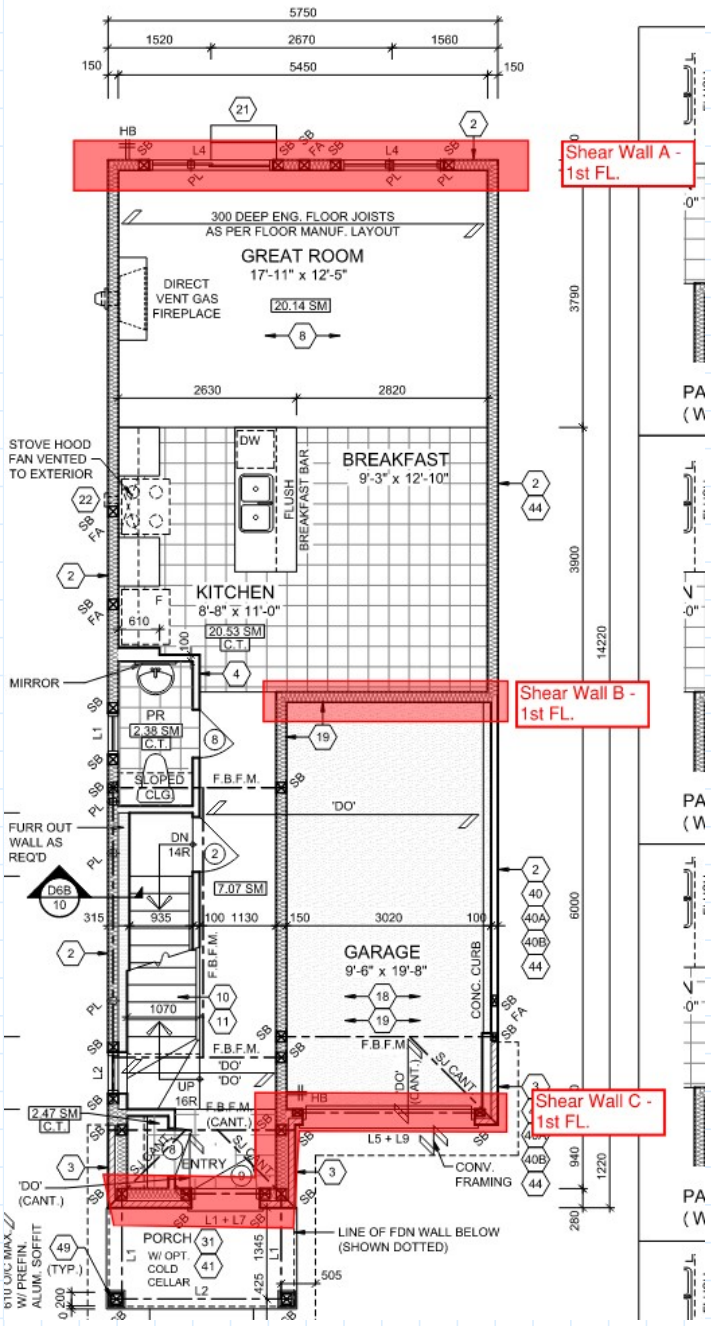
Shear wall A @ 1st Floor



Floor Plane - 1st Floor

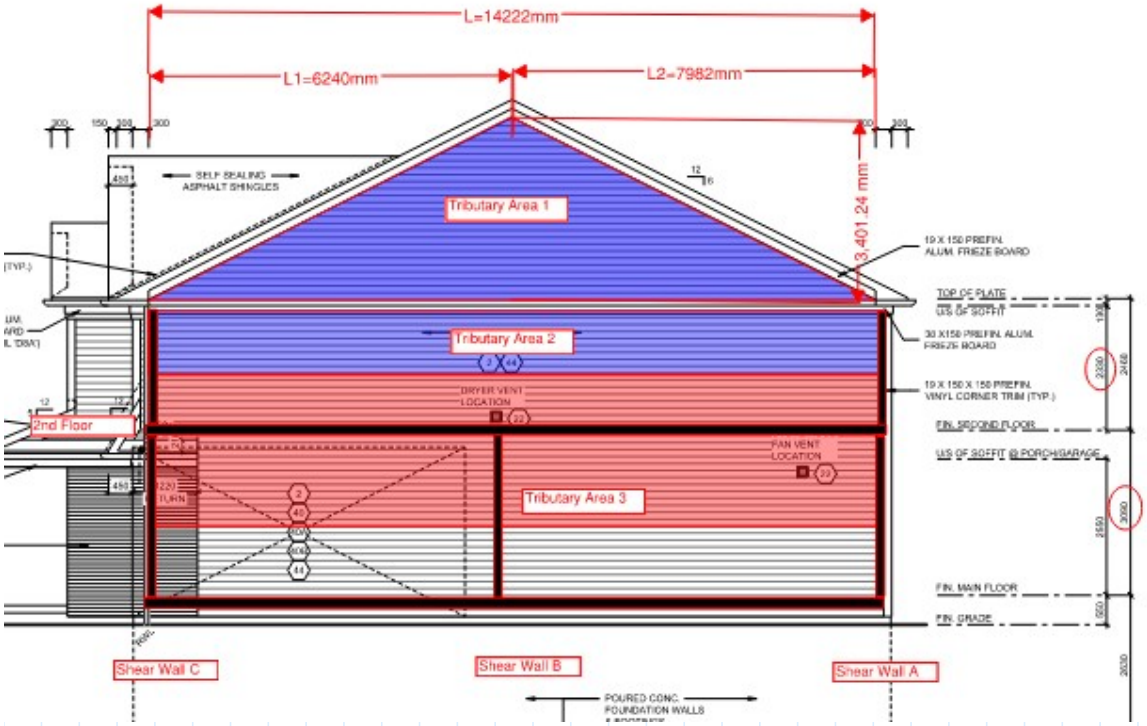
Design Parameters

Geometry Parameters

Building Overall Length	$L := 14222\ mm$
Buidilng Length 1	$L_1 := 6240\ mm$
Building Length 2	$L_{2;} := 7982\ mm$
Buidling Height - 1st FL.	$h_1 := 3090\ mm$
Building Height - 2nd FL.	$h_2 := 2330\ mm$
Roof Height	$h_{roof} := 3401\ mm$

Design Load Parameter

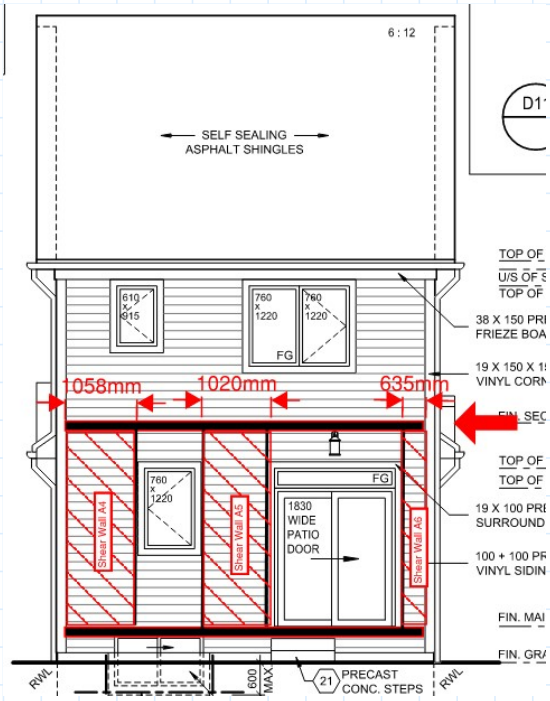
Design Wind Load (Unfactored) $p_{wl} := 0.88\ kPa$



Load Calculation

Reaction Load - Tributary Area 3 $$R_3 := \frac{3 \cdot \left(p_{wl} \cdot \left(0.5 \cdot h_2 + h_1\right) \cdot L\right)}{8} = 19.97\ kN$$

Factored Shear Load on 1st FL. $$V_f := 1.4 \cdot \left(R_3\right) = 27.958\ kN$$



Shear Wall @ 1st Floor

Shear wall A4 Width $b_{a4} := 1058\ mm$

Shear wall A5 Width $b_{a5} := 1020\ mm$

Shear wall A6 Width $b_{a6} := 635\ mm$

Shear wall segment aspect ratio (CSA O86-14 CL.11.3.3.3)

Shear wall A4 Ratio

$$Ratio := \text{if } \frac{h_1}{b_{a4}} \le 3.5 \text{ “OK” else “Not OK”} = \text{“OK”}$$

Shear wall A5 Ratio

$$Ratio := \text{if } \frac{h_1}{b_{a5}} \le 3.5 \text{ “OK” else “Not Ok”} = \text{“OK”}$$

Shear wall A6 Ratio

$$Ratio := \text{if } \frac{h_1}{b_{a6}} \le 3.5 \text{ “OK” else “Not OK”} = \text{“Not OK”}$$

OSB Sheathing Nail Unit Lateral Strength Resistance (CSA O86-14 CL.12.9.4.1)

Design Basis

#1. Frame wall construction incoporates the 1/2" thickness of OSB sheathing at exterior side and 1/2" thickness of gypsum board interior side.
#2. Design screw diameter is 10D and spaced at 4" c/c along the panel edges.
#3. Blocked shear wall is assumed in the design calculation.
#4. Each segmented shear wall is assumed with hold down anchors to resist overtuning

Given Parameters

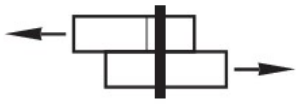
Nail Diameter	$d_f := 3.76\ mm$	10D
Relative Density	$G_{sheathing} := 0.42$	For OSB
Relative Density	$G_{stud} := 0.42$	Stud = Spruce-Pine-Fir
Strength of sheathing	$f_1 := 104 \cdot G_{sheathing} \cdot \left(1 - 0.1 \cdot d_f \cdot mm^{-1}\right) \cdot MPa = 27.256\ MPa$	
Strength of Stud	$f_2 := 50 \cdot G_{stud} \cdot \left(1 - 0.01 \cdot d_f \cdot mm^{-1}\right) \cdot MPa = 20.21\ MPa$	
Sheathing Thickness	$t_1 := 12\ mm$	1/2" Thk. OSB
Nail Embedment	$t_2 := 50\ mm$	2" embedment

Load Factors

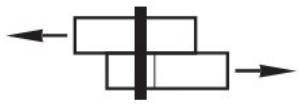
Load Duration Factor	$K_D := 1.15$	Wind = Short Term
Service Condtion Factor	$K_{SF} := 1.00$	Nail in Dry condition
Treatment Factor	$K_T := 1.00$	Pressure Treated Wood

Lateral Strenght (CSA O86-14 CL.12.9.4.1)

(a) $f_1 d_f t_1$



(b) $f_2 d_f t_2$



Shear Strength a	$V_a := f_1 \cdot d_f \cdot t_1 = 1.23\ kN$
Shear Strength b	$V_b := f_2 \cdot d_f \cdot t_2 = 3.8\ kN$
Lateral Strength	$n_u := min\left(V_a, V_b\right) = 1.23\ kN$
Factored lateral Strength	$N_u := n_u \cdot K_D \cdot K_{SF} \cdot K_T = 1.414\ kN$

Ext. Shear wall Strength - OSB panel Shear Strength (CSA O86-14 CL.11.5.1.b)

Given

Reduction Factor	$\phi := 0.8$	
lateral strength	$N_u = 1.414\ kN$	From previous calc.
Number of shear planes	$n_s := 1$	
Fastener spacing along panel edge	$s := 100\ mm$	4" spacing

Fastener spacing factor

Spacing Factor (CSA O86-14 CL.11.4.1)

$$J_s := \begin{cases} 1 & \text{if } s \geq 150\ mm \\ 1 - \left((150\ mm - s) \div 150\ mm \right)^{4.2} & \text{else if } 50\ mm \leq s < 150\ mm \\ \text{"Error"} & \text{else} \end{cases}$$

$J_s = 0.99$

Shear Wall Construction Factor

Shearwall construction factor (CSA O86-14 CL.12.9.4.1)

$J_D := 1.00$ Alll other cases

Unblocked Sheaer wall Factor

Factor for unblocked shearwall (CSA O86-14 CL.11.4.4)

$J_{us} := 1.0$ Blocked Shear wall assumed

Hold Down Factor

Hold-down effect factor (CSA O86-14 CL.11.4.5.)

