City of Puyallup
Building
REVIEWED
FOR
COMPLIANCE
RayC
09/22/2023
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PRRWF20230497
Revision:
Wall height/design.

See Civil permit and plans for site plan and location.

Approval of submitted plans is not an approval of omissions or oversight by this office or noncompliance with any applicable regulations of local government. The contractor is responsible for making sure that the building complies with all applicable building codes and regulations of the local government.

THE APPROVED CONSTRUCTION PLANS AND ALL ENGINEERING MUST BE POSTED ON THE JOB AT ALL INSPECTIONS IN A VISIBLE AND READILY ACCESSIBLE LOCATION.

City of Puyallup
Development & Permitting Services
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SOUTH HILL BUSINESS &TECHNOLOGY CENTER PARKING EXPANSION

STORMWATER PLANTER WALLS

Draft Submittal

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STATE OF WASHINGTON
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REGISTERED
PROFESSIONAL ENGINEER

July 17, 2023

Prepared for
City of Puyallup

CITY OF PUYALLUP

PMX#253-604-6600

July 17, 2023

Prepared by
Parametrix

SOUTH HILL BUSINESS AND TECHNOLOGY CENTER

(East Parking Lot Expansion)

Description of Calculation

In this calculation package the structural design of stormwater planter walls located at the South Hill Business and Technology Center in Puyallup, Washington is presented. Construction of the stormwater planer walls is a portion of the east parking lot expansion project.

Design Codes

The following design codes were used for this design:

- International Building Code (IBC) – 2018 – Global Stability
- AASHTO LRFD Bridge Design Specification – 9th Edition – Structural Design

Summary of Results

The expanded parking lot will contain several stormwater planters whose wall heights range from 3’-0” to 6’-9” (i.e., measured from top of the wall to the bottom of footing). For walls with a height up to 3’ the City of Tacoma’s standard plans for walled bioretention walls and structural footing can be used, however, for walls taller than 3’, four different wall design are prepared in this calculation package. Only the footing width changes by design height change, so that the footing width are 6’, 7’, 8’, and 9’ for walls with 3.75’, 4.75’, 5.75’ and 6.75’ height, respectively.

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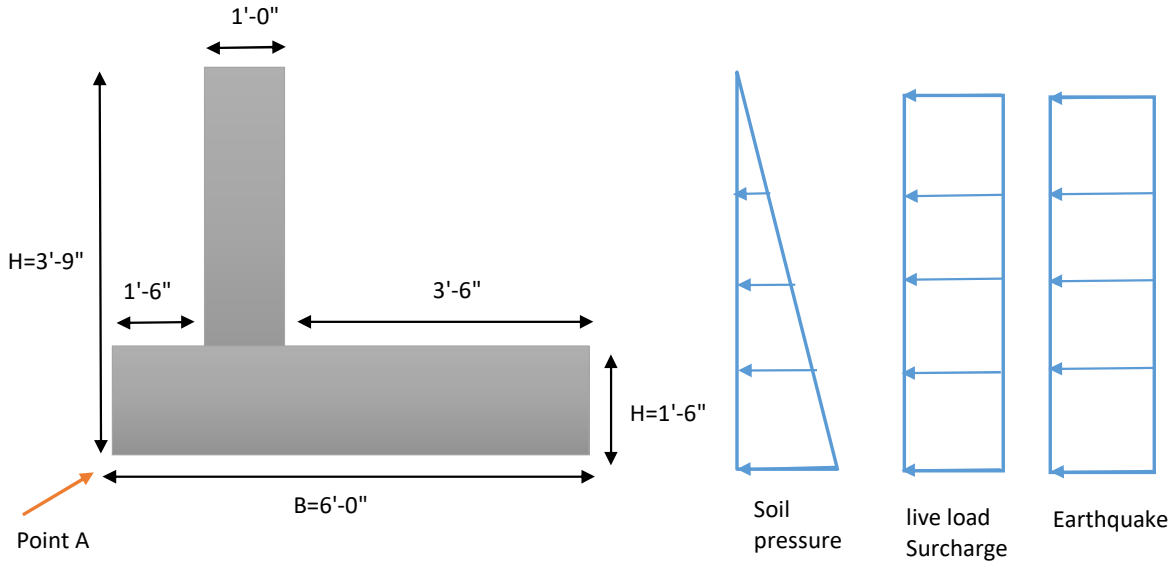
Stability Check- Stormwater planter wall (H=3.75'):

Summary - Factor of Safeties (FOS):

Load Set	FOS	Allowable Factor of Safety
Overturning (1)	11.3	1.5
Overturning (2)	9.6	1.1
Sliding (1)	1.9	1.5
Sliding (2)	1.6	1.1
Bearing (1)	6.4	1
Bearing (2)	6.4	1



Geometry

t_stem	1	ft	Stem thickness
h_stem	2.25	ft	Stem height
t_footing	1.5	ft	Footing thickness
B	6	ft	Footing width
w_toe	1.5	ft	Toe width
H	3.75	ft	Design height
h_backfill	2.25	ft	Backfill height
w_backfill	3.5	ft	Backfill width
h_front fill	0		Frontfill height
w_frontfill	1.5	ft	Frontfill width
w-c	0.155	kcf	Concrete unit weight - per WSDOT BDM Table 3.8-1
w_soil_b	0.125	kcf	Backfill unit weight - per geotech engineer report
w_soil_f	0.11	kcf	Frontfill unit weight - per geotech engineer report
EH_ active	35	pcf	equivalent fluid density (active condition)
EH_ passive	300	pcf	equivalent fluid density (passive condition)
LS_H	70	psf	Live load surcharge pressure = K_a * 250 psf
EQ	30	psf	Seismic earth pressure, per Geotech engineer report = 8H (H is design hight)
µn	0.35		Soil sliding coefficient
qn	3.00	ksf	Allowable soil bearing resistance (per geotech engineer report)

Considered Loads:

DC - dead load of structural components and nonstructural attachments
EH - horizontal earth pressure load
EV - vertical pressure from dead load of earth fill
EQ - earthquake load
LS - live load surcharge

Summary of Unfactored loads and moments

Vertical Loads & Moments				
Load Type	Descriotion	V (kip/ft)	Moment Arm (ft)	MV (kip-ft.)/ft
DC1	Stem dead load	0.35	2.00	0.70
DC2	Footing dead load	1.40	3.00	4.19
EV1	Vertical pressure from dead load of fill on heel	0.98	4.25	4.18
EV2	Vertical pressure from dead load of fill on toe	0.00	0.75	0.00

Horizontal Loads & Moments				
Load Type	Descriotion	H (kip/ft)	Moment Arm (ft)	MH (kip-ft.)/ft
EH_H	Horizontal component of active earth pressure	0.25	1.25	0.31
LS_H	Horizontal component of live load surcharge	0.26	1.88	0.49
EQ	Earthquake load	0.11	1.88	0.21

Stability check per IBC 2018 - section 1807-2.3:

1807.2.3 Safety factor.

Retaining walls shall be designed to resist the lateral action of soil to produce sliding and overturning with a minimum safety factor of 1.5 in each case. The load combinations of Section 1605 shall not apply to this requirement. Instead, design shall be based on 0.7 times nominal earthquake loads, 1.0 times other *nominal loads*, and investigation with one or more of the variable loads set to zero. The safety factor against lateral sliding shall be taken as the available soil resistance at the base of the retaining wall foundation divided by the net lateral force applied to the retaining wall.

Exception: Where earthquake loads are included, the minimum safety factor for retaining wall sliding and overturning shall be 1.1.

load sets:

1. D + EH: Dead load + Soil lateral load
2. D + EH + 0.7*EQ: Dead load + Soil lateral load + 0.7 * Earthquake load

Summary of two load sets:

Load set	Vertical Loads & Moments		Horizontal Loads & Moments	
	V_u (kip/ft)	MV_u (kip-ft.)/ft	H_u (kip/ft)	MH_u (kip-ft.)/ft
D + EH	2.73	9.07	0.51	0.80
D + EH + 0.7 * EQ	2.73	9.07	0.59	0.95

Overturning Check:

1. D + EH:

Resisting Moments:	9.07 (kip-ft.)/ft	
Overturning Moments:	0.80 (kip-ft.)/ft	
Safety factor = Resisting moments / Overturning moments =		**11.34 > 1.5 Okay**

2. D + EH + 0.7*EQ:

Resisting Moments:	9.07	
Overturning Moments:	0.95	
Safety factor = Resisting moments / Overturning moments =		**9.6 > 1.1 Okay**

Sliding Check:

1. D + EH:

Resisting Force:	0.95 (kip-ft.)/ft	
Sliding Load:	0.51 (kip-ft.)/ft	
Safety factor * = Resisting Force / Sliding Load =		**1.88 > 1.5 Okay**

2. D + EH + 0.7*EQ:

Resisting Force:	0.95	
Sliding Load:	0.59	
Safety factor * = Resisting Force / Sliding Load =		**1.6 > 1.1 Okay**

Bearing Check:

1. D + EH:

Eccentricity (e):	0.03 ft	
Soil Bearing Resistance:	3.00 (kip-ft.)/ft	
Bearing Stresses:	0.47 (kip-ft.)/ft	
Safety factor = Soil Bearing Resistance / Bearing Stresses =		**6.41 > 1.0 Okay**

2. D + EH + 0.7*EQ:

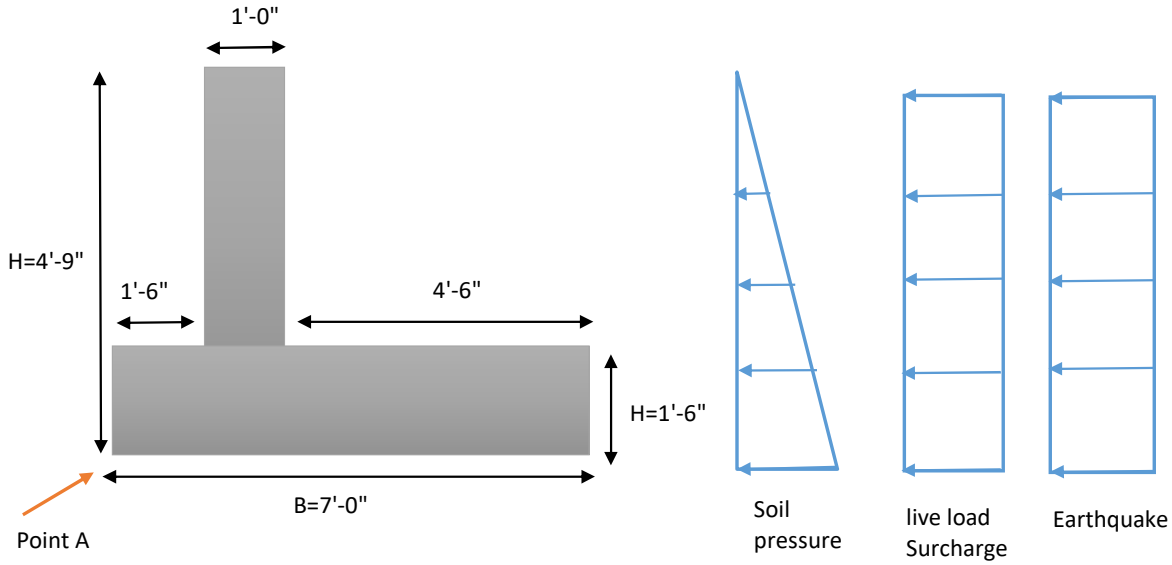
Eccentricity (e):	0.02 ft	
Soil Bearing Resistance:	3.00 (kip-ft.)/ft	
Bearing Stresses:	0.47 (kip-ft.)/ft	
Safety factor = Soil Bearing Resistance / Bearing Stresses =		**6.4 > 1.0 Okay**

