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CS2 ENGINEERS
Civil & Structural Challenge & Success

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Structural Calculations

For

Chung Residence Detached Garage

4027 93rd Ave SE
Mercer Island, WA 98040
(Parcel # 003100-0095)

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Prepared By:	**Sung U. Cho, P.E.**
Prepared Date:	**May 18, 2020**
CS2 No.:	**2000-G**

I. Scope of Work

Provide structural design calculations of detached garage addition onto single-family residential house. The house is located on 4027 93rd Ave SE at City of Bellevue. The information in this report summarizes the requirements for construction of structural elements for the gravity loads and lateral loads resisting in conformance with the International Building Code 2015. The engineering of such structural elements and connections are designed to resist the vertical (gravity) loading particular to concrete foundation. Unless noted otherwise, all means and methods used shall be in keeping with good and generally accepted construction practices.

Please refer to the following calculations and supporting sketches as well as the architectural drawing package as provided by others

II. Loads/Design Criteria: (IBC 2015 & ASCE 7-10)

Please refer to the following calculations

1. Dead Load – See calculation
2. Live Load – Roof = 25 psf (snow load)
3. Seismic – S_S = 1.398, S_1 = 0.537g, S_{DS} = 0.932g, S_{D1} = 0.537g
   Site Class D, I = 1.0, R = 6.5
4. Wind – Exposure B, Basic Wind Speed (V_{3S}) = 85 mph, I = 1.0
5. Concrete compressive strength, f'c = 2,500 psi
6. Concrete steel reinforcing strength, fy = 60,000 psi
7. Allowable soil bearing pressure = 2,000 psf
8. Passive Soil Pressure = 300 pcf

References:

1. IBC 2015
2. ASCE 7-10
3. ACI 318-14
4. SPDWS 2015
5. NDS 2015

III. Conclusions and Recommendations

General contractor shall verify all existing dimensions, member sizes and conditions prior to commencing any work. All dimensions of existing condition shown on the reference are intended as guidelines only and must be verified in field. Any discrepancies shall be called to the attention of the architect or engineer and shall be resolved before proceeding with the work. Contractor shall provide temporary bracing for the structure and structural components until all final connections have been completed in accordance with the plans

Gravity Load Design Calculation

Level			
Member Name	Results	Current Solution	Comments
Wall: Header (HDR1a)	Passed	1 piece(s) 4 x 6 Douglas Fir-Larch No. 1	
Wall: Header (HDR1b)	Passed	1 piece(s) 4 x 12 Douglas Fir-Larch No. 1	

ForteWEB Software Operator	Job Notes
Sung Cho CS2 Engineers.com (425) 408-2748 sung.cho@cs2engineers.com	Chung Residence Garage

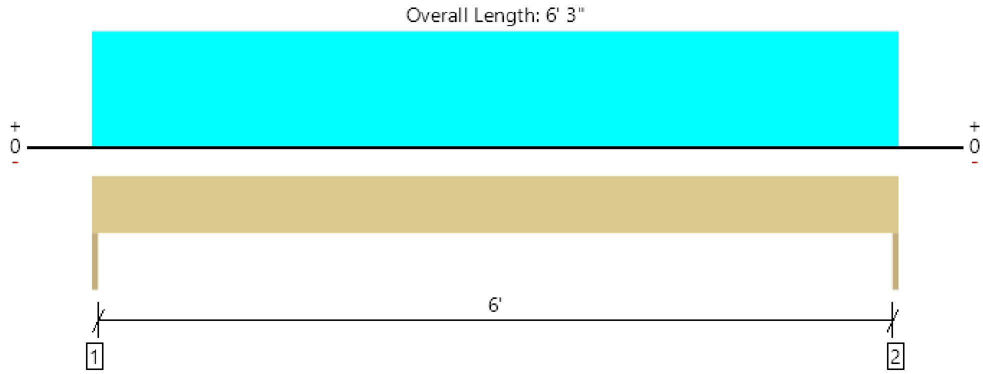
5/18/2020 3:17:42 PM UTC
ForteWEB v2.4
File Name: 2000-G Mercer Island Garage

MEMBER REPORT

PASSED

Level, Wall: Header (HDR1a)

1 piece(s) 4 x 6 Douglas Fir-Larch No. 1



All locations are measured from the outside face of left support (or left cantilever end). All dimensions are horizontal.

Design Results	Actual @ Location	Allowed	Result	LDF	Load: Combination (Pattern)
Member Reaction (lbs)	265 @ 0	3281 (1.50")	Passed (8%)	--	1.0 D + 1.0 S (All Spans)
Shear (lbs)	216 @ 7"	2657	Passed (8%)	1.15	1.0 D + 1.0 S (All Spans)
Moment (Ft-lbs)	414 @ 3' 1 1/2"	2198	Passed (19%)	1.15	1.0 D + 1.0 S (All Spans)
Vert Live Load Defl. (in)	0.021 @ 3' 1 1/2"	0.208	Passed (L/999+)	--	1.0 D + 1.0 S (All Spans)
Vert Total Load Defl. (in)	0.035 @ 3' 1 1/2"	0.313	Passed (L/999+)	--	1.0 D + 1.0 S (All Spans)
Lat Member Reaction (lbs)	167 @ 6' 3"	N/A	Passed (N/A)	1.60	1.0 D + 0.6 W
Lat Shear (lbs)	145 @ 5"	3696	Passed (4%)	1.60	1.0 D + 0.6 W
Lat Moment (Ft-lbs)	262 @ mid-span	2044	Passed (13%)	1.60	1.0 D + 0.6 W
Lat Deflection (in)	0.039 @ mid-span	0.625	Passed (L/999+)	--	1.0 D + 0.6 W
Bi-Axial Bending	0.23	1.00	Passed (23%)	1.60	1.0 D + 0.45 W + 0.75 L + 0.75 S

System : Wall
Member Type : Header
Building Use : Residential
Building Code : IBC 2015
Design Methodology : ASD

- Deflection criteria: LL (L/360) and TL (L/240).
- Lateral deflection criteria: Wind (L/120)
- Applicable calculations are based on NDS.

