# Structural Calculations
# Volume 3

Penn State Solar Decathlon Team
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Penn State

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August 7, 2007

# Calculations

## Table of Contents

# Calcs 1.0X

Calculations Associated with Tech Core

| | DWG / Detail | Completed By | Revised By | DCN # | |
|---|---|---|---|---|---|
| Calc 1.01 | Parapet, Struct line A | Gimbert | Glantz, Owens | N.A. | Reference Appendix 3.03 |

*Conclusions: 8d nail connections can resist 198lbs of Shear force along 24' of Structural Line A. See Appendix 3.04. Racking test for Murus SIPs which resisted 6421lbf with 8d nails over a 10' wall length.*

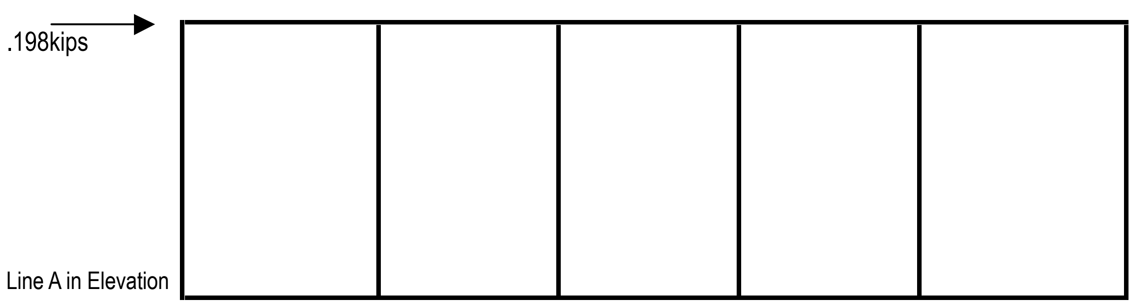
**Assumptions:**

At struct line A, 2 x Framing and connection for Parapet must resist shear of:

= 198.05 lbs

= 0.198 kips

1 Assume screw/ nail connection of framing to OSB components of SIP is adequate to resist shear.
2 Assume A325 grade strength bolt. See Calc 2.06

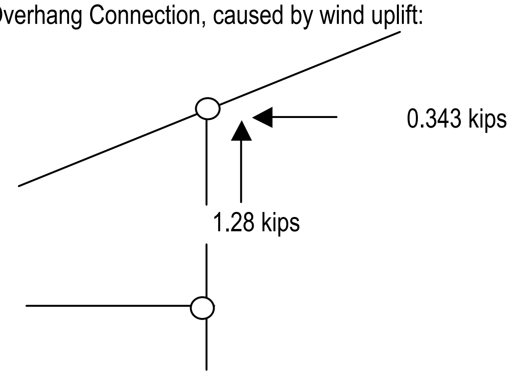


| | DWG / Detail | Completed By | Revised By | DCN # | |
|---|---|---|---|---|---|
| Calc 1.02 | Uplift, Roof Overhang | Benoit | Glantz, Owens | N.A. | Reference Appendix 3.02 |

*Conclusions:*

**Assumptions:**

**1** Condition of Overhang Connection, caused by wind uplift:




**Calculations:**

**Type of Connection:** Window Frame with Polygal Interior Panels connected to Steel HSS 4 x 4 x 5/16, Self-Tapping screw connection.

Moment (M) on Upper connection from Wind Uplift , assumed 20psf of wind pressure:
See Appendix3.01 and 3.02 for reference of wind resultant forces.

| | | | |
|---|---|---|---|
| M = (1.28 kips) (2') + (0.343) (0.64') | = | 2.78 | ft-kips |

*CHECK Capacity of Screw Connection, from NDS:*

| | | | |
|---|---|---|---|
| Assume 1 screw placed 12" o.c. | | | |
| (1.28 kips/ 24') | = | 53.33 | lbs / ft |
| Select Wood Screws, Table 11M from NDS: | | | |
| Smallest Screw Selection Capactiy | = | 76 | lbs |
| 53.33 | < | 76 | GOOD |

# Calcs 2.0X

Calculations Associated with Breezeway

| | DWG / Detail | Completed By | Revised By | DCN # | |
|---|---|---|---|---|---|
| Calc 2.01 | Truss Initial Cal | Milinichik | Glantz, Owens | S-12 | See Appendix 4.02 |

*Conclusions: USE HSS 1/4" x 4" x 4" FOR ALL MEMBERS OF LS TRUSS [ok]; Reference Appendix 4.01 for STAAD results. This calculation was generated by considering a tributary width to the overhead of truss supporting roof @ structural line C.*

**Assumptions:**

**_Loads**

**_Trib Width** 8.92 **ft** *(includes half LS + 2.25' BZWY)*

| **_Item** | | **_psf** | **_plf** | **_factored value** | **_factored** |
|---|---|---|---|---|---|
| Snow Load | SL | 35 | 312.08 | 1.60 | 499.33 |
| PV Load BZWY (adjustable) | LL | 4.6 | 10.16 | 1.60 | 16.25 |
| PV LoadLiving Space | DL | 4.6 | 30.67 | 1.20 | 36.80 |
| EV Tubes | LL | 3.49 | 7.71 | 1.60 | 12.34 |
| STL BWY Frame | DL | 7.58 | 16.73 | 1.20 | 20.08 |
| 4 5/8" SIPs PUR BZWY | DL | 3.75 | 8.28 | 1.20 | 9.94 |
| 6 5/8" SIPs PUR LVG | DL | 4.15 | 27.67 | 1.20 | 33.20 |
| Insulation (spray) | DL | 5 | 33.33 | 1.20 | 40.00 |
| Skylight | DL | 15 | 100.00 | 1.20 | 120.00 |
| | | | | **_Total Factored Dead** | 260.02 |
| | | | | **_Total Factored Live** | 527.93 |

| | | | | |
|---|---|---|---|---|
| **1.4D** | **35.0** | **0.035** | **klf** | |
| **1.2D +1.6(S +LL)** | **787.9** | **0.788** | **klf** | ***controls** |
| **1.2D +1.6(L) + (0.5)S** | **444.7** | **0.445** | **klf** | |
| **1.2D +1.6(Lr)** | **260.0** | **0.260** | **klf** | |

1 All members of truss are joint welded, E70.
2 Truss is assumed to act as a rigid member.

## Solar Decathlon Sketch Template

DCN# S-12
Match question and clarification list

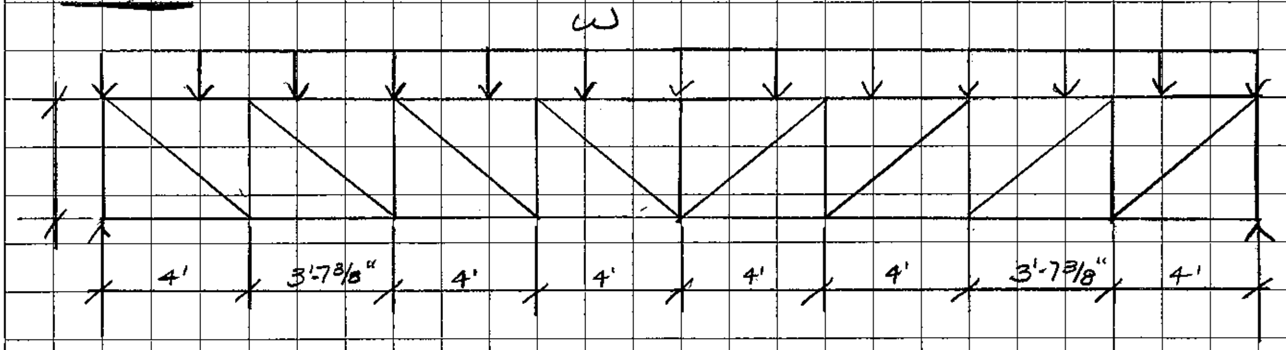
| N/A | CYNTHIA | STRUCTURAL | 1/28/07 |
|---|---|---|---|
| DWG # | Drawn by struct team | Subject (Org Chart) | Date created |

Comments:

A HSS 4x4x1/4 WORKS FOR ALL MEMBERS

FIND: SIZE LIVING SPACE TRUSS

SOLN:




ASSUMPTIONS: TRUSS ACTS AS RIGID MEMBER B/C ALL MEMBERS WELDED

Drawing scale: 4

# Solar Decathlon Sketch Template

DCN# S-12

Match question and clarification list

| | | | |
|---|---|---|---|
| | CYNTHIA | STRUCTURAL | 1/28/07 |
| DWG # | Drawn by | Subject (Org Chart) | Date created |

Comments:

FIND: LOAD ALONG LIVING SPACE TRUSS

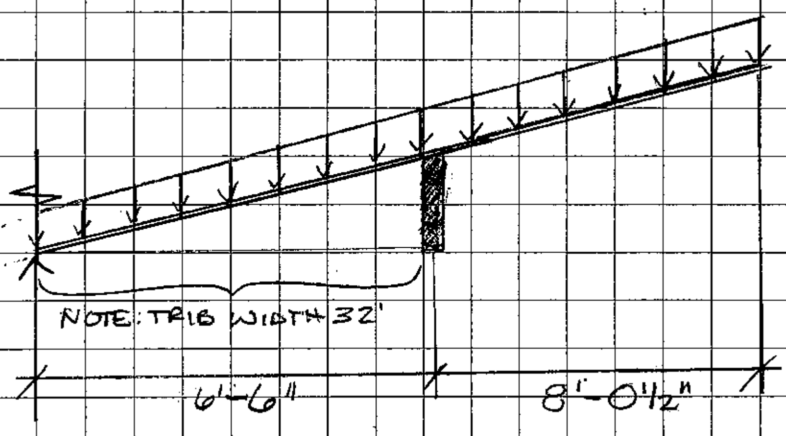
SOLN: ROOF LOADS

LL: 20PSF

DL: VARIES UNDER GEOMETRY CONDITIONS EXPLAINED BELOW & P. 3

$8'\text{-}3\frac{1}{2}'' \cos 14 =$

$= 8'\text{-}\frac{1}{2}''$




$\cos\theta = \frac{a}{h}$

$\theta = 14.0°$

$h\cos\theta = a$

$6'8'' \cos 14° = 6.47'$

$6'5\frac{1}{2}''$

TWO CONDITIONS EXIST:

1. CONSTRUCTION GEOMETRY LOADING
2. FINISHED GEOMETRY LOADING

Drawing scale: 4

# Solar Decathlon Sketch Template

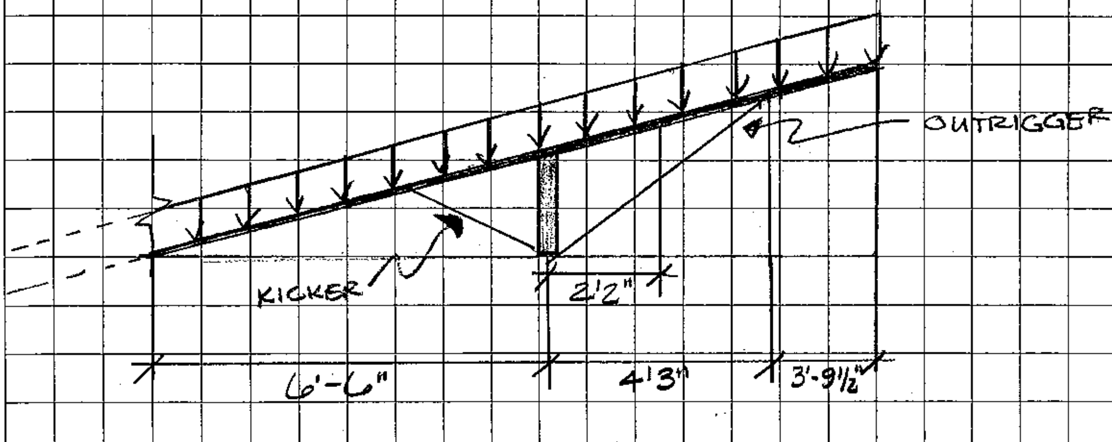
DCN# S-12
Match question and clarification list

| | CYNTHIA | STRUCTURAL | 1/28/07 |
|---|---|---|---|
| DWG # | Drawn by | Subject (Org Chart) | Date created |

Comments:

CONDITION:

1. CONSTRUCTION GEOMETRY LOADING
   - DURING CONSTRUCTION THIS TRUSS WILL BE CARRYING THE LOAD OF ROOF THAT EXTENDS OVER THE BREEZEWAY. OUTRIGGERS TRANSFER THE LOAD (FROM THE BREEZEWAY ROOF) TO THE BOTTOM CHORD OF THE TRUSS. KICKERS BRACE THE BOTTOM CHORD OF THE TRUSS TO RESIST THE LATERAL FORCES




ASSUMPTION: SNOW LOADS ARE NOT PRESENT DURING CONSTRUCTION PHASE

Drawing scale: 4 MORNINGSTAR

# Solar Decathlon Sketch Template

DCN# S-12

Match question and clarification list

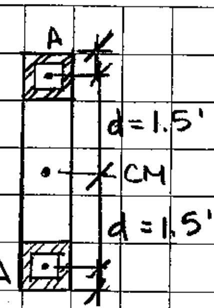
| | | | |
|---|---|---|---|
| | CYNTHIA | STRUCTURAL | 1/30/07 |
| DWG # | Drawn by | Subject (Org Chart) | Date created |

Comments:

HSS 4x4x1/4

$\Delta = 0.29'' < 1/2'' \therefore \underline{OK}$

TRY: HSS 4 x 4 x 1/4 $\quad I = 7.8\,IN^4 \quad A = 3.37\,IN^2$




CHECK: DEFLECTION CRITERIA

$\Delta \le 1/2''$

$I = I_{CM} + Ad^2$ PARALLEL AXIS THEOREM

$I = [7.8 + 3.37(18)^2]2 = 2199\,IN^4$

$W_{TOTAL} = 790\,PLF$

SPAN = 24'

$\Delta = \dfrac{5wl^4}{384EI} = \dfrac{5(790)(24)^4(1728)}{384(29{,}000{,}000)2199} = 0.29'' < 1/2'' \therefore OK$

CHECK: MOMENT $\quad$ TRY: 4x4x1/4

YIELDING: $\phi M_n = (0.9)(18'^k) = 16.2'^k$

$\phi = 0.9$

$M_n = M_P = 18'^k$

$M_P = \min \left| \begin{array}{l} F_y Z = 46(4.69) = 216''k = 18'^k \\ 1.5 M_y = 1.5 F_y S = 1.5(46)(3.9) = 269''^k = 22'^k \end{array} \right.$ (KSI) ($IN^3$)

CONCLUSION • ALL HSS 4x4x1/4 MUST HAVE LESS THAN 18'k OF MOMENT

• 3 OTHER LIMIT STATES DON'T APPLY TO HSS RECT. (LATERAL-TORSIONAL BUCKLING, WEB LOCAL CRIPPLING, FLANGE LOCAL BUCKLING) LRFD 16.1-31

Drawing scale: 4

# Solar Decathlon Sketch Template

DCN# S-12
Match question and clarification list

| | CYNTHIA | STRUCTURAL | 2/1/07 |
|---|---|---|---|
| DWG # | Drawn by | Subject (Org Chart) | Date created |

Comments:

CHECK: SHEAR: $\phi V_n$ $\phi_v = 0.9$

$$\frac{h}{t_w} \leq 2.45\sqrt{E/F_{yw}}$$

$$\frac{4}{2(0.25)} = 8 \leq 2.45\sqrt{29000/46} = 61.5$$

$$\therefore \phi V_n = 0.6 F_{yw} A_w (0.9)$$
$$= 0.6(46)(4(2)(0.25))(0.9) = 50^k$$

CONCLUSION: ALL HSS SECTIONS MUST HAVE LESS THAN $50^k$ OF SHEAR FORCE

CHECK: AXIAL

ASSUMPTIONS
- SINCE EACH MEMBER IS WELDED ALL ENDS ARE FIXED-FIXED
- EACH SEGMENT OF THE TRUSS IS CONSIDERED A MEMBER

TABLE 4-6 LRFD 4-63

$Kl = 0.5(4') = 2'$

A HSS 4×4×1/4 CAN SUPPORT $130^k$ >> TENSION & COMPRESSION FORCES IN MEMBERS

Drawing scale: 4 MORNINGSTAR

| | DWG / Detail | Completed By | Revised By | DCN # | |
|---|---|---|---|---|---|
| Calc 2.02 | | Gimbet, Milinichik | Glantz, Owens | S-45 | Reference Appendix 4.03 |

*Conclusions: Final Design of Truss includes the following configurations:*
*LS Truss with TOP Cord HSS 4" x 4" x 5/16" Tube STL A500 Gr. B*
*LS Truss with BOTTOM Cord HSS 4" x 4" x 5/16" Tube STL A500 Gr. B*
*LS Truss Inner members HSS 4" x 2" x 5/16" Tube STL A500 Gr. B*
*BZWY Frame Outer Members HSS 4" x 4" x 5/16" Tube STL A500 Gr.B*
*BZWY Frame Inner Members HSS 4" x 2" x 5/16" A500 Gr.B Tube STL*

**Assumptions:**

**_Loads**

**_Trib Width** 14.67 **ft** *(includes half LS + 8' BZWY width)*

| | **_Item** | | **_psf** | **_plf** | **_factored value** | **_factored** |
|---|---|---|---|---|---|---|
| ** | Snow Load | SL | 35 | 513.33 | 1.60 | 821.33 |
| | PV Load BZWY | LL | 4.6 | 26.63 | 1.60 | 42.61 |
| | PV Load LVG | DL | 4.6 | 30.67 | 1.20 | 36.80 |
| | EV Tubes | LL | 3.49 | 20.22 | 1.60 | 32.35 |
| | STL BWY Frame | DL | 7.58 | 43.87 | 1.20 | 52.65 |
| | 4 5/8" SIPs PUR BZWY | DL | 3.75 | 21.71 | 1.20 | 26.06 |
| | 6 5/8" SIPs PUR LVG | DL | 4.15 | 27.67 | 1.20 | 33.20 |
| | Insulation (poured) | DL | 5 | 33.33 | 1.20 | 40.00 |
| | Skylight | DL | 15 | 100.00 | 1.20 | 120.00 |
| | Occupancy | Lr | 20 | 0.00 | 1.60 | 0.00 |
| | | | | | **_Total Factored Dead** | 308.70 |
| | | | | | **_Total Factored Live** | 896.30 |

** *See Summary of Load inputs from STAAD data in Appendix 4.03*

**_Load Combinations**

| | | | |
|---|---|---|---|
| **1.4D** | **91.8** | **0.092 klf** | |
| **1.2D +1.6(LL)** | **1804.5** | **1.805 klf** | ***controls** |
| **1.2D +1.6(Lr)** | **370.4** | **0.370 klf** | |

1 All members of truss are joint welded, E70.
2 Truss is assumed to act as a rigid member.
3 For deflection limitations over the 24' spanning length between end SIP panels:

| | | | | |
|---|---|---|---|---|
| L/240 " | 1.2 | inch | IBC Code | |
| L/360 " | 0.8 | inch | IBC Code | |
| | 0.5 | inch | Team Stipulation | ***controls** |

**Calculations:**

**_STAAD MODEL 002**

Deflection Criteria @ Critical Joint(s)

*STAAD Model configuration includes:*

| | |
|---|---|
| LS Truss with TOP Cord | HSS 4" x 4" x 5/16" Tube STL A500 Gr. B |
| LS Truss with BOTTOM Cord | HSS 4" x 2" x 5/16" Channel STL A36 |
| LS Truss Inner members | HSS 4" x 4" x 5/16" Tube STL A500 Gr. B |
| BZWY Frame Outer Members | HSS 4" x 4" x 5/16" Tube STL A500 Gr.B |
| BZWY Frame Inner Members | HSS 4" x 2" x 5/16" A500 Gr.B Tube STL |

| | | | | | |
|---|---|---|---|---|---|
| **Joint 5** | 0.04114 | **Joint 14** | 0.04113 | **Joint 20** | -0.01831 |
| | 0.00005 | | 0.00005 | | 0.00001 |
| | 0.04684 | | 0.04685 | | 0.00068 |
| | 0.00005 | | 0.00005 | | 0.00001 |
| | 0.04226 | | 0.04226 | | 0.00061 |
| | 0.00006 | | 0.00006 | | 0.00001 |
| | 0.05092 | | 0.05092 | | 0.00074 |
| | 0.00516 | | 0.00516 | | 0.00029 |
| | 0.01437 | | 0.01437 | | -0.00266 |
| | 0.00713 | | 0.00713 | | -0.00132 |
| | 0.00212 | | 0.00212 | | -0.00835 |
| | 0.00296 | | 0.00296 | | -0.01163 |
| | 0.00039 | | 0.00039 | | 0.00007 |
| | 0.35642 | | 0.35644 | | 0.00518 |
| | 0.06659 | | 0.0666 | | -0.01231 |
| | 0.02758 | | 0.02758 | | -0.10852 |
| | 0.00363 | | 0.00363 | | -0.01427 |
| | 0.00275 | | 0.00275 | | -0.01083 |
| | 0.00874 | | 0.00875 | | -0.00162 |
| | 0.00663 | | 0.00663 | | -0.00123 |
| **Total** | 0.68579 | **Total** | 0.68583 | **Total** | -0.18345 |
| | Ok for IBC | | Ok for IBC | | Ok |

Check with new summation completed by STAAD:

| | | | | | |
|---|---|---|---|---|---|
| **Joint 5** | -0.63646 | **Joint 14** | -0.63649 | **Joint 20** | -0.04698 |
| | -0.04933 | | -0.04934 | | -0.13645 |
| **Total** | -0.68579 | **Total** | -0.68583 | **Total** | -0.18343 |
| | Ok for IBC | | Ok for IBC | | Ok |

**_STAAD MODEL 003**

Deflection Criteria @ Critical Joint(s)

*STAAD Model configuration includes:*

| | |
|---|---|
| LS Truss with TOP Cord | HSS 4" x 4" x 5/16" Tube STL A500 Gr. B |
| LS Truss with BOTTOM Cord | HSS 4" x 4" x 5/16" Tube STL A500 Gr. B |
| LS Truss Inner members | HSS 4" x 2" x 5/16" Tube STL A500 Gr. B |
| BZWY Frame Outer Members | HSS 4" x 4" x 5/16" Tube STL A500 Gr.B |
| BZWY Frame Inner Members | HSS 4" x 2" x 5/16" A500 Gr.B Tube STL |

| | | | | | |
|---|---|---|---|---|---|
| **Joint 5** | -0.58454 | **Joint 14** | -0.58421 | **Joint 20** | -0.04977 |
| | -0.05104 | | -0.05102 | | -0.13378 |
| **Total** | -0.63558 | **Total** | -0.63523 | **Total** | -0.18355 |
| | Ok for IBC | | Ok for IBC | | Ok |

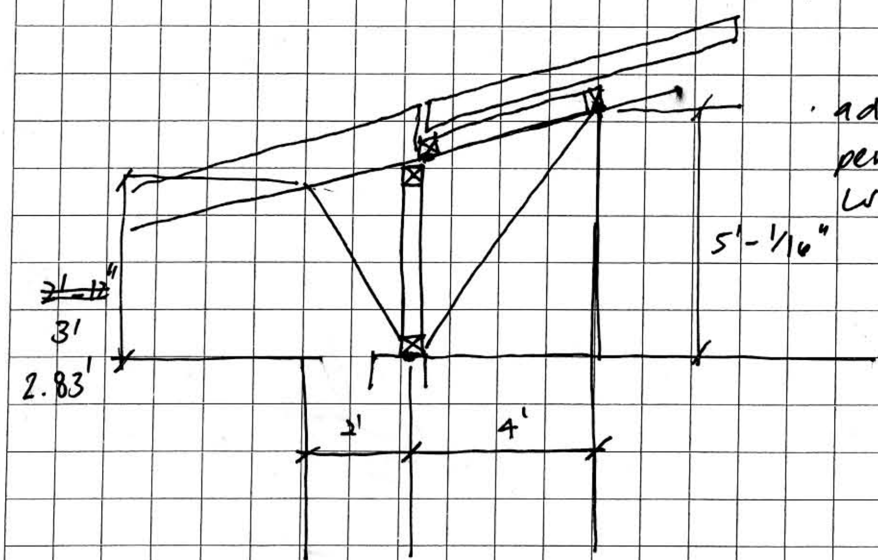
**_STAAD MODEL 004**

Deflection Criteria @ Critical Joint(s)

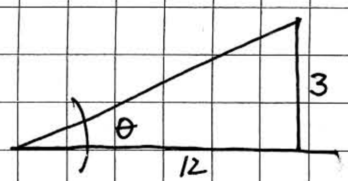
*STAAD Model configuration includes:*

| | |
|---|---|
| LS Truss with TOP Cord | HSS 4" x 4" x 1/2" Tube STL A500 Gr. B |
| LS Truss with BOTTOM Cord | HSS 4" x 4" x 1/2" Tube STL A500 Gr. B |
| LS Truss Inner members | HSS 4" x 2" x 5/16" Tube STL A500 Gr. B |
| BZWY Frame Outer Members | HSS 4" x 4" x 1/2" Tube STL A500 Gr.B |
| BZWY Frame Inner Members | HSS 4" x 2" x 5/16" A500 Gr.B Tube STL |

| | | | | | |
|---|---|---|---|---|---|
| **Joint 5** | -0.51859 | **Joint 14** | -0.51822 | **Joint 20** | -0.05344 |
| | -0.048 | | -0.04797 | | -0.12748 |
| **Total** | -0.56659 | **Total** | -0.56619 | **Total** | -0.18092 |
| | Ok for IBC | | Ok for IBC | | Ok |

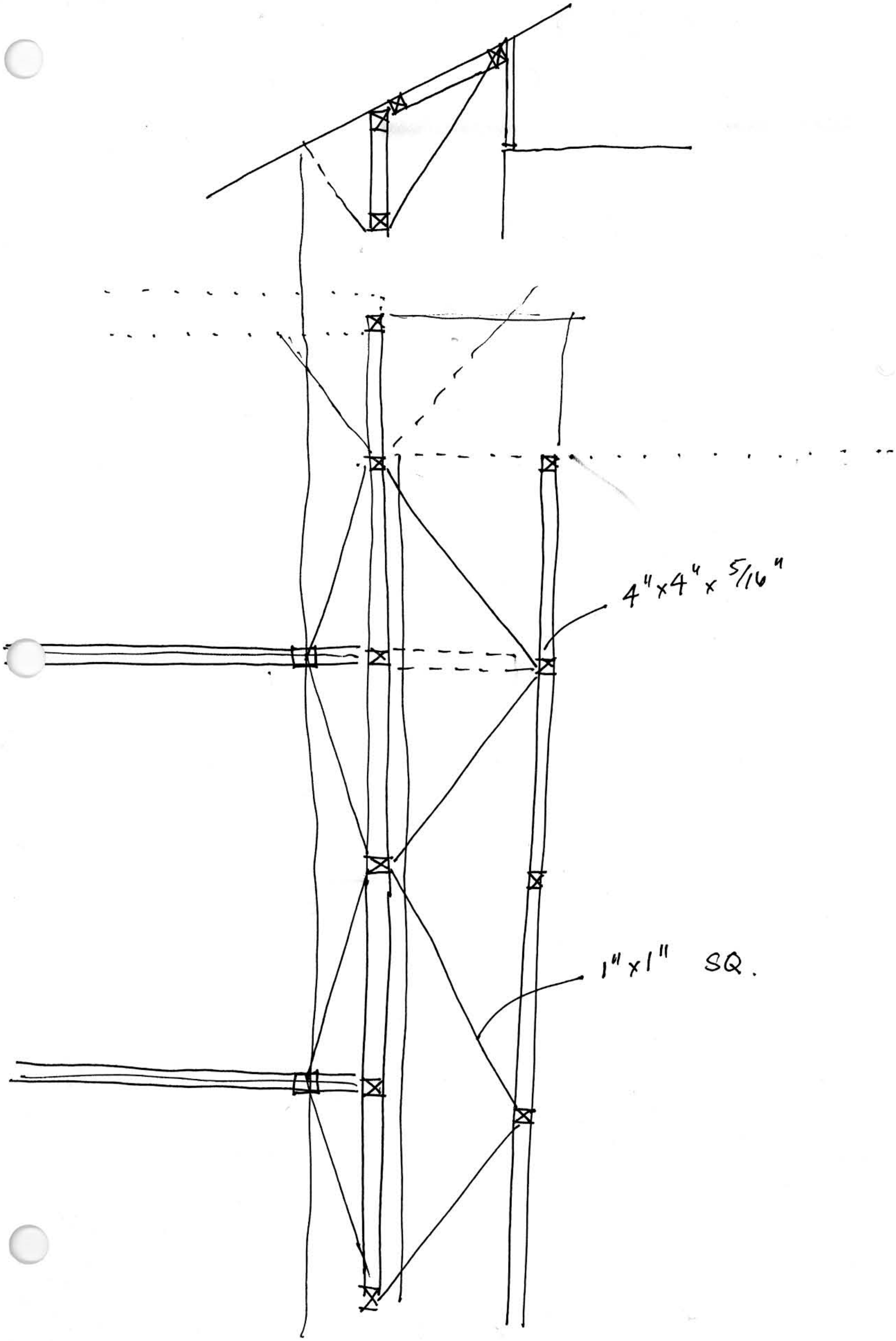


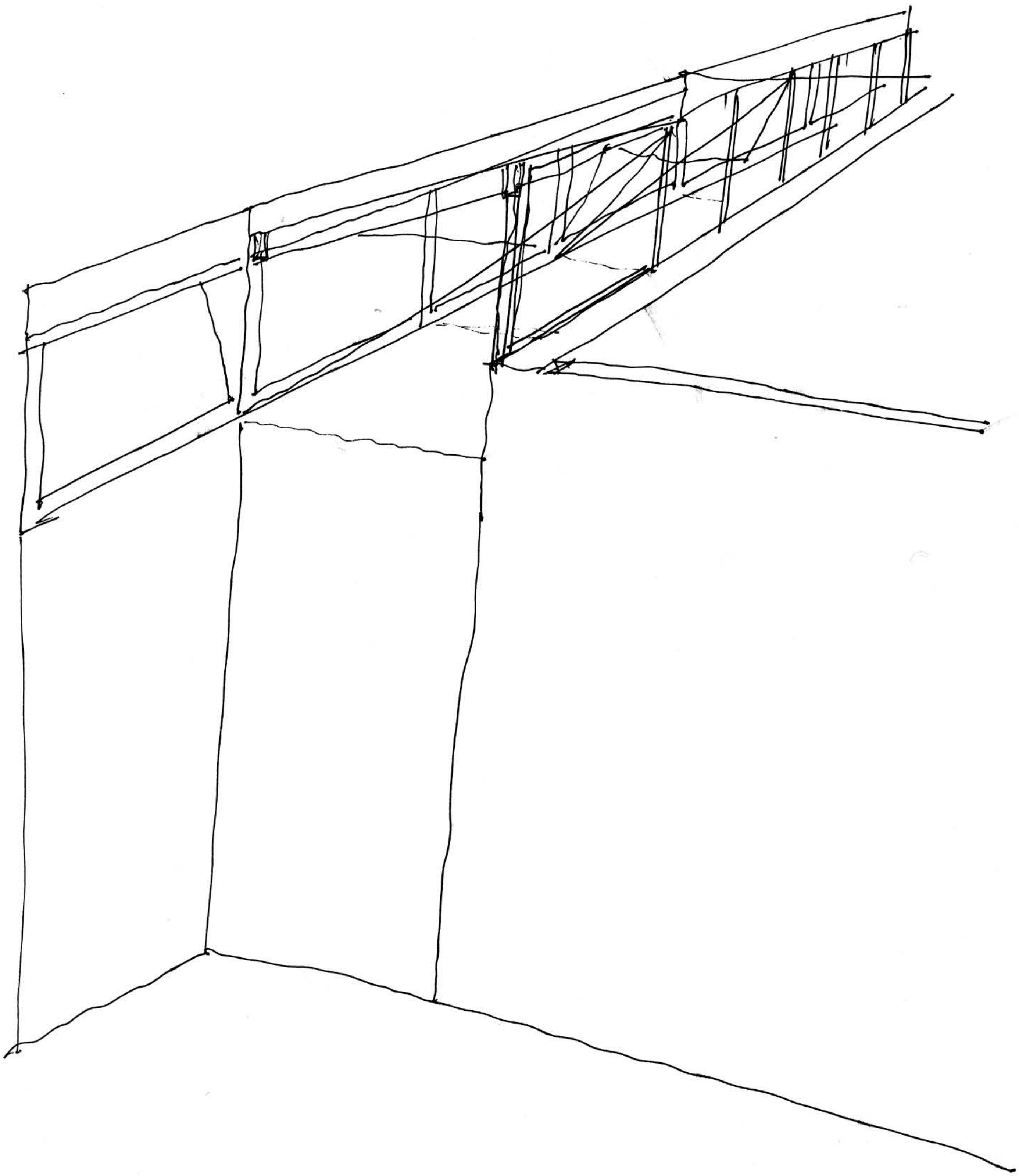

· adding outriggers to permanently frame into LW roof




$\tan\theta = \frac{3}{12}$

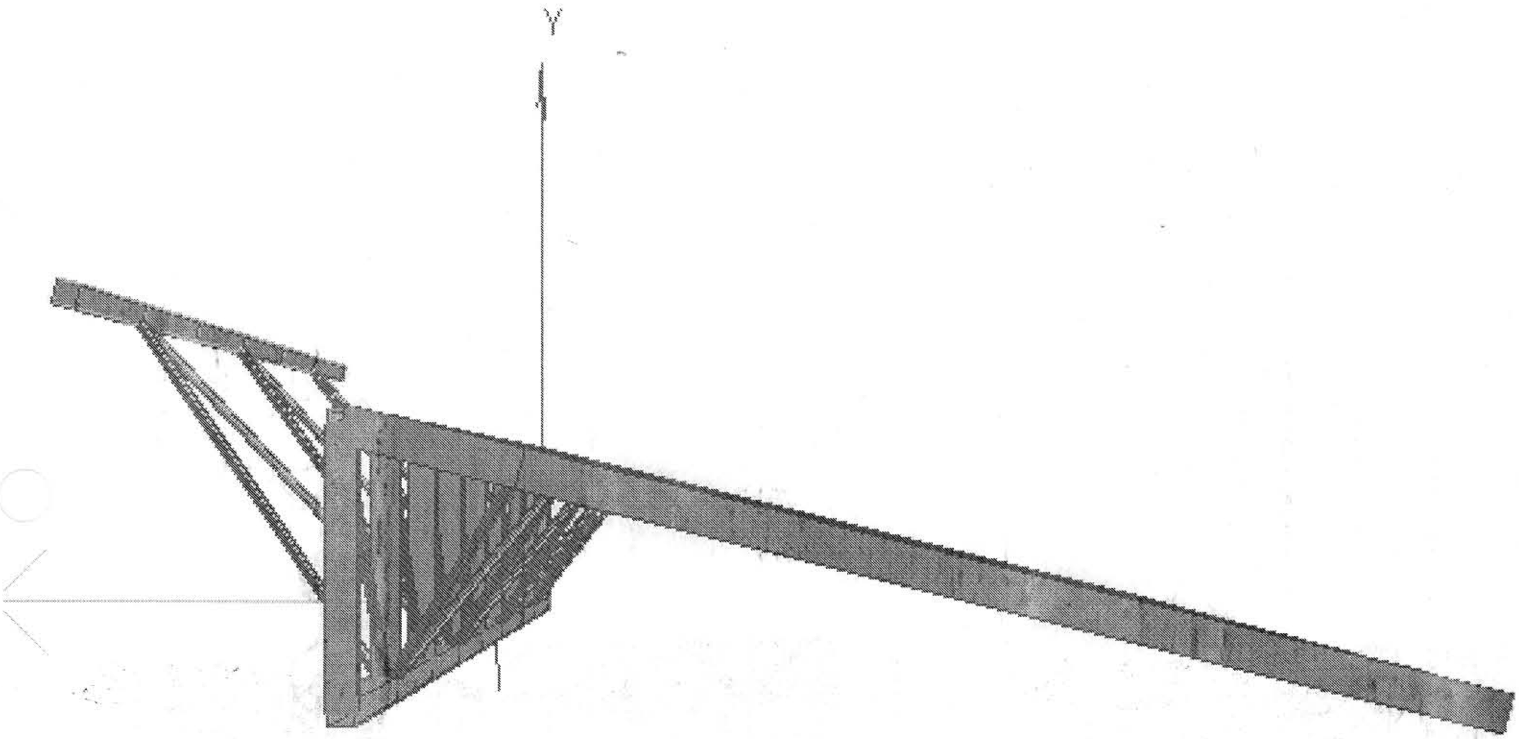
$\theta = 14.036°$


4"x4"x 5/16"
1"x1" SQ.



STL Design
Struct

S-44
02.11.07

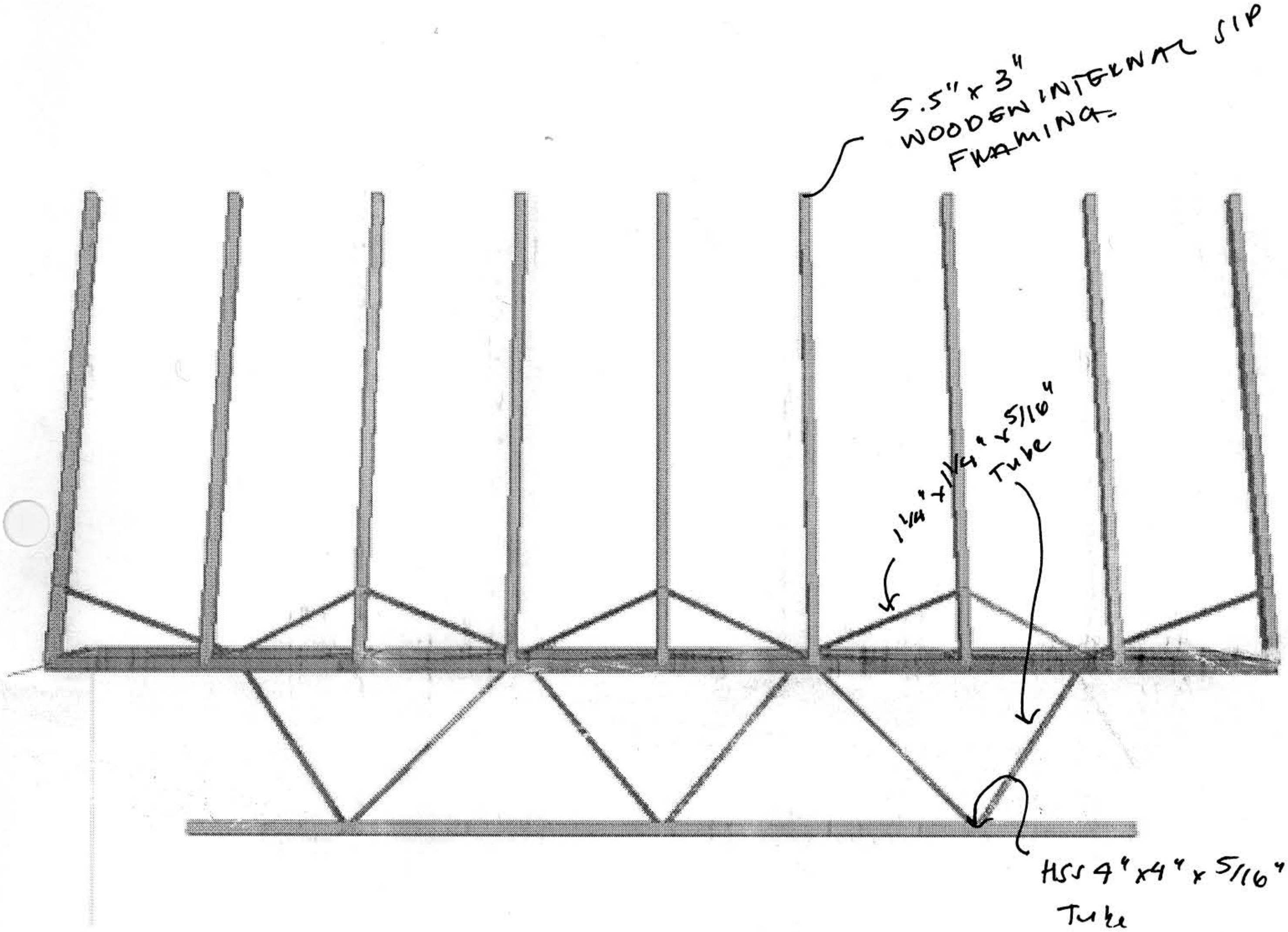


STL Design 02.11.07

This STAAD model contains STL framing and the double 2 x 6 internal framing of the living space SIPs.

For STL member sizes and properties please see assumptions given at beginning of this Calc 2.02.

The 2 x 6 members were modelled with an E = 1,800,000 psi Southern Pine No. 2



S-44

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|---|---|---|---|
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| Job Title STL Design, Struct | Ref | | |
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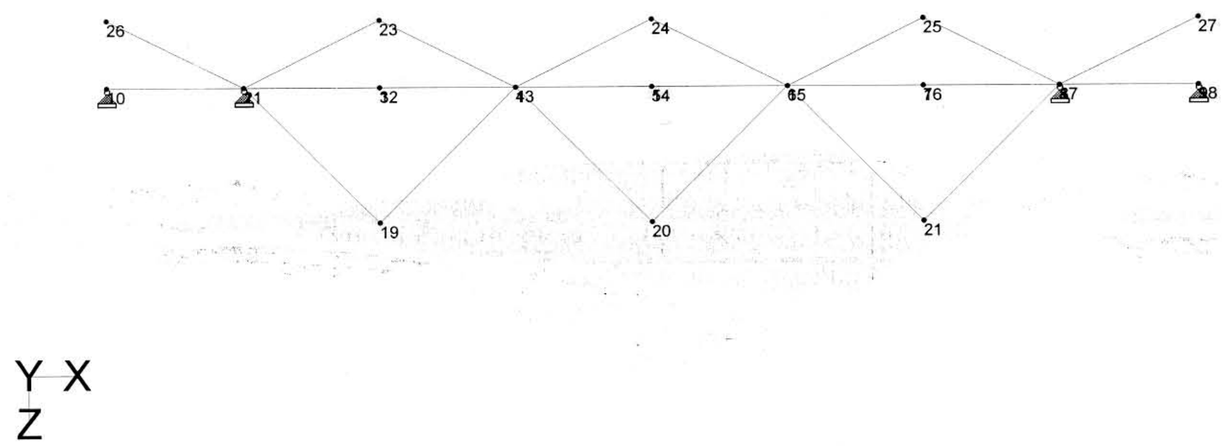

S-44

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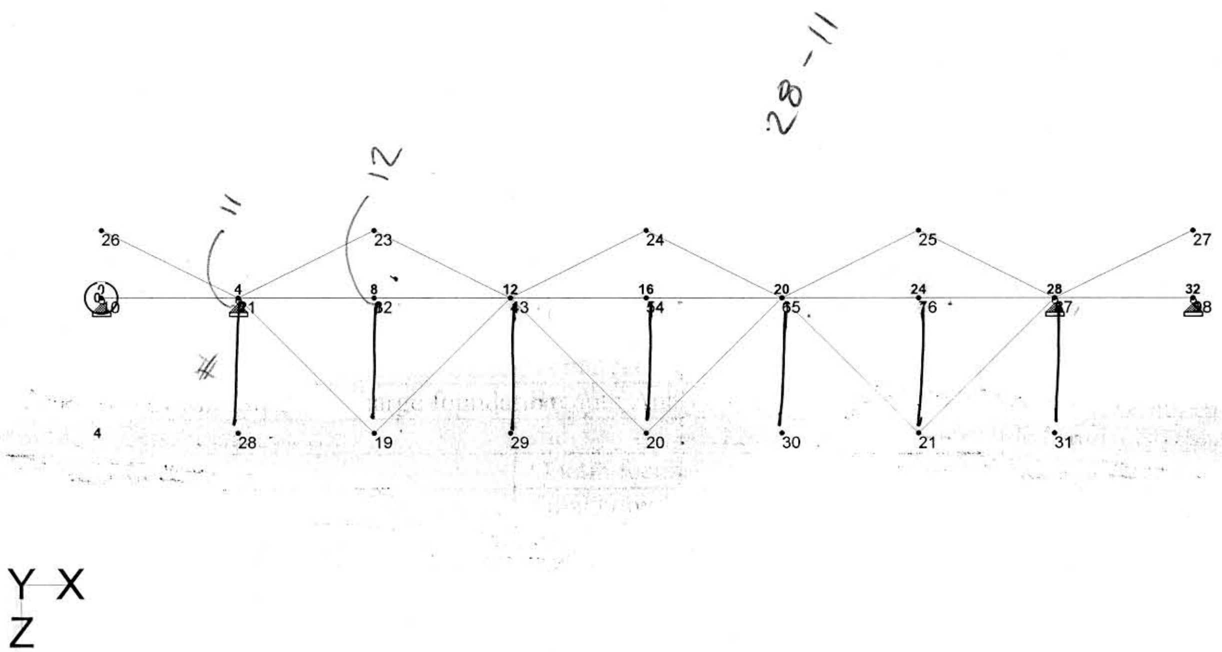


Load 1

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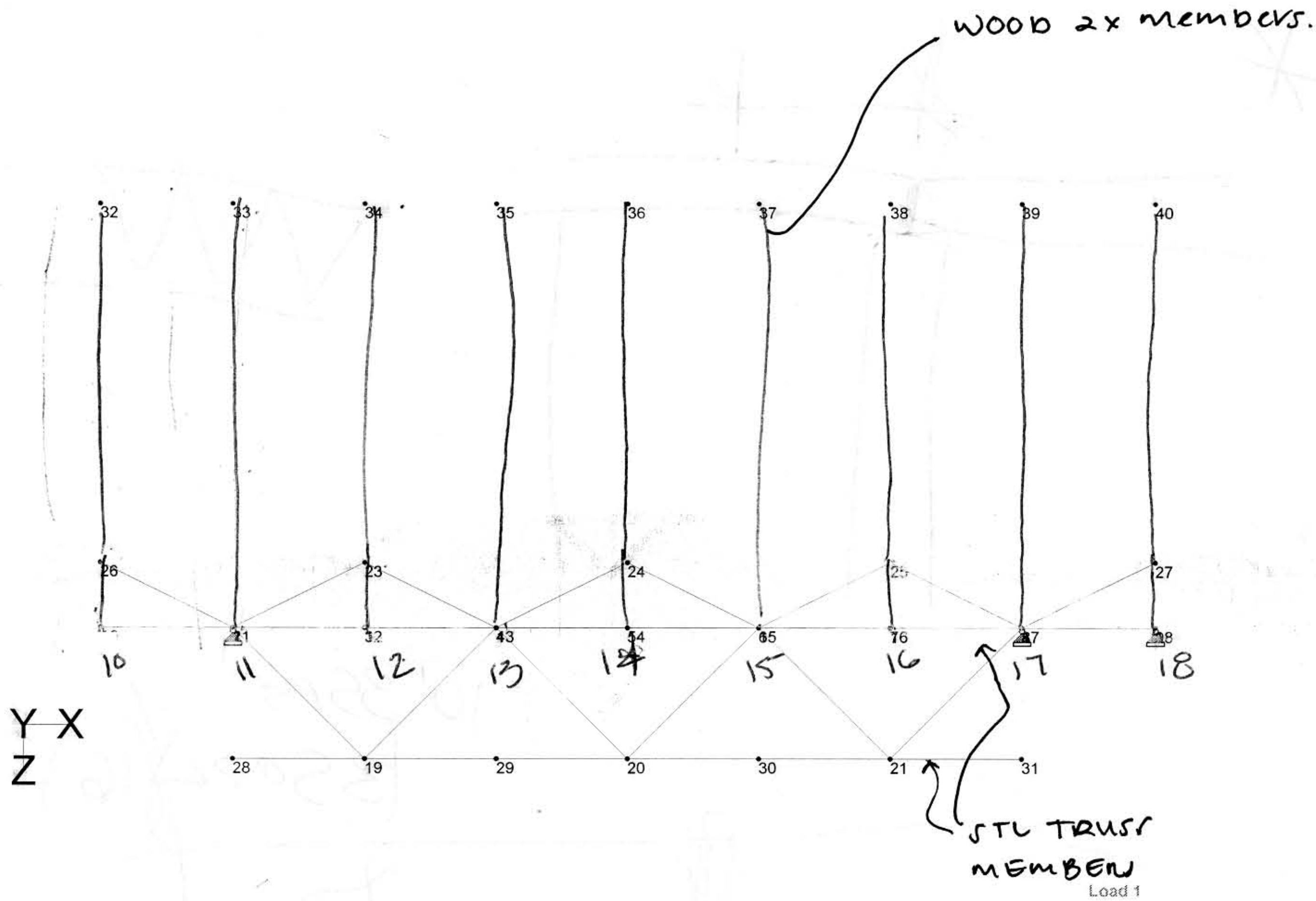
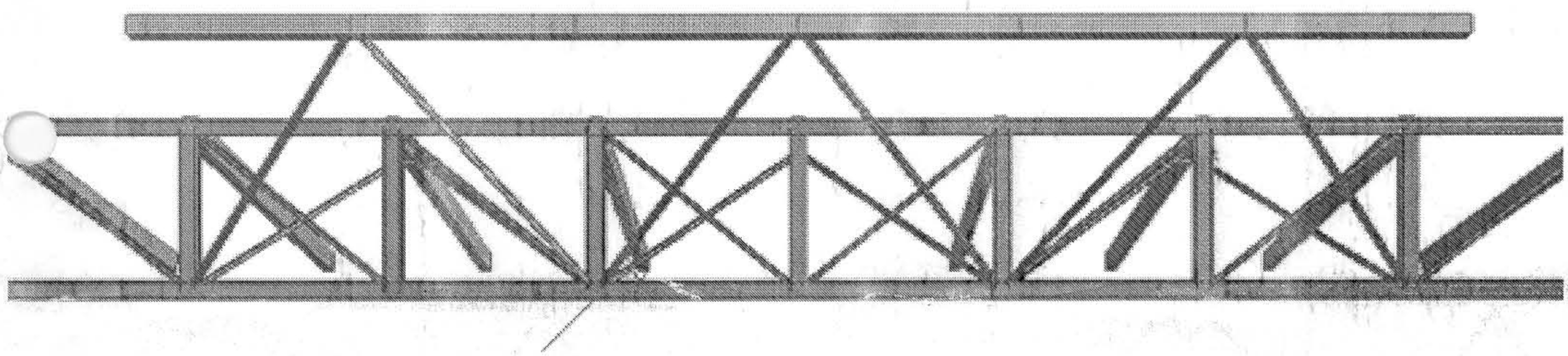


