# HEIFER INTERNATIONAL CENTER

**LITTLE ROCK, ARKANSAS**

## TECHNICAL REPORT II

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September 27, 2013


Photo Credit: Timothy Hursley

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## BUILDING ABSTRACT

# HEIFER INTERNATIONAL CENTER

LITTLE ROCK, ARKANSAS

### ARCHITECTURE

The semi-circular shape is influenced by the non-profit's outreach programs that help communities in need make life-changing decisions, in a circle of equals.

### GENERAL BUILDING DATA

Construction dates | February 2004 to January 2006
Size | 98,000 sq. ft.
Height | 4 stories, 65 ft.
Cost | $18 million
Construction method | Construction Management at Risk

> "GREEN IS FUNCTIONAL AND ATTRACTIVE, AS WELL AS ENERGY EFFICIENT
> (HIGH PERFORMANCE BUILDINGS, 2008)

### LIGHTING/ELECTRICAL

18 | 480Y/277 panels
11 | 208Y/120 panels
Savings of 57.3% over conventional buildings, due to:
- Natural day lighting
- Space occupancy sensors
- T5 lamps

### MEP SYSTEMS

1 | Direct Digital Control System
Light shades minimize heat gain
Variable Air Volume Distribution System
- 8 | Underfloor Air Delivery Systems (2 /floor)
- 2 | Ventilation Units
- Humidity, $CO_2$ and pressure sensors

20,000 gallon rainwater retention tank

### STRUCTURE

Foundation | Geopier™ System, with traditional piers and grade beams, supporting a slab on grade
Framing system | 2'-0" diameter HSS columns
Floor system | 2 ½" concrete on 3" composite deck, supported by a beam and girder system
Lateral system | Steel plate shear wall system acting in both directions

## EXECUTIVE SUMMARY

This technical report provides a structural summary of Heifer International Center, located in Little Rock, Arkansas. It was one of the few Platinum Certified LEED Buildings in the Southern United States. The mostly glass building is semi-circular, at 440'-0" in length and 62'-0" wide. Various joint connections are used throughout the building, including shear and moment connections, and several special connections due to the shape of the building.

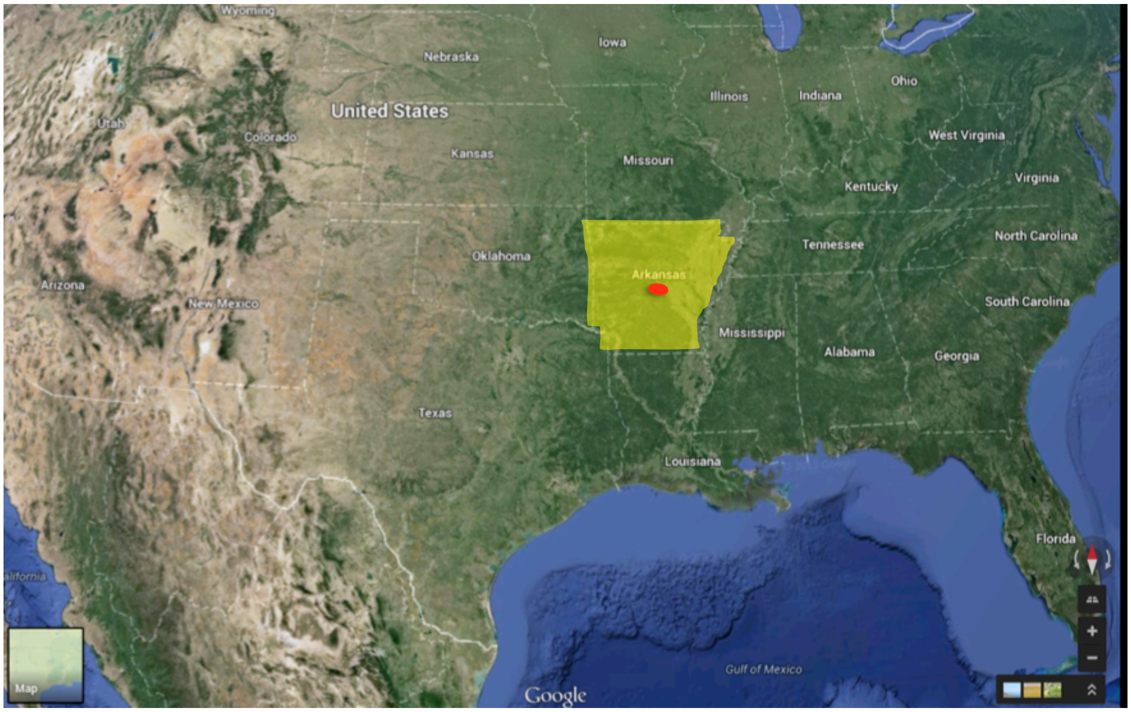
Due to the complexity of the existing site's soil conditions a Rammed Aggregate Pier® System by Geopier Foundation Company, Inc. was used in conjunction with a slab-on-grade, piers, footings and grade beam system. This foundation system supports a system of HSS steel pipes. The office building was designed as a composite floor system, which is reinforced to reduce cracking that occurs over the steel girders.

The lateral system employs a Steel Plate Shear Wall at several locations throughout the building, which utilizes large shear plates and welded C-channels. Due to the length of the building, Heifer International Center was divided into two fairly even sections. This system effectively acts as two separate structures that are linked together with a special seismic joint that prevents the two structures from colliding.

Heifer International Center was designed in accordance with the IBC 2000, which followed the ASCE-7 1998 load specifications. Special consideration was given to the large inverted roof—for both uplift and for excessive snow loads due to drifting. The large water tower collector was specifically designed for large uplift forces, and a different foundation system was used for this section—a 2'-0" thick mat foundation.

The following report discusses each structural system in detail, loads used in the design and codes, standards and regulations that controlled its design and construction.

# SITE AND LOCATION PLAN




## DOCUMENTS REFERENCED

The following section lists the codes and design guides used in Heifer International Center, as well as local regulations that supplemented these codes and standards.

International Code Council
International Building Code 2000 (with Little Rock, Arkansas local amendments)

American Society of Civil Engineers
7-1998: Minimum Design Loads for Buildings and Other Structures

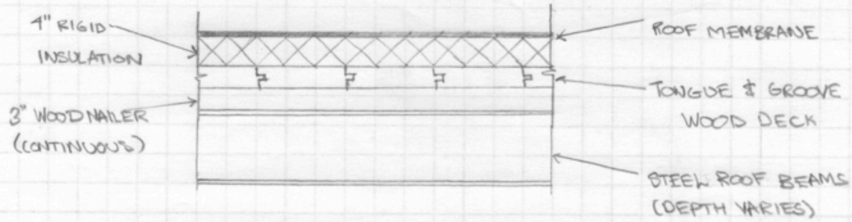
Arkansas Act 1100 of 1991
Earthquake Structural Requirements for Arkansas

Vulcraft Deck Catalog

# GRAVITY LOADS

PORTER-GILL | TECH REPORT 2 | GRAVITY LOADS | 7

TYPICAL ROOF BAY LOADING




REF: 1/A601e

DEAD LOADS

| | | |
|---|---|---|
| ROOF MEMBRANE | 0.29 PSF | (HIC, SHELL PKG #5) |
| 4" RIGID INSULATION | 0.75 PSF / 0.5" × 4" = 6 PSF | (ASCE-7, 399) |
| T&G WOOD DECK | 30 PSF | (BENZIE.NET) |
| 3" WOOD NAILER | 3 PSF / 1" × 3" = 9 PSF | (ASCE-7, 399) |
| MECHANICAL EQP. | 4 PSF | HIC, CORRESPONDANCE |
| LIGHTING EQP. | 4 PSF | HIC, CORRESPONDANCE |
| SPRINKLER | 3 PSF | HIC, CORRESPONDANCE |
| MISC. SUPER DL. | 1 PSF | HIC, CORRESPONDANCE |

57.29 PSF ~ 58 PSF SO, 60 PSF DEAD LOAD

LIVE LOADS

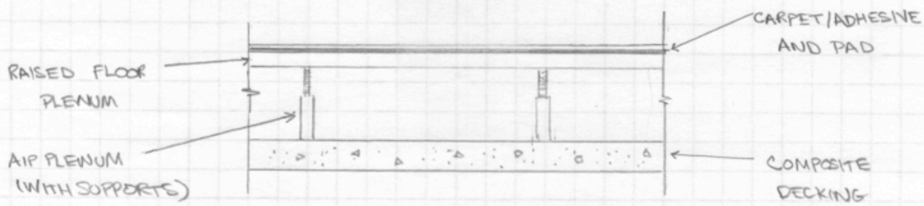
PER "MINIMUM ROOF LIVE LOADS", § 4.9.1

Eqn. 4-2, ROOF LIVE LOAD MUST BE $12 \le L_r \le 20$
FOR $L_r = 20 R_1 R_2$ (BASED ON TRIB. AREA)

TAKE WORST CASE MAXIMUM LOAD OF 20 PSF FOR ROOF LIVE LOADS (CONSERVATIVE).

