West View Residence

4045 West Mercer Way
Mercer Island, WA 98040

STRUCTURAL CALCULATIONS

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Prepared by

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Design Criteria

Address: West View Residence
4045 West Mercer Way
Mercer Island, WA 98040

Seismic (2018 IBC)

Sds := .948 soil factors assuming site class D

Wind (ASCE 7-16)

Wind Speed = 97 mph Exposure D Kzt = 1.0
(exposure and Kzt from Google Earth)
V := 110

Roof Snow (ASCE 7-10)

Pg := 30 psf ws := Pg

Dead Loads

Roof

Ballast	rcob := 0
Roofing Metal Roofing	rf := 1
sheathing 5/8" pw	shtg := 1.9
purlins 11 7/8"TJI@24"	rpurl := 2.0
beams 5 1/4X12PSL@12'	rbm := 1.3
insul 10" BATT	rins := 1
ceiling 5/8 gyp	rclg := 2.2
Mech/misc	rspac := 2.6

wr := rcob + rf + shtg + rpurl + rbm + rins + rspac + rclg
wr = 12 psf

2nd Floor

Flooring hardwood	lf := 2
Sheathing 2 layers 3/4" pw	lshtg := 4.3
purlins 11 7/8"TJI@ 16"	lpurl := 3
beams w10x30 @ 25'	lbm := 2.4
Ceiling 5/8 gyp	lclg := 2.2
Topping 1.5" gypcrete	ltpg := 13.8
Misc/Mech	lmisc := 2.3

w2 := lf + lpurl + lbm + lclg + lshtg + lmisc + ltpg
w2 = 30 psf w2l := 40

1st Floor

Flooring hardwood	lf := 2
Sheathing 2 layers 3/4" pw	lshtg := 4.3
purlins 11 7/8"TJI@ 16"	lpurl := 3
beams w10x30 @ 25'	lbm := 2.4
Ceiling 5/8 gyp	lclg := 2.2
Topping 1.5" gypcrete	ltpg := 13.8
Misc/Mech	lmisc := 2.3

w1 := lf + lpurl + lbm + lclg + lshtg + lmisc + ltpg
w1 = 30 psf w1l := 40

Lateral

Seismic

Main Residence

AreaURoof := 25.17·79 WUroof := AreaURoof·(wr + 2) WUroof = 27838

Ct := .028 x := .8 hn := 22 $Ta := Ct \cdot hn^{x}$ Ta = 0.3

$Rlong := 3.5 \quad Cslong := \frac{Sds}{Rlong \cdot 1.4}$ Cslong = 0.19 above min and below max

$Cslongmax := \frac{Sds}{Rlong \cdot Ta \cdot 1.4}$ Cslongmax = 0.6 Cslongmin := .044·Sds Cslongmin = 0.042

Ct := .02 x := .75 hn := 22 $Ta := Ct \cdot hn^{x}$ Ta = 0.2

$Rtrans := 6.5 \quad Cstrans := \frac{Sds}{Rtrans \cdot 1.4}$ Cstrans = 0.1

Area2ndFloor := 2050

Area1stFloor := 2050

W2ndFloor := Area2ndFloor·(w2 + 3)

W2ndFloor = 67650

W1stFloor := Area1stFloor·(w1 + 3)