S-44

STL Design
Struct

02.11.07



S-44

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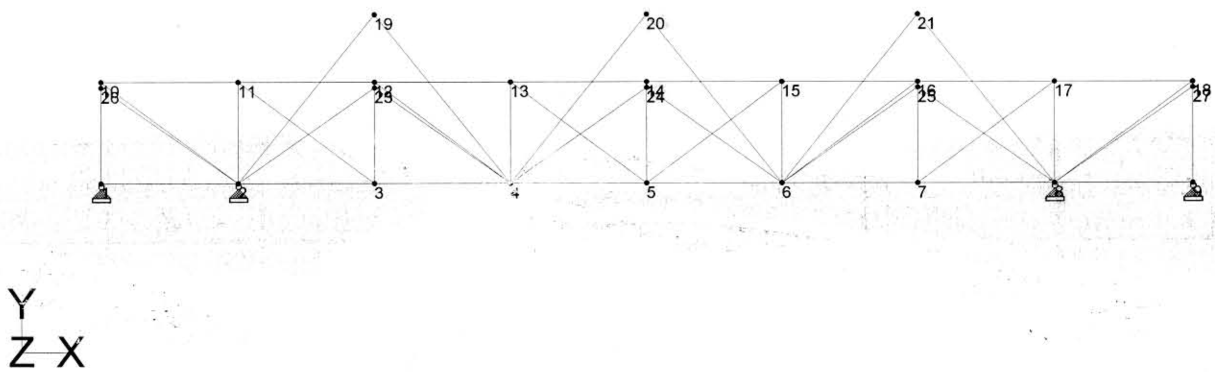
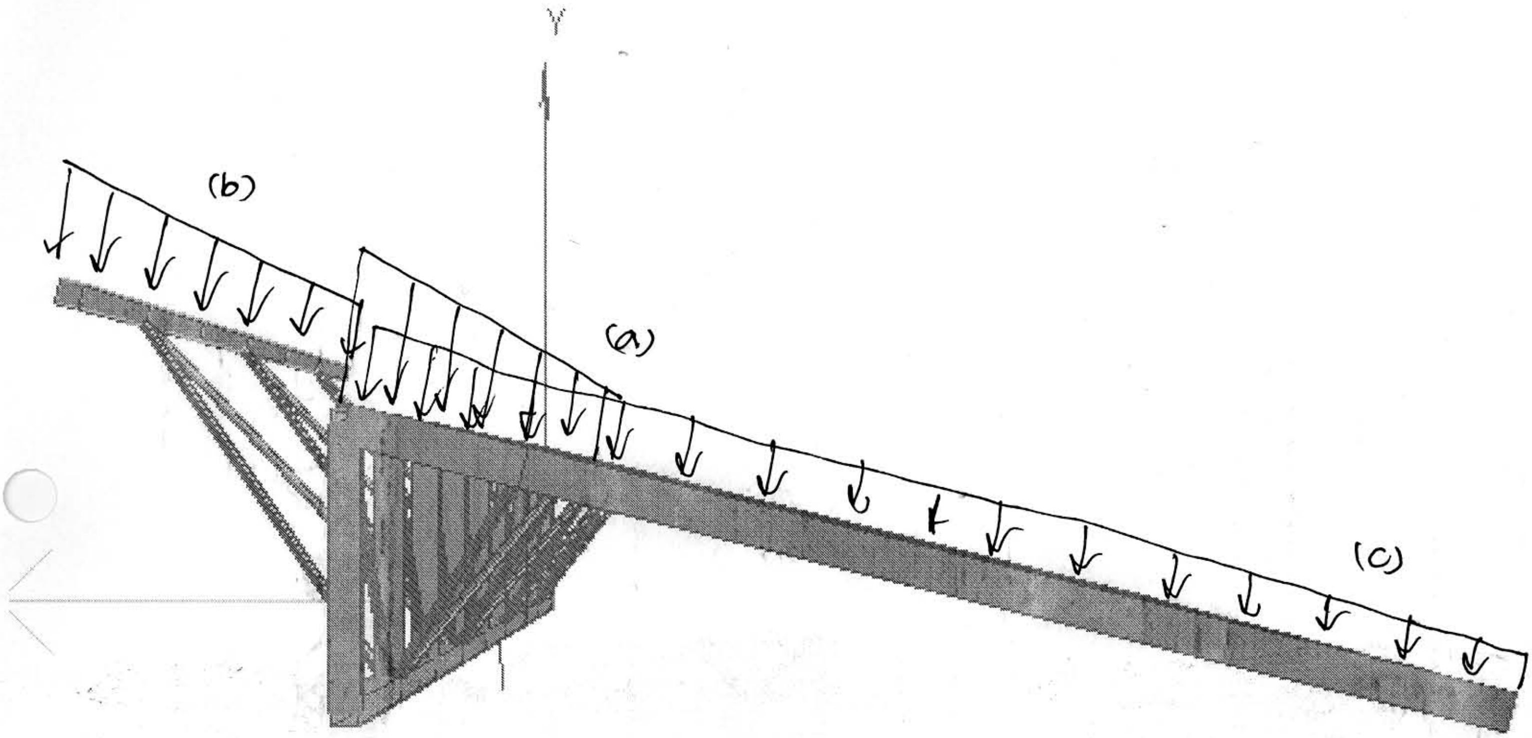


Loads were applied to the structure in STAAD in the following configuration.
Each load was PLF over the length of a member.

(a) indicates a load distributed linearly along the top of the truss.
The loads are derived from half of the breezeway width. [118.10plf]

(b) indicates a load distributed linearly along the outer 4"x 4" member of the Breezeway frame. The loads came from half of the breezeway width + overhang loads including LL from PV and E-Tubes. [288.8plf]

(c) indicates a load distributed linearly along the 5.5" x 3" double 2 x 6 internal framing between living space SIPs. Loads came from dead weight of PVs and SIPs. This load does not account for the fact that the SIPs add to the structural integrity of this system. [195plf]



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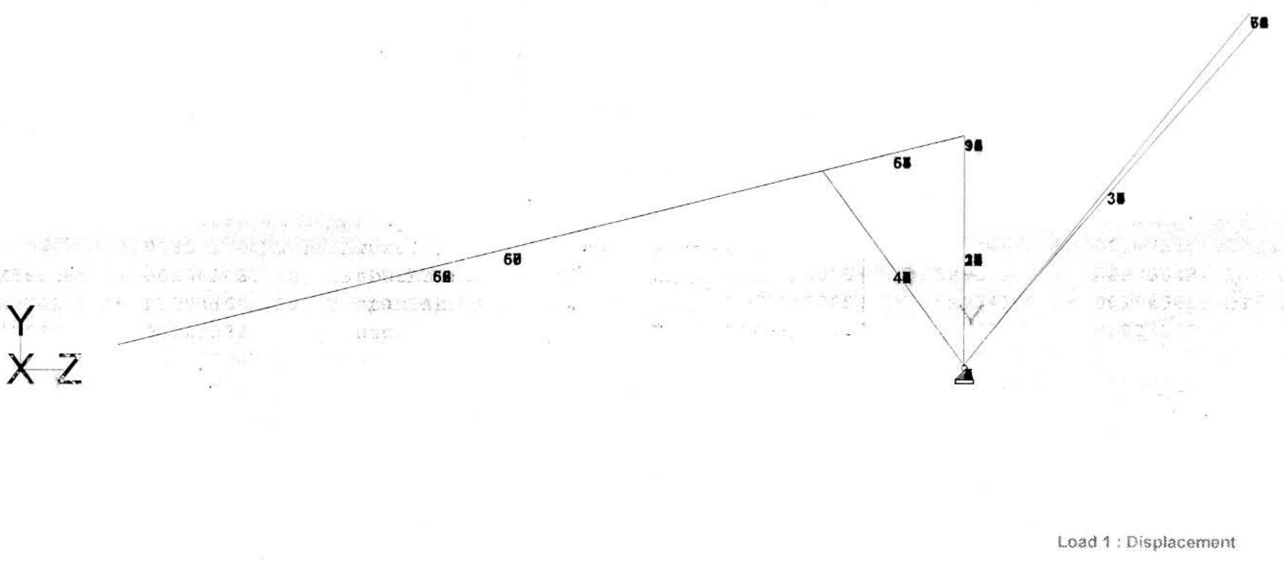
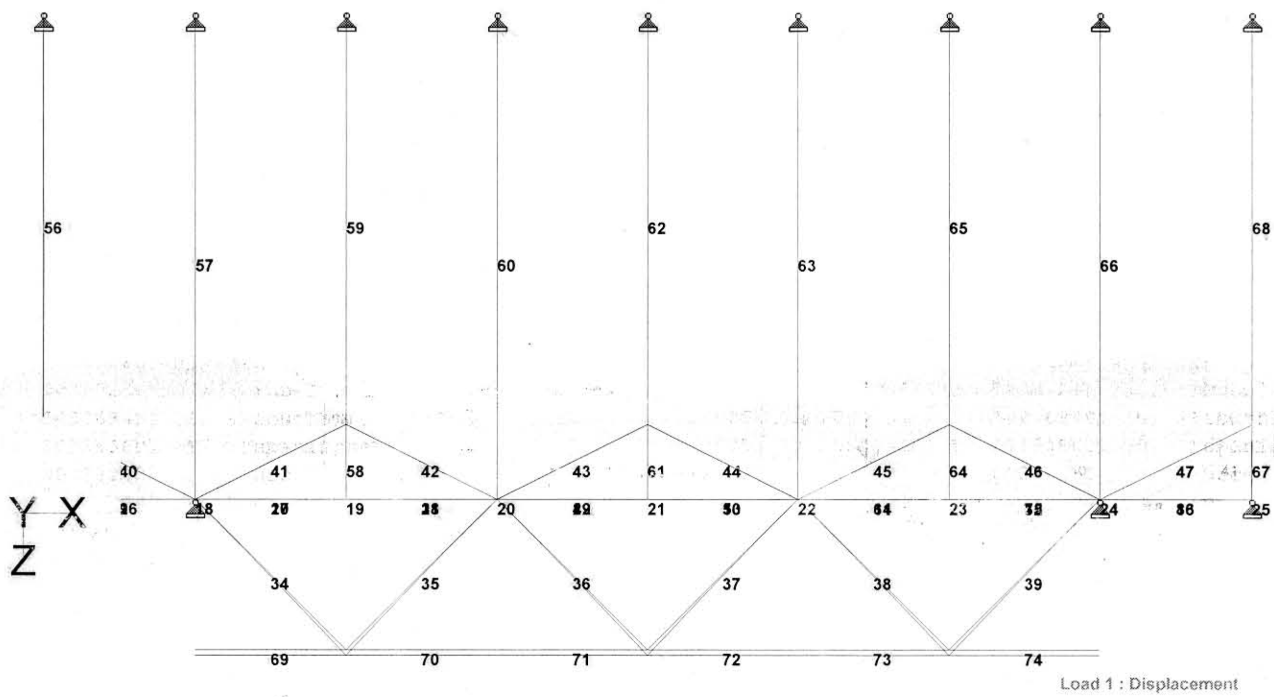
| | By | Date 01-Feb-07 | Chd |
| Client | File S-44 LS Truss Tree Struc | Date/Time 11-Feb-2007 18:32 | |



S-44

| Software licensed to ae | Job No | Sheet No 1 | Rev |
|---|---|---|---|
| | Part | | |
| Job Title Deflection Results | Ref | | |
| | By | Date 01-Feb-07 | Chd |
| Client | File S-44 LS Truss Tree Struc | Date/Time 11-Feb-2007 18:32 | |



| | DWG / Detail | Completed By | Revised By | DCN # | |
|---|---|---|---|---|---|
| Calc 2.03 | Hinge | Terentiuk, Gimbert | Glantz, Owens | S-14 | |

*Conclusions: USE A36 steel 3/4" diameter pin for hinge. This section determines loading and design for hinges supporting breezeway*

**Assumptions:**

**_Loads**

**_Area** 8'-1" x 2'-0" 16 **ft²**

**** when roof in transportation mode**

| _Item | | _psf | _lbs | _factored value | _factored |
|---|---|---|---|---|---|
| PV Load BZWY | DL | 4.6 | 73.60 | 1.40 | 103.04 |
| EV Tubes | DL | 3.49 | 55.87 | 1.40 | 78.22 |
| STL BWY Frame | DL | 7.58 | 121.23 | 1.40 | 169.73 |
| 4 5/8" SIPs PUR BZWY | DL | 3.75 | 60.00 | 1.40 | 84.00 |
| | | | | ***Control** | 434.99 |

**_Area** (4'-6"/2) x 2'-0" 4.5 **ft²**

**** when roof in service mode**

| | | | | | |
|---|---|---|---|---|---|
| Snow | LL | 35 | 157.50 | 1.60 | 252.00 |
| PV Load BZWY | LL | 4.6 | 20.70 | 1.60 | 33.12 |
| EV Tubes | LL | 3.49 | 15.71 | 1.60 | 25.14 |
| STL BWY Frame | DL | 7.58 | 34.10 | 1.20 | 40.92 |
| 4 5/8" SIPs PUR BZWY | DL | 3.75 | 16.88 | 1.20 | 20.25 |
| | | | | | 371.43 |

**_Load Combinations**

| | | | | |
|---|---|---|---|---|
| **1.2D +1.6(S +LL)** | **371.4** | **0.371 k** | **During Use** | ***Control** |
| **1.4D** | **435.0** | **0.435 k** | **During Transportation** | |

*1* Pin is designed to resist shear of self weight of breezeway roof during transportation

*2* Breezeway roof rest in a vertical position, hanging from Piano hinge during the transportation.

*3* Breezeway roof will also be shimmed into place during transportation.

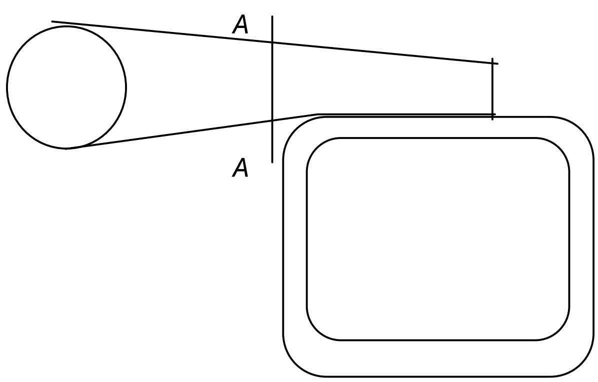
4 Shear would occur between hinge knuckles of pin designed to resist this load.
5 Piano hinge is designed with 2' long knuckles to accept pin along the 24' length.
6 Each Knuckle accepts 4' wide Tributary Width of information of 8' length panel.

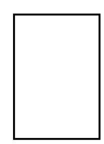
**Calculations:** For a 3/4" diameter bar of A36 Steel:

| | | | |
|---|---|---|---|
| Fy | = | 36 | ksi |
| Fu | = | 58 | ksi |
| Fn | = | 0.4 Fu | |
| | = | 23.2 | |
| Ab | = | $\pi * r^2$ | |
| | = | 0.442 | $in^2$ |
| Ø | = | 0.75 | |
| ØRn | = | ØFnAb | ** shear yielding |
| | = | 7.69 | kips |
| ØRn>Ru | = | 7.69kips > 0.435kips | |

**Results:** For the aesthetic purpose of the home and for transportation loads, the hinge solid rod size is selected at Ø = 3/4" in diameter.

*Check Knuckle Support Plate for Bending and Shear:*



*Section A*
$A_{eff}$ = 1" x

**Assumptions:**

**_Loads**

**_Area** 8'-1" x 2'-0" 16 **$ft^2$**

**** when roof in transportation mode**

| _Item | | _psf | _lbs | _factored value | _factored |
|---|---|---|---|---|---|
| PV Load BZWY | LL | 4.6 | 73.60 | 1.60 | 117.76 |
| EV Tubes | LL | 3.49 | 55.87 | 1.60 | 89.40 |

| | | | | | |
|---|---|---|---|---|---|
| STL BWY Frame | DL | 7.58 | 121.23 | 1.20 | 145.48 |
| 4 5/8" SIPs PUR BZWY | DL | 3.75 | 60.00 | 1.20 | 72.00 |
| | | | | ***Control** | 424.64 |

**_Area** (4'-6"/2) x 2'-0" 4.5 **ft$^2$**

**** when roof in service mode**

| | | | | | |
|---|---|---|---|---|---|
| Snow | LL | 35 | 157.50 | 1.60 | 252.00 |
| PV Load BZWY | LL | 4.6 | 20.70 | 1.60 | 33.12 |
| EV Tubes | LL | 3.49 | 15.71 | 1.60 | 25.14 |
| STL BWY Frame | DL | 7.58 | 34.10 | 1.20 | 40.92 |
| 4 5/8" SIPs PUR BZWY | DL | 3.75 | 16.88 | 1.20 | 20.25 |
| | | | | | 371.43 |

**_Load Combinations**

| | | | | |
|---|---|---|---|---|
| **1.2D +1.6(S +LL)** | **371.4** | **0.371 k** | **During Use** | ***Control** |
| **1.4D** | **435.0** | **0.435 k** | **During Transportation** | |

**Calculations:** For a 3/4" diameter bar of A36 Steel:

*The Knuckle must resist a max Vn: (Reference Calc. 2.07)*

*Vn = 0.425kips/2 = 1.55kips.*

*Vn =* *0.2125 kips*

*The Knuckle must resist a max Mn (as a small cantilevered beam):*

Mn = 0.425kips * (length of knuckle support to HSS 4x4)

Mn = 0.425kips *(1.75")

Mn = 0.7395 kip-in

*It is suggested by manufacture to use a stainless steel pin with a diameter at least the same size as the rod. Try a Ø =1 3/8" pin size:*

*Check Shear:*

Fy = 36 ksi

Fu = 58 ksi

Fn = 0.4 Fu

= 23.2

r = 0.6875

Ab = $\pi * r^2$

= 1.484140625 in$^2$

Ø = 0.75

ØVn = ØFnAb

= 25.82 kips

ØRn = 25.82kips > 1.55kips

*Check Moment:*

Fy = 36 ksi

Fu = 58 ksi

Fn = Fy

= 23.2

r = 0.6875

| | | | |
|---|---|---|---|
| Ab | = | $\pi * r^2$ | |
| | = | 1.484140625 | $in^2$ |
| Ø | = | 0.9 | safety factor |
| d | = | | in |
| ØMn | = | Ø*Fy*A* d | |
| | = | 0.00 | kip-in |
| $M_n > M_u$ | = | 12.02kip-in > 1.55kip-in | |

**Results:** USE a Ø =1 3/8" clevis pin

| | DWG / Detail | Completed By | Revised By | DCN # | |
|---|---|---|---|---|---|
| Calc 2.04 | BZWY Frame | Gimbert | Glantz, Owens | N.A. | Reference Calc 2.07 |

*Conclusions: USE a HSS 4" x 2" x 1/4" Tube steel inside member of frame used to support breezeway roof; reference appendix 4.0# for deflection results given in STAAD.*

**Assumptions:**

**_Loads**

**_TW** 4 **ft**

| _Item | | _psf | _lbs | _factored value | _factored |
|---|---|---|---|---|---|
| PV Load BZWY | LL | 4.6 | 18.40 | 1.60 | 29.44 |
| EV Tubes | LL | 3.49 | 13.97 | 1.60 | 22.35 |
| STL BWY Frame | DL | 7.58 | 30.31 | 1.20 | 36.37 |
| 4 5/8" SIPs PUR BZWY | DL | 3.75 | 15.00 | 1.20 | 18.00 |
| Snow | LL | 35 | 140.00 | 1.60 | 224.00 |
| Occupancy | Lr | 20 | 80.00 | 1.20 | 96.00 |
| | | | | **_Total Factored Dead** | 54.37 |
| | | | | **_Total Factored Live** | 275.79 |

**_Load Combinations**

| | | | |
|---|---|---|---|
| **1.4D** | **54.4** | **0.054 klf** | |
| **1.2D +1.6(S +LL)** | **330.2** | **0.330 klf** | ***controls** |
| **1.2D +1.6(Lr)** | **150.4** | **0.150 klf** | |

1 Pin is designed to resist shear of self weight of breezeway roof during transportation

2 Breezeway roof rest in a vertical position, hanging from Piano hinge during the transportation

3 Breezeway roof will also be shimmed into place during transportation.

4 Shear would occur between hinge Knuckles; pin designed to resist this load.

5 Piano hinge is designed with 2' long knuckles to accept pin along the 24' length.

$M_u = (w * L^2) / 8$

$= \boxed{0.66}$ **ft-kips**

$V_u = (w * L) / 2$

$\boxed{0.66}$ **kips**

**Calculations:**

1 Try a HSS 5/16" x 4" x 2" Tube Section for internal members, I= 5.13in$^3$

| | | | | |
|---|---|---|---|---|
| Sx | = | 2.56 in$^3$ | | |
| Zx | = | 3.43 in$^3$ | | |
| Fy | = | 46 ksi | | |
| Capacity: | | | | |
| ØMn | = | 0.9 * Fy * Z | | |
| | = | $\boxed{11.83}$ | ft-kips | * controls |
| OR | = | 0.9 * 1.5 * Fy * S | | |
| | = | 13.248 | ft-kips | |

2 Try a HSS 1/4" x 4" x 2" Tube Section for internal members, I= 5.13in$^3$

*Check Moment:*

| | | | | | |
|---|---|---|---|---|---|
| Sx | = | 2.25 in$^3$ | | | |
| Zx | = | 2.94 in$^3$ | | | |
| Fy | = | 46 ksi | | | |
| Capacity: | | | | | |
| ØMn | = | 0.9 * Fy * Z | | | |
| | = | $\boxed{10.14}$ | ft-kips | >> 0.66ft-kips | Ok |
| OR | = | 0.9 * 1.5 * Fy * S | | | |
| | = | 11.64 | ft-kips | | |

Mp = 10.14 ft-kips >> Mu = 0.82 ft-kips

*Check Shear:*

| | | | | | |
|---|---|---|---|---|---|
| Aw | = | 2.44 in$^2$ | | | |
| Fy | = | 46 ksi | | | |
| Capacity: | | | | | |
| ØVn | = | 0.9 (0.6 * Fy * Aw) | | | |
| | = | $\boxed{5.05}$ | kips | >> 0.66 kips | Ok |

*Check Tensile Strength:*

| | | | |
|---|---|---|---|
| t | = | 2.44 in$^2$ | |
| $w$ | = | 10.5 lbs/ft | |
| $A$ | = | 2.94 in$^2$ | |
| $I_x$ | = | 5.13 in$^4$ | |
| $I_y$ | = | 1.67 in$^2$ | |
| Fy | = | 46 ksi | |
| Pu | = | 4.96 k | See Calc 2.07 |

| | | | | | |
|---|---|---|---|---|---|
| l | = | 56 " | | | |
| Capacity: | | | | | |
| ØPn | = | 0.9 (0.6 * Fy * Ay) | | | |
| | = | 121.72 | kips | >> 4.96 kips | Ok |

**Results:** USE a HSS 4" x 2" x 1/4" Tube steel inside member of frame used to support breezeway roof.

| | DWG / Detail | Completed By | Revised By | DCN # | |
|---|---|---|---|---|---|
| Calc 2.05 | Columns | Benoit, Gimbert | Glantz, Owens | S-37 | |

*Conclusions: For column in interior end of North SIPs of LS space, USE (1) 2.5" x 2.5" x 1/4" steel tube or 5" x 5" Southern Pine No. 1 lumber for column. Frame remaining column with 2 x dimensional lumber to fill space for door frame and electrical chase.*

**Assumptions:**

**_Loads**

**_TW** 14.67 **ft** *(includes half LS + Full BZWY)*

| **_Item** | | **_psf** | **_plf** | **_factored value** | **_factored** |
|---|---|---|---|---|---|
| Snow Load | SL | 35 | 513.33 | 1.00 | 513.33 |
| PV Load BZWY | LL | 4.6 | 36.80 | 1.00 | 36.80 |
| PV Load LVG | DL | 4.6 | 30.67 | 1.00 | 30.67 |
| EV Tubes | LL | 3.49 | 27.94 | 1.00 | 27.94 |
| STL BWY Frame | DL | 7.58 | 34.10 | 1.00 | 34.10 |
| 4 5/8" SIPs PUR BZWY | DL | 3.75 | 30.00 | 1.00 | 30.00 |
| 6 5/8" SIPs PUR LVG | DL | 4.15 | 27.67 | 1.00 | 27.67 |
| Insulation (poured) | DL | 5 | 73.33 | 1.00 | 73.33 |
| Skylight | DL | 15 | 100.00 | 1.00 | 100.00 |
| LS Truss Self Wt | Dl | 15.77 | 47.31 | 1.00 | 47.31 |
| Occupancy | Lr | 20 | 0.00 | 1.00 | 0.00 |
| | | | | **_Total Dead** | 343.08 |
| | | | | **_Total Live** | 578.07 |

| | **plf** | **klf** | |
|---|---|---|---|
| **D +LL** | **921.1** | **0.921** | **D +LL** |

The column must resist a axial reaction of:

**Pn** = **(32' * 0.921klf) / 2** **Simple beam analysis**

= $\boxed{\textbf{14.74}}$ **kips**

1 Assume 8' column.

*2* Assume column unbraced by end of SIP, Cp = 1.0

3 North SIPs in Living Space provide 4' of bearing length at end of 32' long truss are not considered as structrual entities in these calculations.

**Calculations:**

1 *Try 2x6 Southern Pine No.1*

A = 8.3 $in^2$

Fc* = 1750 psi compression // to grain

$$F_{CE} = \frac{K_{CE} * E'}{(l_e/d)^2}$$

$$= \frac{(0.3)(1700000)}{(8*12"/ft)/1.5")^2}$$

= 124.51

$C_p$ = [(1 + (FCE / Fc*))/2c] - [Sq. Rt.[((1 + (FCE / Fc*))/2c)$^2$ - ((FCE / Fc*)/c)]

= 0.070 where c = 0.8 for sawn lumber

$F_{CE}$ / Fc* = 0.0711

$C_b$ = 1.0000

$C_m$ = 1.0000

$C_t$ = 1.0000

$C_F$ = 1.0000

KL = 8'

F'c = fc ($C_b$) ($C_m$) ($C_t$) ($C_F$) ($C_p$)

= 122.63 psi

Pall = F'c * A

= 1011.71 lbs

So; = 1.01 kips

14.57 No. of 2 x 6 No.1 Southern Pine

For columns in North SIPs of LS space, frame with at least (15) 2 x 6 Southern Pine No.1 Dimensional Lumber

*2 Try 2x6 Dense Select Structural*

| | | | | |
|---|---|---|---|---|
| A | = | 8.3 | $in^2$ | |
| Fc* | = | 2150 | psi | compression // to grain |
| $F_{CE}$ | = | $\frac{K_{CE} * E'}{(l_e/d)^2}$ | | |
| | = | $\frac{(0.3)(1900000)}{(8*12''/ft)/1.5'')^2}$ | | |
| | = | 139.16 | | |

| | | | |
|---|---|---|---|
| $C_p$ | = | [(1 + (FCE / Fc*))/2c] - [Sq. Rt.[((1 + (FCE / Fc*))/2c)2 - ((FCE / Fc*)/c)] | |
| | = | 0.064 | where c = 0.8 for sawn lumber |
| $F_{CE}$ / Fc* | = | 0.0647 | |
| $C_b$ | = | 1.0000 | |
| $C_m$ | = | 1.0000 | |
| $C_t$ | = | 1.0000 | |
| $C_F$ | = | 1.0000 | |
| KL | = | 8' | |
| F'c | = | fc ($C_b$) ($C_m$) ($C_t$) ($C_F$) ($C_p$) | |
| | = | 139.16 | psi |
| Pall | = | F'c * A | |
| | = | 1148.07 | lbs |
| So; | = | 1.148 | kips |

$\boxed{12.84}$ No. of 2 x 6 Dense Select Structural Southern Pine

For columns in North SIPs of LS space, frame with at least (13) 2 x 6 Southern Pine Dense Select Structural

*3 Try 6 x 6 No.1 Dense Post Southern Pine*

| | | | | |
|---|---|---|---|---|
| A | = | 30.3 | $in^2$ | |
| Fc* | = | 975 | psi | compression // to grain |
| $F_{CE}$ | = | $\frac{K_{CE} * E'}{(l_e/d)^2}$ | | |
| | = | $\frac{(0.3)(1500000)}{(8*12''/ft)/5.5'')^2}$ | | |
| | = | 1477.06 | | |

| | | | |
|---|---|---|---|
| $C_p$ | = | [(1 + (FCE / Fc*))/2c] - [Sq. Rt.[((1 + (FCE / Fc*))/2c)$^2$ - ((FCE / Fc*)/c)] | |
| | = | 0.812 | where c = 0.8 for sawn lumber |

| | | | | |
|---|---|---|---|---|
| $F_{CE}$ / Fc* | = | 1.5149 | | |
| $C_b$ | = | 1.0000 | | |
| $C_m$ | = | 1.0000 | | |
| $C_t$ | = | 1.0000 | | |
| $C_F$ | = | 1.0000 | | |
| KL | = | 8' | | |
| F'c | = | fc $(C_b)$ $(C_m)$ $(C_t)$ $(C_F)$ $(C_p)$ | | |
| | = | 792.09 | psi | |
| Pall | = | F'c * A | | |
| | = | 23960.58 | lbs | |
| So; | = | 23.961 | kips | >>14.74kips |

| 0.62 | No. of 6 x 6 No.1 Southern Pine |
|---|---|

For columns in North SIPs of LS space, frame with at (1) 6 x 6 Southern Pine No.1 Dense

*4 Try 5" x 5" No.1 Dense Post Southern Pine*

| | | | | |
|---|---|---|---|---|
| A | = | 25.0 | $in^2$ | |
| Fc* | = | 975 | psi | compression // to grain |
| $F_{CE}$ | = | $\dfrac{K_{CE} * E'}{(l_e/d)^2}$ | | |
| | = | $\dfrac{(0.3)(1500000)}{(8*12''/ft)/5'')^2}$ | | |
| | = | 1220.70 | | |
| $C_p$ | = | [(1 + (FCE / Fc*))/2c] - [Sq. Rt.[((1 + (FCE / Fc*))/2c)2 - ((FCE / Fc*)/c)] | | |
| | = | 0.763 | where c = 0.8 for sawn lumber | |
| $F_{CE}$ / Fc* | = | 1.2520 | | |
| $C_b$ | = | 1.0000 | | |
| $C_m$ | = | 1.0000 | | |
| $C_t$ | = | 1.0000 | | |
| $C_F$ | = | 1.0000 | | |
| KL | = | 8' | | |
| F'c | = | fc $(C_b)$ $(C_m)$ $(C_t)$ $(C_F)$ $(C_p)$ | | |
| | = | 743.44 | psi | |
| Pall | = | F'c * A | | |
| | = | 18585.94 | lbs | |
| So; | = | 18.586 | kips | > 14.74kips |

| 0.79 | No. of 5" x  5" No.1 Southern Pine |
|---|---|

For columns in North SIPs of LS space, frame with at (1) 5" x 5" Southern Pine No.1 Dense

**4** Try HSS 4" x 4" x 1/4" tube steel

| | | | | |
|---|---|---|---|---|
| A | = | 3.37 | $in^2$ | |
| Ix | = | 7.8 | $in^4$ | |
| KL | = | 8 | ft | |
| *From Table 4-6, LRFD manual:* | | | | |
| $Ø_cPn$ | = | 121 | kips | >> 14. 74kips |

**5** Try HSS 2.5" x 2.5" x 1/4" tube steel

| | | | | |
|---|---|---|---|---|
| A | = | 3.37 | $in^2$ | |
| Ix | = | 7.8 | $in^4$ | |
| KL | = | 8 | ft | |
| *From Table 4-6, LRFD manual:* | | | | |
| $Ø_cPn$ | = | 36.3 | kips | > 14. 74kips |

For columns in North SIPs of Living Space, frame with at (1) 2.5" x 2.5" x 1/4" steel tube column and proceed to frame out rest of space with 2 x

| | DWG / Detail | Completed By | Revised By | DCN # | |
|---|---|---|---|---|---|
| Calc 2.06 | SIP to Trailer Shear Conn. | Benoit, Grossenbacher | Glantz, Owens | S-37 | Reference Appendix 3.03 |

*Conclusions: At structural Line C, USE eight (8) bolts to resist shear of wind, uplift and overturning forces on the home. The bolts are designated as A325 PB Type 1 with 1/2" diameter. Use 8d nails every 3 1/2" o.c. at ends of SIPs to attach SIP to 2 x 6 sill and headers as specified by MURUS. This detail for conection can be used throughout the rest of the home. This point in the home represents the most critical shear load to resist over the smallest length of SIP panel.*

**Assumptions:** At struct line C, SIP connection to trailer frame must resist:

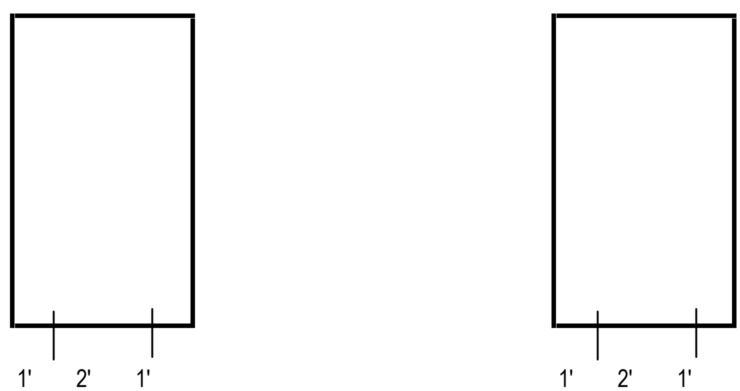
= 3580.00 lbs

= 3.58 kips

1. Assume Connection of SIP to trailer Frame resists remaining Shear
2. Assume A325 grade strength bolt
3. Assume connection of 7/16" OSB to 2 x 6 sill plate and header of SIP are resisting same force of shear as SIP itself.
4. Use 7/16" OSB on exterior surface of PUR 6 5/8" PUR SIP
5. Assume a 24 to 16 span rating
6. Nail recommendation by MURUS is 8d @ 4" o.c.

**Calculations:**

1. Try A325 1/2" diameter bolt placed at 1ft from end of each 4' SIP to connect SIP to Trailer Frame.
2. For a 4' x 8' panels, attachment to trailer using two bolts (Diagram below):




*Check Shear of bolt:*

One (1) bolts A325 PB Type 1 with 1/2" diamter has shear strength of

| | | | | |
|---|---|---|---|---|
| Fy | = | 92 | ksi | |
| Fu | = | 85 | ksi | [see www. portlandbold.com] |
| Fn | = | 0.4 Fu | | |
| | = | 34 | ksi | |

| | | | | |
|---|---|---|---|---|
| Ab | = | $\pi * r^2$ | | |
| | = | 0.196 | $in^2$ | |
| ØRn | = | 0.75 | | |
| ØRn | = | ØFnAb | | |
| | = | 5.00 | kips | |

*Check tearout of bolt through 2 x 6 sill plate:*

One (1) bolts A325 PB Type 1 with 1/2" diamter has shear strength of

From NDS Table 11.B:

| | | | |
|---|---|---|---|
| $t_m$ | = | 1.5 | in |
| $t_s$ | = | 0.25 | in |
| $Z_{//}$ | = | 0.62 | kips |
| $Z_{per}$ | = | 0.36 | kips |

*where Z is a lateral design value given for the connection of a 1/4" thk A36 plate*

For eight (8) bolts along structural line C placed in the 2 x 6 wood plate;

| | | | | |
|---|---|---|---|---|
| $8Z_{//}$ | = | $\boxed{4.96}$ | kips | >3.58kips |

Each bolt has a tearout capacity of :

| | | | | | | |
|---|---|---|---|---|---|---|
| $Z'_{RT}$ | = | $2\ h \times F_v \times t_{scrit}$ | *where $F_v = F'_v$* | | 0.175 | kips |
| | = | $\boxed{6.3}$ | kips | >3.58kips | | Ok |
| | | | | See Appendix 3.02 | | |

*Check hold down of bolt through 2 x 6 sill plate:*

One (1) bolts A325 PB Type 1 with 1/2" diamter has shear strength of

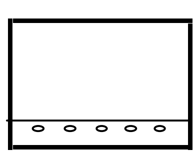
From NDS Table 11.B:

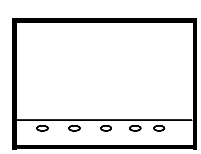
Ft = 67.5ksi

2 The largest Wind force is seen at Structural line C, with 1.87 kips of Shear from Wind:

From NDS Table 4.1 A:

| | | |
|---|---|---|
| *Panel grade* | OSB,Plywood | |
| *Minimum nominal panel thicknes(in.)* | 7/16" | |
| *Minimum Nail penetration in Framing (in.)* | 1 3/8" | |
| *Nail size* | 8d | common |
| *Nail spacing at panel edges.* | 4" > 3.75" as specified by MURUS | |
| $V_n$ = | 490 | plf |





Try 3 1/2" spaced 8d nails with 3/4" edge spacing.

| | | | | | | |
|---|---|---|---|---|---|---|
| $V_u$ | = | 3.48kips/8' | Critical Case at Structural Line C | | | |
| | = | 0.435 | klf | | | |
| | = | $\boxed{435}$ | plf | | < 490plf | **Ok** |

For structural Line C, four (4) bolts will be used accounting for 20kips of shear.

**Results:** Vn = 20kips > Vu = 3.48kips + 14 kips of braking force = 17.58kips
Vn = 490plf > Vu = 435plf for 8d at 4" spacing along OSB

| | DWG / Detail | Completed By | Revised By | DCN # | |
|---|---|---|---|---|---|
| Calc 2.07 | Outrigger, In Breezeway | Gimbert | Glantz, Owens | S-48 | |

*Conclusions: 6.20kips of force are distributed thru two outrigger elements in the breezeway.*

**Assumptions:**

**_Loads**

**_TW** 5.6667 **ft**

| **_Item** | | **_psf** | **_lbs** | **_factored value** | **_factored** |
|---|---|---|---|---|---|
| PV Load BZWY | LL | 4.6 | 26.07 | 1.60 | 41.71 |
| EV Tubes | LL | 3.49 | 19.79 | 1.60 | 31.66 |
| STL BWY Frame | DL | 7.58 | 42.94 | 1.20 | 51.53 |
| 4 5/8" SIPs PUR BZWY | DL | 3.75 | 21.25 | 1.20 | 25.50 |
| Snow | SL | 35 | 198.33 | 1.60 | 317.34 |
| Occupancy | Lr | 20 | 113.33 | 1.20 | 136.00 |
| | | | | **_Total Factored Dead** | 77.03 |
| | | | | **_Total Factored Live** | 390.70 |

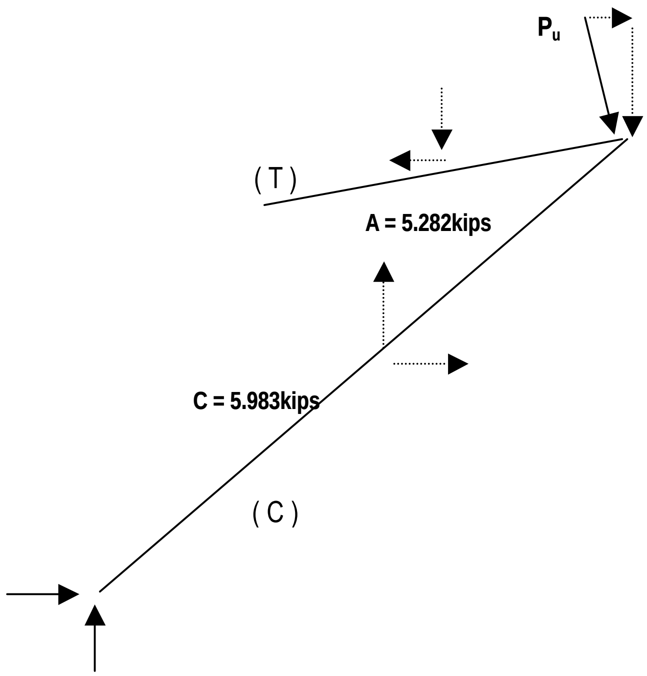
**_Load Combinations**

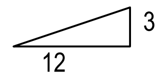
| | | | | |
|---|---|---|---|---|
| **1.4D** | **77.0** | **0.077** | **klf** | |
| **1.2D +1.6(S +LL)** | **467.7** | **0.468** | **klf** | ***controls** |
| **1.2D +1.6(Lr)** | **213.0** | **0.213** | **klf** | |

**Calculations:**

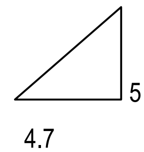
The tributary width of load applied to outriggers in breezeway is 8'

| | | | |
|---|---|---|---|
| **$P_u$** | **=** | **(w x Tw)** | |
| | **=** | **3.74** | **kips** |




$\tan^{-1}(3/12)$ = 14.04 degrees




$\tan^{-1}(5/4.7)$ = 48

| | |
|---|---|
| sin(14.04) = | 0.253 |
| cos(14.04) = | 0.971 |
| sin(48.00) = | 0.743 |
| cos(48.00) = | 0.699 |

€$F_x$ = 0 = Px + Cx - Ax
€$F_y$ = 0 = Cy - Ay - Py

| | | | |
|---|---|---|---|
| Px = | (Pu) (sin 14.04) = | 0.947 | kips |
| Py = | (Pu) (cos 14.04) = | 3.633 | kips |
| Ax = | (A) (cos 14.04) = | 5.129 | kips |
| Ay = | (A) (sin 14.04) = | 1.336 | kips |
| Cx = | (C) (cos 48.00) = | 4.182 | kips |
| Cy = | (C) (sin 48.00) = | 4.445 | kips |

€$F_x$ = 0 = = [(Pu) (sin 14.04)] + [(C) (cos 51.34)] -[(A) (cos 14.04)]

$$C = \frac{[-0.947] + [(A)\ (\cos 14.04)]}{\cos (48.00)]}$$

C = 5.983 kips

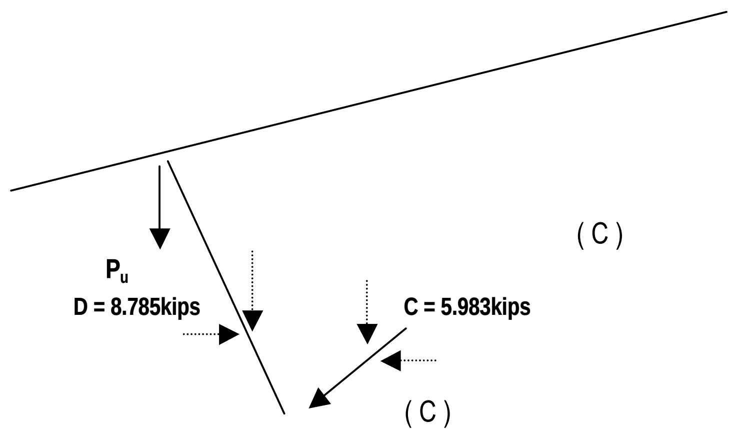
€$F_y$ = 0 = = [(C) (sin 48.00)] - [(A) (sin 14.04)] -[(Pu) (cos 14.04)]

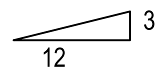
= [((-0.947] + [(A) (cos 14.04)/0.625) 0.743] - [(A) 0.253] -[3.633]

| | | | |
|---|---|---|---|
| 0 | = | [(-0.947 / 0.625) + (A)(0.971)/0.625)(0.743)] - A(0.253) - 3.633 | |
| 0 | = | [(-1.5152 + A1.5536)0.743] - 3.633 - A(0.253) | |
| 0 | = | [-1.126 +A1.154 - 3.633 - A0.253] | |
| A | = | 5.282 | kips |

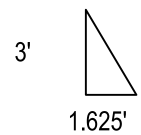
For the Outriggers in the Breezeway Space:
The tributary width of load applied to outriggers in breezeway is 8'

| | | | |
|---|---|---|---|
| **$P_u$** | **=** | **Weight of Outrigger** | |
| | **=** | **0.15** | **kips** |




$\tan^{-1}(3/12)$ = 14.04 degrees




$\tan^{-1}(3/1.625)$ = 61.57

| | |
|---|---|
| sin(14.04) = | 0.253 |
| cos(14.04) = | 0.971 |
| sin(48.00) = | 0.743 |
| cos(48.00) = | 0.699 |
| sin(61.57) = | 0.879 |
| cos(61.57) = | 0.476 |

From previous calculations above:

| | | | |
|---|---|---|---|
| Cx = | (C) (cos 48.00) = | 4.182 | kips |
| Cy = | (C) (sin 48.00) = | 4.445 | kips |
| Dx = Cx = | (D) (cos 14.04) = | 4.182 | kips |
| D = | Cx /(cos 61.57)= | 8.785 | kips |
| Dy = | (D) (sin 14.04) = | 7.722 | kips |

| | DWG / Detail | Completed By | Revised By | DCN # | |
|---|---|---|---|---|---|
| Calc 2.08 | Weld Joints | Terentiuk | Glantz, Owens | S-51 | |

*Conclusions: A 2" Long 1/8" weld of E70 has a weld strength of 8.35 kips. This weld applies to wedge and plate attached to hinge of piano.*

**Assumptions:**

**_Loads**

**_Area** 8'-1" x 24'-0" 192 **$ft^2$**

| **_Item** | | **_psf** | **_lbs** | **_factored value** | **_factored** |
|---|---|---|---|---|---|
| PV Load BZWY | LL | 4.6 | 883.20 | 1.60 | 1413.12 |
| EV Tubes | LL | 3.49 | 670.48 | 1.60 | 1072.76 |
| STL BWY Frame | DL | 7.58 | 1454.82 | 1.20 | 1745.78 |
| 4 5/8" SIPs PUR BZWY | DL | 3.75 | 720.00 | 1.20 | 864.00 |
| | | | | **_Total Factored Dead** | 5095.66 |

**1.2D+1.6L** **5095.7** **5.096 kips** ***controls**

1 Pin is designed to resist shear of self weight of breezeway roof during transportation
2 Breezeway roof rest in a vertical position, hanging from Piano hinge during the transportation
3 Breezeway roof will also be shimmed into place during transportation.
4 Shear would occur between hinge pieces; pin designed to resist this load.
5 Piano hinge is designed with 1' long pieces to accept pin along the 24' length.

