# Structural Calculations

for

**ADDITIONS & ALTERATIONS**

**Wagner Residence**

8828 SE 72nd Place

Mercer Island, WA 98040

*PERMIT SUBMITTAL*

prepared by:
O.G. Engineering, PLLC
3201 1st Ave S, Ste 101
Seattle, WA, 98134
(206) 290-4608

Job No. 21064

Date: 12/22/21

| | |
|---|---|
| Date: | 12/22/2021 |
| Job # | 21064 |

## Vertical Design Loads

| Existing Roof | | |
|---|---|---|
| Comp Shingle Roofing | 3 | psf |
| Sheathing | 2 | |
| 2x6 @24"o.c. | 0.9 | |
| Insulation | 0.2 | |
| Sum | 6.1 | psf |
| Slope: | 3.5 | :12 |
| Slope Correction Factor | 1.04 | |
| Subtotal | 6.4 | psf |
| M/E/P/misc. | 1.6 | psf |
| DL= | 8 | psf |
| SL= | 25 | psf |
| RLL= | 20 | psf |

| Addition Roof | | |
|---|---|---|
| Comp Shingle Roofing | 3 | psf |
| 5/8" Plywood | 2 | |
| Trusses @24"o.c. | 3 | |
| Batt Insulation | 0.4 | |
| 5/8" Gypsum Board | 2.8 | |
| Future Solar Panels | 4 | * |
| Sum | 15.2 | psf |
| Slope: | 3.5 | :12 |
| Slope Correction Factor | 1.04 | |
| Subtotal | 15.8 | psf |
| M/E/P/misc. | 2.2 | psf |
| DL= | 18 | psf |
| SL= | 25 | psf |
| RLL= | 20 | psf |

**As required for solar-ready zone per WA State Building Building Code Amendments*

| Existing Attic | | | |
|---|---|---|---|
| 2x6 @16"o.c. | 1.4 | psf | |
| Batt Insulation | 0.2 | | |
| 5/8" Gypsum Board | 2.8 | | |
| M/E/P/misc. | 1.6 | | |
| DL= | 6 | psf | |
| LL= | 20 | psf | *Limited Storage* |

| Upper Floor | | | |
|---|---|---|---|
| Flooring | 4 | psf | |
| 3/4" Plywood | 2.4 | | |
| 2x10 @16"o.c. | 2.3 | | |
| 5/8" Gypsum Board | 2.8 | | |
| M/E/P/misc. | 1.5 | | |
| DL= | 13 | psf | |
| LL= | 40 | psf | *Living Areas* |

| Main Floor | | | |
|---|---|---|---|
| Flooring | 4 | psf | |
| Subfloor | 2 | | |
| 2x8 @16"o.c. | 1.8 | | |
| Batt Insulation | 0.2 | | |
| M/E/P/misc. | 2 | | |
| DL= | 10 | psf | |
| LL= | 40 | psf | *Living Areas* |

| Exterior Walls | | |
|---|---|---|
| Siding | 3 | psf |
| 1/2" Plywood | 1.6 | |
| 2x6 @16"o.c. | 1.4 | |
| Batt Insulation | 0.2 | |
| 1/2" Gypsum Board | 2.2 | |
| M/E/P/misc. | 1.6 | |
| DL= | 10 | psf |

| Interior Walls | | |
|---|---|---|
| 2 Layers 1/2" Gypsum Board | 4.4 | psf |
| 2x4 @16"o.c. | 0.9 | |
| M/E/P/misc. | 1.7 | |
| DL= | 7 | psf |

| | |
|---|---|
| Date: | 12/22/2021 |
| Job # | 21064 |

## Seismic Design Loads

**Seismic Design Parameters (ASCE 7-16 Section 12.8.1)**

Approximate Fundamental Period

$T = T_a = C_t h_n^x$

| | | | |
|---|---|---|---|
| where: | $C_t$ = | 0.02 | |
| | $h_n$ = | 18 | |
| | x = | 0.75 | |
| | T = | 0.17 | s |

Seismic Response Coefficient

| | |
|---|---|
| $S_s$ = | 1.46 |
| $S_1$ = | 0.50 |
| $S_{ds}$ = | 1.17 |
| $S_{d1}$ = | 0.50 |
| R = | 6.5 |
| ρ = | 1 |
| Ω = | 2.5 |
| $C_d$ = | 4 |
| $I_e$ = | 1 |

$C_s = S_{ds}/(R/I_e)$ = 0.18 W

$T_L$ = 6 s > T

$C_{s,max} = S_{d1}/[T(R/I_e)]$ = 0.44

$C_{s,min} = 0.044 S_{ds} I_e$ = 0.051

$C_{s,min}$ = 0.01

$S_1$ < 0.6

$C_{s,min} = 0.5 S_1/(R/I_e)$ = 0.038 **Ignore**

$C_{s,min,gov}$ = 0.051

**$C_{s,gov}$ = 0.18** (LRFD)

| Effective Seismic Weight | | | | |
|---|---|---|---|---|
| Floor | Area (sf) | $w_{floor}$ (psf) | $w_{walls}$ (psf)[1] | W (lbs) |
| Roof | 1780 | 16 | 10 | 46160 |
| Upper | 2600 | 13 | 20 | 85800 |
| | | | **Sum:** | **131960 lbs** |

[1]Includes weight of interior/exterior walls as uniform area load

| Base Shear (includes ρ) - LRFD Level | | | |
|---|---|---|---|
| $\rho V = \rho C_s W =$ | 0.180 | W = | **23753 lbs** |

| Vertical Distribution of Base Shear (ASCE 7-16 Section 12.8.3) - LRFD Level | | | | | | |
|---|---|---|---|---|---|---|
| Floor | $W_x$ (lbs) | $h_x$ (ft) | $w_x h_x^k$ | $C_{vx}$ | $F_x$ (lbs) | $F_x$ (psf) |
| Roof | 46160 | 21 | 969360 | 0.45 | **10608** | **6.0** |
| Upper | 85800 | 14 | 1201200 | 0.55 | **13145** | **5.1** |
| | | Sum: | 2170560 | | 23753 | |

Where k = 1

| Diaphragm Forces (ASCE 7-16 Section 12.10.1.1) - LRFD Level | | | | | | |
|---|---|---|---|---|---|---|
| Floor | $F_i$ (lbs) | $\sum F_i$ | $W_i$ (lbs) | $\sum W_i$ | $\sum F_i / \sum W_i$ | $F_{px}$ (lbs) |
| Roof | 10608 | 10608 | 46160 | 46160 | 0.23 | 10608 |
| Upper | 13145 | 23753 | 85800 | 131960 | 0.18 | 15444 |

| Floor | $F_{px}$ Min (lbs) | $F_{px}$ Max (lbs) | $F_{px}$ Gov (lbs) | $F_{px}$ Gov (psf) |
|---|---|---|---|---|
| Roof | 7561 | 15122 | **10608** | **6.0** |
| Upper | 14054 | 28108 | **15444** | **5.9** |

ATC Hazards by Location

## Search Information


**Address:** 8828 SE 72nd Pl, Mercer Island, WA 98040, USA

**Coordinates:** 47.5381958, -122.2204908

**Elevation:** 334 ft

**Timestamp:** 2021-12-22T01:34:37.222Z

**Hazard Type:** Seismic

**Reference Document:** ASCE7-16

**Risk Category:** II

**Site Class:** D-default

## Basic Parameters

| Name | Value | Description |
|---|---|---|
| $S_S$ | 1.459 | $MCE_R$ ground motion (period=0.2s) |
| $S_1$ | 0.504 | $MCE_R$ ground motion (period=1.0s) |
| $S_{MS}$ | 1.75 | Site-modified spectral acceleration value |
| $S_{M1}$ | * null | Site-modified spectral acceleration value |
| $S_{DS}$ | 1.167 | Numeric seismic design value at 0.2s SA |
| $S_{D1}$ | * null | Numeric seismic design value at 1.0s SA |

