2720 Residence

2720 71st Avenue SE
Mercer Island, Washington 98040

Structural Engineering Calculations

Supplement Calculations for Architectural Design Revisions

By

Dihong Shao, SE

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Project Name				Page No.
Bm/Jst Location/Description:	**ROOF DECK JOIST FOR SPAN OF 18'-0"**			
Roof				
dead load (psf)	0.00			
live load (psf)	0.00	additional total point load (kips)		0.00
tributary width (ft)	**0.00**	point load location to farthest support (ft)		0.00
Floor				
dead load (psf)	25.00			
live load (psf)	60.00	additional total point load (kips)		0.00
tributary width (ft)	**1.33**	point load location to farthest support (ft)		0.00
Wall				
wall weight (psf)	10.00			
height (ft)	**0.00**			
Beam Span (ft)	**18.00**			
load duration/repetitive factor	**1.00**		**1.00**	
tributary load (plf)	113.05	**11.875 TJI-360@16"**		
moment (kip-ft)	**4.58**	6.18 OK		
shear/reaction (kips)	**1.02**	1.08 OK		
EI x 10^6 (in^2-lbs)	**419**			Total Deflection
Joist Depth (in)	**11.88**	Bending Deflection	0.64	
TJI 110, 210, 230, and 360		Shear Deflection	0.08	0.72
TJI 560		Shear Deflection	0.07	0.71
		Total Deflction Ratio "L" over		**305**
		LL Deflection Ratio: "L" over		**432**

Bm/Jst Location/Description:	**ROOF DECK JOIST FOR SPAN OF 16'-6"**			
Roof				
dead load (psf)	0.00			
live load (psf)	0.00	additional total point load (kips)		0.00
tributary width (ft)	**0.00**	point load location to farthest support (ft)		0.00
Floor				
dead load (psf)	25.00			
live load (psf)	60.00	additional total point load (kips)		0.00
tributary width (ft)	**1.33**	point load location to farthest support (ft)		0.00
Wall				
wall weight (psf)	10.00			
height (ft)	**0.00**			
Beam Span (ft)	**16.50**			
load duration/repetitive factor	**1.00**		**1.00**	
tributary load (plf)	113.05	**11.875 TJI-230@16"**		
moment (kip-ft)	**3.85**	4.125 OK		
shear/reaction (kips)	**0.93**	1.06 OK		
16'TJI-560@16"				
EI x 10^6 (in^2-lbs)	**347**			Total Deflection
Joist Depth (in)	**11.88**	Bending Deflection	0.54	
TJI 110, 210, 230, and 360		Shear Deflection	0.07	0.61
TJI 560		Shear Deflection	0.06	0.60
		Total Deflction Ratio "L" over		**329**
		LL Deflection Ratio: "L" over		**465**

Project Name				**Page No.**
Bm/Jst Location/Description:	**ROOF JOIST FOR SPAN OF 22'-4"**			
Roof				
dead load (psf)	15.00			
live load (psf)	25.00	additional total point load (kips)		0.00
tributary width (ft)	**2.00**	point load location to farthest support (ft)		0.00
Floor				
dead load (psf)	15.00			
live load (psf)	40.00	additional total point load (kips)		0.00
tributary width (ft)	**0.00**	point load location to farthest support (ft)		0.00
Wall				
wall weight (psf)	10.00			
height (ft)	**0.00**			
Beam Span (ft)	**22.33**			
load duration/repetitive factor	**1.00**		**1.00**	
tributary load (plf)	80.00	**11.875 TJI-560@2'-0"**		
moment (kip-ft)	**4.99**	9.5 OK		
shear/reaction (kips)	**0.89**	1.265 OK		
EI x 10^6 (in^2-lbs)	**636**			Total Deflection
Joist Depth (in)	**11.88**	Bending Deflection	0.70	
TJI 110, 210, 230, and 360		Shear Deflection	0.09	0.79
TJI 560		Shear Deflection	0.08	0.78
		Total Deflction Ratio "L" over		**343**
		LL Deflection Ratio: "L" over		**472**

Bm/Jst Location/Description:	**ROOF JOIST FOR SPAN OF 15'-8"**			
Roof				
dead load (psf)	15.00			
live load (psf)	25.00	additional total point load (kips)		0.00
tributary width (ft)	**2.00**	point load location to farthest support (ft)		0.00
Floor				
dead load (psf)	15.00			
live load (psf)	40.00	additional total point load (kips)		0.00
tributary width (ft)	**0.00**	point load location to farthest support (ft)		0.00
Wall				
wall weight (psf)	10.00			
height (ft)	**0.00**			
Beam Span (ft)	**15.67**			
load duration/repetitive factor	**1.00**		**1.00**	
tributary load (plf)	80.00	**11.875 TJI-110@2'-0"**		
moment (kip-ft)	**2.46**	3.16 OK		
shear/reaction (kips)	**0.63**	.910 OK		
EI x 10^6 (in^2-lbs)	**267**			Total Deflection
Joist Depth (in)	**11.88**	Bending Deflection	0.41	
TJI 110, 210, 230, and 360		Shear Deflection	0.04	0.45
TJI 560		Shear Deflection	0.04	0.44
		Total Deflction Ratio "L" over		**423**
		LL Deflection Ratio: "L" over		**582**

Project Name				**Page No.**
Bm/Jst Location/Description:	**MAIN FLOOR JOIST FOR SPAN OF 27'-3"**			
Roof				
dead load (psf)	0.00			
live load (psf)	0.00	additional total point load (kips)		0.00
tributary width (ft)	**0.00**	point load location to farthest support (ft)		0.00
Floor				
dead load (psf)	30.00			
live load (psf)	40.00	additional total point load (kips)		0.00
tributary width (ft)	**1.33**	point load location to farthest support (ft)		0.00
Wall				
wall weight (psf)	10.00			
height (ft)	**0.00**			
Beam Span (ft)	**27.25**			
load duration/repetitive factor	**1.00**		**1.00**	
tributary load (plf)	93.10	**14" TJI-560@16"**		
moment (kip-ft)	**8.64**	11.275 OK		
shear/reaction (kips)	**1.27**	1.265 OK		
EI x 10^6 (in^2-lbs)	**926**			Total Deflection
Joist Depth (in)	**14.00**	Bending Deflection	1.25	
TJI 110, 210, 230, and 360		Shear Deflection	0.13	1.38
TJI 560		Shear Deflection	0.11	1.36
		Total Deflction Ratio "L" over		**240**
		LL Deflection Ratio: "L" over		**421**

Bm/Jst Location/Description:	**MAIN FLOOR JOIST FOR SPAN OF 23'-9"**			
Roof				
dead load (psf)	0.00			
live load (psf)	0.00	additional total point load (kips)		0.00
tributary width (ft)	**0.00**	point load location to farthest support (ft)		0.00
Floor				
dead load (psf)	30.00			
live load (psf)	40.00	additional total point load (kips)		0.00
tributary width (ft)	**1.33**	point load location to farthest support (ft)		0.00
Wall				
wall weight (psf)	10.00			
height (ft)	**0.00**			
Beam Span (ft)	**23.75**			
load duration/repetitive factor	**1.00**		**1.00**	
tributary load (plf)	93.10	**14" TJI-360@16"**		
moment (kip-ft)	**6.56**	7.335 OK		
shear/reaction (kips)	**1.11**	1.08 OK		
EI x 10^6 (in^2-lbs)	**612**			Total Deflection
Joist Depth (in)	**14.00**	Bending Deflection	1.09	
TJI 110, 210, 230, and 360		Shear Deflection	0.10	1.19
TJI 560		Shear Deflection	0.09	1.17
		Total Deflction Ratio "L" over		**243**
		LL Deflection Ratio: "L" over		**424**

Project Name				Page No.
Bm/Jst Location/Description:	**R1**			
Roof				
dead load (psf)	15.00			
live load (psf)	25.00	additional total point load (kips)		0.00
tributary width (ft)	**7.50**	point load location to farthest support (ft)		0.00
Floor				
dead load (psf)	15.00			
live load (psf)	40.00	additional total point load (kips)		0.00
tributary width (ft)	**0.00**	point load location to farthest support (ft)		0.00
Wall				
wall weight (psf)	10.00			
height (ft)	**0.00**			
Beam Span (ft)	**9.00**			
load duration/repetitive factor	**1.15**		**1.00**	
Beam Data Base Number	**9**		**2.0E PSL**	
tributary load (plf)	300.00		**#N/A**	**Beam No.61-88**
moment (kip-ft)	3.04		Provided M	#N/A
shear/reaction (kips)	1.35		Provided V	#N/A
			Provided I	#N/A
	DF#2	Provided	**24F-V4 or 24F-V8 DF GL**	Provided
Required S (in^3)	25.36	30.66	13.21	#N/A
Required I (in^4)	63.22	111.15	63.22	#N/A
Required A (in^2)	18.54	25.38	8.00	#N/A
Size	**4x8**	**Beam No.1-20**	**#N/A**	**Beam No.20-60**

Bm/Jst Location/Description:	**R2**			
Roof				
dead load (psf)	25.00			
live load (psf)	60.00	additional total point load (kips)		0.00
tributary width (ft)	**9.50**	point load location to farthest support (ft)		0.00
Floor				
dead load (psf)	15.00			
live load (psf)	40.00	additional total point load (kips)		0.00
tributary width (ft)	**0.00**	point load location to farthest support (ft)		0.00
Wall				
wall weight (psf)	10.00			
height (ft)	**0.00**			
Beam Span (ft)	**6.00**			
load duration/repetitive factor	**1.00**		**1.00**	
Beam Data Base Number	**10**		**2.0E PSL**	
tributary load (plf)	807.50		**#N/A**	**Beam No.61-88**
moment (kip-ft)	3.63		Provided M	#N/A
shear/reaction (kips)	2.42		Provided V	#N/A
			Provided I	#N/A
	DF#2	Provided	**24F-V4 or 24F-V8 DF GL**	Provided
Required S (in^3)	34.88	49.91	18.17	#N/A
Required I (in^4)	50.42	230.84	50.42	#N/A
Required A (in^2)	38.25	32.38	22.02	#N/A
Size	**4x10**	**Beam No.1-20**	**#N/A**	**Beam No.20-60**

Project Name				Page No.
Bm/Jst Location/Description:	**R3**			
Roof				
dead load (psf)	15.00			
live load (psf)	25.00	additional total point load (kips)		0.00
tributary width (ft)	**10.50**	point load location to farthest support (ft)		0.00
Floor				
dead load (psf)	15.00			
live load (psf)	40.00	additional total point load (kips)		0.00
tributary width (ft)	**0.00**	point load location to farthest support (ft)		0.00
Wall				
wall weight (psf)	10.00			
height (ft)	**0.00**			
Beam Span (ft)	**9.50**			
load duration/repetitive factor	**1.15**		**1.00**	
Beam Data Base Number	**10**		**2.0E PSL**	
tributary load (plf)	420.00		**#N/A**	**Beam No.61-88**
moment (kip-ft)	4.74		Provided M	#N/A
shear/reaction (kips)	2.00		Provided V	#N/A
			Provided I	#N/A

