamma} = 15.7 \text{ ft} > 1.5(5.84 \text{ ft}) + 15.7 \text{ ft} = 1.000$$

$$q_n = (0 \text{ psf})(20.803) + (120 \text{ pcf})(3.0 \text{ ft})(12.287)(1.000) + \frac{1}{2}(120 \text{ pcf})(5.8 \text{ ft})(10.847)(1.000) = 8.22 \text{ ksf}$$

Verify Equivalent Pressure Less Than Factored Bearing Resistance

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

$$q_{eq} \leq q_n \cdot \phi_b \rightarrow 3.36 \text{ ksf} \leq (8.22 \text{ ksf})(0.65) = 5.34 \text{ ksf}$$

$$\rightarrow 3.36 \text{ ksf} \leq 5.34 \text{ ksf}$$

OK



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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 T1 - Begin to Sta. 6+85			

MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	11.9 ft
MSE Wall Width (Reinforcement Length), (B) =	8.3 ft
MSE Wall Length, (L) =	715 ft
Live Surcharge Load, (σ_{LS}) =	250 psf
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf
Retained Soil Friction Angle, (ϕ_{RS}) =	30°
Retained Soil Drained Cohesion, (c_{BS}) =	0 psf
Retained Soil Undrained Shear Strength, [$(s_u)_{RS}$] =	2000 psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.297
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}) =	25°
Bearing Soil Drained Cohesion, (c_{BS}) =	0 psf
Bearing Soil Undrained Shear Strength, [$(s_u)_{BS}$] =	1375 psf
Embedment Depth, (D_f) =	3.0 ft
Depth to Groundwater (Below Bot. of Wall), (D_w) =	15.7 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

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

$$N_{cm} = N_c s_c i_c = 5.150$$

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

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

$$N_c = 5.140$$

$$s_c = 1 + (5.84 \text{ ft} / [(5)(715 \text{ ft})]) = 1.002$$

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

$$N_q = 1.000$$

$$s_q = 1.000$$

$$d_q = \frac{1 + 2 \tan(0^\circ) [1 - \sin(0^\circ)]^2 \tan^{-1}(3.0 \text{ ft} / 5.84 \text{ ft})}{1.000}$$

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

$$C_{wq} = 15.7 \text{ ft} > 3.0 \text{ ft} = 1.000$$

$$N_{\gamma} = 0.000$$

$$s_{\gamma} = 1.000$$

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

$$C_{w\gamma} = 15.7 \text{ ft} > 1.5(5.84 \text{ ft}) + 15.7 \text{ ft} = 1.000$$

$$q_n = (1375 \text{ psf})(5.150) + (120 \text{ pcf})(3.0 \text{ ft})(1.000)(1.000) + \frac{1}{2}(120 \text{ pcf})(5.8 \text{ ft})(0.000)(1.000) = 7.44 \text{ ksf}$$

Verify Equivalent Pressure Less Than Factored Bearing Resistance

$$q_{eq} \leq q_n \cdot \phi_b \rightarrow 3.36 \text{ ksf} \leq (7.44 \text{ ksf})(0.65) = 4.84 \text{ ksf} \rightarrow 3.36 \text{ ksf} \leq 4.84 \text{ ksf} \quad \text{OK}$$

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) =	11.9 ft
MSE Wall Width (Reinforcement Length), (B) =	8.3 ft
MSE Wall Length, (L) =	715 ft
Live Surcharge Load, (σ_{LS}) =	250 psf
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf
Retained Soil Friction Angle, (ϕ_{RS}) =	30°
Retained Soil Drained Cohesion, (c_{BS}) =	0 psf
Retained Soil Undrained Shear Strength, [$(S_u)_{RS}$] =	2000 psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.297
MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf
MSE Backfill Friction Angle, (ϕ_{BF}) =	34°

Bearing Soil Properties:

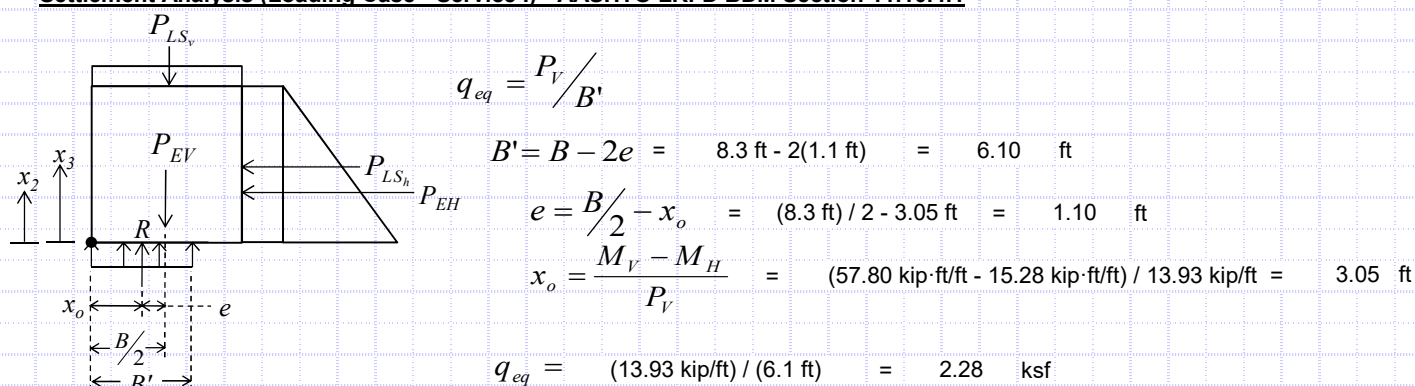
Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
Bearing Soil Friction Angle, (ϕ_{BS}) =	25°
Bearing Soil Drained Cohesion, (c_{BS}) =	0 psf
Bearing Soil Undrained Shear Strength, [$(S_u)_{BS}$] =	1375 psf
Embedment Depth, (D_f) =	3.0 ft
Depth to Groundwater (Below Bot. of Wall), (D_w) =	15.7 ft

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



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

$$M_V = [(120 \text{ pcf})(11.9 \text{ ft})(8.3 \text{ ft})(1.00)](4.2 \text{ ft}) + [(250 \text{ psf})(8.3 \text{ ft})(1.00)](4.2 \text{ ft}) = 57.80 \text{ kip-ft/ft}$$

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

$$M_H = [\frac{1}{2}(120 \text{ pcf})(11.9 \text{ ft})^2(0.297)(1.00)](3.97 \text{ ft}) + [(250 \text{ psf})(11.9 \text{ ft})(0.297)(1.00)](5.95 \text{ ft}) = 15.28 \text{ kip-ft/ft}$$

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

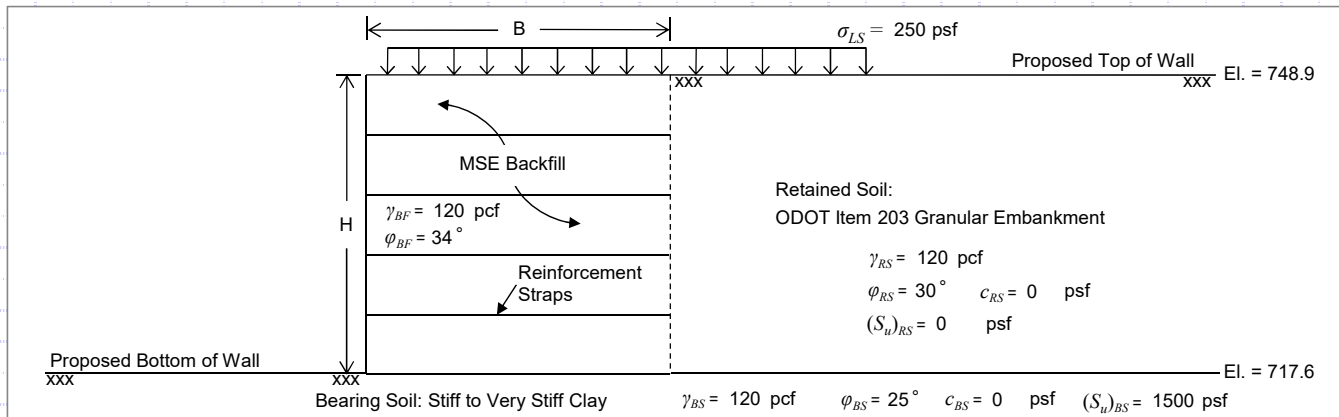
$$P_V = (120 \text{ pcf})(11.9 \text{ ft})(8.3 \text{ ft})(1.00) + (250 \text{ psf})(8.3 \text{ ft})(1.00) = 13.93 \text{ kip/ft}$$

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 T1 - Sta. 6+85 to 7+15 - B-017-0-08 and B-017-3-13 - 31.3 ft. Wall Height



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	31.3 ft
MSE Wall Width (Reinforcement Length), (B) =	32.9 ft
MSE Wall Length, (L) =	30 ft
Live Surcharge Load, (σ _{LS}) =	250 psf
Retained Soil Unit Weight, (γ _{RS}) =	120 pcf
Retained Soil Friction Angle, (φ _{RS}) =	30°
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) =	0.297
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}) =	25°
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) =	5.6 ft