W1stFloor = 67650

hr := 33 hrxWroof := hr·WUroof hrxWroof = 918654.7

h2 := 20.5 h2xW2ndFloor := h2·W2ndFloor h2xW2ndFloor = 1386825

h1 := 10.25 h1xW1stFloor := h1·W1stFloor h1xW1stFloor = 693412.5

SumhxW := hrxWroof + h2xW2ndFloor + h1xW1stFloor SumhxW = 2998892.2

$Csr := \frac{hrxWroof}{SumhxW}$ Csr = 0.3

$Cs2 := \frac{h2xW2ndFloor}{SumhxW}$ Cs2 = 0.5

$Cs1 := \frac{h1xW1stFloor}{SumhxW}$ Cs1 = 0.2

Wtot := WUroof + W2ndFloor + W1stFloor Wtot = 163138

Vsrlong := Wtot·Csr·Cslong Vsrlong = 9668.5

Vsrtrans := Wtot·Csr·Cstrans Vsrtrans = 5206.1

Vs2long := Wtot·Cs2·Cslong Vs2long = 14595.8

$Vs2trans := Wtot \cdot Cs2 \cdot Cstrans$ $Vs2trans = 7859.3$

$Vs1long := Wtot \cdot Cs1 \cdot Cslong$ $Vs1long = 7297.9$

$Vs1trans := Wtot \cdot Cs1 \cdot Cstrans$ $Vs1trans = 3929.6$

$Vsrtrans + Vs2trans + Vs1trans = 16995$

$Vsrlong + Vs2long + Vs1long = 31562.2$

Wind

Basic Wind Speed $BWS := 110$ mph Exposure C

$Alpha := 9.5$ $Zg := 900$ $Ht := 33$

$Kd := .85$ $Kz := 2.01 \cdot \left(\frac{Ht}{Zg}\right)^{\frac{2}{Alpha}}$ $Kz = 1$ $Kzt := 1.0$