* See Section 11.4.8

## Additional Information

| Name | Value | Description |
|---|---|---|
| SDC | * null | Seismic design category |
| $F_a$ | 1.2 | Site amplification factor at 0.2s |
| $F_v$ | * null | Site amplification factor at 1.0s |
| $CR_S$ | 0.902 | Coefficient of risk (0.2s) |
| $CR_1$ | 0.898 | Coefficient of risk (1.0s) |
| PGA | 0.624 | $MCE_G$ peak ground acceleration |
| $F_{PGA}$ | 1.2 | Site amplification factor at PGA |
| $PGA_M$ | 0.749 | Site modified peak ground acceleration |
| $T_L$ | 6 | Long-period transition period (s) |
| SsRT | 1.459 | Probabilistic risk-targeted ground motion (0.2s) |
| SsUH | 1.617 | Factored uniform-hazard spectral acceleration (2% probability of exceedance in 50 years) |
| SsD | 4.297 | Factored deterministic acceleration value (0.2s) |
| S1RT | 0.504 | Probabilistic risk-targeted ground motion (1.0s) |
| S1UH | 0.561 | Factored uniform-hazard spectral acceleration (2% probability of exceedance in 50 years) |
| S1D | 1.639 | Factored deterministic acceleration value (1.0s) |
| PGAd | 1.423 | Factored deterministic acceleration value (PGA) |

## ASCE 7-16 Wind Forces, Chapter 27, Part 1

Project File: 21064_Wagner.ec6

LIC# : KW-06015519, Build:20.21.12.16 O.G. Engineering, PLLC (c) ENERCALC INC 1983-2021

**DESCRIPTION:** 8828 SE 72nd Place

### MWFRS

#### Basic Values

| | | |
|---|---|---|
| Risk Category | 2 | per ASCE 7-16 Table 1.5-1 |
| V : Basic Wind Speed | 98.0 | |
| Kd : Directionality Factor | 0.850 | per ASCE 7-16 Table 26.6-1 |

| | |
|---|---|
| Horizontal Dim. in North-South Direction (B or L) | 43.0 ft |
| Horizontal Dim. in East-West Direction (B or L) | 58.0 ft |
| h : Mean Roof height = | 18.0 ft |

Exposure Category per ASCE 7-16 Section 26.7

| | | | |
|---|---|---|---|
| North : | Exposure B | East : | Exposure B |
| South : | Exposure B | West : | Exposure B |

Topographic Factor per ASCE 7-16 Sec 26.8 & Figure 26.8-1

| | K1 | K2 | K3 | Kzt |
|---|---|---|---|---|
| North : | 0.2650 | 1.0 | 1.0 | 1.600 |
| South : | 0.2650 | 1.0 | 1.0 | 1.600 |
| East : | 0.2650 | 1.0 | 1.0 | 1.600 |
| West : | 0.2650 | 1.0 | 1.0 | 1.600 |

Building Period & Flexibility Category

User has specified the building frequency is >= 1 Hz, therefore considered RIGID for both North-South and East-West directions.

#### Building Story Data

| Level Description | hi ft | Story Ht ft | $E_R$ : X ft | $E_R$ : X ft |
|---|---|---|---|---|
| Roof | 18.00 | 10.00 | 0.000 | 0.000 |
| Upper | 8.00 | 8.00 | 0.000 | 0.000 |

#### Gust Factor

For wind coming from direction indicated

| | | | |
|---|---|---|---|
| North = | **0.850** | South = | **0.850** |
| East = | **0.850** | West = | **0.850** |

#### Enclosure

Check if Building Qualifies as "Ope

| | North Wall | South Wall | East Wall | West Wall | Roof | Total |
|---|---|---|---|---|---|---|
| Agross | 1.0 ft^2 | 1.0 ft^2 | 1.0 ft^2 | 1.0 ft^2 | 1.0 ft^2 | 5.0 ft^2 |
| Aopenings | 0.0 ft^2 | 0.0 ft^2 | 0.0 ft^2 | 0.0 ft^2 | 0.0 ft^2 | 0.0 ft^2 |
| Aopenings >= 0.8 * Agross ? | No | No | No | No | | |

**All four Agross values must be non-zero** **Building does NOT qualify as "Open"**

**User has specified the Building is to be considered Enclosed when NORTH elevation receives positi**

**User has specified the Building is to be considered Enclosed when SOUTH elevation receives positi**

**User has specified the Building is to be considered Enclosed when EAST elevation receives positive**

**User has specified the Building is to be considered Enclosed when WEST elevation receives positive**

#### Velocity Pressures

**When the following walls experience leeward or sidewall pressures, the value of Kh shall be (per Table 2**

North Wall = 0.6055 psf South Wall = 0.6055 psf East Wall = 0.6055 psf West Wall = 0.6055 psf

**When the following walls experience leeward or sidewall pressures, the value of qh shall be (per Table 2**

North Wall = 20.248 psf South Wall = 20.248 psf East Wall = 20.248 psf West Wall = 20.248 psf

**qz : Windward Wall Velocity Pressures at various heights per Eq. 26.10**

| | North Elevation | | South Elevation | | East Elevation | | West Elevation | |
|---|---|---|---|---|---|---|---|---|
| Height Above Base (ft) | Kz | qz | Kz | qz | Kz | qz | Kz | qz |
| 0.00 | 0.575 | 19.22 | 0.575 | 19.22 | 0.575 | 19.22 | 0.575 | 19.22 |
| 5.00 | 0.575 | 19.22 | 0.575 | 19.22 | 0.575 | 19.22 | 0.575 | 19.22 |
| 10.00 | 0.575 | 19.22 | 0.575 | 19.22 | 0.575 | 19.22 | 0.575 | 19.22 |
| 15.00 | 0.575 | 19.22 | 0.575 | 19.22 | 0.575 | 19.22 | 0.575 | 19.22 |

# ASCE 7-16 Wind Forces, Chapter 27, Part 1




**DESCRIPTION:** 8828 SE 72nd Place

## Pressure Coefficients

**GCpi Values when elevation receives positive external press**

**GCpi : Internal pressure coefficient, per sec. 26.13 and Table 26.1**

| | North | | South | | East | | West |
|---|---|---|---|---|---|---|---|
| +/- | 0.180 | +/- | 0.180 | +/- | 0.180 | +/- | 0.180 |

**Specify Cp Values from Figure 27.3-1 for Windward, Leeward & Side Walls**

Cp Values when elevation receives positive external pressure

| | North | South | East | West |
|---|---|---|---|---|
| Windward Wall | 0.80 | 0.80 | 0.80 | 0.80 |
| Leeward Wall | -0.50 | -0.50 | -0.50 | -0.50 |
| Side Walls | -0.70 | -0.70 | -0.70 | -0.70 |

## Wind Pressures

### Wind Pressures when NORTH Elevation receives positive external wind pressure

| | Positive Internal | Negative Internal |
|---|---|---|
| **Leeward Wall Pressures** | -12.250 psf | -4.961 psf |
| **Side Wall Pressures** | -15.692 psf | -8.403 psf |

**Windward Wall Pressures . .**

| Height Above Base (ft) | Positive Internal Pressure (psf) | Negative Internal Pressure (psf) |
|---|---|---|
| 0.00 | 9.42 | 16.71 |
| 5.00 | 9.42 | 16.71 |
| 10.00 | 9.42 | 16.71 |
| 15.00 | 9.42 | 16.71 |

### Wind Pressures when SOUTH Elevation receives positive external wind pressure

| | Positive Internal | Negative Internal |
|---|---|---|
| **Leeward Wall Pressures** | -12.250 psf | -4.961 psf |
| **Side Wall Pressures** | -15.692 psf | -8.403 psf |

**Windward Wall Pressures . .**

| Height Above Base (ft) | Positive Internal Pressure (psf) | Negative Internal Pressure (psf) |
|---|---|---|
| 0.00 | 9.42 | 16.71 |
| 5.00 | 9.42 | 16.71 |
| 10.00 | 9.42 | 16.71 |
| 15.00 | 9.42 | 16.71 |

### Wind Pressures when EAST Elevation receives positive external wind pressure

| | Positive Internal | Negative Internal |
|---|---|---|
| **Leeward Wall Pressures** | -12.250 psf | -4.961 psf |
| **Side Wall Pressures** | -15.692 psf | -8.403 psf |

