STRUCTURAL CALCULATIONS

FALQUIST COMMUNITY DOCK REPAIR
5067 84th AVE
MERCER ISLAND, WA 98040

FOR

SEABORN PILE DRIVING

PROJECT NO. 19299

June 7, 2019

CALCULATIONS

BY

JACOB GUSTAFSON
REVIEWED AND STAMPED

BY

MICHAEL SZRAMEK, PE, SE

MC SQUARED, INC.
1235 EAST 4TH AVENUE, SUITE 101
OLYMPIA, WASHINGTON 98506-4211
(360) 754-9339 FAX (360) 352-2044

STRUCTURAL CALCULATIONS

FOR

FALQUIST COMMUNITY DOCK REPAIR
5067 84TH AVE
MERCER ISLAND, WA 98040

SITE SPECIFIC
LATERAL AND VERTICAL
ANALYSIS AND DESIGN
(DO NOT REUSE)

FOR
SEABORN PILE DRIVING

PROJECT #19299

BY
MC SQUARED, INC.

JAKE GUSTAFSON

REVIEWED BY
MICHAEL SZRAMEK, PE, SE

SCOPE: CLIENT REQUESTED STRUCTURAL ENGINEERING TO PROVIDE LATERAL AND VERTICAL ENGINEERING FOR A WOOD FRAMED PIER IN MERCER ISLAND, WA.

BASIS OF DESIGN IS DRAWINGS PROVIDED BY CLIENT. NO ANALYSIS AND DESIGN OF BRACING, TEMPORARY OR PERMANENT, REQUESTED OR CONDUCTED. ALL BRACING, TEMPORARY AND PERMANENT, SHALL BE RESPONSIBILITY OF CONTRACTOR.

LOADS: 2015 IBC/ASCE 7-10

VERTICAL: PIER
- DL= 12 PSF
- SL= 12.5 PSF (GRATING)
- LL= 60 PSF
- TL= 72 PSF (D+L)

LATERAL:

WIND: 2015 IBC, PER ASCE 7-10, SECTION 26. RISK CATEGORY II, ENCLOSED, 110 MPH EXPOSURE D. SEE ATTACHED WIND CALCULATIONS.

WAVE: 70 MPH SUSTAINED (ASD)

SEISMIC: 2015 IBC, PER ASCE 7-10, SECTION 12, RISK CATEGORY II, IMPORTANCE FACTOR I = 1.0, SITE CLASSIFICATION D, DESIGN CATEGORY D
OMEGA= 3.0
R= 1.5 WOOD FRAMING

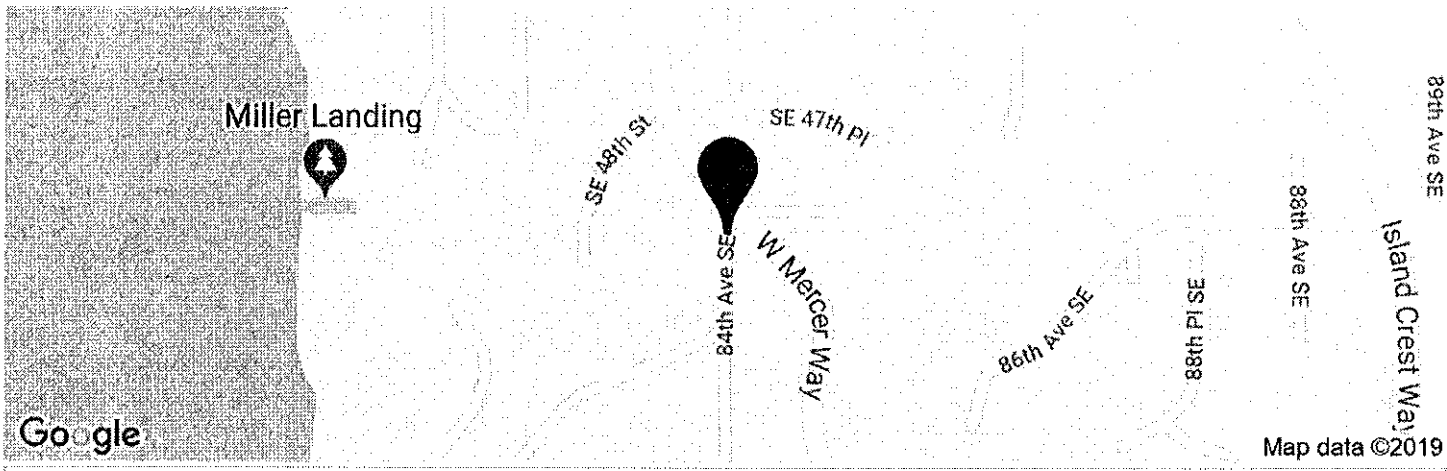
COEFF= 0.829 STRENGTH LEVEL, 0.580 SERVICE