PER DRAWING S001 GEN. NOTES
→ MINIMUM IS 20 PSF, NOT REDUCED FOR TRIB. AREA

TYPICAL FLOOR BAY LOADING




DEAD LOADS

| | | |
|---|---|---|
| CARPET/ADHESIVE | 1 + 0.5 = 1.5 PSF | |
| CONCRETE/STL DECK | | |
| *3" VLI DECK | 51 PSF | (VULCRAFT) |
| CONCRETE PONDING | 8 PSF | |
| COMPUTER FLOOR | 12 PSF | |
| LIGHT ALLOWANCE | 4 PSF | ← HIC, CORRESPONDANCE |
| MECH ALLOWANCE | 4 PSF | |
| SPRINKLER | 3 PSF | |
| MISC. DEAD LOAD | 1 PSF | |
| FRAMING ALLOWANCE | 10 PSF | |

(*TYPICAL BAY USES 2½" NWC WITH 3" VLI DECK)

94.5 PSF ~ 95 PSF DEAD LOAD

LIVE LOADS

OFFICE IS IN TYPICAL BAY

PER ASCE-7 98, (TABLE 4-1) OFFICES ARE 50 PSF + 20 PSF PARTITIONS

OFFICE CORRIDORS ABOVE 1st FLOOR 80 PSF

FOR FLEXIBILITY, USE 80 PSF FOR LIVE LOAD DESIGN

ORIGINAL DESIGN USED 80 PSF LIVE LOAD

PORTER-GILL | TECH REPORT 2 | GRAVITY LOADS | 9

## NON-TYPICAL LOADS

### DEAD LOADS

| | UNIT OF WEIGHT | LOCATION OF LOAD | JUSTIFICATION |
|---|---|---|---|
| 3½" NWC (6½" TOTAL) | 63 PSF | $4^{TH}$ FLOOR | PG. 54 VULCRAFT |

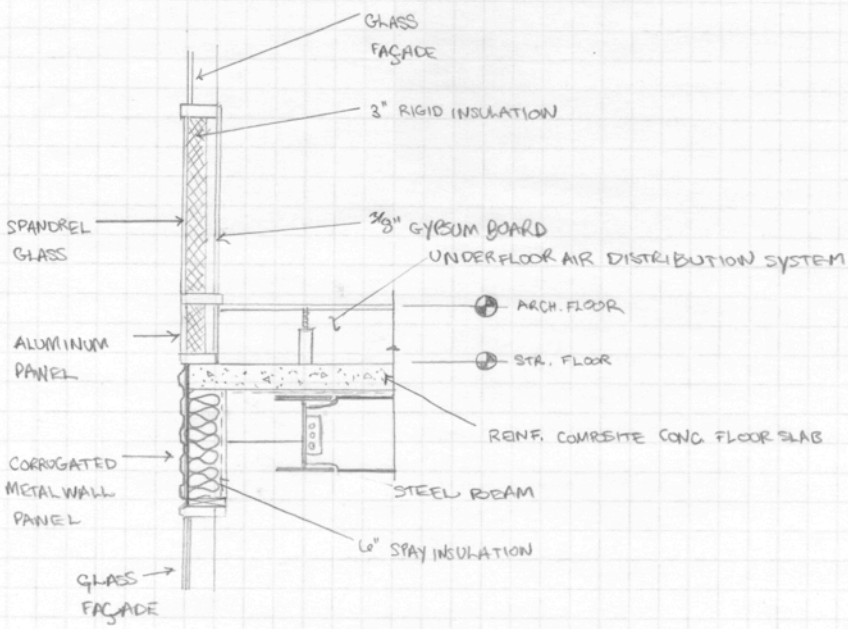
### LIVE LOADS

| | UNIT OF WEIGHT | LOCATION OF LOAD | JUSTIFICATION |
|---|---|---|---|
| BALCONIES | 100 PSF | BALCONIES ALL LEVELS | 100 PSF, EXT. BALCONIES (ASCE-7 1998) |
| STAIRS | 100 PSF | STAIR TOWERS | 100 PSF, STAIRS (ASCE-7 1998) |
| MECHANICAL | 150 PSF | MECHANICAL ROOMS, MULTIPLE LOCATIONS EACH FLOOR | RECOMMENDED INDUSTRY STANDARD |

- MAJORITY OF BUILDING IS OFFICE LOCATIONS, WHICH IS REPRESENTED BY TYPICAL FLOOR LOADING PAGE.
- EACH END OF BUILDING HAS A MECHANICAL ROOM ON EACH LEVEL
- STAIR TOWERS AT CENTER AND BOTH ENDS
- BALCONIES LOCATED THROUGHOUT BUILDING, ON EACH LEVEL, CONCENTRATED ON CENTER SECTION AND PARTS NEAR COMMUNITY KITCHENS

| PORTER-GILL | TECH REPORT 2 | GRAVITY LOADS | 10 |
| --- | --- | --- | --- |

TYPICAL EXTERIOR WALL LOADING




REF. 10/A430

| | |
| --- | --- |
| CURTAIN WALL SYSTEM | 10 PSF |
| 6" SPRAY INSULATION | 1 PSF |
| 3" RIGID INSULATION | 5 PSF |
| METAL FAÇADE ALLOWANCE | 2 PSF |
| GYPSUM BOARD (3/8") | 1.65 PSF |

19.65 PSF ~ 20 PSF

TYPICAL LEVEL HEIGHT: 14'-0"

20 PSF × 14'-0" = 280 PLF ON EDGE OF SLAB

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WALL LOADING PATH

THE LOADS FROM THE WALL SYSTEM ARE TRASFERED TO THE EDGE OF THE COMPOSITE DECK. THIS LOAD IN TURN IS COLLECTED BY THE BEAMS ALONG THE PERIMETER OF THE BUILDING, AND DISTRIBUTED TO HSS COLUMNS IN THE FRAMING SYSTEM. THESE LOADS ARE TRANSFERRED TO THE FOUNDATION SYSTEM, SUPPORTED BY A SYSTEM OF GEOPIERS USED TO REINFORCE THE SOIL.

