MILLER
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STRUCTURAL CALCULATIONS

NWNRC Stairs and Ladder
2600 SE 29th Avenue, Portland, OR
Superior West Engineering

March 6, 2023
Project No. 230211
16 pages

Principal Checked: ARL

This review is only for general conformance with the design concept of the project and with the information given in the contract documents.

- [X] NO EXCEPTIONS TAKEN
- [ ] REVISE & RESUBMIT
- [ ] MAKE CORRECTIONS NOTED
- [ ] SUBMIT SPECIFIED ITEM

Checking does not relieve the contractor of the responsibility for errors and omissions in the submittal or for fabrication, installation or safety methods, verification of dimensions and quantities, or the coordination with other aspects of the work.

DATE: 03/24/2023 BY: ELD

MILLER CONSULTING ENGINEERS, INC.

REGISTERED PROFESSIONAL ENGINEER
99736PE
OREGON
MARCH 8, 2022
BENJAMIN STEER
EXPIRES: 6-30-2024

Project Design Criteria

Structural System Information

Building Code:	2019 Oregon Structural Specialty Code						
Risk Category:	IV						
Structural System:	Component						
Importance Factors:	I_S = 1.20		I_i = 1.25		I_W = 1.00		I_p = 1.50
Gravity System:	Wood Framed Construction						
Seismic System:	Architectural Components						
	Egress Stairways Not Part of Building Seismic Force-Resisting System						
	ap = 1		Rp = 2.5		Ωo = 2		

Loading Information

	Dead	Live	Live Point
Stairs	35 psf	100 psf	300 lbs
Ladder	25 psf	100 psf	300 lbs

Deflection Criteria

	Dead	Live/Wind
Roof	L/360	L/240
Floor	L/360	L/240

Seismic Loading

Seismic design criteria per EoR.

Scope of Work

The scope of work is for the structural design of the ships ladder, stairs, and their attachment to the building.

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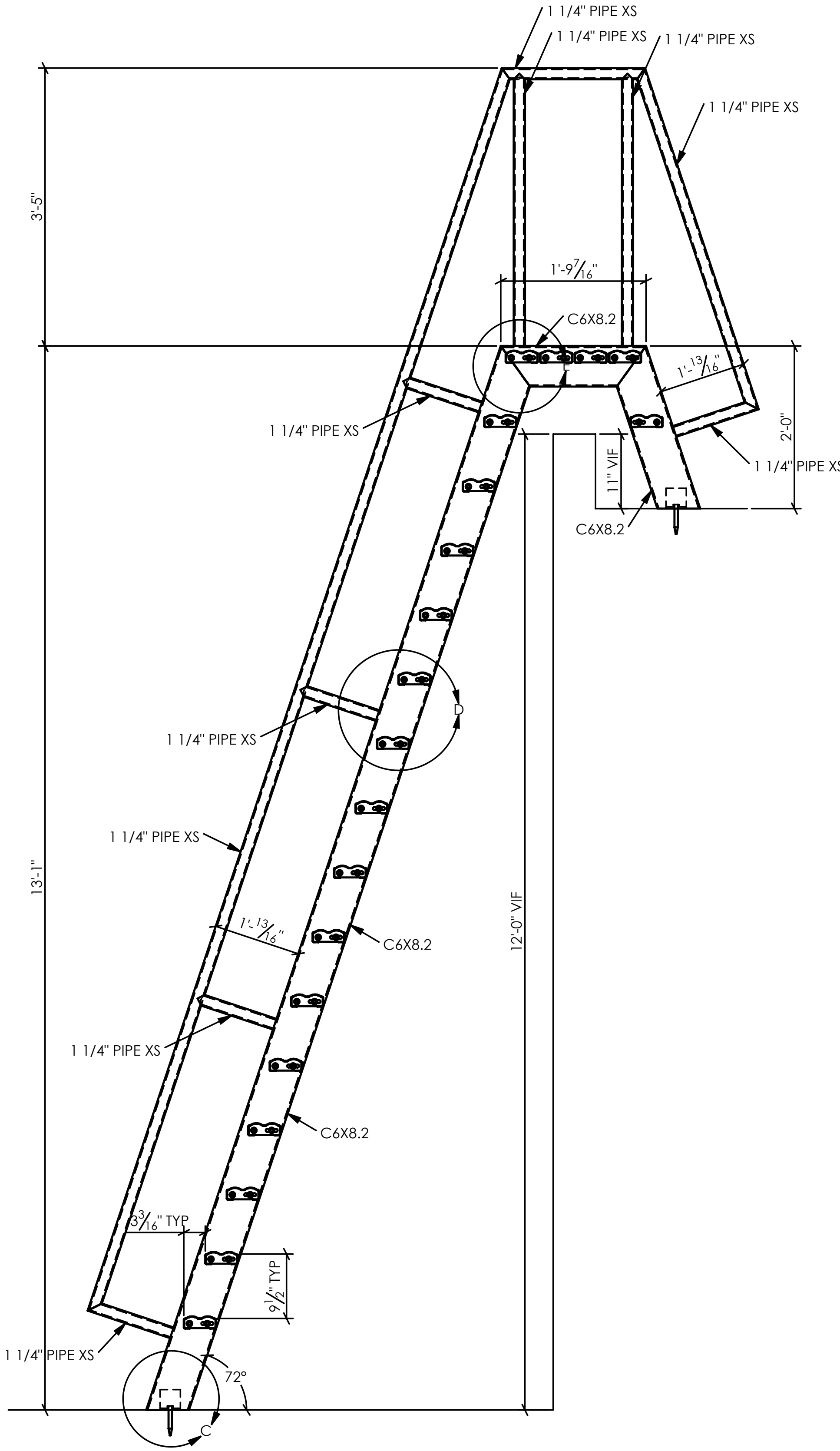