$J_{hd} := 1.00$ Segment with hold down

Shear Wall strength

Shear wall segment linear strength $v_d := N_u \div s = 14.143\ kN \cdot m^{-1}$

Shear wall length $L_s := b_{a4} + b_{a5} = 2.078\ m$

Shear wall strength $V_{rs1} := \phi \cdot v_d \cdot J_D \cdot n_s \cdot J_{us} \cdot J_s \cdot J_{hd} \cdot L_s = 23.278\ kN$

Ext. Shear wall Strength - OSB panel buckling Strength (CSA O86-14 CL.11.5.1.c)

Given

Panel Thickness	$t_1 = 12\ mm$	
Panel Smaller Dimension	$b := min\left(b_{a4}, b_{a5}\right) = 1020\ mm$	
Panel Larger Dimension	$a := h_2 = 2330\ mm$	
Shear wall length	$L_s = 2078\ mm$	
Reduction Factor	$\phi = 0.8$	
Service Condition Factor	$K_S := 1.0$	dry service
Load Duration Factor	$K_D = 1.15$	Wind = Short Term
Treatment Factor	$K_T = 1$	Pressure Treated Wood
Axial Stiffness 0° Orientation	$B_{a.0} := 55000\ MPa$	CSA O86-14 Table 9.3C
Axial Stiffness 90° Orientation	$B_{a.90} := 36000\ MPa$	CSA O86-14 Table 9.3C
Shear through thickness rigidity	$B_v := 11000\ MPa$	CSA O86-14 Table 9.3C

Panel Buckling Strength Calc.

Buckling Coefficient, η

$$\eta := \frac{\left(2 \cdot B_v\right)}{\sqrt{B_{a.0} \cdot B_{a.90}}} = 0.494$$

Buckling Coefficient, α

$$\alpha := \frac{a}{b} \cdot \left(\frac{B_{a.90}}{B_{a.0}}\right)^{\frac{1}{4}} = 2.055$$

Panel Buckling Factor

$$K_{pb} := 1.7 \cdot \left(\eta + 1\right) \cdot e^{\left(\frac{-\alpha}{0.05 \cdot \eta + 0.75}\right)} + \left(0.5 \cdot \eta + 0.8\right) = 1.226$$

Panel Buckling Strength

$$v_{pb} := K_{pb} \cdot \frac{\left(\pi^2 \cdot {t_1}^2\right)}{3000 \cdot b} \cdot \left(B_{a.0} \cdot {B_{a.90}}^3\right)^{\frac{1}{4}} = 22.796\ \frac{kN}{m}$$

Factored Panel buckling Strength

$$V_{rs2} := \phi \cdot v_{pb} \cdot K_D \cdot K_S \cdot K_T \cdot L_s = 43.581\ kN$$

Table 9.3C
Specified strength, stiffness, and rigidity capacities for construction sheathing OSB

Panel mark (CSA O325)	Minimum nominal thickness, mm	Bending, m_p, N•mm/mm		Axial tension, t_p, N/mm		Axial compression, p_p, N/mm		Shear-through-thickness, v_p, N/mm	Planar shear			
									Bending, v_{pb}, N/mm		Shear in-plane, v_{pf}, MPa	
		Capacities relative to major axis*										
		0°	90°	0°	90°	0°	90°	0° and 90°	0°	90°	0°	90°
2R24	9.5	180	57	53	18	62	54	42	3.8	2.4	0.60	0.38
1R24/2F16	11.0	240	68	60	30	71	54	46	4.4	2.4	0.60	0.33
2R32/2F16	12.0	270	100	65	38	77	67	50	4.8	3.0	0.60	0.38
2R40/2F20	15.0	460	160	67	48	92	87	55	6.1	3.8	0.61	0.38
2R48/2F24	18.0	630	240	92	59	110	94	60	7.8	4.4	0.65	0.37
1F16	15.0	310	100	60	43	87	78	47	5.2	3.3	0.52	0.33
1F20	15.0	360	150	67	48	92	87	54	6.1	3.9	0.61	0.39
1F24	18.0	480	230	77	59	110	94	59	7.8	4.5	0.65	0.37
1F32	22.0	640	400	92	75	140	130	64	9.2	6.4	0.63	0.44
1F48	28.5	1200	720	130	110	180	150	85	14.0	10.0	0.73	0.55

Panel mark (CSA O325)	Minimum nominal thickness, mm	Bending stiffness, $B_b = EI$, N•mm²/mm		Axial stiffness (in tension or compression), $B_a = EA$, N/mm		Shear through-thickness rigidity, B_v, N/mm
		Capacities relative to major axis*				
		0°	90°	0°	90°	0° and 90°
2R24	9.5	560 000	100 000	44 000	33 000	10 000
1R24/2F16	11.0	730 000	140 000	48 000	36 000	11 000
2R32/2F16	12.0	1 100 000	220 000	55 000	36 000	11 000
2R40/2F20	15.0	2 100 000	500 000	66 000	38 000	12 000
2R48/2F24	18.0	3 800 000	820 000	77 000	44 000	13 000
1F16	15.0	1 400 000	300 000	56 000	36 000	11 000
1F20	15.0	2 000 000	360 000	56 000	38 000	11 000
1F24	18.0	2 800 000	720 000	75 000	44 000	12 000
1F32	22.0	6 100 000	2 100 000	99 000	55 000	15 000
1F48	28.5	11 000 000	4 400 000	108 000	61 000	20 000

**Orientation of applied force relative to panel's long direction.*

Notes:

(1) *For specified stiffness in bending on edge, use axial stiffness values.*

(2) *The tabulated values are based on dry service conditions and standard-term duration of load.*

(3) *The specified strength in bearing (normal to plane of panel), q_p, is* 4.2 MPa.

(4) *The design values do not apply to panels marked W only.*

Int. Shear wall Strength - Gypsum Wall Shear Strength (CSA O86-14 CL.11.5.1.d)

Design Basis

#1. Height of story doesn't exceed 3.6m
#2. Shearwalls using gypsum board has minimum panel dimension of 1200mm x 2400mm.
#3. Nails for gypsum board connection not placed less than 9mm from panel edge
#4. Blocked wall construction assumed in design calculation.

Given Parameters

Gypsum board thickness	$t_{gypsum} := 12\ mm$	
Fastener spacing along panel edge	$s = 100\ mm$	
Hold Down adjustment factor	$J_{hd} = 1$	Segment with hold down
Shear wall length	$L_s = 2078\ mm$	
Reduction factor	$\phi := 0.7$	

Table 11.5.4
Specified shear strength, v_d, for gypsum wallboard shearwalls, kN/m

Minimum nominal panel thickness, mm	Minimum nail and screw penetration in framing, mm	Wall construction	Panels applied directly to framing		
			Nail and screw spacing at panel edges, mm		
			200	150	100
12.5	19	Unblocked	1.2	1.4	1.6
12.5	19	Blocked	1.4	1.7	2.1
15.9	19	Unblocked	1.5	1.7	2.1
15.9	19	Blocked	1.7	2.2	2.5

Notes:

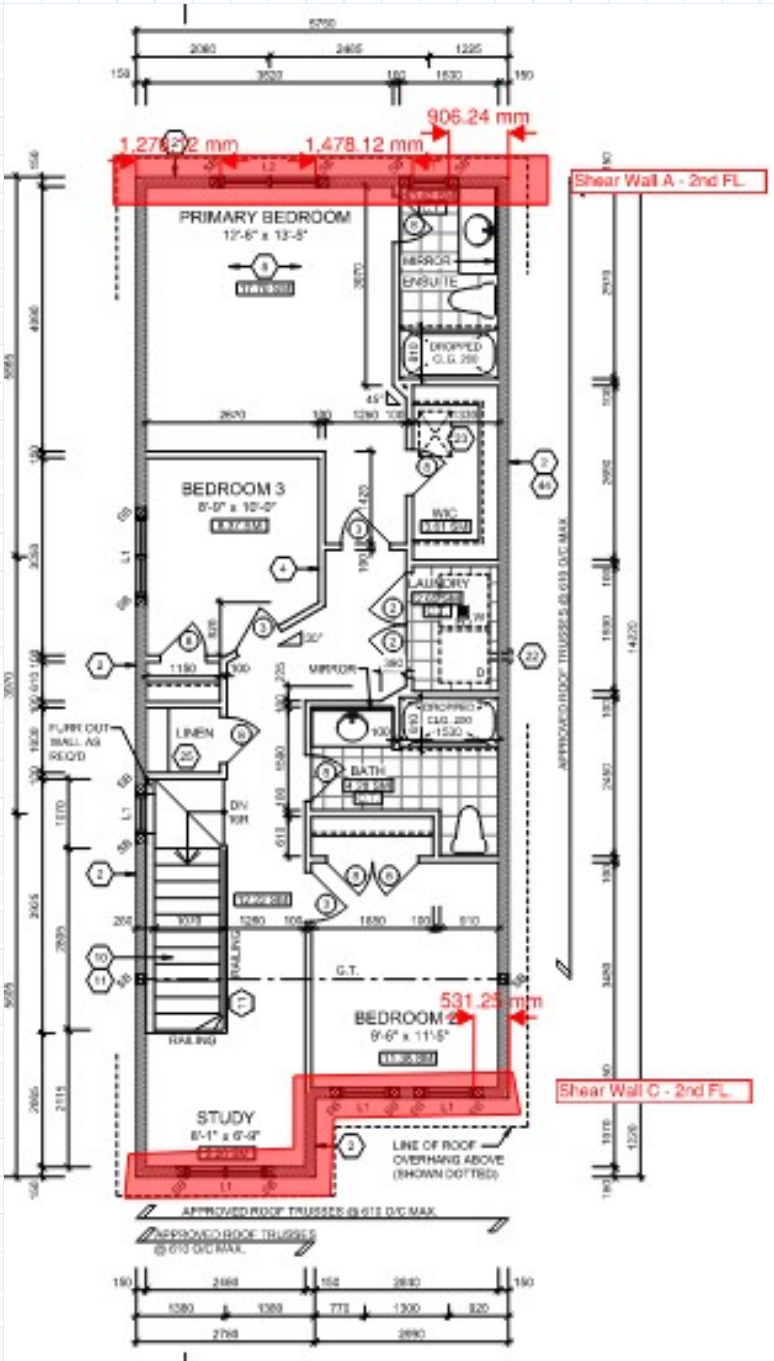
Shear Wall strength

Shear wall segment linear strength	$v_d := 1.6\ kN \cdot m^{-1}$	CSA O86-14 Table 11.5.4
Shear wall length	$L_s = 2.078\ m$	
Shear wall strength	$V_{rs3} := \phi \cdot v_d \cdot J_{hd} \cdot L_s = 2.327\ kN$	

Total Shear Strength

Total Factored Shear Strength	$V_r := min\left(V_{rs1}, V_{rs2}\right) + V_{rs3} = 25.605\ kN$	
Total Factored Load	$V_f = 27.958\ kN$	
	$CSR := \frac{V_f}{V_r} = 1.092$	**Design OK!** Upt 10% over accepatble

Shear wall A @ 2nd Floor



Floor Plane - 2nd Floor

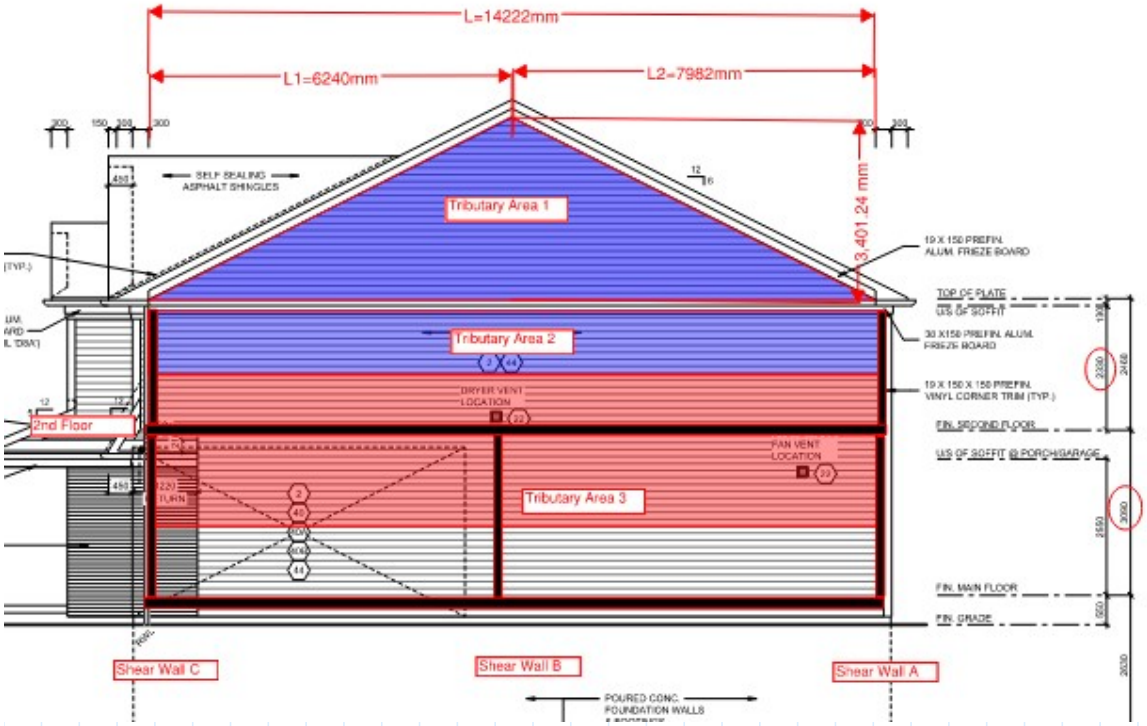
Design Parameters

Geometry Parameters

Building Overall Length	$L := 14222\ mm$
Buidilng Length 1	$L_1 := 6240\ mm$
Building Length 2	$L_{2;} := 7982\ mm$
Buidling Height - 1st FL.	$h_1 := 3090\ mm$
Building Height - 2nd FL.	$h_2 := 2330\ mm$
Roof Height	$h_{roof} := 3401\ mm$