Supports	Bearing Length			Loads to Supports (lbs)				Accessories
	Total	Available	Required	Dead	Snow	Wind	Total	
1 - Trimmer - HF	1.50"	1.50"	1.50"	109	156	86	351	None
2 - Trimmer - HF	1.50"	1.50"	1.50"	109	156	86	351	None

Lateral Connections

Supports	Plate Size	Plate Material	Connector	Type/Model	Quantity	Nailing
Left	2X	Hem Fir	Nails	10d x 3" Box (End)	2	
Right	2X	Hem Fir	Nails	10d x 3" Box (End)	2	

Vertical Loads	Location (Side)	Tributary Width	Dead (0.90)	Snow (1.15)	Wind (1.60)	Comments
0 - Self Weight (PLF)	0 to 6' 3"	N/A	4.9	--	--	
1 - Uniform (PSF)	0 to 6' 3"	2'	15.0	25.0	13.8	Default Load

Lateral Load	Location	Tributary Width	Wind (1.60)	Comments
1 - Uniform (PSF)	Full Length	4'	22.3	

- ASCE/SEI 7 Sec. 30.4: Exposure Category (B), Mean Roof Height (10' 9 5/8"), Topographic Factor (1.0), Wind Directionality Factor (0.85), Basic Wind Speed (110), Risk Category(II), Effective Wind Area determined using full member span and trib. width.
- IBC Table 1604.3, footnote f: Deflection checks are performed using 42% of this lateral wind load.

Member Notes

Header (HDR 1a)
6'-0" Max.

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File Name: 2000-G Mercer Island Garage

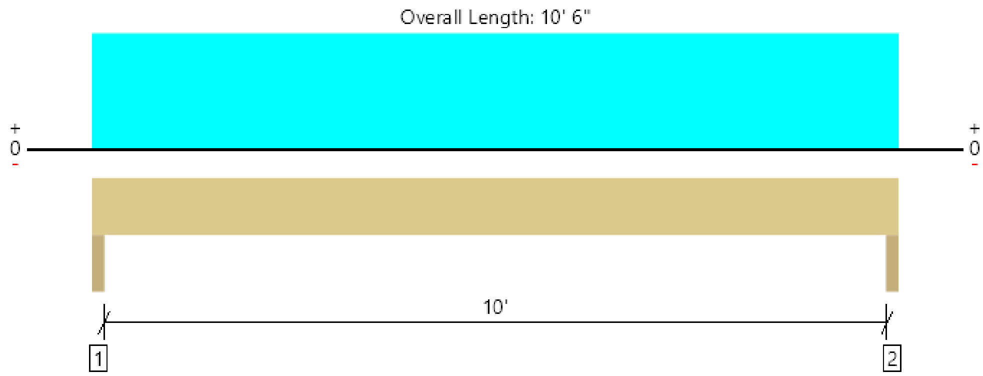
FORTE WEB

MEMBER REPORT

PASSED

Level, Wall: Header (HDR1b)

1 piece(s) 4 x 12 Douglas Fir-Larch No. 1



All locations are measured from the outside face of left support (or left cantilever end). All dimensions are horizontal.

Design Results	Actual @ Location	Allowed	Result	LDF	Load: Combination (Pattern)
Member Reaction (lbs)	2397 @ 1 1/2"	6563 (3.00")	Passed (37%)	--	1.0 D + 1.0 S (All Spans)
Shear (lbs)	1855 @ 1' 2 1/4"	5434	Passed (34%)	1.15	1.0 D + 1.0 S (All Spans)
Moment (Ft-lbs)	5997 @ 5' 3"	7783	Passed (77%)	1.15	1.0 D + 1.0 S (All Spans)
Vert Live Load Defl. (in)	0.098 @ 5' 3"	0.342	Passed (L/999+)	--	1.0 D + 1.0 S (All Spans)
Vert Total Load Defl. (in)	0.161 @ 5' 3"	0.512	Passed (L/766)	--	1.0 D + 1.0 S (All Spans)
Lat Member Reaction (lbs)	265 @ 10' 4 1/2"	N/A	Passed (N/A)	1.60	1.0 D + 0.6 W
Lat Shear (lbs)	244 @ 6 1/2"	7560	Passed (3%)	1.60	1.0 D + 0.6 W
Lat Moment (Ft-lbs)	680 @ mid-span	3706	Passed (18%)	1.60	1.0 D + 0.6 W
Lat Deflection (in)	0.132 @ mid-span	1.025	Passed (L/933)	--	1.0 D + 0.6 W
Bi-Axial Bending	0.73	1.00	Passed (73%)	1.60	1.0 D + 0.45 W + 0.75 L + 0.75 S

System : Wall
Member Type : Header
Building Use : Residential
Building Code : IBC 2015
Design Methodology : ASD

- Deflection criteria: LL (L/360) and TL (L/240).
- Lateral deflection criteria: Wind (L/120)
- Applicable calculations are based on NDS.

Supports	Bearing Length			Loads to Supports (lbs)				Accessories
	Total	Available	Required	Dead	Snow	Wind	Total	
1 - Trimmer - HF	3.00"	3.00"	1.50"	932	1466	808	3206	None
2 - Trimmer - HF	3.00"	3.00"	1.50"	932	1466	808	3206	None

Lateral Connections						
Supports	Plate Size	Plate Material	Connector	Type/Model	Quantity	Nailing
Left	2X	Hem Fir	Nails	10d x 3" Box (End)	4	
Right	2X	Hem Fir	Nails	10d x 3" Box (End)	4	

Vertical Loads	Location (Side)	Tributary Width	Dead (0.90)	Snow (1.15)	Wind (1.60)	Comments
0 - Self Weight (PLF)	0 to 10' 6"	N/A	10.0	--	--	
1 - Uniform (PSF)	0 to 10' 6"	11' 2"	15.0	25.0	13.8	Default Load

Lateral Load	Location	Tributary Width	Wind (1.60)	Comments
1 - Uniform (PSF)	Full Length	4'	21.6	

- ASCE/SEI 7 Sec. 30.4: Exposure Category (B), Mean Roof Height (10' 9 5/8"), Topographic Factor (1.0), Wind Directionality Factor (0.85), Basic Wind Speed (110), Risk Category(II), Effective Wind Area determined using full member span and trib. width.
- IBC Table 1604.3, footnote f: Deflection checks are performed using 42% of this lateral wind load.