## SNOW LOADS

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|---|---|---|---|

SNOW LOADS

§7.4 SLOPED ROOF SNOW LOADS, $p_s$

eqn. 7.2 $\quad p_s = C_s\, p_f$

§7.4.4 STATES $C_s = 1.0$ FOR SAWTOOTH SHAPED ROOF

FIND $p_f$

$$p_f = 0.7 \cdot C_e \cdot C_t \cdot I \cdot p_g$$

$C_e = 0.9$ FROM TABLE 7-2
B/C TERRAIN CATEGORY C, AND FULLY EXPOSED

$C_t = 1.0$ FROM TABLE 7-3
ALL STR. NOT LISTED

$I = 1.0$ FROM TABLE 7-4
B/C BLDG. CLASSIFICATION CATEGORY II

$p_g = 10$ PSF FROM FIGURE 7-1

so, $p_f = 0.7 \cdot 0.9 \cdot 1.0 \cdot 1.0 \cdot 10$

$p_f = 6.3$ PSF SNOW LOAD

BUT PER §7.3 $\quad p_f \geq I(p_g)$ when $p_g \leq 20$ PSF

$6.3 \geq 1.0(10)$

$6.3 \ngeq 10$

**USE 10 PSF FOR SNOW LOAD**

| PORTER-GILL | TECH REPORT 2 | SNOW LOADS | 13 |
|---|---|---|---|

UNBALANCED SNOW LOADS

PER § 7.6.1

W = 37' > 20' AND WITH SLOPES > $\frac{275 \beta p_f}{\gamma W}$

SLOPE = 8° > $\frac{275 \times 1 \times 10}{37 \cdot 100}$

8° > 0.74°

↳ APPLY β AND $1.2(1 + \beta/2)\, p_s/C_e$

where, β = 1.0
b/c L/W = 13.27 > 4

$1.2(1 + 1.0/2) \times \frac{10}{0.9}$ = **20 PSF ON LEEWARD SIDE**

b/c W > 20, WINDWARD IS $0.3 p_s$

0.3(10) = 3 PSF ON WINDWARD SLOPE

↳ INCREASE TO 10 PSF FOR FLAT ROOF SNOW LOAD

# WIND LOADS

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WIND ANALYSIS METHODS

METHOD 1: §6.4 (ASCE-7-98) - METHOD DOES NOT APPLY B/C HIC IS GREATER THAN 30'-0"

METHOD 2: §6.5 (ASCE-7-98) - HIC WILL BE ANALYZED USING THIS PROCEDURE, UNDER ASSUMPTION OF NO UNUSUAL GEOMETRIC IRREGULARITIES EXIST

METHOD 3: §6.6 (ASCE 7-98) - WIND TUNNEL TESTING IS NOT A FEASIBLE ANALYSIS PROCEDURE FOR THIS PROJECT, AND WILL NOT BE USED

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METHOD 2 - WIND DESIGN PROCEDURE (§6.5.3 ASCE-7-98)

STEP 1 - BASIC WIND SPEED 90 MPH PER FIG. 6-1

- WIND DIRECTIONALITY FACTOR, $K_d$ $K_d$ = 0.85 PER. TABLE 6-6

STEP 2 - IMPORTANCE FACTOR, I I = 1.0 PER. TABLE 6-1 (BASED ON BUILDING CATEGORY II FROM TABLE 1-1)

STEP 3 - EXPOSURE CATEGORY(S) C PER §6.5.6.1 (OPEN TERRAIN)

- VELOCITY PRESSURE COEFFICIENT, $K_z$ or $K_h$

CASE 2 WILL BE USED B/C H/C NOT A LOW-RISE BUILDING PER TABLE 6-5

NORTH-SOUTH DIRECTION - MAIN ROOF

TABLE 6-5

| | HEIGHT | $K_z$ |
|---|---|---|
| LEVEL 1 | 2' | 0.85 |
| LEVEL 2 | 16' | 0.86 * |
| LEVEL 3 | 30' | 0.98 |
| LEVEL 4 | 44' | 1.06 * |
| ROOF | 65' | 1.15 * |

* VALUES OBTAINED FROM INTERPOLATION

NORTH-SOUTH DIRECTION - STAIR TOWER

[SIM. TO PREVIOUS TABLE]

TABLE 6-5

| | HEIGHT | $K_z$ |
|---|---|---|
| LEVEL 1 | 2' | 0.85 |
| LEVEL 2 | 16' | 0.86* |
| LEVEL 3 | 30' | 0.98 |
| LEVEL 4 | 44' | 1.06* |
| ROOF | 65' | 1.15* |
| TOP TOWER | 83' | 1.22* |

EAST-WEST DIRECTION - MAIN ROOF

TABLE 6-5

| | HEIGHT | $K_z$ |
|---|---|---|
| LEVEL 1 | 2' | 0.85 |
| LEVEL 2 | 16' | 0.86* |
| LEVEL 3 | 30' | 0.98 |
| LEVEL 4 | 44' | 1.06* |
| ROOF | 65' | 1.15* |

EAST-WEST DIRECTION - STAIR TOWER

| | HEIGHT | $K_z$ |
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| LEVEL 1 | 2' | 0.85 |
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| LEVEL 3 | 30' | 0.98 |
| LEVEL 4 | 44' | 1.06* |
| ROOF | 65' | 1.15* |
| TOP TOWER | 83' | 1.22* |

* VALUES OBTAINED FROM INTERPOLATION

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|---|---|---|---|

STEP 4

PER §6.5.7.1, TOPOGRAPHICAL FACTOR, $K_{zt} = 1.0$

B/C NO HILL/ESCARPMENT

$$K_{zt} = (1 + K_1 K_2 K_3)^2$$

STEP 5 - GUST EFFECT FACTOR

→ ASCE-7 1998 DOES NOT HAVE A METHOD TO CALCULATE THE NATURAL FREQUENCY

IT WILL INSTEAD BE APPROXIMATED USING:

$$n_1 = \frac{1}{T_a},$$

$$\text{where } T_a = C_T h_n^{3/4}$$

PER § 9.5.3.3, $C_T = 0.020$ FOR "ALL OTHER STRS" NOT LISTED

$$h_n = 83' \leftarrow \text{maximum ya}$$

$$T_a = 0.020 \cdot (80)^{3/4} = 0.535 \text{ SEC.}$$

$$n_1 = \frac{1}{0.535} = 1.87$$

→ GUST FACTOR

$$G = 0.925 \left( \frac{1 + 1.7 g_Q I_{\bar{z}} Q}{1 + 1.7 g_v I_{\bar{z}}} \right) \qquad I_{\bar{z}} = c \left( \frac{33}{\bar{z}} \right)^{1/6}$$

$$Q = \sqrt{\frac{1}{1 + 0.63 \left( \frac{B + h}{L_{\bar{z}}} \right)^{0.63}}} \qquad L_{\bar{z}} = \ell \left( \bar{z}/33 \right)^{\bar{\epsilon}}$$

NORTH-SOUTH – MAIN ROOF

$L_{\bar{z}} = \ell(\bar{z}/33)^{\bar{\epsilon}}$ , where $\bar{z} = 0.6h > z_{min}$ PER TABLE 6.4

$0.6(65) > 15$

$39 > 15$ ✓GOOD → $\bar{z} = 39'$

$L_{\bar{z}} = 500\left(\frac{39}{33}\right)^{1/5} = 516.99 \approx 517 = L_{\bar{z}}$

$Q = \sqrt{\frac{1}{1 + 0.63\left(\frac{B+h}{L_{\bar{z}}}\right)^{0.63}}} = \sqrt{\frac{1}{1 + 0.063\left(\frac{491' + 65'}{517}\right)^{0.63}}}$

where, B = 491' $Q = 0.969$

$I_{\bar{z}} = c\left(\frac{33}{\bar{z}}\right)^{1/6} = 0.2\left(\frac{33}{39}\right)^{1/6} = 0.195 = I_{\bar{z}}$

c = 0.2 PER TABLE 6.4

$G = 0.925\left(\frac{1 + 1.7 g_Q I_{\bar{z}} Q}{1 + 1.7 g_v I_{\bar{z}}}\right)$

$= 0.925\left(\frac{1 + 1.7(3.4)(0.195)(0.969)}{1 + 1.7(3.4)(0.195)}\right)$

**0.9098 = G FOR NORTH-SOUTH FOR MAIN ROOF**

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NORTH-SOUTH – STAIR TOWER

$L_{\bar{z}} = \ell(\bar{z}/33)^{\bar{\epsilon}}$ , where $\bar{z} = 0.6h > z_{min}$ PER TABLE 6.4

$0.6(83') > 15'$

$49.8' > 15'$ ✓ → GOOD

$\bar{z} = 49.8'$

$L_{\bar{z}} = 500\left(\frac{49.8}{33}\right)^{1/5} = 542.89 \sim 543 = L_{\bar{z}}$

