THE NEEL COMPANY

SCOPE OF ENGINEERING

Date: 12/30/14 **Proj No:** TW4437

Project: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT

Wall(s):

Wall 1	Wall 4	Wall 7
Wall 2	Wall 5	Wall 8
Wall 3	Wall 6	Wall BR46A

Design: The Neel Company has performed the following analyses for this wall(s).

- Overturning
- Sliding
- Pull out
- Applied bearing pressure

The Neel Company **has not** performed the following analyses for this wall(s).
It is the responsibility of the others to perform the following analyses:

- Bearing capacity of foundation soils
- Settlement analysis
- Slip circle analysis
- Site drainage analysis: (surface run-off must be diverted away from the wall)
- Slope stability analysis for temporary cut-slope
- Scour analysis

Project Engineer: KORAY BOZKURT

8328-D Traford Lane • Springfield, VA 22152 • 703-913-7858 • Fax: 703-913-7859
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TW4437
12/30/14

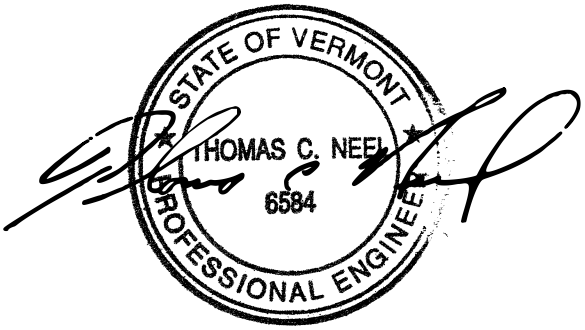
THE NEEL COMPANY

T-WALL® Retaining Wall System

Stability Calculations

PRELIMINARY
I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Waterbury, VT

Stability Calculations



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Wall 1

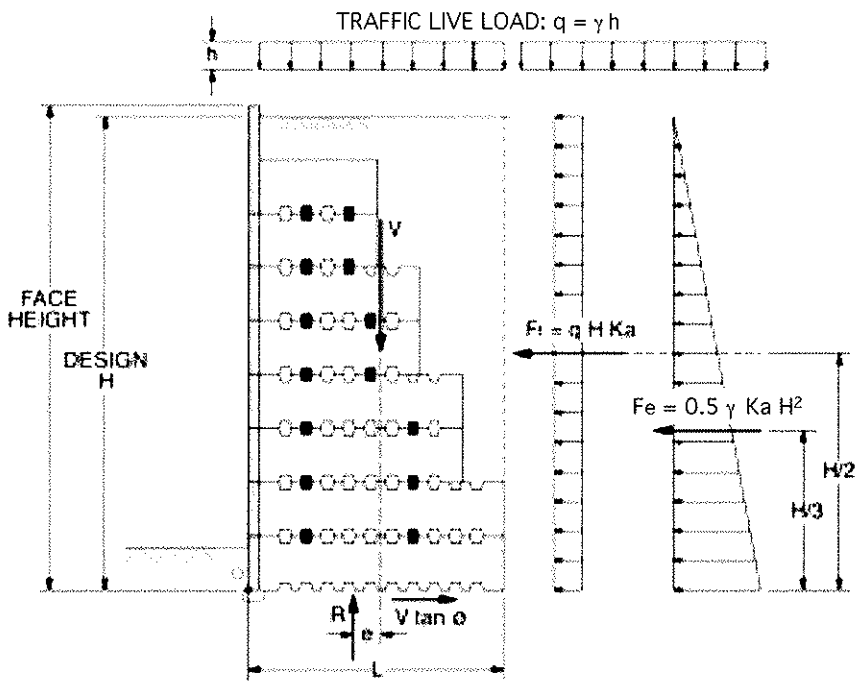
T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
LIMIT STATE: **STRENGTH-I MIN**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)
Level Surcharge and Infinite Slope Condition

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Comment: Wall 1

Project No: TW4437
Date: 12/30/14
Designed By: CTH
Checked by: KD

Load Diagram:



Typical Section (For illustration only, Some details may not apply)

External Stability Calculation (STRENGTH-I MIN)

Stability Against Overturning: (moments about point "O")

Σ Factored Resisting Moments = $\phi V \cdot x_o$ (x_o is the horiz. distance between V and O)

Σ Factored overturning Momen = $\gamma_e F_e (H/3) + \gamma_t F_t (H/2)$

Stability Against Sliding:

Σ Factored Resisting Force = $\phi V \tan \phi_F$

Σ Factored Driving Force = $\gamma_e F_e + \gamma_t F_t$

Bearing Pressure:

Factored Bearing Pressure = $(\gamma_1 V + \gamma_2 qL)/(L - 2e)$ (use factored e)

Eccentricity:

Eccentricity (e) = $\dfrac{L}{2} - \dfrac{(V + qL)(L/2) - [F_V(H/3) + F_t(H/2)]}{V + qL}$

(use factored V, qL, Fe, Ft for factored e)
(q=0, Ft=0 for this case)

T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
Level Surcharge and Infinite Slope Condition
LIMIT STATE: **STRENGTH-I MIN**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)

Revised BZY 3/3/12
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Project No: TW4437
Date: 12/30/14
By: CTH
Checked by: KD

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Wall Name: Wall 1

GRADING GEOMETRY

DISTANCE TO SLOPE (d) =	0	FT	
FILL SURCHARGE =	3.75	FT	
DISTANCE TO BREAK =	5	FT	
SLOPE ANGLE (ß1) =	36.9	DEG	
SLOPE ANGLE (I) =	14.0	DEG	
TRAFFIC SURCHARGE =	2	FT	

WALL GEOMETRY

HEIGHT (H) =	7.50	
BATTER ( ) =	0	
BASE (L) =	8	

BACKFILL SPECIFICATIONS

SELECT	INTERNAL FRICTION (Ø)=	34	DEG	Ka =	0.3298
	WEIGHT ( )=	120	PCF	Ko =	0.4408
	COHESION=	0	(assumed)		
UNCLASSIFIED	INTERNAL FRICTION (Ø)=	30	DEG	Ka =	0.3958
	WEIGHT ( )=	120	PCF		
	COHESION =	0	(assumed)		
FOUNDATION	FOUNDATION TYPE	S	(S for Soil, R for rock)		
	INTERNAL FRICTION (Øf) =	32	DEG	Kp =	3.2546

FRICTION FACTORS

JOINT MATERIAL TO CONCRETE =	0.59	
SELECT FILL TO CONCRETE =	0.50	
UNCLASSIFIED FILL TO CONCRETE =	0.50	
SELECT FILL TO FOUNDATION = tan(ø)	0.62	(Ø is min of select fill and foundation)
PRECAST CONCRETE TO FOUNDATION =	0.50	(0.8*TAN Øf)

SHEAR KEY STRENGTH = 2460 lbs.

WATER PRESSURE

HEIGHT OF WATER TABLE BEHIND WALL =	0	FT	(From bottom of wall)
HEIGHT OF WATER TABLE BEFORE WALL =	0	FT	(From bottom of wall)

Date: 12/30/14
Designed By: CTH
Checked by: KD

RESISTANCE FACTORS

FRICTION BETWEEN SOIL & SOIL :	1.00	
FRICTION BETWEEN SOIL & CONC. :	0.90	
FRICTION BETWEEN JOINT & CONC. :	0.90	
SHEAR THROUGH SHEAR KEY :	0.90	
PASSIVE PRESSURE AGAINST SLIDING :	0.50	(Not used for this project)
PASSIVE PRESSURE AGAINST OVERTURN. :	0.60	(Not used for this project)

LOAD FACTORS

DC (WEIGHT OF CONCRETE) :	0.90
EV (WEIGHT OF SOIL) :	1.00
EARTH PRESSURES (EH)	
HORIZONTAL COMPONENT :	1.50
VERTICAL COMPONENT :	1.50
LL (VEHICULAR LIVE LOAD), LS (LIVE LOAD SURCHARGE) :	1.75
WATER PRESSURE :	1.00

GLOBAL STABILITY

OVERTURNING

SUM FACTORED OVERTURNING MOMENTS	134619
SUM FACTORED RESISTING MOMENTS	255604
PERFORMANCE RATIO	1.90

SLIDING

SUM FACTORED HORIZONTAL FORCE	31222
FACTORED RESISTING FRICTION FORCE	32947
PERFORMANCE RATIO	1.06

MAXIMUM BEARING PRESSURE

Meyerhof distribution which considers a uniform base pressure distribution over an effective width of B' = L - 2e

Live load surcharge is present on the wall and behind the wall

MAXIMUM BEARING PRESSURE: Sv = SUM VERTICAL LOADS/(L-2e)

FACTORED SUM OF VERTICAL LOADS =	71411	LB/5 FT WIDTH			
FACTORED e =	1.36	≤ L/4 =	2.00	ft	ON SOIL
FACTORED BEARING PRESSURE =	2710	PSF			

FACTORED BEARING RESISTANCE =	#N/A	PSF
PERFORMANCE RATIO =	#N/A	

Date: 12/30/14
Designed By: CTH
Checked by: KD

PERFORMANCE RATIO AT EACH LEVEL

Live load is present behind the wall, but not on the wall

LEVEL	HEIGHT	STEM LENGTH	No. OF SHEAR KEYS	FACTORED LOAD EFFECT	FACTORED RESISTANCE	PERFORMANCE RATIO
1	5.00	6.00	2			
			OVERTURNING	70410	101206	1.44
			SLIDING	20504	23086	1.13
			PULLOUT	6709	9807	1.46
2	7.50	8.00	0			
			OVERTURNING	134619	255604	1.90
			SLIDING	31222	32947	1.06
			PULLOUT	5608	10290	1.84
3	10.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
4	12.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
5	15.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
6	17.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
7	20.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
8	22.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
9	25.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
10	27.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
11	30.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
12	32.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A

Date: 12/30/14
Designed By: CTH
Checked by: KD

LEVEL 2

STEM LENGTH = 8.00 FT
HEIGHT = 11.25 FT

EARTH PRESSURE			TRAFFIC SURCHARGE & WATER PRESSURE		
Pa =	3005.87	plf	Pt =	1068.75	plf
Feh =	14580.59	lbs.	Ft =	5343.76	lbs.
Fev =	3645.15	lbs.	Fw =	0.00	lbs.

STABILITY AGAINST SLIDING - LEVEL 2

SLIDING FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
Feh	14580.59	1.50	21870.89
Ft	5343.76	1.75	9351.58
Fw	0.00	1.00	0.00
TOTAL			31222.47

RESISTING FORCE

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
THRU SELECT FILL OR FOUNDATION	42893.03	1.00	0.62	1.00	26802.54
Fev	3645.15	1.50	0.62	1.00	3416.61
THRU JT. MAT'L OR FOUNDATION	6737.63	0.90	0.50	0.90	2728.17
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	0.90	0.00
EMBEDMENT	0.00	#N/A	#N/A	0.50	0.00
TOTAL					32947.32

PERFORMANCE RATIO = 1.06

STABILITY AGAINST PULLOUT - LEVEL 2

PULLOUT FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
PULLOUT FORCE	2699.55	1.50	4049.33
TRAFFIC SURCHARGE FORCE	890.44	1.75	1558.28
WATER PRESSURE	0.00	1.00	0.00
TOTAL			5607.61

RESISTING FORCE

Aeff. = 34.18 SF

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
ON STEM(SOIL TO SOIL IN Aeff)	3788.34	1.00	0.67	1.00	2555.27
ON STEM (SOIL TO CONCRETE IN A	11126.39	1.00	0.50	0.90	5006.87
CONC. UNIT WEIGHT (THROUGH JOINT MATERIAL)	6737.63	0.90	0.50	0.90	2728.17
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	0.90	0.00
					10290.31

PERFORMANCE RATIO = 1.84

Date: 12/30/14
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 2

OVERTURNING MOMENT

	FORCE	MOMENT ARM	OVERTURNING MOMENT	LOAD FACTOR	FACTORED MOMENT
Feh	14580.59	3.75	54677.23	1.50	82015.84
Ft	5343.76	5.63	30058.66	1.75	52602.66
Fw	0.00	0.00	0.00	1.00	0.00
TOTAL					134618.50

RESISTING MOMENT

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED MOMENT
UNIT L1	2774.00	1.14	0.00	0.90	2496.60	2846.12
UNIT L2	2098.00	2.31	0.00	0.90	1888.20	4361.74
SELECT FILL L1	15781.20	3.25	0.00	1.00	15781.20	51288.90
SELECT FILL L2	10321.20	4.25	0.00	1.00	10321.20	43865.10

Date: 12/30/14
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 2 (CONTINUED)

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED MOMENT
STEP L2	6000.00	7.00	0.00	1.00	6000.00	42000.00
EARTH SURCHARGE	12656.25	5.33	0.00	1.00	12656.25	67500.00
Fev	3645.15	8.00	0.00	1.50	5467.72	43741.78
TOTAL					54611.17	255603.65

PERFORMANCE RATIO = 1.90

T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
LIMIT STATE: **STRENGTH-I MAX**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)
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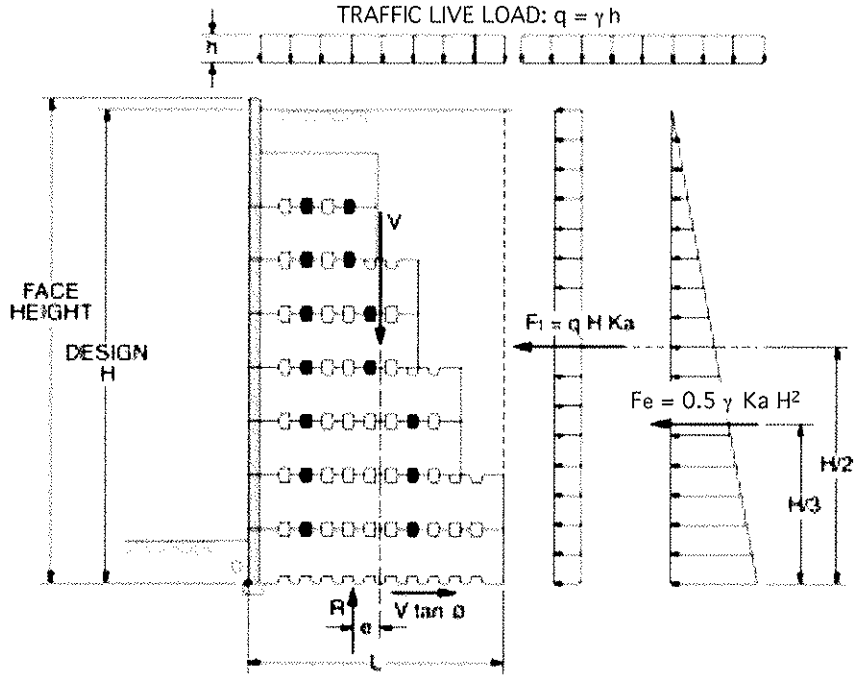
Load Diagram:



Typical Section (For illustration only, Some details may not apply)

External Stability Calculation (STRENGTH-I MAX)

Stability Against Overturning: (moments about point "O")

Σ Factored Resisting Moments = $\phi V \cdot x_O$ (x_O is the horiz. distance between V and O)

Σ Factored overturning Momen = $Y_e F_e (H/3) + Y_t F_t (H/2)$

Stability Against Sliding:

Σ Factored Resisting Force = $\phi V \tan \phi_F$

Σ Factored Driving Force = $Y_e F_e + Y_t F_t$

Bearing Pressure:

Factored Bearing Pressure = $(Y_1 V + Y_2 qL)/(L - 2e)$ (use factored e)

Eccentricity:

Eccentricity (e) = $\dfrac{L}{2} - \dfrac{(V + qL)(L/2) - [F_V(H/3) + F_t(H/2)]}{V + qL}$

(use factored V, qL, Fe, Ft for factored e)
(q=0, Ft=0 for this case)

T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
Level Surcharge and Infinite Slope Condition
LIMIT STATE: **STRENGTH-I MAX**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)

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Project No: TW4437
Date: 12/30/14
By: CTH
Checked by: KD

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Wall Name: Wall 1

GRADING GEOMETRY

DISTANCE TO SLOPE (d) =	0	FT	
FILL SURCHARGE =	3.75	FT	
DISTANCE TO BREAK =	5	FT	
SLOPE ANGLE (ß1) =	36.9	DEG	
SLOPE ANGLE (I) =	14.0	DEG	
TRAFFIC SURCHARGE =	2	FT	

WALL GEOMETRY

HEIGHT (H) =	7.50	
BATTER ( ) =	0	
BASE (L) =	8	

BACKFILL SPECIFICATIONS

SELECT	INTERNAL FRICTION (Ø)=	34	DEG	Ka =	0.3298
	WEIGHT ( )=	120	PCF	Ko =	0.4408
	COHESION=	0	(assumed)		
UNCLASSIFIED	INTERNAL FRICTION (Ø)=	30	DEG	Ka =	0.3958
	WEIGHT ( )=	120	PCF		
	COHESION =	0	(assumed)		
FOUNDATION	FOUNDATION TYPE	S	(S for Soil, R for rock)		
	INTERNAL FRICTION (Ø)=	32	DEG	Kp =	3.2546

FRICTION FACTORS

JOINT MATERIAL TO CONCRETE =	0.59	
SELECT FILL TO CONCRETE =	0.50	
UNCLASSIFIED FILL TO CONCRETE =	0.50	
SELECT FILL TO FOUNDATION = tan(ø)	0.62	(Ø is min of select fill and foundation)
PRECAST CONCRETE TO FOUNDATION =	0.50	(0.8*TAN Øf)

SHEAR KEY STRENGTH = 2460 lbs.

WATER PRESSURE

HEIGHT OF WATER TABLE BEHIND WALL =	0	FT	(From bottom of wall)
HEIGHT OF WATER TABLE BEFORE WALL =	0	FT	(From bottom of wall)

Date: 12/30/14
Designed By: CTH
Checked by: KD

RESISTANCE FACTORS

FRICTION BETWEEN SOIL & SOIL :	1.00	
FRICTION BETWEEN SOIL & CONC. :	0.90	
FRICTION BETWEEN JOINT & CONC. :	0.90	
SHEAR THROUGH SHEAR KEY :	0.90	
PASSIVE PRESSURE AGAINST SLIDING :	0.50	(Not used for this project)
PASSIVE PRESSURE AGAINST OVERTURN. :	0.60	(Not used for this project)

LOAD FACTORS

DC (WEIGHT OF CONCRETE) :	1.25
EV (WEIGHT OF SOIL) :	1.35
EARTH PRESSURES (EH)	
HORIZONTAL COMPONENT :	1.50
VERTICAL COMPONENT :	1.50
LL (VEHICULAR LIVE LOAD), LS (LIVE LOAD SURCHARGE) :	1.75
WATER PRESSURE :	1.00

GLOBAL STABILITY

OVERTURNING

SUM FACTORED OVERTURNING MOMENTS	134619
SUM FACTORED RESISTING MOMENTS	330036
PERFORMANCE RATIO	2.45

SLIDING

SUM FACTORED HORIZONTAL FORCE	31222
FACTORED RESISTING FRICTION FORCE	43389
PERFORMANCE RATIO	1.39

MAXIMUM BEARING PRESSURE

Meyerhof distribution which considers a uniform base pressure distribution over an effective width of B' = L - 2e

Live load surcharge is present on the wall and behind the wall

MAXIMUM BEARING PRESSURE: Sv = SUM VERTICAL LOADS/(L-2e)

FACTORED SUM OF VERTICAL LOADS =	88782	LB/5 FT WIDTH			
FACTORED e =	1.04	≤ L/4 =	2.00	ft	ON SOIL
FACTORED BEARING PRESSURE =	3001	PSF			
FACTORED BEARING RESISTANCE =	#N/A	PSF			
PERFORMANCE RATIO =	#N/A				

Date: 12/30/14
Designed By: CTH
Checked by: KD

PERFORMANCE RATIO AT EACH LEVEL

Live load is present behind the wall, but not on the wall

LEVEL	HEIGHT	STEM LENGTH	No. OF SHEAR KEYS	FACTORED LOAD EFFECT	FACTORED RESISTANCE	PERFORMANCE RATIO
1	5.00	6.00	2			
			OVERTURNING	70410	129793	1.84
			SLIDING	20504	28900	1.41
			PULLOUT	6709	11754	1.75
2	7.50	8.00	0			
			OVERTURNING	134619	330036	2.45
			SLIDING	31222	43389	1.39
			PULLOUT	5608	13998	2.50
3	10.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
4	12.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
5	15.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
6	17.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
7	20.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
8	22.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
9	25.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
10	27.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
11	30.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
12	32.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A

Date: 12/30/14
Designed By: CTH
Checked by: KD

LEVEL 2

STEM LENGTH = 8.00 FT
HEIGHT = 11.25 FT

EARTH PRESSURE			TRAFFIC SURCHARGE & WATER PRESSURE		
Pa =	3005.87	plf	Pt =	1068.75	plf
Feh =	14580.59	lbs.	Ft =	5343.76	lbs.
Fev =	3645.15	lbs.	Fw =	0.00	lbs.

STABILITY AGAINST SLIDING - LEVEL 2

SLIDING FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
Feh	14580.59	1.50	21870.89
Ft	5343.76	1.75	9351.58
Fw	0.00	1.00	0.00
TOTAL			31222.47

RESISTING FORCE

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
THRU SELECT FILL OR FOUNDATION	42893.03	1.35	0.62	1.00	36183.42
Fev	3645.15	1.50	0.62	1.00	3416.61
THRU JT. MAT'L OR FOUNDATION	6737.63	1.25	0.50	0.90	3789.12
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	0.90	0.00
EMBEDMENT	0.00	#N/A	#N/A	0.50	0.00
TOTAL					43389.16

PERFORMANCE RATIO = 1.39

STABILITY AGAINST PULLOUT - LEVEL 2

PULLOUT FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
PULLOUT FORCE	2699.55	1.50	4049.33
TRAFFIC SURCHARGE FORCE	890.44	1.75	1558.28
WATER PRESSURE	0.00	1.00	0.00
TOTAL			5607.61

RESISTING FORCE

Aeff. = 34.18 SF

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
ON STEM(SOIL TO SOIL IN Aeff)	3788.34	1.35	0.67	1.00	3449.61
ON STEM (SOIL TO CONCRETE IN A	11126.39	1.35	0.50	0.90	6759.28
CONC. UNIT WEIGHT (THROUGH JOINT MATERIAL)	6737.63	1.25	0.50	0.90	3789.12
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	0.90	0.00
					13998.01

PERFORMANCE RATIO = 2.50

Date: 12/30/14
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 2

OVERTURNING MOMENT

	FORCE	MOMENT ARM	OVERTURNING MOMENT	LOAD FACTOR	FACTORED MOMENT
Feh	14580.59	3.75	54677.23	1.50	82015.84
Ft	5343.76	5.63	30058.66	1.75	52602.66
Fw	0.00	0.00	0.00	1.00	0.00
TOTAL					134618.50

RESISTING MOMENT

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED MOMENT
UNIT L1	2774.00	1.14	0.00	1.25	3467.50	3952.95
UNIT L2	2098.00	2.31	0.00	1.25	2622.50	6057.98
SELECT FILL L1	15781.20	3.25	0.00	1.35	21304.62	69240.02
SELECT FILL L2	10321.20	4.25	0.00	1.35	13933.62	59217.89

Date: 12/30/14
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 2 (CONTINUED)

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED MOMENT
STEP L2	6000.00	7.00	0.00	1.35	8100.00	56700.00
EARTH SURCHARGE	12656.25	5.33	0.00	1.35	17085.94	91125.00
Fev	3645.15	8.00	0.00	1.50	5467.72	43741.78
TOTAL					71981.90	330035.61

PERFORMANCE RATIO = 2.45

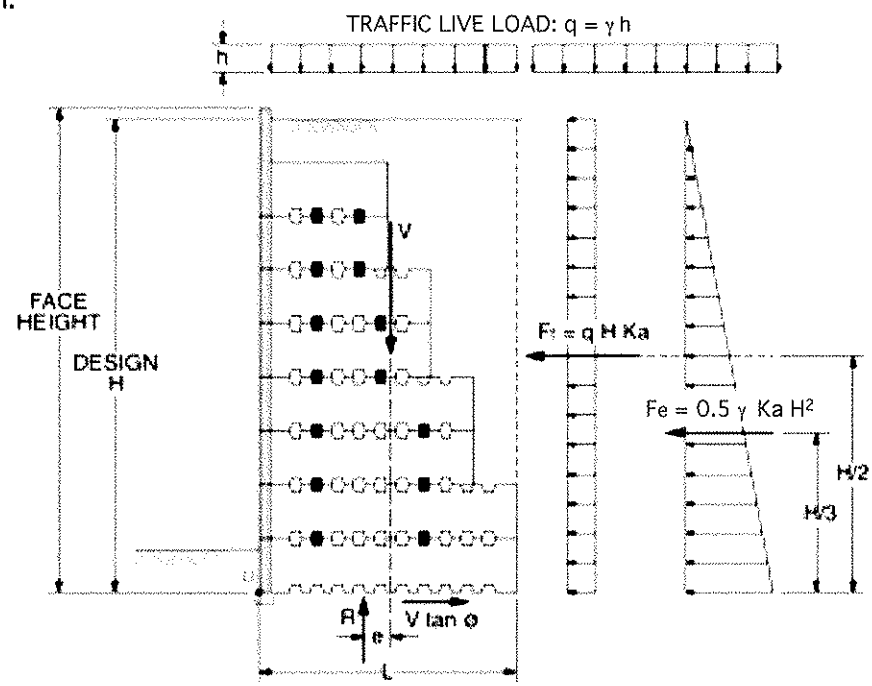
T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
LIMIT STATE: **SERVICE-I**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)
Level Surcharge and Infinite Slope Condition

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Comment: Wall 1

Project No: TW4437
Date: 12/30/14
Designed By: CTH
Checked by: KD

Load Diagram:



Typical Section, All details may not apply

External Stability Calculation (SERVICE-I)

Stability Against Overturning: (moments about point "O")

Σ Factored Resisting Moments = $\phi V \cdot x_o$ (x_o is the horiz. distance between V and O)

Σ Factored overturning Momen = $Y_e F_e (H/3) + Y_t F_t (H/2)$

Stability Against Sliding:

Σ Factored Resisting Force = $\phi V \tan \phi_F$

Σ Factored Driving Force = $Y_e F_e + Y_t F_t$

Bearing Pressure:

Factored Bearing Pressure = $(Y_1 V + Y_2 qL)/(L - 2e)$ (use factored e)

Eccentricity:

Eccentricity (e) = $\dfrac{L}{2} - \dfrac{(V + qL)(L/2) - [F_V(H/3) + F_t(H/2)]}{V + qL}$

(use factored V, qL, Fe, Ft for factored e)

T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
Level Surcharge and Infinite Slope Condition
LIMIT STATE: **SERVICE-I**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858
Project No: TW4437
Date: 12/30/14
By: CTH
Checked by: KD

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Comment: Wall 1

GRADING GEOMETRY

DISTANCE TO SLOPE (d) =	0	FT	
FILL SURCHARGE =	3.75	FT	
DISTANCE TO BREAK =	5	FT	
SLOPE ANGLE (ß1) =	36.9	DEG	
SLOPE ANGLE (I) =	14.0	DEG	
TRAFFIC SURCHARGE =	2	FT	

WALL GEOMETRY

HEIGHT (H) =	7.50	
BATTER ( ) =	0	
BASE (L) =	8	

BACKFILL SPECIFICATIONS

SELECT	INTERNAL FRICTION (Ø)=	34	DEG	Ka =	0.3298
	WEIGHT ( )=	120	PCF	Ko =	0.4408
	COHESION=	0	(assumed)		
UNCLASSIFIED	INTERNAL FRICTION (Ø)=	30	DEG	Ka =	0.3958
	WEIGHT ( )=	120	PCF		
	COHESION =	0	(assumed)		
FOUNDATION	FOUNDATION TYPE	S	(S for Soil, R for rock)		
	INTERNAL FRICTION (Ø)=	32	DEG	Kp =	3.2546

FRICTION FACTORS

JOINT MATERIAL TO CONCRETE =	0.59	
SELECT FILL TO CONCRETE =	0.50	
UNCLASSIFIED FILL TO CONCRETE =	0.50	
SELECT FILL TO FOUNDATION = tan(ø)	0.62	(Ø is min of select fill and foundation)
PRECAST CONCRETE TO FOUNDATION =	0.50	(0.8*TAN Øf)

SHEAR KEY STRENGTH = 2460 lbs.

WATER PRESSURE

HEIGHT OF WATER TABLE BEHIND WALL =	0	FT	(From bottom of wall)
HEIGHT OF WATER TABLE BEFORE WALL =	0	FT	(From bottom of wall)

WIND ON SOUND BARRIER/OTHER STRUCTURE

WIND FORCE =	0	LBS
DISTANCE FROM TOP OF WALL/GUTTER LINE =	0	FT

Date: 12/30/14
Designed By: CTH
Checked by: KD

RESISTANCE FACTORS

FRICTION BETWEEN SOIL & SOIL :	1.00	
FRICTION BETWEEN SOIL & CONC. :	1.00	
FRICTION BETWEEN JOINT & CONC. :	1.00	
SHEAR THROUGH SHEAR KEY :	1.00	
PASSIVE PRESSURE AGAINST SLIDING :	1.00	(Not used for this project)
PASSIVE PRESSURE AGAINST OVERTURN. :	1.00	(Not used for this project)

LOAD FACTORS

DC (WEIGHT OF CONCRETE) :	1.00
EV (WEIGHT OF SOIL) :	1.00
EARTH PRESSURES (EH)	
HORIZONTAL COMPONENT :	1.00
VERTICAL COMPONENT :	1.00
LL (VEHICULAR LIVE LOAD), LS (LIVE LOAD SURCHARGE) :	1.00
WATER PRESSURE :	1.00
WIND LOAD :	0.30

GLOBAL STABILITY

OVERTURNING

SUM FACTORED OVERTURNING MOMENTS:	84736
SUM FACTORED RESISTING MOMENTS:	241824
PERFORMANCE RATIO:	2.85

SLIDING

SUM FACTORED HORIZONTAL FORCE:	19924
FACTORED RESISTING FRICTION FORCE:	32448
PERFORMANCE RATIO:	1.63

MAXIMUM BEARING PRESSURE

Meyerhof distribution which considers a uniform base pressure distribution over an effective width of B' = L - 2e

Live load surcharge is present on the wall and behind the wall

MAXIMUM BEARING PRESSURE: σ_v = SUM VERTICAL LOADS/(L-2e)

FACTORED SUM OF VERTICAL LOADS =	62876	LB/5 FT WIDTH			
FACTORED e =	0.89	≤ L/4 =	2.00	ft	ON SOIL
FACTORED BEARING PRESSURE =	2022	PSF			
FACTORED BEARING CAPACITY =	#N/A	PSF			
PERFORMANCE RATIO =	#N/A				

Date: 12/30/14
Designed By: CTH
Checked by: KD

FACTORS OF SAFETY AT EACH LEVEL

Live load is present behind the wall, but not on the wall

LEVEL	HEIGHT	STEM LENGTH	No. OF SHEAR KEYS	FACTORED LOAD EFFECT	FACTORED RESISTANCE	PERFORMANCE RATIO
1	5.00	6.00	2			
			OVERTURNING	43910	94907	2.16
			SLIDING	12977	23222	1.79
			PULLOUT	4159	10961	2.64
2	7.50	8.00	0			
			OVERTURNING	84736	241824	2.85
			SLIDING	19924	32448	1.63
			PULLOUT	3590	11487	3.20
3	10.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
4	12.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
5	15.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
6	17.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
7	20.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
8	22.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
9	25.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
10	27.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
11	30.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
12	32.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A

Date: 12/30/14
Designed By: CTH
Checked by: KD

LEVEL 2

STEM LENGTH =	8.00	FT
HEIGHT =	11.25	FT

EARTH PRESSURE			TRAFFIC SURCHARGE & WATER PRESSURE		
Pa =	3005.87	plf	Pt =	1068.75	plf
Feh =	14580.59	lbs.	Ft =	5343.76	lbs.
Fev =	3645.15	lbs.	Fw =	0.00	lbs.

STABILITY AGAINST SLIDING - LEVEL 2

SLIDING FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
Feh	14580.59	1.00	14580.59
Ft	5343.76	1.00	5343.76
Fw	0.00	1.00	0.00
WIND LOAD	0.00	0.30	0.00
TOTAL			19924.36

RESISTING FORCE

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
THRU SELECT FILL OR FOUNDATION	42893.03	1.00	0.62	1.00	26802.5
Fev	3645.15	1.00	0.62	1.00	2277.7
THRU JT. MATERIAL OR FOUNDATIC	6737.63	1.00	0.50	1.00	3368.1
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	1.00	0.0
EMBEDMENT	0.00	#N/A	#N/A	1.00	0.0
TOTAL					32448.4

PERFORMANCE RATIO = 1.63

STABILITY AGAINST PULLOUT - LEVEL 2

PULLOUT FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
PULLOUT FORCE =	2699.55	1.00	2699.55
TRAFFIC SURCHARGE FORCE =	890.44	1.00	890.44
WATER PRESSURE =	0.00	1.00	0.00
WIND LOAD =	0.00	0.30	0.00
TOTAL			3590.00

RESISTING FORCE

Aeff. = 34.18 SF

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
ON STEM(SOIL TO SOIL IN Aeff)	3788.34	1.00	0.67	1.00	2555.3
ON STEM (SOIL TO CONCRETE IN A	11126.39	1.00	0.50	1.00	5563.2
THRU JT. MATERIAL OR FOUNDATIC	6737.63	1.00	0.50	1.00	3368.1
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	1.00	0.0
					11486.57

PERFORMANCE RATIO = 3.20

Date: 12/30/14
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 2

OVERTURNING MOMENT

	FORCE	MOMENT ARM	OVERTURNING MOMENT	LOAD FACTOR	FACTORED MOMENT
Feh	14580.59	3.75	54677.2	1.00	54677.2
Ft	5343.76	5.63	30058.7	1.00	30058.7
Fw	0.00	0.00	0.0	1.00	0.0
WIND LOAD	0.00	7.50	0.00	0.30	0.00
TOTAL					84735.9

RESISTING MOMENT

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED RESISTANCE
PANEL L1	2774.00	1.14	0.00	1.00	2774.0	3162.4
PANEL L2	2098.00	2.31	0.00	1.00	2098.0	4846.4
SELECT FILL L1	15781.20	3.25	0.00	1.00	15781.2	51288.9
SELECT FILL L2	10321.20	4.25	0.00	1.00	10321.2	43865.1

Date: 12/30/14
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 2 (CONTINUED)

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED RESISTANCE
STEP L2	6000.00	7.00	0.00	1.00	6000.0	42000.0
EARTH SURCHARGE	12656.25	5.33	0.00	1.00	12656.3	67500.0
Fev	3645.15	8.00	0.00	1.00	3645.1	29161.2
TOTAL					53275.80	241823.93

PERFORMANCE RATIO = 2.85

Wall 2

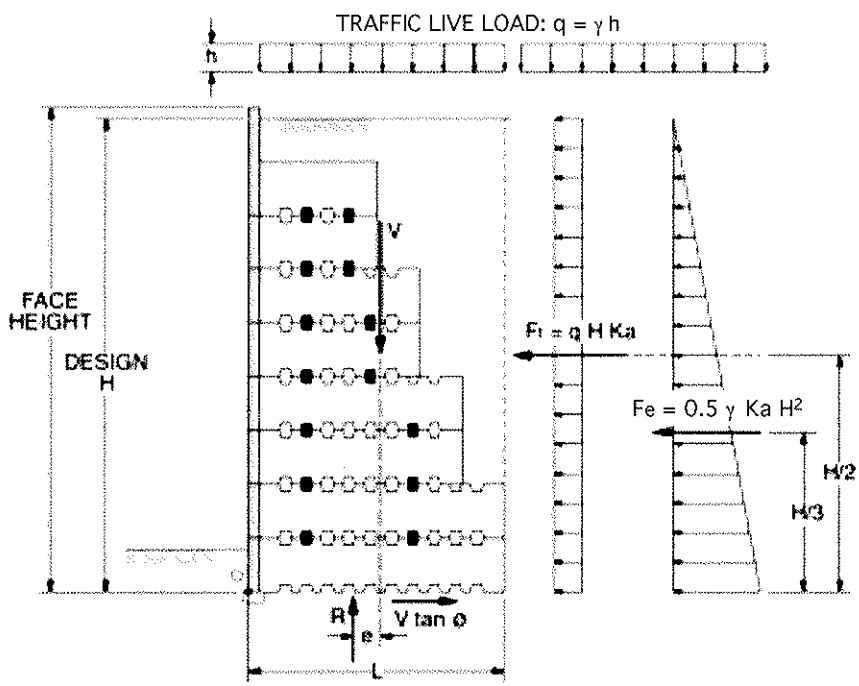
T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
LIMIT STATE: **STRENGTH-I MIN**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)
Level Surcharge and Infinite Slope Condition

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Comment: Wall 2

Project No: 4437
Date: 1/5/15
Designed By: CTH
Checked by: KD

Load Diagram:



Typical Section (For illustration only, Some details may not apply)

External Stability Calculation (STRENGTH-I MIN)

Stability Against Overturning: (moments about point "O")

Σ Factored Resisting Moments = $\phi V \cdot x_o$ (x_o is the horiz. distance between V and O)

Σ Factored overturning Momen = $Y_e F_e (H/3) + Y_t F_t (H/2)$

Stability Against Sliding:

Σ Factored Resisting Force = $\phi V \tan \phi_F$

Σ Factored Driving Force = $Y_e F_e + Y_t F_t$

Bearing Pressure:

Factored Bearing Pressure = $(Y_1 V + Y_2 qL)/(L - 2e)$ (use factored e)

Eccentricity:

Eccentricity (e) = $\dfrac{L}{2} - \dfrac{(V + qL)(L/2) - [F_V(H/3) + F_t(H/2)]}{V + qL}$

(use factored V, qL, Fe, Ft for factored e)
(q=0, Ft=0 for this case)

T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
Level Surcharge and Infinite Slope Condition
LIMIT STATE: STRENGTH-I MIN
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858
Project No: 4437
Date: 1/5/15
By: CTH
Checked by: KD

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Wall Name: Wall 2

GRADING GEOMETRY

DISTANCE TO SLOPE (d) =	0	FT	
FILL SURCHARGE =	3.75	FT	
DISTANCE TO BREAK =	5	FT	
SLOPE ANGLE (ß1) =	36.9	DEG	
SLOPE ANGLE (I) =	11.2	DEG	
TRAFFIC SURCHARGE =	2	FT	

WALL GEOMETRY

HEIGHT (H) =	9.50	
BATTER ( ) =	0	
BASE (L) =	10	

BACKFILL SPECIFICATIONS

SELECT	INTERNAL FRICTION (Ø)=	34	DEG	Ka =	0.3179
	WEIGHT ( )=	120	PCF	Ko =	0.4408
	COHESION=	0	(assumed)		
UNCLASSIFIED	INTERNAL FRICTION (Ø)=	30	DEG	Ka =	0.3796
	WEIGHT ( )=	120	PCF		
	COHESION =	0	(assumed)		
FOUNDATION	FOUNDATION TYPE	S	(S for Soil, R for rock)		
	INTERNAL FRICTION (Øf) =	30	DEG	Kp =	3.0000

FRICTION FACTORS

JOINT MATERIAL TO CONCRETE =	0.59	
SELECT FILL TO CONCRETE =	0.50	
UNCLASSIFIED FILL TO CONCRETE =	0.50	
SELECT FILL TO FOUNDATION = tan(ø)	0.58	(Ø is min of select fill and foundation)
PRECAST CONCRETE TO FOUNDATION =	0.46	(0.8*TAN Øf)

SHEAR KEY STRENGTH = 2460 lbs.