Member Notes
Header (HDR 1a)

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ForteWEB v2.4, Engine: V8.0.1.5, Data: V7.3.2.0

File Name: 2000-G Mercer Island Garage

Stud Wall (roof supporting wall)

Member Data

Species = **Hem Fir**
Size = **2x4**
Grade = **No. 2**

Loads

P_{LL} = **0** lb/ft
P_{SNOW} = **279** lb/ft
P_{DL} = **168** lb/ft
f_{wind} **15.31** psf

Width = 1.5 in
Depth = 3.5 in
A = 5.25 in^2
I = 5.36 in^4
S = 3.06 in^3
Height = **8** ft
$L_{eff. Col.}$ = 8 ft
$L_{eff. Beam.}$ = **8** ft
Spacing = **16" o.c.**

Fc = 1300 psi
Fb = 850 psi
E = 1300000 psi

Adjustment Factors	
C_M	**1.00**
C_t	**1.00**
C_F(Fb)	**1.50**
C_F(Fc)	**1.15**

Case	fc,psi	fb,psi
1	43	0
2	113	0
3	113	320
4	43	640
5	78	640

Factors

R_B = 12.2
K_{bE} = 1.2
F_{bE} = 10446 psi

l_e/d = 27.4 OK
K_{cE} = 0.822
F_{cE} = 1420 psi

	F_c'			F_b'		
Case	Fc*	C_P	F_c'	F_b*	C_L	F_b'
1	1495	0.67	1006	1275	0.99	1266
2	1719	0.62	1069	1466	0.99	1454
3,4,5	1988	0.57	1126	1696	0.99	1680

Wind Deflection
= 0.27
L / 356

Unity Check			
Case			
1: D+L	=	**0.00**	**OK**
2: D+L+S	=	**0.01**	**OK**
3: D+L+S+W/2	=	**0.22**	**OK**
4: D+L+W	=	**0.39**	**OK**
5: D+L+S/2+W	=	**0.41**	**OK**

Bearing	**0.31**	**OK**
Plate:	**Hem Fir**	
Deformation:	**yes**	**0.02" Limit**
F_{cperp}	405 psi	
f_{cperp}	113 psi	
C_b	1.25	
F'_{cperp}	370 psi	

Use 2x4 Hem Fir No. 2 @ 16" o.c.

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Project Title:
Engineer:
Project ID:
Project Descr:

Wall Footing

DESCRIPTION: Garage Wal Footing

Code References

Calculations per ACI 318-14, IBC 2015, CBC 2016, ASCE 7-10
Load Combinations Used : IBC 2015

General Information

Material Properties

f'c : Concrete 28 day strength	=	2.50	ksi
fy : Rebar Yield	=	60.0	ksi
Ec : Concrete Elastic Modulus	=	3,122.0	ksi
Concrete Density	=	145.0	pcf
φ Values Flexure	=	0.90	
Shear	=	0.750	

Analysis Settings

Min Steel % Bending Reinf.	=		
Min Allow % Temp Reinf.	=	0.00180	
Min. Overturning Safety Factor	=	1.0 : 1	
Min. Sliding Safety Factor	=	1.0 : 1	
AutoCalc Footing Weight as DL	:	Yes	

Soil Design Values

Allowable Soil Bearing	=	1.50	ksf
Increase Bearing By Footing Weight	=	No	
Soil Passive Resistance (for Sliding)	=	250.0	pcf
Soil/Concrete Friction Coeff.	=	0.30	

Increases based on footing Depth

Reference Depth below Surface	=	1.50	ft
Allow. Pressure Increase per foot of depth	=		ksf
when base footing is below	=		ft

Increases based on footing Width

Allow. Pressure Increase per foot of width	=		ksf
when footing is wider than	=		ft

Adjusted Allowable Bearing Pressure = 1.50 ksf

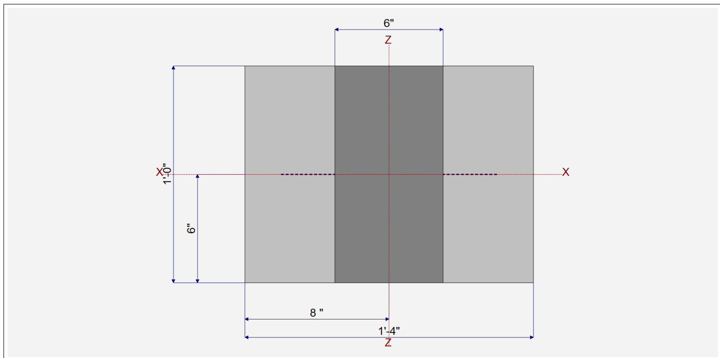
Dimensions

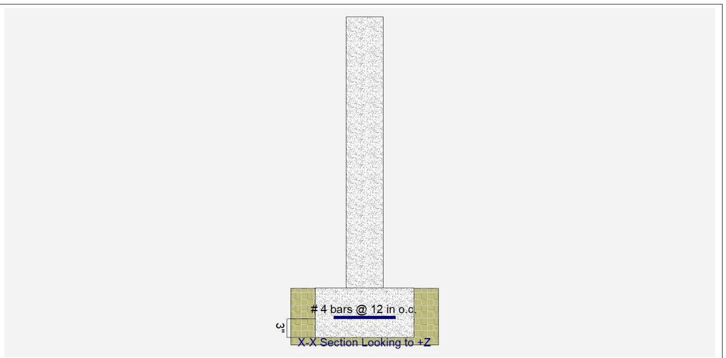
Footing Width	=	1.333	ft
Wall Thickness	=	6.0	in
Wall center offset from center of footing	=	0	in
Footing Thickness	=	8.0	in
Rebar Centerline to Edge of Concrete... at Bottom of footing	=	3.0	in

