Structural Calculations For:

LBH Residence

7450 North Mercer Way

Mercer Island, WA

Prepared for: Stilwell Hanson Architects

Job #: 00834-2018-08

Date: November 13, 2018

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Criteria Sheet

Codes:

Structural:	IBC 2015
Loading:	ASCE 7-10
Wood:	NDS 2015
Steel:	AISC 360-10
Concrete:	ACI 318-14
Masonry:	TMS 402/602-13

Project Location:

Street & Number: 7450 N Mercer Way
City: Mercer Islanc State: WA
ZIP:

Latitude: 47.5919 W
Longitude: -122.2383 N

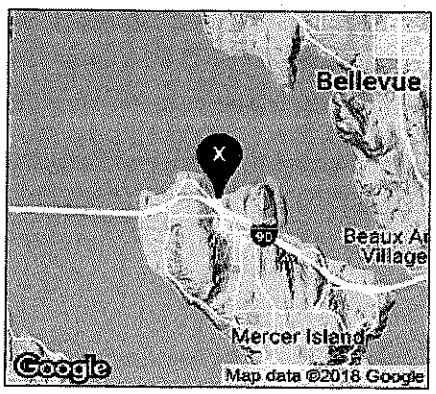
Occupancy Category

Risk Category: II ASCE 7 Table 1.5-1

Seismic Load Summary:

Analysis Procedure: Equivalent Lateral Force Procedure
Lateral System: Wood Structural Panels Rated for Shear Resistance

R: 6.50	C_d= 4
Base Shear V = 30.4 kips	Ω_o= 2.5
S_S= 1.364	S_1= 0.525
S_{DS}= 0.91	S_{D1}= 0.53
C_s= 0.140	I_E= 1.0



Wind Load Summary:

V= 110 K_{zt}= 1.00
Exposure = D

Dead Loads:

Roof

Roofing	2.5	psf
1/2" Sheathing	1.8	psf
Trusses @ 24" oc	2.5	psf
Misc./Mech.	1.4	psf
Ceiling Finish	2.8	psf
Solar Panels	4	
	15	psf
Use	15	psf

Floor

Finish Floor	1	psf
3/4" Sheathing	2.7	psf
Joists @ 16" oc	2.2	psf
Misc./Mech.	2	psf
Ceiling Finish	2.8	
	10.7	psf
Use	12	psf

Live Loads:

Snow	25	psf
Floor	40	psf

Soils:

Allowable Bearing 2000 psf

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Kell Residence
Criteria

DATE 8/14/2018
PROJ. #
DESIGN KWW
SHEET 1

Seismic Design

ASCE 7-10 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

Risk Category	II	I, II, or III, or IV per Table 1.5-1
Site Class	D	per soils report (D assumed, without soils report)
Diaphragm Flexibility	Flexible	

Ω_o	2.5		
S_S	1.364	g	2% in 50 yr, Latitude & Longitude lookup
S_1	0.525	g	2% in 50 yr, Latitude & Longitude lookup
h_n	30	ft	
R	6.50		
I_e	1.0		Table 1.5-2
C_d	4		
Ct	0.02		Table 12.8-2
x	0.075		Table 12.8-2
T	0.03	sec	Eq. 12.8-7
T_0	0.12	sec	
T_s	0.58	sec	
k	1.000		
Fa	1.00		Table 11.4-1
Fv	1.50		Table 11.4-2
S_{MS}	1.36	g	Eq. 11.4-1
S_{M1}	0.79	g	Eq. 11.4-2
S_{DS}	0.909	g	Eq. 11.4-3
S_{D1}	0.525	g	Eq. 11.4-4
Cs	0.140		Eq. 12.8-2
	3.129		Eq. 12.8-3 need not exceed, $T < T_L$
	0.010		Eq. 12.8-5 or 12.8-6 minimum
Cs, design	0.140		
Bldg. Weight	217.2	k	
$V = C_S W$	30.4	k	Eq. 12.8-1, Strength Level Base Shear
$V = C_{Sasd} W$	21	k	Eq. 12.8-1 ASD Base Shear