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Project Name NWNRC Stairs and Ladder

Project # 230211

Location 2600 SE 29th Avenue, Portland, OR

Client Superior West Engineering

By BIS

Ck'd ELD

Date 2/24/2023

ASCE 7-16: SEISMIC DESIGN FORCE, SECTION 13.3

Elements of Structures, Nonstructural Components, and Equipment Supported by Structures

Site Class:	C		*Section 20.3, Table 20.3-1*
Seismic Design Category:	D		*Section 11.6*
Risk Category:	IV		*Table 1.5-1*
S_s =	0.662		***per EoR***
F_a =	1.24		*Table 11.4-1 (Linear interpolation is used)*
S_{MS} =	0.82		*Eqn. 11.4-1*
S_{DS} =	0.545		*Eqn. 11.4-3*
I_p =	1.50		
a_p =	1.0		*Table 13.6-1*
R_p =	2.5		*Table 13.6-1*
z =	24.33	*ft, Component attachment elevation w/ respect to grade*	
h =	24.33	*ft, Structure roof elevation with respect to grade*	
F_p =	0.392	* W_p	*Eqn. 13.3-1*
OR	1.308	* W_p	*Eqn. 13.3-2*
Not less than	0.245	* W_p	*Eqn. 13.3-3*

F_p =	**0.392**	*** W_p**	
$0.2S_{DS}W_p$ =	**0.109**	*** W_p**	*Sec. 13.3.1.2*

McNICHOLS® PLANK GRATING

PLANK

GRIP STRUT® | 2-DIAMOND | 4-3/4" WIDTH

ALUMINUM LOAD TABLE

THICK	DEPTH (mm)	LBS./LF (kg/m)	LOAD/ DEFL	CLEAR SPAN 24"	30"	36"	42"	48"	54"	60"	66"
.0800"	1-1/2" (38.1)	0.85 (1.26)	U	998	639	443	326	248	196	159	131
			D	0.10	0.15	0.22	0.31	0.40	0.51	0.63	0.76
			C	395	316	263	226	197	175	157	143
			D	0.08	0.12	0.18	0.25	0.32	0.41	0.50	0.61
	2" (50.8)	0.92 (1.37)	U	1463	937	650	478	366	289	234	194
			D	0.08	0.13	0.18	0.25	0.33	0.42	0.52	0.63
			C	579	463	386	331	290	257	232	211
			D	0.06	0.10	0.15	0.20	0.27	0.34	0.42	0.51
	2-1/2" (63.5)	1.00 (1.48)	U	2199	1407	977	718	550	434	352	291
			D	0.07	0.10	0.15	0.21	0.28	0.35	0.43	0.53
			C	870	696	580	497	435	387	348	316
			D	0.05	0.08	0.12	0.17	0.22	0.28	0.35	0.42

w_{LL} = 100 psf < 539 psf, **OKAY**
P_{LL} = 300 lbs < 316 lbs, **OKAY**

U - Uniform Load - Lbs. per Square Foot

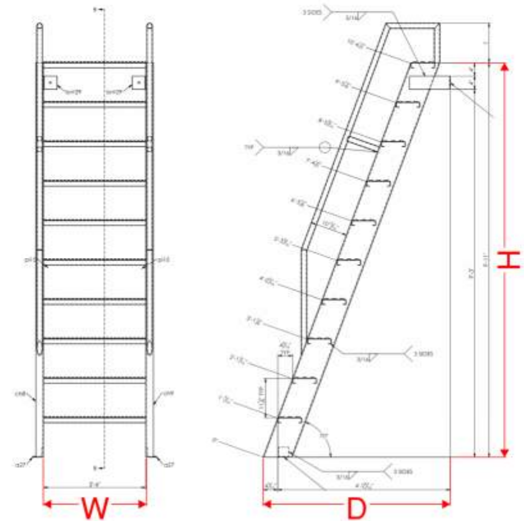
D - Deflection - in Inches

C - Concentrated Load - Lbs. per Square Foot of Width at Mid Span

- Span and loading values to the left of the bolded black line produce a deflection of 1/4" or less under a uniform load of 100 lbs. per square foot, allowing for safe pedestrian comfort. Span and loading values to the right of the bolded black line are applicable to other types of loads at the discretion of a licensed engineer.
- Technical information provided is theoretical and for evaluation by technically skilled persons, with any use thereof to be at their independent discretion and risk. **McNICHOLS** shall have no responsibility or liability for results obtained or damages resulting from improper evaluation or use of Plank Grating.

