PRFO20240367

SITE STRUCTURES
A Division of Kosnik Engineering, PC

Fortress Puyallup
Storm Water Detention Vault

City of Puyallup, Washington

Structural Calculations

02-08-2024

DANIEL J. KOSNIK
STATE OF WASHINGTON
20744
STRUCTURAL ENGINEER
PROFESSIONAL ENGINEER

Project No. S-24-007
First Issue 02-08-2024

10505 19TH Ave SE, Suite D, Everett, WA 98208 ◆ (425) 357-9600 (phone) ◆ e-mail: dan@kosnik.com

Fortress Puyallup
Storm Water Detention Vault

Project No. S-24-007

STRUCTURAL CALCULATIONS INDEX

Fortress Puyallup
Storm Water Detention Vault

DESIGN CRITERIA

Code: 2018 IBC

Permitting: City of Puyallup, Washington

Soil Cover: 1.5ft min to 3.3ft max

Lid Loading: 150 psf uniform live load
HS20 truck wheel loading
Fire truck wheel load GVW=75,000lbs
Fire truck outrigger load 45,000lbs over 18" sq pad.

Uniform live load, HS20 and fire truck wheel and fire truck outrigger load to be applied independently and in combination with the soil cover dead load.

At Grade Grate: Same as lid loading excluding outrigger load.

Foundation Design:

Foundation design is based on the following values provided by Terra Associates, Inc. in their geotechnical report dated 01-12-2022, revised 06-23-2023 and e-mail correspondence of 02-07-2024

Allowable Bearing Pressure: 2,500 psf

Lateral Earth Pressures on Vault Walls (level backfill condition):

At Rest: 55 pcf EFD drained
90pcf EFD saturated

Seismic Addition: E = 8H uniform horz. pressure

Saturated Soil Density: 125 pcf
High ground water elevation 53.00

Material Requirements:

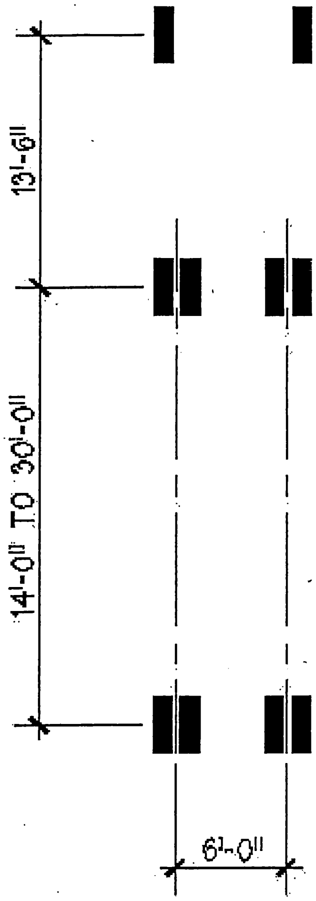
Rebar: Grade 60
Concrete: f'c= 4000 psi walls, footings and grade slab
f'c=3000 psi HC plank void fill & joint grout
Lid: Precast prestresed Hollow Core Plank 12-1/2" thick.

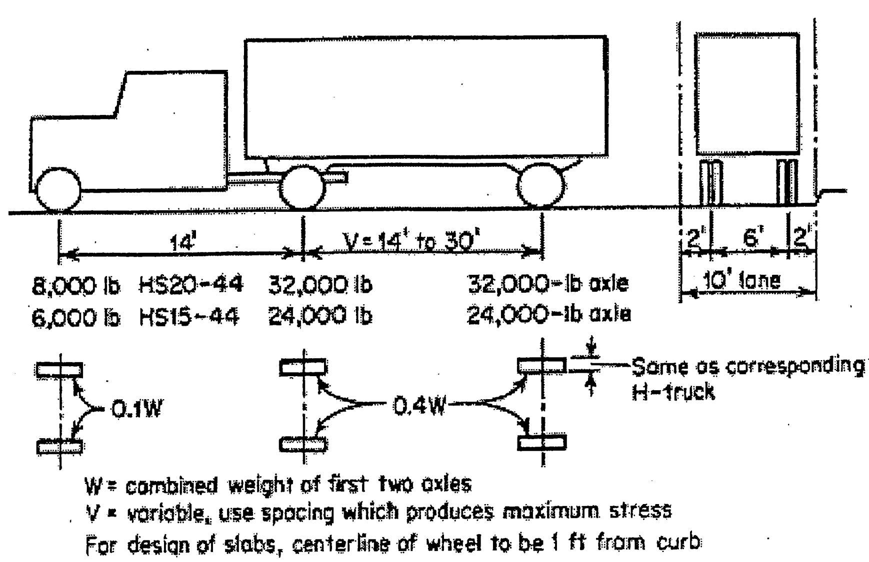
SITE STRUCTURES Project FORTRESS

sheet 2
date 2-08-2024
prj. no. S-24-007

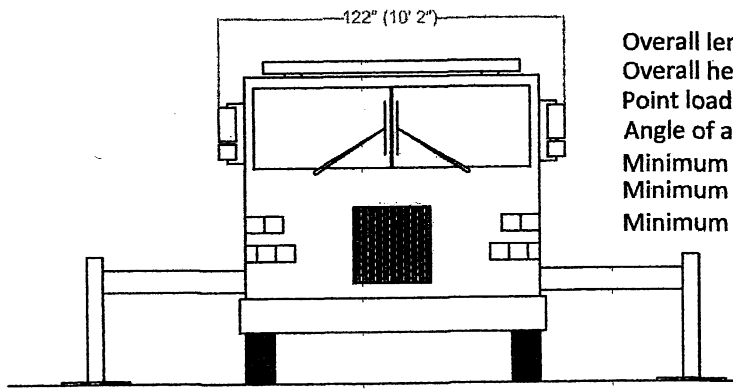
	HS20-44 72,000LBS	HS25-44 90,000LBS
FRONT AXEL:	8,000LBS	10,000LBS
REAR AXEL #1:	32,000LBS	40,000LBS
REAR AXEL #2:	32,000LBS	40,000LBS

Sim to FIRE TRUCK FOR L/D REVIEW

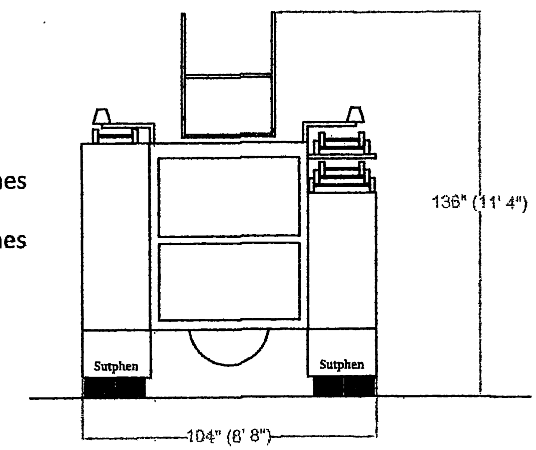


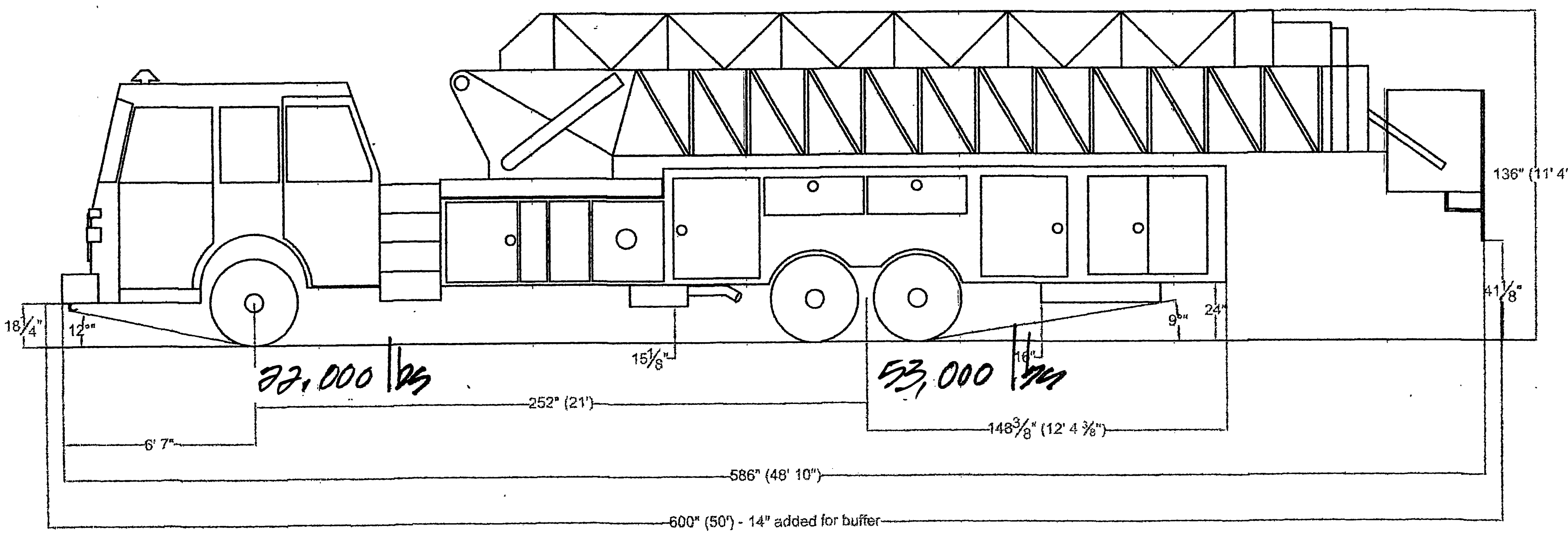


SHEET 3
2-08-2024
S-24-007



Overall length:	48 feet 10 inches
Overall height:	11 feet 4 inches
Point load for outriggers:	
Angle of approach/departure minimum:	9 degrees
Minimum front clearance from ground:	18 ¼ inches
Minimum rear clearance from ground:	16 inches
Minimum center of vehicle clearance:	15 ⅛ inches





SHEET 4
2. 8-24
G.24-007

4.5 Foundations

In our opinion, following the completion of a successful preload program, the building may be supported on conventional spread footing foundations bearing on a minimum of 2 feet of structural fill placed and compacted as recommended in Section 4.2 of this report. Foundations exposed to the weather should bear at a minimum depth of one and one-half feet below adjacent grades for frost protection.

We recommend designing foundations for a net allowable bearing capacity of 2,500 pounds per square foot (psf). For short-term loads, such as wind and seismic, a one-third increase in this allowable capacity can be used. With the expected building loads and this bearing stress applied, in general, total and differential settlements should not exceed 0.5 inches for perimeter foundations and 1 inch for interior column supports.

For designing foundations to resist lateral loads, a base friction coefficient of 0.35 can be used. Passive earth pressures acting on the sides of the footings can also be considered. We recommend calculating this lateral resistance using an equivalent fluid weight of 300 pounds per cubic foot (pcf). We do not recommend including the upper 12 inches of soil in this computation because it can be affected by weather or disturbed by future grading activity. This value assumes the foundation will be constructed neat against competent native soil or backfilled with structural fill, as described in Section 4.2 of this report. The values recommended include a safety factor of 1.5.

4.6 Lateral Earth Pressures for Retaining Walls

The magnitude of earth pressure development on below-grade walls, such as basement or retaining walls, will partly depend upon the quality of the wall backfill. We recommend placing and compacting wall backfill as structural fill as described in Section 4.2 of this report. To guard against hydrostatic pressure development, drainage must be installed behind the wall. A typical wall drainage detail is shown on Figure 4.

With wall backfill placed and compacted as recommended and drainage properly installed, unrestrained walls can be designed for an active earth pressure equivalent to a fluid weighing 35 pcf. For restrained walls, an additional uniform lateral pressure of 100 psf should be included. For evaluating the walls under seismic loading, a uniform earth pressure equivalent to 8H psf, where H is the height of the retained earth in feet, can be used. These values assume a horizontal backfill condition and that no other surcharge loading, such as traffic, sloping embankments, or adjacent buildings, will act on the wall. If such conditions exist, then the imposed loading must be included in the wall design.

