DESIGN NOTES
FOR
STRUCTURES WALL- B-16-G & WALL B-16-H

PROJECT NO. FBR 0142-055,   SA.: 18085

BY: HOANG BUI

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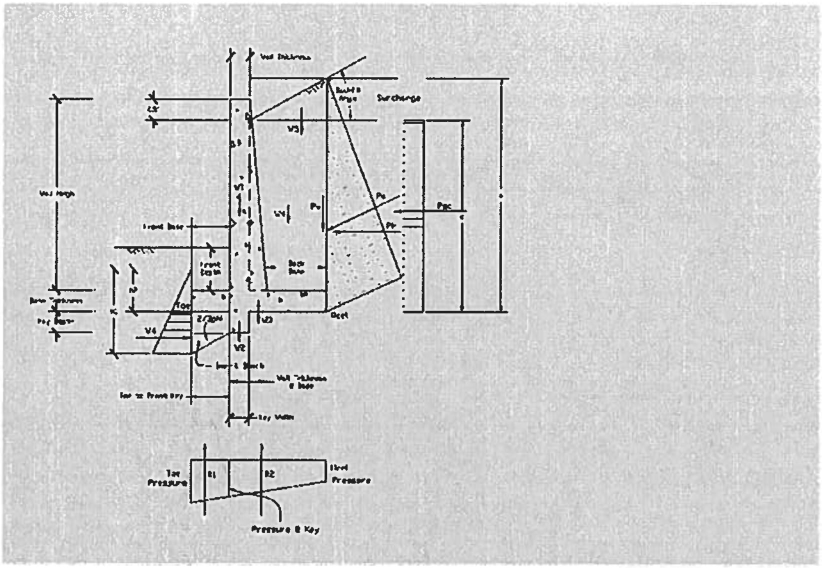
LRFD DESIGN FOR CIP RETAINING WALL B-16-G (SOUTH WALL)
AUTHOR: BUI, HOANG
Oct-12 **DESIGN HEIGHT** 3'



I. INPUT (ENGLISH)

Concrete Density (pcf)	150.00	
Soil Density (pcf)	125.00	
Backfill Slope β (by degree)	0.00	
Internal Friction Angle of Backfill Soil ϕ	34.00	
Internal Friction Angle Soil at Foundation ϕ	30.00	
Friction Angle between Fill and Wall δ (*)	30.00	(*) Table 3.11.5.3-1
Surcharge in Feet	2.00	
Water depth behind wall, from bottom base (ft)	1.5	
Top Wall to Backfill Depth (ft)	0.50	
Height from Top Base to Top Wall (ft)	3.50	
Top wall Thickness (ft)	0.83	H = TOP OF WALL TO BOTTOM OF BASE
Wall Thickness @ Base (ft)	0.83	H/12 to H/10 0.38 0.45
Front Base Length (ft)	1.00	H/10 TO H/8 0.45 0.56
Back Base Length (ft)	1.50	
Base Thickness (ft)	1.00	H/12 to H/10
Shear Key Depth (ft)	1.25	
Shear Key Width (ft)	0.67	
Distance from Toe to Key (ft)	0.00	
Front Soil Depth to Base (ft)	1.50	
Enter 1 for rock foundation, 0 for soil	0.00	
f'c (psi) = 4500 fy (psi)=	60000.00	
Utimate Foundation Bearing (ksf) =	5.30	
Bearing Resistance Factor (**)	0.55	(**) Table 10.5.5.2.2-1
Sliding Resistance Factor (Concrete on Soil) (**)	0.80	(**) Table 10.5.5.2.2-1
Sliding Resistance Factor (Soil on Soil) (**)	0.90	(**) Table 10.5.5.2.2-1
Coefficient of Sliding Resistance (μ)	0.45	

Table 10.5.5.2.2-1 Resistance Factors for Geotechnical Resistance of Shallow Foundations at Strength Limit State

Method / Soil / Condition			Resistance Factor
Bearing Resistance	ϕ_b	Theoretical Method (Munfakh et al., 2001), in clay	0.50
		Theoretical Method (Munfakh et al., 2001), in sand, using CPT	0.50
		Theoretical Method (Munfakh et al., 2001), in sand, using SPT	0.45
		Semi-empirical methods (Meyerhof, 1957), all soils	0.45
		Footing on rock	0.45
		Plate Load Test	0.55
Sliding	ϕ_τ	Precast concrete placed on sand	0.90
		Cast-in Place Concrete on sand	0.80
		Cast-in-Place or precast Concrete on clay	0.85
		Soil on soil	0.90
	ϕ_{ep}	Passive earth pressure component of sliding resistance	0.50

LOAD FACTORS

Load Combination	γ_{DC}	γ_{EV}	γ_{LS}	γ_{EH}	Application
Strength I (Min)	0.90	1.00	1.75	1.5	Sliding & overturning
Strength I (Max)	1.25	1.35	1.75	1.5	Bearing & wall strength
Service I	1.00	1.00	1.00	1.00	Wall crack control

II. OUTPUT

Enter 1 for using Rankine horizontal back fill, otherwise enter 0 — 0

		Not Submergence	Submergence
Angle of B.F. of Wall to Horizontal (degree)	90.00		
Active Fluid Weight (Coefficient and pcf), (Ka)	0.283	35.34	17.70
Passive Fluid Weight (Coefficient and pcf)	3.54	442.14	221.42

h1 = 3.75 a = 4.00 H = 4.50

h2 = 2.50 b = 4.00 0.4H = 1.80

Base Width (ft) = 3.33 0.4H to 0.6H 0.6H = 2.70

Adjust Fluid Weight 1 Trial to match provided (Ka) from Geology Unit

Unactored Horizontal Loads

Loads	Force (K)	Mo. Arm	Moment
Ph1 =	0.11	2.33	0.26
Ph2 =	0.13	0.75	0.10
Ph3 =	0.02	0.50	0.01
Ph,water =	0.07	0.50	0.04
Ph,sc =	0.28	2.00	0.57
	0.62		0.97

Unfactored Vertical Loads

Loads	Force (K)	Mo. Arm	Moment
W1 =	0.44	1.42	0.62
W2 =	0.13	0.34	0.04
W3 =	0.50	1.67	0.83
W4 =	0.56	2.58	1.45
W5 =	0.00	2.83	0.00
Pv1 =	0.00	3.33	0.00
Pv2 =	0.09	3.33	0.30
Pv3 =	0.01	3.33	0.04
	1.73		3.28

Unfactored Sliding Resistance from Shear Key (Horizontal)

Loads	Force (K)
P_P =	1.11

Factored Loads and Moments

Load Combination	vertical Loads V (K)	Moment M_V (K.Ft)	Horiz. Loads V (K)	Moment M_H (K.Ft)
Strength I (Min)	1.67	3.30	0.99	1.59
Strength I (Max)	2.24	4.33	0.99	1.59
Service I	1.73	3.28	0.62	0.97

III. CHECK OVER TURNING

1. CHECK OVERTURNING FOR FOUNDATION RESTS ON SOIL: YES

E_{max} = 0.83 ft.

x_r = 1.02 ft. (LOCATION OF RESULTANT FROM THE TOE)

Actual e = 0.64 ft. GOOD

2. CHECK OVERTURNING FOR FOUNDATION RESTS ON ROCK: NO

E_{max} = N/A ft.

x_r = N/A ft. (LOCATION OF RESULTANT FROM THE TOE)

Actual e = N/A ft.

IV. CHECK BEARING

Actual e = 0.44 ft.

Bearing Resistance = 2.915 ksf

1. CHECK BEARING FOR FOUNDATION RESTS ON SOIL: YES

Vertical Sress (Uniform) = 0.91 ksf GOOD

2. CHECK BEARING FOR FOUNDATION RESTS ON ROCK: NO

Vert. Sress (max.) = N/A ksf

Vert. Sress (min.) = N/A ksf

V. CHECK SLIDING

Friction Resistance = 0.96 k

Factored Sliding Force = 0.99 k

Sliding Resistance = 1.33 k GOOD

VI. ULTIMATE LOADS

Unactored Horizontal Loads on Stem

Loads	Force (K)	Mo. Arm	Moment
Ph1 =	0.11	1.33	0.15
Ph2 =	0.03	0.25	0.01
Ph3 =	0.00	0.17	0.00
Ph,water =	0.01	0.17	0.00
Ph,sc =	0.21	1.50	0.32
	0.36		0.47

Unfactored Vertical Loads behind Stem

Loads	Force (K)	Mo. Arm	Moment
W3 =	0.23	0.75	0.17
W4 =	0.56	0.75	0.42
W5 =	0.00	1.00	0.00
Pv1 =	0.00	1.50	0.00
Pv2 =	0.02	1.50	0.03
Pv3 =	0.00	1.50	0.00
	0.81		0.62

Ultimate Loads

Load Combination	Strength I (Max)		Service I	
	V (K)	M (K.Ft)	V (K)	M (K.Ft)
Toe	0.91	0.46	N/A	N/A
Heel	1.07	0.82	N/A	N/A
Stem	0.59	0.79	0.36	0.47

For conservative the ultimate shear at toe is calculated at front face of wall.

VII. DESIGN FOOTING FOR SHEARS

$Clr_{Top\ Footing}$ = 2 in — $Spacing_{Top}$ = 18 in

$Clr_{Bottom\ Footing}$ = 3 in — $Spacing_{Bottom}$ = 18 in

Top bar Diameter = 0.5 in — β = 2

Bottom bar Diameter = 0.5 in — ϕ_{shear} = 0.9

1. HEEL

$d_{s\ Heel}$ =	9.75	in		$A_{s\ Top}$ =	0.13	in^2
a_{Heel} =	0.17	in				
$d_{v\ Heel}$ =	9.66	in				
$V_{R\ Heel}$ =	13.99	k	>		1.07	k GOOD

2. TOE

$d_{s\ Toe}$ =	8.75	in		$A_{s\ Bottom}$ =	0.13	in^2
a_{Toe} =	0.17	in				
$d_{v\ Toe}$ =	8.66	in				
$V_{R\ Toe}$ =	12.55	k	>		0.91	k GOOD

VIII. DESIGN FOOTING FOR BENDINGS

Use sheet 2 (Heel Bending) for the heel bending design — OK

Use sheet 3 (Toe Bending) for the Toe bending design — OK

IX. DESIGN STEM FOR SHEAR

$Clr_{Back\ Stem}$ =	2	in				
Bar Diameter at Stem =	0.5	in		S_x =	7.66	in
Spacing =	18	in		$A_{s\ Stem}$ =	0.13	in^2
$d_{s\ Stem}$ =	7.75	in		ε_s =	0.000481778	
a_{Stem} =	0.17	in		S_{xe} =	12	in
$d_{v\ Stem}$ =	7.66	in		β =	3.53	
$V_{R\ Stem}$ =	19.55	k	>		0.59	k GOOD

X. DESIGN STEM FOR BENDING

Use sheet 4 (Stem Bending) for the stem bending design — OK

Check control of cracking by distribution of reinforcement (5.7.3.4)

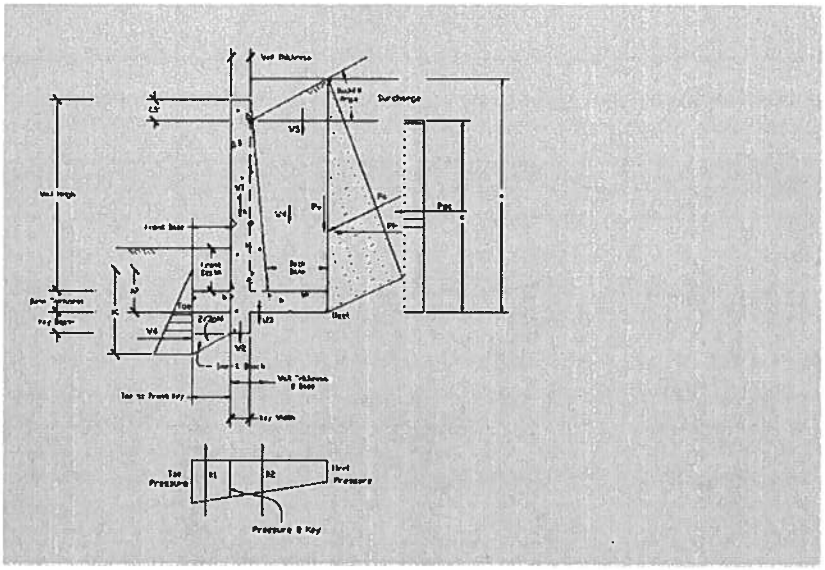
Service Mu =	0.47	k.ft
f_{ss} =	5.67	ksi
d_c =	2.25	in
β_s =	1.32	
S <=	88.96	in

GOOD

SUMMARY OF CONCRETE DESIGN

	BAR DIA. (IN)	SPACING (IN)	COVER (IN)
FOOTING TOP MAT	0.5	18	2
FOOTING BOTTOM MAT	0.5	18	3
STEM	0.5	18	2

LRFD DESIGN FOR CIP RETAINING WALL B-16-G (SOUTH WALL)
AUTHOR: BUI, HOANG
Oct-12 DESIGN HEIGHT 4'



I. INPUT (ENGLISH)

Concrete Density (pcf)	150.00			
Soil Density (pcf)	125.00			
Backfill Slope β (by degree)	0.00			
Internal Friction Angle of Backfill Soil ϕ	34.00			
Internal Friction Angle Soil at Foundation ϕ	30.00			
Friction Angle between Fill and Wall δ (*)	30.00	(*) Table 3.11.5.3-1		
Surcharge in Feet	2.00			
Water depth behind wall, from bottom base (ft)	2.0			
Top Wall to Backfill Depth (ft)	0.50			
Height from Top Base to Top Wall (ft)	4.50			
Top wall Thickness (ft)	0.83	H = TOP OF WALL TO BOTTOM OF BASE		
Wall Thickness @ Base (ft)	0.83	H/12 to H/10	0.46	0.55
Front Base Length (ft)	1.00	H/10 TO H/8	0.55	0.69
Back Base Length (ft)	2.00			
Base Thickness (ft)	1.00	H/12 to H/10		
Shear Key Depth (ft)	1.25			
Shear Key Width (ft)	0.67			
Distance from Toe to Key (ft)	0.00			
Front Soil Depth to Base (ft)	1.50			
Enter 1 for rock foundation, 0 for soil	0.00			
f'c (psi) = 4500 fy (psi)=	60000.00			
Utimate Foundation Bearing (ksf) =	5.30			
Bearing Resistance Factor (**)	0.55	(**) Table 10.5.5.2.2-1		
Sliding Resistance Factor (Concrete on Soil) (**)	0.80	(**) Table 10.5.5.2.2-1		
Sliding Resistance Factor (Soil on Soil) (**)	0.90	(**) Table 10.5.5.2.2-1		
Coefficient of Sliding Resistance (μ)	0.45			

Table 10.5.5.2.2-1 Resistance Factors for Geotechnical Resistance of Shallow Foundations at Strength Limit State

Method / Soil / Condition			Resistance Factor
Bearing Resistance	ϕ_b	Theoretical Method (Munfakh et al., 2001), in clay	0.50
		Theoretical Method (Munfakh et al., 2001), in sand, using CPT	0.50
		Theoretical Method (Munfakh et al., 2001), in sand, using SPT	0.45
		Semi-empirical methods (Meyerhof, 1957), all soils	0.45
		Footing on rock	0.45
		Plate Load Test	0.55
Sliding	ϕ_τ	Precast concrete placed on sand	0.90
		Cast-in Place Concrete on sand	0.80
		Cast-in-Place or precast Concrete on clay	0.85
		Soil on soil	0.90
	ϕ_{ep}	Passive earth pressure component of sliding resistance	0.50

LOAD FACTORS

Load Combination	γ_{DC}	γ_{EV}	γ_{LS}	γ_{EH}	Application
Strength I (Min)	0.90	1.00	1.75	1.5	Sliding & overturning
Strength I (Max)	1.25	1.35	1.75	1.5	Bearing & wall strength
Service I	1.00	1.00	1.00	1.00	Wall crack control

II. OUTPUT

Enter 1 for using Rankine horizontal back fill, otherwise enter 0	0		
Angle of B.F. of Wall to Horizontal (degree)	90.00	Not Submergence	Submergence
Active Fluid Weight (Coefficient and pcf), (Ka)	0.283	35.34	17.70
Passive Fluid Weight (Coefficient and pcf)	3.54	442.14	221.42

h1 = 3.75 a = 5.00 H = 5.50

h2 = 2.50 b = 5.00 0.4H = 2.20

Base Width (ft) = 3.83 0.4H to 0.6H 0.6H = 3.30

Adjust Fluid Weight 1 Trial to match provided (Ka) from Geology Unit

Unactored Horizontal Loads

Loads	Force (K)	Mo. Arm	Moment
Ph1 =	0.16	3.00	0.48
Ph2 =	0.21	1.00	0.21
Ph3 =	0.04	0.67	0.02
Ph,water =	0.12	0.67	0.08
Ph,sc =	0.35	2.50	0.88
	0.88		1.68

Unfactored Vertical Loads

Loads	Force (K)	Mo. Arm	Moment
W1 =	0.56	1.42	0.80
W2 =	0.13	0.34	0.04
W3 =	0.57	1.92	1.10
W4 =	1.00	2.83	2.83
W5 =	0.00	3.17	0.00
Pv1 =	0.00	3.83	0.00
Pv2 =	0.14	3.83	0.55
Pv3 =	0.02	3.83	0.08
	2.43		5.40

Unfactored Sliding Resistance from Shear Key (Horizontal)

Loads	Force (K)
P_p =	1.11

Factored Loads and Moments

Load Combination	vertical Loads V (K)	Moment M_V (K.Ft)	Horiz. Loads V (K)	Moment M_H (K.Ft)
Strength I (Min)	2.38	5.52	1.42	2.74
Strength I (Max)	3.17	7.19	1.42	2.74
Service I	2.43	5.40	0.88	1.68

III. CHECK OVER TURNING

1. CHECK OVERTURNING FOR FOUNDATION RESTS ON SOIL: YES

E_{max} = 0.96 ft.

x_r = 1.17 ft. (LOCATION OF RESULTANT FROM THE TOE)

Actual e = 0.75 ft. GOOD

2. CHECK OVERTURNING FOR FOUNDATION RESTS ON ROCK: NO

E_{max} = N/A ft.

x_r = N/A ft. (LOCATION OF RESULTANT FROM THE TOE)

Actual e = N/A ft.

IV. CHECK BEARING

Actual e = 0.51 ft.

Bearing Resistance = 2.915 ksf

1. CHECK BEARING FOR FOUNDATION RESTS ON SOIL: YES

Vertical Sress (Uniform) = 1.13 ksf GOOD

2. CHECK BEARING FOR FOUNDATION RESTS ON ROCK: NO

Vert. Sress (max.) = N/A ksf

Vert. Sress (min.) = N/A ksf

V. CHECK SLIDING

Friction Resistance = 1.38 k

Factored Sliding Force = 1.42 k

Sliding Resistance = 1.65 k GOOD

VI. ULTIMATE LOADS

Unactored Horizontal Loads on Stem

Loads	Force (K)	Mo. Arm	Moment
Ph1 =	0.16	2.00	0.32
Ph2 =	0.07	0.50	0.04
Ph3 =	0.01	0.33	0.00
Ph,water =	0.03	0.33	0.01
Ph,sc =	0.28	2.00	0.57
	0.55		0.93

Unfactored Vertical Loads behind Stem

Loads	Force (K)	Mo. Arm	Moment
W3 =	0.30	1.00	0.30
W4 =	1.00	1.00	1.00
W5 =	0.00	1.33	0.00
Pv1 =	0.00	2.00	0.00
Pv2 =	0.05	2.00	0.10
Pv3 =	0.01	2.00	0.01
	1.35		1.41

Ultimate Loads

Load Combination	Strength I (Max)		Service I	
	V (K)	M (K.Ft)	V (K)	M (K.Ft)
Toe	1.13	0.57	N/A	N/A
Heel	1.80	1.88	N/A	N/A
Stem	0.90	1.54	0.55	0.93

For conservative the ultimate shear at toe is calculated at front face of wall.

VII. DESIGN FOOTING FOR SHEARS

$Clr_{Top\ Footing}$ =	2	in		$Spacing_{Top}$ =	18	in
$Clr_{Bottom\ Footing}$ =	3	in		$Spacing_{Bottom}$ =	18	in
Top bar Diameter =	0.5	in		β =	2	
Bottom bar Diameter =	0.5	in		ϕ_{shear} =	0.9	

1. HEEL

$d_{s\ Heel}$ =	9.75	in		$A_{s\ Top}$ =	0.13	in^2	
a_{Heel} =	0.17	in					
$d_{v\ Heel}$ =	9.66	in					
$V_{R\ Heel}$ =	13.99	k	>		1.80	k	GOOD

2. TOE

$d_{s\ Toe}$ =	8.75	in		$A_{s\ Bottom}$ =	0.13	in^2	
a_{Toe} =	0.17	in					
$d_{v\ Toe}$ =	8.66	in					
$V_{R\ Toe}$ =	12.55	k	>		1.13	k	GOOD

VIII. DESIGN FOOTING FOR BENDINGS

Use sheet 2 (Heel Bending) for the heel bending design — OK

Use sheet 3 (Toe Bending) for the Toe bending design — OK

IX. DESIGN STEM FOR SHEAR

$Clr_{Back\ Stem}$ =	2	in					
Bar Diameter at Stem =	0.5	in		S_x =	7.66	in	
Spacing =	18	in		$A_{s\ Stem}$ =	0.13	in^2	
$d_{s\ Stem}$ =	7.75	in		ε_s =	0.000871961		
a_{Stem} =	0.17	in		S_{xe} =	12	in	
$d_{v\ Stem}$ =	7.66	in		β =	2.90		
$V_{R\ Stem}$ =	16.10	k	>		0.90	k	GOOD

X. DESIGN STEM FOR BENDING

Use sheet 4 (Stem Bending) for the stem bending design — OK

Check control of cracking by distribution of reinforcement (5.7.3.4)

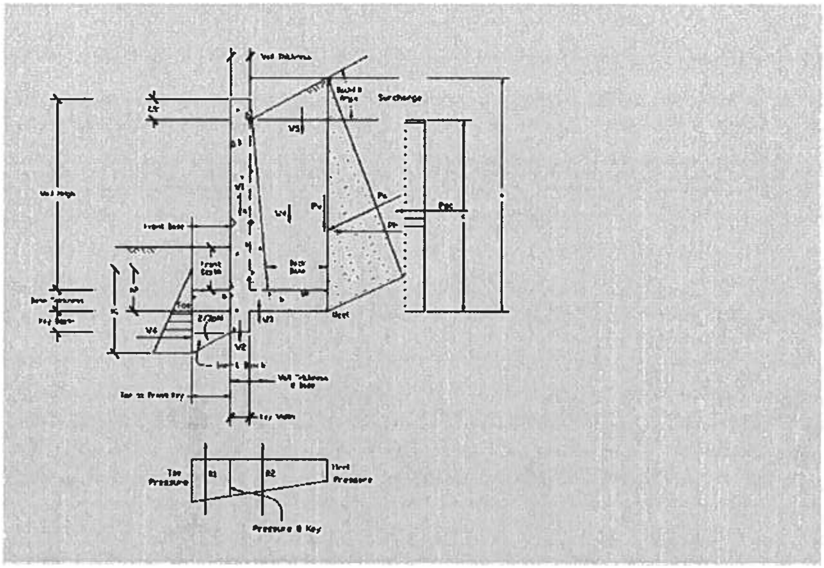
Service Mu =	0.93	k.ft	
f_{ss} =	11.15	ksi	
d_c =	2.25	in	
β_s =	1.32		
S <=	43.01	in	GOOD

SUMMARY OF CONCRETE DESIGN

	BAR DIA. (IN)	SPACING (IN)	COVER (IN)
FOOTING TOP MAT	0.5	18	2
FOOTING BOTTOM MAT	0.5	18	3
STEM	0.5	18	2

4

LRFD DESIGN FOR CIP RETAINING WALL B-16-G (SOUTH WALL)
AUTHOR: BUI, HOANG
Oct-12 **DESIGN HEIGHT** 5'



I. INPUT (ENGLISH)

Concrete Density (pcf)	150.00			
Soil Density (pcf)	125.00			
Backfill Slope β (by degree)	0.00			
Internal Friction Angle of Backfill Soil ϕ	34.00			
Internal Friction Angle Soil at Foundation ϕ	30.00			
Friction Angle between Fill and Wall δ (*)	30.00	(*) Table 3.11.5.3-1		
Surcharge in Feet	2.00			
Water depth behind wall, from bottom base (ft)	2.5			
Top Wall to Backfill Depth (ft)	0.50			
Height from Top Base to Top Wall (ft)	5.50			
Top wall Thickness (ft)	0.83	H = TOP OF WALL TO BOTTOM OF BASE		
Wall Thickness @ Base (ft)	0.83	H/12 to H/10	0.54	0.65
Front Base Length (ft)	1.00	H/10 TO H/8	0.65	0.81
Back Base Length (ft)	2.50			
Base Thickness (ft)	1.00	H/12 to H/10		
Shear Key Depth (ft)	1.25			
Shear Key Width (ft)	0.67			
Distance from Toe to Key (ft)	0.00			
Front Soil Depth to Base (ft)	1.50			
Enter 1 for rock foundation, 0 for soil	0.00			
f'c (psi) = 4500 fy (psi)=	60000.00			
Utimate Foundation Bearing (ksf) =	5.30			
Bearing Resistance Factor (**)	0.55	(**) Table 10.5.5.2.2-1		
Sliding Resistance Factor (Concrete on Soil) (**)	0.80	(**) Table 10.5.5.2.2-1		
Sliding Resistance Factor (Soil on Soil) (**)	0.90	(**) Table 10.5.5.2.2-1		
Coefficient of Sliding Resistance (μ)	0.45			

Table 10.5.5.2.2-1 Resistance Factors for Geotechnical Resistance of Shallow Foundations at Strength Limit State

Method / Soil / Condition			Resistance Factor
Bearing Resistance	ϕ_b	Theoretical Method (Munfakh et al., 2001), in clay	0.50
		Theoretical Method (Munfakh et al., 2001), in sand, using CPT	0.50
		Theoretical Method (Munfakh et al., 2001), in sand, using SPT	0.45
		Semi-empirical methods (Meyerhof, 1957), all soils	0.45
		Footing on rock	0.45
		Plate Load Test	0.55
Sliding	ϕ_τ	Precast concrete placed on sand	0.90
		Cast-in Place Concrete on sand	0.80
		Cast-in-Place or precast Concrete on clay	0.85
		Soil on soil	0.90
	ϕ_{ep}	Passive earth pressure component of sliding resistance	0.50

LOAD FACTORS

Load Combination	γ_{DC}	γ_{EV}	γ_{LS}	γ_{EH}	Application
Strength I (Min)	0.90	1.00	1.75	1.5	Sliding & overturning
Strength I (Max)	1.25	1.35	1.75	1.5	Bearing & wall strength
Service I	1.00	1.00	1.00	1.00	Wall crack control

II. OUTPUT

		Not Submergence	Submergence
Enter 1 for using Rankine horizontal back fill, otherwise enter 0	0		
Angle of B.F. of Wall to Horizontal (degree)	90.00	Not Submergence	Submergence
Active Fluid Weight (Coefficient and pcf), (Ka)	0.28	35.34	17.70
Passive Fluid Weight (Coefficient and pcf)	3.54	442.14	221.42

h1 = 3.75 a = 6.00 H = 6.50

h2 = 2.50 b = 6.00 0.4H = 2.60

Base Width (ft) = 4.33 0.4H to 0.6H 0.6H = 3.90

Adjust Fluid Weight 1 Trial to match provided (Ka) from Geology Unit

Unactored Horizontal Loads

Loads	Force (K)	Mo. Arm	Moment
Ph1 =	0.22	3.67	0.79
Ph2 =	0.31	1.25	0.39
Ph3 =	0.06	0.83	0.05
Ph,water =	0.20	0.83	0.16
Ph,sc =	0.42	3.00	1.27
	1.20		2.66

Unfactored Vertical Loads

Loads	Force (K)	Mo. Arm	Moment
W1 =	0.69	1.42	0.97
W2 =	0.13	0.34	0.04
W3 =	0.65	2.17	1.41
W4 =	1.56	3.08	4.82
W5 =	0.00	3.50	0.00
Pv1 =	0.00	4.33	0.00
Pv2 =	0.21	4.33	0.90
Pv3 =	0.03	4.33	0.14
	3.27		8.28

Unfactored Sliding Resistance from Shear Key (Horizontal)

Loads	Force (K)
P_p =	1.11

Factored Loads and Moments

Load Combination	vertical Loads V (K)	Moment M_V (K.Ft)	Horiz. Loads V (K)	Moment M_H (K.Ft)
Strength I (Min)	3.24	8.56	1.91	4.31
Strength I (Max)	4.30	11.10	1.91	4.31
Service I	3.27	8.28	1.20	2.66

III. CHECK OVER TURNING

1. CHECK OVERTURNING FOR FOUNDATION RESTS ON SOIL: YES

E_{max} = 1.08 ft.

x_r = 1.31 ft. (LOCATION OF RESULTANT FROM THE TOE)

Actual e = 0.85 ft. GOOD

2. CHECK OVERTURNING FOR FOUNDATION RESTS ON ROCK: NO

E_{max} = N/A ft.

x_r = N/A ft. (LOCATION OF RESULTANT FROM THE TOE)

Actual e = N/A ft.