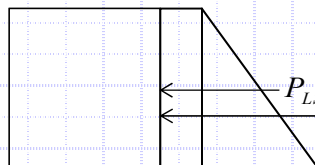
LRFD Load Factors

	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:



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

$$P_{EH} = \frac{1}{2} \gamma_{RS} H^2 K_a \gamma_{EH} = \frac{1}{2} (120 \text{ pcf}) (31.3 \text{ ft})^2 (0.297) (1.5) = 26.19 \text{ kip/ft}$$

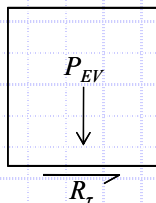
$$P_{LS_h} = \sigma_{LS} H K_a \gamma_{LS} = (250 \text{ psf}) (31.3 \text{ ft}) (0.297) (1.75) = 4.07 \text{ kip/ft}$$

$$P_H = 26.19 \text{ kip/ft} + 4.07 \text{ kip/ft} = 30.26 \text{ kip/ft}$$

Check Sliding Resistance - Drained Condition

Nominal Sliding Resistance:

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



$$P_{EV} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} = (120 \text{ pcf}) (31.3 \text{ ft}) (32.9 \text{ ft}) (1.00) = 123.57 \text{ kip/ft}$$

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

$$\tan \delta = \tan(25) \leq \tan(34) \rightarrow 0.47 \leq 0.67 \rightarrow \tan \delta = 0.47$$

$$R_r = (123.57 \text{ kip/ft}) (0.47) = 58.08 \text{ kip/ft}$$

Verify Sliding Force Less Than Factored Sliding Resistance - Drained Condition

$$P_H \leq R_r \cdot \phi_r \rightarrow 30.26 \text{ kip/ft} \leq (58.08 \text{ kip/ft}) (1.0) = 58.08 \text{ kip/ft} \rightarrow 30.26 \text{ kip/ft} \leq 58.08 \text{ kip/ft} \quad \text{OK}$$

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) =	31.3 ft
MSE Wall Width (Reinforcement Length), (B) =	32.9 ft
MSE Wall Length, (L) =	30 ft
Live Surcharge Load, (σ_{LS}) =	250 psf
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf
Retained Soil Friction Angle, (ϕ_{RS}) =	30°
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) =	0.297
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}) =	25°
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) =	5.6 ft

LRFD Load Factors

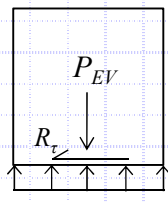
	EV	EH	LS
Strength Ia	1.00	1.50	1.75
Strength Ib	1.35	1.50	1.75
Service I	1.00	1.00	1.00

(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:



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

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

$$q_s = \frac{\sigma_v}{2} = (3.76 \text{ ksf}) / 2 = 1.88 \text{ ksf}$$

$$\sigma_v = \frac{P_{EV}}{B} = (123.57 \text{ kip/ft}) / (32.9 \text{ ft}) = 3.76 \text{ ksf}$$

$$R_{\tau} = (1.50 \text{ ksf} \leq 1.88 \text{ ksf})(32.9 \text{ ft}) = 49.35 \text{ kip/ft}$$

Verify Sliding Force Less Than Factored Sliding Resistance - Undrained Condition

$$P_H \leq R_{\tau} \cdot \phi_{\tau} \rightarrow 30.26 \text{ kip/ft} \leq (49.35 \text{ kip/ft})(1.0) = 49.35 \text{ kip/ft} \rightarrow 30.26 \text{ kip/ft} \leq 49.35 \text{ kip/ft} \quad \text{OK}$$

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) =	31.3 ft
MSE Wall Width (Reinforcement Length), (B) =	32.9 ft
MSE Wall Length, (L) =	30 ft
Live Surcharge Load, (σ_{LS}) =	250 psf
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf
Retained Soil Friction Angle, (ϕ_{RS}) =	30°
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) =	0.297
MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf
MSE Backfill Friction Angle, (ϕ_{BF}) =	34°

Bearing Soil Properties:

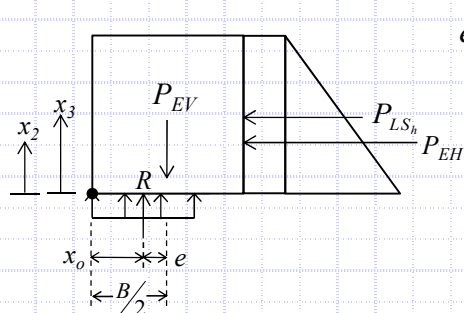
Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
Bearing Soil Friction Angle, (ϕ_{BS}) =	25°
Bearing Soil Drained Cohesion, (c_{BS}) =	0 psf
Bearing Soil Undrained Shear Strength, [$(s_u)_{BS}$] =	1500 psf
Embedment Depth, (D_f) =	4.0 ft
Depth to Groundwater (Below Bot. of Wall), (D_w) =	5.6 ft