Design Load Parameter

Design Wind Load (Unfactored) $p_{wl} := 0.88\ kPa$

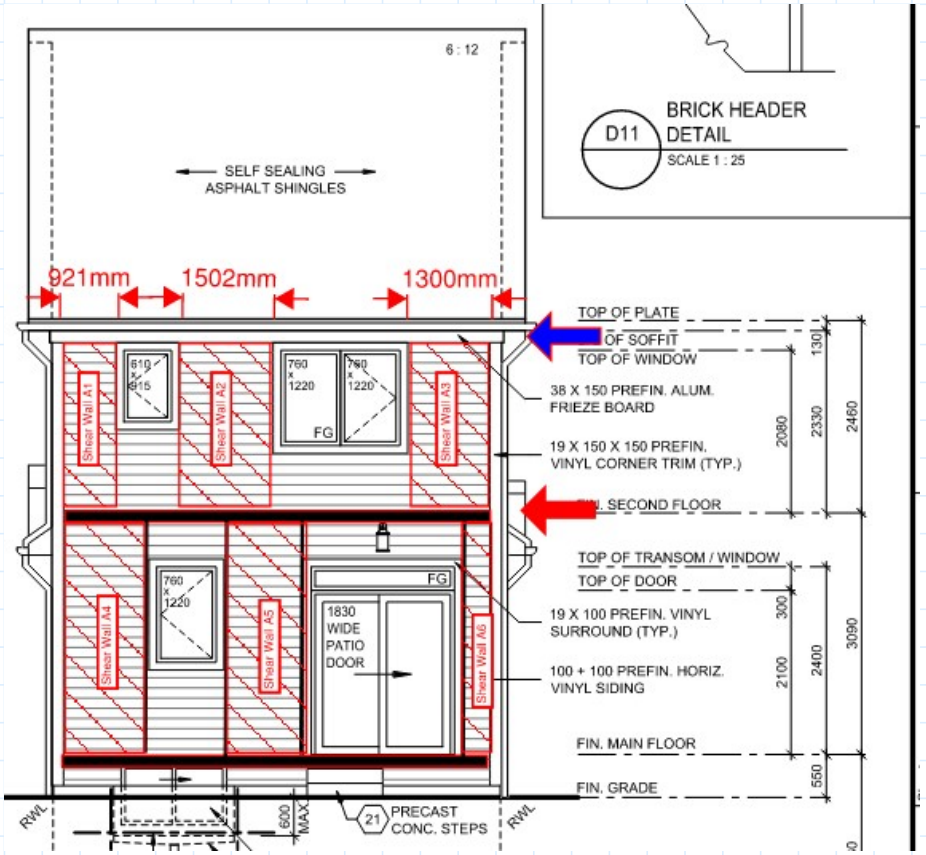


Load Calculation

Reaction Load - Tributary Area 1 $R_1 := \frac{(p_{wl} \cdot h_{roof} \cdot L)}{2} = 21.282\ kN$

Reaction Load - Tributary Area 2 $R_2 := \frac{(p_{wl} \cdot (0.5 \cdot h_2) \cdot L)}{2} = 7.29\ kN$

Factored Shear Load on 2nd FL. $V_f := 1.4 \cdot (R_1 + R_2) = 40.002\ kN$



Shear Wall @ 2nd Floor

Shear wall A1 Width $b_{a1} := 925\ mm$

Shear wall A2 Width $b_{a2} := 1502\ mm$

Shear wall A3 Width $b_{a3} := 1300\ mm$

Shear wall segment aspect ratio (CSA O86-14 CL.11.3.3.3)

Shear wall A1 Ratio

$$Ratio := \begin{cases} \text{if } \dfrac{h_2}{b_{a1}} \le 3.5 \\ \quad \text{“OK”} \\ \text{else} \\ \quad \text{“Need Reduction”} \end{cases} = \text{“OK”}$$

Shear wall A2 Ratio

$$Ratio := \begin{cases} \text{if } \dfrac{h_2}{b_{a2}} \le 3.5 \\ \quad \text{“OK”} \\ \text{else} \\ \quad \text{“Need Reduction”} \end{cases} = \text{“OK”}$$

Shear wall A3 Ratio

$$Ratio := \begin{cases} \text{if } \dfrac{h_2}{b_{a3}} \le 3.5 \\ \quad \text{“OK”} \\ \text{else} \\ \quad \text{“Need Reduction”} \end{cases} = \text{“OK”}$$

OSB Sheathing Nail Unit Lateral Strength Resistance (CSA O86-14 CL.12.9.4.1)

Design Basis

#1. Frame wall construction incoporates the 1/2" thickness of OSB sheathing at exterior side and 1/2" thickness of gypsum board interior side.
#2. Design screw diameter is 10D and spaced at 4" c/c along the panel edges.
#3. Blocked shear wall is assumed in the design calculation.
#4. Each segmented shear wall is assumed with hold down anchors to resist overtuning

Given Parameters

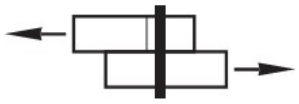
Nail Diameter	$d_f := 3.76\ mm$	10D
Relative Density	$G_{sheathing} := 0.42$	For OSB
Relative Density	$G_{stud} := 0.42$	Stud = Spruce-Pine-Fir
Strength of sheathing	$f_1 := 104 \cdot G_{sheathing} \cdot \left(1 - 0.1 \cdot d_f \cdot mm^{-1}\right) \cdot MPa = 27.256\ MPa$	
Strength of Stud	$f_2 := 50 \cdot G_{stud} \cdot \left(1 - 0.01 \cdot d_f \cdot mm^{-1}\right) \cdot MPa = 20.21\ MPa$	
Sheathing Thickness	$t_1 := 12\ mm$	1/2" Thk. OSB
Nail Embedment	$t_2 := 50\ mm$	2" embedment

Load Factors

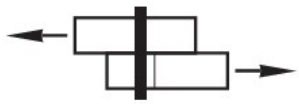
Load Duration Factor	$K_D := 1.15$	Wind = Short Term
Service Condtion Factor	$K_{SF} := 1.00$	Nail in Dry condition
Treatment Factor	$K_T := 1.00$	Pressure Treated Wood

Lateral Strenght (CSA O86-14 CL.12.9.4.1)

(a) $f_1 d_f t_1$



(b) $f_2 d_f t_2$



Shear Strength a	$V_a := f_1 \cdot d_f \cdot t_1 = 1.23\ kN$
Shear Strength b	$V_b := f_2 \cdot d_f \cdot t_2 = 3.8\ kN$
Lateral Strength	$n_u := min\left(V_a, V_b\right) = 1.23\ kN$
Factored lateral Strength	$N_u := n_u \cdot K_D \cdot K_{SF} \cdot K_T = 1.414\ kN$

Ext. Shear wall Strength - OSB panel Shear Strength (CSA O86-14 CL.11.5.1.b)

Given

Reduction Factor	$\phi := 0.8$	
lateral strength	$N_u = 1.414\ kN$	From previous calc.
Number of shear planes	$n_s := 1$	
Fastener spacing along panel edge	$s := 100\ mm$	4" spacing

Fastener spacing factor

Spacing Factor (CSA O86-14 CL.11.4.1)

$$J_s := \begin{cases} 1 & \text{if } s \geq 150\ mm \\ 1 - \left((150\ mm - s) \div 150\ mm \right)^{4.2} & \text{else if } 50\ mm \leq s < 150\ mm \\ \text{"Error"} & \text{else} \end{cases}$$

$J_s = 0.99$

Shear Wall Construction Factor

Shearwall construction factor (CSA O86-14 CL.12.9.4.1)

$J_D := 1.00$ Alll other cases

Unblocked Sheaer wall Factor

Factor for unblocked shearwall (CSA O86-14 CL.11.4.4)

$J_{us} := 1.0$ Blocked Shear wall assumed

Hold Down Factor

Hold-down effect factor (CSA O86-14 CL.11.4.5.)

$J_{hd} := 1.00$ Segment with hold down

Shear Wall strength

Shear wall segment linear strength $v_d := N_u \div s = 14.143\ kN \cdot m^{-1}$

Shear wall length $L_s := b_{a1} + b_{a2} + b_{a3} = 3.727\ m$

Shear wall strength $V_{rs1} := \phi \cdot v_d \cdot J_D \cdot n_s \cdot J_{us} \cdot J_s \cdot J_{hd} \cdot L_s = 41.75\ kN$

Ext. Shear wall Strength - OSB panel buckling Strength (CSA O86-14 CL.11.5.1.c)

Given

Panel Thickness	$t_1 = 12\ mm$	
Panel Smaller Dimension	$b := min\left(b_{a1}, b_{a2}, b_{a3}\right) = 925\ mm$	
Panel Larger Dimension	$a := h_2 = 2330\ mm$	
Shear wall length	$L_s = 3727\ mm$	
Reduction Factor	$\phi = 0.8$	
Service Condition Factor	$K_S := 1.0$	dry service
Load Duration Factor	$K_D = 1.15$	Wind = Short Term
Treatment Factor	$K_T = 1$	Pressure Treated Wood
Axial Stiffness 0° Orientation	$B_{a.0} := 55000\ MPa$	CSA O86-14 Table 9.3C
Axial Stiffness 90° Orientation	$B_{a.90} := 36000\ MPa$	CSA O86-14 Table 9.3C
Shear through thickness rigidity	$B_v := 11000\ MPa$	CSA O86-14 Table 9.3C

Panel Buckling Strength Calc.

Buckling Coefficient, η

$$\eta := \frac{\left(2 \cdot B_v\right)}{\sqrt{B_{a.0} \cdot B_{a.90}}} = 0.494$$

Buckling Coefficient, α

$$\alpha := \frac{a}{b} \cdot \left(\frac{B_{a.90}}{B_{a.0}}\right)^{\frac{1}{4}} = 2.266$$

Panel Buckling Factor

$$K_{pb} := 1.7 \cdot \left(\eta + 1\right) \cdot e^{\left(\frac{-\alpha}{0.05 \cdot \eta + 0.75}\right)} + \left(0.5 \cdot \eta + 0.8\right) = 1.184$$

Panel Buckling Strength

$$v_{pb} := K_{pb} \cdot \frac{\left(\pi^2 \cdot {t_1}^2\right)}{3000 \cdot b} \cdot \left(B_{a.0} \cdot {B_{a.90}}^3\right)^{\frac{1}{4}} = 24.262\ \frac{kN}{m}$$

Factored Panel buckling Strength

$$V_{rs2} := \phi \cdot v_{pb} \cdot K_D \cdot K_S \cdot K_T \cdot L_s = 83.19\ kN$$

Table 9.3C
Specified strength, stiffness, and rigidity capacities for construction sheathing OSB

Panel mark (CSA O325)	Minimum nominal thickness, mm	Bending, m_p, N•mm/mm		Axial tension, t_p, N/mm		Axial compression, p_p, N/mm		Shear-through-thickness, v_p, N/mm	Planar shear			
									Bending, v_{pb}, N/mm		Shear in-plane, v_{pf}, MPa	
		Capacities relative to major axis*										
		0°	90°	0°	90°	0°	90°	0° and 90°	0°	90°	0°	90°
2R24	9.5	180	57	53	18	62	54	42	3.8	2.4	0.60	0.38
1R24/2F16	11.0	240	68	60	30	71	54	46	4.4	2.4	0.60	0.33
2R32/2F16	12.0	270	100	65	38	77	67	50	4.8	3.0	0.60	0.38
2R40/2F20	15.0	460	160	67	48	92	87	55	6.1	3.8	0.61	0.38
2R48/2F24	18.0	630	240	92	59	110	94	60	7.8	4.4	0.65	0.37
1F16	15.0	310	100	60	43	87	78	47	5.2	3.3	0.52	0.33
1F20	15.0	360	150	67	48	92	87	54	6.1	3.9	0.61	0.39
1F24	18.0	480	230	77	59	110	94	59	7.8	4.5	0.65	0.37
1F32	22.0	640	400	92	75	140	130	64	9.2	6.4	0.63	0.44
1F48	28.5	1200	720	130	110	180	150	85	14.0	10.0	0.73	0.55

Panel mark (CSA O325)	Minimum nominal thickness, mm	Bending stiffness, $B_b = EI$, N•mm²/mm		Axial stiffness (in tension or compression), $B_a = EA$, N/mm		Shear through-thickness rigidity, B_v, N/mm
		Capacities relative to major axis*				
		0°	90°	0°	90°	0° and 90°
2R24	9.5	560 000	100 000	44 000	33 000	10 000
1R24/2F16	11.0	730 000	140 000	48 000	36 000	11 000
2R32/2F16	12.0	1 100 000	220 000	55 000	36 000	11 000
2R40/2F20	15.0	2 100 000	500 000	66 000	38 000	12 000
2R48/2F24	18.0	3 800 000	820 000	77 000	44 000	13 000
1F16	15.0	1 400 000	300 000	56 000	36 000	11 000
1F20	15.0	2 000 000	360 000	56 000	38 000	11 000
1F24	18.0	2 800 000	720 000	75 000	44 000	12 000
1F32	22.0	6 100 000	2 100 000	99 000	55 000	15 000
1F48	28.5	11 000 000	4 400 000	108 000	61 000	20 000

**Orientation of applied force relative to panel's long direction.*

Notes:

(1) *For specified stiffness in bending on edge, use axial stiffness values.*

(2) *The tabulated values are based on dry service conditions and standard-term duration of load.*

(3) *The specified strength in bearing (normal to plane of panel), q_p, is* 4.2 MPa.