$q := .00256 \cdot Kd \cdot Kz \cdot Kzt \cdot \frac{BWS^2}{1.4}$ $q = 18.8$

$Vwrlong := 33 \cdot 6 \cdot q$ $Vwrlong = 3731.8$

$Vwrtrans := 78 \cdot 6 \cdot q$ $Vwrtrans = 8820.6$

$Vw2long := 33 \cdot 11.375 \cdot q$ $Vw2trans := 78 \cdot 11.375 \cdot q$

$Vw2long = 7074.9$ $Vw2trans = 16722.4$

$Vw1long := 33 \cdot 10.25 \cdot q$ $Vw1trans := 78 \cdot 10.25 \cdot q$

$Vw1long = 6375.2$ $Vw1trans = 15068.6$

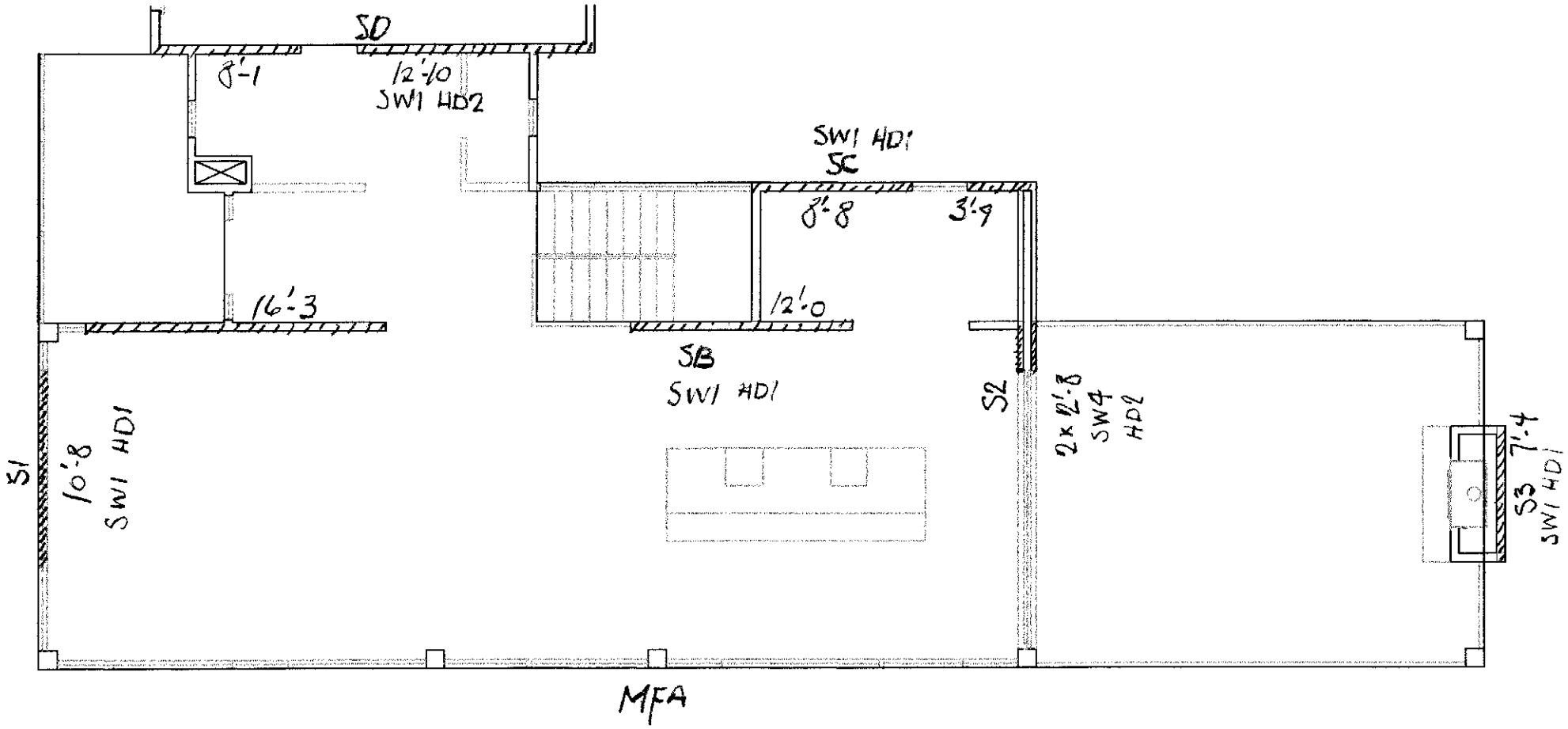
$Vwlong := Vwrlong + Vw2long + Vw1long$

$Vwlong = 17181.8$

$Vwtrans := Vwrtrans + Vw2trans + Vw1trans$

$Vwtrans = 40611.6$

Wind Controls in transverse direction, seismic Controls in longitudinal direction



2ND FLOOR SHEAR WALLS

Shear Walls

2nd Floor to Roof

Shear Wall Redundancy

As long as twice the total shear wall length divided by the story height is greater than or equal to 2, a redundancy factor of 1.0 is allowed.

$H := 11.5$

$L1 := 10.66$	$L1 = 10.7$	$NoBays := \frac{2L1}{H}$	$NoBays = 1.85$	$r1 := 1.3$
$L2 := 2 \cdot 2.66$	$L2 = 5.3$	$NoBays := \frac{2 \cdot L2}{2.5}$	$NoBays = 4.3$	$r2 := 1.0$
$L3 := 7.33$	$L3 = 7.3$	$NoBays := \frac{2 \cdot L3}{H}$	$NoBays = 1.3$	$r3 := 1.3$

Moment Frame A consists of 4 bays therefore rA = 1.0 $rA := 1.0$

$H := 9.5$

$LB := 16.25 + 12$	$LB = 28.3$	$NoBays := \frac{2 \cdot LB}{H}$	$NoBays = 5.9$	$rB := 1.0$
$LC := 8.66 + 3.79$	$LC = 12.4$	$NoBays := \frac{2 \cdot LC}{H}$	$NoBays = 2.6$	$rC := 1.0$
$LD := 8.07 + 12.84$	$LD = 20.9$	$NoBays := \frac{2LD}{H}$	$NoBays = 4.4$	$rD := 1.0$

Shear Wall S1

$L := L1 \quad H := 12.5 \quad r := r1$

$Vs := r \cdot Vsrtrans \cdot \frac{53}{78 \cdot 2}$ $Vs = 2299.4$ $Vw := \frac{Vwrtrans \cdot 53}{78 \cdot 2}$ $Vw = 2996.8$ $V := Vw$

$v := \frac{V}{L}$ $v = 281.1$

$HD := v \cdot H - H \cdot 10 \cdot \frac{L}{2}$ $HD = 2847.8$ **Use: SW1 & HD1**