Reinforcing

Bars along X-X Axis

Bar spacing	=	12.00
Reinforcing Bar Size	=	# 4





Applied Loads

		D	Lr	L	S	W	E	H	
P : Column Load	=	0.1675			0.2790	0.1539			k
OB : Overburden	=								ksf
V-x	=								k
M-zz	=								k-ft

Vx applied = in above top of footing

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Wall Footing

DESCRIPTION: Garage Wal Footing

DESIGN SUMMARY

Design OK

	Factor of Safety	Item	Applied	Capacity	Governing Load Combination
PASS	n/a	Overturning - Z-Z	0.0 k-ft	0.0 k-ft	No Overturning
PASS	n/a	Sliding - X-X	0.0 k	0.0 k	No Sliding
PASS	n/a	Uplift	0.0 k	0.0 k	No Uplift

	Utilization Ratio	Item	Applied	Capacity	Governing Load Combination
PASS	0.2878	Soil Bearing	0.4316 ksf	1.50 ksf	+D+S
PASS	0.01333	Z Flexure (+X)	0.05717 k-ft	4.288 k-ft	+1.20D+1.60S+0.50W
PASS	0.004046	Z Flexure (-X)	0.01735 k-ft	4.288 k-ft	+0.90D
PASS	n/a	1-way Shear (+X)	0.0 psi	75.0 psi	n/a
PASS	0.0	1-way Shear (-X)	0.0 psi	0.0 psi	n/a

Detailed Results

Soil Bearing

Rotation Axis & Load Combination...	Gross Allowable	Xecc	Actual Soil Bearing Stress -X	Actual Soil Bearing Stress +X	Actual / Allowable Ratio
, D Only	1.50 ksf	0.0 in	0.2223 ksf	0.2223 ksf	0.148
, +D+S	1.50 ksf	0.0 in	0.4316 ksf	0.4316 ksf	0.288
, +D+0.750S	1.50 ksf	0.0 in	0.3793 ksf	0.3793 ksf	0.253
, +D+0.60W	1.50 ksf	0.0 in	0.2916 ksf	0.2916 ksf	0.194
, +D+0.450W	1.50 ksf	0.0 in	0.2743 ksf	0.2743 ksf	0.183
, +D+0.750S+0.450W	1.50 ksf	0.0 in	0.4313 ksf	0.4313 ksf	0.288
, +0.60D+0.60W	1.50 ksf	0.0 in	0.2027 ksf	0.2027 ksf	0.135
, +0.60D	1.50 ksf	0.0 in	0.1334 ksf	0.1334 ksf	0.089

Overturning Stability

Units : k-ft

Rotation Axis & Load Combination...	Overturning Moment	Resisting Moment	Stability Ratio	Status

Footing Has NO Overturning

Sliding Stability

Force Application Axis Load Combination...	Sliding Force	Resisting Force	Sliding SafetyRatio	Status

Footing Has NO Sliding

Footing Flexure

Flexure Axis & Load Combination	Mu k-ft	Which Side ?	Tension @ Bot. or Top ?	As Req'd in^2	Gvrn. As in^2	Actual As in^2	Phi*Mn k-ft	Status
, +1.40D	0.02699	-X	Bottom	0.1728	Min Temp %	0.2	4.288	OK
, +1.40D	0.02699	+X	Bottom	0.1728	Min Temp %	0.2	4.288	OK
, +1.20D	0.02313	-X	Bottom	0.1728	Min Temp %	0.2	4.288	OK
, +1.20D	0.02313	+X	Bottom	0.1728	Min Temp %	0.2	4.288	OK
, +1.20D+0.50S	0.03221	-X	Bottom	0.1728	Min Temp %	0.2	4.288	OK
, +1.20D+0.50S	0.03221	+X	Bottom	0.1728	Min Temp %	0.2	4.288	OK
, +1.20D+0.50W	0.02814	-X	Bottom	0.1728	Min Temp %	0.2	4.288	OK
, +1.20D+0.50W	0.02814	+X	Bottom	0.1728	Min Temp %	0.2	4.288	OK
, +1.20D+1.60S	0.05217	-X	Bottom	0.1728	Min Temp %	0.2	4.288	OK
, +1.20D+1.60S	0.05217	+X	Bottom	0.1728	Min Temp %	0.2	4.288	OK
, +1.20D+1.60S+0.50W	0.05717	-X	Bottom	0.1728	Min Temp %	0.2	4.288	OK
, +1.20D+1.60S+0.50W	0.05717	+X	Bottom	0.1728	Min Temp %	0.2	4.288	OK
, +1.20D+W	0.03314	-X	Bottom	0.1728	Min Temp %	0.2	4.288	OK
, +1.20D+W	0.03314	+X	Bottom	0.1728	Min Temp %	0.2	4.288	OK
, +1.20D+0.50S+W	0.04222	-X	Bottom	0.1728	Min Temp %	0.2	4.288	OK
, +1.20D+0.50S+W	0.04222	+X	Bottom	0.1728	Min Temp %	0.2	4.288	OK
, +1.20D+0.70S	0.03584	-X	Bottom	0.1728	Min Temp %	0.2	4.288	OK
, +1.20D+0.70S	0.03584	+X	Bottom	0.1728	Min Temp %	0.2	4.288	OK
, +0.90D+W	0.02736	-X	Bottom	0.1728	Min Temp %	0.2	4.288	OK
, +0.90D+W	0.02736	+X	Bottom	0.1728	Min Temp %	0.2	4.288	OK
, +0.90D	0.01735	-X	Bottom	0.1728	Min Temp %	0.2	4.288	OK
, +0.90D	0.01735	+X	Bottom	0.1728	Min Temp %	0.2	4.288	OK