	DF#2	Provided	**24F-V4 or 24F-V8 DF GL**	Provided
Required S (in^3)	39.55	49.91	20.60	#N/A
Required I (in^4)	104.10	230.84	104.10	#N/A
Required A (in^2)	27.39	32.38	15.77	#N/A
Size	**4x10**	**Beam No.1-20**	**#N/A**	**Beam No.20-60**

Bm/Jst Location/Description:	**R4**			
Roof				
dead load (psf)	25.00			
live load (psf)	60.00	additional total point load (kips)		0.00
tributary width (ft)	**9.50**	point load location to farthest support (ft)		0.00
Floor				
dead load (psf)	15.00			
live load (psf)	40.00	additional total point load (kips)		0.00
tributary width (ft)	**0.00**	point load location to farthest support (ft)		0.00
Wall				
wall weight (psf)	10.00			
height (ft)	**0.00**			
Beam Span (ft)	**16.00**	**I ratio**	0.98	2.0/1.7=1.17 OK
load duration/repetitive factor	**1.00**		**1.00**	
Beam Data Base Number	**85**		**2.0E PSL**	
tributary load (plf)	807.50		**7x11-7/8**	**Beam No.61-88**
moment (kip-ft)	25.84		Provided M	39.81
shear/reaction (kips)	6.46		Provided V	16.07
			Provided I	975.00

	DF#2	Provided	**24F-V4 or 24F-V8 DF GL**	Provided
Required S (in^3)	248.06	280.73	129.20	1200.45
Required I (in^4)	956.17	2456.38	956.17	26244.00
Required A (in^2)	102.00	96.25	58.72	243.00
Size	**6x18**	**Beam No.1-20**	**6-3/4x36**	**Beam No.20-60**

Project Name				Page No.
Bm/Jst Location/Description:	**U1**			
Roof				
dead load (psf)	25.00			
live load (psf)	60.00	additional total point load (kips)		0.00
tributary width (ft)	**15.00**	point load location to farthest support (ft)		0.00
Floor				
dead load (psf)	15.00			
live load (psf)	40.00	additional total point load (kips)		0.00
tributary width (ft)	**6.00**	point load location to farthest support (ft)		0.00
Wall				
wall weight (psf)	10.00			
height (ft)	**10.00**			
Beam Span (ft)	**11.50**			
load duration/repetitive factor	**1.00**		**1.00**	
Beam Data Base Number	**72**		**2.0E PSL**	
tributary load (plf)	1705.00		**3-1/2x14**	**Beam No.61-88**
moment (kip-ft)	28.19		Provided M	27.16
shear/reaction (kips)	9.80		Provided V	9.48
			Provided I	800.00

	DF#2	Provided	**24F-V4 or 24F-V8 DF GL**	Provided
Required S (in^3)	270.58	280.73	140.93	1200.45
Required I (in^4)	749.64	2456.38	749.64	26244.00
Required A (in^2)	154.80	96.25	89.12	243.00
Size	**6x18**	**Beam No.1-20**	**6-3/4x36**	**Beam No.20-60**

Bm/Jst Location/Description:	**U2**			
Roof				
dead load (psf)	15.00			
live load (psf)	25.00	additional total point load (kips)		0.00
tributary width (ft)	**11.00**	point load location to farthest support (ft)		0.00
Floor				
dead load (psf)	15.00			
live load (psf)	40.00	additional total point load (kips)		9.80
tributary width (ft)	**0.00**	point load location to farthest support (ft)		12.00
Wall				
wall weight (psf)	10.00	**S ratio**	1.05	5.5/5.125=1.07
height (ft)	**6.00**	**I ratio**	0.98	
Beam Span (ft)	**21.00**	**A ratio**	0.87	
load duration/repetitive factor	**1.05**		**1.00**	
Beam Data Base Number	**41**		**2.0E PSL**	
tributary load (plf)	500.00		**#N/A**	**Beam No.61-88**
moment (kip-ft)	77.98		Provided M	#N/A
shear/reaction (kips)	10.85		Provided V	#N/A
			Provided I	#N/A

	DF#2	Provided	**24F-V4 or 24F-V8 DF GL**	Provided
Required S (in^3)	712.98	280.73	371.34	353.98
Required I (in^4)	3787.36	2456.38	3787.36	3855.72
Required A (in^2)	130.56	96.25	93.95	107.83
Size	**6x18**	**Beam No.1-20**	**5-1/8x21**	**Beam No.20-60**

Project Name				Page No.
Bm/Jst Location/Description:	**U3**			
Roof				
dead load (psf)	15.00			
live load (psf)	25.00	additional total point load (kips)		0.00
tributary width (ft)	**4.50**	point load location to farthest support (ft)		0.00
Floor				
dead load (psf)	15.00			
live load (psf)	40.00	additional total point load (kips)		0.00
tributary width (ft)	**0.00**	point load location to farthest support (ft)		0.00
Wall				
wall weight (psf)	10.00			
height (ft)	**0.00**			
Beam Span (ft)	**16.50**			
load duration/repetitive factor	**1.00**		**1.00**	
Beam Data Base Number	**16**		**2.0E PSL**	
tributary load (plf)	180.00		**#N/A**	**Beam No.61-88**
moment (kip-ft)	6.13		Provided M	#N/A
shear/reaction (kips)	1.49		Provided V	#N/A
			Provided I	#N/A
	DF#2	Provided	**24F-V4 or 24F-V8 DF GL**	Provided
Required S (in^3)	58.81	82.73	30.63	#N/A
Required I (in^4)	233.75	392.96	233.75	#N/A
Required A (in^2)	23.45	52.25	9.56	#N/A
Size	**6x10**	**Beam No.1-20**	**#N/A**	**Beam No.20-60**

Bm/Jst Location/Description:	**U4**			
Roof				
dead load (psf)	15.00	average of 25 an		
live load (psf)	45.00	additional total point load (kips)		0.00
tributary width (ft)	**16.00**	point load location to farthest support (ft)		0.00
Floor				
dead load (psf)	15.00			
live load (psf)	40.00	additional total point load (kips)		0.00
tributary width (ft)	**8.00**	point load location to farthest support (ft)		0.00
Wall				
wall weight (psf)	10.00			
height (ft)	**10.00**			
Beam Span (ft)	**10.00**			
load duration/repetitive factor	**1.00**		**1.00**	
Beam Data Base Number	**72**		**2.0E PSL**	
tributary load (plf)	1500.00		**3-1/2x14**	**Beam No.61-88**
moment (kip-ft)	18.75		Provided M	27.16
shear/reaction (kips)	7.50		Provided V	9.48
			Provided I	800.00
	DF#2	Provided	**24F-V4 or 24F-V8 DF GL**	Provided
Required S (in^3)	180.00	280.73	93.75	1200.45
Required I (in^4)	433.64	2456.38	433.64	26244.00
Required A (in^2)	118.43	96.25	68.18	243.00
Size	**6x18**	**Beam No.1-20**	**6-3/4x36**	**Beam No.20-60**

Project Name				Page No.
Bm/Jst Location/Description:	**U5**			
Roof				
dead load (psf)	25.00	average of 25 and 60 psf		
live load (psf)	60.00	additional total point load (kips)		0.00
tributary width (ft)	**9.50**	point load location to farthest support (ft)		0.00
Floor				
dead load (psf)	15.00			
live load (psf)	40.00	additional total point load (kips)		0.00
tributary width (ft)	**9.50**	point load location to farthest support (ft)		0.00
Wall				
wall weight (psf)	10.00			
height (ft)	**10.00**			
Beam Span (ft)	**10.00**			
load duration/repetitive factor	**1.00**		**1.00**	
Beam Data Base Number	**71**		**2.0E PSL**	
tributary load (plf)	1430.00		**3-1/2x11-7/8**	**Beam No.61-88**
moment (kip-ft)	17.88		Provided M	19.90
shear/reaction (kips)	7.15		Provided V	8.04
			Provided I	490.00
	DF#2	Provided	**24F-V4 or 24F-V8 DF GL**	Provided
Required S (in^3)	171.60	280.73	89.38	1200.45
Required I (in^4)	413.40	2456.38	413.40	26244.00
Required A (in^2)	94.08	96.25	64.99	243.00
Size	**6x18**	**Beam No.1-20**	**6-3/4x36**	**Beam No.20-60**

Bm/Jst Location/Description:	U6			
Roof				
dead load (psf)	20.00			
live load (psf)	45.00	additional total point load (kips)		0.00
tributary width (ft)	**16.00**	point load location to farthest support (ft)		0.00
Floor				
dead load (psf)	15.00			
live load (psf)	40.00	additional total point load (kips)		0.00
tributary width (ft)	**8.00**	point load location to farthest support (ft)		0.00
Wall				
wall weight (psf)	10.00			
height (ft)	**10.00**			
Beam Span (ft)	**16.00**	**I ratio**	1.17	
load duration/repetitive factor	**1.00**		**1.00**	
Beam Data Base Number	**86**		**2.0E PSL**	
tributary load (plf)	1580.00		**7x14**	**Beam No.61-88**
moment (kip-ft)	50.56		Provided M	54.33
shear/reaction (kips)	12.64		Provided V	18.95
			Provided I	1600.00
	DF#2	Provided	**24F-V4 or 24F-V8 DF GL**	Provided
Required S (in^3)	485.38	280.73	252.80	1200.45
Required I (in^4)	1870.90	2456.38	1870.90	26244.00
Required A (in^2)	149.69	96.25	114.90	243.00
Size	**6x18**	**Beam No.1-20**	**6-3/4x36**	**Beam No.20-60**

Project Name				Page No.
Bm/Jst Location/Description:	**U6 STEEL BM**			
Roof				
dead load (psf)	20.00			
live load (psf)	45.00	additional total point load (kips)		0.00
tributary width (ft)	**16.00**	point load location to farthest support (ft)		0.00
Floor				
dead load (psf)	15.00			
live load (psf)	40.00	additional total point load (kips)		0.00
tributary width (ft)	**8.00**	point load location to farthest support (ft)		0.00
Wall				
wall weight (psf)	10.00			
height (ft)	**10.00**			
Beam Span (ft)	**16.00**			
load duration/repetitive factor	**1.00**		**1.00**	
Beam Data Base Number			**STEEL BEAM**	**W12x26**
tributary load (plf)	1580.00		Required	Provided
moment (kip-ft)	50.56	**S**	25.79	33.40
shear/reaction (kips)	12.64	**BxH**		6.5" x 12.25"
		I	150.47	204.00
	DF#2	Provided	**24F-V4 or 24F-V8 DF GL**	Provided
Required S (in^3)	485.38	#N/A	252.80	#N/A
Required I (in^4)	1870.90	#N/A	1870.90	#N/A
Required A (in^2)	199.59	#N/A	76.60	#N/A
Size	**#N/A**	**Beam No.1-20**	**#N/A**	**Beam No.20-60**