Shear Wall S2

$L := L2 \quad H := 2 \quad r := r2$

$Vs := r \cdot Vsrtrans \cdot (.5)$ $Vs = 2603.1$ $Vw := \frac{Vwrtrans}{2}$ $Vw = 4410.3$ $V := Vw$

$v := \frac{V}{L}$ $v = 829$ $Lreq := \frac{v}{770} \cdot \frac{L}{2}$ $Lreq = 2.9$

$HD := v \cdot H - H \cdot 10 \cdot \frac{L}{2}$ $HD = 1604.8$ **Use: SW5 & HD1**

Shear Wall S3

$L := L3 \quad H := 12.5 \quad r := r3$

$Vs := r \cdot Vsrtrans \cdot \frac{25}{78 \cdot 2}$ $Vs = 1084.6$ $Vw := \frac{Vwrtrans \cdot 25}{78 \cdot 2}$ $Vw = 1413.6$ $V := Vw$

$v := \frac{V}{L}$ $v = 192.8$

$HD := v \cdot H - H \cdot 10 \cdot \frac{L}{2}$ $HD = 1952.5$ **Use: SW1 & HD1**

Moment Frame MA

$H := 12.5 \quad r := rA$

$Vs := r \cdot Vsrlong \cdot \frac{17.5}{33 \cdot 2}$ $Vs = 2563.6$ $Vw := \frac{Vwrlong \cdot 17.5}{33 \cdot 2}$ $Vw = 989.5$ $V := Vs$

See Risa Model for design of moment frame

Shear Wall SB

$L := LB \quad H := 11 \quad r := r1$

$Vs := r \cdot Vsrlong \cdot .5$ $Vs = 6284.5$ $Vw := \frac{Vwrlong}{2}$ $Vw = 1865.9$ $V := Vs$

