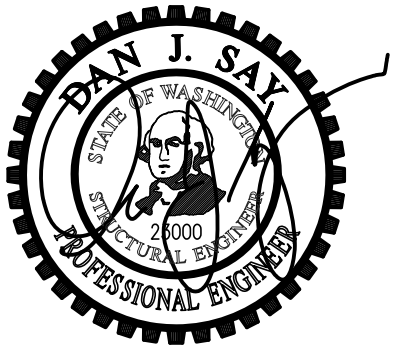
Structural Calculations for:

McLear Residence

9120 SE 50th St

Mercer Island, WA 98040



Prepared for: Brandt Design Group

Job #: 01519-2020-13-00

Date: March 19, 2021

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Criteria Sheet

Codes

Structural	IBC 2018
Loading	ASCE 7-16
Wood:	NDS 2018
Steel:	AISC 360-16
Concrete:	ACI 318-14
Masonry:	TMS 402/602-16

Project Location

Street & Number	9120 SE 50th st		
City:	Mercer Island	State:	WA
ZIP:	98040		
Latitude:	47.5579	N	
Longitude:	-122.2155	W	
Ground Elevation	345	ft	

Occupancy Category

Risk Category: II — ASCE 7 Table 1.5-1

Seismic Load Summary:

Analysis Procedure:	Equivalent Lateral Force Procedure		
Lateral System:	Light-frame (wood) Walls Sheathed with Wood Structural Panels Rated for Shear Resistance		
R:	6.50	C_d=	4
Base Shear V =	12 kips	Ω_o=	2.5
S_S=	1.438	S_1=	0.499
S_{DS}=	1.00	S_{D1}=	0.50
C_s=	0.154	I_E=	1.0

Story Information

# Stories Above Grade (Including Mezzanine Levels)	2

Horizontal and Vertical Irregularities:

Is the building a "Regular Structure"? (No horizontal or vertical irregularities)	Yes

Wind Load Summary:

V=	98	K_{ZT}=	1.00
Exposure =	C		

Dead Loads:

Roof			Floor		
Roofing	2.5	psf	Finish Floor	1	psf
1/2" Sheathing	1.8	psf	3/4" Sheathing	2.7	psf
Trusses @ 24" oc	2.5	psf	Joists @ 16" oc	2.2	psf
Misc./Mech.	1.5	psf	Misc./Mech.	2	psf
Ceiling Finish	2.8	psf	Ceiling Finish	2.8	
Solar Panels	4			10.7	psf
	15	psf	Use	12	psf
Use	15	psf			

Deck		
5/4x IPE	7.5	psf
3/4" Sheathing	2.7	psf
Joists @ 16" oc	2.2	psf
Ceiling Finish	2.5	
	14.9	psf
Use	15	psf

Live Loads:

Snow	25	psf	Deck	60	psf
Floor	40	psf			

Soils:

Soils Report Provided? Yes

Allowable Bearing	3000	psf	Active	55/35	pcf (Restrained/Unrestrained)
Sliding, μ	0.5		Seismic Surcharge	8H	
Passive	300	pcf			

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McLear		DATE	3/19/2021
Criteria		PROJ. #	01519-2020-13
		DESIGN	BDM
		SHEET	1

Seismic Design

ASCE 7-16 Seismic Analysis Equivalent Lateral Force Procedure

Seismic Force Resisting System Per Table 12.2-1		
	System	Bearing Wall Systems
	Type:	Light-frame (wood) Walls Sheathed with Wood Structural Panels Rated for Shear Resistance

Seismic Design Cat.	D	
Risk Category	II	I, II, or III, or IV per Table 1.5-1
Site Class	C	Per soils report.
Diaphragm Flexibility	Flexible	

Section 12.8.1.3 Exceptions

Regular Structure	Yes
≤ 5 Stories above grade	Yes
T ≤ 0.5s	Yes
ρ = 1.0	Yes
Not Site Class E or F	Yes
Risk Category I or II	Yes