WATER PRESSURE

HEIGHT OF WATER TABLE BEHIND WALL =	0	FT	(From bottom of wall)
HEIGHT OF WATER TABLE BEFORE WALL =	0	FT	(From bottom of wall)

Date: 01/05/15
Designed By: CTH
Checked by: KD

RESISTANCE FACTORS

FRICTION BETWEEN SOIL & SOIL :	1.00	
FRICTION BETWEEN SOIL & CONC. :	0.90	
FRICTION BETWEEN JOINT & CONC. :	0.90	
SHEAR THROUGH SHEAR KEY :	0.90	
PASSIVE PRESSURE AGAINST SLIDING :	0.50	(Not used for this project)
PASSIVE PRESSURE AGAINST OVERTURN. :	0.60	(Not used for this project)

LOAD FACTORS

DC (WEIGHT OF CONCRETE) :	0.90
EV (WEIGHT OF SOIL) :	1.00
EARTH PRESSURES (EH)	
HORIZONTAL COMPONENT :	1.50
VERTICAL COMPONENT :	1.50
LL (VEHICULAR LIVE LOAD), LS (LIVE LOAD SURCHARGE) :	1.75
WATER PRESSURE :	1.00

GLOBAL STABILITY

OVERTURNING

SUM FACTORED OVERTURNING MOMENTS	199919
SUM FACTORED RESISTING MOMENTS	479193
PERFORMANCE RATIO	2.40

SLIDING

SUM FACTORED HORIZONTAL FORCE	39984
FACTORED RESISTING FRICTION FORCE	46674
PERFORMANCE RATIO	1.17

MAXIMUM BEARING PRESSURE

Meyerhof distribution which considers a uniform base pressure distribution over an effective width of B' = L - 2e

Live load surcharge is present on the wall and behind the wall

MAXIMUM BEARING PRESSURE: Sv = SUM VERTICAL LOADS/(L-2e)

FACTORED SUM OF VERTICAL LOADS =	104818	LB/5 FT WIDTH			
FACTORED e =	1.33	≤ L/4 =	2.50	ft	ON SOIL
FACTORED BEARING PRESSURE =	2859	PSF			
FACTORED BEARING RESISTANCE =	#N/A	PSF			
PERFORMANCE RATIO =	#N/A				

Date: 01/05/15
Designed By: CTH
Checked by: KD

PERFORMANCE RATIO AT EACH LEVEL

Live load is present behind the wall, but not on the wall

LEVEL	HEIGHT	STEM LENGTH	No. OF SHEAR KEYS	FACTORED LOAD EFFECT	FACTORED RESISTANCE	PERFORMANCE RATIO
1	4.50	6.00	2			
			OVERTURNING	58495	89452	1.53
			SLIDING	17983	21171	1.18
			PULLOUT	5522	9393	1.70
2	7.00	8.00	2			
			OVERTURNING	115456	232825	2.02
			SLIDING	27936	37562	1.34
			PULLOUT	5134	14633	2.85
3	9.50	10.00	0			
			OVERTURNING	199919	479193	2.40
			SLIDING	39984	46674	1.17
			PULLOUT	6713	16056	2.39
4	12.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
5	14.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
6	17.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
7	19.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
8	22.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
9	24.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
10	27.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
11	29.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
12	32.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A

Date: 01/05/15
Designed By: CTH
Checked by: KD

LEVEL 3			
STEM LENGTH =	10.00	FT	
HEIGHT =	13.25	FT	

EARTH PRESSURE			TRAFFIC SURCHARGE & EARTH PRESSURE		
Pa =	3998.54	plf	Pt =	1207.11	plf
Feh =	19614.31	lbs.	Ft =	6035.53	lbs.
Fev =	3871.25	lbs.	Fw =	0.00	lbs.

STABILITY AGAINST SLIDING - LEVEL 3

SLIDING FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
Feh	19614.31	1.50	29421.47
Ft	6035.53	1.75	10562.18
Fw	0.00	1.00	0.00
TOTAL			39983.64

RESISTING FORCE

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
THRU SELECT FILL OR FOUNDATION	68260.43	1.00	0.58	1.00	39410.17
Fev	3871.25	1.50	0.58	1.00	3352.60
THRU JT. MAT'L OR FOUNDATION	10454.63	0.90	0.46	0.90	3911.32
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	0.90	0.00
EMBEDMENT	0.00	#N/A	#N/A	0.50	0.00
TOTAL					46674.09

PERFORMANCE RATIO = 1.17

STABILITY AGAINST PULLOUT - LEVEL 3

PULLOUT FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
PULLOUT FORCE	3473.89	1.50	5210.83
TRAFFIC SURCHARGE FORCE	858.40	1.75	1502.20
WATER PRESSURE	0.00	1.00	0.00
TOTAL			6713.03

RESISTING FORCE Aeff. = 44.18 SF

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
ON STEM(SOIL TO SOIL IN Aeff)	6083.90	1.00	0.67	1.00	4103.64
ON STEM (SOIL TO CONCRETE IN A	17868.45	1.00	0.50	0.90	8040.80
THRU JT. MAT'L OR FOUNDATION	10454.63	0.90	0.46	0.90	3911.32
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	0.90	0.00
TOTAL					16055.76

PERFORMANCE RATIO = 2.39

Date: 01/05/15
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 3

OVERTURNING MOMENT

	FORCE	MOMENT ARM	OVERTURNING MOMENT	LOAD FACTOR	FACTORED MOMENT
Feh	19614.31	4.42	86629.87	1.50	129944.81
Ft	6035.53	6.63	39985.38	1.75	69974.42
Fw	0.00	0.00	0.00	1.00	0.00
TOTAL					199919.23

RESISTING MOMENT

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED MOMENT
UNIT L1	2586.00	1.20	0.00	0.90	2327.40	2792.88
UNIT L2	2098.00	2.31	0.00	0.90	1888.20	4361.74
UNIT L3	2360.00	3.09	0.00	0.90	2124.00	6563.16
SELECT FILL L1	14131.20	3.25	0.00	1.00	14131.20	45926.40
SELECT FILL L2	10321.20	4.25	0.00	1.00	10321.20	43865.10
SELECT FILL L3	13112.40	5.25	0.00	1.00	13112.40	68840.10

Date: 01/05/15
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 3 (CONTINUED)

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED MOMENT
STEP L2	5400.00	7.00	0.00	1.00	5400.00	37800.00
STEP L3	8400.00	9.00	0.00	1.00	8400.00	75600.00
EARTH SURCHARGE	20306.25	6.67	0.00	1.00	20306.25	135375.00
Fev	3871.25	10.00	0.00	1.50	5806.87	58068.68
TOTAL					83817.52	479193.07

PERFORMANCE RATIO = 2.40

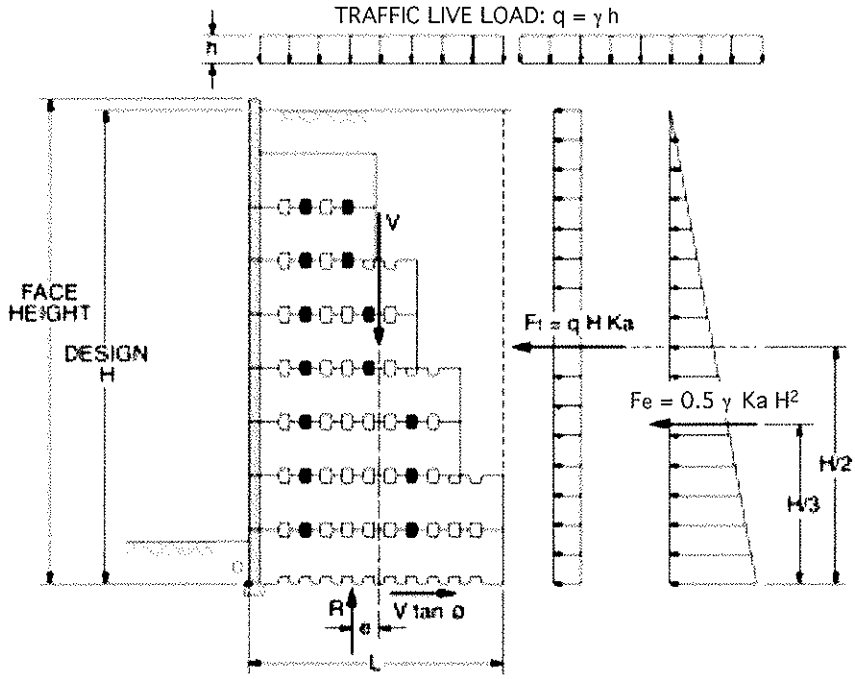
T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
LIMIT STATE: **STRENGTH-I MAX**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)
Level Surcharge and Infinite Slope Condition

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Comment: Wall 2

Project No: 4437
Date: 1/5/15
Designed By: CTH
Checked by: KD

Load Diagram:



Typical Section (For illustration only, Some details may not apply)

External Stability Calculation (STRENGTH-I MAX)

Stability Against Overturning: (moments about point "O")

Σ Factored Resisting Moments = $\phi V \cdot x_O$ (x_O is the horiz. distance between V and O)

Σ Factored overturning Momen = $Y_e F_e (H/3) + Y_t F_t (H/2)$

Stability Against Sliding:

Σ Factored Resisting Force = $\phi V \tan \phi_F$

Σ Factored Driving Force = $Y_e F_e + Y_t F_t$

Bearing Pressure:

Factored Bearing Pressure = $(Y_1 V + Y_2 qL)/(L - 2e)$ (use factored e)

Eccentricity:

Eccentricity (e) = $\dfrac{L}{2} - \dfrac{(V + qL)(L/2) - [F_V(H/3) + F_t(H/2)]}{V + qL}$

(use factored V, qL, Fe, Ft for factored e)
(q=0, Ft=0 for this case)

T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
Level Surcharge and Infinite Slope Condition
LIMIT STATE: STRENGTH-I MAX
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858

Project No: 4437
Date: 1/5/15
By: CTH
Checked by: KD

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Wall Name: Wall 2

GRADING GEOMETRY

DISTANCE TO SLOPE (d) =	0	FT	
FILL SURCHARGE =	3.75	FT	
DISTANCE TO BREAK =	5	FT	
SLOPE ANGLE (ß1) =	36.9	DEG	
SLOPE ANGLE (I) =	11.2	DEG	
TRAFFIC SURCHARGE =	2	FT	

WALL GEOMETRY

HEIGHT (H) =	9.50	
BATTER ( ) =	0	
BASE (L) =	10	

BACKFILL SPECIFICATIONS

SELECT	INTERNAL FRICTION (Ø)=	34	DEG	Ka =	0.3179
	WEIGHT ( )=	120	PCF	Ko =	0.4408
	COHESION=	0	(assumed)		
UNCLASSIFIED	INTERNAL FRICTION (Ø)=	30	DEG	Ka =	0.3796
	WEIGHT ( )=	120	PCF		
	COHESION =	0	(assumed)		
FOUNDATION	FOUNDATION TYPE	S	(S for Soil, R for rock)		
	INTERNAL FRICTION (Ø)=	30	DEG	Kp =	3.0000

FRICTION FACTORS

JOINT MATERIAL TO CONCRETE =	0.59	
SELECT FILL TO CONCRETE =	0.50	
UNCLASSIFIED FILL TO CONCRETE =	0.50	
SELECT FILL TO FOUNDATION = tan(ø)	0.58	(Ø is min of select fill and foundation)
PRECAST CONCRETE TO FOUNDATION =	0.46	(0.8*TAN Øf)

SHEAR KEY STRENGTH = 2460 lbs.

WATER PRESSURE

HEIGHT OF WATER TABLE BEHIND WALL =	0	FT	(From bottom of wall)
HEIGHT OF WATER TABLE BEFORE WALL =	0	FT	(From bottom of wall)

Date: 01/05/15
Designed By: CTH
Checked by: KD

RESISTANCE FACTORS

FRICTION BETWEEN SOIL & SOIL :	1.00	
FRICTION BETWEEN SOIL & CONC. :	0.90	
FRICTION BETWEEN JOINT & CONC. :	0.90	
SHEAR THROUGH SHEAR KEY :	0.90	
PASSIVE PRESSURE AGAINST SLIDING :	0.50	(Not used for this project)
PASSIVE PRESSURE AGAINST OVERTURN. :	0.60	(Not used for this project)

LOAD FACTORS

DC (WEIGHT OF CONCRETE) :	1.25
EV (WEIGHT OF SOIL) :	1.35
EARTH PRESSURES (EH)	
HORIZONTAL COMPONENT :	1.50
VERTICAL COMPONENT :	1.50
LL (VEHICULAR LIVE LOAD), LS (LIVE LOAD SURCHARGE) :	1.75
WATER PRESSURE :	1.00

GLOBAL STABILITY

OVERTURNING

SUM FACTORED OVERTURNING MOMENTS	199919
SUM FACTORED RESISTING MOMENTS	627120
PERFORMANCE RATIO	3.14

SLIDING

SUM FACTORED HORIZONTAL FORCE	39984
FACTORED RESISTING FRICTION FORCE	61989
PERFORMANCE RATIO	1.55

MAXIMUM BEARING PRESSURE

Meyerhof distribution which considers a uniform base pressure distribution over an effective width of B' = L - 2e

Live load surcharge is present on the wall and behind the wall

MAXIMUM BEARING PRESSURE: Sv = SUM VERTICAL LOADS/(L-2e)

FACTORED SUM OF VERTICAL LOADS =	132368	LB/5 FT WIDTH			
FACTORED e =	0.98	≤ L/4 =	2.50	ft	ON SOIL
FACTORED BEARING PRESSURE =	3292	PSF			
FACTORED BEARING RESISTANCE =	#N/A	PSF			
PERFORMANCE RATIO =	#N/A				

Date: 01/05/15
Designed By: CTH
Checked by: KD

PERFORMANCE RATIO AT EACH LEVEL

Live load is present behind the wall, but not on the wall

LEVEL	HEIGHT	STEM LENGTH	No. OF SHEAR KEYS	FACTORED LOAD EFFECT	FACTORED RESISTANCE	PERFORMANCE RATIO
1	4.50	6.00	2			
			OVERTURNING	58495	116141	1.99
			SLIDING	17983	26560	1.48
			PULLOUT	5522	11192	2.03
2	7.00	8.00	2			
			OVERTURNING	115456	303889	2.63
			SLIDING	27936	48377	1.73
			PULLOUT	5134	18326	3.57
3	9.50	10.00	0			
			OVERTURNING	199919	627120	3.14
			SLIDING	39984	61989	1.55
			PULLOUT	6713	21827	3.25
4	12.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
5	14.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
6	17.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
7	19.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
8	22.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
9	24.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
10	27.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
11	29.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
12	32.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A

Date: 01/05/15
Designed By: CTH
Checked by: KD

LEVEL 3		
STEM LENGTH =	10.00	FT
HEIGHT =	13.25	FT

EARTH PRESSURE			TRAFFIC SURCHARGE & EARTH PRESSURE		
Pa =	3998.54	plf	Pt =	1207.11	plf
Feh =	19614.31	lbs.	Ft =	6035.53	lbs.
Fev =	3871.25	lbs.	Fw =	0.00	lbs.

STABILITY AGAINST SLIDING - LEVEL 3

SLIDING FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
Feh	19614.31	1.50	29421.47
Ft	6035.53	1.75	10562.18
Fw	0.00	1.00	0.00
TOTAL			39983.64

RESISTING FORCE

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
THRU SELECT FILL OR FOUNDATION	68260.43	1.35	0.58	1.00	53203.74
Fev	3871.25	1.50	0.58	1.00	3352.60
THRU JT. MAT'L OR FOUNDATION	10454.63	1.25	0.46	0.90	5432.38
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	0.90	0.00
EMBEDMENT	0.00	#N/A	#N/A	0.50	0.00
TOTAL					61988.72

PERFORMANCE RATIO = 1.55

STABILITY AGAINST PULLOUT - LEVEL 3

PULLOUT FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
PULLOUT FORCE	3473.89	1.50	5210.83
TRAFFIC SURCHARGE FORCE	858.40	1.75	1502.20
WATER PRESSURE	0.00	1.00	0.00
TOTAL			6713.03

RESISTING FORCE

Aeff. = 44.18 SF

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
ON STEM(SOIL TO SOIL IN Aeff)	6083.90	1.35	0.67	1.00	5539.91
ON STEM (SOIL TO CONCRETE IN A	17868.45	1.35	0.50	0.90	10855.08
THRU JT. MAT'L OR FOUNDATION	10454.63	1.25	0.46	0.90	5432.38
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	0.90	0.00
TOTAL					21827.38

PERFORMANCE RATIO = 3.25

Date: 01/05/15
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 3

OVERTURNING MOMENT

	FORCE	MOMENT ARM	OVERTURNING MOMENT	LOAD FACTOR	FACTORED MOMENT
Feh	19614.31	4.42	86629.87	1.50	129944.81
Ft	6035.53	6.63	39985.38	1.75	69974.42
Fw	0.00	0.00	0.00	1.00	0.00
TOTAL					199919.23

RESISTING MOMENT

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED MOMENT
UNIT L1	2586.00	1.20	0.00	1.25	3232.50	3879.00
UNIT L2	2098.00	2.31	0.00	1.25	2622.50	6057.98
UNIT L3	2360.00	3.09	0.00	1.25	2950.00	9115.50
SELECT FILL L1	14131.20	3.25	0.00	1.35	19077.12	62000.64
SELECT FILL L2	10321.20	4.25	0.00	1.35	13933.62	59217.89
SELECT FILL L3	13112.40	5.25	0.00	1.35	17701.74	92934.14

Date: 01/05/15
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 3 (CONTINUED)

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED MOMENT
STEP L2	5400.00	7.00	0.00	1.35	7290.00	51030.00
STEP L3	8400.00	9.00	0.00	1.35	11340.00	102060.00
EARTH SURCHARGE	20306.25	6.67	0.00	1.35	27413.44	182756.25
Fev	3871.25	10.00	0.00	1.50	5806.87	58068.68
TOTAL					111367.79	627120.07

PERFORMANCE RATIO = 3.14

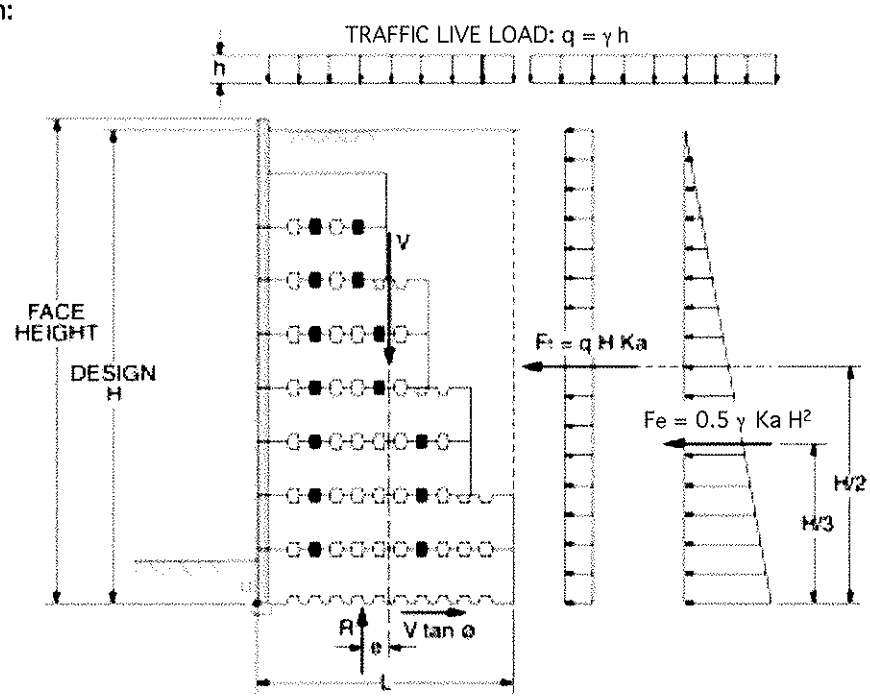
T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
LIMIT STATE: **SERVICE-I**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)
Level Surcharge and Infinite Slope Condition

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Comment: Wall 2

Project No: 4437
Date: 01/05/15
Designed By: CTH
Checked by: KD

Load Diagram:



Typical Section, All details may not apply

External Stability Calculation (SERVICE-I)

Stability Against Overturning: (moments about point "O")

Σ Factored Resisting Moments = $\phi V \cdot x_o$ (x_o is the horiz. distance between V and O)

Σ Factored overturning Momen = $Y_e F_e (H/3) + Y_t F_t (H/2)$

Stability Against Sliding:

Σ Factored Resisting Force = $\phi V \tan \phi_F$

Σ Factored Driving Force = $Y_e F_e + Y_t F_t$

Bearing Pressure:

Factored Bearing Pressure = $(Y_1 V + Y_2 qL)/(L - 2e)$ (use factored e)

Eccentricity:

Eccentricity (e) = $\dfrac{L}{2} - \dfrac{(V + qL)(L/2) - [F_V(H/3) + F_t(H/2)]}{V + qL}$

(use factored V, qL, Fe, Ft for factored e)

T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
Level Surcharge and Infinite Slope Condition
LIMIT STATE: **SERVICE-I**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858
Project No: 4437
Date: 1/5/15
By: CTH
Checked by: KD

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Comment: Wall 2

GRADING GEOMETRY

DISTANCE TO SLOPE (d) =	0	FT	
FILL SURCHARGE =	3.75	FT	
DISTANCE TO BREAK =	5	FT	
SLOPE ANGLE (ß1) =	36.9	DEG	
SLOPE ANGLE (I) =	11.2	DEG	
TRAFFIC SURCHARGE =	2	FT	

WALL GEOMETRY

HEIGHT (H) =	9.50	
BATTER ( ) =	0	
BASE (L) =	10	

BACKFILL SPECIFICATIONS

SELECT	INTERNAL FRICTION (Ø)=	34	DEG	Ka =	0.3179
	WEIGHT ( )=	120	PCF	Ko =	0.4408
	COHESION=	0	(assumed)		
UNCLASSIFIED	INTERNAL FRICTION (Ø)=	30	DEG	Ka =	0.3796
	WEIGHT ( )=	120	PCF		
	COHESION =	0	(assumed)		
FOUNDATION	FOUNDATION TYPE	S	(S for Soil, R for rock)		
	INTERNAL FRICTION (Ø)=	30	DEG	Kp =	3.0000

FRICTION FACTORS

JOINT MATERIAL TO CONCRETE =	0.59	
SELECT FILL TO CONCRETE =	0.50	
UNCLASSIFIED FILL TO CONCRETE =	0.50	
SELECT FILL TO FOUNDATION = tan(ø)	0.58	(Ø is min of select fill and foundation)
PRECAST CONCRETE TO FOUNDATION =	0.46	(0.8*TAN Øf)

SHEAR KEY STRENGTH = 2460 lbs.

WATER PRESSURE

HEIGHT OF WATER TABLE BEHIND WALL =	0	FT	(From bottom of wall)
HEIGHT OF WATER TABLE BEFORE WALL =	0	FT	(From bottom of wall)

WIND ON SOUND BARRIER/OTHER STRUCTURE

WIND FORCE =	0	LBS
DISTANCE FROM TOP OF WALL/GUTTER LINE =	0	FT

Date: 01/05/15
Designed By: CTH
Checked by: KD

RESISTANCE FACTORS

FRICTION BETWEEN SOIL & SOIL :	1.00	
FRICTION BETWEEN SOIL & CONC. :	1.00	
FRICTION BETWEEN JOINT & CONC. :	1.00	
SHEAR THROUGH SHEAR KEY :	1.00	
PASSIVE PRESSURE AGAINST SLIDING :	1.00	(Not used for this project)
PASSIVE PRESSURE AGAINST OVERTURN. :	1.00	(Not used for this project)

LOAD FACTORS

DC (WEIGHT OF CONCRETE) :	1.00
EV (WEIGHT OF SOIL) :	1.00
EARTH PRESSURES (EH)	
HORIZONTAL COMPONENT :	1.00
VERTICAL COMPONENT :	1.00
LL (VEHICULAR LIVE LOAD), LS (LIVE LOAD SURCHARGE) :	1.00
WATER PRESSURE :	1.00
WIND LOAD :	0.30

GLOBAL STABILITY

OVERTURNING

SUM FACTORED OVERTURNING MOMENTS:	126615
SUM FACTORED RESISTING MOMENTS:	461361
PERFORMANCE RATIO:	3.64

SLIDING

SUM FACTORED HORIZONTAL FORCE:	25650
FACTORED RESISTING FRICTION FORCE:	46474
PERFORMANCE RATIO:	1.81

MAXIMUM BEARING PRESSURE

Meyerhof distribution which considers a uniform base pressure distribution over an effective width of B' = L - 2e

Live load surcharge is present on the wall and behind the wall

MAXIMUM BEARING PRESSURE: σ_v = SUM VERTICAL LOADS/(L-2e)

FACTORED SUM OF VERTICAL LOADS =	94586	LB/5 FT WIDTH			
FACTORED e =	0.83	≤ L/4 =	2.50	ft	ON SOIL
FACTORED BEARING PRESSURE =	2266	PSF			
FACTORED BEARING CAPACITY =	#N/A	PSF			
PERFORMANCE RATIO =	#N/A				

Date: 01/05/15
Designed By: CTH
Checked by: KD

FACTORS OF SAFETY AT EACH LEVEL

Live load is present behind the wall, but not on the wall

LEVEL	HEIGHT	STEM LENGTH	No. OF SHEAR KEYS	FACTORED LOAD EFFECT	FACTORED RESISTANCE	PERFORMANCE RATIO
1	4.50	6.00	2			
			OVERTURNING	36413	85259	2.34
			SLIDING	11362	21523	1.89
			PULLOUT	3411	10502	3.08
2	7.00	8.00	2			
			OVERTURNING	72584	223427	3.08
			SLIDING	17808	37922	2.13
			PULLOUT	3280	16375	4.99
3	9.50	10.00	0			
			OVERTURNING	126615	461361	3.64
			SLIDING	25650	46474	1.81
			PULLOUT	4332	17867	4.12
4	12.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
5	14.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
6	17.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
7	19.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
8	22.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
9	24.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
10	27.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
11	29.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
12	32.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A

Date: 01/05/15
Designed By: CTH
Checked by: KD

LEVEL 3

STEM LENGTH = 10.00 FT
HEIGHT = 13.25 FT

EARTH PRESSURE			TRAFFIC SURCHARGE & WATER PRESSURE		
Pa =	3998.54	plf	Pt =	1207.11	plf
Feh =	19614.31	lbs.	Ft =	6035.53	lbs.
Fev =	3871.25	lbs.	Fw =	0.00	lbs.

STABILITY AGAINST SLIDING - LEVEL 3

SLIDING FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
Feh	19614.31	1.00	19614.31
Ft	6035.53	1.00	6035.53
Fw	0.00	1.00	0.00
WIND LOAD	0.00	0.30	0.00
TOTAL			25649.84

RESISTING FORCE

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
THRU SELECT FILL OR FOUNDATION	68260.43	1.00	0.58	1.00	39410.2
Fev	3871.25	1.00	0.58	1.00	2235.1
THRU JT. MATERIAL OR FOUNDATIC	10454.63	1.00	0.46	1.00	4828.8
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	1.00	0.0
EMBEDMENT	0.00	#N/A	#N/A	1.00	0.0
TOTAL					46474.0

PERFORMANCE RATIO = 1.81

STABILITY AGAINST PULLOUT - LEVEL 3

PULLOUT FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
PULLOUT FORCE =	3473.89	1.00	3473.89
TRAFFIC SURCHARGE FORCE =	858.40	1.00	858.40
WATER PRESSURE =	0.00	1.00	0.00
TOTAL			4332.29

RESISTING FORCE

Aeff. = 44.18 SF

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
ON STEM(SOIL TO SOIL IN Aeff)	6083.90	1.00	0.67	1.00	4103.6
ON STEM (SOIL TO CONCRETE IN A	17868.45	1.00	0.50	1.00	8934.2
THRU JT. MATERIAL OR FOUNDATIC	10454.63	1.00	0.46	1.00	4828.8
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	1.00	0.0
TOTAL					17866.7

PERFORMANCE RATIO = 4.12

Date: 01/05/15
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 3

OVERTURNING MOMENT

	FORCE	MOMENT ARM	OVERTURNING MOMENT	LOAD FACTOR	FACTORED MOMENT
Feh	19614.31	4.42	86629.9	1.00	86629.9
Ft	6035.53	6.63	39985.4	1.00	39985.4
Fw	0.00	0.00	0.0	1.00	0.0
WIND LOAD	0.00	9.50	0.00	0.30	0.00
TOTAL					126615.3

RESISTING MOMENT

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED RESISTANCE
PANEL L1	2586.00	1.20	0.00	1.00	2586.0	3103.2
PANEL L2	2098.00	2.31	0.00	1.00	2098.0	4846.4
PANEL L3	2360.00	3.09	0.00	1.00	2360.0	7292.4
SELECT FILL L1	14131.20	3.25	0.00	1.00	14131.2	45926.4
SELECT FILL L2	10321.20	4.25	0.00	1.00	10321.2	43865.1
SELECT FILL L3	13112.40	5.25	0.00	1.00	13112.4	68840.1

Date: 01/05/15
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 3 (CONTINUED)

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED RESISTANCE
STEP L2	5400.00	7.00	0.00	1.00	5400.0	37800.0
STEP L3	8400.00	9.00	0.00	1.00	8400.0	75600.0
EARTH SURCHARGE	20306.25	6.67	0.00	1.00	20306.3	135375.0
Fev	3871.25	10.00	0.00	1.00	3871.2	38712.5
TOTAL					82586.30	461361.04

PERFORMANCE RATIO = 3.64

Wall 3

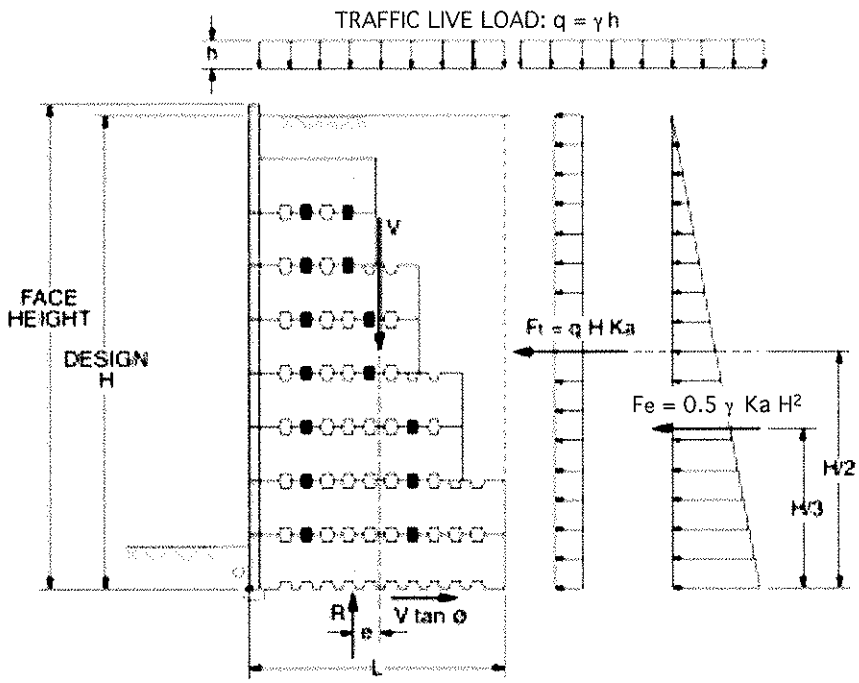
T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
LIMIT STATE: **STRENGTH-I MIN**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)
Level Surcharge and Infinite Slope Condition

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Comment: Wall 3

Project No: 4437
Date: 12/30/14
Designed By: CTH
Checked by: KD

Load Diagram:



Typical Section (For illustration only, Some details may not apply)

External Stability Calculation (STRENGTH-I MIN)

Stability Against Overturning: (moments about point "O")

Σ Factored Resisting Moments = $\phi V \cdot x_0$ (x_0 is the horiz. distance between V and O)

Σ Factored overturning Momen = $Y_e F_e (H/3) + Y_t F_t (H/2)$

Stability Against Sliding:

Σ Factored Resisting Force = $\phi V \tan \phi_F$

Σ Factored Driving Force = $Y_e F_e + Y_t F_t$

Bearing Pressure:

Factored Bearing Pressure = $(Y_1 V + Y_2 qL)/(L - 2e)$ (use factored e)

Eccentricity:

Eccentricity (e) = $\dfrac{L}{2} - \dfrac{(V + qL)(L/2) - [F_V(H/3) + F_t(H/2)]}{V + qL}$

(use factored V, qL, Fe, Ft for factored e)
(q=0, Ft=0 for this case)

T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
Level Surcharge and Infinite Slope Condition
LIMIT STATE: STRENGTH-I MIN
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858

Project No: 4437
Date: 12/30/14
By: CTH
Checked by: KD

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Wall Name: Wall 3

GRADING GEOMETRY

DISTANCE TO SLOPE (d) =	0	FT	
FILL SURCHARGE =	3.75	FT	
DISTANCE TO BREAK =	5	FT	
SLOPE ANGLE (ß1) =	36.9	DEG	
SLOPE ANGLE (I) =	10.1	DEG	
TRAFFIC SURCHARGE =	2	FT	

WALL GEOMETRY

HEIGHT (H) =	10.50	
BATTER ( ) =	0	
BASE (L) =	10	

BACKFILL SPECIFICATIONS

SELECT	INTERNAL FRICTION (Ø)=	34	DEG	Ka =	0.3140
	WEIGHT ( )=	120	PCF	Ko =	0.4408
	COHESION=	0	(assumed)		
UNCLASSIFIED	INTERNAL FRICTION (Ø)=	30	DEG	Ka =	0.3743
	WEIGHT ( )=	120	PCF		
	COHESION =	0	(assumed)		
FOUNDATION	FOUNDATION TYPE	S	(S for Soil, R for rock)		
	INTERNAL FRICTION (Øf) =	30	DEG	Kp =	3.0000

FRICTION FACTORS

JOINT MATERIAL TO CONCRETE =	0.59	
SELECT FILL TO CONCRETE =	0.50	
UNCLASSIFIED FILL TO CONCRETE =	0.50	
SELECT FILL TO FOUNDATION = tan(ø)	0.58	(Ø is min of select fill and foundation)
PRECAST CONCRETE TO FOUNDATION =	0.46	(0.8*TAN Øf)

SHEAR KEY STRENGTH = 2460 lbs.

WATER PRESSURE

HEIGHT OF WATER TABLE BEHIND WALL =	0	FT	(From bottom of wall)
HEIGHT OF WATER TABLE BEFORE WALL =	0	FT	(From bottom of wall)

Date: 12/30/14
Designed By: CTH
Checked by: KD

RESISTANCE FACTORS

FRICTION BETWEEN SOIL & SOIL :	1.00	
FRICTION BETWEEN SOIL & CONC. :	0.90	
FRICTION BETWEEN JOINT & CONC. :	0.90	
SHEAR THROUGH SHEAR KEY :	0.90	
PASSIVE PRESSURE AGAINST SLIDING :	0.50	(Not used for this project)
PASSIVE PRESSURE AGAINST OVERTURN. :	0.60	(Not used for this project)

LOAD FACTORS

DC (WEIGHT OF CONCRETE) :	0.90
EV (WEIGHT OF SOIL) :	1.00
EARTH PRESSURES (EH)	
HORIZONTAL COMPONENT :	1.50
VERTICAL COMPONENT :	1.50
LL (VEHICULAR LIVE LOAD), LS (LIVE LOAD SURCHARGE) :	1.75
WATER PRESSURE :	1.00

GLOBAL STABILITY

OVERTURNING

SUM FACTORED OVERTURNING MOMENTS	239737
SUM FACTORED RESISTING MOMENTS	511259
PERFORMANCE RATIO	2.13

SLIDING

SUM FACTORED HORIZONTAL FORCE	44871
FACTORED RESISTING FRICTION FORCE	50175
PERFORMANCE RATIO	1.12

MAXIMUM BEARING PRESSURE

Meyerhof distribution which considers a uniform base pressure distribution over an effective width of B' = L - 2e

Live load surcharge is present on the wall and behind the wall

MAXIMUM BEARING PRESSURE: Sv = SUM VERTICAL LOADS/(L-2e)

FACTORED SUM OF VERTICAL LOADS =	111061	LB/5 FT WIDTH			
FACTORED e =	1.61	≤ L/4 =	2.50	ft	ON SOIL
FACTORED BEARING PRESSURE =	3276	PSF			
FACTORED BEARING RESISTANCE =	#N/A	PSF			
PERFORMANCE RATIO =	#N/A				

Date: 12/30/14
Designed By: CTH
Checked by: KD

PERFORMANCE RATIO AT EACH LEVEL

Live load is present behind the wall, but not on the wall

LEVEL	HEIGHT	STEM LENGTH	No. OF SHEAR KEYS	FACTORED LOAD EFFECT	FACTORED RESISTANCE	PERFORMANCE RATIO
1	5.50	6.00	2			
			OVERTURNING	77371	101955	1.32
			SLIDING	21458	23766	1.11
			PULLOUT	7478	10221	1.37
2	8.00	8.00	2			
			OVERTURNING	143921	254159	1.77
			SLIDING	32128	40932	1.27
			PULLOUT	5709	15786	2.77
3	10.50	10.00	0			
			OVERTURNING	239737	511259	2.13
			SLIDING	44871	50175	1.12
			PULLOUT	7274	17471	2.40
4	13.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
5	15.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
6	18.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
7	20.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
8	23.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
9	25.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
10	28.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
11	30.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
12	33.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A

Date: 12/30/14
Designed By: CTH
Checked by: KD

LEVEL 3

STEM LENGTH =	10.00	FT
HEIGHT =	14.25	FT

EARTH PRESSURE			TRAFFIC SURCHARGE & EARTH PRESSURE		
Pa =	4560.33	plf	Pt =	1280.09	plf
Feh =	22446.55	lbs.	Ft =	6400.46	lbs.
Fev =	4008.31	lbs.	Fw =	0.00	lbs.

