Rule High School Athletic Field Renovation

Chancellor's Honors Program Senior Thesis

The University of Tennessee, Knoxville

Nathan Foust

2013

Nathan Foust
Spring 2013

CE 400: Rule High School Athletic Field Renovation
Dr. Jennifer Retherford

Rule High School is located in the north Knoxville neighborhood known as Mechanicsville. It was built in 1927 and occupied until 1990. The school closed and has since been abandoned except for a small section still used by the City of Knoxville. Rule High School sits atop of a hill that boasts some of the best views of downtown Knoxville, and has significant cultural and historical value. The campus includes a 2-story school building and an adjacent football field. It is located in a neighborhood of government and low-income housing, but the Community Design Center (CDC) would like to begin planning to rehabilitate the building and revitalize the area. Our task was to perform and engineering assessment of the campus.

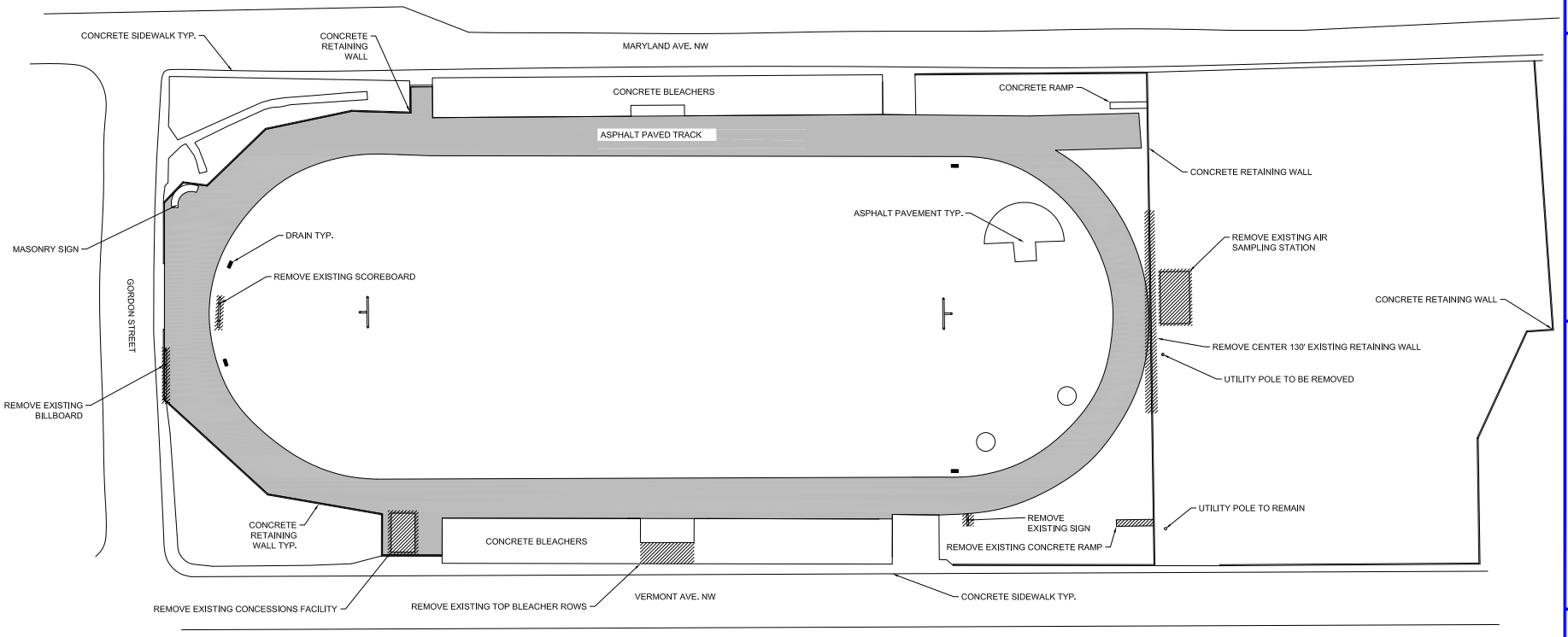
After 23 years of abandonment the school is falling apart in some places and the interior needs to be completely gutted and renovated. However, the structural components of the building seem to be in adequate condition. Because of the significant damage, degradation, and vandalism of the building, as well as the scale of the project, our group chose to propose a renovation of the adjacent football stadium in the hopes of revitalizing the area by providing a public place for recreation and community sports. The site consists of existing concrete bleachers, a concessions facility, asphalt track, and football field.

After a preliminary site visit we identified some key deficiencies of the site that included drainage, access, and structural problems. We divided our group into sub-teams to address each problem and design a solution. The proposed new structures were as follows:

- New drainage system to capture rainwater and runoff to reuse in irrigation
- New retaining wall and pedestrian ramp to provide access from a new parking lot to the site
- New concessions and restroom facility
- New press box and storage structure
- New welcome sign and scoreboard

I was in charge of the site plan, site layout and ultimately a new retaining wall structure. A key component that we wanted to address was ADA (American Disability Act) compatibility in all of our structures. Handicap access does not exist for all elements of the site right now, so we wanted to improve accessibility. We also wanted to allow the site to be used for community recreation leagues by building a press box, new scoreboard, and restroom and concessions facilities. The goal of this project is to give the community a safe, well constructed, and easy to access place for after school recreation and community sports leagues.

Under the direction of Dr. Jennifer Retherford we designed the proposed structures for the site. The following document contains site plan, detail drawings, and calculations for the retaining wall for this project. This new entry way provides access from the new parking lot to the site and makes the site accessible for those with disability by being in compliance with ADA. The reinforced concrete retaining wall dimensions and design is shown and all calculations were performed in accordance with ACI 318 and ASCE 7. I produced all of the material included, and it embodies a complete engineering design. We presented our final design proposal to faculty, staff and students from the Department of Civil Engineering, as well as local practicing engineers on April 24, 2013. Our proposal was very well received and we ultimately received an A for CE 400.



DEMOLITION AND EXISTING SITE PLAN

SCALE: 1" = 30'

SHEET NOTES
1. ITEMS TO BE DEMOLISHED INDICATED AS ▨

RULE OBSERVATION COALITION OF KNOXVILLE

Project:

Rule High School Football Complex

Knoxville ,TN

Customer:

CE 400: Senior Design Project

Drawn By:

Nathan W. Foust

Date:

4/24/13

Sheet:

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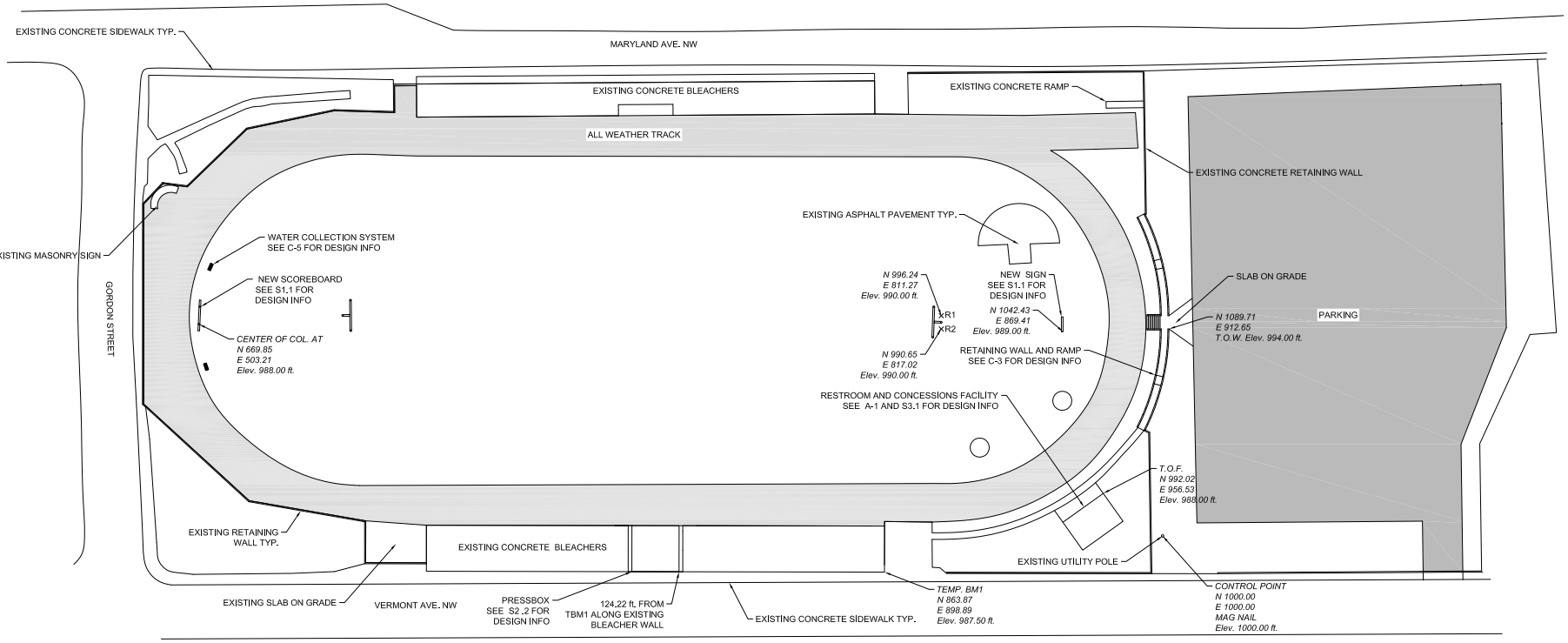

PROPOSED SITE PLAN
SCALE: 1" = 30'

RULE
OBSERVATION
COALITION OF
KNOXVILLE

Project:

Rule High School Football Complex

Knoxville ,TN

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Nathan W. Foust

Date:

4/24/13

Sheet:

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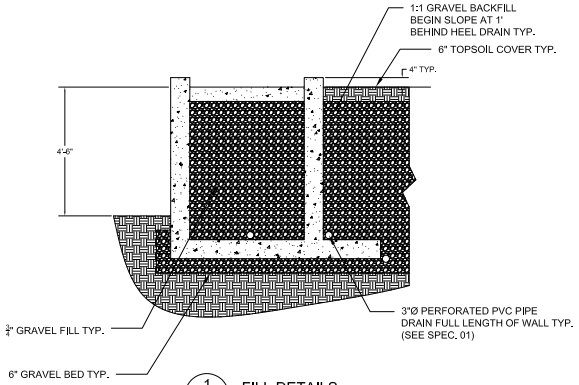
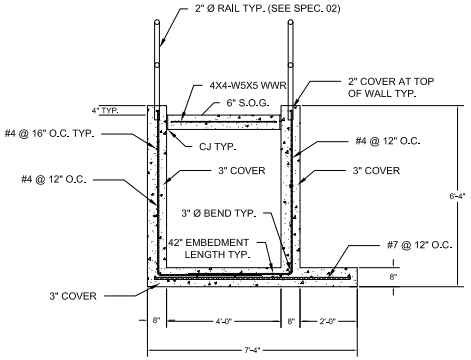
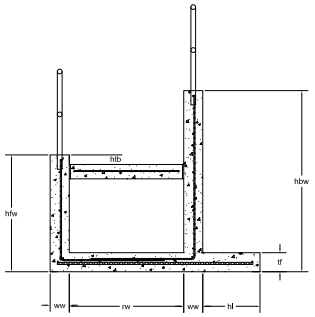


1 C-3 FILL DETAILS
SCALE: 1" = 2'

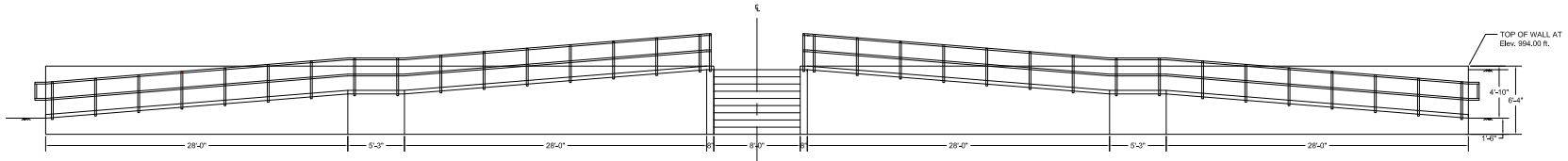


1 C-3 REINFORCEMENT DETAIL
SCALE: 1" = 2'

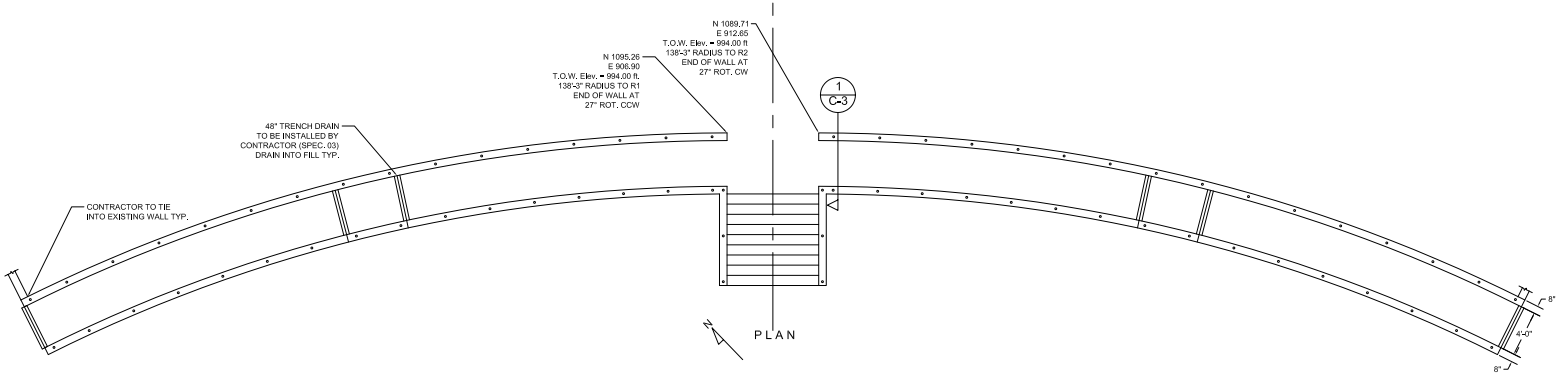


RETAINING WALL DIMENSIONS
SCALE: 1" = 2'

RETAINING WALL DIMENSIONS								
DIST. FROM ℄	hfw	hbw	htb	ww	rw	hl	tf
4'-8"	6'-4"	6'-4"	0'-4"	0'-8"	4'-0"	2'-0"	0'-8"
11'-8"	5'-9"	6'-4"	0'-4"	0'-8"	4'-0"	2'-0"	0'-8"
18'-8"	5'-3"	6'-4"	0'-4"	0'-8"	4'-0"	2'-0"	0'-8"
25'-8"	4'-8"	6'-4"	0'-4"	0'-8"	4'-0"	2'-0"	0'-8"
32'-8"	4'-1"	6'-4"	0'-4"	0'-8"	4'-0"	2'-0"	0'-8"
37'-11"	4'-1"	6'-4"	0'-4"	0'-8"	4'-0"	2'-0"	0'-8"
44'-11"	3'-6"	6'-4"	0'-4"	0'-8"	4'-0"	2'-0"	0'-8"
51'-11"	3'-0"	6'-4"	0'-4"	0'-8"	4'-0"	2'-0"	0'-8"
58'-11"	2'-5"	6'-4"	0'-4"	0'-8"	4'-0"	2'-0"	0'-8"
65'-11"	1'-10"	6'-4"	0'-4"	0'-8"	4'-0"	2'-0"	0'-8"