If all exceptions are met, S_{DS} may be taken as 1, but not less than 0.7*(Calculated S_{DS})

S_S	1.438 g	2% in 50 yr, Latitude & Longitude lookup
S_1	0.499 g	2% in 50 yr, Latitude & Longitude lookup
R	6.50	
C_d	4.0	
Ω_o	2.5	
I_e	1.00	Table 1.5-2
h_n	19.5 ft	
Ct	0.02	Table 12.8-2
x	0.75	Table 12.8-2
T_a	0.19 sec	
T	0.19 sec	Eq. 12.8-7
T_0	0.10 sec	
T_S	0.50 sec	
T_L	6.00 sec	
F_a	1.20	Table 11.4-1
F_v	1.50	Table 11.4-2
S_{MS}	1.73 g	Eq. 11.4-1
S_{M1}	0.75 g	Eq. 11.4-2
S_{DS}	1.000 g	Eq. 11.4-3
S_{D1}	0.499 g	Eq. 11.4-4
C_s	***0.154 Controls***	Eq. 12.8-2
	0.414	Eq. 12.8-3 need not exceed, T < T_L
	0.010	Eq. 12.8-5 or 12.8-6 minimum
C_s, design	0.154	
Bldg. Weight	80.9 k	
V = C_SW	12.4 k	Eq. 12.8-1, Strength Level Base Shear
V = C_{sasd}W	8.7 k	Eq. 12.8-1 ASD Base Shear

Building Period Per Alternate Analysis

T (sec)	

Per Geotech Report

F_a	
F_v	

$$T_a = C_t h_n^x \quad \text{Eq. 12.8.7}$$

$$S_{MS} = F_a S_S \quad \text{Eq. 11.4-1}$$
$$S_{M1} = F_v S_1 \quad \text{Eq. 11.4-2}$$
$$S_{DS} = {}^2/_3 S_{MS} \quad \text{Eq. 11.4-3}$$
$$S_{D1} = {}^2/_3 S_{M1} \quad \text{Eq. 11.4-4}$$

$$C_S = \frac{S_{DS}}{(R/I_e)} \quad \text{Eq. 12.8-2}$$
$$C_S = \frac{S_{D1}}{T(R/I_e)} \quad \text{Eq. 12.8-3}$$
$$C_S = \frac{S_{D1} T_L}{T^2(R/I_e)} \quad \text{Eq. 12.8-4}$$
$$C_S \geq 0.044 S_{DS} I_e \quad \text{Eq. 12.8-5}$$
$$C_S \geq 0.01 \quad \text{Eq. 12.8-5}$$

$$C_{VX} = w_x h_x^k / \sum_{i=1}^{n} w_x h_i^k \quad \text{Eq. 12.8-12}$$

$$F_{px} = {}^{\sum_{i=x}^{n} F_i}/_{\sum_{i=x}^{n} w_i} w_{px} \quad \text{Eq. 12.10-1}$$
$$F_{px} \geq 0.2 S_{DS} I_e w_{px} \quad \text{Eq. 12.10-2}$$
$$F_{px} \leq 0.4 S_{DS} I_e w_{px} \quad \text{Eq. 12.10-3}$$

Vertical Distribution ASD ρ= 1 k= 1.000

Level	h_x (ft)	W_x (k)	h_x^k (ft)	$W_x h_x^k$	Story Shear ASD			Diaphragm Force (ρ not included)				
					C_{vx} (%)	F_x (k)	SV (k)	$F_{px,calc}$	$F_{px,min}$	$F_{px,max}$	$F_{px,design}$	$\gamma=F_{px}/F_x$
Upper Roof	19.5	31.9	19.5	622	0.540	4.7	**4.7**	4.7	4.5	8.9	**4.7**	1.00
Lower Roof	15.8	17.8	15.8	280	0.243	2.1	**6.8**	2.4	2.5	5.0	**2.5**	1.18
Main	8.0	31	8.0	250	0.217	1.9	**8.7**	3.4	4.4	8.7	**4.4**	2.31
Σ		80.9		1152		**8.7**						