SOILS: ASSUMED VALUES PER TABLE 1806.2, 2015 IBC
ALLOWABLE PASSIVE PRESSURE = 400 PSF

OSHPD 4

84th Ave SE, Mercer Island, WA 98040, USA

Latitude, Longitude: 47.5600248, -122.2269981



Date	6/7/2019, 8:25:47 AM
Design Code Reference Document	ASCE7-10
Risk Category	II
Site Class	D - Stiff Soil

Type	Value	Description
S_S	1.435	MCE_R ground motion. (for 0.2 second period)
S_1	0.551	MCE_R ground motion. (for 1.0s period)
S_{MS}	1.435	Site-modified spectral acceleration value
S_{M1}	0.826	Site-modified spectral acceleration value
S_{DS}	0.956	Numeric seismic design value at 0.2 second SA
S_{D1}	0.551	Numeric seismic design value at 1.0 second SA

Type	Value	Description
SDC	D	Seismic design category
F_a	1	Site amplification factor at 0.2 second
F_v	1.5	Site amplification factor at 1.0 second
PGA	0.595	MCE_G peak ground acceleration
F_{PGA}	1	Site amplification factor at PGA
PGA_M	0.595	Site modified peak ground acceleration
T_L	6	Long-period transition period in seconds
SsRT	1.435	Probabilistic risk-targeted ground motion. (0.2 second)
SsUH	1.508	Factored uniform-hazard (2% probability of exceedance in 50 years) spectral acceleration
SsD	3.433	Factored deterministic acceleration value. (0.2 second)
S1RT	0.551	Probabilistic risk-targeted ground motion. (1.0 second)
S1UH	0.593	Factored uniform-hazard (2% probability of exceedance in 50 years) spectral acceleration.
S1D	1.306	Factored deterministic acceleration value. (1.0 second)
PGAd	1.33	Factored deterministic acceleration value. (Peak Ground Acceleration)
C_{RS}	0.951	Mapped value of the risk coefficient at short periods
C_{R1}	0.929	Mapped value of the risk coefficient at a period of 1 s