Bm/Jst Location/Description:	**U7 STEEL BM**			
Roof				
dead load (psf)	25.00			
live load (psf)	60.00	additional total point load (kips)		0.00
tributary width (ft)	**9.50**	point load location to farthest support (ft)		0.00
Floor				
dead load (psf)	15.00			
live load (psf)	40.00	additional total point load (kips)		6.46
tributary width (ft)	**14.00**	point load location to farthest support (ft)		15.00
Wall				
wall weight (psf)	10.00			
height (ft)	**10.00**			
Beam Span (ft)	**21.00**			
load duration/repetitive factor	**1.00**		**1.00**	
Beam Data Base Number			**STEEL BEAM**	**W14x53**
tributary load (plf)	1677.50		Required	Provided
moment (kip-ft)	120.16	**S**	61.28	77.80
shear/reaction (kips)	22.23	**BxH**		8.06" x 13.92"
		I	469.34	541.00
	DF#2	Provided	**24F-V4 or 24F-V8 DF GL**	Provided
Required S (in^3)	1153.52	#N/A	600.79	#N/A
Required I (in^4)	5835.74	#N/A	5835.74	#N/A
Required A (in^2)	350.98	#N/A	134.70	#N/A
Size	**#N/A**	**Beam No.1-20**	**#N/A**	**Beam No.20-60**

Project Name				Page No.
Bm/Jst Location/Description:	**U8 STEEL BM**			
Roof				
dead load (psf)	15.00			
live load (psf)	25.00	additional total point load (kips)		12.64
tributary width (ft)	**15.00**	point load location to farthest support (ft)		10.50
Floor				
dead load (psf)	15.00			
live load (psf)	40.00	additional total point load (kips)		22.23
tributary width (ft)	**2.00**	point load location to farthest support (ft)		11.50
Wall				
wall weight (psf)	10.00			
height (ft)	**10.00**			
Beam Span (ft)	**18.50**			
load duration/repetitive factor	**1.00**		**1.00**	
Beam Data Base Number			**STEEL BEAM**	**W18x55**
tributary load (plf)	810.00		Required	Provided
moment (kip-ft)	188.77	**S**	96.27	98.30
shear/reaction (kips)	28.48	**BxH**		7.5" x 18.25"
		I	649.55	890.00
	DF#2	Provided	**24F-V4 or 24F-V8 DF GL**	Provided
Required S (in^3)	1812.17	#N/A	943.84	#N/A
Required I (in^4)	8076.49	#N/A	8076.49	#N/A
Required A (in^2)	449.76	#N/A	172.61	#N/A
Size	**#N/A**	**Beam No.1-20**	**#N/A**	**Beam No.20-60**

Bm/Jst Location/Description:	**NOT USED STEEL BM**			
Roof				
dead load (psf)	15.00			
live load (psf)	25.00	additional total point load (kips)		0.00
tributary width (ft)	**15.00**	point load location to farthest support (ft)		0.00
Floor				
dead load (psf)	15.00			
live load (psf)	40.00	additional total point load (kips)		10.00
tributary width (ft)	**6.00**	point load location to farthest support (ft)		15.50
Wall				
wall weight (psf)	10.00			
height (ft)	**19.50**			
Beam Span (ft)	**22.00**			
load duration/repetitive factor	**1.00**		**1.00**	
Beam Data Base Number			**STEEL BEAM**	**W14x53**
tributary load (plf)	1125.00		Required	Provided
moment (kip-ft)	113.86	**S**	58.07	77.80
shear/reaction (kips)	19.42	**BxH**		8.06" x 13.92"
		I	465.91	541.00
	DF#2	Provided	**24F-V4 or 24F-V8 DF GL**	Provided
Required S (in^3)	1093.04	#N/A	569.29	#N/A
Required I (in^4)	5793.09	#N/A	5793.09	#N/A
Required A (in^2)	306.65	#N/A	117.69	#N/A
Size	**#N/A**	**Beam No.1-20**	**#N/A**	**Beam No.20-60**

Project Name				Page No.
Bm/Jst Location/Description:	**U9**			
Roof				
dead load (psf)	25.00			
live load (psf)	60.00	additional total point load (kips)		0.00
tributary width (ft)	**3.00**	point load location to farthest support (ft)		0.00
Floor				
dead load (psf)	15.00			
live load (psf)	40.00	additional total point load (kips)		0.00
tributary width (ft)	**0.00**	point load location to farthest support (ft)		0.00
Wall				
wall weight (psf)	10.00			
height (ft)	**4.00**			
Beam Span (ft)	**14.50**			
load duration/repetitive factor	**1.00**		**1.00**	
Beam Data Base Number	**16**		**2.0E PSL**	
tributary load (plf)	295.00		**#N/A**	**Beam No.61-88**
moment (kip-ft)	7.75		Provided M	#N/A
shear/reaction (kips)	2.14		Provided V	#N/A
			Provided I	#N/A
	DF#2	Provided	**24F-V4 or 24F-V8 DF GL**	Provided
Required S (in^3)	74.43	82.73	38.76	#N/A
Required I (in^4)	259.99	392.96	259.99	#N/A
Required A (in^2)	33.77	52.25	15.55	#N/A
Size	**6x10**	**Beam No.1-20**	**#N/A**	**Beam No.20-60**

Bm/Jst Location/Description:	**M1**			
Roof				
dead load (psf)	15.00			
live load (psf)	25.00	additional total point load (kips)		0.00
tributary width (ft)	**11.00**	point load location to farthest support (ft)		0.00
Floor				
dead load (psf)	15.00	**BOTH MAIN AND UPPER FLOORS**		
live load (psf)	40.00	additional total point load (kips)		0.00
tributary width (ft)	**11.00**	point load location to farthest support (ft)		0.00
Wall				
wall weight (psf)	10.00			
height (ft)	**22.00**			
Beam Span (ft)	**15.50**			
load duration/repetitive factor	**1.00**		**1.00**	
Beam Data Base Number	**86**		**2.0E PSL**	
tributary load (plf)	1265.00		**7x14**	**Beam No.61-88**
moment (kip-ft)	37.99		Provided M	54.33
shear/reaction (kips)	9.80		Provided V	18.95
			Provided I	1600.00
	DF#2	Provided	**24F-V4 or 24F-V8 DF GL**	Provided
Required S (in^3)	364.70	280.73	189.95	1200.45
Required I (in^4)	1361.82	2456.38	1361.82	26244.00
Required A (in^2)	154.80	96.25	89.12	243.00
Size	**6x18**	**Beam No.1-20**	**6-3/4x36**	**Beam No.20-60**

Project Name				Page No.
Bm/Jst Location/Description:	**M2**			
Roof				
dead load (psf)	25.00			
live load (psf)	60.00	additional total point load (kips)		0.00
tributary width (ft)	**9.50**	point load location to farthest support (ft)		0.00
Floor				
dead load (psf)	15.00			
live load (psf)	40.00	additional total point load (kips)		0.00
tributary width (ft)	**9.50**	point load location to farthest support (ft)		0.00
Wall				
wall weight (psf)	10.00			
height (ft)	**22.00**			
Beam Span (ft)	**6.00**			
load duration/repetitive factor	**1.00**		**1.00**	
Beam Data Base Number	**69**		**2.0E PSL**	
tributary load (plf)	1550.00		**3-1/2x9-1/2**	**Beam No.61-88**
moment (kip-ft)	6.98		Provided M	13.06
shear/reaction (kips)	4.65		Provided V	6.43
			Provided I	250.00
	DF#2	Provided	**24F-V4 or 24F-V8 DF GL**	Provided
Required S (in^3)	66.96	280.73	34.88	1200.45
Required I (in^4)	96.79	2456.38	96.79	26244.00
Required A (in^2)	48.95	96.25	42.27	243.00
Size	**6x18**	**Beam No.1-20**	**6-3/4x36**	**Beam No.20-60**

Bm/Jst Location/Description:	**M3**			
Roof				
dead load (psf)	15.00			
live load (psf)	25.00	additional total point load (kips)		0.00
tributary width (ft)	**0.00**	point load location to farthest support (ft)		0.00
Floor				
dead load (psf)	15.00			
live load (psf)	40.00	additional total point load (kips)		0.00
tributary width (ft)	**14.00**	point load location to farthest support (ft)		0.00
Wall				
wall weight (psf)	10.00			
height (ft)	**0.00**			
Beam Span (ft)	**6.00**			
load duration/repetitive factor	**1.00**		**1.00**	
Beam Data Base Number	**10**		**2.0E PSL**	
tributary load (plf)	770.00		**#N/A**	**Beam No.61-88**
moment (kip-ft)	3.47		Provided M	#N/A
shear/reaction (kips)	2.31		Provided V	#N/A
			Provided I	#N/A
	DF#2	Provided	**24F-V4 or 24F-V8 DF GL**	Provided
Required S (in^3)	33.26	49.91	17.33	#N/A
Required I (in^4)	48.08	230.84	48.08	#N/A
Required A (in^2)	30.40	32.38	21.00	#N/A
Size	**4x10**	**Beam No.1-20**	**#N/A**	**Beam No.20-60**

Project Name				Page No.
Bm/Jst Location/Description:	**M4**			
Roof				
dead load (psf)	15.00			
live load (psf)	25.00	additional total point load (kips)		0.00
tributary width (ft)	**0.00**	point load location to farthest support (ft)		0.00
Floor				
dead load (psf)	15.00			
live load (psf)	40.00	additional total point load (kips)		0.00
tributary width (ft)	**14.00**	point load location to farthest support (ft)		0.00
Wall				
wall weight (psf)	10.00			
height (ft)	**22.00**			
Beam Span (ft)	**11.00**	**DOUBLE THE CANTILEVER SPAN**		
load duration/repetitive factor	**1.00**		**1.00**	

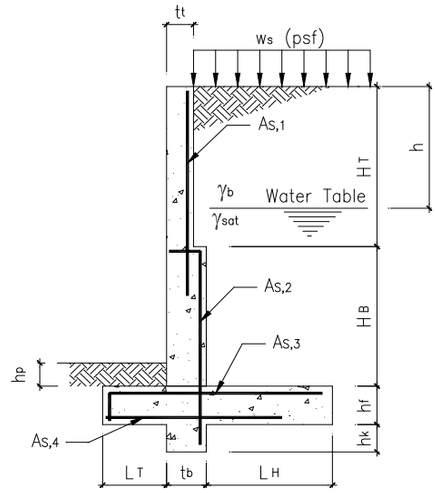
Beam Data Base Number			**STEEL BEAM**	**W10x22**
tributary load (plf)	990.00		Required	Provided
moment (kip-ft)	14.97	**S**	7.64	23.20
shear/reaction (kips)	5.45	**BxH**		5.75" x 10.125"
		I	30.64	118.00

	DF#2	Provided	**24F-V4 or 24F-V8 DF GL**	Provided
Required S (in^3)	143.75	#N/A	74.87	#N/A
Required I (in^4)	380.93	#N/A	380.93	#N/A
Required A (in^2)	85.98	#N/A	33.00	#N/A
Size	**#N/A**	**Beam No.1-20**	**#N/A**	**Beam No.20-60**