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McLear

Seismic Criteria

DATE 3/19/2021
PROJ. # 01519-2020-13
DESIGN BDM
SHEET 2

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Wind Design - MWFRS

ASCE 7 Chapter 27 - Directional Procedure

Design Method	ASD

Wind Coefficients

Exposure	C	
V=	98	mph
K_d=	0.85	Table 26.6-1
K_h=	0.90	Table 26.10-1
K_e=	0.99	Table 26.9-1
G=	0.85	26.9.4

Transverse Wind Pressures

L/B = 0.74 h/L = 0.42

Pressure Coefficients from Figure 27.3-1:

Bldg Face	C_p
Windward Wall	0.8
Leeward Wall	-0.50
Windward Roof	-0.87 / -0.18
Leeward Roof	-0.44

Location and Building Dimensions

Calculate Kzt?	No	
Kzt	1.00	
Roof Type	Monoslope	
Roof Angle - Transverse Dir	4.17	degrees
Roof Angle - Long Dir	0	degrees
Ground to top of roof	21.5	ft
Bot of roof to top of roof	2.5	ft
Mean Roof Height, h	20.25	ft
Short Plan Dimension	48	ft
Long Plan Dimension	65	ft
Parapet ?	No	
Ground to top of parapet		ft
Average Parapet Height		ft
Ht of 2nd Level Above Grade	8	ft

Velocity Pressure at Mean Roof Height, q_h =	18.7	psf

Wall Pressures (Unfactored): ASD

Ht	K_z	q_z	$P_{ww\ walls}$	P_{lwalls}	**P_{walls} (psf)**
0-15	0.85	17.54	11.93	7.93	**11.9**
15-20	0.9	18.57	12.63	7.93	**12.3**
20-25	0.94	19.40	13.19	7.93	**12.7**
25-30	0.98	20.23	13.75	7.93	**13.0**
30-40	1.04	21.46	14.60	7.93	**13.5**
41-50	1.09	22.50	15.30	7.93	**13.9**
51-60	1.13	23.32	15.86	7.93	**14.3**
61-70	1.17	24.15	16.42	7.93	**14.6**
71-80	1.21	24.97	16.98	7.93	**14.9**
81-90	1.24	25.59	17.40	7.93	**15.2**
91-100	1.26	26.00	17.68	7.93	**15.4**

Roof Pressures (Unfactored) ASD

Windward		Leeward	**Horiz Proj (psf)**
Max	Min		
-2.9	-13.9	-6.9	**4.80**

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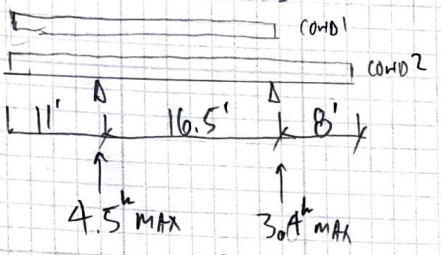
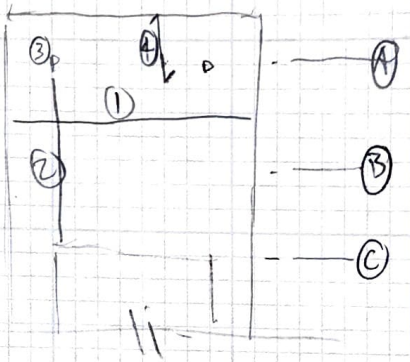
MCCLEAR GRAVITY

UPPER ROOF FRAMING

① - PURLIN

$w_{DL} = 15(4) = 60^{\#}$ $w_{SL} = 25(4) = 100^{\#}$

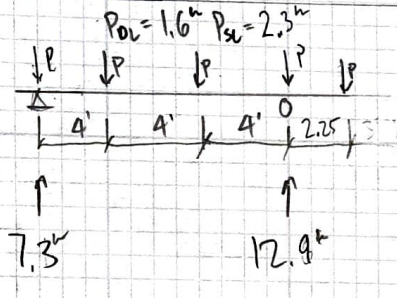




$M_{max\ ASD} = 12.5^{k\cdot ft}$ $M_{max\ ULT} = 15.1^{k\cdot ft}$ HSS 8x6x1/2 $\phi M_n = 105$ ok