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Wall Footing

DESCRIPTION: Garage Wal Footing

One Way Shear

Units : k

Load Combination...	Vu @ -X	Vu @ +X	Vu:Max	Phi Vn	Vu / Phi*Vn	Status
+1.40D	0 psi	0 psi	0 psi	75 psi	0	OK
+1.20D	0 psi	0 psi	0 psi	75 psi	0	OK
+1.20D+0.50S	0 psi	0 psi	0 psi	75 psi	0	OK
+1.20D+0.50W	0 psi	0 psi	0 psi	75 psi	0	OK
+1.20D+1.60S	0 psi	0 psi	0 psi	75 psi	0	OK
+1.20D+1.60S+0.50W	0 psi	0 psi	0 psi	75 psi	0	OK
+1.20D+W	0 psi	0 psi	0 psi	75 psi	0	OK
+1.20D+0.50S+W	0 psi	0 psi	0 psi	75 psi	0	OK
+1.20D+0.70S	0 psi	0 psi	0 psi	75 psi	0	OK
+0.90D+W	0 psi	0 psi	0 psi	75 psi	0	OK
+0.90D	0 psi	0 psi	0 psi	75 psi	0	OK

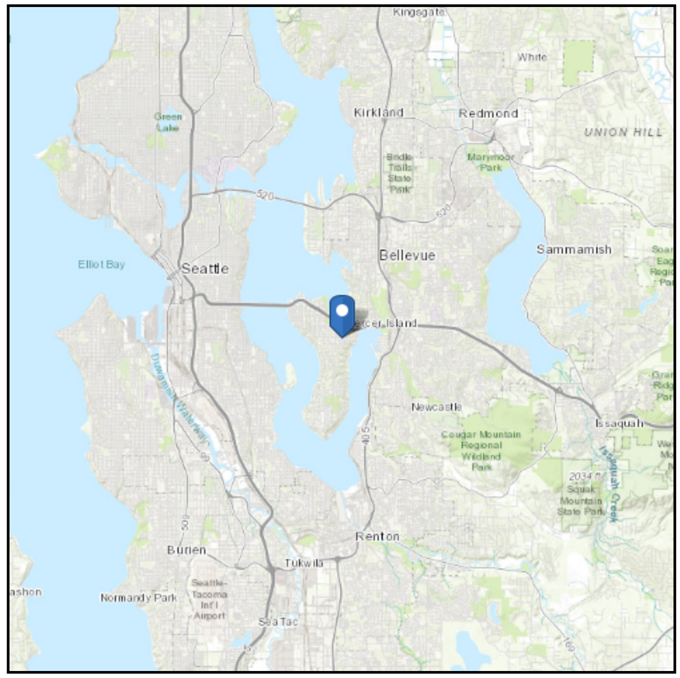
Lateral Load Design Calculation

ASCE 7 Hazards Report

Address:
4027 93rd Ave SE
Mercer Island, Washington
98040

Standard: ASCE/SEI 7-10
Risk Category: II
Soil Class: D - Stiff Soil

Elevation: 317.44 ft (NAVD 88)
Latitude: 47.57356
Longitude: -122.215157



Wind

Results:

Wind Speed:	110 Vmph
10-year MRI	72 Vmph
25-year MRI	79 Vmph
50-year MRI	85 Vmph
100-year MRI	91 Vmph

Data Source: ASCE/SEI 7-10, Fig. 26.5-1A and Figs. CC-1–CC-4, incorporating errata of March 12, 2014

Date Accessed: Mon May 18 2020

Value provided is 3-second gust wind speeds at 33 ft above ground for Exposure C Category, based on linear interpolation between contours. Wind speeds are interpolated in accordance with the 7-10 Standard. Wind speeds correspond to approximately a 7% probability of exceedance in 50 years (annual exceedance probability = 0.00143, MRI = 700 years).

Site is not in a hurricane-prone region as defined in ASCE/SEI 7-10 Section 26.2.

Mountainous terrain, gorges, ocean promontories, and special wind regions should be examined for unusual wind conditions.

ASCE
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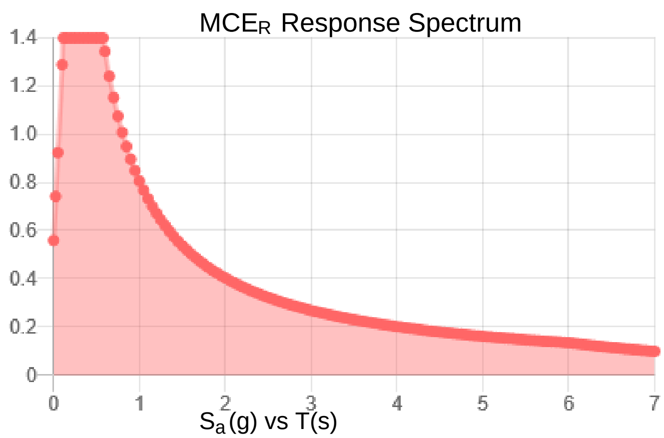
Seismic

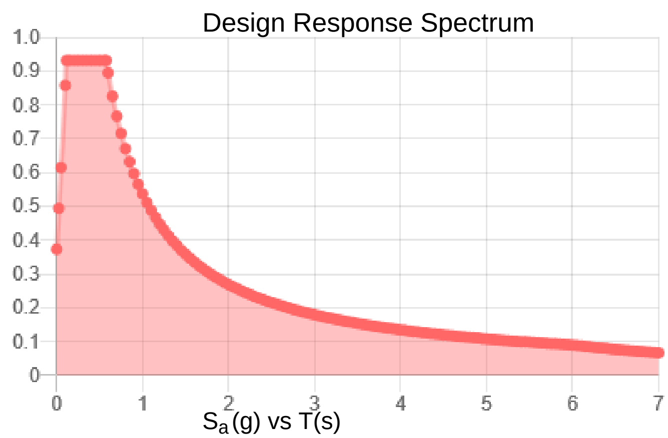
Site Soil Class: D - Stiff Soil

Results:

S_S :	1.398	S_{DS} :	0.932
S_1 :	0.537	S_{D1} :	0.537
F_a :	1	T_L :	6
F_v :	1.5	PGA :	0.576
S_{MS} :	1.398	PGA_M :	0.576
S_{M1} :	0.805	F_{PGA} :	1
		I_e :	1

Seismic Design Category D





Data Accessed: Mon May 18 2020

Date Source: USGS Seismic Design Maps based on ASCE/SEI 7-10, incorporating Supplement 1 and errata of March 31, 2013, and ASCE/SEI 7-10 Table 1.5-2. Additional data for site-specific ground motion procedures in accordance with ASCE/SEI 7-10 Ch. 21 are available from USGS.