**Windward Wall Pressures . .**

| Height Above Base (ft) | Positive Internal Pressure (psf) | Negative Internal Pressure (psf) |
|---|---|---|
| 0.00 | 9.42 | 16.71 |
| 5.00 | 9.42 | 16.71 |
| 10.00 | 9.42 | 16.71 |
| 15.00 | 9.42 | 16.71 |

## ASCE 7-16 Wind Forces, Chapter 27, Part 1

**DESCRIPTION:** 8828 SE 72nd Place

### Wind Pressures when WEST Elevation receives positive external wind pressure

| | Positive Internal | Negative Internal |
|---|---|---|
| **Leeward Wall Pressures** | -12.250 psf | -4.961 psf |
| **Side Wall Pressures** | -15.692 psf | -8.403 psf |

| **Windward Wall Pressures . .** Height Above Base (ft) | Positive Internal Pressure (psf) | Negative Internal Pressure (psf) |
|---|---|---|
| 0.00 | 9.42 | 16.71 |
| 5.00 | 9.42 | 16.71 |
| 10.00 | 9.42 | 16.71 |
| 15.00 | 9.42 | 16.71 |

## Story Forces for Design Wind Load Cases

**Values below are calculated based on a building with dimensions B x L x h as defined on the "Basic Valu**

| Load Case | Windward Wall | Building level | Ht. Range | Trib. Height | Wind Shear Components (k) In "Y" Direction | In "X" Direction | Eccentricity for (ft) "Y" Shear | "X" Shear | Mt, (ft-k) |
|---|---|---|---|---|---|---|---|---|---|
| CASE 1 | North | Level 2 | 13.00' -> 18.0 | 5.00 | -6.35 | --- | --- | --- | --- |
| CASE 1 | North | Level 1 | 4.00' -> 13.0 | 9.00 | -11.31 | --- | --- | --- | --- |
| CASE 1 | South | Level 2 | 13.00' -> 18.0 | 5.00 | 6.35 | --- | --- | --- | --- |
| CASE 1 | South | Level 1 | 4.00' -> 13.0 | 9.00 | 11.31 | --- | --- | --- | --- |
| CASE 1 | East | Level 2 | 13.00' -> 18.0 | 5.00 | --- | -4.71 | --- | --- | --- |
| CASE 1 | East | Level 1 | 4.00' -> 13.0 | 9.00 | --- | -8.39 | --- | --- | --- |
| CASE 1 | West | Level 2 | 13.00' -> 18.0 | 5.00 | --- | 4.71 | --- | --- | --- |
| CASE 1 | West | Level 1 | 4.00' -> 13.0 | 9.00 | --- | 8.39 | --- | --- | --- |
| CASE 2 | North | Level 2 | 13.00' -> 18.0 | 5.00 | -4.76 | --- | --- | 8.46 - | 40.3 |
| CASE 2 | North | Level 1 | 4.00' -> 13.0 | 9.00 | -8.49 | --- | --- | 8.46 - | 71.8 |
| CASE 2 | South | Level 2 | 13.00' -> 18.0 | 5.00 | 4.76 | --- | --- | 8.46 - | 40.3 |
| CASE 2 | South | Level 1 | 4.00' -> 13.0 | 9.00 | 8.49 | --- | --- | 8.46 - | 71.8 |
| CASE 2 | East | Level 2 | 13.00' -> 18.0 | 5.00 | --- | -3.53 | 6.27 | --- - | 22.1 |
| CASE 2 | East | Level 1 | 4.00' -> 13.0 | 9.00 | --- | -6.29 | 6.27 | --- - | 39.5 |
| CASE 2 | West | Level 2 | 13.00' -> 18.0 | 5.00 | --- | 3.53 | 6.27 | --- - | 22.1 |
| CASE 2 | West | Level 1 | 4.00' -> 13.0 | 9.00 | --- | 6.29 | 6.27 | --- - | 39.5 |
| CASE 3 | North & East | Level 2 | 13.00' -> 18.0 | 5.00 | -4.76 | -3.53 | --- | --- | --- |
| CASE 3 | North & East | Level 1 | 4.00' -> 13.0 | 9.00 | -8.49 | -6.29 | --- | --- | --- |
| CASE 3 | North & West | Level 2 | 13.00' -> 18.0 | 5.00 | -4.76 | 3.53 | --- | --- | --- |
| CASE 3 | North & West | Level 1 | 4.00' -> 13.0 | 9.00 | -8.49 | 6.29 | --- | --- | --- |
| CASE 3 | South & West | Level 2 | 13.00' -> 18.0 | 5.00 | 4.76 | 3.53 | --- | --- | --- |
| CASE 3 | South & West | Level 1 | 4.00' -> 13.0 | 9.00 | 8.49 | 6.29 | --- | --- | --- |
| CASE 3 | South & East | Level 2 | 13.00' -> 18.0 | 5.00 | 4.76 | -3.53 | --- | --- | --- |
| CASE 3 | South & East | Level 1 | 4.00' -> 13.0 | 9.00 | 8.49 | -6.29 | --- | --- | --- |
| CASE 4 | North & East | Level 2 | 13.00' -> 18.0 | 5.00 | -3.57 | -2.65 | 6.27 | 8.46 - | 46.9 |
| CASE 4 | North & East | Level 1 | 4.00' -> 13.0 | 9.00 | -6.37 | -4.72 | 6.27 | 8.46 - | 83.5 |
| CASE 4 | North & West | Level 2 | 13.00' -> 18.0 | 5.00 | -3.57 | 2.65 | 6.27 | 8.46 - | 46.9 |
| CASE 4 | North & West | Level 1 | 4.00' -> 13.0 | 9.00 | -6.37 | 4.72 | 6.27 | 8.46 - | 83.5 |
| CASE 4 | South & West | Level 2 | 13.00' -> 18.0 | 5.00 | 3.57 | 2.65 | 6.27 | 8.46 - | 46.9 |

## ASCE 7-16 Wind Forces, Chapter 27, Part 1

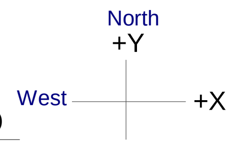
Project File: 21064_Wagner.ec6

LIC# : KW-06015519, Build:20.21.12.16 O.G. Engineering, PLLC 

**DESCRIPTION:** 8828 SE 72nd Place

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| CASE 4 | South & West | Level 1 | 4.00' -> | 13.0 | 9.00 | 6.37 | 4.72 | 6.27 | 8.46 - | 83.5 |
| CASE 4 | South & East | Level 2 | 13.00' -> | 18.0 | 5.00 | 3.57 | -2.65 | 6.27 | 8.46 - | 46.9 |
| CASE 4 | South & East | Level 1 | 4.00' -> | 13.0 | 9.00 | 6.37 | -4.72 | 6.27 | 8.46 - | 83.5 |
| Min per ASCE 27.1. | North | Level 2 | 13.00' -> | 18.0 | 5.00 | -4.64 | --- | --- | --- | --- |
| Min per ASCE 27.1. | North | Level 1 | 4.00' -> | 13.0 | 9.00 | -8.35 | --- | --- | --- | --- |
| Min per ASCE 27.1. | South | Level 2 | 13.00' -> | 18.0 | 5.00 | 4.64 | --- | --- | --- | --- |
| Min per ASCE 27.1. | South | Level 1 | 4.00' -> | 13.0 | 9.00 | 8.35 | --- | --- | --- | --- |
| Min per ASCE 27.1. | East | Level 2 | 13.00' -> | 18.0 | 5.00 | --- | -3.44 | --- | --- | --- |
| Min per ASCE 27.1. | East | Level 1 | 4.00' -> | 13.0 | 9.00 | --- | -6.19 | --- | --- | --- |
| Min per ASCE 27.1. | West | Level 2 | 13.00' -> | 18.0 | 5.00 | --- | 3.44 | --- | --- | --- |
| Min per ASCE 27.1. | West | Level 1 | 4.00' -> | 13.0 | 9.00 | --- | 6.19 | --- | --- | --- |