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



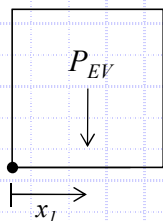
$$e = B/2 - x_o$$

$$x_o = \frac{M_{EV} - M_H}{P_{EV}} = (2032.73 \text{ kip-ft/ft} - 336.86 \text{ kip-ft/ft}) / (123.57 \text{ kip/ft}) = 13.72 \text{ ft}$$

$$\begin{aligned} M_{EV} &= 2032.73 \text{ kip-ft/ft} \\ M_H &= 336.86 \text{ kip-ft/ft} \\ P_{EV} &= 123.57 \text{ kip/ft} \end{aligned} \quad \left. \begin{array}{l} \\ \\ \end{array} \right\} \text{Defined below}$$

$$e = (32.9 \text{ ft})/2 - 13.72 \text{ ft} = 2.73 \text{ ft}$$

Resisting Moment, M_{EV} :



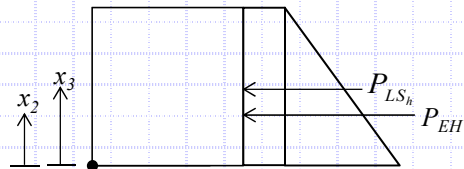
$$M_{EV} = P_{EV}(x_1)$$

$$P_{EV} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} = (120 \text{ pcf})(31.3 \text{ ft})(32.9 \text{ ft})(1.00) = 123.57 \text{ kip/ft}$$

$$x_1 = B/2 = (32.9 \text{ ft})/2 = 16.45 \text{ ft}$$

$$M_{EV} = (123.57 \text{ kip/ft})(16.45 \text{ ft}) = 2032.73 \text{ kip-ft/ft}$$

Overturning Moment, M_H :



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

$$P_{EH} = \frac{1}{2} \gamma_{RS} H^2 K_a \gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(31.3 \text{ ft})^2(0.297)(1.5) = 26.19 \text{ kip/ft}$$

$$P_{LS_h} = \sigma_{LS} H K_a \gamma_{LS} = (250 \text{ psf})(31.3 \text{ ft})(0.297)(1.75) = 4.07 \text{ kip/ft}$$

$$x_2 = H/3 = (31.3 \text{ ft})/3 = 10.43 \text{ ft}$$

$$x_3 = H/2 = (31.3 \text{ ft})/2 = 15.65 \text{ ft}$$

$$M_H = (26.19 \text{ kip/ft})(10.43 \text{ ft}) + (4.07 \text{ kip/ft})(15.65 \text{ ft}) = 336.86 \text{ kip-ft/ft}$$

Check Eccentricity

$$e < e_{\max} \rightarrow 2.73 \text{ ft} < 10.97 \text{ ft} \quad \text{OK}$$

$$\text{Limiting Eccentricity: } e_{\max} = B/3 \rightarrow e_{\max} = (32.9 \text{ ft})/3 = 10.97 \text{ ft}$$



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	31.3 ft
MSE Wall Width (Reinforcement Length), (B) =	32.9 ft
MSE Wall Length, (L) =	30 ft
Live Surcharge Load, (σ_{LS}) =	250 psf
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf
Retained Soil Friction Angle, (ϕ_{RS}) =	30°
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) =	0.297
MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf
MSE Backfill Friction Angle, (ϕ_{BF}) =	34°

Bearing Soil Properties:

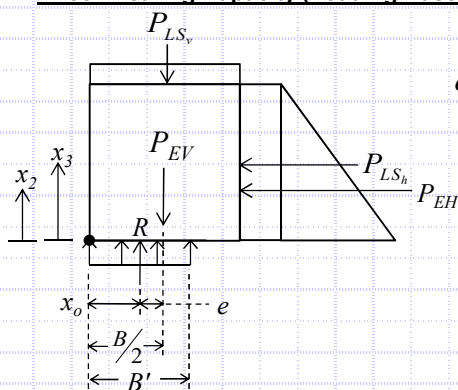
Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
Bearing Soil Friction Angle, (ϕ_{BS}) =	25°
Bearing Soil Drained Cohesion, (c_{BS}) =	0 psf
Bearing Soil Undrained Shear Strength, [$(S_u)_{BS}$] =	1500 psf
Embedment Depth, (D_f) =	4.0 ft
Depth to Groundwater (Below Bot. of Wall), (D_w) =	5.6 ft