$Q = \sqrt{\frac{1}{1 + 0.63\left(\frac{B+h}{L_{\bar{z}}}\right)^{0.63}}} = \sqrt{\frac{1}{1 + 0.063\left(\frac{491' + 83}{543}\right)^{0.63}}}$

where, B = 491'
(assume entire length of bldg is 83'-0")

$Q = 0.969$

$I_{\bar{z}} = c\left(\frac{33}{\bar{z}}\right)^{1/6} = 0.2\left(\frac{33}{49.8}\right)^{1/6} = 0.189 = I_{\bar{z}}$

c = 0.2 PER TABLE 6.4

$G = 0.925\left(\frac{1 + 1.7 g_Q I_{\bar{z}} \cdot Q}{1 + 1.7 g_v I_{\bar{z}}}\right)$

$= 0.925\left(\frac{1 + 1.7(3.4)(0.189)(0.969)}{1 + 1.7(3.4)(0.189)}\right)$

0.9100 = G FOR NORTH-SOUTH FOR STAIR TOWER

PORTER-GILL | TECH REPORT 2 | WIND LOADS | '10

EAST-WEST – MAIN ROOF

$L_{\bar{z}} = \ell(\bar{z}/33)^{\bar{\epsilon}}$, where $\bar{z} = 0.6h > z_{min}$ PER TABLE 6.4

$0.6(65) > 15$

$39 > 15$ ✓GOOD → $\bar{z} = 39'$

$L_{\bar{z}} = 500\left(\frac{39}{33}\right)^{1/5} = 516.99 \sim 517 = L_{\bar{z}}$

$Q = \sqrt{\frac{1}{1 + 0.063\left(\frac{B+h}{L_{\bar{z}}}\right)^{0.63}}} = \sqrt{\frac{1}{1 + 0.063\left(\frac{64' + 65'}{517}\right)^{0.63}}}$

where B = 64' (short side) (conservative)

$Q = 0.987$

$I_{\bar{z}} = c\left(\frac{33}{\bar{z}}\right)^{1/6} = 0.2\left(\frac{33}{39}\right)^{1/6} = 0.195 = I_{\bar{z}}$

$c = 0.2$ PER TABLE 6.4

$G = 0.925\left(\frac{1 + 1.7 g_Q I_{\bar{z}} Q}{1 + 1.7 g_v I_{\bar{z}}}\right)$

$= 0.925\left(\frac{1 + 1.7(3.4)(0.195)(0.987)}{1 + 1.7(3.4)(0.195)}\right)$

**0.9186 = G FOR EAST-WEST FOR MAIN ROOF**

EAST-WEST - STAIR TOWER

$L_{\bar{z}} = \ell(\bar{z}/33)^{\bar{\epsilon}}$, where $\bar{z} = 0.6h > z_{min}$ PER PAGE 6.4

$0.6(83) > 15$

$49.8' > 15$ ✓ GOOD → $\bar{z} = 49.8'$

$$L_{\bar{z}} = 500\left(\frac{49.8}{33}\right)^{1/5} = 542.89 \sim 543 = L_{\bar{z}}$$

$$Q = \sqrt{\frac{1}{1 + 0.63\left(\frac{B+h}{L_{\bar{z}}}\right)^{0.63}}} = \sqrt{\frac{1}{1 + 0.063\left(\frac{64' + 83'}{543}\right)^{0.63}}}$$

where, B = 64' (assuming entire width is 83' tall)

$Q = 0.986$

$$I_{\bar{z}} = c\left(\frac{33}{\bar{z}}\right)^{1/6} = 0.2\left(\frac{33}{49.8}\right)^{1/6} = 0.187 = I_{\bar{z}}$$

c = 0.2 FROM TABLE 6.4

$$G = 0.925\left(\frac{1 + 1.7\, g_Q I_{\bar{z}} Q}{1 + 1.7\, g_v I_{\bar{z}}}\right)$$

$$= 0.925\left(\frac{1 + 1.7(3.4)(0.187)(0.986)}{1 + 1.7(3.4)(0.187)}\right)$$

**0.9183 = G FOR EAST-WEST FOR STAIR TOWER**

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STEP 6

PER §6.5.9, BUILDING CLASSIFIED AS ENCLOSED AS THE ENCLOSURE CLASSIFICATION

STEP 7

INTERNAL PRESSURE COEFFICIENT, $GC_{pi}$

PER §6.5.11.1 → TABLE 6-7

$\pm 0.18$

STEP 8

PER §6.5.11.2.1, EXTERNAL PRESSURE COEFFICIENT FOR MWFRS, $C_p$

PER FIG 6-3, WALL PRESSURE COEFICIENT, $C_p$

NORTH-SOUTH

WINDWARD $L/B$ → ALL, so $C_p = 0.8$ with $q_z$
LEEWARD $L/B = 64/491 = 0.13034$
which is 0-1, so $C_p = -0.5$ (with $q_h$)

EAST-WEST

WINDWARD $L/B$ → ALL, so $C_p = 0.8$ with $q_z$
LEEWARD $L/B = 491/64 = 7.6719$
which is $\geq 4$, so $C_p = -0.2$ (with $q_h$)

PORTER-GILL | TECH REPORT 2 | WIND LOADS | 23

STEP 9

VELOCITY PRESSURE

$$q_z = 0.00256 K_z K_{zt} K_d V^2 \cdot I \quad (lb/ft^2)$$

$K_d = 0.85$ $\qquad K_{zt} = 1.0$
$V = 90$ MPH $\qquad K_z$ = CHANGES
$I = 1.0$

NORTH-SOUTH - MAIN ROOF

LEVEL 1 $q_z = 0.00256(1.0)(0.85)(90^2)(1.0)[0.85]$

$= 14.98$ PSF $= q_{z1}$

LEVEL 2 $q_z = [17.6256] \cdot 0.86$

$= 15.16$ PSF $= q_{z2}$

LEVEL 3 $q_z = [17.6256] \cdot 0.98$

$= 17.27$ PSF $= q_{z3}$

LEVEL 4 $q_z = [17.6256] \cdot 1.06$

$= 18.68$ PSF $= q_{z4}$

LEVEL 5 $q_z = [17.6256] \cdot 1.15$

$= 20.27$ PSF $= q_{z5} = q_h$

NORTH-SOUTH - STAIR TOWER

| | | |
|---|---|---|
| LEVEL 1 | 14.98 PSF | |
| LEVEL 2 | 15.16 PSF | |
| LEVEL 3 | 17.27 PSF | ← FROM PREVIOUS PAGE, $q_z$ |
| LEVEL 4 | 18.68 PSF | |
| LEVEL 5 | 20.27 PSF | |

TOP TOWER $q_z = [17.6256] \cdot 1.22 =$

$= 21.50$ PSF $= q_{z\,TOP\,TOWER} = q_h$

EAST-WEST - MAIN ROOF

| | | |
|---|---|---|
| LEVEL 1 | 14.98 PSF | |
| LEVEL 2 | 15.16 PSF | |
| LEVEL 3 | 17.27 PSF | ← FROM PREV. PAGE, $q_h$ |
| LEVEL 4 | 18.68 PSF | |
| LEVEL 5 | 20.27 PSF | |

EAST-WEST - STAIR TOWER

| | | |
|---|---|---|
| LEVEL 1 | 14.98 PSF | |
| LEVEL 2 | 15.16 PSF | |
| LEVEL 3 | 17.27 PSF | ← FROM PREV. PAGE |
| LEVEL 4 | 18.68 PSF | |
| LEVEL 5 | 20.27 PSF | |
| TOP TOWER | 21.5 PSF | |

PORTER-GILL | TECH REPORT 2 | WIND LOADS | 25

STEP 10

PER §6.5.12

$p = qGC_p - q_i(GC_{pi})$

VALUE OF PARTICULAR q @ height

VALUE $q_h$ (top of str.)