### Base Shear for Design Wind Load Cas




**Values below are calculated based on a building with dimensions B x L x h as defined on the "General" t**

| Load Case | Windward Wall | Leeward Wall | Wind Base Shear Components (k) In "Y" Direction | In "X" Direction | | Mt, (ft-k) |
|---|---|---|---|---|---|---|
| Case 1 | North | South | -17.66 | --- | | --- |
| Case 1 | South | North | 17.66 | --- | | --- |
| Case 1 | East | West | --- | -13.09 | | --- |
| Case 1 | West | East | --- | 13.09 | | --- |
| Case 2 | North | South | -13.25 | --- | /- | 112.1 |
| Case 2 | South | North | 13.25 | --- | /- | 112.1 |
| Case 2 | East | West | --- | -9.82 | -/- | 61.6 |
| Case 2 | West | East | --- | 9.82 | -/- | 61.6 |
| Case 3 | North & East | South & West | -13.25 | -9.82 | | --- |
| Case 3 | North & West | South & East | -13.25 | 9.82 | | --- |
| Case 3 | South & West | North & East | 13.25 | 9.82 | | --- |
| Case 3 | South & East | North & West | 13.25 | -9.82 | | --- |
| Case 4 | North & East | South & West | -9.94 | -7.37 | /- | 130.4 |
| Case 4 | North & West | South & East | -9.94 | 7.37 | /- | 130.4 |
| Case 4 | South & West | North & East | 9.94 | 7.37 | /- | 130.4 |
| Case 4 | South & East | North & West | 9.94 | -7.37 | /- | 130.4 |
| Min per ASCE 27.1.5 | North | South | -12.99 | --- | | --- |
| Min per ASCE 27.1.5 | South | North | 12.99 | --- | | --- |
| Min per ASCE 27.1.5 | East | West | --- | -9.63 | | --- |
| Min per ASCE 27.1.5 | West | East | --- | 9.63 | | --- |

## GOVERNING LATERAL LOAD ON MLFRS

SEISMIC BASE SHEAR

$V_{SEISMIC} = \underset{EL, LRFD}{\underline{23753^{\#}}}$

WIND BASE SHEAR

$V_{WIND} = \underset{WL, LRFD}{\underline{17660^{\#}}}$

$V_{SEISMIC} > V_{WIND}$

∴ SEISMIC GOVERNS MLFRS DESIGN

ROOF FRAMING

(RH8) ROOF HEADER

SPAN = 6'-0" W = 18 + 20 + 25 psf TRIB = 25'/2 = 12'-6"
DL LL SL

USE 4x10

## UPPER FLOOR FRAMING

**(UFJ1)** UPPER FLOOR JOIST

SPAN = 9'-6"   W = 13 + 40 PSF (DL, LL)   **USE 2x10 @ 16" o.c.**

**(UFB2)** UPPER FLOOR BEAM

SPAN = 7'-0"   W = 18 + 20 + 25 PSF (DL, LL, SL)   TRIB = 25'/2 = 12'-6"

**USE 4x10**

**(UFB3)** UPPER FLOOR BEAM

BACK SPAN = 6'-0"
CANTILEVER = 3"

P = 790 + 880 + 1000 # (DL, LL, SL) (UFB 2) @ x = 6'-3"

**USE 4x10**

**(UFB4)** UPPER FLOOR BEAM

SPAN = 21'-6"

**USE 5 1/4 x 14 PSL**

UF: W1 = 13 + 40 PSF (DL, LL)   TRIB = 7'/2 = 3'-6"

ROOF: W2 = 18 + 20 + 25 PSF (DL, LL, SL)   TRIB = 2'/2 = 1'

WALL: W3 = 10 PSF (DL)   TRIB = 10'

**(UFH5-6)** UPPER FLOOR HEADER

**USE 4x8** OK BY INSPECTION

**(UFB7)** UPPER FLOOR BEAM (WORST CASE)

SPAN = 11'-6"

**USE 5 1/4 x 9 1/4 PSL**

UF: W1 = 13 + 40 PSF (DL, LL)   TRIB = 7'/2 = 3'-6"

ROOF: W2 = 18 + 20 + 25 PSF (DL, LL, SL)   TRIB = 4'/2 = 2'

WALL: W3 = 10 PSF (DL)   TRIB = 10'

## UFB 8 UPPER FLOOR BEAM

SPAN = 11'-3"

$P_1 = \underset{DL}{1040} + \underset{RL}{230} + \underset{SL}{\overset{UFB7}{890}} + \underset{LL}{810}$ # @ x = 4'

USE 7 x 9 1/4 PSL

$P_2 = \left(\underset{DL}{18} + \underset{RL}{20} + \underset{SL}{\overset{ROOF}{25}}\right)\left(\frac{4'}{2}\right)\left(\frac{10'}{2}\right) + \left(\underset{DL}{13} + \underset{LL}{\overset{UF}{40}}\right)\left(\frac{9'}{2}\right)\left(\frac{10'}{2}\right)$

$+ \underset{DL}{\overset{WALL}{(10)}}(10')\left(\frac{10'}{2}\right) = \underset{DL}{970} + \underset{RL}{840} + \underset{SL}{900} + \underset{LL}{1000}$ #

@ x = 2' (UFB 8)

$P_3 = \underset{LRFD}{1.4} \times \underset{\Omega}{2.5} \times \frac{\overset{OTM}{7572\#\cdot ft}}{\underset{L_{WALL}}{11'-9"}} = \underset{EL/LRFD}{2260}$ # @ x = 4' SW (UF.E)

$P_3 = 1.4 \times 2.5 \times \frac{7055\#\cdot ft}{10'-9"} = \underset{EL/LRFD}{2300}$ # @ x = 2' SW (UF.F)

## UFB 9 UPPER FLOOR BEAM

SPAN = 19'-9"

USE W8x35

$W_1 = \underset{DL}{13} + \underset{LL}{\overset{UF}{40}}$ PSF   TRIB = $\frac{17'}{2}$ = 8'-6" FROM x = 0' TO 11'-9"

$W_2 = \underset{DL}{13} + \underset{LL}{\overset{UF}{40}}$ PSF   TRIB = $\frac{19'}{2}$ = 9'-6" FROM x = 11'-9" TO 19'-9"

$P = \underset{DL}{540} + \underset{RL}{\overset{UFB8}{220}} + \underset{LL}{470} + \underset{SL}{280} + \underset{EL}{390}$ # @ x = 11'-9"

## UFH 10 UPPER FLOOR HEADER

SPAN = 4'

USE 3 1/2 x 9 1/4 PSL

$W = \underset{DL}{18} + \underset{RL}{\overset{ROOF}{20}} + \underset{SL}{25}$ PSF   TRIB = $\frac{25'}{2}$ = 12'-6"

$P = \underset{DL}{1680} + \underset{RL}{\overset{UFB9}{900}} + \underset{SL}{110} + \underset{LL}{3610} + \underset{EL}{160}$ # @ x = 2'-9"

## UFH 11 UPPER FLOOR HEADER

SPAN = 16'-0"

USE 3 1/4 x 14 PSL

$W = \underset{DL}{18} + \underset{RL}{\overset{ROOF}{20}} + \underset{SL}{25}$ PSF   TRIB = $\frac{4'}{2}$ + 1'-3" = 3'-3"

$P = \underset{DL}{1470} + \underset{RL}{\overset{UFB8}{810}} + \underset{SL}{930} + \underset{LL}{1340} + \underset{EL}{431}$ # @ x = 10'-0"

## Multiple Simple Beam

Project File: 21064_Wagner.ec6

LIC# : KW-06015519, Build:20.21.12.16 O.G. Engineering, PLLC 

**Description :** Roof Framing

**Wood Beam Design :** RH8 - Roof Header

**Calculations per NDS 2018, IBC 2018, CBC 2019, ASCE 7-16**

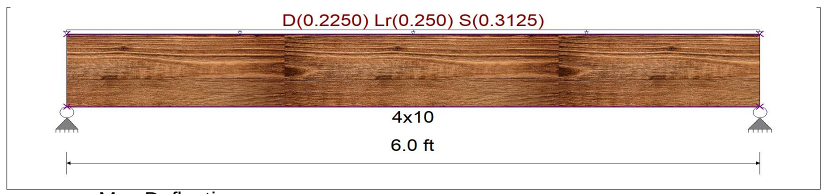
BEAM Size : **4x10, Sawn, Fully Braced**
Using Allowable Stress Design with ASCE 7-16 Load Combinations, Major Axis Bending