$\Delta_{MAX\ @\ TIP} = .60" = 2\ell/440$ ok

② - GIRDER



$M_{max\ ASD} = 12.8^{k\cdot ft}$ $M_{max\ ULT} = 18.4^{k\cdot ft}$ HSS 8x6x1/2 $\phi M_n = 105$ ok

$\Delta_{max} = .09"$ ok

③ - COLUMN

$P_{max\ ASD} = 12.9^k$ $H_T = 12'$ HSS 3x3x3/8 $P_n/\Omega_c = 27.6^k$ ok

④ - RAFTERS

$L = 6.25'$ $A = 3'$ $R_1 = 96^{\#}$/NO UPLIFT $f_b = .61^{ksi}$ $\Delta_{TL} = .169" = 2\ell/425$

$w_{TL} = 40^{\#}$ $w_{TL} = 40^{\#}$ $R_2 = .27^k$ $f_v = 35^{psi}$

$w_{DL} = 10^{\#}$ $M = .19^{k\cdot ft}$

LVL 1 3/4 x 3 1/2 @ 12

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PROJECT MCCLEAR

DATE 01519-2020-13

PROJ # BPM

DESIGN

SHEET 4

Lower Roof Framing

① – Porch

$w_1 = w_2 = 170^{\#/'}$ P→0

$L = 9.75'$ $A = 4.5'$

$R_1 = .65^k$ $R_2 = 1.77^k$

$M = 1.72^{k\cdot ft}$

$f_b = .84^{ksi}$

$f_v = 65^{psi}$

$\Delta_{TL} = .08'' = \ell/2098$

(2) 2x8 DF#1

② – HDR

$w = 417^{\#/'}$

$L = 8.25'$

$R = 1.72^k$

$M = 3.55^{k\cdot ft}$ $M_n/\Omega_b = 14.0^{k\cdot ft}$

$\Delta_{TL} = .21'' = \ell/474$

HSS 5x2x½ Flat

③ – Rafter

$w = 40^{\#/'}$ $L = 3.25'$

$R = .13^k$

$M = .21^{k\cdot ft}$

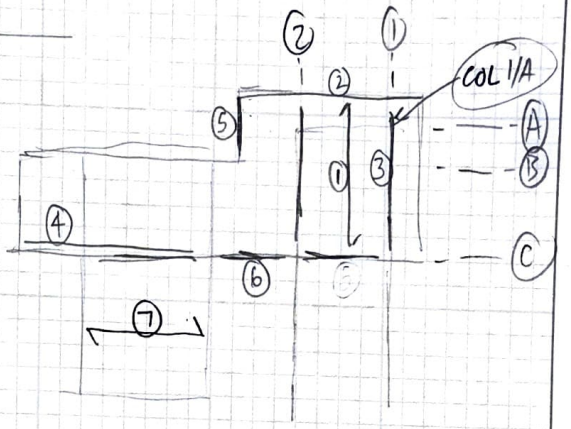
$f_b = .83^{ksi}$

$f_v = 37^{psi}$

$\Delta_{TL} = .14'' = \ell/564$

2x4 @ 12

Main Floor Framing



① - Deck Joists

$w = 100^{\#}$ $L = 15.25'$ $R = .76^{k}$ $M = 2.91^{k\cdot ft}$

$f_b = 1.14^{ksi}$ $f_v = 42^{psi}$ $\Delta_{TL} = .55" = \ell/334$

(2) LVL 1¾x7¼ @16

② - Deck Rim

$w = 572^{\#}$ $L = 12.5'$ $A = 5'$ $R_1 = 3.6^{k}$ $R_2 = 7.0^{k}$ $M = 11.17^{k\cdot ft} < 21.0^{k\cdot ft}$