Snow

Results:

Ground Snow Load, p_g :	15 lb/ft^2
Elevation:	317.4 ft
Data Source:	ASCE/SEI 7-10, Fig. 7-1.
Date Accessed:	Mon May 18 2020

Values provided are ground snow loads. In areas designated "case study required," extreme local variations in ground snow loads preclude mapping at this scale. Site-specific case studies are required to establish ground snow loads at elevations not covered.

CS2 ENGINEERS Civil & Structural Challenge & Success			
Project: Chung Residence Garage (4027 93rd Ave SE)			
Client: Owner		**Job No.:**	2000-G
By: S. Cho		**Date:**	5/18/20
Subject: Design Calculations		**Page:**	

Design & Loading Criteria

Roof Dead Load:		
Roofing =	2.8	psf
Insulation =	0.5	psf
Roof sheathing =	1.7	psf
Trusses @ 24" o.c. =	6.0	psf
5/8" GWB =	2.8	psf
M & E =	0.5	psf
Miscellaneous =	0.5	psf
Roof dead load total =	14.8	psf
USE =	15.0	psf
Roof Live Load:	25	psf
Total Roof Load =	40.0	psf

Floor Dead Load:		
Floor Cover =	1.0	psf
Insulation =	1.0	psf
Floor sheathing =	2.7	psf
Joists @ 16" o.c. =	2.8	psf
5/8" GWB =	2.8	psf
M & E =	1.0	psf
Miscellaneous =	0.5	psf
Floor dead load total =	11.8	psf
USE =	12.0	psf
Floor Live Load:	40	psf
Total Floor Load =	52.0	psf

Wall Dead Load:		
2x Stud @ 16" o.c. =	2.0	psf
7/16" Sheathing =	1.8	psf
Gypsum sheathing =	2.0	psf
Insulation =	1.0	psf
Siding =	2.0	psf
Miscellaneous =	0.5	psf
Wall dead load total =	9.3	psf
USE =	10.0	psf

DESIGN REFERENCES:

·ASCE 7-10, MINIMUM DESIGN LOADS FOR BUILDINGS AND OTHER STRUCTURE.
·IBC 2015, INTERNATIONAL BUILDING CODE 2012 W/ SBC 2012.
·ACI 318-14, BUILDING CODE REQUIREMENTS FOR STRUCTURAL CONCRETE AND COMMENTARY.
·NDS 2015, NATIONAL DESIGN SPECIFICATION FOR WOOD CONSTRUCTION WITH COMMENTARY.
·AWC SDPWS-2015, SPECIAL DESIGN PROVISIONS FOR WIND AND SEISMIC WITH COMMENTARY.
·AISC 360-10, SPECIFICATION FOR STRUCTURAL STEEL BUILDINGS: STEEL DESIGN MANUAL

Calculate Seismic Design Base Shear

Structure Height, h_h, (ft)	=	10.8	(Mean roof height)	Per USGS S_s =	1.398
S_{DS} = 2/3 S_{MS}	=	0.932	(per USGS)	S_1 =	0.537
S_{D1} = 2/3 S_{M1}	=	0.537	(per USGS)	S_{MS} =	1.398
Risk Category= Standard-Occupancy Buildings	=	II		S_{M1} =	0.805
Seismic Design Category per S_{DS}	=	D			
Occupancy Importance Factor, I_E	=	1	(ASCE 7, Table 11.5.1)		
Response Modification Factor, **R**	=	6.5	(ASCE 7, Table 12.2-1)		
Building Period Coefficient, C_t	=	0.02	(ASCE 7, Table 12.8-2)		
$T = C_t \times (h_n)^{3/4}$	=	0.119	(ASCE 7, Eq 12.8-7)		
T_L = long-period transaction	=	6	(ASCE 7, Fig 22-15)		
$C_s = S_{DS}/(R/I_E)$	=	0.143	(ASCE 7, Eq 12.8-2)		
But need not exceed:					
$C_S = S_{D1}/[T(R/I_E)]$	=	0.693	(ASCE 7, Eq 12.8-3)		
But not less than:					
$C_S = 0.44 S_{DS} I_E$;(not less than 0.01)	=	0.041	(ASCE 7, Eq 12.8-5)		
$C_S = 0.5 S_1/(R/I_E)$ (if S_1 > or = 0.6g)	=	N/A	(ASCE 7, Eq 12.8-6)		
Seismic Base Shear, $V_S = C_S W$, (kips)	=	**0.143**	**x Weight**	$F_{px,\,min}$ =	
Seismic Base Shear, $V_S/1.4 = C_S W$, (kips)	=	**0.102**	**x Weight (ASD)**	$F_{px,\,max}$ =	

Calculate Seismic Force for Components (Per ASCE7-05 Chapter 13)

Component amplification factor, a_p	=	1	(ASCE 7, Table 13.5.1 & 13.6.1)
Component Importance factor, I_p	=	1	(ASCE 7, Section 13.3)
Component operating weight, W_p	=	W_p	(lb)
Component response modification factor, R_p	=	2.5	(ASCE 7, Table 13.5.1 & 13.6.1)
Height of attachment / Mean roof height, **z/h**	=	1	(z/h need not exceed 1.0)

Seismic Design Force, $F_p = \dfrac{(0.4 a_p S_{DS} W_P)(1+2xz/h)}{R_p/I_p}$ = 0.447 W_p (Eq. 13.3-1)