Wood Species : Douglas Fir-Larch Wood Grade : No.1

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Fb - Tension | 1000 psi | Fc - Prll | 1500 psi | Fv | 180 psi | Ebend- xx | 1700 ksi | Density | 31.21 pcf |
| Fb - Compr | 1000 psi | Fc - Perp | 625 psi | Ft | 675 psi | Eminbend - xx | 620 ksi | | |

*Applied Loads*

Unif Load: D = 0.0180, Lr = 0.020, S = 0.0250 k/ft, Trib= 12.50 ft




**Design Summary**

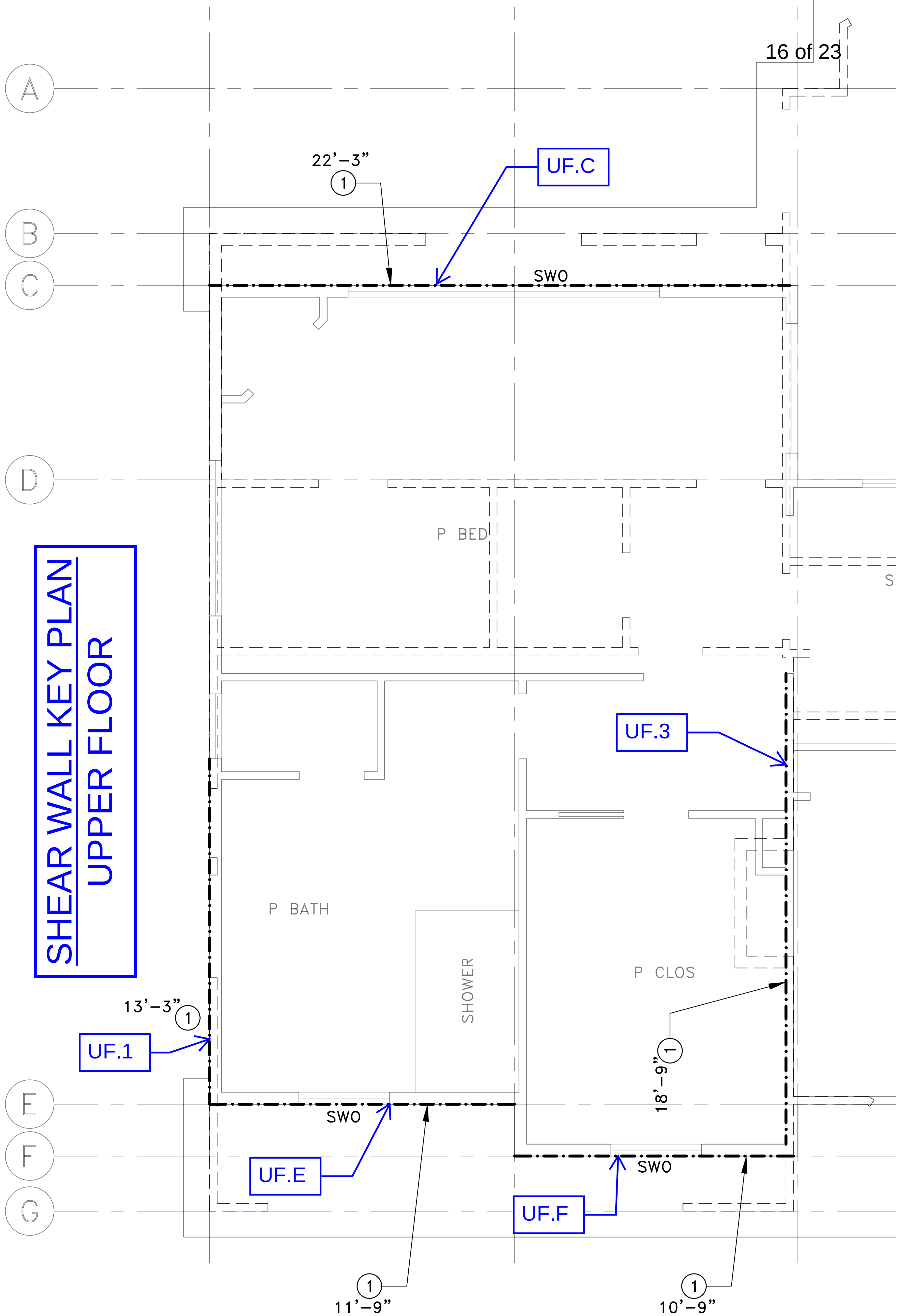
Max fb/Fb Ratio = **0.421** : 1
fb : Actual : 581.53 psi at 3.000 ft in Span # 1
Fb : Allowable : 1,380.00 psi
Load Comb : +D+S

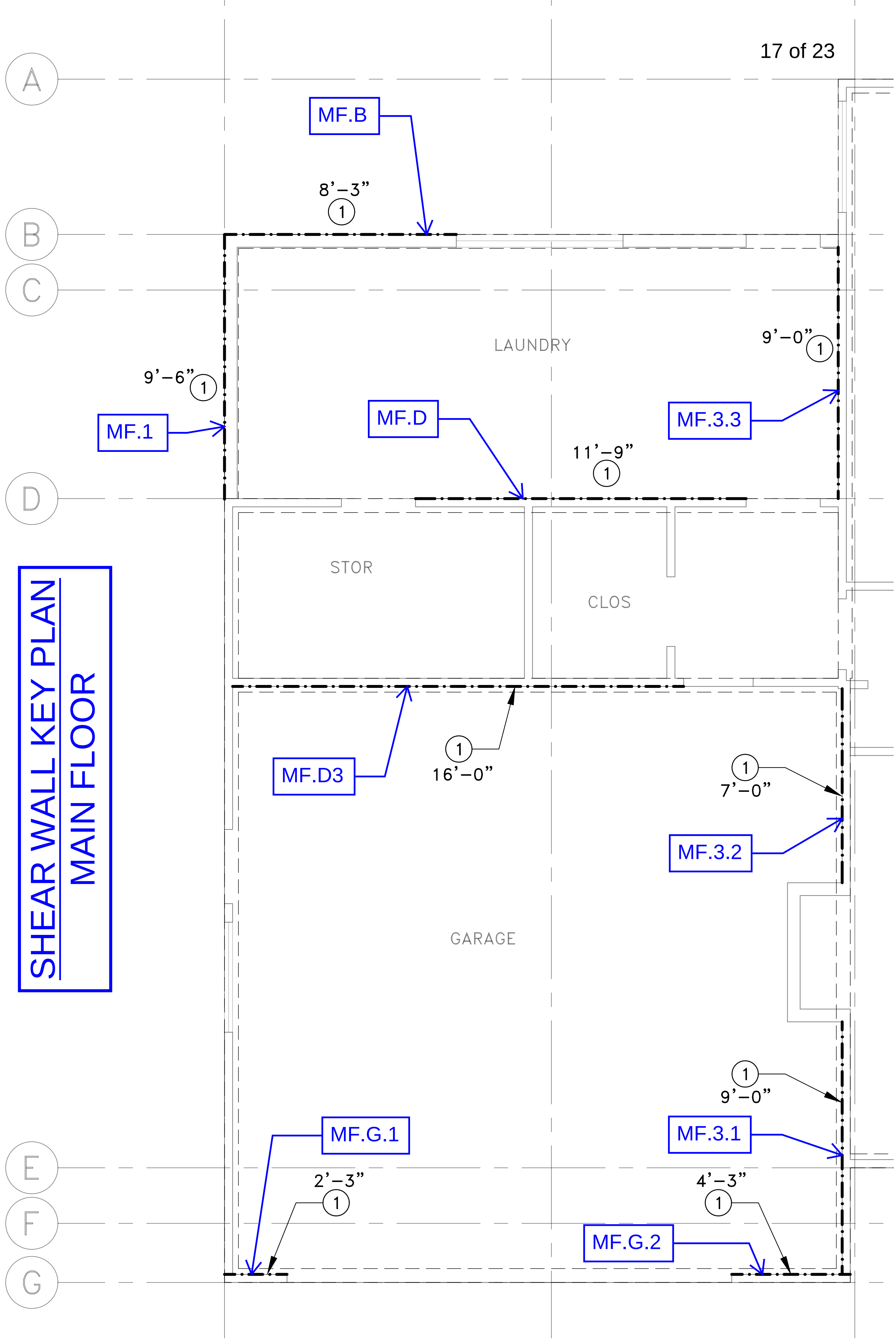
Max fv/FvRatio = **0.269** : 1
fv : Actual : 55.78 psi at 5.240 ft in Span # 1
Fv : Allowable : 207.00 psi
Load Comb : +D+S

| Max Reactions (k) | D | L | Lr | S | W | E | H |
|---|---|---|---|---|---|---|---|
| Left Support | 0.68 | | 0.75 | 0.94 | | | |
| Right Support | 0.68 | | 0.75 | 0.94 | | | |