## North-South - Main Roof



### Windward

| q | · | G | · | $C_p$ | - | $q_h = q_i$ | · | $GC_{pi}$ | = | p | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 14.98 | · | 0.9098 | · | 0.8 | - | 20.27 | · | 0.18 | = | 7.25 | psf |
| 15.16 | · | 0.9098 | · | 0.8 | - | 20.27 | · | 0.18 | = | 7.39 | psf |
| 17.27 | · | 0.9098 | · | 0.8 | - | 20.27 | · | 0.18 | = | 8.92 | psf |
| 18.68 | · | 0.9098 | · | 0.8 | - | 20.27 | · | 0.18 | = | 9.95 | psf |
| 20.27 | · | 0.9098 | · | 0.8 | - | 20.27 | · | 0.18 | = | 11.10 | psf |

## North-South - Main Roof

### Leeward

| q | · | G | · | $C_p$ | - | $q_h = q_i$ | · | $GC_{pi}$ | = | p | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 20.27 | · | 0.9098 | · | -0.5 | - | 20.27 | · | -0.18 | = | -5.57 | psf |
| 20.27 | · | 0.9098 | · | -0.5 | - | 20.27 | · | -0.18 | = | -5.57 | psf |
| 20.27 | · | 0.9098 | · | -0.5 | - | 20.27 | · | -0.18 | = | -5.57 | psf |
| 20.27 | · | 0.9098 | · | -0.5 | - | 20.27 | · | -0.18 | = | -5.57 | psf |
| 20.27 | · | 0.9098 | · | -0.5 | - | 20.27 | · | -0.18 | = | -5.57 | psf |

## East-West - Main Roof

### Windward

| q | · | G | · | $C_p$ | - | $q_h = q_i$ | · | $GC_{pi}$ | = | p | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 14.98 | · | 0.9186 | · | 0.8 | - | 20.27 | · | 0.18 | = | 7.36 | psf |
| 15.16 | · | 0.9186 | · | 0.8 | - | 20.27 | · | 0.18 | = | 7.49 | psf |
| 17.27 | · | 0.9186 | · | 0.8 | - | 20.27 | · | 0.18 | = | 9.04 | psf |
| 18.68 | · | 0.9186 | · | 0.8 | - | 20.27 | · | 0.18 | = | 10.08 | psf |
| 20.27 | · | 0.9186 | · | 0.8 | - | 20.27 | · | 0.18 | = | 11.25 | psf |

## East-West - Main Roof

### Leeward

| q | · | G | · | $C_p$ | - | $q_h = q_i$ | · | $GC_{pi}$ | = | p | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 20.27 | · | 0.9186 | · | -0.2 | - | 20.27 | · | -0.18 | = | -0.08 | psf |
| 20.27 | · | 0.9186 | · | -0.2 | - | 20.27 | · | -0.18 | = | -0.08 | psf |
| 20.27 | · | 0.9186 | · | -0.2 | - | 20.27 | · | -0.18 | = | -0.08 | psf |
| 20.27 | · | 0.9186 | · | -0.2 | - | 20.27 | · | -0.18 | = | -0.08 | psf |
| 20.27 | · | 0.9186 | · | -0.2 | - | 20.27 | · | -0.18 | = | -0.08 | psf |

PORTER-GILL TECH REPORT 2 WIND LOADS

## North-South - Stair Tower

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**Windward**

| q | · | G | · | $C_p$ | - | $q_h = q_i$ | · | $GC_{pi}$ | = | p | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 14.98 | · | 0.9100 | · | 0.8 | - | 21.5 | · | 0.18 | = | 7.04 | psf |
| 15.16 | · | 0.9100 | · | 0.8 | - | 21.5 | · | 0.18 | = | 7.17 | psf |
| 17.27 | · | 0.9100 | · | 0.8 | - | 21.5 | · | 0.18 | = | 8.70 | psf |
| 18.68 | · | 0.9100 | · | 0.8 | - | 21.5 | · | 0.18 | = | 9.73 | psf |
| 20.27 | · | 0.9100 | · | 0.8 | - | 21.5 | · | 0.18 | = | 10.89 | psf |
| 21.5 | · | 0.9100 | · | 0.8 | - | 21.5 | · | 0.18 | = | 11.78 | psf |

## North-South - Stair Tower

**Leeward**

| q | · | G | · | $C_p$ | - | $q_h = q_i$ | · | $GC_{pi}$ | = | p | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 21.5 | · | 0.9100 | · | -0.5 | - | 21.5 | · | -0.18 | = | -5.91 | psf |
| 21.5 | · | 0.9100 | · | -0.5 | - | 21.5 | · | -0.18 | = | -5.91 | psf |
| 21.5 | · | 0.9100 | · | -0.5 | - | 21.5 | · | -0.18 | = | -5.91 | psf |
| 21.5 | · | 0.9100 | · | -0.5 | - | 21.5 | · | -0.18 | = | -5.91 | psf |
| 21.5 | · | 0.9100 | · | -0.5 | - | 21.5 | · | -0.18 | = | -5.91 | psf |
| 21.5 | · | 0.9100 | · | -0.5 | - | 21.5 | · | -0.18 | = | -5.91 | psf |

## East-West - Stair Tower

**Windward**

| q | · | G | · | $C_p$ | - | $q_h = q_i$ | · | $GC_{pi}$ | = | p | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 14.98 | · | 0.9183 | · | 0.8 | - | 21.5 | · | 0.18 | = | 7.13 | psf |
| 15.16 | · | 0.9183 | · | 0.8 | - | 21.5 | · | 0.18 | = | 7.27 | psf |
| 17.27 | · | 0.9183 | · | 0.8 | - | 21.5 | · | 0.18 | = | 8.82 | psf |
| 18.68 | · | 0.9183 | · | 0.8 | - | 21.5 | · | 0.18 | = | 9.85 | psf |
| 20.27 | · | 0.9183 | · | 0.8 | - | 21.5 | · | 0.18 | = | 11.02 | psf |
| 21.5 | · | 0.9183 | · | 0.8 | - | 21.5 | · | 0.18 | = | 11.92 | psf |

## East-West - Stair Tower

**Leeward**

| q | · | G | · | $C_p$ | - | $q_h = q_i$ | · | $GC_{pi}$ | = | p | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 21.5 | · | 0.9183 | · | -0.2 | - | 21.5 | · | -0.18 | = | -0.08 | psf |
| 21.5 | · | 0.9183 | · | -0.2 | - | 21.5 | · | -0.18 | = | -0.08 | psf |
| 21.5 | · | 0.9183 | · | -0.2 | - | 21.5 | · | -0.18 | = | -0.08 | psf |
| 21.5 | · | 0.9183 | · | -0.2 | - | 21.5 | · | -0.18 | = | -0.08 | psf |
| 21.5 | · | 0.9183 | · | -0.2 | - | 21.5 | · | -0.18 | = | -0.08 | psf |
| 21.5 | · | 0.9183 | · | -0.2 | - | 21.5 | · | -0.18 | = | -0.08 | psf |

PORTER-GILL TECH REPORT 2 WIND LOADS

## Total Shear Calcualtion

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### North-South - Main Roof

*where the width is 491'-0" minus 22'-0" = 469'-0"*

| Level | Floor Height | Pressure Windward | Pressure Leeward | Trib. Area | Force |
|---|---|---|---|---|---|
| 1 | 9 | 7.25 | -5.57 | 4221 | 54 |
| 2 | 14 | 7.39 | -5.57 | 6566 | 85 |
| 3 | 14 | 8.92 | -5.57 | 6566 | 95 |
| 4 | 17.5 | 9.95 | -5.57 | 8207.5 | 127 |
| Roof | 10.5 | 11.10 | -5.57 | 4924.5 | 82 |
| | | TOTAL SHEAR IN N-S DIRECTION OF MAIN ROOF: | | | 444 |