bing maps

5067 84th Ave SE, Mercer Island, WA 98040

Data from: Zillow · Redfin · GreatSchools

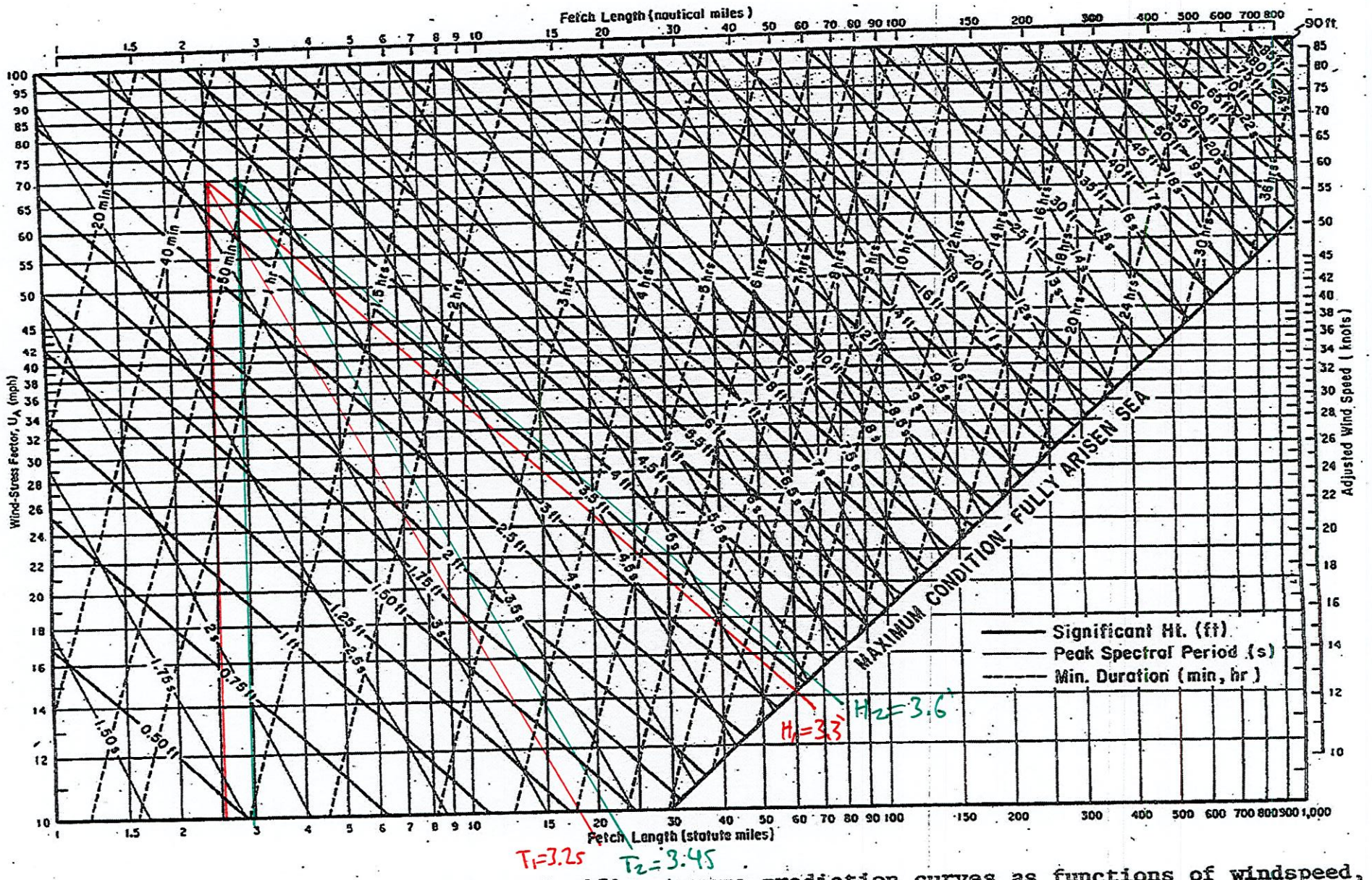
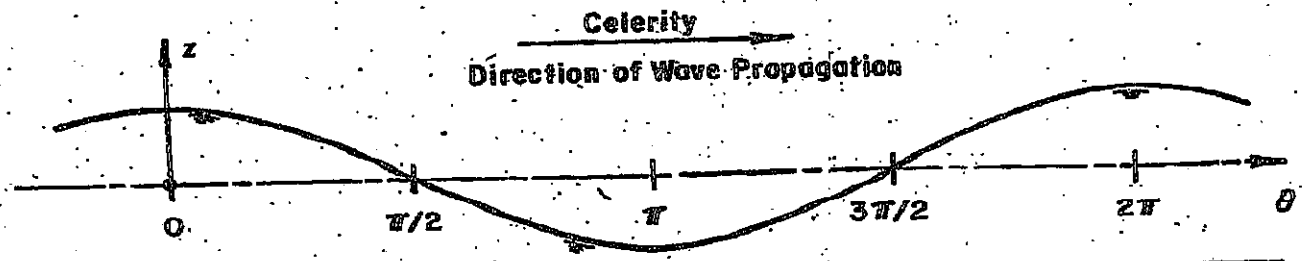


Figure 3-24. Nomograms of deepwater significant wave prediction curves as functions of windspeed, fetch length, and wind duration (English units).