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

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

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

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

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

Vertical Distribution

ASD — ρ= 1.0

Level	hx (ft)	Wx	hx^k (ft)	Wxhx^k	Cvx (%)	Story Shear ASD Fx (k)	SV (k)	Diaphragm Force (ρ not included) Fpx_{calc}	Fpx_{min}	Fpx_{max}	Fpx_{design}	γ=Fpx/Fx
Roof	30.0	64.08	30.0	1922.4	0.456	9.7	**9.7**	9.69	8.16	16.32	**9.69**	1.00
3	20.0	76.56	20.0	1531.2	0.363	7.7	**17.4**	9.48	9.75	19.49	**9.75**	1.26
2	10.0	77	10.0	765.6	0.181	3.9	**21.3**	7.50	9.75	19.49	**9.75**	2.53
	S	217.2		4219.2		21.3						

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Wind Design - MWFRS

ASCE 7-10 Chapter 27 - Directional Procedure

Design Method	ASD

Wind Coefficients

Exposure	D	
V=	110	mph
K_d=	0.85	Table 26.6-1
K_h=	1.17	Table 27.3-1
G=	0.85	26.9.4

Location and Building Dimensions

Calculate Kzt?	NO	
Kzt	1	
Roof Angle - Transverse Dir	14	degrees
Roof Angle - Long Dir	14	degrees
Ground to top of roof	34	ft
Bot of roof to top of roof	5	ft
Mean Roof Height, h	31.5	ft
Short Plan Dimension	60	ft
Long Plan Dimension	67	ft
Parapet ?	No	
Ground to top of parapet		ft

Velocity Pressure at Mean Roof Height, q_h =	30.8	psf

Transverse Wind Pressures

L/B = 0.9 h/L = 0.5

Pressure Coefficients from Figure 27.4-1:

Bldg Face	C_p
Windward Wall	0.8
Leeward Wall	-0.50
Windward Roof	-0.76 / -0.18
Leeward Roof	-0.51

Wall Pressures (Unfactored): ASD

Ht	K_z	q_z	$P_{ww\ walls}$	$P_{lwwalls}$	P_{walls} (psf)
0-15	1.03	27.12	18.44	13.09	**18.92**
15-20	1.08	28.44	19.34	13.09	**19.46**
20-25	1.12	29.49	20.05	13.09	**19.89**
25-30	1.16	30.54	20.77	13.09	**20.32**
30-40	1.22	32.12	21.84	13.09	**20.96**
41-50	1.27	33.44	22.74	13.09	**21.50**
51-60	1.31	34.49	23.45	13.09	**21.93**
61-70	1.34	35.28	23.99	13.09	**22.25**
71-80	1.38	36.33	24.71	13.09	**22.68**
81-90	1.4	36.86	25.07	13.09	**22.89**
91-100	1.43	37.65	25.60	13.09	**23.22**

Roof Pressures (Unfactored) ASD

Windward		Leeward	Horiz Proj (psf)
Max	Min		
-4.7	-19.8	-13.2	**2.61**

Parapet (Unf) ASD

Windward	Leeward	Total (psf)
-N/A-	-N/A-	**-N/A-**

Transverse Direction

Base Shear (kips)	**38.5**

Longitudinal Wind Pressures

L/B = 1.1 h/L = 0.5

Pressure Coefficients from Figure 27.4-1:

Bldg Face	C_p
Windward Wall	0.8
Leeward Wall	-0.48
Windward Roof	-0.72 / -0.16
Leeward Roof	-0.5

Wall Pressures (Unfactored): ASD

Ht	K_z	q_z	$P_{ww\ walls}$	$P_{lwwalls}$	P_{walls} (psf)
0-15	1.03	27.12	18.44	12.48	**18.55**
15-20	1.08	28.44	19.34	12.48	**19.09**
20-25	1.12	29.49	20.05	12.48	**19.52**
25-30	1.16	30.54	20.77	12.48	**19.95**
30-40	1.22	32.12	21.84	12.48	**20.59**
41-50	1.27	33.44	22.74	12.48	**21.13**
51-60	1.31	34.49	23.45	12.48	**21.56**
61-70	1.34	35.28	23.99	12.48	**21.88**
71-80	1.38	36.33	24.71	12.48	**22.31**
81-90	1.4	36.86	25.07	12.48	**22.53**
91-100	1.43	37.65	25.60	12.48	**22.85**

Roof Pressures (Unfactored) ASD

Windward		Leeward	Horiz Proj (psf)
Max	Min		
-4.3	-18.8	-13.1	**2.52**

Parapet (Unf) ASD

Windward	Leeward	Total (psf)
-N/A-	-N/A-	**-N/A-**

Longitudinal Direction

Base Shear (kips)	**33.8**

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LATERAL LOADS

SEISMIC:

ROOF:
A: 3204ft²
W: (15psf + 5psf)(3204ft²) = 64.08k
V_R = 9.7k

UPPER LEVEL:
A: 3480ft²
W: (12psf + 10psf)(3480ft²) = 76.56k
V_u = 7.7k

MAIN LEVEL:
A: 3480ft²
W: 74.52k
V_m = 3.9k

V_{BASE} = 21.3k

WIND:

ROOF: V_R = (8')(19.52psf) = 156plf

UPPER: V_u = (11')(18.5psf) = 204plf

MAIN: V_m = (11')(18.5psf) = 204plf

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PROJECT: KELL RESIDENCE
DATE: 8/14/18
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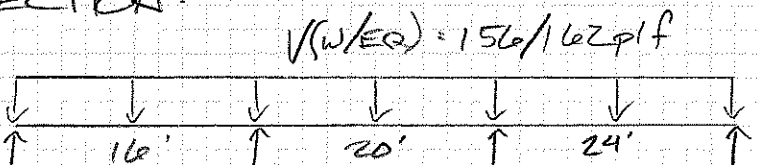
DESIGN: KWM
SHEET

LATERAL DESIGN:

E-W DIRECTION:

ROOF:



R(W/EQ):	(E)	(E)	3.4/3.6k	1.9/2.0k
lw:	NO	NO	36.5'	14.5'
Vmin:	CHANGE	CHANGE	93/99plf	131/138plf
SW:			(E) W6	W6
FOT:			1.0k	1.1k
OGD:			.5k	.6k
EFOT:			.5k	.5k
HD:	↓	↓	NOT CRITICAL	NOT CRITICAL

UPPER LEVEL: NO CHANGE

MAIN LEVEL: NO CHANGE

MAIN LEVEL DECK:

A: (16'x28'): 448ft²

W = (15psf)(448ft²) = 6.72k

V_D = (.228)(.7)(6.72k) = 1.07k

V_D = 1.07k

$C_s = .140\left(\frac{6.5}{4}\right) = 0.228$

8" CONC. SW: A_{cv} = (8')(84") = 672in²

$V_c = 2\sqrt{f'c}\,A_{cv}$

= 67.2k

ϕV_c = 40.3k D.C.R. = 2.7% OK

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PROJ. # KWW
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GRAVITY DESIGN

ROOF:

① RAFTER LVL 1¾×11⅞ @24"oc
l = 18.5' w = (15psf+25psf)(2') = 80plf
R = 740#
M = 3423'#
fb = 999psi
fv = 48psi
Δ = .432" = l/514

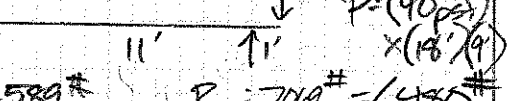
② BEAM GL 5⅛×12
l = 17' w = (40psf)(5.5') = 220plf
R = 1870#
M = 7948'#
fb = 775psi
fv = 40psi
Δ = .311" = l/655
NOT USED

③ RIDGE GL 5⅛×13½
l = 18.5' w = (40psf)(8.5') = 340plf
R = 3145#
M = 14546'#
fb = 1121psi
fv = 60psi
Δ = .474" = l/469
NOT USED

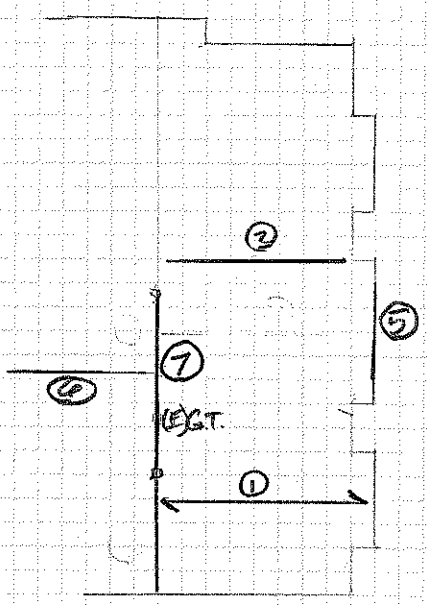
④ HDR GL 5⅛×9
l = 7' w = (40psf)(18') = 720plf
R = 2520#
M = 4410'#
fb = 765psi
fv = 64psi
Δ = .069" = l/210
NOT USED