ELEVATION



PLAN

RETAINING WALL RAMP DETAIL
SCALE: 1" = 5'

SHEET NOTES
1. STRUCTURE SYMMETRIC ABOUT CENTERLINE
2. CONTRACTOR RESPONSIBLE FOR HANDRAIL DESIGN AND INSTALLATION (SEE SPEC. 02)
3. 4000 psi CONCRETE
4. 11" STAIR TREAD, 7" STAIR RISER, CONTRACTOR TO DESIGN STAIR

RULE OBSERVATION COALITION OF KNOXVILLE

Project:
Rule High School Football Complex
Knoxville ,TN

Customer:
CE 400: Senior Design Project

Drawn By:
Nathan W. Foust

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4/24/13

Sheet:
C-3

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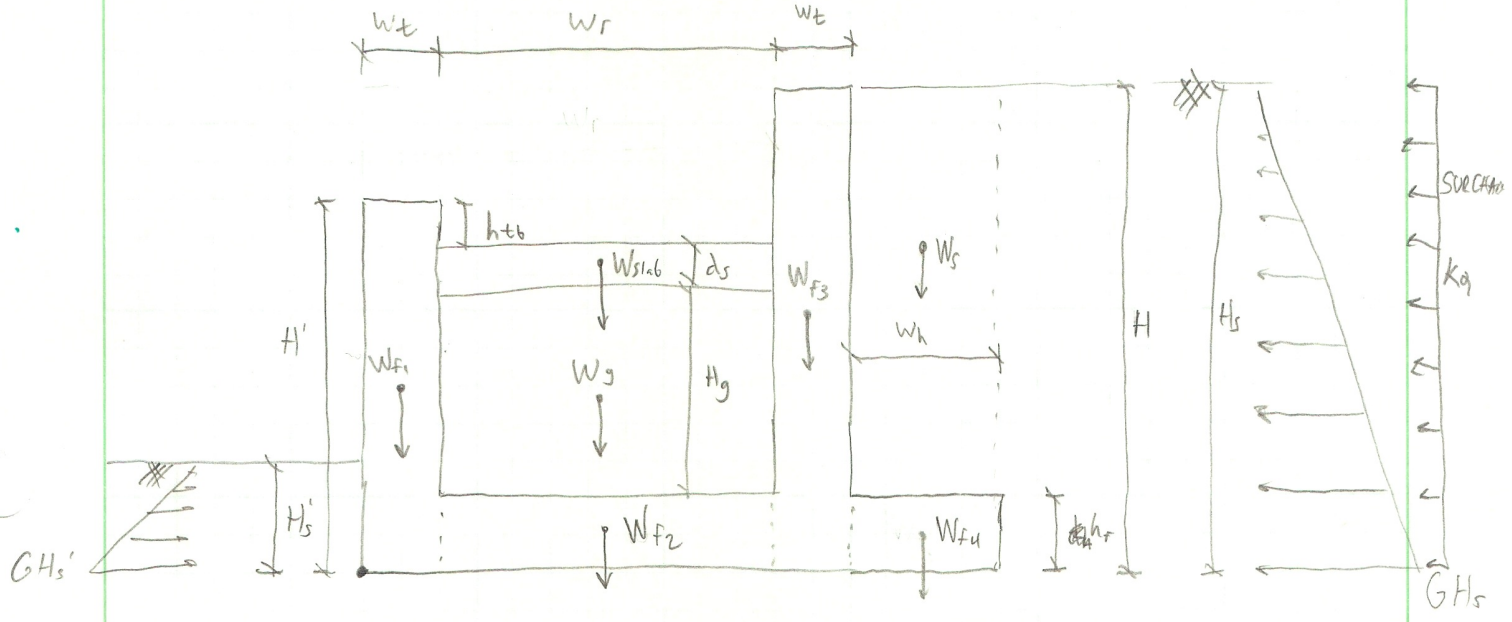
RETAINING WALL
DESIGN CALCULATIONS

RETAINING WALL GEOTECHNICAL DESIGN

* SEE ATTACHED SPREADSHEET



SLIDING) DRIVING = $\frac{1}{2}(GH_s)H_s = \frac{GH_s^2}{2}$.

RESISTING = $\frac{1}{2}(GH'_s)H'_s + (W_{f1} + W_{f2} + W_{f3} + W_{f4} + W_g + W_s + W_{slab})\mu$

OVERTURNING) DRIVING = $\frac{1}{2}(GH_s)(H_s)(\frac{1}{3}H_s) = \frac{GH_s^3}{6}$

RESISTING = $\frac{1}{2}(GH'_s)(H'_s)(\frac{1}{3}H'_s) + W_{f1}(w_t/2) + (W_{f2} + W_g + W_{slab})(w_t + \frac{w_r}{2})$

$+ W_s(\frac{w_t}{2} + w_t + w_r) + (W_s + W_{f4})(\frac{w_h}{2} + 2w_t + w_r)$

$= \frac{GH'^3_s}{6} + \frac{W_{f1}w_t}{2} + (W_{f2} + W_g + W_{slab})(w_t + \frac{w_r}{2}) + W_s(\frac{w_t}{2} + w_t + w_r) + (W_s + W_{f4})(\frac{w_h}{2} + 2w_t + w_r)$

Retaining Wall-Geotechnical Design Calculations

Foust

Section	1	Top of Ramp

Soil and Material Properties

Ys=	110	pcf	unit weight of soil	[Coduto 126]
Yg=	130	pcf	unit weight of gravel	[Coduto 126]
Yc=	150	pcf	unit weight of concrete	
thetas=	28	degrees	soil friction angle	
thetag=	34	degrees	gravel friction angle	
Ksoil=	0.361033		soil coefficient of active earth pressure (Rankine)	
Kgravel=	0.282715		gravel coefficient of active earth pressure (Rankine)	
Gh=	39.71368	pcf	soil equivalent horizontal fluid unit weight	
Gv=	39.71368	pcf	soil equivalent vertical fluid unit weight	[Coduto 776]
Gh=	36.75294	pcf	gravel equivalent horizontal fluid unit weight	
Gv=	36.75294	pcf	gravel equivalent vertical fluid unit weight	
u=	0.35		coefficient of friction	[Coduto 277]

Dimensions

H=	6.33333	ft.	back wall height
H'=	6.33333	ft.	front wall height
Hs=	6	ft.	backfill height
Hs'=	1.5	ft.	frontfill height
hg=	4.833331	ft.	gravel fill height
hf=	0.666666	ft.	footing thickness
htb=	0.333333	ft.	toe board height
wt=	0.666666	ft.	wall width
wr=	4	ft.	ramp width
wh=	2	ft.	heel length
ds=	0.5	ft.	slab thickness

Loads				Moment Arms about Toe
Wf1=	633.3324	lb/ft	footing weight 1	0.333333 ft.
Wf2=	399.9996	lb/ft	footing weight 2	2.666666 ft.
Wf3=	633.3324	lb/ft	footing weight 3	4.999999 ft.
Wf4=	199.9998	lb/ft	footing weight 4	6.333332 ft.
Wg=	2513.332	lb/ft	gravel fill weight	2.666666 ft.
Wslab=	300	lb/ft	slab weight	2.666666 ft.
Ws=	2036.667	lb/ft	backfill weight	6.333332 ft.
q=	250	lb/ft	surcharge load	6.333332 ft.
theta=	70.67873	lb/ft	surcharge pressure	3 ft.
LL=	100	lb/ft	live load	2.666666 ft.
Pa/b=	661.5529	lb/ft	active lateral earth pressure	2 ft.
Va/b=	661.5529	lb/ft	shear earth pressure	6.333332 ft.