**Calculations:** For a 2" long 1/8" E70 weld

Weld Strength: ØRn= ØFw*Aw

| | | | |
|---|---|---|---|
| Lw | = | 2 | " |
| tw | = | 0.125 | " |
| $F_{Exx}$ | = | 70 | ksi |
| Θ | = | 90 | ° |
| Fw | = | $0.6*Fexx*(1.0+0.5*sin^{1.5}\Theta)$ | |
| | = | 63 | ksi |
| Aw | = | 0.707*Lw*tw | |
| | = | 0.1768 | $in^2$ |

| | | | |
|---|---|---|---|
| **Ø** | = | 0.75 | |
| **ØRn** | **=** | **ØFw*Aw** | |
| | = | 8.35 | kips |
| **ØRn** | = | 8.35kips > 5.10kips | |

**Results:** A E70 weld of at least 2" long and 1/8" thick is required.

| | DWG / Detail | Completed By | Revised By | DCN # | |
|---|---|---|---|---|---|
| Calc 2.09 | Outrigger, Buckling | Williams, Gimbert | Glantz, Owens | S-48 | Reference Calc 2.07 |

*Conclusions: USE an 1.36" pipe of length 7.44" for diagonal bracing / outriggers on the home; use a 1.24" diameter of solid A36 bar of length 6.28' for later design of diagonal bracing / outriggers; The Outrigger RODs will be a 1 3/8" diameter solid ROD.*

**Calculations:**

$P_u =$ 3.1 kips

$P_n = Ø_t(0.75F_u)A_g$

$Ø_t P_n > P_u$

$F_u$ = 58 ksi

Require $A_g$ = $P_u / Ø_t(0.75Fu)$

= 0.095019157 $in^2$

From $A_g$ = $\pi d^2/4$

d = 0.345 in

Minimum diameter should be 5/8" = 0.625"

*Check critical buckling load of the outrigger ROD design:*

$$Pcr = \frac{\pi^2 E I}{L^2}$$

OR

$$\sigma cr = \frac{\pi^2 E}{(L/r)^2}$$

From Calc 2.07; a load of 6.2 kips is distributed to the outriggers based on a 8' tributary width. With two outriggers taking this load at the point of analysis, we can assume that 3.1 kips is distributed to each outrigger.

Assess critical buckling load, If the following exists:

*1* $$Pcr = \frac{\pi^2 E I}{L^2} = 3.10 \text{ kips}$$

then; $I = Ar^4$

where $A = \pi R^2$ and $r = R/2$

$r$ = radius of gyration for a bar is d/4 or R/2

$$Pcr = \frac{\pi^2 E I}{L^2}$$

$$Pcr = \frac{\pi^2 E(\pi R^2 (R/2)^2)}{L^3}$$

$$Pcr = \frac{E \pi^3 (R^4/4)}{L^3}$$

| | | | |
|---|---|---|---|
| Pcr | 3.000 | kips | C / 2 Rod in BZWY |
| E | 29000 | ksi | |
| L | 7.44 | ft | Length of Rod |
| | 89.28 | in | |
| $p^3$ | 31.0063 | | |

$$R^4 = \frac{4 Pcr\ L^2}{E\ \pi^3}$$

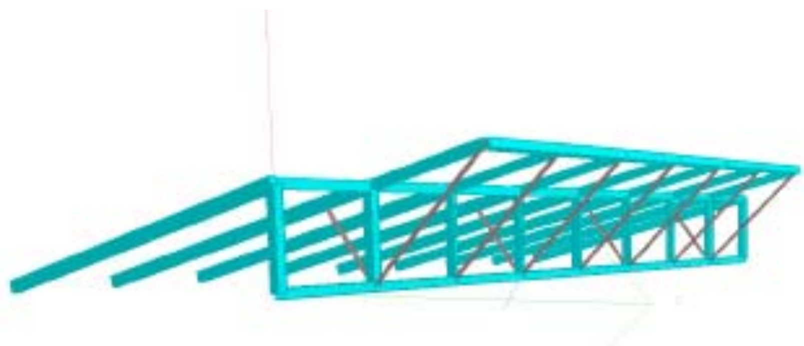
$$= 0.106$$

R = 0.571 "

So, where f = 0.85;

Diameter of bar can be at least 2R/0.85 = $\boxed{1.34}$ in Ok

**2** Try Rod length at 6.28" with new orientation (see image below):



$$Pcr = \frac{E \pi^3 (R^4/4)}{L^3}$$

| | | |
|---|---|---|
| Pcr | 3 | kips |
| E | 29000 | ksi |
| L | 6.28 | ft |
| | 75.36 | in |
| $p^3$ | 31.0063 | |

$$R^4 = \frac{4 Pcr\ L^2}{E\ \pi^3}$$

$$= 0.0757906$$

R = 0.529 "

So where f = 0.85 is the safety factor;

| | | | |
|---|---|---|---|
| Diameter of bar can be at least 2R/0.85 = | 1.24 | in | **Ok** |

*Check strength:*

| | | | | |
|---|---|---|---|---|
| $f_c$ | 0.85 | | Design safety factor | |
| fy | 36 | ksi | A36 Steel | |
| d | 1.34 | in | | |
| A = | $\pi d^2 /4$ | $in^2$ | | |
| | 1.417 | $in^2$ | | |
| Fy = | 43.4 | kips | >> 3.1 kips | **Ok** |

**Results:** USE a 1 3/8" diameter Rod for the design of the outriggers in the breezeway.
Configuration remains as first design.

| | DWG / Detail | Completed By | Revised By | DCN # | |
|---|---|---|---|---|---|
| Calc 2.10 | Clevis and Pin Size | Williams, Gimbert | Glantz, Owens | S-51 | Reference Calc 2.07 |
| *Conclusions: USE a no. 3 clevis to support a 3.1 kips load and accept a 1 3/8" rod diameter and a 1 3/8" diameter pin. Tapping as specified by manufacturer.* | | | | | |

**Assumptions:**

**_Loads**

*The Clevis Pin must resist a max Vn: (Reference Calc. 2.07)*

*Vn = 3.1kips/2 = 1.55kips.*

*The pin must resist a max Mn:*

Mn = 3.1kips * (grip length (3/8" +1/16" +1/16" /2)

Mn = 3.1kips *(0.5")

Mn = 1.55 kip-in

1 Clevis Pin is checked to resist axial load in the threaded rod of the clevis.

2 Check Clevis Pin Selection where Ø = 1 3/4" max

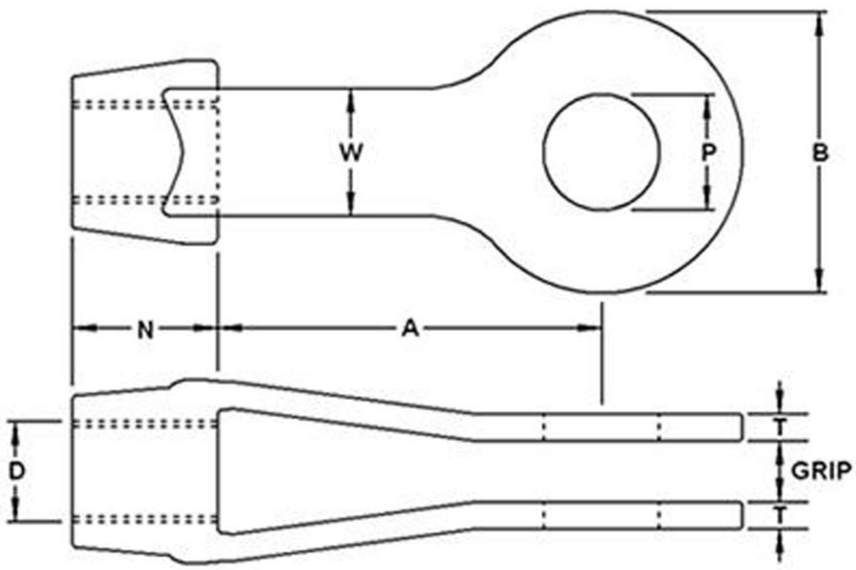
**Calculations:**

*It is suggested by manufacture to use a stainless steel pin with a diameter at least the same size as the rod. Try a Ø =1 3/8" pin size:*

| | | | | |
|---|---|---|---|---|
| *Check Shear:* | Fy | = | 36 | ksi |
| | Fu | = | 58 | ksi |
| | Fn | = | 0.4 Fu | |
| | | = | 23.2 | |
| | r | = | 0.6875 | |
| | Ab | = | $\pi * r^2$ | |
| | | = | 1.484140625 | $in^2$ |
| | Ø | = | 0.75 | |
| | ØRn | = | ØFnAb | |
| | | = | 25.82 | kips |
| | ØRn | = | 25.82kips > 1.55kips | |
| *Check Moment:* | Fy | = | 36 | ksi |
| | Fu | = | 58 | ksi |
| | Fn | = | Fy | |

| | | | |
|---|---|---|---|
| | = | 23.2 | |
| r | = | 0.6875 | |
| Ab | = | $\pi * r^2$ | |
| | = | 1.484140625 | $in^2$ |
| Ø | = | 0.9 | safety factor |
| d | = | 0.25 | in |
| ØMn | = | Ø*Fy*A* d | |
| | = | 12.02 | kip-in |
| $M_n > M_u$ | = | 12.02kip-in > 1.55kip-in | |

# Clevises




| Clevis Number | Dimensions in Inches | | | | | | | Weight Pounds With Pin | Safe Working Load, Kips |
|---|---|---|---|---|---|---|---|---|---|
| | Max, D | Max, P | B | N | A | W | T | | |
| 2 | 5/8 | 3/4 | 1-7/16 | 5/8 | 3-7/8 | 1-1/16 | 5/16 (+1/32 -0) | 1.5 | 7.0 |
| 2½ | 7/8 | 1-1/2 | 2-1/2 | 1-1/8 | 4 | 1-1/4 | 5/16 (+1/32 -0) | 2.5 | 7.5 |
| 3 | 1-3/8 | 1-3/4 | 3 | 1-5/16 | 5 | 1-1/2 | 1/2 (+1/32 -0) | 5.0 | 15 |
| 3½ | 1-1/2 | 2 | 3-1/2 | 1-5/8 | 6 | 1-3/4 | 1/2 (+1/32 -0) | 8.0 | 18 |
| 4 | 1-3/4 | 2-1/4 | 4 | 1-3/4 | 6 | 2 | 1/2 (+1/32 -0) | 11.0 | 21 |
| 5 | 2 | 2-1/2 | 5 | 2-1/4 | 7 | 2-1/2 | 1/2 (+1/16 -0) | 21.0 | 37.5 |
| 6 | 2-1/2 | 3 | 6 | 2-3/4 | 8 | 3 | 3/4 (+3/32 -0) | 32.0 | 54 |
| 7 | 3 | 3-3/4 | 7 | 3 | 9 | 3-1/2 | 7/8 (+1/8 -0) | 53.0 | 68.5 |
| 8 | 4 | 4 | 8 | 4 | 10 | 4 | 1-1/2 (+1/8 -0) | 80.0 | 135 |

## Clevis Numbers for Various Rods and Pins

| Diameter of Tap Inches | Diameter of Pin in Inches | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5/8 | 3/4 | 7/8 | 1 | 1¼ | 1½ | 1¾ | 2 | 2¼ | 2½ | 2¾ | 3 | 3¼ | 3½ | 3¾ | 4 |
| 5/8 | 2 | 2 | 2½ | 2½ | 2½ | 2½ | | | | | | | | | | |
| 3/4 | | 2½ | 2½ | 2½ | 2½ | 2½ | | | | | | | | | | |
| 7/8 | | | 2½ | 2½ | 2½ | 2½ | | | | | | | | | | |
| 1 | | | | 3 | 3 | 3 | 3 | | | | | | | | | |
| 1¼ | | | | 3 | 3 | 3 | 3 | 3½ | | | | | | | | |
| 1⅜ | | | | 3 | 3 | 3 | 3½ | 3½ | 4 | | | | | | | |
| 1½ | | | | 3½ | 3½ | 3½ | 4 | 4 | 5 | | | | | | | |
| 1¾ | | | | | 4 | 4 | 5 | 5 | 5 | 5 | | | | | | |
| 2 | | | | | | 5 | 5 | 5 | 5 | 5 | 6 | 6 | | | | |
| 2¼ | | | | | | | | 6 | 6 | 6 | 6 | 6 | 7 | 7 | | |
| 2½ | | | | | | | | 6 | 6 | 6 | 7 | 7 | 7 | 7 | 7 | |
| 2¾ | | | | | | | | | | 7 | 7 | 7 | 7 | 8 | 8 | |
| 3 | | | | | | | | | | 7 | 8 | 8 | 8 | 8 | 8 | 8 |
| 3¼ | | | | | | | | | | | 8 | 8 | 8 | 8 | 8 | 8 |
| 3½ | | | | | | | | | | | 8 | 8 | 8 | 8 | [illegible] | [illegible] |
| 3¾ | | | | | | | | | | | 8 | 8 | 8 | 8 | 8 | 8 |
| 4 | | | | | | | | | | | 8 | 8 | 8 | 8 | 8 | 8 |

| | DWG / Detail | Completed By | Revised By | DCN # | |
|---|---|---|---|---|---|
| Calc 2.11 | SIP bearing Block length | Gimbet, | Glantz, Owens | | |

*The bearing block on the South Wall which holds the LS Roof SIPs will be made from two (2) 2 x 4 beveled lumber (1.5" +1.5" = 3" of width). The block is beveled at the angle of the roof (14 degrees) so the bearing length of this block is 3.09"*

Conclusions: *The bearing block on the South Wall can be shorten to 3" in width, with an angled bearing length of 3.09"*

**Assumptions:**

**_Loads**

**_Trib Width** 4.00 **ft** *(TW of one panel)*

| **_Item** | | **_psf** | **_plf** | **_factored value** | **_factored** |
|---|---|---|---|---|---|
| Snow Load | SL | 35 | 140.00 | 1.60 | 224.00 |
| PV Load LVG | DL | 4.6 | 18.40 | 1.20 | 22.08 |
| 6 5/8" SIPs PUR LVG | DL | 4.15 | 16.60 | 1.20 | 19.92 |
| Insulation (poured) | DL | 5 | 20.00 | 1.20 | 24.00 |
| Skylight | DL | 15 | 60.00 | 1.20 | 72.00 |
| | | | | **_Total Factored Dead** | 138.00 |
| | | | | **_Total Factored Live** | 224.00 |

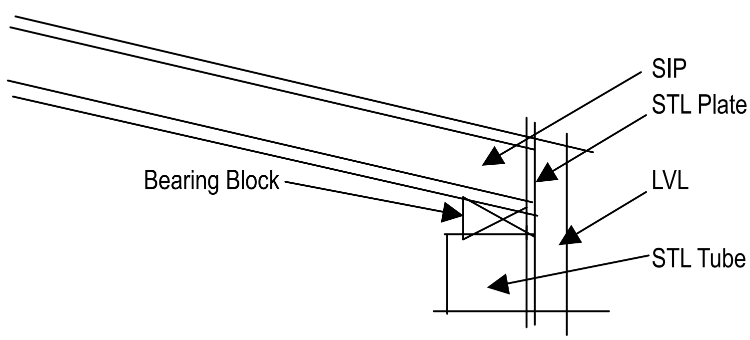
*See Summary of Load inputs from STAAD data in Appendix 4.03*

**_Load Combinations**

| | | | |
|---|---|---|---|
| **1.4D** | **161.0** | **0.161 klf** | |
| **1.2D +1.6(S +LL)** | **362.0** | **0.362 klf** | ***controls** |

1. The bearing of the LS Roof SIPs is taken by a wooden bearing block at the South Wall.

** 2. The SIP roof panels is assumed to act like a 4' wide beam, bearing on the South Wall.



**Calculations:**

| | | | | | | |
|---|---|---|---|---|---|---|
| ** Wu | = | 0.36 klf | | | | |
| Vu | = | $(W_u \times L) / 2$ | | | | |
| where L = 12.77' | | Length of Roof SIP | | | | |
| Vu | = | $\boxed{2.31}$ kips | | | | |

*Check Shear of Panel:*

| | | | | | | |
|---|---|---|---|---|---|---|
| ØVn | = | Ø *Fy * tw * N | | | | |
| | | Fy | = | 22 | psi , shear strength of panel | |
| | | tw | = | 48 | in. , width of one panel | |
| | | h | = | 6.625 | in. , bearing length | |
| | | Ø | = | 1.0 | safety factor | |
| ØVn | = | $\boxed{6996.00}$ | | lbs | | |
| | = | 7.00 | | kips | > 2.31 | Ok |

*Check Bearing of Wooden Block:*

| | | | | | | |
|---|---|---|---|---|---|---|
| ØRn | = | Ø *Fy * tw * N | | | | |
| | | Zper | = | 425 | psi , crushing wood per to grain | |
| | | tw | = | 48 | in. , width of one panel | |
| | | N | = | 3.09 | in. , bearing length | |
| | | Ø | = | 1.0 | safety factor | |
| | tan (14) | | | x | | |
| | | | | 3 | " | |
| | x | | | 0.747 | " | |
| | N | | = | Sq. Rt. $((0.747^2) + (3^2))$ | | |
| | | | = | 3.09 | " | |
| ØRn | = | $\boxed{63036.00}$ | | lbs | | |
| | = | 63.04 | | kips | > 2.31 | Ok |

| | | | | | |
|---|---|---|---|---|---|
| **Results:** | ØRn | > | Ru | | |
| | 63.04 | > | 2.31 | kips | **OK** |
| **Results:** | ØVn | > | Vu | | |
| | 7.00 | > | 2.31 | kips | **OK** |

The bearing block on the South Wall can be shorten to 3" in width, with an angled bearing length of 3.09"

# Calcs 3.0X

Calculations Associated with Living Space

| | DWG / Detail | Completed By | Revised By | DCN # | |
|---|---|---|---|---|---|
| Calc 3.01 | STL | Milinichik | Glantz, Owens | S-10 | Ref. Appendix 4.01 |

*Conclusions: USE HSS 5/16" x 4"x 4" FOR STL HEADER ON SOUTHERN WALL [ok]; See Appendix # for STAAD results.*

**Assumptions:**

**_Loads**

**_TW** 6.5 **ft**

| **_Item** | | **_psf** | **_plf** | **_lbs** |
|---|---|---|---|---|
| Snow Load | SL | 35 | 227.50 | |
| PV Load BZWY | LL | 4.6 | 10.16 | |
| Exterior Rack | LL | 4.6 | 42.50 | 340 |
| 6 5/8" SIP PUR LVG | DL | 4.15 | 27.67 | |
| Skylight | DL | | | 5 |
| STL Self Wt | DL | | 12.20 | |

1. End of SIP acts as a point load to STl header above.
2. 2 x 8 bearing plate ripped to match a 6 5/8" SIP width was not considered to add to strength. All deflection resisted by STL tube header.
3. All moving loads were considered to be live loads.
4. Deflection is limited to 1/4" or L/1152 over 24' span

**Results:** A HSS 1/4" x 4" x 4" will be sufficient as a header member on Southern Wall; for safety during transportation and for consistency, USE a HSS 5/16" x 4" x 4"

$\Delta$ = 0.1374” ~ 1/8” < ¼”

| | DWG / Detail | Completed By | Revised By | DCN # | |
|---|---|---|---|---|---|
| Calc 3.02 | Weld Joints, | Benoit | Glantz, Owens | S-50,52,53 | Reference Appendix 3.01 |

*Conclusions: USE a weld of 3/16" in thickness over 4" in length. This weld configuration can be used for connecting the STL header together at SE and SW corners and for attaching the STL header to the base of the Truss.*

**Assumptions:**

The minimum weld size for a [4" x 4" x 5/16" ] is 3/16"

Maximum $t_w = t_p$ - 1/16

| | | | |
|---|---|---|---|
| $t_p$ | = | 0.3125 | in |
| $t_w$ | = | 0.25 | in |

Minimum length of $l_w \geq 4t_w$

| | | | |
|---|---|---|---|
| $l_w$ | = | 1 | in |

**Calculations:**

*1* Try a Weld Size of 5/16":

For weld of thickness 5/16" and 4" in length:

| | | | |
|---|---|---|---|
| Fy | = | 36 | ksi |
| Fu | = | 58 | ksi |
| Fn | = | 0.6 Fu | |
| | = | 34.8 | |
| Anw | = | t x $l_w$ | |
| | = | 1.25 | $in^2$ |
| Ø | = | 0.75 | |
| ØRn | = | ØFnAnw | |
| | = | 32.63 | kips |

*2* For weld of thickness 3/16" and 4" in length:

| | | | | |
|---|---|---|---|---|
| Fy | = | 36 | ksi | |
| Fu | = | 58 | ksi | |
| Fn | = | 0.6 Fu | | |
| | = | 34.8 | | |
| Anw | = | t x $l_w$ | | |
| | = | 0.75 | $in^2$ | |
| Ø | = | 0.75 | | |
| ØRn | = | ØFnAnw | | |
| | = | 19.58 | kips | >>10 kips of brake load<br>See Appendix 3.01 |

| | DWG / Detail | Completed By | Revised By | DCN # | |
|---|---|---|---|---|---|
| Calc 3.03 | SIP Framing, LS | Grossenbacher | Glantz, Owens | S-35 | Ref. App 4.06 |

*Conclusions: According to MURUS SIP Company, Use double 2 x 6 for internal support of Living Space SIPs.*

**Assumptions:**

**_Loads**

**_TW** 4.00 **ft**

| **_Item** | | **_psf** | **_plf** | **_factored value** | **_factored** |
|---|---|---|---|---|---|
| Snow Load | SL | 35 | 140.00 | 1.00 | 140.00 |
| PV Load LVG | DL | 4.6 | 18.40 | 1.00 | 18.40 |
| 6 5/8" SIPs PUR LVG | DL | 4.15 | 16.60 | 1.00 | 16.60 |
| Insulation (poured) | DL | 5 | 20.00 | 1.00 | 20.00 |
| Occupancy | Lr | 20 | 0.00 | 1.00 | 0.00 |
| | | | | **_Total Dead** | 55.00 |
| | | | | **_Total Live** | 140.00 |

| | **plf** | **klf** |
|---|---|---|
| **D +LL** | **195.0** | **0.195** |

**$M_u$** = **$(w * L^2) / 8$**

= $\boxed{4442.34}$ **ft-lbs**

**$V_u$** = **(w *L) / 2 * 2**

= $\boxed{658.125}$ **flbs**

1 Assume SIP acts as only dead weight to the framing members.
2 ASD wood design, no factored loads
**3** Assume roof rafters frame 4'-0" o.c.
4 Assume $A_T$ = 4' x 13.5' = 54 $ft^2$
5 Assume double member framing

**Calculations:**

**1** Try four 2x6 NO. 1 Spruce-Pine-Fir, $C_L$ = 1.0, $C_M$ =1.0, $C_T$=1.0

A = 33.0 $in^2$

Fb = 875 psi

$C_D$ = 1.15

$C_F$ = 1.3

F'b = $C_F * C_D * Fb$

= $\boxed{1308.13}$ psi

$$F'b = \frac{M_U}{S}$$

So;

| | | | | | |
|---|---|---|---|---|---|
| S req'd | = | $\boxed{40.75}$ $in^3$ | | | |
| S available | = | $bd^2 / 6$ | | | |
| | = | $(1.5)*(5.5)^2 / 6$ | | | |
| | = | 7.56 $in^3$ | | < 41$in^7$ | NO GOOD |

*NEED six (6) 2 x 6 for internal framing does not work for design; no good*

Try 2 x 10 LVL Grade 1.6E Lumber

| | | | |
|---|---|---|---|
| A | = | 13.1 | $in^2$ |
| Fb | = | 2600 | psi |
| d | = | 6 | inch |

| | | | | |
|---|---|---|---|---|
| F'b | = | $Fb * [12/d]^{0.136}$ | | |
| | = | $\boxed{2857.14}$ psi | | |
| fb | = | $\frac{M_U}{S}$ | < | 2857.14 |

So;

| | | |
|---|---|---|
| S req'd | = | $\boxed{18.66}$ $in^3$ |

| | | | | | |
|---|---|---|---|---|---|
| For LVL 2 x 10, S | = | $bd^2 / 6$ | | | |
| | = | $(1.75)*(7.5)^2 / 6$ | | | |
| | = | 26.32 | > | 18.66 | Ok |

USE (1) 2 x 10 LVL grade 1.6E Lumber for internal framing

MURUS response to this design Question:

"6 5/8 inch thick PUR panels work with 2 x 6 reinforcement. The program indicated a live load deflection of L/441 and a total load deflection of L/273." Murus has accounted for the interaction of framing with SIPs, adding to the overall structural stability of the system.

| | DWG / Detail | Completed By | Revised By | DCN # | |
|---|---|---|---|---|---|
| Calc 3.04 | SIP Framing, LS | Grossenbacher | Glantz, Owens | S-35 | Ref. App 4.06 |

*Conclusions: According to MURUS SIP Company, Use double 2 x 6 for internal support of Living Space SIPs. The following letter details the structural computer assessment from the Murus company with approval from their own Structural PE.*

murus
STRUCTURAL INSULATING PANELS

3234 Route 549, PO Box 220
Mansfield, PA 16933
(570) 549-2100 Fax: (570) 549-2101

***Letter of Transmittal***

| | | | |
|---|---|---|---|
| To: | Engineering Projects Inc. | Date: | June 19, 2007 |
| | 1903 East College Avenue | Attention: | Brennan Glantz, PE |
| | State College, PA 16801 | Re: | PSU - Solar Decathlon |

***We are sending you:***

- ☐ Attached
- ☐ Prints
- ☐ Panel Layout
- ☐ Preliminary Plans
- ☐ Design Plans
- ☐ Final Design Plans
- ☐ Final Drawings
- ☐ Pre-Cut Drawings
- ☐ Change Order
- ☐ Samples
- X Other: Stamped Roof Panel Span Calculations

| Copies | Date | No | Revision | Description |
|---|---|---|---|---|
| 4 | 5/31/07 | Page 1 of 1 | NA | Roof Panel Span Calculations |
| | | | | |
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| | | | | |
| | | | | |
| | | | | |

***THESE ARE TRANSMITTED AS CHECKED BELOW:***

- ☐ For Approval
- ☐ Approved as Submitted
- ☐ Resubmit
- ☐ Copies for Approval
- ☐ For your use
- ☐ Approved as Noted
- ☐ Submit
- X Copies for Distribution
- ☐ As requested
- ☐ Returned for corrections
- ☐ For review and comment
- ☐ Prints returned after loan to us
- ☐ Other:

Remarks: These are stamped panel span calculations from our P.E. Please let me know if you need anything else.

Copy To: File

Signed: Joshua Sherman

JAMES R. FRANDSEN P.E.
Licensed Professional Engineer

P.O. Box 426 • 3310 Route 352 • Big Flats • New York 14814
Phone: (607) 562-3560 • Fax: (607) 562-8105

Roof Panel Span Calculations May 31, 2007

The following is input and output from the computer program used to calculate deflection and stresses in Murus structural insulating panels. The headings (Living Space, Breezeway, and Mechanical Core) correspond to the area on the Penn State – Solar Decathlon architectural drawings that the analyzed roof is covering.

Living Space:

Input - Panel: 6 5/8" OSB/OSB PUR with (2) 2X splines
Loading: simple span; 3:12 slope; 12ft horizontal span; 15psf DL; 30psf SL

Results - Total load deflection over span = 1/261
Live load deflection over span = 1/391
Normal stress in OSB skins = ± 213psi < 780psi allowable
Shear stress in core = 1.8psi < 6psi allowable

Breezeway:

Input - Panel: 4 5/8" OSB/OSB PUR with (2) 2X splines
Loading: overhang; 2:12 slope; 4ft horizontal span; 3ft-9in horizontal overhang; 15psf DL; 30psf SL

Results - Total load deflection over span = 1/268
Live load deflection over span = 1/402
Normal stress in OSB skins = ± 173psi < 780psi allowable
Shear stress in core = 0.9psi < 6psi allowable

Mechanical Core:

Input - Panel: 6 5/8" OSB/OSB PUR with single 2X splines
Loading: simple span; 0:12 slope; 7ft span; 40psf DL; 35psf SL

Results - Total load deflection over span = 1/346
Live load deflection over span = 1/707
Normal stress in OSB skins = ± 148psi < 780psi allowable
Shear stress in core = 1.7psi < 6psi allowable

COMMONWEALTH OF ... REGISTERED PROFESSIONAL JAMES R. FRANDSEN ENGINEER No.

6-12-07

JAMES R. FRANDSEN P.E.
Licensed Professional Engineer

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REGISTERED PROFESSIONAL ENGINEER
JAMES R. FRANDSEN

6-12-07

# Calcs 4.0X

Calculations Associated with Site Design

| Site Element Foundations | | Completed By | Revised By | DCN # | |
|---|---|---|---|---|---|
| Calc 4.01 | Bearing Elements | Ault, Gimbert | Glantz, Owens | C-700s | |

*Conclusions: All Site Enclosures and Encasements for Batteries conform to the soil pressure requirements stipulated in the Solar Decathlon Code, to bear less than 1500psf.*

**Assumptions:**

1 As stated in Solar Decathlon Code, IBC, make sure the foundations, water tanks, and all other site components comply with section 3.8 " Impact on the Turf "
Section 3.8 states: Low-impact footings and tie-downs must be used to support structures on the grass portion of the National Mall. Teams will not be permitted to build or place floors directly on the grass. Teams will be required to support all water tanks to minimize damage to the National Mall turf.

2 Soil: 1500-psf (71.8-kPa) load-bearing pressure on top of the soil

**Summary:**

| _Unit | _lbs (enclosed + equipment) | _lbs (enclosure) | _Bearing Area ($in^2$) | _psf on soil (< 1500psf) |
|---|---|---|---|---|
| E1 | | 2070 | 421.25 | 707.6 |
| E2 | | 2388 | 449 | 769.7 |
| M1 | | 1800 | 369.5 | 701.5 |
| M2 | | 925 | 296 | 450 |
| M3 | | 2226 | 409.5 | 782.8 |
| M4 | | 1138 | 264 | 620 |
| C1 | | 1113 | 248 | 646 |
| C2 | | 793 | 224 | 509.8 |
| C3 | | 2300 | 390 | 850 |
| C4 | | 496 | 146.5 | 487.5 |
| C5 (over East Wastewater Tank also) | | 4600 | 1086 | 609.9 |
| C6 | | 1793 | 422 | 611.8 |
| C7 | | 351 | 136 | 371.7 |
| C8 | | 1091 | 258 | 609 |
| C9 | | 2672 | 703 | 547.3 |
| C10 | | 3155 | 831 | 546.7 |
| Car-Home Kiosk | 1000 | 2100 | 1248 | 357.7 |
| AC Battery Bank Enclosure (2 total) | 5432 (each) | 2284 | 969.01 | 1146.63 |
| West Wastewater Tank and Pump Enclosure | 0 | 2090 | 612 | 491.7 |
| West Wastewater Tank and Pump | 2175 | 0 | 585.75 | 534.69 |
| DC Battery Bank Enclosure | 500 | 1104 | 380.25 | 607.4 |
| Supply Water Tank Enclosure | 0 | 3060 | 1365 | 322 |

**Calculations: _For the General Plant Boxes, E1:**

| | | |
|---|---|---|
| soil & plant wtg | 1770 | lbs |
| s.w.e wtg | 300 | lbs |
| TOTAL | 2070 | lbs |

If soil bearing capacity is 1500psf, then the required bearing area is:

| | | | | |
|---|---|---|---|---|
| Solar D Area Req'd | (MAX Load) /1500psf | = | 1.38 | $ft^2$ |
| | | | 198.72 | $in^2$ |
| Bearing Area of Enclosure (including 2x, 4x) | | = | 421.25 | $in^2$ |
| | CHECK Bearing Area > Required Area | = | 421.25 > 198.72 | OK |

**_For the General Plant Boxes, E2:**

| | | |
|---|---|---|
| soil & plant wtg | 1980 | lbs |
| s.w.e wtg | 400 | lbs |
| TOTAL | 2380 | lbs |

If soil bearing capacity is 1500psf, then the required bearing area is:

| | | | | |
|---|---|---|---|---|
| Solar D Area Req'd | (MAX Load) /1500psf | = | 1.59 | $ft^2$ |
| | | | 228.48 | $in^2$ |
| Bearing Area of Enclosure (including 2x, 4x) | | = | 449 | $in^2$ |
| | CHECK Bearing Area > Required Area | = | 449 > 228.48 | OK |

**_For the General Plant Boxes, M!:**

| | | |
|---|---|---|
| soil & plant wtg | 1500 | lbs |
| s.w.e wtg | 300 | lbs |
| TOTAL | 1800 | lbs |

If soil bearing capacity is 1500psf, then the required bearing area is:

| | | | | |
|---|---|---|---|---|
| Solar D Area Req'd | (MAX Load) /1500psf | = | 1.20 | $ft^2$ |
| | | | 172.80 | $in^2$ |
| Bearing Area of Enclosure (including 2x, 4x) | | = | 369.5 | $in^2$ |
| | CHECK Bearing Area > Required Area | = | 369.5 >172.80 | OK |

**_For the General Plant Boxes, M2:**

| | | |
|---|---|---|
| soil & plant wtg | 725 | lbs |
| s.w.e wtg | 200 | lbs |
| TOTAL | 925 | lbs |

If soil bearing capacity is 1500psf, then the required bearing area is:

| | | | | |
|---|---|---|---|---|
| Solar D Area Req'd | (MAX Load) /1500psf | = | 0.62 | $ft^2$ |
| | | | 88.80 | $in^2$ |
| Bearing Area of Enclosure (including 2x, 4x) | | = | 296 | $in^2$ |
| | CHECK Bearing Area > Required Area | = | 296 > 88.80 | OK |

**_For the General Plant Boxes, M3:**

| | | |
|---|---|---|
| soil & plant wtg | 1826 | lbs |
| s.w.e wtg | 400 | lbs |
| TOTAL | 2226 | lbs |

If soil bearing capacity is 1500psf, then the required bearing area is:

| | | | | |
|---|---|---|---|---|
| Solar D Area Req'd | (MAX Load) /1500psf | = | 1.48 | $ft^2$ |
| | | | 213.70 | $in^2$ |
| Bearing Area of Enclosure (including 2x, 4x) | | = | 409.5 | $in^2$ |
| | CHECK Bearing Area > Required Area | = | 409.5 > 213.70 | OK |

**_For the General Plant Boxes, M4:**

| | | |
|---|---|---|
| soil & plant wtg | 888 | lbs |
| s.w.e wtg | 250 | lbs |
| TOTAL | 1138 | lbs |

If soil bearing capacity is 1500psf, then the required bearing area is:

| | | | | |
|---|---|---|---|---|
| Solar D Area Req'd | (MAX Load) /1500psf | = | 0.76 | $ft^2$ |
| | | | 109.25 | $in^2$ |
| Bearing Area of Enclosure (including 2x, 4x) | | = | 264 | $in^2$ |
| | CHECK Bearing Area > Required Area | = | 264 > 109.25 | OK |

**_For the General Plant Boxes, C1:**

| | | |
|---|---|---|
| soil & plant wtg | 863 | lbs |
| s.w.e wtg | 250 | lbs |
| TOTAL | 1113 | lbs |

If soil bearing capacity is 1500psf, then the required bearing area is:

| | | | | |
|---|---|---|---|---|
| Solar D Area Req'd | (MAX Load) /1500psf | = | 0.74 | $ft^2$ |
| | | | 106.85 | $in^2$ |
| Bearing Area of Enclosure (including 2x, 4x) | | = | 248 | $in^2$ |
| | CHECK Bearing Area > Required Area | = | 264 > 106.85 | OK |

**_For the General Plant Boxes, C2:**

| | | |
|---|---|---|
| soil & plant wtg | 593 | lbs |
| s.w.e wtg | 200 | lbs |
| TOTAL | 793 | lbs |

If soil bearing capacity is 1500psf, then the required bearing area is:

| | | | | |
|---|---|---|---|---|
| Solar D Area Req'd | (MAX Load) /1500psf | = | 0.53 | $ft^2$ |
| | | | 76.13 | $in^2$ |
| Bearing Area of Enclosure (including 2x, 4x) | | = | 224 | $in^2$ |
| | CHECK Bearing Area > Required Area | = | 224 > 76.13 | OK |

**_For the Tree Planter Box, C3:**

| | | |
|---|---|---|
| soil & plant wtg | 2000 | lbs |
| s.w.e wtg | 300 | lbs |
| TOTAL | 2300 | lbs |

If soil bearing capacity is 1500psf, then the required bearing area is:

| | | | | |
|---|---|---|---|---|
| Solar D Area Req'd | (MAX Load) /1500psf | = | 1.53 | $ft^2$ |
| | | | 220.80 | $in^2$ |
| Bearing Area of Enclosure (including 2x, 4x) | | = | 390 | $in^2$ |
| | CHECK Bearing Area > Required Area | = | 390 > 220.80 | OK |

**_For the Small General Plant Box, C4:**

| | | |
|---|---|---|
| soil & plant wtg | 396 | lbs |
| s.w.e wtg | 100 | lbs |
| TOTAL | 496 | lbs |

If soil bearing capacity is 1500psf, then the required bearing area is:

| | | | | |
|---|---|---|---|---|
| Solar D Area Req'd | (MAX Load) /1500psf | = | 0.33 | $ft^2$ |
| | | | 47.62 | $in^2$ |
| Bearing Area of Enclosure (including 2x, 4x) | | = | 146.5 | $in^2$ |
| | CHECK Bearing Area > Required Area | = | 146.5 > 47.62 | OK |

**_For the NE Waste Water Enclosure, C5:**

| | | |
|---|---|---|
| soil & plant wtg | 3900 | lbs |
| s.w.e wtg | 700 | lbs |
| TOTAL | 4600 | lbs |

If soil bearing capacity is 1500psf, then the required bearing area is:

| | | | | |
|---|---|---|---|---|
| Solar D Area Req'd | (MAX Load) /1500psf | = | 3.07 | $ft^2$ |
| | | | 441.60 | $in^2$ |
| Bearing Area of Enclosure (including 2x, 4x) | | = | 1086 | $in^2$ |
| | CHECK Bearing Area > Required Area | = | 1086 > 441.60 | OK |

**_For the General Plant Box, C6:**

| | | |
|---|---|---|
| soil & plant wtg | 1493 | lbs |
| s.w.e wtg | 300 | lbs |
| TOTAL | 1793 | lbs |

If soil bearing capacity is 1500psf, then the required bearing area is:

| | | | | |
|---|---|---|---|---|
| Solar D Area Req'd | (MAX Load) /1500psf | = | 1.20 | $ft^2$ |
| | | | 172.13 | $in^2$ |
| Bearing Area of Enclosure (including 2x, 4x) | | = | 422 | $in^2$ |
| | CHECK Bearing Area > Required Area | = | 422 > 172.13 | OK |

**_For the General Plant Box, C7:**

| | | |
|---|---|---|
| soil & plant wtg | 251 | lbs |

| | | |
|---|---|---|
| s.w.e wtg | 100 | lbs |
| TOTAL | 351 | lbs |

If soil bearing capacity is 1500psf, then the required bearing area is:

| | | | | |
|---|---|---|---|---|
| Solar D Area Req'd | (MAX Load) /1500psf | = | 0.23 | $ft^2$ |
| | | | 33.70 | $in^2$ |
| Bearing Area of Enclosure (including 2x, 4x) | | = | 136 | $in^2$ |
| | CHECK Bearing Area > Required Area | = | 136 > 33.70 | OK |

## _For the General Plant Box, C8:

| | | |
|---|---|---|
| soil & plant wtg | 891 | lbs |
| s.w.e wtg | 200 | lbs |
| TOTAL | 1091 | lbs |

If soil bearing capacity is 1500psf, then the required bearing area is:

| | | | | |
|---|---|---|---|---|
| Solar D Area Req'd | (MAX Load) /1500psf | = | 0.73 | $ft^2$ |
| | | | 104.74 | $in^2$ |
| Bearing Area of Enclosure (including 2x, 4x) | | = | 258 | $in^2$ |
| | CHECK Bearing Area > Required Area | = | 258 > 104.74 | OK |

## _For the General Plant Box, C9:

| | | |
|---|---|---|
| soil & plant wtg | 2172 | lbs |
| s.w.e wtg | 500 | lbs |
| TOTAL | 2672 | lbs |

If soil bearing capacity is 1500psf, then the required bearing area is:

| | | | | |
|---|---|---|---|---|
| Solar D Area Req'd | (MAX Load) /1500psf | = | 1.78 | $ft^2$ |
| | | | 256.51 | $in^2$ |
| Bearing Area of Enclosure (including 2x, 4x) | | = | 703 | $in^2$ |
| | CHECK Bearing Area > Required Area | = | 703 > 256.51 | OK |

## _For the General Plant Box, C10:

| | | |
|---|---|---|
| soil & plant wtg | 2155 | lbs |
| s.w.e wtg | 1000 | lbs |
| TOTAL | 3155 | lbs |

If soil bearing capacity is 1500psf, then the required bearing area is:

| | | | | |
|---|---|---|---|---|
| Solar D Area Req'd | (MAX Load) /1500psf | = | 2.10 | $ft^2$ |
| | | | 302.88 | $in^2$ |
| Bearing Area of Enclosure (including 2x, 4x) | | = | 831 | $in^2$ |
| | CHECK Bearing Area > Required Area | = | 813 > 302.88 | OK |

## _For the Car-Home Kiosk:

| | | |
|---|---|---|
| soil & plant wtg | - | lbs |
| s.w.e wtg | 2100 | lbs |

| | | |
|---|---|---|
| TOTAL | 2100 | lbs |

If soil bearing capacity is 1500psf, then the required bearing area is:

| | | | | |
|---|---|---|---|---|
| Solar D Area Req'd | (MAX Load) /1500psf | = | 1.40 | $ft^2$ |
| | | | 201.60 | $in^2$ |
| Bearing Area of Enclosure (including 2x, 4x) | | = | 1248 | $in^2$ |
| | CHECK Bearing Area > Required Area | = | 1248 > 201.60 | OK |

## _For the AC Battery Enclosure:

| | | |
|---|---|---|
| soil & plant wtg | 5432 | lbs |
| s.w.e wtg | 2284 | lbs |
| TOTAL | 7716 | lbs |

If soil bearing capacity is 1500psf, then the required bearing area is:

| | | | | |
|---|---|---|---|---|
| Solar D Area Req'd | (MAX Load) /1500psf | = | 5.14 | $ft^2$ |
| | | | 740.74 | $in^2$ |
| Bearing Area of Enclosure (2 x 4, steel frame to support wtg): | | = | 969.01 | $in^2$ |
| | CHECK Bearing Area > Required Area | = | 969.01 > 740.74 | OK |

## _For DC Battery Bank Enclosure:

| | | |
|---|---|---|
| battery wtg | 500 | lbs |
| s.w.e wtg | 604 | lbs |
| TOTAL | 1104 | lbs |

If soil bearing capacity is 1500psf, then the required bearing area is:

| | | | | |
|---|---|---|---|---|
| Solar D Area Req'd | (MAX Load) /1500psf | = | 0.74 | $ft^2$ |
| | | | 105.98 | $in^2$ |
| Bearing Area of Enclosure (including 2x, 4x) | | = | 380.25 | $in^2$ |
| | CHECK Bearing Area > Required Area | = | 380.25 > 105.98 | OK |

## _For the NWest Wastewater Tank and Pump Encasement:

| | | |
|---|---|---|
| wtg | - | lbs |
| s.w.e wtg | 2090 | lbs |
| TOTAL | 2090 | lbs |

If soil bearing capacity is 1500psf, then the required bearing area is:

| | | | | |
|---|---|---|---|---|
| Solar D Area Req'd | (MAX Load) /1500psf | = | 1.39 | $ft^2$ |
| | | | 200.64 | $in^2$ |
| Bearing Area of Enclosure (including 2x, 4x) | | = | 612 | $in^2$ |
| | CHECK Bearing Area > Required Area | = | 612 > 200.64 | OK |

## _For the NWest Wastewater Tank and Pump, 2 x 4 frame support:

| | | |
|---|---|---|
| water wtg = (250gal) * (8.3lbs/gal) | 2075 | |
| tank wtg | 100 | lbs |
| TOTAL | 2175 | lbs |

If soil bearing capacity is 1500psf, then the required bearing area is:

| | | | | |
|---|---|---|---|---|
| Solar D Area Req'd | (MAX Load) /1500psf | = | 1.45 | $ft^2$ |
| | | | 208.80 | $in^2$ |
| Bearing Area of Enclosure (including 2x, 4x) | | = | 585.75 | $in^2$ |
| | CHECK Bearing Area > Required Area | = | 585.75 > 208.80 | OK |

## _For the Supply Water Tank Encasement:

| | | |
|---|---|---|
| wtg | - | lbs |
| s.w.e wtg | - | lbs |
| TOTAL | 3060 | lbs |

If soil bearing capacity is 1500psf, then the required bearing area is:

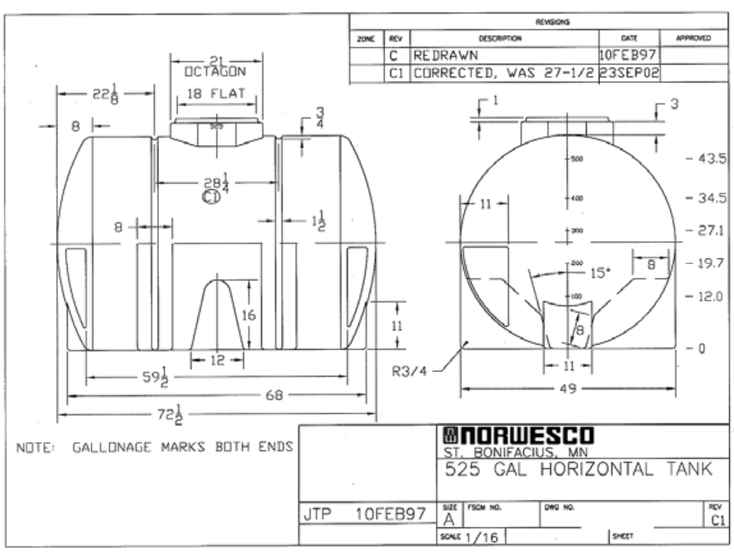
| | | | | |
|---|---|---|---|---|
| Solar D Area Req'd | (MAX Load) /1500psf | = | 2.04 | $ft^2$ |
| | | | 293.76 | $in^2$ |
| Bearing Area of Enclosure (including 2x, 4x) | | = | 1365 | $in^2$ |
| | CHECK Bearing Area > Required Area | = | 1365 >> 293.75 | OK |

## _For the Supply Water Tank, self supporting within enclosure:

| | | |
|---|---|---|
| water wtg = (525gal) * (8.3lbs/gal) | 4357.5 | |
| tank wtg | 100 | lbs |
| TOTAL | 4457.5 | lbs |

If soil bearing capacity is 1500psf, then the required bearing area is:

| | | | | |
|---|---|---|---|---|
| Solar D Area Req'd | (MAX Load) /1500psf | = | 2.97 | $ft^2$ |
| | | | 427.92 | $in^2$ |
| Bearing Area of Tank Feet = (8")(49")(2) + (2)(4.25")(49") = | | = | 1200.5 | $in^2$ |
| | (See diagram below for bearing detail) | | | |
| | CHECK Bearing Area > Required Area | = | 1200.5 > 427.92 | OK |



**_For the Supply Water Tank Enclosure:**

| | | |
|---|---|---|
| wtg | - | lbs |
| s.w.e wtg | - | lbs |
| TOTAL | 3060 | lbs |

If soil bearing capacity is 1500psf, then the required bearing area is:

| | | | | |
|---|---|---|---|---|
| Solar D Area Req'd | (MAX Load) /1500psf | = | 2.04 | $ft^2$ |
| | | | 293.76 | $in^2$ |
| Bearing Area of Enclosure (including 2x, 4x) | | = | 1365 | $in^2$ |
| | CHECK Bearing Area > Required Area | = | 1365 << 293.75 | OK |

# Appendix 1.0X

Trailer Loads and Foundation Design

| _Trailer Tonage / Loads | Completed By | Revised By | DCN # | | |
|---|---|---|---|---|---|
| Appendix 1.01 | Gimbert | Owens | N.A. | | |

*The following section details the dead weight of home. Weights are organized by trailers. The sections are labeled as "Technical Core" [34.25 kips or 17.12 tons in service load] and "Living Space" [45.86 kips or 20.84tons in service load]*