* conservatively passive resistance associated with soil above the footing toe are disregarded

Stability Check- Stormwater planter wall (H=4.75'):

Summary - Factor of Safeties (FOS):

Load Set	FOS	Allowable Factor of Safety
Overturning (1)	10.9	1.5
Overturning (2)	9.0	1.1
Sliding (1)	1.9	1.5
Sliding (2)	1.6	1.1
Bearing (1)	5.2	1
Bearing (2)	5.1	1



Geometry

t_stem	1	ft	Stem thickness
h_stem	3.25	ft	Stem height
t_footing	1.5	ft	Footing thickness
B	7	ft	Footing width
w_toe	1.5	ft	Toe width
H	4.75	ft	Design height
h_backfill	3.25	ft	Backfill height
w_backfill	4.5	ft	Backfill width
h_front fill	0		Frontfill height
w_frontfill	1.5	ft	Frontfill width
w-c	0.155	kcf	Concrete unit weight - per WSDOT BDM Table 3.8-1
w_soil_b	0.125	kcf	Backfill unit weight - per geotech engineer report
w_soil_f	0.11	kcf	Frontfill unit weight - per geotech engineer report
EH_ active	35	pcf	equivalent fluid density (active condition)
EH_ passive	300	pcf	equivalent fluid density (passive condition)
LS_H	70	psf	Live load surcharge pressure = K_a * 250 psf
EQ	38	psf	Seismic earth pressure, per Geotech engineer report = 8H (H is design hight)
µn	0.35		Soil sliding coefficient
qn	3.00	ksf	Allowable soil bearing resistance (per geotech engineer report)

Considered Loads:

DC - dead load of structural components and nonstructural attachments
EH - horizontal earth pressure load
EV - vertical pressure from dead load of earth fill
EQ - earthquake load
LS - live load surcharge

Summary of Unfactored loads and moments

Vertical Loads & Moments				
Load Type	Descriotion	V (kip/ft)	Moment Arm (ft)	MV (kip-ft.)/ft
DC1	Stem dead load	0.50	2.00	1.01
DC2	Footing dead load	1.63	3.50	5.70
EV1	Vertical pressure from dead load of fill on heel	1.83	4.75	8.68
EV2	Vertical pressure from dead load of fill on toe	0.00	0.75	0.00

Horizontal Loads & Moments				
Load Type	Descriotion	H (kip/ft)	Moment Arm (ft)	MH (kip-ft.)/ft
EH_H	Horizontal component of active earth pressure	0.39	1.58	0.63
LS_H	Horizontal component of live load surcharge	0.33	2.38	0.79
EQ	Earthquake load	0.18	2.38	0.43

Stability check per IBC 2018 - section 1807-2.3:

1807.2.3 Safety factor.

Retaining walls shall be designed to resist the lateral action of soil to produce sliding and overturning with a minimum safety factor of 1.5 in each case. The load combinations of Section 1605 shall not apply to this requirement. Instead, design shall be based on 0.7 times nominal earthquake loads, 1.0 times other *nominal loads*, and investigation with one or more of the variable loads set to zero. The safety factor against lateral sliding shall be taken as the available soil resistance at the base of the retaining wall foundation divided by the net lateral force applied to the retaining wall.

Exception: Where earthquake loads are included, the minimum safety factor for retaining wall sliding and overturning shall be 1.1.

load sets:

1. D + EH: Dead load + Soil lateral load
2. D + EH + 0.7*EQ: Dead load + Soil lateral load + 0.7 * Earthquake load

Summary of two load sets:

Load set	Vertical Loads & Moments		Horizontal Loads & Moments	
	V_u (kip/ft)	MV_u (kip-ft.)/ft	H_u (kip/ft)	MH_u (kip-ft.)/ft
D + EH	3.96	15.39	0.73	1.41
D + EH + 0.7 * EQ	3.96	15.39	0.85	1.71

Overturning Check:

1. D + EH:

Resisting Moments:	15.39	(kip-ft.)/ft	
Overturning Moments:	1.41	(kip-ft.)/ft	
Safety factor = Resisting moments / Overturning moments =			**10.88 > 1.5 Okay**

2. D + EH + 0.7*EQ:

Resisting Moments:	15.39		
Overturning Moments:	1.71		
Safety factor = Resisting moments / Overturning moments =			**9.0 > 1.1 Okay**

Sliding Check:

1. D + EH:

Resisting Force:	1.39	(kip-ft.)/ft	
Sliding Load:	0.73	(kip-ft.)/ft	
Safety factor * = Resisting Force / Sliding Load =			**1.91 > 1.5 Okay**

2. D + EH + 0.7*EQ:

Resisting Force:	1.39		
Sliding Load:	0.85		
Safety factor * = Resisting Force / Sliding Load =			**1.6 > 1.1 Okay**

Bearing Check:

1. D + EH:

Eccentricity (e):	0.03	ft	
Soil Bearing Resistance:	3.00	(kip-ft.)/ft	
Bearing Stresses:	0.58	(kip-ft.)/ft	
Safety factor = Soil Bearing Resistance / Bearing Stresses =			**5.18 > 1.0 Okay**