IV. CHECK BEARING

Actual e = 0.59 ft.

Bearing Resistance = 2.915 ksf

1. CHECK BEARING FOR FOUNDATION RESTS ON SOIL: YES

Vertical Sress (Uniform) = 1.36 ksf GOOD

2. CHECK BEARING FOR FOUNDATION RESTS ON ROCK: NO

Vert. Sress (max.) = N/A ksf

Vert. Sress (min.) = N/A ksf

V. CHECK SLIDING

Friction Resistance = 1.87 k

Factored Sliding Force = 1.91 k

Sliding Resistance = 2.05 k GOOD

VI. ULTIMATE LOADS

Unactored Horizontal Loads on Stem

Loads	Force (K)	Mo. Arm	Moment
Ph1 =	0.22	2.67	0.58
Ph2 =	0.13	0.75	0.10
Ph3 =	0.02	0.50	0.01
Ph,water =	0.07	0.50	0.04
Ph,sc =	0.35	2.50	0.88
	0.79		**1.61**

Unfactored Vertical Loads behind Stem

Loads	Force (K)	Mo. Arm	Moment
W3 =	0.38	1.25	0.47
W4 =	1.56	1.25	1.95
W5 =	0.00	1.67	0.00
Pv1 =	0.00	2.50	0.00
Pv2 =	0.09	2.50	0.22
Pv3 =	0.01	2.50	0.03
	2.04		**2.67**

Ultimate Loads

Load Combination	Strength I (Max)		Service I	
	V (K)	M (K.Ft)	V (K)	M (K.Ft)
Toe	1.36	0.68	N/A	N/A
Heel	2.73	3.60	N/A	N/A
Stem	1.28	2.63	0.79	1.61

For conservative the ultimate shear at toe is calculated at front face of wall.

VII. DESIGN FOOTING FOR SHEARS

$Clr_{Top\ Footing}$ =	2	in	$Spacing_{Top}$ =	18	in
$Clr_{Bottom\ Footing}$ =	3	in	$Spacing_{Bottom}$ =	18	in
Top bar Diameter =	0.5	in	β =	2	
Bottom bar Diameter =	0.5	in	ϕ_{shear} =	0.9	

1. HEEL

$d_{s\ Heel}$ =	9.75	in	$A_{s\ Top}$ =	0.13	in^2
a_{Heel} =	0.17	in			
$d_{v\ Heel}$ =	9.66	in			
$V_{R\ Heel}$ =	13.99	k	>	2.73	k GOOD

2. TOE

$d_{s\ Toe}$ =	8.75	in	$A_{s\ Bottom}$ =	0.13	in^2
a_{Toe} =	0.17	in			
$d_{v\ Toe}$ =	8.66	in			
$V_{R\ Toe}$ =	12.55	k	>	1.36	k GOOD

VIII. DESIGN FOOTING FOR BENDINGS

Use sheet 2 (Heel Bending) for the heel bending design — OK

Use sheet 3 (Toe Bending) for the Toe bending design — OK

IX. DESIGN STEM FOR SHEAR

$Clr_{Back\ Stem}$ =	2	in			
Bar Diameter at Stem =	0.5	in	S_x =	7.66	in
Spacing =	18	in	$A_{s\ Stem}$ =	0.13	in^2
$d_{s\ Stem}$ =	7.75	in	ε_s =	0.001420614	
a_{Stem} =	0.17	in	S_{xe} =	12	in
$d_{v\ Stem}$ =	7.66	in	β =	2.32	
$V_{R\ Stem}$ =	12.89	k	>	1.28	k GOOD

X. DESIGN STEM FOR BENDING

Use sheet 4 (Stem Bending) for the stem bending design — OK

Check control of cracking by distribution of reinforcement (5.7.3.4)

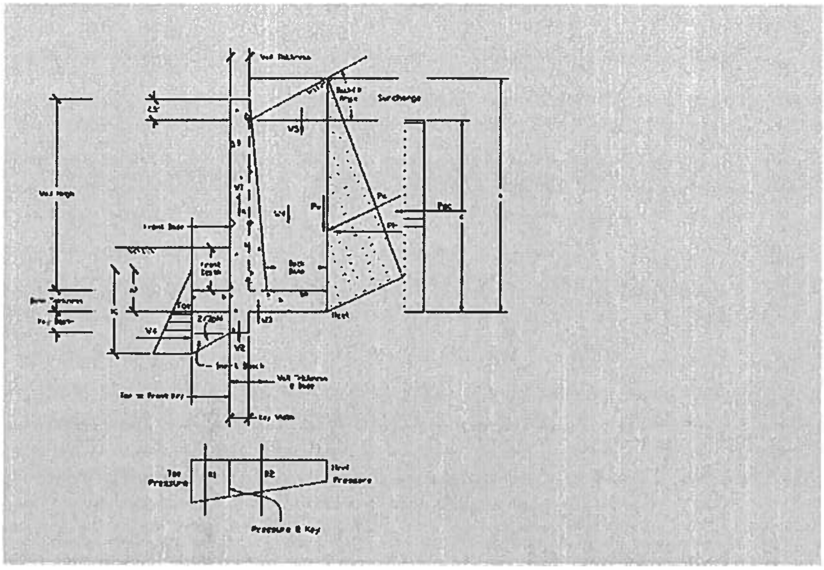
Service Mu =	1.61	k.ft	
f_{ss} =	19.20	ksi	
d_c =	2.25	in	
β_s =	1.32		
S <=	23.09	in	GOOD

SUMMARY OF CONCRETE DESIGN

	BAR DIA. (IN)	SPACING (IN)	COVER (IN)
FOOTING TOP MAT	0.5	18	2
FOOTING BOTTOM MAT	0.5	18	3
STEM	0.5	18	2

5

LRFD DESIGN FOR CIP RETAINING WALL
AUTHOR: BUI, HOANG
Oct-12 DESIGN HEIGHT 6'



I. INPUT (ENGLISH)

Concrete Density (pcf)	150.00	
Soil Density (pcf)	125.00	
Backfill Slope β (by degree)	0.00	
Internal Friction Angle of Backfill Soil ϕ	34.00	
Internal Friction Angle of Soil at Foundation ϕ	30.00	
Friction Angle between Fill and Wall δ (*)	30.00	(*) Table 3.11.5.3-1
Surcharge in Feet	2.00	
Water depth behind wall, from bottom base (ft)	3.0	
Top Wall to Backfill Depth (ft)	0.50	
Height from Top Base to Top Wall (ft)	6.50	
Top wall Thickness (ft)	0.83	H = TOP OF WALL TO BOTTOM OF BASE
Wall Thickness @ Base (ft)	0.83	H/12 to H/10 0.63 0.75
Front Base Length (ft)	1.00	H/10 TO H/8 0.75 0.94
Back Base Length (ft)	3.25	
Base Thickness (ft)	1.00	H/12 to H/10
Shear Key Depth (ft)	1.25	
Shear Key Width (ft)	0.67	
Distance from Toe to Key (ft)	0.00	
Front Soil Depth to Base (ft)	1.50	
Enter 1 for rock foundation, 0 for soil	0.00	
f'c (psi) = 4500 fy (psi)=	60000.00	
Utimate Foundation Bearing (ksf) =	5.30	
Bearing Resistance Factor (**)	0.55	(**) Table 10.5.5.2.2-1
Sliding Resistance Factor (Concrete on Soil) (**)	0.80	(**) Table 10.5.5.2.2-1
Sliding Resistance Factor (Soil on Soil) (**)	0.90	(**) Table 10.5.5.2.2-1

Table 10.5.5.2.2-1 Resistance Factors for Geotechnical Resistance of Shallow Foundations at Strength Limit State

Method / Soil / Condition			Resistance Factor
Bearing Resistance	ϕ_b	Theoretical Method (Munfakh et al., 2001), in clay	0.50
		Theoretical Method (Munfakh et al., 2001), in sand, using CPT	0.50
		Theoretical Method (Munfakh et al., 2001), in sand, using SPT	0.45
		Semi-empirical methods (Meyerhof, 1957), all soils	0.45
		Footing on rock	0.45
		Plate Load Test	0.55
Sliding	ϕ_τ	Precast concrete placed on sand	0.90
		Cast-in Place Concrete on sand	0.80
		Cast-in-Place or precast Concrete on clay	0.85
		Soil on soil	0.90
	ϕ_{ep}	Passive earth pressure component of sliding resistance	0.50

10/61

LOAD FACTORS

Load Combination	γ_{DC}	γ_{EV}	γ_{LS}	γ_{EH}	Application
Strength I (Min)	0.90	1.00	1.75	1.5	Sliding & overturning
Strength I (Max)	1.25	1.35	1.75	1.5	Bearing & wall strength
Service I	1.00	1.00	1.00	1.00	Wall crack control

II. OUTPUT

Enter 1 for using Rankine horizontal back fill, otherwise enter 0	0			
Angle of B.F. of Wall to Horizontal (degree)	90.00	Not Submergence	Submergence	
Active Fluid Weight (Coefficient and pcf). (Ka)	0.28	35.34	17.70	
Passive Fluid Weight (Coefficient and pcf)	3.54	442.14	221.42	
h1 = 3.75 a =	7.00			H = 7.50
h2 = 2.50 b =	7.00			0.4H = 3.00
Base Width (ft) =	5.08	0.4H to 0.6H		0.6H = 4.50
		Adjust Fluid Weight	1	Trial to match provided (Ka) from Geology Unit

Unactored Horizontal Loads

Loads	Force (K)	Mo. Arm	Moment
Ph1 =	0.28	4.33	1.23
Ph2 =	0.42	1.50	0.64
Ph3 =	0.08	1.00	0.08
Ph,water =	0.28	1.00	0.28
Ph,sc =	0.49	3.50	1.73
	1.56		3.95

Unfactored Vertical Loads

Loads	Force (K)	Mo. Arm	Moment
W1 =	0.81	1.42	1.15
W2 =	0.13	0.34	0.04
W3 =	0.76	2.54	1.94
W4 =	2.44	3.46	8.43
W5 =	0.00	4.00	0.00
Pv1 =	0.00	5.08	0.00
Pv2 =	0.29	5.08	1.45
Pv3 =	0.05	5.08	0.23
	4.47		13.25

Unfactored Sliding Resistance from Shear Key (Horizontal)

Loads	Force (K)
P_p =	1.11

Factored Loads and Moments

Load Combination	vertical Loads V (K)	Moment M_V (K.Ft)	Horiz. Loads V (K)	Moment M_H (K.Ft)
Strength I (Min)	4.47	13.78	2.47	6.36
Strength I (Max)	5.91	17.83	2.47	6.36
Service I	4.47	13.25	1.56	3.95

III. CHECK OVER TURNING

1. CHECK OVERTURNING FOR FOUNDATION RESTS ON SOIL: **YES**

E_{max} = 1.27 ft.

x_r = 1.66 ft. (LOCATION OF RESULTANT FROM THE TOE)

Actual e = 0.88 ft. **GOOD**

2. CHECK OVERTURNING FOR FOUNDATION RESTS ON ROCK: **NO**

E_{max} = N/A ft.

x_r = N/A ft. (LOCATION OF RESULTANT FROM THE TOE)

Actual e = N/A ft.

IV. CHECK BEARING

Actual e = 0.60 ft.

Bearing Resistance = 2.915 ksf

1. CHECK BEARING FOR FOUNDATION RESTS ON SOIL: **YES**

Vertical Sress (Uniform) = 1.53 ksf **GOOD**

2. CHECK BEARING FOR FOUNDATION RESTS ON ROCK: **NO**

Vert. Sress (max.) = N/A ksf

Vert. Sress (min.) = N/A ksf

V. CHECK SLIDING

Friction Resistance = 2.58 k

Factored Sliding Force = 2.47 k

Sliding Resistance = 2.62 k **GOOD**

VI. ULTIMATE LOADS

Unactored Horizontal Loads on Stem

Loads	Force (K)	Mo. Arm	Moment
Ph1 =	0.28	3.33	0.94
Ph2 =	0.21	1.00	0.21
Ph3 =	0.04	0.67	0.02
Ph,water =	0.12	0.67	0.08
Ph,sc =	0.42	3.00	1.27
	1.08		2.53

Unfactored Vertical Loads behind Stem

Loads	Force (K)	Mo. Arm	Moment
W3 =	0.49	1.63	0.79
W4 =	2.44	1.63	3.96
W5 =	0.00	2.17	0.00
Pv1 =	0.00	3.25	0.00
Pv2 =	0.14	3.25	0.46
Pv3 =	0.02	3.25	0.07
	3.09		5.28

Ultimate Loads

Load Combination	Strength I (Max)		Service I	
	V (K)	M (K.Ft)	V (K)	M (K.Ft)
Toe	1.53	0.76	N/A	N/A
Heel	4.15	7.13	N/A	N/A
Stem	1.72	4.12	1.08	2.53

For conservative the ultimate shear at toe is calculated at front face of wall.

VII. DESIGN FOOTING FOR SHEARS

$Clr_{Top\ Footing}$ =	2	in	$Spacing_{Top}$ =	15	in
$Clr_{Bottom\ Footing}$ =	3	in	$Spacing_{Bottom}$ =	15	in
Top bar Diameter =	0.625	in	β =	2	
Bottom bar Diameter =	0.625	in	ϕ_{shear} =	0.9	

1. HEEL

$d_{s\ Heel}$ =	9.6875	in	$A_{s\ Top}$ =	0.25	in^2
a_{Heel} =	0.32	in			
$d_{v\ Heel}$ =	9.53	in			
$V_{R\ Heel}$ =	13.79	k	>	4.15	k GOOD

2. TOE

$d_{s\ Toe}$ =	8.6875	in	$A_{s\ Bottom}$ =	0.25	in^2
a_{Toe} =	0.32	in			
$d_{v\ Toe}$ =	8.64	in			
$V_{R\ Toe}$ =	12.51	k	>	1.53	k GOOD

VIII. DESIGN FOOTING FOR BENDINGS

Use sheet 2 (Heel Bending) for the heel bending design — OK

Use sheet 3 (Toe Bending) for the Toe bending design — OK

IX. DESIGN STEM FOR SHEAR

$Clr_{Back\ Stem}$ =	2	in			
Bar Diameter at Stem =	0.625	in	S_x =	7.53	in
Spacing =	15	in	$A_{s\ Stem}$ =	0.25	in^2
$d_{s\ Stem}$ =	7.69	in	ε_s =	0.001164751	
a_{Stem} =	0.32	in	S_{xe} =	12	in
$d_{v\ Stem}$ =	7.53	in	β =	2.56	
$V_{R\ Stem}$ =	13.96	k	>	1.72	k GOOD

X. DESIGN STEM FOR BENDING

Use sheet 4 (Stem Bending) for the stem bending design — OK

Check control of cracking by distribution of reinforcement (5.7.3.4)

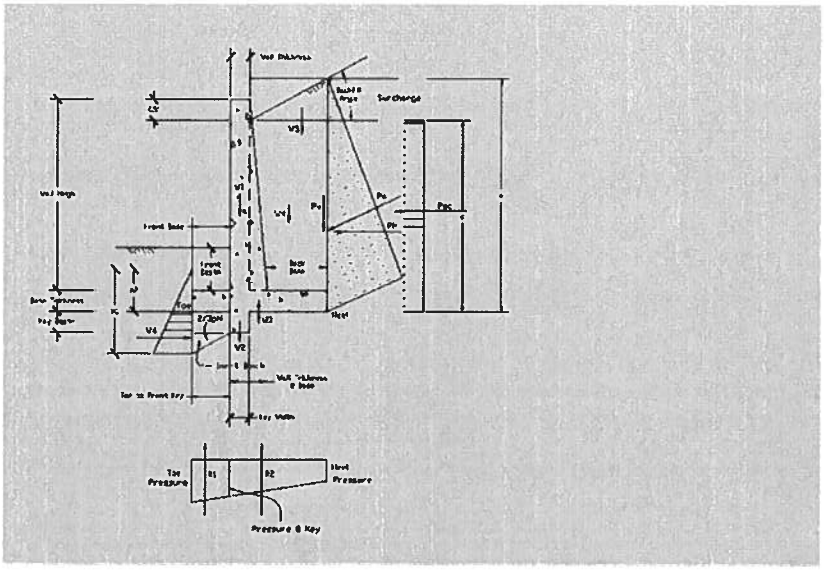
Service Mu =	2.53	k.ft	
f_{ss} =	16.46	ksi	
d_c =	2.31	in	
β_s =	1.33		
S <=	27.35	in	GOOD

SUMMARY OF CONCRETE DESIGN

	BAR DIA. (IN)	SPACING (IN)	COVER (IN)
FOOTING TOP MAT	0.625	15	2
FOOTING BOTTOM MAT	0.625	15	3
STEM	0.625	15	2

6

LRFD DESIGN FOR CIP RETAINING WALL
AUTHOR: BUI, HOANG
Oct-12 DESIGN HEIGHT 7'



I. INPUT (ENGLISH)

Concrete Density (pcf)	150.00			
Soil Density (pcf)	125.00			
Backfill Slope β (by degree)	0.00			
Internal Friction Angle of Backfill Soil ϕ	34.00			
Internal Friction Angle of Soil at Foundation ϕ	30.00			
Friction Angle between Fill and Wall δ (*)	30.00	(*) Table 3.11.5.3-1		
Surcharge in Feet	2.00			
Water depth behind wall, from bottom base (ft)	3.5			
Top Wall to Backfill Depth (ft)	0.50			
Height from Top Base to Top Wall (ft)	7.50			
Top wall Thickness (ft)	0.83	H = TOP OF WALL TO BOTTOM OF BASE		
Wall Thickness @ Base (ft)	0.83	H/12 to H/10	0.71	0.85
Front Base Length (ft)	1.00	H/10 TO H/8	0.85	1.06
Back Base Length (ft)	4.00			
Base Thickness (ft)	1.00	H/12 to H/10		
Shear Key Depth (ft)	1.25			
Shear Key Width (ft)	0.67			
Distance from Toe to Key (ft)	0.00			
Front Soil Depth to Base (ft)	1.50			
Enter 1 for rock foundation, 0 for soil	0.00			
f'c (psi) = 4500 fy (psi)=	60000.00			
Utimate Foundation Bearing (ksf) =	5.30			
Bearing Resistance Factor (**)	0.55	(**) Table 10.5.5.2.2-1		
Sliding Resistance Factor (Concrete on Soil) (**)	0.80	(**) Table 10.5.5.2.2-1		
Sliding Resistance Factor (Soil on Soil) (**)	0.90	(**) Table 10.5.5.2.2-1		

Table 10.5.5.2.2-1 Resistance Factors for Geotechnical Resistance of Shallow Foundations at Strength Limit State

Method / Soil / Condition			Resistance Factor
Bearing Resistance	ϕ_b	Theoretical Method (Munfakh et al., 2001), in clay	0.50
		Theoretical Method (Munfakh et al., 2001), in sand, using CPT	0.50
		Theoretical Method (Munfakh et al., 2001), in sand, using SPT	0.45
		Semi-empirical methods (Meyerhof, 1957), all soils	0.45
		Footing on rock	0.45
		Plate Load Test	0.55
Sliding	ϕ_τ	Precast concrete placed on sand	0.90
		Cast-in Place Concrete on sand	0.80
		Cast-in-Place or precast Concrete on clay	0.85
		Soil on soil	0.90
	ϕ_{ep}	Passive earth pressure component of sliding resistance	0.50

LOAD FACTORS

Load Combination	γ_{DC}	γ_{EV}	γ_{LS}	γ_{EH}	Application
Strength I (Min)	0.90	1.00	1.75	1.5	Sliding & overturning
Strength I (Max)	1.25	1.35	1.75	1.5	Bearing & wall strength
Service I	1.00	1.00	1.00	1.00	Wall crack control

II. OUTPUT

Enter 1 for using Rankine horizontal back fill, otherwise enter 0 — 0

		Not Submergence	Submergence
Angle of B.F. of Wall to Horizontal (degree)	90.00		
Active Fluid Weight (Coefficient and pcf), (Ka)	0.28	35.34	17.70
Passive Fluid Weight (Coefficient and pcf)	3.54	442.14	221.42

h1 = 3.75 a = 8.00 H = 8.50

h2 = 2.50 b = 8.00 0.4H = 3.40

Base Width (ft) = 5.83 0.4H to 0.6H 0.6H = 5.10

Adjust Fluid Weight 1 Trial to match provided (Ka) from Geology Unit

Unactored Horizontal Loads

Loads	Force (K)	Mo. Arm	Moment
Ph1 =	0.36	5.00	1.79
Ph2 =	0.56	1.75	0.97
Ph3 =	0.11	1.17	0.13
Ph,water =	0.38	1.17	0.45
Ph,sc =	0.57	4.00	2.26
	1.97		5.60

Unfactored Vertical Loads

Loads	Force (K)	Mo. Arm	Moment
W1 =	0.94	1.42	1.33
W2 =	0.13	0.34	0.04
W3 =	0.87	2.92	2.55
W4 =	3.50	3.83	13.42
W5 =	0.00	4.50	0.00
Pv1 =	0.00	5.83	0.00
Pv2 =	0.38	5.83	2.19
Pv3 =	0.06	5.83	0.37
	5.88		19.89

Unfactored Sliding Resistance from Shear Key (Horizontal)

Loads	Force (K)
P_p =	1.11

Factored Loads and Moments

Load Combination	vertical Loads V (K)	Moment M_V (K.Ft)	Horiz. Loads V (K)	Moment M_H (K.Ft)
Strength I (Min)	5.90	20.78	3.10	8.96
Strength I (Max)	7.80	26.85	3.10	8.96
Service I	5.88	19.89	1.97	5.60

III. CHECK OVER TURNING

1. CHECK OVERTURNING FOR FOUNDATION RESTS ON SOIL: YES

E_{max} = 1.46 ft.

x_r = 2.00 ft. (LOCATION OF RESULTANT FROM THE TOE)

Actual e = 0.91 ft. GOOD

2. CHECK OVERTURNING FOR FOUNDATION RESTS ON ROCK: NO

E_{max} = N/A ft.

x_r = N/A ft. (LOCATION OF RESULTANT FROM THE TOE)

Actual e = N/A ft.

IV. CHECK BEARING

Actual e = 0.62 ft.

Bearing Resistance = 2.915 ksf

1. CHECK BEARING FOR FOUNDATION RESTS ON SOIL: YES

Vertical Sress (Uniform) = 1.70 ksf GOOD

2. CHECK BEARING FOR FOUNDATION RESTS ON ROCK: NO

Vert. Sress (max.) = N/A ksf

Vert. Sress (min.) = N/A ksf

V. CHECK SLIDING

Friction Resistance = 3.41 k

Factored Sliding Force = 3.10 k

Sliding Resistance = 3.28 k GOOD

VI. ULTIMATE LOADS

Unactored Horizontal Loads on Stem

Loads	Force (K)	Mo. Arm	Moment
Ph1 =	0.36	4.00	1.43
Ph2 =	0.31	1.25	0.39
Ph3 =	0.06	0.83	0.05
Ph,water =	0.20	0.83	0.16
Ph,sc =	0.49	3.50	1.73
	1.41		3.76

Unfactored Vertical Loads behind Stem

Loads	Force (K)	Mo. Arm	Moment
W3 =	0.60	2.00	1.20
W4 =	3.50	2.00	7.00
W5 =	0.00	2.67	0.00
Pv1 =	0.00	4.00	0.00
Pv2 =	0.21	4.00	0.83
Pv3 =	0.03	4.00	0.13
	4.34		9.16

Ultimate Loads

Load Combination	Strength I (Max)		Service I	
	V (K)	M (K.Ft)	V (K)	M (K.Ft)
Toe	1.70	0.85	N/A	N/A
Heel	5.84	12.39	N/A	N/A
Stem	2.24	6.07	1.41	3.76

For conservative the ultimate shear at toe is calculated at front face of wall.