(4) *The design values do not apply to panels marked W only.*

Int. Shear wall Strength - Gypsum Wall Shear Strength (CSA O86-14 CL.11.5.1.d)

Design Basis

#1. Height of story doesn't exceed 3.6m
#2. Shearwalls using gypsum board has minimum panel dimension of 1200mm x 2400mm.
#3. Nails for gypsum board connection not placed less than 9mm from panel edge
#4. Blocked wall construction assumed in design calculation.

Given Parameters

Gypsum board thickness	$t_{gypsum} := 12\ mm$	
Fastener spacing along panel edge	$s = 100\ mm$	
Hold Down adjustment factor	$J_{hd} = 1$	Segment with hold down
Shear wall length	$L_s = 3727\ mm$	
Reduction factor	$\phi := 0.7$	

Table 11.5.4
Specified shear strength, v_d, for gypsum wallboard shearwalls, kN/m

Minimum nominal panel thickness, mm	Minimum nail and screw penetration in framing, mm	Wall construction	Panels applied directly to framing		
			Nail and screw spacing at panel edges, mm		
			200	150	100
12.5	19	Unblocked	1.2	1.4	1.6
12.5	19	Blocked	1.4	1.7	2.1
15.9	19	Unblocked	1.5	1.7	2.1
15.9	19	Blocked	1.7	2.2	2.5

Notes:

Shear Wall strength

Shear wall segment linear strength	$v_d := 1.6\ kN \cdot m^{-1}$	CSA O86-14 Table 11.5.4
Shear wall length	$L_s = 3.727\ m$	
Shear wall strength	$V_{rs3} := \phi \cdot v_d \cdot J_{hd} \cdot L_s = 4.174\ kN$	

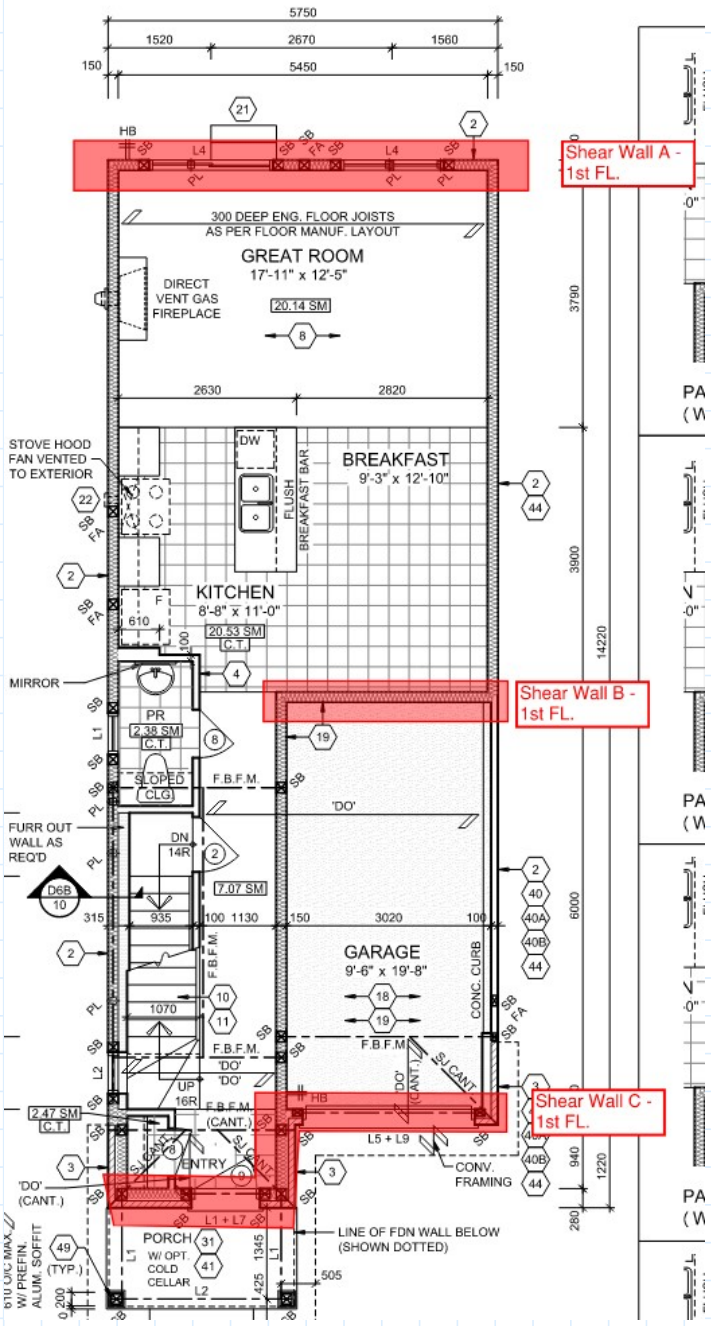
Total Shear Strength

Total Factored Shear Strength	$V_r := min\left(V_{rs1}, V_{rs2}\right) + V_{rs3} = 45.924\ kN$
Total Factored Load	$V_f = 40.002\ kN$

$$CSR := \frac{V_f}{V_r} = 0.871$$

Design OK!

Shear wall B @ 1st Floor



Floor Plane - 1st Floor

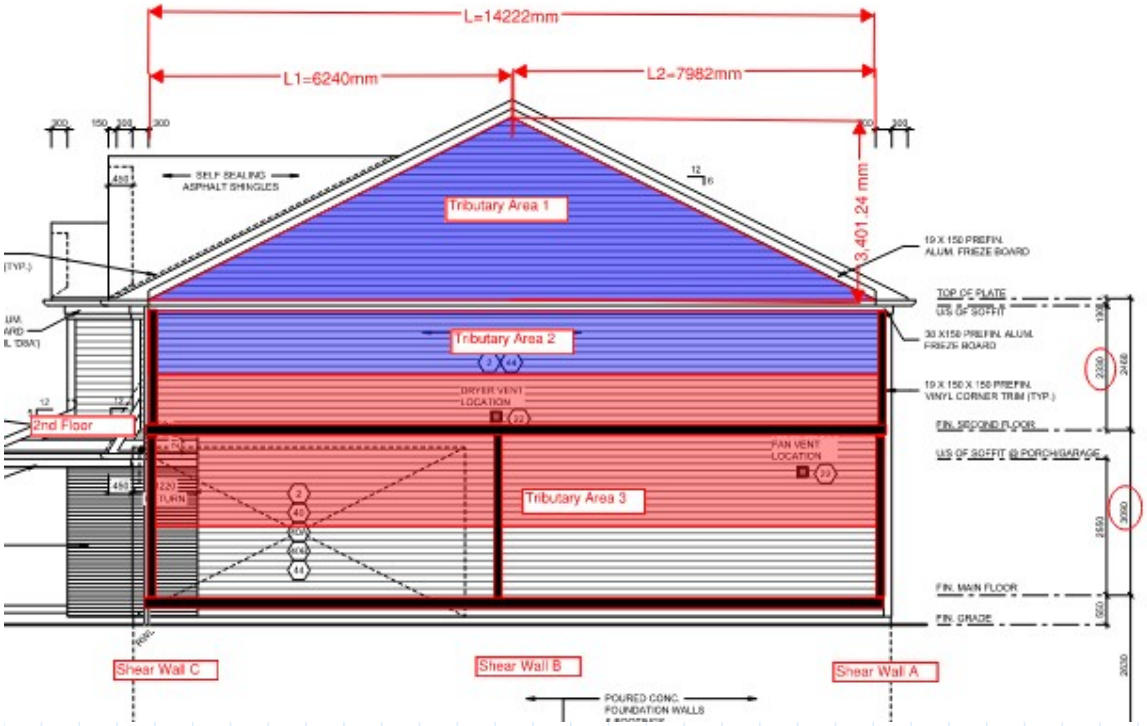
Design Parameters

Geometry Parameters

Building Overall Length	$L := 14222\ mm$
Buidilng Length 1	$L_1 := 6240\ mm$
Building Length 2	$L_{2;} := 7982\ mm$
Buidling Height - 1st FL.	$h_1 := 3090\ mm$
Building Height - 2nd FL.	$h_2 := 2330\ mm$
Roof Height	$h_{roof} := 3401\ mm$

Design Load Parameter

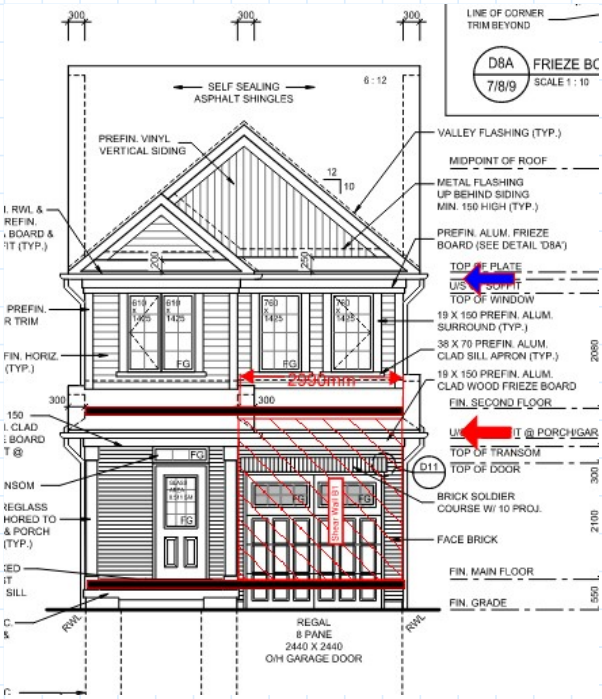
Design Wind Load (Unfactored) $p_{wl} := 0.88\ kPa$



Load Calculation

Reaction Load - Tributary Area 3 $$R_3 := \frac{3 \cdot \left(p_{wl} \cdot \left(0.5 \cdot h_2 + h_1\right) \cdot L\right)}{8} = 19.97\ kN$$

Factored Shear Load on 1st FL. $$V_f := 1.4 \cdot \left(R_3\right) = 27.958\ kN$$



Shear Wall @ 1st Floor

Shear wall B1 Width $b_{b1} := 2990\ mm$

Shear wall segment aspect ratio (CSA O86-14 CL.11.3.3.3)

Shear wall B1 Ratio

$$Ratio := \begin{cases} \text{if } \dfrac{h_1}{b_{b1}} \le 3.5 \\ \quad \text{“OK”} \\ \text{else} \\ \quad \text{“Not OK”} \end{cases} = \text{“OK”}$$

OSB Sheathing Nail Unit Lateral Strength Resistance (CSA O86-14 CL.12.9.4.1)

Design Basis

#1. Frame wall construction incoporates the 1/2" thickness of OSB sheathing at exterior side and 1/2" thickness of gypsum board interior side.
#2. Design screw diameter is 10D and spaced at 4" c/c along the panel edges.
#3. Blocked shear wall is assumed in the design calculation.
#4. Each segmented shear wall is assumed with hold down anchors to resist overtuning

Given Parameters

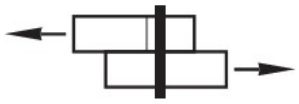
Nail Diameter	$d_f := 3.76\ mm$	10D
Relative Density	$G_{sheathing} := 0.42$	For OSB
Relative Density	$G_{stud} := 0.42$	Stud = Spruce-Pine-Fir
Strength of sheathing	$f_1 := 104 \cdot G_{sheathing} \cdot \left(1 - 0.1 \cdot d_f \cdot mm^{-1}\right) \cdot MPa = 27.256\ MPa$	
Strength of Stud	$f_2 := 50 \cdot G_{stud} \cdot \left(1 - 0.01 \cdot d_f \cdot mm^{-1}\right) \cdot MPa = 20.21\ MPa$	
Sheathing Thickness	$t_1 := 12\ mm$	1/2" Thk. OSB
Nail Embedment	$t_2 := 50\ mm$	2" embedment