2. D + EH + 0.7*EQ:

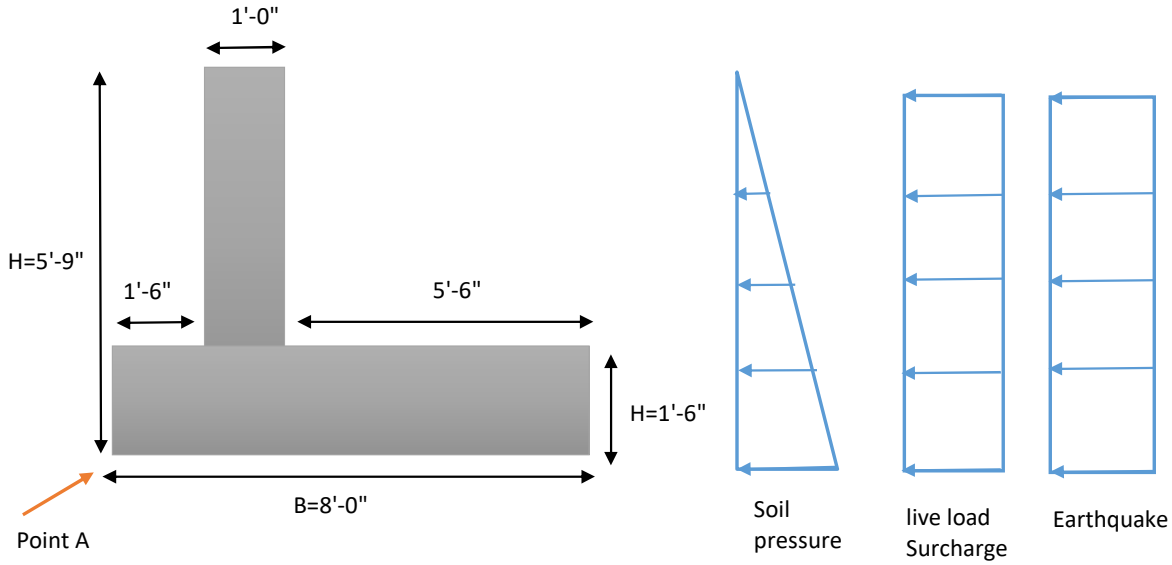
Eccentricity (e):	0.05	ft	
Soil Bearing Resistance:	3.00	(kip-ft.)/ft	
Bearing Stresses:	0.59	(kip-ft.)/ft	
Safety factor = Soil Bearing Resistance / Bearing Stresses =			**5.1 > 1.0 Okay**

* conservatively passive resistance associated with soil above the footing toe are disregarded

Stability Check- Stormwater planter wall (H=5.75'):

Summary - Factor of Safeties (FOS):

Load Set	FOS	Allowable Factor of Safety
Overturning (1)	10.6	1.5
Overturning (2)	8.6	1.1
Sliding (1)	1.9	1.5
Sliding (2)	1.6	1.1
Bearing (1)	4.4	1
Bearing (2)	4.1	1



Geometry

t_stem	1	ft	Stem thickness
h_stem	4.25	ft	Stem height
t_footing	1.5	ft	Footing thickness
B	8	ft	Footing width
w_toe	1.5	ft	Toe width
H	5.75	ft	Design height
h_backfill	4.25	ft	Backfill height
w_backfill	5.5	ft	Backfill width
h_front fill	0		Frontfill height
w_frontfill	1.5	ft	Frontfill width
w-c	0.155	kcf	Concrete unit weight - per WSDOT BDM Table 3.8-1
w_soil_b	0.125	kcf	Backfill unit weight - per geotech engineer report
w_soil_f	0.11	kcf	Frontfill unit weight - per geotech engineer report
EH_ active	35	pcf	equivalent fluid density (active condition)
EH_ passive	300	pcf	equivalent fluid density (passive condition)
LS_H	70	psf	Live load surcharge pressure = K_a * 250 psf
EQ	46	psf	Seismic earth pressure, per Geotech engineer report = 8H (H is design hight)
µn	0.35		Soil sliding coefficient
qn	3.00	ksf	Allowable soil bearing resistance (per geotech engineer report)

Considered Loads:

DC - dead load of structural components and nonstructural attachments
EH - horizontal earth pressure load
EV - vertical pressure from dead load of earth fill
EQ - earthquake load
LS - live load surcharge

Summary of Unfactored loads and moments

Vertical Loads & Moments				
Load Type	Descriotion	V (kip/ft)	Moment Arm (ft)	MV (kip-ft.)/ft
DC1	Stem dead load	0.66	2.00	1.32
DC2	Footing dead load	1.86	4.00	7.44
EV1	Vertical pressure from dead load of fill on heel	2.92	5.25	15.34
EV2	Vertical pressure from dead load of fill on toe	0.00	0.75	0.00

Horizontal Loads & Moments				
Load Type	Descriotion	H (kip/ft)	Moment Arm (ft)	MH (kip-ft.)/ft
EH_H	Horizontal component of active earth pressure	0.58	1.92	1.11
LS_H	Horizontal component of live load surcharge	0.40	2.88	1.16
EQ	Earthquake load	0.26	2.88	0.76

Stability check per IBC 2018 - section 1807-2.3:

1807.2.3 Safety factor.

Retaining walls shall be designed to resist the lateral action of soil to produce sliding and overturning with a minimum safety factor of 1.5 in each case. The load combinations of Section 1605 shall not apply to this requirement. Instead, design shall be based on 0.7 times nominal earthquake loads, 1.0 times other *nominal loads*, and investigation with one or more of the variable loads set to zero. The safety factor against lateral sliding shall be taken as the available soil resistance at the base of the retaining wall foundation divided by the net lateral force applied to the retaining wall.