Retaining Wall Design Based on ACI 318 — 4ft Retaining Wall

INPUT DATA & DESIGN SUMMARY

CONCRETE STRENGTH	f_c'	=	2.5	ksi		
REBAR YIELD STRESS	f_y	=	60	ksi		
LATERAL SOIL PRESSURE	$P_a=k_a\,\gamma_b$	=	35	pcf (equivalent fluid pressure)		
BACKFILL SPECIFIC WEIGHT	γ_b	=	110	pcf		
SATURATED SPECIFIC WEIGHT	γ_{sat}	=	118	pcf		
WATER TABLE DEPTH	h	=	10	ft		
PASSIVE PRESSURE	P_p	=	400	psf / ft		
SURCHARGE WEIGHT	w_s	=	40	psf		
FRICTION COEFFICIENT	μ	=	0.4			
ALLOW SOIL PRESSURE	Qa	=	1.5	ksf		
THICKNESS OF TOP STEM	tt	=	8	in		
THICKNESS OF KEY & STEM	tb	=	8	in		
TOE WIDTH	L_T	=	0.67	ft		
HEEL WIDTH	L_H	=	1.16	ft		
HEIGHT OF TOP STEM	H_T	=	3.5	ft		
HEIGHT OF BOT. STEM	H_B	=	0.5	ft		
FOOTING THICKNESS	hf	=	12	in		
KEY DEPTH	hk	=	0	in		
SOIL OVER TOE	hp	=	6	in		
TOP STEM REINF. ($A_{s,1}$)		#	5	@	15	in o.c.
$A_{s,1}$ LOCATION (0=at soil face, 1=at middle, 2=at each face)					1	at middle
BOT. STEM REINF. ($A_{s,2}$)		#	5	@	15	in o.c.
$A_{s,2}$ LOCATION (0=at soil face, 1=at middle, 2=at each face)					1	at middle
TOP REINF.OF FOOTING ($A_{s,3}$)		#	5	@	18	in o.c.
BOT. REINF.OF FOOTING ($A_{s,4}$)		#	5	@	18	in



[THE WALL DESIGN IS ADEQUATE.]

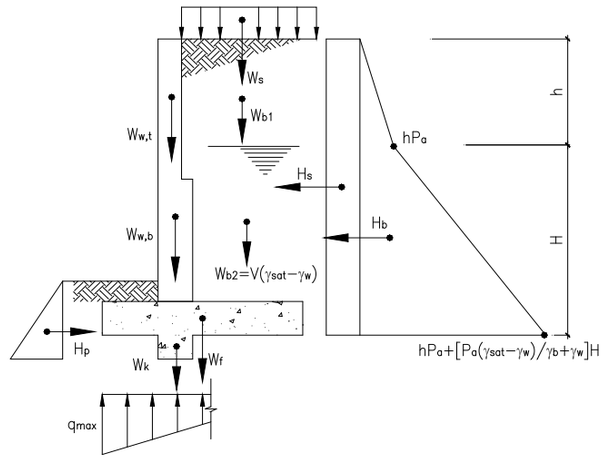
ANALYSIS

SERVICE LOADS

$H_b = 0.5\,P_a\,h^2 + h\,P_a\,H + 0.5\,[P_a\,(\gamma_{sat} - \gamma_w) / \gamma_b + \gamma_w]\,H^2$ = 0.44 kips

Where h = 5 ft , H = 0 ft

$H_s = w_s\,P_a\,(H_T + H_B + h_f) / \gamma_b$	=	0.06 kips
$H_p = 0.5\,P_p\,(h_p + h_f + h_k)^2$	=	0.45 kips
$W_s = w_s\,(L_H + t_b - t_t)$	=	0.05 kips
$W_b = W_{b1} + W_{b2}$	=	0.51 kips
Where W_{b1} = 0.51 kips , W_{b2} =		0.00 kips
$W_f = h_f\,(L_H + t_b + L_T)\,\gamma_c$	=	0.37 kips
$W_k = h_k\,t_b\,\gamma_c$	=	0.00 kips
$W_{w,t} = t_t\,H_T\,\gamma_c$	=	0.35 kips
$W_{w,b} = t_b\,H_B\,\gamma_c$	=	0.05 kips



FACTORED LOADS

$\gamma H_b = 1.6\,H_b$	=	0.70	kips
$\gamma H_s = 1.6\,H_s$	=	0.10	kips
$\gamma W_s = 1.6\,W_s$	=	0.07	kips
$\gamma W_b = 1.2\,W_b$	=	0.61	kips
$\gamma W_f = 1.2\,W_f$	=	0.45	kips
$\gamma W_k = 1.2\,W_k$	=	0.00	kips
$\gamma W_{w,t} = 1.2\,W_{w,t}$	=	0.42	kips
$\gamma W_{w,b} = 1.2\,W_{w,b}$	=	0.06	kips

OVERTURNING MOMENT

	H	γH	y	H y	γH y
H_b	0.44	0.70	1.67	0.73	1.17
H_s	0.06	0.10	2.50	0.16	0.25
Σ	0.50	0.80		**0.89**	1.42

RESISTING MOMENT

	W	γW	x	W x	γW x
W_s	0.05	0.07	1.92	0.09	0.14
W_b	0.51	0.61	1.92	0.98	1.17
W_f	0.37	0.45	1.25	0.47	0.56
W_k	0.00	0.00	1.00	0.00	0.00
$W_{w,t}$	0.35	0.42	1.00	0.35	0.42
$W_{w,b}$	0.05	0.06	1.00	0.05	0.06
Σ	1.33	1.62		**1.94**	2.36

OVERTURNING FACTOR OF SAFETY (1806.1)

$$SF = \frac{\Sigma Wx}{\Sigma Hy}$$

2.18 **>** 1.5

[Satisfactory]

CHECK SOIL BEARING CAPACITY (ACI 318-05 SEC.15.2.2)

$L = L_T \quad t_b \quad L_H$ = 2.50 ft

$$e = \frac{L}{2} - \frac{\Sigma M_x - \Sigma M_y}{\Sigma W} = 0.46 \text{ ft}$$

$$q_{MAX} = \begin{cases} \dfrac{\Sigma W\left(1+\dfrac{6e}{L}\right)}{BL}, & for \quad e \le \dfrac{L}{6} \\ \dfrac{2\Sigma W}{3B(0.5L-e)}, & for \quad e > \dfrac{L}{6} \end{cases} = 1.13 \text{ ksf} < Q_a \quad \textbf{[Satisfactory]}$$

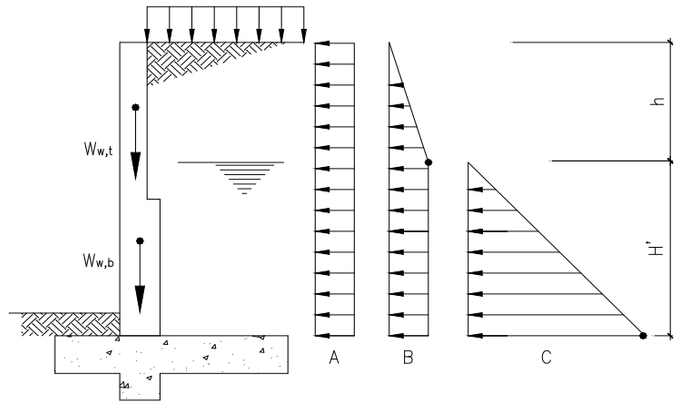
CHECK FLEXURE CAPACITY, AS,1 & AS,2, FOR STEM (ACI 318-05 SEC.15.4.2, 10.2, 10.5.4, 7.12.2, 12.2, & 12.5)

h = 4 ft , H' = 0 ft

A = $w_s P_a / \gamma_b$ = 13 plf

B = $h P_a$ = 140 plf

C = $[P_a (\gamma_{sat} - \gamma_w) / \gamma_b + \gamma_w]$ H' = 0 plf



At base of top stem

Mu = 0.52 ft-kips

Vu = 0.41 kips

Pu = 0.42 kips

At base of bottom stem

Mu = 0.76 ft-kips

Vu = 0.53 kips

Pu = 0.48 kips

		At top stem		At base of bottom stem	
$\phi M_n = \phi A_S f_y \left(d - \dfrac{A_S f_y - P_u}{1.7 b f'_c}\right)$	=	4.15	ft-kips ,	4.15	ft-kips
		>	M_u	>	M_u
		[Satisfactory]		**[Satisfactory]**	
where d	=	4.00	in ,	4.00	in
b	=	12	in ,	12	in
ϕ	=	0.9	(ACI 318 Fig R9.3.2)	0.9	(ACI 318 Fig R9.3.2)
A_s	=	0.248	in^2 ,	0.248	in^2
ρ	=	0.005		0.005	
$\rho_{MAX} = \dfrac{0.85\beta_1 f'_c}{f_y}\dfrac{\varepsilon_u}{\varepsilon_u+\varepsilon_t}$	=	0.013		0.013	
		>	ρ	>	ρ
		[Satisfactory]		**[Satisfactory]**	
$\rho_{MIN} = 0.0018\dfrac{t}{d}$	=	0.004		0.004	
		<	ρ	<	ρ
		[Satisfactory]		**[Satisfactory]**	

CHECK SHEAR CAPACITY FOR STEM (ACI 318-05 SEC.15.5.2, 11.1.3.1, & 11.3)

		At top stem		At base of bottom stem	
$V_{allowable} = 2\phi b d \sqrt{f'_c}$	=	3.60	kips ,	3.60	kips
		>	V_u	>	V_u
		[Satisfactory]		**[Satisfactory]**	

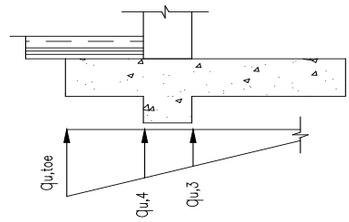
where ϕ = 0.75 (ACI 318-05, Section 9.3.2.3)

CHECK HEEL FLEXURE CAPACITY, AS,3, FOR FOOTING (ACI 318-05 SEC.15.4.2, 10.2, 10.3.5, 10.5.4, 7.12.2, 12.2, & 12.5)

$$\rho_{MAX} = \frac{0.85\beta_1 f'_c}{f_y}\frac{\varepsilon_u}{\varepsilon_u+\varepsilon_t} = 0.013 \qquad \rho_{MIN} = \frac{0.0018}{2}\frac{h_f}{d} = 0.001$$

$$M_{u,3} = \begin{cases} \dfrac{L_H}{2}\left(\gamma w_s \quad w_b\right)\dfrac{L_H}{L} \quad w_f \quad \dfrac{\left(q_{u,3}+2q_{u,heel}\right)bL_H^2}{6}, & for \quad e_u \quad \dfrac{L}{6} \\ \dfrac{L_H}{2}\left(\gamma w_s + + w_b\right)\dfrac{L_H}{L} \quad w_f \quad \dfrac{q_{u,3} b S^2}{6}, & for \quad e_u \quad \dfrac{L}{6} \end{cases} = 0.51 \text{ ft-kips}$$

$$\rho = \frac{0.85 f_c' \left(1 - \sqrt{1 - \frac{M_{u,3}}{0.383 b d^2 f_c'}}\right)}{f_y} = 0.000$$



where d = 10.19 in $q_{u,\,toe}$ = 1.86 ksf
e_u = 0.67 ft $q_{u,\,heel}$ = n/a ksf
S = 0.40 ft $q_{u,\,3}$ = 0.43 ksf