Loading and Geometry (ASD)

DL =	25	psf	
LL =	250	lbs x2	
E_H =	0.392	g	
H =	14.00	ft max	ladder height
D =	7.00	ft max	distance from wall
W =	2.5	ft max	tread width
L =	15.65	ft	$= \sqrt{(14')^2+(7')^2}$



Stringer

A =	739	lbs	= [(25 psf)(15.65')(2.5')+2(250 lbs)]/(2 stringers)
V_X =	739	lbs	= [(25 psf)(15.65')(2.5')+2(250 lbs)]/(2 stringers)

Conservative to assume the stringer takes gravity load similar to column and beam.

$w_{GRAVITY}$ =	69.9	plf	= (25 psf)(2.5')(15.65')/(7')/(2 stringers)
M_X =	1303	lbs-ft	$= [(69.9 \text{ plf})(7')^2/8+2(250 \text{ lbs})(7')/4]$
$w_{SEISMIC}$ =	8.6	plf	= 0.7(0.392497152g)(25 psf)(2.5')/(2 stringers)
V_Y =	67	lbs	= (8.6 plf)(15.65')/2
M_Y =	263	lbs-ft	$= (8.6 \text{ plf})(15.65')^2/8$

See next page for stringer design.

Use C 6X8.2

Δ_X =	0.021	in	= L/4059	Gravity
Δ_Y =	0.582	in	= L/323	Seismic

STRINGER

Steel Column/Beam Design - AISC 13th Addition

Shape: C **Shape Capacity = 0.75 < 1.0**

Size: 6X8.2

	ASD	
Weight =	8	plf
Pr =	0.739	k, axial compression load
Mr_x =	1.303	ft-k, strong axis moment
Mr_y =	0.263	ft-k, weak axis moment
Vr_y =	0.739	k, strong axis shear
Vr_x =	0.067	k, weak axis shear
K_x =	1.00	*(Table C-C2.2, pg 16.1-240)*
K_y =	1.00	*(Table C-C2.2, pg 16.1-240)*
Lb_x =	15.65	ft
Lb_y =	15.65	ft
KL/r x =	80.27	
KL/r y =	350.43	**KL/r should not exceed 200**
E =	29000	ksi
Fy =	36	ksi
d =	6	in
Ag =	2.39	in^2
tf =	0.343	in
bf =	1.92	in
tw =	0.2	in
hw =	4.38	in
Z_x =	5.16	in^3
Z_y =	0.987	in^3
S_x =	4.35	in^3
S_y =	0.488	in^3
I_x =	13.1	in^4
I_y =	0.687	in^4
r_x =	2.34	in
r_y =	0.536	in
J =	0.0736	in^4
Cw =	4.7	in^6

Section is Compact in the flange for flexure

Section is Compact in the flange for compression

Section is Compact in the web for flexure

Section is Compact in the web for compression

Axial Capacity, Chapter E		
Aeff =	2.39	in^2
Q =	1.00	
Qs =	1.00	*(Section E7, pg 16.1-43)*
Qa =	1.00	*(Section E7, pg 16.1-42)*
Fe_x =	44.4	ksi, *(Section E3 pg 16.1-33)*
Fe_y =	2.3	ksi, *(Section E3 pg 16.1-33)*
Fcr_x =	25.6	ksi, *(Section E3 pg 16.1-33)*
Fcr_y =	2.0	ksi, *(Section E3 pg 16.1-33)*
Pn_x =	61	k, *(Section E3 pg 16.1-33)*
Pn_y =	5	k, *(Section E3 pg 16.1-33)*
Moment Capacity, Chapter F		
Cb =	1	
Mn_x =	5.8	*ft-k, (section F2 pg. 16.1-47)*
Mn_y =	2.3	*ft-k, (section F6 pg. 16.1-54)*
Shear Capacity: Chapter G		
kv_x =	5	*(Section G2, pg 16.1-65)*
kv_x =	1.2	*(Section G7, pg 16.1-68)*
Cv_x =	1.00	*(Section G2, pg 16.1-65)*
Cv_y =	1.00	*(Section G2, pg 16.1-65)*
Aw_x =	1.20	in^2, *(Section G5, pg 16.1-68)*
Aw_y =	1.32	in^2, *(Section G5, pg 16.1-68)*
Vn_x =	25.9	*k, (Section G6, pg 16.1-68)*
Vn_y =	28.4	*k, (Section G6, pg 16.1-68)*

Allowable Capacties: Rn / Ω (ASD); Rn * Φ (LRFD)