Load Factors

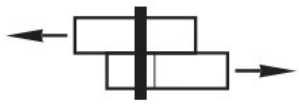
Load Duration Factor	$K_D := 1.15$	Wind = Short Term
Service Condtion Factor	$K_{SF} := 1.00$	Nail in Dry condition
Treatment Factor	$K_T := 1.00$	Pressure Treated Wood

Lateral Strenght (CSA O86-14 CL.12.9.4.1)

(a) $f_1 d_f t_1$



(b) $f_2 d_f t_2$



Shear Strength a	$V_a := f_1 \cdot d_f \cdot t_1 = 1.23\ kN$
Shear Strength b	$V_b := f_2 \cdot d_f \cdot t_2 = 3.8\ kN$
Lateral Strength	$n_u := min\left(V_a, V_b\right) = 1.23\ kN$
Factored lateral Strength	$N_u := n_u \cdot K_D \cdot K_{SF} \cdot K_T = 1.414\ kN$

Ext. Shear wall Strength - OSB panel Shear Strength (CSA O86-14 CL.11.5.1.b)

Given

Reduction Factor	$\phi := 0.8$	
lateral strength	$N_u = 1.414\ kN$	From previous calc.
Number of shear planes	$n_s := 1$	
Fastener spacing along panel edge	$s := 100\ mm$	4" spacing

Fastener spacing factor

Spacing Factor
(CSA O86-14 CL.11.4.1)

$$J_s := \begin{cases} 1 & \text{if } s \geq 150\ mm \\ 1 - \left(\left(150\ mm - s \right) \div 150\ mm \right)^{4.2} & \text{else if } 50\ mm \leq s < 150\ mm \\ \text{“Error”} & \text{else} \end{cases}$$

$$J_s = 0.99$$

Shear Wall Construction Factor

Shearwall construction factor
(CSA O86-14 CL.12.9.4.1)

$J_D := 1.00$ — Alll other cases

Unblocked Sheaer wall Factor

Factor for unblocked shearwall
(CSA O86-14 CL.11.4.4)

$J_{us} := 1.0$ — Blocked Shear wall assumed

Hold Down Factor

Hold-down effect factor
(CSA O86-14 CL.11.4.5.)

$J_{hd} := 1.00$ — Segment with hold down

Shear Wall strength

Shear wall segment linear strength

$$v_d := N_u \div s = 14.143\ kN \cdot m^{-1}$$

Shear wall length

$$L_s := b_{b1} = 2.99\ m$$

Shear wall strength

$$V_{rs1} := \phi \cdot v_d \cdot J_D \cdot n_s \cdot J_{us} \cdot J_s \cdot J_{hd} \cdot L_s = 33.494\ kN$$

Ext. Shear wall Strength - OSB panel buckling Strength (CSA O86-14 CL.11.5.1.c)

Given

Panel Thickness	$t_1 = 12\ mm$	
Panel Smaller Dimension	$b := min(b_{b1}) = 2990\ mm$	
Panel Larger Dimension	$a := h_2 = 2330\ mm$	
Shear wall length	$L_s = 2990\ mm$	
Reduction Factor	$\phi = 0.8$	
Service Condition Factor	$K_S := 1.0$	dry service
Load Duration Factor	$K_D = 1.15$	Wind = Short Term
Treatment Factor	$K_T = 1$	Pressure Treated Wood
Axial Stiffness 0° Orientation	$B_{a.0} := 55000\ MPa$	CSA O86-14 Table 9.3C
Axial Stiffness 90° Orientation	$B_{a.90} := 36000\ MPa$	CSA O86-14 Table 9.3C
Shear through thickness rigidity	$B_v := 11000\ MPa$	CSA O86-14 Table 9.3C

Panel Buckling Strength Calc.

Buckling Coefficient, η

$$\eta := \frac{(2 \cdot B_v)}{\sqrt{B_{a.0} \cdot B_{a.90}}} = 0.494$$

Buckling Coefficient, α

$$\alpha := \frac{a}{b} \cdot \left(\frac{B_{a.90}}{B_{a.0}}\right)^{\frac{1}{4}} = 0.701$$

Panel Buckling Factor

$$K_{pb} := 1.7 \cdot (\eta + 1) \cdot e^{\left(\frac{-\alpha}{0.05 \cdot \eta + 0.75}\right)} + (0.5 \cdot \eta + 0.8) = 2.075$$

Panel Buckling Strength

$$v_{pb} := K_{pb} \cdot \frac{(\pi^2 \cdot {t_1}^2)}{3000 \cdot b} \cdot \left(B_{a.0} \cdot {B_{a.90}}^3\right)^{\frac{1}{4}} = 13.16\ \frac{kN}{m}$$

Factored Panel buckling Strength

$$V_{rs2} := \phi \cdot v_{pb} \cdot K_D \cdot K_S \cdot K_T \cdot L_s = 36.2\ kN$$

Table 9.3C
Specified strength, stiffness, and rigidity capacities for construction sheathing OSB

Panel mark (CSA O325)	Minimum nominal thickness, mm	Bending, m_p, N•mm/mm		Axial tension, t_p, N/mm		Axial compression, p_p, N/mm		Shear-through-thickness, v_p, N/mm	Planar shear			
									Bending, v_{pb}, N/mm		Shear in-plane, v_{pf}, MPa	
		Capacities relative to major axis*										
		0°	90°	0°	90°	0°	90°	0° and 90°	0°	90°	0°	90°
2R24	9.5	180	57	53	18	62	54	42	3.8	2.4	0.60	0.38
1R24/2F16	11.0	240	68	60	30	71	54	46	4.4	2.4	0.60	0.33
2R32/2F16	12.0	270	100	65	38	77	67	50	4.8	3.0	0.60	0.38
2R40/2F20	15.0	460	160	67	48	92	87	55	6.1	3.8	0.61	0.38
2R48/2F24	18.0	630	240	92	59	110	94	60	7.8	4.4	0.65	0.37
1F16	15.0	310	100	60	43	87	78	47	5.2	3.3	0.52	0.33
1F20	15.0	360	150	67	48	92	87	54	6.1	3.9	0.61	0.39
1F24	18.0	480	230	77	59	110	94	59	7.8	4.5	0.65	0.37
1F32	22.0	640	400	92	75	140	130	64	9.2	6.4	0.63	0.44
1F48	28.5	1200	720	130	110	180	150	85	14.0	10.0	0.73	0.55

Panel mark (CSA O325)	Minimum nominal thickness, mm	Bending stiffness, $B_b = EI$, N•mm²/mm		Axial stiffness (in tension or compression), $B_a = EA$, N/mm		Shear through-thickness rigidity, B_v, N/mm
		Capacities relative to major axis*				
		0°	90°	0°	90°	0° and 90°
2R24	9.5	560 000	100 000	44 000	33 000	10 000
1R24/2F16	11.0	730 000	140 000	48 000	36 000	11 000
2R32/2F16	12.0	1 100 000	220 000	55 000	36 000	11 000
2R40/2F20	15.0	2 100 000	500 000	66 000	38 000	12 000
2R48/2F24	18.0	3 800 000	820 000	77 000	44 000	13 000
1F16	15.0	1 400 000	300 000	56 000	36 000	11 000
1F20	15.0	2 000 000	360 000	56 000	38 000	11 000
1F24	18.0	2 800 000	720 000	75 000	44 000	12 000
1F32	22.0	6 100 000	2 100 000	99 000	55 000	15 000
1F48	28.5	11 000 000	4 400 000	108 000	61 000	20 000

**Orientation of applied force relative to panel's long direction.*

Notes:

(1) *For specified stiffness in bending on edge, use axial stiffness values.*

(2) *The tabulated values are based on dry service conditions and standard-term duration of load.*

(3) *The specified strength in bearing (normal to plane of panel), q_p, is* 4.2 MPa.

(4) *The design values do not apply to panels marked W only.*

Int. Shear wall Strength - Gypsum Wall Shear Strength (CSA O86-14 CL.11.5.1.d)

Design Basis

#1. Height of story doesn't exceed 3.6m
#2. Shearwalls using gypsum board has minimum panel dimension of 1200mm x 2400mm.
#3. Nails for gypsum board connection not placed less than 9mm from panel edge
#4. Blocked wall construction assumed in design calculation.

Given Parameters

Gypsum board thickness	$t_{gypsum} := 12\ mm$	
Fastener spacing along panel edge	$s = 100\ mm$	
Hold Down adjustment factor	$J_{hd} = 1$	Segment with hold down
Shear wall length	$L_s = 2990\ mm$	
Reduction factor	$\phi := 0.7$	

Table 11.5.4
Specified shear strength, v_d, for gypsum wallboard shearwalls, kN/m

Minimum nominal panel thickness, mm	Minimum nail and screw penetration in framing, mm	Wall construction	Panels applied directly to framing		
			Nail and screw spacing at panel edges, mm		
			200	150	100
12.5	19	Unblocked	1.2	1.4	1.6
12.5	19	Blocked	1.4	1.7	2.1
15.9	19	Unblocked	1.5	1.7	2.1
15.9	19	Blocked	1.7	2.2	2.5

Notes:

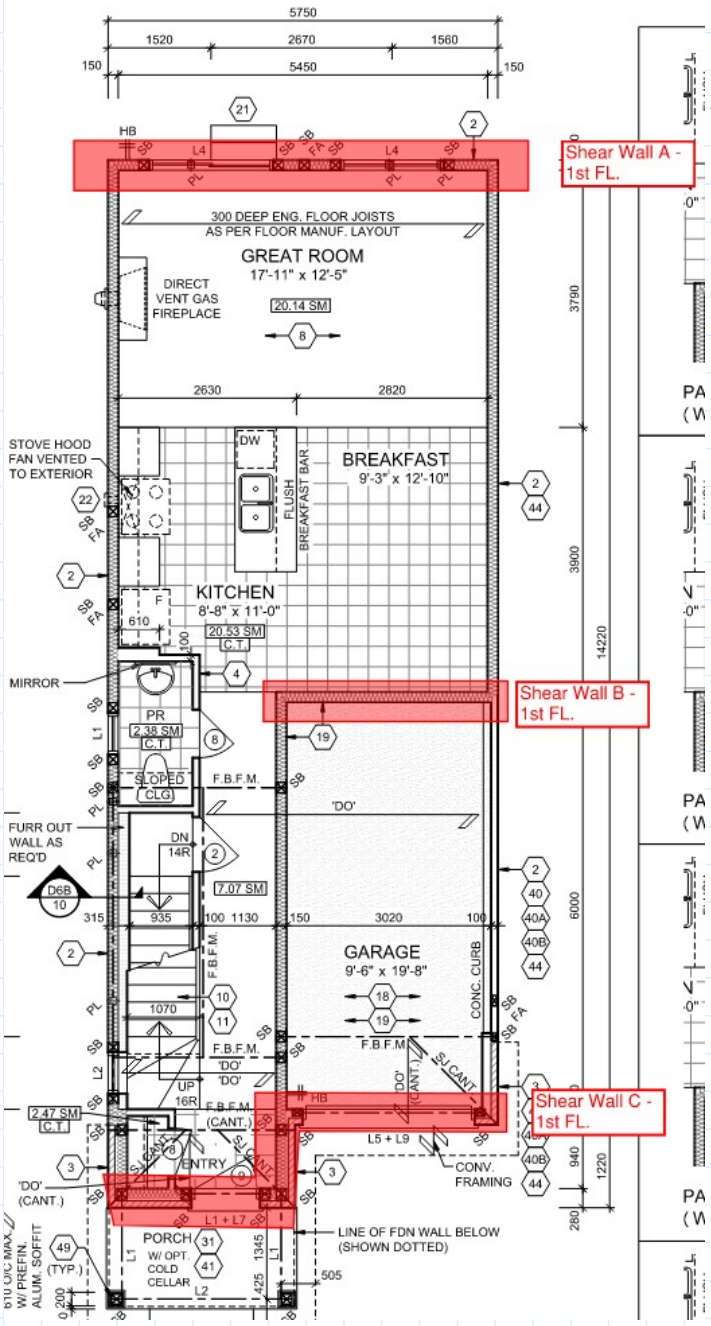
Shear Wall strength

Shear wall segment linear strength	$v_d := 1.6\ kN \cdot m^{-1}$	CSA O86-14 Table 11.5.4
Shear wall length	$L_s = 2.99\ m$	
Shear wall strength	$V_{rs3} := \phi \cdot v_d \cdot J_{hd} \cdot L_s = 3.349\ kN$	

Total Shear Strength

Total Factored Shear Strength	$V_r := min\left(V_{rs1}, V_{rs2}\right) + V_{rs3} = 36.843\ kN$	
Total Factored Load	$V_f = 27.958\ kN$	
	$CSR := \frac{V_f}{V_r} = 0.759$	**Design OK!**