Pp/b	44.67789	lb/ft	passive lateral earth pressure	0.5 ft.
Qa/b	424.0724	lb/ft	surcharge lateral earth pressure	3 ft.

Stability [Coduto 276]

Bearing

Pf/b=	1500	psf	allowable bearing capacity	1.416309
W/b=	1059.091	psf	avg. bearing pressure	
W/b=	1348.654	psf	max bearing pressure* from geotechnical load calculator (worst case)	
FS=	3.33666		factor of safety bearing	

Sliding

Vf/b=	2710.51	lb.	resisting forces
Pa/b	1085.625	lb.	driving forces
FS=	2.496727		factor of safety sliding

Overturning

Mr/b	30367.88	lb.-ft./ft.	resisting moments
Md/b	2595.323	lb.-ft./ft.	driving moments
FS=	11.701		factor of safety

* TDOT GEOTECHNICAL MANUAL FOR FS REQUIREMENTS.
SEE REFERENCE pg 20.

Retaining Wall-Geotechnical Design Calculations

Foust

Section	2	Middle Landing

Soil and Material Properties

Ys=	110	pcf	unit weight of soil	[Coduto 126]
Yg=	130	pcf	unit weight of gravel	[Coduto 126]
Yc=	150	pcf	unit weight of concrete	
thetas=	28	degrees	soil friction angle	
thetag=	34	degrees	gravel friction angle	
K=	0.361033		soil coefficient of active earth pressure (Rankine)	
K=	0.282715		gravel coefficient of active earth pressure (Rankine)	
Gh=	39.71368	pcf	soil lequivalent horizontal fluid unit weight	
Gv=	39.71368	pcf	soil equivalent vertical fluid unit weight	[Coduto 776]
Gh=	36.75294	pcf	gravel equivalent horizontal fluid unit weight	
Gv=	36.75294	pcf	gravel equivalent vertical fluid unit weight	
u=	0.35		coefficient of friction	[Coduto 277]

Dimensions

H=	6.33333	ft.	back wall height
H'=	4.04333	ft.	front wall height
Hs=	6	ft.	backfill height
Hs'=	1.5	ft.	frontfill height
hg=	2.54333	ft.	gravel fill height
hf=	0.666667	ft.	footing thickness
htb=	0.333333	ft.	toe board height
wt=	0.666667	ft.	wall width
wr=	4	ft.	ramp width
wh=	2	ft.	heel length
ds=	0.5	ft.	slab thickness

Loads				Moment Arms about Toe
Wf1=	404.333	lb/ft	footing weight 1	0.333333 ft.
Wf2=	400	lb/ft	footing weight 2	2.666667 ft.
Wf3=	633.333	lb/ft	footing weight 3	5 ft.
Wf4=	200	lb/ft	footing weight 4	6.333333 ft.
Wg=	1322.532	lb/ft	gravel fill weight	2.666667 ft.
Wslab=	300	lb/ft	slab weight	2.666667 ft.
Ws=	2036.667	lb/ft	backfill weight	6.333333 ft.
q=	250	lb/ft	surcharge load	6.333333 ft.
theta=	70.67873	lb/ft	surcharge pressure	3 ft.
LL=	100	lb/ft	live load	2.666667 ft.
Pa/b=	661.5529	lb/ft	active lateral earth pressure	2 ft.
Va/b=	1161.553	lb/ft	shear earth pressure	5.333333 ft.

Pp/b	44.67789	lb/ft	passive lateral earth pressure	0.5 ft.
Qa/b	424.0724	lb/ft	surcharge lateral earth pressure	3 ft.

Stability [Coduto 276]

Bearing

Pf/b=	1500	psf	allowable bearing capacity
W/b=	845.027	psf	bearing pressure
FS=	5.325274		factor of safety bearing

Sliding

Vf/b=	2213.58	lb.	resisting forces
Pa/b=	1085.625		driving forces
FS=	2.038991		factor of safety sliding

Overturning

Mr/b	27116.09	lb.-ft./ft.	resisting moments
Md/b	2595.323	lb.-ft./ft.	driving moments
FS=	10.44806		factor of safety

Retaining Wall-Geotechnical Design Calculations

Foust

Section	3	Bottom of Ramp

Soil and Material Properties

Ys=	110	pcf	unit weight of soil	
Yg=	130	pcf	unit weight of gravel	[Coduto 126]
Yc=	150	pcf	unit weight of concrete	[Coduto 126]
thetas=	28	degrees	soil friction angle	
thetag=	34	degrees	gravel friction angle	
K=	0.361033		soil coefficient of active earth pressure (Rankine)	
K=	0.282715		gravel coefficient of active earth pressure (Rankine)	
Gh=	39.71368	pcf	soil lequivalent horizontal fluid unit weight	
Gv=	39.71368	pcf	soil equivalent vertical fluid unit weight	
Gh=	36.75294	pcf	gravel equivalent horizontal fluid unit weight	[Coduto 776]
Gv=	36.75294	pcf	gravel equivalent vertical fluid unit weight	
u=	0.35		coefficient of friction	
				[Coduto 277]

Dimensions

H=	6.33333	ft.	back wall height
H'=	1.83333	ft.	front wall height
Hs=	6	ft.	backfill height
Hs'=	1.5	ft.	frontfill height
hg=	0.333397	ft.	gravel fill height
hf=	0.6666	ft.	footing thickness
htb=	0.333333	ft.	toe board height
wt=	0.666666	ft.	wall width
wr=	4	ft.	ramp width
wh=	2	ft.	heel length
ds=	0.5	ft.	slab thickness

Loads				Moment Arms about Toe	
Wf1=	183.3328	lb/ft	footing weight 1	0.333333	ft.
Wf2=	399.96	lb/ft	footing weight 2	2.666666	ft.
Wf3=	633.3324	lb/ft	footing weight 3	4.999999	ft.
Wf4=	199.98	lb/ft	footing weight 4	6.333332	ft.
Wg=	173.3664	lb/ft	gravel fill weight	2.666666	ft.
Wslab=	300	lb/ft	slab weight	2.666666	ft.
Ws=	2036.684	lb/ft	backfill weight	6.333332	ft.
q=	250	lb/ft	surcharge load	6.333332	ft.
theta=	70.67873	lb/ft	surcharge pressure	3	ft.
LL=	100	lb/ft	live load	2.666666	ft.
Pa/b=	661.5529	lb/ft	active lateral earth pressure	2	ft.
Va/b=	661.5529	lb/ft	shear earth pressure	5.333332	ft.

Pp/b=	44.67789	lb/ft	passive lateral earth pressure	0.5 ft.
Qa/b=	424.0724	lb/ft	surcharge lateral earth pressure	3 ft.