Max Deflections

| | | | |
|---|---|---|---|
| Transient Downward | 0.023 in | Total Downward | 0.040 in |
| Ratio | 3084 | Ratio | 1793 |
| | LC: S Only | | LC: +D+S |
| Transient Upward | 0.000 in | Total Upward | 0.000 in |
| Ratio | 9999 | Ratio | 9999 |
| | LC: | | LC: |


SHEAR WALL KEY PLAN
UPPER FLOOR
A
B
C
D
E
F
G
22'–3"
1
UF.C
SWO
P BED
S
UF.3
P BATH
SHOWER
P CLOS
13'–3"
1
UF.1
1
18'–9"
SWO
UF.E
SWO
UF.F
1
11'–9"
1
10'–9"


SHEAR WALL KEY PLAN
MAIN FLOOR
A
B
C
D
E
F
G
MF.B
8'–3"
1
LAUNDRY
9'–6"
MF.1
MF.D
11'–9"
9'–0"
MF.3.3
STOR
CLOS
MF.D3
16'–0"
7'–0"
MF.3.2
GARAGE
9'–0"
MF.3.1
MF.G.1
2'–3"
4'–3"
MF.G.2

Date: 12/22/2021
Job # 21064

# Plywood Shear Wall Design

*Refer to Shear Wall Key Plans*

| Story Forces - ASD Level | |
|---|---|
| Floor | $F_x$ (psf) |
| Roof | 4.2 |
| Upper | 3.5 |

| Plywood Grade |
|---|
| CD-X |

*Struct 1 or CD-X*

***15/32" Plywood, w/ 10d nails, min. 1-1/2" penetration into framing members***

**$R_d$ (Dead Load Resistance Factor) = 0.6-0.14$S_{ds}$ = 0.44**

| Wall Mark Capacity (Grade Struct 1) | | |
|---|---|---|
| Wall Mark | Edge Nailing | Capacity (plf) |
| 1 | 6"o.c. | 340 |
| 2 | 4"o.c. | 510 |
| 3 | 3"o.c. | 665 |
| 4 | 2"o.c. | 870 |
| Dbl 2 | 4"o.c. Both Sides | 1020 |
| Dbl 3 | 3"o.c. Both Sides | 1330 |
| Dbl 4 | 2"o.c. Both Sides | 1740 |

| Wall Mark Capacity (Grade CD-X) | | |
|---|---|---|
| Wall Mark | Edge Nailing | Capacity (plf) |
| 1 | 6"o.c. | 310 |
| 2 | 4"o.c. | 460 |
| 3 | 3"o.c. | 600 |
| 4 | 2"o.c. | 770 |
| Dbl 2 | 4"o.c. Both Sides | 920 |
| Dbl 3 | 3"o.c. Both Sides | 1200 |
| Dbl 4 | 2"o.c. Both Sides | 1540 |

| Holdown Schedule | |
|---|---|
| Holdown | Capacity (lb) |
| HDU2 | 3075 |
| HDU4 | 4565 |
| HDU5 | 5645 |
| HDU8 | 6970 |
| MSTC28 | 1540 |
| MSTC40 | 3080 |
| MSTC52 | 4620 |

Notes

1) $Wall_{abv}$ = Shear wall on story above that adds shear to subject wall
2) $V_{abv}$ = Shear demand from wall on story above
3) $V_{cur}$ = Shear demand from current story = $A_T \times F_x$
4) V = Total shear demand in wall = $V_{abv} + V_{cur}$
5) v = unit shear demand = V / L
6) Allowable shear reduction multiplier of 2xL/h for walls w/ h>2L (=1 if h<2L)
7) OTM = Wall overturning moment = V x h
8) $w_{DL}$ = Distributed resisting dead load on top of wall
9) $P_{DL,END}$ = Minimum resisting point dead load on end of wall
10) RM = Resisting Moment from $w_{DL}$ & $P_{DL,END}$, mulitplied by $R_d$ above
11) $T_{end}$ = Tension at end of wall from current story shear = (OTM - RM) / L
12) $T_{abv}$ = Tension from wall holdown on story above
13) $T = T_{end} + T_{abv}$

**Roof Diaphragm**

| Walls in North-South Direction | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wall | L (ft) | h (ft) | $A_T$ (sf) | $Wall_{abv}$ [1] | $V_{abv}$ [2] (lbs) | $V_{cur}$ [3] (lbs) | V[4] (lb) | v[5] (plf) | Wall Mark | h>2L? | 2xL/h[6] | Capacity (plf) |
| UF.1 | 13.25 | 8.25 | 425 | none | 0 | 1773 | 1773 | 134 | 1 | no | 1 | 310 |
| UF.3 | 18.75 | 8.25 | 890 | none | 0 | 3713 | 3713 | 198 | 1 | no | 1 | 310 |

| Holdowns for Walls in North-South Direction | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Wall | OTM[7] (lb-ft) | $w_{DL}$ [8] (plf) | $P_{DL,END}$ [9] (lb) | RM[10] (lb-ft) | $T_{end}$ [11] (lb) | $T_{abv}$ [12] (lb) | T[13] (lb) | Holdown | Capacity | |
| UF.1 | 14627 | 305 | 610 | 15204 | -44 | | -44 | NONE | #N/A | *Close enough* |
| UF.3 | 30630 | 305 | 610 | 28375 | 120 | | 120 | NONE | #N/A | *Close enough* |

| Walls in East-West Direction | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wall | L (ft) | h (ft) | $A_T$ (sf) | $Wall_{abv}$ [1] | $V_{abv}$ [2] (lbs) | $V_{cur}$ [3] (lbs) | V[4] (lb) | v[5] (plf) | Wall Mark | h>2L? | 2xL/h[6] | Capacity (plf) |
| UF.C* | 22.25 | 8.25 | 425 | none | 0 | 1773 | 1773 | 182 | 1 | no | 1 | 310 |
| UF.E* | 11.75 | 8.25 | 220 | none | 0 | 918 | 918 | 152 | 1 | no | 1 | 310 |
| UF.F* | 10.75 | 8.25 | 205 | none | 0 | 855 | 855 | 151 | 1 | no | 1 | 310 |

| Holdowns for Walls in East-West Direction | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Wall | OTM[7] (lb-ft) | $w_{DL}$ [8] (plf) | $P_{DL,END}$ [9] (lb) | RM[10] (lb-ft) | $T_{end}$ [11] (lb) | $T_{abv}$ [12] (lb) | T[13] (lb) | Holdown | Capacity |
| UF.C* | 14627 | 100 | 400 | 14679 | -2 | | -2 | NONE | #N/A |
| UF.E* | 7572 | 100 | 400 | 5061 | 214 | | 214 | MSTC40 | 3080 |
| UF.F* | 7055 | 100 | 400 | 4396 | 247 | | 247 | MSTC40 | 3080 |