$v := \frac{V}{L}$ $v = 222.5$

$HD := v \cdot H - H \cdot 10 \cdot \frac{L}{2}$ $HD = 893.3$ **Use: SW1 & HD1**

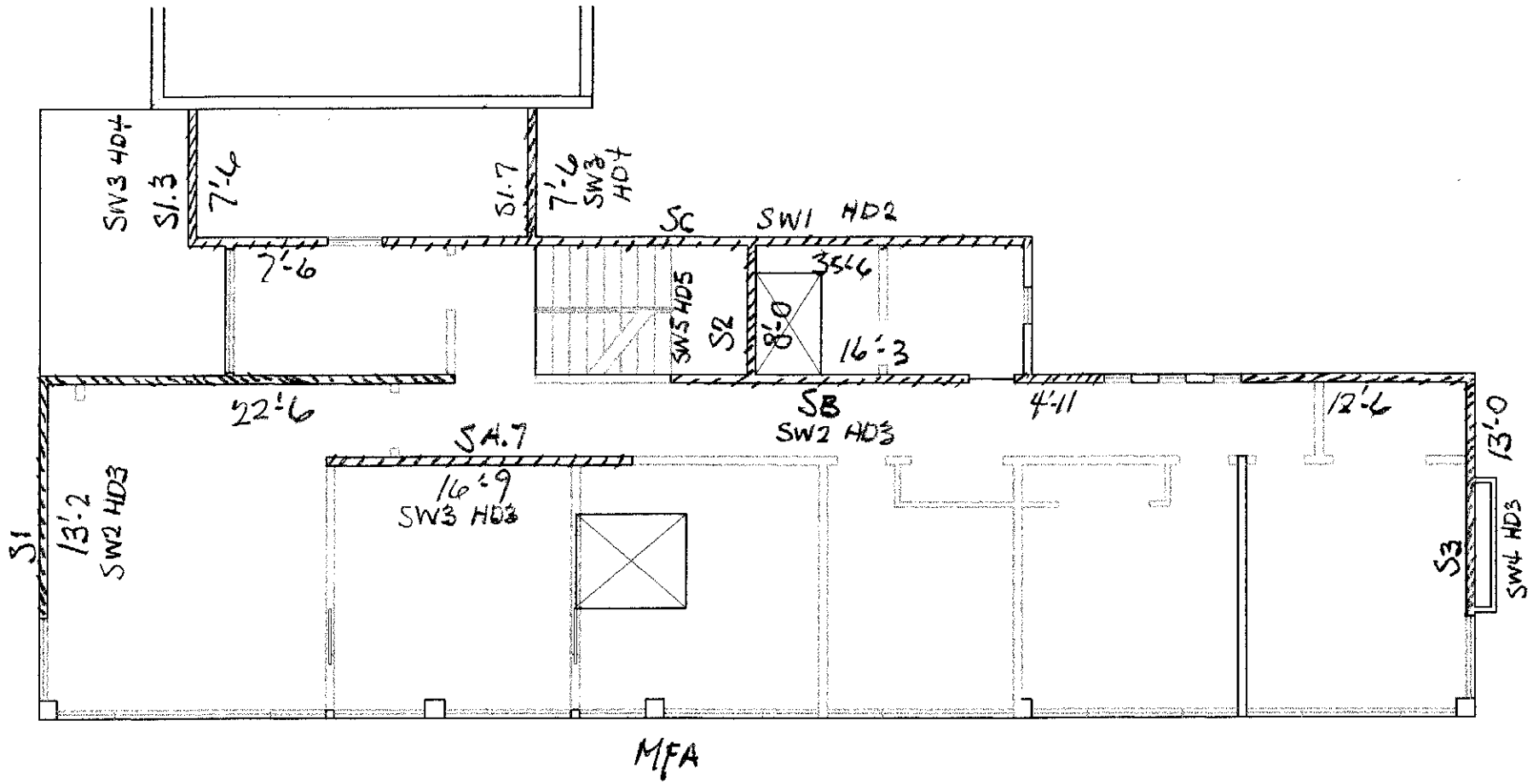
Shear Wall SC

$L := LC \quad H := 8 \quad r := r1$

$Vs := r \cdot Vsrlong \cdot .25$ $Vs = 3142.3$ $Vw := \frac{Vwrlong}{4}$ $Vw = 933$ $V := Vs$

$v := \frac{V}{L}$ $v = 252.4$

$HD := v \cdot H - H \cdot 10 \cdot \frac{L}{2}$ $HD = 1521.1$ **Use: SW1 & HD1**



1ST FLOOR SHEAR WALLS

Shear Wall SD

$L := LD \quad H := 8 \quad r := r1$

$Vs := r \cdot Vsrlong \cdot .5 \quad Vs = 6284.5 \quad Vw := \frac{Vwrlong}{2} \quad Vw = 1865.9 \quad V := Vs$

$v := \frac{V}{L} \quad v = 300.6$

$HD := v \cdot H - H \cdot 10 \cdot \frac{L}{2} \quad HD = 1568$ **Use: SW1 & HD2**

1st Floor to 2nd Floor

Shear Wall Redundancy

As long as twice the total shear wall length divided by the story height is greater than or equal to 2, a redundancy factor of 1.0 is allowed.

$H := 9.5$

$L1 := 13.14$	$L1 = 13.1$	$NoBays := \frac{2L1}{H}$	$NoBays = 2.77$	$r1 := 1.0$
$L13 := 7.5$	$L13 = 7.5$	$NoBays := \frac{2L13}{H}$	$NoBays = 1.58$	$r13 := 1.3$
$L17 := 7.5$	$L17 = 7.5$	$NoBays := \frac{2L17}{H}$	$NoBays = 1.58$	$r17 := 1.3$
$L2 := 8$	$L2 = 8$	$NoBays := \frac{2 \cdot L2}{H}$	$NoBays = 1.7$	$r2 := 1.3$
$L3 := 13$	$L3 = 13$	$NoBays := \frac{2 \cdot L3}{H}$	$NoBays = 2.7$	$r3 := 1.0$