$(A_{S,3})_{required}$ = 0.13 in^2 / ft < $A_{S,3}$ **[Satisfactory]**

CHECK TOE FLEXURE CAPACITY, AS,4, FOR FOOTING (ACI 318-05 SEC.15.4.2, 10.2, 10.3.5, 10.5.4, 7.12.2, 12.2, & 12.5)

$$\rho_{MAX} = \frac{0.85 \beta_1 f_c'}{f_y} \frac{\varepsilon_u}{\varepsilon_u + \varepsilon_t} = 0.013 \qquad \rho_{MIN} = MIN\left(\frac{4}{3}\rho,\ \frac{0.0018}{2}\frac{h_f}{d}\right) = 0.000$$

$$M_{u,4} = \frac{\left(q_{u,4} + 2q_{u,toe}\right) b L_T^2}{6} \frac{L_T^2}{2L} \gamma w_f = 0.32 \text{ ft-kips}$$

where d = 8.69 in
$q_{u,\,4}$ = 1.14 ksf

$$\rho = \frac{0.85 f_c' \left(1 - \sqrt{1 - \frac{M_{u,4}}{0.383 b d^2 f_c'}}\right)}{f_y} = 0.000$$

$(A_{S,4})_{required}$ = 0.01 in^2 / ft < $A_{S,4}$ **[Satisfactory]**

CHECK SLIDING CAPACITY (IBC 1806.1)

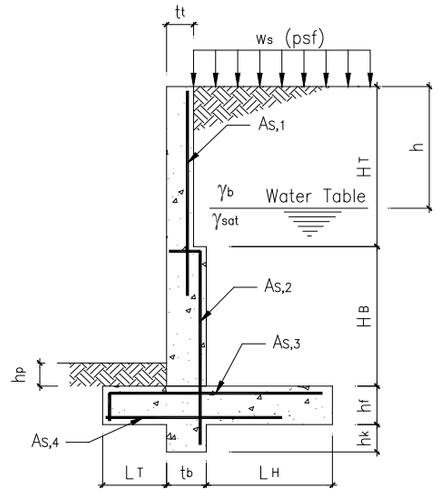
1.5 (H_b + H_s) = 0.75 kips < $H_p + \mu \Sigma W$ = 0.98 kips
[Satisfactory]

Technical References:
1. Alan Williams: "Structural Engineering Reference Manual", Professional Publications, Inc, 2001.
2. Alan Williams: "Structural Engineering License Review Problems and Solutions", Oxford University Press, 2003.

Retaining Wall Design Based on ACI 318 — 6ft Retaining Wall

INPUT DATA & DESIGN SUMMARY

CONCRETE STRENGTH	f_c'	=	2.5	ksi		
REBAR YIELD STRESS	f_y	=	60	ksi		
LATERAL SOIL PRESSURE	$P_a=k_a\,\gamma_b$	=	35	pcf (equivalent fluid pressure)		
BACKFILL SPECIFIC WEIGHT	γ_b	=	110	pcf		
SATURATED SPECIFIC WEIGHT	γ_{sat}	=	118	pcf		
WATER TABLE DEPTH	h	=	10	ft		
PASSIVE PRESSURE	P_p	=	400	psf / ft		
SURCHARGE WEIGHT	w_s	=	40	psf		
FRICTION COEFFICIENT	μ	=	0.4			
ALLOW SOIL PRESSURE	Qa	=	1.5	ksf		
THICKNESS OF TOP STEM	tt	=	8	in		
THICKNESS OF KEY & STEM	tb	=	8	in		
TOE WIDTH	L_T	=	1	ft		
HEEL WIDTH	L_H	=	1.83	ft		
HEIGHT OF TOP STEM	H_T	=	5.5	ft		
HEIGHT OF BOT. STEM	H_B	=	0.5	ft		
FOOTING THICKNESS	hf	=	12	in		
KEY DEPTH	hk	=	0	in		
SOIL OVER TOE	hp	=	6	in		
TOP STEM REINF. ($A_{s,1}$)		#	5	@	12	in o.c.
$A_{s,1}$ LOCATION (0=at soil face, 1=at middle, 2=at each face)					1	at middle
BOT. STEM REINF. ($A_{s,2}$)		#	5	@	12	in o.c.
$A_{s,2}$ LOCATION (0=at soil face, 1=at middle, 2=at each face)					1	at middle
TOP REINF.OF FOOTING ($A_{s,3}$)		#	5	@	18	in o.c.
BOT. REINF.OF FOOTING ($A_{s,4}$)		#	5	@	18	in



[THE WALL DESIGN IS ADEQUATE.]

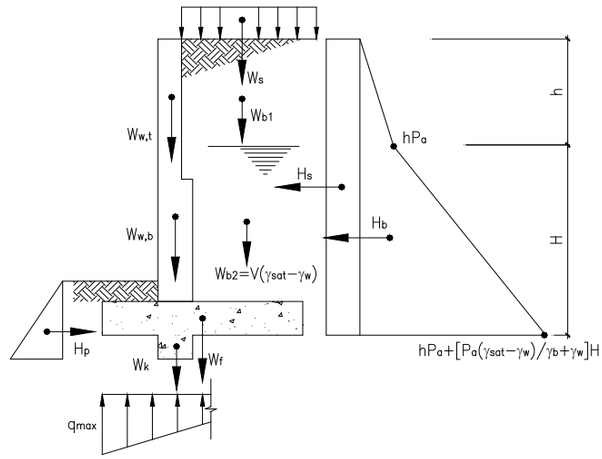
ANALYSIS

SERVICE LOADS

$H_b = 0.5\,P_a\,h^2 + h\,P_a\,H + 0.5\,[P_a\,(\gamma_{sat} - \gamma_w) / \gamma_b + \gamma_w]\,H^2$ = 0.86 kips

Where h = 7 ft , H = 0 ft

$H_s = w_s\,P_a\,(H_T + H_B + h_f) / \gamma_b$	=	0.08 kips
$H_p = 0.5\,P_p\,(h_p + h_f + h_k)^2$	=	0.45 kips
$W_s = w_s\,(L_H + t_b - t_t)$	=	0.06 kips
$W_b = W_{b1} + W_{b2}$	=	1.21 kips
Where W_{b1} = 1.21 kips , W_{b2} =		0.00 kips
$W_f = h_f\,(L_H + t_b + L_T)\,\gamma_c$	=	0.52 kips
$W_k = h_k\,t_b\,\gamma_c$	=	0.00 kips
$W_{w,t} = t_t\,H_T\,\gamma_c$	=	0.55 kips
$W_{w,b} = t_b\,H_B\,\gamma_c$	=	0.05 kips



FACTORED LOADS

$\gamma H_b = 1.6\,H_b$	=	1.37 kips
$\gamma H_s = 1.6\,H_s$	=	0.12 kips
$\gamma W_s = 1.6\,W_s$	=	0.10 kips
$\gamma W_b = 1.2\,W_b$	=	1.45 kips
$\gamma W_f = 1.2\,W_f$	=	0.63 kips
$\gamma W_k = 1.2\,W_k$	=	0.00 kips
$\gamma W_{w,t} = 1.2\,W_{w,t}$	=	0.66 kips
$\gamma W_{w,b} = 1.2\,W_{w,b}$	=	0.06 kips

OVERTURNING MOMENT

	H	γH	y	H y	γH y
Hb	0.86	1.37	2.33	2	3.20
Hs	0.08	0.12	3.50	0.27	0.44
Σ	0.94	1.50		**2.27**	3.64

RESISTING MOMENT

	W	γW	x	W x	γW x
Ws	0.06	0.10	2.58	0.17	0.26
Wb	1.21	1.45	2.58	3.12	3.74
Wf	0.52	0.63	1.75	0.92	1.10
Wk	0.00	0.00	1.33	0.00	0.00
Ww,t	0.55	0.66	1.33	0.73	0.88
Ww,b	0.05	0.06	1.33	0.07	0.08
Σ	2.40	2.90		**5.00**	6.07

OVERTURNING FACTOR OF SAFETY (1806.1)

$$SF = \frac{\Sigma Wx}{\Sigma Hy}$$

2.2 **>** 1.5

[Satisfactory]

CHECK SOIL BEARING CAPACITY (ACI 318-05 SEC.15.2.2)

$L = L_T \quad t_b \quad L_H$ = 3.50 ft

$$e = \frac{L}{2} - \frac{\Sigma M_x - \Sigma M_y}{\Sigma W} = 0.61 \text{ ft}$$

$$q_{MAX} = \begin{cases} \dfrac{\Sigma W\left(1+\dfrac{6e}{L}\right)}{BL}, & for \quad e \le \dfrac{L}{6} \\ \dfrac{2\Sigma W}{3B(0.5L-e)}, & for \quad e > \dfrac{L}{6} \end{cases} = 1.40 \text{ ksf} < Q_a \quad \textbf{[Satisfactory]}$$

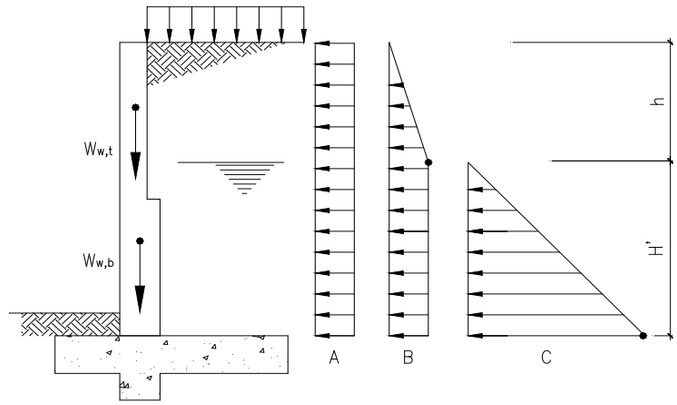
CHECK FLEXURE CAPACITY, AS,1 & AS,2, FOR STEM (ACI 318-05 SEC.15.4.2, 10.2, 10.5.4, 7.12.2, 12.2, & 12.5)

h = 6 ft , H' = 0 ft

A = $w_s P_a / \gamma_b$ = 11 plf

B = $h P_a$ = 210 plf

C = $[P_a (\gamma_{sat} - \gamma_w) / \gamma_b + \gamma_w]$ H' = 0 plf



At base of top stem

Mu = 1.82 ft-kips

Vu = 0.95 kips

Pu = 0.66 kips

At base of bottom stem

Mu = 2.34 ft-kips

Vu = 0.72 kips

Pu = 0.66 kips

$$\phi M_n = -\left[A_S f_y \left(d - \frac{A_S f_y - P_u}{1.7 b f'_c} \right) \right]$$