VII. DESIGN FOOTING FOR SHEARS

$Clr_{Top\ Footing}$ =	2	in		$Spacing_{Top}$ =	15	in
$Clr_{Bottom\ Footing}$ =	3	in		$Spacing_{Bottom}$ =	15	in
Top bar Diameter =	0.75	in		β =	2	
Bottom bar Diameter =	0.625	in		ϕ_{shear} =	0.9	

1. HEEL

$d_{s\ Heel}$ =	9.625	in		$A_{s\ Top}$ =	0.35	in^2
a_{Heel} =	0.46	in				
$d_{v\ Heel}$ =	9.39	in				
$V_{R\ Heel}$ =	13.60	k	>		5.84	k GOOD

2. TOE

$d_{s\ Toe}$ =	8.6875	in		$A_{s\ Bottom}$ =	0.25	in^2
a_{Toe} =	0.32	in				
$d_{v\ Toe}$ =	8.64	in				
$V_{R\ Toe}$ =	12.51	k	>		1.70	k GOOD

VIII. DESIGN FOOTING FOR BENDINGS

Use sheet 2 (Heel Bending) for the heel bending design — OK

Use sheet 3 (Toe Bending) for the Toe bending design — OK

IX. DESIGN STEM FOR SHEAR

$Clr_{Back\ Stem}$ =	2	in				
Bar Diameter at Stem =	0.625	in		S_x =	7.53	in
Spacing =	15	in		$A_{s\ Stem}$ =	0.25	in^2
$d_{s\ Stem}$ =	7.69	in		ε_s =	0.001674594	
a_{Stem} =	0.32	in		S_{xe} =	12	in
$d_{v\ Stem}$ =	7.53	in		β =	2.13	
$V_{R\ Stem}$ =	11.59	k	>		2.24	k GOOD

X. DESIGN STEM FOR BENDING

Use sheet 4 (Stem Bending) for the stem bending design — OK

Check control of cracking by distribution of reinforcement (5.7.3.4)

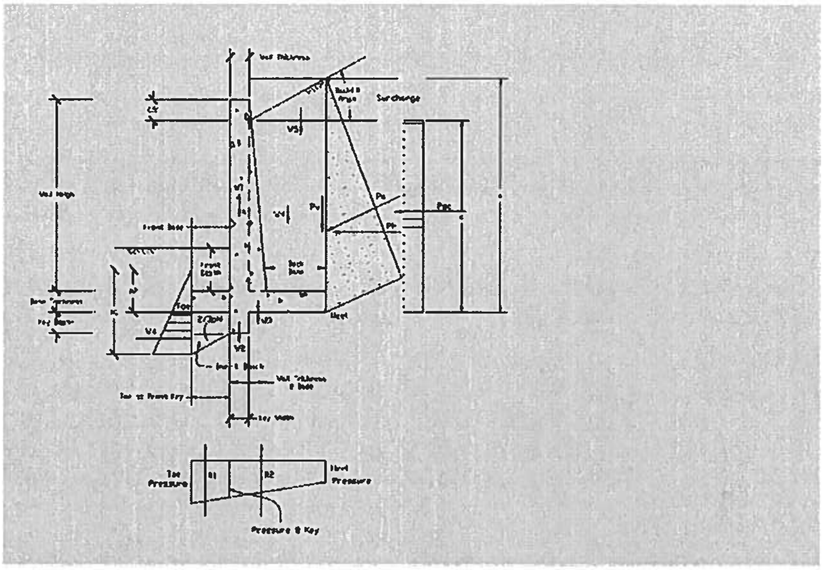
Service Mu =	3.76	k.ft	
f_{ss} =	24.41	ksi	
d_c =	2.31	in	
β_s =	1.33		
S <=	16.93	in	GOOD

SUMMARY OF CONCRETE DESIGN

	BAR DIA. (IN)	SPACING (IN)	COVER (IN)
FOOTING TOP MAT	0.75	15	2
FOOTING BOTTOM MAT	0.625	15	3
STEM	0.625	15	2

7

LRFD DESIGN FOR CIP RETAINING WALL
AUTHOR: BUI, HOANG
Oct-12 DESIGN HEIGHT 8'



I. INPUT (ENGLISH)

Concrete Density (pcf)	150.00			
Soil Density (pcf)	125.00			
Backfill Slope β (by degree)	0.00			
Internal Friction Angle of Backfill Soil ϕ	34.00			
Internal Friction Angle of Soil at Foundation ϕ	30.00			
Friction Angle between Fill and Wall δ (*)	30.00	(*) Table 3.11.5.3-1		
Surcharge in Feet	2.00			
Water depth behind wall, from bottom base (ft)	4.0			
Top Wall to Backfill Depth (ft)	0.50			
Height from Top Base to Top Wall (ft)	8.50			
Top wall Thickness (ft)	0.83	H = TOP OF WALL TO BOTTOM OF BASE		
Wall Thickness @ Base (ft)	0.83	H/12 to H/10	0.79	0.95
Front Base Length (ft)	1.00	H/10 TO H/8	0.95	1.19
Back Base Length (ft)	4.75			
Base Thickness (ft)	1.00	H/12 to H/10		
Shear Key Depth (ft)	1.25			
Shear Key Width (ft)	0.67			
Distance from Toe to Key (ft)	0.00			
Front Soil Depth to Base (ft)	1.50			
Enter 1 for rock foundation, 0 for soil	0.00			
f'c (psi) = 4500 fy (psi)=	60000.00			
Utimate Foundation Bearing (ksf) =	5.30			
Bearing Resistance Factor (**)	0.55	(**) Table 10.5.5.2.2-1		
Sliding Resistance Factor (Concrete on Soil) (**)	0.80	(**) Table 10.5.5.2.2-1		
Sliding Resistance Factor (Soil on Soil) (**)	0.90	(**) Table 10.5.5.2.2-1		

Table 10.5.5.2.2-1 Resistance Factors for Geotechnical Resistance of Shallow Foundations at Strength Limit State

Method / Soil / Condition			Resistance Factor
Bearing Resistance	ϕ_b	Theoretical Method (Munfakh et al., 2001), in clay	0.50
		Theoretical Method (Munfakh et al., 2001), in sand, using CPT	0.50
		Theoretical Method (Munfakh et al., 2001), in sand, using SPT	0.45
		Semi-empirical methods (Meyerhof, 1957), all soils	0.45
		Footing on rock	0.45
		Plate Load Test	0.55
Sliding	ϕ_τ	Precast concrete placed on sand	0.90
		Cast-in Place Concrete on sand	0.80
		Cast-in-Place or precast Concrete on clay	0.85
		Soil on soil	0.90
	ϕ_{ep}	Passive earth pressure component of sliding resistance	0.50

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LOAD FACTORS

Load Combination	γ_{DC}	γ_{EV}	γ_{LS}	γ_{EH}	Application
Strength I (Min)	0.90	1.00	1.75	1.5	Sliding & overturning
Strength I (Max)	1.25	1.35	1.75	1.5	Bearing & wall strength
Service I	1.00	1.00	1.00	1.00	Wall crack control

II. OUTPUT

Enter 1 for using Rankine horizontal back fill, otherwise enter 0		0		
Angle of B.F. of Wall to Horizontal (degree)		90.00	Not Submergence	Submergence
Active Fluid Weight (Coefficient and pcf), (Ka)		0.28	35.34	17.70
Passive Fluid Weight (Coefficient and pcf)		3.54	442.14	221.42

h1 = 3.75 a = 9.00 H = 9.50

h2 = 2.50 b = 9.00 0.4H = 3.80

Base Width (ft) = 6.58 0.4H to 0.6H 0.6H = 5.70

Adjust Fluid Weight 1 Trial to match provided (Ka) from Geology Unit

Unactored Horizontal Loads

Loads	Force (K)	Mo. Arm	Moment
Ph1 =	0.44	5.67	2.50
Ph2 =	0.71	2.00	1.41
Ph3 =	0.14	1.33	0.19
Ph,water =	0.50	1.33	0.67
Ph,sc =	0.64	4.50	2.86
	2.43		7.63

Unfactored Vertical Loads

Loads	Force (K)	Mo. Arm	Moment
W1 =	1.06	1.42	1.51
W2 =	0.13	0.34	0.04
W3 =	0.99	3.29	3.25
W4 =	4.75	4.21	19.99
W5 =	0.00	5.00	0.00
Pv1 =	0.00	6.58	0.00
Pv2 =	0.48	6.58	3.14
Pv3 =	0.08	6.58	0.54
	7.48		28.46

Unfactored Sliding Resistance from Shear Key (Horizontal)

Loads	Force (K)
P_p =	1.11

Factored Loads and Moments

Load Combination	vertical Loads V (K)	Moment M_V (K.Ft)	Horiz. Loads V (K)	Moment M_H (K.Ft)
Strength I (Min)	7.55	29.82	3.80	12.17
Strength I (Max)	9.97	38.50	3.80	12.17
Service I	7.48	28.46	2.43	7.63

III. CHECK OVER TURNING

1. CHECK OVERTURNING FOR FOUNDATION RESTS ON SOIL: YES

E_{max} = 1.65 ft.

x_r = 2.34 ft. (LOCATION OF RESULTANT FROM THE TOE)

Actual e = 0.95 ft. GOOD

2. CHECK OVERTURNING FOR FOUNDATION RESTS ON ROCK: NO

E_{max} = N/A ft.

x_r = N/A ft. (LOCATION OF RESULTANT FROM THE TOE)

Actual e = N/A ft.

IV. CHECK BEARING

Actual e = 0.65 ft.

Bearing Resistance = 2.915 ksf

1. CHECK BEARING FOR FOUNDATION RESTS ON SOIL: YES

Vertical Sress (Uniform) = 1.89 ksf GOOD

2. CHECK BEARING FOR FOUNDATION RESTS ON ROCK: NO

Vert. Sress (max.) = N/A ksf

Vert. Sress (min.) = N/A ksf

V. CHECK SLIDING

Friction Resistance = 4.36 k

Factored Sliding Force = 3.80 k

Sliding Resistance = 4.04 k GOOD

VI. ULTIMATE LOADS

Unactored Horizontal Loads on Stem

Loads	Force (K)	Mo. Arm	Moment
Ph1 =	0.44	4.67	2.06
Ph2 =	0.42	1.50	0.64
Ph3 =	0.08	1.00	0.08
Ph,water =	0.28	1.00	0.28
Ph,sc =	0.57	4.00	2.26
	1.79		5.32

Unfactored Vertical Loads behind Stem

Loads	Force (K)	Mo. Arm	Moment
W3 =	0.71	2.38	1.69
W4 =	4.75	2.38	11.28
W5 =	0.00	3.17	0.00
Pv1 =	0.00	4.75	0.00
Pv2 =	0.29	4.75	1.36
Pv3 =	0.05	4.75	0.22
	5.79		14.55

Ultimate Loads

Load Combination	Strength I (Max)		Service I	
	V (K)	M (K.Ft)	V (K)	M (K.Ft)
Toe	1.89	0.94	N/A	N/A
Heel	7.80	19.71	N/A	N/A
Stem	2.83	8.55	1.79	5.32

For conservative the ultimate shear at toe is calculated at front face of wall.

VII. DESIGN FOOTING FOR SHEARS

$Clr_{Top\ Footing}$ =	2	in	$Spacing_{Top}$ =	11	in
$Clr_{Bottom\ Footing}$ =	3	in	$Spacing_{Bottom}$ =	11	in
Top bar Diameter =	0.75	in	β =	2	
Bottom bar Diameter =	0.625	in	ϕ_{shear} =	0.9	

1. HEEL

$d_{s\ Heel}$ =	9.625	in	$A_{s\ Top}$ =	0.48	in^2
a_{Heel} =	0.63	in			
$d_{v\ Heel}$ =	9.31	in			
$V_{R\ Heel}$ =	13.48	k	>	7.80	k GOOD

2. TOE

$d_{s\ Toe}$ =	8.6875	in	$A_{s\ Bottom}$ =	0.33	in^2
a_{Toe} =	0.44	in			
$d_{v\ Toe}$ =	8.64	in			
$V_{R\ Toe}$ =	12.51	k	>	1.89	k GOOD

VIII. DESIGN FOOTING FOR BENDINGS

Use sheet 2 (Heel Bending) for the heel bending design — OK

Use sheet 3 (Toe Bending) for the Toe bending design — OK

IX. DESIGN STEM FOR SHEAR

$Clr_{Back\ Stem}$ =	2	in			
Bar Diameter at Stem =	0.625	in	S_x =	7.47	in
Spacing =	11	in	$A_{s\ Stem}$ =	0.33	in^2
$d_{s\ Stem}$ =	7.69	in	ε_s =	0.00170606	
a_{Stem} =	0.44	in	S_{xe} =	12	in
$d_{v\ Stem}$ =	7.47	in	β =	2.11	
$V_{R\ Stem}$ =	11.39	k	>	2.83	k GOOD

X. DESIGN STEM FOR BENDING

Use sheet 4 (Stem Bending) for the stem bending design — OK

Check control of cracking by distribution of reinforcement (5.7.3.4)

Service Mu =	5.32	k.ft
f_{ss} =	25.54	ksi
d_c =	2.31	in
β_s =	1.33	
S <=	15.98	in

GOOD

SUMMARY OF CONCRETE DESIGN

	BAR DIA. (IN)	SPACING (IN)	COVER (IN)
FOOTING TOP MAT	0.75	11	2
FOOTING BOTTOM MAT	0.625	11	3
STEM	0.625	11	2

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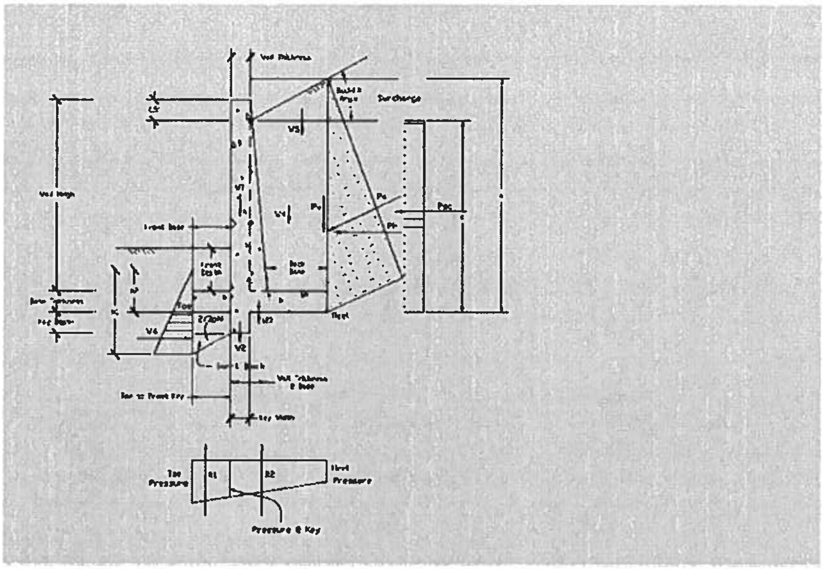
LRFD DESIGN FOR CIP RETAINING WALL
AUTHOR: BUI, HOANG
Oct-12 DESIGN HEIGHT 9'



I. INPUT (ENGLISH)

Concrete Density (pcf)	150.00	
Soil Density (pcf)	125.00	
Backfill Slope β (by degree)	0.00	
Internal Friction Angle of Backfill Soil ϕ	34.00	
Internal Friction Angle of Soil at Foundation ϕ	30.00	
Friction Angle between Fill and Wall δ (*)	30.00	(*) Table 3.11.5.3-1
Surcharge in Feet	2.00	
Water depth behind wall, from bottom base (ft)	4.5	
Top Wall to Backfill Depth (ft)	0.50	
Height from Top Base to Top Wall (ft)	9.50	
Top wall Thickness (ft)	0.83	H = TOP OF WALL TO BOTTOM OF BASE
Wall Thickness @ Base (ft)	0.83	H/12 to H/10 0.88 1.05
Front Base Length (ft)	1.00	H/10 TO H/8 1.05 1.31
Back Base Length (ft)	5.50	
Base Thickness (ft)	1.00	H/12 to H/10
Shear Key Depth (ft)	1.25	
Shear Key Width (ft)	0.67	
Distance from Toe to Key (ft)	0.00	
Front Soil Depth to Base (ft)	1.50	
Enter 1 for rock foundation, 0 for soil	0.00	
f'c (psi) = 4500 fy (psi)=	60000.00	
Ulimate Foundation Bearing (ksf) =	7.18	
Bearing Resistance Factor (**)	0.55	(**) Table 10.5.5.2.2-1
Sliding Resistance Factor (Concrete on Soil) (**)	0.80	(**) Table 10.5.5.2.2-1
Sliding Resistance Factor (Soil on Soil) (**)	0.90	(**) Table 10.5.5.2.2-1

Table 10.5.5.2.2-1 Resistance Factors for Geotechnical Resistance of Shallow Foundations at Strength Limit State

Method / Soil / Condition			Resistance Factor
Bearing Resistance	ϕ_b	Theoretical Method (Munfakh et al., 2001), in clay	0.50
		Theoretical Method (Munfakh et al., 2001), in sand, using CPT	0.50
		Theoretical Method (Munfakh et al., 2001), in sand, using SPT	0.45
		Semi-empirical methods (Meyerhof, 1957), all soils	0.45
		Footing on rock	0.45
		Plate Load Test	0.55
Sliding	ϕ_τ	Precast concrete placed on sand	0.90
		Cast-in Place Concrete on sand	0.80
		Cast-in-Place or precast Concrete on clay	0.85
		Soil on soil	0.90
	ϕ_{ep}	Passive earth pressure component of sliding resistance	0.50

LOAD FACTORS

Load Combination	γ_{DC}	γ_{EV}	γ_{LS}	γ_{EH}	Application
Strength I (Min)	0.90	1.00	1.75	1.5	Sliding & overturning
Strength I (Max)	1.25	1.35	1.75	1.5	Bearing & wall strength
Service I	1.00	1.00	1.00	1.00	Wall crack control

II. OUTPUT

Enter 1 for using Rankine horizontal back fill, otherwise enter 0		0			
Angle of B.F. of Wall to Horizontal (degree)		90.00	Not Submergence	Submergence	
Active Fluid Weight (Coefficient and pcf), (Ka)		0.28	35.34	17.70	
Passive Fluid Weight (Coefficient and pcf)		3.54	442.14	221.42	
h1 = 3.75	a =	10.00			H = 10.50
h2 = 2.50	b =	10.00			0.4H = 4.20
	Base Width (ft) =	7.33	0.4H to 0.6H		0.6H = 6.30
			Adjust Fluid Weight	1	Trial to match provided (Ka) from Geology Unit

Unactored Horizontal Loads

Loads	Force (K)	Mo. Arm	Moment
Ph1 =	0.53	6.33	3.39
Ph2 =	0.87	2.25	1.97
Ph3 =	0.18	1.50	0.27
Ph,water =	0.63	1.50	0.95
Ph,sc =	0.71	5.00	3.53
	2.93		10.10

Unfactored Vertical Loads

Loads	Force (K)	Mo. Arm	Moment
W1 =	1.19	1.42	1.68
W2 =	0.13	0.34	0.04
W3 =	1.10	3.67	4.03
W4 =	6.19	4.58	28.36
W5 =	0.00	5.50	0.00
Pv1 =	0.00	7.33	0.00
Pv2 =	0.59	7.33	4.33
Pv3 =	0.10	7.33	0.76
	9.29		39.20

Unfactored Sliding Resistance from Shear Key (Horizontal)

Loads	Force (K)
P_p =	1.11

Factored Loads and Moments

Load Combination	vertical Loads V (K)	Moment M_V (K.Ft)	Horiz. Loads V (K)	Moment M_H (K.Ft)
Strength I (Min)	9.40	41.17	4.57	16.04
Strength I (Max)	12.41	53.11	4.57	16.04
Service I	9.29	39.20	2.93	10.10

III. CHECK OVER TURNING

1. CHECK OVERTURNING FOR FOUNDATION RESTS ON SOIL: YES

E_{max} = 1.83 ft.

x_r = 2.67 ft. (LOCATION OF RESULTANT FROM THE TOE)

Actual e = 0.99 ft. GOOD

2. CHECK OVERTURNING FOR FOUNDATION RESTS ON ROCK: NO

E_{max} = N/A ft.

x_r = N/A ft. (LOCATION OF RESULTANT FROM THE TOE)

Actual e = N/A ft.

IV. CHECK BEARING

Actual e = 0.68 ft.

Bearing Resistance = 3.949 ksf

1. CHECK BEARING FOR FOUNDATION RESTS ON SOIL: YES

Vertical Sress (Uniform) = 2.08 ksf GOOD

2. CHECK BEARING FOR FOUNDATION RESTS ON ROCK: NO

Vert. Sress (max.) = N/A ksf

Vert. Sress (min.) = N/A ksf

V. CHECK SLIDING

Friction Resistance = 5.43 k

Factored Sliding Force = 4.57 k

Sliding Resistance = 4.90 k GOOD

VI. ULTIMATE LOADS

Unactored Horizontal Loads on Stem

Loads	Force (K)	Mo. Arm	Moment
Ph1 =	0.53	5.33	2.85
Ph2 =	0.56	1.75	0.97
Ph3 =	0.11	1.17	0.13
Ph,water =	0.38	1.17	0.45
Ph,sc =	0.64	4.50	2.86
	2.22		7.26

Unfactored Vertical Loads behind Stem

Loads	Force (K)	Mo. Arm	Moment
W3 =	0.83	2.75	2.27
W4 =	6.19	2.75	17.02
W5 =	0.00	3.67	0.00
Pv1 =	0.00	5.50	0.00
Pv2 =	0.38	5.50	2.06
Pv3 =	0.06	5.50	0.34
	7.45		21.69

Ultimate Loads

Load Combination	Strength I (Max)		Service I	
	V (K)	M (K.Ft)	V (K)	M (K.Ft)
Toe	2.08	1.04	N/A	N/A
Heel	10.04	29.42	N/A	N/A
Stem	3.49	11.61	2.22	7.26

For conservative the ultimate shear at toe is calculated at front face of wall.

VII. DESIGN FOOTING FOR SHEARS

$Clr_{Top\ Footing}$ =	2	in	$Spacing_{Top}$ =	9	in	
$Clr_{Bottom\ Footing}$ =	3	in	$Spacing_{Bottom}$ =	9	in	
Top bar Diameter =	0.875	in	β =	2		
Bottom bar Diameter =	0.75	in	ϕ_{shear} =	0.9		

1. HEEL

$d_{s\ Heel}$ =	9.5625	in	$A_{s\ Top}$ =	0.80	in^2	
a_{Heel} =	1.05	in				
$d_{v\ Heel}$ =	9.04	in				
$V_{R\ Heel}$ =	13.09	k	>	10.04	k	GOOD

2. TOE

$d_{s\ Toe}$ =	8.625	in	$A_{s\ Bottom}$ =	0.59	in^2	
a_{Toe} =	0.77	in				
$d_{v\ Toe}$ =	8.64	in				
$V_{R\ Toe}$ =	12.51	k	>	2.08	k	GOOD

VIII. DESIGN FOOTING FOR BENDINGS

Use sheet 2 (Heel Bending) for the heel bending design — OK

Use sheet 3 (Toe Bending) for the Toe bending design — OK

IX. DESIGN STEM FOR SHEAR

$Clr_{Back\ Stem}$ =	2	in				
Bar Diameter at Stem =	0.75	in	S_x =	7.24	in	
Spacing =	9	in	$A_{s\ Stem}$ =	0.59	in^2	
$d_{s\ Stem}$ =	7.62	in	ε_s =	0.00133012		
a_{Stem} =	0.77	in	S_{xe} =	12	in	
$d_{v\ Stem}$ =	7.24	in	β =	2.40		
$V_{R\ Stem}$ =	12.59	k	>	3.49	k	GOOD

X. DESIGN STEM FOR BENDING

Use sheet 4 (Stem Bending) for the stem bending design — OK

Check control of cracking by distribution of reinforcement (5.7.3.4)

Service Mu =	7.26	k.ft
f_{ss} =	20.43	ksi
d_c =	2.38	in
β_s =	1.34	
S <=	20.84	in

GOOD

SUMMARY OF CONCRETE DESIGN

	BAR DIA. (IN)	SPACING (IN)	COVER (IN)
FOOTING TOP MAT	0.875	9	2
FOOTING BOTTOM MAT	0.75	9	3
STEM	0.75	9	2

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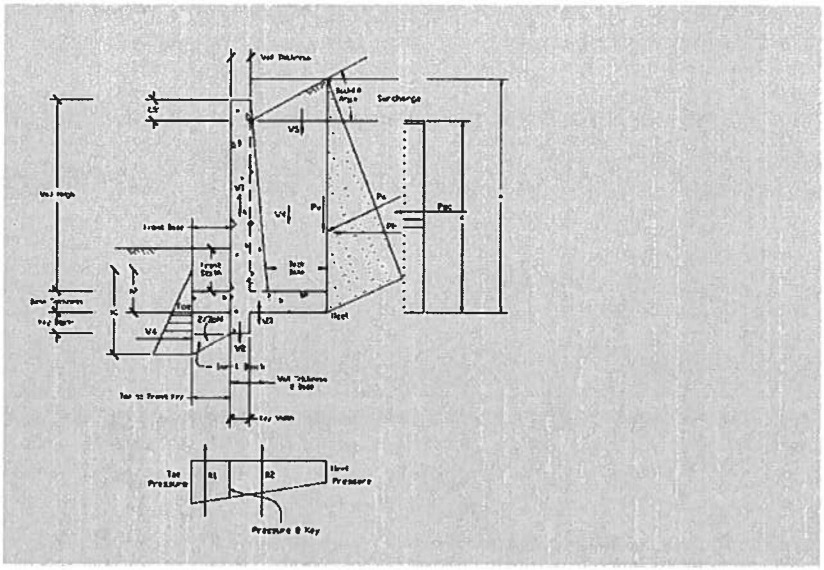
LRFD DESIGN FOR CIP RETAINING WALL
AUTHOR: BUI, HOANG
Oct-12 DESIGN HEIGHT 10'



I. INPUT (ENGLISH)

Concrete Density (pcf)	150.00	
Soil Density (pcf)	125.00	
Backfill Slope β (by degree)	0.00	
Internal Friction Angle of Backfill Soil ϕ	34.00	
Internal Friction Angle of Soil at Foundation ϕ	30.00	
Friction Angle between Fill and Wall δ (*)	30.00	(*) Table 3.11.5.3-1
Surcharge in Feet	2.00	
Water depth behind wall, from bottom base (ft)	5.0	
Top Wall to Backfill Depth (ft)	0.50	
Height from Top Base to Top Wall (ft)	10.50	
Top wall Thickness (ft)	0.83	H = TOP OF WALL TO BOTTOM OF BASE
Wall Thickness @ Base (ft)	0.83	H/12 to H/10 0.96 1.15
Front Base Length (ft)	1.00	H/10 TO H/8 1.15 1.44
Back Base Length (ft)	6.00	
Base Thickness (ft)	1.00	H/12 to H/10
Shear Key Depth (ft)	1.25	
Shear Key Width (ft)	0.67	
Distance from Toe to Key (ft)	0.00	
Front Soil Depth to Base (ft)	1.50	
Enter 1 for rock foundation, 0 for soil	0.00	
f'c (psi) = 4500 fy (psi)=	60000.00	
Utimate Foundation Bearing (ksf) =	7.18	
Bearing Resistance Factor (**)	0.55	(**) Table 10.5.5.2.2-1
Sliding Resistance Factor (Concrete on Soil) (**)	0.80	(**) Table 10.5.5.2.2-1
Sliding Resistance Factor (Soil on Soil) (**)	0.90	(**) Table 10.5.5.2.2-1

Table 10.5.5.2.2-1 Resistance Factors for Geotechnical Resistance of Shallow Foundations at Strength Limit State

Method / Soil / Condition			Resistance Factor
Bearing Resistance	ϕ_b	Theoretical Method (Munfakh et al., 2001), in clay	0.50
		Theoretical Method (Munfakh et al., 2001), in sand, using CPT	0.50
		Theoretical Method (Munfakh et al., 2001), in sand, using SPT	0.45
		Semi-empirical methods (Meyerhof, 1957), all soils	0.45
		Footing on rock	0.45
		Plate Load Test	0.55
Sliding	ϕ_τ	Precast concrete placed on sand	0.90
		Cast-in Place Concrete on sand	0.80
		Cast-in-Place or precast Concrete on clay	0.85
		Soil on soil	0.90
	ϕ_{ep}	Passive earth pressure component of sliding resistance	0.50

LOAD FACTORS

Load Combination	γ_{DC}	γ_{EV}	γ_{LS}	γ_{EH}	Application
Strength I (Min)	0.90	1.00	1.75	1.5	Sliding & overturning
Strength I (Max)	1.25	1.35	1.75	1.5	Bearing & wall strength
Service I	1.00	1.00	1.00	1.00	Wall crack control

II. OUTPUT

Enter 1 for using Rankine horizontal back fill, otherwise enter 0		0		
Angle of B.F. of Wall to Horizontal (degree)		90.00	Not Submergence	Submergence
Active Fluid Weight (Coefficient and pcf), (Ka)		0.28	35.34	17.70
Passive Fluid Weight (Coefficient and pcf)		3.54	442.14	221.42

h1 = 3.75 a = 11.00 H = 11.50

h2 = 2.50 b = 11.00 0.4H = 4.60

Base Width (ft) = 7.83 0.4H to 0.6H 0.6H = 6.90

Adjust Fluid Weight 1 Trial to match provided (Ka) from Geology Unit

Unactored Horizontal Loads

Loads	Force (K)	Mo. Arm	Moment
Ph1 =	0.64	7.00	4.45
Ph2 =	1.06	2.50	2.65
Ph3 =	0.22	1.67	0.37
Ph,water =	0.78	1.67	1.30
Ph,sc =	0.78	5.50	4.28
	3.47		13.05

Unfactored Vertical Loads

Loads	Force (K)	Mo. Arm	Moment
W1 =	1.31	1.42	1.86
W2 =	0.13	0.34	0.04
W3 =	1.17	3.92	4.60
W4 =	7.50	4.83	36.25
W5 =	0.00	5.83	0.00
Pv1 =	0.00	7.83	0.00
Pv2 =	0.72	7.83	5.60
Pv3 =	0.13	7.83	1.00
	10.96		49.36

Unfactored Sliding Resistance from Shear Key (Horizontal)

Loads	Force (K)
P_p =	1.11

Factored Loads and Moments

Load Combination	vertical Loads V (K)	Moment M_V (K.Ft)	Horiz. Loads V (K)	Moment M_H (K.Ft)
Strength I (Min)	11.12	52.01	5.41	20.64
Strength I (Max)	14.66	66.97	5.41	20.64
Service I	10.96	49.36	3.47	13.05

III. CHECK OVER TURNING

1. CHECK OVERTURNING FOR FOUNDATION RESTS ON SOIL: YES

E_{max} = 1.96 ft.

x_r = 2.82 ft. (LOCATION OF RESULTANT FROM THE TOE)

Actual e = 1.10 ft. GOOD

2. CHECK OVERTURNING FOR FOUNDATION RESTS ON ROCK: NO

E_{max} = N/A ft.

x_r = N/A ft. (LOCATION OF RESULTANT FROM THE TOE)

Actual e = N/A ft.