Exception: Where earthquake loads are included, the minimum safety factor for retaining wall sliding and overturning shall be 1.1.

load sets:

1. D + EH: Dead load + Soil lateral load
2. D + EH + 0.7*EQ: Dead load + Soil lateral load + 0.7 * Earthquake load

Summary of two load sets:

Load set	Vertical Loads & Moments		Horizontal Loads & Moments	
	V_u (kip/ft)	MV_u (kip-ft.)/ft	H_u (kip/ft)	MH_u (kip-ft.)/ft
D + EH	5.44	24.10	0.98	2.27
D + EH + 0.7 * EQ	5.44	24.10	1.17	2.80

Overturning Check:

1. D + EH:

Resisting Moments:	24.10	(kip-ft.)/ft
Overturning Moments:	2.27	(kip-ft.)/ft

Safety factor = Resisting moments / Overturning moments = **10.63 > 1.5 Okay**

2. D + EH + 0.7*EQ:

Resisting Moments:	24.10	
Overturning Moments:	2.80	

Safety factor = Resisting moments / Overturning moments = **8.6 > 1.1 Okay**

Sliding Check:

1. D + EH:

Resisting Force:	1.90	(kip-ft.)/ft
Sliding Load:	0.98	(kip-ft.)/ft

Safety factor * = Resisting Force / Sliding Load = **1.94 > 1.5 Okay**

2. D + EH + 0.7*EQ:

Resisting Force:	1.90	
Sliding Load:	1.17	

Safety factor * = Resisting Force / Sliding Load = **1.6 > 1.1 Okay**

Bearing Check:

1. D + EH:

Eccentricity (e):	0.01	ft
Soil Bearing Resistance:	3.00	(kip-ft.)/ft
Bearing Stresses:	0.69	(kip-ft.)/ft

Safety factor = Soil Bearing Resistance / Bearing Stresses = **4.37 > 1.0 Okay**

2. D + EH + 0.7*EQ:

Eccentricity (e):	0.09	ft
Soil Bearing Resistance:	3.00	(kip-ft.)/ft
Bearing Stresses:	0.72	(kip-ft.)/ft

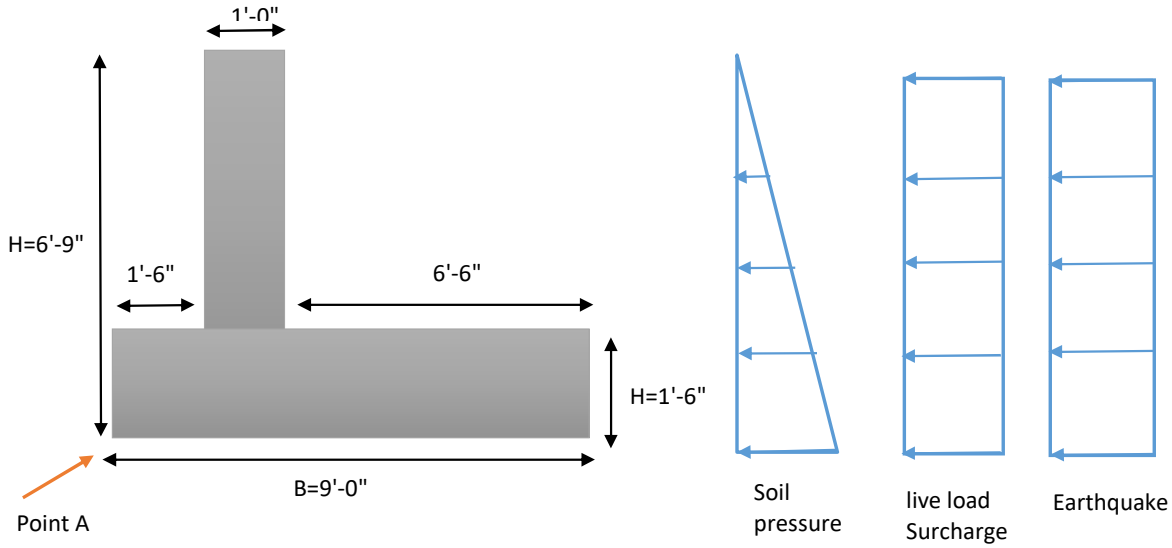
Safety factor = Soil Bearing Resistance / Bearing Stresses = **4.1 > 1.0 Okay**

* conservatively passive resistance associated with soil above the footing toe are disregarded

Stability Check- Stormwater planter wall (H=6.75'):

Summary - Factor of Safeties (FOS):

Load Set	FOS	Allowable Factor of Safety
Overturning (1)	10.5	1.5
Overturning (2)	8.4	1.1
Sliding (1)	2.0	1.5
Sliding (2)	1.6	1.1
Bearing (1)	3.7	1
Bearing (2)	3.5	1



Geometry

t_stem	1	ft	Stem thickness
h_stem	5.25	ft	Stem height
t_footing	1.5	ft	Footing thickness
B	9	ft	Footing width
w_toe	1.5	ft	Toe width
H	6.75	ft	Design height
h_backfill	5.25	ft	Backfill height
w_backfill	6.5	ft	Backfill width
h_front fill	0		Frontfill height
w_frontfill	1.5	ft	Frontfill width
w-c	0.155	kcf	Concrete unit weight - per WSDOT BDM Table 3.8-1
w_soil_b	0.125	kcf	Backfill unit weight - per geotech engineer report
w_soil_f	0.11	kcf	Frontfill unit weight - per geotech engineer report
EH_ active	35	pcf	equivalent fluid density (active condition)
EH_ passive	300	pcf	equivalent fluid density (passive condition)
LS_H	70	psf	Live load surcharge pressure = K_a * 250 psf
EQ	54	psf	Seismic earth pressure, per Geotech engineer report = 8H (H is design hight)
µn	0.35		Soil sliding coefficient
qn	3.00	ksf	Allowable soil bearing resistance (per geotech engineer report)

Considered Loads:

DC - dead load of structural components and nonstructural attachments
EH - horizontal earth pressure load
EV - vertical pressure from dead load of earth fill
EQ - earthquake load
LS - live load surcharge

Summary of Unfactored loads and moments

Vertical Loads & Moments				
Load Type	Descriotion	V (kip/ft)	Moment Arm (ft)	MV (kip-ft.)/ft
DC1	Stem dead load	0.81	2.00	1.63
DC2	Footing dead load	2.09	4.50	9.42
EV1	Vertical pressure from dead load of fill on heel	4.27	5.75	24.53
EV2	Vertical pressure from dead load of fill on toe	0.00	0.75	0.00

Horizontal Loads & Moments				
Load Type	Descriotion	H (kip/ft)	Moment Arm (ft)	MH (kip-ft.)/ft
EH_H	Horizontal component of active earth pressure	0.80	2.25	1.79
LS_H	Horizontal component of live load surcharge	0.47	3.38	1.59
EQ	Earthquake load	0.36	3.38	1.23

Stability check per IBC 2018 - section 1807-2.3:

1807.2.3 Safety factor.

Retaining walls shall be designed to resist the lateral action of soil to produce sliding and overturning with a minimum safety factor of 1.5 in each case. The load combinations of Section 1605 shall not apply to this requirement. Instead, design shall be based on 0.7 times nominal earthquake loads, 1.0 times other *nominal loads*, and investigation with one or more of the variable loads set to zero. The safety factor against lateral sliding shall be taken as the available soil resistance at the base of the retaining wall foundation divided by the net lateral force applied to the retaining wall.