### North-South - Stair Tower

*where the width is 22'-0"*

| Level | Floor Height | Pressure Windward | Pressure Leeward | Trib. Area | Force |
|---|---|---|---|---|---|
| 1 | 9 | 7.04 | -5.91 | 198 | 3 |
| 2 | 14 | 7.17 | -5.91 | 308 | 4 |
| 3 | 14 | 8.70 | -5.91 | 308 | 5 |
| 4 | 17.5 | 9.73 | -5.91 | 385 | 6 |
| Roof | 19.5 | 10.89 | -5.91 | 429 | 7 |
| Tower Top | 9.00 | 11.78 | -5.91 | 198 | 4 |
| | | TOTAL SHEAR IN N-S DIRECTION OF STAIR TOWER: | | | 28 |

### East-West - Main Roof

*where the width is 64'-0"*

| Level | Floor Height | Pressure Windward | Pressure Leeward | Trib. Area | Force |
|---|---|---|---|---|---|
| 1 | 9 | 7.36 | -0.08 | 576 | 4 |
| 2 | 14 | 7.49 | -0.08 | 896 | 7 |
| 3 | 14 | 9.04 | -0.08 | 896 | 8 |
| 4 | 17.5 | 10.08 | -0.08 | 1120 | 11 |
| Roof | 10.5 | 11.25 | -0.08 | 672 | 8 |
| | | TOTAL SHEAR IN N-S DIRECTION OF MAIN ROOF: | | | 38 |

### East West - Stair Tower

*where the width is 22'-0"*

| Level | Floor Height | Pressure Windward | Pressure Leeward | Trib. Area | Force |
|---|---|---|---|---|---|
| 1 | 9 | 7.13 | -0.08 | 198 | 1 |
| 2 | 14 | 7.27 | -0.08 | 308 | 2 |
| 3 | 14 | 8.82 | -0.08 | 308 | 3 |
| 4 | 17.5 | 9.85 | -0.08 | 385 | 4 |
| Roof | 19.5 | 11.02 | -0.08 | 429 | 5 |
| Tower Top | 9.00 | 11.92 | -0.08 | 198 | 2 |
| | | TOTAL SHEAR IN N-S DIRECTION OF STAIR TOWER: | | | 17 |

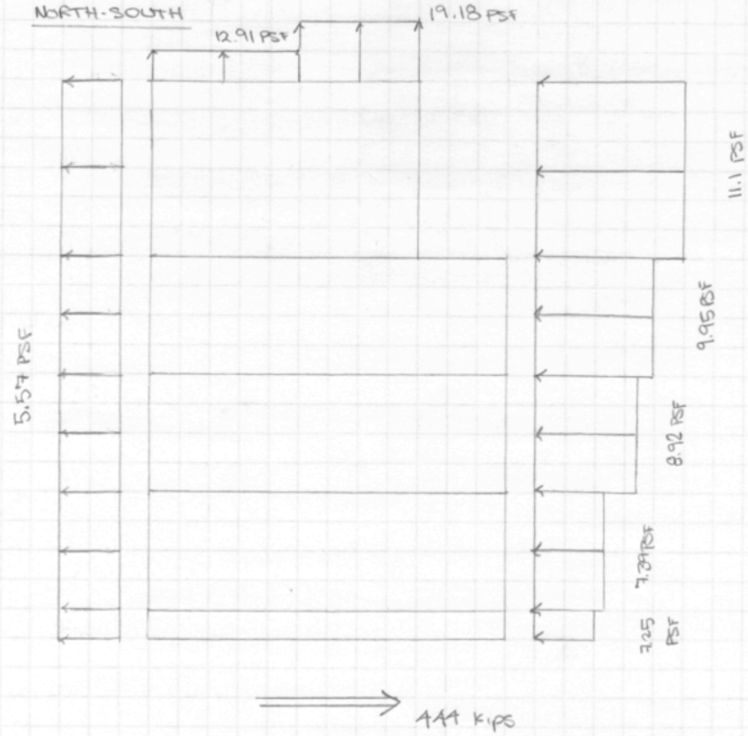
**Total Shear Calcualtion (cont…)** 

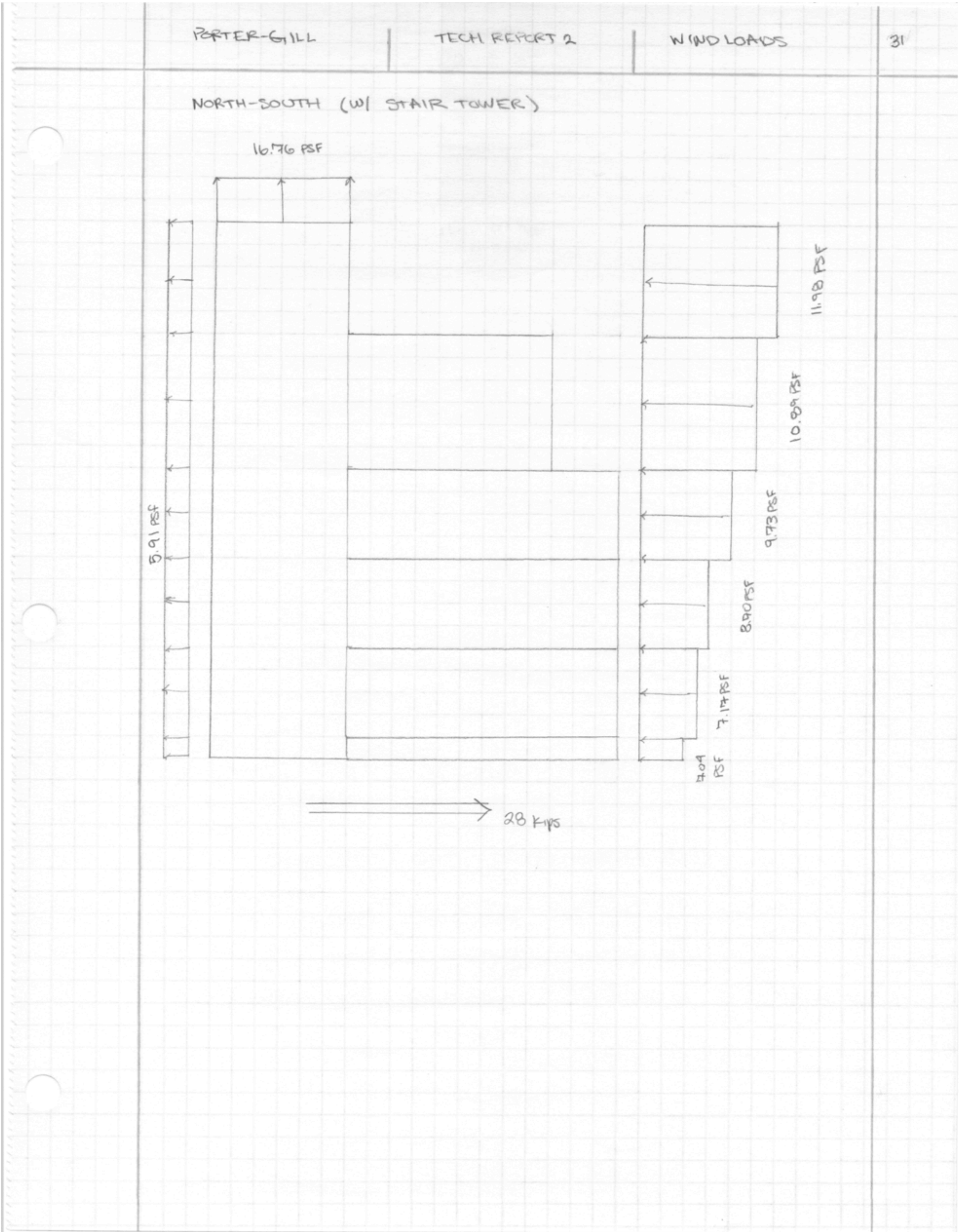
| | Shear (kips) | |
|---|---|---|
| **North-South - Main Roof** | 444 | |
| **North-South - Stair Tower** | 28 | |
| | 472 | WIND LOAD BASE SHEAR IN NORTH-SOUTH |
| **East-West - Main Roof** | 38 | |
| **East-West - Stair Tower** | 17 | |
| | 56 | WIND LOAD BASE SHEAR IN EAST-WEST |