IV. CHECK BEARING

Actual e = 0.76 ft.

Bearing Resistance = 3.949 ksf

1. CHECK BEARING FOR FOUNDATION RESTS ON SOIL: YES

Vertical Sress (Uniform) = 2.32 ksf GOOD

2. CHECK BEARING FOR FOUNDATION RESTS ON ROCK: NO

Vert. Sress (max.) = N/A ksf

Vert. Sress (min.) = N/A ksf

V. CHECK SLIDING

Friction Resistance = 6.42 k

Factored Sliding Force = 5.41 k

Sliding Resistance = 5.69 k GOOD

VI. ULTIMATE LOADS

Unactored Horizontal Loads on Stem

Loads	Force (K)	Mo. Arm	Moment
Ph1 =	0.64	6.00	3.82
Ph2 =	0.71	2.00	1.41
Ph3 =	0.14	1.33	0.19
Ph,water =	0.50	1.33	0.67
Ph,sc =	0.71	5.00	3.53
	2.69		9.62

Unfactored Vertical Loads behind Stem

Loads	Force (K)	Mo. Arm	Moment
W3 =	0.90	3.00	2.70
W4 =	7.50	3.00	22.50
W5 =	0.00	4.00	0.00
Pv1 =	0.00	6.00	0.00
Pv2 =	0.48	6.00	2.86
Pv3 =	0.08	6.00	0.49
	8.96		28.55

Ultimate Loads

Load Combination	Strength I (Max)		Service I	
	V (K)	M (K.Ft)	V (K)	M (K.Ft)
Toe	2.32	1.16	N/A	N/A
Heel	12.09	38.78	N/A	N/A
Stem	4.21	15.31	2.69	9.62

For conservative the ultimate shear at toe is calculated at front face of wall.

VII. DESIGN FOOTING FOR SHEARS

$Clr_{Top\ Footing}$ =	2	in	$Spacing_{Top}$ =	7	in	
$Clr_{Bottom\ Footing}$ =	3	in	$Spacing_{Bottom}$ =	7	in	
Top bar Diameter =	0.875	in	β =	2		
Bottom bar Diameter =	0.75	in	ϕ_{shear} =	0.9		

1. HEEL

$d_{s\ Heel}$ =	9.5625	in	$A_{s\ Top}$ =	1.03	in^2	
a_{Heel} =	1.35	in				
$d_{v\ Heel}$ =	8.89	in				
$V_{R\ Heel}$ =	12.87	k	>	12.09	k	GOOD

2. TOE

$d_{s\ Toe}$ =	8.625	in	$A_{s\ Bottom}$ =	0.76	in^2	
a_{Toe} =	0.99	in				
$d_{v\ Toe}$ =	8.64	in				
$V_{R\ Toe}$ =	12.51	k	>	2.32	k	GOOD

VIII. DESIGN FOOTING FOR BENDINGS

Use sheet 2 (Heel Bending) for the heel bending design — OK

Use sheet 3 (Toe Bending) for the Toe bending design — OK

IX. DESIGN STEM FOR SHEAR

$Clr_{Back\ Stem}$ =	2	in				
Bar Diameter at Stem =	0.75	in	S_x =	7.20	in	
Spacing =	7	in	$A_{s\ Stem}$ =	0.76	in^2	
$d_{s\ Stem}$ =	7.62	in	ε_s =	0.001353736		
a_{Stem} =	0.99	in	S_{xe} =	12	in	
$d_{v\ Stem}$ =	7.20	in	β =	2.38		
$V_{R\ Stem}$ =	12.41	k	>	4.21	k	GOOD

X. DESIGN STEM FOR BENDING

Use sheet 4 (Stem Bending) for the stem bending design — OK

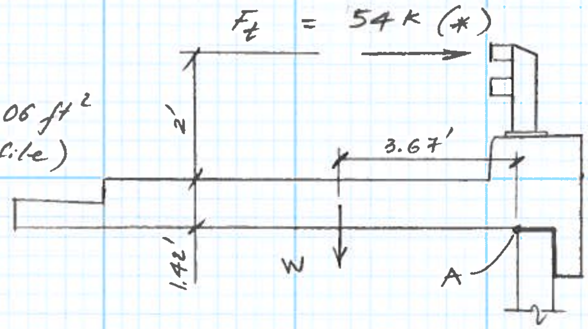
Check control of cracking by distribution of reinforcement (5.7.3.4)

Service Mu =	9.62	k.ft	
f_{ss} =	21.17	ksi	
d_c =	2.38	in	
β_s =	1.34		
S <=	19.94	in	GOOD

SUMMARY OF CONCRETE DESIGN

	BAR DIA. (IN)	SPACING (IN)	COVER (IN)
FOOTING TOP MAT	0.875	7	2
FOOTING BOTTOM MAT	0.75	7	3
STEM	0.75	7	2

10



Cross Section Area = $17.06\ ft^2$
(Measured from Cad file)

(*) : for TL 3 or TL 4

$W = (17.06)(0.15) = 2.56$ k per ft

1) Sliding of the traffic Railing - Moment Slab

$\phi R_n \geq \gamma_{CT} F_{ts}$

$\phi = 0.8$ (Table 10.5.5-1)

$\gamma_{CT} = 1.0$ (Extreme event for CT load)

$R_n = \gamma_{DC} W \tan \phi_s$, $\phi_s = 34°$, $\gamma_{DC} = 0.9$ for DL

The soil - Moment slab interface is smooth ⇒ use $0.8 \tan \phi_s$

$R_n = (0.9)(2.56)(0.8) \tan 34° = 1.24$ k per ft

Assume the moment slab has a rigid body behavior = 60 ft upper limit

$0.8\,(1.24)(60) = 59.68\ k > (1.0)(54) = 54\ k$ Say OK

COLORADO DEPARTMENT OF TRANSPORTATION

DESIGN COMPUTATIONS (Grid)

2) Overturning of the traffic Railing - Moment Slab

$\phi M_n \geq \gamma_{CT} F_t H$

$\phi = 0.9$

$\gamma_{CT} = 1.0$, $\gamma_{DC} = 0.9$

$F_t = 54\,K$

$H = 2 + 1.42 = 3.42'$, $L = 3.67'$

$M_n = \gamma_{DC} W L (60) = 0.9(2.56)(3.67)(60) = 507.3\ k.ft$

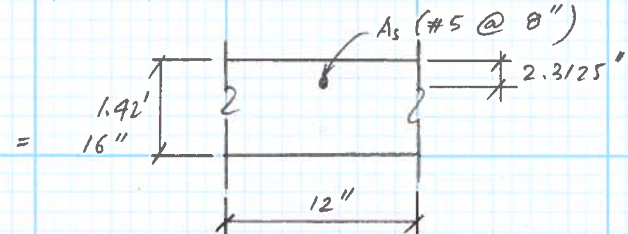
$\phi M_n = 0.9(507.3) = 456.6\ k.ft > (1.0)(54)(3.42) = 184.7\ k.ft$ OK

3) Reinforcing design:

Distribution Length = 16 ft

$M_u = \frac{184.7}{16} = 11.54\ k.ft$ per ft. $< M_R = 28.01\ k.ft$ per ft

OK



By: HB Date 07/13	Project no. FBR 0142-055	Project code (SA#): 18085	
Chk'd: CT Date 08/13	Structure no. Wall B-16-G	Sheet 26 of 61	

Ultimate Moment Using Strain Compatibility

Project Number: FBR 0142-055

Moment Slab Moment Capacity

Hoang Bui, 08/01/2013

Concrete		Depth (Fr. Top)	Width
		16.00	12.00
		0.00	0.00
		0.00	0.00
		0.00	0.00
		0.00	0.00
		0.00	0.00
Mill Reinforcing		Depth (Fr. Top)	Area
		13.69	0.47
		0.00	0.00
		0.00	0.00
		0.00	0.00
		0.00	0.00
		0.00	0.00
		0.00	0.00
		0.00	0.00
		0.00	0.00
Pre-tension Steel		Depth (Fr. Top)	Area
	T1	0.00	0.00
	T2	0.00	0.00
	T3	0.00	0.00
Material Properties			
	Percent of Jacking =	75	%
	Final Losses =	20	%
	E_{ps} =	28500	ksi
	fy (Prestressed Steel) =	270	ksi
	E_s =	29000	ksi
	fy (Mill Steel) =	60	ksi
	f'c =	4.5	ksi

27/61

ULTIMATE MOMENT CAPACITY

Pj (T1)= 0.00 (Jacking Force after Losses)

Pj (T2)= 0.00 (Jacking Force after Losses)

Pj (T3)= 0.00 (Jacking Force after Losses)

Trial distance from the top to the N.A. (in) = 0.74

a = 0.61

Concrete	Depth (Fr. Top)	Width	Block Thickness	Arm (fr. N.A.)	Block Area	Arm x Area
	16.00	12.00	0.61	0.43	7.29	3.16
	0.00	0.00	-16.00	-7.26	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
					7.29	3.16

Centroid of Compression Block (From Top) = 0.304

	Depth (Fr. Top)	Area	Yi (fr. N.A.)	Strain (Tension)	Strain (Comp.)	* Stress (Ten.)	Stress (Comp.)	Tension (Ti)	(1) Ti x Yi	Comp. (Ci)	(1) Ci x Yi	Ti x di	(2) Ti x Arm	(2) Ci x Arm	(2) Ti x Arm x Phi	(2) Ci x Arm x Phi
Mill Reinforcing	13.69	0.47	12.95	0.05273	0.00000	60.00	0.00	27.90	361.33	0.00	0.00	381.88	373.40	0.00	336.06	0.00
	0.00	0.00	0.74	0.00000	0.00300	0.00	60.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.74	0.00000	0.00300	0.00	60.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.74	0.00000	0.00300	0.00	60.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.74	0.00000	0.00300	0.00	60.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.74	0.00000	0.00300	0.00	60.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.74	0.00000	0.00300	0.00	60.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.74	0.00000	0.00300	0.00	60.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.74	0.00000	0.00300	0.00	60.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pre-tension T1	0.00	0.00	0.74	0.00000	0.00300	0.00	85.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pre-tension T2	0.00	0.00	0.74	0.00000	0.00300	0.00	85.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pre-tension T3	0.00	0.00	0.74	0.00000	0.00300	0.00	85.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
								27.90	361.33	0.00	0.00	381.88	373.40	0.00	336.06	0.00

Press to solve for Mn 0.000000000

d_t = 13.69

Resistance Factor for Mill Steel = 0.90 TENSION CONTROLLED

Resistance Factor for Prestressed Steel = 1.00 TENSION CONTROLLED

Mn = 31.12 K.ft

Mr = 28.01 K.ft

C/d_t = 0.05 OK

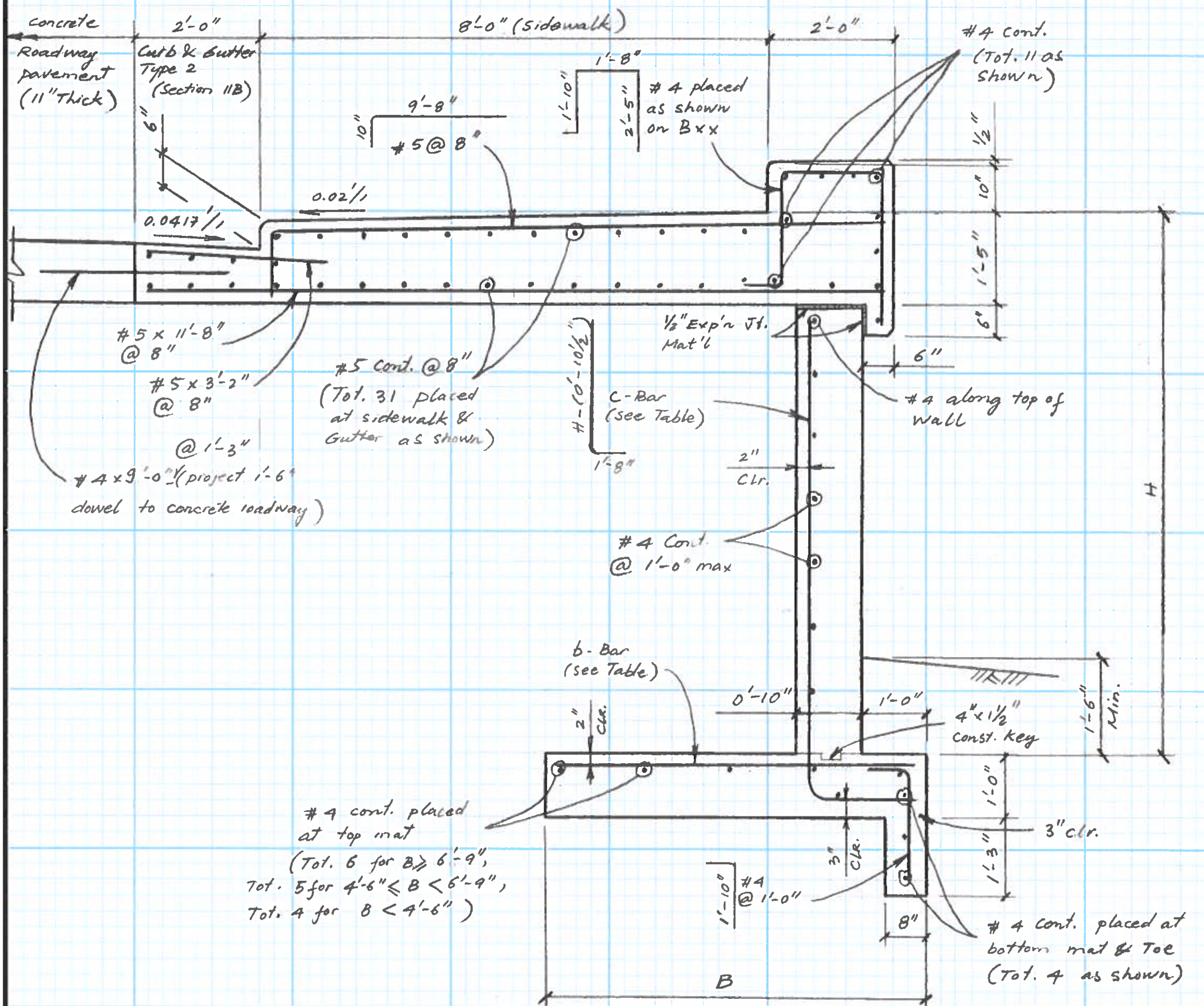
* Not exceed the yield point stress in the tension prestressing steel by Collins & Mitchell equation (Prestressed Concrete Structures, eq. 3-26)

(1) Moment about N.A.

(2) Moment about Centroid of Compession Bock(s)

COLORADO DEPARTMENT OF TRANSPORTATION

DESIGN COMPUTATIONS (Grid)



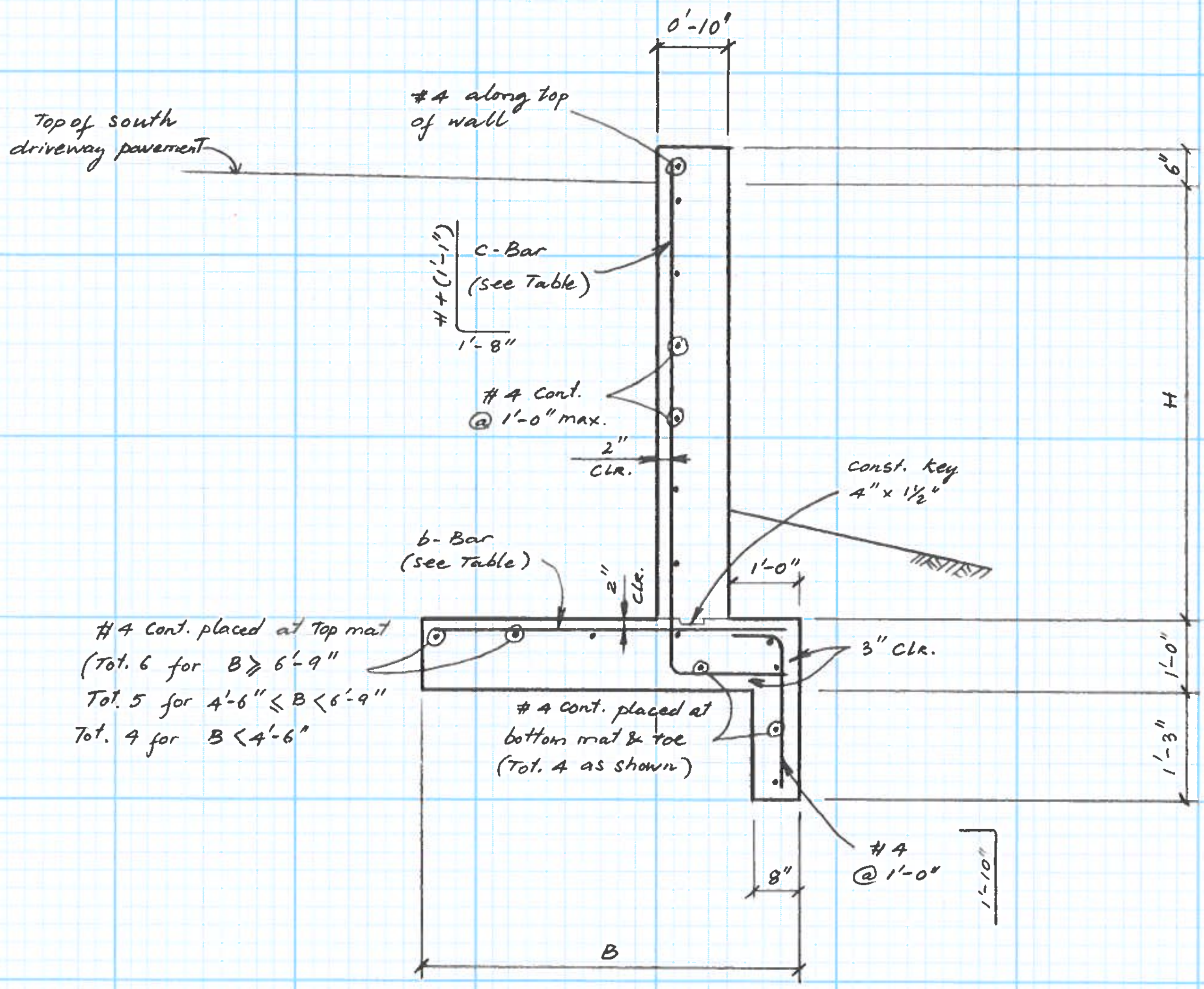
TYPICAL SECTION WITH MOMENT SLAB

(Bridge Rail & pedestrian Rail not shown for Clarity)

H	B	c - Bar	b - Bar
H < 3'	3'-6"	#4 @ 1'-6"	#4 x 3'-2" @ 1'-6"
3' ≤ H < 4'	4'-0"	#4 @ 1'-6"	#4 x 3'-8" @ 1'-6"
4' ≤ H < 5'	4'-6"	#4 @ 1'-6"	#4 x 4'-2" @ 1'-6"
5' ≤ H < 6'	5'-3"	#5 @ 1'-3"	#5 x 4'-11" @ 1'-3"
6' ≤ H < 7'	6'-0"	#5 @ 1'-3"	#6 x 5'-8" @ 1'-3"
7' ≤ H < 8'	6'-9"	#5 @ 11"	#6 x 6'-5" @ 11"
8' ≤ H < 9'	7'-6"	#6 @ 9"	#7 x 7'-2" @ 9"
9' ≤ H ≤ 10'	8'-0"	#6 @ 7"	#7 x 7'-8" @ 7"

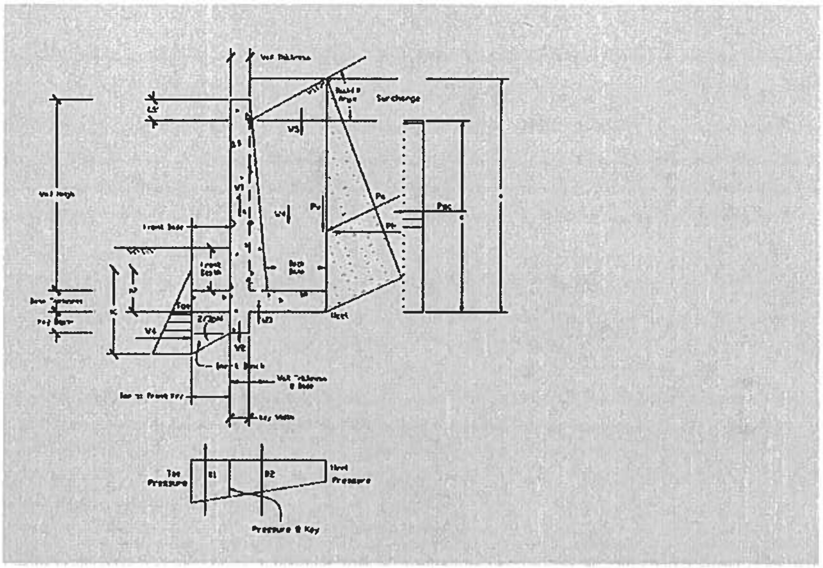
By: HB Date 7/13	Project no. FBR 0142-055	Project code (SA#): 18085
Chk'd: CT Date 8/13	Structure no. Wall B-16-G (SOUTH WALL)	Sheet 29 of 61

CDOT Form #1034 3/02



TYPICAL SECTION W/O MOMENT SLAB

LRFD DESIGN FOR CIP RETAINING WALL B-16-H (NORTH WALL)
AUTHOR: BUI, HOANG
Oct-12 DESIGN HEIGHT 3'



I. INPUT (ENGLISH)

Concrete Density (pcf)	150.00			
Soil Density (pcf)	125.00			
Backfill Slope β (by degree)	26.57			
Internal Friction Angle of Backfill Soil ϕ	34.00			
Internal Friction Angle Soil at Foundation ϕ	30.00			
Friction Angle between Fill and Wall δ (*)	30.00	(*) Table 3.11.5.3-1		
Surcharge in Feet	2.00			
Water depth behind wall, from bottom base (ft)	1.5			
Top Wall to Backfill Depth (ft)	0.50			
Height from Top Base to Top Wall (ft)	3.50			
Top wall Thickness (ft)	0.83	H = TOP OF WALL TO BOTTOM OF BASE		
Wall Thickness @ Base (ft)	0.83	H/12 to H/10	0.40	0.48
Front Base Length (ft)	1.00	H/10 TO H/8	0.4833	0.60
Back Base Length (ft)	2.00			
Base Thickness (ft)	1.33	H/12 to H/10		
Shear Key Depth (ft)	1.25			
Shear Key Width (ft)	0.67			
Distance from Toe to Key (ft)	0.00			
Front Soil Depth to Base (ft)	1.50			
Enter 1 for rock foundation, 0 for soil	0.00			
f'c (psi) = 4500 fy (psi)=	60000.00			
Utimate Foundation Bearing (ksf) =	4.60			
Bearing Resistance Factor (**)	0.55	(**) Table 10.5.5.2.2-1		
Sliding Resistance Factor (Concrete on Soil) (**)	0.80	(**) Table 10.5.5.2.2-1		
Sliding Resistance Factor (Soil on Soil) (**)	0.90	(**) Table 10.5.5.2.2-1		
Coefficient of Sliding Resistance (μ)	0.45			

Table 10.5.5.2.2-1 Resistance Factors for Geotechnical Resistance of Shallow Foundations at Strength Limit State

		Method / Soil / Condition	Resistance Factor
Bearing Resistance	ϕ_b	Theoretical Method (Munfakh et al., 2001), in clay	0.50
		Theoretical Method (Munfakh et al., 2001), in sand, using CPT	0.50
		Theoretical Method (Munfakh et al., 2001), in sand, using SPT	0.45
		Semi-empirical methods (Meyerhof, 1957), all soils	0.45
		Footing on rock	0.45
		Plate Load Test	0.55
Sliding	ϕ_τ	Precast concrete placed on sand	0.90
		Cast-in Place Concrete on sand	0.80
		Cast-in-Place or precast Concrete on clay	0.85
		Soil on soil	0.90
	ϕ_{ep}	Passive earth pressure component of sliding resistance	0.50

LOAD FACTORS

Load Combination	γ_{DC}	γ_{EV}	γ_{LS}	γ_{EH}	Application
Strength I (Min)	0.90	1.00	1.75	1.5	Sliding & overturning
Strength I (Max)	1.25	1.35	1.75	1.5	Bearing & wall strength
Service I	1.00	1.00	1.00	1.00	Wall crack control

II. OUTPUT

Enter 1 for using Rankine horizontal back fill, otherwise enter 0 — 1

		Not Submergence	Submergence
Angle of B.F. of Wall to Horizontal (degree)	90.00		
Active Fluid Weight (Coefficient and pcf), (Ka)	0.412	51.53	25.81
Passive Fluid Weight (Coefficient and pcf)	3.54	442.14	221.42

h1 = 4.08 a = 5.33 H = 4.83

h2 = 2.83 b = 4.33 0.4H = 1.93

Base Width (ft) = 3.83 0.4H to 0.6H 0.6H = 2.90

Adjust Fluid Weight 1 Trial to match provided (Ka) from Geology Unit

Unactored Horizontal Loads

Loads	Force (K)	Mo. Arm	Moment
Ph1 =	0.34	2.78	0.94
Ph2 =	0.26	0.75	0.20
Ph3 =	0.03	0.50	0.01
Ph,water =	0.07	0.50	0.04
Ph,sc =	0.45	2.17	0.97
	1.15		2.15

Unfactored Vertical Loads

Loads	Force (K)	Mo. Arm	Moment
W1 =	0.44	1.42	0.62
W2 =	0.13	0.34	0.04
W3 =	0.77	1.92	1.47
W4 =	0.75	2.83	2.12
W5 =	0.12	3.17	0.40
Pv1 =	0.17	3.83	0.65
Pv2 =	0.18	3.83	0.69
Pv3 =	0.01	3.83	0.06
	2.57		6.04

Unfactored Sliding Resistance from Shear Key (Horizontal)

Loads	Force (K)
P_p =	1.23

Factored Loads and Moments

Load Combination	vertical Loads V (K)	Moment M_V (K.Ft)	Horiz. Loads V (K)	Moment M_H (K.Ft)
Strength I (Min)	2.62	6.53	1.83	3.47
Strength I (Max)	3.39	8.15	1.83	3.47
Service I	2.57	6.04	1.15	2.15

III. CHECK OVER TURNING

1. CHECK OVERTURNING FOR FOUNDATION RESTS ON SOIL: YES

E_{max} = 0.96 ft.

x_r = 1.17 ft. (LOCATION OF RESULTANT FROM THE TOE)

Actual e = 0.75 ft. GOOD

2. CHECK OVERTURNING FOR FOUNDATION RESTS ON ROCK: NO

E_{max} = N/A ft.

x_r = N/A ft. (LOCATION OF RESULTANT FROM THE TOE)

Actual e = N/A ft.