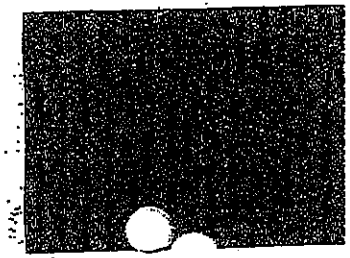
Velocity	$u = +;\ w = 0$	$u = 0;\ w = +$	$u = -;\ w = 0$	$u = 0;\ w = -$	$u = +;\ w = 0$
Acceleration	$a_x = 0;\ a_z = -$	$a_x = +;\ a_z = 0$	$a_x = 0;\ a_z = +$	$a_x = -;\ a_z = 0$	$a_x = 0;\ a_z = -$
θ	0	$\pi/2$	π	$3\pi/2$	2π

Figure 2-3. Local fluid velocities and accelerations.

$a_x < 12$

RELATIVE DEPTH	SHALLOW WATER $\frac{d}{L} < \frac{1}{25}$	TRANSITIONAL WATER $\frac{1}{25} < \frac{d}{L} < \frac{1}{2}$	DEEP WATER $\frac{d}{L} > \frac{1}{2}$
1. Wave profile	Same As →	$\eta = \frac{H}{2}\cos\left[\frac{2\pi x}{L} - \frac{2\pi t}{T}\right] = \frac{H}{2}\cos\theta$	Same As ←
2. Wave celerity	$C = \frac{L}{T} = \sqrt{gd}$	$C = \frac{L}{T} = \frac{gT}{2\pi}\tanh\left(\frac{2\pi d}{L}\right)$	$C = C_0 = \frac{L}{T} = \frac{gT}{2\pi}$
3. Wavelength	$L = T\sqrt{gd} = CT$	$L = \frac{gT^2}{2\pi}\tanh\left(\frac{2\pi d}{L}\right)$	$L = L_0 = \frac{gT^2}{2\pi} = C_0 T$
4. Group velocity	$C_g = C = \sqrt{gd}$	$C_g = nC = \frac{1}{2}\left[1 + \frac{4\pi d/L}{\sinh(4\pi d/L)}\right]\cdot C$	$C_g = \frac{1}{2}C = \frac{gT}{4\pi}$
5. Water Particle Velocity (a) Horizontal	$u = \frac{H}{2}\sqrt{\frac{g}{d}}\cos\theta$	$u = \frac{H}{2}\frac{gT}{L}\frac{\cosh[2\pi(z+d)/L]}{\cosh(2\pi d/L)}\cos\theta$	$u = \frac{\pi H}{T}e^{\frac{2\pi z}{L}}\cos\theta$
(b) Vertical	$w = \frac{H\pi}{T}\left(1+\frac{z}{d}\right)\sin\theta$	$w = \frac{H}{2}\frac{gT}{L}\frac{\sinh[2\pi(z+d)/L]}{\cosh(2\pi d/L)}\sin\theta$	$w = \frac{\pi H}{T}e^{\frac{2\pi z}{L}}\sin\theta$
6. Water Particle Accelerations (a) Horizontal	$a_x = \frac{H\pi}{T}\sqrt{\frac{g}{d}}\sin\theta$	$a_x = \frac{g\pi H}{L}\frac{\cosh[2\pi(z+d)/L]}{\cosh(2\pi d/L)}\sin\theta$	$a_x = 2H\left(\frac{\pi}{T}\right)^2 e^{\frac{2\pi z}{L}}\sin\theta$
(b) Vertical	$a_z = -2H\left(\frac{\pi}{T}\right)^2\left(1+\frac{z}{d}\right)\cos\theta$	$a_z = -\frac{g\pi H}{L}\frac{\sinh[2\pi(z+d)/L]}{\cosh(2\pi d/L)}\cos\theta$	$a_z = -2H\left(\frac{\pi}{T}\right)^2 e^{\frac{2\pi z}{L}}\cos\theta$
7. Water Particle Displacements (a) Horizontal	$\xi = -\frac{HT}{4\pi}\sqrt{\frac{g}{d}}\sin\theta$	$\xi = -\frac{H}{2}\frac{\cosh[2\pi(z+d)/L]}{\sinh(2\pi d/L)}\sin\theta$	$\xi = -\frac{H}{2}e^{\frac{2\pi z}{L}}\sin\theta$
(b) Vertical	$\zeta = \frac{H}{2}\left(1+\frac{z}{d}\right)\cos\theta$	$\zeta = \frac{H}{2}\frac{\sinh[2\pi(z+d)/L]}{\sinh(2\pi d/L)}\cos\theta$	$\zeta = \frac{H}{2}e^{\frac{2\pi z}{L}}\cos\theta$
8. Subsurface Pressure	$p = \rho g(\eta - z)$	$p = \rho g\eta\frac{\cosh[2\pi(z+d)/L]}{\cosh(2\pi d/L)} - \rho g z$	$p = \rho g\eta e^{\frac{2\pi z}{L}} - \rho g z$