Exception: Where earthquake loads are included, the minimum safety factor for retaining wall sliding and overturning shall be 1.1.

load sets:

1. D + EH: Dead load + Soil lateral load
2. D + EH + 0.7*EQ: Dead load + Soil lateral load + 0.7 * Earthquake load

Summary of two load sets:

Load set	Vertical Loads & Moments		Horizontal Loads & Moments	
	V_u (kip/ft)	MV_u (kip-ft.)/ft	H_u (kip/ft)	MH_u (kip-ft.)/ft
D + EH	7.17	35.57	1.27	3.39
D + EH + 0.7 * EQ	7.17	35.57	1.52	4.25

Overturning Check:

1. D + EH:

Resisting Moments:	35.57	(kip-ft.)/ft
Overturning Moments:	3.39	(kip-ft.)/ft

Safety factor = Resisting moments / Overturning moments = **10.50 > 1.5 Okay**

2. D + EH + 0.7*EQ:

Resisting Moments:	35.57	
Overturning Moments:	4.25	

Safety factor = Resisting moments / Overturning moments = **8.4 > 1.1 Okay**

Sliding Check:

1. D + EH:

Resisting Force:	2.51	(kip-ft.)/ft
Sliding Load:	1.27	(kip-ft.)/ft

Safety factor * = Resisting Force / Sliding Load = **1.98 > 1.5 Okay**

2. D + EH + 0.7*EQ:

Resisting Force:	2.51	
Sliding Load:	1.52	

Safety factor * = Resisting Force / Sliding Load = **1.6 > 1.1 Okay**

Bearing Check:

1. D + EH:

Eccentricity (e):	0.01	ft
Soil Bearing Resistance:	3.00	(kip-ft.)/ft
Bearing Stresses:	0.80	(kip-ft.)/ft

Safety factor = Soil Bearing Resistance / Bearing Stresses = **3.73 > 1.0 Okay**

2. D + EH + 0.7*EQ:

Eccentricity (e):	0.13	ft
Soil Bearing Resistance:	3.00	(kip-ft.)/ft
Bearing Stresses:	0.87	(kip-ft.)/ft

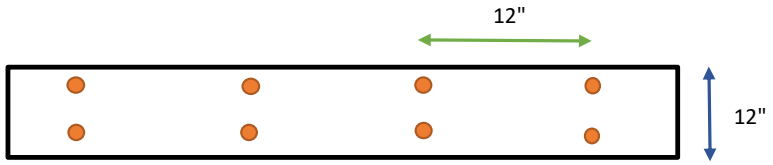
Safety factor = Soil Bearing Resistance / Bearing Stresses = **3.5 > 1.0 Okay**

* conservatively passive resistance associated with soil above the footing toe are disregarded

Wall Flexural Resistance (at critical section):

#6 vertical bars spaced at 12" with a staggered pattern is used:

The top view of wall:



Concrete Properties			**Reinforcment Properties**			**Design Moments**		
f'c =	4	ksi	Fy =	60	ksi			
wc =	0.150	kcf	Es =	29000	ksi	M_u =	2.95	k-ft
Ec =	4266	ksi						

Section Geometry

b =	12.00	in
h =	12.00	in
Cover =	2	in

Flexural Reinforcement

Layer	Bar Size	# of Bars	As (in^2)	d (in)
1	# 6	1.000	0.44	9.63
2				
3				
4				

As =	0.44	in^2	
d =	9.63	in	
dt =	9.63	in	
S	12.00	in	Reinforcement Spacing

Flexural Strength Check

c =	0.761	in	Solve for c using goal seek. (Press Control + i to run macro)
ε_c =	0.003		Concrete compression strain limit per LRFD 5.6.2.1
B_1 =	0.85		Rectangualr stress distribution factor per LRFD 5.6.2.2
a =	0.647	in	a = B_1c per LRFD 5.6.2.2
C =	26.4	kip	Concrete Compression Force: C = 0.85f'c*a*bf
ε_s =	0.03493		Reinforcment Strain: $\varepsilon_s = \varepsilon_c(d/c - 1)$
fs =	60.0	ksi	Reinforcement Tension Stress: fs = min(ε_s*Es,Fy)
T =	26.4	kip	Reinforcement Tension Force: T = fs*As
T - C =	0.000	kip	Sum of Forces
Mn =	20.5	k-ft	Nominal Moment Strength: Mn = T(d - a/2)
ϕ =	0.9		ϕ = 0.75 + 0.15(εt-εcl/εtl -εcl)=<0.9 per LRFD 5.5.4.2-2
ϕMn =	18.4	k-ft	Factored Moment Strength

18.4 > 3 OK

Flexural Crack Control

γ_e =	0.75		Exposure factor per LRFD 5.6.7
dc =	2.38	in	Distance from extreme tension fiber to CG of closest bar
s =	12.00	in	Spacing of steel reinforcment
n =	6.80		Modular Ratio: n = Es/Ec
ρ =	0.00381		Reinforcment Ratio: ρ = As/(b*d)

k =	0.203		k = SQRT[(ρn)^2 + 2ρn] - ρn
j =	0.932		j = 1 - k/3
$fs_{service}$ =	9.0	ksi	$fs_{service} = M_{service} / (As*j*d)$
βs =	1.35		βs = 1 + dc/[0.7*(h-dc)]
smax =	38.48	in	