IV. CHECK BEARING

Actual e = 0.54 ft.

Bearing Resistance = 2.53 ksf

1. CHECK BEARING FOR FOUNDATION RESTS ON SOIL: YES

Vertical Sress (Uniform) = 1.23 ksf GOOD

2. CHECK BEARING FOR FOUNDATION RESTS ON ROCK: NO

Vert. Sress (max.) = N/A ksf

Vert. Sress (min.) = N/A ksf

V. CHECK SLIDING

Friction Resistance = 1.51 k

Factored Sliding Force = 1.83 k

Sliding Resistance = 1.82 k GOOD

VI. ULTIMATE LOADS

Unactored Horizontal Loads on Stem

Loads	Force (K)	Mo. Arm	Moment
Ph1 =	0.34	1.44	0.49
Ph2 =	0.02	0.08	0.00
Ph3 =	0.00	0.06	0.00
Ph,water =	0.00	0.06	0.00
Ph,sc =	0.31	1.50	0.46
	0.67		0.95

Unfactored Vertical Loads behind Stem

Loads	Force (K)	Mo. Arm	Moment
W3 =	0.40	1.00	0.40
W4 =	0.75	1.00	0.75
W5 =	0.12	1.33	0.17
Pv1 =	0.17	2.00	0.34
Pv2 =	0.01	2.00	0.03
Pv3 =	0.00	2.00	0.00
	1.46		1.68

Ultimate Loads

Load Combination	Strength I (Max)		Service I	
	V (K)	M (K.Ft)	V (K)	M (K.Ft)
Toe	1.23	0.61	N/A	N/A
Heel	1.95	2.28	N/A	N/A
Stem	1.08	1.55	0.67	0.95

For conservative the ultimate shear at toe is calculated at front face of wall.

VII. DESIGN FOOTING FOR SHEARS

$Clr_{Top\ Footing}$ =	2	in	$Spacing_{Top}$ =	18	in
$Clr_{Bottom\ Footing}$ =	3	in	$Spacing_{Bottom}$ =	18	in
Top bar Diameter =	0.5	in	β =	2	
Bottom bar Diameter =	0.5	in	ϕ_{shear} =	0.9	

1. HEEL

$d_{s\ Heel}$ =	13.746	in	$A_{s\ Top}$ =	0.13	in^2
a_{Heel} =	0.17	in			
$d_{v\ Heel}$ =	13.66	in			
$V_{R\ Heel}$ =	19.78	k	>	1.95	k GOOD

2. TOE

$d_{s\ Toe}$ =	12.746	in	$A_{s\ Bottom}$ =	0.13	in^2
a_{Toe} =	0.17	in			
$d_{v\ Toe}$ =	12.66	in			
$V_{R\ Toe}$ =	18.33	k	>	1.23	k GOOD

VIII. DESIGN FOOTING FOR BENDINGS

Use sheet 2 (Heel Bending) for the heel bending design — OK

Use sheet 3 (Toe Bending) for the Toe bending design — OK

IX. DESIGN STEM FOR SHEAR

$Clr_{Back\ Stem}$ =	2	in			
Bar Diameter at Stem =	0.5	in	S_x =	7.66	in
Spacing =	18	in	$A_{s\ Stem}$ =	0.13	in^2
$d_{s\ Stem}$ =	7.75	in	ε_s =	0.000923118	
a_{Stem} =	0.17	in	S_{xe} =	12	in
$d_{v\ Stem}$ =	7.66	in	β =	2.84	
$V_{R\ Stem}$ =	15.73	k	>	1.08	k GOOD

X. DESIGN STEM FOR BENDING

Use sheet 4 (Stem Bending) for the stem bending design — OK

Check control of cracking by distribution of reinforcement (5.7.3.4)

Service Mu =	0.95	k.ft
f_{ss} =	11.42	ksi
d_c =	2.25	in
β_s =	1.32	
S <=	41.87	in

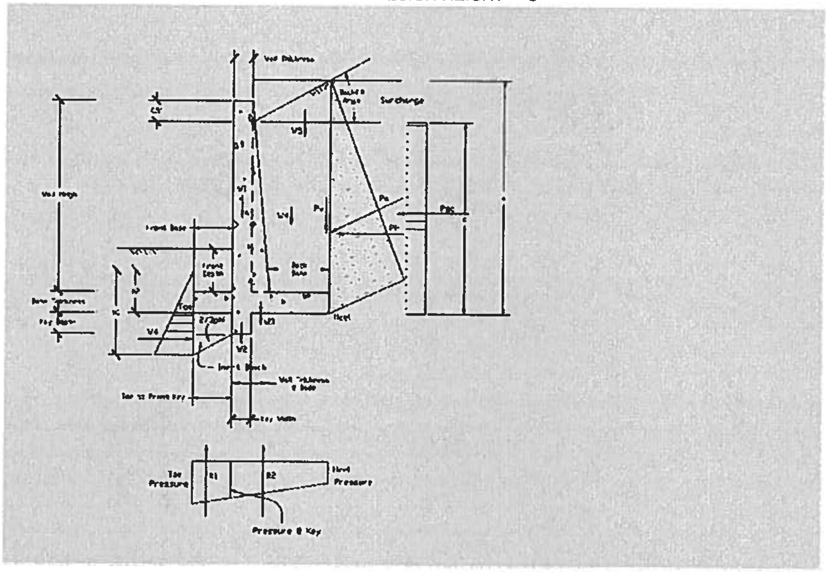
GOOD

SUMMARY OF CONCRETE DESIGN

	BAR DIA. (IN)	SPACING (IN)	COVER (IN)
FOOTING TOP MAT	0.5	18	2
FOOTING BOTTOM MAT	0.5	18	3
STEM	0.5	18	2

LRFD DESIGN FOR CIP RETAINING WALL B-16-H (NORTH WALL)
AUTHOR: BUI, HOANG
Oct-12

DESIGN HEIGHT 3'



I. INPUT (ENGLISH)

Concrete Density (pcf)	150.00	
Soil Density (pcf)	125.00	
Backfill Slope β (by degree)	26.57	
Internal Friction Angle of Backfill Soil ϕ	34.00	
Internal Friction Angle Soil at Foundation ϕ	30.00	
Friction Angle between Fill and Wall δ (*)	30.00	(*) Table 3.11.5.3-1
Surcharge in Feet	2.00	
Water depth behind wall, from bottom base (ft)	2.0	
Top Wall to Backfill Depth (ft)	0.50	
Height from Top Base to Top Wall (ft)	3.50	
Top wall Thickness (ft)	0.83	H = TOP OF WALL TO BOTTOM OF BASE
Wall Thickness @ Base (ft)	0.83	H/12 to H/10 0.40 0.48
Front Base Length (ft)	1.00	H/10 TO H/8 0.4833 0.60
Back Base Length (ft)	3.75	
Base Thickness (ft)	1.33	H/12 to H/10
Shear Key Depth (ft)	1.25	
Shear Key Width (ft)	0.67	
Distance from Toe to Key (ft)	0.00	
Front Soil Depth to Base (ft)	-1.00	WITH 2.5' RIPRAP AT TOE
Enter 1 for rock foundation, 0 for soil	0.00	
f'c (psi) = 4500 fy (psi)=	60000.00	
Ultimate Foundation Bearing (ksf) =	5.20	
Bearing Resistance Factor (**)	0.55	(**) Table 10.5.5.2.2-1
Sliding Resistance Factor (Concrete on Soil) (**)	0.80	(**) Table 10.5.5.2.2-1
Sliding Resistance Factor (Soil on Soil) (**)	0.90	(**) Table 10.5.5.2.2-1
Coefficient of Sliding Resistance (μ)	0.45	

Table 10.5.5.2.2-1 Resistance Factors for Geotechnical Resistance of Shallow Foundations at Strength Limit State

		Method / Soil / Condition	Resistance Factor
Bearing Resistance	ϕ_b	Theoretical Method (Munfakh et al., 2001), in clay	0.50
		Theoretical Method (Munfakh et al., 2001), in sand, using CPT	0.50
		Theoretical Method (Munfakh et al., 2001), in sand, using SPT	0.45
		Semi-empirical methods (Meyerhof, 1957), all soils	0.45
		Footing on rock	0.45
		Plate Load Test	0.55
Sliding	ϕ_τ	Precast concrete placed on sand	0.90
		Cast-in Place Concrete on sand	0.80
		Cast-in-Place or precast Concrete on clay	0.85
		Soil on soil	0.90
	ϕ_{ep}	Passive earth pressure component of sliding resistance	0.50

LOAD FACTORS

Load Combination	γ_{DC}	γ_{EV}	γ_{LS}	γ_{EH}	Application
Strength I (Min)	0.90	1.00	1.75	1.5	Sliding & overturning
Strength I (Max)	1.25	1.35	1.75	1.5	Bearing & wall strength
Service I	1.00	1.00	1.00	1.00	Wall crack control

II. OUTPUT

Enter 1 for using Rankine horizontal back fill, otherwise enter 0	1		
Angle of B.F. of Wall to Horizontal (degree)	90.00	Not Submergence	Submergence
Active Fluid Weight (Coefficient and pcf), (Ka)	0.412	51.53	25.81
Passive Fluid Weight (Coefficient and pcf)	3.54	442.14	221.42

h1 = 1.58 a = 6.21 H = 4.83

h2 = 0.33 b = 4.33 0.4H = 1.93

Base Width (ft) = 5.58 0.4H to 0.6H 0.6H = 2.90

Adjust Fluid Weight 1 Trial to match provided (Ka) from Geology Unit

Unactored Horizontal Loads

Loads	Force (K)	Mo. Arm	Moment
Ph1 =	0.41	3.40	1.39
Ph2 =	0.39	1.00	0.39
Ph3 =	0.05	0.67	0.03
Ph,water =	0.12	0.67	0.08
Ph,sc =	0.45	2.17	0.97
	1.41		**2.86**

Unfactored Vertical Loads

Loads	Force (K)	Mo. Arm	Moment
W1 =	0.44	1.42	0.62
W2 =	0.13	0.34	0.04
W3 =	1.12	2.79	3.12
W4 =	1.41	3.71	5.21
W5 =	0.44	4.33	1.90
Pv1 =	0.20	5.58	1.14
Pv2 =	0.26	5.58	1.46
Pv3 =	0.03	5.58	0.15
	4.02		**13.64**

Unfactored Sliding Resistance from Shear Key (Horizontal)

Loads	Force (K)
P_p =	0.34

Factored Loads and Moments

Load Combination	vertical Loads V (K)	Moment M_V (K.Ft)	Horiz. Loads V (K)	Moment M_H (K.Ft)
Strength I (Min)	4.10	14.64	2.12	4.53
Strength I (Max)	5.33	18.46	2.12	4.53
Service I	4.02	13.64	1.41	2.86

III. CHECK OVER TURNING

1. CHECK OVERTURNING FOR FOUNDATION RESTS ON SOIL: YES

E_{max} = 1.40 ft.

x_r = 2.47 ft. (LOCATION OF RESULTANT FROM THE TOE)

Actual e = 0.32 ft. GOOD

2. CHECK OVERTURNING FOR FOUNDATION RESTS ON ROCK: NO

E_{max} = N/A ft.

x_r = N/A ft. (LOCATION OF RESULTANT FROM THE TOE)

Actual e = N/A ft.

IV. CHECK BEARING

Actual e = 0.18 ft.

Bearing Resistance = 2.86 ksf

1. CHECK BEARING FOR FOUNDATION RESTS ON SOIL: YES

Vertical Sress (Uniform) = 1.02 ksf GOOD

2. CHECK BEARING FOR FOUNDATION RESTS ON ROCK: NO

Vert. Sress (max.) = N/A ksf

Vert. Sress (min.) = N/A ksf

V. CHECK SLIDING

Friction Resistance = 2.36 k

Factored Sliding Force = 2.12 k

Sliding Resistance = 2.06 k GOOD

VI. ULTIMATE LOADS

Unactored Horizontal Loads on Stem

Loads	Force (K)	Mo. Arm	Moment
Ph1 =	0.41	2.07	0.84
Ph2 =	0.09	0.33	0.03
Ph3 =	0.01	0.22	0.00
Ph,water =	0.01	0.22	0.00
Ph,sc =	0.31	1.50	0.46
	0.82		1.34

Unfactored Vertical Loads behind Stem

Loads	Force (K)	Mo. Arm	Moment
W3 =	0.75	1.88	1.41
W4 =	1.41	1.88	2.64
W5 =	0.44	2.50	1.10
Pv1 =	0.20	3.75	0.77
Pv2 =	0.06	3.75	0.22
Pv3 =	0.00	3.75	0.01
	2.86		6.14

Ultimate Loads

Load Combination	Strength I (Max)		Service I	
	V (K)	M (K.Ft)	V (K)	M (K.Ft)
Toe	1.02	0.51	N/A	N/A
Heel	3.83	8.30	N/A	N/A
Stem	1.31	2.13	0.82	1.34

For conservative the ultimate shear at toe is calculated at front face of wall.

VII. DESIGN FOOTING FOR SHEARS

$Clr_{Top\ Footing}$ =	2	in	$Spacing_{Top}$ =	18	in
$Clr_{Bottom\ Footing}$ =	3	in	$Spacing_{Bottom}$ =	18	in
Top bar Diameter =	0.625	in	β =	2	
Bottom bar Diameter =	0.5	in	ϕ_{shear} =	0.9	

1. HEEL

$d_{s\ Heel}$ =	13.6835	in	$A_{s\ Top}$ =	0.20	in^2
a_{Heel} =	0.27	in			
$d_{v\ Heel}$ =	13.55	in			
$V_{R\ Heel}$ =	19.62	k	>	3.83	k GOOD

2. TOE

$d_{s\ Toe}$ =	12.746	in	$A_{s\ Bottom}$ =	0.13	in^2
a_{Toe} =	0.17	in			
$d_{v\ Toe}$ =	12.66	in			
$V_{R\ Toe}$ =	18.33	k	>	1.02	k GOOD

VIII. DESIGN FOOTING FOR BENDINGS

Use sheet 2 (Heel Bending) for the heel bending design — OK

Use sheet 3 (Toe Bending) for the Toe bending design — OK

IX. DESIGN STEM FOR SHEAR

$Clr_{Back\ Stem}$ =	2	in			
Bar Diameter at Stem =	0.5	in	S_x =	7.66	in
Spacing =	18	in	$A_{s\ Stem}$ =	0.13	in^2
$d_{s\ Stem}$ =	7.75	in	ε_s =	0.001224774	
a_{Stem} =	0.17	in	S_{xe} =	12	in
$d_{v\ Stem}$ =	7.66	in	β =	2.50	
$V_{R\ Stem}$ =	13.87	k	>	1.31	k GOOD

X. DESIGN STEM FOR BENDING

Use sheet 4 (Stem Bending) for the stem bending design — OK

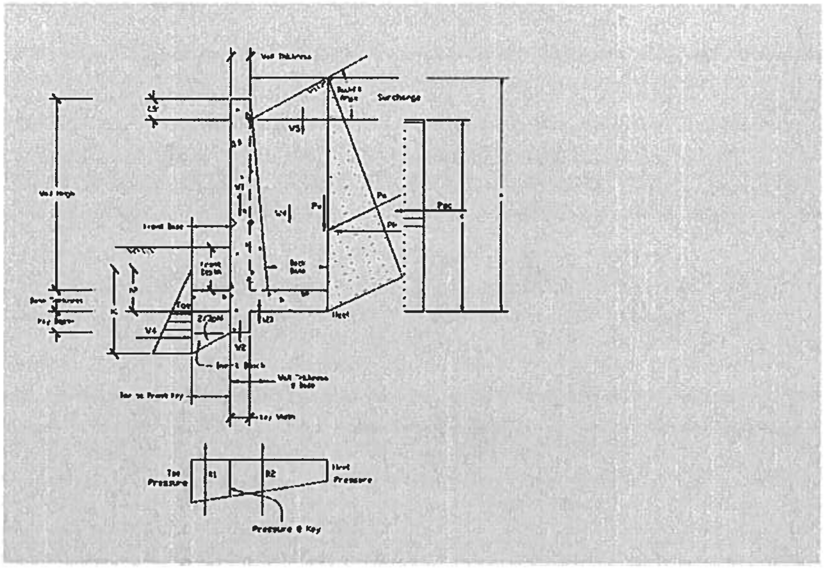
Check control of cracking by distribution of reinforcement (5.7.3.4)

Service Mu =	1.34	k.ft	
f_{ss} =	16.06	ksi	
d_c =	2.25	in	
β_s =	1.32		
S <=	28.48	in	GOOD

SUMMARY OF CONCRETE DESIGN

	BAR DIA. (IN)	SPACING (IN)	COVER (IN)
FOOTING TOP MAT	0.625	18	2
FOOTING BOTTOM MAT	0.5	18	3
STEM	0.5	18	2

LRFD DESIGN FOR CIP RETAINING WALL B-16-H (NORTH WALL)
AUTHOR: BUI, HOANG
Oct-12 DESIGN HEIGHT 4'



I. INPUT (ENGLISH)

Concrete Density (pcf)	150.00	
Soil Density (pcf)	125.00	
Backfill Slope β (by degree)	26.57	
Internal Friction Angle of Backfill Soil ϕ	34.00	
Internal Friction Angle Soil at Foundation ϕ	30.00	
Friction Angle between Fill and Wall δ (*)	30.00	(*) Table 3.11.5.3-1
Surcharge in Feet	2.00	
Water depth behind wall, from bottom base (ft)	2.0	
Top Wall to Backfill Depth (ft)	0.50	
Height from Top Base to Top Wall (ft)	4.50	
Top wall Thickness (ft)	0.83	H = TOP OF WALL TO BOTTOM OF BASE
Wall Thickness @ Base (ft)	0.83	H/12 to H/10 0.49 0.58
Front Base Length (ft)	1.00	H/10 TO H/8 0.5833 0.73
Back Base Length (ft)	3.00	
Base Thickness (ft)	1.33	H/12 to H/10
Shear Key Depth (ft)	1.25	
Shear Key Width (ft)	0.67	
Distance from Toe to Key (ft)	0.00	
Front Soil Depth to Base (ft)	1.50	
Enter 1 for rock foundation, 0 for soil	0.00	
f'c (psi) = 4500 fy (psi)=	60000.00	
Utimate Foundation Bearing (ksf) =	5.20	
Bearing Resistance Factor (**)	0.55	(**) Table 10.5.5.2.2-1
Sliding Resistance Factor (Concrete on Soil) (**)	0.80	(**) Table 10.5.5.2.2-1
Sliding Resistance Factor (Soil on Soil) (**)	0.90	(**) Table 10.5.5.2.2-1
Coefficient of Sliding Resistance (μ)	0.45	

Table 10.5.5.2.2-1 Resistance Factors for Geotechnical Resistance of Shallow Foundations at Strength Limit State

Method / Soil / Condition			Resistance Factor
Bearing Resistance	ϕ_b	Theoretical Method (Munfakh et al., 2001), in clay	0.50
		Theoretical Method (Munfakh et al., 2001), in sand, using CPT	0.50
		Theoretical Method (Munfakh et al., 2001), in sand, using SPT	0.45
		Semi-empirical methods (Meyerhof, 1957), all soils	0.45
		Footing on rock	0.45
		Plate Load Test	0.55
Sliding	ϕ_τ	Precast concrete placed on sand	0.90
		Cast-in Place Concrete on sand	0.80
		Cast-in-Place or precast Concrete on clay	0.85
		Soil on soil	0.90
	ϕ_{ep}	Passive earth pressure component of sliding resistance	0.50

LOAD FACTORS

Load Combination	γ_{DC}	γ_{EV}	γ_{LS}	γ_{EH}	Application
Strength I (Min)	0.90	1.00	1.75	1.5	Sliding & overturning
Strength I (Max)	1.25	1.35	1.75	1.5	Bearing & wall strength
Service I	1.00	1.00	1.00	1.00	Wall crack control

II. OUTPUT

Enter 1 for using Rankine horizontal back fill, otherwise enter 0 — 1

		Not Submergence	Submergence
Angle of B.F. of Wall to Horizontal (degree)	90.00		
Active Fluid Weight (Coefficient and pcf), (Ka)	0.412	51.53	25.81
Passive Fluid Weight (Coefficient and pcf)	3.54	442.14	221.42

h1 = 4.08 a = 6.83 H = 5.83

h2 = 2.83 b = 5.33 0.4H = 2.33

Base Width (ft) = 4.83 0.4H to 0.6H 0.6H = 3.50

Adjust Fluid Weight 1 Trial to match provided (Ka) from Geology Unit

Unactored Horizontal Loads

Loads	Force (K)	Mo. Arm	Moment
Ph1 =	0.54	3.61	1.94
Ph2 =	0.45	1.00	0.45
Ph3 =	0.05	0.67	0.03
Ph,water =	0.12	0.67	0.08
Ph,sc =	0.55	2.67	1.47
	1.70		3.97

Unfactored Vertical Loads

Loads	Force (K)	Mo. Arm	Moment
W1 =	0.56	1.42	0.80
W2 =	0.13	0.34	0.04
W3 =	0.97	2.42	2.34
W4 =	1.50	3.33	5.00
W5 =	0.28	3.83	1.08
Pv1 =	0.27	4.83	1.30
Pv2 =	0.30	4.83	1.45
Pv3 =	0.03	4.83	0.13
	4.03		12.13

Unfactored Sliding Resistance from Shear Key (Horizontal)

Loads	Force (K)
P_p =	1.23

Factored Loads and Moments

Load Combination	vertical Loads V (K)	Moment M_V (K.Ft)	Horiz. Loads V (K)	Moment M_H (K.Ft)
Strength I (Min)	4.16	13.26	2.56	6.32
Strength I (Max)	5.37	16.49	2.56	6.32
Service I	4.03	12.13	1.70	3.97

III. CHECK OVER TURNING

1. CHECK OVERTURNING FOR FOUNDATION RESTS ON SOIL: YES

E_{max} = 1.21 ft.

x_r = 1.67 ft. (LOCATION OF RESULTANT FROM THE TOE)

Actual e = 0.75 ft. GOOD

2. CHECK OVERTURNING FOR FOUNDATION RESTS ON ROCK: NO

E_{max} = N/A ft.

x_r = N/A ft. (LOCATION OF RESULTANT FROM THE TOE)

Actual e = N/A ft.

IV. CHECK BEARING

Actual e = 0.52 ft.

Bearing Resistance = 2.86 ksf

1. CHECK BEARING FOR FOUNDATION RESTS ON SOIL: YES

Vertical Sress (Uniform) = 1.42 ksf GOOD

2. CHECK BEARING FOR FOUNDATION RESTS ON ROCK: NO

Vert. Sress (max.) = N/A ksf

Vert. Sress (min.) = N/A ksf

V. CHECK SLIDING

Friction Resistance = 2.40 k

Factored Sliding Force = 2.56 k

Sliding Resistance = 2.54 k GOOD

VI. ULTIMATE LOADS

Unactored Horizontal Loads on Stem

Loads	Force (K)	Mo. Arm	Moment
Ph1 =	0.54	2.28	1.23
Ph2 =	0.11	0.33	0.04
Ph3 =	0.01	0.22	0.00
Ph,water =	0.01	0.22	0.00
Ph,sc =	0.41	2.00	0.82
	1.08		**2.09**

Unfactored Vertical Loads behind Stem

Loads	Force (K)	Mo. Arm	Moment
W3 =	0.60	1.50	0.90
W4 =	1.50	1.50	2.25
W5 =	0.28	2.00	0.56
Pv1 =	0.27	3.00	0.81
Pv2 =	0.07	3.00	0.22
Pv3 =	0.00	3.00	0.01
	2.73		**4.75**

Ultimate Loads

Load Combination	Strength I (Max)		Service I	
	V (K)	M (K.Ft)	V (K)	M (K.Ft)
Toe	1.42	0.71	N/A	N/A
Heel	3.67	6.47	N/A	N/A
Stem	1.72	3.34	1.08	2.09

For conservative the ultimate shear at toe is calculated at front face of wall.