(ASD)	Pc, k	Mc, ft-k	Vc, k
x-axis	**2.9**	**3.5**	**17.3**
y-axis		**1.4**	**19.0**

Interaction Equations:

Pr/Pc =	0.25	> 0.2, Equation H1-1a controls
	0.75	< 1.0 OK

Equation H1-1a, AISC 13 ed., pg 16.1-70

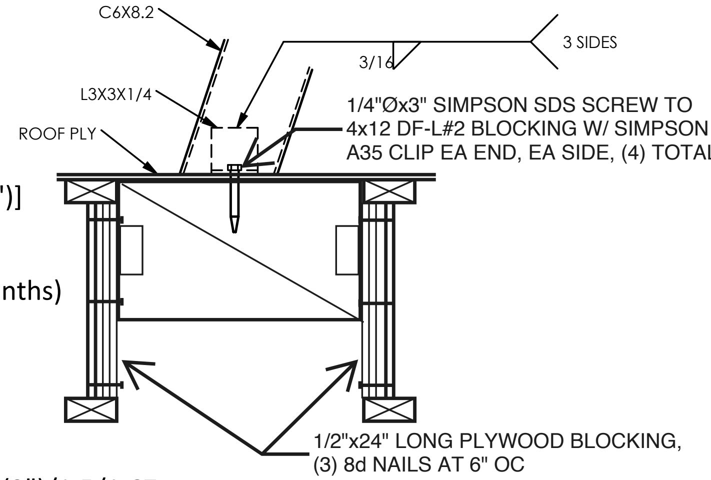
Use C 6X8.2

Stringer KL/r y > 200, OKAY, stringers partially braced by treads at ~12" OC.

TOP & BOTTOM CONNECTION

(ASD)

$V_{SEISMIC}$ =	200	lbs	200 lbs min



WELD FROM STRINGER TO BENT PLATE

Try	3/16" weld on (3) sides, 4" long each		
$v_{SEISMIC}$ =	25	lbs/in	= (200 lbs)/(2*4'')
$m_{SEISMIC}$ =	0	lbs/in	= (0 lbs-in)/[(4'')(4'')]
Σ =	25	lbs/in	
R_n/Ω =	2784	lbs/in	= (928 psi)(3 sixteenths)
Utilization =	0.9%	< 100%, OKAY	

BENT PLATE

Try	L3x3x1/4		
$V_{Y, CAP}$ =	10778	lbs	= (36000 psi)(1/4")(3")/1.5/1.67
$M_{Y, CAP}$ =	1010	lbs-in	= (36000 psi)(1/4")²(3")/4/1.67
Utilization =	1.9%	< 100%, OKAY	

WOOD ANCHORAGE

T =	200	lbs	
V =	200	lbs	
R =	283	lbs	
α =	45	°	
Try	1/4”Øx3”	Simpson SDS screw into 4x DF-L#2 blocking	
T_{CAP} =	344	lbs	= (172 lbs/in)(2")
V_{CAP} =	280	lbs	
R_n =	309	lbs	[NDS 2018 Eqn. 12.4-1]
Utilization =	91.6%	< 100%, OKAY	

Conclusion: Use L3x3x1/4 w/ 3/16" weld on (3) sides, 4" long each to stringer and 1/4”Øx3” Simpson SDS screw into 4x DF-L#2 blocking at top of ships ladder.

STEEL GUARDRAIL DESIGN

(ASD)

TOP RAIL

L =	4	ft	
P =	200	lbs	
V_P =	200	lbs	= P
M_P =	200	lbs-ft	= (200 lbs)(4')/4
	2400	lbs-in	

Try 1¼"Ø SCH 40 pipe

F_Y =	35000	psi	
A_V =	0.63	in^2	
Z =	0.305	in^3	
V_{CAP} =	3930	lbs	= 0.6(35000 psi)(0.63 in^2)/2/1.67
M_{CAP} =	6392	lbs-in	= (35000 psi)(0.305 in^3)/1.67
Shear Utilization =	5.1%		= (200 lbs)/(3930 lbs)
Bending Utilization =	37.5%		= (2400 lbs-in)/(6392 lbs-in)

OKAY

POST

S =	4	ft	post spacing
H =	1.083	ft	post height
	13	in	
P_{TOP} =	200	lbs	
V =	200	lbs	= P
M =	217	lbs-ft	= (200 lbs)(1.083')
	2600	lbs-in	

Try 1¼"Ø SCH 40 pipe at 4'-0" OC

F_Y =	35000	psi	
A_V =	0.63	in^2	
Z =	0.305	in^3	
V_{CAP} =	3930	lbs	= 0.6(35000 psi)(0.63 in^2)/2/1.67
M_{CAP} =	6392	lbs-in	= 0.9(35000 psi)(0.305 in^3)
Shear Utilization =	5.1%		= (200 lbs)/(3930 lbs)
Bending Utilization =	40.7%		= (2600 lbs-in)/(6392 lbs-in)