12 < 38.5 OK

Minimum Reinforcement Check

I =	1728	in^4	Moment of Inertia
St =	288	in^3	Section Modulus for Extreme Tensile Fiber
ϒ1	1.6		flexural cracking variability factor LRFD 5.6.3.3
ϒ3	0.67		ratio of specified minimum yield strength to ultimate tensile of the nonprestressed reinforcement
fr =	0.480	ksi	Modulus of Rupture per LRFD 5.4.2.6
Mcr =	12.3	k-ft	Cracking Moment: Mcr = ϒ3*[(ϒ1*fr)Sc]
Mcr =	12.3	k-ft	
1.33Mu =	3.9	k-ft	1.33Mu Controls

3.9 < 18.4 OK

Interface Shear Resistance (at Stem - Footing Connection, AASHTO 5.7.4.3)

fy	60.00	ksi	Specified minimum yield strength of reinforcement (ksi)
f'c	4.00	ksi	Compressive strength of concrete for use on design (ksi)
c	0.24	ksi	for normal weight concrete placed against roughened surface to 0.25'
μ	1.00		for normal weight concrete placed against roughened surface to 0.25'
t	12.00	in	the wall thickness
Avc	144.00	in^2/ft	area of concrete considered to be engaged in interface shear transfe
Avf	0.88	in^2/ft	area of interface shear reinforcement crossing the shear plane
Pc	0.00	kip	permanent net compressive force normal to the shear plane
K1	0.25		fraction of concrete strength available to resist interface shear (AASHTO 5.7.4.4
K2	1.50		limiting interface shear resistance (AASHTO 5.7.4.4)
φ	1.00		AASHTO 5.5.4.2
Vni	87.36	kip/ft	
φVni	87.36	kip/ft	

φVni > Vu = 1.37kips/ft Ok

Wall Shear Strength (at critical section):

Vu	1.37	kip/ft	
ϕ =	0.9		
bv	12.00	in	
dv	9.30	in	= max (ds-a/2= 9.3 in, 0.9*de = 8.66 in, 0.72*h= 8.64 in)
β	2		AASHTO 5.7.3.4.1
Vc	14.11	kip	Vc=0.0316 * β * sqrt(fc) [b_v * d_v]
ΦVc	12.70	kip	Ok

Shrinkage and Temperature Reinforcement (AASHTO 5.10.6)

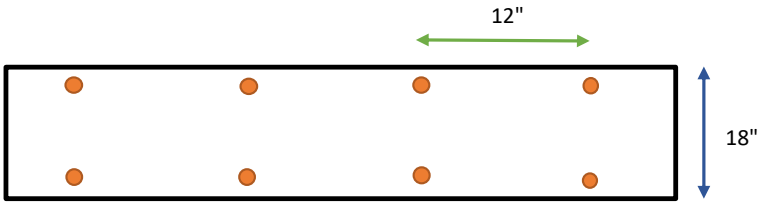
As	0.11 in^2/ft	1.3bh/(2*(b+h)*fy)	area of reinforcement in each direction and each face
		0.11=<As=<0.6	
b	12 in		
h	12 in		

#4 @ 12" reinforcement should be used for bars that are parallel to barrier

Footing Flexural Resistance (at critical section):

#6 vertical bars spaced at 12" with a staggered pattern is used:

Footing side view:



Concrete Properties			**Reinforcment Properties**			**Design Moments**			
f'c =	4	ksi	Fy =	60	ksi				
wc =	0.150	kcf	Es =	29000	ksi	M_u =	20.01	k-ft	moment due to soil bearing
Ec =	4266	ksi					2.95	k-ft	moment due to wall loads

Section Geometry

b =	12.00	in
h =	18.00	in
Cover =	2	in

Flexural Reinforcement

Layer	Bar Size	# of Bars	As (in^2)	d (in)
1	# 6	1.000	0.44	15.63
2				
3				
4				

As =	0.44	in^2	
d =	15.63	in	
dt =	15.63	in	
S	12.00	in	Reinforcement Spacing

Flexural Strength Check

c =	0.761	in	Solve for c using goal seek. (Press Control + i to run macro)
ε_c =	0.003		Concrete compression strain limit per LRFD 5.6.2.1
B_1 =	0.85		Rectangualr stress distribution factor per LRFD 5.6.2.2
a =	0.647	in	a = B_1c per LRFD 5.6.2.2
C =	26.4	kip	Concrete Compression Force: C = 0.85f'c*a*bf
ε_s =	0.05858		Reinforcment Strain: $\varepsilon_s = \varepsilon_c(d/c - 1)$
fs =	60.0	ksi	Reinforcement Tension Stress: fs = min(ε_s*Es,Fy)
T =	26.4	kip	Reinforcement Tension Force: T = fs*As
T - C =	0.000	kip	Sum of Forces
Mn =	33.7	k-ft	Nominal Moment Strength: Mn = T(d - a/2)
ϕ =	0.9		ϕ = 0.75 + 0.15(εt-εcl/εtl -εcl)=<0.9 per LRFD 5.5.4.2-2
ϕMn =	30.3	k-ft	Factored Moment Strength

30.3 > 20 OK

Flexural Crack Control

γ_e =	0.75		Exposure factor per LRFD 5.6.7
dc =	2.38	in	Distance from extreme tension fiber to CG of closest bar
s =	12.00	in	Spacing of steel reinforcment
n =	6.80		Modular Ratio: n = Es/Ec
ρ =	0.00235		Reinforcment Ratio: ρ = As/(b*d)

k =	0.163		k = SQRT[(ρn)^2 + 2ρn] - ρn
j =	0.946		j = 1 - k/3
$fs_{service}$ =	5.5	ksi	$fs_{service} = M_{service} / (As*j*d)$
βs =	1.22		βs = 1 + dc/[0.7*(h-dc)]
smax =	74.34	in	