	At top stem		At base of bottom stem	
	= 5.09	ft-kips ,	5.09	ft-kips
	> M_u		> M_u	
	[Satisfactory]		**[Satisfactory]**	
where d	= 4.00	in ,	4.00	in
b	= 12	in ,	12	in
ϕ	= 0.9	(ACI 318 Fig R9.3.2)	0.9	(ACI 318 Fig R9.3.2)
A_s	= 0.31	in^2 ,	0.31	in^2
ρ	= 0.006		0.006	
$\rho_{MAX} = \dfrac{0.85\beta_1 f'_c}{f_y}\dfrac{\varepsilon_u}{\varepsilon_u+\varepsilon_t}$	= 0.013		0.013	
	> ρ		> ρ	
	[Satisfactory]		**[Satisfactory]**	
$\rho_{MIN} = 0.0018\dfrac{t}{d}$	= 0.004		0.004	
	< ρ		< ρ	
	[Satisfactory]		**[Satisfactory]**	

CHECK SHEAR CAPACITY FOR STEM (ACI 318-05 SEC.15.5.2, 11.1.3.1, & 11.3)

$$V_{allowable} = 2\phi b d \sqrt{f'_c}$$

	At top stem		At base of bottom stem	
	= 3.60	kips ,	3.60	kips
	> V_u		> V_u	
	[Satisfactory]		**[Satisfactory]**	

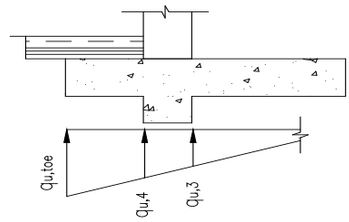
where ϕ = 0.75 (ACI 318-05, Section 9.3.2.3)

CHECK HEEL FLEXURE CAPACITY, AS,3, FOR FOOTING (ACI 318-05 SEC.15.4.2, 10.2, 10.3.5, 10.5.4, 7.12.2, 12.2, & 12.5)

$$\rho_{MAX} = \frac{0.85\beta_1 f'_c}{f_y}\frac{\varepsilon_u}{\varepsilon_u+\varepsilon_t} = 0.013 \qquad \rho_{MIN} = \frac{0.0018}{2}\frac{h_f}{d} = 0.001$$

$$M_{u,3} = \begin{cases} \dfrac{L_H}{2}\left(\gamma w_s \quad w_b\right)\dfrac{L_H}{L} \quad w_f & \dfrac{\left(q_{u,3}+2q_{u,heel}\right)bL_H^2}{6}, \quad for \quad e_u \quad \dfrac{L}{6} \\ \dfrac{L_H}{2}\left(\gamma w_s + + w_b\right)\dfrac{L_H}{L} \quad w_f & \dfrac{q_{u,3}bS^2}{6}, \quad for \quad e_u \quad \dfrac{L}{6} \end{cases} = 1.63 \text{ ft-kips}$$

$$\rho = \frac{0.85 f_c' \left(1 - \sqrt{1 - \frac{M_{u,3}}{0.383 b d^2 f_c'}}\right)}{f_y} = 0.000$$



where d = 10.19 in $q_{u,\,toe}$ = 2.31 ksf
e_u = 0.91 ft $q_{u,\,heel}$ = n/a ksf
S = 0.84 ft $q_{u,\,3}$ = 0.78 ksf

$(A_{S,3})_{required}$ = 0.13 in^2 / ft < $A_{S,3}$ **[Satisfactory]**

CHECK TOE FLEXURE CAPACITY, AS,4, FOR FOOTING (ACI 318-05 SEC.15.4.2, 10.2, 10.3.5, 10.5.4, 7.12.2, 12.2, & 12.5)

$$\rho_{MAX} = \frac{0.85 \beta_1 f_c'}{f_y} \frac{\varepsilon_u}{\varepsilon_u + \varepsilon_t} = 0.013 \qquad \rho_{MIN} = MIN\left(\frac{4}{3}\rho,\ \frac{0.0018}{2}\frac{h_f}{d}\right) = 0.000$$

$$M_{u,4} = \frac{\left(q_{u,4} + 2q_{u,toe}\right) b L_T^2}{6} \frac{L_T^2}{2L} \gamma w_f = 0.91 \text{ ft-kips}$$

where d = 8.69 in
$q_{u,\,4}$ = 1.39 ksf

$$\rho = \frac{0.85 f_c' \left(1 - \sqrt{1 - \frac{M_{u,4}}{0.383 b d^2 f_c'}}\right)}{f_y} = 0.000$$

$(A_{S,4})_{required}$ = 0.03 in^2 / ft < $A_{S,4}$ **[Satisfactory]**

CHECK SLIDING CAPACITY (IBC 1806.1)

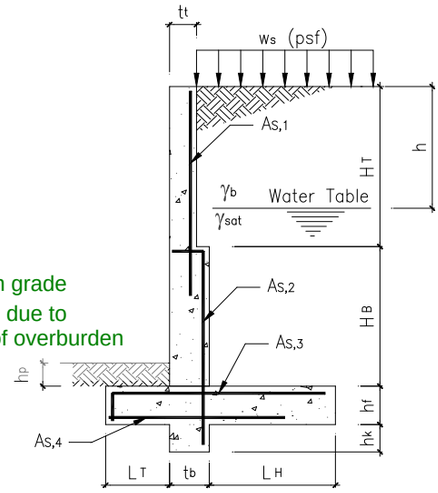
1.5 (H_b + H_s) = 1.4 kips < $H_p + \mu \Sigma W$ = 1.41 kips
[Satisfactory]

Technical References:
1. Alan Williams: "Structural Engineering Reference Manual", Professional Publications, Inc, 2001.
2. Alan Williams: "Structural Engineering License Review Problems and Solutions", Oxford University Press, 2003.

Retaining Wall Design Based on ACI 318 — 8ft Retaining Wall

INPUT DATA & DESIGN SUMMARY

CONCRETE STRENGTH	f_c'	=	2.5	ksi	
REBAR YIELD STRESS	f_y	=	60	ksi	
LATERAL SOIL PRESSURE	$P_a=k_a\,\gamma_b$	=	35	pcf (equivalent fluid pressure)	
BACKFILL SPECIFIC WEIGHT	γ_b	=	110	pcf	
SATURATED SPECIFIC WEIGHT	γ_{sat}	=	118	pcf	
WATER TABLE DEPTH	h	=	10	ft	
PASSIVE PRESSURE	P_p	=	400	psf / ft	
SURCHARGE WEIGHT	w_s	=	40	psf	
FRICTION COEFFICIENT	μ	=	0.6	no sliding due to conc slab on grade	
ALLOW SOIL PRESSURE	Q_a	=	1.6	ksf bearing capacity increase due to excavation and removal of overburden existing soil	
THICKNESS OF TOP STEM	t_t	=	8	in	
THICKNESS OF KEY & STEM	t_b	=	8	in	
TOE WIDTH	L_T	=	1.75	ft	
HEEL WIDTH	L_H	=	2.08	ft	
HEIGHT OF TOP STEM	H_T	=	7.5	ft	
HEIGHT OF BOT. STEM	H_B	=	0.5	ft	
FOOTING THICKNESS	h_f	=	12	in	
KEY DEPTH	h_k	=	0	in	
SOIL OVER TOE	h_p	=	6	in	
TOP STEM REINF. ($A_{s,1}$)		#	5	@ 10	in o.c.
$A_{s,1}$ LOCATION (0=at soil face, 1=at middle, 2=at each face)			1		at middle
BOT. STEM REINF. ($A_{s,2}$)		#	5	@ 10	in o.c.
$A_{s,2}$ LOCATION (0=at soil face, 1=at middle, 2=at each face)			1		at middle
TOP REINF.OF FOOTING ($A_{s,3}$)		#	5	@ 12	in o.c.
BOT. REINF.OF FOOTING ($A_{s,4}$)		#	5	@ 12	in



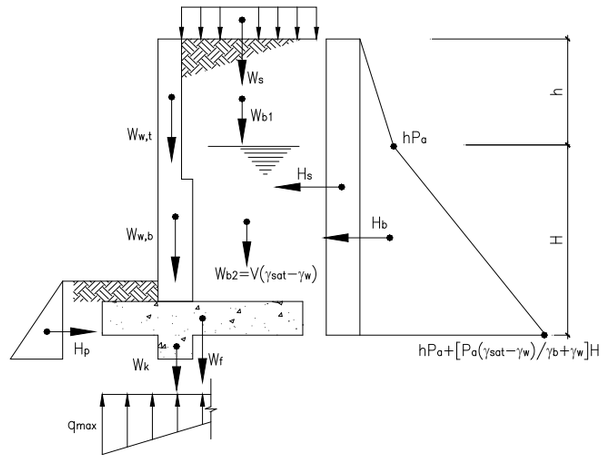
[THE WALL DESIGN IS ADEQUATE.]

ANALYSIS

SERVICE LOADS

$$H_b = 0.5\,P_a\,h^2 + h\,P_a\,H + 0.5\,[P_a(\gamma_{sat}-\gamma_w)/\gamma_b+\gamma_w]\,H^2$$

	=	1.42	kips
Where h = 9 ft ,	H =	0	ft
$H_s = w_s\,P_a\,(H_T + H_B + h_f)/\gamma_b$	=	0.11	kips
$H_p = 0.5\,P_p\,(h_p + h_f + h_k)^2$	=	0.45	kips
$W_s = w_s\,(L_H + t_b - t_t)$	=	0.08	kips
$W_b = W_{b1} + W_{b2}$	=	1.83	kips
Where W_{b1} = 1.83 kips ,	W_{b2} =	0.00	kips
$W_f = h_f\,(L_H + t_b + L_T)\,\gamma_c$	=	0.67	kips
$W_k = h_k\,t_b\,\gamma_c$	=	0.00	kips
$W_{w,t} = t_t\,H_T\,\gamma_c$	=	0.75	kips
$W_{w,b} = t_b\,H_B\,\gamma_c$	=	0.05	kips



FACTORED LOADS

$\gamma H_b = 1.6\,H_b$	=	2.27	kips
$\gamma H_s = 1.6\,H_s$	=	0.18	kips
$\gamma W_s = 1.6\,W_s$	=	0.13	kips
$\gamma W_b = 1.2\,W_b$	=	2.20	kips
$\gamma W_f = 1.2\,W_f$	=	0.81	kips
$\gamma W_k = 1.2\,W_k$	=	0.00	kips
$\gamma W_{w,t} = 1.2\,W_{w,t}$	=	0.90	kips
$\gamma W_{w,b} = 1.2\,W_{w,b}$	=	0.06	kips

OVERTURNING MOMENT

	H	γH	y	H y	γH y
H_b	1.42	2.27	3.00	4.25	6.80
H_s	0.11	0.18	4.50	0.52	0.82
Σ	1.53	2.45		**4.77**	7.63