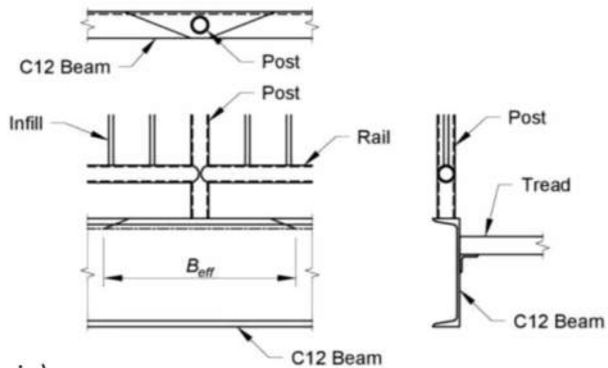
OKAY

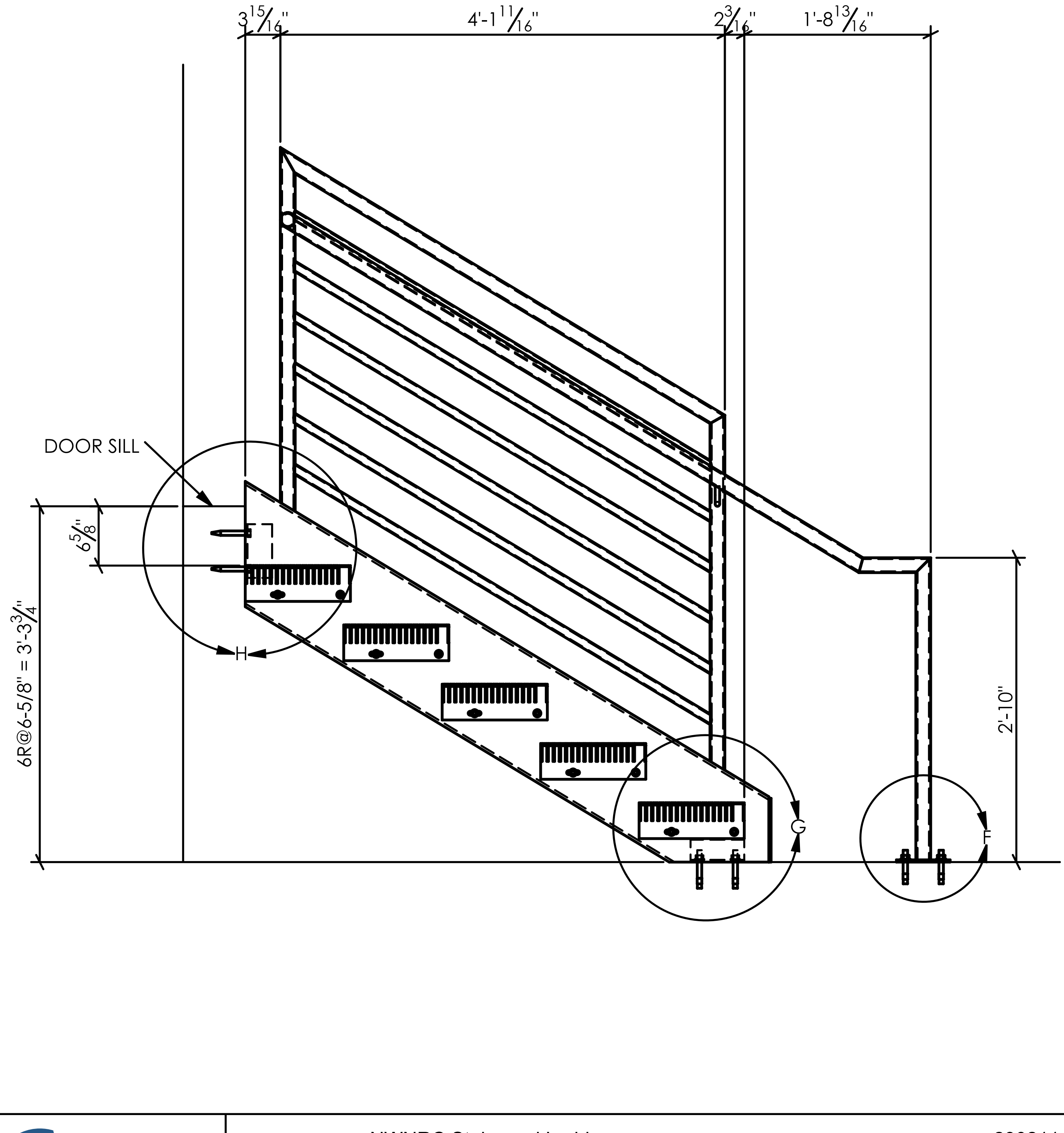
POST WELD TO CHANNEL

V =	200	lbs	
M =	2600	lbs-in	
Try	3/16	'' fillet weld all-round post to baseplate	
v =	38	lbs/in	= (200 lbs)/[π1.66''Ø]
m =	1201	lbs/in	= (2600 lbs)/[π(1.66''Ø²/4]
Σ =	1240	lbs/in	= 38 lbs+1201 lbs
R_n =	2784	lbs/in	= (928 psi)(3 sixteenths)
Weld Utilization =	44.5%		= (1240 lbs/in)/(2784 lbs/in)
	OKAY		