Shear wall C @ 1st Floor



Floor Plane - 1st Floor

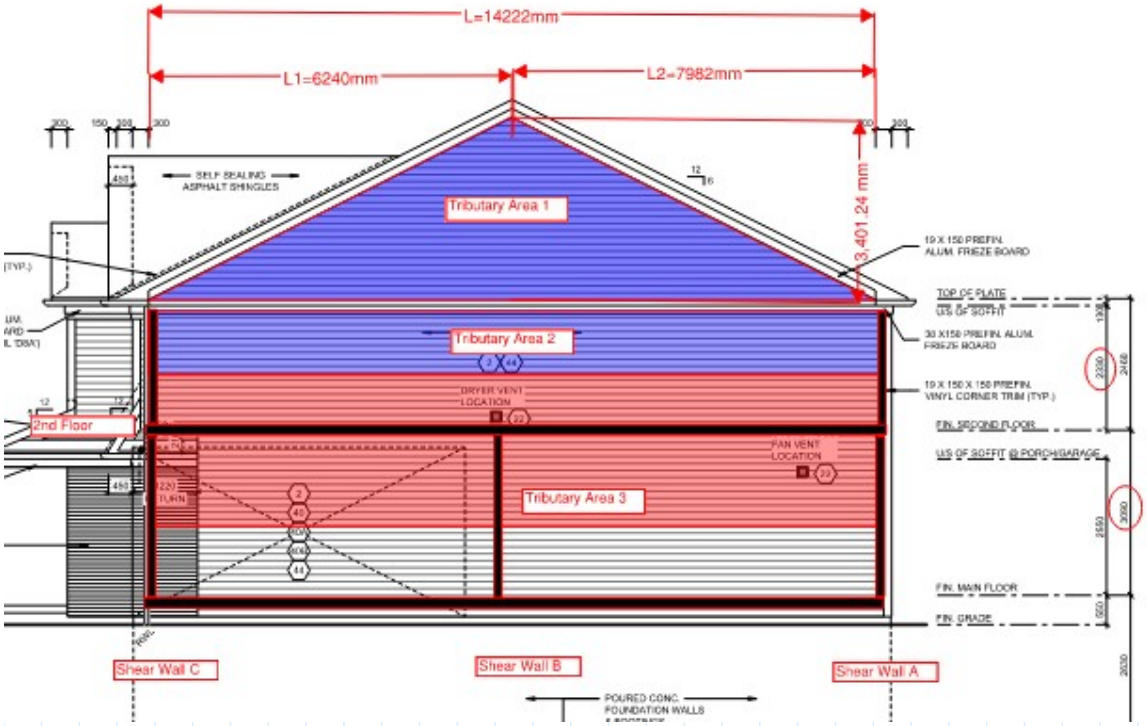
Design Parameters

Geometry Parameters

Building Overall Length	$L := 14222\ mm$
Buidilng Length 1	$L_1 := 6240\ mm$
Building Length 2	$L_{2;} := 7982\ mm$
Buidling Height - 1st FL.	$h_1 := 3090\ mm$
Building Height - 2nd FL.	$h_2 := 2330\ mm$
Roof Height	$h_{roof} := 3401\ mm$

Design Load Parameter

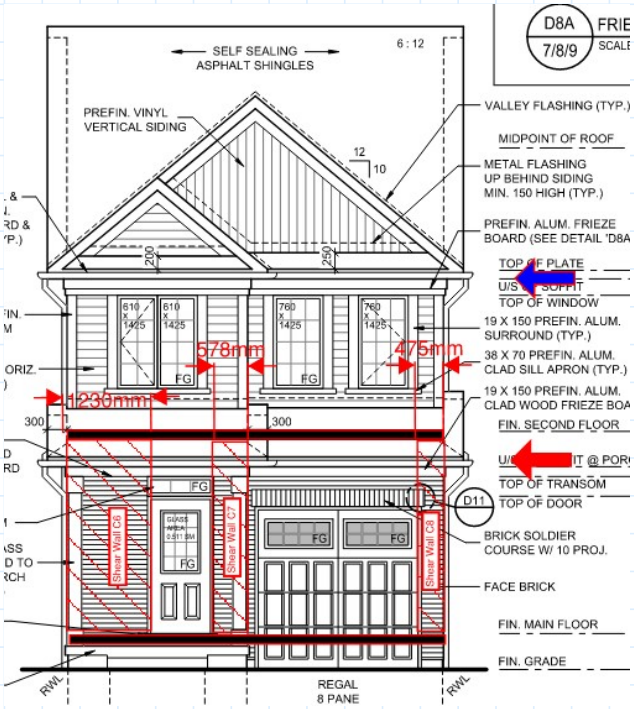
Design Wind Load (Unfactored) $p_{wl} := 0.88\ kPa$



Load Calculation

Reaction Load - Tributary Area 3 $$R_3 := \frac{3 \cdot \left(p_{wl} \cdot \left(0.5 \cdot h_2 + h_1\right) \cdot L\right)}{8} = 19.97\ kN$$

Factored Shear Load on 1st FL. $$V_f := 1.4 \cdot \left(R_3\right) = 27.958\ kN$$



Shear Wall @ 1st Floor

Shear wall C6 Width $b_{c6} := 1230\ mm$

Shear wall C7 Width $b_{c7} := 578\ mm$

Shear wall C8 Width $b_{c8} := 475\ mm$

Shear wall segment aspect ratio (CSA O86-14 CL.11.3.3.3)

Shear wall C6 Ratio

$$Ratio := \begin{cases} \text{if } \dfrac{h_1}{b_{c6}} \le 3.5 \\ \quad \text{“OK”} \\ \text{else} \\ \quad \text{“Not OK”} \end{cases} = \text{“OK”}$$

Shear wall C7 Ratio

$$Ratio := \begin{cases} \text{if } \dfrac{h_1}{b_{c7}} \le 3.5 \\ \quad \text{“OK”} \\ \text{else} \\ \quad \text{“Not OK”} \end{cases} = \text{“Not OK”}$$

Shear wall C8 Ratio

$$Ratio := \begin{cases} \text{if } \dfrac{h_1}{b_{c8}} \le 3.5 \\ \quad \text{“OK”} \\ \text{else} \\ \quad \text{“Not OK”} \end{cases} = \text{“Not OK”}$$

OSB Sheathing Nail Unit Lateral Strength Resistance (CSA O86-14 CL.12.9.4.1)

Design Basis

#1. Frame wall construction incoporates the 1/2" thickness of OSB sheathing at exterior side and 1/2" thickness of gypsum board interior side.
#2. Design screw diameter is 10D and spaced at 4" c/c along the panel edges.
#3. Blocked shear wall is assumed in the design calculation.
#4. Each segmented shear wall is assumed with hold down anchors to resist overtuning

Given Parameters

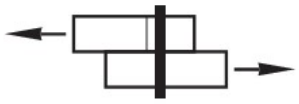
Nail Diameter	$d_f := 3.76\ mm$	10D
Relative Density	$G_{sheathing} := 0.42$	For OSB
Relative Density	$G_{stud} := 0.42$	Stud = Spruce-Pine-Fir
Strength of sheathing	$f_1 := 104 \cdot G_{sheathing} \cdot \left(1 - 0.1 \cdot d_f \cdot mm^{-1}\right) \cdot MPa = 27.256\ MPa$	
Strength of Stud	$f_2 := 50 \cdot G_{stud} \cdot \left(1 - 0.01 \cdot d_f \cdot mm^{-1}\right) \cdot MPa = 20.21\ MPa$	
Sheathing Thickness	$t_1 := 12\ mm$	1/2" Thk. OSB
Nail Embedment	$t_2 := 50\ mm$	2" embedment

Load Factors

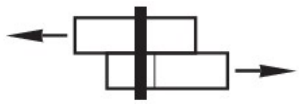
Load Duration Factor	$K_D := 1.15$	Wind = Short Term
Service Condtion Factor	$K_{SF} := 1.00$	Nail in Dry condition
Treatment Factor	$K_T := 1.00$	Pressure Treated Wood

Lateral Strenght (CSA O86-14 CL.12.9.4.1)

(a) $f_1 d_f t_1$



(b) $f_2 d_f t_2$



Shear Strength a	$V_a := f_1 \cdot d_f \cdot t_1 = 1.23\ kN$
Shear Strength b	$V_b := f_2 \cdot d_f \cdot t_2 = 3.8\ kN$
Lateral Strength	$n_u := min\left(V_a, V_b\right) = 1.23\ kN$
Factored lateral Strength	$N_u := n_u \cdot K_D \cdot K_{SF} \cdot K_T = 1.414\ kN$

Ext. Shear wall Strength - OSB panel Shear Strength (CSA O86-14 CL.11.5.1.b)

Given

Reduction Factor	$\phi := 0.8$	
lateral strength	$N_u = 1.414\ kN$	From previous calc.
Number of shear planes	$n_s := 1$	
Fastener spacing along panel edge	$s := 100\ mm$	4" spacing

Fastener spacing factor

Spacing Factor (CSA O86-14 CL.11.4.1)

$$J_s := \begin{cases} 1 & \text{if } s \geq 150\ mm \\ 1 - \left((150\ mm - s) \div 150\ mm \right)^{4.2} & \text{else if } 50\ mm \leq s < 150\ mm \\ \text{"Error"} & \text{else} \end{cases}$$

$J_s = 0.99$

Shear Wall Construction Factor

Shearwall construction factor (CSA O86-14 CL.12.9.4.1)

$J_D := 1.00$ Alll other cases

Unblocked Sheaer wall Factor

Factor for unblocked shearwall (CSA O86-14 CL.11.4.4)

$J_{us} := 1.0$ Blocked Shear wall assumed

Hold Down Factor

Hold-down effect factor (CSA O86-14 CL.11.4.5.)

$J_{hd} := 1.00$ Segment with hold down

Shear Wall strength

Shear wall segment linear strength $v_d := N_u \div s = 14.143\ kN \cdot m^{-1}$

Shear wall length $L_s := b_{c6} = 1.23\ m$

Shear wall strength $V_{rs1} := \phi \cdot v_d \cdot J_D \cdot n_s \cdot J_{us} \cdot J_s \cdot J_{hd} \cdot L_s = 13.779\ kN$

Ext. Shear wall Strength - OSB panel buckling Strength (CSA O86-14 CL.11.5.1.c)

Given

Panel Thickness	$t_1 = 12\ mm$	
Panel Smaller Dimension	$b := min(b_{c6}) = 1230\ mm$	
Panel Larger Dimension	$a := h_2 = 2330\ mm$	
Shear wall length	$L_s = 1230\ mm$	
Reduction Factor	$\phi = 0.8$	
Service Condition Factor	$K_S := 1.0$	dry service
Load Duration Factor	$K_D = 1.15$	Wind = Short Term
Treatment Factor	$K_T = 1$	Pressure Treated Wood
Axial Stiffness 0° Orientation	$B_{a.0} := 55000\ MPa$	CSA O86-14 Table 9.3C
Axial Stiffness 90° Orientation	$B_{a.90} := 36000\ MPa$	CSA O86-14 Table 9.3C
Shear through thickness rigidity	$B_v := 11000\ MPa$	CSA O86-14 Table 9.3C

Panel Buckling Strength Calc.