$\Delta_{TL} = .37" = \ell/411$

MC 6x18

③ - Bm

$w = 100^{\#}$ $P = 7.0^{k}$ $L = 11.5'$ $A = 3.25'$ $R_1 = -1.4^{k}$ $R_2 = 9.9^{k}$ $M = 23.3^{k\cdot ft} < 75.9^{k\cdot ft}$ ok

$\Delta_{TL} = .22" = \ell/350$

HSS 7x7x5/8

④ - Ledger

$w_1 = w_2 = 188^{\#}$ $L = 12'$ $A = 4'$ $R_1 = 1.0^{k}$ $R_2 = 2.0^{k}$ $M = 2.67^{k\cdot ft}$

$f_b = 1.05^{ksi}$ $f_v = 67^{psi}$ $\Delta_{TL} = .22" = \ell/436$

4x8

⑤ - Bm

$w_1 = w_2 = 100^{\#}$ $L = 7'$ $A = 3.25'$ $R_1 = -.16^{k}$ $R_2 = 2.1^{k}$ $M = 3.58^{k\cdot ft}$

$f_b = .93^{ksi}$ $f_v = 47^{psi}$ $\Delta_{TL} = .18" = \ell/435$

(3) LVL 1¾x7¼

⑥ - Bm

$w_1 = 455^{\#}$ $w_2 = 188^{\#}$ $P = 7.3^{k} + 1.4^{k} = 8.7^{k}$ $L_1 = 7.25'$ $L_2 = 3'$ $R_1 = 4.8^{k}$ $R_2 = 7.8^{k}$ $M = 22.5^{k\cdot ft} < M_n/\Omega_b = 53.8$

$\Delta_{TL} = .17" = \ell/707$

HSS 8x4x½

⑦ - Joists

$w = 67^{\#}$ $L = 12'$ $R = .40^{k}$ $M = 1.21^{k\cdot ft}$

$f_b = .68^{ksi}$ $f_v = 38^{psi}$ $\Delta_{TL} = .24" = \ell/592$

2x10 @16

Col ①/Ⓐ

$P = 12.9^{k} + 9.9^{k} = 22.8^{k}$ $H_T = 8'$

HSS 4x4x¼ $P_n/\Omega_c = 71.0^{k}$

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LATERAL DESIGN

- FOR NEW DECK ROOF USE OPEN FRONT STRUCTURE
  L'/W' = 17'/24' = .71 (5% OVER .67 ∴ OK BY ENGINEERING JUDGMENT)
  L' = 17' < 35' OK

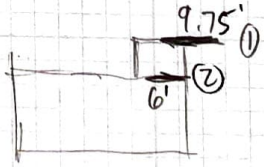
@ UPPER ROOF LATERAL LOADS FROM WIND ARE NEGLIGIBLE
∴ DESIGN FOR SEISMIC LOAD
UPPER ROOF TOTAL V_{eq} = 4.7ᵏ
NEW DECK ROOF V_{eq} = .16(4.7ᵏ) = .76ᵏ

- E/W DIRECTION

UPPER ROOF:
NEW ROOF OPEN FRONT STRUCTURE E/W
ACC FOR V_{eq} = .76ᵏ + 3.94ᵏ/2 = 2.73ᵏ
- CHECK WIND LOAD OF EXIST HOUSE TO SEE IF CONTROLS
  V_W = 38#(12.3 PLF)/2 = 2.39ᵏ < 2.73ᵏ
  ∴ USE SEISMIC LOAD FOR DESIGN

SW DESIGN:
V = 2.73ᵏ L = 7.75'
υ = 352 PLF SW = W3
OT = 3.17ᵏ HD = HDU4
CHECK CHORD FORCE: $V_{CH} = \left[\frac{(.76/17')(17')^2}{2}\right]/24 = .269^k$ ∴ CS14 OK