STABILITY AGAINST SLIDING - LEVEL 3

SLIDING FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
Feh	22446.55	1.50	33669.83
Ft	6400.46	1.75	11200.80
Fw	0.00	1.00	0.00
TOTAL			44870.63

RESISTING FORCE

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
THRU SELECT FILL OR FOUNDATION	73720.43	1.00	0.58	1.00	42562.51
Fev	4008.31	1.50	0.58	1.00	3471.30
THRU JT. MAT'L OR FOUNDATION	11069.63	0.90	0.46	0.90	4141.40
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	0.90	0.00
EMBEDMENT	0.00	#N/A	#N/A	0.50	0.00
TOTAL					50175.21

PERFORMANCE RATIO = 1.12

STABILITY AGAINST PULLOUT - LEVEL 3

PULLOUT FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
PULLOUT FORCE	3859.96	1.50	5789.94
TRAFFIC SURCHARGE FORCE	847.79	1.75	1483.63
WATER PRESSURE	0.00	1.00	0.00
TOTAL			7273.56

RESISTING FORCE

Aeff. = 44.18 SF

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
ON STEM(SOIL TO SOIL IN Aeff)	6677.45	1.00	0.67	1.00	4504.00
ON STEM (SOIL TO CONCRETE IN A	19611.72	1.00	0.50	0.90	8825.27
THRU JT. MAT'L OR FOUNDATION	11069.63	0.90	0.46	0.90	4141.40
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	0.90	0.00
TOTAL					17470.67

PERFORMANCE RATIO = 2.40

Date: 12/30/14
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 3

OVERTURNING MOMENT

	FORCE	MOMENT ARM	OVERTURNING MOMENT	LOAD FACTOR	FACTORED MOMENT
Feh	22446.55	4.75	106621.12	1.50	159931.69
Ft	6400.46	7.13	45603.26	1.75	79805.70
Fw	0.00	0.00	0.00	1.00	0.00
TOTAL					239737.39

RESISTING MOMENT

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED MOMENT
UNIT L1	2961.00	1.08	0.00	0.90	2664.90	2878.09
UNIT L2	2098.00	2.31	0.00	0.90	1888.20	4361.74
UNIT L3	2360.00	3.09	0.00	0.90	2124.00	6563.16
SELECT FILL L1	17431.20	3.25	0.00	1.00	17431.20	56651.40
SELECT FILL L2	10321.20	4.25	0.00	1.00	10321.20	43865.10
SELECT FILL L3	13112.40	5.25	0.00	1.00	13112.40	68840.10

Date: 12/30/14
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 3 (CONTINUED)

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED MOMENT
STEP L2	6600.00	7.00	0.00	1.00	6600.00	46200.00
STEP L3	9600.00	9.00	0.00	1.00	9600.00	86400.00
EARTH SURCHARGE	20306.25	6.67	0.00	1.00	20306.25	135375.00
Fev	4008.31	10.00	0.00	1.50	6012.47	60124.69
TOTAL					90060.62	511259.29

PERFORMANCE RATIO = 2.13

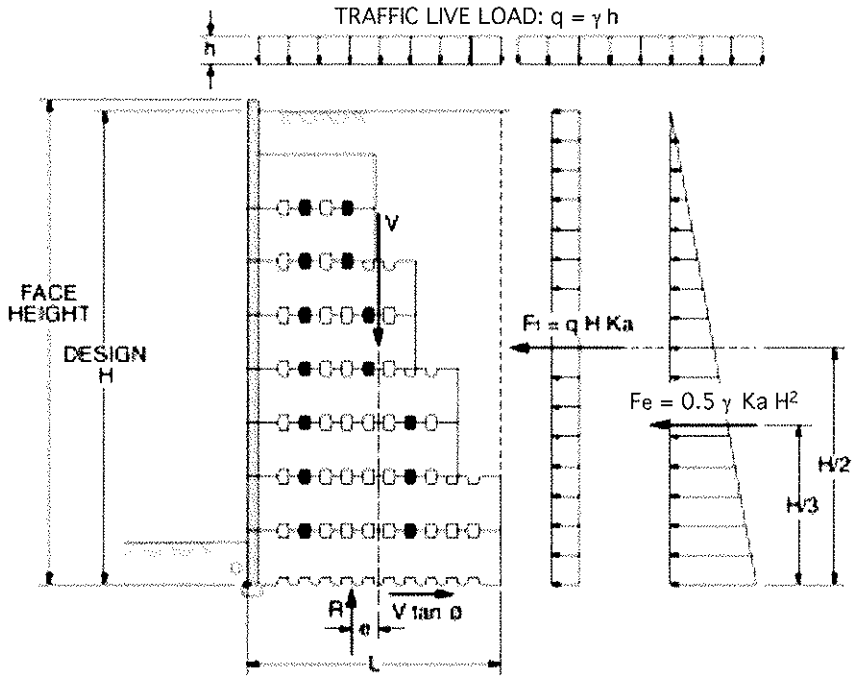
T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
LIMIT STATE: **STRENGTH-I MAX**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)
Level Surcharge and Infinite Slope Condition

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Comment: Wall 3

Project No: 4437
Date: 12/30/14
Designed By: CTH
Checked by: KD

Load Diagram:



Typical Section (For illustration only, Some details may not apply)

External Stability Calculation (STRENGTH-I MAX)

Stability Against Overturning: (moments about point "O")

Σ Factored Resisting Moments = $\phi V \cdot x_O$ (x_O is the horiz. distance between V and O)

Σ Factored overturning Momen = $\gamma_e F_e (H/3) + \gamma_t F_t (H/2)$

Stability Against Sliding:

Σ Factored Resisting Force = $\phi V \tan \phi_F$

Σ Factored Driving Force = $\gamma_e F_e + \gamma_t F_t$

Bearing Pressure:

Factored Bearing Pressure = $(\gamma_1 V + \gamma_2 qL)/(L - 2e)$ (use factored e)

Eccentricity:

Eccentricity (e) = $\dfrac{L}{2} - \dfrac{(V + qL)(L/2) - [F_V(H/3) + F_t(H/2)]}{V + qL}$

(use factored V, qL, Fe, Ft for factored e)
(q=0, Ft=0 for this case)

T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
Level Surcharge and Infinite Slope Condition
LIMIT STATE: STRENGTH-I MAX
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858

Project No: 4437
Date: 12/30/14
By: CTH
Checked by: KD

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Wall Name: Wall 3

GRADING GEOMETRY

DISTANCE TO SLOPE (d) =	0	FT	
FILL SURCHARGE =	3.75	FT	
DISTANCE TO BREAK =	5	FT	
SLOPE ANGLE (ß1) =	36.9	DEG	
SLOPE ANGLE (I) =	10.1	DEG	
TRAFFIC SURCHARGE =	2	FT	

WALL GEOMETRY

HEIGHT (H) =	10.50	
BATTER ( ) =	0	
BASE (L) =	10	

BACKFILL SPECIFICATIONS

SELECT	INTERNAL FRICTION (Ø)=	34	DEG	Ka =	0.3140
	WEIGHT ( )=	120	PCF	Ko =	0.4408
	COHESION=	0	(assumed)		
UNCLASSIFIED	INTERNAL FRICTION (Ø)=	30	DEG	Ka =	0.3743
	WEIGHT ( )=	120	PCF		
	COHESION =	0	(assumed)		
FOUNDATION	FOUNDATION TYPE	S	(S for Soil, R for rock)		
	INTERNAL FRICTION (Ø)=	30	DEG	Kp =	3.0000

FRICTION FACTORS

JOINT MATERIAL TO CONCRETE =	0.59	
SELECT FILL TO CONCRETE =	0.50	
UNCLASSIFIED FILL TO CONCRETE =	0.50	
SELECT FILL TO FOUNDATION = tan(ø)	0.58	(Ø is min of select fill and foundation)
PRECAST CONCRETE TO FOUNDATION =	0.46	(0.8*TAN Øf)

SHEAR KEY STRENGTH = 2460 lbs.

WATER PRESSURE

HEIGHT OF WATER TABLE BEHIND WALL =	0	FT	(From bottom of wall)
HEIGHT OF WATER TABLE BEFORE WALL =	0	FT	(From bottom of wall)

Date: 12/30/14
Designed By: CTH
Checked by: KD

RESISTANCE FACTORS

FRICTION BETWEEN SOIL & SOIL :	1.00	
FRICTION BETWEEN SOIL & CONC. :	0.90	
FRICTION BETWEEN JOINT & CONC. :	0.90	
SHEAR THROUGH SHEAR KEY :	0.90	
PASSIVE PRESSURE AGAINST SLIDING :	0.50	(Not used for this project)
PASSIVE PRESSURE AGAINST OVERTURN. :	0.60	(Not used for this project)

LOAD FACTORS

DC (WEIGHT OF CONCRETE) :	1.25
EV (WEIGHT OF SOIL) :	1.35
EARTH PRESSURES (EH)	
HORIZONTAL COMPONENT :	1.50
VERTICAL COMPONENT :	1.50
LL (VEHICULAR LIVE LOAD), LS (LIVE LOAD SURCHARGE) :	1.75
WATER PRESSURE :	1.00

GLOBAL STABILITY

OVERTURNING

SUM FACTORED OVERTURNING MOMENTS	239737
SUM FACTORED RESISTING MOMENTS	669693
PERFORMANCE RATIO	2.79

SLIDING

SUM FACTORED HORIZONTAL FORCE	44871
FACTORED RESISTING FRICTION FORCE	66683
PERFORMANCE RATIO	1.49

MAXIMUM BEARING PRESSURE

Meyerhof distribution which considers a uniform base pressure distribution over an effective width of B' = L - 2e

Live load surcharge is present on the wall and behind the wall

MAXIMUM BEARING PRESSURE: Sv = SUM VERTICAL LOADS/(L-2e)

FACTORED SUM OF VERTICAL LOADS =	140737	LB/5 FT WIDTH			
FACTORED e =	1.20	≤ L/4 =	2.50	ft	ON SOIL
FACTORED BEARING PRESSURE =	3703	PSF			
FACTORED BEARING RESISTANCE =	#N/A	PSF			
PERFORMANCE RATIO =	#N/A				

Date: 12/30/14
Designed By: CTH
Checked by: KD

PERFORMANCE RATIO AT EACH LEVEL

Live load is present behind the wall, but not on the wall

LEVEL	HEIGHT	STEM LENGTH	No. OF SHEAR KEYS	FACTORED LOAD EFFECT	FACTORED RESISTANCE	PERFORMANCE RATIO
1	5.50	6.00	2			
			OVERTURNING	77371	132431	1.71
			SLIDING	21458	30004	1.40
			PULLOUT	7478	12316	1.65
2	8.00	8.00	2			
			OVERTURNING	143921	331951	2.31
			SLIDING	32128	52873	1.65
			PULLOUT	5709	19892	3.48
3	10.50	10.00	0			
			OVERTURNING	239737	669693	2.79
			SLIDING	44871	66683	1.49
			PULLOUT	7274	23746	3.26
4	13.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
5	15.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
6	18.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
7	20.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
8	23.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
9	25.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
10	28.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
11	30.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
12	33.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A

Date: 12/30/14
Designed By: CTH
Checked by: KD

LEVEL 3

STEM LENGTH = 10.00 FT
HEIGHT = 14.25 FT

EARTH PRESSURE			TRAFFIC SURCHARGE & EARTH PRESSURE		
Pa =	4560.33	plf	Pt =	1280.09	plf
Feh =	22446.55	lbs.	Ft =	6400.46	lbs.
Fev =	4008.31	lbs.	Fw =	0.00	lbs.

STABILITY AGAINST SLIDING - LEVEL 3

SLIDING FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
Feh	22446.55	1.50	33669.83
Ft	6400.46	1.75	11200.80
Fw	0.00	1.00	0.00
TOTAL			44870.63

RESISTING FORCE

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
THRU SELECT FILL OR FOUNDATION	73720.43	1.35	0.58	1.00	57459.38
Fev	4008.31	1.50	0.58	1.00	3471.30
THRU JT. MAT'L OR FOUNDATION	11069.63	1.25	0.46	0.90	5751.95
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	0.90	0.00
EMBEDMENT	0.00	#N/A	#N/A	0.50	0.00
TOTAL					66682.63

PERFORMANCE RATIO = 1.49

STABILITY AGAINST PULLOUT - LEVEL 3

PULLOUT FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
PULLOUT FORCE	3859.96	1.50	5789.94
TRAFFIC SURCHARGE FORCE	847.79	1.75	1483.63
WATER PRESSURE	0.00	1.00	0.00
TOTAL			7273.56

RESISTING FORCE

Aeff. = 44.18 SF

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
ON STEM(SOIL TO SOIL IN Aeff)	6677.45	1.35	0.67	1.00	6080.39
ON STEM (SOIL TO CONCRETE IN A	19611.72	1.35	0.50	0.90	11914.12
THRU JT. MAT'L OR FOUNDATION	11069.63	1.25	0.46	0.90	5751.95
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	0.90	0.00
TOTAL					23746.46

PERFORMANCE RATIO = 3.26

Date: 12/30/14
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 3

OVERTURNING MOMENT

	FORCE	MOMENT ARM	OVERTURNING MOMENT	LOAD FACTOR	FACTORED MOMENT
Feh	22446.55	4.75	106621.12	1.50	159931.69
Ft	6400.46	7.13	45603.26	1.75	79805.70
Fw	0.00	0.00	0.00	1.00	0.00
TOTAL					239737.39

RESISTING MOMENT

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED MOMENT
UNIT L1	2961.00	1.08	0.00	1.25	3701.25	3997.35
UNIT L2	2098.00	2.31	0.00	1.25	2622.50	6057.98
UNIT L3	2360.00	3.09	0.00	1.25	2950.00	9115.50
SELECT FILL L1	17431.20	3.25	0.00	1.35	23532.12	76479.39
SELECT FILL L2	10321.20	4.25	0.00	1.35	13933.62	59217.89
SELECT FILL L3	13112.40	5.25	0.00	1.35	17701.74	92934.14

Date: 12/30/14
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 3 (CONTINUED)

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED MOMENT
STEP L2	6600.00	7.00	0.00	1.35	8910.00	62370.00
STEP L3	9600.00	9.00	0.00	1.35	12960.00	116640.00
EARTH SURCHARGE	20306.25	6.67	0.00	1.35	27413.44	182756.25
Fev	4008.31	10.00	0.00	1.50	6012.47	60124.69
TOTAL					119737.14	669693.18

PERFORMANCE RATIO = 2.79

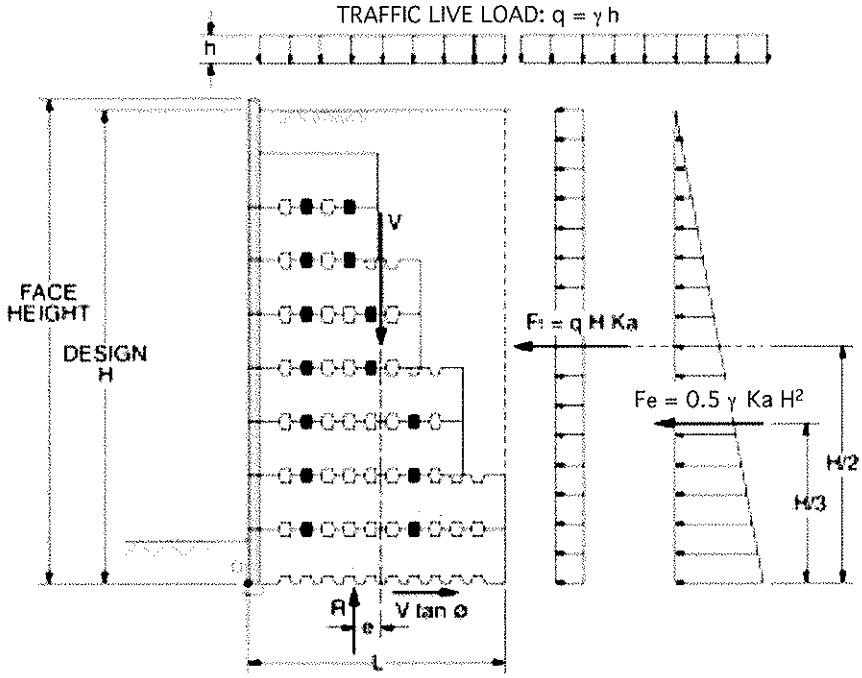
T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
LIMIT STATE: **SERVICE-I**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)
Level Surcharge and Infinite Slope Condition

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Comment: Wall 3

Project No: 4437
Date: 12/30/14
Designed By: CTH
Checked by: KD

Load Diagram:



Typical Section, All details may not apply

External Stability Calculation (SERVICE-I)

Stability Against Overturning: (moments about point "O")

Σ Factored Resisting Moments = $\phi V \cdot x_o$ (x_o is the horiz. distance between V and O)

Σ Factored overturning Momen = $\gamma_e F_e (H/3) + \gamma_t F_t (H/2)$

Stability Against Sliding:

Σ Factored Resisting Force = $\phi V \tan \phi_F$

Σ Factored Driving Force = $\gamma_e F_e + \gamma_t F_t$

Bearing Pressure:

Factored Bearing Pressure = $(\gamma_1 V + \gamma_2 qL)/(L - 2e)$ (use factored e)

Eccentricity:

Eccentricity (e) = $\dfrac{L}{2} - \dfrac{(V + qL)(L/2) - [F_V(H/3) + F_t(H/2)]}{V + qL}$

(use factored V, qL, Fe, Ft for factored e)

T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
Level Surcharge and Infinite Slope Condition
LIMIT STATE: **SERVICE-I**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858

Project No: 4437
Date: 12/30/14
By: CTH
Checked by: KD

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Comment: Wall 3

GRADING GEOMETRY

DISTANCE TO SLOPE (d) =	0	FT	
FILL SURCHARGE =	3.75	FT	
DISTANCE TO BREAK =	5	FT	
SLOPE ANGLE (ß1) =	36.9	DEG	
SLOPE ANGLE (I) =	10.1	DEG	
TRAFFIC SURCHARGE =	2	FT	

WALL GEOMETRY

HEIGHT (H) =	10.50	
BATTER ( ) =	0	
BASE (L) =	10	

BACKFILL SPECIFICATIONS

SELECT	INTERNAL FRICTION (Ø)=	34	DEG	Ka =	0.3140
	WEIGHT ( )=	120	PCF	Ko =	0.4408
	COHESION=	0	(assumed)		
UNCLASSIFIED	INTERNAL FRICTION (Ø)=	30	DEG	Ka =	0.3743
	WEIGHT ( )=	120	PCF		
	COHESION =	0	(assumed)		
FOUNDATION	FOUNDATION TYPE	S	(S for Soil, R for rock)		
	INTERNAL FRICTION (Ø)=	30	DEG	Kp =	3.0000

FRICTION FACTORS

JOINT MATERIAL TO CONCRETE =	0.59	
SELECT FILL TO CONCRETE =	0.50	
UNCLASSIFIED FILL TO CONCRETE =	0.50	
SELECT FILL TO FOUNDATION = tan(ø)	0.58	(Ø is min of select fill and foundation)
PRECAST CONCRETE TO FOUNDATION =	0.46	(0.8*TAN Øf)

SHEAR KEY STRENGTH = 2460 lbs.

WATER PRESSURE

HEIGHT OF WATER TABLE BEHIND WALL =	0	FT	(From bottom of wall)
HEIGHT OF WATER TABLE BEFORE WALL =	0	FT	(From bottom of wall)

WIND ON SOUND BARRIER/OTHER STRUCTURE

WIND FORCE =	0	LBS
DISTANCE FROM TOP OF WALL/GUTTER LINE =	0	FT

Date: 12/30/14
Designed By: CTH
Checked by: KD

RESISTANCE FACTORS

FRICTION BETWEEN SOIL & SOIL :	1.00	
FRICTION BETWEEN SOIL & CONC. :	1.00	
FRICTION BETWEEN JOINT & CONC. :	1.00	
SHEAR THROUGH SHEAR KEY :	1.00	
PASSIVE PRESSURE AGAINST SLIDING :	1.00	(Not used for this project)
PASSIVE PRESSURE AGAINST OVERTURN. :	1.00	(Not used for this project)

LOAD FACTORS

DC (WEIGHT OF CONCRETE) :	1.00
EV (WEIGHT OF SOIL) :	1.00
EARTH PRESSURES (EH)	
HORIZONTAL COMPONENT :	1.00
VERTICAL COMPONENT :	1.00
LL (VEHICULAR LIVE LOAD), LS (LIVE LOAD SURCHARGE) :	1.00
WATER PRESSURE :	1.00
WIND LOAD :	0.30

GLOBAL STABILITY

OVERTURNING

SUM FACTORED OVERTURNING MOMENTS:	152224
SUM FACTORED RESISTING MOMENTS:	492751
PERFORMANCE RATIO:	3.24

SLIDING

SUM FACTORED HORIZONTAL FORCE:	28847
FACTORED RESISTING FRICTION FORCE:	49990
PERFORMANCE RATIO:	1.73

MAXIMUM BEARING PRESSURE

Meyerhof distribution which considers a uniform base pressure distribution over an effective width of B' = L - 2e

Live load surcharge is present on the wall and behind the wall

MAXIMUM BEARING PRESSURE: σ_v = SUM VERTICAL LOADS/(L-2e)

FACTORED SUM OF VERTICAL LOADS =	100798	LB/5 FT WIDTH			
FACTORED e =	1.03	≤ L/4 =	2.50	ft	ON SOIL
FACTORED BEARING PRESSURE =	2537	PSF			
FACTORED BEARING CAPACITY =	#N/A	PSF			
PERFORMANCE RATIO =	#N/A				

Date: 12/30/14
Designed By: CTH
Checked by: KD

FACTORS OF SAFETY AT EACH LEVEL

Live load is present behind the wall, but not on the wall

LEVEL	HEIGHT	STEM LENGTH	No. OF SHEAR KEYS	FACTORED LOAD EFFECT	FACTORED RESISTANCE	PERFORMANCE RATIO
1	5.50	6.00	2			
			OVERTURNING	48378	97208	2.01
			SLIDING	13613	24097	1.77
			PULLOUT	4656	11419	2.45
2	8.00	8.00	2			
			OVERTURNING	90780	244063	2.69
			SLIDING	20539	41288	2.01
			PULLOUT	3665	17651	4.82
3	10.50	10.00	0			
			OVERTURNING	152224	492751	3.24
			SLIDING	28847	49990	1.73
			PULLOUT	4708	19423	4.13
4	13.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
5	15.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
6	18.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
7	20.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
8	23.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
9	25.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
10	28.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
11	30.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
12	33.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A

Date: 12/30/14
Designed By: CTH
Checked by: KD

LEVEL 3

STEM LENGTH = 10.00 FT
HEIGHT = 14.25 FT

EARTH PRESSURE			TRAFFIC SURCHARGE & WATER PRESSURE		
Pa =	4560.33	plf	Pt =	1280.09	plf
Feh =	22446.55	lbs.	Ft =	6400.46	lbs.
Fev =	4008.31	lbs.	Fw =	0.00	lbs.

STABILITY AGAINST SLIDING - LEVEL 3

SLIDING FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
Feh	22446.55	1.00	22446.55
Ft	6400.46	1.00	6400.46
Fw	0.00	1.00	0.00
WIND LOAD	0.00	0.30	0.00
TOTAL			28847.01

RESISTING FORCE

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
THRU SELECT FILL OR FOUNDATION	73720.43	1.00	0.58	1.00	42562.5
Fev	4008.31	1.00	0.58	1.00	2314.2
THRU JT. MATERIAL OR FOUNDATIC	11069.63	1.00	0.46	1.00	5112.8
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	1.00	0.0
EMBEDMENT	0.00	#N/A	#N/A	1.00	0.0
TOTAL					49989.5

PERFORMANCE RATIO = 1.73

STABILITY AGAINST PULLOUT - LEVEL 3

PULLOUT FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
PULLOUT FORCE =	3859.96	1.00	3859.96
TRAFFIC SURCHARGE FORCE =	847.79	1.00	847.79
WATER PRESSURE =	0.00	1.00	0.00
TOTAL			4707.75

RESISTING FORCE

Aeff. = 44.18 SF

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
ON STEM(SOIL TO SOIL IN Aeff)	6677.45	1.00	0.67	1.00	4504.0
ON STEM (SOIL TO CONCRETE IN A	19611.72	1.00	0.50	1.00	9805.9
THRU JT. MATERIAL OR FOUNDATIC	11069.63	1.00	0.46	1.00	5112.8
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	1.00	0.0
TOTAL					19422.7

PERFORMANCE RATIO = 4.13

Date: 12/30/14
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 3

OVERTURNING MOMENT

	FORCE	MOMENT ARM	OVERTURNING MOMENT	LOAD FACTOR	FACTORED MOMENT
Feh	22446.55	4.75	106621.1	1.00	106621.1
Ft	6400.46	7.13	45603.3	1.00	45603.3
Fw	0.00	0.00	0.0	1.00	0.0
WIND LOAD	0.00	10.50	0.00	0.30	0.00
TOTAL					152224.4

RESISTING MOMENT

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED RESISTANCE
PANEL L1	2961.00	1.08	0.00	1.00	2961.0	3197.9
PANEL L2	2098.00	2.31	0.00	1.00	2098.0	4846.4
PANEL L3	2360.00	3.09	0.00	1.00	2360.0	7292.4
SELECT FILL L1	17431.20	3.25	0.00	1.00	17431.2	56651.4
SELECT FILL L2	10321.20	4.25	0.00	1.00	10321.2	43865.1
SELECT FILL L3	13112.40	5.25	0.00	1.00	13112.4	68840.1

Date: 12/30/14
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 3 (CONTINUED)

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED RESISTANCE
STEP L2	6600.00	7.00	0.00	1.00	6600.0	46200.0
STEP L3	9600.00	9.00	0.00	1.00	9600.0	86400.0
EARTH SURCHARGE	20306.25	6.67	0.00	1.00	20306.3	135375.0
Fev	4008.31	10.00	0.00	1.00	4008.3	40083.1
TOTAL					88798.36	492751.39

PERFORMANCE RATIO = 3.24

Wall 4

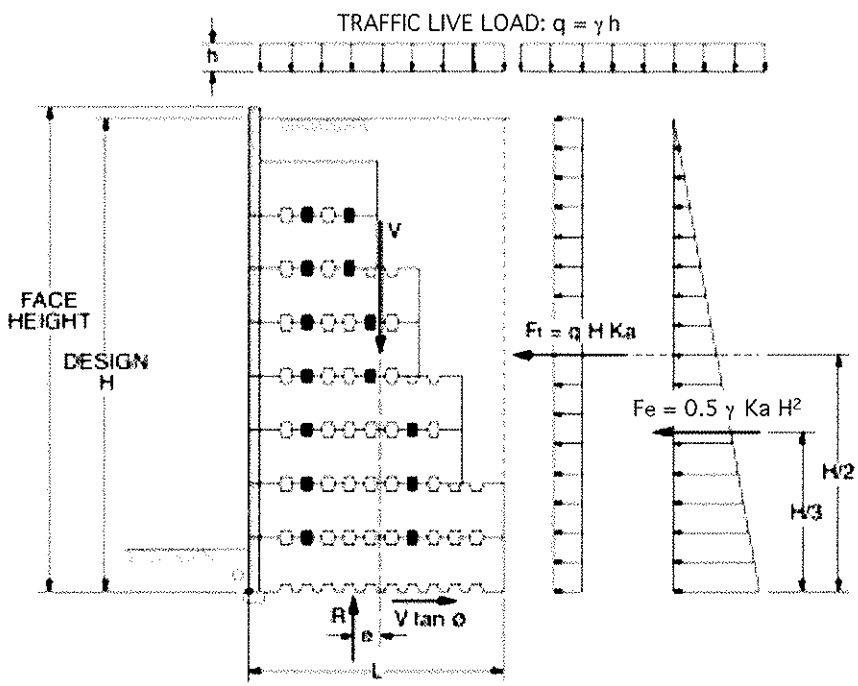
T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
LIMIT STATE: **STRENGTH-I MIN**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)
Level Surcharge and Infinite Slope Condition

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Comment: Wall 4

Project No: TW4437
Date: 1/19/15
Designed By: CTH
Checked by: KD

Load Diagram:



Typical Section (For illustration only, Some details may not apply)

External Stability Calculation (STRENGTH-I MIN)

Stability Against Overturning: (moments about point "O")

Σ Factored Resisting Moments = $\phi V \cdot x_0$ (x_0 is the horiz. distance between V and O)

Σ Factored overturning Momen = $\gamma_e F_e (H/3) + \gamma_t F_t (H/2)$

Stability Against Sliding:

Σ Factored Resisting Force = $\phi V \tan \phi_F$

Σ Factored Driving Force = $\gamma_e F_e + \gamma_t F_t$

Bearing Pressure:

Factored Bearing Pressure = $(\gamma_1 V + \gamma_2 qL)/(L - 2e)$ (use factored e)

Eccentricity:

Eccentricity (e) = $\dfrac{L}{2} - \dfrac{(V + qL)(L/2) - [F_V(H/3) + F_t(H/2)]}{V + qL}$

(use factored V, qL, Fe, Ft for factored e)
(q=0, Ft=0 for this case)

T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
Level Surcharge and Infinite Slope Condition
LIMIT STATE: **STRENGTH-I MIN**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858
Project No: TW4437
Date: 1/19/15
By: CTH
Checked by: KD

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Wall Name: Wall 4

GRADING GEOMETRY

DISTANCE TO SLOPE (d) =	0	FT	
FILL SURCHARGE =	3.75	FT	
DISTANCE TO BREAK =	5	FT	
SLOPE ANGLE (ß1) =	36.9	DEG	
SLOPE ANGLE (I) =	8.5	DEG	
TRAFFIC SURCHARGE =	2	FT	

WALL GEOMETRY

HEIGHT (H) =	12.50	
BATTER ( ) =	0	
BASE (L) =	10	

BACKFILL SPECIFICATIONS

SELECT	INTERNAL FRICTION (Ø)=	34	DEG	Ka =	0.3083
	WEIGHT ( )=	120	PCF	Ko =	0.4408
	COHESION=	0	(assumed)		
UNCLASSIFIED	INTERNAL FRICTION (Ø)=	30	DEG	Ka =	0.3667
	WEIGHT ( )=	120	PCF		
	COHESION =	0	(assumed)		
FOUNDATION	FOUNDATION TYPE	S	(S for Soil, R for rock)		
	INTERNAL FRICTION (Øf) =	30	DEG	Kp =	3.0000

FRICTION FACTORS

JOINT MATERIAL TO CONCRETE =	0.59	
SELECT FILL TO CONCRETE =	0.50	
UNCLASSIFIED FILL TO CONCRETE =	0.50	
SELECT FILL TO FOUNDATION = tan(ø)	0.58	(Ø is min of select fill and foundation)
PRECAST CONCRETE TO FOUNDATION =	0.46	(0.8*TAN Øf)

SHEAR KEY STRENGTH = 2460 lbs.

WATER PRESSURE

HEIGHT OF WATER TABLE BEHIND WALL =	0	FT	(From bottom of wall)
HEIGHT OF WATER TABLE BEFORE WALL =	0	FT	(From bottom of wall)

Date: 01/19/15
Designed By: CTH
Checked by: KD

RESISTANCE FACTORS

FRICTION BETWEEN SOIL & SOIL :	1.00	
FRICTION BETWEEN SOIL & CONC. :	0.90	
FRICTION BETWEEN JOINT & CONC. :	0.90	
SHEAR THROUGH SHEAR KEY :	0.90	
PASSIVE PRESSURE AGAINST SLIDING :	0.50	(Not used for this project)
PASSIVE PRESSURE AGAINST OVERTURN. :	0.60	(Not used for this project)

LOAD FACTORS

DC (WEIGHT OF CONCRETE) :	0.90
EV (WEIGHT OF SOIL) :	1.00
EARTH PRESSURES (EH)	
HORIZONTAL COMPONENT :	1.50
VERTICAL COMPONENT :	1.50
LL (VEHICULAR LIVE LOAD), LS (LIVE LOAD SURCHARGE) :	1.75
WATER PRESSURE :	1.00

GLOBAL STABILITY

OVERTURNING

SUM FACTORED OVERTURNING MOMENTS	335069
SUM FACTORED RESISTING MOMENTS	576001
PERFORMANCE RATIO	1.72

SLIDING

SUM FACTORED HORIZONTAL FORCE	55602
FACTORED RESISTING FRICTION FORCE	57159
PERFORMANCE RATIO	1.03

MAXIMUM BEARING PRESSURE

Meyerhof distribution which considers a uniform base pressure distribution over an effective width of B' = L - 2e

Live load surcharge is present on the wall and behind the wall

MAXIMUM BEARING PRESSURE: Sv = SUM VERTICAL LOADS/(L-2e)

FACTORED SUM OF VERTICAL LOADS =	123703	LB/5 FT WIDTH			
FACTORED e =	2.20	≤ L/4 =	2.50	ft	ON SOIL
FACTORED BEARING PRESSURE =	4424	PSF			
FACTORED BEARING RESISTANCE =	#N/A	PSF			
PERFORMANCE RATIO =	#N/A				

Date: 01/19/15
Designed By: CTH
Checked by: KD

PERFORMANCE RATIO AT EACH LEVEL

Live load is present behind the wall, but not on the wall

LEVEL	HEIGHT	STEM LENGTH	No. OF SHEAR KEYS	FACTORED LOAD EFFECT	FACTORED RESISTANCE	PERFORMANCE RATIO
1	5.00	6.00	2			
			OVERTURNING	65917	92604	1.40
			SLIDING	19231	22119	1.15
			PULLOUT	6334	9807	1.55
2	7.50	8.00	2			
			OVERTURNING	126175	236645	1.88
			SLIDING	29315	38669	1.32
			PULLOUT	5315	15210	2.86
3	10.00	8.00	2			
			OVERTURNING	214192	297110	1.39
			SLIDING	41439	47665	1.15
			PULLOUT	6859	18504	2.70
4	12.50	10.00	0			
			OVERTURNING	335069	576001	1.72
			SLIDING	55602	57159	1.03
			PULLOUT	8402	20623	2.45
5	15.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
6	17.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
7	20.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
8	22.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
9	25.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
10	27.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
11	30.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
12	32.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A

Date: 01/19/15
Designed By: CTH
Checked by: KD

LEVEL 4

STEM LENGTH = 10.00 FT
HEIGHT = 16.25 FT

EARTH PRESSURE			TRAFFIC SURCHARGE & WATER PRESSURE		
Pa =	5809.55	plf	Pt =	1430.04	plf
Feh =	28726.38	lbs.	Ft =	7150.22	lbs.
Fev =	4308.96	lbs.	Fw =	0.00	lbs.

STABILITY AGAINST SLIDING - LEVEL 4

SLIDING FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
Feh	28726.38	1.50	43089.57
Ft	7150.22	1.75	12512.88
Fw	0.00	1.00	0.00
TOTAL			55602.45

RESISTING FORCE

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
THRU SELECT FILL OR FOUNDATION	84011.63	1.00	0.58	1.00	48504.13
Fev	4308.96	1.50	0.58	1.00	3731.67
THRU JT. MAT'L OR FOUNDATION	13160.63	0.90	0.46	0.90	4923.69
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	0.90	0.00
EMBEDMENT	0.00	#N/A	#N/A	0.50	0.00
TOTAL					57159.49

PERFORMANCE RATIO = 1.03

STABILITY AGAINST PULLOUT - LEVEL 4

PULLOUT FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
PULLOUT FORCE	4630.41	1.50	6945.61
TRAFFIC SURCHARGE FORCE	832.39	1.75	1456.69
WATER PRESSURE	0.00	1.00	0.00
TOTAL			8402.30

RESISTING FORCE

Aeff. = 44.18 SF

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
ON STEM(SOIL TO SOIL IN Aeff)	7864.55	1.00	0.67	1.00	5304.71
ON STEM (SOIL TO CONCRETE IN A	23098.24	1.00	0.50	0.90	10394.21
CONC. UNIT WEIGHT (THROUGH JOINT MATERIAL)	13160.63	0.90	0.46	0.90	4923.69
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	0.90	0.00
TOTAL					20622.61

PERFORMANCE RATIO = 2.45

Date: 01/19/15
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 4

OVERTURNING MOMENT

	FORCE	MOMENT ARM	OVERTURNING MOMENT	LOAD FACTOR	FACTORED MOMENT
Feh	28726.38	5.42	155601.24	1.50	233401.86
Ft	7150.22	8.13	58095.51	1.75	101667.15
Fw	0.00	0.00	0.00	1.75	0.00
TOTAL					335069.01

RESISTING MOMENT

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED MOMENT
UNIT L1	2774.00	1.14	0.00	0.90	2496.60	2846.12
UNIT L2	2098.00	2.31	0.00	0.90	1888.20	4361.74
UNIT L3	2098.00	2.31	0.00	0.90	1888.20	4361.74
UNIT L4	2360.00	3.09	0.00	0.90	2124.00	6563.16
SELECT FILL L1	15781.20	3.25	0.00	1.00	15781.20	51288.90
SELECT FILL L2	10321.20	4.25	0.00	1.00	10321.20	43865.10
SELECT FILL L3	10321.20	4.25	0.00	1.00	10321.20	43865.10
SELECT FILL L4	13112.40	5.25	0.00	1.00	13112.40	68840.10

Date: 01/19/15
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 4 (CONTINUED)

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED MOMENT
STEP L2	6000.00	7.00	0.00	1.00	6000.00	42000.00
STEP L3	0.00	8.00	0.00	1.00	0.00	0.00
STEP L4	12000.00	9.00	0.00	1.00	12000.00	108000.00
EARTH SURCHARGE	20306.25	6.67	0.00	1.00	20306.25	135375.00
Fev	4308.96	10.00	0.00	1.50	6463.44	64634.36
TOTAL					102702.69	576001.33

PERFORMANCE RATIO = 1.72

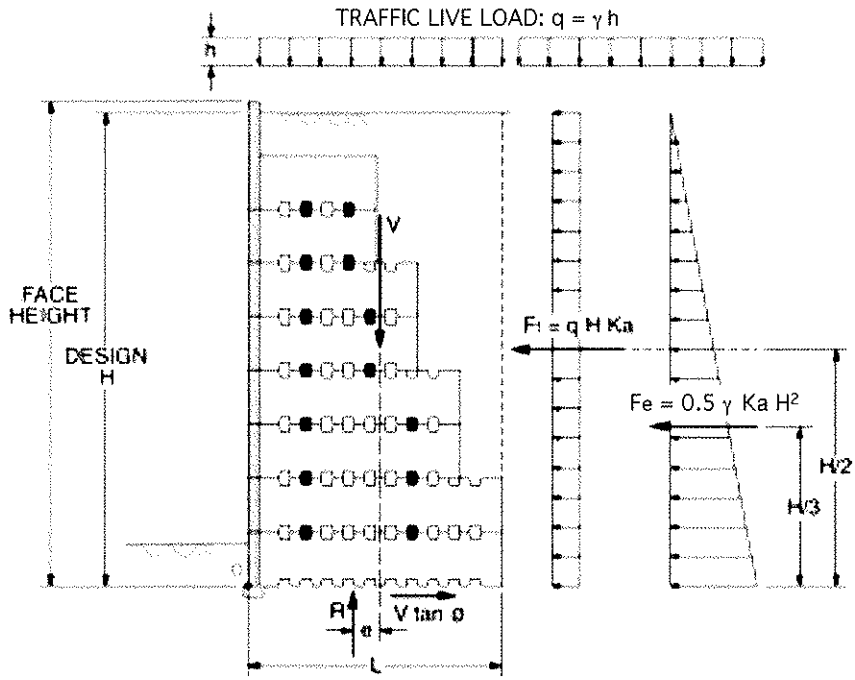
T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
LIMIT STATE: **STRENGTH-I MAX**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)
Level Surcharge and Infinite Slope Condition

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Comment: Wall 4

Project No: TW4437
Date: 1/19/15
Designed By: CTH
Checked by: KD

Load Diagram:



Typical Section (For illustration only, Some details may not apply)

External Stability Calculation (STRENGTH-I MAX)

Stability Against Overturning: (moments about point "O")

Σ Factored Resisting Moments = $\phi V \cdot x_O$ (x_o is the horiz. distance between V and O)

Σ Factored overturning Momen = $\gamma_e F_e (H/3) + \gamma_t F_t (H/2)$

Stability Against Sliding:

Σ Factored Resisting Force = $\phi V \tan \phi_F$

Σ Factored Driving Force = $\gamma_e F_e + \gamma_t F_t$

Bearing Pressure:

Factored Bearing Pressure = $(\gamma_1 V + \gamma_2 qL)/(L - 2e)$ (use factored e)

Eccentricity:

Eccentricity (e) = $\dfrac{L}{2} - \dfrac{(V + qL)(L/2) - [F_v(H/3) + F_t(H/2)]}{V + qL}$

(use factored V, qL, Fe, Ft for factored e)
(q=0, Ft=0 for this case)

T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
Level Surcharge and Infinite Slope Condition
LIMIT STATE: **STRENGTH-I MAX**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858

Project No: TW4437
Date: 1/19/15
By: CTH
Checked by: KD

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Wall Name: Wall 4

GRADING GEOMETRY

DISTANCE TO SLOPE (d) =	0	FT	
FILL SURCHARGE =	3.75	FT	
DISTANCE TO BREAK =	5	FT	
SLOPE ANGLE (ß1) =	36.9	DEG	
SLOPE ANGLE (I) =	8.5	DEG	
TRAFFIC SURCHARGE =	2	FT	

WALL GEOMETRY

HEIGHT (H) =	12.50	
BATTER ( ) =	0	
BASE (L) =	10	

BACKFILL SPECIFICATIONS

SELECT	INTERNAL FRICTION (Ø)=	34	DEG	Ka =	0.3083
	WEIGHT ( )=	120	PCF	Ko =	0.4408
	COHESION=	0	(assumed)		
UNCLASSIFIED	INTERNAL FRICTION (Ø)=	30	DEG	Ka =	0.3667
	WEIGHT ( )=	120	PCF		
	COHESION =	0	(assumed)		
FOUNDATION	FOUNDATION TYPE	S	(S for Soil, R for rock)		
	INTERNAL FRICTION (Ø)=	30	DEG	Kp =	3.0000

FRICTION FACTORS

JOINT MATERIAL TO CONCRETE =	0.59	
SELECT FILL TO CONCRETE =	0.50	
UNCLASSIFIED FILL TO CONCRETE =	0.50	
SELECT FILL TO FOUNDATION = tan(ø)	0.58	(Ø is min of select fill and foundation)
PRECAST CONCRETE TO FOUNDATION =	0.46	(0.8*TAN Øf)

SHEAR KEY STRENGTH = 2460 lbs.