Buckling Coefficient, η

$$\eta := \frac{(2 \cdot B_v)}{\sqrt{B_{a.0} \cdot B_{a.90}}} = 0.494$$

Buckling Coefficient, α

$$\alpha := \frac{a}{b} \cdot \left(\frac{B_{a.90}}{B_{a.0}}\right)^{\frac{1}{4}} = 1.704$$

Panel Buckling Factor

$$K_{pb} := 1.7 \cdot (\eta + 1) \cdot e^{\left(\frac{-\alpha}{0.05 \cdot \eta + 0.75}\right)} + (0.5 \cdot \eta + 0.8) = 1.329$$

Panel Buckling Strength

$$v_{pb} := K_{pb} \cdot \frac{(\pi^2 \cdot {t_1}^2)}{3000 \cdot b} \cdot \left(B_{a.0} \cdot {B_{a.90}}^3\right)^{\frac{1}{4}} = 20.485\ \frac{kN}{m}$$

Factored Panel buckling Strength

$$V_{rs2} := \phi \cdot v_{pb} \cdot K_D \cdot K_S \cdot K_T \cdot L_s = 23.181\ kN$$

Table 9.3C
Specified strength, stiffness, and rigidity capacities for construction sheathing OSB

Panel mark (CSA O325)	Minimum nominal thickness, mm	Bending, m_p, N•mm/mm		Axial tension, t_p, N/mm		Axial compression, p_p, N/mm		Shear-through-thickness, v_p, N/mm	Planar shear			
									Bending, v_{pb}, N/mm		Shear in-plane, v_{pf}, MPa	
		Capacities relative to major axis*										
		0°	90°	0°	90°	0°	90°	0° and 90°	0°	90°	0°	90°
2R24	9.5	180	57	53	18	62	54	42	3.8	2.4	0.60	0.38
1R24/2F16	11.0	240	68	60	30	71	54	46	4.4	2.4	0.60	0.33
2R32/2F16	12.0	270	100	65	38	77	67	50	4.8	3.0	0.60	0.38
2R40/2F20	15.0	460	160	67	48	92	87	55	6.1	3.8	0.61	0.38
2R48/2F24	18.0	630	240	92	59	110	94	60	7.8	4.4	0.65	0.37
1F16	15.0	310	100	60	43	87	78	47	5.2	3.3	0.52	0.33
1F20	15.0	360	150	67	48	92	87	54	6.1	3.9	0.61	0.39
1F24	18.0	480	230	77	59	110	94	59	7.8	4.5	0.65	0.37
1F32	22.0	640	400	92	75	140	130	64	9.2	6.4	0.63	0.44
1F48	28.5	1200	720	130	110	180	150	85	14.0	10.0	0.73	0.55

Panel mark (CSA O325)	Minimum nominal thickness, mm	Bending stiffness, $B_b = EI$, N•mm²/mm		Axial stiffness (in tension or compression), $B_a = EA$, N/mm		Shear through-thickness rigidity, B_v, N/mm
		Capacities relative to major axis*				
		0°	90°	0°	90°	0° and 90°
2R24	9.5	560 000	100 000	44 000	33 000	10 000
1R24/2F16	11.0	730 000	140 000	48 000	36 000	11 000
2R32/2F16	12.0	1 100 000	220 000	55 000	36 000	11 000
2R40/2F20	15.0	2 100 000	500 000	66 000	38 000	12 000
2R48/2F24	18.0	3 800 000	820 000	77 000	44 000	13 000
1F16	15.0	1 400 000	300 000	56 000	36 000	11 000
1F20	15.0	2 000 000	360 000	56 000	38 000	11 000
1F24	18.0	2 800 000	720 000	75 000	44 000	12 000
1F32	22.0	6 100 000	2 100 000	99 000	55 000	15 000
1F48	28.5	11 000 000	4 400 000	108 000	61 000	20 000

**Orientation of applied force relative to panel's long direction.*

Notes:

(1) *For specified stiffness in bending on edge, use axial stiffness values.*

(2) *The tabulated values are based on dry service conditions and standard-term duration of load.*

(3) *The specified strength in bearing (normal to plane of panel), q_p, is* 4.2 MPa.

(4) *The design values do not apply to panels marked W only.*

Int. Shear wall Strength - Gypsum Wall Shear Strength (CSA O86-14 CL.11.5.1.d)

Design Basis

#1. Height of story doesn't exceed 3.6m
#2. Shearwalls using gypsum board has minimum panel dimension of 1200mm x 2400mm.
#3. Nails for gypsum board connection not placed less than 9mm from panel edge
#4. Blocked wall construction assumed in design calculation.

Given Parameters

Gypsum board thickness	$t_{gypsum} := 12\ mm$	
Fastener spacing along panel edge	$s = 100\ mm$	
Hold Down adjustment factor	$J_{hd} = 1$	Segment with hold down
Shear wall length	$L_s = 1230\ mm$	
Reduction factor	$\phi := 0.7$	

Table 11.5.4
Specified shear strength, v_d, for gypsum wallboard shearwalls, kN/m

Minimum nominal panel thickness, mm	Minimum nail and screw penetration in framing, mm	Wall construction	Panels applied directly to framing		
			Nail and screw spacing at panel edges, mm		
			200	150	100
12.5	19	Unblocked	1.2	1.4	1.6
12.5	19	Blocked	1.4	1.7	2.1
15.9	19	Unblocked	1.5	1.7	2.1
15.9	19	Blocked	1.7	2.2	2.5

Notes:

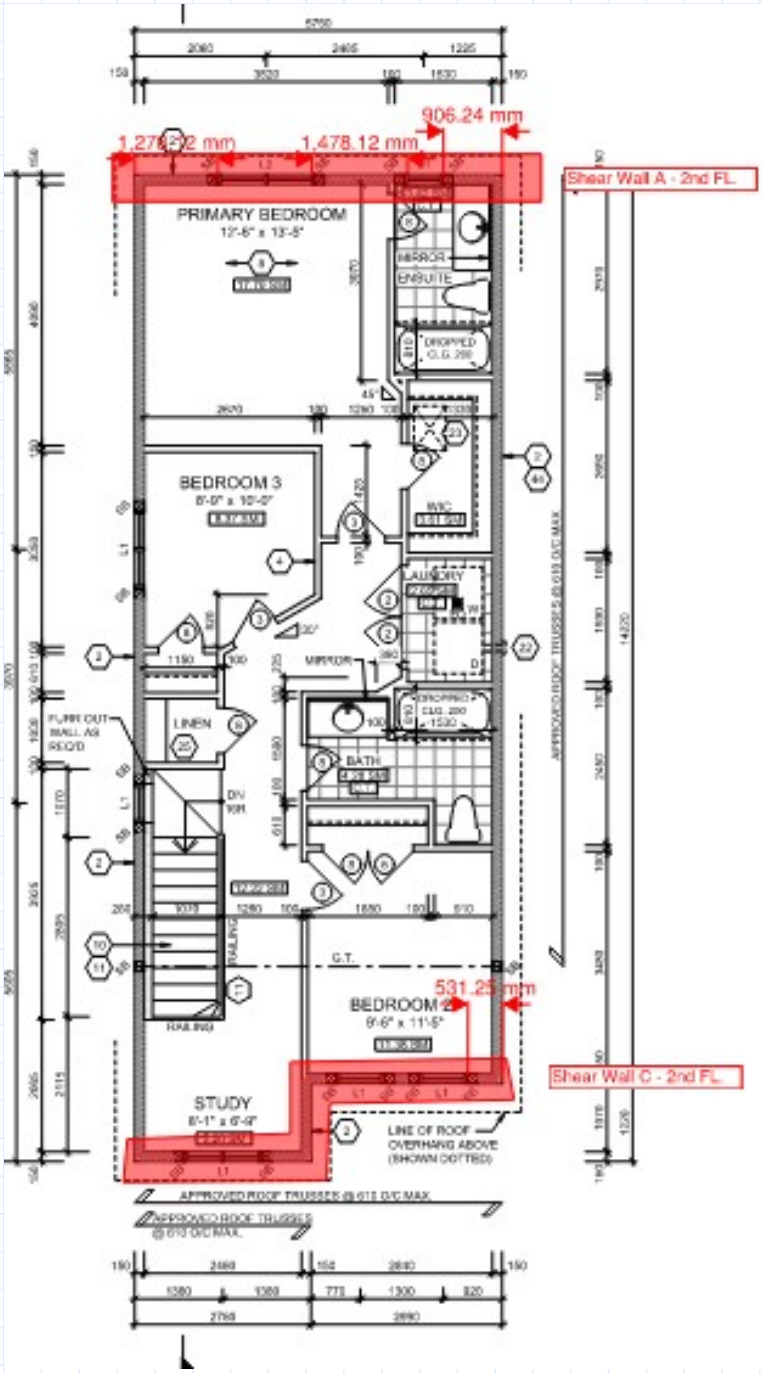
Shear Wall strength

Shear wall segment linear strength	$v_d := 1.6\ kN \cdot m^{-1}$	CSA O86-14 Table 11.5.4
Shear wall length	$L_s = 1.23\ m$	
Shear wall strength	$V_{rs3} := \phi \cdot v_d \cdot J_{hd} \cdot L_s = 1.378\ kN$	

Total Shear Strength

Total Factored Shear Strength	$V_r := min\left(V_{rs1}, V_{rs2}\right) + V_{rs3} = 15.156\ kN$	
Total Factored Load	$V_f = 27.958\ kN$	
	$CSR := \frac{V_f}{V_r} = 1.845$	**Design Not OK!**

Shear wall C @ 2nd Floor



Floor Plane - 2nd Floor

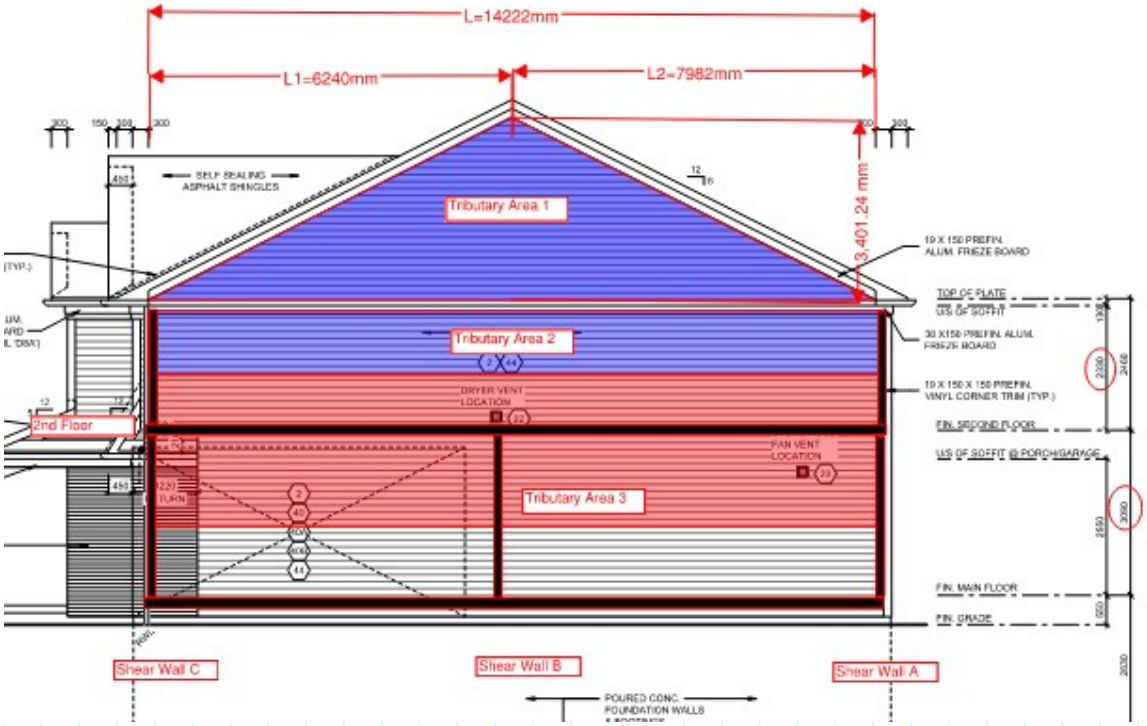
Design Parameters

Geometry Parameters

Building Overall Length	$L := 14222\ mm$
Buidilng Length 1	$L_1 := 6240\ mm$
Building Length 2	$L_{2;} := 7982\ mm$
Buidling Height - 1st FL.	$h_1 := 3090\ mm$
Building Height - 2nd FL.	$h_2 := 2330\ mm$
Roof Height	$h_{roof} := 3401\ mm$

Design Load Parameter

Design Wind Load (Unfactored) $p_{wl} := 0.88\ kPa$

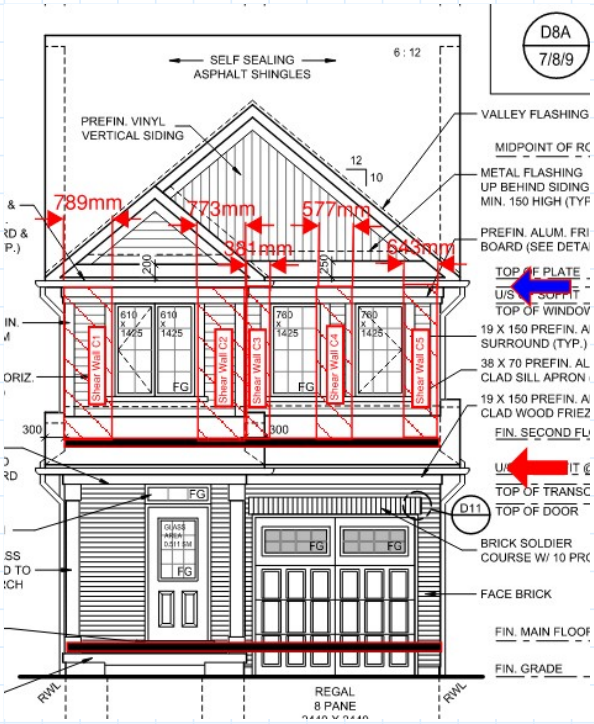


Load Calculation

Reaction Load - Tributary Area 1 $R_1 := \frac{(p_{wl} \cdot h_{roof} \cdot L)}{2} = 21.282\ kN$

Reaction Load - Tributary Area 2 $R_2 := \frac{(p_{wl} \cdot (0.5 \cdot h_2) \cdot L)}{2} = 7.29\ kN$