**Upper Floor Diaphragm**

| Walls in North-South Direction | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wall | L (ft) | h (ft) | $A_T$ (sf) | $Wall_{abv}$[1] | $V_{abv}$[2] (lbs) | $V_{cur}$[3] (lbs) | V[4] (lb) | v[5] (plf) | Wall Mark | h>2L? | 2xL/h[6] | Capacity (plf) |
| MF.1 | 9.5 | 7.75 | 460 | UF.1 | 1773 | 1628 | 3401 | 358 | 2 | no | 1 | 460 |
| MF.3.1 | 9 | 7.75 | 470 | UF.3 | 1337 | 1663 | 3000 | 333 | 2 | no | 1 | 460 |
| MF.3.2 | 7 | 7.75 | 360 | UF.3 | 1040 | 1274 | 2314 | 331 | 2 | no | 1 | 460 |
| MF.3.3 | 9 | 7.75 | 470 | UF.3 | 1337 | 1663 | 3000 | 333 | 2 | no | 1 | 460 |

| Holdowns for Walls in North-South Direction | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Wall | OTM[7] (lb-ft) | $w_{DL}$[8] (plf) | $P_{DL,END}$[9] (lb) | RM[10] (lb-ft) | $T_{end}$[11] (lb) | $T_{abv}$[12] (lb) | T[13] (lb) | Holdown | Capacity |
| MF.1 | 26357 | 80 | 360 | 3066 | 2452 | | 2452 | HDU2 | 3075 |
| MF.3.1 | 23249 | 80 | 360 | 2827 | 2269 | | 2269 | HDU2 | 3075 |
| MF.3.2 | 17931 | 80 | 360 | 1954 | 2282 | | 2282 | HDU2 | 3075 |
| MF.3.3 | 23249 | 80 | 360 | 2827 | 2269 | | 2269 | HDU2 | 3075 |

| Walls in East-West Direction | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wall | L (ft) | h (ft) | $A_T$ (sf) | $Wall_{abv}$[1] | $V_{abv}$[2] (lbs) | $V_{cur}$[3] (lbs) | V[4] (lb) | v[5] (plf) | Wall Mark | h>2L? | 2xL/h[6] | Capacity (plf) |
| MF.B | 8.25 | 7.75 | 130 | UF.C | 1773 | 460 | 2233 | 271 | 1 | no | 1 | 310 |
| MF.D | 11.75 | 7.75 | 180 | none | 0 | 637 | 637 | 54 | 1 | no | 1 | 310 |
| MF.D3 | 16 | 7.75 | 310 | none | 0 | 1097 | 1097 | 69 | 1 | no | 1 | 310 |
| MF.G.1 | 2.25 | 7.75 | 90 | UF.E&F | 614 | 319 | 932 | 414 | 4 | yes | 0.58 | 447 |
| MF.G.2 | 4.25 | 7.75 | 175 | UF.E&F | 1227 | 619 | 1847 | 435 | 4 | no | 1 | 770 |

| Holdowns for Walls in East-West Direction | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Wall | OTM[7] (lb-ft) | $w_{DL}$[8] (plf) | $P_{DL,END}$[9] (lb) | RM[10] (lb-ft) | $T_{end}$[11] (lb) | $T_{abv}$[12] (lb) | T[13] (lb) | Holdown | Capacity |
| MF.B | 17306 | 80 | 360 | 2483 | 1797 | | 1797 | HDU2 | 3075 |
| MF.D | 4937 | 150 | 500 | 7079 | -182 | | -182 | NONE | #N/A |
| MF.D3 | 8502 | 160 | 500 | 12423 | -245 | | -245 | NONE | #N/A |
| MF.G.1 | 7225 | 80 | 500 | 579 | 2954 | | 2954 | HDU2 | 3075 |
| MF.G.2 | 14312 | 80 | 500 | 1242 | 3075 | | 3075 | HDU2 | 3075 |

**Shear wall with force-transfer around openings; see additional spreadsheet to follow*

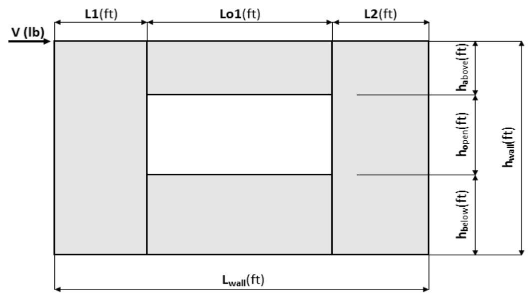
# Force Transfer Around Openings Calculator

ONE OPENING

The force transfer around openings (FTAO) method of shear wall analysis is an approach that aims to reinforce the wall such that it performs as if there was no opening. This approach lends certain advantages over segmented shear walls: more versatility, because it allows for narrower wall segments while still meeting the height-to-width ratios and, often, fewer required hold-downs.

**Project Information**

**Code:** **Date:**
**Designer:**
**Client:**
**Project:**
**Wall Line:** UF.C




**Shear Wall Calculation Variables**

| | | | | | | |
|---|---|---|---|---|---|---|
| V | 1773 lbf | | Opening 1 | Adj. Factor Method = | | 2bs/h |
| L1 | 5.25 ft | ha1 | 1.50 ft | Wall Pier Aspect Ratio | | Adj. Factor |
| L2 | 5.25 ft | ho1 | 4.50 ft | P1=ho1/L1= | 0.86 | N/A |
| $h_{wall}$ | 8.00 ft | hb1 | 2.00 ft | P2=ho2/L2= | 0.86 | N/A |
| $L_{wall}$ | 22.25 ft | Lo1 | 11.75 ft | | | |

**1. Hold-down forces: H = $Vh_{wall}/L_{wall}$** 637 lbf

**2. Unit shear above + below opening**

| | |
|---|---|
| First opening: va1 = vb1 = H/(ha1+hb1) = | 182 plf |

**3. Total boundary force above + below openings**

| | |
|---|---|
| First opening: O1 = va1 x (Lo1) = | 2140 lbf |

**4. Corner forces**

| | |
|---|---|
| F1 = O1(L1)/(L1+L2) = | 1070 lbf |
| F2 = O1(L2)/(L1+L2) = | 1070 lbf |

**5. Tributary length of openings**

| | |
|---|---|
| T1 = (L1*Lo1)/(L1+L2) = | 5.88 ft |
| T2 = (L2*Lo1)/(L1+L2) = | 5.88 ft |

**6. Unit shear beside opening**

| | | |
|---|---|---|
| V1 = (V/L)(L1+T1)/L1 = | 169 plf | |
| V2 = (V/L)(T2+L2)/L2 = | 169 plf | |
| Check V1*L1+V2*L2=V? | 1773 lbf | **OK** |

**7. Resistance to corner forces**

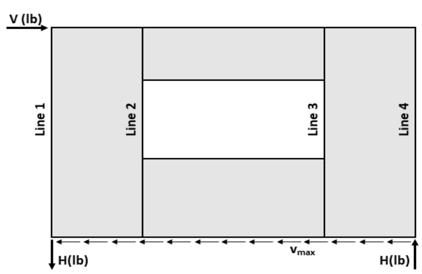
| | |
|---|---|
| R1 = V1*L1 = | 886 lbf |
| R2 = V2*L2 = | 886 lbf |

**8. Difference corner force + resistance**

| | |
|---|---|
| R1-F1 = | -184 lbf |
| R2-F2 = | -184 lbf |

**9. Unit shear in corner zones**

| | |
|---|---|
| vc1 = (R1-F1)/L1 = | -35 plf |
| vc2 = (R2-F2)/L2 = | -35 plf |




**Check Summary of Shear Values for One Opening**

| | | | | |
|---|---|---|---|---|
| Line 1: vc1(ha1+hb1)+V1(ho1)=H? | | -122 | 760 | 637 lbf |
| Line 2: va1(ha1+hb1)-vc1(ha1+hb1)-V1(ho1)=0? | 637 | -122 | 760 | 0 |
| Line 3: va1(ha1+hb1)-vc2(ha1+hb1)-V1(ho1)=0? | 637 | -122 | 760 | 0 |
| Line 4: vc2(ha1+hb1)+V2(ho1)=H? | | -122 | 760 | 637 lbf |

## Design Summary*

| | |
|---|---|
| **Req. Sheathing Capacity** | 182 plf |
| **Req. Strap Force** | 1070 lbf |
| **Req. HD Force (H)** | 637 lbf |
| **Req. Shear Wall Anchorage Force ($v_{max}$)** | 80 plf |

*The Design Summary assumes that the shear wall is designed as blocked.

# Force Transfer Around Openings Calculator

ONE OPENING

The force transfer around openings (FTAO) method of shear wall analysis is an approach that aims to reinforce the wall such that it performs as if there was no opening. This approach lends certain advantages over segmented shear walls: more versatility, because it allows for narrower wall segments while still meeting the height-to-width ratios and, often, fewer required hold-downs.