Max. seismic design force, $F_{pmax} = 1.6 S_{DS} I_p W_P$ = 1.491 W_p (Eq. 13.3-2)

Min. seismic design force, $F_{pmin} = 0.3 S_{DS} I_p W_P$ = 0.280 W_p (Eq. 13.3-3)

Seismic Design Force, Fp = 0.447 W_p

Seismic Design Force, Fp/1.4 = 0.320 W_p

Longitudinal Direction

Level	Height h_x (ft)	Weight w_x (lbs)	$w_x h_x$ (lb-ft)	%	$F_{x\,Long}$ (lbs)	F_x Coef.	Story Shear (V_x)
R	10.8	8909	96217.2	100%	912	0.102	912
2	0	0	0	0%	0	0.000	912
1	0	0	0	0%	0	0.000	912
Σ		8909	96217.2	100%	912		

$F_{px,\,min}$ = 1186

$F_{px,\,max}$ = 2372

Transverse Direction

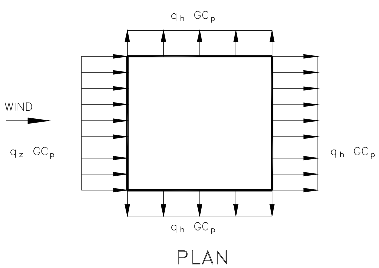
Level	Height h_x (ft)	Weight w_x (lbs)	$w_x h_x$ (lb-ft)	%	$F_{x\,Tras}$ (lbs)	F_x Coef.	Story Shear (V_x)
R	10.8	8909	96217.2	100%	912	0.102	912
2	0	0	0	0%	0	0.000	912
1	0	0	0	0%	0	0.000	912
Σ		8909	96217.2	100%	912		

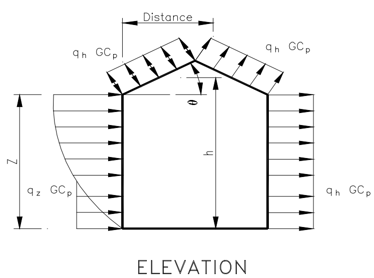
Wind Load Calculation (Method 2 - Analytical)

(Reference: IBC 2012, Section 1609 & ASCE 7-10, Chapter 27)

Wind Velocity Pressure:

Basic Wind Speed, V_{3s}, (mph)	=	110	(ASCE 7-10, Figure 6-1)
Exposure Category	=	B	(ASCE 7-10, Section 6.5.6)
Building Category	=	II	(IBC Table 1604.5)
Wind Load Importance Factor, I_w	=	1.0	(IBC Table 1604.5)
Velocity pressure exposure coefficient, K_z	=	See Table	(ASCE 7-10, Table 6-3)
Topographic Factor, K_{zt}	=	1.00	(ASCE 7-10, Figure 6-4)
Wind Directionality Factor, K_d	=	0.85	(ASCE 7-10, Table 6-4).
Velocity Pressure, q_z, (lb/ft^2)	=	$0.00256K_zK_{zt}K_dV^2I_w$	(ASCE 7-10, Eq. 6-15)
	=	26.33 Kz	(ASCE 7-10, Section 6.5.10)
Gust effect factor, G	=	0.85	(ASCE 7-10, Section 6.5.8)





Width, B =	20	ft
Length, L =	16	ft
Height to eave, h_e =	8	ft
Height to ridge, h_r =	13.5	ft
Mean roof height =	10.8	ft
θ =	22.6	deg
q_h, (lb/ft^2) =	15.01	

L/B = 0.8
h/L = 0.7

Internal Pressure Coefficent, C_{pi} = **0.18** → q_hGC_{pi} = **2.30**

$p = qGC_p - q_i(GC_{pi})$ (ASCE 7-10, Eq 6-17)

MWFRS Pressure:

	Height Z, (ft)	K_z	q_z or q_h	Cp	qGC_p	Net Pressure (p), psf (+GCpi)	Net Pressure (p), psf (-GCpi)	Total Wind Load
Winward Wall	0-15	0.57	**15.01**	0.8	10.21	7.91	12.50	15.31
	0	0.00	0.00	0.8	0.00	0.00	0.00	0.00
	0	0.00	0.00	0.8	0.00	0.00	0.00	0.00
	0	0.00	0.00	0.8	0.00	0.00	0.00	0.00
Leeward Wall	All		15.01	-0.4	-5.10	-7.40	-2.81	
Side Wall	All		15.01	-0.7	-8.93	-11.23	-6.63	
Windward Roof	-		15.01	-0.6	-7.65	-9.95	-5.36	0.00
			15.01	-0.09	-1.15	-3.44	1.15	6.51
Leeward Roof	-		15.01	-0.6	-7.65	-9.95	-5.36	

Horizontal Distance from windward edge

0 to h		15.01	-0.9	-11.48	-13.78	-9.18
h to 2h		15.01	-0.5	-6.38	-8.67	-4.08
> 2h		15.01	-0.3	-3.83	-6.12	-1.53

(Where h = 4 ft)

Vertical Wall = 15.31 psf
Vertical Roof = 6.28 psf or **-13.78 psf**
Horizontal Roof = 1.68 psf
OR Not less than (10psf)xA_f

CS2 ENGINEERS Civil & Structural Challenge & Success Green Design For Our Environment	Project: CHUNG RESIDENCE GARAGE	By: S. CHO	Page:
	Location:	Date:	
	Client:	Check:	Job No:
	Subject:	Date:	

LATERAL LOAD DESIGN

– SEISMIC LOAD

① SEISMIC WEIGHT. & LOAD

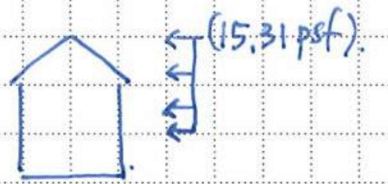
ROOF WT. = (15 psf)(22.33' × 18') = 6029#

WALL WT. = (½)(10 psf)(8')(20'+20'+16'+16') = 2880#

TOTAL WT = 6029# + 2880# = 8909#

V_x = 912#, $F_{x,min.}$ = 1186# (CONTROL)