Factored Shear Load on 2nd FL. $V_f := 1.4 \cdot (R_1 + R_2) = 40.002\ kN$



Shear Wall @ 2nd Floor

Shear wall C1 Width $b_{c1} := 740\ mm$

Shear wall C2 Width $b_{c2} := 740\ mm$

Shear wall C3 Width $b_{c3} := 404\ mm$

Shear wall C4 Width $b_{c4} := 584\ mm$

Shear wall C5 Width $b_{c5} := 540\ mm$

Shear wall segment aspect ratio (CSA O86-14 CL.11.3.3.3)

Shear wall C1 Ratio

$$Ratio := \begin{cases} \text{if } \frac{h_2}{b_{c1}} \le 3.5 \\ \quad \text{“OK”} \\ \text{else} \\ \quad \text{“Not OK”} \end{cases} = \text{“OK”}$$

Shear wall C2 Ratio

$$Ratio := \begin{cases} \text{if } \frac{h_2}{b_{c2}} \le 3.5 \\ \quad \text{“OK”} \\ \text{else} \\ \quad \text{“Not Ok”} \end{cases} = \text{“OK”}$$

Shear wall C3 Ratio

$$Ratio := \begin{cases} \text{if } \frac{h_2}{b_{c3}} \le 3.5 \\ \quad \text{“OK”} \\ \text{else} \\ \quad \text{“Not OK”} \end{cases} = \text{“Not OK”}$$

Shear wall C4 Ratio

$$Ratio := \begin{cases} \text{if } \frac{h_2}{b_{c4}} \le 3.5 \\ \quad \text{“OK”} \\ \text{else} \\ \quad \text{“Not OK”} \end{cases} = \text{“Not OK”}$$

Shear wall C5 Ratio

$$Ratio := \begin{cases} \text{if } \frac{h_2}{b_{c5}} \le 3.5 \\ \quad \text{“OK”} \\ \text{else} \\ \quad \text{“Not OK”} \end{cases} = \text{“Not OK”}$$

OSB Sheathing Nail Unit Lateral Strength Resistance (CSA O86-14 CL.12.9.4.1)

Design Basis

#1. Frame wall construction incoporates the 1/2" thickness of OSB sheathing at exterior side and 1/2" thickness of gypsum board interior side.
#2. Design screw diameter is 10D and spaced at 4" c/c along the panel edges.
#3. Blocked shear wall is assumed in the design calculation.
#4. Each segmented shear wall is assumed with hold down anchors to resist overtuning

Given Parameters

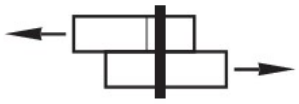
Nail Diameter	$d_f := 3.76\ mm$	10D
Relative Density	$G_{sheathing} := 0.42$	For OSB
Relative Density	$G_{stud} := 0.42$	Stud = Spruce-Pine-Fir
Strength of sheathing	$f_1 := 104 \cdot G_{sheathing} \cdot \left(1 - 0.1 \cdot d_f \cdot mm^{-1}\right) \cdot MPa = 27.256\ MPa$	
Strength of Stud	$f_2 := 50 \cdot G_{stud} \cdot \left(1 - 0.01 \cdot d_f \cdot mm^{-1}\right) \cdot MPa = 20.21\ MPa$	
Sheathing Thickness	$t_1 := 12\ mm$	1/2" Thk. OSB
Nail Embedment	$t_2 := 50\ mm$	2" embedment

Load Factors

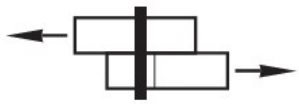
Load Duration Factor	$K_D := 1.15$	Wind = Short Term
Service Condtion Factor	$K_{SF} := 1.00$	Nail in Dry condition
Treatment Factor	$K_T := 1.00$	Pressure Treated Wood

Lateral Strenght (CSA O86-14 CL.12.9.4.1)

(a) $f_1 d_f t_1$



(b) $f_2 d_f t_2$



Shear Strength a	$V_a := f_1 \cdot d_f \cdot t_1 = 1.23\ kN$
Shear Strength b	$V_b := f_2 \cdot d_f \cdot t_2 = 3.8\ kN$
Lateral Strength	$n_u := min\left(V_a, V_b\right) = 1.23\ kN$
Factored lateral Strength	$N_u := n_u \cdot K_D \cdot K_{SF} \cdot K_T = 1.414\ kN$

Ext. Shear wall Strength - OSB panel Shear Strength (CSA O86-14 CL.11.5.1.b)

Given

Reduction Factor	$\phi := 0.8$	
lateral strength	$N_u = 1.414\ kN$	From previous calc.
Number of shear planes	$n_s := 1$	
Fastener spacing along panel edge	$s := 100\ mm$	4" spacing

Fastener spacing factor

Spacing Factor (CSA O86-14 CL.11.4.1)

$$J_s := \begin{cases} 1 & \text{if } s \geq 150\ mm \\ 1 - \left((150\ mm - s) \div 150\ mm \right)^{4.2} & \text{else if } 50\ mm \leq s < 150\ mm \\ \text{"Error"} & \text{else} \end{cases}$$

$J_s = 0.99$

Shear Wall Construction Factor

Shearwall construction factor (CSA O86-14 CL.12.9.4.1)

$J_D := 1.00$ Alll other cases

Unblocked Sheaer wall Factor

Factor for unblocked shearwall (CSA O86-14 CL.11.4.4)

$J_{us} := 1.0$ Blocked Shear wall assumed

Hold Down Factor

Hold-down effect factor (CSA O86-14 CL.11.4.5.)

$J_{hd} := 1.00$ Segment with hold down

Shear Wall strength

Shear wall segment linear strength $v_d := N_u \div s = 14.143\ kN \cdot m^{-1}$

Shear wall length $L_s := b_{c1} + b_{c2} = 1.48\ m$

Shear wall strength $V_{rs1} := \phi \cdot v_d \cdot J_D \cdot n_s \cdot J_{us} \cdot J_s \cdot J_{hd} \cdot L_s = 16.579\ kN$

Ext. Shear wall Strength - OSB panel buckling Strength (CSA O86-14 CL.11.5.1.c)

Given

Panel Thickness	$t_1 = 12\ mm$	
Panel Smaller Dimension	$b := min\left(b_{c1}, b_{c2}\right) = 740\ mm$	
Panel Larger Dimension	$a := h_2 = 2330\ mm$	
Shear wall length	$L_s = 1480\ mm$	
Reduction Factor	$\phi = 0.8$	
Service Condition Factor	$K_S := 1.0$	dry service
Load Duration Factor	$K_D = 1.15$	Wind = Short Term
Treatment Factor	$K_T = 1$	Pressure Treated Wood
Axial Stiffness 0° Orientation	$B_{a.0} := 55000\ MPa$	CSA O86-14 Table 9.3C
Axial Stiffness 90° Orientation	$B_{a.90} := 36000\ MPa$	CSA O86-14 Table 9.3C
Shear through thickness rigidity	$B_v := 11000\ MPa$	CSA O86-14 Table 9.3C

Panel Buckling Strength Calc.

Buckling Coefficient, η

$$\eta := \frac{\left(2 \cdot B_v\right)}{\sqrt{B_{a.0} \cdot B_{a.90}}} = 0.494$$

Buckling Coefficient, α

$$\alpha := \frac{a}{b} \cdot \left(\frac{B_{a.90}}{B_{a.0}}\right)^{\frac{1}{4}} = 2.832$$

Panel Buckling Factor

$$K_{pb} := 1.7 \cdot \left(\eta + 1\right) \cdot e^{\left(\frac{-\alpha}{0.05 \cdot \eta + 0.75}\right)} + \left(0.5 \cdot \eta + 0.8\right) = 1.113$$

Panel Buckling Strength

$$v_{pb} := K_{pb} \cdot \frac{\left(\pi^2 \cdot {t_1}^2\right)}{3000 \cdot b} \cdot \left(B_{a.0} \cdot {B_{a.90}}^3\right)^{\frac{1}{4}} = 28.515\ \frac{kN}{m}$$

Factored Panel buckling Strength

$$V_{rs2} := \phi \cdot v_{pb} \cdot K_D \cdot K_S \cdot K_T \cdot L_s = 38.826\ kN$$

Table 9.3C
Specified strength, stiffness, and rigidity capacities for construction sheathing OSB

Panel mark (CSA O325)	Minimum nominal thickness, mm	Bending, m_p, N•mm/mm		Axial tension, t_p, N/mm		Axial compression, p_p, N/mm		Shear-through-thickness, v_p, N/mm	Planar shear			
									Bending, v_{pb}, N/mm		Shear in-plane, v_{pf}, MPa	
		Capacities relative to major axis*										
		0°	90°	0°	90°	0°	90°	0° and 90°	0°	90°	0°	90°
2R24	9.5	180	57	53	18	62	54	42	3.8	2.4	0.60	0.38
1R24/2F16	11.0	240	68	60	30	71	54	46	4.4	2.4	0.60	0.33
2R32/2F16	12.0	270	100	65	38	77	67	50	4.8	3.0	0.60	0.38
2R40/2F20	15.0	460	160	67	48	92	87	55	6.1	3.8	0.61	0.38
2R48/2F24	18.0	630	240	92	59	110	94	60	7.8	4.4	0.65	0.37
1F16	15.0	310	100	60	43	87	78	47	5.2	3.3	0.52	0.33
1F20	15.0	360	150	67	48	92	87	54	6.1	3.9	0.61	0.39
1F24	18.0	480	230	77	59	110	94	59	7.8	4.5	0.65	0.37
1F32	22.0	640	400	92	75	140	130	64	9.2	6.4	0.63	0.44
1F48	28.5	1200	720	130	110	180	150	85	14.0	10.0	0.73	0.55

Panel mark (CSA O325)	Minimum nominal thickness, mm	Bending stiffness, $B_b = EI$, N•mm²/mm		Axial stiffness (in tension or compression), $B_a = EA$, N/mm		Shear through-thickness rigidity, B_v, N/mm
		Capacities relative to major axis*				
		0°	90°	0°	90°	0° and 90°
2R24	9.5	560 000	100 000	44 000	33 000	10 000
1R24/2F16	11.0	730 000	140 000	48 000	36 000	11 000
2R32/2F16	12.0	1 100 000	220 000	55 000	36 000	11 000
2R40/2F20	15.0	2 100 000	500 000	66 000	38 000	12 000
2R48/2F24	18.0	3 800 000	820 000	77 000	44 000	13 000
1F16	15.0	1 400 000	300 000	56 000	36 000	11 000
1F20	15.0	2 000 000	360 000	56 000	38 000	11 000
1F24	18.0	2 800 000	720 000	75 000	44 000	12 000
1F32	22.0	6 100 000	2 100 000	99 000	55 000	15 000
1F48	28.5	11 000 000	4 400 000	108 000	61 000	20 000

**Orientation of applied force relative to panel's long direction.*

Notes:

(1) *For specified stiffness in bending on edge, use axial stiffness values.*

(2) *The tabulated values are based on dry service conditions and standard-term duration of load.*

(3) *The specified strength in bearing (normal to plane of panel), q_p, is* 4.2 MPa.

(4) *The design values do not apply to panels marked W only.*

Int. Shear wall Strength - Gypsum Wall Shear Strength (CSA O86-14 CL.11.5.1.d)

Design Basis

#1. Height of story doesn't exceed 3.6m
#2. Shearwalls using gypsum board has minimum panel dimension of 1200mm x 2400mm.
#3. Nails for gypsum board connection not placed less than 9mm from panel edge
#4. Blocked wall construction assumed in design calculation.

Given Parameters

Gypsum board thickness	$t_{gypsum} := 12\ mm$	
Fastener spacing along panel edge	$s = 100\ mm$	
Hold Down adjustment factor	$J_{hd} = 1$	Segment with hold down
Shear wall length	$L_s = 1480\ mm$	
Reduction factor	$\phi := 0.7$	

Table 11.5.4
Specified shear strength, v_d, for gypsum wallboard shearwalls, kN/m

Minimum nominal panel thickness, mm	Minimum nail and screw penetration in framing, mm	Wall construction	Panels applied directly to framing		
			Nail and screw spacing at panel edges, mm		
			200	150	100
12.5	19	Unblocked	1.2	1.4	1.6
12.5	19	Blocked	1.4	1.7	2.1
15.9	19	Unblocked	1.5	1.7	2.1
15.9	19	Blocked	1.7	2.2	2.5

Notes:

Shear Wall strength

Shear wall segment linear strength	$v_d := 1.6\ kN \cdot m^{-1}$	CSA O86-14 Table 11.5.4
Shear wall length	$L_s = 1.48\ m$	
Shear wall strength	$V_{rs3} := \phi \cdot v_d \cdot J_{hd} \cdot L_s = 1.658\ kN$	

Total Shear Strength

Total Factored Shear Strength	$V_r := min\left(V_{rs1}, V_{rs2}\right) + V_{rs3} = 18.237\ kN$	
Total Factored Load	$V_f = 40.002\ kN$	
	$CSR := \frac{V_f}{V_r} = 2.193$	**Design Not OK!**