Stability

Bearing [Coduto 276]

Pf/b=	1500	psf	allowable bearing capacity
W/b=	658.1804	psf	bearing pressure
FS=	6.837031		factor of safety bearing

Sliding

Vf/b=	1734.007	lb.	resisting forces
Pa/b=	1085.625	lb.	driving forces
FS=	1.597243		factor of safety sliding

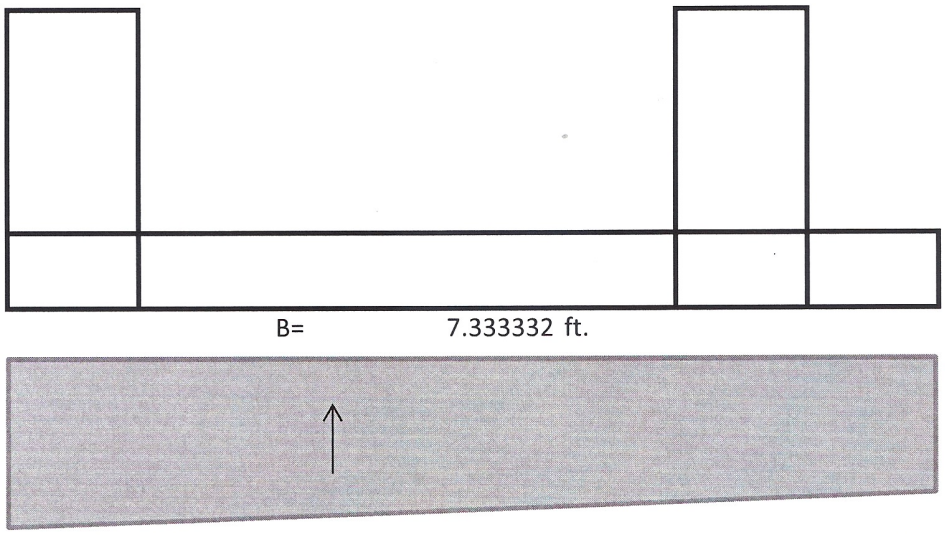
Overturning

Mr/b	23977.85	lb.-ft./ft.	resisting moments
Md/b	2595.323	lb.-ft./ft.	driving moments
FS=	9.238869		factor of safety

Bearing Pressure Calculator- Geotechnical

Component	Load (lb)	x1 (ft.)	M (lb-ft)		
Wf1=	633.3324	6.999999	4433.326		
Wf2=	400	4.666666	1866.666	r=	3.303856
Wfill=	2513.332	4.666666	11728.88		
LL=	700	4.666666	3266.666		
Wf3=	633.333	2.333333	1477.777		
Wf4=	200	1	200		
Wsoil+Wq=	2686.68	1	2686.684		
Md/b=	-	-	2595.323		
Total	7766.681		28255.32		
		e (ft.)			
R=	7766.681	0.334161	28255.32	Coduto 161	
qmin=	769.5322				
qmax=	1348.654				

Bearing Pressure			B/6=	1.222222
qmin=	769.5322	psf		
qmax=	1348.654	psf		
Avg.=	1059.091	psf	check	1059.09311



qmax= 1348.654 lb/ft

qmin= 769.5 lb/ft

x1

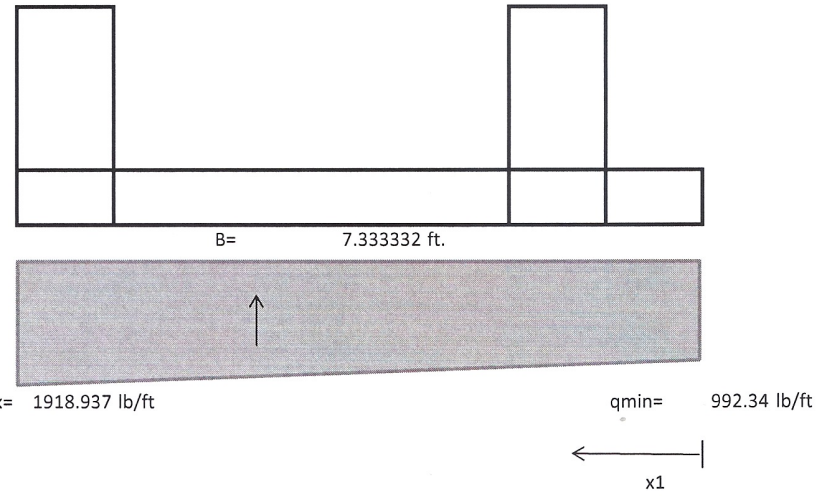
Bearing Pressure Calculator- Structural

Component	Load (lb)	x1 (ft.)	M (lb-ft)	Load Factor	Mu (lb-ft)	Fac. Load
Wf1=	633.3324	6.999999	4433.326	1.2	5319.99	759.9988
Wf2=	400	4.666666	1866.666	1.2	2240	480
Wfill=	2513.332	4.666666	11728.88	1.2	14074.7	3015.999
LL=	700	4.666666	3266.666	1.6	5226.67	1120
Wf3=	633.333	2.333333	1477.777	1.2	1773.33	759.9996
Wf4=	200	1	200	1.2	240	240
Wsoil+Wq=	2686.68	1	2686.684	1.6	4298.69	4298.694
Md/b=	-	-	2595.323	1.6	4152.52	
Total	10674.69		28255.32		37325.9	
		e (ft.)				
R=	10674.69	0.389006	28255.32		37325.9	Coduto 161
qmin=	992.3425					
qmax=	1918.937					

	load	loc
R	10674.69	3.107663

Bearing Pressure B/6= 1.222222

qmin=	992.3425 psf
qmax=	1918.937 psf
Avg.=	1455.64 psf



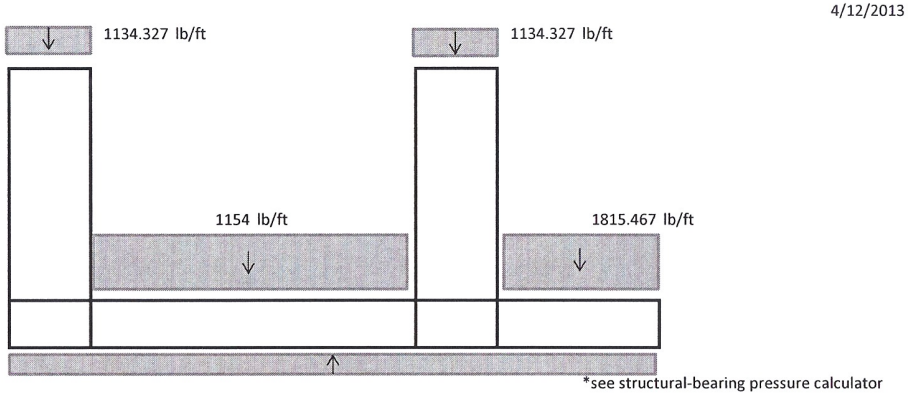
Structural Load Calculator

4/12/2013

Gravity Loads

Componen	Unf. Load (lb)	Load Factor	Fac. Load (lb)	Length (ft.)	Dist. Load (lb/ft)
Wf1=	633.33	1.20	760.00	0.67	1134.33
Wf2=	400.00	1.20	480.00	4.00	120.00
Wf3=	633.33	1.20	760.00	0.67	1134.33
Wf4=	200.00	1.20	240.00	2.50	96.00
Wfill=	2513.33	1.20	3016.00	4.00	754.00
Wsoil=	2036.67	1.60	3258.67	2.50	1303.47
S1=	700.00	1.60	1120.00	4.00	280.00
S2=	650.00	1.60	1040.00	2.50	416.00