⑤ HDR GL 5⅛×10½
l = 12' P = 3145# @6'
R = 1573#
M = 9435'#
fb = 1202psi
fv = 44psi
Δ = .220" = l/655

⑥ BEAM GL 5⅛×12



R = 589#
M = 6480'#
fb = 632psi
fv = 158psi
Δ = .034" = l/712
R2 = 709# = 6480#



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(7) BEAM GL 5 1/8 x 13 1/2

$\ell = 13.5'$ $w = (40_{psf})(20') = 800_{plf}$

$R = 5400^{\#}$

$M = 18225'^{\#}$

$f_b = 1405_{psi}$

$f_v = 98_{psi}$

$\Delta = .316" = \ell/513$

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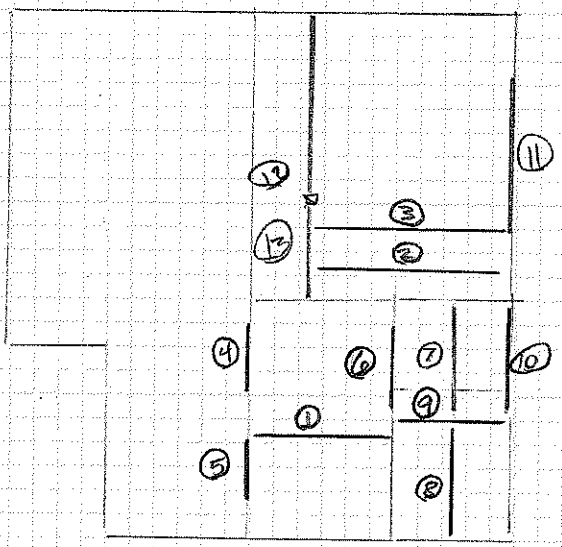
UPPER LEVEL FRAMING:

(1) BEAM (3)LVL 13/4x14
l = 17' w = (50psf)(9') = 450#/lf
P = 5460# @ 12'
R1 = 2158# R2 = 4381#
M = 21069
fb = 1474psi
fv = 98psi
Δ = .363" = l/562

(2) BEAM (2)LVL 13/4x14
l = 20.5' w = 67#/lf
P = 1234# @ 17'
R1 = 897# R2 = 1710#
M = 6010#
fb = 631psi NOT USED
fv = 50psi
Δ = .284" = l/866

(3) BEAM (2)LVL 13/4x14
l = 22' w = 67#/lf
P = 2520# @ 18.5'
R1 = 1138# R2 = 2856#
M = 9663#
fb = 1014psi
fv = 85psi
Δ = .499" = l/529

(4) HDR GL 3 1/2x9
l = 7' w = (50psf)(9') = 450#/lf
P = 4381# @ 5'
R1 = 2827# R2 = 4704#
M = 8509
fb = 2161psi
fv = 208psi
Δ = .171" = l/490



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(5) HDR GL 5½x9
l = 9' w: 450plf
P = 5504# @ 8'
R1 = 2637# R2 = 6917#
M = 7724'# NOT USED
fb = 1248psi
fv = 199psi
Δ = .189" = l/571

(6) HDR (E) GL 3⅛x12
l = 9' w = (50psf)(11) + 7200#/9 = 1350plf
R = 6075#
M = 13669'#
fb = 2187psi
fv = 189psi
Δ = .246" = l/439

(7) BEAM (E) RSL 5¼x11⅞
l = 14' w = (50psf)(3') + (40psf)(11') = 590plf
R = 4130#
M = 14455'#
fb = 1406psi
fv = 85psi
Δ = .316" = l/531

(8) BEAM (E) RSL 5¼x11⅞
l = 15' w = (50psf)(3') + (40psf)(11') = 590plf
R = 4425#
M = 16594'#
fb = 1614psi NOT USED
fv = 92psi
Δ = .417" = l/432

(9) BEAM (3) LVL 1¾x14
l = 10' P = 4130# + 4425# = 8555# C5'
R = 4278#
M = 21388'# NOT USED
fb = 1497psi
fv = 87psi
Δ = .128" = l/936

(10) BEAM GL 3⅛x12
l = 15' w = (40psf)(2.5') = 100plf
R = 750#
M = 2813'# NOT USED
fb = 450psi
fv = 26psi
Δ = .141" = l/1280