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



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

$$B' = B - 2e = 32.9 \text{ ft} - 2(1.86 \text{ ft}) = 29.18 \text{ ft}$$

$$e = B/2 - x_o = (32.9 \text{ ft}) / 2 - 14.59 \text{ ft} = 1.86 \text{ ft}$$

$$x_o = \frac{M_V - M_H}{P_V} = (2981.01 \text{ kip-ft/ft} - 336.78 \text{ kip-ft/ft}) / 181.22 \text{ kip/ft} = 14.59 \text{ ft}$$

$$q_{eq} = (181.22 \text{ kip/ft}) / (29.18 \text{ ft}) = 6.21 \text{ ksf}$$

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

$$M_V = [(120 \text{ pcf})(31.3 \text{ ft})(32.9 \text{ ft})(1.35)](16.45 \text{ ft}) + [(250 \text{ psf})(32.9 \text{ ft})(1.75)](16.45 \text{ ft}) = 2981.01 \text{ kip-ft/ft}$$

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

$$M_H = \left[\frac{1}{2} (120 \text{ pcf})(31.3 \text{ ft})^2 (0.297)(1.5) \right](10.43 \text{ ft}) + [(250 \text{ psf})(31.3 \text{ ft})(0.297)(1.75)](15.65 \text{ ft}) = 336.78 \text{ kip-ft/ft}$$

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

$$P_V = (120 \text{ pcf})(31.3 \text{ ft})(32.9 \text{ ft})(1.35) + (250 \text{ psf})(32.9 \text{ ft})(1.75) = 181.22 \text{ kip/ft}$$

Check Bearing Resistance - Drained Condition

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

$$N_{cm} = N_c s_c i_c = 31.08$$

$$N_{qm} = N_q s_q d_q i_q = 16.15$$

$$N_{\gamma m} = N_\gamma s_\gamma i_\gamma = 6.65$$

$$N_c = 20.72$$

$$s_c = 1 + (29.18 \text{ ft} / 30 \text{ ft})(10.66 / 20.72)$$

$$= 1.500$$

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

$$N_q = 10.66$$

$$s_q = 1.454$$

$$d_q = 1 + 2 \tan(25^\circ) [1 - \sin(25^\circ)]^2 \tan^{-1}(4.0 \text{ ft} / 29.18 \text{ ft})$$

$$= 1.042$$

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

$$C_{wq} = 5.6 \text{ ft} > 4.0 \text{ ft} = 1.000$$

$$N_\gamma = 10.88$$

$$s_\gamma = 0.611$$

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

$$C_{w\gamma} = 5.6 \text{ ft} < 1.5(29.18 \text{ ft}) + 4.0 \text{ ft} = 0.564$$

$$q_n = (0 \text{ psf})(31.080) + (120 \text{ pcf})(4.0 \text{ ft})(16.151)(1.000) + \frac{1}{2}(120 \text{ pcf})(29.2 \text{ ft})(6.648)(0.564) = 14.32 \text{ ksf}$$

Verify Equivalent Pressure Less Than Factored Bearing Resistance

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

$$q_{eq} \leq q_n \cdot \phi_b \rightarrow 6.21 \text{ ksf} \leq (14.32 \text{ ksf})(0.65) = 9.31 \text{ ksf}$$

$$\rightarrow 6.21 \text{ ksf} \leq 9.31 \text{ ksf}$$

OK



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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 T1 - Sta. 6+85 to 7+15			

MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	31.3 ft
MSE Wall Width (Reinforcement Length), (B) =	32.9 ft
MSE Wall Length, (L) =	30 ft
Live Surcharge Load, (σ_{LS}) =	250 psf
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf
Retained Soil Friction Angle, (ϕ_{RS}) =	30 °
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) =	0.297
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}) =	25 °
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) =	5.6 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