## _Summary

### _Overall

| _Item | | _weight | |
|---|---|---|---|
| Chassis 1 | | 10.91 | kips |
| Chassis 2 | | 11.05 | kips |
| Structrual STL | | 4.15 | kips |
| SIPs | | 6.54 | kips |

| | | | |
|---|---|---|---|
| Trailer 1 Transport Weight | Technical Core | 33.35 | kips |
| Trailer 2 Transport Weight | Living Space | 41.60 | kips |
| | **Total** | **74.95** | **kips** |

| | | | |
|---|---|---|---|
| Trailer 1 Service Weight | Technical Core | 28.98 | kips |
| Trailer 2 Service Weight | Living Space | 40.35 | kips |
| | **Total** | **69.33** | **kips** |

**_Abbreviations**

NT = Not transported
LS = Living Space
TC = Technical Core

## _Technical Core / Breezeway Dead Weights : on Trailer 1 (12.5' x 32')

### _General Equipment Interior

| _Item | _empty | _full | |
|---|---|---|---|
| Grey Water Heat Recovery Unit | | 40.00 | lbs |
| Energy Recovery Ventilator (w/ ducts) | | 58.00 | lbs |
| AHU | | 120.00 | lbs |
| Outdoor Radiator (heat dump) | | 70.00 | lbs |
| Buffer Tank (chiller h20 side) | | 180.00 | lbs |
| Fin-Tube Heat Dump Coil | | 100.00 | lbs |
| | **Total** | **0.57** | **kips** |

### _Mech Room Equipment

| _Item | _empty | _full | |
|---|---|---|---|
| Solar Storage tank | 412 | 1362.00 | lbs |
| Hydrogen Heat Pump | | 220.00 | lbs |
| Supply/ Return manifolds (rad floor) | 2 | 8.00 | lbs |
| Pressure tank | | 60.00 | lbs |
| Heat Storage Tank | 73 | 232.00 | lbs |
| Heat Pump Water Heater Tank | 105 | 356.00 | lbs |
| Heat Pump Water Heater (wall?) | | 80.00 | lbs |
| Tankless Electric Heater | | 80.00 | lbs |
| | **Total** | **1.04** | **kips** |

### _Kitchen

| _Item | _empty | _full | |
|---|---|---|---|
| Refrigerator | 400 | 1500.00 | lbs |
| Water heater | | 100.00 | lbs |
| Microwave | | 21.00 | lbs |
| Dishwasher | 50-120 | 100.00 | |
| Stove | 100-200 | 200.00 | lbs |
| Washer/Dryer | 250-280 | 300.00 | lbs |
| Faucet | | 6.00 | lbs |
| Cabinetry - upper | | 100.00 | lbs |
| Cabinetry - lower w/ coutnertop | | 100.00 | lbs |
| | **Total** | **2.43** | **kips** |

### _Bathroom

| _Item | _empty | _full | |
|---|---|---|---|
| Tub/ Shower | 174 | 674.00 | lbs |
| Shower Fixtures | | 10.00 | lbs |
| Toilet | | 100.00 | lbs |
| Sink | | 100.00 | lbs |
| Faucet | | 5.00 | lbs |
| TP Holder | | 2.00 | lbs |
| Medicine Cabinet / Mirror | | 15.00 | lbs |
| Towel Bar | | 5.00 | lbs |
| | **Total** | **0.91** | **kips** |

### _General Equipment Exterior

| _Item | _empty | _full |
|---|---|---|

| | | | |
|---|---|---|---|
| Fin-Tube Heat Collection from PV | | 100.00 | lbs |
| Supply H20 Tank (500g to 600g) | | ~4400 to ~5500 | gal |
| | 200 | | lbs |
| Waste H20 Tank ((650g to 750g) | | ~4600 to ~5500 | gal |
| | 200 | | lbs |
| | **Total** | **0.30** | **kips** |

## _Floor

| _Item | | _weight | |
|---|---|---|---|
| 3/8" OSB | 1.2psf | 345.60 | lbs |
| 3/4" Radiant tubing and grooved decking | 3psf | 864.00 | lbs |
| 1" x 1' x 1' Slate (w/ latex grout) | 15psf | 4320.00 | lbs |
| | **Total** | **5.53** | **kips** |

## _Structural Components / Walls

| _Item | _empty | _weight | |
|---|---|---|---|
| Interior Walls (standard 2 x) | 64plf | 1408.00 | lbs |
| SIP Wall North (24') (6 5/8" PUR) | 33.2lbs/ft | 332.00 | lbs |
| SIP Wall Header South (24') (6 5/8" PUR) | 16.6lbs/ft | 398.40 | lbs |
| SIP Wall East (10') (6 5/8" PUR) | | 332.00 | lbs |
| SIP Wall West (10') (6 5/8" PUR) | | 332.00 | lbs |
| TRESPA Wall North (24') | 40lbs/ft | 960.00 | lbs |
| TRESPA Wall East (10') | | 400.00 | lbs |
| TRESPA Wall West (10') | | 400.00 | lbs |
| 1/2" GPDW Interior Wall (91') | 21.25lbs/ft | 1933.75 | lbs |
| | **Total** | **6.50** | lbs |

## _Roof

**kips**

| | _Item | | _weight | |
|---|---|---|---|---|
| | SIP Technical Space Roof (6 5/8" PUR) | | 796.80 | lbs |
| **NT** | Roof Garden (saturated) | 40psf | 6400.00 | lbs |
| | | **Total** | **0.80** | **kips** |

## _TC / BZWY Chassis Weight 32' x 12.5'

| _Item | _Member | _Length (ft) | _lbs /ft | _full weight | |
|---|---|---|---|---|---|
| 1 | W12 x 58 | 32 | 58 | 1856 | lbs |
| 2 | W12 x 58 | 32 | 58 | 1856 | lbs |
| 3 | W12 x 58 | 32 | 58 | 1856 | lbs |
| 4 | W12 x 58 | 32 | 58 | 1856 | lbs |
| 5 | W12 x 58 | 12.5 | 58 | 725 | lbs |
| 6 | W12 x 58 | 12.5 | 58 | 725 | lbs |
| 7 | W10 x 17 | 12.5 | 17 | 212.5 | lbs |
| 8 | W10 x 17 | 12.5 | 17 | 212.5 | lbs |
| 9 | W10 x 17 | 12.5 | 17 | 212.5 | lbs |
| 10 | W10 x 17 | 12.5 | 17 | 212.5 | lbs |
| 11 | W10 x 17 | 12.5 | 17 | 212.5 | lbs |
| 12 | W10 x 17 | 12.5 | 17 | 212.5 | lbs |
| 13 | W10 x 17 | 12.5 | 17 | 212.5 | lbs |
| 16 | Cold formed stl jst | 275 | 2 | 550 | lbs |
| | | | **Total** | **10.91** | **kips** |

| | | |
|---|---|---|
| **Tech Core** | **18.07** | **kips** |

| | | |
|---|---|---|
| **Tech Core Chasis** | **10.91** | **kips** |
| **Tech Core Total (w/ chassis)** | $\boxed{\textbf{28.98}}$ | **kips** |
| | 14.49 | **tons** |

## _Living Space Dead Weights : on Trailer 2 (13' x 32')

### _General Mech Equipment

| _Item | | _weight | |
|---|---|---|---|
| | | | lbs |
| | Total | 0.00 | kips |

### _Bedroom

| _Item | | _weight | |
|---|---|---|---|
| Bed (full) | | 150.00 | lbs |
| Moveable Furniture Piece | | 1000.00 | lbs |
| | Total | 1.15 | kips |

### _Dinning / Living

| _Item | | _weight | |
|---|---|---|---|
| Couch | approx | 200.00 | lbs |
| Table | approx | 100.00 | lbs |
| | Total | 0.30 | kips |

### _Floor

| _Item | | _weight | |
|---|---|---|---|
| 3/8" OSB decking | 1.2psf | 624.00 | lbs |
| 3/4" Radiant tubing and grooved decking | 3psf | 1248.00 | lbs |
| 1" x 1' x 1' Slate (w/ latex grout) | 30psf | 6240.00 | lbs |
| | Total | 8.11 | kips |

### _Structural Components / Walls

| _Item | | _full | |
|---|---|---|---|
| SIP Wall South (6 5/8" PUR) | 33.2lbs/ft | 531.20 | lbs |
| SIP Wall North (6 5/8" PUR) | | 265.60 | lbs |
| SIP Wall East (6 5/8" PUR) | | 365.20 | lbs |
| SIP Wall West (6 5/8" PUR) | | 365.20 | lbs |
| SLATE Wall South (16') | 59.54lbs/ft | 952.64 | lbs |
| SLATE Wall North (8') | | 476.32 | lbs |
| SLATE Wall East (9') | | 535.86 | lbs |
| SLATE Wall West (9') | | 535.86 | lbs |
| 1/2" GPDW Interior Wall Surface (42') | 21.25lbs/ft | 892.50 | lbs |
| South Gutter (L8 x 8 x 1/2") | 26.7/bs/ft | 960.00 | lbs |
| STL Truss (32' long) | | 1513.95 | lbs |
| STL Header (58' in total length) | 12.2/bs/ft | 707.60 | lbs |
| Skylight (2) | 10.8lbs each | 21.60 | lbs |
| 4' Window units (2) | 8psf | 256.00 | lbs |
| 2' Window units (2) | 8psf | 128.00 | lbs |
| 8' Door units (1) | 8psf | 512.00 | lbs |
| Sliding Shelves (Exterior S. Wall, 4 units) | 340lbs each | 1360.00 | lbs |
| Sliding Shelves (Interior S. Wall, 4 units) | 649lbs each | 2596.00 | lbs |
| East /West SIP above 8' | 16.6lbs/ft | 431.60 | lbs |
| | Total | 13.41 | kips |

## _Roof

| _Item | | | _weight | |
|---|---|---|---|---|
| SIP Living Space Roof | | | 1792.80 | lbs |
| SIP Breezeway Roof | | | 796.80 | lbs |
| STL Breezeway Roof | | | 966.95 | lbs |
| PVs BreezewayRoof | | 4.60psf | 755.87 | lbs |
| Evacuated Tubes Breezeway | | | 110.00 | lbs |
| PVs Living Space Roof | | 4.60psf | 1909.55 | lbs |
| | | **Total** | **6.33** | **kips** |

## _LS Chassis Weight 32' x 13'

| _Item | _Member | _Length (ft) | _lbs /ft | _full weight | |
|---|---|---|---|---|---|
| 1 | W12 x 58 | 32 | 58 | 1856 | lbs |
| 2 | W12 x 58 | 32 | 58 | 1856 | lbs |
| 3 | W12 x 58 | 32 | 58 | 1856 | lbs |
| 4 | W12 x 58 | 32 | 58 | 1856 | lbs |
| 5 | W12 x 58 | 13 | 58 | 754 | lbs |
| 6 | W12 x 58 | 13 | 58 | 754 | lbs |
| 5 | W10 x 17 | 13 | 17 | 221 | lbs |
| 6 | W10 x 17 | 13 | 17 | 221 | lbs |
| 7 | W10 x 17 | 13 | 17 | 221 | lbs |
| 8 | W10 x 17 | 13 | 17 | 221 | lbs |
| 9 | W10 x 17 | 13 | 17 | 221 | lbs |
| 10 | W10 x 17 | 13 | 17 | 221 | lbs |
| 11 | W10 x 17 | 13 | 17 | 221 | lbs |
| 12 | Cold formed stl jsts | 286 | 2 | 572 | lbs |
| | | | **Total** | **11.05** | **kips** |

| | | |
|---|---|---|
| **Living Space** | **29.30** | **kips** |
| **Living Space Chasis** | **11.05** | **kips** |
| **Living Space Total (w/ chassis)** | **40.35** | **kips** |
| | 20.18 | **tons** |

| _Foundation Load | Completed By | Revised By | DCN # | |
|---|---|---|---|---|
| Appendix 1.02 | Benoit, Gimbert, | Glantz Owens | N.A. | Ref. DWG S-101 for layout; Ref. Appendix 1.01, 3.02, 3,03 |

*The following calculations detail the distribution of loads of the home to the foundation while on the mall. The Solar Decthalon requires a 1500psf load distribution on the mall to reduce the impact of the home on the grounds. USE 17 2' x 2' Pad piers for LS trailer.   USE 16 2' x 2' Pad piers for TC trailer.*

## _Loads

**_AREA_LS Trailer** 416 **ft$^2$**

| _Item | | _lbs | _kips | _factored value |
|---|---|---|---|---|
| Dead Weight | DL | | 40.35 | 1.40 |
| Living Space (50psf) | LL | 20800 | 20.80 | 1.20 |
| Snow (30psf) | LL | 12480 | 12.48 | 1.60 |
| Uplift Windward | WL | | 8.01 | 0.80 |
| Uplift Leeward | WL | | 1.35 | 0.80 |

| | | | |
|---|---|---|---|
| **1.4D** | **56.5** | **kips** | |
| **1.2D +1.6(S +LL)** | **101.7** | **kips** | ***controls** |
| **1.2D +1.6S + 0.8W** | **75.9** | **kips** | |
| **Unfactored** | **73.63** | **kips** | |

**_AREA_TC Trailer** 400 **ft**

| _Item | | _lbs | _kips | _factored value |
|---|---|---|---|---|
| Dead Weight | DL | | 28.98 | 1.00 |
| Tech core (50psf) | LL | 12800 | 12.80 | 1.60 |
| Breezeway (100[sf) | LL | 14400 | 14.40 | 1.20 |
| Snow (30psf) | LL | 12000 | 12.00 | 1.60 |
| Uplift Windward | WL | | 8.01 | 0.80 |
| Uplift Leeward | WL | | 1.35 | 0.80 |

| | | | |
|---|---|---|---|
| **1.4D** | **17.92** | **kips** | |
| **1.2D +1.6(S +LL)** | **97.49** | **kips** | ***controls** |
| **1.2D +1.6S + 0.8W** | **61.46** | **kips** | |
| **Unfactored** | **56.18** | **kips** | |

**Assumptions:**

1. Assume trailer beds are designed to handle 20 ton  = 40 kip load.
2. Soil bearing capacity is 1500psf for Solar D and referenced from IRC
3. Assume 100psf for corridor loading, entire house and surrounding area are treated as means of egress.
4. Concrete Pad load distribution design  is based on ASD in accordance with IBC 1805.4.1.1

## Calculations:

### _Foundation Piers required for LS Trailer:

1 If soil bearing capacity is 1500psf, then the required bearing area is:

| | | | | |
|---|---|---|---|---|
| Solar D Area Req'd | (MAX Load x 1000) /1500psf | = | 67.78 | $ft^2$ |
| Bearing Area of a Pier Pad | | = | 4 | $ft^2$ |
| 24"x 24" Area = $4ft^2$ | No. of Piers | = | 17 | piers |

**_Check Load to each Individual Pier:**

| | | | | |
|---|---|---|---|---|
| | Unfactored Load | = | 73.63 | kips |
| | | | 73632.104 | lbs |
| IF area of LS trailer is 13' x 32', then | | | | |
| Distributed Load = 0.00 | Distributed Load | = | 177.00 | psf |

Try Assigning 22 piers to the LS trailer frame:

| | | | |
|---|---|---|---|
| Largest Tributar\rea for a pier(4ft x 6.5ft) | = | 26 | $ft^2$ |
| Load to Individual Pier (177psf x $26ft^2$) | = | 4602.01 | lbs |
| Load placed on soil from Pier (150pcf x 2' x 2' x 0.33') | = | 264 | lbs |
| TOTAL wtg to Individual Pier | = | 4866.01 | lbs |
| *Check code compliance = (TOTAL wtg / Bearing sq. ft.)* | = | 1216.50 | psf |
| | | < 1500psf | OK |

*USE twenty two (22) High Concrete Incorp. 4 ' x 4' concrete pads to support cribbing pier.*

### 2 _Foundation Piers required for TC Trailer:

If soil bearing capacity is 1000psf, then the required bearing area is:

| | | | | |
|---|---|---|---|---|
| Solar D Area Req'd | (MAX Load x 1000) /1500psf | = | 65.00 | $ft^2$ |
| Bearing Area of a 2' x 2' Pier Pad | | = | 4 | $ft^2$ |
| 24" x 24" Area | No. of Piers | = | 16 | piers |

**_Check Load to each Individual Pier:**

| | | | | |
|---|---|---|---|---|
| | Unfactored Load | = | 56.18 | kips |
| | | | 56178.05 | lbs |
| IF area of LS trailer is 13' x 32', then | | | | |
| Distributed Load = 0.00 | Distributed Load | = | 135.04 | psf |

Try assigning 22 piers to the TC trailer frame:

| | | | |
|---|---|---|---|
| Largest Tributar\rea for a pier(4ft x 6.5ft) | = | 26 | $ft^2$ |
| Load to Individual Pier (177psf x $26ft^2$) | = | 3511.13 | lbs |
| Load placed on soil from Pier (150pcf x 2' x 2' x 0.33') | = | 264 | lbs |
| TOTAL wtg to Individual Pier | = | 3775.13 | lbs |
| *Check code compliance = (TOTAL wtg / Bearing sq. ft.)* | = | 943.78 | psf |
| | | < 1500psf | OK |

3 **_Check House Foundation for Uplift:**
See Appendix 3.02 for Wind Analysis and Uplift Check.

| _Trailer Design | | Completed By | Revised By | DCN # | |
|---|---|---|---|---|---|
| Appendix 1.03 | | Schnure Trailers | Glantz | N.A. | |

*The following calculations are provided for the team by Schnure trailer company. They detail the design of two low-boy trailers. The trailers will be framed using W12 x 58 members around the exterior and W10 x 77 as internal members.*

We have estimated the beam possibilities based upon your requirements for:

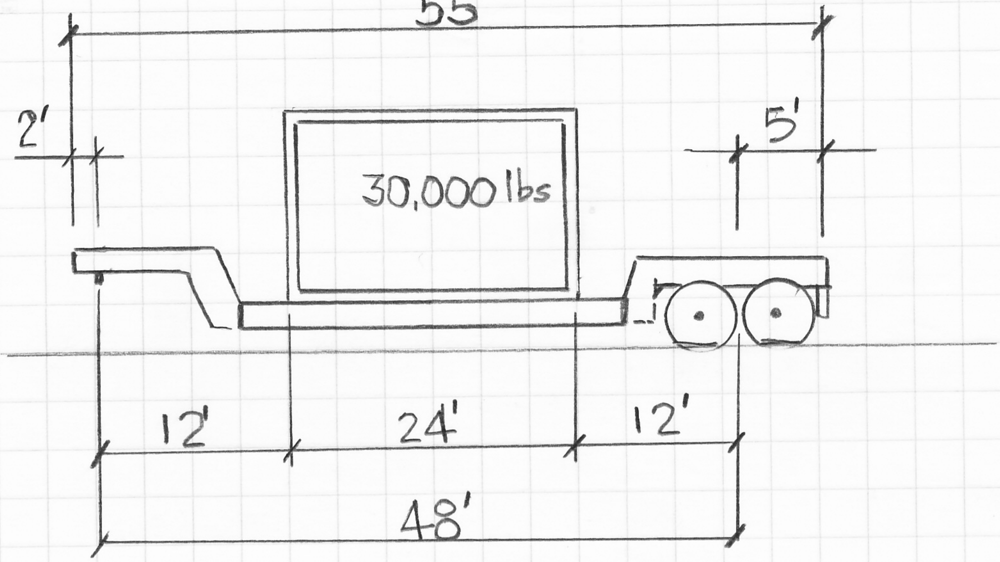
1. 40,000lbs (as verified with Schnure) uniform loading, 24' long, centered on a 32' bed length.
determine if there's a W10 beam that will accomplish the task
2. Use 10" beam as customer's first choice; provide alternative beam depths that might have merit

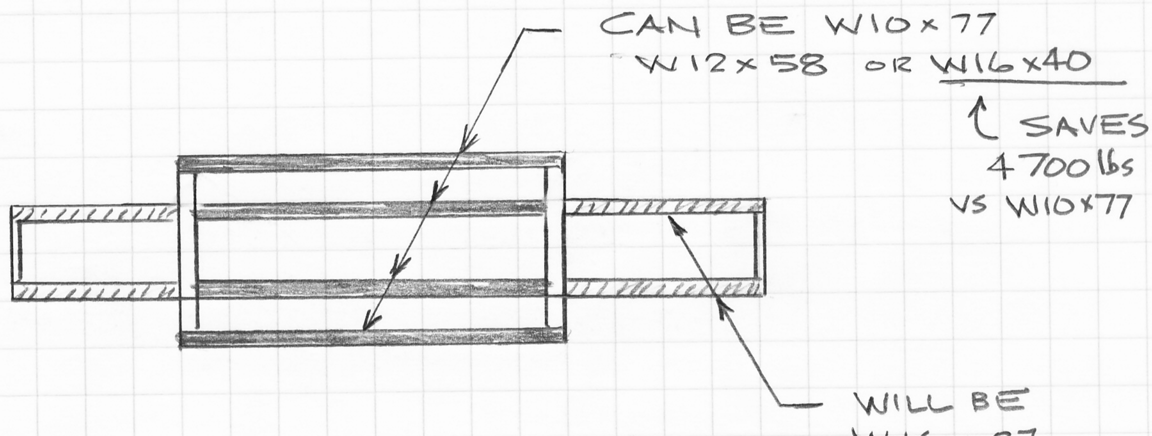
3. Staying with the specified W10 beam size, the task can be accomplished using four (4) W10X77 beams in the bed area, and two (2) W16X87 or equivalent beams for the neck and rear area.

4. If PSU can increase the deck height sufficiently to use a 16" beam, the choice of four (4) W16X40 beams in the bed area will save approximately 4700lbs in the total trailer weight, and it is approximately 14% better for reducing deflection.

5. Our beam selection is based upon 1.5" pre-camber on the bed beams, and a total deflection of 2" loaded, hence 1/2" sag under full load. To eliminate the 1/2" sag, the 10" beam would have to go to W10X112 as a minimum. The weight of bed would increase about 4500lbs.

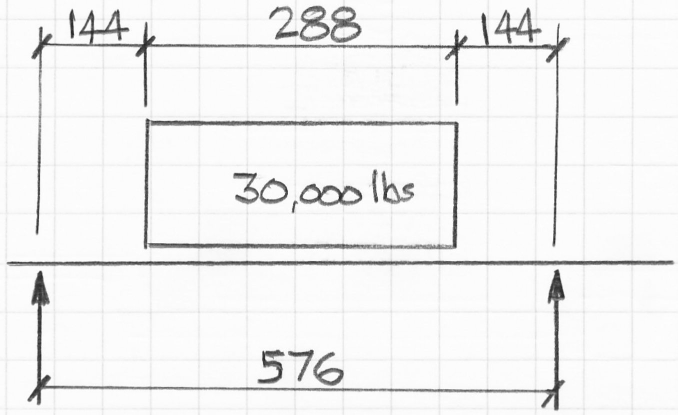
**SCHNURE MANUFACTURING CO, INC    HONEY BROOK, PA**
Pennsylvania State University ~ Housing Module Trailer
Beam Sizing Estimate


PLAN VIEW
PRIMARY MEMBERS ONLY

FOR CLARITY, CROSSMEMBERS NOT SHOWN




ALL PRIMARY MEMBERS 50,000 PSI YIELD
ALLOWABLE TENSION/BENDING STRESS 30,000 PSI

PRE CAMBER BED 1½"

ALLOWABLE DEFLECTION 2"    HENCE ½" SAG UNDER LOAD

DETERMINE REQ'D SECTION MODULUS
FOR STRESS TO BE ≤ 30,000 PSI

$$a = \frac{b}{L} = \frac{144}{576} = .25$$

$$M = \frac{1}{8} WL (1 + 2a)$$

$$M = (.125)(30{,}000)(576)(1 + .5)$$

$$M = 3{,}240{,}000$$

$$S = \frac{M}{Z} \qquad Z = \frac{M}{S} = \frac{3240000}{30{,}000} \qquad Z = 108$$

OR 27 EACH BED BEAM
54 EACH NECK AND REAR BEAM

DETERMINE REQ'D MOMENT OF INERTIA
FOR DEFLECTION TO BE 2" OR LESS

$$\delta = \frac{WL^3}{EI\,384(1-2a)}\left(5-24a^2+16a^4\right)$$

$$2 = \frac{(30000)(576^3)}{(29000000)(I)(384)(.5)}\left[5-1.5+.063\right]$$

TOTAL I = 1834

FOUR BED BEAMS  I = 458 EACH

NECK & REAR BEAMS  I = 917 EACH

BEAM CHOICES

| | BED I = 458 | Z = 27 | WT | NECK & DECK I = 917 | Z = 54 | WT |
|---|---|---|---|---|---|---|
| W10x77 | 455 | 85 | 9856 | | | |
| W12x58 | 475 | 78 | 7424 | | | |
| W12x106 | | | | 933 | 145 | 5088 |
| W16x40 | 518 | 64.7 | 5120 | | | |
| W16x87 | | | | 954 | 117 | 4176 |
| W18x60 | | | | 984 | 108 | 2880 |

# Appendix 2.0X

Braking Loads

| _Braking Loads | Completed By | Revised By | DCN # | |
|---|---|---|---|---|
| APPENDIX 2.01 | Cynthia | Glantz | S-3 | Ref. Appendix 2.01 |
| *Conclusions: Breaking force on the home = 12.06 kips ~ 13kips* | | | | |

$W_{TOTAL}$ = 40.35 kips

$$m = \frac{W}{g}$$

$$= \frac{40{,}352 \text{ lbs}}{32.3 \text{ ft/s}^s}$$

$$= \boxed{1249.29} \text{ slugs (lbs-s}^s\text{/ft)}$$

Assumptions: Stopping distance is 337ft
Speed of Truck is at 55mph = 80.67ft/sec

$$t = \frac{2d}{v}$$

$$= \frac{(2)(337)}{80.67}$$

$$= 8.36 \text{ sec}$$

$$a = \frac{v}{t}$$

$$= \frac{80.67}{8.36}$$

$$= 9.65 \text{ ft/s}^2$$

0.30 g

F = m x a

$$= 12{,}056 \text{ lbs}$$

$$= \boxed{12.06} \text{ kips}$$

| _Braking Force Mass Distr. | Completed By | Revised By | DCN # | |
|---|---|---|---|---|
| APPENDIX 2.02 | Gimbert, Benoit | Glantz | S-3 | Ref. Appendix 2.01 |

*This Appendix details the distribution of the braking force throughout the home based on Mass. These numbers are used to verify shear design of the SIPs.*

## _ Distribution of Braking Force based on Mass

The acceleration affects the mass of the load, and therefore, the braking loads should be applied based on the distribution of the mass through the chassis, walls, truss, and house.

| *section* | *weight (kips)* | *% of total weight* | *Weight Chassis* | *Weight Midheight Bot* | *Weight Midheight Top* | *Weight Roof* |
|---|---|---|---|---|---|---|
| CHASSIS | 6.64 | 19.41% | 19.41% | | | |
| FLOOR | 13.73 | 40.13% | 40.13% | | | |
| WALLS < 8' | 4.9 | 14.32% | | 14.32% | | |
| FURNITURE | 1.5 | 4.38% | 4.38% | | | |
| SHELVES | 2.2 | 6.43% | | 6.43% | | |
| WALLS >8' | 0.43 | 1.26% | | | 1.26% | |
| TRUSS | 1.51 | 4.41% | | | 4.41% | |
| STL HEADER | 0.7 | 2.05% | | | 2.05% | |
| SIP ROOF | 1.8 | 5.26% | | | | 5.26% |
| BRWY ROOF | 0.8 | 2.34% | | | | 2.34% |
| TOTAL | 34.21 | 100.00% | 63.93% | 20.75% | 7.72% | 7.60% |

A 40 kip load is used and the mass break down is simplified to 64, 21, 8 and 7%. Also the resulting load on the truss is divided evenly to the top and bottom cords.

| | *Total* | *Chassis* | *Midheight Bot* | *Midheight Top* | *Roof* |
|---|---|---|---|---|---|
| | 100.00% | 63.93% | 20.75% | 7.72% | 7.60% |
| Total load application of 13 kip load and 0.3 g acceleration (kips): | 3.88 | 2.48 | 0.81 | 0.30 | 0.00 |
| | *Total* | *Chassis* | *Truss Bottom* | *Truss Top* | *Roof* |
| | 3.88 kips | 2.89 kips | 0.55 kips | 0.15 kips | 0.00 kips |

# Appendix 3.0X

Wind Loads

| _Wind Loads and Diagrams | Completed By | Revised By | DCN # | |
|---|---|---|---|---|
| Appendix 3.01 | Benoit, Gimbert | Glantz, Owens | N.A. | |

*Conclusions:  The wind loads were calculated based on ASCE7-02 with reference to ASCE7-05 and follow Method 2 - the analytical approach. Each step is detailed and assumption present. A summary of the loads is given with plan and section diagrams.*

*Using Method 2 - Analytical Procedure*

**6.5.1 Scope**

1 The building or other structure is a regular shaped…….

2 the building does not have response characteristics making it subject to across -wind loading, vortex shedding, instability due to galloping or flutter; or does not have a site location for which channeling effects or buffeting in the wake of upwind obstructions warrant special considerations.

**6.5.2 Limitations**

The provisions of Section 6.5 take into consideration the load magnification caused by gusts in resonance with along-wind vibrations of flexible buildings or other structures.

**6.5.2.1 Shielding**

There shall be no reduction in velocity pressure due to apparent shielding afforded by buildings and other structures or terrain features.

**6.5.2.2 Air-Permeable Cladding**

Design wind loads determined from Section 6.5 shall be used for air-permeable cladding unless approved test data or recognized literature demonstrate lower loads for the type of air-permeable cladding being considered.

*Solar Shingles and wooden slats as attached cladding*

**6.5.3 Design Procedure**

---

1 **Basic Wind Speed V and Wind Directionality Factor $K_d$**

---


**6.5.4 Basic Wind Speed**

| | | |
|---|---|---|
| V | 90 | mph |

**6.5.4.4 Wind Directionality Factor**

| | | |
|---|---|---|
| $K_d$ | 0.85 | Table 6-4 |

---

2 **An Importance Factor I**

---

**From Table 1-1:**

Category II - all buildings and other structures, the building represent no hazard to human health or phycial safety as described in categories III and IV

**6.5.5 Importance Factor**

| | | |
|---|---|---|
| I | 1.00 | Table 6-1 |

---

3 **An exposure category or exposure categories and velocity pressure coefficients, $K_z$ or $K_h$**

---

**6.5.6 Exposure Category**

Exposure C: Open Terrain with scattered obstrucitons having heights generally less than 30 ft for most wind directions, all 1-story strucutres with a mean roof height less than 30 feet are less than 1500 ft or ten times the height of the structure, whichever is greater, from an open field that prevents the use of exposure B

**6.5.6.6 Velocity Pressure Exposure Coefficient**

| | | | | |
|---|---|---|---|---|
| $K_z$ | 0-15 | 0.85 | | |
| | 20 | 0.90 | Table 6-3 | |
| $K_h$ | 13.5 | 0.835 | (interpolated) | **USE 0.9** |

h = 13.5' (mean roof building height, eave height shall be used for roof angle less than or equal to 10 degrees

## 4 A Topographial Factor $K_{zt}$

**6.5.7 Velocity Pressure Exposure Coefficient**

| | | |
|---|---|---|
| $K_{zt}$ | 1.00 | flat terrain |

## 5 A Gust Effect Factor G or $G_f$

**6.5.8 Gust Effect Factor**

For rigid structures as defined in Section 6.2, a building having a fundamental frequency greater than or equal to 1 Hz

| | |
|---|---|
| G | 0.85 |

## 6 An Enclosure Classification

**6.5.9 Enclosure Classifications**

Enclosed: The building does not comply with the requirements for open or partially enclosed buildings; see below

| | | | | |
|---|---|---|---|---|
| south | $A_g$ | T Area | 524.65 | $FT^2$ |
| | | T glass surface | 179.6 | $FT^2$ |
| | $A_o$ | T opening | 28.5 | $FT^3$ (door) |
| | | | 38.6 | $FT^4$ (glass) |
| | | | 67.1 | $FT^5$ |
| north | $A_g$ | T Area | 524.65 | $FT^2$ |
| | $A_o$ | T opening | 0 | $FT^3$ (door) |
| | | | 0.69 | $FT^4$ (glass) |
| | | | 0.69 | $FT^5$ |
| east | $A_g$ | T Area | 336.46 | $FT^2$ |
| | $A_o$ | T opening | 20 | $FT^3$ (door) |
| | | | 8.95 | $FT^4$ (glass) |
| | | | 28.95 | $FT^5$ |
| west | $A_g$ | T Area | 336.46 | $FT^2$ |
| | $A_o$ | T opening | 20 | $FT^3$ (door) |
| | | | 61.33 | $FT^3$ (gar. door) |
| | | | 7.27 | $FT^4$ (glass) |
| | | | 88.6 | $FT^5$ |

For Partially Enclosed, the following must apply:

a $A_o > 1.10A_{oi}$

| | $A_o$ | $1.10A_{oi}$ | |
|---|---|---|---|
| south | 67.1 | 130.064 | no |
| north | 0.69 | 203.115 | no |
| east | 28.95 | 172.029 | no |
| west | 88.6 | 106.414 | no |

b $A_o > 0.01A_g$

| | $A_o$ | $0.01A_g$ | |
|---|---|---|---|
| south | 67.1 | 5.2465 | yes |
| north | 0.69 | 5.2465 | yes |
| east | 28.95 | 3.3646 | yes |
| west | 88.6 | 336.47 | yes |

## 7 Internal Pressure Coefficient GCpi

**6.5.11.1 Internal Pressure Coefficient**

| | | | |
|---|---|---|---|
| $GC_{pi}$ | 0.18 | *Enclosed* | Table 6-5 |
| | -0.18 | | |

## 8 External Pressure Coefficient $C_p$ or $GC_{pf}$

**6.5.11.2.1 MWFRS Internal Pressure Coefficient**

External pressure coefficients for main wind force resisitng systems, $C_p$

| | (e-w) | (n-s) | |
|---|---|---|---|
| L | **32** | **25** | (Length of BLDG parallel) |
| B | **25** | **32** | (Length of BLDG perpend.) |
| h | **13.5** | **13.5** | (mean roof heighter) |

### Wall

| | 0-8' | |
|---|---|---|
| Windward | 0.80 | |
| Leeward: Wind blowing (e-w), per 25' | | |
| L/B | 1.28 | |
| $C_p$ | -0.44 | *interpolation equation for L/B bet. 1 and 2* |
| Leeward: Wind blowing (n-s), per 32' | | |
| L/B | 0.78 | |
| $C_p$ | -0.50 | |
| Sidewalls | | |
| $C_p$ | -0.70 | |

### Roof

8' - 16'

**Wind blowing (e-w), per 25', Parallel to ridge for all angles**

Windward:

| | | | |
|---|---|---|---|
| h/L | 0.42 | <0.5 | |
| | | $C_p$ | |
| 0 to h/2 | 0'-6.25' | -0.90 | -0.18 |
| h/2 to h | 6.25' - 13.5' | -0.90 | -0.18 |
| h to 2h | 13.5' - 26' | -0.50 | -0.18 |
| >2h | 26' - 32' | -0.30 | -0.18 |

Leeward:

| | | | |
|---|---|---|---|
| h/L | 0.42 | <0.5 | |
| | | $C_p$ | |
| 0 to h/2 | 0'-6.25' | -0.90 | -0.18 |
| h/2 to h | 6.25' - 13.5' | -0.90 | -0.18 |
| h to 2h | 13.5' - 26' | -0.50 | -0.18 |
| >2h | | | |

**Wind blowing (s-n), per 32', normal to ridge for angles >10**

Windward:

| | | | | |
|---|---|---|---|---|
| h/L | 0.54 | >0.5 | | *interpolate bet. 0.5 and 1* |
| $C_p$ | -0.72 | | 0.2 | from 8' to 12'-3.5", angel at 15 |
| $C_p$ | -0.21 | | 0.2 | from12'-3.5" to 16', angel at 30 |

Leeward:

| | | | | |
|---|---|---|---|---|
| h/L | 0.54 | >0.5 | | *interpolate bet. 0.5 and 1* |
| $C_p$ | -0.51 | | -0.18 | from 8' to 12'-3.5", angel at 15 |
| $C_p$ | -0.60 | | -0.18 | from12'-3.5" to 16', angel at 30 |

**Wind blowing (n-s), per 32', normal to ridge for angles <10**

Windward:

h/L 0.54 >0.5 *interpolate bet. 0.5 and 1*

| | | $C_p$ | |
|---|---|---|---|
| 0 to h/2 | 0'-6.25' | -0.92 | -0.18 |
| h/2 to h | 6.25' - 13.5' | -0.88 | -0.18 |
| h to 2h | 13.5' - 26' | -0.52 | -0.18 |
| >2h | 26' - 32' | -0.33 | -0.18 |

## 9 Parapets / Overhangs

**6.5.11.4 MWFRS - Roof Overhangs**

External positive pressure coefficients on the bottom surface of windward overhang

**Roof Overhangs:**

Cp = 0.80

**6.5.11.5.1 MWFRS - Parapets**

External pressure coefficients for main wind force resisitng systems, $C_p$

**Parapet:** 1' on technical core

Windward:

$GC_{pn}$ 1.8

Leeward:

$GC_{pn}$ -1.1

## 10 Velocity pressure, $q_z$ and $q_h$

**6.5.10 Velocity Pressure**

Calculated by: $q_z = 0.00256\ K_z K_{zt} K_d V^2 I$ (lbs/ft$^2$)

$q_{0'-15'}$ = 14.98 psf

$q_{20'}$ = 15.86 psf

## 11 Design wind load p or F

**6.5.12 Design Wind loads on enclosed and partially enclosed buildings**

Design wind pressure for the MWFRS by: $p = qGC_p - q_i(GC_{pi})$ (lbs/ft$^2$)

Walls

| Windward: | _P | _[+ or -] | |
|---|---|---|---|
| $p_{0'-15'}$ = | 10.19 | 2.86 | psf |
| $p_{20'}$ = | 10.79 | 2.86 | psf |

Leeward: Wind blowing (e-w), per 25'

| | | | |
|---|---|---|---|
| $p_{0'-15'}$ = | -5.65 | 2.86 | psf |
| $p_{20'}$ = | -5.99 | 2.86 | psf |

Leeward: Wind blowing (n-s), per 32'

| | | | |
|---|---|---|---|
| $p_{0'-15'}$ = | -6.37 | 2.86 | psf |
| $p_{20'}$ = | -6.74 | 2.86 | psf |

Sidewalls

| | | | |
|---|---|---|---|
| $p_{0'-15'}$ = | -8.91 | 2.86 | psf |
| $p_{20'}$ = | -9.44 | 2.86 | psf |

Parapet

| | | |
|---|---|---|
| $p_{windwrd}$ = | 24.27 | psf |
| $p_{leeward}$ = | -14.83 | psf |

## Roof

**Wind blowing (e-w), per 25', Parallel to ridge for all angles**

| Windward: | | (+ or -) | |
|---|---|---|---|
| $p_{0'-6.25'}$ | -12.14 | 2.86 | psf |
| $p_{6.25' - 13.5'}$ | -12.14 | 2.86 | psf |
| $p_{13.5' - 26'}$ | -6.74 | 2.86 | psf |
| $p_{26 - 32'}$ | -4.05 | 2.86 | psf |

**Wind blowing (s-n), per 32', normal to ridge for angles >10**

Windward:

| | | | |
|---|---|---|---|
| $p_{15\ degree}$ | -9.76 | 2.86 | psf |
| $p_{30\ degree}$ | -2.80 | 2.86 | psf |

**Wind blowing (n-s), per 32', normal to ridge for angles <10**

Windward:

| | | | |
|---|---|---|---|
| $p_{0'-6.25'}$ | -12.43 | 2.86 | psf |
| $p_{6.25' - 13.5'}$ | -11.92 | 2.86 | psf |
| $p_{13.5' - 26'}$ | -6.96 | 2.86 | psf |
| $p_{26 - 32'}$ | -4.48 | 2.86 | psf |

**Wind blowing (n-s), per 32', normal to ridge for angles >10**

Leeward:

| | | | |
|---|---|---|---|
| $p_{15\ degree}$ | -6.85 | 2.86 | psf |
| $p_{30\ degree}$ | -8.09 | 2.86 | psf |

OR

| | | | |
|---|---|---|---|
| p ($C_p$= 0.18) | -2.43 | 2.86 | psf |

**Roof Overhangs**

| | | | |
|---|---|---|---|
| p ($C_p$= 0.8) | 10.79 | 2.86 | psf |

**use 20psf as recommended by PE

12 **Components and Cladding**

| | | | |
|---|---|---|---|
| $q_h$ | 15.86 | | |
| $GC_{pi}$ | 0.18 | *Enclosed* | Table 6-5 |
| | -0.18 | | |
| $GC_p$ | 0.3 | Zone 2 | Figure 6-11C |
| | -1.2 | | |

Design wind pressure for Components and Cladding by: $p = q_h GC_p - q_{hi}(GC_{pi})$ (lbs/ft$^2$)

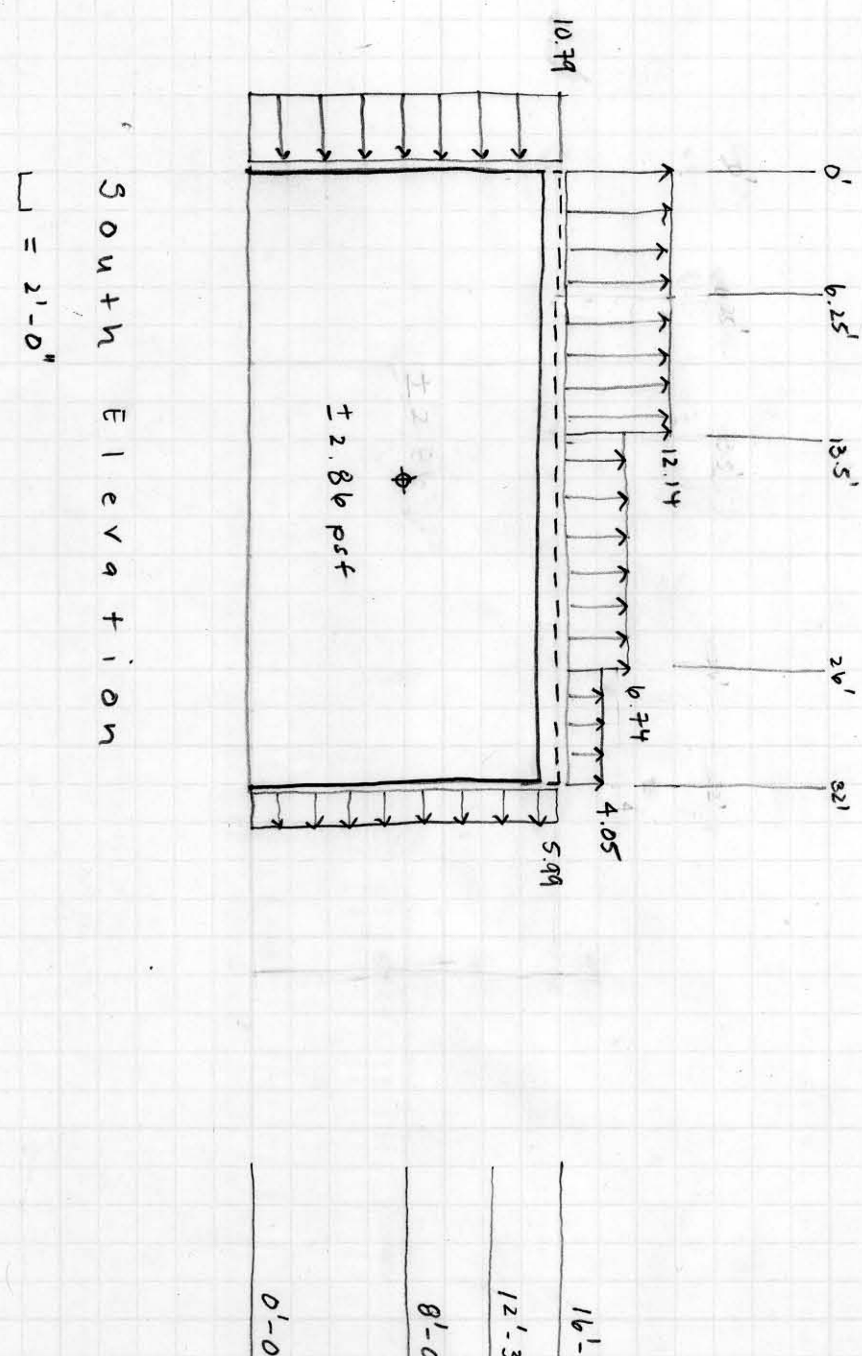
Windward: (+ or -)

| | | | |
|---|---|---|---|
| $p_l$ = | 4.76 | 2.85 | psf |

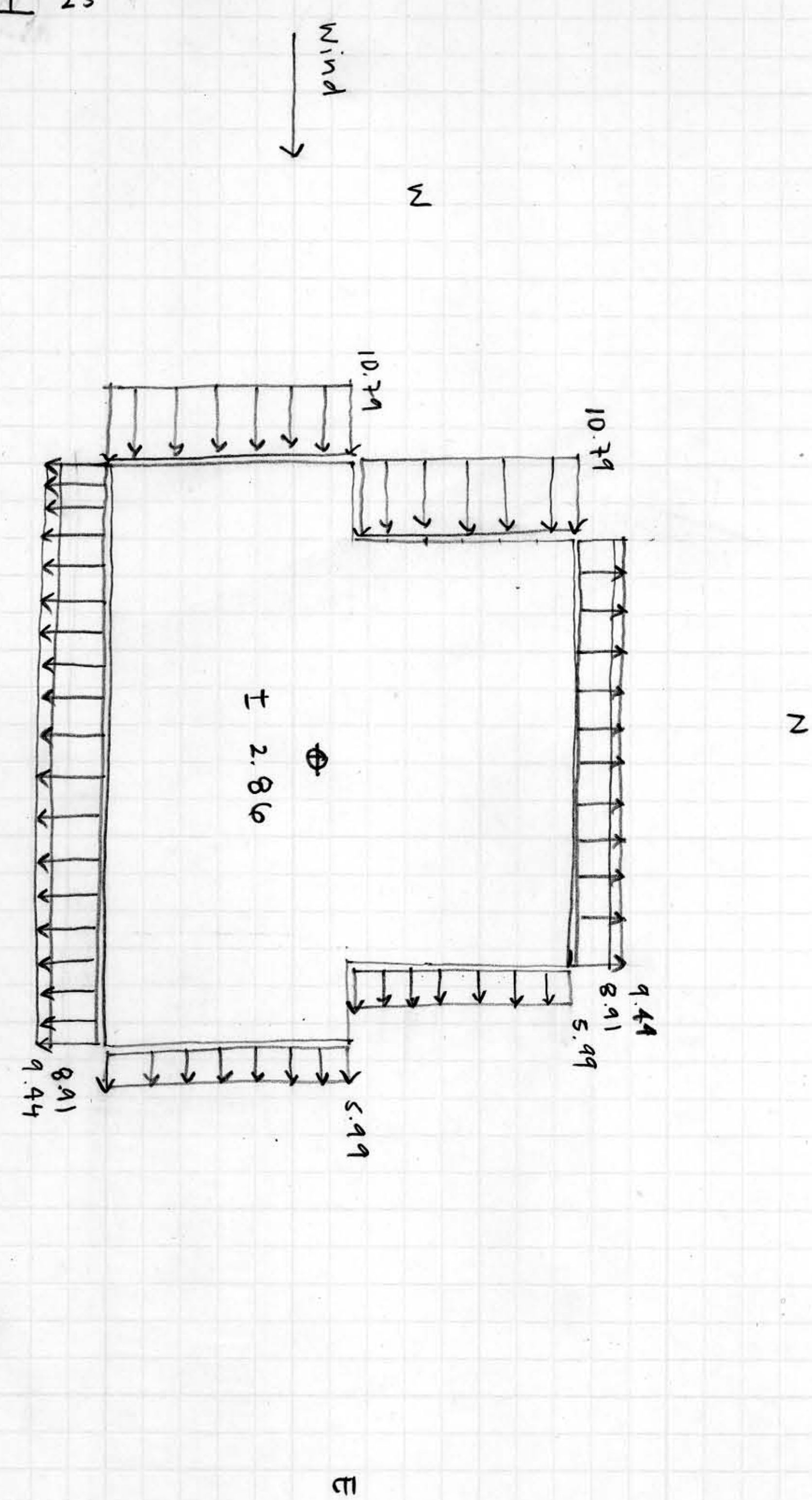
Leeward: (+ or -)

| | | | |
|---|---|---|---|
| p = | -19.03 | 2.85 | psf |

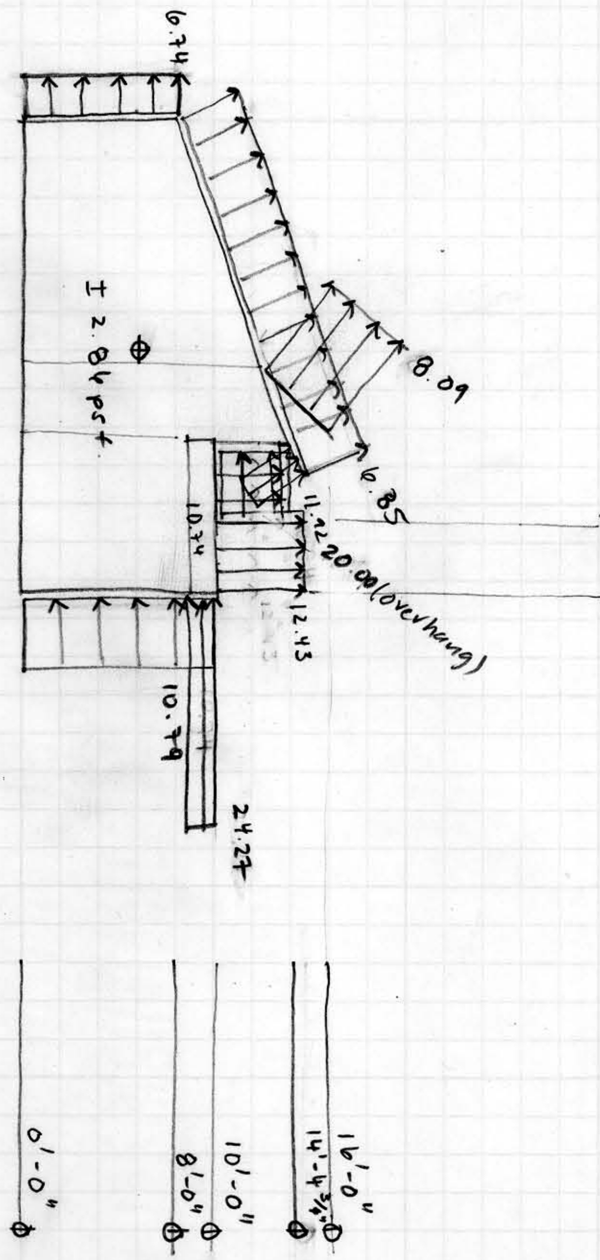
wind (e-w) direction, ⊥ 25' length
parallel to ridge



wind (e-w), ⊥ 25'