(11) BEAM (E) RSL 5¼x16 OK
l = 15' w = (40psf)(10') + (50psf)(10.5') + (40psf)(8') = 1245plf
R = 9338#
M = 35016'#
fb = 1876psi
fv = 137psi
Δ = .440" = l/409

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(12) (E) BEAM W12x53

L: 21' $w = (10psf + 40psf)(17.5') = 875plf$

R = 9188#

M = 48234'#

f_b = 8.2ksi

Δ = .31" < L/81

NOT USED

(13) (E) BEAM W12x53

L: 14' w = 875plf

P = 1870# @ 7'

OK

R = 7060# R_2 = 7060#

M = 27983'#

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MAIN LEVEL:

(1) JOISTS D.F. 2x12 @16" oc
l: 15' w = (10psf + 60psf)(1.33') = 93plf
R = 698#
M = 2616'#
f_b = 992psi
f_v = 54psi
Δ: .397" = l/454

(2) BEAM W12x58
l = 27' w = (70psf)(8') = 560plf
R = 7560#
M = 51030'#
f_b = 7.9ksi
Δ: .486" = l/667

(3) HDR GL 5 1/8x12
l: 10' w = (70psf)(8') = 560plf
P_1 = 3097# @3'
P_2 = 8850# @7'
R_1 = 7633# R_2 = 9950#
M = 27330'#
f_b = 2666psi f'_b = (2400psi)(1.15) = 2760psi
f_v = 186psi
Δ: .353" = l/340

(4) BEAM (4) LVL 1 3/4x14
l: 9' w = (15psf + 40psf)(12.5') = 688plf
P: 9188# + 7060# = 16248# @4.5'
R = 11220#
M = 42524'#
f_b = 2284psi
f_v = 159psi
Δ: .165" = l/655

NOT USED f'_{cL} = 750 = 16248/15D = 21.6in²
⇒ 4"x6" MIN PL

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(5) BEAM (2) LVL 1¾x11⅞

$l = 9'$ $w_1 = (55psf)(18') = 990plf$ (0'-3.5')

$w_2 = (55psf)(12.5') = 688plf$ (3.5'-9')

$R_1 = 3947\#$ $R_2 = 3302\#$

$M = 7922'\#$

$f_b = 1156psi$ NOT USED

$f_v = 107psi$

$\Delta = .119" = l/909$

(6) BEAM PSL 5¼x11⅞

$l = 5'$ $P = 3302\# + 11220\# = 14522\#$ @ 2.5'

$R = 7261\#$

$M = 18153'\#$

$f_b = 1765psi$ NOT USED

$f_v = 175psi$

$\Delta = .041" = l/1480$

(7) BEAM (2) LVL 1¾x11⅞

$l = 9'$ $w = (55psf)(8') = 440\#$

$R = 1980\#$

$M = 4455'\#$

$f_b = 650psi$ NOT USED

$f_v = 51psi$

$\Delta = .066" = l/1624$

SSF STRUCTURAL ENGINEERING

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PROJECT Kelc

DATE 10/18/18

PROJ. # KLW

DESIGN

SHEET

TRELLIS

D.F.

(1) RAFTER (2) 2½" × 7½" @ 24" o.c.

ℓ = 15' $w = (15psf + 25psf)(2') = 80plf$

R = 600#

M = 2250'#

f_b = 576psi

f_v = 22psi

Δ = .346" = $\ell/521$

(2) BEAM W12×35

ℓ = 28 $w = (40psf)(10') = 400plf$

R = 5600#

M = 39200'#

f_b = 10.3ksi

Δ = .669" = $\ell/502$

LATERAL DESIGN: TIMBER FRAME (R=1.5)

$V = 0.7 K_s W$

$= 0.7(.140)(15psf \times 8' \times 33')\left(\frac{6.5}{7.5}\right) = 1682\#$

(4) COLUMNS : 6×6

V = 420#

M = 2100'#

f_b = 909psi

f_v = 21psi OK

Δ = .265" = $\ell/2216$

SHEARWALL

ℓ_w = 2.25'

v_{unit} = 373plf

SW: W3

F_{OT} = 3.0k

=> HDU4

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SSF STRUCTURAL ENGINEERING

PROJECT: KELL RESIDENCE

DATE: 9/24/18

PROJ. #

DESIGN: KWW