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

$$N_{cm} = N_c s_c i_c = 6.140$$

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

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

$$N_c = 5.140$$

$$s_c = 1 + (29.18 \text{ ft} / [(5)(30 \text{ ft})]) = 1.195$$

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

$$N_q = 1.000$$

$$s_q = 1.000$$

$$d_q = 1 + 2 \tan(0^\circ) [1 - \sin(0^\circ)]^2 \tan^{-1}(4.0 \text{ ft} / 29.18 \text{ ft})$$

$$1.000$$

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

$$C_{wq} = 5.6 \text{ ft} > 4.0 \text{ ft} = 1.000$$

$$N_{\gamma} = 0.000$$

$$s_{\gamma} = 1.000$$

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

$$C_{w\gamma} = 5.6 \text{ ft} < 1.5(29.18 \text{ ft}) + 4.0 \text{ ft} = 0.564$$

$$q_n = (1500 \text{ psf})(6.140) + (120 \text{ pcf})(4.0 \text{ ft})(1.000)(1.000) + \frac{1}{2}(120 \text{ pcf})(29.2 \text{ ft})(0.000)(0.564) = 9.69 \text{ ksf}$$

Verify Equivalent Pressure Less Than Factored Bearing Resistance

$$q_{eq} \leq q_n \cdot \phi_b \rightarrow 6.21 \text{ ksf} \leq (9.69 \text{ ksf})(0.65) = 6.30 \text{ ksf} \rightarrow 6.21 \text{ ksf} \leq 6.30 \text{ ksf} \quad \text{OK}$$

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) =	31.3 ft
MSE Wall Width (Reinforcement Length), (B) =	32.9 ft
MSE Wall Length, (L) =	30 ft
Live Surcharge Load, (σ_{LS}) =	250 psf
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf
Retained Soil Friction Angle, (ϕ_{RS}) =	30°
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) =	0.297
MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf
MSE Backfill Friction Angle, (ϕ_{BF}) =	34°

Bearing Soil Properties:

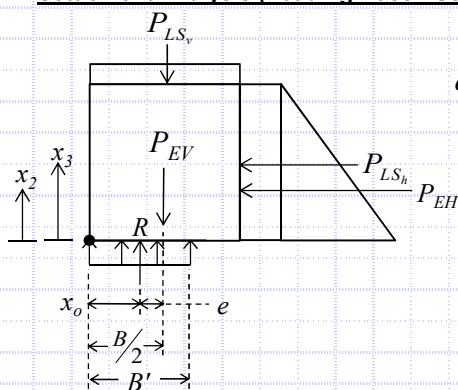
Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
Bearing Soil Friction Angle, (ϕ_{BS}) =	25°
Bearing Soil Drained Cohesion, (c_{BS}) =	0 psf
Bearing Soil Undrained Shear Strength, [$(S_u)_{BS}$] =	1500 psf
Embedment Depth, (D_f) =	4.0 ft
Depth to Groundwater (Below Bot. of Wall), (D_w) =	5.6 ft

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



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

$$B' = B - 2e = 32.9 \text{ ft} - 2(1.66 \text{ ft}) = 29.58 \text{ ft}$$

$$e = B/2 - x_o = (32.9 \text{ ft}) / 2 - 14.79 \text{ ft} = 1.66 \text{ ft}$$

$$x_o = \frac{M_V - M_H}{P_V} = (2168.07 \text{ kip-ft/ft} - 218.46 \text{ kip-ft/ft}) / 131.8 \text{ kip/ft} = 14.79 \text{ ft}$$

$$q_{eq} = (131.8 \text{ kip/ft}) / (29.58 \text{ ft}) = 4.46 \text{ ksf}$$

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

$$M_V = [(120 \text{ pcf})(31.3 \text{ ft})(32.9 \text{ ft})(1.00)](16.5 \text{ ft}) + [(250 \text{ psf})(32.9 \text{ ft})(1.00)](16.5 \text{ ft}) = 2168.07 \text{ kip-ft/ft}$$