**Project Information**

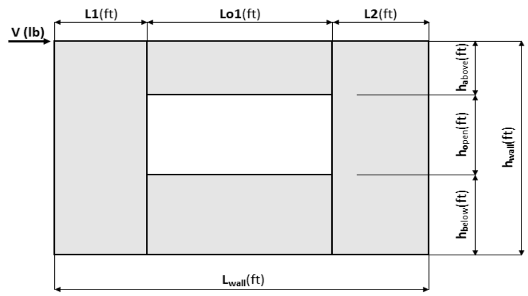
**Code:** **Date:**

**Designer:**

**Client:**

**Project:**

**Wall Line:** UF.E




**Shear Wall Calculation Variables**

| | | | | | | |
|---|---|---|---|---|---|---|
| V | 918 lbf | | Opening 1 | Adj. Factor Method = | | 2bs/h |
| L1 | 3.50 ft | ha1 | 1.25 ft | Wall Pier Aspect Ratio | | Adj. Factor |
| L2 | 4.75 ft | ho1 | 4.00 ft | P1=ho1/L1= | 1.14 | N/A |
| $h_{wall}$ | 8.25 ft | hb1 | 3.00 ft | P2=ho2/L2= | 0.84 | N/A |
| $L_{wall}$ | 11.75 ft | Lo1 | 3.50 ft | | | |

**1. Hold-down forces: H = $Vh_{wall}/L_{wall}$** 644 lbf

**2. Unit shear above + below opening**

First opening: va1 = vb1 = H/(ha1+hb1) = 152 plf

**3. Total boundary force above + below openings**

First opening: O1 = va1 x (Lo1) = 531 lbf

**4. Corner forces**

F1 = O1(L1)/(L1+L2) = 225 lbf

F2 = O1(L2)/(L1+L2) = 306 lbf

**5. Tributary length of openings**

T1 = (L1*Lo1)/(L1+L2) = 1.48 ft

T2 = (L2*Lo1)/(L1+L2) = 2.02 ft

**6. Unit shear beside opening**

V1 = (V/L)(L1+T1)/L1 = 111 plf

V2 = (V/L)(T2+L2)/L2 = 111 plf

Check V1*L1+V2*L2=V? 918 lbf **OK**

**7. Resistance to corner forces**

R1 = V1*L1 = 389 lbf

R2 = V2*L2 = 528 lbf

**8. Difference corner force + resistance**

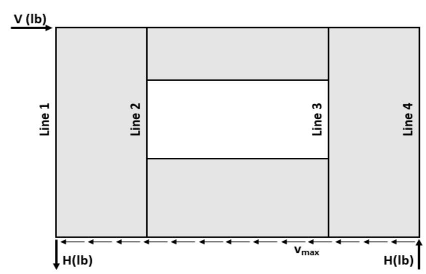
R1-F1 = 164 lbf

R2-F2 = 223 lbf

**9. Unit shear in corner zones**

vc1 = (R1-F1)/L1 = 47 plf

vc2 = (R2-F2)/L2 = 47 plf




**Check Summary of Shear Values for One Opening**

| | | | | |
|---|---|---|---|---|
| Line 1: vc1(ha1+hb1)+V1(ho1)=H? | | 199 | 445 | 644 lbf |
| Line 2: va1(ha1+hb1)-vc1(ha1+hb1)-V1(ho1)=0? | 644 | 199 | 445 | 0 |
| Line 3: va1(ha1+hb1)-vc2(ha1+hb1)-V1(ho1)=0? | 644 | 199 | 445 | 0 |
| Line 4: vc2(ha1+hb1)+V2(ho1)=H? | | 199 | 445 | 644 lbf |

## Design Summary*

| | |
|---|---|
| **Req. Sheathing Capacity** | 152 plf |
| **Req. Strap Force** | 306 lbf |
| **Req. HD Force (H)** | 644 lbf |
| **Req. Shear Wall Anchorage Force ($v_{max}$)** | 78 plf |

*The Design Summary assumes that the shear wall is designed as blocked.

**APA**

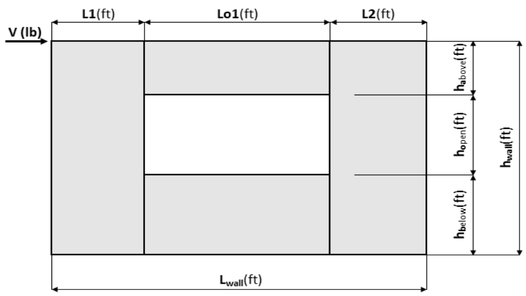
# Force Transfer Around Openings Calculator

ONE OPENING

The force transfer around openings (FTAO) method of shear wall analysis is an approach that aims to reinforce the wall such that it performs as if there was no opening. This approach lends certain advantages over segmented shear walls: more versatility, because it allows for narrower wall segments while still meeting the height-to-width ratios and, often, fewer required hold-downs.

**Project Information**

**Code:** **Date:**
**Designer:**
**Client:**
**Project:**
**Wall Line:** UF.F




**Shear Wall Calculation Variables**

| | | | | | | |
|---|---|---|---|---|---|---|
| V | 855 lbf | | Opening 1 | Adj. Factor Method = | | 2bs/h |
| L1 | 3.75 ft | ha1 | 1.25 ft | Wall Pier Aspect Ratio | | Adj. Factor |
| L2 | 3.75 ft | ho1 | 4.00 ft | P1=ho1/L1= | 1.07 | N/A |
| $h_{wall}$ | 8.25 ft | hb1 | 3.00 ft | P2=ho2/L2= | 1.07 | N/A |
| $L_{wall}$ | 11.00 ft | Lo1 | 3.50 ft | | | |

**1. Hold-down forces: H = $Vh_{wall}/L_{wall}$** 641 lbf

**2. Unit shear above + below opening**

First opening: va1 = vb1 = H/(ha1+hb1) = 151 plf

**3. Total boundary force above + below openings**

First opening: O1 = va1 x (Lo1) = 528 lbf

**4. Corner forces**

F1 = O1(L1)/(L1+L2) = 264 lbf
F2 = O1(L2)/(L1+L2) = 264 lbf

**5. Tributary length of openings**

T1 = (L1*Lo1)/(L1+L2) = 1.75 ft
T2 = (L2*Lo1)/(L1+L2) = 1.75 ft

**6. Unit shear beside opening**

V1 = (V/L)(L1+T1)/L1 = 114 plf
V2 = (V/L)(T2+L2)/L2 = 114 plf
Check V1*L1+V2*L2=V? 855 lbf **OK**

**7. Resistance to corner forces**

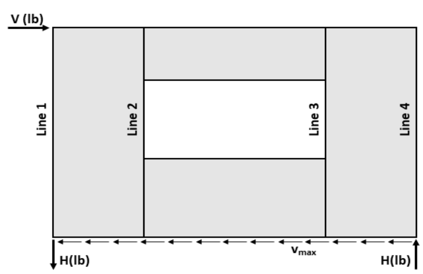
R1 = V1*L1 = 428 lbf
R2 = V2*L2 = 428 lbf

**8. Difference corner force + resistance**

R1-F1 = 163 lbf
R2-F2 = 163 lbf

**9. Unit shear in corner zones**

vc1 = (R1-F1)/L1 = 44 plf
vc2 = (R2-F2)/L2 = 44 plf




**Check Summary of Shear Values for One Opening**

| | | | | |
|---|---|---|---|---|
| Line 1: vc1(ha1+hb1)+V1(ho1)=H? | | 185 | 456 | 641 lbf |
| Line 2: va1(ha1+hb1)-vc1(ha1+hb1)-V1(ho1)=0? | 641 | 185 | 456 | 0 |
| Line 3: va1(ha1+hb1)-vc2(ha1+hb1)-V1(ho1)=0? | 641 | 185 | 456 | 0 |
| Line 4: vc2(ha1+hb1)+V2(ho1)=H? | | 185 | 456 | 641 lbf |

## Design Summary*

| | |
|---|---|
| **Req. Sheathing Capacity** | 151 plf |
| **Req. Strap Force** | 264 lbf |
| **Req. HD Force (H)** | 641 lbf |
| **Req. Shear Wall Anchorage Force ($v_{max}$)** | 78 plf |

*The Design Summary assumes that the shear wall is designed as blocked.