Figure 2-6. Summary of linear (Airy) wave theory—wave characteristics.



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FAX (360) 352-2044

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WAVE LOADS — DESIGN VELOCITY = 70 MPH SUSTAINED, EXPOSURE D

FETCH 1 = 2.5 mi

T = 3.2 s
H = 3.3'
d = 7'

$L_o = \frac{gT^2}{2\pi} = 52.5'$ $d/L = 0.13$ ∴ TRANSITION WATER

$L_e = L_o \cdot \tanh\left(\frac{2\pi d}{L}\right)$ = 35.9
= 44.16
= 39.9
= 42.1
= 41.0 ← USE 41'

FETCH 2 = 2.9 mi

T = 3.4 s
H = 3.6'
d = 7'

$L_o = \frac{gT^2}{2\pi} = 59.2'$ $d/L = 0.12$ ∴ TRANSITION

$L_e = L_o \cdot \tanh\left(\frac{2\pi d}{L}\right)$ = 37.36
= 48.9
= 42.4
= 46.0
= 44.0 ⇒ SAY 45'

ACCELERATION

$$a_x = \frac{g\pi H}{L} \cdot \frac{\cosh\left[\frac{2\pi(d+z)}{L}\right]}{\cosh(kd)} \cdot \sin\theta$$

$a_1 = 8.14$ ← USE

$a_2 = 8.09$

TOTAL WAVE LOAD (25' VESSEL) – 2000#

$P_W = \frac{2.14}{32.2} = 0.253W$

$TL = .253 \cdot 2000 = 2023\#$

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WIND LOADS: (V = 110MPH LRFD, 85 ASD) EXPOSURE D

$q = 0.00256 \cdot K_d \cdot K_{zt} \cdot K_h \cdot V^2$ $K_d = 1$, $K_h = 1.03$, $K_d = 0.85$

$= 27.12$ PSF LRFD

$F_w = G \cdot C_F \cdot A \cdot q$ $G = 0.85$

C_F: $S/h = 1$ $B/S = 25/6 = 4.2 \rightarrow$ SAY 4 $\therefore C_F = 1.35$

$(F_w)_{LRFD} = 1.35 \cdot 0.85 \cdot 27.12 \cdot A$

$= 31.12$ PSF (LRFD)

$(F_w)_{ASD} = 31.12 \cdot .06 = 18.7$ PSF ASD

$A_{BROADSIDE} = 25' \times 6' = 150\ ft^2$

$A_{HEADON} = 6' \times 9' = 54\ ft^2$

$(F_w)_B = 150 \cdot 18.7 = 2805\ \#$ ⇐ USE

$(F_w)_H = 54 \cdot 18.7 = 1010\ \#$

TOTAL WIND + WAVE:

$W = .75(2023 + 2805)$

$= 3621$

LOAD TO PILES

$w = \frac{3621\ \#}{25'} = 145$ PLF

LOAD PER PILE $= \frac{145 \times 12.25'}{2}$ $= \frac{887\ \#}{\text{PILE}}$

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SEISMIC

$S_{DS} = 0.956$, $R = 1.5$

DOCK DL = 12PSF

$$C_S = \frac{0.956}{1.5} = 0.637$$

$V_E = \rho \cdot C_S \cdot W$, $\rho = 1.3$

$V_E = 1.3 \cdot .637 \cdot W$

$V_E = 0.829W$ LRFD

$= 0.580W$ ASD

DOCK Wt $= 12PSF \cdot (6 \times 119')$

$= 8568\#$

LOAD PER PILE : $\frac{8568\#}{22 PILES} = 390\#/PILE$

∴ WIND + WAVE CONTROLS

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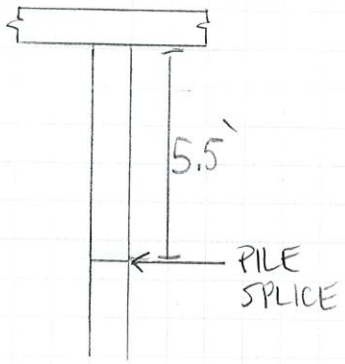
PILE REPAIR



$M = 5.5' \cdot 887\# = 4879 FT.\#$

$T = C = \frac{M}{d} = \frac{4879 \times 12}{12} = 4879\#$

TRY AT 12" PILE ⇒ ¼" PLATE, DOUBLE SHEAR

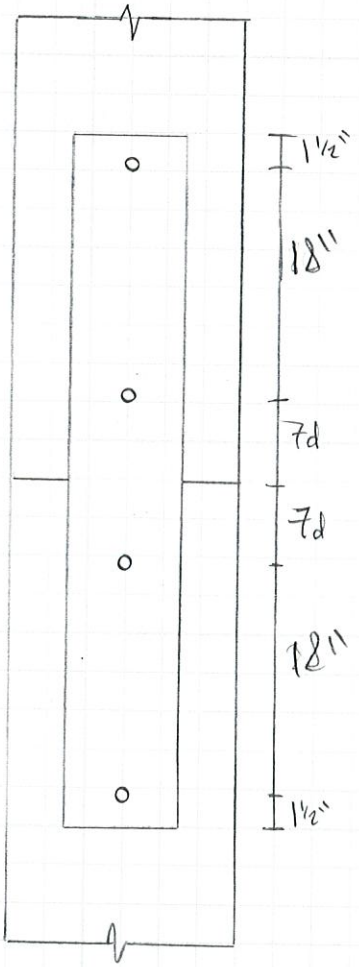
TRY 1" ϕ BOLT, $Z_\perp = 3000\#$

$Z'_\perp = 3000 \cdot 1.6 \cdot .7 = 3360\#$

TRY @ 18"

$T = \frac{4879\# \cdot 12"}{18} = 3253\#$

⇒ CALL GOOD



CHECK M IN OTHER DIRECTION

✓ $Z_{11} = 5720(1.6)(0.7) = 6406\# \geq 3253\#$

⇒ USE 6' ARC SECTION 12" ϕ PIPE FASTENED w/ (2) 1" ϕ BOLTS

TOTAL PIPE SECTION LENGTH = 53"

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VERTICAL LOADS

DL = 12 PSF

SL = $\frac{25\ PSF}{2}$ = 12.5 PSF

LL = 60 PSF

STRINGERS: @ MAX SPAN

SPAN = 12'-6"

TW = 15"

⇒ #2 PT DF 4x8 ✓ GOOD

BEAM CAPS: @ MAX TW

SPAN ≈ 4'

TW = $\frac{24'-6"}{2}$

⇒ #1 PT DF 6x8 ✓ GOOD

Printed: 7 JUN 2019, 10:37AM

Multiple Simple Beam

File = m:\ENGINE~1\2-ENER~1.0\19299.ec6
ENERCALC, INC. 1983-2017, Build:6.17.3.29, Ver:6.17.3.29
Lic. # : KW-06005122
Licensee : MC SQUARED, INC.