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

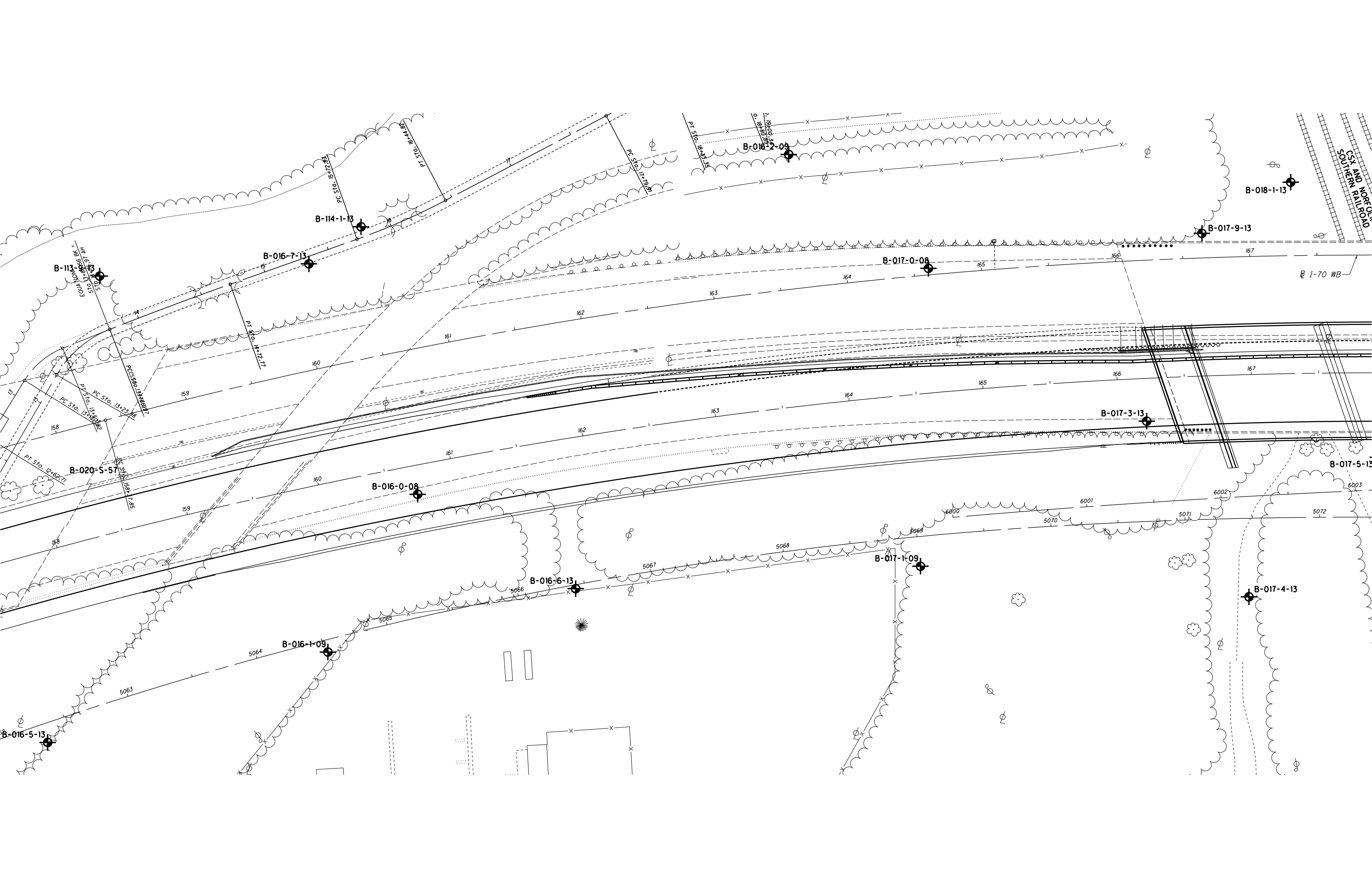
$$M_H = [\frac{1}{2}(120 \text{ pcf})(31.3 \text{ ft})^2(0.297)(1.00)](10.43 \text{ ft}) + [(250 \text{ psf})(31.3 \text{ ft})(0.297)(1.00)](15.65 \text{ ft}) = 218.46 \text{ kip-ft/ft}$$

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

$$P_V = (120 \text{ pcf})(31.3 \text{ ft})(32.9 \text{ ft})(1.00) + (250 \text{ psf})(32.9 \text{ ft})(1.00) = 131.8 \text{ kip/ft}$$

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
 TYPE: STRUCTURE
 PID: 77372 BR ID: FRA-70-1358R
 START: 7/30/13 END: 8/2/13

DRILLING FIRM / OPERATOR: RII / J.B.
 SAMPLING FIRM / LOGGER: RII / S.B.
 DRILLING METHOD: 4.25" HSA / RC
 SAMPLING METHOD: SPT / HQ

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

STATION / OFFSET: 166+20.53 / 31.8' RT
 ALIGNMENT: BL I-70 EB
 ELEVATION: 740.3 (MSL) EOB: 87.0 ft.
 LAT / LONG: 39.953028358, -83.008033736