VII. DESIGN FOOTING FOR SHEARS

$Clr_{Top\ Footing}$ =	2	in	$Spacing_{Top}$ =	16	in
$Clr_{Bottom\ Footing}$ =	3	in	$Spacing_{Bottom}$ =	16	in
Top bar Diameter =	0.5	in	β =	2	
Bottom bar Diameter =	0.5	in	ϕ_{shear} =	0.9	

1. HEEL

$d_{s\ Heel}$ =	13.746	in	$A_{s\ Top}$ =	0.15	in^2
a_{Heel} =	0.19	in			
$d_{v\ Heel}$ =	13.65	in			
$V_{R\ Heel}$ =	19.76	k	>	3.67	k GOOD

2. TOE

$d_{s\ Toe}$ =	12.746	in	$A_{s\ Bottom}$ =	0.15	in^2
a_{Toe} =	0.19	in			
$d_{v\ Toe}$ =	12.65	in			
$V_{R\ Toe}$ =	18.32	k	>	1.42	k GOOD

VIII. DESIGN FOOTING FOR BENDINGS

Use sheet 2 (Heel Bending) for the heel bending design — OK

Use sheet 3 (Toe Bending) for the Toe bending design — OK

IX. DESIGN STEM FOR SHEAR

$Clr_{Back\ Stem}$ =	2	in			
Bar Diameter at Stem =	0.5	in	S_x =	7.65	in
Spacing =	16	in	$A_{s\ Stem}$ =	0.15	in^2
$d_{s\ Stem}$ =	7.75	in	ε_s =	0.001630188	
a_{Stem} =	0.19	in	S_{xe} =	12	in
$d_{v\ Stem}$ =	7.65	in	β =	2.16	
$V_{R\ Stem}$ =	11.96	k	>	1.72	k GOOD

X. DESIGN STEM FOR BENDING

Use sheet 4 (Stem Bending) for the stem bending design — OK

Check control of cracking by distribution of reinforcement (5.7.3.4)

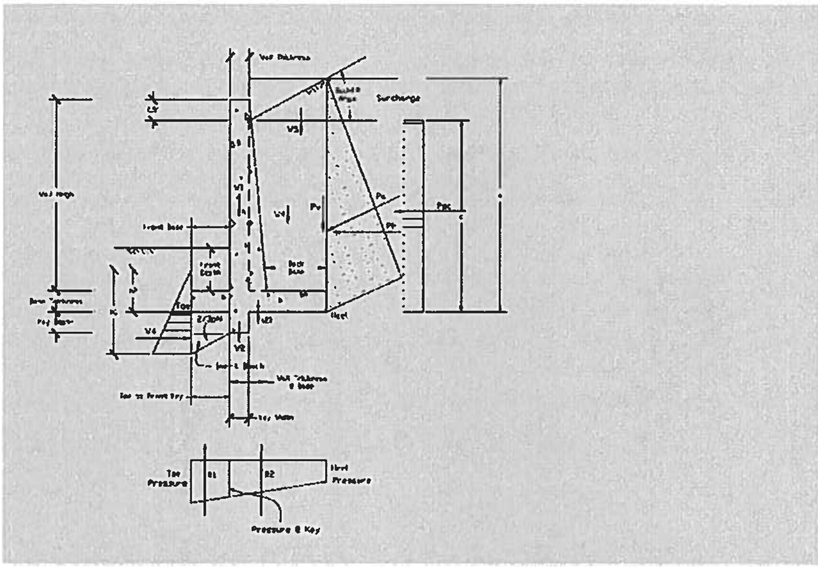
Service Mu =	2.09	k.ft
f_{ss} =	22.27	ksi
d_c =	2.25	in
β_s =	1.32	
S <=	19.28	in

GOOD

SUMMARY OF CONCRETE DESIGN

	BAR DIA. (IN)	SPACING (IN)	COVER (IN)
FOOTING TOP MAT	0.5	16	2
FOOTING BOTTOM MAT	0.5	16	3
STEM	0.5	16	2

LRFD DESIGN FOR CIP RETAINING WALL B-16-H (NORTH WALL)
AUTHOR: BUI, HOANG
Oct-12 DESIGN HEIGHT **4'**



I. INPUT (ENGLISH)

Concrete Density (pcf)	150.00			
Soil Density (pcf)	125.00			
Backfill Slope β (by degree)	26.57			
Internal Friction Angle of Backfill Soil ϕ	34.00			
Internal Friction Angle Soil at Foundation ϕ	30.00			
Friction Angle between Fill and Wall δ (*)	30.00	(*) Table 3.11.5.3-1		
Surcharge in Feet	2.00			
Water depth behind wall, from bottom base (ft)	2.0			
Top Wall to Backfill Depth (ft)	0.50			
Height from Top Base to Top Wall (ft)	4.16			
Top wall Thickness (ft)	0.83	H = TOP OF WALL TO BOTTOM OF BASE		
Wall Thickness @ Base (ft)	0.83	H/12 to H/10	0.46	0.55
Front Base Length (ft)	1.00	H/10 TO H/8	0.5493	0.69
Back Base Length (ft)	4.50			
Base Thickness (ft)	1.33	H/12 to H/10		
Shear Key Depth (ft)	1.25			
Shear Key Width (ft)	0.67			
Distance from Toe to Key (ft)	0.00			
Front Soil Depth to Base (ft)	-1.00	WITH 2.5' RIPRAP AT TOE		
Enter 1 for rock foundation, 0 for soil	0.00			
f'c (psi) = 4500 fy (psi)=	60000.00			
Utimate Foundation Bearing (ksf) =	5.20			
Bearing Resistance Factor (**)	0.55	(**) Table 10.5.5.2.2-1		
Sliding Resistance Factor (Concrete on Soil) (**)	0.80	(**) Table 10.5.5.2.2-1		
Sliding Resistance Factor (Soil on Soil) (**)	0.90	(**) Table 10.5.5.2.2-1		
Coefficient of Sliding Resistance (μ)	0.45			

Table 10.5.5.2.2-1 Resistance Factors for Geotechnical Resistance of Shallow Foundations at Strength Limit State

Method / Soil / Condition			Resistance Factor
Bearing Resistance	ϕ_b	Theoretical Method (Munfakh et al., 2001), in clay	0.50
		Theoretical Method (Munfakh et al., 2001), in sand, using CPT	0.50
		Theoretical Method (Munfakh et al., 2001), in sand, using SPT	0.45
		Semi-empirical methods (Meyerhof, 1957), all soils	0.45
		Footing on rock	0.45
		Plate Load Test	0.55
Sliding	ϕ_τ	Precast concrete placed on sand	0.90
		Cast-in Place Concrete on sand	0.80
		Cast-in-Place or precast Concrete on clay	0.85
		Soil on soil	0.90
	ϕ_{ep}	Passive earth pressure component of sliding resistance	0.50

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LOAD FACTORS

Load Combination	γ_{DC}	γ_{EV}	γ_{LS}	γ_{EH}	Application
Strength I (Min)	0.90	1.00	1.75	1.5	Sliding & overturning
Strength I (Max)	1.25	1.35	1.75	1.5	Bearing & wall strength
Service I	1.00	1.00	1.00	1.00	Wall crack control

II. OUTPUT

Enter 1 for using Rankine horizontal back fill, otherwise enter 0	1			
Angle of B.F. of Wall to Horizontal (degree)	90.00	Not Submergence	Submergence	
Active Fluid Weight (Coefficient and pcf), (Ka)	0.412	51.53	25.81	
Passive Fluid Weight (Coefficient and pcf)	3.54	442.14	221.42	
h1 = 1.58 a =	7.24			H = 5.49
h2 = 0.33 b =	4.99			0.4H = 2.20
Base Width (ft) =	6.33	0.4H to 0.6H		0.6H = 3.30
		Adjust Fluid Weight	1	Trial to match provided (Ka) from Geology Unit

Unactored Horizontal Loads

Loads	Force (K)	Mo. Arm	Moment
Ph1 =	0.63	3.75	2.37
Ph2 =	0.48	1.00	0.48
Ph3 =	0.05	0.67	0.03
Ph,water =	0.12	0.67	0.08
Ph,sc =	0.51	2.50	1.28
	1.80		4.26

Unfactored Vertical Loads

Loads	Force (K)	Mo. Arm	Moment
W1 =	0.52	1.42	0.74
W2 =	0.13	0.34	0.04
W3 =	1.27	3.17	4.01
W4 =	2.06	4.08	8.41
W5 =	0.63	4.83	3.06
Pv1 =	0.32	6.33	2.01
Pv2 =	0.33	6.33	2.06
Pv3 =	0.03	6.33	0.17
	5.27		20.49

Unfactored Sliding Resistance from Shear Key (Horizontal)

Loads	Force (K)
P_p =	0.34

Factored Loads and Moments

Load Combination	vertical Loads V (K)	Moment M_V (K.Ft)	Horiz. Loads V (K)	Moment M_H (K.Ft)
Strength I (Min)	5.42	22.13	2.70	6.71
Strength I (Max)	7.03	27.82	2.70	6.71
Service I	5.27	20.49	1.80	4.26

III. CHECK OVER TURNING

1. CHECK OVERTURNING FOR FOUNDATION RESTS ON SOIL: YES

E_{max} = 1.58 ft.

x_r = 2.85 ft. (LOCATION OF RESULTANT FROM THE TOE)

Actual e = 0.32 ft. GOOD

2. CHECK OVERTURNING FOR FOUNDATION RESTS ON ROCK: NO

E_{max} = N/A ft.

x_r = N/A ft. (LOCATION OF RESULTANT FROM THE TOE)

Actual e = N/A ft.

IV. CHECK BEARING

Actual e = 0.16 ft.

Bearing Resistance = 2.86 ksf

1. CHECK BEARING FOR FOUNDATION RESTS ON SOIL: YES

Vertical Sress (Uniform) = 1.17 ksf GOOD

2. CHECK BEARING FOR FOUNDATION RESTS ON ROCK: NO

Vert. Sress (max.) = N/A ksf

Vert. Sress (min.) = N/A ksf

V. CHECK SLIDING

Friction Resistance = 3.13 k

Factored Sliding Force = 2.70 k

Sliding Resistance = 2.67 k GOOD

VI. ULTIMATE LOADS

Unactored Horizontal Loads on Stem

Loads	Force (K)	Mo. Arm	Moment
Ph1 =	0.63	2.41	1.53
Ph2 =	0.12	0.33	0.04
Ph3 =	0.01	0.22	0.00
Ph,water =	0.01	0.22	0.00
Ph,sc =	0.38	1.83	0.69
	1.15		2.26

Unfactored Vertical Loads behind Stem

Loads	Force (K)	Mo. Arm	Moment
W3 =	0.90	2.25	2.02
W4 =	2.06	2.25	4.63
W5 =	0.63	3.00	1.90
Pv1 =	0.32	4.50	1.43
Pv2 =	0.08	4.50	0.36
Pv3 =	0.00	4.50	0.01
	3.99		10.36

Ultimate Loads

Load Combination	Strength I (Max)		Service I	
	V (K)	M (K.Ft)	V (K)	M (K.Ft)
Toe	1.17	0.58	N/A	N/A
Heel	5.36	14.05	N/A	N/A
Stem	1.82	3.57	1.15	2.26

For conservative the ultimate shear at toe is calculated at front face of wall.

VII. DESIGN FOOTING FOR SHEARS

$Clr_{Top\ Footing}$ =	2	in	$Spacing_{Top}$ =	16	in
$Clr_{Bottom\ Footing}$ =	3	in	$Spacing_{Bottom}$ =	16	in
Top bar Diameter =	0.75	in	β =	2	
Bottom bar Diameter =	0.5	in	ϕ_{shear} =	0.9	

1. HEEL

$d_{s\ Heel}$ =	13.621	in	$A_{s\ Top}$ =	0.33	in^2
a_{Heel} =	0.43	in			
$d_{v\ Heel}$ =	13.40	in			
$V_{R\ Heel}$ =	19.41	k	>	5.36	k GOOD

2. TOE

$d_{s\ Toe}$ =	12.746	in	$A_{s\ Bottom}$ =	0.15	in^2
a_{Toe} =	0.19	in			
$d_{v\ Toe}$ =	12.65	in			
$V_{R\ Toe}$ =	18.32	k	>	1.17	k GOOD

VIII. DESIGN FOOTING FOR BENDINGS

Use sheet 2 (Heel Bending) for the heel bending design — OK

Use sheet 3 (Toe Bending) for the Toe bending design — OK

IX. DESIGN STEM FOR SHEAR

$Clr_{Back\ Stem}$ =	2	in			
Bar Diameter at Stem =	0.5	in	S_x =	7.65	in
Spacing =	16	in	$A_{s\ Stem}$ =	0.15	in^2
$d_{s\ Stem}$ =	7.75	in	ε_s =	0.001736936	
a_{Stem} =	0.19	in	S_{xe} =	12	in
$d_{v\ Stem}$ =	7.65	in	β =	2.08	
$V_{R\ Stem}$ =	11.54	k	>	1.82	k GOOD

X. DESIGN STEM FOR BENDING

Use sheet 4 (Stem Bending) for the stem bending design — OK

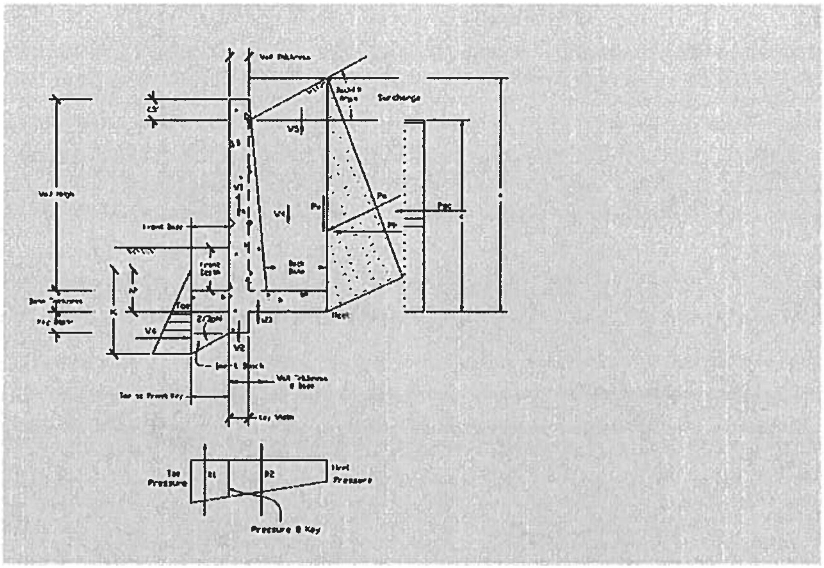
Check control of cracking by distribution of reinforcement (5.7.3.4)

Service Mu =	2.26	k.ft	
f_{ss} =	24.12	ksi	
d_c =	2.25	in	
β_s =	1.32		
S <=	17.46	in	GOOD

SUMMARY OF CONCRETE DESIGN

	BAR DIA. (IN)	SPACING (IN)	COVER (IN)
FOOTING TOP MAT	0.75	16	2
FOOTING BOTTOM MAT	0.5	16	3
STEM	0.5	16	2

LRFD DESIGN FOR CIP RETAINING WALL B-16-H (NORTH WALL)
AUTHOR: BUI, HOANG
Oct-12 **DESIGN HEIGHT** 5'



I. INPUT (ENGLISH)

Concrete Density (pcf)	150.00			
Soil Density (pcf)	125.00			
Backfill Slope β (by degree)	26.57			
Internal Friction Angle of Backfill Soil ϕ	34.00			
Internal Friction Angle Soil at Foundation ϕ	30.00			
Friction Angle between Fill and Wall δ (*)	30.00	(*) Table 3.11.5.3-1		
Surcharge in Feet	2.00			
Water depth behind wall, from bottom base (ft)	2.5			
Top Wall to Backfill Depth (ft)	0.50			
Height from Top Base to Top Wall (ft)	5.50			
Top wall Thickness (ft)	0.83	H = TOP OF WALL TO BOTTOM OF BASE		
Wall Thickness @ Base (ft)	0.83	H/12 to H/10	0.57	0.68
Front Base Length (ft)	1.00	H/10 TO H/8	0.6833	0.85
Back Base Length (ft)	4.00			
Base Thickness (ft)	1.33	H/12 to H/10		
Shear Key Depth (ft)	1.25			
Shear Key Width (ft)	0.67			
Distance from Toe to Key (ft)	0.00			
Front Soil Depth to Base (ft)	1.50			
Enter 1 for rock foundation, 0 for soil	0.00			
f'c (psi) = 4500 fy (psi)=	60000.00			
Utimate Foundation Bearing (ksf) =	5.20			
Bearing Resistance Factor (**)	0.55	(**) Table 10.5.5.2.2-1		
Sliding Resistance Factor (Concrete on Soil) (**)	0.80	(**) Table 10.5.5.2.2-1		
Sliding Resistance Factor (Soil on Soil) (**)	0.90	(**) Table 10.5.5.2.2-1		
Coefficient of Sliding Resistance (μ)	0.45			

Table 10.5.5.2.2-1 Resistance Factors for Geotechnical Resistance of Shallow Foundations at Strength Limit State

Method / Soil / Condition			Resistance Factor
Bearing Resistance	ϕ_b	Theoretical Method (Munfakh et al., 2001), in clay	0.50
		Theoretical Method (Munfakh et al., 2001), in sand, using CPT	0.50
		Theoretical Method (Munfakh et al., 2001), in sand, using SPT	0.45
		Semi-empirical methods (Meyerhof, 1957), all soils	0.45
		Footing on rock	0.45
		Plate Load Test	0.55
Sliding	ϕ_τ	Precast concrete placed on sand	0.90
		Cast-in Place Concrete on sand	0.80
		Cast-in-Place or precast Concrete on clay	0.85
		Soil on soil	0.90
	ϕ_{ep}	Passive earth pressure component of sliding resistance	0.50

LOAD FACTORS

Load Combination	γ_{DC}	γ_{EV}	γ_{LS}	γ_{EH}	Application
Strength I (Min)	0.90	1.00	1.75	1.5	Sliding & overturning
Strength I (Max)	1.25	1.35	1.75	1.5	Bearing & wall strength
Service I	1.00	1.00	1.00	1.00	Wall crack control

II. OUTPUT

Enter 1 for using Rankine horizontal back fill, otherwise enter 0		1			
Angle of B.F. of Wall to Horizontal (degree)		90.00	Not Submergence	Submergence	
Active Fluid Weight (Coefficient and pcf), (Ka)		0.412	51.53	25.81	
Passive Fluid Weight (Coefficient and pcf)		3.54	442.14	221.42	
h1 =	4.08	a = 8.33			H = 6.83
h2 =	2.83	b = 6.33			0.4H = 2.73
		Base Width (ft) = 5.83	0.4H to 0.6H		0.6H = 4.10
			Adjust Fluid Weight	1	Trial to match provided (Ka) from Geology Unit

Unactored Horizontal Loads

Loads	Force (K)	Mo. Arm	Moment
Ph1 =	0.78	4.44	3.48
Ph2 =	0.67	1.25	0.84
Ph3 =	0.07	0.83	0.06
Ph,water =	0.20	0.83	0.16
Ph,sc =	0.65	3.17	2.07
	2.38		6.61

Unfactored Vertical Loads

Loads	Force (K)	Mo. Arm	Moment
W1 =	0.69	1.42	0.97
W2 =	0.13	0.34	0.04
W3 =	1.17	2.92	3.40
W4 =	2.50	3.83	9.58
W5 =	0.50	4.50	2.25
Pv1 =	0.39	5.83	2.29
Pv2 =	0.45	5.83	2.64
Pv3 =	0.04	5.83	0.24
	5.87		21.42

Unfactored Sliding Resistance from Shear Key (Horizontal)

Loads	Force (K)
P_p =	1.23

Factored Loads and Moments

Load Combination	vertical Loads V (K)	Moment M_V (K.Ft)	Horiz. Loads V (K)	Moment M_H (K.Ft)
Strength I (Min)	6.11	23.57	3.56	10.44
Strength I (Max)	7.85	29.26	3.56	10.44
Service I	5.87	21.42	2.38	6.61

III. CHECK OVER TURNING

1. CHECK OVERTURNING FOR FOUNDATION RESTS ON SOIL: YES

E_{max} = 1.46 ft.

x_r = 2.15 ft. (LOCATION OF RESULTANT FROM THE TOE)

Actual e = 0.77 ft. GOOD

2. CHECK OVERTURNING FOR FOUNDATION RESTS ON ROCK: NO

E_{max} = N/A ft.

x_r = N/A ft. (LOCATION OF RESULTANT FROM THE TOE)

Actual e = N/A ft.

IV. CHECK BEARING

Actual e = 0.52 ft.

Bearing Resistance = 2.86 ksf

1. CHECK BEARING FOR FOUNDATION RESTS ON SOIL: YES

Vertical Sress (Uniform) = 1.64 ksf GOOD

2. CHECK BEARING FOR FOUNDATION RESTS ON ROCK: NO

Vert. Sress (max.) = N/A ksf

Vert. Sress (min.) = N/A ksf

V. CHECK SLIDING

Friction Resistance = 3.53 k

Factored Sliding Force = 3.56 k

Sliding Resistance = 3.44 k GOOD

VI. ULTIMATE LOADS

Unactored Horizontal Loads on Stem

Loads	Force (K)	Mo. Arm	Moment
Ph1 =	0.78	3.11	2.44
Ph2 =	0.24	0.58	0.14
Ph3 =	0.02	0.39	0.01
Ph,water =	0.04	0.39	0.02
Ph,sc =	0.52	2.50	1.29
	1.60		3.89

Unfactored Vertical Loads behind Stem

Loads	Force (K)	Mo. Arm	Moment
W3 =	0.80	2.00	1.60
W4 =	2.50	2.00	5.00
W5 =	0.50	2.67	1.33
Pv1 =	0.39	4.00	1.57
Pv2 =	0.16	4.00	0.65
Pv3 =	0.01	4.00	0.04
	4.36		10.19

Ultimate Loads

Load Combination	Strength I (Max)		Service I	
	V (K)	M (K.Ft)	V (K)	M (K.Ft)
Toe	1.64	0.82	N/A	N/A
Heel	5.90	13.94	N/A	N/A
Stem	2.53	6.16	1.60	3.89

For conservative the ultimate shear at toe is calculated at front face of wall.

VII. DESIGN FOOTING FOR SHEARS

$Clr_{Top\ Footing}$ =	2	in	$Spacing_{Top}$ =	15	in
$Clr_{Bottom\ Footing}$ =	3	in	$Spacing_{Bottom}$ =	15	in
Top bar Diameter =	0.75	in	β =	2	
Bottom bar Diameter =	0.625	in	ϕ_{shear} =	0.9	

1. HEEL

$d_{s\ Heel}$ =	13.621	in	$A_{s\ Top}$ =	0.35	in^2
a_{Heel} =	0.46	in			
$d_{v\ Heel}$ =	13.39	in			
$V_{R\ Heel}$ =	19.39	k	>	5.90	k GOOD

2. TOE

$d_{s\ Toe}$ =	12.6835	in	$A_{s\ Bottom}$ =	0.25	in^2
a_{Toe} =	0.32	in			
$d_{v\ Toe}$ =	12.52	in			
$V_{R\ Toe}$ =	18.13	k	>	1.64	k GOOD

VIII. DESIGN FOOTING FOR BENDINGS

Use sheet 2 (Heel Bending) for the heel bending design — OK

Use sheet 3 (Toe Bending) for the Toe bending design — OK

IX. DESIGN STEM FOR SHEAR

$Clr_{Back\ Stem}$ =	2	in			
Bar Diameter at Stem =	0.625	in	S_x =	7.52	in
Spacing =	15	in	$A_{s\ Stem}$ =	0.25	in^2
$d_{s\ Stem}$ =	7.68	in	ε_s =	0.001735608	
a_{Stem} =	0.32	in	S_{xe} =	12	in
$d_{v\ Stem}$ =	7.52	in	β =	2.09	
$V_{R\ Stem}$ =	11.36	k	>	2.53	k GOOD

X. DESIGN STEM FOR BENDING

Use sheet 4 (Stem Bending) for the stem bending design — OK

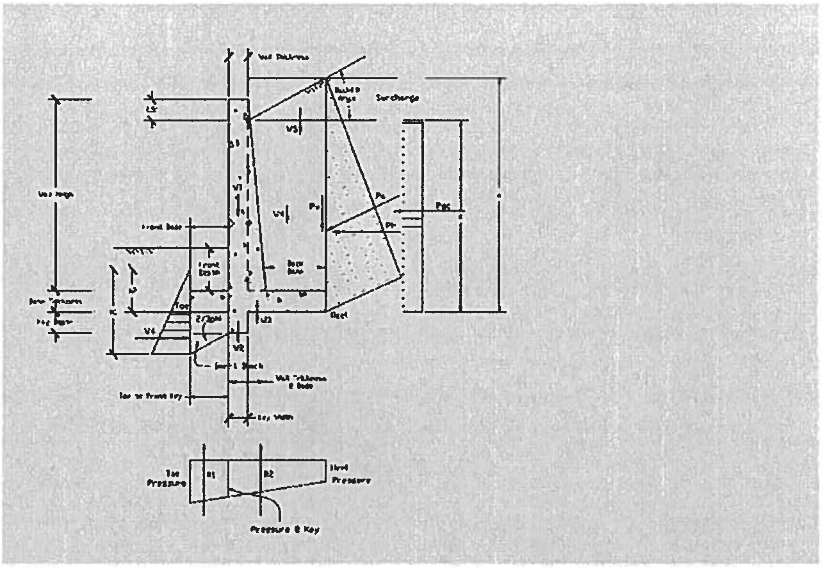
Check control of cracking by distribution of reinforcement (5.7.3.4)

Service Mu =	3.89	k.ft	
f_{ss} =	25.29	ksi	
d_c =	2.31	in	
β_s =	1.33		
S <=	16.18	in	GOOD

SUMMARY OF CONCRETE DESIGN

	BAR DIA. (IN)	SPACING (IN)	COVER (IN)
FOOTING TOP MAT	0.75	15	2
FOOTING BOTTOM MAT	0.625	15	3
STEM	0.625	15	2

LRFD DESIGN FOR CIP RETAINING WALL B-16-H (NORTH WALL)
AUTHOR: BUI, HOANG
Oct-12 DESIGN HEIGHT 6'



I. INPUT (ENGLISH)

Concrete Density (pcf)	150.00	
Soil Density (pcf)	125.00	
Backfill Slope β (by degree)	26.57	
Internal Friction Angle of Backfill Soil ϕ	34.00	
Internal Friction Angle of Soil at Foundation ϕ	30.00	
Friction Angle between Fill and Wall δ (*)	30.00	(*) Table 3.11.5.3-1
Surcharge in Feet	2.00	
Water depth behind wall, from bottom base (ft)	3.0	
Top Wall to Backfill Depth (ft)	0.50	
Height from Top Base to Top Wall (ft)	6.50	
Top wall Thickness (ft)	0.83	H = TOP OF WALL TO BOTTOM OF BASE
Wall Thickness @ Base (ft)	0.83	H/12 to H/10 0.65 0.78
Front Base Length (ft)	1.00	H/10 TO H/8 0.7833 0.98
Back Base Length (ft)	5.00	
Base Thickness (ft)	1.33	H/12 to H/10
Shear Key Depth (ft)	1.25	
Shear Key Width (ft)	0.67	
Distance from Toe to Key (ft)	0.00	
Front Soil Depth to Base (ft)	1.50	
Enter 1 for rock foundation, 0 for soil	0.00	
f'c (psi) = 4500 fy (psi)=	60000.00	
Utimate Foundation Bearing (ksf) =	5.20	
Bearing Resistance Factor (**)	0.55	(**) Table 10.5.5.2.2-1
Sliding Resistance Factor (Concrete on Soil) (**)	0.80	(**) Table 10.5.5.2.2-1
Sliding Resistance Factor (Soil on Soil) (**)	0.90	(**) Table 10.5.5.2.2-1

Table 10.5.5.2.2-1 Resistance Factors for Geotechnical Resistance of Shallow Foundations at Strength Limit State

Method / Soil / Condition			Resistance Factor
Bearing Resistance	ϕ_b	Theoretical Method (Munfakh et al., 2001), in clay	0.50
		Theoretical Method (Munfakh et al., 2001), in sand, using CPT	0.50
		Theoretical Method (Munfakh et al., 2001), in sand, using SPT	0.45
		Semi-empirical methods (Meyerhof, 1957), all soils	0.45
		Footing on rock	0.45
		Plate Load Test	0.55
Sliding	ϕ_τ	Precast concrete placed on sand	0.90
		Cast-in Place Concrete on sand	0.80
		Cast-in-Place or precast Concrete on clay	0.85
		Soil on soil	0.90
	ϕ_{ep}	Passive earth pressure component of sliding resistance	0.50

LOAD FACTORS

Load Combination	γ_{DC}	γ_{EV}	γ_{LS}	γ_{EH}	Application
Strength I (Min)	0.90	1.00	1.75	1.5	Sliding & overturning
Strength I (Max)	1.25	1.35	1.75	1.5	Bearing & wall strength
Service I	1.00	1.00	1.00	1.00	Wall crack control

II. OUTPUT

Enter 1 for using Rankine horizontal back fill, otherwise enter 0		1		
Angle of B.F. of Wall to Horizontal (degree)		90.00	Not Submergence	Submergence
Active Fluid Weight (Coefficient and pcf), (Ka)		0.41	51.53	25.81
Passive Fluid Weight (Coefficient and pcf)		3.54	442.14	221.42

h1 = 4.08 a = 9.83 H = 7.83

h2 = 2.83 b = 7.33 0.4H = 3.13

Base Width (ft) = 6.83 0.4H to 0.6H 0.6H = 4.70

Adjust Fluid Weight 1 Trial to match provided (Ka) from Geology Unit

Unactored Horizontal Loads

Loads	Force (K)	Mo. Arm	Moment
Ph1 =	1.08	5.28	5.68
Ph2 =	0.94	1.50	1.42
Ph3 =	0.10	1.00	0.10
Ph,water =	0.28	1.00	0.28
Ph,sc =	0.76	3.67	2.77
	3.16		**10.25**

Unfactored Vertical Loads

Loads	Force (K)	Mo. Arm	Moment
W1 =	0.81	1.42	1.15
W2 =	0.13	0.34	0.04
W3 =	1.37	3.42	4.67
W4 =	3.75	4.33	16.25
W5 =	0.78	5.17	4.04
Pv1 =	0.54	6.83	3.68
Pv2 =	0.64	6.83	4.35
Pv3 =	0.06	6.83	0.41
	8.07		**34.59**

Unfactored Sliding Resistance from Shear Key (Horizontal)

Loads	Force (K)
P_p =	1.23

Factored Loads and Moments

Load Combination	vertical Loads V (K)	Moment M_V (K.Ft)	Horiz. Loads V (K)	Moment M_H (K.Ft)
Strength I (Min)	8.46	38.22	4.74	16.07
Strength I (Max)	10.85	47.37	4.74	16.07
Service I	8.07	34.59	3.16	10.25

III. CHECK OVER TURNING

1. CHECK OVERTURNING FOR FOUNDATION RESTS ON SOIL: **YES**

E_{max} = 1.71 ft.

x_r = 2.62 ft. (LOCATION OF RESULTANT FROM THE TOE)

Actual e = 0.80 ft. **GOOD**

2. CHECK OVERTURNING FOR FOUNDATION RESTS ON ROCK: **NO**

E_{max} = N/A ft.

x_r = N/A ft. (LOCATION OF RESULTANT FROM THE TOE)

Actual e = N/A ft.