WATER PRESSURE

HEIGHT OF WATER TABLE BEHIND WALL =	0	FT	(From bottom of wall)
HEIGHT OF WATER TABLE BEFORE WALL =	0	FT	(From bottom of wall)

Date: 01/19/15
Designed By: CTH
Checked by: KD

RESISTANCE FACTORS

FRICTION BETWEEN SOIL & SOIL :	1.00	
FRICTION BETWEEN SOIL & CONC. :	0.90	
FRICTION BETWEEN JOINT & CONC. :	0.90	
SHEAR THROUGH SHEAR KEY :	0.90	
PASSIVE PRESSURE AGAINST SLIDING :	0.50	(Not used for this project)
PASSIVE PRESSURE AGAINST OVERTURN. :	0.60	(Not used for this project)

LOAD FACTORS

DC (WEIGHT OF CONCRETE) :	1.25
EV (WEIGHT OF SOIL) :	1.35
EARTH PRESSURES (EH)	
HORIZONTAL COMPONENT :	1.50
VERTICAL COMPONENT :	1.50
LL (VEHICULAR LIVE LOAD), LS (LIVE LOAD SURCHARGE) :	1.75
WATER PRESSURE :	1.00

GLOBAL STABILITY

OVERTURNING

SUM FACTORED OVERTURNING MOMENTS	335069
SUM FACTORED RESISTING MOMENTS	755685
PERFORMANCE RATIO	2.26

SLIDING

SUM FACTORED HORIZONTAL FORCE	55602
FACTORED RESISTING FRICTION FORCE	76051
PERFORMANCE RATIO	1.37

MAXIMUM BEARING PRESSURE

Meyerhof distribution which considers a uniform base pressure distribution over an effective width of B' = L - 2e

Live load surcharge is present on the wall and behind the wall

MAXIMUM BEARING PRESSURE: Sv = SUM VERTICAL LOADS/(L-2e)

FACTORED SUM OF VERTICAL LOADS =	157713	LB/5 FT WIDTH			
FACTORED e =	1.67	≤ L/4 =	2.50	ft	ON SOIL
FACTORED BEARING PRESSURE =	4732	PSF			
FACTORED BEARING RESISTANCE =	#N/A	PSF			
PERFORMANCE RATIO =	#N/A				

Date: 01/19/15
Designed By: CTH
Checked by: KD

PERFORMANCE RATIO AT EACH LEVEL

Live load is present behind the wall, but not on the wall

LEVEL	HEIGHT	STEM LENGTH	No. OF SHEAR KEYS	FACTORED LOAD EFFECT	FACTORED RESISTANCE	PERFORMANCE RATIO
1	5.00	6.00	2			
			OVERTURNING	65917	121191	1.84
			SLIDING	19231	27933	1.45
			PULLOUT	6334	11754	1.86
2	7.50	8.00	2			
			OVERTURNING	126175	311077	2.47
			SLIDING	29315	50047	1.71
			PULLOUT	5315	19109	3.60
3	10.00	8.00	2			
			OVERTURNING	214192	388591	1.81
			SLIDING	41439	61870	1.49
			PULLOUT	6859	23595	3.44
4	12.50	10.00	0			
			OVERTURNING	335069	755685	2.26
			SLIDING	55602	76051	1.37
			PULLOUT	8402	28032	3.34
5	15.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
6	17.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
7	20.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
8	22.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
9	25.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
10	27.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
11	30.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
12	32.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A

Date: 01/19/15
Designed By: CTH
Checked by: KD

LEVEL 4

STEM LENGTH = 10.00 FT
HEIGHT = 16.25 FT

EARTH PRESSURE			TRAFFIC SURCHARGE & WATER PRESSURE		
Pa =	5809.55	plf	Pt =	1430.04	plf
Feh =	28726.38	lbs.	Ft =	7150.22	lbs.
Fev =	4308.96	lbs.	Fw =	0.00	lbs.

STABILITY AGAINST SLIDING - LEVEL 4

SLIDING FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
Feh	28726.38	1.50	43089.57
Ft	7150.22	1.75	12512.88
Fw	0.00	1.00	0.00
TOTAL			55602.45

RESISTING FORCE

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
THRU SELECT FILL OR FOUNDATION	84011.63	1.35	0.58	1.00	65480.58
Fev	4308.96	1.50	0.58	1.00	3731.67
THRU JT. MAT'L OR FOUNDATION	13160.63	1.25	0.46	0.90	6838.46
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	0.90	0.00
EMBEDMENT	0.00	#N/A	#N/A	0.50	0.00
TOTAL					76050.71

PERFORMANCE RATIO = 1.37

STABILITY AGAINST PULLOUT - LEVEL 4

PULLOUT FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
PULLOUT FORCE	4630.41	1.50	6945.61
TRAFFIC SURCHARGE FORCE	832.39	1.75	1456.69
WATER PRESSURE	0.00	1.00	0.00
TOTAL			8402.30

RESISTING FORCE

Aeff. = 44.18 SF

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
ON STEM(SOIL TO SOIL IN Aeff)	7864.55	1.35	0.67	1.00	7161.35
ON STEM (SOIL TO CONCRETE IN A	23098.24	1.35	0.50	0.90	14032.18
CONC. UNIT WEIGHT (THROUGH JOINT MATERIAL)	13160.63	1.25	0.46	0.90	6838.46
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	0.90	0.00
TOTAL					28032.00

PERFORMANCE RATIO = 3.34

Date: 01/19/15
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 4

OVERTURNING MOMENT

	FORCE	MOMENT ARM	OVERTURNING MOMENT	LOAD FACTOR	FACTORED MOMENT
Feh	28726.38	5.42	155601.24	1.50	233401.86
Ft	7150.22	8.13	58095.51	1.75	101667.15
Fw	0.00	0.00	0.00	1.75	0.00
TOTAL					335069.01

RESISTING MOMENT

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED MOMENT
UNIT L1	2774.00	1.14	0.00	1.25	3467.50	3952.95
UNIT L2	2098.00	2.31	0.00	1.25	2622.50	6057.98
UNIT L3	2098.00	2.31	0.00	1.25	2622.50	6057.98
UNIT L4	2360.00	3.09	0.00	1.25	2950.00	9115.50
SELECT FILL L1	15781.20	3.25	0.00	1.35	21304.62	69240.02
SELECT FILL L2	10321.20	4.25	0.00	1.35	13933.62	59217.89
SELECT FILL L3	10321.20	4.25	0.00	1.35	13933.62	59217.89
SELECT FILL L4	13112.40	5.25	0.00	1.35	17701.74	92934.14

Date: 01/19/15
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 4 (CONTINUED)

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED MOMENT
STEP L2	6000.00	7.00	0.00	1.35	8100.00	56700.00
STEP L3	0.00	8.00	0.00	1.35	0.00	0.00
STEP L4	12000.00	9.00	0.00	1.35	16200.00	145800.00
EARTH SURCHARGE	20306.25	6.67	0.00	1.35	27413.44	182756.25
Fev	4308.96	10.00	0.00	1.50	6463.44	64634.36
TOTAL					136712.97	755684.93

PERFORMANCE RATIO = 2.26

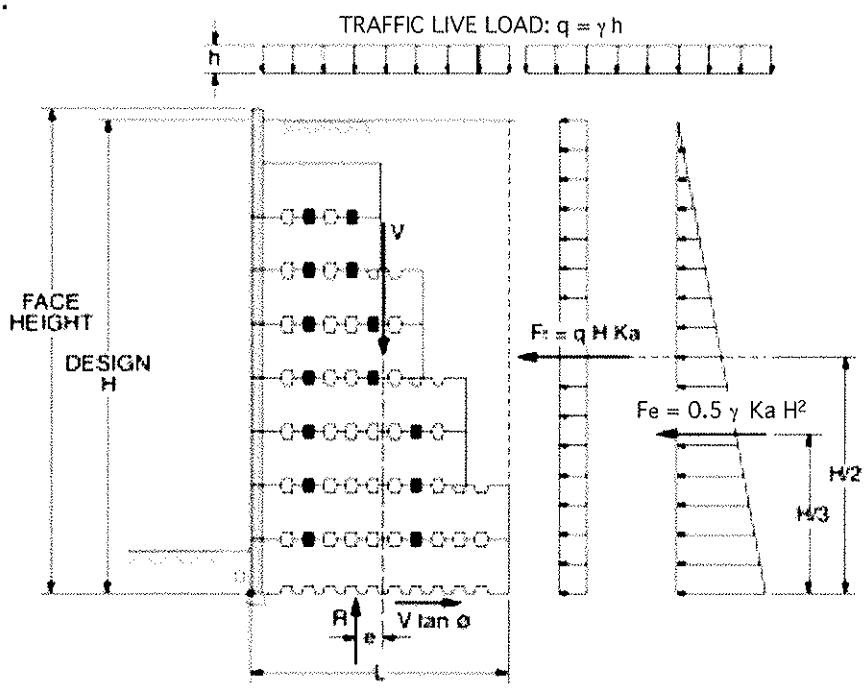
T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
LIMIT STATE: **SERVICE-I**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)
Level Surcharge and Infinite Slope Condition

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Comment: Wall 4

Project No: TW4437
Date: 01/19/15
Designed By: CTH
Checked by: KD

Load Diagram:



Typical Section, All details may not apply

External Stability Calculation (SERVICE-I)

Stability Against Overturning: (moments about point "O")

Σ Factored Resisting Moments = $\phi V \cdot x_o$ (x_o is the horiz. distance between V and O)

Σ Factored overturning Momen = $\gamma_e F_e (H/3) + \gamma_t F_t (H/2)$

Stability Against Sliding:

Σ Factored Resisting Force = $\phi V \tan \phi_F$

Σ Factored Driving Force = $\gamma_e F_e + \gamma_t F_t$

Bearing Pressure:

Factored Bearing Pressure = $(\gamma_1 V + \gamma_2 qL)/(L - 2e)$ (use factored e)

Eccentricity:

Eccentricity (e) = $\dfrac{L}{2} - \dfrac{(V + qL)(L/2) - [F_V(H/3) + F_t(H/2)]}{V + qL}$

(use factored V, qL, Fe, Ft for factored e)

T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
Level Surcharge and Infinite Slope Condition
LIMIT STATE: **SERVICE-I**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858

Project No: TW4437
Date: 1/19/15
By: CTH
Checked by: KD

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Comment: Wall 4

GRADING GEOMETRY

DISTANCE TO SLOPE (d) =	0	FT	
FILL SURCHARGE =	3.75	FT	
DISTANCE TO BREAK =	5	FT	
SLOPE ANGLE (ß1) =	36.9	DEG	
SLOPE ANGLE (I) =	8.5	DEG	
TRAFFIC SURCHARGE =	2	FT	

WALL GEOMETRY

HEIGHT (H) =	12.50	
BATTER ( ) =	0	
BASE (L) =	10	

BACKFILL SPECIFICATIONS

SELECT	INTERNAL FRICTION (Ø)=	34	DEG	Ka =	0.3083
	WEIGHT ( )=	120	PCF	Ko =	0.4408
	COHESION=	0	(assumed)		
UNCLASSIFIED	INTERNAL FRICTION (Ø)=	30	DEG	Ka =	0.3667
	WEIGHT ( )=	120	PCF		
	COHESION =	0	(assumed)		
FOUNDATION	FOUNDATION TYPE	S	(S for Soil, R for rock)		
	INTERNAL FRICTION (Ø)=	30	DEG	Kp =	3.0000

FRICTION FACTORS

JOINT MATERIAL TO CONCRETE =	0.59	
SELECT FILL TO CONCRETE =	0.50	
UNCLASSIFIED FILL TO CONCRETE =	0.50	
SELECT FILL TO FOUNDATION = tan(ø)	0.58	(Ø is min of select fill and foundation)
PRECAST CONCRETE TO FOUNDATION =	0.46	(0.8*TAN Øf)

SHEAR KEY STRENGTH = 2460 lbs.

WATER PRESSURE

HEIGHT OF WATER TABLE BEHIND WALL =	0	FT	(From bottom of wall)
HEIGHT OF WATER TABLE BEFORE WALL =	0	FT	(From bottom of wall)

WIND ON SOUND BARRIER/OTHER STRUCTURE

WIND FORCE =	0	LBS
DISTANCE FROM TOP OF WALL/GUTTER LINE =	0	FT

Date: 01/19/15
Designed By: CTH
Checked by: KD

RESISTANCE FACTORS

FRICTION BETWEEN SOIL & SOIL :	1.00	
FRICTION BETWEEN SOIL & CONC. :	1.00	
FRICTION BETWEEN JOINT & CONC. :	1.00	
SHEAR THROUGH SHEAR KEY :	1.00	
PASSIVE PRESSURE AGAINST SLIDING :	1.00	(Not used for this project)
PASSIVE PRESSURE AGAINST OVERTURN. :	1.00	(Not used for this project)

LOAD FACTORS

DC (WEIGHT OF CONCRETE) :	1.00
EV (WEIGHT OF SOIL) :	1.00
EARTH PRESSURES (EH)	
HORIZONTAL COMPONENT :	1.00
VERTICAL COMPONENT :	1.00
LL (VEHICULAR LIVE LOAD), LS (LIVE LOAD SURCHARGE) :	1.00
WATER PRESSURE :	1.00
WIND LOAD :	0.30

GLOBAL STABILITY

OVERTURNING

SUM FACTORED OVERTURNING MOMENTS:	213697
SUM FACTORED RESISTING MOMENTS:	556471
PERFORMANCE RATIO:	2.60

SLIDING

SUM FACTORED HORIZONTAL FORCE:	35877
FACTORED RESISTING FRICTION FORCE:	57071
PERFORMANCE RATIO:	1.59

MAXIMUM BEARING PRESSURE

Meyerhof distribution which considers a uniform base pressure distribution over an effective width of B' = L - 2e

Live load surcharge is present on the wall and behind the wall

MAXIMUM BEARING PRESSURE: σ_v = SUM VERTICAL LOADS/(L-2e)

FACTORED SUM OF VERTICAL LOADS =	113481	LB/5 FT WIDTH			
FACTORED e =	1.45	≤ L/4 =	2.50	ft	ON SOIL
FACTORED BEARING PRESSURE =	3197	PSF			
FACTORED BEARING CAPACITY =	#N/A	PSF			
PERFORMANCE RATIO =	#N/A				

Date: 01/19/15
Designed By: CTH
Checked by: KD

FACTORS OF SAFETY AT EACH LEVEL

Live load is present behind the wall, but not on the wall

LEVEL	HEIGHT	STEM LENGTH	No. OF SHEAR KEYS	FACTORED LOAD EFFECT	FACTORED RESISTANCE	PERFORMANCE RATIO
1	5.00	6.00	2			
			OVERTURNING	41137	89172	2.17
			SLIDING	12179	22577	1.85
			PULLOUT	3930	10961	2.79
2	7.50	8.00	2			
			OVERTURNING	79476	229185	2.88
			SLIDING	18718	39220	2.10
			PULLOUT	3405	17014	5.00
3	10.00	8.00	2			
			OVERTURNING	135862	286055	2.11
			SLIDING	26618	48107	1.81
			PULLOUT	4434	20712	4.67
4	12.50	10.00	0			
			OVERTURNING	213697	556471	2.60
			SLIDING	35877	57071	1.59
			PULLOUT	5463	22932	4.20
5	15.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
6	17.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
7	20.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
8	22.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
9	25.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
10	27.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
11	30.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
12	32.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A

Date: 01/19/15
Designed By: CTH
Checked by: KD

LEVEL 4

STEM LENGTH = 10.00 FT
HEIGHT = 16.25 FT

EARTH PRESSURE			TRAFFIC SURCHARGE & WATER PRESSURE		
Pa =	5809.55	plf	Pt =	1430.04	plf
Feh =	28726.38	lbs.	Ft =	7150.22	lbs.
Fev =	4308.96	lbs.	Fw =	0.00	lbs.

SLIDING FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
Feh	28726.38	1.00	28726.38
Ft	7150.22	1.00	7150.22
Fw	0.00	1.00	0.00
WIND LOAD	0.00	0.30	0.00
TOTAL			35876.60

RESISTING FORCE

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
THRU SELECT FILL OR FOUNDATION	84011.63	1.00	0.58	1.00	48504.1
Fev	4308.96	1.00	0.58	1.00	2487.8
THRU JT. MATERIAL OR FOUNDATIC	13160.63	1.00	0.46	1.00	6078.6
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	1.00	0.0
EMBEDMENT	0.00	#N/A	#N/A	1.00	0.0
TOTAL					57070.5

PERFORMANCE RATIO = 1.59

STABILITY AGAINST PULLOUT - LEVEL 4

PULLOUT FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
PULLOUT FORCE =	4630.41	1.00	4630.41
TRAFFIC SURCHARGE FORCE =	832.39	1.00	832.39
WATER PRESSURE =	0.00	1.00	0.00
TOTAL			5462.80

RESISTING FORCE

Aeff. = 44.18 SF

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
ON STEM(SOIL TO SOIL IN Aeff)	7864.55	1.00	0.67	1.00	5304.7
ON STEM (SOIL TO CONCRETE IN A	23098.24	1.00	0.50	1.00	11549.1
THRU JT. MATERIAL OR FOUNDATIC	13160.63	1.00	0.46	1.00	6078.6
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	1.00	0.0
TOTAL					22932.5

PERFORMANCE RATIO = 4.20

Date: 01/19/15
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 4

OVERTURNING MOMENT

	FORCE	MOMENT ARM	OVERTURNING MOMENT	LOAD FACTOR	FACTORED MOMENT
Feh	28726.38	5.42	155601.2	1.00	155601.2
Ft	7150.22	8.13	58095.5	1.00	58095.5
Fw	0.00	0.00	0.0	1.00	0.0
WIND LOAD	0.00	12.50	0.00	0.30	0.00
TOTAL					213696.8

RESISTING MOMENT

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED RESISTANCE
PANEL L1	2774.00	1.14	0.00	1.00	2774.0	3162.4
PANEL L2	2098.00	2.31	0.00	1.00	2098.0	4846.4
PANEL L3	2098.00	2.31	0.00	1.00	2098.0	4846.4
PANEL L4	2360.00	3.09	0.00	1.00	2360.0	7292.4
SELECT FILL L1	15781.20	3.25	0.00	1.00	15781.2	51288.9
SELECT FILL L2	10321.20	4.25	0.00	1.00	10321.2	43865.1
SELECT FILL L3	10321.20	4.25	0.00	1.00	10321.2	43865.1
SELECT FILL L4	13112.40	5.25	0.00	1.00	13112.4	68840.1

Date: 01/19/15
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 4 (CONTINUED)

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED RESISTANCE
STEP L2	6000.00	7.00	0.00	1.00	6000.0	42000.0
STEP L3	0.00	8.00	0.00	1.00	0.0	0.0
STEP L4	12000.00	9.00	0.00	1.00	12000.0	108000.0
EARTH SURCHARGE	20306.25	6.67	0.00	1.00	20306.3	135375.0
Fev	4308.96	10.00	0.00	1.00	4309.0	43089.6
TOTAL					101481.21	556471.29

PERFORMANCE RATIO = 2.60

Wall 5

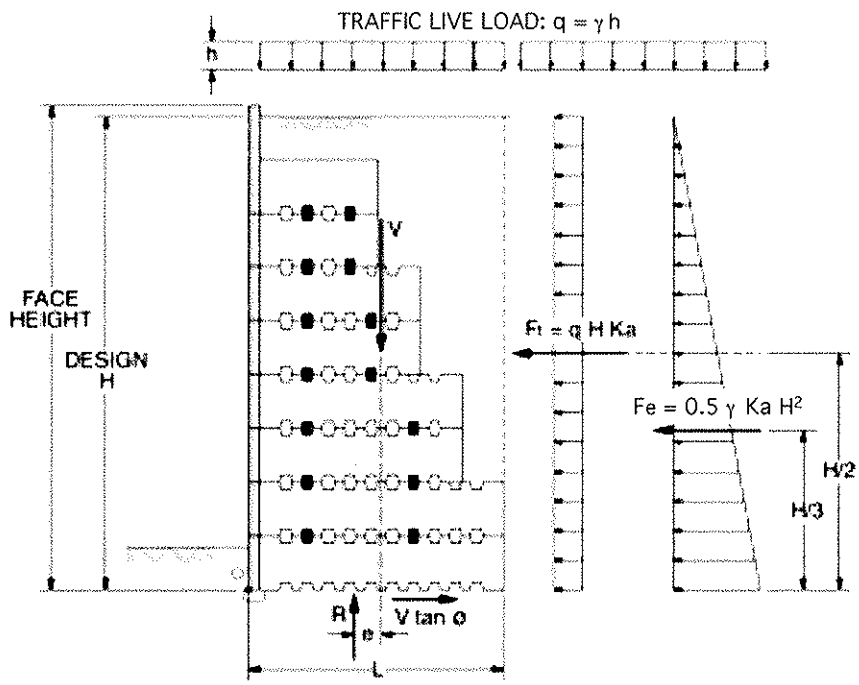
T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
LIMIT STATE: **STRENGTH-I MIN**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)
Level Surcharge and Infinite Slope Condition

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Comment: Wall 5

Project No: 4437
Date: 12/30/14
Designed By: CTH
Checked by: KD

Load Diagram:



Typical Section (For illustration only, Some details may not apply)

External Stability Calculation (STRENGTH-I MIN)

Stability Against Overturning: (moments about point "O")

Σ Factored Resisting Moments = $\phi V \cdot x_0$ (x_0 is the horiz. distance between V and O)

Σ Factored overturning Momen = $Y_e F_e (H/3) + Y_t F_t (H/2)$

Stability Against Sliding:

Σ Factored Resisting Force = $\phi V \tan \phi_F$

Σ Factored Driving Force = $Y_e F_e + Y_t F_t$

Bearing Pressure:

Factored Bearing Pressure = $(Y_1 V + Y_2 qL)/(L - 2e)$ (use factored e)

Eccentricity:

Eccentricity (e) = $\dfrac{L}{2} - \dfrac{(V + qL)(L/2) - [F_V(H/3) + F_t(H/2)]}{V + qL}$

(use factored V, qL, Fe, Ft for factored e)
(q=0, Ft=0 for this case)

T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
Level Surcharge and Infinite Slope Condition
LIMIT STATE: **STRENGTH-I MIN**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858
Project No: 4437
Date: 12/30/14
By: CTH
Checked by: KD

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Wall Name: Wall 5

GRADING GEOMETRY

DISTANCE TO SLOPE (d) =	0	FT	
FILL SURCHARGE =	3.75	FT	
DISTANCE TO BREAK =	5	FT	
SLOPE ANGLE (ß1) =	36.9	DEG	
SLOPE ANGLE (I) =	10.6	DEG	
TRAFFIC SURCHARGE =	2	FT	

WALL GEOMETRY

HEIGHT (H) =	10.00	
BATTER ( ) =	0	
BASE (L) =	10	

BACKFILL SPECIFICATIONS

SELECT	INTERNAL FRICTION (Ø)=	34	DEG	Ka =	0.3158
	WEIGHT ( )=	120	PCF	Ko =	0.4408
	COHESION=	0	(assumed)		
UNCLASSIFIED	INTERNAL FRICTION (Ø)=	30	DEG	Ka =	0.3768
	WEIGHT ( )=	120	PCF		
	COHESION =	0	(assumed)		
FOUNDATION	FOUNDATION TYPE	S	(S for Soil, R for rock)		
	INTERNAL FRICTION (Øf) =	30	DEG	Kp =	3.0000

FRICTION FACTORS

JOINT MATERIAL TO CONCRETE =	0.59	
SELECT FILL TO CONCRETE =	0.50	
UNCLASSIFIED FILL TO CONCRETE =	0.50	
SELECT FILL TO FOUNDATION = tan(ø)	0.58	(Ø is min of select fill and foundation)
PRECAST CONCRETE TO FOUNDATION =	0.46	(0.8*TAN Øf)

SHEAR KEY STRENGTH = 2460 lbs.

WATER PRESSURE

HEIGHT OF WATER TABLE BEHIND WALL =	0	FT	(From bottom of wall)
HEIGHT OF WATER TABLE BEFORE WALL =	0	FT	(From bottom of wall)

Date: 12/30/14
Designed By: CTH
Checked by: KD

RESISTANCE FACTORS

FRICTION BETWEEN SOIL & SOIL :	1.00	
FRICTION BETWEEN SOIL & CONC. :	0.90	
FRICTION BETWEEN JOINT & CONC. :	0.90	
SHEAR THROUGH SHEAR KEY :	0.90	
PASSIVE PRESSURE AGAINST SLIDING :	0.50	(Not used for this project)
PASSIVE PRESSURE AGAINST OVERTURN. :	0.60	(Not used for this project)

LOAD FACTORS

DC (WEIGHT OF CONCRETE) :	0.90
EV (WEIGHT OF SOIL) :	1.00
EARTH PRESSURES (EH)	
HORIZONTAL COMPONENT :	1.50
VERTICAL COMPONENT :	1.50
LL (VEHICULAR LIVE LOAD), LS (LIVE LOAD SURCHARGE) :	1.75
WATER PRESSURE :	1.00

GLOBAL STABILITY

OVERTURNING

SUM FACTORED OVERTURNING MOMENTS	219204
SUM FACTORED RESISTING MOMENTS	495216
PERFORMANCE RATIO	2.26

SLIDING

SUM FACTORED HORIZONTAL FORCE	42386
FACTORED RESISTING FRICTION FORCE	48424
PERFORMANCE RATIO	1.14

MAXIMUM BEARING PRESSURE

Meyerhof distribution which considers a uniform base pressure distribution over an effective width of B' = L - 2e

Live load surcharge is present on the wall and behind the wall

MAXIMUM BEARING PRESSURE: Sv = SUM VERTICAL LOADS/(L-2e)

FACTORED SUM OF VERTICAL LOADS =	107937	LB/5 FT WIDTH			
FACTORED e =	1.47	≤ L/4 =	2.50	ft	ON SOIL
FACTORED BEARING PRESSURE =	3058	PSF			
FACTORED BEARING RESISTANCE =	#N/A	PSF			
PERFORMANCE RATIO =	#N/A				

Date: 12/30/14
Designed By: CTH
Checked by: KD

PERFORMANCE RATIO AT EACH LEVEL

Live load is present behind the wall, but not on the wall

LEVEL	HEIGHT	STEM LENGTH	No. OF SHEAR KEYS	FACTORED LOAD EFFECT	FACTORED RESISTANCE	PERFORMANCE RATIO
1	5.00	6.00	2			
			OVERTURNING	67503	95714	1.42
			SLIDING	19682	22469	1.14
			PULLOUT	6468	9807	1.52
2	7.50	8.00	2			
			OVERTURNING	129163	243499	1.89
			SLIDING	29993	39247	1.31
			PULLOUT	5421	15210	2.81
3	10.00	10.00	0			
			OVERTURNING	219204	495216	2.26
			SLIDING	42386	48424	1.14
			PULLOUT	6993	16763	2.40
4	12.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
5	15.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
6	17.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
7	20.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
8	22.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
9	25.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
10	27.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
11	30.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
12	32.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A

Date: 12/30/14
Designed By: CTH
Checked by: KD

LEVEL 3

STEM LENGTH = 10.00 FT
HEIGHT = 13.75 FT

EARTH PRESSURE			TRAFFIC SURCHARGE & EARTH PRESSURE		
Pa =	4274.12	plf	Pt =	1243.38	plf
Feh =	21004.58	lbs.	Ft =	6216.91	lbs.
Fev =	3938.36	lbs.	Fw =	0.00	lbs.

STABILITY AGAINST SLIDING - LEVEL 3

SLIDING FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
Feh	21004.58	1.50	31506.87
Ft	6216.91	1.75	10879.58
Fw	0.00	1.00	0.00
TOTAL			42386.45

RESISTING FORCE

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
THRU SELECT FILL OR FOUNDATION	70990.43	1.00	0.58	1.00	40986.34
Fev	3938.36	1.50	0.58	1.00	3410.72
THRU JT. MAT'L OR FOUNDATION	10762.63	0.90	0.46	0.90	4026.55
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	0.90	0.00
EMBEDMENT	0.00	#N/A	#N/A	0.50	0.00
TOTAL					48423.60

PERFORMANCE RATIO = 1.14

STABILITY AGAINST PULLOUT - LEVEL 3

PULLOUT FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
PULLOUT FORCE	3667.00	1.50	5500.51
TRAFFIC SURCHARGE FORCE	852.78	1.75	1492.36
WATER PRESSURE	0.00	1.00	0.00
TOTAL			6992.87

RESISTING FORCE

Aeff. = 44.18 SF

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
ON STEM(SOIL TO SOIL IN Aeff)	6380.67	1.00	0.67	1.00	4303.82
ON STEM (SOIL TO CONCRETE IN A	18740.08	1.00	0.50	0.90	8433.04
THRU JT. MAT'L OR FOUNDATION	10762.63	0.90	0.46	0.90	4026.55
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	0.90	0.00
TOTAL					16763.40

PERFORMANCE RATIO = 2.40

Date: 12/30/14
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 3

OVERTURNING MOMENT

	FORCE	MOMENT ARM	OVERTURNING MOMENT	LOAD FACTOR	FACTORED MOMENT
Feh	21004.58	4.58	96270.99	1.50	144406.48
Ft	6216.91	6.88	42741.22	1.75	74797.14
Fw	0.00	0.00	0.00	1.00	0.00
TOTAL					219203.62

RESISTING MOMENT

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED MOMENT
UNIT L1	2774.00	1.14	0.00	0.90	2496.60	2846.12
UNIT L2	2098.00	2.31	0.00	0.90	1888.20	4361.74
UNIT L3	2360.00	3.09	0.00	0.90	2124.00	6563.16
SELECT FILL L1	15781.20	3.25	0.00	1.00	15781.20	51288.90
SELECT FILL L2	10321.20	4.25	0.00	1.00	10321.20	43865.10
SELECT FILL L3	13112.40	5.25	0.00	1.00	13112.40	68840.10

Date: 12/30/14
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 3 (CONTINUED)

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED MOMENT
STEP L2	6000.00	7.00	0.00	1.00	6000.00	42000.00
STEP L3	9000.00	9.00	0.00	1.00	9000.00	81000.00
EARTH SURCHARGE	20306.25	6.67	0.00	1.00	20306.25	135375.00
Fev	3938.36	10.00	0.00	1.50	5907.54	59075.38
TOTAL					86937.39	495215.51

PERFORMANCE RATIO = 2.26

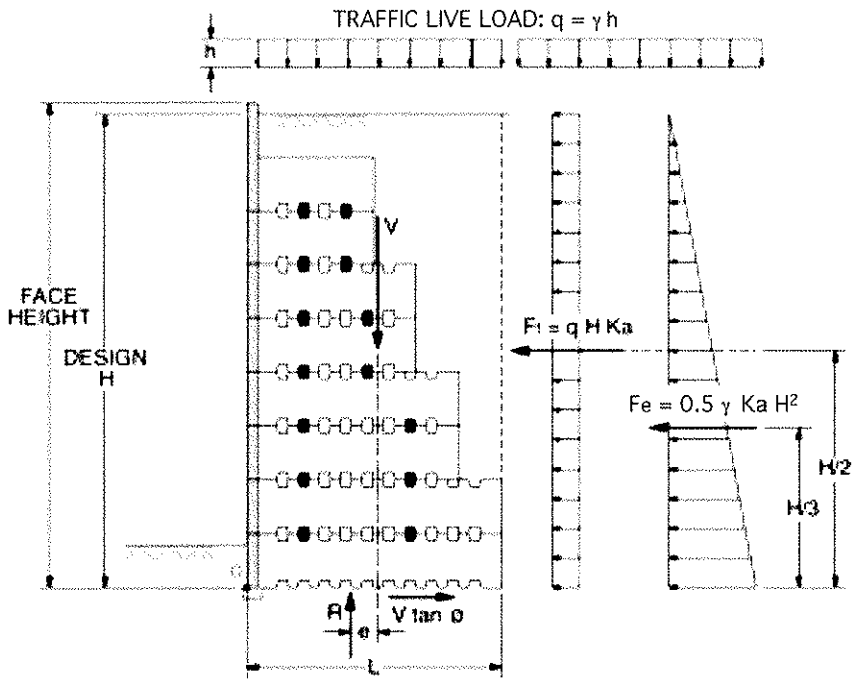
T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
LIMIT STATE: **STRENGTH-I MAX**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)
Level Surcharge and Infinite Slope Condition

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Comment: Wall 5

Project No: 4437
Date: 12/30/14
Designed By: CTH
Checked by: KD

Load Diagram:



Typical Section (For illustration only, Some details may not apply)

External Stability Calculation (STRENGTH-I MAX)

Stability Against Overturning: (moments about point "O")

Σ Factored Resisting Moments = $\phi V \cdot x_O$ (x_O is the horiz. distance between V and O)

Σ Factored overturning Momen = $Y_e F_e (H/3) + Y_t F_t (H/2)$

Stability Against Sliding:

Σ Factored Resisting Force = $\phi V \tan \phi_F$

Σ Factored Driving Force = $Y_e F_e + Y_t F_t$

Bearing Pressure:

Factored Bearing Pressure = $(Y_1 V + Y_2 qL)/(L - 2e)$ (use factored e)

Eccentricity:

Eccentricity (e) = $\dfrac{L}{2} - \dfrac{(V + qL)(L/2) - [F_V(H/3) + F_t(H/2)]}{V + qL}$

(use factored V, qL, Fe, Ft for factored e)
(q=0, Ft=0 for this case)

T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
Level Surcharge and Infinite Slope Condition
LIMIT STATE: **STRENGTH-I MAX**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858
Project No: 4437
Date: 12/30/14
By: CTH
Checked by: KD

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Wall Name: Wall 5

GRADING GEOMETRY

DISTANCE TO SLOPE (d) =	0	FT	
FILL SURCHARGE =	3.75	FT	
DISTANCE TO BREAK =	5	FT	
SLOPE ANGLE (ß1) =	36.9	DEG	
SLOPE ANGLE (I) =	10.6	DEG	
TRAFFIC SURCHARGE =	2	FT	

WALL GEOMETRY

HEIGHT (H) =	10.00	
BATTER ( ) =	0	
BASE (L) =	10	

BACKFILL SPECIFICATIONS

SELECT	INTERNAL FRICTION (Ø)=	34	DEG	Ka =	0.3158
	WEIGHT ( )=	120	PCF	Ko =	0.4408
	COHESION=	0	(assumed)		
UNCLASSIFIED	INTERNAL FRICTION (Ø)=	30	DEG	Ka =	0.3768
	WEIGHT ( )=	120	PCF		
	COHESION =	0	(assumed)		
FOUNDATION	FOUNDATION TYPE	S	(S for Soil, R for rock)		
	INTERNAL FRICTION (Ø)=	30	DEG	Kp =	3.0000

FRICTION FACTORS

JOINT MATERIAL TO CONCRETE =	0.59	
SELECT FILL TO CONCRETE =	0.50	
UNCLASSIFIED FILL TO CONCRETE =	0.50	
SELECT FILL TO FOUNDATION = tan(ø)	0.58	(Ø is min of select fill and foundation)
PRECAST CONCRETE TO FOUNDATION =	0.46	(0.8*TAN Øf)

SHEAR KEY STRENGTH = 2460 lbs.