RESISTING MOMENT

	W	γW	x	W x	γW x
W_s	0.08	0.13	3.46	0.29	0.46
W_b	1.83	2.20	3.46	6.33	7.59
W_f	0.67	0.81	2.25	1.52	1.82
W_k	0.00	0.00	2.08	0.00	0.00
$W_{w,t}$	0.75	0.90	2.08	1.56	1.88
$W_{w,b}$	0.05	0.06	2.08	0.10	0.13
Σ	3.39	4.10		**9.80**	11.87

OVERTURNING FACTOR OF SAFETY (1806.1)

$$SF = \frac{\Sigma Wx}{\Sigma Hy}$$

2.05 **>** 1.5

[Satisfactory]

CHECK SOIL BEARING CAPACITY (ACI 318-05 SEC.15.2.2)

$L = L_T \quad t_b \quad L_H$ = 4.50 ft

$$e = \frac{L}{2} - \frac{\Sigma W_x \quad \Sigma W_y}{\Sigma W} = 0.76 \text{ ft}$$

$$q_{MAX} = \begin{cases} \dfrac{\Sigma W\left(1+\dfrac{6e}{L}\right)}{BL}, & for \quad e \le \dfrac{L}{6} \\ \dfrac{2\Sigma W}{3B(0.5L-e)}, & for \quad e > \dfrac{L}{6} \end{cases} = 1.52 \text{ ksf} < Q_a \quad \textbf{[Satisfactory]}$$

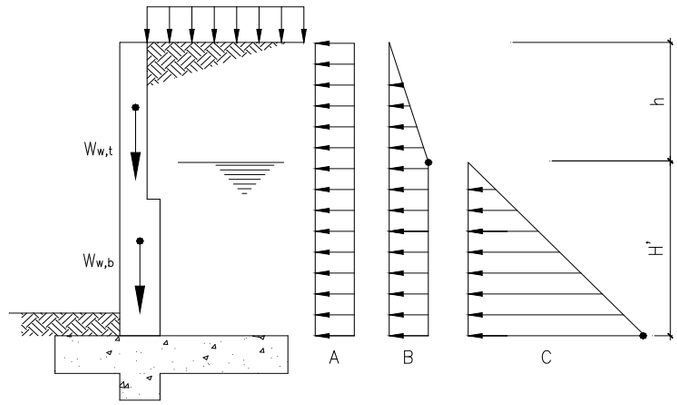
CHECK FLEXURE CAPACITY, AS,1 & AS,2, FOR STEM (ACI 318-05 SEC.15.4.2, 10.2, 10.5.4, 7.12.2, 12.2, & 12.5)

h = 8 ft , H' = 0 ft

A = $w_s P_a / \gamma_b$ = 13 plf

B = $h P_a$ = 280 plf

C = $[P_a (\gamma_{sat} - \gamma_w) / \gamma_b + \gamma_w]$ H' = 0 plf



At base of top stem

Mu = 4.51 ft-kips

Vu = 1.73 kips

Pu = 0.90 kips

At base of bottom stem

Mu = 5.43 ft-kips

Vu = 1.95 kips

Pu = 0.96 kips

	At top stem		At base of bottom stem	
$\phi M_n = \phi A_S f_y \left(d - \dfrac{A_S f_y - P_u}{1.7 b f'_c}\right)$ =	5.99	ft-kips ,	5.99	ft-kips
	>	M_u	>	M_u
	[Satisfactory]		**[Satisfactory]**	
where d =	4.00	in ,	4.00	in
b =	12	in ,	12	in
ϕ =	0.9	(ACI 318 Fig R9.3.2)	0.9	(ACI 318 Fig R9.3.2)
A_s =	0.372	in^2 ,	0.372	in^2
ρ =	0.008		0.008	
$\rho_{MAX} = \dfrac{0.85\beta_1 f'_c}{f_y}\dfrac{\varepsilon_u}{\varepsilon_u+\varepsilon_t}$ =	0.013		0.013	
	>	ρ	>	ρ
	[Satisfactory]		**[Satisfactory]**	
$\rho_{MIN} = 0.0018\dfrac{t}{d}$ =	0.004		0.004	
	<	ρ	<	ρ
	[Satisfactory]		**[Satisfactory]**	

CHECK SHEAR CAPACITY FOR STEM (ACI 318-05 SEC.15.5.2, 11.1.3.1, & 11.3)

	At top stem		At base of bottom stem	
$V_{allowable} = 2\phi b d \sqrt{f'_c}$ =	3.60	kips ,	3.60	kips
	>	V_u	>	V_u
	[Satisfactory]		**[Satisfactory]**	

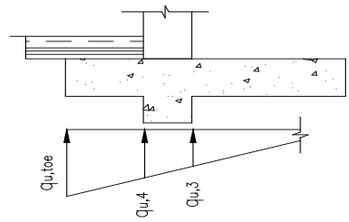
where ϕ = 0.75 (ACI 318-05, Section 9.3.2.3)

CHECK HEEL FLEXURE CAPACITY, AS,3, FOR FOOTING (ACI 318-05 SEC.15.4.2, 10.2, 10.3.5, 10.5.4, 7.12.2, 12.2, & 12.5)

$$\rho_{MAX} = \frac{0.85\beta_1 f'_c}{f_y}\frac{\varepsilon_u}{\varepsilon_u+\varepsilon_t} = 0.013 \qquad \rho_{MIN} = \frac{0.0018}{2}\frac{h_f}{d} = 0.001$$

$$M_{u,3} = \begin{cases} \dfrac{L_H}{2}\left(\gamma w_s \quad w_b\right)\dfrac{L_H}{L} \quad w_f \quad \dfrac{\left(q_{u,3}+2q_{u,heel}\right)bL_H^2}{6}, & for \quad e_u \quad \dfrac{L}{6} \\ \dfrac{L_H}{2}\left(\gamma w_s + w_b\right)\dfrac{L_H}{L} \quad w_f \quad \dfrac{q_{u,3}bS^2}{6}, & for \quad e_u \quad \dfrac{L}{6} \end{cases} = 2.77 \text{ ft-kips}$$

$$\rho = \frac{0.85 f_c' \left(1 - \sqrt{1 - \frac{M_{u,3}}{0.383 b d^2 f_c'}}\right)}{f_y} = 0.000$$



where d = 10.19 in $q_{u,toe}$ = 2.64 ksf
e_u = 1.21 ft $q_{u,heel}$ = n/a ksf
S = 0.69 ft $q_{u,3}$ = 0.59 ksf

$(A_{S,3})_{required}$ = 0.13 in^2 / ft < $A_{S,3}$ **[Satisfactory]**

CHECK TOE FLEXURE CAPACITY, AS,4, FOR FOOTING (ACI 318-05 SEC.15.4.2, 10.2, 10.3.5, 10.5.4, 7.12.2, 12.2, & 12.5)

$$\rho_{MAX} = \frac{0.85 \beta_1 f_c'}{f_y} \frac{\varepsilon_u}{\varepsilon_u + \varepsilon_t} = 0.013 \qquad \rho_{MIN} = MIN\left(\frac{4}{3}\rho,\ \frac{0.0018}{2}\frac{h_f}{d}\right) = 0.001$$

$$M_{u,4} = \frac{\left(q_{u,4} + 2q_{u,toe}\right) b L_T^2}{6} \frac{L_T^2}{2L} \gamma w_f = 3.01 \text{ ft-kips}$$

where d = 8.69 in
$q_{u,4}$ = 1.15 ksf

$$\rho = \frac{0.85 f_c' \left(1 - \sqrt{1 - \frac{M_{u,4}}{0.383 b d^2 f_c'}}\right)}{f_y} = 0.001$$

$(A_{S,4})_{required}$ = 0.10 in^2 / ft < $A_{S,4}$ **[Satisfactory]**

CHECK SLIDING CAPACITY (IBC 1806.1)

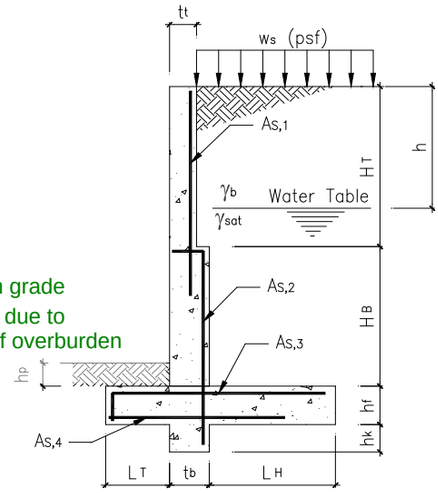
1.5 (H_b + H_s) = 2.3 kips < $H_p + \mu \Sigma W$ = 2.48 kips
[Satisfactory]

Technical References:
1. Alan Williams: "Structural Engineering Reference Manual", Professional Publications, Inc, 2001.
2. Alan Williams: "Structural Engineering License Review Problems and Solutions", Oxford University Press, 2003.

Retaining Wall Design Based on ACI 318 — 10ft Retaining Wall

INPUT DATA & DESIGN SUMMARY

CONCRETE STRENGTH	f_c'	=	2.5	ksi	
REBAR YIELD STRESS	f_y	=	60	ksi	
LATERAL SOIL PRESSURE	$P_a=k_a\,\gamma_b$	=	35	pcf (equivalent fluid pressure)	
BACKFILL SPECIFIC WEIGHT	γ_b	=	110	pcf	
SATURATED SPECIFIC WEIGHT	γ_{sat}	=	118	pcf	
WATER TABLE DEPTH	h	=	20	ft	
PASSIVE PRESSURE	P_p	=	400	psf / ft	
SURCHARGE WEIGHT	w_s	=	40	psf	
FRICTION COEFFICIENT	μ	=	0.7	no sliding due to conc slab on grade	
ALLOW SOIL PRESSURE	Q_a	=	1.7	ksf bearing capacity increase due to	
THICKNESS OF TOP STEM	t_t	=	8	in excavation and removal of overburden	
THICKNESS OF KEY & STEM	t_b	=	8	in existing soil	
TOE WIDTH	L_T	=	2.5	ft	
HEEL WIDTH	L_H	=	2.33	ft	
HEIGHT OF TOP STEM	H_T	=	9.5	ft	
HEIGHT OF BOT. STEM	H_B	=	0.5	ft	
FOOTING THICKNESS	h_f	=	12	in	
KEY DEPTH	h_k	=	0	in	
SOIL OVER TOE	h_p	=	6	in	
TOP STEM REINF. ($A_{s,1}$)		#	6	@ 9	in o.c.
$A_{s,1}$ LOCATION (0=at soil face, 1=at middle, 2=at each face)			0		at soil face
BOT. STEM REINF. ($A_{s,2}$)		#	6	@ 9	in o.c.
$A_{s,2}$ LOCATION (0=at soil face, 1=at middle, 2=at each face)			0		at soil face
TOP REINF.OF FOOTING ($A_{s,3}$)		#	5	@ 12	in o.c.
BOT. REINF.OF FOOTING ($A_{s,4}$)		#	5	@ 12	in **[THE WALL DESIGN IS ADEQUATE.]**