Friction at the base of the wall foundation and passive earth pressure will provide resistance to these lateral loads. Values for these parameters are provided in Section 4.5.

SHEET 5
2.8.24
9.24-007

Dan Kosnik

From: Carolyn Decker <CDecker@terra-associates.com>
Sent: Wednesday, February 07, 2024 8:04 AM
To: Dan Kosnik
Subject: RE: Fortress Puyallup - Storm Vault BCE #22085

Dan,

You can use 55 and 90 for the at rest pressures. No need to add the 100 psf.

Carolyn S. Decker, P.E.
President

TERRA ASSOCIATES, INC.
12220 113th Avenue NE, Suite 130
Kirkland, Washington 98034
Office - 425-821-7777, Ext 103
Fax - 425-821-4334
Cell - 206-255-4988
cdecker@terra-associates.com
www.terra-associates.com

From: Dan Kosnik <Dan@kosnik.com>
Sent: Wednesday, February 7, 2024 6:19 AM
To: Carolyn Decker <CDecker@terra-associates.com>
Subject: RE: Fortress Puyallup - Storm Vault BCE #22085

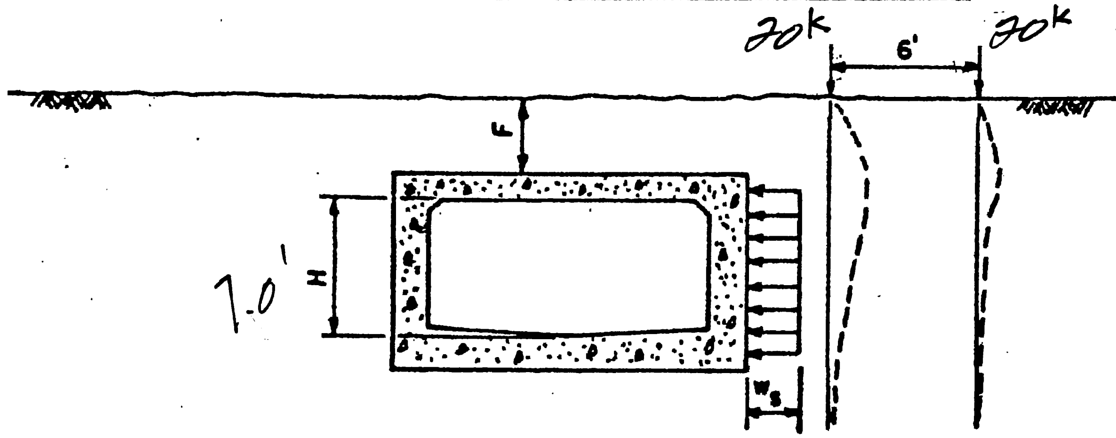
Carolyn,

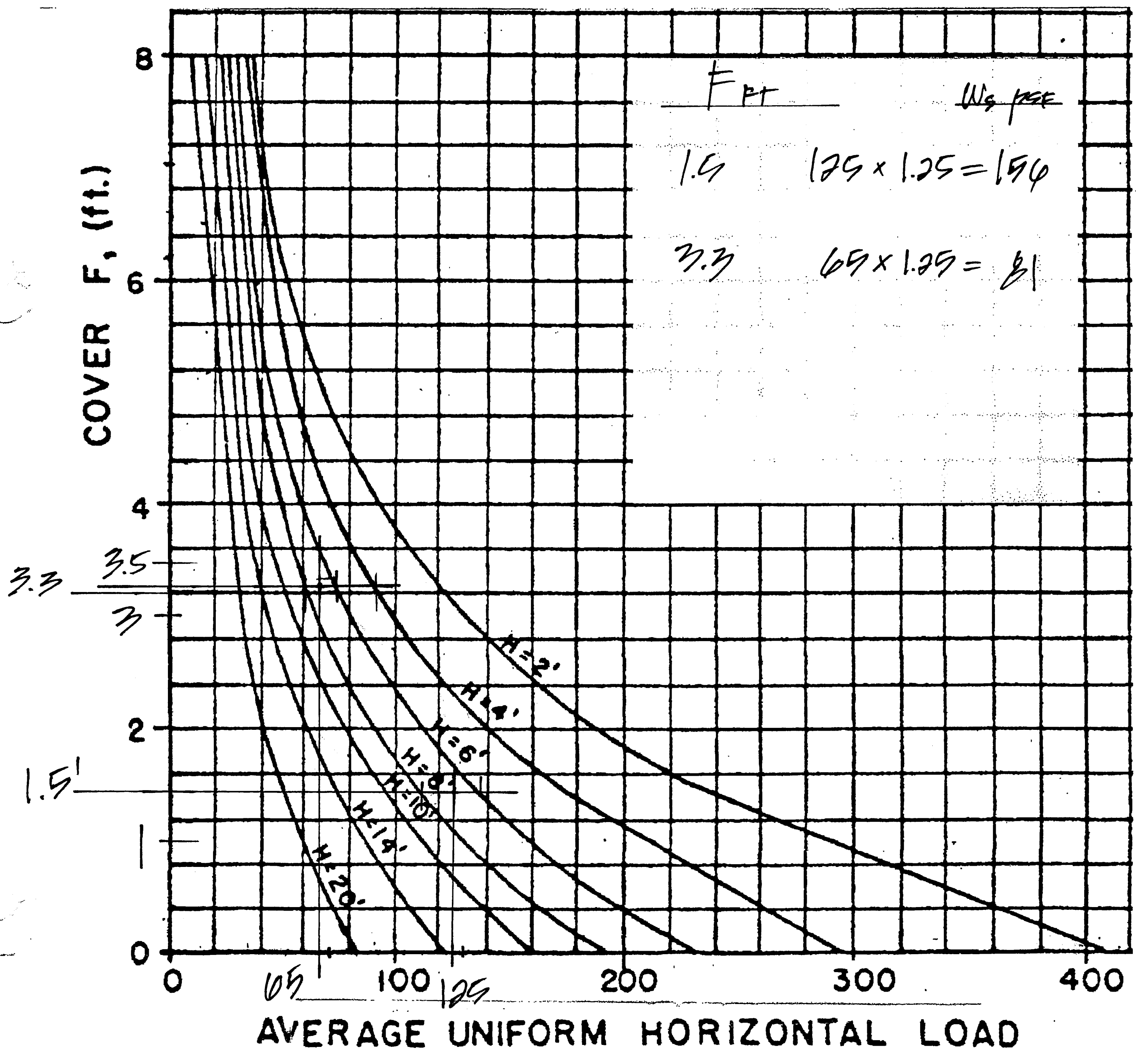
Do I add the 100psf uniform horz pressure to the 90pcf EFD or as an alternate can I use 55pcfEFD for the drained at rest earth pressure – see attachment?

Dan Kosnik, SE
Site Structures / Kosnik Engineering, PC
10505 19TH AVE SE, Suite D | EVERETT | WA | 98208
Office: 425-357-9600 Cell: 425-210-0352

SHEET 6
2-08-2024
S-24-007

HS25-44 TRUCK LIVE LOAD ON WALLS





SITE STRUCTURES
10511 19th Ave SE, Suite C
Everett, WA, (425)-357-9600

Project Fortress

sheet 7
date 2.2.24
prj. no. S-24-007

PRECAST HOLLOW CORE PLANK REVIEW

Lid Data

Soil Desity	125 pcf
Soil Cover depth over lid	3 ft
Plank design clear span	20 ft
Design Uniform Live Load	150 psf
Design Superimposed Load	525 psf

Plank capacity based on uniform superimposed load tables

Plank span	28 ft	
No of tendons	11	
Allowable superimposed loads		413 psf

Allowable superimposed loads base of design span of	20.25 ft	
Based on flexural capacity		790 psf
Based on shear capacity		571 psf

ok w/ 2 END VOIDS FILLED

Plank capacity based on truck load charts

Plank span	20.25 ft
No of tendons	11
Allowable soil cover without knee-walls	NA ft
Allowable soil cover with knee-walls	0.5 to 5.4 ft

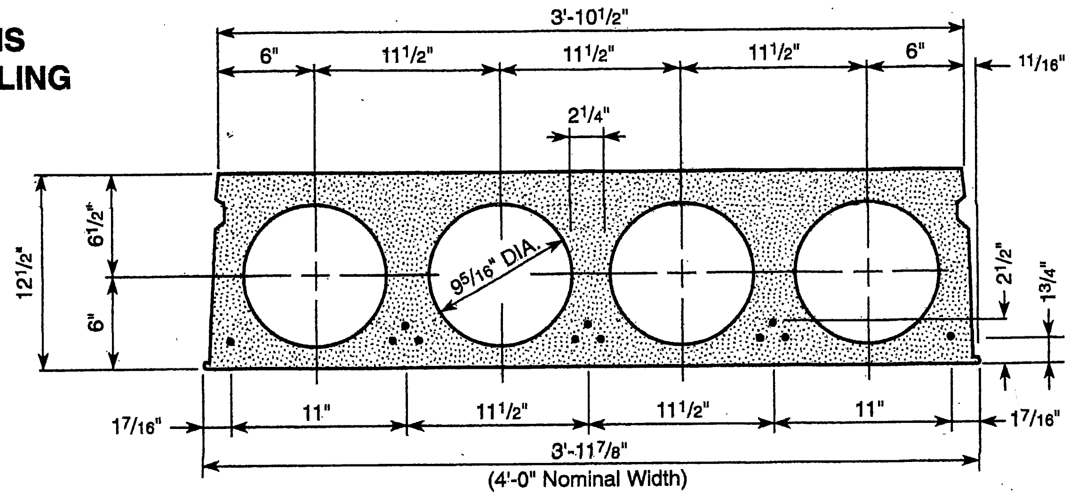
ok w/ knee-walls @ MH

SHEET 8
2-08-2024
S-24-007

CONCRETE TECHNOLOGY CORPORATION

12 1/2" HOLLOW CORE SLAB

DIMENSIONS FOR DETAILING



SPAN-LOAD TABLE

ALLOWABLE SUPERIMPOSED LOAD in pounds per square foot										
Effective Prestress (KIPS)	No. of 1/2" ø STRANDS	SIMPLE SPAN in feet								
		28	32	36	40	44	48	52	56	60
70.7	3	78	44	20						
77.7	4	126	80	49	26					
101.3	5	174	117	78	50	27				
124.8	6	221	153	106	70	43	23*			
148.4	7	267	186	129	89	59	36			
172.0	8	307	216	153	108	74	49	29		
195.5	9	343	243	174	125	89	61	40	23*	
219.1	10	378[1]	270	195	142	103	73	50	31*	
242.7	11	413[1]	297	217	160	117	85	60	40	24*

SECTION PROPERTIES (with shear keys grouted)

$A = 313\ in^2$ $\quad Z_t = 1019\ in^3$ $\quad Z_b = 947\ in^3$ $\quad w = 84$ psf

$I = 6136\ in^4$ $\quad Y_t = 6.02$ in $\quad Y_b = 6.48$ in

NOTES:

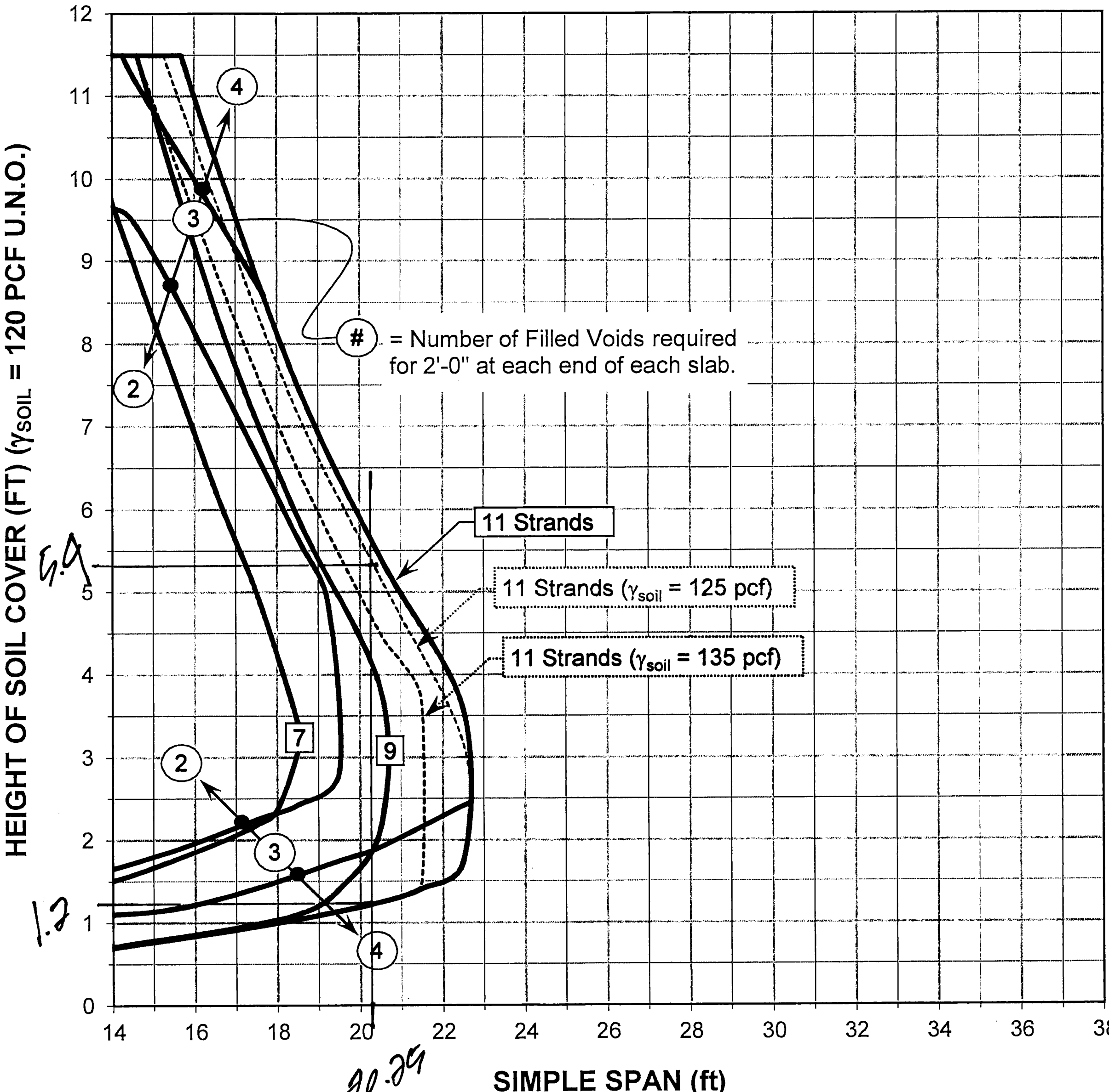
1. The values given in this table are based on hollow core slabs without shear reinforcement. Superscripts (1, 2, etc.) following values in the table indicate the number of filled voids required at the ends of slabs to develop the allowable superimposed load. See page 2, "SHEAR" for discussion.
2. Asterisk (*) following values in the table indicate that the total deflection under all loads is greater than L/360 but less than L/180.
3. Interpolation between values is acceptable. Do not extrapolate values into the blank spaces of the table.
4. These Span-Load Tables are intended as an aid to preliminary sizing. Sound engineering judgement is required for the application of this information to specific design cases.

CONCRETE TECHNOLOGY CORPORATION

12½" HOLLOW CORE SLAB

2-08-2024
S-24-007

45 KIP OUTRIGGER ON 18"x18" PADS @ 15'-0" O.C.



GENERAL NOTES:

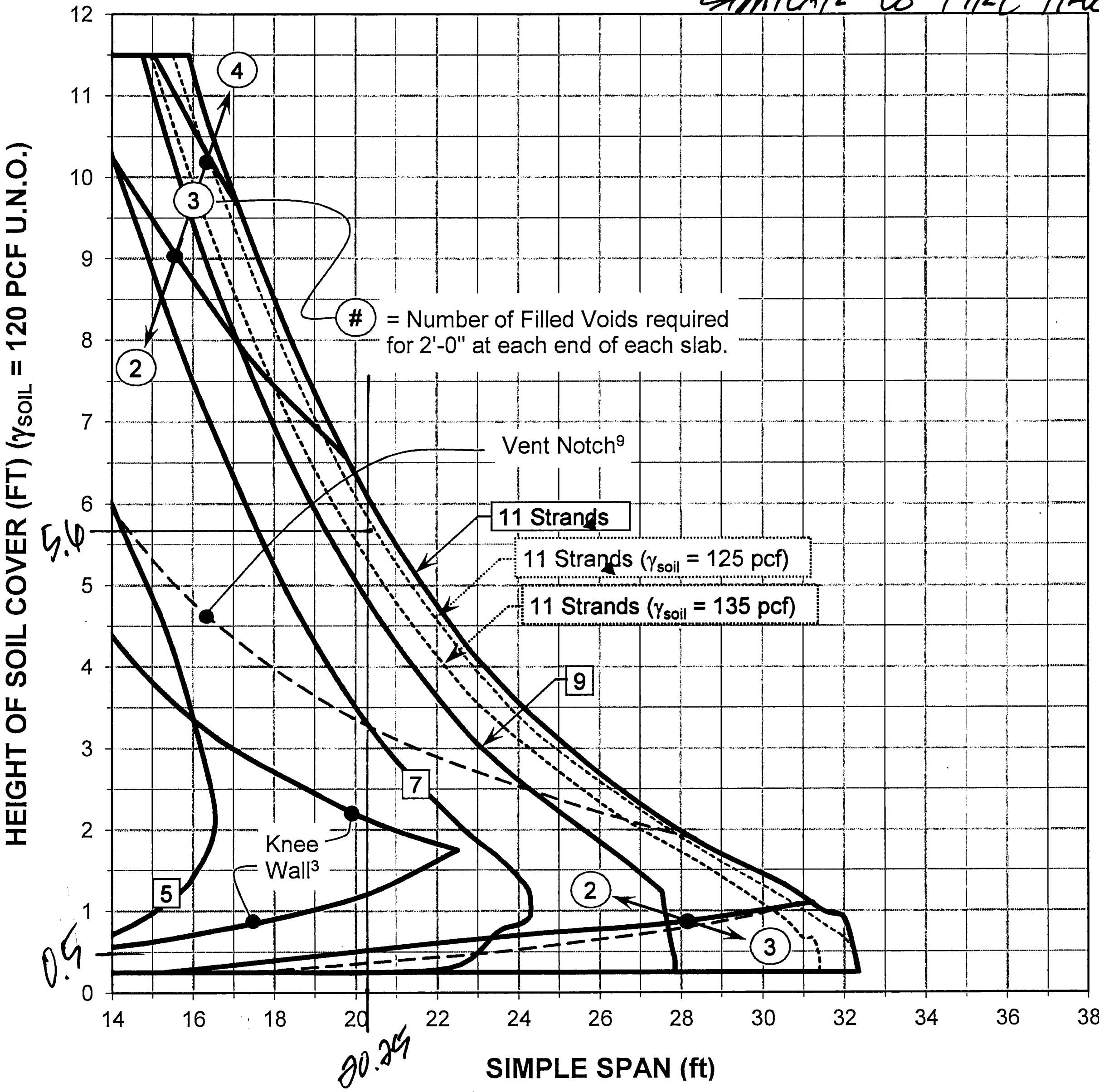
1.) A minimum cover depth of nine inches is required.
2.) Simple Span is centerline of bearing to centerline of bearing.
3.) Knee walls are required at all manhole and vent openings.
4.) Interpolation between strand contours is acceptable. DO NOT extrapolate beyond the bounds of this chart.
5.) Soil cover is assumed to be uniform.
6.) Except as noted, soil cover unit weight is assumed to be 120 pcf.
7.) Minimum span length = 14'-0".
8.) The values shown on this chart are in compliance with IBC 2015 & ACI 318-14.

CONCRETE TECHNOLOGY CORPORATION

12½" HOLLOW CORE SLAB
HS25-44

SIMILAR to FIRE TRUCK

2-08-2024
S24-007

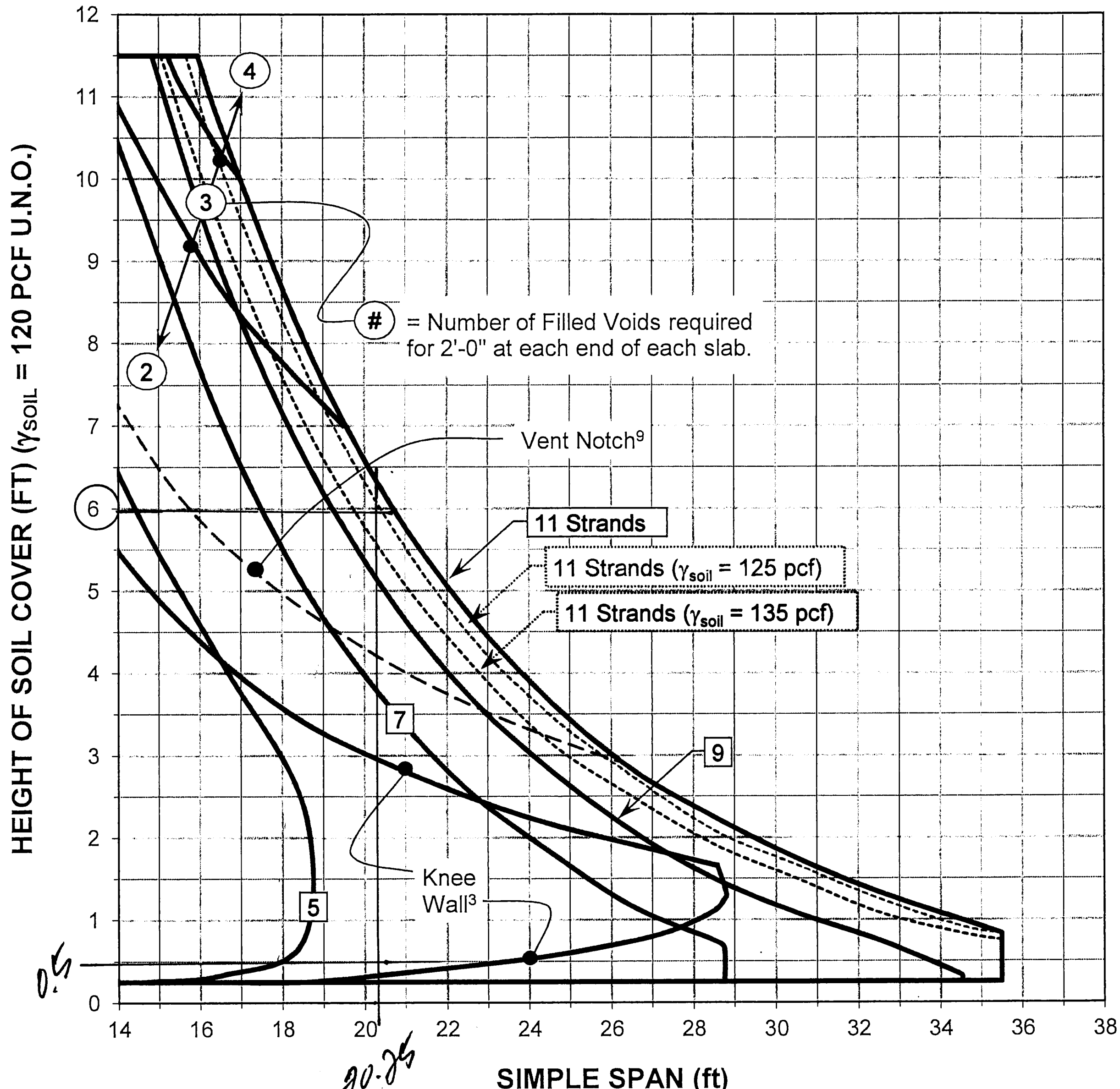


GENERAL NOTES:

1.) A minimum cover depth of six inches OR a three inch thick cast in place concrete topping slab is required.
2.) Simple Span is centerline of bearing to centerline of bearing.
3.) The Knee Wall envelope represents the maximum span and height of soil cover that can be supported by slabs with standard notches for manhole openings, assuming void fill concrete f'c = 3,000 psi. Points falling outside this envelope require knee walls to support the slabs at manhole openings.
4.) Interpolation between strand contours is acceptable. DO NOT extrapolate beyond the bounds of this chart.
5.) Soil cover is assumed to be uniform.
6.) Except as noted, soil cover unit weight is assumed to be 120 pcf.
7.) Minimum span length = 14'-0".
8.) The values shown on this chart are in compliance with IBC 2015 & ACI 318-14.
9.) The Vent Notch envelope represents the maximum span and minimum/maximum height of soil cover that can be supported by slabs with 6½" standard notches in adjacent slabs to accommodate 12" diameter vents, assuming void fill concrete f'c = 3,000 psi. Refer to Detail 3 on page 13 of this brochure for vent notch details.