CHANNEL FLANGE STRENGTH CHECK

M =	2600	lbs-in	
N =	1.66	in	guardrail post diameter
k =	0.8125	in	beam fillet dimension
t_f =	0.343	in	flange thickness
b_f =	1.92	in	flange width
B_{EFF} =	14.465	in	$= N+2(2.5)[(k-t_f/2)+b_f]$
t_w =	0.2	in	web thickness
Z_{FLANGE} =	0.14465	in³	$= B_{EFF}t_w^2/4$
M_{CAP} =	3118	lbs-in	$= f_y Z_{FLANGE}/\Omega$
Bending Utilization =	83.4%		= (2600 lbs-in)/(3118 lbs-in)
	OKAY		





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Project # 230211

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By BIS

Ck'd ELD

Date 2/24/2023

ASCE 7-16: SEISMIC DESIGN FORCE, SECTION 13.3

Elements of Structures, Nonstructural Components, and Equipment Supported by Structures

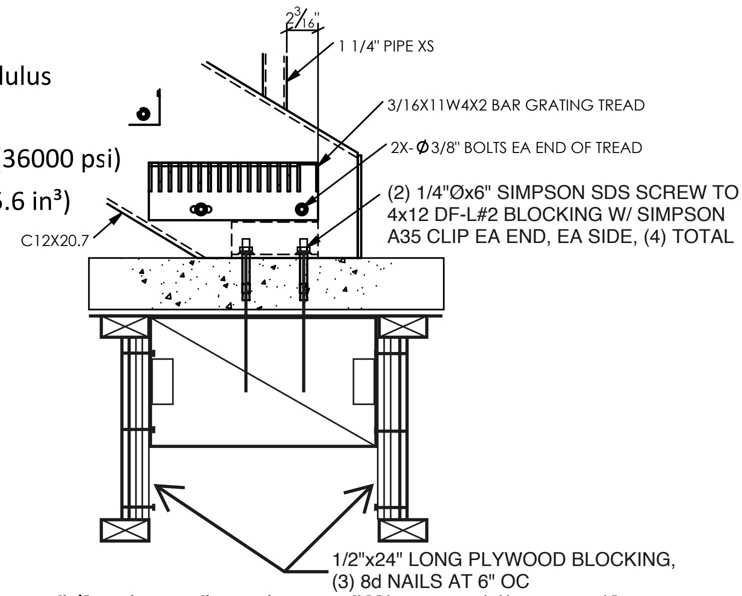
Site Class:	C		*Section 20.3, Table 20.3-1*
Seismic Design Category:	D		*Section 11.6*
Risk Category:	IV		*Table 1.5-1*
S_s =	0.983		***per EoR***
S_1 =	0.421		***per EoR***
S_{DS} =	0.786		*Eqn. 11.4-3*
I_p =	1.50		**egress stairs*
a_p =	1.0		*Table 13.6-1*
R_p =	2.5		*Table 13.6-1*
z =	17	*ft, Component attachment elevation w/ respect to grade*	
h =	24.33	*ft, Structure roof elevation with respect to grade*	
F_p =	0.452	* W_p	*Eqn. 13.3-1*
OR	1.887	* W_p	*Eqn. 13.3-2*
Not less than	0.354	* W_p	*Eqn. 13.3-3*

F_p =	**0.452**	*** W_p**	
$0.2S_{DS}W_p$ =	**0.157**	*** W_p**	*Sec. 13.3.1.2*

STRINGER

(LRFD)

w_{DL} =	35	psf	uniform dead load
w_{LL} =	100	psf	uniform live load
W =	2.000	ft	tributary width
w_{ASD} =	270.0	plf	= (35+100 psf)(2')
w_{LRFD} =	404.0	plf	= [1.2(35 psf)+1.6(100 psf)](2')
L =	4.75	ft	length of member
R1 =	960	lbs	= (404 plf)(4.75')/2
R2 =	960	lbs	= (404 plf)(4.75')/2
V =	960	lbs	max reaction
M =	1139	lbs-ft	= (404 plf)(4.75')²/8
	13673	lbs-in	
Try:	C12x20.7		
Φ =	0.9		
F_y =	36000	psi	
E =	29,000,000	psi	
A_V =	3.384	in²	shear area
Z =	25.6	in³	plastic section modulus
I =	129	in^4	section modulus
V_{CAP} =	65785	lbs	= 0.9(3.384 in²)0.6(36000 psi)
M_{CAP} =	829440	lbs-in	= 0.9(36000 psi)(25.6 in³)
Δ_{TL} =	0.001	in	
Δ_{LL} =	0.001	in	
TL Deflection =	L/68951	**OKAY**	L/240 limit
LL Deflection =	L/93084	**OKAY**	L/360 limit
Shear Utilization =	1.5%	**OKAY**	
Bending Utilization =	1.6%	**OKAY**	