Description :

Wood Beam Design : Stringers

Calculations per NDS 2015, IBC 2015, CBC 2016, ASCE 7-10

BEAM Size : **4x8, Sawn, Fully Braced**
Using Allowable Stress Design with IBC 2015 Load Combinations, Major Axis Bending

Wood Species :	Douglas Fir - Larch					Wood Grade :	No.2		
Fb - Tension	900.0 psi	Fc - Prll	1,350.0 psi	Fv	180.0 psi	Ebend- xx	1,600.0 ksi	Density	31.20 pcf
Fb - Compr	900.0 psi	Fc - Perp	625.0 psi	Ft	575.0 psi	Eminbend - xx	580.0 ksi		

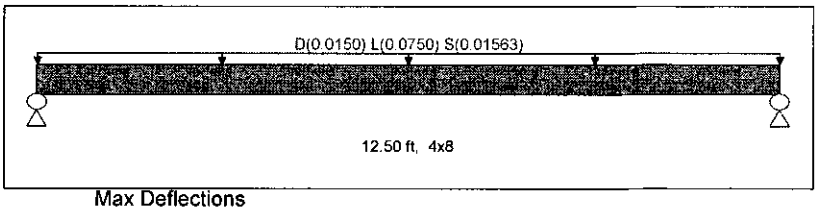
Applied Loads

Unif Load: D = 0.0120, L = 0.060, S = 0.01250 k/ft, Trib= 1.250 ft

Design Summary

Max fb/Fb Ratio = **0.752** : 1
fb : Actual : 687.96 psi at 6.250 ft in Span # 1
Fb : Allowable : 914.94 psi
Load Comb : +D+L+H

Max fv/FvRatio = **0.216** : 1
fv : Actual : 30.15 psi at 0.000 ft in Span # 1
Fv : Allowable : 139.68 psi
Load Comb : +D+L+H



Max Reactions (k)	D	L	Lr	S	W	E	H
Left Support	0.09	0.47		0.10			
Right Support	0.09	0.47		0.10			

Max Deflections

Downward L+Lr+S	0.233 in	Downward Total	0.279 in
Upward L+Lr+S	0.000 in	Upward Total	0.000 in
Live Load Defl Ratio	644 >360	Total Defl Ratio	536 >240

Wood Beam Design : Stringers

Calculations per NDS 2015, IBC 2015, CBC 2016, ASCE 7-10

BEAM Size : **6x8, Sawn, Fully Braced**
Using Allowable Stress Design with IBC 2015 Load Combinations, Major Axis Bending

Wood Species :	Douglas Fir - Larch					Wood Grade :	No.1		
Fb - Tension	1,200.0 psi	Fc - Prll	1,000.0 psi	Fv	170.0 psi	Ebend- xx	1,600.0 ksi	Density	31.20 pcf
Fb - Compr	1,200.0 psi	Fc - Perp	625.0 psi	Ft	825.0 psi	Eminbend - xx	580.0 ksi		

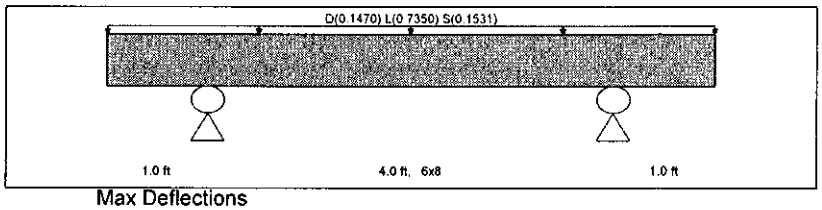
Applied Loads

Unif Load: D = 0.0120, L = 0.060, S = 0.01250 k/ft, Trib= 12.250 ft

Design Summary

Max fb/Fb Ratio = **0.377** : 1
fb : Actual : 307.90 psi at 2.000 ft in Span # 2
Fb : Allowable : 816.00 psi
Load Comb : +D+L+H