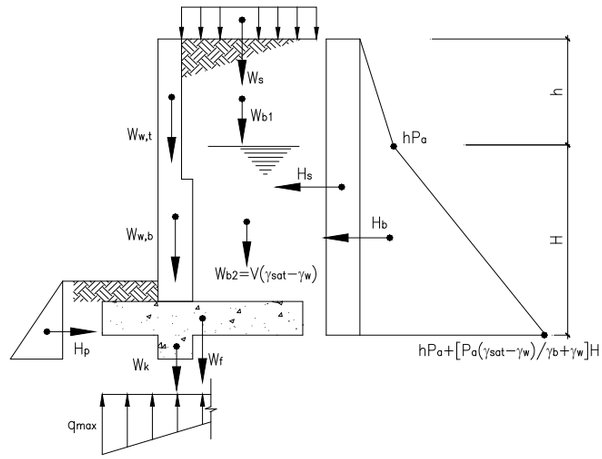
ANALYSIS

SERVICE LOADS

$H_b = 0.5\,P_a\,h^2 + h\,P_a\,H + 0.5\,[P_a(\gamma_{sat}-\gamma_w)/\gamma_b+\gamma_w]\,H^2$ = 2.12 kips

Where h = 11 ft , H = 0 ft

$H_s = w_s\,P_a\,(H_T + H_B + h_f)/\gamma_b$	=	0.14 kips
$H_p = 0.5\,P_p\,(h_p + h_f + h_k)^2$	=	0.45 kips
$W_s = w_s\,(L_H + t_b - t_t)$	=	0.09 kips
$W_b = W_{b1} + W_{b2}$	=	2.56 kips
Where W_{b1} = 2.56 kips , W_{b2} =		0.00 kips
$W_f = h_f\,(L_H + t_b + L_T)\,\gamma_c$	=	0.82 kips
$W_k = h_k\,t_b\,\gamma_c$	=	0.00 kips
$W_{w,t} = t_t\,H_T\,\gamma_c$	=	0.95 kips
$W_{w,b} = t_b\,H_B\,\gamma_c$	=	0.05 kips



FACTORED LOADS

$\gamma H_b = 1.6\,H_b$	=	3.39 kips
$\gamma H_s = 1.6\,H_s$	=	0.22 kips
$\gamma W_s = 1.6\,W_s$	=	0.15 kips
$\gamma W_b = 1.2\,W_b$	=	3.08 kips
$\gamma W_f = 1.2\,W_f$	=	0.99 kips
$\gamma W_k = 1.2\,W_k$	=	0.00 kips
$\gamma W_{w,t} = 1.2\,W_{w,t}$	=	1.14 kips
$\gamma W_{w,b} = 1.2\,W_{w,b}$	=	0.06 kips

OVERTURNING MOMENT

	H	γH	y	H y	γH y
H_b	2.12	3.39	3.67	7.76	12.42
H_s	0.14	0.22	5.50	0.77	1.23
Σ	2.26	3.61		**8.53**	13.65

RESISTING MOMENT

	W	γW	x	W x	γW x
W_s	0.09	0.15	4.33	0.40	0.65
W_b	2.56	3.08	4.33	11.10	13.32
W_f	0.82	0.99	2.75	2.27	2.72
W_k	0.00	0.00	2.83	0.00	0.00
$W_{w,t}$	0.95	1.14	2.83	2.69	3.23
$W_{w,b}$	0.05	0.06	2.83	0.14	0.17
Σ	4.48	5.41		**16.61**	20.09

OVERTURNING FACTOR OF SAFETY (1806.1)

$$SF = \frac{\Sigma Wx}{\Sigma Hy}$$

1.95 > 1.5

[Satisfactory]

CHECK SOIL BEARING CAPACITY (ACI 318-05 SEC.15.2.2)

$L = L_T \quad t_b \quad L_H$ = 5.50 ft

$$e = \frac{L}{2} - \frac{\Sigma M_x - \Sigma M_y}{\Sigma W} = 0.95 \text{ ft}$$

$$q_{MAX} = \begin{cases} \dfrac{\Sigma W\left(1+\dfrac{6e}{L}\right)}{BL}, & for \quad e \le \dfrac{L}{6} \\ \dfrac{2\Sigma W}{3B(0.5L-e)}, & for \quad e > \dfrac{L}{6} \end{cases} = 1.66 \text{ ksf} < Q_a \quad \textbf{[Satisfactory]}$$

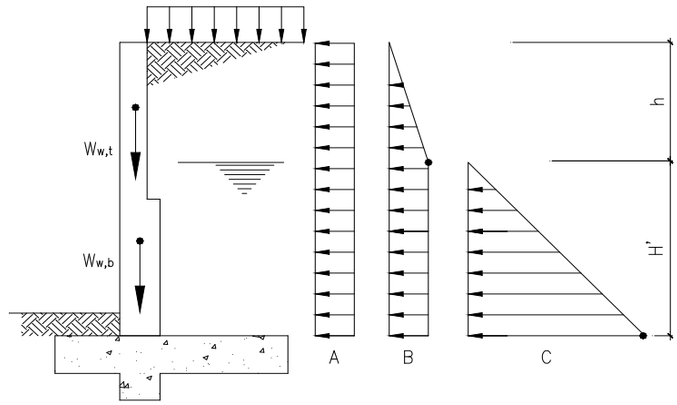
CHECK FLEXURE CAPACITY, AS,1 & AS,2, FOR STEM (ACI 318-05 SEC.15.4.2, 10.2, 10.5.4, 7.12.2, 12.2, & 12.5)

h = 10 ft , H' = 0 ft

A = $w_s P_a / \gamma_b$ = 13 plf

B = $h P_a$ = 350 plf

C = $[P_a (\gamma_{sat} - \gamma_w) / \gamma_b + \gamma_w]$ H' = 0 plf



At base of top stem

Mu = 8.92 ft-kips

Vu = 2.72 kips

Pu = 1.14 kips

At base of bottom stem

Mu = 10.35 ft-kips

Vu = 3.00 kips

Pu = 1.20 kips

		At top stem		At base of bottom stem	
$\phi M_n = \phi A_S f_y \left(d - \dfrac{A_S f_y - P_u}{1.7 b f'_c}\right)$	=	13.09	ft-kips ,	13.09	ft-kips
	>	M_u		>	M_u
		[Satisfactory]		**[Satisfactory]**	
where d	=	5.63	in ,	5.63	in
b	=	12	in ,	12	in
ϕ	=	0.9	(ACI 318 Fig R9.3.2)	0.9	(ACI 318 Fig R9.3.2)
A_s	=	0.58667	in^2 ,	0.586667	in^2
ρ	=	0.009		0.009	
$\rho_{MAX} = \dfrac{0.85\beta_1 f'_c}{f_y}\dfrac{\varepsilon_u}{\varepsilon_u+\varepsilon_t}$	=	0.013		0.013	
	>	ρ		>	ρ
		[Satisfactory]		**[Satisfactory]**	
$\rho_{MIN} = 0.0018\dfrac{t}{d}$	=	0.003		0.003	
	<	ρ		<	ρ
		[Satisfactory]		**[Satisfactory]**	

CHECK SHEAR CAPACITY FOR STEM (ACI 318-05 SEC.15.5.2, 11.1.3.1, & 11.3)

		At top stem		At base of bottom stem	
$V_{allowable} = 2\phi b d \sqrt{f'_c}$	=	5.06	kips ,	5.06	kips
	>	V_u		>	V_u
		[Satisfactory]		**[Satisfactory]**	

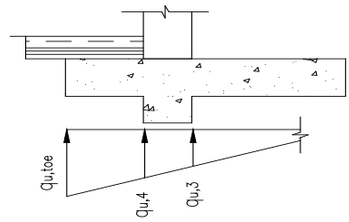
where ϕ = 0.75 (ACI 318-05, Section 9.3.2.3)

CHECK HEEL FLEXURE CAPACITY, AS,3, FOR FOOTING (ACI 318-05 SEC.15.4.2, 10.2, 10.3.5, 10.5.4, 7.12.2, 12.2, & 12.5)

$$\rho_{MAX} = \frac{0.85\beta_1 f'_C}{f_y}\frac{\varepsilon_u}{\varepsilon_u+\varepsilon_t} = 0.013 \qquad \rho_{MIN} = \frac{0.0018}{2}\frac{h_f}{d} = 0.001$$

$$M_{u,3} = \begin{cases} \dfrac{L_H}{2}\left(\gamma w_s \quad w_b\right)\dfrac{L_H}{L} \quad w_f \quad \dfrac{\left(q_{u,3}+2q_{u,heel}\right)bL_H^2}{6}, & for \quad e_u \quad \dfrac{L}{6} \\ \dfrac{L_H}{2}\left(\gamma w_s + w_b\right)\dfrac{L_H}{L} \quad w_f \quad \dfrac{q_{u,3}bS^2}{6}, & for \quad e_u \quad \dfrac{L}{6} \end{cases} = 4.24 \text{ ft-kips}$$

$$\rho = \frac{0.85 f_c' \left(1 - \sqrt{1 - \frac{M_{u,3}}{0.383 b d^2 f_c'}}\right)}{f_y} = 0.001$$



where d = 10.19 in $q_{u,toe}$ = 3.04 ksf
e_u = 1.56 ft $q_{u,heel}$ = n/a ksf
S = 0.40 ft $q_{u,3}$ = 0.34 ksf

$(A_{S,3})_{required}$ = 0.13 in^2 / ft < $A_{S,3}$ **[Satisfactory]**

CHECK TOE FLEXURE CAPACITY, AS,4, FOR FOOTING (ACI 318-05 SEC.15.4.2, 10.2, 10.3.5, 10.5.4, 7.12.2, 12.2, & 12.5)

$$\rho_{MAX} = \frac{0.85 \beta_1 f_c'}{f_y} \frac{\varepsilon_u}{\varepsilon_u + \varepsilon_t} = 0.013 \qquad \rho_{MIN} = MIN\left(\frac{4}{3}\rho,\ \frac{0.0018}{2}\frac{h_f}{d}\right) = 0.001$$

$$M_{u,4} = \frac{\left(q_{u,4} + 2q_{u,toe}\right) b L_T^2}{6} \frac{L_T^2}{2L} \gamma w_f = 6.71 \text{ ft-kips}$$

where d = 8.69 in
$q_{u,4}$ = 0.91 ksf

$$\rho = \frac{0.85 f_c' \left(1 - \sqrt{1 - \frac{M_{u,4}}{0.383 b d^2 f_c'}}\right)}{f_y} = 0.002$$

$(A_{S,4})_{required}$ = 0.18 in^2 / ft < $A_{S,4}$ **[Satisfactory]**

CHECK SLIDING CAPACITY (IBC 1806.1)

1.5 (H_b + H_s) = 3.39 kips < $H_p + \mu \Sigma W$ = 3.59 kips
[Satisfactory]

Technical References:
1. Alan Williams: "Structural Engineering Reference Manual", Professional Publications, Inc, 2001.
2. Alan Williams: "Structural Engineering License Review Problems and Solutions", Oxford University Press, 2003.