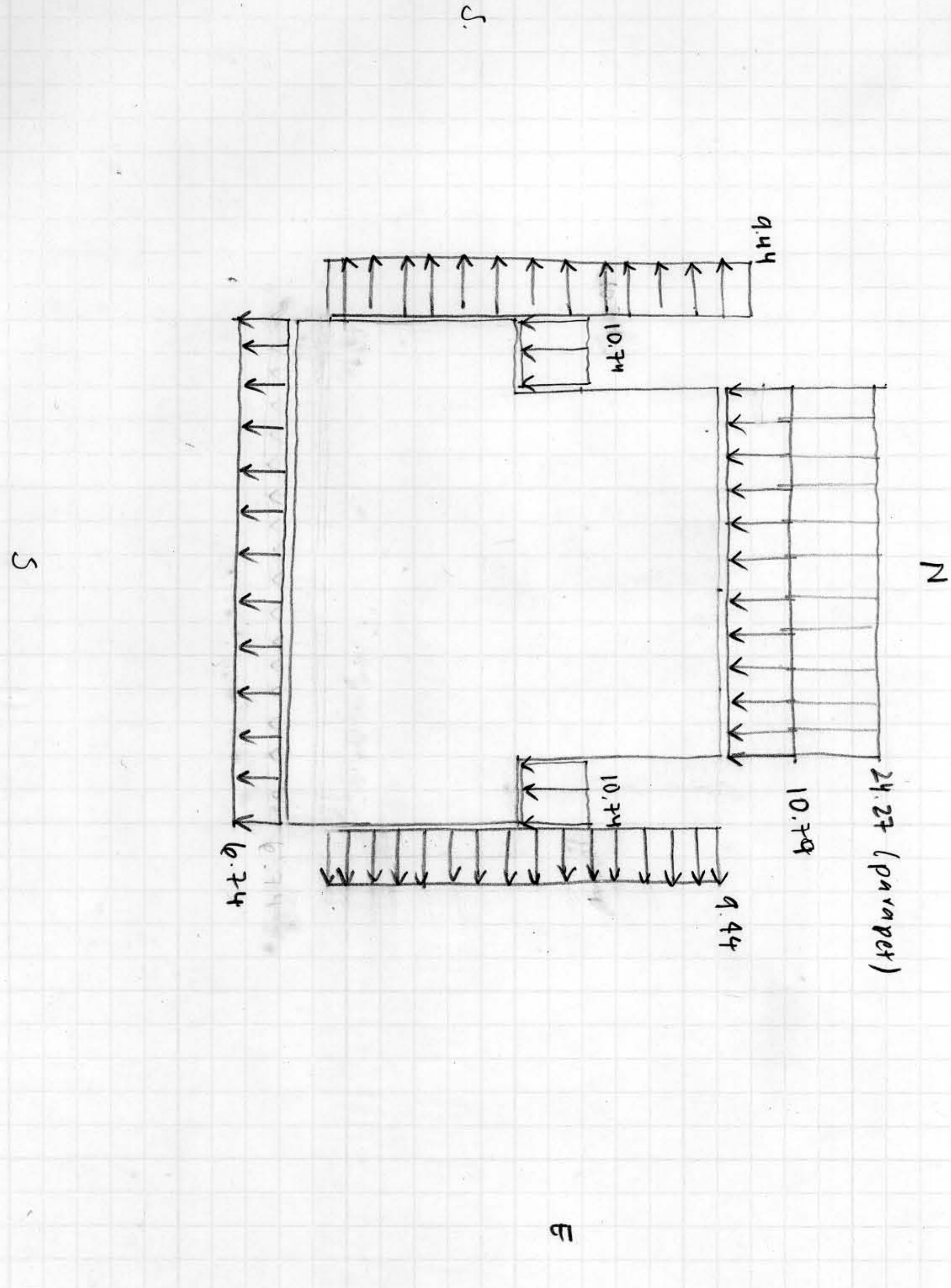


wind (n-s) direction, ⊥ 32' length
normal to ridge

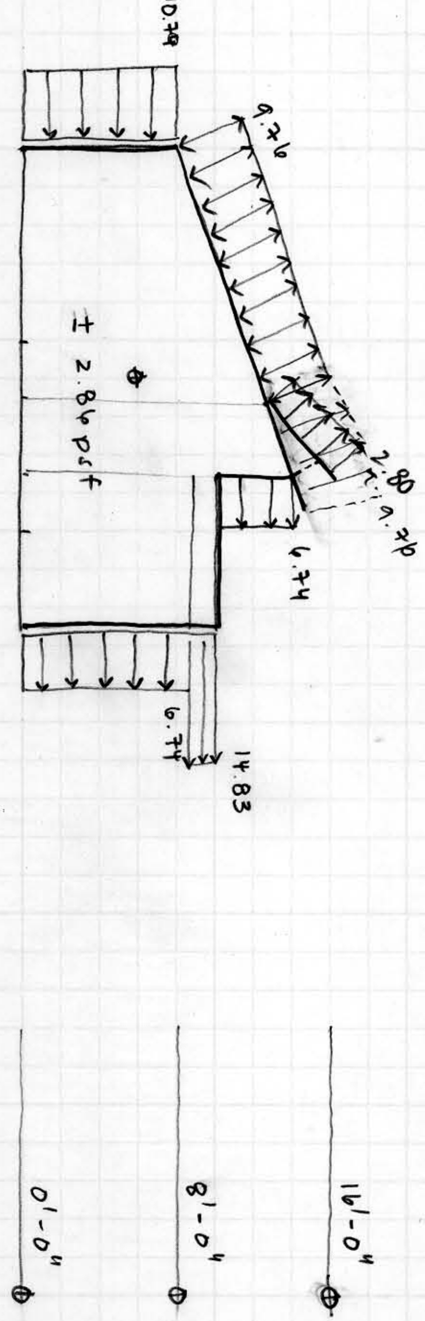



20 psf uplift

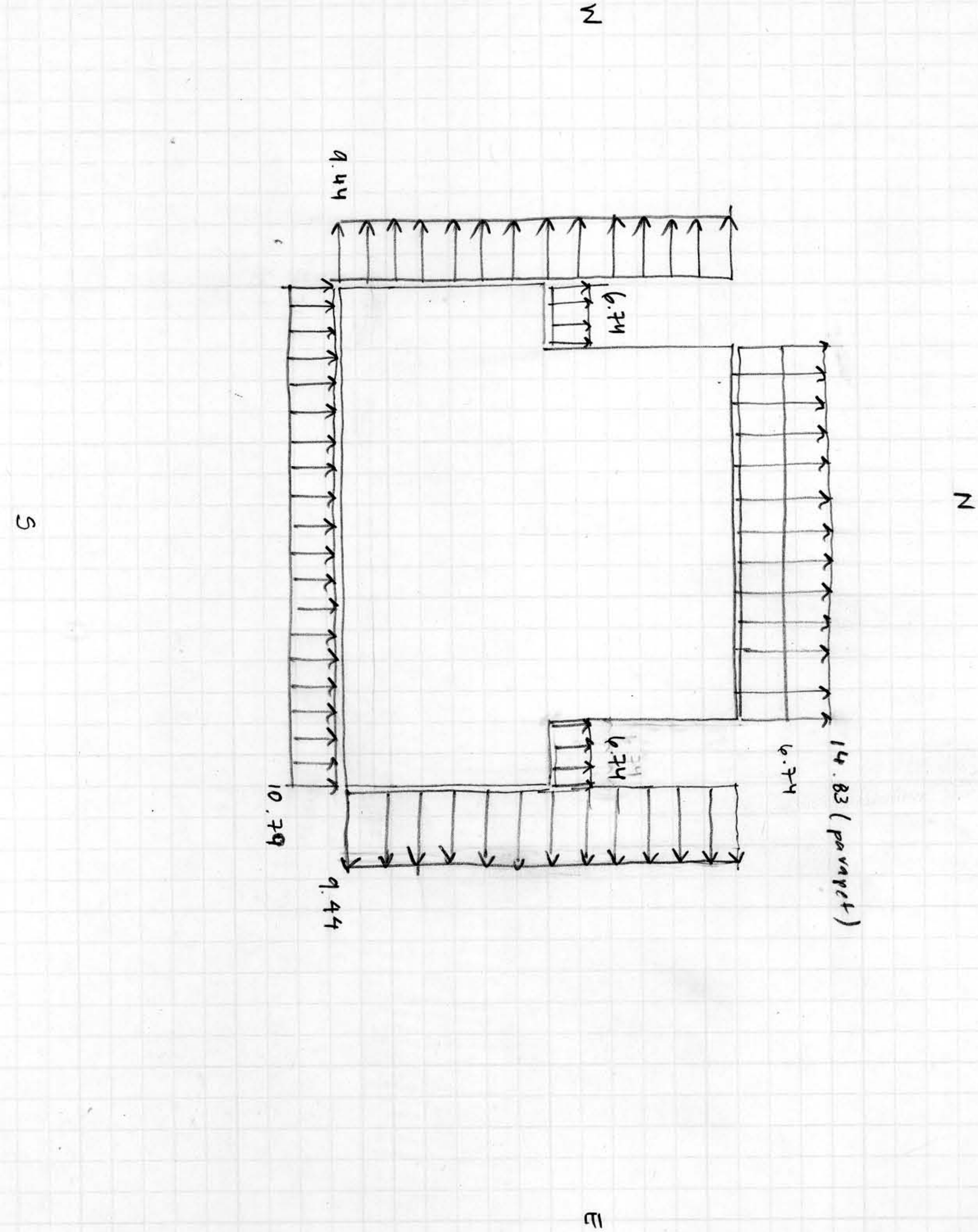
wind (n-s), ⊥ 32'



wind (s-n) direction, $\perp$ 32' length
normal to ridge.



wind (s-n), ⊥ 32'



| _Wind Overturning/Uplift | Completed By | Revised By | DCN # | |
|---|---|---|---|---|
| Appendix 3.02 | Benoit, Gimbert | Glantz, Owens | N.A. | Reference Appendix 3.01 |

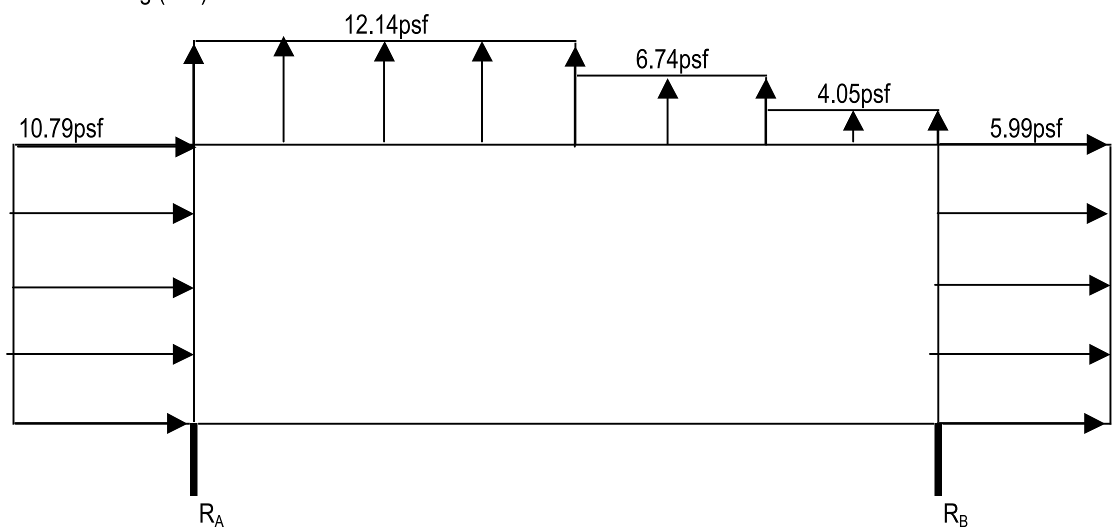
*Conclusions: The home does not require additional tie-downs due to the self weight of the structure.*

**Assumptions:**

*1* Assume building is square for simplicity.

**Calculations:**

*1* Wind Blowing (e-w) SOUTH ELEVATION:




M@B = 25.5 x [-(10.79 x 16' x 8') - (5.99 x 16' x 8') - (12.14 x 13.5' x 25.25') - (6.74 x 12.5' x 12.25') - (4.05 x 6' x 3')]

= -188471.14 ft-lbs

= -188.47 ft-kips

$R_A$ = $M_B$/32'

= $\boxed{-5.89}$ kips (T)

M@A = 25.5 x [(10.79 x 16' x 8') + (5.99 x 16' x 8') - (12.14 x 13.5' x 6.75') - (6.74 x 12.5' x 19.25') - (4.05 x 6' x 29')]

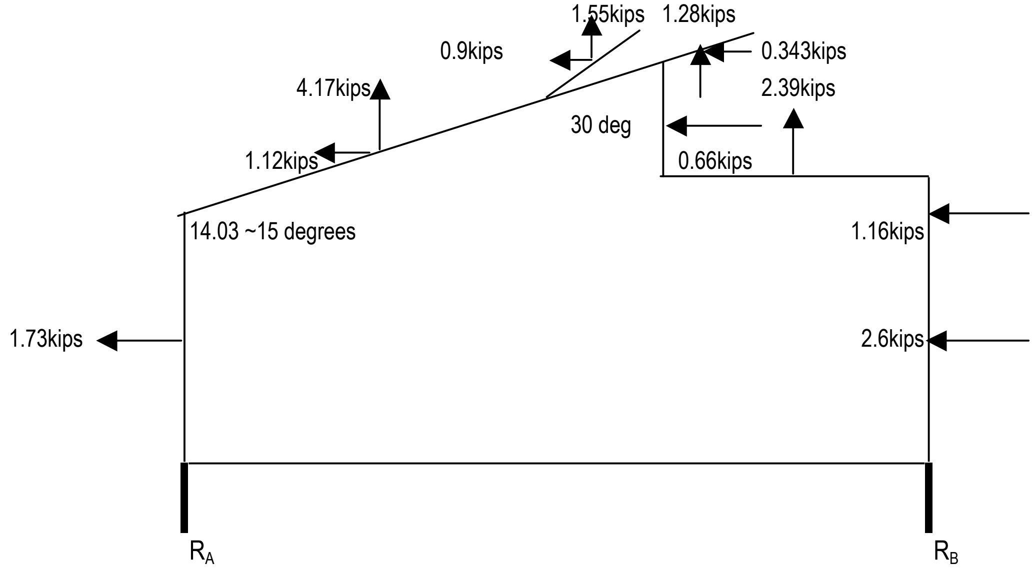
= -32765.72 ft-lbs

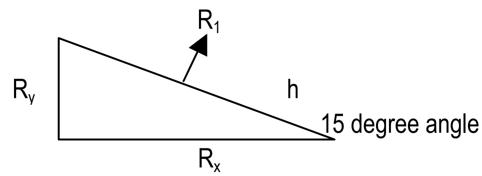
= -32.77 ft-kips

$R_B$ = $M_A$/32'

= $\boxed{-1.02}$ kips (T)

2 Wind Blowing (n-s) EAST ELEVATION:



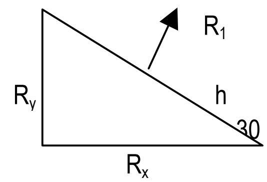




$$\cos(15) = \frac{19'}{h} \qquad h = 19.67'$$

$$\cos(15) = \frac{x}{9.835'} \qquad x = 9.5'$$

$$\sin(15) = \frac{y}{9.835} \qquad y = 2.55'$$

| | | | |
|---|---|---|---|
| $R_1$ | = | 19.67' x 32' x 6.85psf | |
| $R_x$ | = | $R_1$ cos75 | |
| | = | 1.116 | kips |
| $R_y$ | = | $R_1$ sin75 | |
| | = | 4.165 | kips |

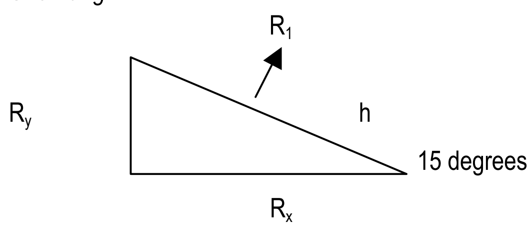



30 degrees, largest angle adjustable rack can be assessed at.

| | | | |
|---|---|---|---|
| cos (30) | = | $\frac{6'}{h}$ | h = 6.93'/2 = 3.465' |
| cos (15) | = | $\frac{x}{3.465'}$ | x = 3' |
| sin (30) | = | $\frac{y}{3.465'}$ | y = 1.73' |

| | | | |
|---|---|---|---|
| $R_1$ | = | 8.09psf x 32' x 6.93' | |
| $R_x$ | = | $R_1$ cos60 | |
| | = | 0.9 | kips |
| $R_y$ | = | $R_1$ sin60 | |
| | = | 1.55 | kips |

*Overhang:*



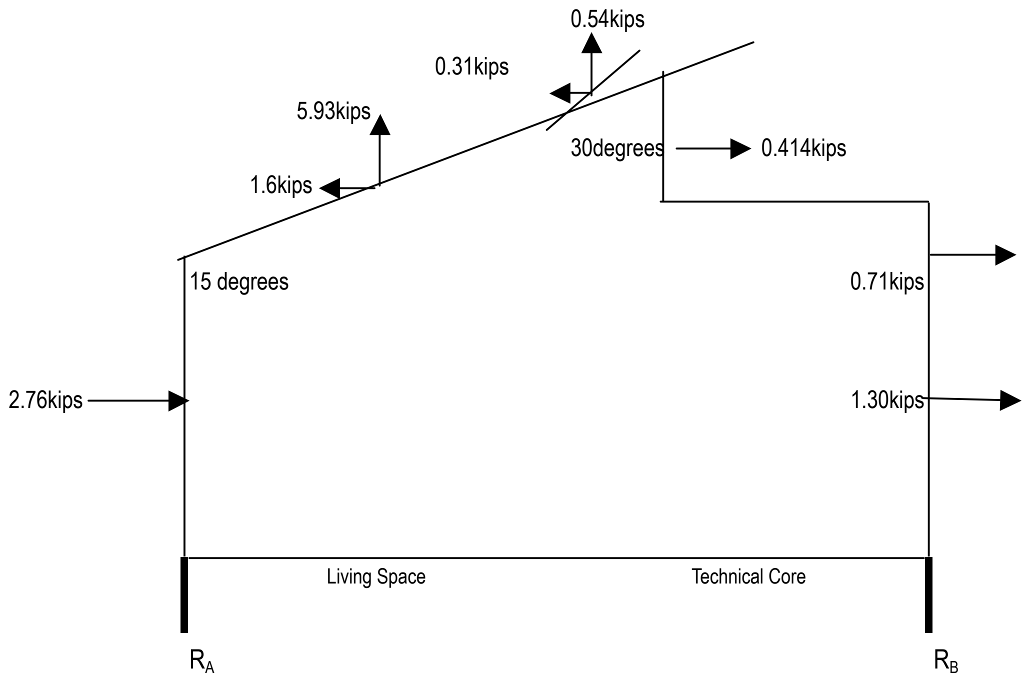

| | | | |
|---|---|---|---|
| cos (30) | = | $\frac{6'}{h}$ | h =2.07'/2 = 1.035 |
| cos (15) | = | $\frac{x}{3.465'}$ | x = 2' |
| sin (15) | = | $\frac{y}{3.465'}$ | y = 0.53' |

| | | | |
|---|---|---|---|
| $R_1$ | = | 20.00psf x 32' x 2.07' | |
| $R_x$ | = | $R_1$ cos75 | |
| | = | 0.343 | kips |
| $R_y$ | = | $R_1$ sin75 | |
| | = | 1.280 | kips |

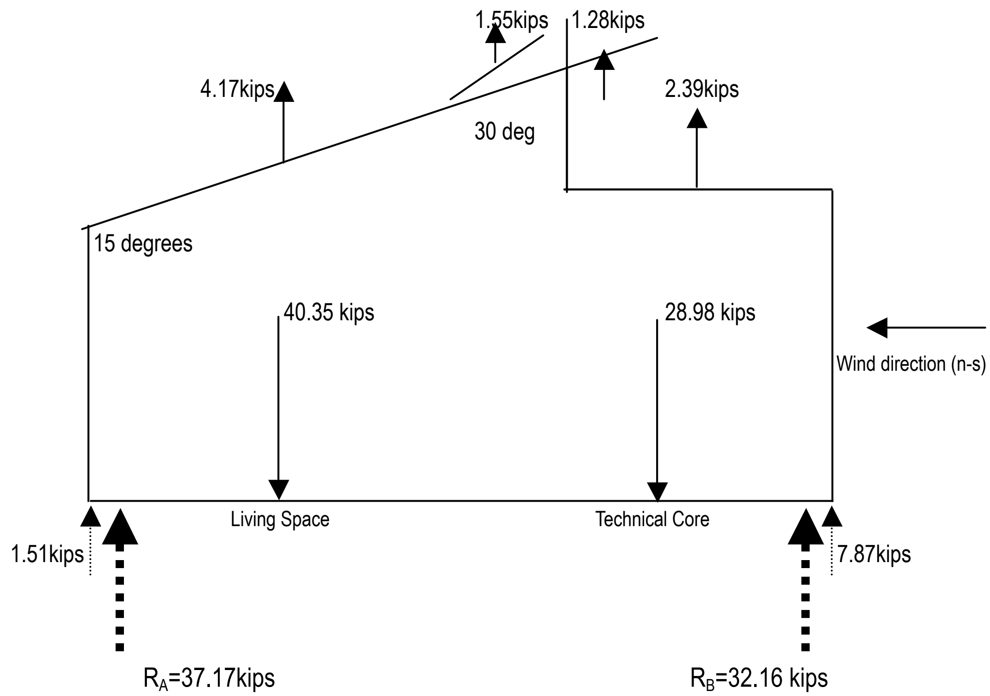
| | | | | |
|---|---|---|---|---|
| *M@A* | = | *(1.73 x 4) + (1.16 x 9) + (2.6 x 4) + (0.66 x 11.28) + (4.17 x 9.5) + (2.39 x 21) + (1.12 x 10.55) + (1.28 x 18) + (0.343 x 12.82) + (0.9 x 13.21) + (1.55 x 16)* | | |
| | = | *200.77* | *ft-kips* | |
| **$R_B$** | **=** | **$M_A$/25.5'** | | |
| | **=** | $\boxed{\textbf{7.87}}$ | **kips** | **(T)** |

| | | | | |
|---|---|---|---|---|
| **$R_A$** | **=** | **4.17 +1.55 + 1.27 + 2.39 - 7.87** | | |
| | **=** | **$\boxed{1.51}$** | **kips** | **(T)** |

3 Wind Blowing (s-n) EAST ELEVATION:




| | | | | |
|---|---|---|---|---|
| M@A | = | (2.76 x 4) + (1.3 x 4) + (0.71 x 9) + (0.414 x 11.28) - (1.6 x 10.55) - (5.93 x 9.5) - (0.31 x 13.21) - (0.54 x 16) | | |
| | = | -58.65 | ft-kips | |
| **$R_B$** | **=** | **$M_B$/25.5'** | | |
| | **=** | **$\boxed{-2.30}$** | **kips** | **(T)** |
| **$R_A$** | **=** | **5.93 + 0.54 - 2.30** | | |
| | **=** | **$\boxed{4.17}$** | **kips** | **(T)** |




4 *Check Overturning / Uplift on the home:*

| | | |
|---|---|---|
| Total Weight of TC Trailer = | 28.98 | kips |
| Total Weight of LS Trailer = | 40.35 | kips |
| Total Weight = | 69.33 | kips |

Due to dead weight:, Reaction at supports are as follows:

$R_B$ = [-[(45.86) x 6.5'] - [(34.25) x 19.25']]/25.5
= 32.16 kips (Comp)
$R_A$ = 45.86 + 34.25 - $R_B$
= 37.17 kips (Comp)

Worst Wind case is demonstrated in the N-S direction

M@A = 200.77 - [(37.17) x 6.5'] - [(32.16) x 19.25']
= -619.34 ft-kips
$R_B$ = $M_A$/25.5'
= -24.29 kips (Comp) *GOOD*
$R_A$ = 4.17 +1.55 +1.27 +2.39 +7.87+1.51 + 29.67-40.35 -34.25
= -26.17 kips (Comp) *GOOD*

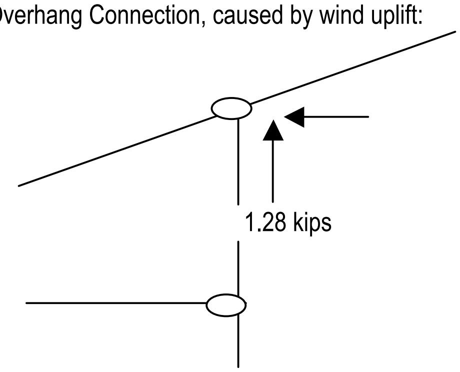
From all Wind cases, the following is summarized:

$R_B$ = 32.16 kips (Comp) > 7.87 kips > 2.30 kips >1.02kips
$R_A$ = 37.17 kips (Comp) > 1.51kips > 4.17kips > 5.89kips

*Hold downs are NOT required due to the compensation of the dead weight of the home.*
*The reactions created by the dead weight of the home far exceed the worst case scenario casued by wind (200.77ft-kips) in the N-S direction in addition to the other cases check for uplift and overturning.*

5 *Check Connection at Roof Overhang for Uplift:*

**1** Condition of Overhang Connection, caused by wind uplift:




**Type of Connection:** Window Frame with Polygal Interior Panels connected to Steel HSS 4 x 4 x 5/16, Self-Tapping screw connection.

Moment (M) on Upper connection from Wind Uplift , assumed 20psf of wind pressure:
See Appendix3.01 and 3.02 for reference of wind resultant forces.

| | | | |
|---|---|---|---|
| M = (1.28 kips) (2') + (0.343) (0.64') | = | 2.78 | ft-kips |

*CHECK Capacity of Screw Connection, from NDS:*

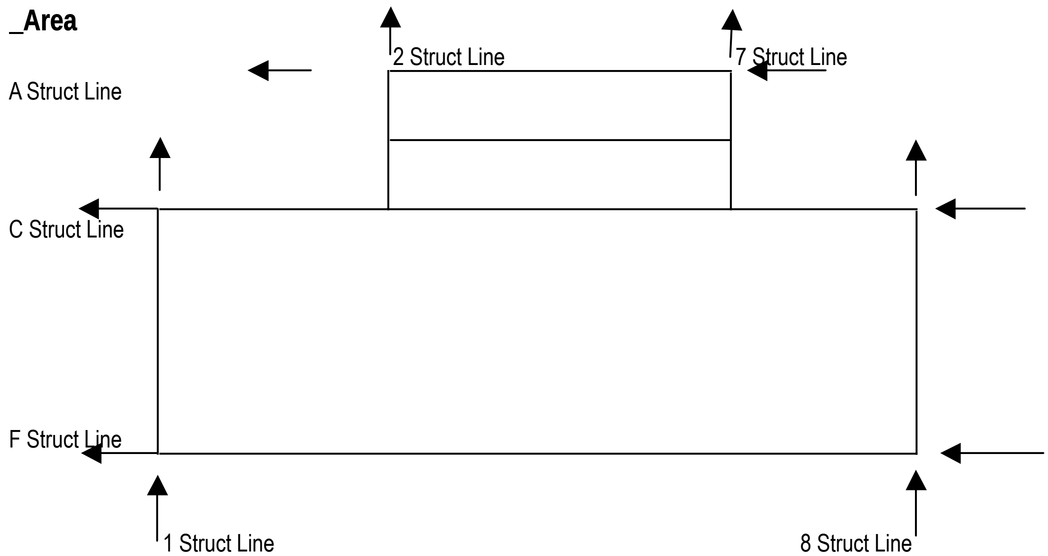
| | | | |
|---|---|---|---|
| Assume 1 screw placed 12" o.c. | | | |
| (1.28 kips/ 24') | = | 53.33 | lbs / ft |
| Select Wood Screws, Table 11M from NDS: | | | |
| Smallest Screw Selection Capactiy | = | 76 | lbs |
| 53.33 | < | 76 | GOOD |

**Results:** 1. Hold downs are NOT required due to the compensation of the dead weight of the home.
2. The reactions created by the dead weight of the home far exceed the worst case scenario casued by wind (200.77ft-kips) in the N-S direction in addition to the other cases check for uplift and overturning.
3. The screw connection at a maximum of 12" o.c is sufficient to resit wind uplift of roof overhang.

| _Shear Design, SIP+Screw | | Completed By | Revised By | DCN # | |
|---|---|---|---|---|---|
| Appendix 3.03 | | Benoit, Gimbert | Glantz, Owens | S-38 | Ref. Appendix 3.02, 3.04 |
| *Conclusions: SIPs are adequate to resist shear placed on the home due to wind loads as analyzed in Appendix 3.02.* | | | | | |

**Assumptions:**

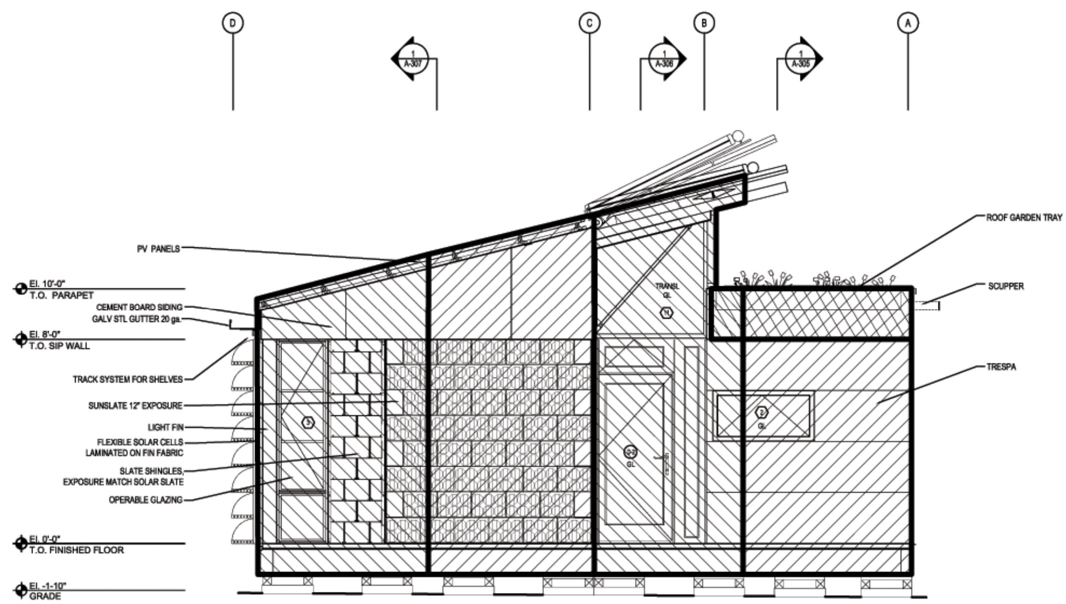
**_Area**




1 MURUS has conducted Racking tests on a 4 5/8" x 8' x 10' panel. A point load was applied at the top of this panel. Panels were combined with the MURUS cam-lock system. The results indicate a failure load of 6421lbf over a 8' length of wall, this value indiates a 802.63 lbs/ft. For a 2 x 4 spline connection, a 8' length wall indicates a failure load of 964.38 lbs/ft. See Appendix 3.04 for further iteration on these numbers.

**Calculations:**

*For wind traveling in the East / West direction:*




| **_Area 1** | **_Area 2** | **_Area 3** | **_Area 4** |
|---|---|---|---|
| 78.32 ft[1] | 86.77 ft[2] | 83.74 ft[3] | 74.21 ft[4] |

| **_Item** | **_ft2** | **_psf (windward)** | **_lbs** | **_psf (leeward)** | **_lbs** |
|---|---|---|---|---|---|
| Area 1 | 78.32 | 11.00 | 861.52 | 10.00 | 783.20 |
| Area 2 | 86.77 | 11.00 | 954.47 | 10.00 | 867.70 |
| Area 3 | 83.74 | 11.00 | 921.14 | 10.00 | 837.40 |
| Area 4 | 74.21 | 11.00 | 816.31 | 10.00 | 742.10 |
| Parapet | 11.65 | 11.00 | 128.15 | 10.00 | 116.50 |

** see diagram of East Elevation on following pages for designated areas

** areas are taken h/2' from ground as specified in ASCE7-05 for Low Rise buildings.

** leeward values = 6psf, minimum by code is 10psf

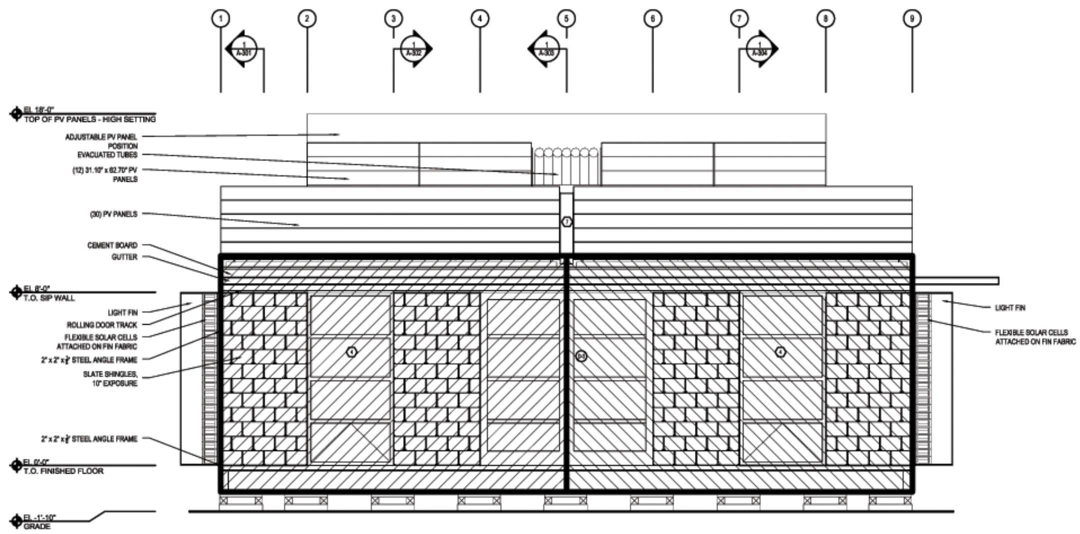
| | | | |
|---|---|---|---|
| $V_{LINE\ F}$ = | 861.52 + 783.20 = | 1644.72 | **Shear Resisted by SIPs, Structural Line F |
| $V_{LINE\ C}$ = | 954+867+921+837 = | 3580.71 | **Shear resisted by SIPs Structural Line C |
| $V_{LINE\ A}$ = | 816.31 + 742.10 = | 1558.41 | **Shear resisted by SIPS on Structural Line A |
| $V_{PARAPET}$ = | 128.15 + 69.9 = | 244.65 | **Shear resisted by 2 x framing |

| Each SIP has the capacity to resist: | **_capacity** > | **_force (lbs)** | |
|---|---|---|---|
| $V_{LINE\ F}$ = (16' of SIP) x 964.38lbs/ft = | 15430 | 1644.72 | **Ok** |
| $V_{LINE\ C}$ = (8' of SIP) x 964.38lbs/ft = | 7715 | 3580.71 | **Ok** |
| $V_{LINE\ A}$ = (24' of SIP) x802.63.lbs/ft= | 19263 | 1558.41 | **Ok** |

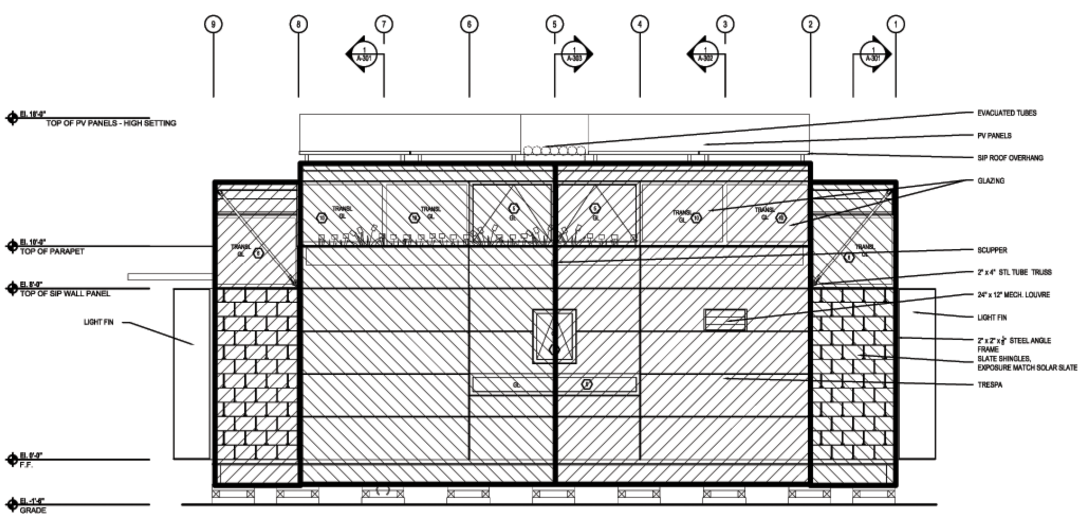
At struct line A, 2 x Framing and connection for Parapet must resist shear of:

| | | | |
|---|---|---|---|
| See Calc 1.01 | $V_{PARAPET}$ | = | 244.65 lbs |
| | | = | 0.24 kips |

2 *For wind traveling in the South / North direction:*



| **_Area 1** | **_Area 2** |
|---|---|
| 174.96 $ft^2$ | 174.96 $ft^3$ |



| **_Area 3** | **_Area 4** | **_Area 5** | **_Area 6** |
|---|---|---|---|
| 56.81 $ft^1$ | 179.68 $ft^2$ | 179.68 $ft^3$ | 56.81 $ft^4$ |

| _Item | _ft$^2$ | _psf (windward) | _lbs | _psf (leeward) | _lbs |
|---|---|---|---|---|---|
| Area 1 | 174.96 | 10.79 | 1887.82 | | 0.00 |
| Area 2 | 174.96 | 10.79 | 1887.82 | | 0.00 |
| Area 3 | 56.81 | | 0.00 | 10 | 568.10 |
| Area 4 | 179.68 | | 0.00 | 10 | 1796.80 |
| Area 5 | 179.68 | | 0.00 | 10 | 1796.80 |
| Area 6 | 56.81 | | 0.00 | 10 | 568.10 |

** see diagram of North elevation on the following pages for area designation

** leeward values = 6.74psf, minimum by code is 10psf

$V_{LINE\ 1}$ = 1887.82 + 568.10 2455.92 **Shear Resisted by SIPs of Struct Line 1

$V_{LINE\ 8}$ = 1887.82 + 568.11 2455.92 **Shear resisted by SIPs of struct Line 8

$V_{LINE\ 2}$ = 1796.80 **Shear Resisted by SIPs of Struct Line 2

$V_{LINE\ 7}$ = 1796.80 **Shear resisted by SIPs of struct Line 7

Each SIP has the capacity to resist:

| | _capacity > | _force (lbs) | |
|---|---|---|---|
| $V_{LINE\ 1}$ = (11.6' of SIP) x 964.38lbs/ft = | 10608.13 | 2455.92 | **Ok** |
| $V_{LINE\ 8}$ = (11.6' of SIP) x 964.38lbs/ft = | 10608.13 | 2455.92 | **Ok** |
| $V_{LINE\ 2}$ = (8' of Framing) x 650lbs/ft = | 5200.00 | 1796.80 | **Ok** |
| $V_{LINE\ 7}$ = (8' of SIP) x 802.63lbs/ft = | 5136.80 | 1796.80 | **Ok** |

| _Racking Test | Completed By | Revised By | DCN # | |
|---|---|---|---|---|
| Appendix 3.04 | MURUS | Glantz | | |

*Conclusions: SIPs with cam-lock connection retain a 802.63lbs/ft shear resistance. SIPs with 2 x 4 Stud connection retain a 964.38lbs/ft shear resistance.*

*From the enclosed report, we can assume the following:*

For two (2) 4' x 10' Murus PUR SIP Panel, with 2 x 4 NO. 2 Grade Stud connection:

| | | | | |
|---|---|---|---|---|
| Average Resisted Force | 7715 over 8' | = | 964.38 | lbs /ft |

For two (2) 4' x 10' Murus PUR SIP Panel, with five (5) Cam-Lock connection:

| | | | | |
|---|---|---|---|---|
| Average Resisted Force | 6421 over 8' | = | 802.63 | lbs /ft |

# PFS Technical Report

PFS TEST REPORT # 01-22
RACKING LOAD TESTS
FOR
THE MURUS COMPANY
MANSFIELD, PENNSYLVANIA

Testing
Inspection
Quality Control
Certification
Labeling
Listing
Engineering
Research

PFS Corporation
An Employee-Owned Company

Assurance you can build on

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# MANSFIELD, PENNSYLVANIA

**BY:**
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# PFS TEST REPORT #01-22
# RACKING LOAD TESTS
# FOR
# THE MURUS COMPANY
# MANSFIELD, PENNSYLVANIA

## General

The PFS Corporation, Madison, Wisconsin, performed client requested testing services for The Murus Company, Mansfield, Pennsylvania. A PFS representative witnessed the manufacturing and sampled the test materials at the client's facilities on May 5, 2001. The testing was performed in accordance with procedures and methods referenced in ICBO, ES AC 04, ASTM E 72-98 Standard, *"Standard Test Methods of Conducting Strength Tests of Panels for Building Construction,"* Section 14. The test samples were received in good order at PFS Laboratory on June 1, 2001. The tests were performed from June 16, 2001 through June 21, 2001.

## Materials

The tests were performed on two (2) different central spline designs; each had outside to outside dimensions of 8-ft-by-10-ft –by-4-1/2-in. thick and each were made up of two 4-ft x 10-ft panels. Both designs had urethane foamed-in-place core (2.2 to 2.4 lb density) with 7/16 OSB skins by Weyerhaeuser on both sides.

Design 1: Central spline consisted of a SPF 2 x 4, No. 2 grade stud. The panels fit to the spline in a male and female arrangement. The connection to the spline was with 8d common smooth shaft nails, spaced 4-in. on centers, with a 3/8-in. edge distance.

Design 2: Central spline consisted of a five cam-lock connection system that held the panel assembles together.

Both designs had a continuous No. 2, SPF grade marked stamped 2 x 4-dimension lumber member for the header and the sill plates. The plates were installed with Great Stuff, minimal expanding, polyurethane foam sealant applied to bond the plates to the core and panel facings. The facings were fastened to the plates by gun nailing 8d common smooth shaft nails spaced 3-½ -inches-on-center with a ¾ inch edge distance. The plate's outside faces were flush with the panel edges.

## Test Method

The specimen was tested with the panel splice connection vertical using a structural test fixture. Three dial gages, accurate to 0.001-inch, were used to monitor the deflections at the head opposite the loading (Dial #3), the sill forward movement (Dial #2), and the uplift below the loading side (Dial #1).

The ICBO ES recommended 3/4-in. thick dissipation board was mounted to the bottom of the panel sill to allow for panel facings free movement during the test. The loads were monitored with an electronic load cell and readout system. The load was applied to the specimen's top corner by a hydraulic ram. The E72 recommended hold down rods were implemented for testing. The panel's sill was firmly connected to the test fixture.

An initial preload of 200 lbf was applied and released. The load was then applied and released in three stages to 800, 1600, and 2400 lbf to establish set characteristics. After the specimens were loaded as specified, any residual deflection (set) in the panel was recorded. The deflection readings were recorded at each 200 lbf load increment. The load was applied continuously throughout the test at an approximate rate of 400 lbf per minute and was applied until ultimate failure occurred. The maximum load and the failure mode were recorded.

## Test Results

| | Design 1 | Design 2 |
|---|---|---|
| | 2" x 4" Stud at Center | Cam-locks at Center |
| Test Number | Max. Load (lbf) | Max. Load (lbf) |
| 1 | 8326 | 6697 |
| 2 | 8059 | 5953 |
| 3 | 6760 | 6613 |
| **Average** | **7715** | **6421** |

The test results are shown on Tables 1 through 6 and Figures 1 through 3.

## FAILURE MODE DESCRIPTION

Design 1 indicated fastener withdrawal and partial tear to the OSB facing edge at the sill plate.

Design 2 indicated vertical displacement between panels at the cam-lock interface.

## TEST REPORT DUPLICATION

This report shall not be reproduced, without the written approval of The Murus Company and /or PFS Corporation, Madison, Wisconsin.

The report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the federal government.