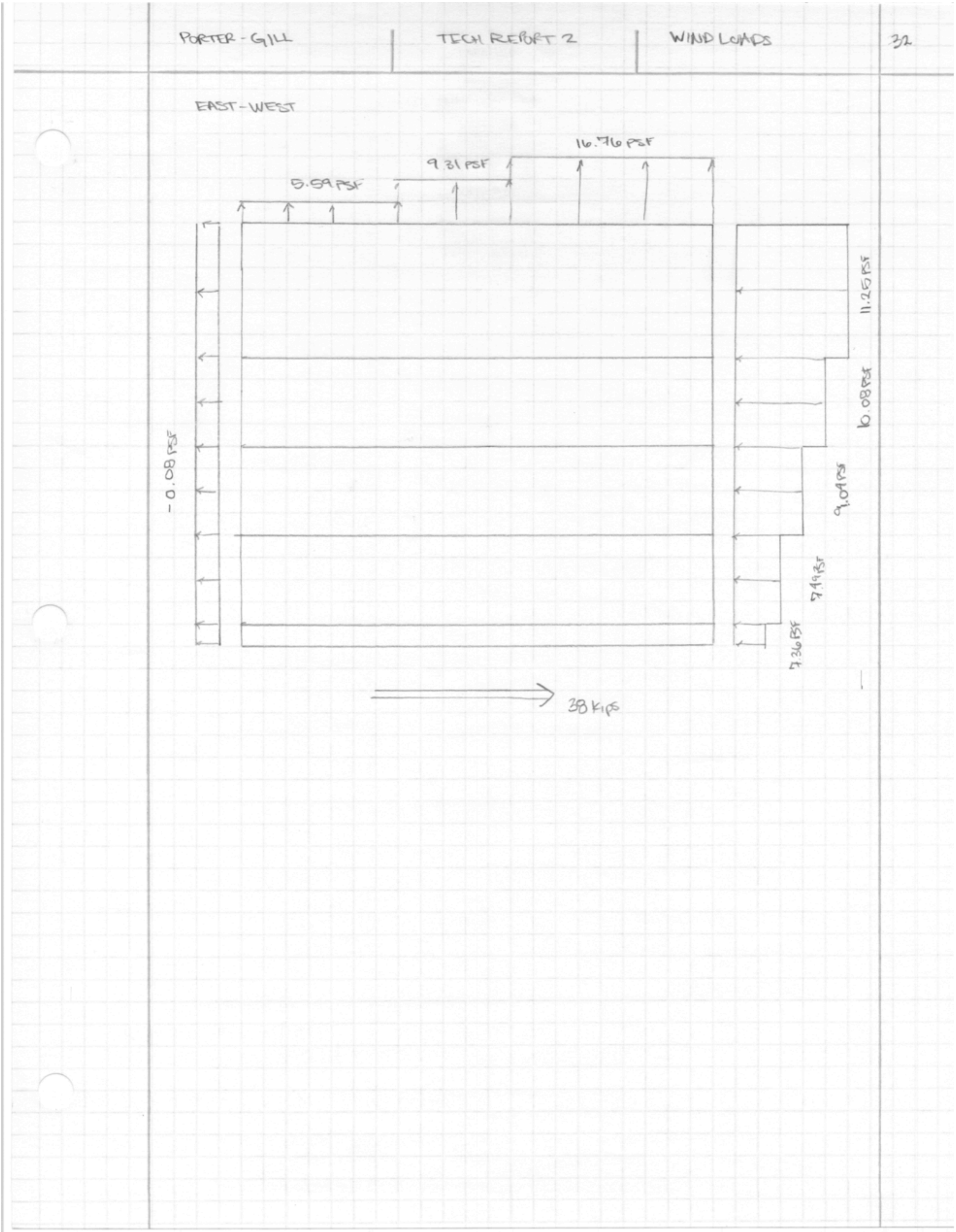
PORTER-GILL | TECH REPORT 2 | WIND LOADS | 30

GRAPHIC OF WIND PRESSURE VS HEIGHT

NORTH-SOUTH

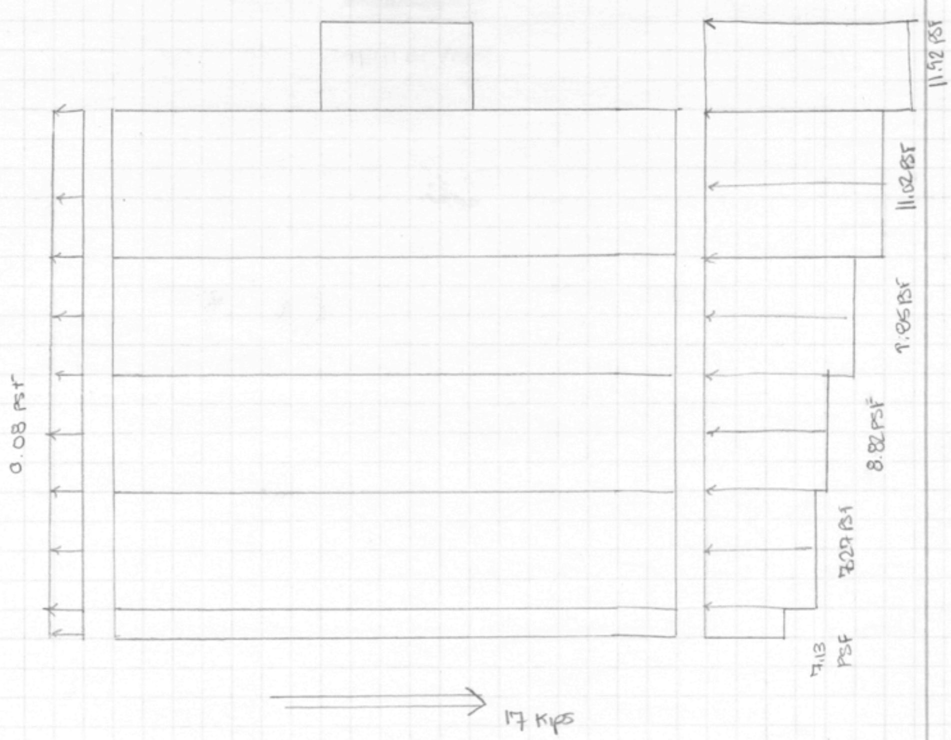



PORTER-GILL
TECH REPORT 2
WIND LOADS
31
NORTH-SOUTH (W/ STAIR TOWER)
16.76 PSF
5.91 PSF
11.98 PSF
10.89 PSF
9.73 PSF
8.90 PSF
7.14 PSF
7.04 PSF
28 Kips


PORTER-GILL
TECH REPORT 2
WIND LOADS
32
EAST-WEST
16.76 PSF
9.31 PSF
5.59 PSF
-0.08 PSF
11.25 PSF
10.08 PSF
9.09 PSF
7.19 PSF
7.36 PSF
38 KIPS

PORTER-GILL | TECH REPORT 2 | WIND LOADS | 33

EAST-WEST (W/ STAIR TOWER)



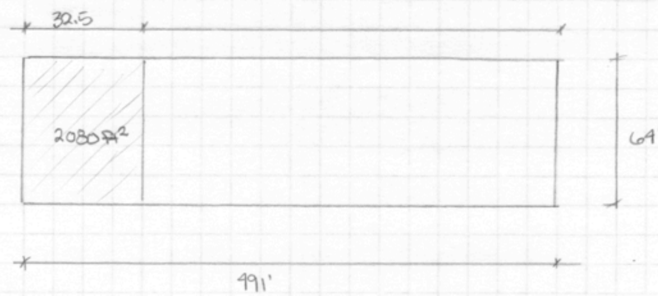
PORTER-GILL | TECH REPORT 2 | WIND LOADS | 34

ROOF LOAD - WIND PRESSURE

THE BUILDING WILL BE IDEALIZED AS A 64' x 491' RECTANGLE

PER FIG 6-3, ROOF COEFF.