12 < 74.3 OK

Minimum Reinforcement Check

I =	5832	in^4	Moment of Inertia
St =	648	in^3	Section Modulus for Extreme Tensile Fiber
ϒ1	1.6		flexural cracking variability factor LRFD 5.6.3.3
ϒ3	0.67		ratio of specified minimum yield strength to ultimate tensile of the nonprestressed reinforcement
fr =	0.480	ksi	Modulus of Rupture per LRFD 5.4.2.6
Mcr =	27.8	k-ft	Cracking Moment: Mcr = ϒ3*[(ϒ1*fr)Sc]
Mcr =	27.8	k-ft	
1.33Mu =	3.9	k-ft	1.33Mu Controls

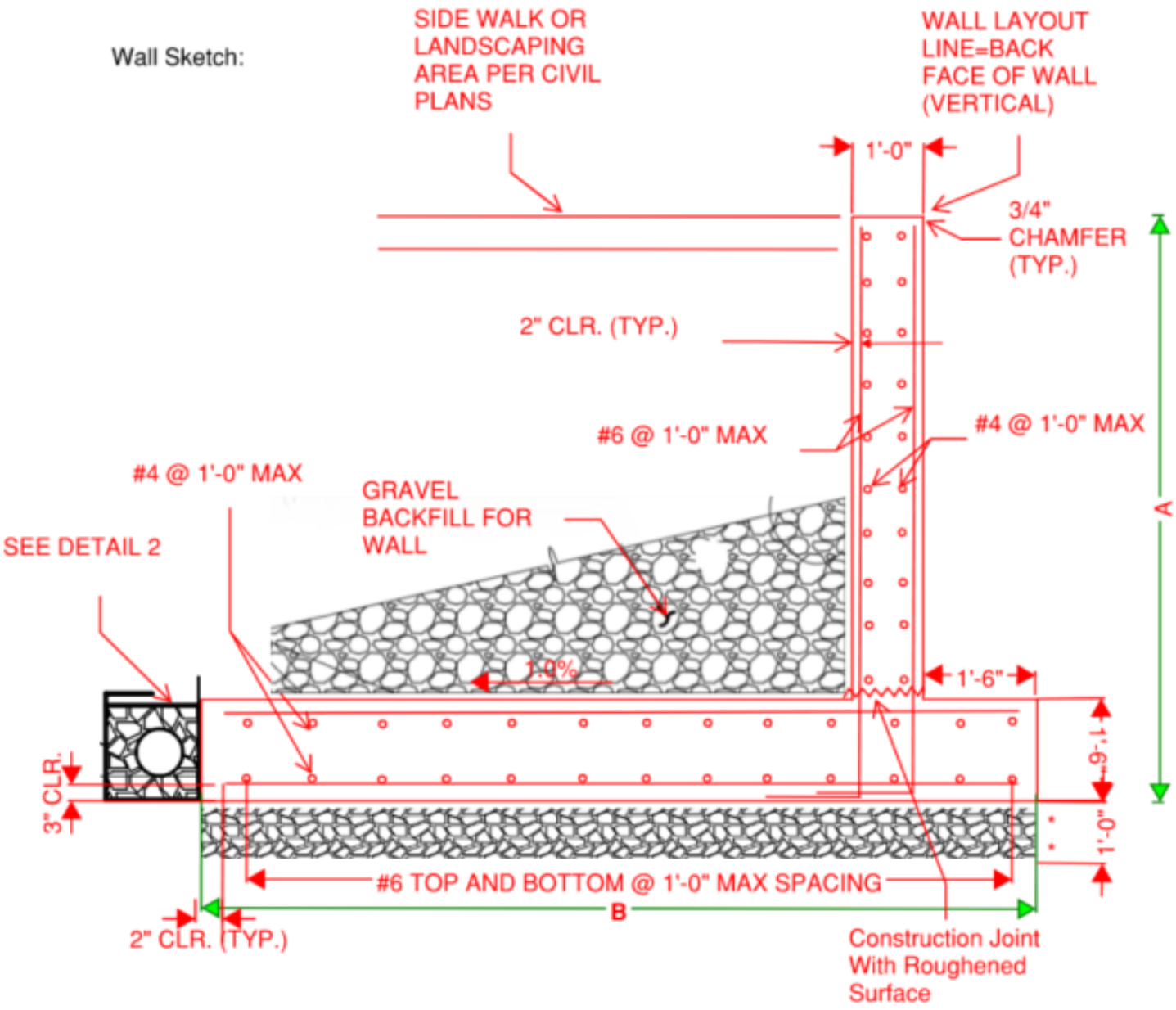
3.9 < 30.3 OK

Shrinkage and temperature reinforcement (AASHTO 5.10.6)

As	0.11	in^2/ft	1.3bh/(2*(b+h)*fy) area of reinforcement in each direction and each face 0.11=<As=<0.6
b	12	in	
h	18	in	

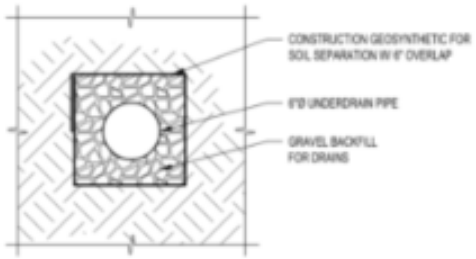
#4 @ 12" reinforcement should be used for bars that are parallel to barrier

Wall Sketch:



** GRAVEL BACKFILL FOR FOUNDATIONS CLASS A

A= 6.75' => B=9'
A= 5.75' => B=8'
A= 4.75' => B=7'
A= 3.75' => B=6'



DETAIL 2
1/2" = 1'-0"
S-19