Testing Performed by:

Al Adams
Lab Technician

Report Reviewed by:

Richard Reinhard, P.E.
Technical Director

Tests Witnessed by and Report Prepared by:

Dwight E. McDonald
Lab Testing Manager

| _Shear Connection | Completed By | Revised By | DCN # | |
|---|---|---|---|---|
| Appendix 3.05 | Benoit, Grossenbacher | Glantz, Owens | S-37 | Reference Appendix 3.03 |

*Conclusions: For SIP Connection to resist shear from Wind, USE four (4) bolts to resist shear of wind, uplift and overturning forces on the home. The bolts are designated as A325 PB Type 1 with 1/2" diameter. Use 8d nails every 3 3/4" o.c. at ends of SIPs to attach SIP to 2 x 6 sill and headers as specified by MURUS.*

At struct line C, SIP connection to trailer frame must resist:

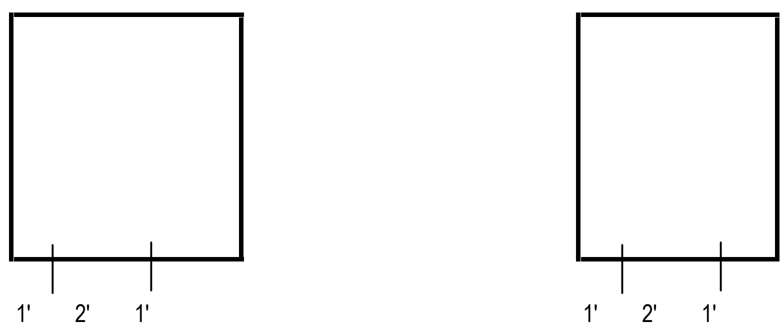
| | | |
|---|---|---|
| = | 3580.71 | lbs |
| = | 3.58 | kips |

Assume Connection of SIP to trailer Frame resists remaining Shear

1 Assume A325 grade strength bolt
2 Assume connection of 7/16" OSB to 2 x 6 sill plate and header of SIP are resisting same
3 Use 7/16" OSB on eterior surfaces of PUR 6 5/8" PUR SIPs
4 Assume a 24 to 16 span rating
5 Nail recommendation by MURUS is 8d

**Calculations:**

1 Try A 325 1/2" diameter bolt every 1' for connecting SIP to Trailer frame:
(see diagram below):




*Check Shear of bolt:*

One (1) bolts A325 PB Type 1 with 1/2" diamter has shear strength of

| | | | | |
|---|---|---|---|---|
| Fy | = | 92 | ksi | www.portlandbolt.com |
| Fu | = | 85 | ksi | |
| Fn | = | 0.4 Fu | | |
| | = | 34 | ksi | |
| Ab | = | $\pi * r^2$ | | |
| | = | 0.196 | $in^2$ | |
| ØRn | = | 0.75 | | |
| ØRn | = | ØFnAb | | |
| | = | 5.00 | kips | |

*Check tearout of bolt through 2 x 6 sill plate:*

One (1) bolts A325 PB Type 1 with 1/2" diamter has shear strength of
From NDS Table 11.B:

| | | | |
|---|---|---|---|
| $t_m$ | = | 1.5 | in |

$t_s$ = 0.25 in

$Z_{//}$ = 0.62 kips
$Z_{per}$ = 0.36 kips

*where Z is a lateral design value given for the connection of a 1/4" thk A36 plate*

For four (4) bolts along structural line C;

$4Z_{//}$ = $\boxed{2.48}$ kips

Each bolt has a tearout capacity of :

$Z'_{RT}$ = $2\ h \times F_v \times t_{scrit}$ *where* $F_v = F'_v$ 0.175 kips

= $\boxed{6.3}$ kips >1.87kips Ok

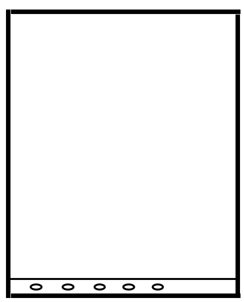
See Appendix 3.02

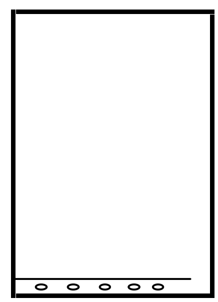
*2* The largest Wind force is seen at Structural line C, with 3.58 kips of Shear from Wind:

From Table NDS table 4.1 A:

| | |
|---|---|
| *Panel grade* | OSB,Plywood |
| *Minimum nominal panel thicknes(in.)* | 7/16" |
| *Minimum Nail penetration in Framing (in.)* | 1 3/8" |
| *Nail size* | 8d |
| *Nail spacing at panel edges.* | 4" > 3.75" as specified by MURUS |

$V_n$ = 490 plf





Try 3 1/2" spaced 8d nails with 3/4" edge spacing.

$V_u$ = 3.58 kips/8' Critical Case at Structural Line C

= 0.4475 klf

= $\boxed{447.5}$ plf < 490plf **Ok**

For structural Line C, four (4) bolts will be used accounting for 20kips of shear.

**Results:**

Vn = 20kips > Vu = 1.87kips +10kips = 11.87 kips

Vn = 490plf > Vu = 447.5plf for 8d nails at 4" spacing along OSB

# Appendix 4.0X

Computational Analyses

| **_Steel Header** | Completed By | Revised By | DCN # | |
|---|---|---|---|---|
| Appendix 4.01 | Milinichik | Glantz, Owens | S-10 | |

*Description: The following is the STAAD output data details the design of the header along the Southern wall. The critical point of deflection occurred from load case 8, giving 0.13893" of deflection under service load.*

```
****************************************************
*                                                  *
*           STAAD.Pro                              *
*           Version  2006    Bld 1002.US           *
*           Proprietary Program of                 *
*           Research Engineers,  Intl.             *
*           Date=    JAN 26, 2007                  *
*           Time=    22:55:14                      *
*                                                  *
*      USER ID: ae                                 *
****************************************************
```

```
     1. STAAD SPACE
INPUT FILE: Structure1.STD
     2. START JOB INFORMATION
     3. ENGINEER DATE 26-JAN-07
     4. END JOB INFORMATION
     5. INPUT WIDTH 79
     6. UNIT FEET KIP
     7. JOINT COORDINATES
     8. 1 0 0 0; 2 3.625 0 0; 3 4 0 0; 4 4.375 0 0; 5 8 0 0
     9. MEMBER INCIDENCES
    10. 1 1 2; 2 2 3; 3 3 4; 4 4 5
    11. DEFINE MATERIAL START
    12. ISOTROPIC STEEL
    13. E 4.176E+006
    14. POISSON 0.3
    15. DENSITY 0.489024
    16. ALPHA 6.5E-006
    17. DAMP 0.03
    18. END DEFINE MATERIAL
    19. MEMBER PROPERTY AMERICAN
    20. 1 TO 4 TABLE ST HSST4X4X0.25
    21. CONSTANTS
    22. MATERIAL STEEL ALL
    23. SUPPORTS
    24. 1 5 PINNED
    25. LOAD 1 LOADTYPE GRAVITY  TITLE SELF-WEIGHT
    26. SELFWEIGHT Y -1
    27. LOAD 2 LOADTYPE LIVE  TITLE SNOW
    28. MEMBER LOAD
    29. 1 TO 4 UNI GY -0.2275
    30. LOAD 3 LOADTYPE DEAD  TITLE SIP SELFWEIGHT
    31. MEMBER LOAD
    32. 1 4 UNI GY -0.028
    33. LOAD 4 LOADTYPE LIVE  TITLE PV RACK AND PANELS
    34. MEMBER LOAD
    35. 1 4 UNI GY -0.005
    36. LOAD 5 LOADTYPE LIVE  TITLE PLANT RACK
    37. JOINT LOAD
    38. 1 5 FY -0.17
    39. LOAD 6 LOADTYPE LIVE  TITLE PLANT RACK CENTER
    40. JOINT LOAD
```

```
41. 3 FY -0.34
42. LOAD 7 LOADTYPE DEAD  TITLE SKYLIGHT
43. JOINT LOAD
44. 2 4 FY -0.005
45. LOAD COMB 8 NO LOAD FACTORS
46. 1 1 2 1 3 1 4 1 5 1 6 1 7 1
47. LOAD COMB 9 1.2D + 1.6L
48. 1 1.2 2 1.6 3 1.2 4 1.6 5 1.6 6 1.6 7 1.2
49. PERFORM ANALYSIS


        P R O B L E M   S T A T I S T I C S
        -----------------------------------

    NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =      5/      4/      2
    ORIGINAL/FINAL BAND-WIDTH=      1/      1/      12 DOF
    TOTAL PRIMARY LOAD CASES =     7, TOTAL DEGREES OF FREEDOM =      24
    SIZE OF STIFFNESS MATRIX =         1 DOUBLE  KILO-WORDS
    REQRD/AVAIL. DISK SPACE  =      12.0/   15471.2 MB


***WARNING -  INSTABILITY AT JOINT      5    DIRECTION = MX
 PROBABLE CAUSE SINGULAR-ADDING WEAK SPRING
 K-MATRIX DIAG=  3.2820512E+03 L-MATRIX DIAG=  4.5474735E-13 EQN NO      22
 ***NOTE - VERY WEAK SPRING ADDED FOR STABILITY

   **NOTE** STAAD DETECTS INSTABILITIES AS EXCESSIVE LOSS OF SIGNIFICANT DIGITS
            DURING DECOMPOSITION. WHEN A DECOMPOSED DIAGONAL IS LESS THAN THE
            BUILT-IN REDUCTION FACTOR TIMES THE ORIGINAL STIFFNESS MATRIX DIAGONAL,
            STAAD PRINTS A SINGULARITY NOTICE. THE BUILT-IN REDUCTION FACTOR
            IS   1.000E-09

            THE ABOVE CONDITIONS COULD ALSO BE CAUSED BY VERY STIFF OR VERY WEAK
            ELEMENTS AS WELL AS TRUE SINGULARITIES.


50. LOAD LIST ALL
51. PRINT JOINT DISPLACEMENTS ALL
```

JOINT DISPLACEMENT (INCH RADIANS) STRUCTURE TYPE = SPACE

------------------

| JOINT | LOAD | X-TRANS | Y-TRANS | Z-TRANS | X-ROTAN | Y-ROTAN | Z-ROTAN |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | -0.00016 |
| | 2 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | -0.00309 |
| | 3 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | -0.00033 |
| | 4 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | -0.00006 |
| | 5 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| | 6 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | -0.00087 |
| | 7 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | -0.00003 |
| | 8 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | -0.00452 |
| | 9 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | -0.00703 |
| 2 | 1 | 0.00000 | -0.00467 | 0.00000 | 0.00000 | 0.00000 | -0.00002 |
| | 2 | 0.00000 | -0.09275 | 0.00000 | 0.00000 | 0.00000 | -0.00043 |
| | 3 | 0.00000 | -0.00971 | 0.00000 | 0.00000 | 0.00000 | -0.00004 |
| | 4 | 0.00000 | -0.00173 | 0.00000 | 0.00000 | 0.00000 | -0.00001 |
| | 5 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| | 6 | 0.00000 | -0.02771 | 0.00000 | 0.00000 | 0.00000 | -0.00015 |
| | 7 | 0.00000 | -0.00081 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| | 8 | 0.00000 | -0.13738 | 0.00000 | 0.00000 | 0.00000 | -0.00067 |
| | 9 | 0.00000 | -0.21373 | 0.00000 | 0.00000 | 0.00000 | -0.00104 |
| 3 | 1 | 0.00000 | -0.00472 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| | 2 | 0.00000 | -0.09374 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| | 3 | 0.00000 | -0.00981 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| | 4 | 0.00000 | -0.00175 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| | 5 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| | 6 | 0.00000 | -0.02810 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| | 7 | 0.00000 | -0.00081 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| | 8 | 0.00000 | -0.13893 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| | 9 | 0.00000 | -0.21615 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| 4 | 1 | 0.00000 | -0.00467 | 0.00000 | 0.00000 | 0.00000 | 0.00002 |
| | 2 | 0.00000 | -0.09275 | 0.00000 | 0.00000 | 0.00000 | 0.00043 |
| | 3 | 0.00000 | -0.00971 | 0.00000 | 0.00000 | 0.00000 | 0.00004 |
| | 4 | 0.00000 | -0.00173 | 0.00000 | 0.00000 | 0.00000 | 0.00001 |
| | 5 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| | 6 | 0.00000 | -0.02771 | 0.00000 | 0.00000 | 0.00000 | 0.00015 |
| | 7 | 0.00000 | -0.00081 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| | 8 | 0.00000 | -0.13738 | 0.00000 | 0.00000 | 0.00000 | 0.00067 |
| | 9 | 0.00000 | -0.21373 | 0.00000 | 0.00000 | 0.00000 | 0.00104 |
| 5 | 1 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00016 |
| | 2 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00309 |
| | 3 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00033 |
| | 4 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00006 |
| | 5 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| | 6 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00087 |
| | 7 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00003 |
| | 8 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00452 |
| | 9 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00703 |

SUPPORT REACTIONS -UNIT KIP FEET STRUCTURE TYPE = SPACE

-----------------

| JOINT | LOAD | FORCE-X | FORCE-Y | FORCE-Z | MOM-X | MOM-Y | MOM Z |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 0.00 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 2 | 0.00 | 0.91 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 3 | 0.00 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 4 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 5 | 0.00 | 0.17 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 6 | 0.00 | 0.17 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 8 | 0.00 | 1.42 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 9 | 0.00 | 2.21 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5 | 1 | 0.00 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 2 | 0.00 | 0.91 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 3 | 0.00 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 4 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 5 | 0.00 | 0.17 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 6 | 0.00 | 0.17 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 8 | 0.00 | 1.42 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 9 | 0.00 | 2.21 | 0.00 | 0.00 | 0.00 | 0.00 |

************** END OF LATEST ANALYSIS RESULT **************

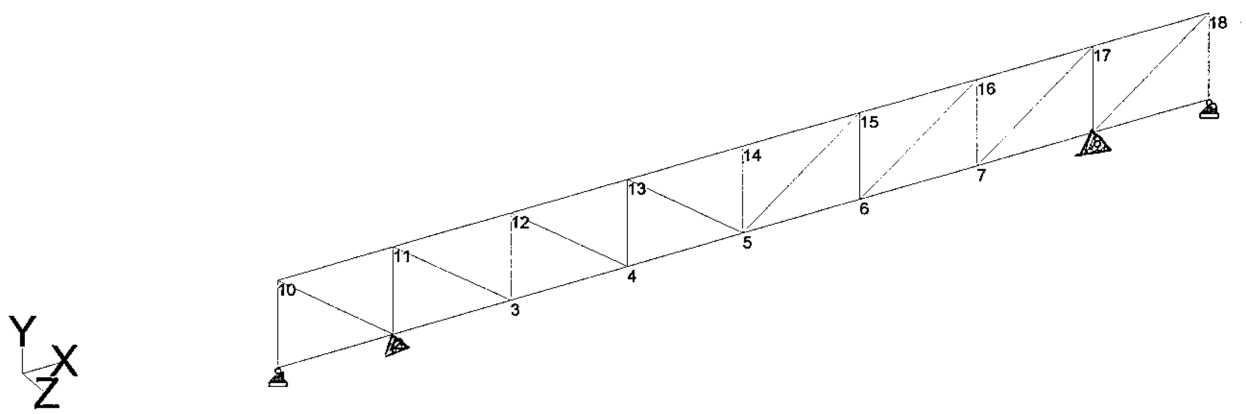
53. PRINT MAXFORCE ENVELOPE ALL

| **_Truss design 01.28.07** | Completed By | Revised By | DCN # | |
|---|---|---|---|---|
| Appendix 4.02 | Milinichik | Glantz, Owens | S-12 | |

*Conclusions: The following is the STAAD output data for the initial design of the Truss on the north wall of the living space.*

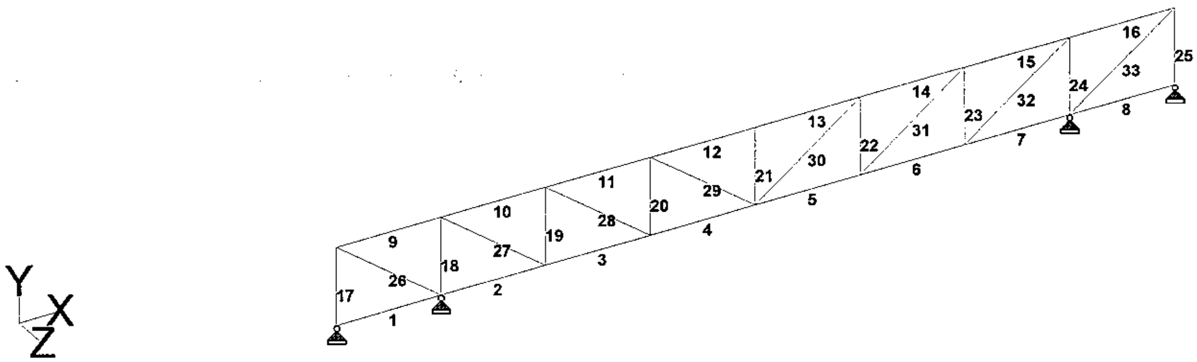
S-12

| Software licensed to ae | Job No | Sheet No 1 | Rev |
|---|---|---|---|
| Job Title | Part | | |
| | Ref | | |
| | By | Date 01-Feb-07 | Chd |
| Client | File LivingSpaceTruss.std | Date/Time 01-Feb-2007 23:04 | |




Load 1

| Software licensed to ae | Job No | Sheet No 1 | Rev |
|---|---|---|---|
| | Part | | |
| Job Title | Ref | | |
| | By | Date 01-Feb-07 | Chd |
| Client | File LivingSpaceTruss.std | Date/Time 02-Feb-2007 00:45 | |




Load 1

```
****************************************************
*                                                  *
*           STAAD.Pro                              *
*           Version  2006    Bld 1002.US           *
*           Proprietary Program of                 *
*           Research Engineers,  Intl.             *
*           Date=     FEB  2, 2007                 *
*           Time=      0:52: 0                     *
*                                                  *
*      USER ID: ae                                 *
****************************************************
```

```
     1. STAAD SPACE
INPUT FILE: LivingSpaceTruss.STD
     2. START JOB INFORMATION
     3. ENGINEER DATE 01-FEB-07
     4. END JOB INFORMATION
     5. INPUT WIDTH 79
     6. UNIT FEET KIP
     7. JOINT COORDINATES
     8. 1 0 0 0; 2 4 0 0; 3 8 0 0; 4 12 0 0; 5 16 0 0; 6 20 0 0; 7 24 0 0; 8 28 0 0
     9. 9 32 0 0; 10 0 3 0; 11 4 3 0; 12 8 3 0; 13 12 3 0; 14 16 3 0; 15 20 3 0
    10. 16 24 3 0; 17 28 3 0; 18 32 3 0
    11. MEMBER INCIDENCES
    12. 1 1 2; 2 2 3; 3 3 4; 4 4 5; 5 5 6; 6 6 7; 7 7 8; 8 8 9; 9 10 11; 10 11 12
    13. 11 12 13; 12 13 14; 13 14 15; 14 15 16; 15 16 17; 16 17 18; 17 10 1; 18 11 2
    14. 19 12 3; 20 13 4; 21 14 5; 22 15 6; 23 16 7; 24 17 8; 25 18 9; 26 10 2
    15. 27 11 3; 28 12 4; 29 13 5; 30 5 15; 31 6 16; 32 7 17; 33 8 18
    16. DEFINE MATERIAL START
    17. ISOTROPIC STEEL
    18. E 4.176E+006
    19. POISSON 0.3
    20. DENSITY 0.489024
    21. ALPHA 6.5E-006
    22. DAMP 0.03
    23. END DEFINE MATERIAL
    24. MEMBER PROPERTY AMERICAN
    25. 1 TO 33 TABLE ST HSST4X4X0.25
    26. CONSTANTS
    27. MATERIAL STEEL ALL
    28. SUPPORTS
    29. 1 2 8 9 PINNED
    30. LOAD 1 LOADTYPE GRAVITY  TITLE SELF-WEIGHT
    31. SELFWEIGHT Y -1
    32. LOAD 2 LOADTYPE LIVE  TITLE LIVE-ROOF
    33. MEMBER LOAD
    34. 9 TO 16 UNI GY -0.29
    35. LOAD 3 LOADTYPE LIVE  TITLE BZY-PV
    36. MEMBER LOAD
    37. 9 TO 16 UNI GY -0.037
    38. LOAD 4 LOADTYPE LIVE  TITLE BZY-EV
    39. MEMBER LOAD
    40. 9 TO 16 UNI GY -0.028
```

```
41. LOAD 5 LOADTYPE DEAD  TITLE LVG-PV
42. MEMBER LOAD
43. 9 TO 16 UNI GY -0.03
44. LOAD 6 LOADTYPE DEAD  TITLE LVG-SIPS
45. MEMBER LOAD
46. 9 TO 16 UNI GY -0.027
47. LOAD 7 LOADTYPE DEAD  TITLE LVG-INSUL
48. MEMBER LOAD
49. 9 TO 16 UNI GY -0.033
50. LOAD 8 LOADTYPE DEAD  TITLE BZY-STL-FRMG
51. MEMBER LOAD
52. 9 TO 16 UNI GY -0.061
53. LOAD 9 LOADTYPE DEAD  TITLE BZY-SIP
54. MEMBER LOAD
55. 9 TO 16 UNI GY -0.031
56. LOAD COMB 10 NO LOAD FACTORS
57. 1 1.0 2 1.0 3 1.0 4 1.0 5 1.0 6 1.0 7 1.0 8 1.0 9 1.0
58. LOAD COMB 11 LOAD FACTORS 1.2D + 1.6L
59. 1 1.2 2 1.6 3 1.6 4 1.6 5 1.2 6 1.2 7 1.2 8 1.2 9 1.2
60. PERFORM ANALYSIS


       P R O B L E M   S T A T I S T I C S
       -----------------------------------

 NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =     18/     33/      4
 ORIGINAL/FINAL BAND-WIDTH=    10/      4/      30 DOF
 TOTAL PRIMARY LOAD CASES =     9, TOTAL DEGREES OF FREEDOM =      96
 SIZE OF STIFFNESS MATRIX =         3 DOUBLE  KILO-WORDS
 REQRD/AVAIL. DISK SPACE  =      12.1/ 238292.8 MB


***WARNING -  INSTABILITY AT JOINT    18   DIRECTION = MX
 PROBABLE CAUSE SINGULAR-ADDING WEAK SPRING
 K-MATRIX DIAG=  3.3191728E+04 L-MATRIX DIAG=  5.0931703E-11 EQN NO      94
 ***NOTE - VERY WEAK SPRING ADDED FOR STABILITY

  **NOTE** STAAD DETECTS INSTABILITIES AS EXCESSIVE LOSS OF SIGNIFICANT DIGITS
           DURING DECOMPOSITION. WHEN A DECOMPOSED DIAGONAL IS LESS THAN THE
           BUILT-IN REDUCTION FACTOR TIMES THE ORIGINAL STIFFNESS MATRIX DIAGONAL,
           STAAD PRINTS A SINGULARITY NOTICE. THE BUILT-IN REDUCTION FACTOR
           IS   1.000E-09

           THE ABOVE CONDITIONS COULD ALSO BE CAUSED BY VERY STIFF OR VERY WEAK
           ELEMENTS AS WELL AS TRUE SINGULARITIES.


61. LOAD LIST 10 11
62. PRINT JOINT DISPLACEMENTS ALL
```

JOINT DISPLACEMENT (INCH RADIANS) STRUCTURE TYPE = SPACE

| JOINT | LOAD | X-TRANS | Y-TRANS | Z-TRANS | X-ROTAN | Y-ROTAN | Z-ROTAN |
|---|---|---|---|---|---|---|---|
| 1 | 10 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | -0.00003 |
| | 11 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | -0.00004 |
| 2 | 10 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | -0.00020 |
| | 11 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | -0.00029 |
| 3 | 10 | -0.00318 | -0.02746 | 0.00000 | 0.00000 | 0.00000 | -0.00048 |
| | 11 | -0.00459 | -0.03965 | 0.00000 | 0.00000 | 0.00000 | -0.00069 |
| 4 | 10 | -0.00272 | -0.04863 | 0.00000 | 0.00000 | 0.00000 | -0.00028 |
| | 11 | -0.00392 | -0.07022 | 0.00000 | 0.00000 | 0.00000 | -0.00040 |
| 5 | 10 | 0.00000 | -0.05710 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| | 11 | 0.00000 | -0.08246 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| 6 | 10 | 0.00272 | -0.04863 | 0.00000 | 0.00000 | 0.00000 | 0.00028 |
| | 11 | 0.00392 | -0.07022 | 0.00000 | 0.00000 | 0.00000 | 0.00040 |
| 7 | 10 | 0.00318 | -0.02746 | 0.00000 | 0.00000 | 0.00000 | 0.00048 |
| | 11 | 0.00459 | -0.03965 | 0.00000 | 0.00000 | 0.00000 | 0.00069 |
| 8 | 10 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00020 |
| | 11 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00029 |
| 9 | 10 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00003 |
| | 11 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00004 |
| 10 | 10 | 0.00583 | 0.00113 | 0.00000 | 0.00000 | 0.00000 | -0.00025 |
| | 11 | 0.00841 | 0.00162 | 0.00000 | 0.00000 | 0.00000 | -0.00036 |
| 11 | 10 | 0.00836 | -0.00296 | 0.00000 | 0.00000 | 0.00000 | -0.00031 |
| | 11 | 0.01207 | -0.00428 | 0.00000 | 0.00000 | 0.00000 | -0.00045 |
| 12 | 10 | 0.00739 | -0.02947 | 0.00000 | 0.00000 | 0.00000 | -0.00043 |
| | 11 | 0.01067 | -0.04256 | 0.00000 | 0.00000 | 0.00000 | -0.00062 |
| 13 | 10 | 0.00408 | -0.04984 | 0.00000 | 0.00000 | 0.00000 | -0.00025 |
| | 11 | 0.00589 | -0.07197 | 0.00000 | 0.00000 | 0.00000 | -0.00036 |
| 14 | 10 | 0.00000 | -0.05788 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| | 11 | 0.00000 | -0.08359 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| 15 | 10 | -0.00408 | -0.04984 | 0.00000 | 0.00000 | 0.00000 | 0.00025 |
| | 11 | -0.00589 | -0.07197 | 0.00000 | 0.00000 | 0.00000 | 0.00036 |
| 16 | 10 | -0.00739 | -0.02947 | 0.00000 | 0.00000 | 0.00000 | 0.00043 |
| | 11 | -0.01067 | -0.04256 | 0.00000 | 0.00000 | 0.00000 | 0.00062 |
| 17 | 10 | -0.00836 | -0.00296 | 0.00000 | 0.00000 | 0.00000 | 0.00031 |
| | 11 | -0.01207 | -0.00428 | 0.00000 | 0.00000 | 0.00000 | 0.00045 |
| 18 | 10 | -0.00583 | 0.00113 | 0.00000 | 0.00000 | 0.00000 | 0.00025 |
| | 11 | -0.00841 | 0.00162 | 0.00000 | 0.00000 | 0.00000 | 0.00036 |

************** END OF LATEST ANALYSIS RESULT **************

63. PRINT SUPPORT REACTION ALL

SUPPORT REACTIONS -UNIT KIP FEET STRUCTURE TYPE = SPACE
-----------------

| JOINT | LOAD | FORCE-X | FORCE-Y | FORCE-Z | MOM-X | MOM-Y | MOM Z |
|---|---|---|---|---|---|---|---|
| 1 | 10 | -0.04 | -3.15 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 11 | -0.06 | -4.55 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 10 | 1.40 | 12.49 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 11 | 2.01 | 18.03 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8 | 10 | -1.40 | 12.49 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 11 | -2.01 | 18.03 | 0.00 | 0.00 | 0.00 | 0.00 |
| 9 | 10 | 0.04 | -3.15 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 11 | 0.06 | -4.55 | 0.00 | 0.00 | 0.00 | 0.00 |

************** END OF LATEST ANALYSIS RESULT **************

64. PRINT MAXFORCE ENVELOPE ALL

MEMBER FORCE ENVELOPE

ALL UNITS ARE KIP FEET

MAX AND MIN FORCE VALUES AMONGST ALL SECTION LOCATIONS

| MEMB | | FY/ FZ | DIST DIST | LD LD | MZ/ MY | DIST DIST | LD LD | FX | DIST | LD |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | MAX | -0.11 | 0.00 | 10 | 0.49 | 4.00 | 11 | | | |
| | | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 10 |
| | MIN | -0.21 | 4.00 | 11 | -0.26 | 0.00 | 11 | | | |
| | | 0.00 | 4.00 | 11 | 0.00 | 4.00 | 11 | 0.00 | 4.00 | 11 |
| 2 | MAX | 0.40 | 0.00 | 11 | 0.92 | 0.00 | 11 | | | |
| | | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 10 | 9.34 C | 0.00 | 11 |
| | MIN | 0.24 | 4.00 | 10 | -0.57 | 4.00 | 11 | | | |
| | | 0.00 | 4.00 | 11 | 0.00 | 4.00 | 11 | 6.47 C | 4.00 | 10 |
| 3 | MAX | 0.13 | 0.00 | 11 | 0.11 | 0.00 | 11 | | | |
| | | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 10 | 0.94 T | 0.00 | 10 |
| | MIN | 0.05 | 4.00 | 10 | -0.30 | 4.00 | 11 | | | |
| | | 0.00 | 4.00 | 11 | 0.00 | 4.00 | 11 | 1.36 T | 4.00 | 11 |
| 4 | MAX | 0.09 | 0.00 | 11 | -0.01 | 0.00 | 10 | | | |
| | | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 10 | 5.53 T | 0.00 | 10 |
| | MIN | 0.02 | 4.00 | 10 | -0.26 | 4.00 | 11 | | | |
| | | 0.00 | 4.00 | 11 | 0.00 | 4.00 | 11 | 7.98 T | 4.00 | 11 |
| 5 | MAX | -0.02 | 0.00 | 10 | -0.01 | 4.00 | 10 | | | |
| | | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 10 | 5.53 T | 0.00 | 10 |
| | MIN | -0.09 | 4.00 | 11 | -0.26 | 0.00 | 11 | | | |
| | | 0.00 | 4.00 | 11 | 0.00 | 4.00 | 11 | 7.98 T | 4.00 | 11 |
| 6 | MAX | -0.05 | 0.00 | 10 | 0.11 | 4.00 | 11 | | | |
| | | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 10 | 0.94 T | 0.00 | 10 |
| | MIN | -0.13 | 4.00 | 11 | -0.30 | 0.00 | 11 | | | |
| | | 0.00 | 4.00 | 11 | 0.00 | 4.00 | 11 | 1.36 T | 4.00 | 11 |
| 7 | MAX | -0.24 | 0.00 | 10 | 0.92 | 4.00 | 11 | | | |
| | | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 10 | 9.34 C | 0.00 | 11 |
| | MIN | -0.40 | 4.00 | 11 | -0.57 | 0.00 | 11 | | | |
| | | 0.00 | 4.00 | 11 | 0.00 | 4.00 | 11 | 6.47 C | 4.00 | 10 |
| 8 | MAX | 0.21 | 0.00 | 11 | 0.49 | 0.00 | 11 | | | |
| | | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 10 |
| | MIN | 0.11 | 4.00 | 10 | -0.26 | 4.00 | 11 | | | |
| | | 0.00 | 4.00 | 11 | 0.00 | 4.00 | 11 | 0.00 | 4.00 | 11 |
| 9 | MAX | 1.28 | 0.00 | 11 | 1.74 | 4.00 | 11 | | | |
| | | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 10 | 5.17 T | 0.00 | 10 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| MIN | -1.92 | 4.00 | 11 | -0.56 | 1.67 | 11 | | | |
| | 0.00 | 4.00 | 11 | 0.00 | 4.00 | 11 | 7.46 T | 4.00 | 11 |
| 10 MAX | 1.89 | 0.00 | 11 | 1.71 | 0.00 | 11 | | | |
| | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 10 | 2.87 C | 0.00 | 11 |
| MIN | -1.31 | 4.00 | 11 | -0.52 | 2.33 | 11 | | | |
| | 0.00 | 4.00 | 11 | 0.00 | 4.00 | 11 | 1.99 C | 4.00 | 10 |
| 11 MAX | 1.73 | 0.00 | 11 | 1.23 | 0.00 | 11 | | | |
| | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 10 | 9.73 C | 0.00 | 11 |
| MIN | -1.47 | 4.00 | 11 | -0.64 | 2.00 | 11 | | | |
| | 0.00 | 4.00 | 11 | 0.00 | 4.00 | 11 | 6.74 C | 4.00 | 10 |
| 12 MAX | 1.67 | 0.00 | 11 | 1.06 | 0.00 | 11 | | | |
| | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 10 | 11.99 C | 0.00 | 11 |
| MIN | -1.53 | 4.00 | 11 | -0.68 | 2.00 | 11 | | | |
| | 0.00 | 4.00 | 11 | 0.00 | 4.00 | 11 | 8.31 C | 4.00 | 10 |
| 13 MAX | 1.53 | 0.00 | 11 | 1.06 | 4.00 | 11 | | | |
| | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 10 | 11.99 C | 0.00 | 11 |
| MIN | -1.67 | 4.00 | 11 | -0.68 | 2.00 | 11 | | | |
| | 0.00 | 4.00 | 11 | 0.00 | 4.00 | 11 | 8.31 C | 4.00 | 10 |
| 14 MAX | 1.47 | 0.00 | 11 | 1.23 | 4.00 | 11 | | | |
| | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 10 | 9.73 C | 0.00 | 11 |
| MIN | -1.73 | 4.00 | 11 | -0.64 | 2.00 | 11 | | | |
| | 0.00 | 4.00 | 11 | 0.00 | 4.00 | 11 | 6.74 C | 4.00 | 10 |
| 15 MAX | 1.31 | 0.00 | 11 | 1.71 | 4.00 | 11 | | | |
| | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 10 | 2.87 C | 0.00 | 11 |
| MIN | -1.89 | 4.00 | 11 | -0.52 | 1.67 | 11 | | | |
| | 0.00 | 4.00 | 11 | 0.00 | 4.00 | 11 | 1.99 C | 4.00 | 10 |
| 16 MAX | 1.92 | 0.00 | 11 | 1.74 | 0.00 | 11 | | | |
| | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 10 | 5.17 T | 0.00 | 10 |
| MIN | -1.28 | 4.00 | 11 | -0.56 | 2.33 | 11 | | | |
| | 0.00 | 4.00 | 11 | 0.00 | 4.00 | 11 | 7.46 T | 4.00 | 11 |
| 17 MAX | 0.06 | 0.00 | 11 | -0.05 | 0.00 | 10 | | | |
| | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 10 | 3.04 T | 3.00 | 10 |
| MIN | 0.04 | 3.00 | 10 | -0.26 | 3.00 | 11 | | | |
| | 0.00 | 3.00 | 11 | 0.00 | 3.00 | 11 | 4.43 T | 0.00 | 11 |
| 18 MAX | -0.05 | 0.00 | 10 | 0.02 | 3.00 | 11 | | | |
| | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 10 | 11.63 C | 3.00 | 11 |
| MIN | -0.07 | 3.00 | 11 | -0.19 | 0.00 | 11 | | | |
| | 0.00 | 3.00 | 11 | 0.00 | 3.00 | 11 | 8.01 C | 0.00 | 10 |
| 19 MAX | -0.31 | 0.00 | 10 | 0.70 | 3.00 | 11 | | | |
| | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 10 | 7.93 C | 3.00 | 11 |
| MIN | -0.44 | 3.00 | 11 | -0.63 | 0.00 | 11 | | | |
| | 0.00 | 3.00 | 11 | 0.00 | 3.00 | 11 | 5.45 C | 0.00 | 10 |
| 20 MAX | -0.14 | 0.00 | 10 | 0.33 | 3.00 | 11 | | | |
| | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 10 | 4.77 C | 3.00 | 11 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| MIN | -0.21 | 3.00 | 11 | -0.30 | 0.00 | 11 | | | |
| | 0.00 | 3.00 | 11 | 0.00 | 3.00 | 11 | 3.25 C | 0.00 | 10 |
| 21 MAX | 0.00 | 0.00 | 11 | 0.00 | 0.00 | 11 | | | |
| | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 10 | 3.11 C | 3.00 | 11 |
| MIN | 0.00 | 3.00 | 10 | 0.00 | 3.00 | 10 | | | |
| | 0.00 | 3.00 | 11 | 0.00 | 3.00 | 11 | 2.10 C | 0.00 | 10 |
| 22 MAX | 0.21 | 0.00 | 11 | 0.30 | 0.00 | 11 | | | |
| | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 10 | 4.77 C | 3.00 | 11 |
| MIN | 0.14 | 3.00 | 10 | -0.33 | 3.00 | 11 | | | |
| | 0.00 | 3.00 | 11 | 0.00 | 3.00 | 11 | 3.25 C | 0.00 | 10 |
| 23 MAX | 0.44 | 0.00 | 11 | 0.63 | 0.00 | 11 | | | |
| | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 10 | 7.93 C | 3.00 | 11 |
| MIN | 0.31 | 3.00 | 10 | -0.70 | 3.00 | 11 | | | |
| | 0.00 | 3.00 | 11 | 0.00 | 3.00 | 11 | 5.45 C | 0.00 | 10 |
| 24 MAX | 0.07 | 0.00 | 11 | 0.19 | 0.00 | 11 | | | |
| | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 10 | 11.63 C | 3.00 | 11 |
| MIN | 0.05 | 3.00 | 10 | -0.02 | 3.00 | 11 | | | |
| | 0.00 | 3.00 | 11 | 0.00 | 3.00 | 11 | 8.01 C | 0.00 | 10 |
| 25 MAX | -0.04 | 0.00 | 10 | 0.26 | 3.00 | 11 | | | |
| | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 10 | 3.04 T | 3.00 | 10 |
| MIN | -0.06 | 3.00 | 11 | 0.05 | 0.00 | 10 | | | |
| | 0.00 | 3.00 | 11 | 0.00 | 3.00 | 11 | 4.43 T | 0.00 | 11 |
| 26 MAX | -0.09 | 0.00 | 10 | 0.40 | 5.00 | 11 | | | |
| | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 10 | 9.39 C | 5.00 | 11 |
| MIN | -0.19 | 5.00 | 11 | -0.40 | 0.00 | 11 | | | |
| | 0.00 | 5.00 | 11 | 0.00 | 5.00 | 11 | 6.47 C | 0.00 | 10 |
| 27 MAX | 0.08 | 0.00 | 11 | 0.22 | 0.00 | 11 | | | |
| | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 10 | 8.89 T | 5.00 | 10 |
| MIN | 0.01 | 5.00 | 10 | -0.02 | 5.00 | 11 | | | |
| | 0.00 | 5.00 | 11 | 0.00 | 5.00 | 11 | 12.88 T | 0.00 | 11 |
| 28 MAX | 0.03 | 0.00 | 11 | -0.03 | 0.00 | 10 | | | |
| | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 10 | 5.54 T | 5.00 | 10 |
| MIN | -0.03 | 5.00 | 11 | -0.08 | 2.50 | 11 | | | |
| | 0.00 | 5.00 | 11 | 0.00 | 5.00 | 11 | 8.04 T | 0.00 | 11 |
| 29 MAX | 0.04 | 0.00 | 11 | -0.04 | 0.00 | 10 | | | |
| | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 10 | 1.77 T | 5.00 | 10 |
| MIN | -0.02 | 5.00 | 11 | -0.13 | 3.75 | 11 | | | |
| | 0.00 | 5.00 | 11 | 0.00 | 5.00 | 11 | 2.60 T | 0.00 | 11 |
| 30 MAX | 0.02 | 0.00 | 11 | -0.04 | 5.00 | 10 | | | |
| | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 10 | 1.77 T | 0.00 | 10 |
| MIN | -0.04 | 5.00 | 11 | -0.13 | 1.25 | 11 | | | |
| | 0.00 | 5.00 | 11 | 0.00 | 5.00 | 11 | 2.60 T | 5.00 | 11 |
| 31 MAX | 0.03 | 0.00 | 11 | -0.03 | 5.00 | 10 | | | |
| | 0.00 | 0.00 | 10 | 0.00 | 0.00 | 10 | 5.54 T | 0.00 | 10 |

```
   MIN      -0.03   5.00   11       -0.08   2.50   11
             0.00   5.00   11        0.00   5.00   11       8.04 T    5.00   11

32 MAX      -0.01   0.00   10        0.22   5.00   11
             0.00   0.00   10        0.00   0.00   10       8.89 T    0.00   10
   MIN      -0.08   5.00   11       -0.02   0.00   11
             0.00   5.00   11        0.00   5.00   11      12.88 T    5.00   11

33 MAX       0.19   0.00   11        0.40   0.00   11
             0.00   0.00   10        0.00   0.00   10       9.39 C    0.00   11
   MIN       0.09   5.00   10       -0.40   5.00   11
             0.00   5.00   11        0.00   5.00   11       6.47 C    5.00   10


********** END OF FORCE ENVELOPE FROM INTERNAL STORAGE **********


65. FINISH


          *********** END OF THE STAAD.Pro RUN ***********

            **** DATE= FEB  2,2007   TIME=  0:52: 1 ****
```

| **_Truss Design 02.20.07** | Completed By | Revised By | DCN # | |
|---|---|---|---|---|
| Appendix 4.03 | Gimbet, Milinichik | Glantz, Owens | S-45 | |

*Conclusions: The following is the STAAD output data for the design of the Truss on the north wall of the living space. This STAAD file is composed of multiple elements including the outriggers to support the truss from the north and south, the breezeway steel frame, the living space SIP internal 2 x 6 framing of Southern Pine No.1 dimensional lumber. The outriggers in this model are framed out of plane to the 2 x 6 internal supporting lumber of the living space SIP design.*

```
****************************************************
*                                                  *
*           STAAD.Pro                              *
*           Version  2006    Bld 1002.US           *
*           Proprietary Program of                 *
*           Research Engineers,  Intl.             *
*           Date=    FEB 23, 2007                  *
*           Time=    17:17:48                      *
*                                                  *
*      USER ID: PSUAE                              *
****************************************************
```

```
     1. STAAD SPACE
INPUT FILE: S-44 LS Truss Tree Structure with SIPS 4X4 Vier.STD
     2. START JOB INFORMATION
     3. ENGINEER DATE 01-FEB-07
     4. END JOB INFORMATION
     5. INPUT WIDTH 79
     6. UNIT FEET KIP
     7. JOINT COORDINATES
     8. 1 0 0 0; 2 4 0 0; 3 8 0 0; 4 12 0 0; 5 16 0 0; 6 20 0 0; 7 24 0 0; 8 28 0 0
     9. 9 32 0 0; 10 0 3.25 0; 11 4 3.25 0; 12 8 3.25 0; 13 12 3.25 0; 14 16 3.25 0
    10. 15 20 3.25 0; 16 24 3.25 0; 17 28 3.25 0; 18 32 3.25 0; 19 8 4.375 4.5
    11. 20 16 4.375 4.5; 21 24 4.375 4.5; 23 8 2.75 -2; 24 16 2.75 -2; 25 24 2.75 -2
    12. 26 0 2.75 -2; 27 32 2.75 -2; 28 4 4.375 4.5; 29 12 4.375 4.5; 30 20 4.375 4.5
    13. 31 28 4.375 4.5; 32 0 0 -13; 33 4 0 -13; 34 8 0 -13; 35 12 0 -13; 36 16 0 -13
    14. 37 20 0 -13; 38 24 0 -13; 39 28 0 -13; 40 32 0 -13
    15. MEMBER INCIDENCES
    16. 1 1 2; 2 2 3; 3 3 4; 4 4 5; 5 5 6; 6 6 7; 7 7 8; 8 8 9; 9 10 11; 10 11 12
    17. 11 12 13; 12 13 14; 13 14 15; 14 15 16; 15 16 17; 16 17 18; 17 10 1; 18 11 2
    18. 19 12 3; 20 13 4; 21 14 5; 22 15 6; 23 16 7; 24 17 8; 25 18 9; 26 11 28
    19. 27 12 19; 28 13 29; 29 14 20; 30 15 30; 31 16 21; 32 17 31; 34 2 19; 35 19 4
    20. 36 4 20; 37 20 6; 38 6 21; 39 21 8; 41 2 23; 42 23 4; 43 4 24; 44 24 6
    21. 45 6 25; 46 25 8; 55 10 26; 56 26 32; 57 11 33; 58 12 23; 59 23 34; 60 13 35
    22. 61 14 24; 62 24 36; 63 15 37; 64 16 25; 65 25 38; 66 17 39; 67 18 27; 68 27 40
    23. 69 28 19; 70 19 29; 71 29 20; 72 20 30; 73 30 21; 74 21 31
    24. DEFINE MATERIAL START
    25. ISOTROPIC STEEL
    26. E 4.176E+006
    27. POISSON 0.3
    28. DENSITY 0.489024
    29. ALPHA 6.5E-006
    30. DAMP 0.03
    31. ISOTROPIC SOUTH
    32. E 259200
    33. POISSON 0.3
    34. DENSITY 9.383E-005
    35. ALPHA 3E-006
    36. END DEFINE MATERIAL
    37. MEMBER PROPERTY AMERICAN
    38. 34 TO 39 41 TO 46 TABLE ST HSST1.25X1.25X0.188
    39. 1 TO 18 24 TO 26 32 69 TO 74 TABLE ST HSST4X4X0.313
    40. MEMBER PROPERTY AMERICAN
```

```
41. 55 TO 68 PRIS YD 0.458333 ZD 0.25
42. 19 TO 23 27 TO 31 TABLE ST HSST4X2X0.313
43. CONSTANTS
44. BETA 345.96 MEMB 69 TO 74
45. BETA 90 MEMB 19 TO 23
46. MATERIAL STEEL MEMB 1 TO 32 34 TO 39 41 TO 46 69 TO 74
47. MATERIAL SOUTH MEMB 55 TO 68
48. SUPPORTS
49. 1 2 8 9 32 TO 40 PINNED
50. LOAD 1 LOADTYPE GRAVITY  TITLE SELF-WEIGHT
51. SELFWEIGHT Y -1
52. LOAD 2 LOADTYPE DEAD  TITLE PV LS
53. MEMBER LOAD
54. 55 56 67 68 UNI GY -0.0092
55. LOAD 3 LOADTYPE DEAD  TITLE PV LS
56. MEMBER LOAD
57. 57 TO 66 UNI GY -0.0184
58. LOAD 4 LOADTYPE DEAD  TITLE SIP LS
59. MEMBER LOAD
60. 55 56 67 68 UNI GY -0.0083
61. LOAD 5 LOADTYPE DEAD  TITLE SIP LS
62. MEMBER LOAD
63. 57 TO 66 UNI GY -0.0166
64. LOAD 6 LOADTYPE DEAD  TITLE INSUL LS
65. MEMBER LOAD
66. 55 56 67 68 UNI GY -0.01
67. LOAD 7 LOADTYPE DEAD  TITLE INSUL LS
68. MEMBER LOAD
69. 57 TO 66 UNI GY -0.02
70. LOAD 8 LOADTYPE DEAD  TITLE SKYLIGHT LS
71. MEMBER LOAD
72. 61 62 UNI GY -0.00875
73. LOAD 9 LOADTYPE DEAD  TITLE STL FRAME TRUSS
74. MEMBER LOAD
75. 9 TO 16 UNI GY -0.0164
76. LOAD 10 LOADTYPE DEAD  TITLE SIP TRUSS
77. MEMBER LOAD
78. 9 TO 16 UNI GY -0.00814
79. LOAD 11 LOADTYPE DEAD  TITLE STL FRAME BZWY OR
80. MEMBER LOAD
81. 69 TO 74 UNI GY -0.0157
82. LOAD 12 LOADTYPE DEAD  TITLE SIP BZWY OR
83. MEMBER LOAD
84. 69 TO 74 UNI GY -0.02186
85. LOAD 13 LOADTYPE SNOW  TITLE SNOW
86. MEMBER LOAD
87. 55 56 67 68 UNI GY -0.07
88. LOAD 14 LOADTYPE SNOW  TITLE SNOW LS
89. MEMBER LOAD
90. 57 TO 66 UNI GY -0.14
91. LOAD 15 LOADTYPE SNOW  TITLE SNOW TRUSS
92. MEMBER LOAD
93. 9 TO 16 UNI GY -0.076
94. LOAD 16 LOADTYPE SNOW  TITLE SNOW BZWY OR
95. MEMBER LOAD
96. 69 TO 74 UNI GY -0.204
```

```
 97. LOAD 17 LOADTYPE LIVE  TITLE PV BZWY OR
 98. MEMBER LOAD
 99. 69 TO 74 UNI GY -0.02682
100. LOAD 18 LOADTYPE LIVE  TITLE EV BZWY OR
101. MEMBER LOAD
102. 69 TO 74 UNI GY -0.02035
103. LOAD 19 LOADTYPE LIVE  TITLE PV TRUSS
104. MEMBER LOAD
105. 9 TO 16 UNI GY -0.00998
106. LOAD 20 LOADTYPE LIVE  TITLE EV TRUSS
107. MEMBER LOAD
108. 9 TO 16 UNI GY -0.00757
109. LOAD COMB 21 (1.2) DEAD
110. 1 1.2 2 1.2 3 1.2 4 1.2 5 1.2 6 1.2 7 1.2 8 1.2 9 1.2 10 1.2 11 1.2 12 1.2
111. LOAD COMB 22 (1.6) LIVE
112. 13 1.6 14 1.6 15 1.6 16 1.6 17 1.6 18 1.6 19 1.6 20 1.6
113. LOAD COMB 23 SERVICE LOAD PART 1
114. 1 1.0 2 1.0 3 1.0 4 1.0 5 1.0 6 1.0 7 1.0 8 1.0 9 1.0 10 1.0 11 1.0 12 1.0 -
115. 13 1.0 14 1.0 15 1.0
116. LOAD COMB 24 SERVICE LOAD PART 2
117. 16 1.0 17 1.0 18 1.0 19 1.0 20 1.0
118. PERFORM ANALYSIS


       P R O B L E M   S T A T I S T I C S
       -----------------------------------

  NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =     39/     64/     13
  ORIGINAL/FINAL BAND-WIDTH=     21/      8/      48 DOF
  TOTAL PRIMARY LOAD CASES =    20, TOTAL DEGREES OF FREEDOM =     195
  SIZE OF STIFFNESS MATRIX =        10 DOUBLE  KILO-WORDS
  REQRD/AVAIL. DISK SPACE  =      12.3/ 159618.6 MB


119. LOAD LIST 21 TO 24
120. PRINT JOINT DISPLACEMENTS ALL
```