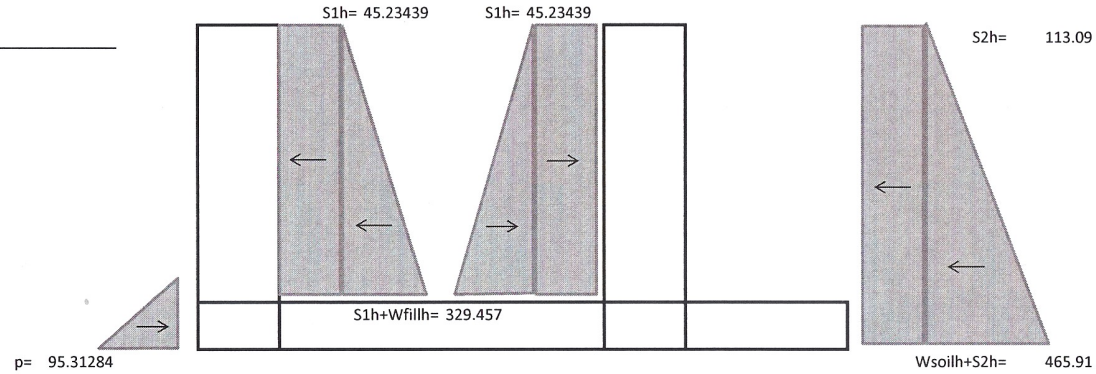
5238.11945
10674.66



*see structural-bearing pressure calculator

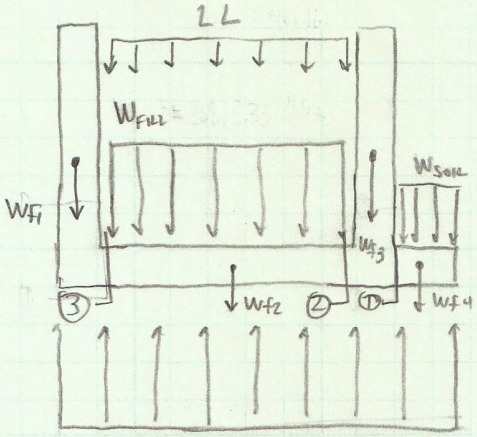
Lateral Loads

	Unf. Load (lb/ft)	Load Factor	Fac. Load (lb/ft)
p=	59.57	1.60	95.31
S1h=	28.27	1.60	45.23
Wfillh=	177.64	1.60	284.22
S2h=	70.68	1.60	113.09
Wsoilh=	220.52	1.60	352.83



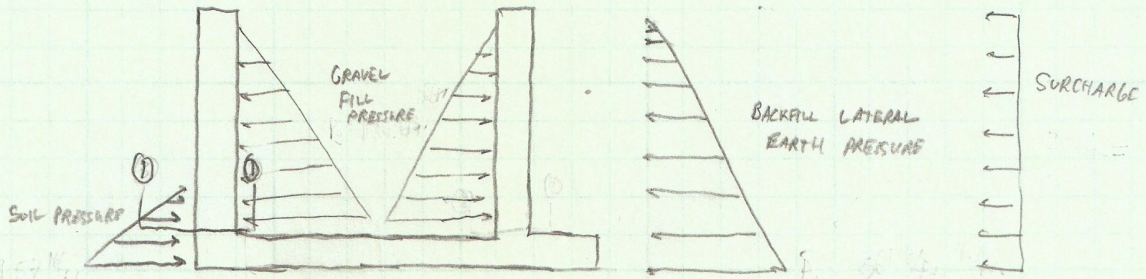
LOADS: FROM GEOTECHNICAL DESIGN + STRUCTURAL LOAD CALCULATOR

GRAVITY LOADS)

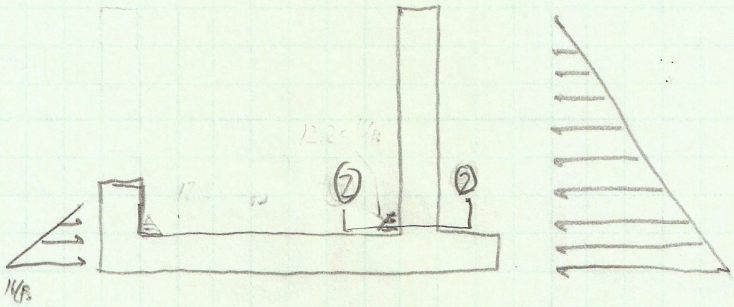


BEARING PRESSURE ⇒ SEE PG. 2.1 FOR DETAIL

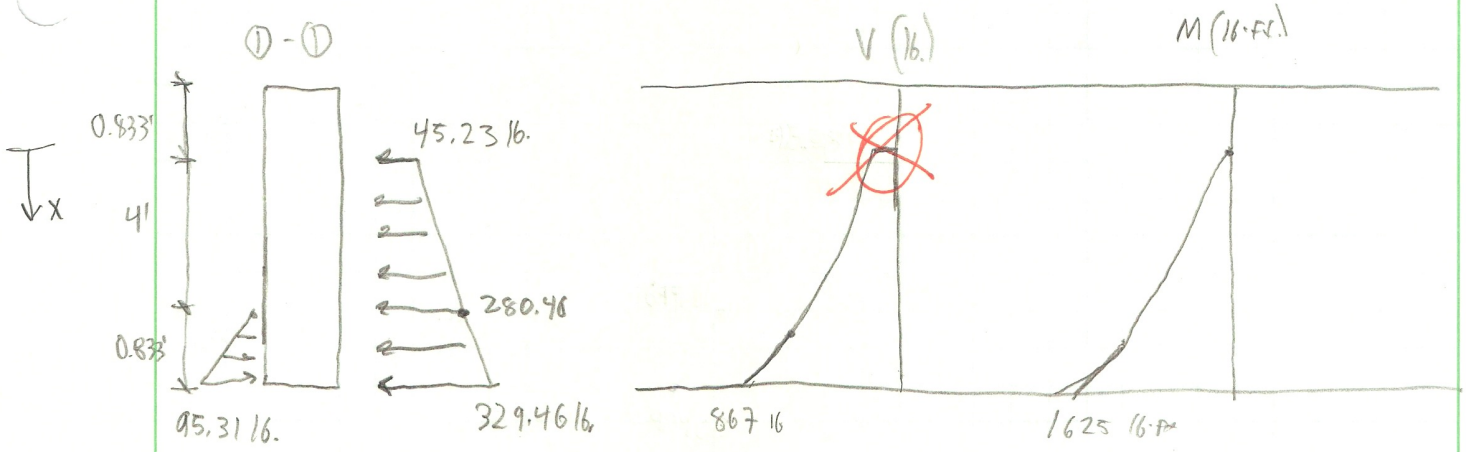
LATERAL LOADS) SECTION 1



LATERAL LOADS) SECTION 3



DESIGN SHEAR AND MOMENT) LATERAL LOADS



$w(x) = 58.81x + 45.23 \qquad 0 \le x \le 4'$

$w(x) = (58.81x + 45.23) - (114.37x - 457.48) \qquad 4 \le x \le 4.833'$

$V(x) = 29.41x^2 + 45.23x + C \;,\; C = 0 \qquad 0 \le x \le 4'$

$V(x) = (29.41x^2 + 45.23x) - (57.185x^2 - 457.48x) + C \qquad 4 \le x \le 4.833$

$651.48 - (-914.96) + C = 651.48 \Rightarrow C = -914.96$

$V(x) = (29.41x^2 + 45.23x) - (57.185x^2 - 457.48x) - 914.96 \qquad 4 \le x \le 4.833$

$M(x) = 9.803x^3 + 22.62x^2 + C \;,\; C = 0 \qquad 0 \le x \le 4 \qquad M(x=4) = 989.312 \text{ lb-ft}$

$M(x) = (9.803x^3 + 22.62x^2) - (19.06x^3 - 228.74x^2) - 914.96x + C \qquad 4 \le x \le 4.833$

$M(4) = 989.312 + 2440 - 3659.84 + C = 989.312$

$C = 1219.84$

$M(x) = (9.803x^3 + 22.62x^2) - (19.06x^3 - 228.74x^2) - 914.96x + 1219.84 \qquad 4 \le x \le 4.833$