Max fv/FvRatio = **0.337** : 1
fv : Actual : 44.47 psi at 3.387 ft in Span # 2
Fv : Allowable : 131.92 psi
Load Comb : +D+L+H



Max Reactions (k)	D	L	Lr	S	W	E	H
Left Support	0.44	2.21		0.46			
Right Support	0.44	2.21		0.46			

Max Deflections

Downward L+Lr+S	0.010 in	Downward Total	0.012 in
Upward L+Lr+S	-0.006 in	Upward Total	-0.008 in
Live Load Defl Ratio	3790 >360	Total Defl Ratio	3158 >240

IMPACT SERIES

With the success of our Legacy panels, we're thrilled to bring a more affordable option to the ThruFlow™ lineup. Our Impact panels combine our trademark eco-friendly, maintenance-free design with consumer-first pricing, so that *everyone* can enjoy our products.

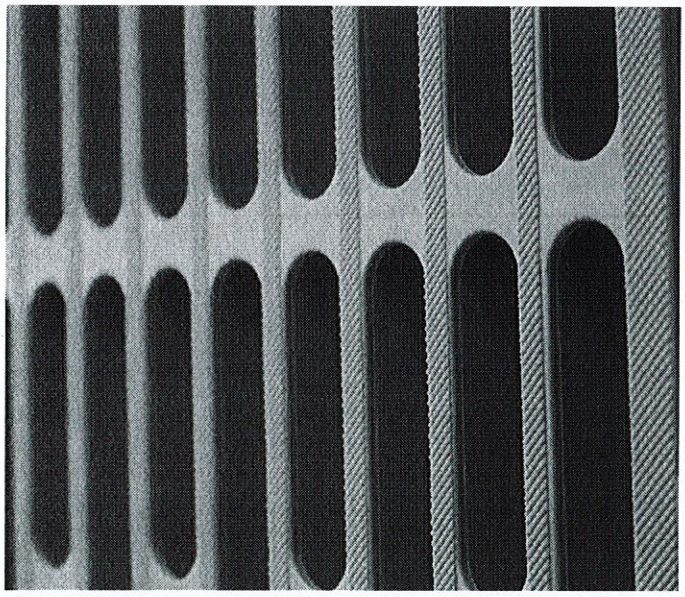
> *Our Impact panels are one of the newest and the most cost effective panels in our product line.*

Our Impact panels use an additive-free Polymer construction. This minimalist compound feature allows us to maintain our panels' signature durability but at a more approachable price point. The affordability of our Impact panels gives you one less thing to worry about, so you can truly relax and go with the flow.

But at ThruFlow we believe that a lesser price point shouldn't mean fewer features or lower quality. Our Impact panels include the same traits that made our Legacy panels such a success with consumers: easy-to-assemble, maintenance-free, non-slip and UV-resistant surface, and a lifetime limited warranty.

Spec Sheet	Click to Download Impact Spec Sheet
ThruFlow™ Warranty	Lifetime Limited Warranty
Substructure	3' panel - 18" centers 4' panel - 16" centers 5' panel - 15" centers
Safety	360° engineered non-slip surface Exceeds ADA spec's
Light Penetration	50%
Lightweight	On a per sq. ft. basis ThruFlow™ is 70% lighter than other decking products: 1.4lbs/ft2
Ultraviolet Protection	Industry leading UV protection
Colours	
Load	All panels sizes exceed 1300lbs load capacity surpassing the commercial construction requirements
Thickness	All Panels 1.2" thick
Size	1' x 3', 1' x 4' , 1' x 5'
Material	Base material is non-reinforced virgin polypropylene

ThruFlow Installation Guide



Impact panels use an unreinforced Polymer construction, which maintains the ThruFlow appearance, strength, and durability, while appealing to the cost consious consumer.