JOINT DISPLACEMENT (INCH RADIANS) STRUCTURE TYPE = SPACE

| JOINT | LOAD | X-TRANS | Y-TRANS | Z-TRANS | X-ROTAN | Y-ROTAN | Z-ROTAN |
|---|---|---|---|---|---|---|---|
| 1 | 21 | 0.00000 | 0.00000 | 0.00000 | 0.00014 | 0.00034 | 0.00005 |
| | 22 | 0.00000 | 0.00000 | 0.00000 | 0.00047 | 0.00094 | 0.00016 |
| | 23 | 0.00000 | 0.00000 | 0.00000 | 0.00044 | 0.00092 | 0.00013 |
| | 24 | 0.00000 | 0.00000 | 0.00000 | -0.00003 | -0.00005 | 0.00001 |
| 2 | 21 | 0.00000 | 0.00000 | 0.00000 | 0.00001 | -0.00079 | -0.00053 |
| | 22 | 0.00000 | 0.00000 | 0.00000 | 0.00010 | -0.00216 | -0.00150 |
| | 23 | 0.00000 | 0.00000 | 0.00000 | 0.00010 | -0.00210 | -0.00127 |
| | 24 | 0.00000 | 0.00000 | 0.00000 | -0.00003 | 0.00009 | -0.00011 |
| 3 | 21 | -0.00053 | -0.09675 | 0.08438 | -0.00148 | -0.00224 | -0.00238 |
| | 22 | -0.00172 | -0.28011 | 0.23052 | -0.00378 | -0.00611 | -0.00703 |
| | 23 | -0.00114 | -0.23522 | 0.22582 | -0.00417 | -0.00599 | -0.00587 |
| | 24 | -0.00037 | -0.02048 | -0.01143 | 0.00057 | 0.00030 | -0.00051 |
| 4 | 21 | -0.00073 | -0.20863 | 0.17972 | -0.00292 | -0.00129 | -0.00138 |
| | 22 | -0.00245 | -0.61684 | 0.49112 | -0.00757 | -0.00353 | -0.00411 |
| | 23 | -0.00146 | -0.51456 | 0.48136 | -0.00807 | -0.00345 | -0.00342 |
| | 24 | -0.00068 | -0.04483 | -0.02464 | 0.00090 | 0.00017 | -0.00030 |
| 5 | 21 | 0.00000 | -0.23773 | 0.20547 | -0.00354 | 0.00000 | 0.00000 |
| | 22 | 0.00000 | -0.69995 | 0.56216 | -0.00919 | 0.00000 | 0.00000 |
| | 23 | 0.00000 | -0.58454 | 0.55058 | -0.00985 | 0.00000 | 0.00000 |
| | 24 | 0.00000 | -0.05104 | -0.02801 | 0.00115 | 0.00000 | 0.00000 |
| 6 | 21 | 0.00073 | -0.20863 | 0.17972 | -0.00292 | 0.00129 | 0.00138 |
| | 22 | 0.00245 | -0.61684 | 0.49112 | -0.00757 | 0.00353 | 0.00411 |
| | 23 | 0.00146 | -0.51456 | 0.48136 | -0.00807 | 0.00345 | 0.00342 |
| | 24 | 0.00068 | -0.04483 | -0.02464 | 0.00090 | -0.00017 | 0.00030 |
| 7 | 21 | 0.00053 | -0.09675 | 0.08438 | -0.00148 | 0.00224 | 0.00238 |
| | 22 | 0.00172 | -0.28011 | 0.23052 | -0.00378 | 0.00611 | 0.00703 |
| | 23 | 0.00114 | -0.23522 | 0.22582 | -0.00417 | 0.00599 | 0.00587 |
| | 24 | 0.00037 | -0.02048 | -0.01143 | 0.00057 | -0.00030 | 0.00051 |
| 8 | 21 | 0.00000 | 0.00000 | 0.00000 | 0.00001 | 0.00079 | 0.00053 |
| | 22 | 0.00000 | 0.00000 | 0.00000 | 0.00010 | 0.00216 | 0.00150 |
| | 23 | 0.00000 | 0.00000 | 0.00000 | 0.00010 | 0.00210 | 0.00127 |
| | 24 | 0.00000 | 0.00000 | 0.00000 | -0.00003 | -0.00009 | 0.00011 |
| 9 | 21 | 0.00000 | 0.00000 | 0.00000 | 0.00014 | -0.00034 | -0.00005 |
| | 22 | 0.00000 | 0.00000 | 0.00000 | 0.00047 | -0.00094 | -0.00016 |
| | 23 | 0.00000 | 0.00000 | 0.00000 | 0.00044 | -0.00092 | -0.00013 |
| | 24 | 0.00000 | 0.00000 | 0.00000 | -0.00003 | 0.00005 | -0.00001 |
| 10 | 21 | 0.00231 | 0.00000 | -0.00162 | -0.00046 | 0.00017 | 0.00004 |
| | 22 | 0.00678 | -0.00002 | -0.00513 | -0.00151 | 0.00044 | 0.00009 |
| | 23 | 0.00560 | -0.00002 | -0.00473 | -0.00141 | 0.00047 | 0.00008 |
| | 24 | 0.00056 | 0.00001 | 0.00017 | 0.00008 | -0.00006 | 0.00000 |
| 11 | 21 | 0.00239 | -0.00063 | -0.00247 | -0.00064 | -0.00023 | -0.00055 |
| | 22 | 0.00701 | -0.00191 | -0.00558 | -0.00180 | -0.00070 | -0.00160 |
| | 23 | 0.00580 | -0.00151 | -0.00921 | -0.00220 | -0.00052 | -0.00134 |
| | 24 | 0.00058 | -0.00021 | 0.00367 | 0.00054 | -0.00010 | -0.00013 |
| 12 | 21 | 0.00208 | -0.09678 | 0.02401 | -0.00166 | -0.00101 | -0.00227 |
| | 22 | 0.00611 | -0.28019 | 0.07630 | -0.00427 | -0.00294 | -0.00673 |
| | 23 | 0.00509 | -0.23528 | 0.05169 | -0.00490 | -0.00255 | -0.00560 |
| | 24 | 0.00046 | -0.02049 | 0.01600 | 0.00084 | -0.00014 | -0.00050 |

JOINT DISPLACEMENT (INCH RADIANS) STRUCTURE TYPE = SPACE

| JOINT | LOAD | X-TRANS | Y-TRANS | Z-TRANS | X-ROTAN | Y-ROTAN | Z-ROTAN |
|---|---|---|---|---|---|---|---|
| 13 | 21 | 0.00114 | -0.20865 | 0.05343 | -0.00343 | -0.00038 | -0.00138 |
| | 22 | 0.00335 | -0.61694 | 0.15967 | -0.00924 | -0.00114 | -0.00413 |
| | 23 | 0.00279 | -0.51458 | 0.12951 | -0.00985 | -0.00096 | -0.00342 |
| | 24 | 0.00025 | -0.04488 | 0.01481 | 0.00123 | -0.00007 | -0.00031 |
| 14 | 21 | 0.00000 | -0.23759 | 0.06312 | -0.00326 | 0.00000 | 0.00000 |
| | 22 | 0.00000 | -0.69956 | 0.19352 | -0.00839 | 0.00000 | 0.00000 |
| | 23 | 0.00000 | -0.58421 | 0.15038 | -0.00935 | 0.00000 | 0.00000 |
| | 24 | 0.00000 | -0.05102 | 0.02316 | 0.00139 | 0.00000 | 0.00000 |
| 15 | 21 | -0.00114 | -0.20865 | 0.05343 | -0.00343 | 0.00038 | 0.00138 |
| | 22 | -0.00335 | -0.61694 | 0.15967 | -0.00924 | 0.00114 | 0.00413 |
| | 23 | -0.00279 | -0.51458 | 0.12951 | -0.00985 | 0.00096 | 0.00342 |
| | 24 | -0.00025 | -0.04488 | 0.01481 | 0.00123 | 0.00007 | 0.00031 |
| 16 | 21 | -0.00208 | -0.09678 | 0.02401 | -0.00166 | 0.00101 | 0.00227 |
| | 22 | -0.00611 | -0.28019 | 0.07630 | -0.00427 | 0.00294 | 0.00673 |
| | 23 | -0.00509 | -0.23528 | 0.05169 | -0.00490 | 0.00255 | 0.00560 |
| | 24 | -0.00046 | -0.02049 | 0.01600 | 0.00084 | 0.00014 | 0.00050 |
| 17 | 21 | -0.00239 | -0.00063 | -0.00247 | -0.00064 | 0.00023 | 0.00055 |
| | 22 | -0.00701 | -0.00191 | -0.00558 | -0.00180 | 0.00070 | 0.00160 |
| | 23 | -0.00580 | -0.00151 | -0.00921 | -0.00220 | 0.00052 | 0.00134 |
| | 24 | -0.00058 | -0.00021 | 0.00367 | 0.00054 | 0.00010 | 0.00013 |
| 18 | 21 | -0.00231 | 0.00000 | -0.00162 | -0.00046 | -0.00017 | -0.00004 |
| | 22 | -0.00678 | -0.00002 | -0.00513 | -0.00151 | -0.00044 | -0.00009 |
| | 23 | -0.00560 | -0.00002 | -0.00473 | -0.00141 | -0.00047 | -0.00008 |
| | 24 | -0.00056 | 0.00001 | 0.00017 | 0.00008 | 0.00006 | 0.00000 |
| 19 | 21 | 0.00111 | -0.01923 | 0.00487 | -0.00143 | -0.00024 | -0.00084 |
| | 22 | 0.00530 | -0.11063 | 0.03574 | -0.00274 | -0.00082 | -0.00305 |
| | 23 | 0.00083 | 0.00007 | -0.00733 | -0.00443 | -0.00053 | -0.00181 |
| | 24 | 0.00342 | -0.08523 | 0.03372 | 0.00152 | -0.00018 | -0.00080 |
| 20 | 21 | 0.00000 | -0.04880 | 0.01671 | -0.00323 | 0.00000 | 0.00000 |
| | 22 | 0.00000 | -0.22860 | 0.07926 | -0.00762 | 0.00000 | 0.00000 |
| | 23 | 0.00000 | -0.04977 | 0.01803 | -0.00914 | 0.00000 | 0.00000 |
| | 24 | 0.00000 | -0.13378 | 0.04543 | 0.00169 | 0.00000 | 0.00000 |
| 21 | 21 | -0.00111 | -0.01923 | 0.00487 | -0.00143 | 0.00024 | 0.00084 |
| | 22 | -0.00530 | -0.11063 | 0.03574 | -0.00274 | 0.00082 | 0.00305 |
| | 23 | -0.00083 | 0.00007 | -0.00733 | -0.00443 | 0.00053 | 0.00181 |
| | 24 | -0.00342 | -0.08523 | 0.03372 | 0.00152 | 0.00018 | 0.00080 |
| 23 | 21 | 0.11426 | -0.14627 | 0.03613 | -0.00273 | -0.00575 | -0.00125 |
| | 22 | 0.32779 | -0.41810 | 0.10885 | -0.00831 | -0.01651 | -0.00375 |
| | 23 | 0.29134 | -0.37799 | 0.08763 | -0.00798 | -0.01463 | -0.00303 |
| | 24 | 0.00875 | -0.00521 | 0.01051 | 0.00050 | -0.00048 | -0.00035 |
| 24 | 21 | 0.00000 | -0.29206 | 0.07570 | -0.00241 | 0.00000 | 0.00000 |
| | 22 | 0.00000 | -0.83502 | 0.22316 | -0.00626 | 0.00000 | 0.00000 |
| | 23 | 0.00000 | -0.74663 | 0.18912 | -0.00712 | 0.00000 | 0.00000 |
| | 24 | 0.00000 | -0.01864 | 0.01344 | 0.00120 | 0.00000 | 0.00000 |
| 25 | 21 | -0.11426 | -0.14627 | 0.03613 | -0.00273 | 0.00575 | 0.00125 |
| | 22 | -0.32779 | -0.41810 | 0.10885 | -0.00831 | 0.01651 | 0.00375 |
| | 23 | -0.29134 | -0.37799 | 0.08763 | -0.00798 | 0.01463 | 0.00303 |
| | 24 | -0.00875 | -0.00521 | 0.01051 | 0.00050 | 0.00048 | 0.00035 |

**JOINT DISPLACEMENT (INCH RADIANS) STRUCTURE TYPE = SPACE**

| JOINT | LOAD | X-TRANS | Y-TRANS | Z-TRANS | X-ROTAN | Y-ROTAN | Z-ROTAN |
|---|---|---|---|---|---|---|---|
| 26 | 21 | -0.00076 | -0.03513 | 0.00737 | -0.00211 | 0.00011 | 0.00005 |
| | 22 | -0.00132 | -0.11818 | 0.02507 | -0.00712 | 0.00029 | 0.00013 |
| | 23 | -0.00305 | -0.10465 | 0.02204 | -0.00625 | 0.00031 | 0.00012 |
| | 24 | 0.00159 | 0.00152 | -0.00023 | 0.00005 | -0.00003 | 0.00000 |
| 27 | 21 | 0.00076 | -0.03513 | 0.00737 | -0.00211 | -0.00011 | -0.00005 |
| | 22 | 0.00132 | -0.11818 | 0.02507 | -0.00712 | -0.00029 | -0.00013 |
| | 23 | 0.00305 | -0.10465 | 0.02204 | -0.00625 | -0.00031 | -0.00012 |
| | 24 | -0.00159 | 0.00152 | -0.00023 | 0.00005 | 0.00003 | 0.00000 |
| 28 | 21 | 0.00110 | 0.02122 | -0.00793 | -0.00049 | -0.00024 | -0.00085 |
| | 22 | 0.00524 | 0.01973 | -0.01096 | -0.00021 | -0.00082 | -0.00274 |
| | 23 | 0.00082 | 0.10161 | -0.03501 | -0.00221 | -0.00058 | -0.00218 |
| | 24 | 0.00337 | -0.07160 | 0.02155 | 0.00167 | -0.00013 | -0.00024 |
| 29 | 21 | 0.00055 | -0.04874 | 0.01345 | -0.00258 | -0.00013 | -0.00028 |
| | 22 | 0.00265 | -0.23277 | 0.06373 | -0.00571 | -0.00047 | -0.00115 |
| | 23 | 0.00041 | -0.04955 | 0.01319 | -0.00752 | -0.00027 | -0.00040 |
| | 24 | 0.00171 | -0.13655 | 0.03785 | 0.00180 | -0.00013 | -0.00055 |
| 30 | 21 | -0.00055 | -0.04874 | 0.01345 | -0.00258 | 0.00013 | 0.00028 |
| | 22 | -0.00265 | -0.23277 | 0.06373 | -0.00571 | 0.00047 | 0.00115 |
| | 23 | -0.00041 | -0.04955 | 0.01319 | -0.00752 | 0.00027 | 0.00040 |
| | 24 | -0.00171 | -0.13655 | 0.03785 | 0.00180 | 0.00013 | 0.00055 |
| 31 | 21 | -0.00110 | 0.02122 | -0.00793 | -0.00049 | 0.00024 | 0.00085 |
| | 22 | -0.00524 | 0.01973 | -0.01096 | -0.00021 | 0.00082 | 0.00274 |
| | 23 | -0.00082 | 0.10161 | -0.03501 | -0.00221 | 0.00058 | 0.00218 |
| | 24 | -0.00337 | -0.07160 | 0.02155 | 0.00167 | 0.00013 | 0.00024 |
| 32 | 21 | 0.00000 | 0.00000 | 0.00000 | 0.00332 | -0.00004 | 0.00009 |
| | 22 | 0.00000 | 0.00000 | 0.00000 | 0.01125 | -0.00009 | 0.00022 |
| | 23 | 0.00000 | 0.00000 | 0.00000 | 0.00984 | -0.00011 | 0.00023 |
| | 24 | 0.00000 | 0.00000 | 0.00000 | -0.00004 | 0.00003 | -0.00002 |
| 33 | 21 | 0.00000 | 0.00000 | 0.00000 | 0.00651 | -0.00008 | -0.00059 |
| | 22 | 0.00000 | 0.00000 | 0.00000 | 0.02191 | -0.00022 | -0.00172 |
| | 23 | 0.00000 | 0.00000 | 0.00000 | 0.01938 | -0.00020 | -0.00141 |
| | 24 | 0.00000 | 0.00000 | 0.00000 | -0.00026 | 0.00000 | -0.00016 |
| 34 | 21 | 0.00000 | 0.00000 | 0.00000 | 0.00678 | 0.00314 | -0.00347 |
| | 22 | 0.00000 | 0.00000 | 0.00000 | 0.02164 | 0.00897 | -0.01012 |
| | 23 | 0.00000 | 0.00000 | 0.00000 | 0.01934 | 0.00806 | -0.00871 |
| | 24 | 0.00000 | 0.00000 | 0.00000 | -0.00017 | 0.00016 | -0.00051 |
| 35 | 21 | 0.00000 | 0.00000 | 0.00000 | 0.00991 | -0.00032 | -0.00139 |
| | 22 | 0.00000 | 0.00000 | 0.00000 | 0.03155 | -0.00096 | -0.00417 |
| | 23 | 0.00000 | 0.00000 | 0.00000 | 0.02815 | -0.00079 | -0.00346 |
| | 24 | 0.00000 | 0.00000 | 0.00000 | -0.00017 | -0.00008 | -0.00031 |
| 36 | 21 | 0.00000 | 0.00000 | 0.00000 | 0.00888 | 0.00000 | 0.00000 |
| | 22 | 0.00000 | 0.00000 | 0.00000 | 0.02538 | 0.00000 | 0.00000 |
| | 23 | 0.00000 | 0.00000 | 0.00000 | 0.02362 | 0.00000 | 0.00000 |
| | 24 | 0.00000 | 0.00000 | 0.00000 | -0.00036 | 0.00000 | 0.00000 |
| 37 | 21 | 0.00000 | 0.00000 | 0.00000 | 0.00991 | 0.00032 | 0.00139 |
| | 22 | 0.00000 | 0.00000 | 0.00000 | 0.03155 | 0.00096 | 0.00417 |
| | 23 | 0.00000 | 0.00000 | 0.00000 | 0.02815 | 0.00079 | 0.00346 |
| | 24 | 0.00000 | 0.00000 | 0.00000 | -0.00017 | 0.00008 | 0.00031 |

JOINT DISPLACEMENT (INCH RADIANS) STRUCTURE TYPE = SPACE

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| JOINT | LOAD | X-TRANS | Y-TRANS | Z-TRANS | X-ROTAN | Y-ROTAN | Z-ROTAN |
|---|---|---|---|---|---|---|---|
| 38 | 21 | 0.00000 | 0.00000 | 0.00000 | 0.00678 | -0.00314 | 0.00347 |
| | 22 | 0.00000 | 0.00000 | 0.00000 | 0.02164 | -0.00897 | 0.01012 |
| | 23 | 0.00000 | 0.00000 | 0.00000 | 0.01934 | -0.00806 | 0.00871 |
| | 24 | 0.00000 | 0.00000 | 0.00000 | -0.00017 | -0.00016 | 0.00051 |
| 39 | 21 | 0.00000 | 0.00000 | 0.00000 | 0.00651 | 0.00008 | 0.00059 |
| | 22 | 0.00000 | 0.00000 | 0.00000 | 0.02191 | 0.00022 | 0.00172 |
| | 23 | 0.00000 | 0.00000 | 0.00000 | 0.01938 | 0.00020 | 0.00141 |
| | 24 | 0.00000 | 0.00000 | 0.00000 | -0.00026 | 0.00000 | 0.00016 |
| 40 | 21 | 0.00000 | 0.00000 | 0.00000 | 0.00332 | 0.00004 | -0.00009 |
| | 22 | 0.00000 | 0.00000 | 0.00000 | 0.01125 | 0.00009 | -0.00022 |
| | 23 | 0.00000 | 0.00000 | 0.00000 | 0.00984 | 0.00011 | -0.00023 |
| | 24 | 0.00000 | 0.00000 | 0.00000 | -0.00004 | -0.00003 | 0.00002 |

************** END OF LATEST ANALYSIS RESULT **************

121. PRINT SUPPORT REACTION ALL

SUPPORT REACTIONS -UNIT KIP FEET STRUCTURE TYPE = SPACE

| JOINT | LOAD | FORCE-X | FORCE-Y | FORCE-Z | MOM-X | MOM-Y | MOM Z |
|---|---|---|---|---|---|---|---|
| 1 | 21 | -0.20 | -0.25 | 0.06 | 0.00 | 0.00 | 0.00 |
| | 22 | -0.58 | -0.82 | 0.05 | 0.00 | 0.00 | 0.00 |
| | 23 | -0.49 | -0.63 | 0.07 | 0.00 | 0.00 | 0.00 |
| | 24 | -0.04 | -0.10 | 0.01 | 0.00 | 0.00 | 0.00 |
| 2 | 21 | 3.93 | 4.63 | -0.46 | 0.00 | 0.00 | 0.00 |
| | 22 | 14.18 | 15.71 | 1.07 | 0.00 | 0.00 | 0.00 |
| | 23 | 7.73 | 9.25 | -3.77 | 0.00 | 0.00 | 0.00 |
| | 24 | 4.41 | 4.43 | 4.06 | 0.00 | 0.00 | 0.00 |
| 8 | 21 | -3.93 | 4.63 | -0.46 | 0.00 | 0.00 | 0.00 |
| | 22 | -14.18 | 15.71 | 1.07 | 0.00 | 0.00 | 0.00 |
| | 23 | -7.73 | 9.25 | -3.77 | 0.00 | 0.00 | 0.00 |
| | 24 | -4.41 | 4.43 | 4.06 | 0.00 | 0.00 | 0.00 |
| 9 | 21 | 0.20 | -0.25 | 0.06 | 0.00 | 0.00 | 0.00 |
| | 22 | 0.58 | -0.82 | 0.05 | 0.00 | 0.00 | 0.00 |
| | 23 | 0.49 | -0.63 | 0.07 | 0.00 | 0.00 | 0.00 |
| | 24 | 0.04 | -0.10 | 0.01 | 0.00 | 0.00 | 0.00 |
| 32 | 21 | 0.00 | 0.24 | 0.29 | 0.00 | 0.00 | 0.00 |
| | 22 | 0.00 | 0.81 | 0.93 | 0.00 | 0.00 | 0.00 |
| | 23 | 0.00 | 0.72 | 0.86 | 0.00 | 0.00 | 0.00 |
| | 24 | 0.00 | -0.01 | -0.03 | 0.00 | 0.00 | 0.00 |
| 33 | 21 | 0.00 | 0.46 | 0.48 | 0.00 | 0.00 | 0.00 |
| | 22 | 0.00 | 1.43 | 1.14 | 0.00 | 0.00 | 0.00 |
| | 23 | 0.00 | 1.43 | 1.74 | 0.00 | 0.00 | 0.00 |
| | 24 | 0.00 | -0.16 | -0.63 | 0.00 | 0.00 | 0.00 |
| 34 | 21 | -0.02 | 0.35 | 0.10 | 0.00 | 0.00 | 0.00 |
| | 22 | -0.06 | 0.88 | -0.85 | 0.00 | 0.00 | 0.00 |
| | 23 | -0.06 | 1.33 | 1.44 | 0.00 | 0.00 | 0.00 |
| | 24 | 0.00 | -0.48 | -1.89 | 0.00 | 0.00 | 0.00 |
| 35 | 21 | 0.00 | 0.32 | -0.20 | 0.00 | 0.00 | 0.00 |
| | 22 | 0.00 | 1.02 | -0.88 | 0.00 | 0.00 | 0.00 |
| | 23 | 0.00 | 1.07 | -0.10 | 0.00 | 0.00 | 0.00 |
| | 24 | 0.00 | -0.16 | -0.62 | 0.00 | 0.00 | 0.00 |
| 36 | 21 | 0.00 | 0.25 | -0.54 | 0.00 | 0.00 | 0.00 |
| | 22 | 0.00 | 0.38 | -2.92 | 0.00 | 0.00 | 0.00 |
| | 23 | 0.00 | 0.91 | -0.48 | 0.00 | 0.00 | 0.00 |
| | 24 | 0.00 | -0.46 | -1.80 | 0.00 | 0.00 | 0.00 |
| 37 | 21 | 0.00 | 0.32 | -0.20 | 0.00 | 0.00 | 0.00 |
| | 22 | 0.00 | 1.02 | -0.88 | 0.00 | 0.00 | 0.00 |
| | 23 | 0.00 | 1.07 | -0.10 | 0.00 | 0.00 | 0.00 |
| | 24 | 0.00 | -0.16 | -0.62 | 0.00 | 0.00 | 0.00 |
| 38 | 21 | 0.02 | 0.35 | 0.10 | 0.00 | 0.00 | 0.00 |
| | 22 | 0.06 | 0.88 | -0.85 | 0.00 | 0.00 | 0.00 |
| | 23 | 0.06 | 1.33 | 1.44 | 0.00 | 0.00 | 0.00 |
| | 24 | 0.00 | -0.48 | -1.89 | 0.00 | 0.00 | 0.00 |
| 39 | 21 | 0.00 | 0.46 | 0.48 | 0.00 | 0.00 | 0.00 |
| | 22 | 0.00 | 1.43 | 1.14 | 0.00 | 0.00 | 0.00 |
| | 23 | 0.00 | 1.43 | 1.74 | 0.00 | 0.00 | 0.00 |
| | 24 | 0.00 | -0.16 | -0.63 | 0.00 | 0.00 | 0.00 |

SUPPORT REACTIONS -UNIT KIP FEET STRUCTURE TYPE = SPACE

| JOINT | LOAD | FORCE-X | FORCE-Y | FORCE-Z | MOM-X | MOM-Y | MOM Z |
|---|---|---|---|---|---|---|---|
| 40 | 21 | 0.00 | 0.24 | 0.29 | 0.00 | 0.00 | 0.00 |
| | 22 | 0.00 | 0.81 | 0.93 | 0.00 | 0.00 | 0.00 |
| | 23 | 0.00 | 0.72 | 0.86 | 0.00 | 0.00 | 0.00 |
| | 24 | 0.00 | -0.01 | -0.03 | 0.00 | 0.00 | 0.00 |

************** END OF LATEST ANALYSIS RESULT **************

122. PRINT MAXFORCE ENVELOPE ALL

MEMBER FORCE ENVELOPE
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ALL UNITS ARE KIP FEET

MAX AND MIN FORCE VALUES AMONGST ALL SECTION LOCATIONS

| MEMB | | FY/ FZ | DIST DIST | LD LD | MZ/ MY | DIST DIST | LD LD | FX | DIST | LD |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | MAX | -0.06 | 0.00 | 24 | 2.51 | 4.00 | 22 | | | |
| | | 0.80 | 0.00 | 22 | 3.03 | 4.00 | 22 | 0.00 | 0.00 | 21 |
| | MIN | -0.87 | 4.00 | 22 | -0.99 | 0.00 | 22 | | | |
| | | -0.03 | 4.00 | 24 | -0.18 | 0.00 | 22 | 0.00 | 4.00 | 24 |
| 2 | MAX | 2.06 | 0.00 | 22 | 6.66 | 0.00 | 22 | | | |
| | | 0.05 | 0.00 | 24 | 3.57 | 0.00 | 22 | 4.25 C | 0.00 | 22 |
| | MIN | 0.15 | 4.00 | 24 | -1.57 | 4.00 | 22 | | | |
| | | -0.87 | 4.00 | 22 | -0.20 | 0.00 | 24 | 0.93 C | 4.00 | 24 |
| 3 | MAX | 1.89 | 0.00 | 22 | 2.44 | 0.00 | 22 | | | |
| | | 0.05 | 0.00 | 24 | 0.42 | 0.00 | 23 | 1.81 C | 0.00 | 22 |
| | MIN | 0.13 | 4.00 | 24 | -5.13 | 4.00 | 22 | | | |
| | | -0.80 | 4.00 | 22 | -2.78 | 4.00 | 22 | 0.49 C | 4.00 | 21 |
| 4 | MAX | -0.03 | 0.00 | 24 | -0.08 | 4.00 | 24 | | | |
| | | 0.37 | 0.00 | 22 | 0.12 | 0.00 | 24 | 1.68 T | 0.00 | 24 |
| | MIN | -0.42 | 4.00 | 22 | -2.74 | 0.00 | 22 | | | |
| | | -0.02 | 4.00 | 24 | -2.37 | 0.00 | 22 | 6.06 T | 4.00 | 22 |
| 5 | MAX | 0.42 | 0.00 | 22 | -0.08 | 0.00 | 24 | | | |
| | | 0.02 | 0.00 | 24 | 0.12 | 4.00 | 24 | 1.68 T | 0.00 | 24 |
| | MIN | 0.03 | 4.00 | 24 | -2.74 | 4.00 | 22 | | | |
| | | -0.37 | 4.00 | 22 | -2.37 | 4.00 | 22 | 6.06 T | 4.00 | 22 |
| 6 | MAX | -0.13 | 0.00 | 24 | 2.44 | 4.00 | 22 | | | |
| | | 0.80 | 0.00 | 22 | 0.42 | 4.00 | 23 | 1.81 C | 0.00 | 22 |
| | MIN | -1.89 | 4.00 | 22 | -5.13 | 0.00 | 22 | | | |
| | | -0.05 | 4.00 | 24 | -2.78 | 0.00 | 22 | 0.49 C | 4.00 | 21 |
| 7 | MAX | -0.15 | 0.00 | 24 | 6.66 | 4.00 | 22 | | | |
| | | 0.87 | 0.00 | 22 | 3.57 | 4.00 | 22 | 4.25 C | 0.00 | 22 |
| | MIN | -2.06 | 4.00 | 22 | -1.57 | 0.00 | 22 | | | |
| | | -0.05 | 4.00 | 24 | -0.20 | 4.00 | 24 | 0.93 C | 4.00 | 24 |
| 8 | MAX | 0.87 | 0.00 | 22 | 2.51 | 0.00 | 22 | | | |
| | | 0.03 | 0.00 | 24 | 3.03 | 0.00 | 22 | 0.00 | 0.00 | 21 |
| | MIN | 0.06 | 4.00 | 24 | -0.99 | 4.00 | 22 | | | |
| | | -0.80 | 4.00 | 22 | -0.18 | 4.00 | 22 | 0.00 | 4.00 | 24 |
| 9 | MAX | -0.04 | 0.00 | 24 | 2.86 | 4.00 | 22 | | | |
| | | 0.18 | 0.00 | 22 | 0.88 | 4.00 | 22 | 0.04 T | 0.00 | 24 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| MIN | -1.24 | 4.00 | 22 | -0.90 | 0.00 | 22 | | | |
| | 0.01 | 4.00 | 24 | 0.00 | 0.00 | 24 | 0.58 T | 4.00 | 22 |
| 10 MAX | 2.44 | 0.00 | 22 | 6.83 | 0.00 | 22 | | | |
| | 0.35 | 0.00 | 23 | 1.62 | 4.00 | 23 | 2.24 C | 0.00 | 22 |
| MIN | 0.10 | 4.00 | 24 | -1.71 | 4.00 | 22 | | | |
| | -0.18 | 4.00 | 24 | -0.34 | 4.00 | 24 | 0.28 C | 4.00 | 24 |
| 11 MAX | 2.38 | 0.00 | 22 | 3.16 | 0.00 | 22 | | | |
| | 0.40 | 0.00 | 22 | 0.30 | 4.00 | 24 | 6.83 C | 0.00 | 22 |
| MIN | 0.10 | 4.00 | 24 | -5.16 | 4.00 | 22 | | | |
| | 0.11 | 4.00 | 21 | -1.63 | 0.00 | 22 | 0.52 C | 4.00 | 24 |
| 12 MAX | 0.00 | 0.00 | 24 | -0.05 | 4.00 | 24 | | | |
| | 0.06 | 0.00 | 23 | 0.33 | 0.00 | 24 | 8.30 C | 0.00 | 22 |
| MIN | -0.75 | 4.00 | 22 | -2.59 | 0.00 | 22 | | | |
| | -0.18 | 4.00 | 24 | -0.88 | 4.00 | 22 | 0.63 C | 4.00 | 24 |
| 13 MAX | 0.75 | 0.00 | 22 | -0.05 | 0.00 | 24 | | | |
| | 0.18 | 0.00 | 24 | 0.33 | 4.00 | 24 | 8.30 C | 0.00 | 22 |
| MIN | 0.00 | 4.00 | 24 | -2.59 | 4.00 | 22 | | | |
| | -0.06 | 4.00 | 23 | -0.88 | 0.00 | 22 | 0.63 C | 4.00 | 24 |
| 14 MAX | -0.10 | 0.00 | 24 | 3.16 | 4.00 | 22 | | | |
| | -0.11 | 0.00 | 21 | 0.30 | 0.00 | 24 | 6.83 C | 0.00 | 22 |
| MIN | -2.38 | 4.00 | 22 | -5.16 | 0.00 | 22 | | | |
| | -0.40 | 4.00 | 22 | -1.63 | 4.00 | 22 | 0.52 C | 4.00 | 24 |
| 15 MAX | -0.10 | 0.00 | 24 | 6.83 | 4.00 | 22 | | | |
| | 0.18 | 0.00 | 24 | 1.62 | 0.00 | 23 | 2.24 C | 0.00 | 22 |
| MIN | -2.44 | 4.00 | 22 | -1.71 | 0.00 | 22 | | | |
| | -0.35 | 4.00 | 23 | -0.34 | 0.00 | 24 | 0.28 C | 4.00 | 24 |
| 16 MAX | 1.24 | 0.00 | 22 | 2.86 | 0.00 | 22 | | | |
| | -0.01 | 0.00 | 24 | 0.88 | 0.00 | 22 | 0.04 T | 0.00 | 24 |
| MIN | 0.04 | 4.00 | 24 | -0.90 | 4.00 | 22 | | | |
| | -0.18 | 4.00 | 22 | 0.00 | 4.00 | 24 | 0.58 T | 4.00 | 22 |
| 17 MAX | 0.58 | 0.00 | 22 | 0.90 | 0.00 | 22 | | | |
| | 0.76 | 0.00 | 22 | 0.13 | 0.00 | 24 | 0.08 C | 3.25 | 23 |
| MIN | 0.04 | 3.25 | 24 | -0.99 | 3.25 | 22 | | | |
| | -0.04 | 3.25 | 24 | -2.35 | 0.00 | 22 | 0.03 T | 3.25 | 24 |
| 18 MAX | -0.20 | 0.00 | 24 | 4.25 | 3.25 | 22 | | | |
| | 1.57 | 0.00 | 23 | 1.26 | 3.25 | 23 | 5.81 C | 0.00 | 22 |
| MIN | -2.65 | 3.25 | 22 | -4.37 | 0.00 | 22 | | | |
| | -0.31 | 3.25 | 24 | -3.86 | 0.00 | 23 | 0.63 C | 3.25 | 24 |
| 19 MAX | 0.08 | 0.00 | 22 | 0.35 | 0.00 | 23 | | | |
| | 2.45 | 0.00 | 22 | 4.00 | 3.25 | 22 | 0.17 C | 0.00 | 22 |
| MIN | 0.00 | 3.25 | 24 | -0.09 | 0.00 | 24 | | | |
| | 0.18 | 3.25 | 24 | -3.94 | 0.00 | 22 | 0.02 C | 3.25 | 24 |
| 20 MAX | -0.06 | 0.00 | 24 | 0.71 | 3.25 | 22 | | | |
| | 1.45 | 0.00 | 22 | 2.36 | 3.25 | 22 | 0.21 C | 0.00 | 22 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| MIN | -0.11 | 3.25 | 22 | -0.20 | 0.00 | 24 | | | |
| | 0.10 | 3.25 | 24 | -2.36 | 0.00 | 22 | 0.02 C | 0.00 | 21 |
| 21 MAX | 0.04 | 0.00 | 24 | 1.05 | 3.25 | 23 | | | |
| | 0.00 | 0.00 | 22 | 0.00 | 3.25 | 22 | 0.05 T | 0.00 | 24 |
| MIN | -0.75 | 3.25 | 22 | -1.47 | 0.00 | 22 | | | |
| | 0.00 | 3.25 | 24 | 0.00 | 0.00 | 22 | 0.85 T | 3.25 | 22 |
| 22 MAX | -0.06 | 0.00 | 24 | 0.71 | 3.25 | 22 | | | |
| | -0.10 | 0.00 | 24 | 2.36 | 0.00 | 22 | 0.21 C | 0.00 | 22 |
| MIN | -0.11 | 3.25 | 22 | -0.20 | 0.00 | 24 | | | |
| | -1.45 | 3.25 | 22 | -2.36 | 3.25 | 22 | 0.02 C | 0.00 | 21 |
| 23 MAX | 0.08 | 0.00 | 22 | 0.35 | 0.00 | 23 | | | |
| | -0.18 | 0.00 | 24 | 3.94 | 0.00 | 22 | 0.17 C | 0.00 | 22 |
| MIN | 0.00 | 3.25 | 24 | -0.09 | 0.00 | 24 | | | |
| | -2.45 | 3.25 | 22 | -4.00 | 3.25 | 22 | 0.02 C | 3.25 | 24 |
| 24 MAX | 2.65 | 0.00 | 22 | 4.37 | 0.00 | 22 | | | |
| | 1.57 | 0.00 | 23 | 1.26 | 3.25 | 23 | 5.81 C | 0.00 | 22 |
| MIN | 0.20 | 3.25 | 24 | -4.25 | 3.25 | 22 | | | |
| | -0.31 | 3.25 | 24 | -3.86 | 0.00 | 23 | 0.63 C | 3.25 | 24 |
| 25 MAX | -0.04 | 0.00 | 24 | 0.99 | 3.25 | 22 | | | |
| | 0.76 | 0.00 | 22 | 0.13 | 0.00 | 24 | 0.08 C | 3.25 | 23 |
| MIN | -0.58 | 3.25 | 22 | -0.90 | 0.00 | 22 | | | |
| | -0.04 | 3.25 | 24 | -2.35 | 0.00 | 22 | 0.03 T | 3.25 | 24 |
| 26 MAX | 0.60 | 0.00 | 22 | 2.01 | 0.00 | 22 | | | |
| | 0.17 | 0.00 | 22 | 0.34 | 4.64 | 22 | 0.05 C | 0.00 | 23 |
| MIN | 0.12 | 4.64 | 21 | -0.75 | 4.64 | 22 | | | |
| | 0.02 | 4.64 | 23 | -0.46 | 0.00 | 22 | 0.08 T | 4.64 | 24 |
| 27 MAX | 0.21 | 0.00 | 22 | 0.82 | 0.00 | 22 | | | |
| | 0.11 | 0.00 | 22 | 0.18 | 4.64 | 22 | 0.29 C | 0.00 | 23 |
| MIN | 0.01 | 4.64 | 24 | -0.27 | 4.64 | 23 | | | |
| | 0.01 | 4.64 | 24 | -0.35 | 0.00 | 22 | 2.71 T | 4.64 | 22 |
| 28 MAX | 0.20 | 0.00 | 22 | 1.26 | 0.00 | 22 | | | |
| | 0.02 | 0.00 | 22 | 0.06 | 4.64 | 22 | 0.10 C | 0.00 | 23 |
| MIN | 0.00 | 4.64 | 21 | -0.12 | 4.64 | 24 | | | |
| | 0.00 | 4.64 | 24 | -0.05 | 0.00 | 22 | 0.19 T | 4.64 | 24 |
| 29 MAX | 0.00 | 0.00 | 24 | 1.09 | 4.64 | 22 | | | |
| | 0.00 | 0.00 | 24 | 0.00 | 0.00 | 22 | 1.17 T | 0.00 | 21 |
| MIN | -0.40 | 4.64 | 22 | -0.78 | 0.00 | 23 | | | |
| | 0.00 | 4.64 | 22 | 0.00 | 4.64 | 22 | 5.17 T | 4.64 | 22 |
| 30 MAX | 0.20 | 0.00 | 22 | 1.26 | 0.00 | 22 | | | |
| | 0.00 | 0.00 | 24 | 0.05 | 0.00 | 22 | 0.10 C | 0.00 | 23 |
| MIN | 0.00 | 4.64 | 21 | -0.12 | 4.64 | 24 | | | |
| | -0.02 | 4.64 | 22 | -0.06 | 4.64 | 22 | 0.19 T | 4.64 | 24 |
| 31 MAX | 0.21 | 0.00 | 22 | 0.82 | 0.00 | 22 | | | |
| | -0.01 | 0.00 | 24 | 0.35 | 0.00 | 22 | 0.29 C | 0.00 | 23 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| MIN | 0.01 | 4.64 | 24 | -0.27 | 4.64 | 23 | | | |
| | -0.11 | 4.64 | 22 | -0.18 | 4.64 | 22 | 2.71 T | 4.64 | 22 |
| 32 MAX | 0.60 | 0.00 | 22 | 2.01 | 0.00 | 22 | | | |
| | -0.02 | 0.00 | 23 | 0.46 | 0.00 | 22 | 0.05 C | 0.00 | 23 |
| MIN | 0.12 | 4.64 | 21 | -0.75 | 4.64 | 22 | | | |
| | -0.17 | 4.64 | 22 | -0.34 | 4.64 | 22 | 0.08 T | 4.64 | 24 |
| 34 MAX | 0.01 | 0.00 | 23 | 0.01 | 0.00 | 21 | | | |
| | 0.00 | 0.00 | 24 | 0.00 | 0.00 | 24 | 8.84 C | 0.00 | 22 |
| MIN | -0.01 | 7.44 | 21 | -0.02 | 7.44 | 22 | | | |
| | 0.00 | 7.44 | 22 | -0.02 | 7.44 | 22 | 0.86 C | 7.44 | 23 |
| 35 MAX | 0.01 | 0.00 | 23 | 0.03 | 0.00 | 23 | | | |
| | 0.00 | 0.00 | 24 | 0.03 | 0.00 | 22 | 1.00 T | 7.44 | 21 |
| MIN | -0.01 | 7.44 | 21 | 0.00 | 0.00 | 24 | | | |
| | -0.01 | 7.44 | 22 | -0.01 | 7.44 | 22 | 3.94 T | 7.44 | 22 |
| 36 MAX | 0.01 | 0.00 | 21 | 0.02 | 7.44 | 23 | | | |
| | 0.00 | 0.00 | 23 | 0.01 | 7.44 | 22 | 4.25 C | 0.00 | 22 |
| MIN | -0.01 | 7.44 | 23 | -0.03 | 0.00 | 22 | | | |
| | 0.00 | 7.44 | 24 | -0.02 | 0.00 | 23 | 0.91 C | 7.44 | 21 |
| 37 MAX | 0.01 | 0.00 | 23 | 0.02 | 0.00 | 23 | | | |
| | 0.00 | 0.00 | 24 | 0.01 | 0.00 | 22 | 4.25 C | 0.00 | 22 |
| MIN | -0.01 | 7.44 | 21 | -0.03 | 7.44 | 22 | | | |
| | 0.00 | 7.44 | 23 | -0.02 | 7.44 | 23 | 0.91 C | 0.00 | 21 |
| 38 MAX | 0.01 | 0.00 | 21 | 0.03 | 7.44 | 23 | | | |
| | 0.01 | 0.00 | 22 | 0.03 | 7.44 | 22 | 1.00 T | 0.00 | 21 |
| MIN | -0.01 | 7.44 | 23 | 0.00 | 7.44 | 24 | | | |
| | 0.00 | 7.44 | 24 | -0.01 | 0.00 | 22 | 3.94 T | 7.44 | 22 |
| 39 MAX | 0.01 | 0.00 | 21 | 0.01 | 7.44 | 21 | | | |
| | 0.00 | 0.00 | 22 | 0.00 | 7.44 | 24 | 8.84 C | 0.00 | 22 |
| MIN | -0.01 | 7.44 | 23 | -0.02 | 0.00 | 22 | | | |
| | 0.00 | 7.44 | 24 | -0.02 | 0.00 | 22 | 0.86 C | 0.00 | 23 |
| 41 MAX | 0.04 | 0.00 | 23 | 0.13 | 0.00 | 22 | | | |
| | 0.03 | 0.00 | 22 | 0.12 | 5.25 | 22 | 3.31 C | 0.00 | 22 |
| MIN | 0.00 | 5.25 | 24 | -0.07 | 5.25 | 22 | | | |
| | 0.00 | 5.25 | 24 | -0.04 | 0.00 | 22 | 0.02 C | 5.25 | 24 |
| 42 MAX | 0.04 | 0.00 | 22 | 0.11 | 0.00 | 22 | | | |
| | 0.06 | 0.00 | 22 | 0.10 | 5.25 | 22 | 0.58 C | 0.00 | 22 |
| MIN | 0.00 | 5.25 | 24 | -0.10 | 5.25 | 22 | | | |
| | 0.00 | 5.25 | 24 | -0.20 | 0.00 | 22 | 0.06 T | 5.25 | 24 |
| 43 MAX | 0.00 | 0.00 | 21 | 0.01 | 5.25 | 23 | | | |
| | 0.03 | 0.00 | 22 | 0.06 | 5.25 | 22 | 3.19 C | 0.00 | 22 |
| MIN | -0.01 | 5.25 | 23 | -0.05 | 0.00 | 22 | | | |
| | 0.00 | 5.25 | 24 | -0.09 | 0.00 | 22 | 0.09 C | 5.25 | 24 |
| 44 MAX | 0.01 | 0.00 | 23 | 0.01 | 0.00 | 23 | | | |
| | 0.00 | 0.00 | 24 | 0.06 | 0.00 | 22 | 3.19 C | 0.00 | 22 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| MIN | 0.00 | 5.25 | 21 | -0.05 | 5.25 | 22 | | | |
| | -0.03 | 5.25 | 22 | -0.09 | 5.25 | 22 | 0.09 C | 5.25 | 24 |
| 45 MAX | 0.00 | 0.00 | 24 | 0.11 | 5.25 | 22 | | | |
| | 0.00 | 0.00 | 24 | 0.10 | 0.00 | 22 | 0.58 C | 0.00 | 22 |
| MIN | -0.04 | 5.25 | 22 | -0.10 | 0.00 | 22 | | | |
| | -0.06 | 5.25 | 22 | -0.20 | 5.25 | 22 | 0.06 T | 5.25 | 24 |
| 46 MAX | 0.00 | 0.00 | 24 | 0.13 | 5.25 | 22 | | | |
| | 0.00 | 0.00 | 24 | 0.12 | 0.00 | 22 | 3.31 C | 0.00 | 22 |
| MIN | -0.04 | 5.25 | 23 | -0.07 | 0.00 | 22 | | | |
| | -0.03 | 5.25 | 22 | -0.04 | 5.25 | 22 | 0.02 C | 5.25 | 24 |
| 55 MAX | 0.90 | 0.00 | 22 | 2.26 | 0.00 | 22 | | | |
| | 0.00 | 0.00 | 24 | 0.01 | 0.00 | 23 | 0.79 C | 2.06 | 22 |
| MIN | 0.00 | 2.06 | 24 | 0.01 | 2.06 | 24 | | | |
| | 0.00 | 2.06 | 23 | 0.00 | 0.00 | 24 | 0.03 T | 2.06 | 24 |
| 56 MAX | 0.67 | 0.00 | 22 | 0.64 | 0.00 | 22 | | | |
| | 0.00 | 0.00 | 24 | 0.01 | 0.00 | 23 | 1.10 C | 11.34 | 22 |
| MIN | -0.56 | 11.34 | 22 | -1.43 | 6.61 | 22 | | | |
| | 0.00 | 11.34 | 23 | 0.00 | 0.00 | 24 | 0.03 T | 11.34 | 24 |
| 57 MAX | 1.80 | 0.00 | 22 | 4.66 | 0.00 | 22 | | | |
| | 0.00 | 0.00 | 22 | 0.00 | 13.40 | 21 | 2.03 C | 13.40 | 23 |
| MIN | -1.11 | 13.40 | 22 | -2.80 | 7.82 | 22 | | | |
| | 0.00 | 13.40 | 24 | -0.01 | 0.00 | 22 | 0.65 T | 13.40 | 24 |
| 58 MAX | 0.03 | 0.00 | 24 | 1.84 | 2.06 | 22 | | | |
| | -0.06 | 0.00 | 24 | 3.13 | 0.00 | 22 | 0.34 C | 2.06 | 23 |
| MIN | -0.94 | 2.06 | 22 | 0.06 | 2.06 | 24 | | | |
| | -2.02 | 2.06 | 22 | -1.04 | 2.06 | 22 | 2.30 T | 0.00 | 22 |
| 59 MAX | 1.40 | 0.00 | 22 | 1.91 | 0.00 | 22 | | | |
| | 0.06 | 0.00 | 22 | 0.00 | 11.34 | 21 | 1.72 C | 11.34 | 23 |
| MIN | -1.06 | 11.34 | 22 | -2.60 | 6.61 | 22 | | | |
| | 0.00 | 11.34 | 24 | -0.72 | 0.00 | 22 | 1.95 T | 11.34 | 24 |
| 60 MAX | 1.71 | 0.00 | 22 | 3.34 | 0.00 | 22 | | | |
| | 0.00 | 0.00 | 22 | 0.00 | 0.00 | 24 | 0.16 C | 13.40 | 23 |
| MIN | -1.21 | 13.40 | 22 | -3.35 | 7.82 | 22 | | | |
| | 0.00 | 13.40 | 24 | 0.00 | 0.00 | 22 | 1.34 T | 0.00 | 22 |
| 61 MAX | -0.09 | 0.00 | 24 | 1.81 | 2.06 | 22 | | | |
| | 0.00 | 0.00 | 24 | 0.00 | 0.00 | 22 | 1.19 T | 2.06 | 21 |
| MIN | -2.42 | 2.06 | 22 | -2.72 | 0.00 | 22 | | | |
| | 0.00 | 2.06 | 22 | 0.00 | 2.06 | 22 | 4.98 T | 0.00 | 22 |
| 62 MAX | 1.39 | 0.00 | 22 | 1.75 | 0.00 | 22 | | | |
| | 0.00 | 0.00 | 22 | 0.00 | 11.34 | 24 | 0.24 T | 11.34 | 23 |
| MIN | -1.08 | 11.34 | 22 | -2.66 | 6.61 | 22 | | | |
| | 0.00 | 11.34 | 24 | 0.00 | 0.00 | 22 | 3.36 T | 0.00 | 22 |
| 63 MAX | 1.71 | 0.00 | 22 | 3.34 | 0.00 | 22 | | | |
| | 0.00 | 0.00 | 24 | 0.00 | 0.00 | 22 | 0.16 C | 13.40 | 23 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | MIN | -1.21 | 13.40 | 22 | -3.35 | 7.82 | 22 | | | |
| | | 0.00 | 13.40 | 22 | 0.00 | 0.00 | 24 | 1.34 T | 0.00 | 22 |
| 64 | MAX | 0.03 | 0.00 | 24 | 1.84 | 2.06 | 22 | | | |
| | | 2.02 | 0.00 | 22 | 1.04 | 2.06 | 22 | 0.34 C | 2.06 | 23 |
| | MIN | -0.94 | 2.06 | 22 | 0.06 | 2.06 | 24 | | | |
| | | 0.06 | 2.06 | 24 | -3.13 | 0.00 | 22 | 2.30 T | 0.00 | 22 |
| 65 | MAX | 1.40 | 0.00 | 22 | 1.91 | 0.00 | 22 | | | |
| | | 0.00 | 0.00 | 24 | 0.72 | 0.00 | 22 | 1.72 C | 11.34 | 23 |
| | MIN | -1.06 | 11.34 | 22 | -2.60 | 6.61 | 22 | | | |
| | | -0.06 | 11.34 | 22 | 0.00 | 11.34 | 22 | 1.95 T | 11.34 | 24 |
| 66 | MAX | 1.80 | 0.00 | 22 | 4.66 | 0.00 | 22 | | | |
| | | 0.00 | 0.00 | 24 | 0.01 | 0.00 | 22 | 2.03 C | 13.40 | 23 |
| | MIN | -1.11 | 13.40 | 22 | -2.80 | 7.82 | 22 | | | |
| | | 0.00 | 13.40 | 22 | 0.00 | 13.40 | 24 | 0.65 T | 13.40 | 24 |
| 67 | MAX | 0.90 | 0.00 | 22 | 2.26 | 0.00 | 22 | | | |
| | | 0.00 | 0.00 | 23 | 0.00 | 0.00 | 24 | 0.79 C | 2.06 | 22 |
| | MIN | 0.00 | 2.06 | 24 | 0.01 | 2.06 | 24 | | | |
| | | 0.00 | 2.06 | 24 | -0.01 | 0.00 | 23 | 0.03 T | 2.06 | 24 |
| 68 | MAX | 0.67 | 0.00 | 22 | 0.64 | 0.00 | 22 | | | |
| | | 0.00 | 0.00 | 23 | 0.00 | 0.00 | 24 | 1.10 C | 11.34 | 22 |
| | MIN | -0.56 | 11.34 | 22 | -1.43 | 6.61 | 22 | | | |
| | | 0.00 | 11.34 | 24 | -0.01 | 0.00 | 23 | 0.03 T | 11.34 | 24 |
| 69 | MAX | 0.60 | 0.00 | 22 | 1.13 | 4.00 | 24 | | | |
| | | 0.04 | 0.00 | 23 | 0.34 | 0.00 | 22 | 0.02 T | 0.00 | 23 |
| | MIN | -0.96 | 4.00 | 22 | -0.43 | 4.00 | 23 | | | |
| | | -0.45 | 4.00 | 22 | -0.66 | 4.00 | 22 | 0.17 T | 4.00 | 22 |
| 70 | MAX | 1.32 | 0.00 | 22 | 1.16 | 0.00 | 24 | | | |
| | | 0.42 | 0.00 | 22 | 0.37 | 4.00 | 22 | 6.58 C | 0.00 | 22 |
| | MIN | -0.24 | 4.00 | 22 | -1.52 | 3.33 | 22 | | | |
| | | -0.08 | 4.00 | 23 | -0.52 | 0.00 | 22 | 1.03 C | 4.00 | 23 |
| 71 | MAX | 0.09 | 0.00 | 24 | 1.58 | 4.00 | 22 | | | |
| | | 0.00 | 0.00 | 23 | 0.43 | 0.00 | 22 | 6.56 C | 0.00 | 22 |
| | MIN | -1.59 | 4.00 | 22 | -1.68 | 0.00 | 22 | | | |
| | | -0.52 | 4.00 | 22 | -0.86 | 4.00 | 22 | 1.02 C | 4.00 | 23 |
| 72 | MAX | 1.59 | 0.00 | 22 | 1.58 | 0.00 | 22 | | | |
| | | 0.52 | 0.00 | 22 | 0.43 | 4.00 | 22 | 6.56 C | 0.00 | 22 |
| | MIN | -0.09 | 4.00 | 24 | -1.68 | 4.00 | 22 | | | |
| | | 0.00 | 4.00 | 23 | -0.86 | 0.00 | 22 | 1.02 C | 4.00 | 23 |
| 73 | MAX | 0.24 | 0.00 | 22 | 1.16 | 4.00 | 24 | | | |
| | | 0.08 | 0.00 | 23 | 0.37 | 0.00 | 22 | 6.58 C | 0.00 | 22 |
| | MIN | -1.32 | 4.00 | 22 | -1.52 | 0.67 | 22 | | | |
| | | -0.42 | 4.00 | 22 | -0.52 | 4.00 | 22 | 1.03 C | 4.00 | 23 |
| 74 | MAX | 0.96 | 0.00 | 22 | 1.13 | 0.00 | 24 | | | |
| | | 0.45 | 0.00 | 22 | 0.34 | 4.00 | 22 | 0.02 T | 0.00 | 23 |

```
    MIN     -0.60   4.00    22       -0.43   0.00    23
            -0.04   4.00    23       -0.66   0.00    22       0.17 T   4.00    22


 ********** END OF FORCE ENVELOPE FROM INTERNAL STORAGE **********


 123. FINISH


          *********** END OF THE STAAD.Pro RUN ***********

            **** DATE= FEB 23,2007   TIME= 17:17:50 ****

      ************************************************************
      *          For questions on STAAD.Pro, please contact       *
      *    Research Engineers Offices at the following locations  *
      *                                                           *
      *                 Telephone                 Email           *
      *  USA:       +1 (714)974-2500        support@reiusa.com    *
      *  CANADA     +1 (905)632-4771        detech@odandetech.com *
      *  CANADA     +1 (604)629 6087        staad@dowco.com       *
      *  UK         +44(1454)207-000        support@reel.co.uk    *
      *  FRANCE     +33(0)1 64551084        support@reel.co.uk    *
      *  GERMANY    +49/931/40468-71        info@reig.de          *
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      *  JAPAN      +81(03)5952-6500        eng-eye@crc.co.jp     *
      *  CHINA      +86(411)363-1983        support@reiasia.net   *
      *  THAILAND   +66(0)2645-1018/19     support@thai.reiusa.com *
      *                                                           *
      *  North America                     support@reiusa.com     *
      *  Europe                            support@reel.co.uk     *
      *  Asia                              support@reiasia.net    *
      ************************************************************
```
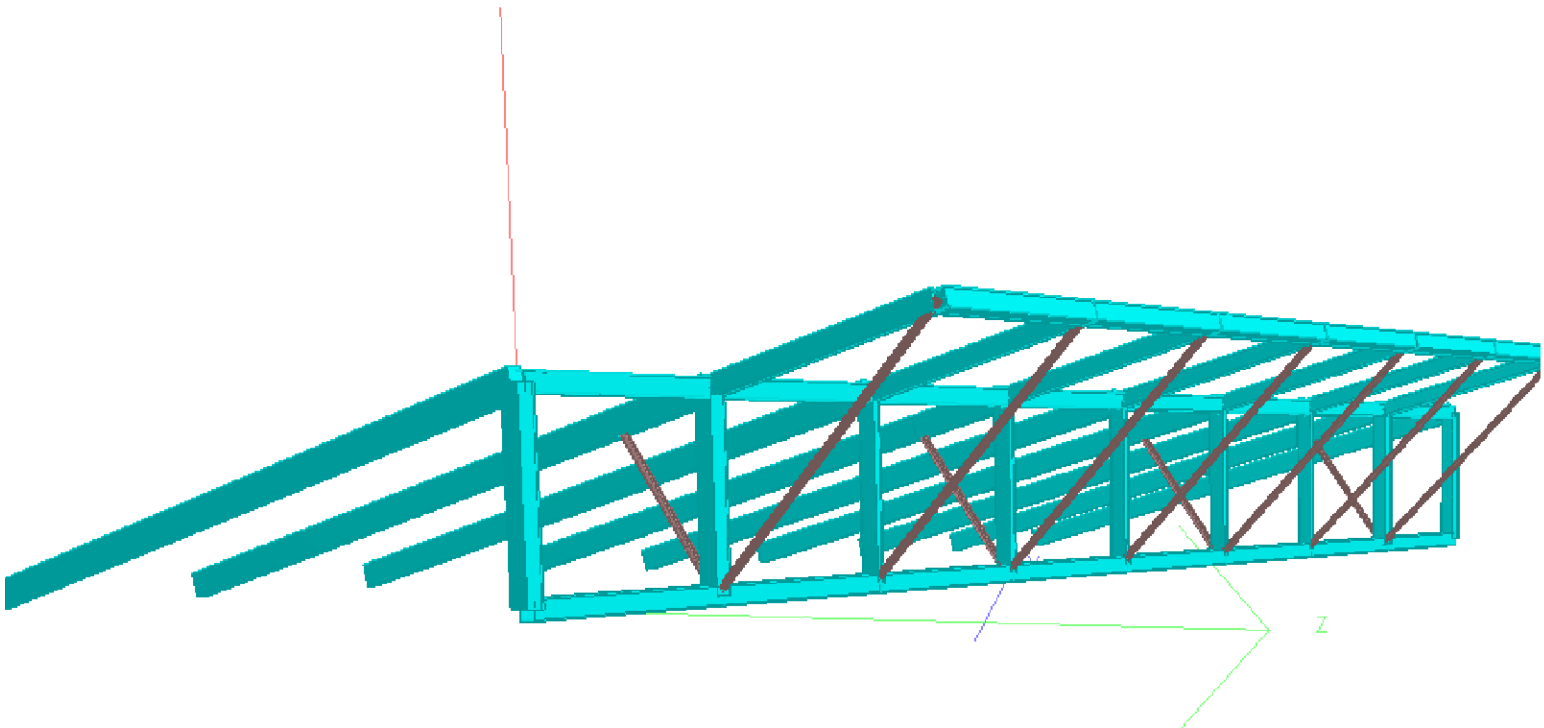