WATER PRESSURE

HEIGHT OF WATER TABLE BEHIND WALL =	0	FT	(From bottom of wall)
HEIGHT OF WATER TABLE BEFORE WALL =	0	FT	(From bottom of wall)

Date: 12/30/14
Designed By: CTH
Checked by: KD

RESISTANCE FACTORS

FRICTION BETWEEN SOIL & SOIL :	1.00	
FRICTION BETWEEN SOIL & CONC. :	0.90	
FRICTION BETWEEN JOINT & CONC. :	0.90	
SHEAR THROUGH SHEAR KEY :	0.90	
PASSIVE PRESSURE AGAINST SLIDING :	0.50	(Not used for this project)
PASSIVE PRESSURE AGAINST OVERTURN. :	0.60	(Not used for this project)

LOAD FACTORS

DC (WEIGHT OF CONCRETE) :	1.25
EV (WEIGHT OF SOIL) :	1.35
EARTH PRESSURES (EH)	
HORIZONTAL COMPONENT :	1.50
VERTICAL COMPONENT :	1.50
LL (VEHICULAR LIVE LOAD), LS (LIVE LOAD SURCHARGE) :	1.75
WATER PRESSURE :	1.00

GLOBAL STABILITY

OVERTURNING

SUM FACTORED OVERTURNING MOMENTS	219204
SUM FACTORED RESISTING MOMENTS	648400
PERFORMANCE RATIO	2.96

SLIDING

SUM FACTORED HORIZONTAL FORCE	42386
FACTORED RESISTING FRICTION FORCE	64335
PERFORMANCE RATIO	1.52

MAXIMUM BEARING PRESSURE

Meyerhof distribution which considers a uniform base pressure distribution over an effective width of B' = L - 2e

Live load surcharge is present on the wall and behind the wall

MAXIMUM BEARING PRESSURE: Sv = SUM VERTICAL LOADS/(L-2e)

FACTORED SUM OF VERTICAL LOADS =	136551	LB/5 FT WIDTH			
FACTORED e =	1.09	≤ L/4 =	2.50	ft	ON SOIL
FACTORED BEARING PRESSURE =	3491	PSF			

FACTORED BEARING RESISTANCE =	#N/A	PSF
PERFORMANCE RATIO =	#N/A	

Date: 12/30/14
Designed By: CTH
Checked by: KD

PERFORMANCE RATIO AT EACH LEVEL

Live load is present behind the wall, but not on the wall

LEVEL	HEIGHT	STEM LENGTH	No. OF SHEAR KEYS	FACTORED LOAD EFFECT	FACTORED RESISTANCE	PERFORMANCE RATIO
1	5.00	6.00	2			
			OVERTURNING	67503	124301	1.84
			SLIDING	19682	28283	1.44
			PULLOUT	6468	11754	1.82
2	7.50	8.00	2			
			OVERTURNING	129163	317931	2.46
			SLIDING	29993	50625	1.69
			PULLOUT	5421	19109	3.52
3	10.00	10.00	0			
			OVERTURNING	219204	648400	2.96
			SLIDING	42386	64335	1.52
			PULLOUT	6993	22787	3.26
4	12.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
5	15.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
6	17.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
7	20.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
8	22.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
9	25.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
10	27.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
11	30.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
12	32.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A

Date: 12/30/14
Designed By: CTH
Checked by: KD

LEVEL 3

STEM LENGTH = 10.00 FT
HEIGHT = 13.75 FT

EARTH PRESSURE			TRAFFIC SURCHARGE & EARTH PRESSURE		
Pa =	4274.12	plf	Pt =	1243.38	plf
Feh =	21004.58	lbs.	Ft =	6216.91	lbs.
Fev =	3938.36	lbs.	Fw =	0.00	lbs.

STABILITY AGAINST SLIDING - LEVEL 3

SLIDING FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
Feh	21004.58	1.50	31506.87
Ft	6216.91	1.75	10879.58
Fw	0.00	1.00	0.00
TOTAL			42386.45

RESISTING FORCE

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
THRU SELECT FILL OR FOUNDATION	70990.43	1.35	0.58	1.00	55331.56
Fev	3938.36	1.50	0.58	1.00	3410.72
THRU JT. MAT'L OR FOUNDATION	10762.63	1.25	0.46	0.90	5592.42
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	0.90	0.00
EMBEDMENT	0.00	#N/A	#N/A	0.50	0.00
TOTAL					64334.70

PERFORMANCE RATIO = 1.52

STABILITY AGAINST PULLOUT - LEVEL 3

PULLOUT FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
PULLOUT FORCE	3667.00	1.50	5500.51
TRAFFIC SURCHARGE FORCE	852.78	1.75	1492.36
WATER PRESSURE	0.00	1.00	0.00
TOTAL			6992.87

RESISTING FORCE

Aeff. = 44.18 SF

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
ON STEM(SOIL TO SOIL IN Aeff)	6380.67	1.35	0.67	1.00	5810.15
ON STEM (SOIL TO CONCRETE IN A	18740.08	1.35	0.50	0.90	11384.60
THRU JT. MAT'L OR FOUNDATION	10762.63	1.25	0.46	0.90	5592.42
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	0.90	0.00
TOTAL					22787.18

PERFORMANCE RATIO = 3.26

Date: 12/30/14
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 3

OVERTURNING MOMENT

	FORCE	MOMENT ARM	OVERTURNING MOMENT	LOAD FACTOR	FACTORED MOMENT
Feh	21004.58	4.58	96270.99	1.50	144406.48
Ft	6216.91	6.88	42741.22	1.75	74797.14
Fw	0.00	0.00	0.00	1.00	0.00
TOTAL					219203.62

RESISTING MOMENT

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED MOMENT
UNIT L1	2774.00	1.14	0.00	1.25	3467.50	3952.95
UNIT L2	2098.00	2.31	0.00	1.25	2622.50	6057.98
UNIT L3	2360.00	3.09	0.00	1.25	2950.00	9115.50
SELECT FILL L1	15781.20	3.25	0.00	1.35	21304.62	69240.02
SELECT FILL L2	10321.20	4.25	0.00	1.35	13933.62	59217.89
SELECT FILL L3	13112.40	5.25	0.00	1.35	17701.74	92934.14

Date: 12/30/14
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 3 (CONTINUED)

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED MOMENT
STEP L2	6000.00	7.00	0.00	1.35	8100.00	56700.00
STEP L3	9000.00	9.00	0.00	1.35	12150.00	109350.00
EARTH SURCHARGE	20306.25	6.67	0.00	1.35	27413.44	182756.25
Fev	3938.36	10.00	0.00	1.50	5907.54	59075.38
TOTAL					115550.96	648400.09

PERFORMANCE RATIO = 2.96

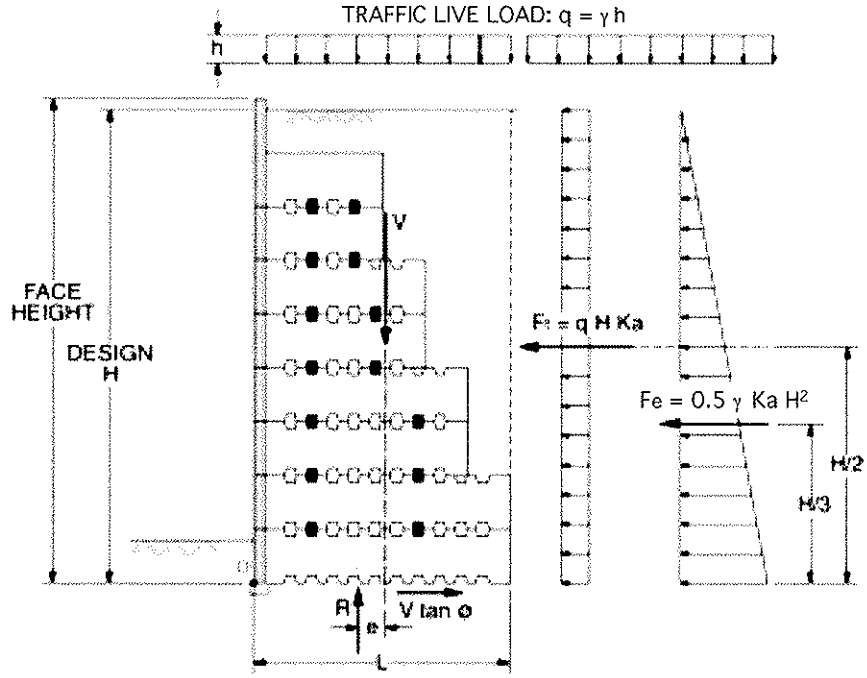
T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
LIMIT STATE: **SERVICE-I**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)
Level Surcharge and Infinite Slope Condition

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Comment: Wall 5

Project No: 4437
Date: 12/30/14
Designed By: CTH
Checked by: KD

Load Diagram:



Typical Section, All details may not apply

External Stability Calculation (SERVICE-I)

Stability Against Overturning: (moments about point "O")

Σ Factored Resisting Moments = $\phi V \cdot x_o$ (x_o is the horiz. distance between V and O)

Σ Factored overturning Momen = $\gamma_e F_e (H/3) + \gamma_t F_t (H/2)$

Stability Against Sliding:

Σ Factored Resisting Force = $\phi V \tan \phi_F$

Σ Factored Driving Force = $\gamma_e F_e + \gamma_t F_t$

Bearing Pressure:

Factored Bearing Pressure = $(\gamma_1 V + \gamma_2 qL)/(L - 2e)$ (use factored e)

Eccentricity:

Eccentricity (e) = $\dfrac{L}{2} - \dfrac{(V + qL)(L/2) - [F_V(H/3) + F_t(H/2)]}{V + qL}$

(use factored V, qL, Fe, Ft for factored e)

T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
Level Surcharge and Infinite Slope Condition
LIMIT STATE: **SERVICE-I**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858
Project No: 4437
Date: 12/30/14
By: CTH
Checked by: KD

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Comment: Wall 5

GRADING GEOMETRY

DISTANCE TO SLOPE (d) =	0	FT	
FILL SURCHARGE =	3.75	FT	
DISTANCE TO BREAK =	5	FT	
SLOPE ANGLE (ß1) =	36.9	DEG	
SLOPE ANGLE (I) =	10.6	DEG	
TRAFFIC SURCHARGE =	2	FT	

WALL GEOMETRY

HEIGHT (H) =	10.00	
BATTER ( ) =	0	
BASE (L) =	10	

BACKFILL SPECIFICATIONS

SELECT	INTERNAL FRICTION (Ø)=	34	DEG	Ka =	0.3158
	WEIGHT ( )=	120	PCF	Ko =	0.4408
	COHESION=	0	(assumed)		
UNCLASSIFIED	INTERNAL FRICTION (Ø)=	30	DEG	Ka =	0.3768
	WEIGHT ( )=	120	PCF		
	COHESION =	0	(assumed)		
FOUNDATION	FOUNDATION TYPE	S	(S for Soil, R for rock)		
	INTERNAL FRICTION (Ø)=	30	DEG	Kp =	3.0000

FRICTION FACTORS

JOINT MATERIAL TO CONCRETE =	0.59	
SELECT FILL TO CONCRETE =	0.50	
UNCLASSIFIED FILL TO CONCRETE =	0.50	
SELECT FILL TO FOUNDATION = tan(ø)	0.58	(Ø is min of select fill and foundation)
PRECAST CONCRETE TO FOUNDATION =	0.46	(0.8*TAN Øf)

SHEAR KEY STRENGTH = 2460 lbs.

WATER PRESSURE

HEIGHT OF WATER TABLE BEHIND WALL =	0	FT	(From bottom of wall)
HEIGHT OF WATER TABLE BEFORE WALL =	0	FT	(From bottom of wall)

WIND ON SOUND BARRIER/OTHER STRUCTURE

WIND FORCE =	0	LBS
DISTANCE FROM TOP OF WALL/GUTTER LINE =	0	FT

Date: 12/30/14
Designed By: CTH
Checked by: KD

RESISTANCE FACTORS

FRICTION BETWEEN SOIL & SOIL :	1.00	
FRICTION BETWEEN SOIL & CONC. :	1.00	
FRICTION BETWEEN JOINT & CONC. :	1.00	
SHEAR THROUGH SHEAR KEY :	1.00	
PASSIVE PRESSURE AGAINST SLIDING :	1.00	(Not used for this project)
PASSIVE PRESSURE AGAINST OVERTURN. :	1.00	(Not used for this project)

LOAD FACTORS

DC (WEIGHT OF CONCRETE) :	1.00
EV (WEIGHT OF SOIL) :	1.00
EARTH PRESSURES (EH)	
HORIZONTAL COMPONENT :	1.00
VERTICAL COMPONENT :	1.00
LL (VEHICULAR LIVE LOAD), LS (LIVE LOAD SURCHARGE) :	1.00
WATER PRESSURE :	1.00
WIND LOAD :	0.30

GLOBAL STABILITY

OVERTURNING

SUM FACTORED OVERTURNING MOMENTS:	139012
SUM FACTORED RESISTING MOMENTS:	477054
PERFORMANCE RATIO:	3.43

SLIDING

SUM FACTORED HORIZONTAL FORCE:	27221
FACTORED RESISTING FRICTION FORCE:	48231
PERFORMANCE RATIO:	1.77

MAXIMUM BEARING PRESSURE

Meyerhof distribution which considers a uniform base pressure distribution over an effective width of B' = L - 2e

Live load surcharge is present on the wall and behind the wall

MAXIMUM BEARING PRESSURE: σ_v = SUM VERTICAL LOADS/(L-2e)

FACTORED SUM OF VERTICAL LOADS =	97691	LB/5 FT WIDTH			
FACTORED e =	0.93	≤ L/4 =	2.50	ft	ON SOIL
FACTORED BEARING PRESSURE =	2398	PSF			
FACTORED BEARING CAPACITY =	#N/A	PSF			
PERFORMANCE RATIO =	#N/A				

Date: 12/30/14
Designed By: CTH
Checked by: KD

FACTORS OF SAFETY AT EACH LEVEL

Live load is present behind the wall, but not on the wall

LEVEL	HEIGHT	STEM LENGTH	No. OF SHEAR KEYS	FACTORED LOAD EFFECT	FACTORED RESISTANCE	PERFORMANCE RATIO
1	5.00	6.00	2			
			OVERTURNING	42118	91245	2.17
			SLIDING	12462	22810	1.83
			PULLOUT	4012	10961	2.73
2	7.50	8.00	2			
			OVERTURNING	81340	233754	2.87
			SLIDING	19147	39605	2.07
			PULLOUT	3472	17014	4.90
3	10.00	10.00	0			
			OVERTURNING	139012	477054	3.43
			SLIDING	27221	48231	1.77
			PULLOUT	4520	18645	4.13
4	12.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
5	15.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
6	17.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
7	20.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
8	22.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
9	25.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
10	27.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
11	30.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
12	32.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A

Date: 12/30/14
Designed By: CTH
Checked by: KD

LEVEL 3

STEM LENGTH =	10.00	FT
HEIGHT =	13.75	FT

EARTH PRESSURE			TRAFFIC SURCHARGE & WATER PRESSURE		
Pa =	4274.12	plf	Pt =	1243.38	plf
Feh =	21004.58	lbs.	Ft =	6216.91	lbs.
Fev =	3938.36	lbs.	Fw =	0.00	lbs.

STABILITY AGAINST SLIDING - LEVEL 3

SLIDING FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
Feh	21004.58	1.00	21004.58
Ft	6216.91	1.00	6216.91
Fw	0.00	1.00	0.00
WIND LOAD	0.00	0.30	0.00
TOTAL			27221.48

RESISTING FORCE

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
THRU SELECT FILL OR FOUNDATION	70990.43	1.00	0.58	1.00	40986.3
Fev	3938.36	1.00	0.58	1.00	2273.8
THRU JT. MATERIAL OR FOUNDATIC	10762.63	1.00	0.46	1.00	4971.0
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	1.00	0.0
EMBEDMENT	0.00	#N/A	#N/A	1.00	0.0
TOTAL					48231.2

PERFORMANCE RATIO = 1.77

STABILITY AGAINST PULLOUT - LEVEL 3

PULLOUT FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
PULLOUT FORCE =	3667.00	1.00	3667.00
TRAFFIC SURCHARGE FORCE =	852.78	1.00	852.78
WATER PRESSURE =	0.00	1.00	0.00
TOTAL			4519.78

RESISTING FORCE

Aeff. = 44.18 SF

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
ON STEM(SOIL TO SOIL IN Aeff)	6380.67	1.00	0.67	1.00	4303.8
ON STEM (SOIL TO CONCRETE IN A	18740.08	1.00	0.50	1.00	9370.0
THRU JT. MATERIAL OR FOUNDATIC	10762.63	1.00	0.46	1.00	4971.0
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	1.00	0.0
TOTAL					18644.9

PERFORMANCE RATIO = 4.13

Date: 12/30/14
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 3

OVERTURNING MOMENT

	FORCE	MOMENT ARM	OVERTURNING MOMENT	LOAD FACTOR	FACTORED MOMENT
Feh	21004.58	4.58	96271.0	1.00	96271.0
Ft	6216.91	6.88	42741.2	1.00	42741.2
Fw	0.00	0.00	0.0	1.00	0.0
WIND LOAD	0.00	10.00	0.00	0.30	0.00
TOTAL					139012.2

RESISTING MOMENT

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED RESISTANCE
PANEL L1	2774.00	1.14	0.00	1.00	2774.0	3162.4
PANEL L2	2098.00	2.31	0.00	1.00	2098.0	4846.4
PANEL L3	2360.00	3.09	0.00	1.00	2360.0	7292.4
SELECT FILL L1	15781.20	3.25	0.00	1.00	15781.2	51288.9
SELECT FILL L2	10321.20	4.25	0.00	1.00	10321.2	43865.1
SELECT FILL L3	13112.40	5.25	0.00	1.00	13112.4	68840.1

Date: 12/30/14
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 3 (CONTINUED)

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED RESISTANCE
STEP L2	6000.00	7.00	0.00	1.00	6000.0	42000.0
STEP L3	9000.00	9.00	0.00	1.00	9000.0	81000.0
EARTH SURCHARGE	20306.25	6.67	0.00	1.00	20306.3	135375.0
Fev	3938.36	10.00	0.00	1.00	3938.4	39383.6
TOTAL					85691.41	477053.83

PERFORMANCE RATIO = 3.43

Wall 6

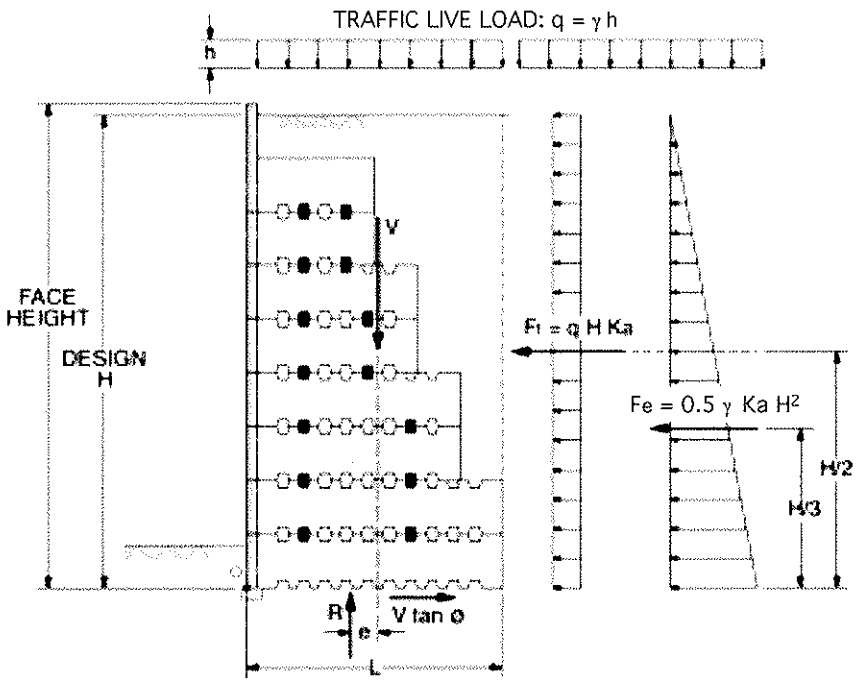
T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
LIMIT STATE: **STRENGTH-I MIN**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)
Level Surcharge and Infinite Slope Condition

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Comment: Wall 6

Project No: 4437
Date: 1/7/15
Designed By: CTH
Checked by: KD

Load Diagram:



Typical Section (For illustration only, Some details may not apply)

External Stability Calculation (STRENGTH-I MIN)

Stability Against Overturning: (moments about point "O")

Σ Factored Resisting Moments = $\phi V \cdot x_o$ (x_o is the horiz. distance between V and O)

Σ Factored overturning Momen = $Y_e F_e (H/3) + Y_t F_t (H/2)$

Stability Against Sliding:

Σ Factored Resisting Force = $\phi V \tan \phi_F$

Σ Factored Driving Force = $Y_e F_e + Y_t F_t$

Bearing Pressure:

Factored Bearing Pressure = $(Y_1 V + Y_2 qL)/(L - 2e)$ (use factored e)

Eccentricity:

Eccentricity (e) = $\dfrac{L}{2} - \dfrac{(V + qL)(L/2) - [F_V(H/3) + F_t(H/2)]}{V + qL}$

(use factored V, qL, Fe, Ft for factored e)
(q=0, Ft=0 for this case)

T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
Level Surcharge and Infinite Slope Condition
LIMIT STATE: STRENGTH-I MIN
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858

Project No: 4437
Date: 1/7/15
By: CTH
Checked by: KD

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Wall Name: Wall 6

GRADING GEOMETRY

DISTANCE TO SLOPE (d) =	0	FT	
FILL SURCHARGE =	3.75	FT	
DISTANCE TO BREAK =	5	FT	
SLOPE ANGLE (ß1) =	36.9	DEG	
SLOPE ANGLE (I) =	8.9	DEG	
TRAFFIC SURCHARGE =	2	FT	

WALL GEOMETRY

HEIGHT (H) =	12.00	
BATTER ( ) =	0	
BASE (L) =	10	

BACKFILL SPECIFICATIONS

SELECT	INTERNAL FRICTION (Ø)=	34	DEG	Ka =	0.3095
	WEIGHT ( )=	120	PCF	Ko =	0.4408
	COHESION=	0	(assumed)		
UNCLASSIFIED	INTERNAL FRICTION (Ø)=	30	DEG	Ka =	0.3683
	WEIGHT ( )=	120	PCF		
	COHESION =	0	(assumed)		
FOUNDATION	FOUNDATION TYPE	S	(S for Soil, R for rock)		
	INTERNAL FRICTION (Øf) =	30	DEG	Kp =	3.0000

FRICTION FACTORS

JOINT MATERIAL TO CONCRETE =	0.59	
SELECT FILL TO CONCRETE =	0.50	
UNCLASSIFIED FILL TO CONCRETE =	0.50	
SELECT FILL TO FOUNDATION = tan(ø)	0.58	(Ø is min of select fill and foundation)
PRECAST CONCRETE TO FOUNDATION =	0.46	(0.8*TAN Øf)

SHEAR KEY STRENGTH = 2460 lbs.

WATER PRESSURE

HEIGHT OF WATER TABLE BEHIND WALL =	0	FT	(From bottom of wall)
HEIGHT OF WATER TABLE BEFORE WALL =	0	FT	(From bottom of wall)

Date: 01/07/15
Designed By: CTH
Checked by: KD

RESISTANCE FACTORS

FRICTION BETWEEN SOIL & SOIL :	1.00	
FRICTION BETWEEN SOIL & CONC. :	0.90	
FRICTION BETWEEN JOINT & CONC. :	0.90	
SHEAR THROUGH SHEAR KEY :	0.90	
PASSIVE PRESSURE AGAINST SLIDING :	0.50	(Not used for this project)
PASSIVE PRESSURE AGAINST OVERTURN. :	0.60	(Not used for this project)

LOAD FACTORS

DC (WEIGHT OF CONCRETE) :	0.90
EV (WEIGHT OF SOIL) :	1.00
EARTH PRESSURES (EH)	
HORIZONTAL COMPONENT :	1.50
VERTICAL COMPONENT :	1.50
LL (VEHICULAR LIVE LOAD), LS (LIVE LOAD SURCHARGE) :	1.75
WATER PRESSURE :	1.00

GLOBAL STABILITY

OVERTURNING

SUM FACTORED OVERTURNING MOMENTS	309185
SUM FACTORED RESISTING MOMENTS	559820
PERFORMANCE RATIO	1.81

SLIDING

SUM FACTORED HORIZONTAL FORCE	52802
FACTORED RESISTING FRICTION FORCE	55401
PERFORMANCE RATIO	1.05

MAXIMUM BEARING PRESSURE

Meyerhof distribution which considers a uniform base pressure distribution over an effective width of B' = L - 2e

Live load surcharge is present on the wall and behind the wall

MAXIMUM BEARING PRESSURE: Sv = SUM VERTICAL LOADS/(L-2e)

FACTORED SUM OF VERTICAL LOADS =	120567	LB/5 FT WIDTH			
FACTORED e =	2.05	≤ L/4 =	2.50	ft	ON SOIL
FACTORED BEARING PRESSURE =	4087	PSF			
FACTORED BEARING RESISTANCE =	#N/A	PSF			
PERFORMANCE RATIO =	#N/A				

Date: 01/07/15
Designed By: CTH
Checked by: KD

PERFORMANCE RATIO AT EACH LEVEL

Live load is present behind the wall, but not on the wall

LEVEL	HEIGHT	STEM LENGTH	No. OF SHEAR KEYS	FACTORED LOAD EFFECT	FACTORED RESISTANCE	PERFORMANCE RATIO
1	4.50	6.00	2			
			OVERTURNING	56970	86393	1.52
			SLIDING	17526	20827	1.19
			PULLOUT	5394	9393	1.74
2	7.00	8.00	2			
			OVERTURNING	112498	225900	2.01
			SLIDING	27238	36978	1.36
			PULLOUT	5023	14633	2.91
3	9.50	8.00	2			
			OVERTURNING	194864	286408	1.47
			SLIDING	38996	45978	1.18
			PULLOUT	6571	17927	2.73
4	12.00	10.00	0			
			OVERTURNING	309185	559820	1.81
			SLIDING	52802	55401	1.05
			PULLOUT	8119	19915	2.45
5	14.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
6	17.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
7	19.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
8	22.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
9	24.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
10	27.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
11	29.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
12	32.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A

Date: 01/07/15
Designed By: CTH
Checked by: KD

LEVEL 4

STEM LENGTH = 10.00 FT
HEIGHT = 15.75 FT

EARTH PRESSURE			TRAFFIC SURCHARGE & WATER PRESSURE		
Pa =	5481.72	plf	Pt =	1392.18	plf
Feh =	27080.01	lbs.	Ft =	6960.91	lbs.
Fev =	4231.25	lbs.	Fw =	0.00	lbs.

STABILITY AGAINST SLIDING - LEVEL 4

SLIDING FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
Feh	27080.01	1.50	40620.02
Ft	6960.91	1.75	12181.59
Fw	0.00	1.00	0.00
TOTAL			52801.61

RESISTING FORCE

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
THRU SELECT FILL OR FOUNDATION	81281.63	1.00	0.58	1.00	46927.97
Fev	4231.25	1.50	0.58	1.00	3664.37
THRU JT. MAT'L OR FOUNDATION	12852.63	0.90	0.46	0.90	4808.46
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	0.90	0.00
EMBEDMENT	0.00	#N/A	#N/A	0.50	0.00
TOTAL					55400.80

PERFORMANCE RATIO = 1.05

STABILITY AGAINST PULLOUT - LEVEL 4

PULLOUT FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
PULLOUT FORCE	4437.98	1.50	6656.96
TRAFFIC SURCHARGE FORCE	835.69	1.75	1462.45
WATER PRESSURE	0.00	1.00	0.00
TOTAL			8119.42

RESISTING FORCE

Aeff. = 44.18 SF

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
ON STEM(SOIL TO SOIL IN Aeff)	7567.77	1.00	0.67	1.00	5104.53
ON STEM (SOIL TO CONCRETE IN A	22226.61	1.00	0.50	0.90	10001.97
CONC. UNIT WEIGHT (THROUGH JOINT MATERIAL)	12852.63	0.90	0.46	0.90	4808.46
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	0.90	0.00
TOTAL					19914.97

PERFORMANCE RATIO = 2.45

Date: 01/07/15
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 4

OVERTURNING MOMENT

	FORCE	MOMENT ARM	OVERTURNING MOMENT	LOAD FACTOR	FACTORED MOMENT
Feh	27080.01	5.25	142170.05	1.50	213255.08
Ft	6960.91	7.88	54817.17	1.75	95930.04
Fw	0.00	0.00	0.00	1.75	0.00
TOTAL					309185.12

RESISTING MOMENT

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED MOMENT
UNIT L1	2586.00	1.20	0.00	0.90	2327.40	2792.88
UNIT L2	2098.00	2.31	0.00	0.90	1888.20	4361.74
UNIT L3	2098.00	2.31	0.00	0.90	1888.20	4361.74
UNIT L4	2360.00	3.09	0.00	0.90	2124.00	6563.16
SELECT FILL L1	14131.20	3.25	0.00	1.00	14131.20	45926.40
SELECT FILL L2	10321.20	4.25	0.00	1.00	10321.20	43865.10
SELECT FILL L3	10321.20	4.25	0.00	1.00	10321.20	43865.10
SELECT FILL L4	13112.40	5.25	0.00	1.00	13112.40	68840.10

Date: 01/07/15
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 4 (CONTINUED)

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED MOMENT
STEP L2	5400.00	7.00	0.00	1.00	5400.00	37800.00
STEP L3	0.00	8.00	0.00	1.00	0.00	0.00
STEP L4	11400.00	9.00	0.00	1.00	11400.00	102600.00
EARTH SURCHARGE	20306.25	6.67	0.00	1.00	20306.25	135375.00
Fev	4231.25	10.00	0.00	1.50	6346.88	63468.77
TOTAL					99566.93	559820.00

PERFORMANCE RATIO = 1.81

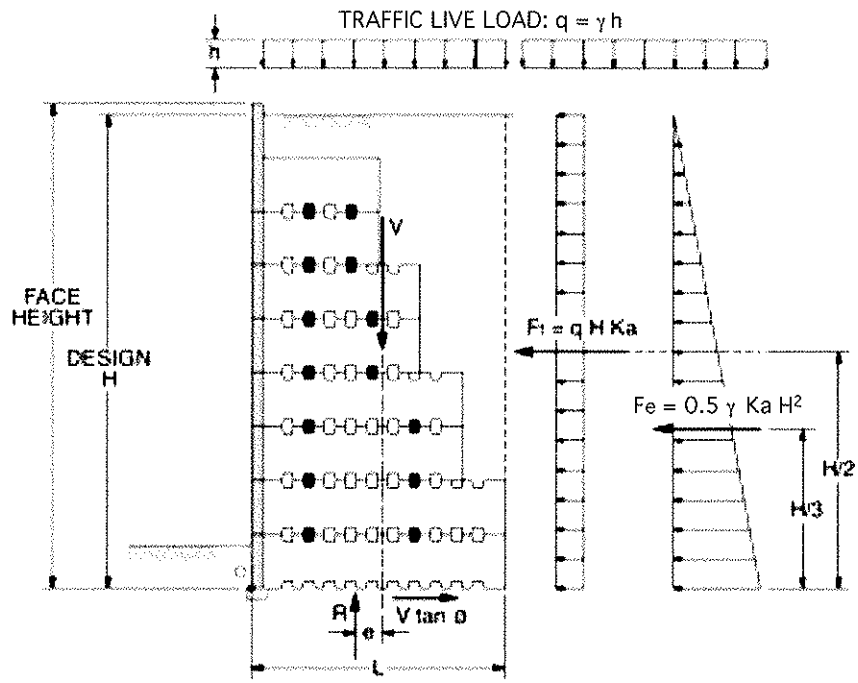
T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
LIMIT STATE: **STRENGTH-I MAX**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)
Level Surcharge and Infinite Slope Condition

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Comment: Wall 6

Project No: 4437
Date: 1/7/15
Designed By: CTH
Checked by: KD

Load Diagram:



Typical Section (For illustration only, Some details may not apply)

External Stability Calculation (STRENGTH-I MAX)

Stability Against Overturning: (moments about point "O")

Σ Factored Resisting Moments = $\phi V \cdot x_0$ (x_0 is the horiz. distance between V and O)

Σ Factored overturning Momen = $\gamma_e F_e (H/3) + \gamma_t F_t (H/2)$

Stability Against Sliding:

Σ Factored Resisting Force = $\phi V \tan \phi_F$

Σ Factored Driving Force = $\gamma_e F_e + \gamma_t F_t$

Bearing Pressure:

Factored Bearing Pressure = $(\gamma_1 V + \gamma_2 qL)/(L - 2e)$ (use factored e)

Eccentricity:

Eccentricity (e) = $\dfrac{L}{2} - \dfrac{(V + qL)(L/2) - [F_V(H/3) + F_t(H/2)]}{V + qL}$

(use factored V, qL, Fe, Ft for factored e)
(q=0, Ft=0 for this case)

T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
Level Surcharge and Infinite Slope Condition
LIMIT STATE: **STRENGTH-I MAX**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858
Project No: 4437
Date: 1/7/15
By: CTH
Checked by: KD

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Wall Name: Wall 6

GRADING GEOMETRY

DISTANCE TO SLOPE (d) =	0	FT	
FILL SURCHARGE =	3.75	FT	
DISTANCE TO BREAK =	5	FT	
SLOPE ANGLE (ß1) =	36.9	DEG	
SLOPE ANGLE (I) =	8.9	DEG	
TRAFFIC SURCHARGE =	2	FT	

WALL GEOMETRY

HEIGHT (H) =	12.00	
BATTER ( ) =	0	
BASE (L) =	10	

BACKFILL SPECIFICATIONS

SELECT	INTERNAL FRICTION (Ø)=	34	DEG	Ka =	0.3095
	WEIGHT ( )=	120	PCF	Ko =	0.4408
	COHESION=	0	(assumed)		
UNCLASSIFIED	INTERNAL FRICTION (Ø)=	30	DEG	Ka =	0.3683
	WEIGHT ( )=	120	PCF		
	COHESION =	0	(assumed)		
FOUNDATION	FOUNDATION TYPE	S	(S for Soil, R for rock)		
	INTERNAL FRICTION (Ø)=	30	DEG	Kp =	3.0000

FRICTION FACTORS

JOINT MATERIAL TO CONCRETE =	0.59	
SELECT FILL TO CONCRETE =	0.50	
UNCLASSIFIED FILL TO CONCRETE =	0.50	
SELECT FILL TO FOUNDATION = tan(ø)	0.58	(Ø is min of select fill and foundation)
PRECAST CONCRETE TO FOUNDATION =	0.46	(0.8*TAN Øf)

SHEAR KEY STRENGTH = 2460 lbs.

WATER PRESSURE

HEIGHT OF WATER TABLE BEHIND WALL =	0	FT	(From bottom of wall)
HEIGHT OF WATER TABLE BEFORE WALL =	0	FT	(From bottom of wall)

Date: 01/07/15
Designed By: CTH
Checked by: KD

RESISTANCE FACTORS

FRICTION BETWEEN SOIL & SOIL :	1.00	
FRICTION BETWEEN SOIL & CONC. :	0.90	
FRICTION BETWEEN JOINT & CONC. :	0.90	
SHEAR THROUGH SHEAR KEY :	0.90	
PASSIVE PRESSURE AGAINST SLIDING :	0.50	(Not used for this project)
PASSIVE PRESSURE AGAINST OVERTURN. :	0.60	(Not used for this project)

LOAD FACTORS

DC (WEIGHT OF CONCRETE) :	1.25
EV (WEIGHT OF SOIL) :	1.35
EARTH PRESSURES (EH)	
HORIZONTAL COMPONENT :	1.50
VERTICAL COMPONENT :	1.50
LL (VEHICULAR LIVE LOAD), LS (LIVE LOAD SURCHARGE) :	1.75
WATER PRESSURE :	1.00

GLOBAL STABILITY

OVERTURNING

SUM FACTORED OVERTURNING MOMENTS	309185
SUM FACTORED RESISTING MOMENTS	734246
PERFORMANCE RATIO	2.37

SLIDING

SUM FACTORED HORIZONTAL FORCE	52802
FACTORED RESISTING FRICTION FORCE	73696
PERFORMANCE RATIO	1.40

MAXIMUM BEARING PRESSURE

Meyerhof distribution which considers a uniform base pressure distribution over an effective width of B' = L - 2e

Live load surcharge is present on the wall and behind the wall

MAXIMUM BEARING PRESSURE: Sv = SUM VERTICAL LOADS/(L-2e)

FACTORED SUM OF VERTICAL LOADS =	153514	LB/5 FT WIDTH			
FACTORED e =	1.55	≤ L/4 =	2.50	ft	ON SOIL
FACTORED BEARING PRESSURE =	4446	PSF			
FACTORED BEARING RESISTANCE =	#N/A	PSF			
PERFORMANCE RATIO =	#N/A				

Date: 01/07/15
Designed By: CTH
Checked by: KD

PERFORMANCE RATIO AT EACH LEVEL

Live load is present behind the wall, but not on the wall

LEVEL	HEIGHT	STEM LENGTH	No. OF SHEAR KEYS	FACTORED LOAD EFFECT	FACTORED RESISTANCE	PERFORMANCE RATIO
1	4.50	6.00	2			
			OVERTURNING	56970	113082	1.98
			SLIDING	17526	26216	1.50
			PULLOUT	5394	11192	2.07
2	7.00	8.00	2			
			OVERTURNING	112498	296965	2.64
			SLIDING	27238	47793	1.75
			PULLOUT	5023	18326	3.65
3	9.50	8.00	2			
			OVERTURNING	194864	374522	1.92
			SLIDING	38996	59620	1.53
			PULLOUT	6571	22812	3.47
4	12.00	10.00	0			
			OVERTURNING	309185	734246	2.37
			SLIDING	52802	73696	1.40
			PULLOUT	8119	27072	3.33
5	14.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
6	17.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
7	19.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
8	22.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
9	24.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
10	27.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
11	29.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
12	32.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A

Date: 01/07/15
Designed By: CTH
Checked by: KD

LEVEL 4

STEM LENGTH = 10.00 FT
HEIGHT = 15.75 FT

EARTH PRESSURE			TRAFFIC SURCHARGE & WATER PRESSURE		
Pa =	5481.72	plf	Pt =	1392.18	plf
Feh =	27080.01	lbs.	Ft =	6960.91	lbs.
Fev =	4231.25	lbs.	Fw =	0.00	lbs.