WOOD ANCHORAGE

C_S =	0.452		
$V_{SEISMIC}$ =	188	lbs	= (0.452)(960 lbs)(35 psf)/[1.2(35 psf)+1.6(100 psf)][(ap = 2.5)/(ap = 1.0)]
T =	200	lbs	
V =	200	lbs	
R =	283	lbs	
α =	45	°	
Try	1/4”Øx3” Simpson SDS screw into 4x DF-L#2 blocking		
T_{CAP} =	344	lbs	= (172 lbs/in)(2")
V_{CAP} =	280	lbs	
R_n =	309	lbs	[NDS 2018 Eqn. 12.4-1]
Utilization =	91.6%	< 100%, OKAY	

Use minimum C12x20.7 w/ 1/4”Øx3” Simpson SDS screw into 4x DF-L#2 blocking

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STEEL GUARDRAIL DESIGN

(ASD)

TOP RAIL

$L =$	4	ft					
$P =$	200	lbs		$w =$	50	plf	
$V_P =$	200	lbs	= P	$V_w =$	200	lbs	= (50 plf)(4')
$M_P =$	200	lbs-ft	= (200 lbs)(4')/4	$M_w =$	100	lbs-ft	= (50 plf)(4')²/8
	2400	lbs-in			1200	lbs-in	

Try 1¼"Ø SCH 40 pipe

$F_Y =$	35000	psi	
$A_V =$	0.63	in²	
$Z =$	0.305	in³	
$V_{CAP} =$	3930	lbs	= 0.6(35000 psi)(0.63 in²)/2/1.67
$M_{CAP} =$	6392	lbs-in	= (35000 psi)(0.305 in³)/1.67
Shear Utilization =	5.1%		= (200 lbs)/(3930 lbs)
Bending Utilization =	37.5%		= (2400 lbs-in)/(6392 lbs-in)

OKAY

POST

$S =$	4	ft	post spacing
$H =$	3.500	ft	post height
	42	in	
$P_{TOP} =$	200	lbs	
$V =$	200	lbs	= P
$M =$	700	lbs-ft	= (200 lbs)(3.5')
	8400	lbs-in	

Try 1¼"Ø SCH 80 pipe at 4'-0'' OC

$F_Y =$	35000	psi	
$A_V =$	0.84	in²	
$Z =$	0.393	in³	
$V_{CAP} =$	5263	lbs	= 0.6(35000 psi)(0.84 in²)/2/1.67
$M_{CAP} =$	8237	lbs-in	= (35000 psi)(0.393 in³)/1.67
Shear Utilization =	3.8%		= (200 lbs)/(5263 lbs)
Bending Utilization =	102.0%		= (8400 lbs-in)/(8237 lbs-in)

W/IN 5%, OKAY

HANDRAIL

V =	200	lbs	
M =	200	lbs-ft	
	2400	lbs-in	
Try	1¼"Ø SCH 40 pipe		
F_Y =	35000	psi	
A_V =	0.63	in²	
Z =	0.305	in³	
V_{CAP} =	6549	lbs	= (0.63 in²)/2(35000 psi)/1.67
M_{CAP} =	6392	lbs-in	= (35000 psi)(0.305 in³)/1.67
Shear Utilization =	3.1%		= (200 lbs)/(6549 lbs)
Bending Utilization =	37.5%		= (2400 lbs-in)/(6392 lbs-in)
	OKAY		

HANDRAIL SUPPORT

P =	200	lbs	= P
M =	466	lbs-in	= (200)(1.5''+1.66''/2)
Try	1/2	"Ø bar	
F_Y =	36000	psi	
A_V =	0.20	in²	= π(0.5'')²/4
Z =	0.021	in³	= π(0.5'')³/6
V_{CAP} =	2116	lbs	= (0.2 in²)/2(36000 psi)/1.67
M_{CAP} =	449	lbs-in	= (36000 psi)(0.021 in³)/1.67
Shear Utilization =	9.5%		= (200 lbs)/(2116 lbs)
Bending Utilization =	103.8%		= (466 lbs-in)/(449 lbs-in)
	W/IN 5%, OKAY		

HANDRAIL SUPPORT WELD

V =	200	lbs	
M =	466	lbs-in	
Try	3/16	'' fillet weld all-round bar to post	
v =	127	lbs/in	= (200 lbs)/[π(0.5''Ø)]
m =	1519	lbs/in	= (200 lbs)/[π(0.5''Ø+2*0.1875''/3)²/4]
Σ =	1646	lbs/in	= 127 lbs+1519 lbs
R_n =	2784	lbs/in	= (928 psi)(3 sixteenths)
Weld Utilization =	59.1%		= (1646 lbs/in)/(2784 lbs/in)
	OKAY		