2-08-2024
S-24-007

12½" HOLLOW CORE SLAB
HS20-44

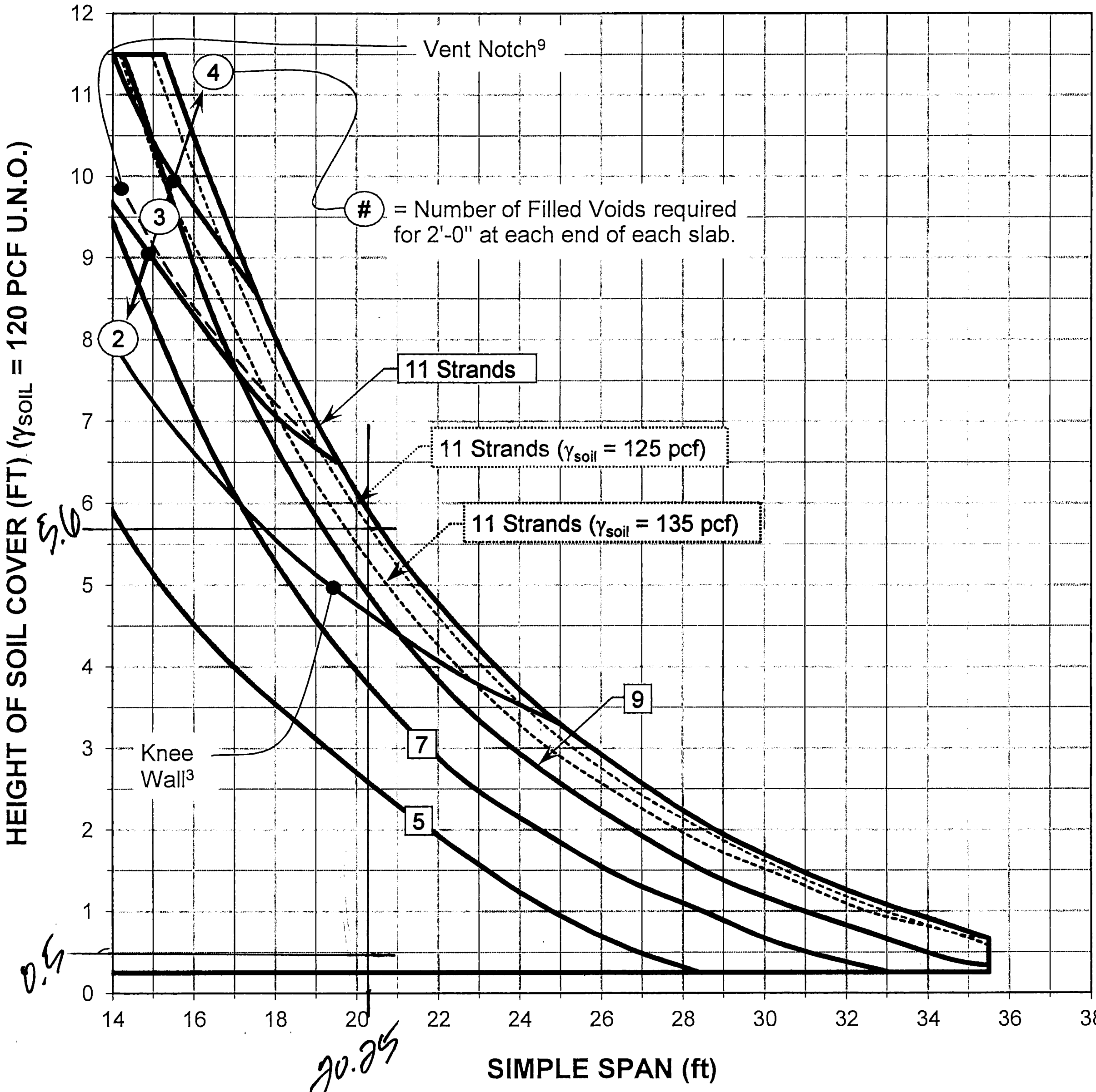


GENERAL NOTES:
1.) A minimum cover depth of six inches OR a three inch thick cast in place concrete topping slab is required.
2.) Simple Span is centerline of bearing to centerline of bearing.
3.) The Knee Wall envelope represents the maximum span and height of soil cover that can be supported by slabs with standard notches for manhole openings, assuming void fill concrete f'c = 3,000 psi. Points falling outside this envelope require knee walls to support the slabs at manhole openings.
4.) Interpolation between strand contours is acceptable. DO NOT extrapolate beyond the bounds of this chart.
5.) Soil cover is assumed to be uniform.
6.) Except as noted, soil cover unit weight is assumed to be 120 pcf.
7.) Minimum span length = 14'-0".
8.) The values shown on this chart are in compliance with IBC 2015 & ACI 318-14.
9.) The Vent Notch envelope represents the maximum span and height of soil cover that can be supported by slabs with 6½" standard notches in adjacent slabs to accommodate 12" diameter vents, assuming void fill concrete f'c = 3,000 psi. Refer to Detail 3 on page 13 of this brochure for vent notch details.

SHEET 12

2-08-2024
S-24-007

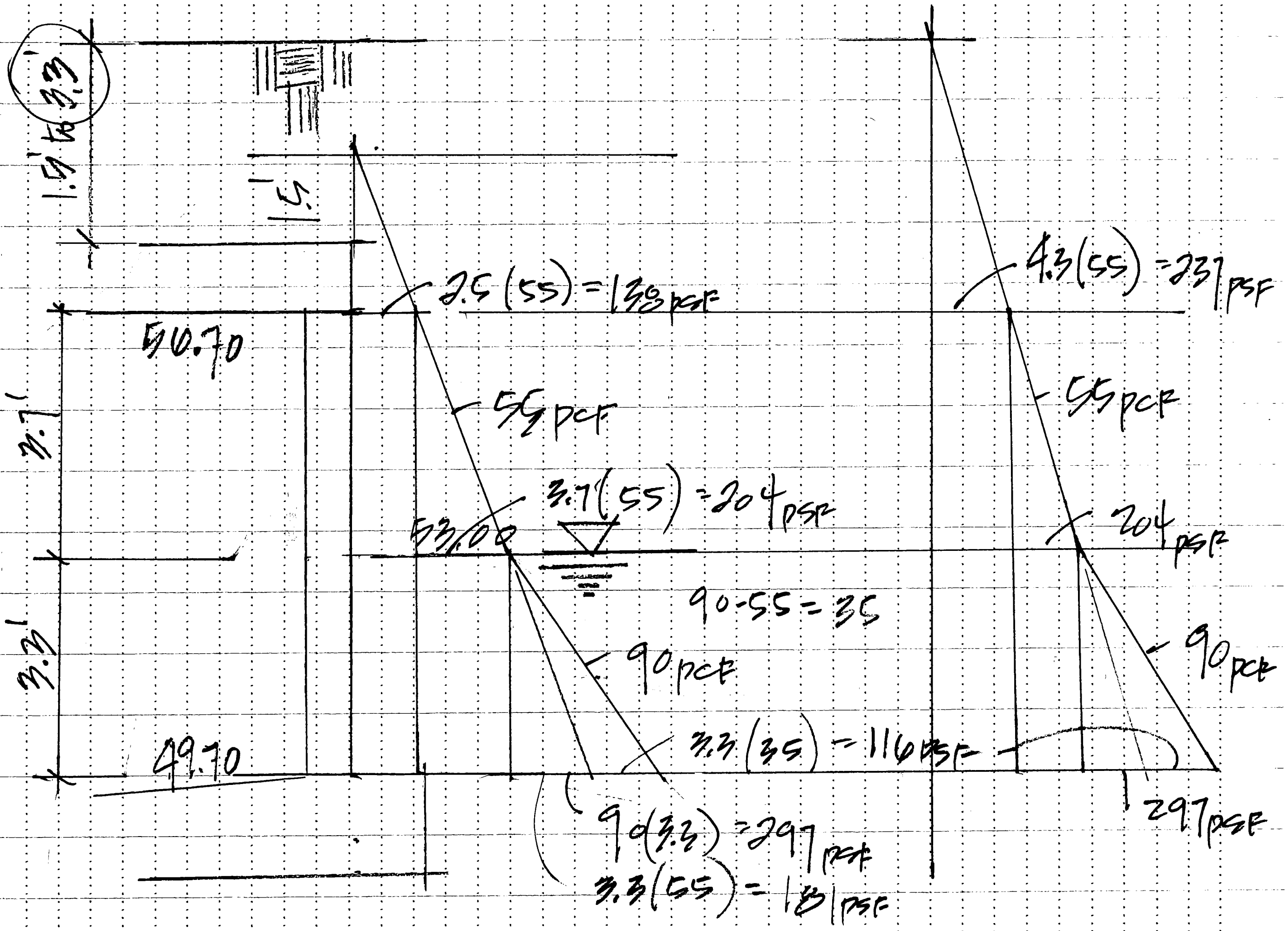
12½" HOLLOW CORE SLAB
150 PSF



GENERAL NOTES:

1.) A minimum cover depth of six inches OR a three inch thick cast in place concrete topping slab is required.
2.) Simple Span is centerline of bearing to centerline of bearing.
3.) The Knee Wall envelope represents the maximum span and height of soil cover that can be supported by slabs with standard notches for manhole openings, assuming void fill concrete f'c = 3,000 psi. Points falling outside this envelope require knee walls to support the slabs at manhole openings.
4.) Interpolation between strand contours is acceptable. DO NOT extrapolate beyond the bounds of this chart.
5.) Soil cover is assumed to be uniform.
6.) Except as noted, soil cover unit weight is assumed to be 120 pcf.
7.) Minimum span length = 14'-0".
8.) The values shown on this chart are in compliance with IBC 2015 & ACI 318-14.
9.) The Vent Notch envelope represents the maximum span and height of soil cover that can be supported by slabs with 6½" standard notches in adjacent slabs to accommodate 12" diameter vents, assuming void fill concrete f'c = 3,000 psi. Refer to Detail 3 on page 13 of this brochure for vent notch details.