IV. CHECK BEARING

Actual e = 0.53 ft.

Bearing Resistance = 2.86 ksf

1. CHECK BEARING FOR FOUNDATION RESTS ON SOIL: **YES**

Vertical Sress (Uniform) = 1.88 ksf **GOOD**

2. CHECK BEARING FOR FOUNDATION RESTS ON ROCK: **NO**

Vert. Sress (max.) = N/A ksf

Vert. Sress (min.) = N/A ksf

V. CHECK SLIDING

Friction Resistance = 4.88 k

Factored Sliding Force = 4.74 k

Sliding Resistance = 4.52 k **GOOD**

VI. ULTIMATE LOADS

Unactored Horizontal Loads on Stem

Loads	Force (K)	Mo. Arm	Moment
Ph1 =	1.08	3.94	4.24
Ph2 =	0.42	0.83	0.35
Ph3 =	0.03	0.56	0.02
Ph,water =	0.09	0.56	0.05
Ph,sc =	0.62	3.00	1.86
	2.24		**6.52**

Unfactored Vertical Loads behind Stem

Loads	Force (K)	Mo. Arm	Moment
W3 =	1.00	2.50	2.50
W4 =	3.75	2.50	9.38
W5 =	0.78	3.33	2.60
Pv1 =	0.54	5.00	2.69
Pv2 =	0.29	5.00	1.43
Pv3 =	0.02	5.00	0.09
	6.37		**18.69**

Ultimate Loads

Load Combination	Strength I (Max)		Service I	
	V (K)	M (K.Ft)	V (K)	M (K.Ft)
Toe	1.88	0.94	N/A	N/A
Heel	8.63	25.61	N/A	N/A
Stem	3.51	10.24	2.24	6.52

For conservative the ultimate shear at toe is calculated at front face of wall.

VII. DESIGN FOOTING FOR SHEARS

$Clr_{Top\ Footing}$ =	2	in	$Spacing_{Top}$ =	11	in
$Clr_{Bottom\ Footing}$ =	3	in	$Spacing_{Bottom}$ =	11	in
Top bar Diameter =	0.75	in	β =	2	
Bottom bar Diameter =	0.625	in	ϕ_{shear} =	0.9	

1. HEEL

$d_{s\ Heel}$ =	13.621	in	$A_{s\ Top}$ =	0.48	in^2
a_{Heel} =	0.63	in			
$d_{v\ Heel}$ =	13.31	in			
$V_{R\ Heel}$ =	19.27	k	>	8.63	k GOOD

2. TOE

$d_{s\ Toe}$ =	12.6835	in	$A_{s\ Bottom}$ =	0.33	in^2
a_{Toe} =	0.44	in			
$d_{v\ Toe}$ =	12.46	in			
$V_{R\ Toe}$ =	18.05	k	>	1.88	k GOOD

VIII. DESIGN FOOTING FOR BENDINGS

Use sheet 2 (Heel Bending) for the heel bending design — OK

Use sheet 3 (Toe Bending) for the Toe bending design — OK

IX. DESIGN STEM FOR SHEAR

$Clr_{Back\ Stem}$ =	2	in			
Bar Diameter at Stem =	0.625	in	S_x =	7.46	in
Spacing =	11	in	$A_{s\ Stem}$ =	0.33	in^2
$d_{s\ Stem}$ =	7.68	in	ε_s =	0.002057517	
a_{Stem} =	0.44	in	S_{xe} =	12	in
$d_{v\ Stem}$ =	7.46	in	β =	1.89	
$V_{R\ Stem}$ =	10.20	k	>	3.51	k GOOD

X. DESIGN STEM FOR BENDING

Use sheet 4 (Stem Bending) for the stem bending design — OK

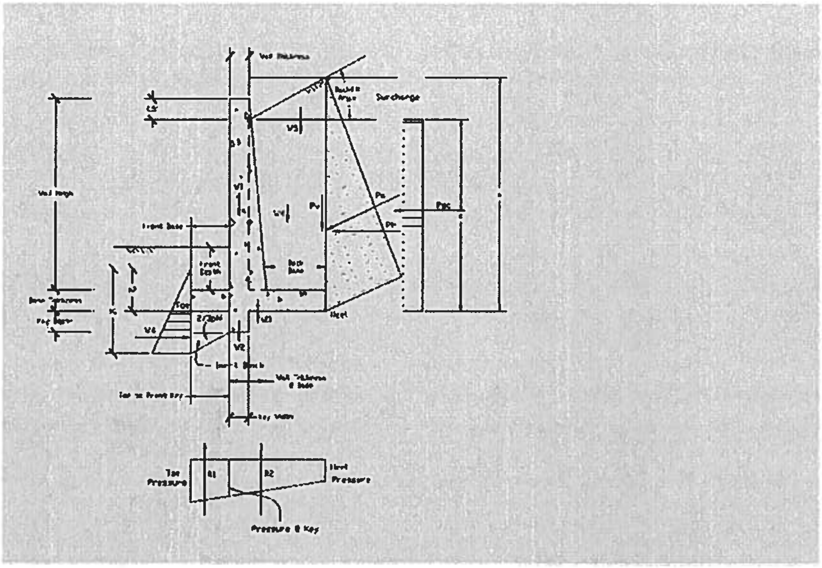
Check control of cracking by distribution of reinforcement (5.7.3.4)

Service Mu =	6.52	k.ft	
f_{ss} =	31.31	ksi	
d_c =	2.31	in	
β_s =	1.33		
S <=	12.18	in	GOOD

SUMMARY OF CONCRETE DESIGN

	BAR DIA. (IN)	SPACING (IN)	COVER (IN)
FOOTING TOP MAT	0.75	11	2
FOOTING BOTTOM MAT	0.625	11	3
STEM	0.625	11	2

LRFD DESIGN FOR CIP RETAINING WALL B-16-H (NORTH WALL)
AUTHOR: BUI, HOANG
Oct-12 DESIGN HEIGHT 7'



I. INPUT (ENGLISH)

Concrete Density (pcf)	150.00			
Soil Density (pcf)	125.00			
Backfill Slope β (by degree)	26.57			
Internal Friction Angle of Backfill Soil ϕ	34.00			
Internal Friction Angle of Soil at Foundation ϕ	30.00			
Friction Angle between Fill and Wall δ (*)	30.00	(*) Table 3.11.5.3-1		
Surcharge in Feet	2.00			
Water depth behind wall, from bottom base (ft)	3.5			
Top Wall to Backfill Depth (ft)	0.50			
Height from Top Base to Top Wall (ft)	7.50			
Top wall Thickness (ft)	0.83	H = TOP OF WALL TO BOTTOM OF BASE		
Wall Thickness @ Base (ft)	0.83	H/12 to H/10	0.74	0.88
Front Base Length (ft)	1.00	H/10 TO H/8	0.8833	1.10
Back Base Length (ft)	6.00			
Base Thickness (ft)	1.33	H/12 to H/10		
Shear Key Depth (ft)	1.25			
Shear Key Width (ft)	0.67			
Distance from Toe to Key (ft)	0.00			
Front Soil Depth to Base (ft)	1.50			
Enter 1 for rock foundation, 0 for soil	0.00			
f'c (psi) = 4500 fy (psi)=	60000.00			
Utimate Foundation Bearing (ksf) =	5.30			
Bearing Resistance Factor (**)	0.55	(**) Table 10.5.5.2.2-1		
Sliding Resistance Factor (Concrete on Soil) (**)	0.80	(**) Table 10.5.5.2.2-1		
Sliding Resistance Factor (Soil on Soil) (**)	0.90	(**) Table 10.5.5.2.2-1		

Table 10.5.5.2.2-1 Resistance Factors for Geotechnical Resistance of Shallow Foundations at Strength Limit State

Method / Soil / Condition			Resistance Factor
Bearing Resistance	ϕ_b	Theoretical Method (Munfakh et al., 2001), in clay	0.50
		Theoretical Method (Munfakh et al., 2001), in sand, using CPT	0.50
		Theoretical Method (Munfakh et al., 2001), in sand, using SPT	0.45
		Semi-empirical methods (Meyerhof, 1957), all soils	0.45
		Footing on rock	0.45
		Plate Load Test	0.55
Sliding	ϕ_τ	Precast concrete placed on sand	0.90
		Cast-in Place Concrete on sand	0.80
		Cast-in-Place or precast Concrete on clay	0.85
		Soil on soil	0.90
	ϕ_{ep}	Passive earth pressure component of sliding resistance	0.50

LOAD FACTORS

Load Combination	γ_{DC}	γ_{EV}	γ_{LS}	γ_{EH}	Application
Strength I (Min)	0.90	1.00	1.75	1.5	Sliding & overturning
Strength I (Max)	1.25	1.35	1.75	1.5	Bearing & wall strength
Service I	1.00	1.00	1.00	1.00	Wall crack control

II. OUTPUT

Enter 1 for using Rankine horizontal back fill, otherwise enter 0		1			
Angle of B.F. of Wall to Horizontal (degree)		90.00	Not Submergence	Submergence	
Active Fluid Weight (Coefficient and pcf), (Ka)		0.412	51.53	25.81	
Passive Fluid Weight (Coefficient and pcf)		3.54	442.14	221.42	
h1 = 4.08	a =	11.33			H = 8.83
h2 = 2.83	b =	8.33			0.4H = 3.53
	Base Width (ft) =	7.83	0.4H to 0.6H		0.6H = 5.30
			Adjust Fluid Weight	1	Trial to match provided (Ka) from Geology Unit

Unactored Horizontal Loads

Loads	Force (K)	Mo. Arm	Moment
Ph1 =	1.41	6.11	8.64
Ph2 =	1.26	1.75	2.21
Ph3 =	0.14	1.17	0.16
Ph,water =	0.38	1.17	0.45
Ph,sc =	0.86	4.17	3.58
	4.06		**15.04**

Unfactored Vertical Loads

Loads	Force (K)	Mo. Arm	Moment
W1 =	0.94	1.42	1.33
W2 =	0.13	0.34	0.04
W3 =	1.57	3.92	6.13
W4 =	5.25	4.83	25.37
W5 =	1.12	5.83	6.56
Pv1 =	0.71	7.83	5.54
Pv2 =	0.85	7.83	6.68
Pv3 =	0.08	7.83	0.64
	10.64		**52.29**

Unfactored Sliding Resistance from Shear Key (Horizontal)

Loads	Force (K)
P_p =	1.23

Factored Loads and Moments

Load Combination	vertical Loads V (K)	Moment M_V (K.Ft)	Horiz. Loads V (K)	Moment M_H (K.Ft)
Strength I (Min)	11.20	57.97	6.09	23.46
Strength I (Max)	14.35	71.77	6.09	23.46
Service I	10.64	52.29	4.06	15.04

III. CHECK OVER TURNING

1. CHECK OVERTURNING FOR FOUNDATION RESTS ON SOIL: **YES**

E_{max} = 1.96 ft.

x_r = 3.08 ft. (LOCATION OF RESULTANT FROM THE TOE)

Actual e = 0.84 ft. **GOOD**

2. CHECK OVERTURNING FOR FOUNDATION RESTS ON ROCK: **NO**

E_{max} = N/A ft.

x_r = N/A ft. (LOCATION OF RESULTANT FROM THE TOE)

Actual e = N/A ft.

IV. CHECK BEARING

Actual e = 0.55 ft.

Bearing Resistance = 2.915 ksf

1. CHECK BEARING FOR FOUNDATION RESTS ON SOIL: **YES**

Vertical Sress (Uniform) = 2.13 ksf **GOOD**

2. CHECK BEARING FOR FOUNDATION RESTS ON ROCK: **NO**

Vert. Sress (max.) = N/A ksf

Vert. Sress (min.) = N/A ksf

V. CHECK SLIDING

Friction Resistance = 6.47 k

Factored Sliding Force = 6.09 k

Sliding Resistance = 5.79 k **GOOD**

VI. ULTIMATE LOADS

Unactored Horizontal Loads on Stem

Loads	Force (K)	Mo. Arm	Moment
Ph1 =	1.41	4.78	6.76
Ph2 =	0.65	1.08	0.70
Ph3 =	0.05	0.72	0.04
Ph,water =	0.15	0.72	0.11
Ph,sc =	0.72	3.50	2.53
	2.99		10.13

Unfactored Vertical Loads behind Stem

Loads	Force (K)	Mo. Arm	Moment
W3 =	1.20	3.00	3.60
W4 =	5.25	3.00	15.75
W5 =	1.12	4.00	4.50
Pv1 =	0.71	6.00	4.24
Pv2 =	0.44	6.00	2.63
Pv3 =	0.03	6.00	0.19
	8.75		30.91

Ultimate Loads

Load Combination	Strength I (Max)		Service I	
	V (K)	M (K.Ft)	V (K)	M (K.Ft)
Toe	2.13	1.07	N/A	N/A
Heel	11.87	42.42	N/A	N/A
Stem	4.66	15.83	2.99	10.13

For conservative the ultimate shear at toe is calculated at front face of wall.

VII. DESIGN FOOTING FOR SHEARS

$Clr_{Top\ Footing}$ =	2	in	$Spacing_{Top}$ =	9	in
$Clr_{Bottom\ Footing}$ =	3	in	$Spacing_{Bottom}$ =	9	in
Top bar Diameter =	0.875	in	β =	2	
Bottom bar Diameter =	0.75	in	ϕ_{shear} =	0.9	

1. HEEL

$d_{s\ Heel}$ =	13.5585	in	$A_{s\ Top}$ =	0.80	in^2
a_{Heel} =	1.05	in			
$d_{v\ Heel}$ =	13.03	in			
$V_{R\ Heel}$ =	18.87	k	>	11.87	k GOOD

2. TOE

$d_{s\ Toe}$ =	12.621	in	$A_{s\ Bottom}$ =	0.59	in^2
a_{Toe} =	0.77	in			
$d_{v\ Toe}$ =	12.24	in			
$V_{R\ Toe}$ =	17.72	k	>	2.13	k GOOD

VIII. DESIGN FOOTING FOR BENDINGS

Use sheet 2 (Heel Bending) for the heel bending design — OK

Use sheet 3 (Toe Bending) for the Toe bending design — OK

IX. DESIGN STEM FOR SHEAR

$Clr_{Back\ Stem}$ =	2	in			
Bar Diameter at Stem =	0.75	in	S_x =	7.24	in
Spacing =	9	in	$A_{s\ Stem}$ =	0.59	in^2
$d_{s\ Stem}$ =	7.62	in	ε_s =	0.001809024	
a_{Stem} =	0.77	in	S_{xe} =	12	in
$d_{v\ Stem}$ =	7.24	in	β =	2.04	
$V_{R\ Stem}$ =	10.67	k	>	4.66	k GOOD

X. DESIGN STEM FOR BENDING

Use sheet 4 (Stem Bending) for the stem bending design — OK

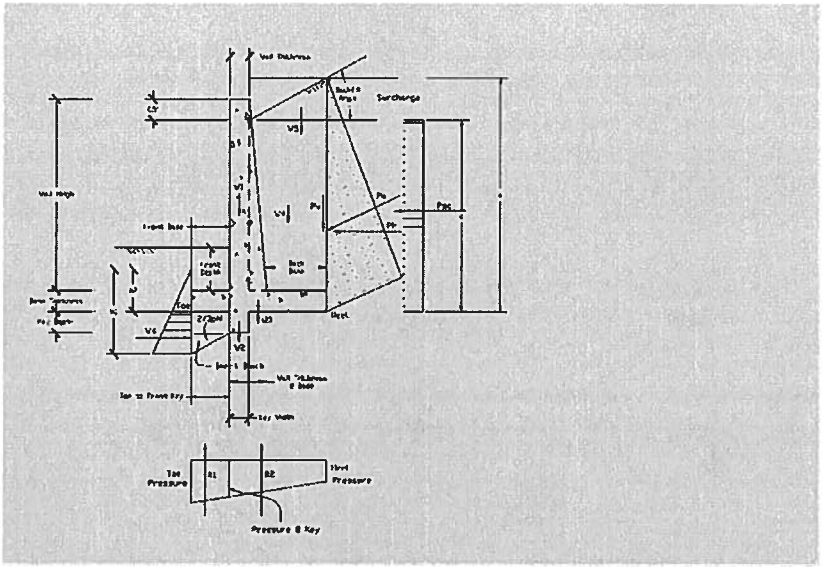
Check control of cracking by distribution of reinforcement (5.7.3.4)

Service Mu =	10.13	k.ft	
f_{ss} =	28.52	ksi	
d_c =	2.38	in	
β_s =	1.34		
S <=	13.58	in	GOOD

SUMMARY OF CONCRETE DESIGN

	BAR DIA. (IN)	SPACING (IN)	COVER (IN)
FOOTING TOP MAT	0.875	9	2
FOOTING BOTTOM MAT	0.75	9	3
STEM	0.75	9	2

LRFD DESIGN FOR CIP RETAINING WALL B-16-H (NORTH WALL)
AUTHOR: BUI, HOANG
Oct-12 DESIGN HEIGHT 8'



I. INPUT (ENGLISH)

Concrete Density (pcf)	150.00	
Soil Density (pcf)	125.00	
Backfill Slope β (by degree)	26.57	
Internal Friction Angle of Backfill Soil ϕ	34.00	
Internal Friction Angle of Soil at Foundation ϕ	30.00	
Friction Angle between Fill and Wall δ (*)	30.00	(*) Table 3.11.5.3-1
Surcharge in Feet	2.00	
Water depth behind wall, from bottom base (ft)	4.0	
Top Wall to Backfill Depth (ft)	0.50	
Height from Top Base to Top Wall (ft)	8.50	
Top wall Thickness (ft)	0.83	H = TOP OF WALL TO BOTTOM OF BASE
Wall Thickness @ Base (ft)	0.83	H/12 to H/10 0.82 0.98
Front Base Length (ft)	1.00	H/10 TO H/8 0.9833 1.23
Back Base Length (ft)	7.00	
Base Thickness (ft)	1.33	H/12 to H/10
Shear Key Depth (ft)	1.25	
Shear Key Width (ft)	0.67	
Distance from Toe to Key (ft)	0.00	
Front Soil Depth to Base (ft)	1.50	
Enter 1 for rock foundation, 0 for soil	0.00	
f'c (psi) = 4500 fy (psi)=	60000.00	
Ultimate Foundation Bearing (ksf) =	5.30	
Bearing Resistance Factor (**)	0.55	(**) Table 10.5.5.2.2-1
Sliding Resistance Factor (Concrete on Soil) (**)	0.80	(**) Table 10.5.5.2.2-1
Sliding Resistance Factor (Soil on Soil) (**)	0.90	(**) Table 10.5.5.2.2-1

Table 10.5.5.2.2-1 Resistance Factors for Geotechnical Resistance of Shallow Foundations at Strength Limit State

Method / Soil / Condition			Resistance Factor
Bearing Resistance	ϕ_b	Theoretical Method (Munfakh et al., 2001), in clay	0.50
		Theoretical Method (Munfakh et al., 2001), in sand, using CPT	0.50
		Theoretical Method (Munfakh et al., 2001), in sand, using SPT	0.45
		Semi-empirical methods (Meyerhof, 1957), all soils	0.45
		Footing on rock	0.45
		Plate Load Test	0.55
Sliding	ϕ_τ	Precast concrete placed on sand	0.90
		Cast-in Place Concrete on sand	0.80
		Cast-in-Place or precast Concrete on clay	0.85
		Soil on soil	0.90
	ϕ_{ep}	Passive earth pressure component of sliding resistance	0.50

52/61

LOAD FACTORS

Load Combination	γ_{DC}	γ_{EV}	γ_{LS}	γ_{EH}	Application
Strength I (Min)	0.90	1.00	1.75	1.5	Sliding & overturning
Strength I (Max)	1.25	1.35	1.75	1.5	Bearing & wall strength
Service I	1.00	1.00	1.00	1.00	Wall crack control

II. OUTPUT

Enter 1 for using Rankine horizontal back fill, otherwise enter 0	1		
Angle of B.F. of Wall to Horizontal (degree)	90.00	Not Submergence	Submergence
Active Fluid Weight (Coefficient and pcf), (Ka)	0.412	51.53	25.81
Passive Fluid Weight (Coefficient and pcf)	3.54	442.14	221.42

h1 = 4.08 a = 12.83 H = 9.83

h2 = 2.83 b = 9.33 0.4H = 3.93

Base Width (ft) = 8.83 0.4H to 0.6H 0.6H = 5.90

Adjust Fluid Weight 1 Trial to match provided (Ka) from Geology Unit

Unactored Horizontal Loads

Loads	Force (K)	Mo. Arm	Moment
Ph1 =	1.80	6.94	12.49
Ph2 =	1.63	2.00	3.26
Ph3 =	0.18	1.33	0.25
Ph,water =	0.50	1.33	0.67
Ph,sc =	0.96	4.67	4.49
	5.07		21.14

Unfactored Vertical Loads

Loads	Force (K)	Mo. Arm	Moment
W1 =	1.06	1.42	1.51
W2 =	0.13	0.34	0.04
W3 =	1.77	4.42	7.80
W4 =	7.00	5.33	37.33
W5 =	1.53	6.50	9.95
Pv1 =	0.90	8.83	7.94
Pv2 =	1.10	8.83	9.70
Pv3 =	0.11	8.83	0.94
	13.59		75.22

Unfactored Sliding Resistance from Shear Key (Horizontal)

Loads	Force (K)
P_p =	1.23

Factored Loads and Moments

Load Combination	vertical Loads V (K)	Moment M_V (K.Ft)	Horiz. Loads V (K)	Moment M_H (K.Ft)
Strength I (Min)	14.35	83.58	7.61	32.84
Strength I (Max)	18.37	103.40	7.61	32.84
Service I	13.59	75.22	5.07	21.14

III. CHECK OVER TURNING

1. CHECK OVERTURNING FOR FOUNDATION RESTS ON SOIL: YES

E_{max} = 2.21 ft.

x_r = 3.54 ft. (LOCATION OF RESULTANT FROM THE TOE)

Actual e = 0.88 ft. GOOD

2. CHECK OVERTURNING FOR FOUNDATION RESTS ON ROCK: NO

E_{max} = N/A ft.

x_r = N/A ft. (LOCATION OF RESULTANT FROM THE TOE)

Actual e = N/A ft.

IV. CHECK BEARING

Actual e = 0.57 ft.

Bearing Resistance = 2.915 ksf

1. CHECK BEARING FOR FOUNDATION RESTS ON SOIL: YES

Vertical Sress (Uniform) = 2.39 ksf GOOD

2. CHECK BEARING FOR FOUNDATION RESTS ON ROCK: NO

Vert. Sress (max.) = N/A ksf

Vert. Sress (min.) = N/A ksf

V. CHECK SLIDING

Friction Resistance = 8.28 k

Factored Sliding Force = 7.61 k

Sliding Resistance = 7.24 k GOOD

VI. ULTIMATE LOADS

Unactored Horizontal Loads on Stem

Loads	Force (K)	Mo. Arm	Moment
Ph1 =	1.80	5.61	10.09
Ph2 =	0.92	1.33	1.23
Ph3 =	0.08	0.89	0.07
Ph,water =	0.22	0.89	0.20
Ph,sc =	0.82	4.00	3.30
	3.85		14.89

Unfactored Vertical Loads behind Stem

Loads	Force (K)	Mo. Arm	Moment
W3 =	1.40	3.50	4.90
W4 =	7.00	3.50	24.50
W5 =	1.53	4.67	7.15
Pv1 =	0.90	7.00	6.29
Pv2 =	0.62	7.00	4.35
Pv3 =	0.05	7.00	0.33
	11.50		47.52

Ultimate Loads

Load Combination	Strength I (Max)		Service I	
	V (K)	M (K.Ft)	V (K)	M (K.Ft)
Toe	2.39	1.20	N/A	N/A
Heel	15.62	65.31	N/A	N/A
Stem	5.98	23.16	3.85	14.89

For conservative the ultimate shear at toe is calculated at front face of wall.