PICKETS

	Horizontal		
S =	4	in OC	picket spacing
L_{PICKET} =	48	in	
P =	50	lbs	50 lbs over 12" SQ
V =	50	lbs	
M =	50	lbs-in	= (50 lbs)(4')/4

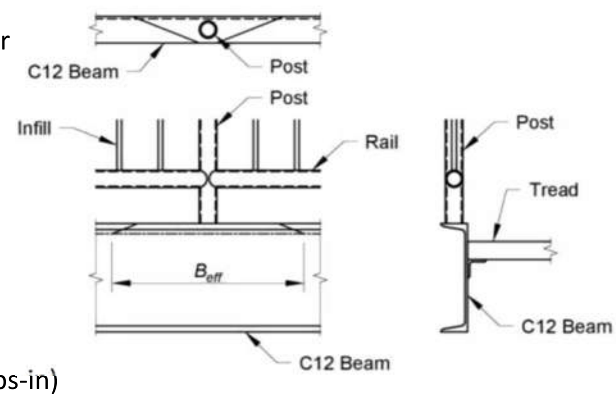
Try	3/4"Ø SCH 40 pipe		at 0'-4'' OC
F_Y =	35000	psi	
A_V =	0.16	in^2	
Z =	0.0942	in^3	
V_{CAP} =	1635	lbs	= (0.16 in^2)/2(35000 psi)/1.67
M_{CAP} =	1974	lbs-in	= (35000 psi)(0.0942 in^3)/1.67
Shear Utilization =	3.1%		= (50 lbs)/(1635 lbs)
Bending Utilization =	2.5%		= (50 lbs-in)/(1974 lbs-in)
	OKAY		

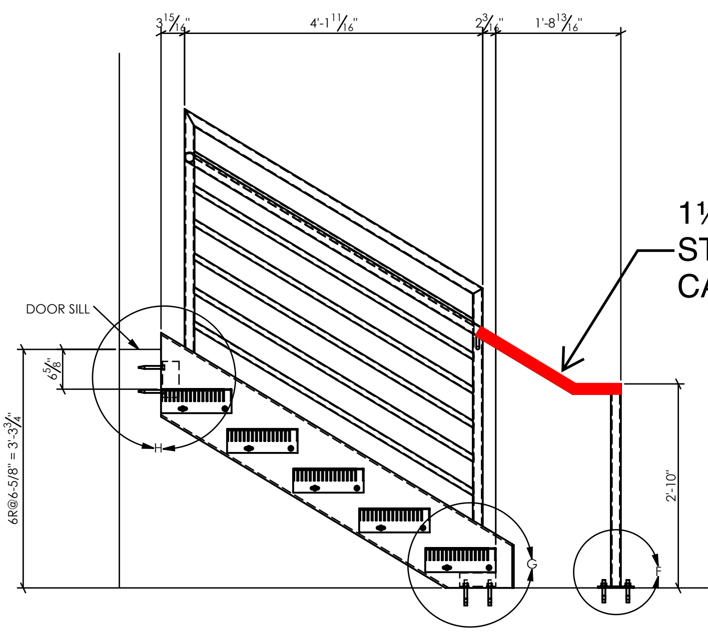
POST WELD TO CHANNEL

V =	200	lbs	
M =	8400	lbs-in	
Try	1/4	" fillet weld all-round post to baseplate	
v =	38	lbs/in	= (200 lbs)/[π1.66"Ø]
m =	3519	lbs/in	= (8400 lbs-in)/[π(1.66"Ø+0.25"/3)²/4]
Σ =	3557	lbs/in	= 38 lbs+3519 lbs
R_n =	3712	lbs/in	= (928 psi)(4 sixteenths)
Weld Utilization =	95.8%		= (3557 lbs/in)/(3712 lbs/in)
	OKAY		

CHANNEL FLANGE STRENGTH CHECK

M =	8400	lbs-in	
N =	1.66	in	guardrail post diameter
k =	1.125	in	beam fillet dimension
t_f =	0.501	in	flange thickness
b_f =	2.94	in	flange width
B_{EFF} =	20.7325	in	$= N+2(2.5)[(k-t_f/2)+b_f]$
t_w =	0.282	in	web thickness
Z_{FLANGE} =	0.412183	in³	$= B_{EFF}t_w^2/4$
M_{CAP} =	8885	lbs-in	$= f_y Z_{FLANGE}/\Omega$
Bending Utilization =	94.5%		= (8400 lbs-in)/(8885 lbs-in)
	OKAY		





1¼"Ø SCH 40 PIPE
STRONG ENOUGH TO
CANTILEVER 1'-11"

M = (200 lbs)(1'-11") = 4600 lbs-in
M_{CAP} = (35000 psi)(0.305 in³)/1.67 = 6392 lbs-in
Utilization = 72.0% < 100%, **OKAY**