STABILITY AGAINST SLIDING - LEVEL 4

SLIDING FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
Feh	27080.01	1.50	40620.02
Ft	6960.91	1.75	12181.59
Fw	0.00	1.00	0.00
TOTAL			52801.61

RESISTING FORCE

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
THRU SELECT FILL OR FOUNDATION	81281.63	1.35	0.58	1.00	63352.76
Fev	4231.25	1.50	0.58	1.00	3664.37
THRU JT. MAT'L OR FOUNDATION	12852.63	1.25	0.46	0.90	6678.42
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	0.90	0.00
EMBEDMENT	0.00	#N/A	#N/A	0.50	0.00
TOTAL					73695.55

PERFORMANCE RATIO = 1.40

STABILITY AGAINST PULLOUT - LEVEL 4

PULLOUT FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
PULLOUT FORCE	4437.98	1.50	6656.96
TRAFFIC SURCHARGE FORCE	835.69	1.75	1462.45
WATER PRESSURE	0.00	1.00	0.00
TOTAL			8119.42

RESISTING FORCE

Aeff. = 44.18 SF

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
ON STEM(SOIL TO SOIL IN Aeff)	7567.77	1.35	0.67	1.00	6891.11
ON STEM (SOIL TO CONCRETE IN A	22226.61	1.35	0.50	0.90	13502.67
CONC. UNIT WEIGHT (THROUGH JOINT MATERIAL)	12852.63	1.25	0.46	0.90	6678.42
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	0.90	0.00
TOTAL					27072.20

PERFORMANCE RATIO = 3.33

Date: 01/07/15
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 4

OVERTURNING MOMENT

	FORCE	MOMENT ARM	OVERTURNING MOMENT	LOAD FACTOR	FACTORED MOMENT
Feh	27080.01	5.25	142170.05	1.50	213255.08
Ft	6960.91	7.88	54817.17	1.75	95930.04
Fw	0.00	0.00	0.00	1.75	0.00
TOTAL					309185.12

RESISTING MOMENT

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED MOMENT
UNIT L1	2586.00	1.20	0.00	1.25	3232.50	3879.00
UNIT L2	2098.00	2.31	0.00	1.25	2622.50	6057.98
UNIT L3	2098.00	2.31	0.00	1.25	2622.50	6057.98
UNIT L4	2360.00	3.09	0.00	1.25	2950.00	9115.50
SELECT FILL L1	14131.20	3.25	0.00	1.35	19077.12	62000.64
SELECT FILL L2	10321.20	4.25	0.00	1.35	13933.62	59217.89
SELECT FILL L3	10321.20	4.25	0.00	1.35	13933.62	59217.89
SELECT FILL L4	13112.40	5.25	0.00	1.35	17701.74	92934.14

Date: 01/07/15
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 4 (CONTINUED)

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED MOMENT
STEP L2	5400.00	7.00	0.00	1.35	7290.00	51030.00
STEP L3	0.00	8.00	0.00	1.35	0.00	0.00
STEP L4	11400.00	9.00	0.00	1.35	15390.00	138510.00
EARTH SURCHARGE	20306.25	6.67	0.00	1.35	27413.44	182756.25
Fev	4231.25	10.00	0.00	1.50	6346.88	63468.77
TOTAL					132513.91	734246.02

PERFORMANCE RATIO = 2.37

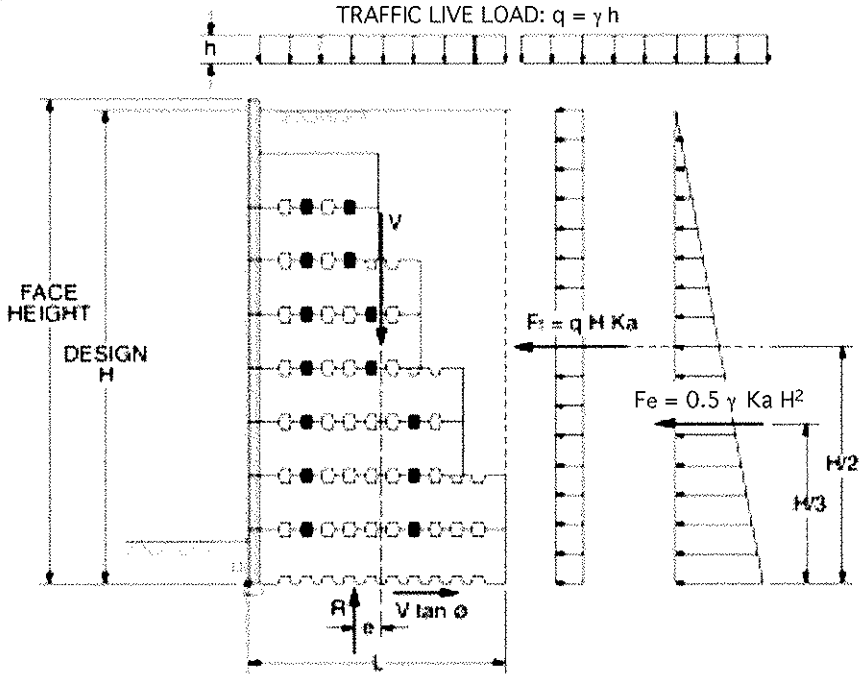
T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
LIMIT STATE: **SERVICE-I**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)
Level Surcharge and Infinite Slope Condition

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Comment: Wall 6

Project No: 4437
Date: 01/07/15
Designed By: CTH
Checked by: KD

Load Diagram:



Typical Section, All details may not apply

External Stability Calculation (SERVICE-I)

Stability Against Overturning: (moments about point "O")

Σ Factored Resisting Moments = $\phi V \cdot x_o$ (x_o is the horiz. distance between V and O)

Σ Factored overturning Momen = $\gamma_e F_e (H/3) + \gamma_t F_t (H/2)$

Stability Against Sliding:

Σ Factored Resisting Force = $\phi V \tan \phi_F$

Σ Factored Driving Force = $\gamma_e F_e + \gamma_t F_t$

Bearing Pressure:

Factored Bearing Pressure = $(\gamma_1 V + \gamma_2 qL)/(L - 2e)$ (use factored e)

Eccentricity:

Eccentricity (e) = $\dfrac{L}{2} - \dfrac{(V + qL)(L/2) - [F_V(H/3) + F_t(H/2)]}{V + qL}$

(use factored V, qL, Fe, Ft for factored e)

T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
Level Surcharge and Infinite Slope Condition
LIMIT STATE: **SERVICE-I**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858
Project No: 4437
Date: 1/7/15
By: CTH
Checked by: KD

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Comment: Wall 6

GRADING GEOMETRY

DISTANCE TO SLOPE (d) =	0	FT	
FILL SURCHARGE =	3.75	FT	
DISTANCE TO BREAK =	5	FT	
SLOPE ANGLE (ß1) =	36.9	DEG	
SLOPE ANGLE (I) =	8.9	DEG	
TRAFFIC SURCHARGE =	2	FT	

WALL GEOMETRY

HEIGHT (H) =	12.00	
BATTER ( ) =	0	
BASE (L) =	10	

BACKFILL SPECIFICATIONS

SELECT	INTERNAL FRICTION (Ø)=	34	DEG	Ka =	0.3095
	WEIGHT ( )=	120	PCF	Ko =	0.4408
	COHESION=	0	(assumed)		
UNCLASSIFIED	INTERNAL FRICTION (Ø)=	30	DEG	Ka =	0.3683
	WEIGHT ( )=	120	PCF		
	COHESION =	0	(assumed)		
FOUNDATION	FOUNDATION TYPE	S	(S for Soil, R for rock)		
	INTERNAL FRICTION (Ø)=	30	DEG	Kp =	3.0000

FRICTION FACTORS

JOINT MATERIAL TO CONCRETE =	0.59	
SELECT FILL TO CONCRETE =	0.50	
UNCLASSIFIED FILL TO CONCRETE =	0.50	
SELECT FILL TO FOUNDATION = tan(ø)	0.58	(Ø is min of select fill and foundation)
PRECAST CONCRETE TO FOUNDATION =	0.46	(0.8*TAN Øf)

SHEAR KEY STRENGTH = 2460 lbs.

WATER PRESSURE

HEIGHT OF WATER TABLE BEHIND WALL =	0	FT	(From bottom of wall)
HEIGHT OF WATER TABLE BEFORE WALL =	0	FT	(From bottom of wall)

WIND ON SOUND BARRIER/OTHER STRUCTURE

WIND FORCE =	0	LBS
DISTANCE FROM TOP OF WALL/GUTTER LINE =	0	FT

Date: 01/07/15
Designed By: CTH
Checked by: KD

RESISTANCE FACTORS

FRICTION BETWEEN SOIL & SOIL :	1.00	
FRICTION BETWEEN SOIL & CONC. :	1.00	
FRICTION BETWEEN JOINT & CONC. :	1.00	
SHEAR THROUGH SHEAR KEY :	1.00	
PASSIVE PRESSURE AGAINST SLIDING :	1.00	(Not used for this project)
PASSIVE PRESSURE AGAINST OVERTURN. :	1.00	(Not used for this project)

LOAD FACTORS

DC (WEIGHT OF CONCRETE) :	1.00
EV (WEIGHT OF SOIL) :	1.00
EARTH PRESSURES (EH)	
HORIZONTAL COMPONENT :	1.00
VERTICAL COMPONENT :	1.00
LL (VEHICULAR LIVE LOAD), LS (LIVE LOAD SURCHARGE) :	1.00
WATER PRESSURE :	1.00
WIND LOAD :	0.30

GLOBAL STABILITY

OVERTURNING

SUM FACTORED OVERTURNING MOMENTS:	196987
SUM FACTORED RESISTING MOMENTS:	540673
PERFORMANCE RATIO:	2.74

SLIDING

SUM FACTORED HORIZONTAL FORCE:	34041
FACTORED RESISTING FRICTION FORCE:	55307
PERFORMANCE RATIO:	1.62

MAXIMUM BEARING PRESSURE

Meyerhof distribution which considers a uniform base pressure distribution over an effective width of B' = L - 2e

Live load surcharge is present on the wall and behind the wall

MAXIMUM BEARING PRESSURE: σ_v = SUM VERTICAL LOADS/(L-2e)

FACTORED SUM OF VERTICAL LOADS =	110366	LB/5 FT WIDTH			
FACTORED e =	1.34	≤ L/4 =	2.50	ft	ON SOIL
FACTORED BEARING PRESSURE =	3017	PSF			
FACTORED BEARING CAPACITY =	#N/A	PSF			
PERFORMANCE RATIO =	#N/A				

Date: 01/07/15
Designed By: CTH
Checked by: KD

FACTORS OF SAFETY AT EACH LEVEL

Live load is present behind the wall, but not on the wall

LEVEL	HEIGHT	STEM LENGTH	No. OF SHEAR KEYS	FACTORED LOAD EFFECT	FACTORED RESISTANCE	PERFORMANCE RATIO
1	4.50	6.00	2			
			OVERTURNING	35473	83220	2.35
			SLIDING	11076	21294	1.92
			PULLOUT	3333	10502	3.15
2	7.00	8.00	2			
			OVERTURNING	70743	218810	3.09
			SLIDING	17367	37533	2.16
			PULLOUT	3209	16375	5.10
3	9.50	8.00	2			
			OVERTURNING	123444	275709	2.23
			SLIDING	25021	46423	1.86
			PULLOUT	4242	20073	4.73
4	12.00	10.00	0			
			OVERTURNING	196987	540673	2.74
			SLIDING	34041	55307	1.62
			PULLOUT	5274	22154	4.20
5	14.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
6	17.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
7	19.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
8	22.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
9	24.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
10	27.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
11	29.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
12	32.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A

Date: 01/07/15
Designed By: CTH
Checked by: KD

LEVEL 4

STEM LENGTH = 10.00 FT
HEIGHT = 15.75 FT

EARTH PRESSURE			TRAFFIC SURCHARGE & WATER PRESSURE		
Pa =	5481.72	plf	Pt =	1392.18	plf
Feh =	27080.01	lbs.	Ft =	6960.91	lbs.
Fev =	4231.25	lbs.	Fw =	0.00	lbs.

SLIDING FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
Feh	27080.01	1.00	27080.01
Ft	6960.91	1.00	6960.91
Fw	0.00	1.00	0.00
WIND LOAD	0.00	0.30	0.00
TOTAL			34040.92

RESISTING FORCE

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
THRU SELECT FILL OR FOUNDATION	81281.63	1.00	0.58	1.00	46928.0
Fev	4231.25	1.00	0.58	1.00	2442.9
THRU JT. MATERIAL OR FOUNDATIC	12852.63	1.00	0.46	1.00	5936.4
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	1.00	0.0
EMBEDMENT	0.00	#N/A	#N/A	1.00	0.0
TOTAL					55307.3

PERFORMANCE RATIO = 1.62

STABILITY AGAINST PULLOUT - LEVEL 4

PULLOUT FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
PULLOUT FORCE =	4437.98	1.00	4437.98
TRAFFIC SURCHARGE FORCE =	835.69	1.00	835.69
WATER PRESSURE =	0.00	1.00	0.00
TOTAL			5273.66

RESISTING FORCE

Aeff. = 44.18 SF

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
ON STEM(SOIL TO SOIL IN Aeff)	7567.77	1.00	0.67	1.00	5104.5
ON STEM (SOIL TO CONCRETE IN A	22226.61	1.00	0.50	1.00	11113.3
THRU JT. MATERIAL OR FOUNDATIC	12852.63	1.00	0.46	1.00	5936.4
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	1.00	0.0
TOTAL					22154.2

PERFORMANCE RATIO = 4.20

Date: 01/07/15
Designed By: CIH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 4

OVERTURNING MOMENT

	FORCE	MOMENT ARM	OVERTURNING MOMENT	LOAD FACTOR	FACTORED MOMENT
Feh	27080.01	5.25	142170.1	1.00	142170.1
Ft	6960.91	7.88	54817.2	1.00	54817.2
Fw	0.00	0.00	0.0	1.00	0.0
WIND LOAD	0.00	12.00	0.00	0.30	0.00
TOTAL					196987.2

RESISTING MOMENT

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED RESISTANCE
PANEL L1	2586.00	1.20	0.00	1.00	2586.0	3103.2
PANEL L2	2098.00	2.31	0.00	1.00	2098.0	4846.4
PANEL L3	2098.00	2.31	0.00	1.00	2098.0	4846.4
PANEL L4	2360.00	3.09	0.00	1.00	2360.0	7292.4
SELECT FILL L1	14131.20	3.25	0.00	1.00	14131.2	45926.4
SELECT FILL L2	10321.20	4.25	0.00	1.00	10321.2	43865.1
SELECT FILL L3	10321.20	4.25	0.00	1.00	10321.2	43865.1
SELECT FILL L4	13112.40	5.25	0.00	1.00	13112.4	68840.1

Date: 01/07/15
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 4 (CONTINUED)

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED RESISTANCE
STEP L2	5400.00	7.00	0.00	1.00	5400.0	37800.0
STEP L3	0.00	8.00	0.00	1.00	0.0	0.0
STEP L4	11400.00	9.00	0.00	1.00	11400.0	102600.0
EARTH SURCHARGE	20306.25	6.67	0.00	1.00	20306.3	135375.0
Fev	4231.25	10.00	0.00	1.00	4231.3	42312.5
TOTAL					98365.50	540672.58

PERFORMANCE RATIO = 2.74

Wall 7

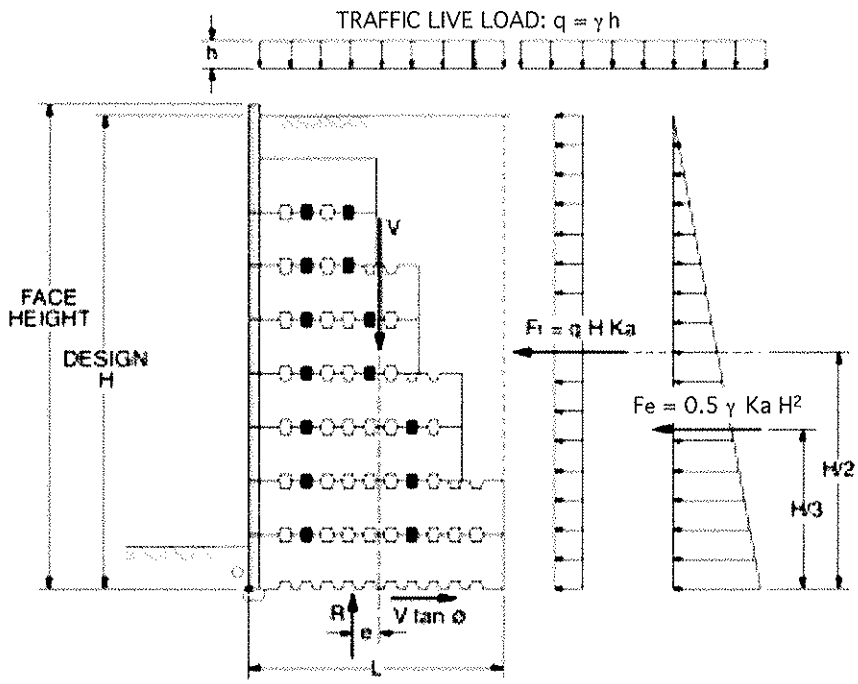
T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
LIMIT STATE: **STRENGTH-I MIN**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)
Level Surcharge and Infinite Slope Condition

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Comment: Wall 7

Project No: TW4437
Date: 1/2/15
Designed By: CH
Checked by: KD

Load Diagram:



Typical Section (For illustration only, Some details may not apply)

External Stability Calculation (STRENGTH-I MIN)

Stability Against Overturning: (moments about point "O")

Σ Factored Resisting Moments = $\phi V \cdot x_0$ (x_0 is the horiz. distance between V and O)

Σ Factored overturning Momen = $Y_e F_e (H/3) + Y_t F_t (H/2)$

Stability Against Sliding:

Σ Factored Resisting Force = $\phi V \tan \phi_F$

Σ Factored Driving Force = $Y_e F_e + Y_t F_t$

Bearing Pressure:

Factored Bearing Pressure = $(Y_1 V + Y_2 qL)/(L - 2e)$ (use factored e)

Eccentricity:

Eccentricity (e) = $\dfrac{L}{2} - \dfrac{(V + qL)(L/2) - [F_V(H/3) + F_t(H/2)]}{V + qL}$

(use factored V, qL, Fe, Ft for factored e)
(q=0, Ft=0 for this case)

T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
Level Surcharge and Infinite Slope Condition
LIMIT STATE: **STRENGTH-I MIN**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858
Project No: TW4437
Date: 1/2/15
By: CH
Checked by: KD

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Wall Name: Wall 7

GRADING GEOMETRY

DISTANCE TO SLOPE (d) =	0	FT	
FILL SURCHARGE =	3.75	FT	
DISTANCE TO BREAK =	5	FT	
SLOPE ANGLE (ß1) =	36.9	DEG	
SLOPE ANGLE (I) =	12.4	DEG	
TRAFFIC SURCHARGE =	2	FT	

WALL GEOMETRY

HEIGHT (H) =	8.50	
BATTER ( ) =	0	
BASE (L) =	8	

BACKFILL SPECIFICATIONS

SELECT	INTERNAL FRICTION (Ø)=	34	DEG	Ka =	0.3230
	WEIGHT ( )=	120	PCF	Ko =	0.4408
	COHESION=	0	(assumed)		
UNCLASSIFIED	INTERNAL FRICTION (Ø)=	30	DEG	Ka =	0.3865
	WEIGHT ( )=	120	PCF		
	COHESION =	0	(assumed)		
FOUNDATION	FOUNDATION TYPE	S	(S for Soil, R for rock)		
	INTERNAL FRICTION (Øf) =	32	DEG	Kp =	3.2546

FRICTION FACTORS

JOINT MATERIAL TO CONCRETE =	0.59	
SELECT FILL TO CONCRETE =	0.50	
UNCLASSIFIED FILL TO CONCRETE =	0.50	
SELECT FILL TO FOUNDATION = tan(ø)	0.62	(Ø is min of select fill and foundation)
PRECAST CONCRETE TO FOUNDATION =	0.50	(0.8*TAN Øf)

SHEAR KEY STRENGTH = 2460 lbs.

WATER PRESSURE

HEIGHT OF WATER TABLE BEHIND WALL =	0	FT	(From bottom of wall)
HEIGHT OF WATER TABLE BEFORE WALL =	0	FT	(From bottom of wall)

Date: 01/02/15
Designed By: CH
Checked by: KD

RESISTANCE FACTORS

FRICTION BETWEEN SOIL & SOIL :	1.00	
FRICTION BETWEEN SOIL & CONC. :	0.90	
FRICTION BETWEEN JOINT & CONC. :	0.90	
SHEAR THROUGH SHEAR KEY :	0.90	
PASSIVE PRESSURE AGAINST SLIDING :	0.50	(Not used for this project)
PASSIVE PRESSURE AGAINST OVERTURN. :	0.60	(Not used for this project)

LOAD FACTORS

DC (WEIGHT OF CONCRETE) :	0.90
EV (WEIGHT OF SOIL) :	1.00
EARTH PRESSURES (EH)	
HORIZONTAL COMPONENT :	1.50
VERTICAL COMPONENT :	1.50
LL (VEHICULAR LIVE LOAD), LS (LIVE LOAD SURCHARGE) :	1.75
WATER PRESSURE :	1.00

GLOBAL STABILITY

OVERTURNING

SUM FACTORED OVERTURNING MOMENTS	164964
SUM FACTORED RESISTING MOMENTS	276035
PERFORMANCE RATIO	1.67

SLIDING

SUM FACTORED HORIZONTAL FORCE	35428
FACTORED RESISTING FRICTION FORCE	35981
PERFORMANCE RATIO	1.02

MAXIMUM BEARING PRESSURE

Meyerhof distribution which considers a uniform base pressure distribution over an effective width of B' = L - 2e

Live load surcharge is present on the wall and behind the wall

MAXIMUM BEARING PRESSURE: Sv = SUM VERTICAL LOADS/(L-2e)

FACTORED SUM OF VERTICAL LOADS =	76403	LB/5 FT WIDTH			
FACTORED e =	1.67	≤ L/4 =	2.00	ft	ON SOIL
FACTORED BEARING PRESSURE =	3274	PSF			

FACTORED BEARING RESISTANCE =	#N/A	PSF
PERFORMANCE RATIO =	#N/A	

Date: 01/02/15
Designed By: CH
Checked by: KD

PERFORMANCE RATIO AT EACH LEVEL

Live load is present behind the wall, but not on the wall

LEVEL	HEIGHT	STEM LENGTH	No. OF SHEAR KEYS	FACTORED LOAD EFFECT	FACTORED RESISTANCE	PERFORMANCE RATIO
1	6.00	6.00	2			
			OVERTURNING	91048	113526	1.25
			SLIDING	24058	25663	1.07
			PULLOUT	8797	10635	1.21
2	8.50	8.00	0			
			OVERTURNING	164964	276035	1.67
			SLIDING	35428	35981	1.02
			PULLOUT	6157	11407	1.85
3	11.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
4	13.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
5	16.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
6	18.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
7	21.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
8	23.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
9	26.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
10	28.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
11	31.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
12	33.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A

Date: 01/02/15
Designed By: CH
Checked by: KD

LEVEL 2

STEM LENGTH = 8.00 FT
HEIGHT = 12.25 FT

EARTH PRESSURE			TRAFFIC SURCHARGE & WATER PRESSURE		
Pa =	3479.81	plf	Pt =	1136.27	plf
Feh =	16990.60	lbs.	Ft =	5681.33	lbs.
Fev =	3747.93	lbs.	Fw =	0.00	lbs.

STABILITY AGAINST SLIDING - LEVEL 2

SLIDING FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
Feh	16990.60	1.50	25485.90
Ft	5681.33	1.75	9942.32
Fw	0.00	1.00	0.00
TOTAL			35428.22

RESISTING FORCE

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
THRU SELECT FILL OR FOUNDATION	47273.03	1.00	0.62	1.00	29539.46
Fev	3747.93	1.50	0.62	1.00	3512.95
THRU JT. MAT'L OR FOUNDATION	7232.63	0.90	0.50	0.90	2928.60
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	0.90	0.00
EMBEDMENT	0.00	#N/A	#N/A	0.50	0.00
TOTAL					35981.01

PERFORMANCE RATIO = 1.02

STABILITY AGAINST PULLOUT - LEVEL 2

PULLOUT FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
PULLOUT FORCE	3087.12	1.50	4630.67
TRAFFIC SURCHARGE FORCE	872.09	1.75	1526.16
WATER PRESSURE	0.00	1.00	0.00
TOTAL			6156.83

RESISTING FORCE

Aeff. = 34.18 SF

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
ON STEM(SOIL TO SOIL IN Aeff)	4247.53	1.00	0.67	1.00	2865.00
ON STEM (SOIL TO CONCRETE IN A	12475.04	1.00	0.50	0.90	5613.77
CONC. UNIT WEIGHT (THROUGH JOINT MATERIAL)	7232.63	0.90	0.50	0.90	2928.60
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	0.90	0.00
					11407.37

PERFORMANCE RATIO = 1.85

Date: 01/02/15
Designed By: CH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 2

OVERTURNING MOMENT

	FORCE	MOMENT ARM	OVERTURNING MOMENT	LOAD FACTOR	FACTORED MOMENT
Feh	16990.60	4.08	69378.28	1.50	104067.42
Ft	5681.33	6.13	34798.13	1.75	60896.73
Fw	0.00	0.00	0.00	1.00	0.00
TOTAL					164964.15

RESISTING MOMENT

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED MOMENT
UNIT L1	3149.00	1.03	0.00	0.90	2834.10	2919.12
UNIT L2	2098.00	2.31	0.00	0.90	1888.20	4361.74
SELECT FILL L1	19081.20	3.25	0.00	1.00	19081.20	62013.90
SELECT FILL L2	10321.20	4.25	0.00	1.00	10321.20	43865.10

Date: 01/02/15
Designed By: CH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 2 (CONTINUED)

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED MOMENT
STEP L2	7200.00	7.00	0.00	1.00	7200.00	50400.00
EARTH SURCHARGE	12656.25	5.33	0.00	1.00	12656.25	67500.00
Fev	3747.93	8.00	0.00	1.50	5621.89	44975.12
TOTAL					59602.84	276034.98

PERFORMANCE RATIO = 1.67

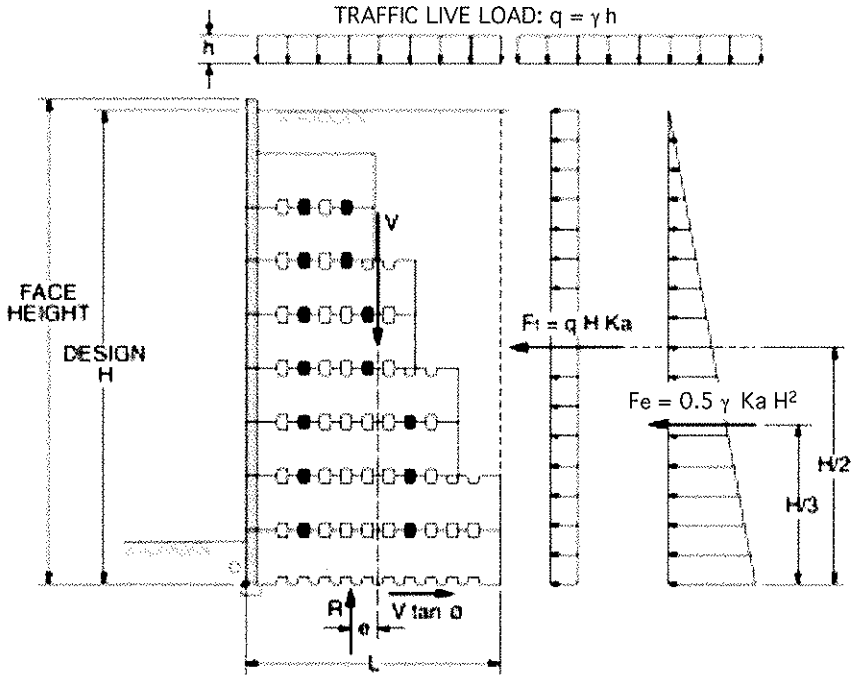
T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
LIMIT STATE: **STRENGTH-I MAX**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)
Level Surcharge and Infinite Slope Condition

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Comment: Wall 7

Project No: TW4437
Date: 1/2/15
Designed By: CH
Checked by: KD

Load Diagram:



Typical Section (For illustration only, Some details may not apply)

External Stability Calculation (STRENGTH-I MAX)

Stability Against Overturning: (moments about point "O")

Σ Factored Resisting Moments = $\phi V \cdot x_O$ (x_O is the horiz. distance between V and O)

Σ Factored overturning Momen = $\gamma_e F_e (H/3) + \gamma_t F_t (H/2)$

Stability Against Sliding:

Σ Factored Resisting Force = $\phi V \tan \phi_F$

Σ Factored Driving Force = $\gamma_e F_e + \gamma_t F_t$

Bearing Pressure:

Factored Bearing Pressure = $(\gamma_1 V + \gamma_2 qL)/(L - 2e)$ (use factored e)

Eccentricity:

Eccentricity (e) = $\dfrac{L}{2} - \dfrac{(V + qL)(L/2) - [F_V(H/3) + F_t(H/2)]}{V + qL}$

(use factored V, qL, Fe, Ft for factored e)
(q=0, Ft=0 for this case)

T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
Level Surcharge and Infinite Slope Condition
LIMIT STATE: **STRENGTH-I MAX**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858

Project No: TW4437
Date: 1/2/15
By: CH
Checked by: KD

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Wall Name: Wall 7

GRADING GEOMETRY

DISTANCE TO SLOPE (d) =	0	FT	
FILL SURCHARGE =	3.75	FT	
DISTANCE TO BREAK =	5	FT	
SLOPE ANGLE (ß1) =	36.9	DEG	
SLOPE ANGLE (I) =	12.4	DEG	
TRAFFIC SURCHARGE =	2	FT	

WALL GEOMETRY

HEIGHT (H) =	8.50	
BATTER ( ) =	0	
BASE (L) =	8	

BACKFILL SPECIFICATIONS

SELECT	INTERNAL FRICTION (Ø)=	34	DEG	Ka =	0.3230
	WEIGHT ( )=	120	PCF	Ko =	0.4408
	COHESION=	0	(assumed)		
UNCLASSIFIED	INTERNAL FRICTION (Ø)=	30	DEG	Ka =	0.3865
	WEIGHT ( )=	120	PCF		
	COHESION =	0	(assumed)		
FOUNDATION	FOUNDATION TYPE	S	(S for Soil, R for rock)		
	INTERNAL FRICTION (Ø)=	32	DEG	Kp =	3.2546

FRICTION FACTORS

JOINT MATERIAL TO CONCRETE =	0.59	
SELECT FILL TO CONCRETE =	0.50	
UNCLASSIFIED FILL TO CONCRETE =	0.50	
SELECT FILL TO FOUNDATION = tan(ø)	0.62	(Ø is min of select fill and foundation)
PRECAST CONCRETE TO FOUNDATION =	0.50	(0.8*TAN Øf)

SHEAR KEY STRENGTH = 2460 lbs.

WATER PRESSURE

HEIGHT OF WATER TABLE BEHIND WALL =	0	FT	(From bottom of wall)
HEIGHT OF WATER TABLE BEFORE WALL =	0	FT	(From bottom of wall)

Date: 01/02/15
Designed By: CH
Checked by: KD

RESISTANCE FACTORS

FRICTION BETWEEN SOIL & SOIL :	1.00	
FRICTION BETWEEN SOIL & CONC. :	0.90	
FRICTION BETWEEN JOINT & CONC. :	0.90	
SHEAR THROUGH SHEAR KEY :	0.90	
PASSIVE PRESSURE AGAINST SLIDING :	0.50	(Not used for this project)
PASSIVE PRESSURE AGAINST OVERTURN. :	0.60	(Not used for this project)

LOAD FACTORS

DC (WEIGHT OF CONCRETE) :	1.25
EV (WEIGHT OF SOIL) :	1.35
EARTH PRESSURES (EH)	
HORIZONTAL COMPONENT :	1.50
VERTICAL COMPONENT :	1.50
LL (VEHICULAR LIVE LOAD), LS (LIVE LOAD SURCHARGE) :	1.75
WATER PRESSURE :	1.00

GLOBAL STABILITY

OVERTURNING

SUM FACTORED OVERTURNING MOMENTS	164964
SUM FACTORED RESISTING MOMENTS	357189
PERFORMANCE RATIO	2.17

SLIDING

SUM FACTORED HORIZONTAL FORCE	35428
FACTORED RESISTING FRICTION FORCE	47459
PERFORMANCE RATIO	1.34

MAXIMUM BEARING PRESSURE

Meyerhof distribution which considers a uniform base pressure distribution over an effective width of B' = L - 2e

Live load surcharge is present on the wall and behind the wall

MAXIMUM BEARING PRESSURE: Sv = SUM VERTICAL LOADS/(L-2e)

FACTORED SUM OF VERTICAL LOADS =	95480	LB/5 FT WIDTH			
FACTORED e =	1.28	≤ L/4 =	2.00	ft	ON SOIL
FACTORED BEARING PRESSURE =	3514	PSF			

FACTORED BEARING RESISTANCE =	#N/A	PSF
PERFORMANCE RATIO =	#N/A	

Date: 01/02/15
Designed By: CH
Checked by: KD

PERFORMANCE RATIO AT EACH LEVEL

Live load is present behind the wall, but not on the wall

LEVEL	HEIGHT	STEM LENGTH	No. OF SHEAR KEYS	FACTORED LOAD EFFECT	FACTORED RESISTANCE	PERFORMANCE RATIO
1	6.00	6.00	2			
			OVERTURNING	91048	145895	1.60
			SLIDING	24058	32325	1.34
			PULLOUT	8797	12879	1.46
2	8.50	8.00	0			
			OVERTURNING	164964	357189	2.17
			SLIDING	35428	47459	1.34
			PULLOUT	6157	15514	2.52
3	11.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
4	13.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
5	16.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
6	18.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
7	21.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
8	23.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
9	26.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
10	28.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
11	31.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
12	33.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A

Date: 01/02/15
Designed By: CH
Checked by: KD

LEVEL 2			
STEM LENGTH =	8.00	FT	
HEIGHT =	12.25	FT	

EARTH PRESSURE			TRAFFIC SURCHARGE & WATER PRESSURE		
Pa =	3479.81	plf	Pt =	1136.27	plf
Feh =	16990.60	lbs.	Ft =	5681.33	lbs.
Fev =	3747.93	lbs.	Fw =	0.00	lbs.

STABILITY AGAINST SLIDING - LEVEL 2

SLIDING FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
Feh	16990.60	1.50	25485.90
Ft	5681.33	1.75	9942.32
Fw	0.00	1.00	0.00
TOTAL			35428.22

RESISTING FORCE

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
THRU SELECT FILL OR FOUNDATION	47273.03	1.35	0.62	1.00	39878.28
Fev	3747.93	1.50	0.62	1.00	3512.95
THRU JT. MAT'L OR FOUNDATION	7232.63	1.25	0.50	0.90	4067.50
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	0.90	0.00
EMBEDMENT	0.00	#N/A	#N/A	0.50	0.00
TOTAL					47458.72

PERFORMANCE RATIO = 1.34

STABILITY AGAINST PULLOUT - LEVEL 2

PULLOUT FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
PULLOUT FORCE	3087.12	1.50	4630.67
TRAFFIC SURCHARGE FORCE	872.09	1.75	1526.16
WATER PRESSURE	0.00	1.00	0.00
TOTAL			6156.83

RESISTING FORCE

Aeff. = 34.18 SF

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
ON STEM(SOIL TO SOIL IN Aeff)	4247.53	1.35	0.67	1.00	3867.75
ON STEM (SOIL TO CONCRETE IN A	12475.04	1.35	0.50	0.90	7578.59
CONC. UNIT WEIGHT (THROUGH JOINT MATERIAL)	7232.63	1.25	0.50	0.90	4067.50
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	0.90	0.00
					15513.84

PERFORMANCE RATIO = 2.52

Date: 01/02/15
Designed By: CH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 2

OVERTURNING MOMENT

	FORCE	MOMENT ARM	OVERTURNING MOMENT	LOAD FACTOR	FACTORED MOMENT
Feh	16990.60	4.08	69378.28	1.50	104067.42
Ft	5681.33	6.13	34798.13	1.75	60896.73
Fw	0.00	0.00	0.00	1.00	0.00
TOTAL					164964.15

RESISTING MOMENT

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED MOMENT
UNIT L1	3149.00	1.03	0.00	1.25	3936.25	4054.34
UNIT L2	2098.00	2.31	0.00	1.25	2622.50	6057.98
SELECT FILL L1	19081.20	3.25	0.00	1.35	25759.62	83718.77
SELECT FILL L2	10321.20	4.25	0.00	1.35	13933.62	59217.89

Date: 01/02/15
Designed By: CH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 2 (CONTINUED)

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED MOMENT
STEP L2	7200.00	7.00	0.00	1.35	9720.00	68040.00
EARTH SURCHARGE	12656.25	5.33	0.00	1.35	17085.94	91125.00
Fev	3747.93	8.00	0.00	1.50	5621.89	44975.12
TOTAL					78679.82	357189.08

PERFORMANCE RATIO = 2.17

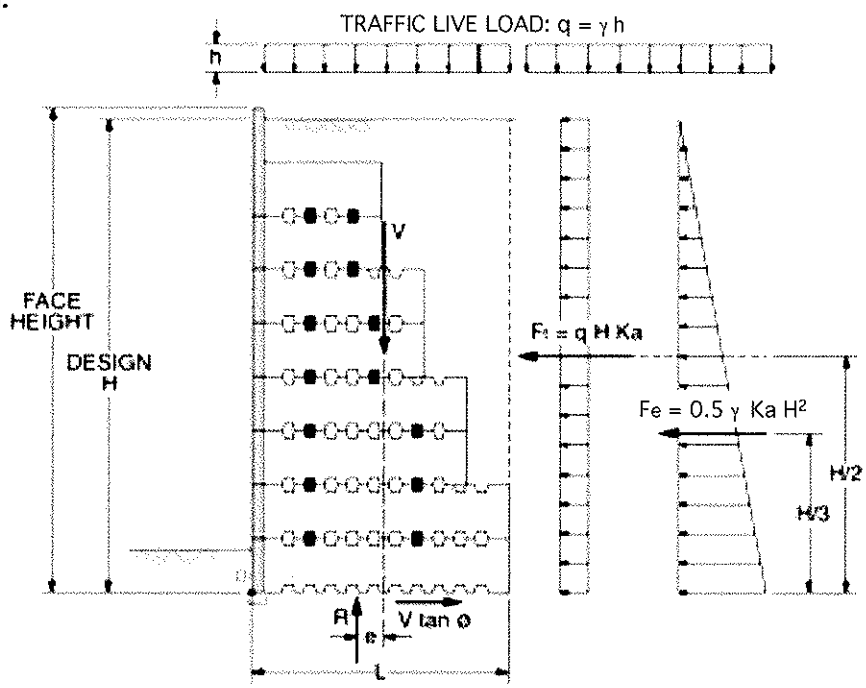
T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
LIMIT STATE: **SERVICE-I**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)
Level Surcharge and Infinite Slope Condition

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Comment: Wall 7

Project No: TW4437
Date: 01/02/15
Designed By: CH
Checked by: KD

Load Diagram:



Typical Section, All details may not apply

External Stability Calculation (SERVICE-I)

Stability Against Overturning: (moments about point "O")

Σ Factored Resisting Moments = $\phi V \cdot x_o$ (x_o is the horiz. distance between V and O)

Σ Factored overturning Momen = $\gamma_e F_e (H/3) + \gamma_t F_t (H/2)$

Stability Against Sliding:

Σ Factored Resisting Force = $\phi V \tan \phi_F$

Σ Factored Driving Force = $\gamma_e F_e + \gamma_t F_t$

Bearing Pressure:

Factored Bearing Pressure = $(\gamma_1 V + \gamma_2 qL)/(L - 2e)$ (use factored e)

Eccentricity:

Eccentricity (e) = $\dfrac{L}{2} - \dfrac{(V + qL)(L/2) - [F_V(H/3) + F_t(H/2)]}{V + qL}$

(use factored V, qL, Fe, Ft for factored e)

T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
Level Surcharge and Infinite Slope Condition
LIMIT STATE: **SERVICE-I**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)

Revised BZY 3/3/12
The Neel Company
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Project No: TW4437
Date: 1/2/15
By: CH
Checked by: KD

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Comment: Wall 7

GRADING GEOMETRY

DISTANCE TO SLOPE (d) =	0	FT	
FILL SURCHARGE =	3.75	FT	
DISTANCE TO BREAK =	5	FT	
SLOPE ANGLE (ß1) =	36.9	DEG	
SLOPE ANGLE (I) =	12.4	DEG	
TRAFFIC SURCHARGE =	2	FT	

WALL GEOMETRY

HEIGHT (H) =	8.50	
BATTER ( ) =	0	
BASE (L) =	8	

BACKFILL SPECIFICATIONS

SELECT	INTERNAL FRICTION (Ø)=	34	DEG	Ka =	0.3230
	WEIGHT ( )=	120	PCF	Ko =	0.4408
	COHESION=	0	(assumed)		
UNCLASSIFIED	INTERNAL FRICTION (Ø)=	30	DEG	Ka =	0.3865
	WEIGHT ( )=	120	PCF		
	COHESION =	0	(assumed)		
FOUNDATION	FOUNDATION TYPE	S	(S for Soil, R for rock)		
	INTERNAL FRICTION (Ø)=	32	DEG	Kp =	3.2546

FRICTION FACTORS

JOINT MATERIAL TO CONCRETE =	0.59	
SELECT FILL TO CONCRETE =	0.50	
UNCLASSIFIED FILL TO CONCRETE =	0.50	
SELECT FILL TO FOUNDATION = tan(ø)	0.62	(Ø is min of select fill and foundation)
PRECAST CONCRETE TO FOUNDATION =	0.50	(0.8*TAN Øf)

SHEAR KEY STRENGTH = 2460 lbs.