PERIMETER WALL REVIEW



CASE 1

CASE 2

SURCHARGE = 196 psf

SURCHARGE = 81 psf

MOM DUE TO SATURATED SOIL $F = 116(3.3/2) = 191^{\#}$

$R_T = 191(3.3/3) \div 7 = 30^{\#}$

Y to ZERO SHEAR $30 = 35(X)^2/2$ $X = 1.3'$

$M = 30(3.7+1.3) - 30(1.3/3) = 137^{1-\#}$

EFD = 0.2 pcf
4.87 pcf

EQUIV TRIANG OVER FULL HEIGHT $137 = EFD(7)^{7}/2(0.1283)7$

CASE 1

$M_{SURCHARGE} = 156(7)^2 \div 8 = 956^{1-\#}$

$M_{SOIL\ PRESS}$

$= 138(7)^2 \div 8 = 845^{1-\#}$

$+ \left[(55+7)(7)^2 \div 2\right] 0.1283(7) = 1364^{1-\#}$

$M_{TOTAL} = 956 + 845 + 1364 = \underline{\underline{3165}}^{1-\#}$

CASE 2

$M_{SURCHARGE} = 81(7)^2 \div 8 = 496^{1-\#}$

$M_{SOIL\ PRESS}$

$= 237(7)^2 \div 8 = 1452^{1-\#}$

$+ \quad 1364^{1-\#}$

$M_{SOIL\ PRESS}$ $2816^{1-\#}$

$M_{TOTAL} = 496 + 1452 + 1364 = \underline{\underline{3312}}^{1-\#}$

CASE 2 CONTROLS DESIGN

SEISMIC PRESSURE COMPONENT $= 8H = 8(7) = 56$ PSF

SITE STRUCTURES
10511 19th Ave SE, Suite C
Everett, WA, (425)-357-9600

Project Fortress

sheet 17
date 2-08-2024
prj. no. S-24-007

Design Data 3.3' COVER w/ TRAFFIC SURCHARGE

Soil Density	125 pcf		
Soil Cover depth to the top of the wall	4.3 ft	Ws1 =	236.5 psf
Wall height	7 ft	Ws2 =	385 psf
Soil Pressure EFW	55 pcf		

Surcharge Information

uniform	S1 =	0 psf (on surface of ground)	Equiv Ws =	0 psf
truck	Ws =	0 psf (on surface of wall - see design chart)		

Critical Design Surcharge pressure = 107 psf (on the surface of the wall)

Calculated Design Forces

W1=	343.5	F1 =	2405 lbs	R top =	1651 lbs
W2=	385	F2 =	1348 lbs	R bot =	2101 lbs
M1 =	2104	M total=	**3314** ft-lbs		
M2 =	1210				

Wall Reinforcing

Wall thickness	8 inches	Comp block (a) =	0.39 inches
Clear cover	2 inches	Depth to CL bar (d) =	5.69 inches
Rebar size	5	d-a/2 =	5.49 inches
Rebar area	0.31 sq-in		
Bar spacing	14 inches ✓	ΦMn =	**6501** ft-lbs ok
Rebar strength fy	60 ksi		
Conc strength f'c	4000 psi	Mu =	**5303** ft-lbs
Load Factor	1.6		

max tension reinforcing spacing: f_s = 27527 psi ok

s =	16.8 in
s =	17.4 in
s_{max} =	**16.8** in - OK

Anchorage at Top of the Wall

Ru = **2642** plf

#5 hairpins net #5@ 15"o/c — ΦVn = 6700plf

#5 hairpins net #5@ 18"o/c — ΦVn = 5580plf

14" @ 28" o/c

Anchorage at Bottom of the Wall

Ru = **3361** plf

Nominal Shear friction capacity of the footing to wall Dowel **8131** plf

Rebar Dowel Size =	5
Dowel Area =	0.31 sq-in
Dowel strength fy=	60 ksi
Dowel Spacing =	14 inches
Coefficient of friction =	0.6 smooth surface

SITE STRUCTURES
10511 19th Ave SE, Suite C
Everett, WA, (425)-357-9600

Project Fortress

sheet 16
date 2-06-2024
prj. no. S-24-007

Design Data 3.3' cover w/o traffic surcharge

Soil Density	125 pcf		
Soil Cover depth to the top of the wall	4.3 ft	Ws1 =	236.5 psf
Wall height	7 ft	Ws2 =	385 psf
Soil Pressure EFW	55 pcf		

Surcharge Information

uniform	S1 =	0 psf (on surface of ground)	Equiv Ws =	0 psf
truck	Ws =	0 psf (on surface of wall - see design chart)		

Critical Design Surcharge pressure = 26 psf (on the surface of the wall)

Calculated Design Forces

W1= 262.5	F1 = 1838 lbs	R top =	1368 lbs
W2= 385	F2 = 1348 lbs	R bot =	1817 lbs

M1 = 1608 M total= **2818** ft-lbs
M2 = 1210

Wall Reinforcing

Wall thickness	8 inches	Comp block (a) =	0.39 inches
Clear cover	2 inches	Depth to CL bar (d) =	5.69 inches
Rebar size	5	d-a/2 =	5.49 inches
Rebar area	0.31 sq-in		
Bar spacing	14 inches	ΦMn =	**6501** ft-lbs
Rebar strength fy	60 ksi		
Conc strength f'c	4000 psi	Mu =	**4509** ft-lbs
Load Factor	1.6		

ok

max tension reinforcing spacing: f_s = 23406 psi ok

s = 20.6 in
s = 20.5 in
s_{max} = **20.5** in - OK

Anchorage at Top of the Wall

Ru = **2189** plf

#5 hairpins net #5@ 15"o/c ΦVn = 6700plf

#5 hairpins net #5@ 18"o/c ΦVn = 5580plf

14" c 28"

Anchorage at Bottom of the Wall

Ru = **2907** plf

Nominal Shear friction capacity of the footing to wall Dowel **8131** plf

Rebar Dowel Size =	5
Dowel Area =	0.31 sq-in
Dowel strength fy=	60 ksi
Dowel Spacing =	14 inches
Coefficient of friction =	0.6 smooth surface

SITE STRUCTURES
10511 19th Ave SE, Suite C
Everett, WA, (425)-357-9600

Load Combination 1.2D+1.0E+1.0L+1.6H

E=	56 psf				
L=	81 psf	Wall Height		Total Force	
Total=	137 psf	7.00 ft		959	lbs
SAT SOIL ADJ	– + 26 103 psf				
H=		1838	1348	3186	lbs
Total Force				4145	lbs
Factored Load				6057	lbs
Average Load Factor				**1.46**	

SITE STRUCTURES
10511 19th Ave SE, Suite C
Everett, WA, (425)-357-9600

Project Fortress

sheet 19
date 2-08-2024
prj. no. S-24-007

Design Data 3.3' COVER LOAD COMB 1.2D+1.0E+1.0L+1.6H

Soil Density	125 pcf		
Soil Cover depth to the top of the wall	4.3 ft	Ws1 =	236.5 psf
Wall height	7 ft	Ws2 =	385 psf
Soil Pressure EFW	55 pcf		

Surcharge Information

uniform	S1 =	0 psf (on surface of ground)	Equiv Ws =	0 psf
truck	Ws =	0 psf (on surface of wall - see design chart)		

Critical Design Surcharge pressure = ✓163 psf (on the surface of the wall)

Calculated Design Forces

W1= 399.5	F1 = 2797 lbs	R top =	1847 lbs
W2= 385	F2 = 1348 lbs	R bot =	2297 lbs
M1 = 2447	M total= **3657** ft-lbs		
M2 = 1210			

Wall Reinforcing

Wall thickness	8 inches	Comp block (a) =	0.39 inches
Clear cover	2 inches	Depth to CL bar (d) =	5.69 inches
Rebar size	5	d-a/2 =	5.49 inches
Rebar area	0.31 sq-in		
Bar spacing	14 inches	ΦMn =	**6501** ft-lbs
Rebar strength fy	60 ksi		OK
Conc strength f'c	4000 psi	Mu =	**5339** ft-lbs
Load Factor	1.46		

max tension reinforcing spacing: f_s = 30376 psi OK

s = 14.8 in
s = 15.8 in
s_{max} = **14.8** in - OK

Anchorage at Top of the Wall

Ru = **2697** plf

#5 hairpins net #5@ 15"o/c ΦVn = 6700plf

#5 hairpins net #5@ 18"o/c ΦVn = 5580plf

14" @ 28" o/c

Anchorage at Bottom of the Wall

Ru =	**3353** plf	Rebar Dowel Size =	5
		Dowel Area =	0.31 sq-in
Nominal Shear friction capacity		Dowel strength fy=	60 ksi
of the footing to wall Dowel	**8131** plf	Dowel Spacing =	14 inches
		Coefficient of friction =	0.6 smooth surface

4.8.3.3 Point Load

OUTRIGGER LOAD REVIEW

Point loads are loads such as outrigger loads from a concrete pump or crane. A wheel load from a concrete truck may also be considered a point load when the concrete truck is adjacent an excavation and in the process of the unloading. The truck could be positioned either parallel or perpendicular to the excavation.

The general equation for determining the pressure at distance h below the ground line is: (See Figure 4-50)

For $m \leq 0.4$:

$$\sigma_h = 0.28 \frac{Q_p}{H^2} \frac{n^2}{(0.16 + n^2)^3} \qquad \text{Eq. 4-70}$$

For $m > 0.4$

$$\sigma_h = 1.77 \frac{Q_p}{H^2} \frac{m^2 n^2}{(m^2 + n^2)^3} \qquad \text{Eq. 4-71}$$

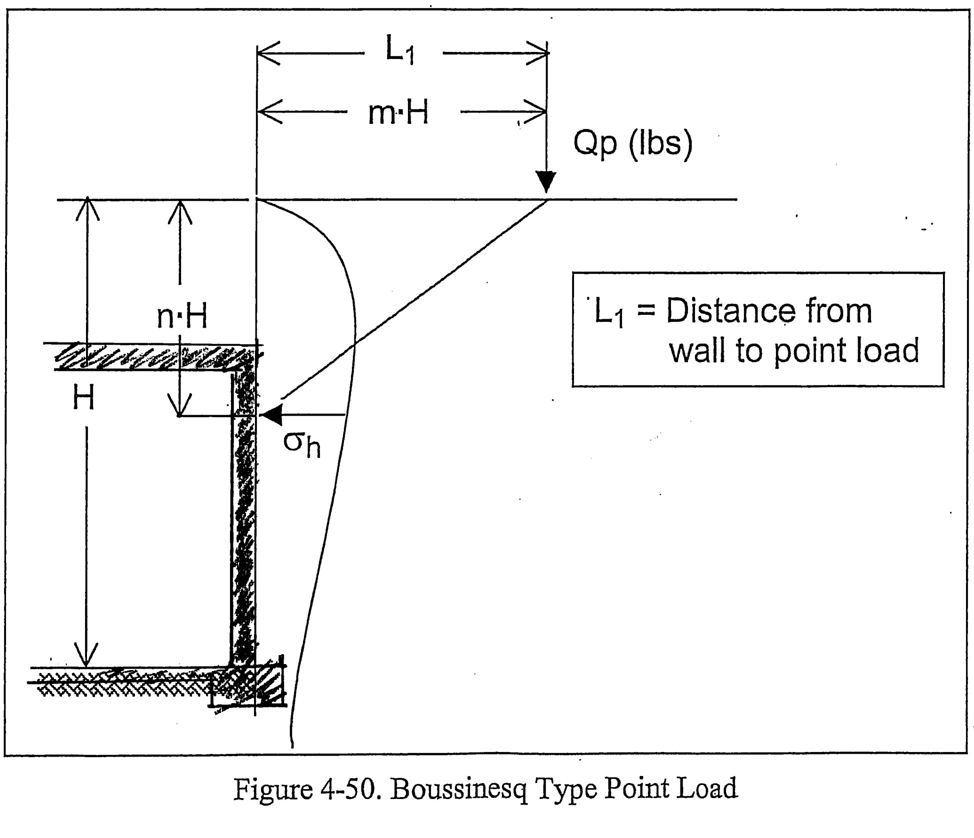


Figure 4-50. Boussinesq Type Point Load

SHEET 70
2-08-2024
S-24-007

In addition, σ_h is further adjusted by the following when the point is further away from the line closest to the point load: (see Figure 4-51)