EXPLORATION ID
B-017-3-13
 PAGE
 1 OF 3

MATERIAL DESCRIPTION AND NOTES	ELEV. 740.3	DEPTHS	SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	BACK FILL
								GR	CS	FS	SI	CL	LL	PL	PI			
0.5'- ASPHALT (6.0")	739.8																	
0.3'- AGGREGATE BASE (4.0")	739.5																	
FILL: STIFF TO VERY STIFF, BROWN CLAY, "AND" SILT, TRACE TO LITTLE FINE TO COARSE SAND, TRACE TO SOME FINE GRAVEL, DAMP TO MOIST.		1	4	18	78	SS-1	3.25	-	-	-	-	-	-	-	-	17	A-7-6 (V)	
		2	4	10														
		3																
		4	5	2	8	SS-2	1.50	26	13	6	36	19	43	16	27	16	A-7-6 (11)	
		5	4															
		6	2															
		7	3	10	33	SS-3	2.25	-	-	-	-	-	-	-	-	18	A-7-6 (V)	
		8	5															
		9	3															
		10	4	12	44	SS-4	2.75	-	-	-	-	-	-	-	-	15	A-7-6 (V)	
		11	5															
		12	2	3	8	SS-5	2.00	-	-	-	-	-	-	-	-	16	A-7-6 (V)	
		13	3															
		14	1	3	8	SS-6	1.25	21	9	5	36	29	43	17	26	19	A-7-6 (13)	
		15	3															
		16	3	4	12	SS-7	1.25	-	-	-	-	-	-	-	-	17	A-7-6 (V)	
		17	5															
		18	4	-	67	3S-7A	1.25	-	-	-	-	-	-	-	-	16	A-7-6 (V)	
		19	2	7	16	SS-8	3.00	5	3	3	35	54	50	18	32	22	A-7-6 (18)	
		20	5															
		21	3															
		22	4	12	83	SS-9	3.00	-	-	-	-	-	-	-	-	24	A-7-6 (V)	
		23	5															
		24	3															
		25	3	10	89	SS-10	2.00	-	-	-	-	-	-	-	-	26	A-7-6 (V)	
		26	5															
		27	3	9	25	SS-11	3.75	-	-	-	-	-	-	-	-	21	A-7-6 (V)	
		28	10					-	-	-	-	-	-	-	-	16	A-1-b (V)	
		29	3															
			5	18	33	SS-12	-	-	-	-	-	-	-	-	-	13	A-1-b (V)	
			9															
FILL: MEDIUM DENSE, BLACK GRAVEL AND SAND, TRACE SILT, MOIST.	713.3																	

[illegible]

PID: 77372	BR ID: FRA-70-1358R	PROJECT: FRA-70-12.68 - PHASE 4A	STATION / OFFSET: 166+20.53 / 31.8 RT						START: 7/30/13		END: 8/2/13		PG 3 OF 3		B-017-3-13								
MATERIAL DESCRIPTION AND NOTES			ELEV. 678.2	DEPTHS	SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	BACK FILL			
										GR	CS	FS	SI	CL	LL	PL	PI						
VERY STIFF TO HARD, GRAY SILT AND CLAY , SOME COARSE TO FINE SAND, SOME FINE GRAVEL, DAMP. (same as above)			673.3		63																		
					64	20																	
					65	25	84	67	SS-19	4.50	-	-	-	-	-	-	-	-	9	A-6a (V)			
VERY DENSE, BROWN AND GRAY GRAVEL , SOME COARSE TO FINE SAND, TRACE SILT, MOIST.			668.3		66																		
					67																		
					68																		
HARD, BROWN TO GRAY CLAY , TRACE COARSE TO FINE SAND, TRACE FINE GRAVEL, DAMP.			656.8	-TR	69	3																	
					70	30	85	67	SS-20	-	-	-	-	-	-	-	-	9	A-1-a (V)				
					71	36																	
AUGER REFUSAL @ 83.5'			653.3	EOB	72																		
					73																		
					74	4																	
SHALE : BLACK AND GRAY, SLIGHTLY TO HIGHLY WEATHERED, VERY WEAK TO SLIGHTLY STRONG, THINLY LAMINATED TO THIN BEDDED, FISSILE, HIGHLY TO MODERATELY FRACTURED, OPEN APERTURE, SLIGHTLY ROUGH; RQD 26%, REC 81%. -QU @ 86.0' = 222 PSI					75	19	49	72	SS-21	4.50	-	-	-	-	-	-	-	-	17	A-7-6 (V)			
					76	19																	
					77																		
					78																		
					79	10																	
					80	24	83	72	SS-22	4.5+	8	2	3	41	46	41	19	22	10	A-7-6 (13)			
					81																		
					82																		
					83	4																	
					84	20	-	59	SS-23	4.5+	-	-	-	-	-	-	-	-	15	A-7-6 (V)			
					85	50/5"																	
					86	0		56	RC-1														
					87	46		100	RC-2														
NOTES: SEEPAGE ENCOUNTERED @ 48.5'; GROUNDWATER ENCOUNTERED INITIALLY @ 58.5'																							
ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 100 LBS BENTONITE CHIPS AND SOIL CUTTINGS																							