WATER PRESSURE

HEIGHT OF WATER TABLE BEHIND WALL =	0	FT	(From bottom of wall)
HEIGHT OF WATER TABLE BEFORE WALL =	0	FT	(From bottom of wall)

WIND ON SOUND BARRIER/OTHER STRUCTURE

WIND FORCE =	0	LBS
DISTANCE FROM TOP OF WALL/GUTTER LINE =	0	FT

Date: 01/02/15
Designed By: CH
Checked by: KD

RESISTANCE FACTORS

FRICTION BETWEEN SOIL & SOIL :	1.00	
FRICTION BETWEEN SOIL & CONC. :	1.00	
FRICTION BETWEEN JOINT & CONC. :	1.00	
SHEAR THROUGH SHEAR KEY :	1.00	
PASSIVE PRESSURE AGAINST SLIDING :	1.00	(Not used for this project)
PASSIVE PRESSURE AGAINST OVERTURN. :	1.00	(Not used for this project)

LOAD FACTORS

DC (WEIGHT OF CONCRETE) :	1.00
EV (WEIGHT OF SOIL) :	1.00
EARTH PRESSURES (EH)	
HORIZONTAL COMPONENT :	1.00
VERTICAL COMPONENT :	1.00
LL (VEHICULAR LIVE LOAD), LS (LIVE LOAD SURCHARGE) :	1.00
WATER PRESSURE :	1.00
WIND LOAD :	0.30

GLOBAL STABILITY

OVERTURNING

SUM FACTORED OVERTURNING MOMENTS:	104176
SUM FACTORED RESISTING MOMENTS:	261852
PERFORMANCE RATIO:	2.51

SLIDING

SUM FACTORED HORIZONTAL FORCE:	22672
FACTORED RESISTING FRICTION FORCE:	35497
PERFORMANCE RATIO:	1.57

MAXIMUM BEARING PRESSURE

Meyerhof distribution which considers a uniform base pressure distribution over an effective width of B' = L - 2e

Live load surcharge is present on the wall and behind the wall

MAXIMUM BEARING PRESSURE: σ_v = SUM VERTICAL LOADS/(L-2e)

FACTORED SUM OF VERTICAL LOADS =	67854	LB/5 FT WIDTH			
FACTORED e =	1.11	≤ L/4 =	2.00	ft	ON SOIL
FACTORED BEARING PRESSURE =	2348	PSF			
FACTORED BEARING CAPACITY =	#N/A	PSF			
PERFORMANCE RATIO =	#N/A				

Date: 01/02/15
Designed By: CH
Checked by: KD

FACTORS OF SAFETY AT EACH LEVEL

Live load is present behind the wall, but not on the wall

LEVEL	HEIGHT	STEM LENGTH	No. OF SHEAR KEYS	FACTORED LOAD EFFECT	FACTORED RESISTANCE	PERFORMANCE RATIO
1	6.00	6.00	2			
			OVERTURNING	57025	106728	1.87
			SLIDING	15285	25783	1.69
			PULLOUT	5493	11878	2.16
2	8.50	8.00	0			
			OVERTURNING	104176	261852	2.51
			SLIDING	22672	35497	1.57
			PULLOUT	3959	12718	3.21
3	11.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
4	13.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
5	16.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
6	18.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
7	21.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
8	23.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
9	26.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
10	28.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
11	31.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
12	33.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A

Date: 01/02/15
Designed By: CH
Checked by: KD

LEVEL 2

STEM LENGTH = 8.00 FT
HEIGHT = 12.25 FT

EARTH PRESSURE			TRAFFIC SURCHARGE & WATER PRESSURE		
Pa =	3479.81	plf	Pt =	1136.27	plf
Feh =	16990.60	lbs.	Ft =	5681.33	lbs.
Fev =	3747.93	lbs.	Fw =	0.00	lbs.

STABILITY AGAINST SLIDING - LEVEL 2

SLIDING FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
Feh	16990.60	1.00	16990.60
Ft	5681.33	1.00	5681.33
Fw	0.00	1.00	0.00
WIND LOAD	0.00	0.30	0.00
TOTAL			22671.93

RESISTING FORCE

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
THRU SELECT FILL OR FOUNDATION	47273.03	1.00	0.62	1.00	29539.5
Fev	3747.93	1.00	0.62	1.00	2342.0
THRU JT. MATERIAL OR FOUNDATIC	7232.63	1.00	0.50	1.00	3615.6
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	1.00	0.0
EMBEDMENT	0.00	#N/A	#N/A	1.00	0.0
TOTAL					35497.0

PERFORMANCE RATIO = 1.57

STABILITY AGAINST PULLOUT - LEVEL 2

PULLOUT FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
PULLOUT FORCE =	3087.12	1.00	3087.12
TRAFFIC SURCHARGE FORCE =	872.09	1.00	872.09
WATER PRESSURE =	0.00	1.00	0.00
WIND LOAD =	0.00	0.30	0.00
TOTAL			3959.21

RESISTING FORCE

Aeff. = 34.18 SF

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
ON STEM(SOIL TO SOIL IN Aeff)	4247.53	1.00	0.67	1.00	2865.0
ON STEM (SOIL TO CONCRETE IN A	12475.04	1.00	0.50	1.00	6237.5
THRU JT. MATERIAL OR FOUNDATIC	7232.63	1.00	0.50	1.00	3615.6
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	1.00	0.0
					12718.08

PERFORMANCE RATIO = 3.21

Date: 01/02/15
Designed By: CH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 2

OVERTURNING MOMENT

	FORCE	MOMENT ARM	OVERTURNING MOMENT	LOAD FACTOR	FACTORED MOMENT
Feh	16990.60	4.08	69378.3	1.00	69378.3
Ft	5681.33	6.13	34798.1	1.00	34798.1
Fw	0.00	0.00	0.0	1.00	0.0
WIND LOAD	0.00	8.50	0.00	0.30	0.00
TOTAL					104176.4

RESISTING MOMENT

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED RESISTANCE
PANEL L1	3149.00	1.03	0.00	1.00	3149.0	3243.5
PANEL L2	2098.00	2.31	0.00	1.00	2098.0	4846.4
SELECT FILL L1	19081.20	3.25	0.00	1.00	19081.2	62013.9
SELECT FILL L2	10321.20	4.25	0.00	1.00	10321.2	43865.1

Date: 01/02/15
Designed By: CH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 2 (CONTINUED)

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED RESISTANCE
STEP L2	7200.00	7.00	0.00	1.00	7200.0	50400.0
EARTH SURCHARGE	12656.25	5.33	0.00	1.00	12656.3	67500.0
Fev	3747.93	8.00	0.00	1.00	3747.9	29983.4
TOTAL					58253.58	261852.26

PERFORMANCE RATIO = 2.51

Wall 8

T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
LIMIT STATE: **STRENGTH-I MIN**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)
Level Surcharge and Infinite Slope Condition

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
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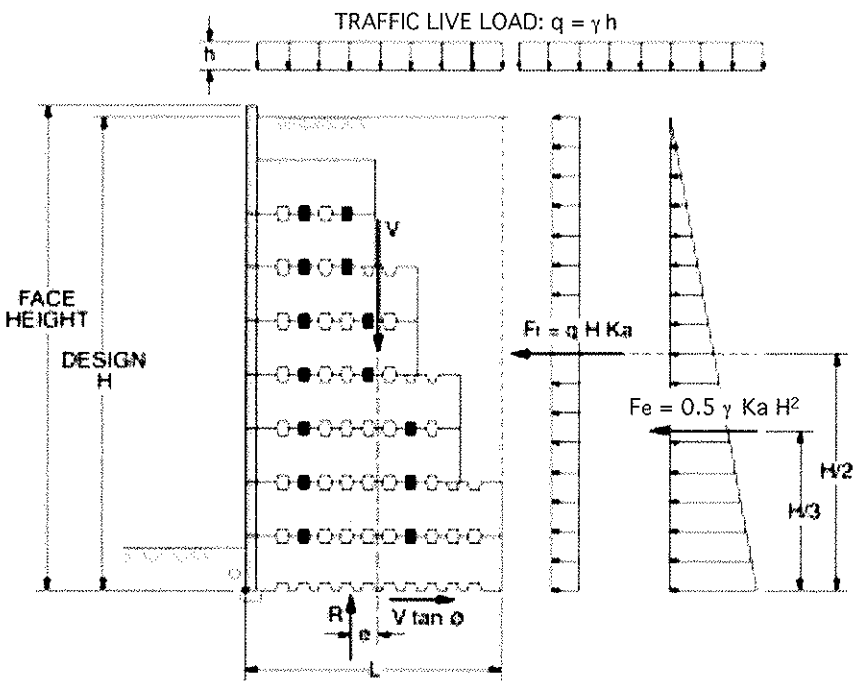
Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Comment: Wall 8

Project No: 4437
Date: 1/2/15
Designed By: CH
Checked by: KD

Load Diagram:



Typical Section (For illustration only, Some details may not apply)

External Stability Calculation (STRENGTH-I MIN)

Stability Against Overturning: (moments about point "O")

Σ Factored Resisting Moments = $\phi V \cdot x_0$ (x_0 is the horiz. distance between V and O)

Σ Factored overturning Momen = $Y_e F_e (H/3) + Y_t F_t (H/2)$

Stability Against Sliding:

Σ Factored Resisting Force = $\phi V \tan \phi_F$

Σ Factored Driving Force = $Y_e F_e + Y_t F_t$

Bearing Pressure:

Factored Bearing Pressure = $(Y_1 V + Y_2 qL)/(L - 2e)$ (use factored e)

Eccentricity:

Eccentricity (e) = $\dfrac{L}{2} - \dfrac{(V + qL)(L/2) - [F_V(H/3) + F_t(H/2)]}{V + qL}$

(use factored V, qL, Fe, Ft for factored e)
(q=0, Ft=0 for this case)

T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
Level Surcharge and Infinite Slope Condition
LIMIT STATE: **STRENGTH-I MIN**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858
Project No: 4437
Date: 1/2/15
By: CH
Checked by: KD

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Wall Name: Wall 8

GRADING GEOMETRY

DISTANCE TO SLOPE (d) =	0	FT	
FILL SURCHARGE =	3.75	FT	
DISTANCE TO BREAK =	5	FT	
SLOPE ANGLE (ß1) =	36.9	DEG	
SLOPE ANGLE (I) =	10.1	DEG	
TRAFFIC SURCHARGE =	2	FT	

WALL GEOMETRY

HEIGHT (H) =	10.50	
BATTER ( ) =	0	
BASE (L) =	10	

BACKFILL SPECIFICATIONS

SELECT	INTERNAL FRICTION (Ø)=	34	DEG	Ka =	0.3140
	WEIGHT ( )=	120	PCF	Ko =	0.4408
	COHESION=	0	(assumed)		
UNCLASSIFIED	INTERNAL FRICTION (Ø)=	30	DEG	Ka =	0.3743
	WEIGHT ( )=	120	PCF		
	COHESION =	0	(assumed)		
FOUNDATION	FOUNDATION TYPE	S	(S for Soil, R for rock)		
	INTERNAL FRICTION (Øf) =	30	DEG	Kp =	3.0000

FRICTION FACTORS

JOINT MATERIAL TO CONCRETE =	0.59	
SELECT FILL TO CONCRETE =	0.50	
UNCLASSIFIED FILL TO CONCRETE =	0.50	
SELECT FILL TO FOUNDATION = tan(ø)	0.58	(Ø is min of select fill and foundation)
PRECAST CONCRETE TO FOUNDATION =	0.46	(0.8*TAN Øf)

SHEAR KEY STRENGTH = 2460 lbs.

WATER PRESSURE

HEIGHT OF WATER TABLE BEHIND WALL =	0	FT	(From bottom of wall)
HEIGHT OF WATER TABLE BEFORE WALL =	0	FT	(From bottom of wall)

Date: 01/02/15
Designed By: CH
Checked by: KD

RESISTANCE FACTORS

FRICTION BETWEEN SOIL & SOIL :	1.00	
FRICTION BETWEEN SOIL & CONC. :	0.90	
FRICTION BETWEEN JOINT & CONC. :	0.90	
SHEAR THROUGH SHEAR KEY :	0.90	
PASSIVE PRESSURE AGAINST SLIDING :	0.50	(Not used for this project)
PASSIVE PRESSURE AGAINST OVERTURN. :	0.60	(Not used for this project)

LOAD FACTORS

DC (WEIGHT OF CONCRETE) :	0.90
EV (WEIGHT OF SOIL) :	1.00
EARTH PRESSURES (EH)	
HORIZONTAL COMPONENT :	1.50
VERTICAL COMPONENT :	1.50
LL (VEHICULAR LIVE LOAD), LS (LIVE LOAD SURCHARGE) :	1.75
WATER PRESSURE :	1.00

GLOBAL STABILITY

OVERTURNING

SUM FACTORED OVERTURNING MOMENTS	239737
SUM FACTORED RESISTING MOMENTS	511259
PERFORMANCE RATIO	2.13

SLIDING

SUM FACTORED HORIZONTAL FORCE	44871
FACTORED RESISTING FRICTION FORCE	50175
PERFORMANCE RATIO	1.12

MAXIMUM BEARING PRESSURE

Meyerhof distribution which considers a uniform base pressure distribution over an effective width of B' = L - 2e

Live load surcharge is present on the wall and behind the wall

MAXIMUM BEARING PRESSURE: Sv = SUM VERTICAL LOADS/(L-2e)

FACTORED SUM OF VERTICAL LOADS =	111061	LB/5 FT WIDTH			
FACTORED e =	1.61	≤ L/4 =	2.50	ft	ON SOIL
FACTORED BEARING PRESSURE =	3276	PSF			
FACTORED BEARING RESISTANCE =	#N/A	PSF			
PERFORMANCE RATIO =	#N/A				

Date: 01/02/15
Designed By: CH
Checked by: KD

PERFORMANCE RATIO AT EACH LEVEL

Live load is present behind the wall, but not on the wall

LEVEL	HEIGHT	STEM LENGTH	No. OF SHEAR KEYS	FACTORED LOAD EFFECT	FACTORED RESISTANCE	PERFORMANCE RATIO
1	5.50	6.00	2			
			OVERTURNING	77371	101955	1.32
			SLIDING	21458	23766	1.11
			PULLOUT	7478	10221	1.37
2	8.00	8.00	2			
			OVERTURNING	143921	254159	1.77
			SLIDING	32128	40932	1.27
			PULLOUT	5709	15786	2.77
3	10.50	10.00	0			
			OVERTURNING	239737	511259	2.13
			SLIDING	44871	50175	1.12
			PULLOUT	7274	17471	2.40
4	13.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
5	15.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
6	18.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
7	20.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
8	23.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
9	25.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
10	28.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
11	30.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
12	33.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A

Date: 01/02/15
Designed By: CH
Checked by: KD

LEVEL 3

STEM LENGTH = 10.00 FT
HEIGHT = 14.25 FT

EARTH PRESSURE			TRAFFIC SURCHARGE & EARTH PRESSURE		
Pa =	4560.33	plf	Pt =	1280.09	plf
Feh =	22446.55	lbs.	Ft =	6400.46	lbs.
Fev =	4008.31	lbs.	Fw =	0.00	lbs.

STABILITY AGAINST SLIDING - LEVEL 3

SLIDING FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
Feh	22446.55	1.50	33669.83
Ft	6400.46	1.75	11200.80
Fw	0.00	1.00	0.00
TOTAL			44870.63

RESISTING FORCE

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
THRU SELECT FILL OR FOUNDATION	73720.43	1.00	0.58	1.00	42562.51
Fev	4008.31	1.50	0.58	1.00	3471.30
THRU JT. MAT'L OR FOUNDATION	11069.63	0.90	0.46	0.90	4141.40
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	0.90	0.00
EMBEDMENT	0.00	#N/A	#N/A	0.50	0.00
TOTAL					50175.21

PERFORMANCE RATIO = 1.12

STABILITY AGAINST PULLOUT - LEVEL 3

PULLOUT FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
PULLOUT FORCE	3859.96	1.50	5789.94
TRAFFIC SURCHARGE FORCE	847.79	1.75	1483.63
WATER PRESSURE	0.00	1.00	0.00
TOTAL			7273.56

RESISTING FORCE

Aeff. = 44.18 SF

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
ON STEM(SOIL TO SOIL IN Aeff)	6677.45	1.00	0.67	1.00	4504.00
ON STEM (SOIL TO CONCRETE IN A	19611.72	1.00	0.50	0.90	8825.27
THRU JT. MAT'L OR FOUNDATION	11069.63	0.90	0.46	0.90	4141.40
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	0.90	0.00
TOTAL					17470.67

PERFORMANCE RATIO = 2.40

Date: 01/02/15
Designed By: CH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 3

OVERTURNING MOMENT

	FORCE	MOMENT ARM	OVERTURNING MOMENT	LOAD FACTOR	FACTORED MOMENT
Feh	22446.55	4.75	106621.12	1.50	159931.69
Ft	6400.46	7.13	45603.26	1.75	79805.70
Fw	0.00	0.00	0.00	1.00	0.00
TOTAL					239737.39

RESISTING MOMENT

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED MOMENT
UNIT L1	2961.00	1.08	0.00	0.90	2664.90	2878.09
UNIT L2	2098.00	2.31	0.00	0.90	1888.20	4361.74
UNIT L3	2360.00	3.09	0.00	0.90	2124.00	6563.16
SELECT FILL L1	17431.20	3.25	0.00	1.00	17431.20	56651.40
SELECT FILL L2	10321.20	4.25	0.00	1.00	10321.20	43865.10
SELECT FILL L3	13112.40	5.25	0.00	1.00	13112.40	68840.10

Date: 01/02/15
Designed By: CH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 3 (CONTINUED)

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED MOMENT
STEP L2	6600.00	7.00	0.00	1.00	6600.00	46200.00
STEP L3	9600.00	9.00	0.00	1.00	9600.00	86400.00
EARTH SURCHARGE	20306.25	6.67	0.00	1.00	20306.25	135375.00
Fev	4008.31	10.00	0.00	1.50	6012.47	60124.69
TOTAL					90060.62	511259.29

PERFORMANCE RATIO = 2.13

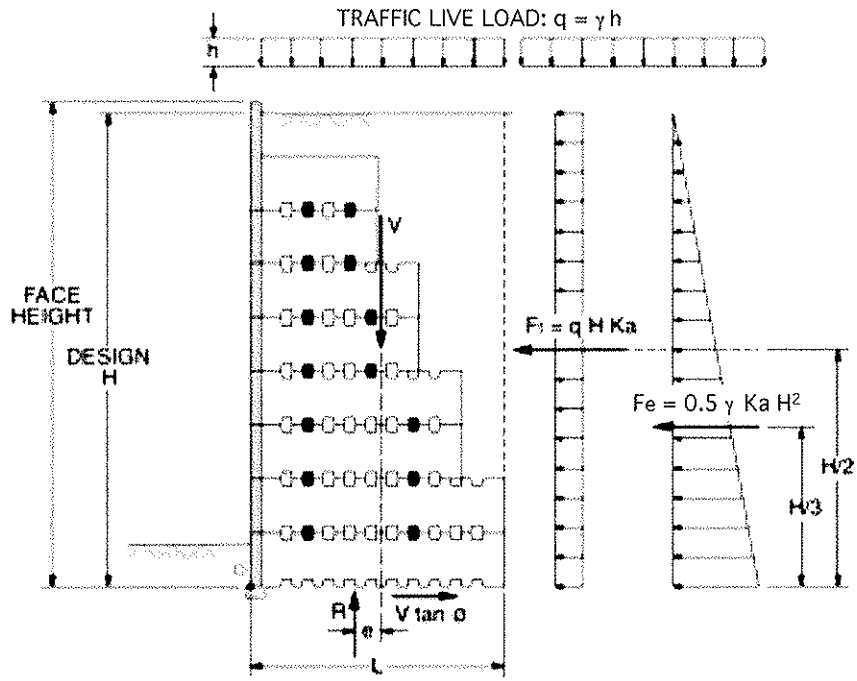
T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
LIMIT STATE: **STRENGTH-I MAX**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)
Level Surcharge and Infinite Slope Condition

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Comment: Wall 8

Project No: 4437
Date: 1/2/15
Designed By: CH
Checked by: KD

Load Diagram:



Typical Section (For illustration only, Some details may not apply)

External Stability Calculation (STRENGTH-I MAX)

Stability Against Overturning: (moments about point "O")

Σ Factored Resisting Moments = $\phi V \cdot x_O$ (x_O is the horiz. distance between V and O)

Σ Factored overturning Momen = $\gamma_e F_e (H/3) + \gamma_t F_t (H/2)$

Stability Against Sliding:

Σ Factored Resisting Force = $\phi V \tan \phi_F$

Σ Factored Driving Force = $\gamma_e F_e + \gamma_t F_t$

Bearing Pressure:

Factored Bearing Pressure = $(\gamma_1 V + \gamma_2 qL)/(L - 2e)$ (use factored e)

Eccentricity:

Eccentricity (e) = $\dfrac{L}{2} - \dfrac{(V + qL)(L/2) - [F_V(H/3) + F_t(H/2)]}{V + qL}$

(use factored V, qL, Fe, Ft for factored e)
(q=0, Ft=0 for this case)

T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
Level Surcharge and Infinite Slope Condition
LIMIT STATE: STRENGTH-I MAX
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858
Project No: 4437
Date: 1/2/15
By: CH
Checked by: KD

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Wall Name: Wall 8

GRADING GEOMETRY

DISTANCE TO SLOPE (d) =	0	FT	
FILL SURCHARGE =	3.75	FT	
DISTANCE TO BREAK =	5	FT	
SLOPE ANGLE (ß1) =	36.9	DEG	
SLOPE ANGLE (I) =	10.1	DEG	
TRAFFIC SURCHARGE =	2	FT	

WALL GEOMETRY

HEIGHT (H) =	10.50	
BATTER ( ) =	0	
BASE (L) =	10	

BACKFILL SPECIFICATIONS

SELECT	INTERNAL FRICTION (Ø)=	34	DEG	Ka =	0.3140
	WEIGHT ( )=	120	PCF	Ko =	0.4408
	COHESION=	0	(assumed)		
UNCLASSIFIED	INTERNAL FRICTION (Ø)=	30	DEG	Ka =	0.3743
	WEIGHT ( )=	120	PCF		
	COHESION =	0	(assumed)		
FOUNDATION	FOUNDATION TYPE	S	(S for Soil, R for rock)		
	INTERNAL FRICTION (Ø)=	30	DEG	Kp =	3.0000

FRICTION FACTORS

JOINT MATERIAL TO CONCRETE =	0.59	
SELECT FILL TO CONCRETE =	0.50	
UNCLASSIFIED FILL TO CONCRETE =	0.50	
SELECT FILL TO FOUNDATION = tan(ø)	0.58	(Ø is min of select fill and foundation)
PRECAST CONCRETE TO FOUNDATION =	0.46	(0.8*TAN Øf)

SHEAR KEY STRENGTH = 2460 lbs.

WATER PRESSURE

HEIGHT OF WATER TABLE BEHIND WALL =	0	FT	(From bottom of wall)
HEIGHT OF WATER TABLE BEFORE WALL =	0	FT	(From bottom of wall)

Date: 01/02/15
Designed By: CH
Checked by: KD

RESISTANCE FACTORS

FRICTION BETWEEN SOIL & SOIL :	1.00	
FRICTION BETWEEN SOIL & CONC. :	0.90	
FRICTION BETWEEN JOINT & CONC. :	0.90	
SHEAR THROUGH SHEAR KEY :	0.90	
PASSIVE PRESSURE AGAINST SLIDING :	0.50	(Not used for this project)
PASSIVE PRESSURE AGAINST OVERTURN. :	0.60	(Not used for this project)

LOAD FACTORS

DC (WEIGHT OF CONCRETE) :	1.25
EV (WEIGHT OF SOIL) :	1.35
EARTH PRESSURES (EH)	
HORIZONTAL COMPONENT :	1.50
VERTICAL COMPONENT :	1.50
LL (VEHICULAR LIVE LOAD), LS (LIVE LOAD SURCHARGE) :	1.75
WATER PRESSURE :	1.00

GLOBAL STABILITY

OVERTURNING

SUM FACTORED OVERTURNING MOMENTS	239737
SUM FACTORED RESISTING MOMENTS	669693
PERFORMANCE RATIO	2.79

SLIDING

SUM FACTORED HORIZONTAL FORCE	44871
FACTORED RESISTING FRICTION FORCE	66683
PERFORMANCE RATIO	1.49

MAXIMUM BEARING PRESSURE

Meyerhof distribution which considers a uniform base pressure distribution over an effective width of B' = L - 2e

Live load surcharge is present on the wall and behind the wall

MAXIMUM BEARING PRESSURE: Sv = SUM VERTICAL LOADS/(L-2e)

FACTORED SUM OF VERTICAL LOADS =	140737	LB/5 FT WIDTH			
FACTORED e =	1.20	≤ L/4 =	2.50	ft	ON SOIL
FACTORED BEARING PRESSURE =	3703	PSF			

FACTORED BEARING RESISTANCE =	#N/A	PSF
PERFORMANCE RATIO =	#N/A	

Date: 01/02/15
Designed By: CH
Checked by: KD

PERFORMANCE RATIO AT EACH LEVEL

Live load is present behind the wall, but not on the wall

LEVEL	HEIGHT	STEM LENGTH	No. OF SHEAR KEYS	FACTORED LOAD EFFECT	FACTORED RESISTANCE	PERFORMANCE RATIO
1	5.50	6.00	2			
			OVERTURNING	77371	132431	1.71
			SLIDING	21458	30004	1.40
			PULLOUT	7478	12316	1.65
2	8.00	8.00	2			
			OVERTURNING	143921	331951	2.31
			SLIDING	32128	52873	1.65
			PULLOUT	5709	19892	3.48
3	10.50	10.00	0			
			OVERTURNING	239737	669693	2.79
			SLIDING	44871	66683	1.49
			PULLOUT	7274	23746	3.26
4	13.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
5	15.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
6	18.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
7	20.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
8	23.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
9	25.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
10	28.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
11	30.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
12	33.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A

Date: 01/02/15
Designed By: CH
Checked by: KD

LEVEL 3

STEM LENGTH = 10.00 FT
HEIGHT = 14.25 FT

EARTH PRESSURE			TRAFFIC SURCHARGE & EARTH PRESSURE		
Pa =	4560.33	plf	Pt =	1280.09	plf
Feh =	22446.55	lbs.	Ft =	6400.46	lbs.
Fev =	4008.31	lbs.	Fw =	0.00	lbs.

STABILITY AGAINST SLIDING - LEVEL 3

SLIDING FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
Feh	22446.55	1.50	33669.83
Ft	6400.46	1.75	11200.80
Fw	0.00	1.00	0.00
TOTAL			44870.63

RESISTING FORCE

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
THRU SELECT FILL OR FOUNDATION	73720.43	1.35	0.58	1.00	57459.38
Fev	4008.31	1.50	0.58	1.00	3471.30
THRU JT. MAT'L OR FOUNDATION	11069.63	1.25	0.46	0.90	5751.95
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	0.90	0.00
EMBEDMENT	0.00	#N/A	#N/A	0.50	0.00
TOTAL					66682.63

PERFORMANCE RATIO = 1.49

STABILITY AGAINST PULLOUT - LEVEL 3

PULLOUT FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
PULLOUT FORCE	3859.96	1.50	5789.94
TRAFFIC SURCHARGE FORCE	847.79	1.75	1483.63
WATER PRESSURE	0.00	1.00	0.00
TOTAL			7273.56

RESISTING FORCE

Aeff. = 44.18 SF

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
ON STEM(SOIL TO SOIL IN Aeff)	6677.45	1.35	0.67	1.00	6080.39
ON STEM (SOIL TO CONCRETE IN A	19611.72	1.35	0.50	0.90	11914.12
THRU JT. MAT'L OR FOUNDATION	11069.63	1.25	0.46	0.90	5751.95
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	0.90	0.00
TOTAL					23746.46

PERFORMANCE RATIO = 3.26

Date: 01/02/15
Designed By: CH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 3

OVERTURNING MOMENT

	FORCE	MOMENT ARM	OVERTURNING MOMENT	LOAD FACTOR	FACTORED MOMENT
Feh	22446.55	4.75	106621.12	1.50	159931.69
Ft	6400.46	7.13	45603.26	1.75	79805.70
Fw	0.00	0.00	0.00	1.00	0.00
TOTAL					239737.39

RESISTING MOMENT

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED MOMENT
UNIT L1	2961.00	1.08	0.00	1.25	3701.25	3997.35
UNIT L2	2098.00	2.31	0.00	1.25	2622.50	6057.98
UNIT L3	2360.00	3.09	0.00	1.25	2950.00	9115.50
SELECT FILL L1	17431.20	3.25	0.00	1.35	23532.12	76479.39
SELECT FILL L2	10321.20	4.25	0.00	1.35	13933.62	59217.89
SELECT FILL L3	13112.40	5.25	0.00	1.35	17701.74	92934.14

Date: 01/02/15
Designed By: CH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 3 (CONTINUED)

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED MOMENT
STEP L2	6600.00	7.00	0.00	1.35	8910.00	62370.00
STEP L3	9600.00	9.00	0.00	1.35	12960.00	116640.00
EARTH SURCHARGE	20306.25	6.67	0.00	1.35	27413.44	182756.25
Fev	4008.31	10.00	0.00	1.50	6012.47	60124.69
TOTAL					119737.14	669693.18

PERFORMANCE RATIO = 2.79

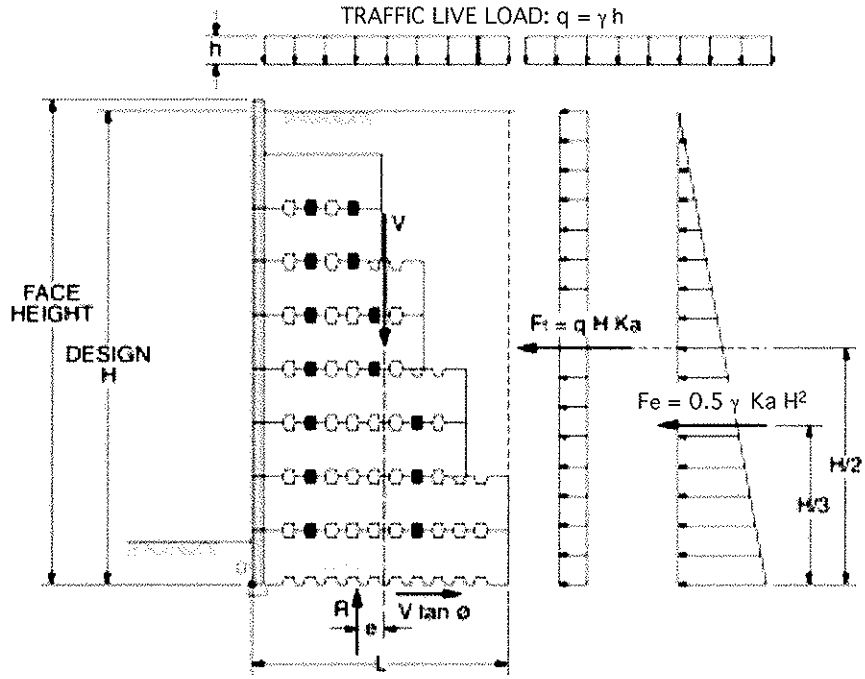
T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
LIMIT STATE: **SERVICE-I**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)
Level Surcharge and Infinite Slope Condition

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Comment: Wall 8

Project No: 4437
Date: 01/02/15
Designed By: CH
Checked by: KD

Load Diagram:



Typical Section, All details may not apply

External Stability Calculation (SERVICE-I)

Stability Against Overturning: (moments about point "O")

Σ Factored Resisting Moments = $\phi V \cdot x_o$ (x_o is the horiz. distance between V and O)

Σ Factored overturning Momen = $\gamma_e F_e (H/3) + \gamma_t F_t (H/2)$

Stability Against Sliding:

Σ Factored Resisting Force = $\phi V \tan \phi_F$

Σ Factored Driving Force = $\gamma_e F_e + \gamma_t F_t$

Bearing Pressure:

Factored Bearing Pressure = $(\gamma_1 V + \gamma_2 qL)/(L - 2e)$ (use factored e)

Eccentricity:

Eccentricity (e) = $\dfrac{L}{2} - \dfrac{(V + qL)(L/2) - [F_V(H/3) + F_t(H/2)]}{V + qL}$

(use factored V, qL, Fe, Ft for factored e)

T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
Level Surcharge and Infinite Slope Condition
LIMIT STATE: **SERVICE-I**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858
Project No: 4437
Date: 1/2/15
By: CH
Checked by: KD

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Comment: Wall 8

GRADING GEOMETRY

DISTANCE TO SLOPE (d) =	0	FT	
FILL SURCHARGE =	3.75	FT	
DISTANCE TO BREAK =	5	FT	
SLOPE ANGLE (ß1) =	36.9	DEG	
SLOPE ANGLE (I) =	10.1	DEG	
TRAFFIC SURCHARGE =	2	FT	

WALL GEOMETRY

HEIGHT (H) =	10.50	
BATTER ( ) =	0	
BASE (L) =	10	

BACKFILL SPECIFICATIONS

SELECT	INTERNAL FRICTION (Ø)=	34	DEG	Ka =	0.3140
	WEIGHT ( )=	120	PCF	Ko =	0.4408
	COHESION=	0	(assumed)		
UNCLASSIFIED	INTERNAL FRICTION (Ø)=	30	DEG	Ka =	0.3743
	WEIGHT ( )=	120	PCF		
	COHESION =	0	(assumed)		
FOUNDATION	FOUNDATION TYPE	S	(S for Soil, R for rock)		
	INTERNAL FRICTION (Ø)=	30	DEG	Kp =	3.0000

FRICTION FACTORS

JOINT MATERIAL TO CONCRETE =	0.59	
SELECT FILL TO CONCRETE =	0.50	
UNCLASSIFIED FILL TO CONCRETE =	0.50	
SELECT FILL TO FOUNDATION = tan(ø)	0.58	(Ø is min of select fill and foundation)
PRECAST CONCRETE TO FOUNDATION =	0.46	(0.8*TAN Øf)

SHEAR KEY STRENGTH = 2460 lbs.

WATER PRESSURE

HEIGHT OF WATER TABLE BEHIND WALL =	0	FT	(From bottom of wall)
HEIGHT OF WATER TABLE BEFORE WALL =	0	FT	(From bottom of wall)

WIND ON SOUND BARRIER/OTHER STRUCTURE

WIND FORCE =	0	LBS
DISTANCE FROM TOP OF WALL/GUTTER LINE =	0	FT

Date: 01/02/15
Designed By: CH
Checked by: KD

RESISTANCE FACTORS

FRICTION BETWEEN SOIL & SOIL :	1.00	
FRICTION BETWEEN SOIL & CONC. :	1.00	
FRICTION BETWEEN JOINT & CONC. :	1.00	
SHEAR THROUGH SHEAR KEY :	1.00	
PASSIVE PRESSURE AGAINST SLIDING :	1.00	(Not used for this project)
PASSIVE PRESSURE AGAINST OVERTURN. :	1.00	(Not used for this project)

LOAD FACTORS

DC (WEIGHT OF CONCRETE) :	1.00
EV (WEIGHT OF SOIL) :	1.00
EARTH PRESSURES (EH)	
HORIZONTAL COMPONENT :	1.00
VERTICAL COMPONENT :	1.00
LL (VEHICULAR LIVE LOAD), LS (LIVE LOAD SURCHARGE) :	1.00
WATER PRESSURE :	1.00
WIND LOAD :	0.30

GLOBAL STABILITY

OVERTURNING

SUM FACTORED OVERTURNING MOMENTS:	152224
SUM FACTORED RESISTING MOMENTS:	492751
PERFORMANCE RATIO:	3.24

SLIDING

SUM FACTORED HORIZONTAL FORCE:	28847
FACTORED RESISTING FRICTION FORCE:	49990
PERFORMANCE RATIO:	1.73

MAXIMUM BEARING PRESSURE

Meyerhof distribution which considers a uniform base pressure distribution over an effective width of B' = L - 2e

Live load surcharge is present on the wall and behind the wall

MAXIMUM BEARING PRESSURE: σ_v = SUM VERTICAL LOADS/(L-2e)

FACTORED SUM OF VERTICAL LOADS =	100798	LB/5 FT WIDTH			
FACTORED e =	1.03	≤ L/4 =	2.50	ft	ON SOIL
FACTORED BEARING PRESSURE =	2537	PSF			
FACTORED BEARING CAPACITY =	#N/A	PSF			
PERFORMANCE RATIO =	#N/A				

Date: 01/02/15
Designed By: CH
Checked by: KD

FACTORS OF SAFETY AT EACH LEVEL

Live load is present behind the wall, but not on the wall

LEVEL	HEIGHT	STEM LENGTH	No. OF SHEAR KEYS	FACTORED LOAD EFFECT	FACTORED RESISTANCE	PERFORMANCE RATIO
1	5.50	6.00	2			
			OVERTURNING	48378	97208	2.01
			SLIDING	13613	24097	1.77
			PULLOUT	4656	11419	2.45
2	8.00	8.00	2			
			OVERTURNING	90780	244063	2.69
			SLIDING	20539	41288	2.01
			PULLOUT	3665	17651	4.82
3	10.50	10.00	0			
			OVERTURNING	152224	492751	3.24
			SLIDING	28847	49990	1.73
			PULLOUT	4708	19423	4.13
4	13.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
5	15.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
6	18.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
7	20.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
8	23.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
9	25.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
10	28.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
11	30.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
12	33.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A

Date: 01/02/15
Designed By: CH
Checked by: KD

LEVEL 3

STEM LENGTH = 10.00 FT
HEIGHT = 14.25 FT

EARTH PRESSURE			TRAFFIC SURCHARGE & WATER PRESSURE		
Pa =	4560.33	plf	Pt =	1280.09	plf
Feh =	22446.55	lbs.	Ft =	6400.46	lbs.
Fev =	4008.31	lbs.	Fw =	0.00	lbs.