VII. DESIGN FOOTING FOR SHEARS

$Clr_{Top\ Footing}$ =	2	in	$Spacing_{Top}$ =	7	in
$Clr_{Bottom\ Footing}$ =	3	in	$Spacing_{Bottom}$ =	7	in
Top bar Diameter =	1	in	β =	2	
Bottom bar Diameter =	0.75	in	ϕ_{shear} =	0.9	

1. HEEL

$d_{s\ Heel}$ =	13.496	in	$A_{s\ Top}$ =	1.35	in^2
a_{Heel} =	1.76	in			
$d_{v\ Heel}$ =	12.62	in			
$V_{R\ Heel}$ =	18.27	k	>	15.62	k GOOD

2. TOE

$d_{s\ Toe}$ =	12.621	in	$A_{s\ Bottom}$ =	0.76	in^2
a_{Toe} =	0.99	in			
$d_{v\ Toe}$ =	12.13	in			
$V_{R\ Toe}$ =	17.56	k	>	2.39	k GOOD

VIII. DESIGN FOOTING FOR BENDINGS

Use sheet 2 (Heel Bending) for the heel bending design — OK

Use sheet 3 (Toe Bending) for the Toe bending design — OK

IX. DESIGN STEM FOR SHEAR

$Clr_{Back\ Stem}$ =	2	in			
Bar Diameter at Stem =	0.75	in	S_x =	7.20	in
Spacing =	7	in	$A_{s\ Stem}$ =	0.76	in^2
$d_{s\ Stem}$ =	7.62	in	ε_s =	0.002029406	
a_{Stem} =	0.99	in	S_{xe} =	12	in
$d_{v\ Stem}$ =	7.20	in	β =	1.90	
$V_{R\ Stem}$ =	9.92	k	>	5.98	k GOOD

X. DESIGN STEM FOR BENDING

Use sheet 4 (Stem Bending) for the stem bending design — OK

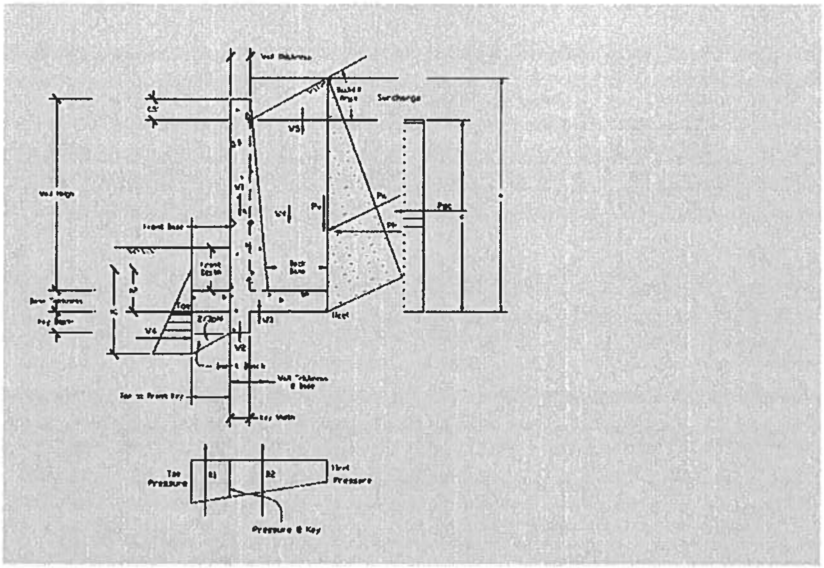
Check control of cracking by distribution of reinforcement (5.7.3.4)

Service Mu =	14.89	k.ft	
f_{ss} =	32.76	ksi	
d_c =	2.38	in	
β_s =	1.34		
S <=	11.20	in	GOOD

SUMMARY OF CONCRETE DESIGN

	BAR DIA. (IN)	SPACING (IN)	COVER (IN)
FOOTING TOP MAT	1	7	2
FOOTING BOTTOM MAT	0.75	7	3
STEM	0.75	7	2

LRFD DESIGN FOR CIP RETAINING WALL B-16-H (NORTH WALL)
AUTHOR: BUI, HOANG
Oct-12 DESIGN HEIGHT 9'



I. INPUT (ENGLISH)

Concrete Density (pcf)	150.00	
Soil Density (pcf)	125.00	
Backfill Slope β (by degree)	26.57	
Internal Friction Angle of Backfill Soil ϕ	34.00	
Internal Friction Angle of Soil at Foundation ϕ	30.00	
Friction Angle between Fill and Wall δ (*)	30.00	(*) Table 3.11.5.3-1
Surcharge in Feet	2.00	
Water depth behind wall, from bottom base (ft)	2.9	only 1/3 of the wall height is submerged in 500yr. Scour
Top Wall to Backfill Depth (ft)	0.50	
Height from Top Base to Top Wall (ft)	9.25	Maximum wall height is 8'-9"
Top wall Thickness (ft)	0.83	H = TOP OF WALL TO BOTTOM OF BASE
Wall Thickness @ Base (ft)	0.83	H/12 to H/10 0.88 1.06
Front Base Length (ft)	1.00	H/10 TO H/8 1.0583 1.32
Back Base Length (ft)	7.66	
Base Thickness (ft)	1.33	H/12 to H/10
Shear Key Depth (ft)	1.25	
Shear Key Width (ft)	0.67	
Distance from Toe to Key (ft)	0.00	
Front Soil Depth to Base (ft)	1.50	
Enter 1 for rock foundation, 0 for soil	0.00	
f'c (psi) = 4500 fy (psi)=	60000.00	
Ultimate Foundation Bearing (ksf) =	7.18	
Bearing Resistance Factor (**)	0.55	(**) Table 10.5.5.2.2-1
Sliding Resistance Factor (Concrete on Soil) (**)	0.80	(**) Table 10.5.5.2.2-1
Sliding Resistance Factor (Soil on Soil) (**)	0.90	(**) Table 10.5.5.2.2-1

Table 10.5.5.2.2-1 Resistance Factors for Geotechnical Resistance of Shallow Foundations at Strength Limit State

Method / Soil / Condition			Resistance Factor
Bearing Resistance	ϕ_b	Theoretical Method (Munfakh et al., 2001), in clay	0.50
		Theoretical Method (Munfakh et al., 2001), in sand, using CPT	0.50
		Theoretical Method (Munfakh et al., 2001), in sand, using SPT	0.45
		Semi-empirical methods (Meyerhof, 1957), all soils	0.45
		Footing on rock	0.45
		Plate Load Test	0.55
Sliding	ϕ_τ	Precast concrete placed on sand	0.90
		Cast-in Place Concrete on sand	0.80
		Cast-in-Place or precast Concrete on clay	0.85
		Soil on soil	0.90
	ϕ_{ep}	Passive earth pressure component of sliding resistance	0.50

LOAD FACTORS

Load Combination	γ_{DC}	γ_{EV}	γ_{LS}	γ_{EH}	Application
Strength I (Min)	0.90	1.00	1.75	1.5	Sliding & overturning
Strength I (Max)	1.25	1.35	1.75	1.5	Bearing & wall strength
Service I	1.00	1.00	1.00	1.00	Wall crack control

II. OUTPUT

Enter 1 for using Rankine horizontal back fill, otherwise enter 0	1			
Angle of B.F. of Wall to Horizontal (degree)	90.00	Not Submergence	Submergence	
Active Fluid Weight (Coefficient and pcf), (Ka)	0.41	51.53	25.81	
Passive Fluid Weight (Coefficient and pcf)	3.54	442.14	221.42	

h1 = 4.08 a = 13.91 H = 10.58

h2 = 2.83 b = 10.08 0.4H = 4.23

Base Width (ft) = 9.49 0.4H to 0.6H 0.6H = 6.35

Adjust Fluid Weight 1 Trial to match provided (Ka) from Geology Unit

Unactored Horizontal Loads

Loads	Force (K)	Mo. Arm	Moment
Ph1 =	2.79	6.58	18.34
Ph2 =	1.48	1.46	2.16
Ph3 =	0.10	0.97	0.10
Ph,water =	0.27	0.97	0.26
Ph,sc =	1.04	5.04	5.24
	5.67		26.09

Unfactored Vertical Loads

Loads	Force (K)	Mo. Arm	Moment
W1 =	1.16	1.42	1.64
W2 =	0.13	0.34	0.04
W3 =	1.90	4.75	9.01
W4 =	8.38	5.66	47.45
W5 =	1.83	6.94	12.73
Pv1 =	1.39	9.49	13.23
Pv2 =	1.00	9.49	9.47
Pv3 =	0.06	9.49	0.54
	15.84		94.09

Unfactored Sliding Resistance from Shear Key (Horizontal)

Loads	Force (K)
P_p =	1.23

Factored Loads and Moments

Load Combination	vertical Loads V (K)	Moment M_V (K.Ft)	Horiz. Loads V (K)	Moment M_H (K.Ft)
Strength I (Min)	16.74	104.64	8.76	40.44
Strength I (Max)	21.43	129.44	8.76	40.44
Service I	15.84	94.09	5.67	26.09

III. CHECK OVER TURNING

1. CHECK OVERTURNING FOR FOUNDATION RESTS ON SOIL: YES

E_{max} = 2.37 ft.

x_r = 3.83 ft. (LOCATION OF RESULTANT FROM THE TOE)

Actual e = 0.91 ft. GOOD

2. CHECK OVERTURNING FOR FOUNDATION RESTS ON ROCK: NO

E_{max} = N/A ft.

x_r = N/A ft. (LOCATION OF RESULTANT FROM THE TOE)

Actual e = N/A ft.

IV. CHECK BEARING

Actual e = 0.59 ft.

Bearing Resistance = 3.949 ksf

1. CHECK BEARING FOR FOUNDATION RESTS ON SOIL: YES

Vertical Sress (Uniform) = 2.58 ksf GOOD

2. CHECK BEARING FOR FOUNDATION RESTS ON ROCK: NO

Vert. Sress (max.) = N/A ksf

Vert. Sress (min.) = N/A ksf

V. CHECK SLIDING

Friction Resistance = 9.67 k

Factored Sliding Force = 8.76 k

Sliding Resistance = 8.35 k GOOD

VI. ULTIMATE LOADS

Unactored Horizontal Loads on Stem

Loads	Force (K)	Mo. Arm	Moment
Ph1 =	2.79	5.25	14.63
Ph2 =	0.71	0.79	0.56
Ph3 =	0.03	0.53	0.02
Ph,water =	0.08	0.53	0.04
Ph,sc =	0.90	4.38	3.95
	4.50		19.19

Unfactored Vertical Loads behind Stem

Loads	Force (K)	Mo. Arm	Moment
W3 =	1.53	3.83	5.87
W4 =	8.38	3.83	32.09
W5 =	1.83	5.11	9.36
Pv1 =	1.39	7.66	10.67
Pv2 =	0.48	7.66	3.64
Pv3 =	0.02	7.66	0.13
	13.63		61.76

Ultimate Loads

Load Combination	Strength I (Max)		Service I	
	V (K)	M (K.Ft)	V (K)	M (K.Ft)
Toe	2.58	1.29	N/A	N/A
Heel	18.53	84.96	N/A	N/A
Stem	6.98	29.77	4.50	19.19

For conservative the ultimate shear at toe is calculated at front face of wall.

VII. DESIGN FOOTING FOR SHEARS

$Clr_{Top\ Footing}$ =	2	in	$Spacing_{Top}$ =	6	in
$Clr_{Bottom\ Footing}$ =	3	in	$Spacing_{Bottom}$ =	6	in
Top bar Diameter =	1	in	β =	2	
Bottom bar Diameter =	0.875	in	ϕ_{shear} =	0.9	

1. HEEL

$d_{s\ Heel}$ =	13.496	in	$A_{s\ Top}$ =	1.57	in^2
a_{Heel} =	2.05	in			
$d_{v\ Heel}$ =	12.47	in			
$V_{R\ Heel}$ =	18.05	k	<	18.53	k GOOD

2. TOE

$d_{s\ Toe}$ =	12.5585	in	$A_{s\ Bottom}$ =	1.20	in^2
a_{Toe} =	1.57	in			
$d_{v\ Toe}$ =	11.77	in			
$V_{R\ Toe}$ =	17.05	k	>	2.58	k GOOD

VIII. DESIGN FOOTING FOR BENDINGS

Use sheet 2 (Heel Bending) for the heel bending design — OK

Use sheet 3 (Toe Bending) for the Toe bending design — OK

IX. DESIGN STEM FOR SHEAR

$Clr_{Back\ Stem}$ =	2	in			
Bar Diameter at Stem =	0.875	in	S_x =	7.20	in
Spacing =	6	in	$A_{s\ Stem}$ =	1.20	in^2
$d_{s\ Stem}$ =	7.56	in	ε_s =	0.001622636	
a_{Stem} =	1.57	in	S_{xe} =	12	in
$d_{v\ Stem}$ =	7.20	in	β =	2.17	
$V_{R\ Stem}$ =	11.29	k	>	6.98	k GOOD

X. DESIGN STEM FOR BENDING

Use sheet 4 (Stem Bending) for the stem bending design — OK

Check control of cracking by distribution of reinforcement (5.7.3.4)

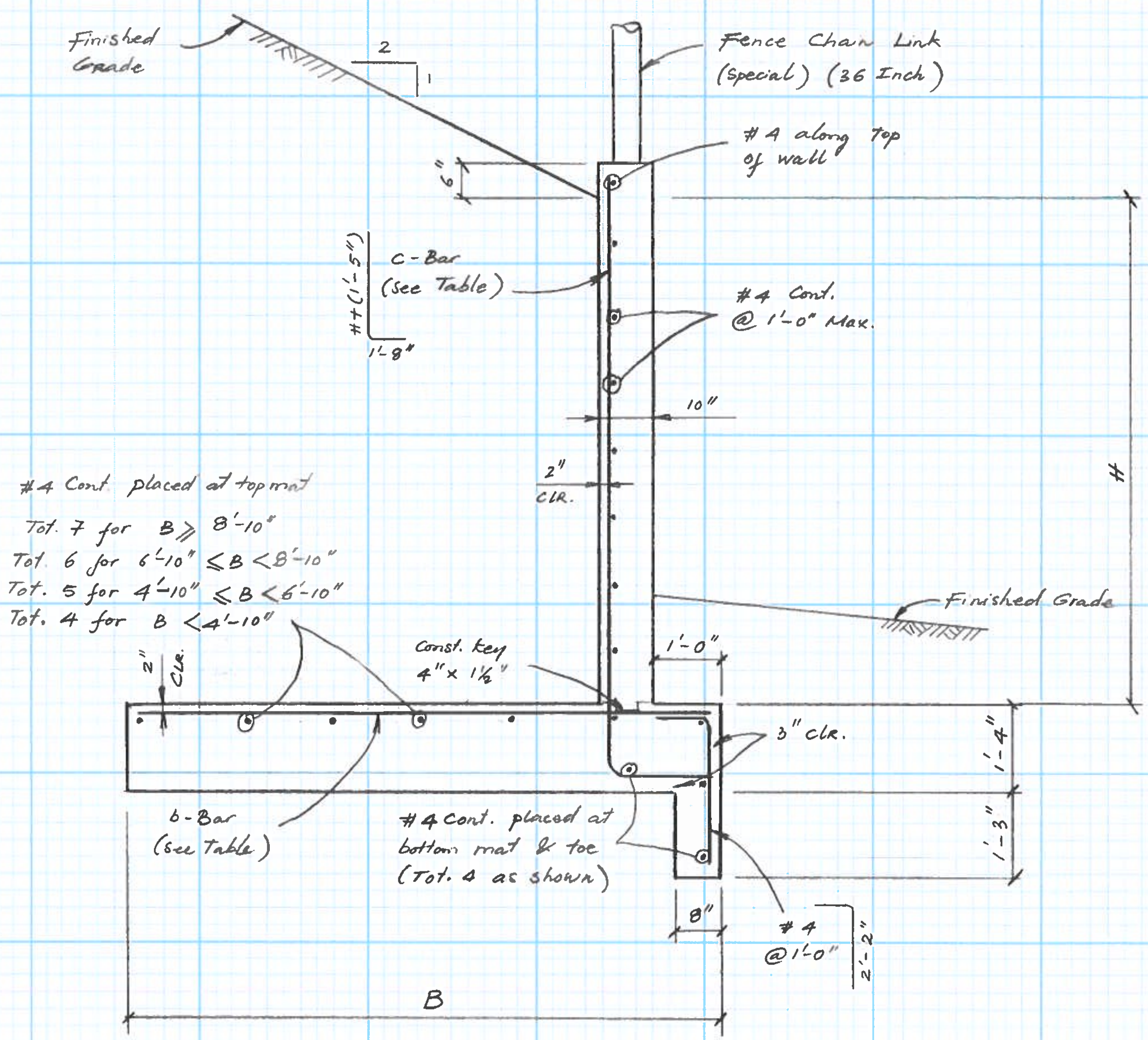
Service Mu =	19.19	k.ft	
f_{ss} =	26.59	ksi	
d_c =	2.44	in	
β_s =	1.35		
S <=	14.65	in	GOOD

SUMMARY OF CONCRETE DESIGN

	BAR DIA. (IN)	SPACING (IN)	COVER (IN)
FOOTING TOP MAT	1	6	2
FOOTING BOTTOM MAT	0.875	6	3
STEM	0.875	6	2

COLORADO DEPARTMENT OF TRANSPORTATION

DESIGN COMPUTATIONS (Grid)



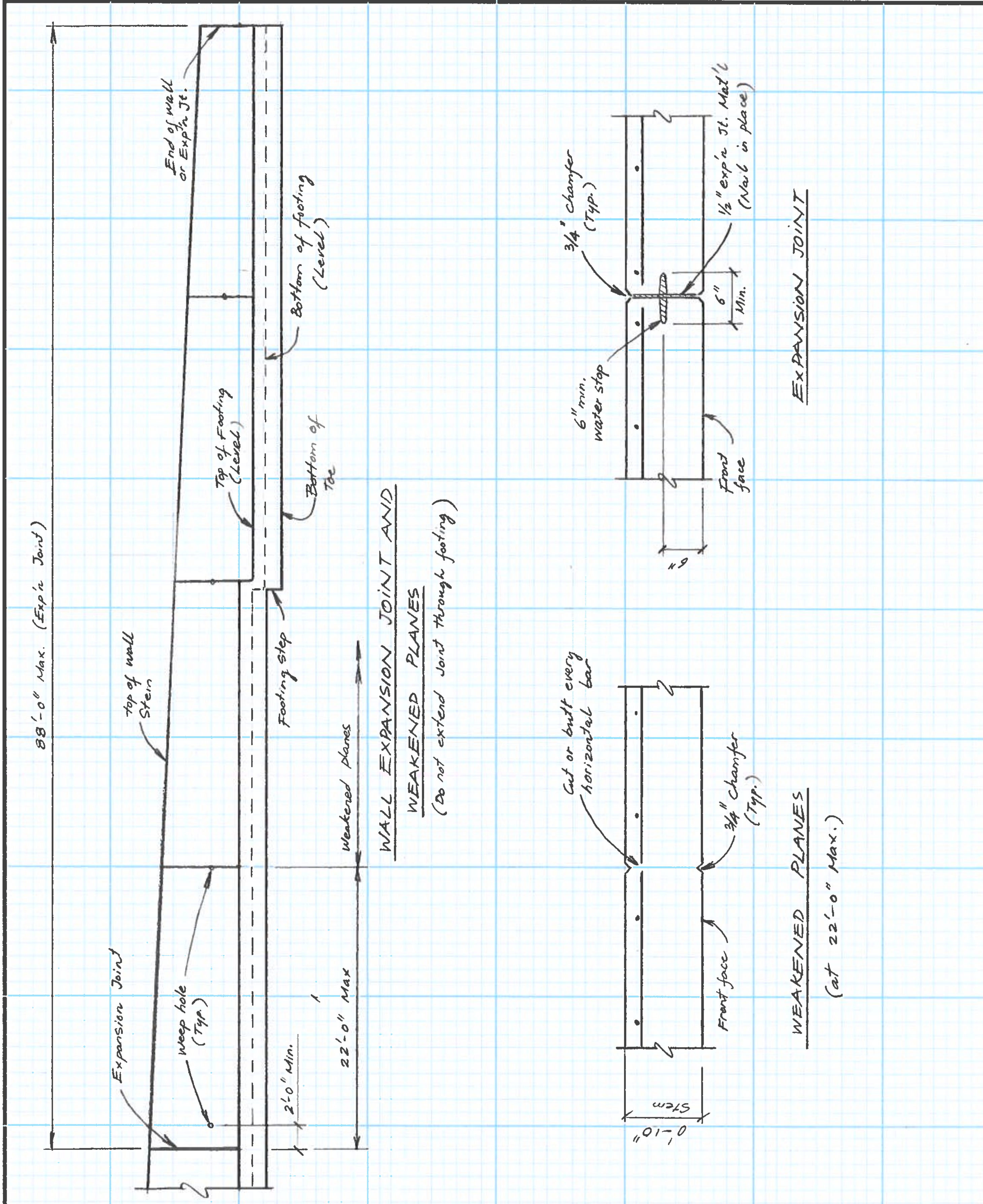
H	B	C- Bar	b- Bar
H < 3	3'-10"	#4 @ 1'-6"	#4 @ 1'-6"
3 ≤ H < 4	4'-10"	#4 @ 1'-4"	#4 @ 1'-4"
4 ≤ H < 5	5'-10"	#6 @ 1'-3"	#5 @ 1'-3"
5 ≤ H < 6	6'-10"	#6 @ 11"	#5 @ 11"
6 ≤ H < 7	7'-10"	#7 @ 9"	#6 @ 9"
7 ≤ H < 8	8'-10"	#8 @ 7"	#6 @ 7"
8 ≤ H < 9	9'-5"	#8 @ 6"	#7 @ 6"

1'-2"

By: HB Date 7/13	Project no. FBR 0142-055		Project code (SA#): 18085
Chk'd: CT Date 8/13	Structure no. Wall-B-16-H (NORTH WALL)		Sheet 58 of 61

COLORADO DEPARTMENT OF TRANSPORTATION

DESIGN COMPUTATIONS (Grid)



By: HB Date 7/13	Project no. FBR 0142-055	Project code (SA#): 18085	
Chk'd: CT Date 8/13	Structure no. Wall - B-16 - G & H	Sheet 59 of 61	

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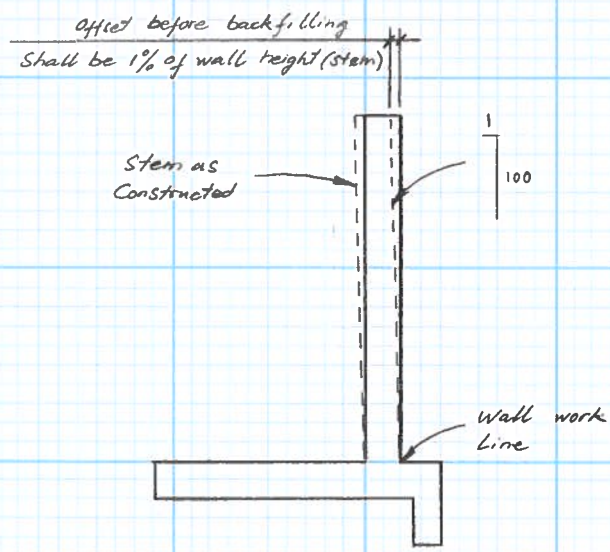
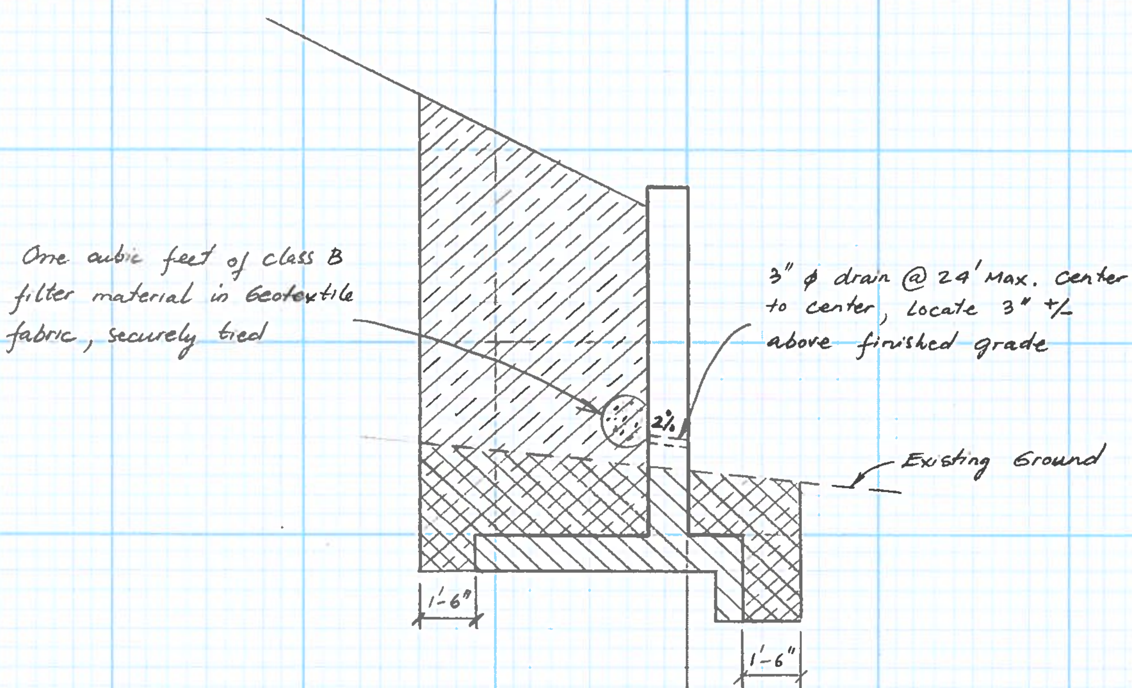


WALL OFFSETS



STRUCTURE EXCAVATION, BACKFILL & DRAIN

Structure Backfill Class 1

Structure Excavation

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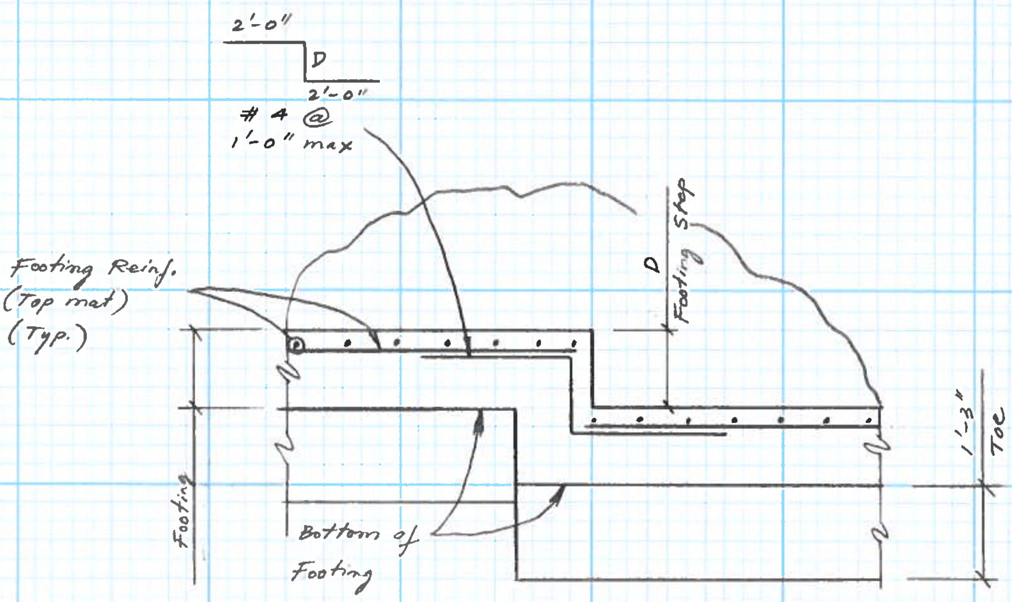

FOOTING STEP DETAIL
(Toe Reinf. not shown for clarity)