LOWER ROOF:
ADD NEW ROOF SEISMIC LOAD TO WALL ABOVE. NO CHANGE TO EXIST
① V = 2.73ᵏ + .30/2 = 2.88ᵏ L = 9.75' υ = 295
SW = W3 OT = 3.17ᵏ + .11ᵏ = 3.28ᵏ HDU4
② V = 2.1ᵏ/2 = 1.05ᵏ L = 6' υ = 175 PLF SW = W6
OT = 1.4ᵏ HD = CS16



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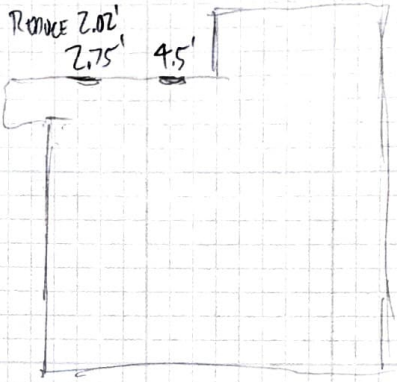
MAIN FLOOR:

NO CHANGE TO EXSTG - ADD SW TO GRID (B) - WILL IMPROVE OVERALL LATERAL RESPONSE BY CONSERVATIVELY TAKING 1/2 LOAD FROM THIS LEVEL

$V_{eq} = 8.7^k/2 = 4.35^k$

$V_w = (745\#)(12.3)/2 = 4.6^k$ USE



$L = 6.5'$ $v = 706$ SW = 2W3

$OT = 4.76^k$ HD = HDU5

- N/S DIRECTION

UPPER ROOF:

EXSTG HOUSE DESIGN IS OPEN FRONT STRUCTURE W/ WALLS ON GRID (4)

CHECK NEW ADDED ROOF LOAD VS EXSTG ROOF LOAD

EXSTG ROOF LOAD WEST FROM (B) TO (G)

NET INCREASE IN LOAD FROM NEW ROOF = 6.10 ≤ 10% THEREFORE NO CHANGES REQ'D.

LOADS IMPOSED FROM CHORD FORCES NEGLIGIBLE COMPARED TO IN PLANE SHEAR.

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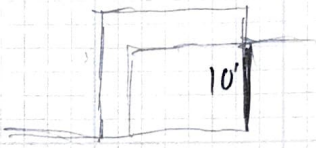
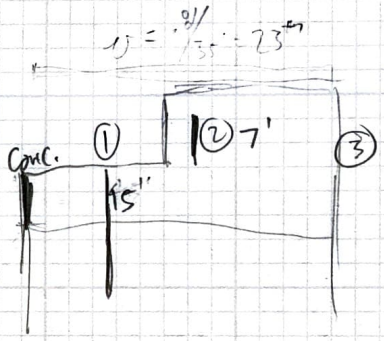
LOW ROOF:

NO ADDED WIND LOADS
NO CHANGE TO EXSTG. DESIGN W&W
PORTION OF ROOF TO SELF SUPPORT
UTILIZE OTHER FRONT STRUCTURE



$V_{eq} = .14(2.1) = .30^k$
$L = 10'$
$v = 30^{th}$
$SW = W6$
$OT = \cancel{\emptyset}$ $HD = \emptyset$

MAIN FLOOR:
NO ADDED WIND LOADS
NO CHANGE TO EXSTG. DESIGN W&W
DECK FLOOR TO SELF SUPPORT



$V_{eq} = .3^k + .27(1.4^k) = .81^k$ ⇒ CONSERVATIVELY USE AT EACH WALL

① - $L = 15'$ $V = .81^k + .3^k$ FROM ABOVE $= 1.11^k$
$v = 74^{th}$ $SW = W6$ $OT = \cancel{\emptyset}$ $HD = \emptyset$

② - $L = 7'$ $V = .81^k$ $v = 116^{th}$ $SW = W6$ $OT = \cancel{\emptyset}$ $HD = \emptyset$

③ - DRAG LOAD INTO EXSTG FLOOR. ADDED LOAD FROM SEISMIC IS NEGLIGIBLE (.14 K) ∴ NO CHANGE
BUT ADD STRAP TO DRAG IN.

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