STABILITY AGAINST SLIDING - LEVEL 3

SLIDING FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
Feh	22446.55	1.00	22446.55
Ft	6400.46	1.00	6400.46
Fw	0.00	1.00	0.00
WIND LOAD	0.00	0.30	0.00
TOTAL			28847.01

RESISTING FORCE

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
THRU SELECT FILL OR FOUNDATION	73720.43	1.00	0.58	1.00	42562.5
Fev	4008.31	1.00	0.58	1.00	2314.2
THRU JT. MATERIAL OR FOUNDATIC	11069.63	1.00	0.46	1.00	5112.8
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	1.00	0.0
EMBEDMENT	0.00	#N/A	#N/A	1.00	0.0
TOTAL					49989.5

PERFORMANCE RATIO = 1.73

STABILITY AGAINST PULLOUT - LEVEL 3

PULLOUT FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
PULLOUT FORCE =	3859.96	1.00	3859.96
TRAFFIC SURCHARGE FORCE =	847.79	1.00	847.79
WATER PRESSURE =	0.00	1.00	0.00
TOTAL			4707.75

RESISTING FORCE Aeff. = 44.18 SF

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
ON STEM(SOIL TO SOIL IN Aeff)	6677.45	1.00	0.67	1.00	4504.0
ON STEM (SOIL TO CONCRETE IN A	19611.72	1.00	0.50	1.00	9805.9
THRU JT. MATERIAL OR FOUNDATIC	11069.63	1.00	0.46	1.00	5112.8
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	1.00	0.0
TOTAL					19422.7

PERFORMANCE RATIO = 4.13

Date: 01/02/15
Designed By: CH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 3

OVERTURNING MOMENT

	FORCE	MOMENT ARM	OVERTURNING MOMENT	LOAD FACTOR	FACTORED MOMENT
Feh	22446.55	4.75	106621.1	1.00	106621.1
Ft	6400.46	7.13	45603.3	1.00	45603.3
Fw	0.00	0.00	0.0	1.00	0.0
WIND LOAD	0.00	10.50	0.00	0.30	0.00
TOTAL					152224.4

RESISTING MOMENT

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED RESISTANCE
PANEL L1	2961.00	1.08	0.00	1.00	2961.0	3197.9
PANEL L2	2098.00	2.31	0.00	1.00	2098.0	4846.4
PANEL L3	2360.00	3.09	0.00	1.00	2360.0	7292.4
SELECT FILL L1	17431.20	3.25	0.00	1.00	17431.2	56651.4
SELECT FILL L2	10321.20	4.25	0.00	1.00	10321.2	43865.1
SELECT FILL L3	13112.40	5.25	0.00	1.00	13112.4	68840.1

Date: 01/02/15
Designed By: CH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 3 (CONTINUED)

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED RESISTANCE
STEP L2	6600.00	7.00	0.00	1.00	6600.0	46200.0
STEP L3	9600.00	9.00	0.00	1.00	9600.0	86400.0
EARTH SURCHARGE	20306.25	6.67	0.00	1.00	20306.3	135375.0
Fev	4008.31	10.00	0.00	1.00	4008.3	40083.1
TOTAL					88798.36	492751.39

PERFORMANCE RATIO = 3.24

BR46A PC Gravity Wall

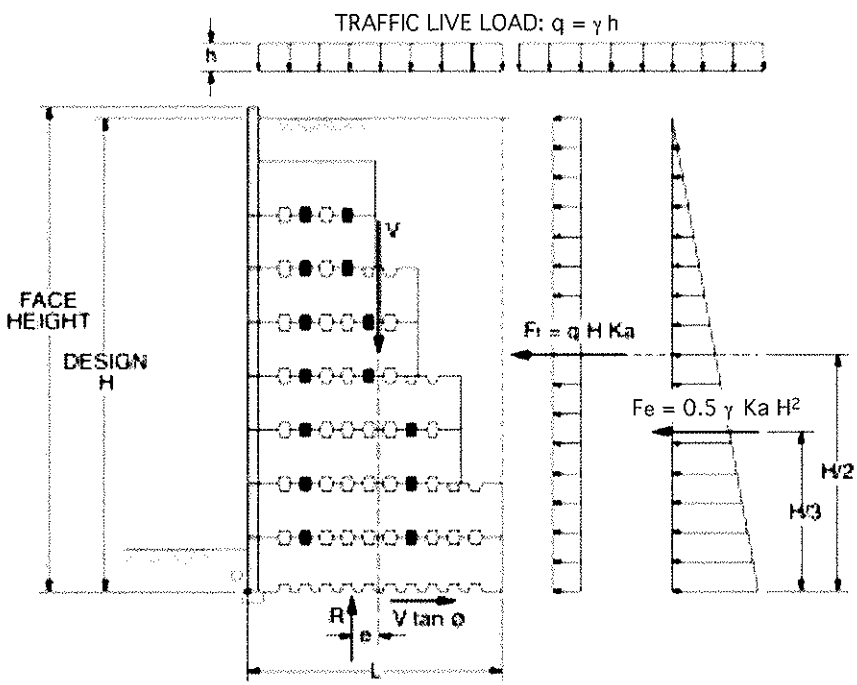
T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
LIMIT STATE: **STRENGTH-I MIN**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)
Level Surcharge and Infinite Slope Condition

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Comment: BR46A PC Gravity Wall

Project No: TW4437
Date: 12/30/14
Designed By: CTH
Checked by: KD

Load Diagram:



Typical Section (For illustration only, Some details may not apply)

External Stability Calculation (STRENGTH-I MIN)

Stability Against Overturning: (moments about point "O")

Σ Factored Resisting Moments = $\phi V \cdot x_0$ (x_0 is the horiz. distance between V and O)

Σ Factored overturning Momen = $\Upsilon_e F_e (H/3) + \Upsilon_t F_t (H/2)$

Stability Against Sliding:

Σ Factored Resisting Force = $\phi V \tan \phi_F$

Σ Factored Driving Force = $\Upsilon_e F_e + \Upsilon_t F_t$

Bearing Pressure:

Factored Bearing Pressure = $(\Upsilon_1 V + \Upsilon_2 qL)/(L - 2e)$ (use factored e)

Eccentricity:

Eccentricity (e) = $\dfrac{L}{2} - \dfrac{(V + qL)(L/2) - [F_V(H/3) + F_t(H/2)]}{V + qL}$

(use factored V, qL, Fe, Ft for factored e)
(q=0, Ft=0 for this case)

T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
Level Surcharge and Infinite Slope Condition
LIMIT STATE: **STRENGTH-I MIN**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858
Project No: TW4437
Date: 12/30/14
By: CTH
Checked by: KD

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Wall Name: BR46A PC Gravity Wall

GRADING GEOMETRY

DISTANCE TO SLOPE (d) =	0	FT	
FILL SURCHARGE =	3.75	FT	
DISTANCE TO BREAK =	5	FT	
SLOPE ANGLE (ß1) =	36.9	DEG	
SLOPE ANGLE (I) =	10.1	DEG	
TRAFFIC SURCHARGE =	2	FT	

WALL GEOMETRY

HEIGHT (H) =	10.50	
BATTER ( ) =	0	
BASE (L) =	10	

BACKFILL SPECIFICATIONS

SELECT	INTERNAL FRICTION (Ø)=	34	DEG	Ka =	0.3140
	WEIGHT ( )=	120	PCF	Ko =	0.4408
	COHESION=	0	(assumed)		
UNCLASSIFIED	INTERNAL FRICTION (Ø)=	30	DEG	Ka =	0.3743
	WEIGHT ( )=	120	PCF		
	COHESION =	0	(assumed)		
FOUNDATION	FOUNDATION TYPE	S	(S for Soil, R for rock)		
	INTERNAL FRICTION (Øf) =	30	DEG	Kp =	3.0000

FRICTION FACTORS

JOINT MATERIAL TO CONCRETE =	0.59	
SELECT FILL TO CONCRETE =	0.50	
UNCLASSIFIED FILL TO CONCRETE =	0.50	
SELECT FILL TO FOUNDATION = tan(ø)	0.58	(Ø is min of select fill and foundation)
PRECAST CONCRETE TO FOUNDATION =	0.46	(0.8*TAN Øf)

SHEAR KEY STRENGTH = 2460 lbs.

WATER PRESSURE

HEIGHT OF WATER TABLE BEHIND WALL =	0	FT	(From bottom of wall)
HEIGHT OF WATER TABLE BEFORE WALL =	0	FT	(From bottom of wall)

Date: 12/30/14
Designed By: CTH
Checked by: KD

RESISTANCE FACTORS

FRICTION BETWEEN SOIL & SOIL :	1.00	
FRICTION BETWEEN SOIL & CONC. :	0.90	
FRICTION BETWEEN JOINT & CONC. :	0.90	
SHEAR THROUGH SHEAR KEY :	0.90	
PASSIVE PRESSURE AGAINST SLIDING :	0.50	(Not used for this project)
PASSIVE PRESSURE AGAINST OVERTURN. :	0.60	(Not used for this project)

LOAD FACTORS

DC (WEIGHT OF CONCRETE) :	0.90
EV (WEIGHT OF SOIL) :	1.00
EARTH PRESSURES (EH)	
HORIZONTAL COMPONENT :	1.50
VERTICAL COMPONENT :	1.50
LL (VEHICULAR LIVE LOAD), LS (LIVE LOAD SURCHARGE) :	1.75
WATER PRESSURE :	1.00

GLOBAL STABILITY

OVERTURNING

SUM FACTORED OVERTURNING MOMENTS	239737
SUM FACTORED RESISTING MOMENTS	511259
PERFORMANCE RATIO	2.13

SLIDING

SUM FACTORED HORIZONTAL FORCE	44871
FACTORED RESISTING FRICTION FORCE	50175
PERFORMANCE RATIO	1.12

MAXIMUM BEARING PRESSURE

Meyerhof distribution which considers a uniform base pressure distribution over an effective width of B' = L - 2e

Live load surcharge is present on the wall and behind the wall

MAXIMUM BEARING PRESSURE: Sv = SUM VERTICAL LOADS/(L-2e)

FACTORED SUM OF VERTICAL LOADS =	111061	LB/5 FT WIDTH			
FACTORED e =	1.61	≤ L/4 =	2.50	ft	ON SOIL
FACTORED BEARING PRESSURE =	3276	PSF			

FACTORED BEARING RESISTANCE =	#N/A	PSF
PERFORMANCE RATIO =	#N/A	

Date: 12/30/14
Designed By: CTH
Checked by: KD

PERFORMANCE RATIO AT EACH LEVEL

Live load is present behind the wall, but not on the wall

LEVEL	HEIGHT	STEM LENGTH	No. OF SHEAR KEYS	FACTORED LOAD EFFECT	FACTORED RESISTANCE	PERFORMANCE RATIO
1	5.50	6.00	2			
			OVERTURNING	77371	101955	1.32
			SLIDING	21458	23766	1.11
			PULLOUT	7478	10221	1.37
2	8.00	8.00	2			
			OVERTURNING	143921	254159	1.77
			SLIDING	32128	40932	1.27
			PULLOUT	5709	15786	2.77
3	10.50	10.00	0			
			OVERTURNING	239737	511259	2.13
			SLIDING	44871	50175	1.12
			PULLOUT	7274	17471	2.40
4	13.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
5	15.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
6	18.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
7	20.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
8	23.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
9	25.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
10	28.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
11	30.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
12	33.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A

Date: 12/30/14
Designed By: CTH
Checked by: KD

LEVEL 3

STEM LENGTH = 10.00 FT
HEIGHT = 14.25 FT

EARTH PRESSURE			TRAFFIC SURCHARGE & EARTH PRESSURE		
Pa =	4560.33	plf	Pt =	1280.09	plf
Feh =	22446.55	lbs.	Ft =	6400.46	lbs.
Fev =	4008.31	lbs.	Fw =	0.00	lbs.

STABILITY AGAINST SLIDING - LEVEL 3

SLIDING FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
Feh	22446.55	1.50	33669.83
Ft	6400.46	1.75	11200.80
Fw	0.00	1.00	0.00
TOTAL			44870.63

RESISTING FORCE

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
THRU SELECT FILL OR FOUNDATION	73720.43	1.00	0.58	1.00	42562.51
Fev	4008.31	1.50	0.58	1.00	3471.30
THRU JT. MAT'L OR FOUNDATION	11069.63	0.90	0.46	0.90	4141.40
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	0.90	0.00
EMBEDMENT	0.00	#N/A	#N/A	0.50	0.00
TOTAL					50175.21

PERFORMANCE RATIO = 1.12

STABILITY AGAINST PULLOUT - LEVEL 3

PULLOUT FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
PULLOUT FORCE	3859.96	1.50	5789.94
TRAFFIC SURCHARGE FORCE	847.79	1.75	1483.63
WATER PRESSURE	0.00	1.00	0.00
TOTAL			7273.56

RESISTING FORCE

Aeff. = 44.18 SF

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
ON STEM(SOIL TO SOIL IN Aeff)	6677.45	1.00	0.67	1.00	4504.00
ON STEM (SOIL TO CONCRETE IN A	19611.72	1.00	0.50	0.90	8825.27
THRU JT. MAT'L OR FOUNDATION	11069.63	0.90	0.46	0.90	4141.40
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	0.90	0.00
TOTAL					17470.67

PERFORMANCE RATIO = 2.40

Date: 12/30/14
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 3

OVERTURNING MOMENT

	FORCE	MOMENT ARM	OVERTURNING MOMENT	LOAD FACTOR	FACTORED MOMENT
Feh	22446.55	4.75	106621.12	1.50	159931.69
Ft	6400.46	7.13	45603.26	1.75	79805.70
Fw	0.00	0.00	0.00	1.00	0.00
TOTAL					239737.39

RESISTING MOMENT

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED MOMENT
UNIT L1	2961.00	1.08	0.00	0.90	2664.90	2878.09
UNIT L2	2098.00	2.31	0.00	0.90	1888.20	4361.74
UNIT L3	2360.00	3.09	0.00	0.90	2124.00	6563.16
SELECT FILL L1	17431.20	3.25	0.00	1.00	17431.20	56651.40
SELECT FILL L2	10321.20	4.25	0.00	1.00	10321.20	43865.10
SELECT FILL L3	13112.40	5.25	0.00	1.00	13112.40	68840.10

Date: 12/30/14
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 3 (CONTINUED)

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED MOMENT
STEP L2	6600.00	7.00	0.00	1.00	6600.00	46200.00
STEP L3	9600.00	9.00	0.00	1.00	9600.00	86400.00
EARTH SURCHARGE	20306.25	6.67	0.00	1.00	20306.25	135375.00
Fev	4008.31	10.00	0.00	1.50	6012.47	60124.69
TOTAL					90060.62	511259.29

PERFORMANCE RATIO = 2.13

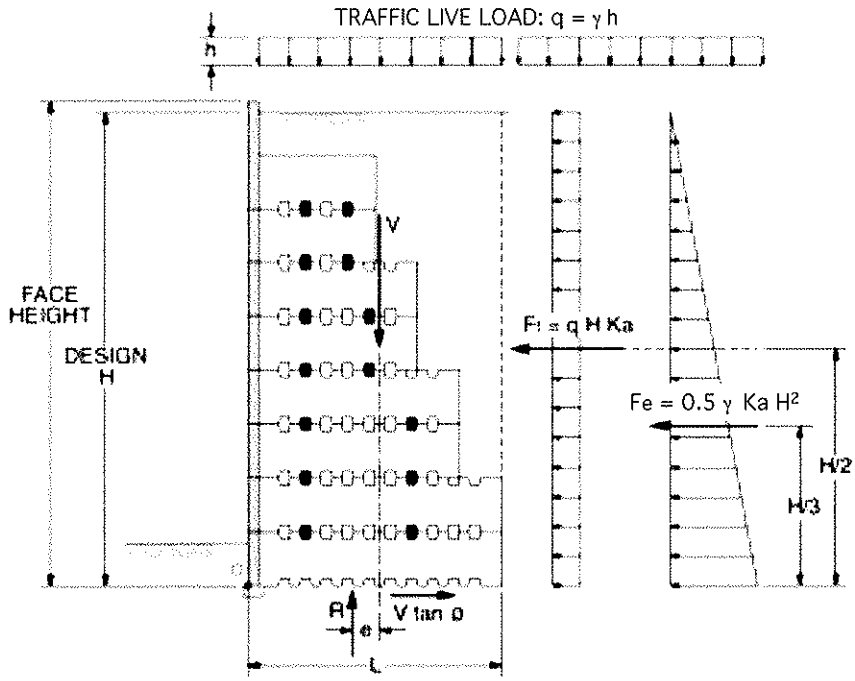
T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
LIMIT STATE: **STRENGTH-I MAX**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)
Level Surcharge and Infinite Slope Condition

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Comment: BR46A PC Gravity Wall

Project No: TW4437
Date: 12/30/14
Designed By: CTH
Checked by: KD

Load Diagram:



Typical Section (For illustration only, Some details may not apply)

External Stability Calculation (STRENGTH-I MAX)

Stability Against Overturning: (moments about point "O")

Σ Factored Resisting Moments = $\phi V \cdot x_O$ (x_O is the horiz. distance between V and O)

Σ Factored overturning Momen = $Y_e F_e (H/3) + Y_t F_t (H/2)$

Stability Against Sliding:

Σ Factored Resisting Force = $\phi V \tan \phi_F$

Σ Factored Driving Force = $Y_e F_e + Y_t F_t$

Bearing Pressure:

Factored Bearing Pressure = $(Y_1 V + Y_2 qL)/(L - 2e)$ (use factored e)

Eccentricity:

Eccentricity (e) = $\dfrac{L}{2} - \dfrac{(V + qL)(L/2) - [F_V(H/3) + F_t(H/2)]}{V + qL}$

(use factored V, qL, Fe, Ft for factored e)
(q=0, Ft=0 for this case)

T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
Level Surcharge and Infinite Slope Condition
LIMIT STATE: **STRENGTH-I MAX**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858

Project No: TW4437
Date: 12/30/14
By: CTH
Checked by: KD

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Wall Name: BR46A PC Gravity Wall

GRADING GEOMETRY

DISTANCE TO SLOPE (d) =	0	FT	
FILL SURCHARGE =	3.75	FT	
DISTANCE TO BREAK =	5	FT	
SLOPE ANGLE (ß1) =	36.9	DEG	
SLOPE ANGLE (I) =	10.1	DEG	
TRAFFIC SURCHARGE =	2	FT	

WALL GEOMETRY

HEIGHT (H) =	10.50	
BATTER ( ) =	0	
BASE (L) =	10	

BACKFILL SPECIFICATIONS

SELECT	INTERNAL FRICTION (Ø)=	34	DEG	Ka =	0.3140
	WEIGHT ( )=	120	PCF	Ko =	0.4408
	COHESION=	0	(assumed)		
UNCLASSIFIED	INTERNAL FRICTION (Ø)=	30	DEG	Ka =	0.3743
	WEIGHT ( )=	120	PCF		
	COHESION =	0	(assumed)		
FOUNDATION	FOUNDATION TYPE	S	(S for Soil, R for rock)		
	INTERNAL FRICTION (Ø)=	30	DEG	Kp =	3.0000

FRICTION FACTORS

JOINT MATERIAL TO CONCRETE =	0.59	
SELECT FILL TO CONCRETE =	0.50	
UNCLASSIFIED FILL TO CONCRETE =	0.50	
SELECT FILL TO FOUNDATION = tan(ø)	0.58	(Ø is min of select fill and foundation)
PRECAST CONCRETE TO FOUNDATION =	0.46	(0.8*TAN Øf)

SHEAR KEY STRENGTH = 2460 lbs.

WATER PRESSURE

HEIGHT OF WATER TABLE BEHIND WALL =	0	FT	(From bottom of wall)
HEIGHT OF WATER TABLE BEFORE WALL =	0	FT	(From bottom of wall)

Date: 12/30/14
Designed By: CTH
Checked by: KD

RESISTANCE FACTORS

FRICTION BETWEEN SOIL & SOIL :	1.00	
FRICTION BETWEEN SOIL & CONC. :	0.90	
FRICTION BETWEEN JOINT & CONC. :	0.90	
SHEAR THROUGH SHEAR KEY :	0.90	
PASSIVE PRESSURE AGAINST SLIDING :	0.50	(Not used for this project)
PASSIVE PRESSURE AGAINST OVERTURN. :	0.60	(Not used for this project)

LOAD FACTORS

DC (WEIGHT OF CONCRETE) :	1.25
EV (WEIGHT OF SOIL) :	1.35
EARTH PRESSURES (EH)	
HORIZONTAL COMPONENT :	1.50
VERTICAL COMPONENT :	1.50
LL (VEHICULAR LIVE LOAD), LS (LIVE LOAD SURCHARGE) :	1.75
WATER PRESSURE :	1.00

GLOBAL STABILITY

OVERTURNING

SUM FACTORED OVERTURNING MOMENTS	239737
SUM FACTORED RESISTING MOMENTS	669693
PERFORMANCE RATIO	2.79

SLIDING

SUM FACTORED HORIZONTAL FORCE	44871
FACTORED RESISTING FRICTION FORCE	66683
PERFORMANCE RATIO	1.49

MAXIMUM BEARING PRESSURE

Meyerhof distribution which considers a uniform base pressure distribution over an effective width of B' = L - 2e

Live load surcharge is present on the wall and behind the wall

MAXIMUM BEARING PRESSURE: Sv = SUM VERTICAL LOADS/(L-2e)

FACTORED SUM OF VERTICAL LOADS =	140737	LB/5 FT WIDTH			
FACTORED e =	1.20	≤ L/4 =	2.50	ft	ON SOIL
FACTORED BEARING PRESSURE =	3703	PSF			

FACTORED BEARING RESISTANCE =	#N/A	PSF
PERFORMANCE RATIO =	#N/A	

Date: 12/30/14
Designed By: CTH
Checked by: KD

PERFORMANCE RATIO AT EACH LEVEL

Live load is present behind the wall, but not on the wall

LEVEL	HEIGHT	STEM LENGTH	No. OF SHEAR KEYS	FACTORED LOAD EFFECT	FACTORED RESISTANCE	PERFORMANCE RATIO
1	5.50	6.00	2			
			OVERTURNING	77371	132431	1.71
			SLIDING	21458	30004	1.40
			PULLOUT	7478	12316	1.65
2	8.00	8.00	2			
			OVERTURNING	143921	331951	2.31
			SLIDING	32128	52873	1.65
			PULLOUT	5709	19892	3.48
3	10.50	10.00	0			
			OVERTURNING	239737	669693	2.79
			SLIDING	44871	66683	1.49
			PULLOUT	7274	23746	3.26
4	13.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
5	15.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
6	18.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
7	20.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
8	23.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
9	25.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
10	28.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
11	30.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
12	33.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A

Date: 12/30/14
Designed By: CTH
Checked by: KD

LEVEL 3

STEM LENGTH = 10.00 FT
HEIGHT = 14.25 FT

EARTH PRESSURE			TRAFFIC SURCHARGE & EARTH PRESSURE		
Pa =	4560.33	plf	Pt =	1280.09	plf
Feh =	22446.55	lbs.	Ft =	6400.46	lbs.
Fev =	4008.31	lbs.	Fw =	0.00	lbs.

STABILITY AGAINST SLIDING - LEVEL 3

SLIDING FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
Feh	22446.55	1.50	33669.83
Ft	6400.46	1.75	11200.80
Fw	0.00	1.00	0.00
TOTAL			44870.63

RESISTING FORCE

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
THRU SELECT FILL OR FOUNDATION	73720.43	1.35	0.58	1.00	57459.38
Fev	4008.31	1.50	0.58	1.00	3471.30
THRU JT. MAT'L OR FOUNDATION	11069.63	1.25	0.46	0.90	5751.95
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	0.90	0.00
EMBEDMENT	0.00	#N/A	#N/A	0.50	0.00
TOTAL					66682.63

PERFORMANCE RATIO = 1.49

STABILITY AGAINST PULLOUT - LEVEL 3

PULLOUT FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
PULLOUT FORCE	3859.96	1.50	5789.94
TRAFFIC SURCHARGE FORCE	847.79	1.75	1483.63
WATER PRESSURE	0.00	1.00	0.00
TOTAL			7273.56

RESISTING FORCE

Aeff. = 44.18 SF

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
ON STEM(SOIL TO SOIL IN Aeff)	6677.45	1.35	0.67	1.00	6080.39
ON STEM (SOIL TO CONCRETE IN A	19611.72	1.35	0.50	0.90	11914.12
THRU JT. MAT'L OR FOUNDATION	11069.63	1.25	0.46	0.90	5751.95
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	0.90	0.00
TOTAL					23746.46

PERFORMANCE RATIO = 3.26

Date: 12/30/14
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 3

OVERTURNING MOMENT

	FORCE	MOMENT ARM	OVERTURNING MOMENT	LOAD FACTOR	FACTORED MOMENT
Feh	22446.55	4.75	106621.12	1.50	159931.69
Ft	6400.46	7.13	45603.26	1.75	79805.70
Fw	0.00	0.00	0.00	1.00	0.00
TOTAL					239737.39

RESISTING MOMENT

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED MOMENT
UNIT L1	2961.00	1.08	0.00	1.25	3701.25	3997.35
UNIT L2	2098.00	2.31	0.00	1.25	2622.50	6057.98
UNIT L3	2360.00	3.09	0.00	1.25	2950.00	9115.50
SELECT FILL L1	17431.20	3.25	0.00	1.35	23532.12	76479.39
SELECT FILL L2	10321.20	4.25	0.00	1.35	13933.62	59217.89
SELECT FILL L3	13112.40	5.25	0.00	1.35	17701.74	92934.14

Date: 12/30/14
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 3 (CONTINUED)

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED MOMENT
STEP L2	6600.00	7.00	0.00	1.35	8910.00	62370.00
STEP L3	9600.00	9.00	0.00	1.35	12960.00	116640.00
EARTH SURCHARGE	20306.25	6.67	0.00	1.35	27413.44	182756.25
Fev	4008.31	10.00	0.00	1.50	6012.47	60124.69
TOTAL					119737.14	669693.18

PERFORMANCE RATIO = 2.79

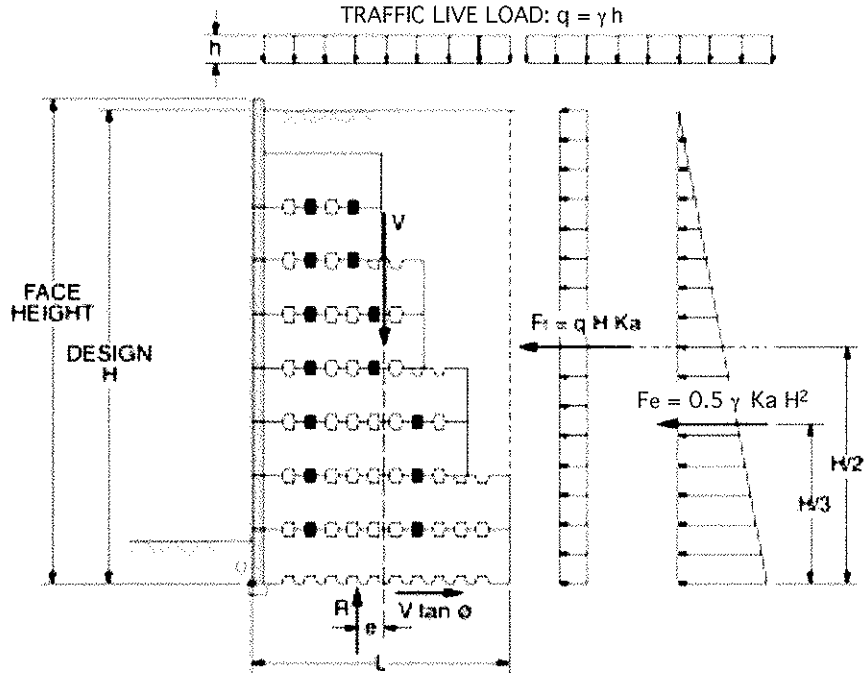
T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
LIMIT STATE: **SERVICE-I**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)
Level Surcharge and Infinite Slope Condition

Revised BZY 3/3/12
The Neel Company
8328-D Traford Lane
Springfield, VA 22152
(703) 913-7858

Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Location: Waterbury, VT
Comment: BR46A PC Gravity Wall

Project No: TW4437
Date: 12/30/14
Designed By: CTH
Checked by: KD

Load Diagram:



Typical Section, All details may not apply

External Stability Calculation (SERVICE-I)

Stability Against Overturning: (moments about point "O")

Σ Factored Resisting Moments = $\phi V \cdot x_o$ (x_o is the horiz. distance between V and O)

Σ Factored overturning Momen = $Y_e F_e (H/3) + Y_t F_t (H/2)$

Stability Against Sliding:

Σ Factored Resisting Force = $\phi V \tan \phi_F$

Σ Factored Driving Force = $Y_e F_e + Y_t F_t$

Bearing Pressure:

Factored Bearing Pressure = $(Y_1 V + Y_2 qL)/(L - 2e)$ (use factored e)

Eccentricity:

Eccentricity (e) = $\dfrac{L}{2} - \dfrac{(V + qL)(L/2) - [F_V(H/3) + F_t(H/2)]}{V + qL}$

(use factored V, qL, Fe, Ft for factored e)

T-WALL Retaining Wall Calculations v11b (LRFD, HWY, 2.5x5.0 Units)
Level Surcharge and Infinite Slope Condition
LIMIT STATE: **SERVICE-I**
PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (4th Ed, 2007)

Revised BZY 3/3/12
The Neel Company
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Project No: TW4437
Project Name: I-89 Bridge Decks Replacement / I-89 Over Stowe Street
Date: 12/30/14
Location: Waterbury, VT
By: CTH
Comment: BR46A PC Gravity Wall
Checked by: KD

GRADING GEOMETRY

DISTANCE TO SLOPE (d) =	0	FT	
FILL SURCHARGE =	3.75	FT	
DISTANCE TO BREAK =	5	FT	
SLOPE ANGLE (ß1) =	36.9	DEG	
SLOPE ANGLE (I) =	10.1	DEG	
TRAFFIC SURCHARGE =	2	FT	

WALL GEOMETRY

HEIGHT (H) =	10.50	
BATTER ( ) =	0	
BASE (L) =	10	

BACKFILL SPECIFICATIONS

SELECT	INTERNAL FRICTION (Ø)=	34	DEG	Ka =	0.3140
	WEIGHT ( )=	120	PCF	Ko =	0.4408
	COHESION=	0	(assumed)		
UNCLASSIFIED	INTERNAL FRICTION (Ø)=	30	DEG	Ka =	0.3743
	WEIGHT ( )=	120	PCF		
	COHESION =	0	(assumed)		
FOUNDATION	FOUNDATION TYPE	S	(S for Soil, R for rock)		
	INTERNAL FRICTION (Ø)=	30	DEG	Kp =	3.0000

FRICTION FACTORS

JOINT MATERIAL TO CONCRETE =	0.59	
SELECT FILL TO CONCRETE =	0.50	
UNCLASSIFIED FILL TO CONCRETE =	0.50	
SELECT FILL TO FOUNDATION = tan(ø)	0.58	(Ø is min of select fill and foundation)
PRECAST CONCRETE TO FOUNDATION =	0.46	(0.8*TAN Øf)

SHEAR KEY STRENGTH = 2460 lbs.

WATER PRESSURE

HEIGHT OF WATER TABLE BEHIND WALL =	0	FT	(From bottom of wall)
HEIGHT OF WATER TABLE BEFORE WALL =	0	FT	(From bottom of wall)

WIND ON SOUND BARRIER/OTHER STRUCTURE

WIND FORCE =	0	LBS
DISTANCE FROM TOP OF WALL/GUTTER LINE =	0	FT

Date: 12/30/14
Designed By: CTH
Checked by: KD

RESISTANCE FACTORS

FRICTION BETWEEN SOIL & SOIL :	1.00	
FRICTION BETWEEN SOIL & CONC. :	1.00	
FRICTION BETWEEN JOINT & CONC. :	1.00	
SHEAR THROUGH SHEAR KEY :	1.00	
PASSIVE PRESSURE AGAINST SLIDING :	1.00	(Not used for this project)
PASSIVE PRESSURE AGAINST OVERTURN. :	1.00	(Not used for this project)

LOAD FACTORS

DC (WEIGHT OF CONCRETE) :	1.00
EV (WEIGHT OF SOIL) :	1.00
EARTH PRESSURES (EH)	
HORIZONTAL COMPONENT :	1.00
VERTICAL COMPONENT :	1.00
LL (VEHICULAR LIVE LOAD), LS (LIVE LOAD SURCHARGE) :	1.00
WATER PRESSURE :	1.00
WIND LOAD :	0.30

GLOBAL STABILITY

OVERTURNING

SUM FACTORED OVERTURNING MOMENTS:	152224
SUM FACTORED RESISTING MOMENTS:	492751
PERFORMANCE RATIO:	3.24

SLIDING

SUM FACTORED HORIZONTAL FORCE:	28847
FACTORED RESISTING FRICTION FORCE:	49990
PERFORMANCE RATIO:	1.73

MAXIMUM BEARING PRESSURE

Meyerhof distribution which considers a uniform base pressure distribution over an effective width of B' = L - 2e

Live load surcharge is present on the wall and behind the wall

MAXIMUM BEARING PRESSURE: σ_v = SUM VERTICAL LOADS/(L-2e)

FACTORED SUM OF VERTICAL LOADS =	100798	LB/5 FT WIDTH			
FACTORED e =	1.03	≤ L/4 =	2.50	ft	ON SOIL
FACTORED BEARING PRESSURE =	2537	PSF			

FACTORED BEARING CAPACITY =	#N/A	PSF
PERFORMANCE RATIO =	#N/A	

Date: 12/30/14
Designed By: CTH
Checked by: KD

FACTORS OF SAFETY AT EACH LEVEL

Live load is present behind the wall, but not on the wall

LEVEL	HEIGHT	STEM LENGTH	No. OF SHEAR KEYS	FACTORED LOAD EFFECT	FACTORED RESISTANCE	PERFORMANCE RATIO
1	5.50	6.00	2			
			OVERTURNING	48378	97208	2.01
			SLIDING	13613	24097	1.77
			PULLOUT	4656	11419	2.45
2	8.00	8.00	2			
			OVERTURNING	90780	244063	2.69
			SLIDING	20539	41288	2.01
			PULLOUT	3665	17651	4.82
3	10.50	10.00	0			
			OVERTURNING	152224	492751	3.24
			SLIDING	28847	49990	1.73
			PULLOUT	4708	19423	4.13
4	13.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
5	15.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
6	18.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
7	20.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
8	23.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
9	25.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
10	28.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
11	30.50	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A
12	33.00	0.00	0			
			OVERTURNING	0	0	#N/A
			SLIDING	0	0	#N/A
			PULLOUT	0	0	#N/A

Date: 12/30/14
Designed By: CTH
Checked by: KD

LEVEL 3

STEM LENGTH = 10.00 FT
HEIGHT = 14.25 FT

EARTH PRESSURE			TRAFFIC SURCHARGE & WATER PRESSURE		
Pa =	4560.33	plf	Pt =	1280.09	plf
Feh =	22446.55	lbs.	Ft =	6400.46	lbs.
Fev =	4008.31	lbs.	Fw =	0.00	lbs.

STABILITY AGAINST SLIDING - LEVEL 3

SLIDING FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
Feh	22446.55	1.00	22446.55
Ft	6400.46	1.00	6400.46
Fw	0.00	1.00	0.00
WIND LOAD	0.00	0.30	0.00
TOTAL			28847.01

RESISTING FORCE

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
THRU SELECT FILL OR FOUNDATION	73720.43	1.00	0.58	1.00	42562.5
Fev	4008.31	1.00	0.58	1.00	2314.2
THRU JT. MATERIAL OR FOUNDATIC	11069.63	1.00	0.46	1.00	5112.8
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	1.00	0.0
EMBEDMENT	0.00	#N/A	#N/A	1.00	0.0
TOTAL					49989.5

PERFORMANCE RATIO = 1.73

STABILITY AGAINST PULLOUT - LEVEL 3

PULLOUT FORCE

	UNFACTORED	LOAD FACTOR	FACTORED
PULLOUT FORCE =	3859.96	1.00	3859.96
TRAFFIC SURCHARGE FORCE =	847.79	1.00	847.79
WATER PRESSURE =	0.00	1.00	0.00
TOTAL			4707.75

RESISTING FORCE

Aeff. = 44.18 SF

	WEIGHT	LOAD FACTOR	FRICTION FACTOR	RESISTANCE FACTOR	FACTORED RESISTANCE
ON STEM(SOIL TO SOIL IN Aeff)	6677.45	1.00	0.67	1.00	4504.0
ON STEM (SOIL TO CONCRETE IN A	19611.72	1.00	0.50	1.00	9805.9
THRU JT. MATERIAL OR FOUNDATIC	11069.63	1.00	0.46	1.00	5112.8
SHEAR KEY (SHEAR STRENGTH)	0.00	#N/A	0	1.00	0.0
TOTAL					19422.7

PERFORMANCE RATIO = 4.13

Date: 12/30/14
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 3

OVERTURNING MOMENT

	FORCE	MOMENT ARM	OVERTURNING MOMENT	LOAD FACTOR	FACTORED MOMENT
Feh	22446.55	4.75	106621.1	1.00	106621.1
Ft	6400.46	7.13	45603.3	1.00	45603.3
Fw	0.00	0.00	0.0	1.00	0.0
WIND LOAD	0.00	10.50	0.00	0.30	0.00
TOTAL					152224.4

RESISTING MOMENT

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED RESISTANCE
PANEL L1	2961.00	1.08	0.00	1.00	2961.0	3197.9
PANEL L2	2098.00	2.31	0.00	1.00	2098.0	4846.4
PANEL L3	2360.00	3.09	0.00	1.00	2360.0	7292.4
SELECT FILL L1	17431.20	3.25	0.00	1.00	17431.2	56651.4
SELECT FILL L2	10321.20	4.25	0.00	1.00	10321.2	43865.1
SELECT FILL L3	13112.40	5.25	0.00	1.00	13112.4	68840.1

Date: 12/30/14
Designed By: CTH
Checked by: KD

STABILITY AGAINST OVERTURNING - LEVEL 3 (CONTINUED)

	WEIGHT	HORIZ. ARM	VERT. ARM	RESISTANCE FACTOR	FACTORED WEIGHT	FACTORED RESISTANCE
STEP L2	6600.00	7.00	0.00	1.00	6600.0	46200.0
STEP L3	9600.00	9.00	0.00	1.00	9600.0	86400.0
EARTH SURCHARGE	20306.25	6.67	0.00	1.00	20306.3	135375.0
Fev	4008.31	10.00	0.00	1.00	4008.3	40083.1
TOTAL					88798.36	492751.39

PERFORMANCE RATIO = 3.24