$$\sigma_h' = \sigma_h \cos^2[(1.1)\theta] \qquad \text{Eq. 4-72}$$

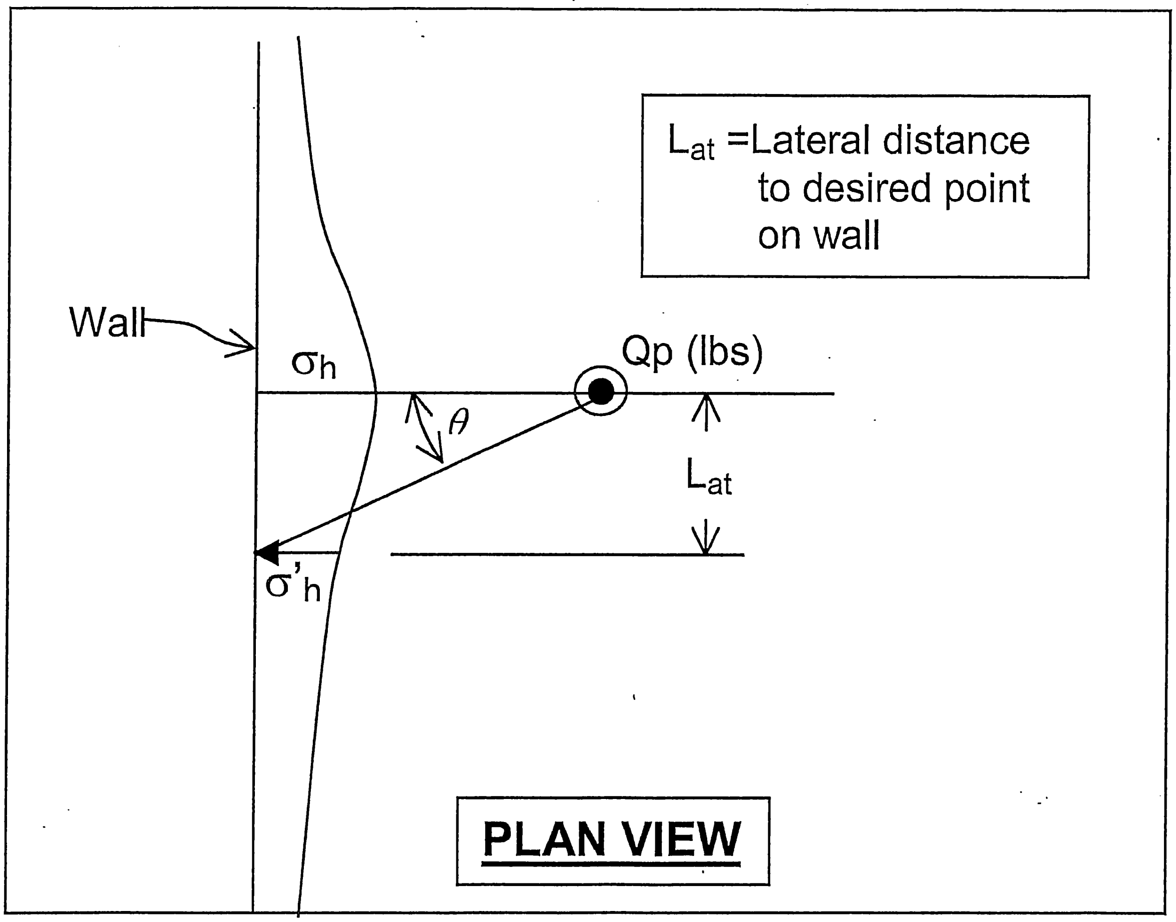


Figure 4-51. Boussinesq Type Point Load with Lateral Offset

SITE STRUCTURES
10511 19th Ave SE, Suite C
Everett, WA, (425)-357-9600

Wall pressure due to outrigger point load

Vault Clear Height	7 ft
Soil Cover	3.3 ft
H	11.3
0.40H	4.52 ft
Point Load	45000.00 lbs
0.28P/H2	98.676482

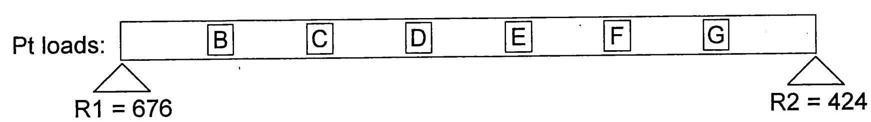
	d	n	n2/(0.16+n2)3	qp	qh	avg
	0.00	0.00	0.00	0	0	0
T	4.30	0.38	5.11	505	323	414
	5.30	0.47	4.01	396	253	324
	6.30	0.56	2.98	294	188	241
	7.30	0.65	2.17	214	137	175
	8.30	0.73	1.58	156	100	128
	9.30	0.82	1.15	114	73	93
	10.30	0.91	0.85	84	54	69
B	11.30	1.00	0.64	63	40	52
	12.30	1.09	0.49	48	31	39

Lat	3.00 ft
Lat/0.4H	0.664
H angle tan inv	33.6 deg
cos2(1.1x0)	0.64

clr hgt/7= 1.00

Point Loads for Bm Analysis

X ft	P lbs
1.00	324
2.00	241
3.00	175
4.00	128
5.00	93
6.00	69



SPAN = 7 FT

Loads

Point LL	Point TL	Distance
324	B = 324	1.0
241	C = 241	2.0
175	D = 175	3.0
128	E = 128	4.0
93	F = 93	5.0
69	G = 69	6.0

Data

Beam Span	7.0 ft	Reaction 1 LL	641 #	Reaction 2 LL	389 #
Beam Wt per ft	10.0 #	Reaction 1 TL	676 #	Reaction 2 TL	424 #
Bm Wt Included	70 #	Maximum V	676 #		
Max Moment	1095 '#	Max V (Reduced)	N/A		
TL Max Defl	L / 240	TL Actual Defl	L / >1000		
LL Max Defl	L / 360	LL Actual Defl	L / >1000		

$$W_{eq} = \frac{1095(8)}{(7)^2} = 178 \text{ psf}$$

SITE STRUCTURES
10511 19th Ave SE, Suite C
Everett, WA, (425)-357-9600

Project Fortress

sheet 22
date 2-08-2024
prj. no. S-24-007

Design Data 3.3FT COVER W/ OUTRIGGER LOAD

Soil Density	125 pcf		
Soil Cover depth to the top of the wall	4.3 ft	Ws1 =	236.5 psf
Wall height	7 ft	Ws2 =	385 psf
Soil Pressure EFW	55 pcf		

Surcharge Information

uniform	S1 =	0 psf (on surface of ground)	Equiv Ws =	0 psf
truck	Ws =	0 psf (on surface of wall - see design chart)		

Critical Design Surcharge pressure = 204 psf (on the surface of the wall) — 178 + 26 = 204 psf

Calculated Design Forces

W1= 440.5	F1 = 3084 lbs	R top =	1991 lbs
W2= 385	F2 = 1348 lbs	R bot =	2440 lbs
M1 = 2698	M total= **3908** ft-lbs		
M2 = 1210			

Wall Reinforcing

Wall thickness	8 inches	Comp block (a) =	0.39 inches
Clear cover	2 inches	Depth to CL bar (d) =	5.69 inches
Rebar size	5	d-a/2 =	5.49 inches
Rebar area	0.31 sq-in		
Bar spacing	14 inches	ΦMn =	**6501** ft-lbs
Rebar strength fy	60 ksi		
Conc strength f'c	4000 psi	Mu =	**6253** ft-lbs
Load Factor	1.6		

ok

max tension reinforcing spacing: f_s = 32462 psi

s =	13.5 in
s =	14.8 in
s_{max} =	**13.5** in

ok w/ PARTIAL BASE FIXITY

PARTIAL BASE FIXITY WILL REDUCE STRESS

Anchorage at Top of the Wall

Ru = **3185** plf

#5 hairpins net #5@ 15"o/c	ΦVn = 6700plf
#5 hairpins net #5@ 18"o/c	ΦVn = 5580plf

14"

@ 18" o/c

Anchorage at Bottom of the Wall

Ru = **3904** plf

Nominal Shear friction capacity of the footing to wall Dowel **8131** plf

Rebar Dowel Size =	5
Dowel Area =	0.31 sq-in
Dowel strength fy=	60 ksi
Dowel Spacing =	14 inches
Coefficient of friction =	0.6 smooth surface

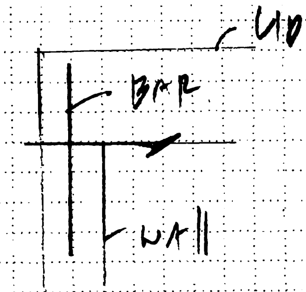
Site Structures
A Division of Kosnik Engineering PC

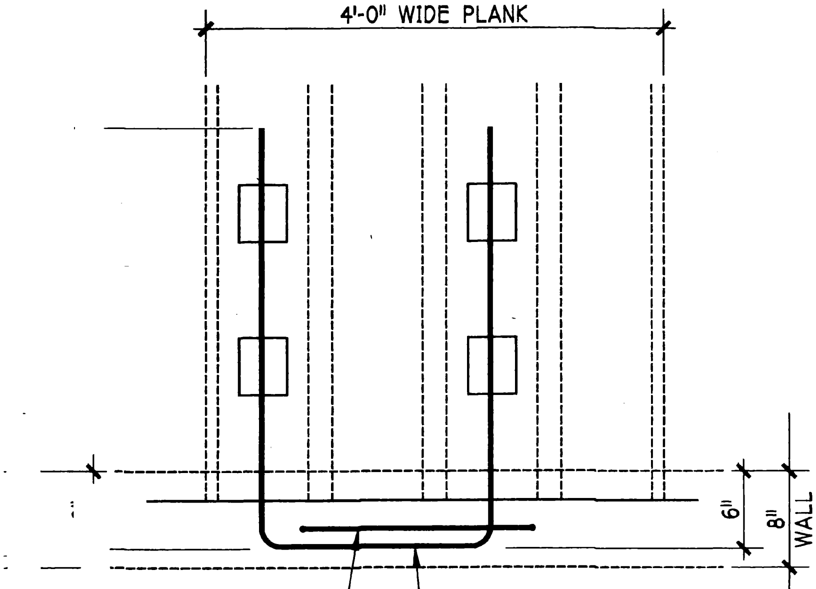
Project: FORTRESS
Sheet: 23
Date: 2-8-24
Job No: S.24-007

LID TO WALL CLOSURE REINF

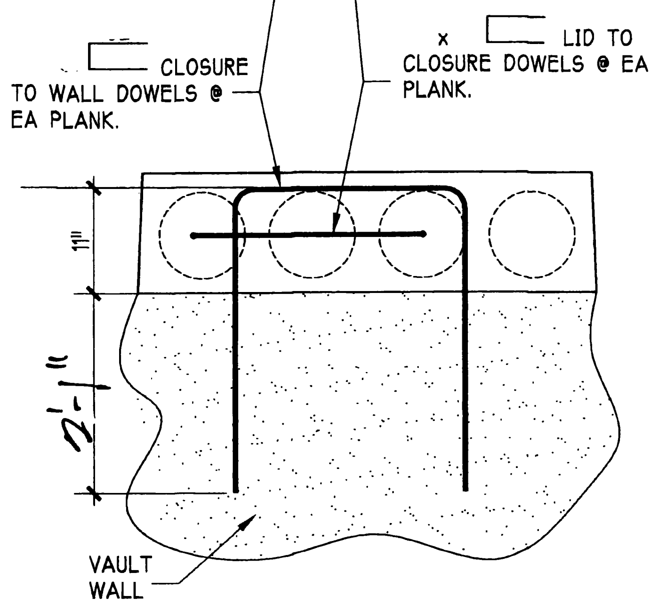
BAR SPACING 12"