② WIND LOAD



W_s = (15.31 psf)(10.8' − 4') = 104.1 plf

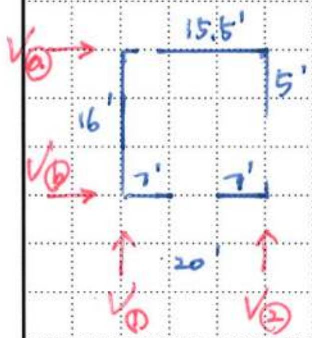
N-S DIRECTION = (104.1 psf)(20')
= 2082#

E-W DIRECTION = (104.1 psf)(16')
= 1666#

CS2 ENGINEERS Civil & Structural Challenge & Success Green Design For Our Environment	Project:	By:	Page:
	Location:	Date:	
	Client:	Check:	Job No:
	Subject:	Date:	

LATERAL LOAD & SHEAR WALL DESIGN

1) N-S DIRECTION



ROOF AREA = 22.33' × 18' = 402 ft²

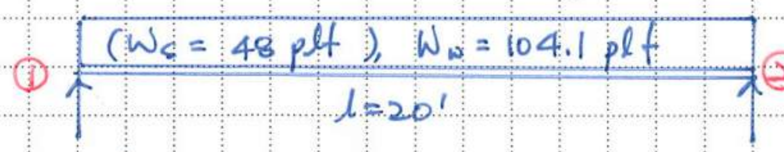
F_x = 1186 #

$f_R = \frac{1186\#}{402\,ft^2} = 3.0$ psf

$W_s = (3.0\text{ psf})(16') = 48$ plf

W_W = = 104.1 plf

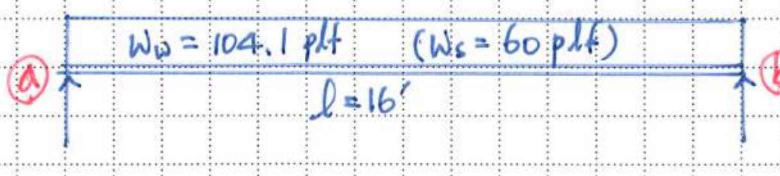
* ( ) DENOTE SHEAR WALL



	①	②
V (#)	1041# (480#)	1041# (480#)
SHEAR WALL LENGTH (ft)	16'	5'
UNIT SHEAR (plf)	65 plf (30 plf)	208 plf (96 plf)
SHEAR WALL	SW1	SW1
HOLD-DOWN	NOT REQ'D.	$\frac{1041 \times 8'}{4.5'} = 1851\#$ STHD 8

2) E-W DIRECTION

$W_w = 104.1$ plf
$W_s = (3.0 \text{ psf})(20') = 60$ plf



	a	b
V (#)	833# (480#)	833# (480#)
SHEAR WALL	15.5'	7' + 7' = 14'
UNIT SHEAR (plf)	54 plf (31 plf)	60 plf (34 plf)
SHEAR WALL	SW 1	SW 1
HOLD-DOWN	$\frac{833\# \times 8'}{15'} = 444\#$	$\frac{60 \times 7' \times 8'}{6.5'} = 517\#$
	NOT REQ'D	NOT REQ'D

Appendix

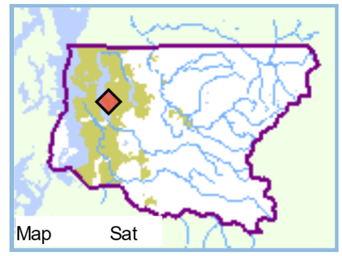
P.O. Box 13423
Mill Creek, WA 98082
TEL: (425) 408-2748
FAX: (425) 954-7539
info@cs2engineers.com

King County

King County Districts and Development Conditions for parcel 0031000095

print

Parcel number	**0031000095**	Drainage Basin	**Mercer Island**
Address	**4027 93RD AVE SE**	Watershed	**Cedar River / Lake Washington**
Jurisdiction	**Mercer Island**	WRIA	**Cedar-Sammamish (8)**
Zipcode	**98040**	PLSS	**NE - 18 - 24 - 5**
Kroll Map page	**89**	Latitude	**47.57354**
Thomas Guide page	**596**	Longitude	**-122.21543**



King County Electoral districts

Voting district	**M-I 41-0770**
King County Council district	**District 6, Claudia Balducci (206) 477-1006**
Congressional district	**9**
Legislative district	**41**
School district	**Mercer Island #400**
Seattle school board district	**does not apply (not in Seattle)**
District Court electoral district	**Northeast**
Regional fire authority district	**does not apply**
Fire district	**does not apply**
Water district	**does not apply**
Sewer district	**does not apply**
Water & Sewer district	**does not apply**
Parks & Recreation district	**does not apply**
Hospital district	**does not apply**
Rural library district	**Rural King County Library System**
Tribal Lands?	**No**

King County planning and critical areas designations*

King County zoning	**NA, check with jurisdiction**
Development conditions	**None**
Comprehensive Plan	**does not apply**
Urban Growth Area	**Urban**
Community Service Area	**does not apply**
Community Planning Area	**Eastside**
Coal mine hazards?	**Check with jurisdiction**
Erosion hazards?	**Check with jurisdiction**
Landslide hazards?	**Check with jurisdiction**
Seismic hazards?	**Check with jurisdiction**
100-year flood plain?	**None mapped**
Urban Unincorporated Status	**does not apply**
Rural town?	**No**
Water service planning area	**City of Mercer Island**
Transportation Concurrency Management	**does not apply**
Forest Production district?	**No**
Agricultural Production district?	**No**
Snoqualmie Valley watershed improvement district?	**No**
Critical aquifer recharge area?	**None mapped**
Wetlands at this parcel?	**Check with jurisdiction**
Within the Tacoma Smelter Plume?	**Under 20 ppm** Estimated Arsenic Concentration in Soil

**Most of these designations apply only to unincorporated areas*

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Contact us at giscenter@kingcounty.gov.