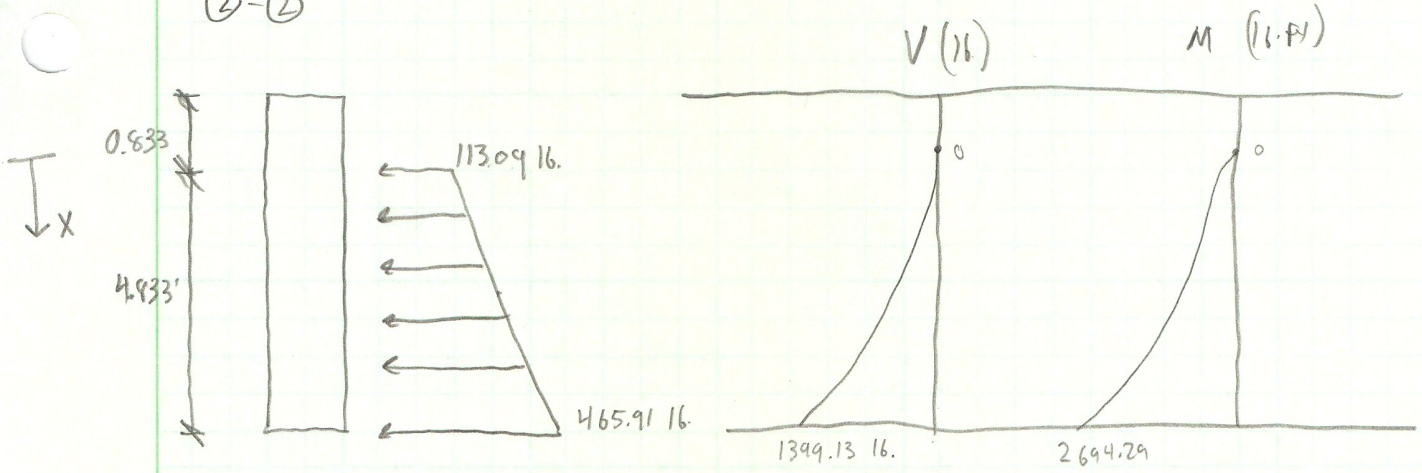
$V(4.833) = 866.12 \text{ lb.}$

$M(4.833) = 1624.30 \text{ lb-ft.}$

$V_{max} = 867 \text{ lb.}$

$M_{max} = 1625 \text{ lb-ft.}$

②-②



$w(x) = 73x + 113.09 \qquad 0 \le x \le 4.833$

$V(x) = 36.5x^2 + 113.09x + C \qquad 0 \le x \le 4.833$

$C = 0$

$V(x) = 36.5x^2 + 113.09x$ MAX AT $x = 4.833'$ $V(4.833) = 1399.13$ lb.

$M(x) = 12.167x^3 + 56.545x^2 + C$

$C = 0$

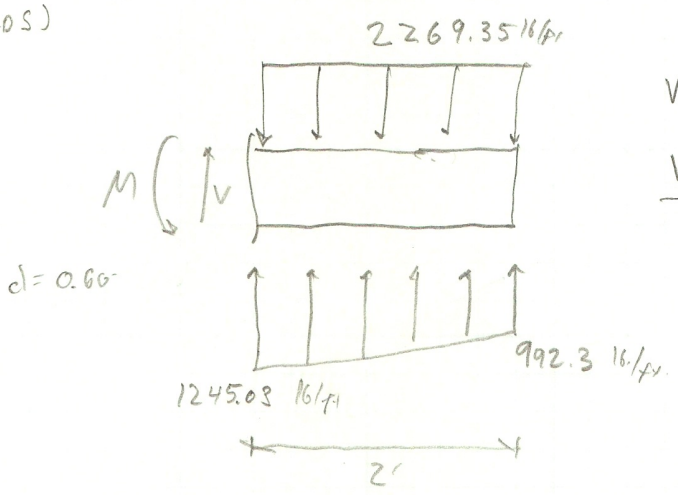
$M(x) = 12.167x^3 + 56.545x^2$ MAX AT $x = 4.833'$ $M(4.833) = 2694.29$ lb·ft.

$V_{max} = 1406$ lb.

$M_{max} = 2695$ lb·ft

SLAB LOADS)

①



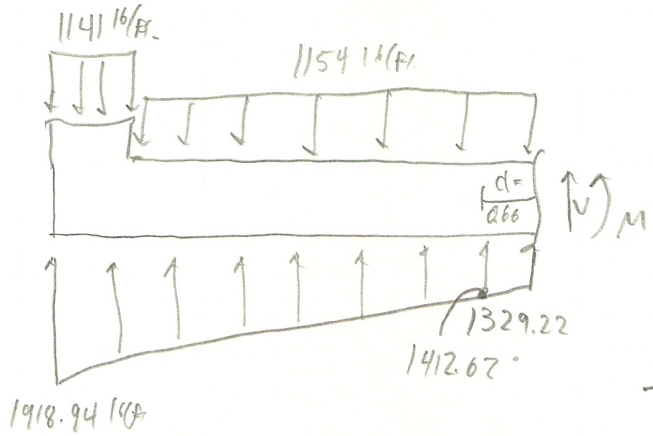
$V_u = [2269.35 \times (2 - 0.66)] - (1619.49)$

$V_u = 1398.75$ lb.

$M_u = [(2269.35 \times 2) \times 1] - [(992.3 \times 2 \times 1) + (1/2 \times 2 \times 252.73) \times 1/3]$

$M_u = 4538.7 - [1984.6 + 84.24] = 2469.86$ lb·ft.

②



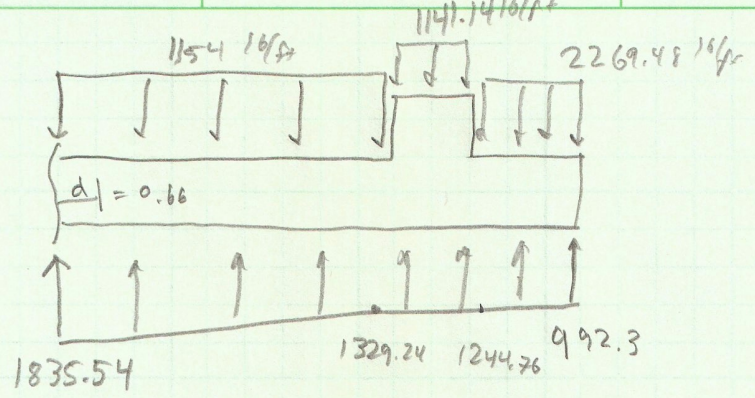
$V_u = \left[\frac{1918.94 + 1412.62}{2}\right](4) - [1154 \times 3.33 + 1141 \times 0.66]$

$V_u = 2067.24$ lb.