SHEAR FRICTION





PLAN VIEW



ELEVATION VIEW

$\mu = 0.60$ $f_y = 60\,ksi$

BAR	ϕV_n
#5	8,370 PLF
#6	11,900 PLF

$\#5 = 0.75(0.31)60(0.60)$
$= 8370\,PLF$

$\#6 = 0.75(0.44)60(0.60)$
$11,900\,PLF$

BARS @ ~~24~~ 24" o/c
#5 = 4185 PLF
#6 = 5950 PLF

#5 @ 18" o/c ϕV_n = 5580 PLF
#5 @ 15" o/c ϕV_n = 6700 PLF
#5 @ 14" o/c ϕV_n = 7174 PLF

SITE STRUCTURES
10511 19th Ave SE, Suite C
Everett, WA, (425)-357-9600

Project Fortress

sheet 24
date 2-06-2024
prj. no. S-24-007

INTERIOR WALL HEADER GEOMETRY AND LOADS ANALYSIS

Header Overburden & Uniform Loads

Lid weight	90 psf			
Soil Desity	125 pcf		Load	Factors
Soil Cover depth over lid	3 ft		LL	1.6
Plank design clear span left	20 ft		DL	1.2
Plank design clear span right	20 ft			
Design Uniform Live Load	150 psf			

Lid tributary width to header 20 ft

Uniform service load to header 12300 plf
Uniform factored load to header 15960 plf

Truck Wheel Loads to Header

Truck type	outrigger ✓
Axle Load	45000 lbs
Wheel Spacing	1 ft
Cover depth	3.0 ft

Axle assumed centered over & perpendicular to header

distribution width	6.50 ft	opening width	4.00 ft
distribution length	8.00 ft	length ea side of hdr	4.00 ft

uniform load @ top of plank 865 psf

wheel load to header from left span 3115 plf
wheel load to header from right span 3115 plf

Total wheel load to header 6231 plf
Factored wheel load to header 9969 plf

Design Loads & Forces in Header

Service 18.5 klf
Factored 25.9 klf

Critical section for shear is at 0.6 feet from the face of the support

Design Vu = 36 k
Design Mu = 52 k-ft

SITE STRUCTURES
10511 19th Ave SE, Suite C
Everett, WA, (425)-357-9600

Project Fortress

sheet 25
date 2-06-2024
prj. no. S-24-007

INTERIOR WALL HEADER DESIGN

Header Data

Header width	8 inches	Concrete Strength	4000 psi
Header span	4.00 ft		
Header depth	24 inches	d =	21.00 inches
ln/d ratio	2.29	Deep Beam limit ln/d < 5.0	

Min shear steel (Area / spacing) ratio	0.012	Min Rebar spacing	
Max spacing of shear steel	4.8 inches	# 3 @	9.17
		# 4 @	16.67
Min horiz steel (Area / spacing) ratio	0.02	# 4 @	10.00
Max spacing of horzontal steel	8 inches	# 5 @	15.50

Review shear capacity of header

#4 U @ 6"o/c

Reinforcing yield strength	60 ksi		
Shear reinforcing area	0.20 sq in	Horz reinf area	0.31 sq in
spacing	6 in	Horz reinf spacing	12 in
Reinf shear capacity ΦVs	34 k	Conc shear capacity ΦVc	18 k
Total Shear Capacity	52 k ok	Factored shear Vu	36 k
Max ΦVn @ ln/d < 2	72 k		
Max ΦVn @ 2 < ln/d < 5	8496 k		

Review flexural capacity of header

min As based on 200 bwd/fy 0.56 sq inches
min As based on eq 10-3 0.53 sq inches

(2)#6 $A_s = 0.88 in^2$

As reqd based on bending model 0.61 sq inches

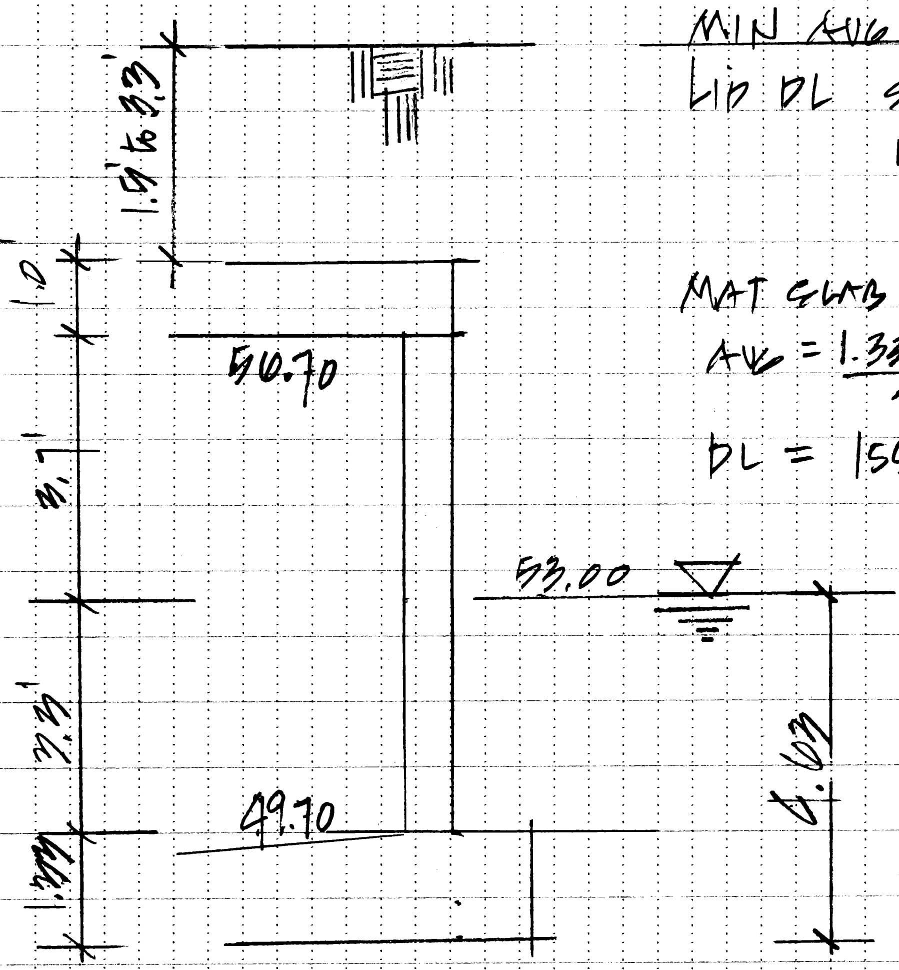
As reqd based on tie - strut model
assume Vu is focused @ the center of the header

then Tu = 41.49 k
As reqd = 0.77 sq inches

Site Structures
A Division of Kosnik Engineering PC

Project FORTRESS
Sheet 26
Date 2-08-2024
Job No S-24-001

BUOYANCY REVIEW



MIN AVG COVER 1.7'

LID DL SOIL 125 (1.7) = 213

LID 90 = 90

303

MAT SLAB DL

$AVG = \frac{1.33+0.83}{2} = 1.08'$

$DL = 155(1.08) = 167$

490 psf

H_2O BUOYANCY FORCE

$F_B = 62.4(4.63)$

$= 289$ psf

$FS = \frac{490}{289} = 1.63$ ok

GRADE SLAB MAT REVIEW

$F_B = 289$ PSF - BUOYANCY ON BOT OF SLAB

MAT SLAB DL = 167 PSF

$W_u = 1.4(289) - 1.0(167) = 238$ PSF

20' CELL WIDTH
SIMPLE SPAN MOM = $238(20)^2 \div 8 = 11{,}900$ '-#/'

6 SPAN CONT
$-M_u = 0.106\, wL^2$ @ 1st INTERIOR SUPPORT
$+M_u = 0.078\, wL^2$ @ END BAY

		MAT T
BOT @ WALLS	$-M_u = 0.106(238)400 = 10{,}090$ '-#/'	16"
TOP @ MIDSPAN	$+M_u = 0.078(238)400 = 7{,}430$ '-#/'	10"

TRY #4 @ 15" + #4 @ 30" ADDED = #4 @ 10" NET

LONGITUDINAL REINF
A_s MIN = $0.0018(16)12 = 0.346$ in²/FT
$0.0018(10)12 = 0.216$ in²/FT
#5 BOT + #4 TOP @ 16" o/c $A_s = 0.38$ in²/FT

BOT @ WALLS

/ #4@10 $A_s = 0.240$
/ #5@15 $A_s = 0.248$

16" SLAB 3" CLR #4@10" o/c
$a = 0.35$ $d - a/2 = 12.58"$ $d = 12.75"$
$\phi M_n = 13{,}335$ 1-#/1 > 10,090 1-#/1 1.32
2-SPAN 11,900 1-#/1 1.12

TOP @ MIDSPAN
10" SLAB 2" CLR #4@10" o/c
$a = 0.35$ $d - a/2 = 7.58$ $d = 7.75"$
$\phi M_n = 8{,}033$ 1-#/1 > 7,430 1-#/1 1.08

A_s MIN - 16" SLAB $A_{s\,min} = 0.0033(12.75)12 = 0.50$
10" SLAB $A_{s\,min} = 0.0033(7.75)12 = 0.30$

A_s REQD
16" SLAB $= 10090(12) \div 54000(12.58) = 0.18 \times 1.3 = 0.23$

10" SLAB $= 7430(12) \div 54000(7.75) = 0.21 \times 1.3 = 0.28$

1.3 × A_s REQD.

GO to 14" o/c spacing w/ ADDED @ 28" o/c

SITE STRUCTURES
10511 19th Ave SE, Suite C
Everett, WA, (425)-357-9600

Project Fortress

sheet 29
date 2-06-2024
prj. no. S-24-007

Design Data : Wall Foundation Design

Allowable Bearing Pressure	2500 psf	Per. wall Cell Width	20 ft
Rebar strength fy =	60 ksi	Int. wall Cell Width left	20 ft
Concrete strength =	4000 psi	Int. wall Cell Width right	20 ft
Soil Desity	125 pcf	Plank weight	90 psf
Soil Cover over the lid	3 ft	Wall Height	7 ft
		Wall Thickness	8 inches
		Interior Wall Thick	10 inches

Perimeter Wall Footing Design

		L.F	Wu
Design live load	1889 plf	1.6	3022.4 plf
Soil Cover dead load	4000 plf	1.2	4800 plf
Plank dead load	960 plf	1.2	1152 plf
Wall dead load	700 plf	1.2	840 plf
total dead load	5660 plf		6792 plf
Total live + dead Load	7549 plf		9814 plf

Required Ftg Width 3.02 ft
Selected Ftg Width 3.167 ft — F38x16 — EXTEND 15" BEYOND EXT FACE OF WALL
Selected Ftg Thickness 16 in

Qu = 3099 psf	Mu =	2422 ft-lbs	at face of wall
	Vu =	3874 plf	at face of wall
As regd = 0.04 sq-in/ft	phi Vn=	16128 plf	at face of wall
Asmin = 0.50 sq-in/ft			
1.33 x As regd = 0.06 sq-in/ft			

Interior Wall Footing Design

		L.F	Wu
Design live load	3000 plf	1.6	4800 plf
Soil Cover dead load	7500 plf	1.2	9000 plf
Plank dead load	1800 plf	1.2	2160 plf
Wall dead load	875 plf	1.2	1050 plf
total dead load	10175 plf		12210 plf
Total live + dead Load	13175 plf		17010 plf

Required Ftg Width 5.27 ft
Selected Ftg Width 5.33 ft
Selected Ftg Thickness 16 in

Qu = 3191 psf	Mu =	8675 ft-lbs	at face of wall
	Vu =	7441 plf	at face of wall
As regd = 0.16 sq-in/ft	phi Vn=	16128 plf	at face of wall
Asmin = 0.50 sq-in/ft			
1.33 x As regd = 0.21 sq-in/ft			