$h/L = 65/64 = 1.02$ b/c 64' IS // TO WIND DIR.




| HORZ. DIST | | Cp-VALUE |
|---|---|---|
| 0 to h/2 → | 0 to 32.5 | -1.3 ** |
| > h/2 → | > 32.5 | -0.7 |

** area reduction possible

AREA IS ≥1000 SQ FT → 0.8 REDUCTION

$-1.3(0.8) = -1.04$

| | |
|---|---|
| Cp-VALUE 1ST | -1.04 |
| Cp-VALUE 2ND | -0.7 |

FOR NORTH-SOUTH DIRECTION

PER FIG 6-3, ROOF COEFF

$h/L = 65/491 = 0.132 \le 0.5$ ✓

| | | |
|---|---|---|
| 0 to h/2 → | 0 to 32.5 | -0.9 |
| h/2 to h | 32.5 to 65 | -0.9 |
| h to 2h | 65 to 130 | -0.5 |
| > 2h | > 130 | -0.3 |

FOR EAST-WEST DIRECTION

## North-South - Roof Uplift Pressure

where h/L = 1.02

**h =** 65 ft

| | q | · | G | · | $C_p$ | = | p | |
|---|---|---|---|---|---|---|---|---|
| 0 to h/2 | 20.27 | · | 0.9098 | · | -1.04 | = | -19.18 | psf |
| > h/2 | 20.27 | · | 0.9098 | · | -0.7 | = | -12.91 | psf |

## East-West - Roof Uplift Pressure

where h/L = 0.132

**h =** 65 ft

| | q | · | G | · | $C_p$ | = | p | |
|---|---|---|---|---|---|---|---|---|
| 0 to h/2 | 20.27 | · | 0.9186 | · | -0.9 | = | -16.76 | psf |
| h/2 to h | 20.27 | · | 0.9186 | · | -0.9 | = | -16.76 | psf |
| h to 2h | 20.27 | · | 0.9186 | · | -0.5 | = | -9.31 | psf |
| > 2h | 20.27 | · | 0.9186 | · | -0.3 | = | -5.59 | psf |

## North-South - Stair Tower Uplift Pressure

where h/L = 1.29

**h =** 83 ft

| | q | · | G | · | $C_p$ | = | p | |
|---|---|---|---|---|---|---|---|---|
| 0 to h/2 | 21.5 | · | 0.9098 | · | -1.04 | = | -20.34 | psf |
| > h/2 | 21.5 | · | 0.9098 | · | -0.7 | = | -13.69 | psf |

## East-West - Stair Tower Uplift Pressure

where h/L =0.169

**h =** 83 ft

| | q | · | G | · | $C_p$ | = | p | |
|---|---|---|---|---|---|---|---|---|
| 0 to h/2 | 21.5 | · | 0.9186 | · | -0.9 | = | -17.77 | psf |
| h/2 to h | 21.5 | · | 0.9186 | · | -0.9 | = | -17.77 | psf |
| h to 2h | 21.5 | · | 0.9186 | · | -0.5 | = | -9.87 | psf |
| > 2h | 21.5 | · | 0.9186 | · | -0.3 | = | -5.92 | psf |

# SEISMIC LOADS

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EARTHQUAKE LOAD

STEP 1

HAZARD EXPOSURE GROUP I

SEISMIC DESIGN CATEGORY C

SEISMIC SITE SOIL CLASS C

$S_S = 0.463$
$S_1 = 0.176$
PER § 9.1.2.1 $S_1 \nleq 0.04g$ AND, $S_S \nleq 0.15g$

AND, THEREFORE, SEISMIC ANALYSIS MUST BE PERFORMED

→ NOT EXEMPT

STEP 2

PER § 9.1.3, SEISMIC USE GROUP I

B/C OCCUPANCY CATEGORY II

PER § 9.1.4, OCCUPANCY IMPORTANCE FACTOR → I = 1.0

B/C SEISMIC USE GROUP I

STEP 3

ADJUST SITE COEFFICIENTS

$S_{MS} = F_a S_S$ where

| | $S_S \leq 0.25$ | 0.463 | $S_S = 0.5$ |
|---|---|---|---|
| SITE CLASS C | 1.2 | x | 1.2 |

→ $1.2 = F_a$

FROM TABLE 9.4.1.2.4a

$S_{M1} = F_v S_1$ where

| | $S_1 \leq 0.1$ | 0.176 | $S_1 = 0.2$ |
|---|---|---|---|
| SITE CLASS C | 1.7 | x | 1.6 |

↳ $x = 1.624 = F_v$

FROM TABLE 9.4.1.2.4b

so, $S_{MS} = F_a S_S = 1.2(0.463) = 0.5556$

$S_{M1} = F_v S_1 = 1.624(0.176) = 0.2858$

STEP 3

DESIGN SPECTRAL RESPONSE ACCELERATION

$S_{DS} = 2/3\, S_{MS} = 2/3(0.5556) = 0.3704$

$S_{D1} = 2/3\, S_{M1} = 2/3(0.2858) = 0.1905$

STEP 4

SEISMIC DESIGN CATEGORY

↳ SDC CATEGORY C PER TABLE 9.4.2.1a

B/C $0.33g \leq S_{DS} \leq 0.5g$
AND SEISMIC USE GROUP I

STEP 5

PER § 9.5.3 AND § 9.5.2.5, ELF SHOULD BE USED FOR

SDC C ⟶ $V = C_s W$, where V is SEISMIC BASE SHEAR

where $C_s = \frac{S_{DS}}{R/I}$ PER § 9.5.3.2.1

↳ SEISMIC RESISTING SYSTEM:

PICK: COMPOSITE STEEL PLATE SHEAR WALLS

$R = 6.5$, $C_d = 5.5$

MORE CONSERVATIVE THAN DESIGN WHERE

$R = 4.5$, $C_d = 2.5$

PORTER-GILL | TECH REPORT 2 | SEISMIC LOADS | 38

$C_S = \frac{S_{DS}}{R/I} = \frac{0.3704}{6.5/1.0} = 0.05698 = C_S$

but,

$C_S > C_S = \frac{S_{D1}}{T(R/I)}$ "NEED NOT EXCEED"

where, $T = T_a = C_T h_n^{3/4} = 0.535$ SEC

(FROM WIND CALCS)

$C_S > C_S = \frac{0.1905}{0.535\left(6.5/1.0\right)} = 0.05478$

$C_S = 0.05698 > 0.05478$

$\therefore C_S = 0.05478$

PER §9.5.3.2.1

but,

$C_S \geq 0.044 I S_{DS}$

$C_S = 0.05478 \geq 0.044(1.0)(0.3704)$

$0.05478 \geq 0.0162976$ ✓ GOOD

$C_S = 0.05478$

STEP 6

PER § 9.5.3.4

$$F_x = C_{vx} \cdot V \quad \text{and} \quad C_{vx} = \frac{w_x h_x^k}{\sum_{i=1}^{n} w_i h_i^k}$$

## Effective Seismic Weight



| Level | hi | Height (ft) | Load (psf) | Area ($ft^2$) | w (kips) | $w*h^k$ | $C_{vx}$ | Story Forces, $f_i$ (kips) | $V_i$ |
|---|---|---|---|---|---|---|---|---|---|
| **Stair Tower Top** | 18 | 83 | 80 | 484 | 39 | 12545 | 0.380 | 21 | 21 |
| **Roof Level** | 21 | 65 | 80 | 31555 | 2524 | 1113260 | 0.204 | 1383 | 1404 |
| **Level 4** | 14 | 44 | 115 | 26500 | 3048 | 597310 | 0.204 | 1669 | 3073 |
| **Level 3** | 14 | 30 | 115 | 26500 | 3048 | 597310 | 0.204 | 1669 | 4743 |
| **Level 2** | 14 | 16 | 115 | 26500 | 3048 | 597310 | 0.004 | 1669 | 6412 |
| **Level 1** | 2 | 2 | 115 | 26500 | 3048 | 12190 | 0.000 | 1669 | 8082 |
| | | | | ∑ | 14753 | 2929926 | | 8082 | |

CHECK: STORY FORCES EQUALS TOTAL SHEAR

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