$M_u = \left[1329.22 \times 4.66 \times \frac{4.66}{2} + \frac{1}{2} \times 4.66 \times 589.72 \times \frac{2}{3} \times 4.66\right] - [0.66 \times 1141 \times 4.33 + 4 \times 1154 \times 2]$

$M_u = [14432.4 + 4268.71] - [3260.75 + 9232] = 6208.36$ lb·ft

(3)



$$M_u = \left[992.3 \times 6.66 \times \frac{6.66}{2} + \frac{1}{2} \times 6.66 \times 843.24 \times \frac{1}{3} \times 5.66\right] -$$

$$\left[1154 \times 4 \times 2 + 1141.14 \times 0.66 \times 4.33 + 2269.48 \times 2 \times 5.66\right]$$

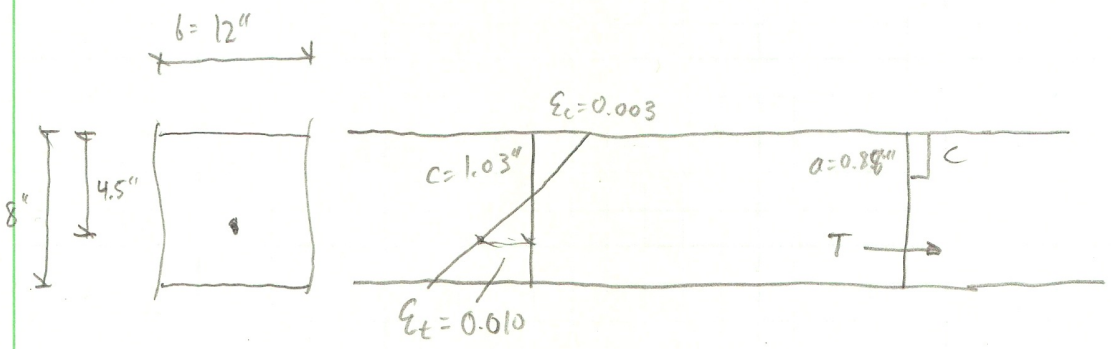
$$M_u = \left[22007.03 + 5297.74\right] - \left[9232 + 3261.15 + 25690.51\right]$$

$$M_u = \underline{-10878.89 \text{ lb-ft.}}$$

$$V_u = \left[\left(\frac{1752.14 + 992.3}{2}\right)(6.66)\right] - \left[1154 \times 3.33 + 1141 \times 0.66 + 2269.48 \times 2\right]$$

$$\underline{V_u = 4.15 \text{ lb.}}$$

STRUCTURAL DESIGN) FOOTING



$\varepsilon_t = 0.005$

$\phi = 0.9$

$\frac{c}{0.003} = \frac{4.5}{0.008} \Rightarrow c = 1.6875$

$a = \beta_1 c = 0.85 \times 1.6875 = 1.43$ in.

LET $d = 4.5$"

$A_s = \frac{0.85 f'_c b a}{f_y} = \frac{0.85(4)(8)(1.43)}{60} =$

$\frac{M_u}{\phi b d^2} = \frac{130548}{(0.9)(12)(4.5)^2} = 597$

FROM GRAPH A.16 $\rho = 0.011 = \frac{A_s}{bd}$ [NILSON 768] DESIGN OF CONCRETE STRUCTURES, 14TH ED.

$\rho = \frac{A_s}{bd} \Rightarrow A_s = (0.011)(12)(4.5) = 0.599\ in^2$

TRY 1 # 7 $A_s = 0.6\ in^2$

$\frac{1.03}{0.003} = \frac{4.5}{(\varepsilon_t + 0.003)}$

$a = \frac{A_s F_y}{0.85 f'_c b} = \frac{(0.6)(60)}{0.85(4)(12)} = 0.88$ in. $\Rightarrow \varepsilon_t = 0.010$

$\phi M_n = A_s f_y (d - a/2) = 0.9(0.60)(60000)\left(4.5 - \frac{0.88}{2}\right) = 131544$ lb-in

$\rho = 0.0181$

$M_u = 130548$ lb-in

$\phi M_n = 131544$ lb-in $> M_u$ ok

$\phi V_c = 2\lambda\sqrt{f'_c}\, b d$ $\lambda = 1.0$

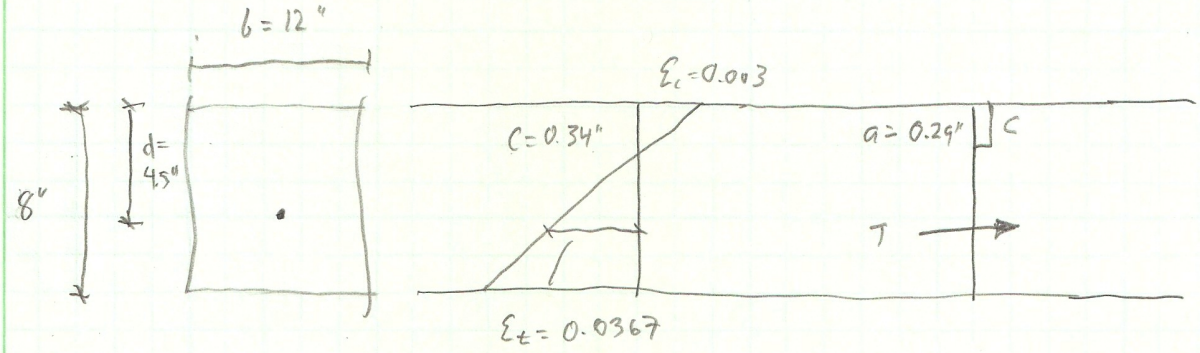
$\phi V_c = (0.75)(2)(1.0)\sqrt{4000}(12)(4.5) = 5122.89$ lb.

$V_u = 20681$ lb.

$\phi V_c = 5123$ lb $> V_u$ ok

USE # 7 @ 12"

STRUCTURAL DESIGN) WALL



$$\frac{M_u}{\phi b d^2} = \frac{32340}{0.9(12)(4.5)^2} = 148$$

FROM GRAPH A.16 $\rho = 0.0034$ [NILSON 768]

$$\rho = \frac{A_s}{bd} \Rightarrow A_s = \rho bd = (0.0034)(12)(4.5) = 0.1836 in^2$$

$\rho = 0.0181$ TRY 1 #4, $A_s = 0.20 in^2$

$a = \beta_1 c \Rightarrow c = 0.34"$ ($\beta_1 = 0.85$)

$$a = \frac{A_s f_y}{0.85 f'_c b} = \frac{(0.20)(60000)}{(0.85)(4000)12} = 0.29 \text{ in.}$$

$$\frac{0.003}{0.34} = \frac{0.003 + \varepsilon_t}{4.5}$$

$\varepsilon_t = 0.0367$

$$\phi M_n = A_s f_y \left(d - \tfrac{a}{2}\right) = (0.20)(60000)\left(4.5 - \frac{0.29}{2}\right) = 52260 \text{ lb·in}$$

$M_u = 32340$ lb·in

$\phi M_n = 52266$ lb·in $> M_u$ ok

$\phi V_c = 2\lambda\sqrt{f'_c}\, b_w d$

$\phi V_c = (0.75)(2)(1.0)\sqrt{4000}\,(12)(4.5) = 5122.68$ lb.

$V_u = 1400$ lb.

$\phi V_c = 5123$ lb $> V_u$ ok

USE #4 @ 12"

STRUCTURAL DESIGN) WALL + FOOTING REINFORCEMENT SPLICE, SHRINKAGE AND CRACKING REINFORCEMENT

ACI

12.2.3 $l_d = \left(\frac{f_y \psi_t \psi_e}{20\lambda\sqrt{f'_c}}\right) d_b = \frac{60000(1.0)(1.0)}{20(1.0)\sqrt{4000}} = 41.5''$

12.10.3 l_d (FLEXURE) = $d \geq 12 d_b$

$l_{d+} = 10.5''$

} DEVELOPMENT LENGTH

14.3.3 $\rho_t = 0.0025$

TRY #4, $A_s = 0.20 in^2$

$\rho = \frac{A_s}{bd} \Rightarrow b = \frac{A_s}{\rho d} = \frac{0.20}{(0.0025)(4.5)} = 17.77 in$

USE #4 @ 16"

} SHRINKAGE

7.12.2.1(b) $f_y = 65,000$ psi

$\rho = 0.0018$

$\rho = \frac{A_s}{bd} \Rightarrow A_s = \rho bd = (0.0018)(6'')(48'') = 0.5184 in^2$

TRY 4X4-W5XW5 $A_s = 0.15 in^2/ft$

$A_s = 0.15 in^2/ft \times 4' = 0.6 in^2$ ok

$d_b = 6.252''$ USE 4X4-W5X5 WW

} SLAB REINFORCEMENT

REINFORCEMENT DETAIL