#6 @ 14" o.c. $A_s = 0.266\ in^2$

Design Data : Wall Foundation Loads Analysis

Soil Desity	125 pcf	Per. wall Cell Width	20 ft
Soil Cover over the lid	3 ft	Int. wall Cell Width left	20 ft
Plank weight	90 psf	Int. wall Cell Width right	20 ft
Uniform Live Load	150 psf		
Truck Rating	HS25-44		
Wall Height	7 ft		

Front Axle Load	10000 lbs
Rear Axle #1 Load	40000 lbs
Rear Axle #2 Load	40000 lbs
Total vehicle wt	90000 lbs

Truck Wheel Load Distribution to Perimeter Wall Foundation

Truck Perpendicular to the perimeter wall w/ rear axle #2 directly over wall & distance to axle #1 = 14ft

total truck load to wall = 52000 lbs
distribution width = 28 ft
Load @ base of wall = **1857** plf

Truck Parallel to the perimeter wall w/ one wheel over wall & 2nd wheel on plank (incl axle 1&2 only)

total truck load to wall = 68000 lbs
calc distribution width = 36 ft
Load @ base of wall = **1889** plf - controls

Truck Wheel Load Distribution to Interior Wall Foundation

Truck Perpendicular to the int. wall w/ rear axle #2&#1 centered over the wall & dist between axles = 14ft

total truck load to wall = 52000 lbs
distribution width = 28 ft
Load @ base of wall = **1857** plf

Truck Perpendicular to the interior wall w/ rear axle #2 directly over wall & distance to axle #1 = 14ft

total truck load to wall = 52000 lbs left plank — Load @ base of wall = **1857** plf
total truck load to wall = 52000 lbs right plank — Load @ base of wall = **1857** plf
distribution width = 28 ft

Truck Parallel to the interior wall w/ one wheel over wall & 2nd wheel on plank (incl axle 1&2 only)

total truck load to wall = 68000 lbs left plank — Load @ base of wall = **1889** plf
total truck load to wall = 68000 lbs right plank — Load @ base of wall = **1889** plf
distribution width = 36 ft

Truck Parallel to the interior wall w/ the truck centered over the wall (incl axle 1&2 only)

total truck load to wall = 68000 lbs
distribution width = 36 ft
Load @ base of wall = **1889** plf

Uniform Live Load distribution to Wall Footings

Perimeter Wall **1500** plf
Interior Wall **3000** plf — controls

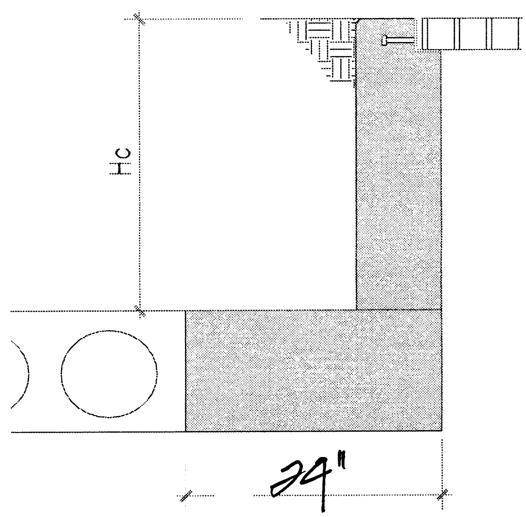
SITE STRUCTURES
10511 19th Ave SE, Suite C
Everett, WA, (425)-357-9600

Project Fortress

Beam Design Below Grated Opening

Design Data

Height of Curb:	3	ft
Curb Thickness:	8	in
Soil Density:	125	pcf
Beam Width:	24	in
Beam Span:	5	ft
Truck Rear Axle Load:	40	k



Calculated Design Forces

Soil Weight =	500	plf
Curb Weight =	300	plf
Self Weight =	313	plf
Wheel Load =	20000	lb

Load Factor: DL 1.2
LL 1.6

Wu = 1335 plf
Pu = 32000 lb

Design for Flexure

Reinf Size	6	
# of Top & Bot Reinf	5	
Area of Steel	2.21	sq-in
Depth to Reinf (d)	10.13	in
Comp Block (a)	2.17	in
d - a/2	9.04	in

(5)#6 T&B

ΦMn = 89879 ft-lbs ok **Mu = 44172** ft-lbs

Design for Shear

Tie Reinf Size	4 ✓	
Area of Steel	0.20	
Depth to Reinf (d)	10.50	
Max Spacing	5.25	in
Reinf Spacing	5	in ✓

ΦVc = 11732 lbs

ΦVs = 42057 lbs

ΦVc +ΦVs = 53789 lbs ok **Vu = 35338** lbs

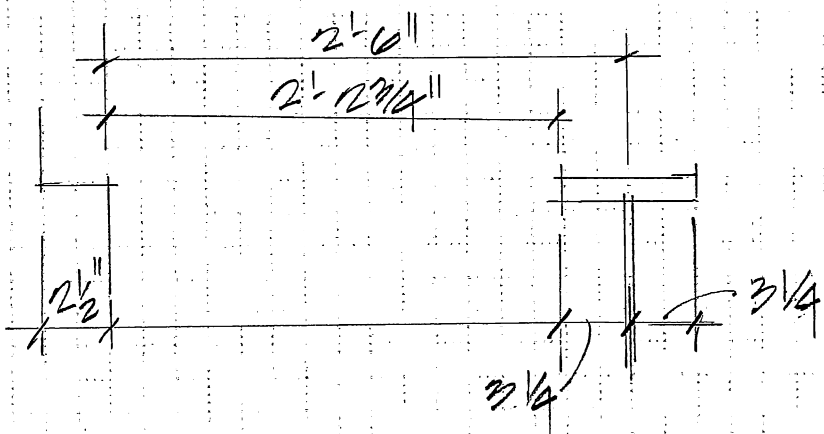
Site Structures
A Division of Kosnik Engineering PC

Project	FORTRESS	Sheet	32
		Date	2-08-2024
		Job No	S-24-007

GRATING HS25 LOADING

HS25 40,000 lb AXLE LOAD
HS 20 32,000 lb AXLE LOAD

GRATING CLEAR SPAN



HS20 EQUIV SPAN

$$\frac{P_{HS20}(L_{HS20})}{4} = \frac{P_{HS25} L_{HS25}}{4}$$

$$L_{HS20} = \frac{P_{HS25}}{P_{HS20}}(L_{HS25})$$

$$= \frac{40}{32}(2.25) = 2.8 \text{ FT}$$

SELECT 3 × 1/4 BRG BARS
H-20 SPAN CAP = 3.1 FT
SEE CHART ON FOLLOWING SHEET.

Site Structures
A Division of Kosnik Engineering PC

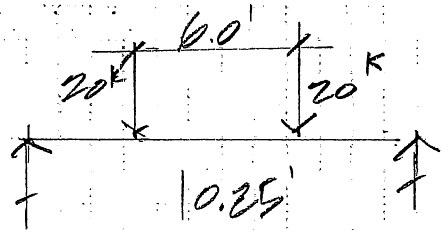
Project FORTRESS
Sheet 33
Date 2-09-2024
Job No S-24-007

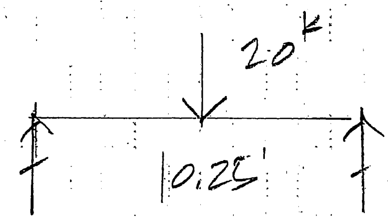
LOAD TABLE: TYPE W-19-4

BEARING BAR SIZE	WEIGHT LBS. PER SQ. FT.	H-20 TRUCK	H-15 TRUCK	H-10 TRUCK
1 x 1/4	10.1	1'-1"	0'-10"	0'-8"
1 x 5/16	12.3	1'-1"	0'-11"	0'-9"
1 x 3/8	14.6	1'-2"	1'-0"	0'-10"
1-1/4 x 1/4	12.3	1'-2"	1'-0"	0'-10"
1-1/4 x 5/16	15.1	1'-3"	1'-1"	0'-11"
1-1/4 x 3/8	17.9	1'-5"	1'-2"	1'-0"
1-1/2 x 1/4	14.6	1'-4"	1'-2"	1'-0"
1-1/2 x 5/16	18.0	1'-6"	1'-4"	1'-2"
1-1/2 x 3/8	21.3	1'-8"	1'-6"	1'-4"
1-3/4 x 1/4	16.9	1'-7"	1'-5"	1'-3"
1-3/4 x 5/16	20.8	1'-9"	1'-7"	1'-5"
1-3/4 x 3/8	24.7	1'-11"	1'-9"	1'-8"
2 x 1/4	19.1	1'-10"	1'-8"	1'-6"
2 x 5/16	23.6	2'-1"	1'-11"	1'-9"
2 x 3/8	28.2	2'-4"	2'-2"	2'-1"
2-1/4 x 1/4	21.4	2'-1"	1'-11"	1'-9"
2-1/4 x 5/16	26.5	2'-5"	2'-3"	2'-2"
2-1/4 x 3/8	31.5	2'-8"	2'-7"	2'-6"
2-1/2 x 1/4	23.7	2'-4"	2'-3"	2'-1"
2-1/2 x 5/16	29.3	2'-9"	2'-7"	2'-7"
2-1/2 x 3/8	34.9	3'-2"	3'-0"	3'-0"
3 x 1/4	28.2	3'-1"	2'-11"	2'-11"
3 x 5/16	35.1	3'-7"	3'-6"	3'-6"
3 x 3/8	41.8	4'-2"	4'-1"	4'-2"
3-1/2 x 1/4	32.8	3'-10"	3'-9"	3'-9"
3-1/2 x 5/16	40.7	4'-8"	4'-7"	4'-8"
3-1/2 x 3/8	48.6	5'-0"	5'-0"	5'-1"
4 x 1/4	37.3	4'-10"	4'-9"	4'-8"
4 x 5/16	46.4	5'-5"	5'-5"	5'-6"
4 x 3/8	55.4	5'-9"	5'-9"	5'-10"
5 x 1/4	46.4	6'-3"	6'-3"	6'-5"
5 x 3/8	68.9	7'-1"	7'-2"	7'-4"
5 x 1/2	91.3	7'-10"	7'-11"	8'-1"
6 x 1/4	55.6	7'-6"	7'-6"	7'-8"
6 x 3/8	82.5	8'-6"	8'-7"	8'-9"
6 x 1/2	109.3	9'-5"	9'-6"	9'-8"
7 x 1/4	64.6	8'-8"	8'-9"	8'-11"
7 x 3/8	96.0	9'-11"	10'-0"	10'-3"
7 x 1/2	127.3	10'-11"	11'-1"	11'-3"

BEAM C GRATING

HS 25 LOAD - 40^k AXLE LOAD





$M_1 = 20\,(2.125) = 42.5^{k-1}$

$M_2 = 20\,(10.25) \div 4 = 51.3^{k-1}$

SELECT W8x28 $M_{allow} = 60.75^{k-1}$ - SEE MOM CHART

$b_f = 6.5''$ 3" BRG $A = 3.0\,(6.5) = 19.5\ in^2$

$R_{MAX} = 20 + 20\,(4/10.25) = 28^k$

$f_{brg} = 28/19.5 = 1.43$ ksi

GO TO 4" MIN BRG $A = 26^{\#}$

$f_{brg} = 28/26 = 1.0$ ksi

USE GALV. ANGLE BRG SEAT 4x4x3/8 X 8" $A = 32^{\#}$

$f_{brg} = 28/32 = 0.875$ ksi

$F_p = 0.35\,(3.0\ ksi) = 1.05$ ksi 4" BRG is ok.

OR 3½x3½x ½ x9" $A = 32^{\#}$

Site Structures
A Division of Kosnik Engineering PC

Project FORTRESS
Sheet 37
Date 2-08-2024
Job No S-24-007

68.75 k-ft
W8x31

60.75 k-ft
W8x28