Moment Frame A consists of 4 bays therefore rA = 1.0 $rA := 1.0$

$H := 9.5$

$LA7 := 16.75$	$LA7 = 16.8$	$NoBays := \frac{2 \cdot LA7}{H}$	$NoBays = 3.5$	$rA7 := 1.0$
$LB := 22.5 + 16.25 + 4.93 + 12.5$	$LB = 56.2$	$NoBays := \frac{2 \cdot LB}{H}$	$NoBays = 11.8$	$rB := 1.0$
$LC := 7.5 + 35.5$	$LC = 43$	$NoBays := \frac{2 \cdot LC}{H}$	$NoBays = 9.1$	$rC := 1.0$
$LD := 24$	$LD = 24$	$NoBays := \frac{2LD}{H}$	$NoBays = 5.1$	$rD := 1.0$

Shear Wall S1

$L := L1 \quad H := 9.5 \quad r := r1$

$Vs := r \cdot (Vsrtrans + Vs2trans) \cdot \frac{8}{2 \cdot 78}$ $Vs = 670$

$Vw := \frac{(Vwrtrans + Vw2trans) \cdot 8}{78 \cdot 2}$ $Vw = 1309.9$ $V := Vw$

$v := \frac{V}{L}$ $v = 99.7$

$HD := v \cdot H - H \cdot 10 \cdot \frac{L}{2}$ $HD = 322.9$ **Use: SW2 & HD3**

Shear Wall S1.3

$L := L13$ $H := 9.5$ $r := r13$

$Vs := r \cdot (Vsrtrans + Vs2trans) \cdot \frac{8 + 18.5}{2 \cdot 78}$ $Vs = 2885.3$

$Vw := \frac{(Vwrtrans + Vw2trans) \cdot (8 + 18.5)}{78 \cdot 2}$ $Vw = 4339$ $V := Vw$

$v := \frac{V}{L}$ $v = 578.5$

$HD := v \cdot H - H \cdot 10 \cdot \frac{L}{2}$ $HD = 5139.9$ **Use: SW3 & HD4**

Shear Wall S1.7

$L := L17$ $H := 9.5$ $r := r17$

$Vs := r \cdot (Vsrtrans + Vs2trans) \cdot \frac{12 + 18.5}{2 \cdot 78}$ $Vs = 3320.8$

$Vw := \frac{(Vwrtrans + Vw2trans) \cdot (12 + 18.5)}{78 \cdot 2}$ $Vw = 4994$ $V := Vw$

$v := \frac{V}{L}$ $v = 665.9$

$HD := v \cdot H - H \cdot 10 \cdot \frac{L}{2}$ $HD = 5969.5$ **Use: SW3 & HD4**

Shear Wall S2

$L := L2$ $H := 9.5$ $r := r2$

$Vs := r \cdot (Vsrtrans + Vs2trans) \cdot \frac{51}{2 \cdot 78}$ $Vs = 5552.8$

$Vw := \frac{(Vwrtrans + Vw2trans) \cdot 51}{78 \cdot 2}$ $Vw = 8350.6$ $V := Vw$

$v := \frac{V}{L}$ $v = 1043.8$

$HD := v \cdot H - H \cdot 10 \cdot \frac{L}{2}$ $HD = 9536.4$ **Use: SW5 & HD5**

Shear Wall S3

$L := L3 \quad H := 9.5 \quad r := r3$

$Vs := r \cdot (Vsrtrans + Vs2trans) \cdot \frac{39}{2 \cdot 78}$ $Vs = 3266.3$

$Vw := \frac{(Vwrtrans + Vw2trans) \cdot 39}{78 \cdot 2}$ $Vw = 6385.8$ $V := Vw$

$v := \frac{V}{L}$ $v = 491.2$

$HD := v \cdot H - H \cdot 10 \cdot \frac{L}{2}$ $HD = 4049$ **Use: SW4 & HD3**

Moment Frame MA

$H := 12.5 \quad r := rA$

$Vs := r \cdot (Vsrlong + Vs2long) \cdot \frac{13.75}{2 \cdot 33}$ $Vs = 5055.1$

$Vw := \frac{(Vwrlong + Vw2long) \cdot 13.75}{33 \cdot 2}$ $Vw = 2251.4$ $V := Vs$

See Risa Model for design of moment frame