| **_Truss Design** | Completed By | Revised By | DCN # | |
|---|---|---|---|---|
| Appendix 4.04 | Gimbet, Milinichik | Glantz, Owens | S-45 | |

*Conclusions: The following is the STAAD output data for the design of the Truss on the north wall of the living space. This STAAD file is composed of multiple elements including the outriggers to support the truss from the north and south, the breezeway steel frame, the living space SIP internal 2 x 6 framing of Southern Pine No.1 dimensional lumber. The outriggers in this model are framed in plane to the 2 x 6 internal supporting lumber of the living space SIP design.*


Z

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****************************************************
*                                                  *
*           STAAD.Pro                              *
*           Version  2006    Bld 1002.US           *
*           Proprietary Program of                 *
*           Research Engineers,  Intl.             *
*           Date=    FEB 28, 2007                  *
*           Time=    23:36:23                      *
*                                                  *
*      USER ID: ae                                 *
****************************************************
```

```
     1. STAAD SPACE
INPUT FILE: S-44 LS Truss Tree Structure with SIPS 4X4 Vier Releases Rev LDs2.STD
     2. START JOB INFORMATION
     3. ENGINEER DATE 01-FEB-07
     4. END JOB INFORMATION
     5. INPUT WIDTH 79
     6. UNIT FEET KIP
     7. JOINT COORDINATES
     8. 1 0 0 0; 2 4 0 0; 3 8 0 0; 4 12 0 0; 5 16 0 0; 6 20 0 0; 7 24 0 0; 8 28 0 0
     9. 9 32 0 0; 10 0 3.25 0; 11 4 3.25 0; 12 8 3.25 0; 13 12 3.25 0; 14 16 3.25 0
    10. 15 20 3.25 0; 16 24 3.25 0; 17 28 3.25 0; 18 32 3.25 0; 19 8 4.375 4.5
    11. 20 16 4.375 4.5; 21 24 4.375 4.5; 23 4 2.75 -2; 24 20 2.75 -2; 25 28 2.75 -2
    12. 26 0 2.75 -2; 27 32 2.75 -2; 28 4 4.375 4.5; 29 12 4.375 4.5; 30 20 4.375
4.5
    13. 31 28 4.375 4.5; 32 0 0 -13; 33 4 0 -13; 34 8 0 -13; 35 12 0 -13; 36 16 0
-13
    14. 37 20 0 -13; 38 24 0 -13; 39 28 0 -13; 40 32 0 -13; 41 12 2.75 -2
    15. MEMBER INCIDENCES
    16. 1 1 2; 2 2 3; 3 3 4; 4 4 5; 5 5 6; 6 6 7; 7 7 8; 8 8 9; 9 10 11; 10 11 12
    17. 11 12 13; 12 13 14; 13 14 15; 14 15 16; 15 16 17; 16 17 18; 17 10 1; 18 11 2
    18. 19 12 3; 20 13 4; 21 14 5; 22 15 6; 23 16 7; 24 17 8; 25 18 9; 26 11 28
    19. 27 12 19; 28 13 29; 29 14 20; 30 15 30; 31 16 21; 32 17 31; 34 2 28; 35 3 19
    20. 36 4 29; 37 5 20; 38 6 30; 39 7 21; 40 8 31; 41 2 23; 42 41 4; 44 24 6
    21. 46 25 8; 55 10 26; 56 26 32; 57 23 33; 58 11 23; 59 12 34; 60 41 35; 61 13
41
    22. 62 14 36; 63 15 37; 64 17 25; 65 16 38; 66 17 39; 67 18 27; 68 27 40; 69 28
19
    23. 70 19 29; 71 29 20; 72 20 30; 73 30 21; 74 21 31
    24. DEFINE MATERIAL START
    25. ISOTROPIC STEEL
    26. E 4.176E+006
    27. POISSON 0.3
    28. DENSITY 0.489024
    29. ALPHA 6.5E-006
    30. DAMP 0.03
    31. ISOTROPIC SOUTH
    32. E 259200
    33. POISSON 0.3
    34. DENSITY 9.383E-005
    35. ALPHA 3E-006
    36. END DEFINE MATERIAL
    37. MEMBER PROPERTY AMERICAN
    38. 1 TO 18 24 TO 26 32 69 TO 74 TABLE ST HSST4X4X0.313
    39. MEMBER PROPERTY AMERICAN
    40. 55 TO 68 PRIS YD 0.458333 ZD 0.25
```

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41. 19 TO 23 27 TO 31 TABLE ST HSST4X2X0.313
42. 34 TO 42 44 46 TABLE ST HSSP1.66X0.14
43. CONSTANTS
44. BETA 345.96 MEMB 69 TO 74
45. BETA 90 MEMB 19 TO 23
46. MATERIAL STEEL MEMB 1 TO 32 34 TO 42 44 46 69 TO 74
47. MATERIAL SOUTH MEMB 55 TO 68
48. SUPPORTS
49. 1 2 8 9 32 TO 40 PINNED
50. MEMBER RELEASE
51. 34 TO 39 41 42 44 46 START MX MY MZ
52. 34 TO 38 41 42 44 46 END MX MY MZ
53. LOAD 1 LOADTYPE GRAVITY  TITLE SELF-WEIGHT
54. SELFWEIGHT Y -1
55. LOAD 2 LOADTYPE DEAD  TITLE PV LS SIP LS INSUL LS
56. MEMBER LOAD
57. 55 56 67 68 UNI GY -0.0275
58. LOAD 3 LOADTYPE DEAD  TITLE PV LS SIP LS INSUL LS
59. MEMBER LOAD
60. 57 TO 66 UNI GY -0.055
61. LOAD 4 LOADTYPE DEAD  TITLE SKYLIGHT LS
62. MEMBER LOAD
63. 61 62 UNI GY -0.00875
64. LOAD 5 LOADTYPE DEAD  TITLE STL FRAME TRUSS TRUSS
65. MEMBER LOAD
66. 9 TO 16 UNI GY -0.02454
67. LOAD 6 LOADTYPE DEAD  TITLE STL FRAME BZWY OR
68. MEMBER LOAD
69. 69 TO 74 UNI GY -0.03756
70. LOAD 7 LOADTYPE SNOW  TITLE SNOW
71. MEMBER LOAD
72. 55 56 67 68 UNI GY -0.07
73. LOAD 8 LOADTYPE SNOW  TITLE SNOW LS
74. MEMBER LOAD
75. 57 TO 66 UNI GY -0.14
76. LOAD 9 LOADTYPE SNOW  TITLE SNOW TRUSS PV TRUSS EV TRUSS
77. MEMBER LOAD
78. 9 TO 16 UNI GY -0.09355
79. LOAD 10 LOADTYPE SNOW  TITLE SNOW BZWY OR BZWY OR BZWY OR
80. MEMBER LOAD
81. 69 TO 74 UNI GY -0.25063
82. LOAD COMB 11 (1.2) DEAD + (1.6) LIVE
83. 1 1.2 2 1.2 3 1.2 4 1.2 5 1.2 6 1.2 7 1.6 8 1.6 9 1.6 10 1.6
84. LOAD COMB 12 SERVICE LOAD
85. 1 1.0 2 1.0 3 1.0 4 1.0 5 1.0 6 1.0 7 1.0 8 1.0 9 1.0 10 1.0
86. PERFORM ANALYSIS
```



P R O B L E M   S T A T I S T I C S
-----------------------------------

```
NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS =    40/    63/    13
ORIGINAL/FINAL BAND-WIDTH=    36/     7/     45 DOF
TOTAL PRIMARY LOAD CASES =   10, TOTAL DEGREES OF FREEDOM =    201
SIZE OF STIFFNESS MATRIX =        10 DOUBLE  KILO-WORDS
REQRD/AVAIL. DISK SPACE  =     12.2/ 151549.2 MB
```

```
   ZERO STIFFNESS IN DIRECTION 1 AT JOINT     24 EQN.NO.     136
         LOADS APPLIED OR DISTRIBUTED HERE FROM ELEMENTS WILL BE IGNORED.
         THIS MAY BE DUE TO ALL MEMBERS AT THIS JOINT BEING RELEASED OR
         EFFECTIVELY RELEASED IN THIS DIRECTION.
   ZERO STIFFNESS IN DIRECTION 4 AT JOINT     24 EQN.NO.     139
   ZERO STIFFNESS IN DIRECTION 5 AT JOINT     24 EQN.NO.     140
   ZERO STIFFNESS IN DIRECTION 6 AT JOINT     24 EQN.NO.     141

***WARNING -  INSTABILITY AT JOINT    24   DIRECTION = FZ
 PROBABLE CAUSE SINGULAR-ADDING WEAK SPRING
 K-MATRIX DIAG=  1.5366646E+02 L-MATRIX DIAG=  0.0000000E+00 EQN NO     138
 ***NOTE - VERY WEAK SPRING ADDED FOR STABILITY

   **NOTE** STAAD DETECTS INSTABILITIES AS EXCESSIVE LOSS OF SIGNIFICANT DIGITS
            DURING DECOMPOSITION. WHEN A DECOMPOSED DIAGONAL IS LESS THAN THE
            BUILT-IN REDUCTION FACTOR TIMES THE ORIGINAL STIFFNESS MATRIX DIAGONAL,
            STAAD PRINTS A SINGULARITY NOTICE. THE BUILT-IN REDUCTION FACTOR
            IS   1.000E-09

            THE ABOVE CONDITIONS COULD ALSO BE CAUSED BY VERY STIFF OR VERY WEAK
            ELEMENTS AS WELL AS TRUE SINGULARITIES.



   87. LOAD LIST 11 12
   88. PRINT JOINT DISPLACEMENTS ALL
   STAAD SPACE                                              -- PAGE NO.    4



  JOINT DISPLACEMENT (INCH RADIANS)    STRUCTURE TYPE = SPACE
  ------------------
```

| JOINT | LOAD | X-TRANS | Y-TRANS | Z-TRANS | X-ROTAN | Y-ROTAN | Z-ROTAN |
|---|---|---|---|---|---|---|---|
| 1 | 11 | 0.00000 | 0.00000 | 0.00000 | 0.00050 | 0.00035 | 0.00045 |
| | 12 | 0.00000 | 0.00000 | 0.00000 | 0.00033 | 0.00026 | 0.00030 |
| 2 | 11 | 0.00000 | 0.00000 | 0.00000 | 0.00059 | -0.00071 | -0.00396 |
| | 12 | 0.00000 | 0.00000 | 0.00000 | 0.00037 | -0.00054 | -0.00266 |
| 3 | 11 | -0.00217 | -0.73964 | 0.08205 | 0.00331 | -0.00320 | -0.01722 |
| | 12 | -0.00146 | -0.49698 | 0.06111 | 0.00207 | -0.00229 | -0.01157 |
| 4 | 11 | -0.00187 | -1.53099 | 0.26348 | 0.00334 | -0.00301 | -0.01091 |
| | 12 | -0.00126 | -1.02917 | 0.18840 | 0.00197 | -0.00210 | -0.00734 |
| 5 | 11 | 0.00002 | -1.82978 | 0.32074 | 0.00455 | 0.00043 | 0.00013 |
| | 12 | 0.00001 | -1.23022 | 0.22898 | 0.00273 | 0.00029 | 0.00009 |
| 6 | 11 | 0.00190 | -1.52032 | 0.23308 | 0.00491 | 0.00314 | 0.01096 |
| | 12 | 0.00128 | -1.02196 | 0.16810 | 0.00302 | 0.00219 | 0.00737 |
| 7 | 11 | 0.00218 | -0.73378 | 0.06781 | 0.00414 | 0.00274 | 0.01707 |
| | 12 | 0.00147 | -0.49301 | 0.05160 | 0.00262 | 0.00198 | 0.01148 |
| 8 | 11 | 0.00000 | 0.00000 | 0.00000 | 0.00144 | 0.00064 | 0.00393 |
| | 12 | 0.00000 | 0.00000 | 0.00000 | 0.00094 | 0.00049 | 0.00264 |
| 9 | 11 | 0.00000 | 0.00000 | 0.00000 | 0.00072 | -0.00030 | -0.00044 |
| | 12 | 0.00000 | 0.00000 | 0.00000 | 0.00048 | -0.00023 | -0.00029 |
| 10 | 11 | 0.01286 | 0.00044 | -0.00712 | -0.00161 | 0.00037 | 0.00053 |
| | 12 | 0.00865 | 0.00029 | -0.00481 | -0.00108 | 0.00026 | 0.00036 |
| 11 | 11 | 0.01350 | -0.00246 | 0.01164 | 0.00045 | -0.00200 | -0.00469 |
| | 12 | 0.00908 | -0.00166 | 0.00744 | 0.00029 | -0.00134 | -0.00314 |
| 12 | 11 | 0.01101 | -0.74002 | 0.19014 | 0.00032 | -0.00443 | -0.01700 |
| | 12 | 0.00740 | -0.49724 | 0.12758 | 0.00006 | -0.00299 | -0.01143 |
| 13 | 11 | 0.00606 | -1.52965 | 0.37807 | 0.00271 | -0.00303 | -0.01098 |
| | 12 | 0.00408 | -1.02828 | 0.25414 | 0.00153 | -0.00204 | -0.00738 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 14 | 11 | -0.00048 | -1.83035 | 0.45511 | 0.00074 | 0.00003 | 0.00010 |
| | 12 | -0.00031 | -1.23060 | 0.30597 | 0.00016 | 0.00002 | 0.00007 |
| 15 | 11 | -0.00699 | -1.52095 | 0.37624 | 0.00055 | 0.00306 | 0.01105 |
| | 12 | -0.00469 | -1.02238 | 0.25290 | 0.00010 | 0.00206 | 0.00743 |
| 16 | 11 | -0.01191 | -0.73421 | 0.18828 | -0.00004 | 0.00435 | 0.01687 |
| | 12 | -0.00800 | -0.49331 | 0.12633 | -0.00018 | 0.00293 | 0.01134 |
| 17 | 11 | -0.01439 | -0.00390 | 0.01446 | -0.00135 | 0.00194 | 0.00468 |
| | 12 | -0.00966 | -0.00263 | 0.00933 | -0.00092 | 0.00130 | 0.00314 |
| 18 | 11 | -0.01375 | 0.00044 | -0.00722 | -0.00191 | -0.00027 | -0.00049 |
| | 12 | -0.00923 | 0.00029 | -0.00488 | -0.00128 | -0.00019 | -0.00033 |
| 19 | 11 | -0.00320 | -0.91674 | 0.23579 | 0.00389 | -0.00448 | -0.01858 |
| | 12 | -0.00212 | -0.60703 | 0.15600 | 0.00244 | -0.00297 | -0.01233 |
| 20 | 11 | -0.00319 | -2.02705 | 0.50465 | 0.00482 | -0.00005 | -0.00021 |
| | 12 | -0.00211 | -1.34411 | 0.33458 | 0.00291 | -0.00003 | -0.00014 |
| 21 | 11 | -0.00319 | -0.92690 | 0.23788 | 0.00462 | 0.00454 | 0.01882 |
| | 12 | -0.00211 | -0.61375 | 0.15738 | 0.00293 | 0.00302 | 0.01248 |
| 23 | 11 | 0.02855 | -0.00716 | 0.00940 | -0.00459 | -0.00163 | -0.00478 |
| | 12 | 0.01924 | -0.00502 | 0.00605 | -0.00309 | -0.00110 | -0.00321 |
| 24 | 11 | 0.00000 | -150.74271 | -204.94771 | 0.00000 | 0.00000 | 0.00000 |
| | 12 | 0.00000 | -125.35497 | -170.78975 | 0.00000 | 0.00000 | 0.00000 |
| 25 | 11 | -0.03287 | 0.00593 | 0.01165 | 0.00131 | 0.00194 | 0.00468 |
| | 12 | -0.02215 | 0.00374 | 0.00750 | 0.00087 | 0.00130 | 0.00314 |



JOINT DISPLACEMENT (INCH RADIANS)    STRUCTURE TYPE = SPACE
------------------

| JOINT | LOAD | X-TRANS | Y-TRANS | Z-TRANS | X-ROTAN | Y-ROTAN | Z-ROTAN |
|---|---|---|---|---|---|---|---|
| 26 | 11 | 0.00791 | -0.14603 | 0.03041 | -0.00902 | 0.00031 | 0.00055 |
| | 12 | 0.00506 | -0.09821 | 0.02043 | -0.00606 | 0.00022 | 0.00037 |
| 27 | 11 | -0.01058 | -0.15167 | 0.03172 | -0.00919 | -0.00025 | -0.00050 |
| | 12 | -0.00684 | -0.10200 | 0.02132 | -0.00618 | -0.00017 | -0.00034 |
| 28 | 11 | -0.00323 | -0.04646 | 0.02404 | 0.00145 | -0.00407 | -0.01656 |
| | 12 | -0.00214 | -0.03013 | 0.01548 | 0.00092 | -0.00270 | -0.01097 |
| 29 | 11 | -0.00319 | -1.70764 | 0.42356 | 0.00388 | -0.00307 | -0.01257 |
| | 12 | -0.00212 | -1.13198 | 0.28071 | 0.00233 | -0.00204 | -0.00835 |
| 30 | 11 | -0.00319 | -1.72367 | 0.42712 | 0.00507 | 0.00303 | 0.01247 |
| | 12 | -0.00211 | -1.14260 | 0.28308 | 0.00312 | 0.00201 | 0.00828 |
| 31 | 11 | -0.00317 | -0.04372 | 0.02551 | 0.00217 | 0.00406 | 0.01672 |
| | 12 | -0.00210 | -0.02826 | 0.01645 | 0.00141 | 0.00269 | 0.01108 |
| 32 | 11 | 0.00000 | 0.00000 | 0.00000 | 0.01438 | 0.00015 | 0.00059 |
| | 12 | 0.00000 | 0.00000 | 0.00000 | 0.00967 | 0.00009 | 0.00040 |
| 33 | 11 | 0.00000 | 0.00000 | 0.00000 | 0.01888 | -0.00071 | -0.00501 |
| | 12 | 0.00000 | 0.00000 | 0.00000 | 0.01270 | -0.00047 | -0.00336 |
| 34 | 11 | 0.00000 | 0.00000 | 0.00000 | 0.03416 | -0.00408 | -0.01709 |
| | 12 | 0.00000 | 0.00000 | 0.00000 | 0.02304 | -0.00274 | -0.01149 |
| 35 | 11 | 0.00000 | 0.00000 | 0.00000 | 0.03354 | -0.00257 | -0.01109 |
| | 12 | 0.00000 | 0.00000 | 0.00000 | 0.02274 | -0.00173 | -0.00746 |
| 36 | 11 | 0.00000 | 0.00000 | 0.00000 | 0.04539 | 0.00002 | 0.00010 |
| | 12 | 0.00000 | 0.00000 | 0.00000 | 0.03085 | 0.00001 | 0.00007 |
| 37 | 11 | 0.00000 | 0.00000 | 0.00000 | 0.04153 | 0.00258 | 0.01117 |
| | 12 | 0.00000 | 0.00000 | 0.00000 | 0.02806 | 0.00173 | 0.00751 |
| 38 | 11 | 0.00000 | 0.00000 | 0.00000 | 0.03428 | 0.00405 | 0.01694 |
| | 12 | 0.00000 | 0.00000 | 0.00000 | 0.02312 | 0.00272 | 0.01139 |
| 39 | 11 | 0.00000 | 0.00000 | 0.00000 | 0.02794 | 0.00072 | 0.00498 |
| | 12 | 0.00000 | 0.00000 | 0.00000 | 0.01879 | 0.00048 | 0.00334 |
| 40 | 11 | 0.00000 | 0.00000 | 0.00000 | 0.01453 | -0.00019 | -0.00051 |
| | 12 | 0.00000 | 0.00000 | 0.00000 | 0.00977 | -0.00012 | -0.00035 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 41 | 11 | 0.01124 | -1.47100 | 0.36255 | -0.00072 | -0.00290 | -0.01101 |
| | 12 | 0.00761 | -0.99571 | 0.24543 | -0.00072 | -0.00195 | -0.00741 |

************** END OF LATEST ANALYSIS RESULT **************

89. PRINT SUPPORT REACTION ALL
STAAD SPACE -- PAGE NO. 6

SUPPORT REACTIONS -UNIT KIP FEET STRUCTURE TYPE = SPACE
-----------------

| JOINT | LOAD | FORCE-X | FORCE-Y | FORCE-Z | MOM-X | MOM-Y | MOM Z |
|---|---|---|---|---|---|---|---|
| 1 | 11 | -1.59 | -3.58 | -0.48 | 0.00 | 0.00 | 0.00 |
| | 12 | -1.07 | -2.39 | -0.30 | 0.00 | 0.00 | 0.00 |
| 2 | 11 | 13.09 | 22.82 | 0.17 | 0.00 | 0.00 | 0.00 |
| | 12 | 8.79 | 15.33 | -0.01 | 0.00 | 0.00 | 0.00 |
| 8 | 11 | -13.08 | 23.34 | 1.08 | 0.00 | 0.00 | 0.00 |
| | 12 | -8.78 | 15.67 | 0.60 | 0.00 | 0.00 | 0.00 |
| 9 | 11 | 1.58 | -3.56 | -0.57 | 0.00 | 0.00 | 0.00 |
| | 12 | 1.06 | -2.37 | -0.36 | 0.00 | 0.00 | 0.00 |
| 32 | 11 | 0.00 | 1.06 | 1.27 | 0.00 | 0.00 | 0.00 |
| | 12 | 0.00 | 0.71 | 0.86 | 0.00 | 0.00 | 0.00 |
| 33 | 11 | 0.00 | 0.92 | -1.48 | 0.00 | 0.00 | 0.00 |
| | 12 | 0.00 | 0.64 | -0.93 | 0.00 | 0.00 | 0.00 |
| 34 | 11 | 0.00 | 1.30 | -0.79 | 0.00 | 0.00 | 0.00 |
| | 12 | 0.00 | 0.88 | -0.50 | 0.00 | 0.00 | 0.00 |
| 35 | 11 | 0.00 | 1.66 | 1.13 | 0.00 | 0.00 | 0.00 |
| | 12 | 0.00 | 1.12 | 0.76 | 0.00 | 0.00 | 0.00 |
| 36 | 11 | 0.00 | 1.74 | 0.53 | 0.00 | 0.00 | 0.00 |
| | 12 | 0.00 | 1.18 | 0.36 | 0.00 | 0.00 | 0.00 |
| 37 | 11 | 0.00 | 1.74 | 0.79 | 0.00 | 0.00 | 0.00 |
| | 12 | 0.00 | 1.17 | 0.53 | 0.00 | 0.00 | 0.00 |
| 38 | 11 | 0.00 | 1.32 | -0.72 | 0.00 | 0.00 | 0.00 |
| | 12 | 0.00 | 0.90 | -0.45 | 0.00 | 0.00 | 0.00 |
| 39 | 11 | 0.00 | 0.91 | -2.23 | 0.00 | 0.00 | 0.00 |
| | 12 | 0.00 | 0.63 | -1.43 | 0.00 | 0.00 | 0.00 |
| 40 | 11 | 0.00 | 1.07 | 1.29 | 0.00 | 0.00 | 0.00 |
| | 12 | 0.00 | 0.72 | 0.87 | 0.00 | 0.00 | 0.00 |

************** END OF LATEST ANALYSIS RESULT **************

90. PRINT MAXFORCE ENVELOPE ALL
STAAD SPACE -- PAGE NO. 7

MEMBER FORCE ENVELOPE
---------------------

ALL UNITS ARE KIP FEET

MAX AND MIN FORCE VALUES AMONGST ALL SECTION LOCATIONS

| MEMB | | FY/ FZ | DIST DIST | LD LD | MZ/ MY | DIST DIST | LD LD | FX | DIST | LD |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | MAX | -1.52 | 0.00 | 12 | 6.65 | 4.00 | 11 | | | |
| | | 0.24 | 0.00 | 11 | 0.96 | 4.00 | 11 | 0.00 | 0.00 | 11 |
| | MIN | -2.33 | 4.00 | 11 | -2.54 | 0.00 | 11 | | | |
| | | 0.18 | 4.00 | 12 | 0.00 | 0.00 | 12 | 0.00 | 4.00 | 12 |
| 2 | MAX | 6.35 | 0.00 | 11 | 18.76 | 0.00 | 11 | | | |
| | | 0.33 | 0.00 | 11 | 1.80 | 4.00 | 11 | 5.38 C | 0.00 | 11 |
| | MIN | 4.21 | 4.00 | 12 | -6.52 | 4.00 | 11 | | | |
| | | 0.18 | 4.00 | 12 | 0.44 | 0.00 | 12 | 3.62 C | 4.00 | 12 |
| 3 | MAX | 3.21 | 0.00 | 11 | 3.48 | 0.00 | 11 | | | |
| | | -0.59 | 0.00 | 12 | 1.67 | 0.00 | 11 | 0.51 T | 0.00 | 12 |
| | MIN | 2.11 | 4.00 | 12 | -9.24 | 4.00 | 11 | | | |
| | | -0.88 | 4.00 | 11 | -1.85 | 4.00 | 11 | 0.75 T | 4.00 | 11 |
| 4 | MAX | 1.13 | 0.00 | 11 | -1.92 | 0.00 | 12 | | | |
| | | 0.13 | 0.00 | 11 | -0.93 | 4.00 | 12 | 3.15 T | 0.00 | 12 |
| | MIN | 0.71 | 4.00 | 12 | -7.26 | 4.00 | 11 | | | |
| | | 0.08 | 4.00 | 12 | -1.85 | 0.00 | 11 | 4.68 T | 4.00 | 11 |
| 5 | MAX | -0.77 | 0.00 | 12 | -1.74 | 4.00 | 12 | | | |
| | | 0.06 | 0.00 | 11 | -0.79 | 4.00 | 12 | 3.12 T | 0.00 | 12 |
| | MIN | -1.21 | 4.00 | 11 | -7.32 | 0.00 | 11 | | | |
| | | 0.04 | 4.00 | 12 | -1.36 | 0.00 | 11 | 4.65 T | 4.00 | 11 |
| 6 | MAX | -2.06 | 0.00 | 12 | 3.42 | 4.00 | 11 | | | |
| | | 0.66 | 0.00 | 11 | 1.51 | 4.00 | 11 | 0.47 T | 0.00 | 12 |
| | MIN | -3.14 | 4.00 | 11 | -9.00 | 0.00 | 11 | | | |
| | | 0.45 | 4.00 | 12 | -1.14 | 0.00 | 11 | 0.70 T | 4.00 | 11 |
| 7 | MAX | -4.18 | 0.00 | 12 | 18.62 | 4.00 | 11 | | | |
| | | -0.21 | 0.00 | 12 | 1.68 | 0.00 | 11 | 5.40 C | 0.00 | 11 |
| | MIN | -6.31 | 4.00 | 11 | -6.48 | 0.00 | 11 | | | |
| | | -0.36 | 4.00 | 11 | 0.25 | 4.00 | 11 | 3.63 C | 4.00 | 12 |
| 8 | MAX | 2.32 | 0.00 | 11 | 6.60 | 0.00 | 11 | | | |
| | | -0.17 | 0.00 | 12 | 0.87 | 0.00 | 11 | 0.00 | 0.00 | 11 |
| | MIN | 1.51 | 4.00 | 12 | -2.54 | 4.00 | 11 | | | |
| | | -0.22 | 4.00 | 11 | -0.01 | 4.00 | 12 | 0.00 | 4.00 | 12 |
| 9 | MAX | -1.51 | 0.00 | 12 | 7.96 | 4.00 | 11 | | | |
| | | 0.55 | 0.00 | 11 | 2.20 | 4.00 | 11 | 1.07 T | 0.00 | 12 |



| MEMB | | FY/ FZ | DIST DIST | LD LD | MZ/ MY | DIST DIST | LD LD | FX | DIST | LD |
|---|---|---|---|---|---|---|---|---|---|---|
| | MIN | -3.04 | 4.00 | 11 | -2.63 | 0.00 | 11 | | | |
| | | 0.37 | 4.00 | 12 | -0.01 | 0.00 | 11 | 1.59 T | 4.00 | 11 |
| 10 | MAX | 6.32 | 0.00 | 11 | 17.78 | 0.00 | 11 | | | |
| | | -0.44 | 0.00 | 12 | 2.44 | 0.00 | 11 | 6.17 C | 0.00 | 11 |
| | MIN | 3.72 | 4.00 | 12 | -5.92 | 4.00 | 11 | | | |
| | | -0.66 | 4.00 | 11 | -0.20 | 4.00 | 11 | 4.15 C | 4.00 | 12 |
| 11 | MAX | 3.62 | 0.00 | 11 | 3.94 | 0.00 | 11 | | | |
| | | -0.16 | 0.00 | 12 | -0.12 | 0.00 | 12 | 12.26 C | 0.00 | 11 |
| | MIN | 1.91 | 4.00 | 12 | -8.96 | 4.00 | 11 | | | |
| | | -0.24 | 4.00 | 11 | -1.12 | 4.00 | 11 | 8.24 C | 4.00 | 12 |
| 12 | MAX | 1.47 | 0.00 | 11 | -1.80 | 0.00 | 12 | | | |
| | | -0.09 | 0.00 | 12 | -0.77 | 0.00 | 12 | 16.18 C | 0.00 | 11 |
| | MIN | 0.46 | 4.00 | 12 | -6.99 | 4.00 | 11 | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | -0.13 | 4.00 | 11 | -1.67 | 4.00 | 11 | 10.88 | C | 4.00 | 12 |
| 13 | MAX | -0.51 | 0.00 | 12 | -1.67 | 4.00 | 12 | | | | |
| | | 0.13 | 0.00 | 11 | -0.76 | 4.00 | 12 | 16.14 | C | 0.00 | 11 |
| | MIN | -1.54 | 4.00 | 11 | -7.07 | 0.00 | 11 | | | | |
| | | 0.09 | 4.00 | 12 | -1.66 | 0.00 | 11 | 10.84 | C | 4.00 | 12 |
| 14 | MAX | -1.88 | 0.00 | 12 | 3.96 | 4.00 | 11 | | | | |
| | | 0.28 | 0.00 | 11 | -0.03 | 4.00 | 12 | 12.19 | C | 0.00 | 11 |
| | MIN | -3.58 | 4.00 | 11 | -8.79 | 0.00 | 11 | | | | |
| | | 0.18 | 4.00 | 12 | -1.15 | 0.00 | 11 | 8.19 | C | 4.00 | 12 |
| 15 | MAX | -3.65 | 0.00 | 12 | 17.51 | 4.00 | 11 | | | | |
| | | 0.62 | 0.00 | 11 | 2.36 | 4.00 | 11 | 6.14 | C | 0.00 | 11 |
| | MIN | -6.21 | 4.00 | 11 | -5.77 | 0.00 | 11 | | | | |
| | | 0.42 | 4.00 | 12 | -0.14 | 0.00 | 11 | 4.12 | C | 4.00 | 12 |
| 16 | MAX | 3.02 | 0.00 | 11 | 7.89 | 0.00 | 11 | | | | |
| | | -0.34 | 0.00 | 12 | 2.02 | 0.00 | 11 | 1.06 | T | 0.00 | 12 |
| | MIN | 1.50 | 4.00 | 12 | -2.61 | 4.00 | 11 | | | | |
| | | -0.50 | 4.00 | 11 | 0.01 | 4.00 | 11 | 1.58 | T | 4.00 | 11 |
| 17 | MAX | 1.59 | 0.00 | 11 | 2.63 | 0.00 | 11 | | | | |
| | | 0.72 | 0.00 | 11 | -0.01 | 3.25 | 12 | 0.87 | T | 3.25 | 12 |
| | MIN | 1.07 | 3.25 | 12 | -2.54 | 3.25 | 11 | | | | |
| | | 0.49 | 3.25 | 12 | -2.36 | 0.00 | 11 | 1.37 | T | 0.00 | 11 |
| 18 | MAX | -5.17 | 0.00 | 12 | 12.10 | 3.25 | 11 | | | | |
| | | -0.27 | 0.00 | 12 | 0.62 | 0.00 | 11 | 7.52 | C | 3.25 | 11 |
| | MIN | -7.70 | 3.25 | 11 | -12.93 | 0.00 | 11 | | | | |
| | | -0.43 | 3.25 | 11 | -0.78 | 3.25 | 11 | 5.03 | C | 0.00 | 12 |
| 19 | MAX | 1.08 | 0.00 | 11 | 2.70 | 0.00 | 11 | | | | |
| | | 6.14 | 0.00 | 11 | 9.99 | 3.25 | 11 | 0.85 | C | 3.25 | 11 |
| | MIN | 0.72 | 3.25 | 12 | -0.80 | 3.25 | 11 | | | | |
| | | 4.12 | 3.25 | 12 | -9.95 | 0.00 | 11 | 0.55 | C | 0.00 | 12 |
| 20 | MAX | -0.07 | 0.00 | 12 | 0.35 | 3.25 | 11 | | | | |
| | | 3.93 | 0.00 | 11 | 6.38 | 3.25 | 11 | 1.92 | T | 3.25 | 12 |



| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | MIN | -0.09 | 3.25 | 11 | 0.03 | 0.00 | 12 | | | | |
| | | 2.64 | 3.25 | 12 | -6.39 | 0.00 | 11 | 2.94 | T | 0.00 | 11 |
| 21 | MAX | 0.90 | 0.00 | 11 | 2.67 | 0.00 | 11 | | | | |
| | | -0.03 | 0.00 | 12 | 0.06 | 0.00 | 11 | 1.26 | C | 3.25 | 11 |
| | MIN | 0.59 | 3.25 | 12 | -0.25 | 3.25 | 11 | | | | |
| | | -0.04 | 3.25 | 11 | -0.06 | 3.25 | 11 | 0.82 | C | 0.00 | 12 |
| 22 | MAX | 1.06 | 0.00 | 11 | 3.10 | 0.00 | 11 | | | | |
| | | -2.65 | 0.00 | 12 | 6.42 | 0.00 | 11 | 1.40 | C | 3.25 | 11 |
| | MIN | 0.69 | 3.25 | 12 | -0.33 | 3.25 | 11 | | | | |
| | | -3.94 | 3.25 | 11 | -6.40 | 3.25 | 11 | 0.91 | C | 0.00 | 12 |
| 23 | MAX | 1.17 | 0.00 | 11 | 3.23 | 0.00 | 11 | | | | |
| | | -4.09 | 0.00 | 12 | 9.86 | 0.00 | 11 | 0.97 | C | 3.25 | 11 |
| | MIN | 0.78 | 3.25 | 12 | -0.57 | 3.25 | 11 | | | | |
| | | -6.08 | 3.25 | 11 | -9.90 | 3.25 | 11 | 0.63 | C | 0.00 | 12 |
| 24 | MAX | 7.61 | 0.00 | 11 | 12.80 | 0.00 | 11 | | | | |
| | | 0.63 | 0.00 | 11 | -0.34 | 3.25 | 12 | 11.93 | C | 3.25 | 11 |
| | MIN | 5.11 | 3.25 | 12 | -11.95 | 3.25 | 11 | | | | |
| | | 0.44 | 3.25 | 12 | -2.60 | 0.00 | 11 | 7.99 | C | 0.00 | 12 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 25 | MAX | -1.06 | 0.00 | 12 | 2.54 | 3.25 | 11 | | | |
| | | 0.79 | 0.00 | 11 | -0.14 | 3.25 | 12 | 0.86 T | 3.25 | 12 |
| | MIN | -1.58 | 3.25 | 11 | -2.61 | 0.00 | 11 | | | |
| | | 0.53 | 3.25 | 12 | -2.77 | 0.00 | 11 | 1.36 T | 0.00 | 11 |
| 26 | MAX | -0.04 | 0.00 | 12 | 0.72 | 4.64 | 11 | | | |
| | | 0.07 | 0.00 | 11 | -0.12 | 4.64 | 12 | 1.90 T | 0.00 | 12 |
| | MIN | -0.17 | 4.64 | 11 | 0.10 | 0.00 | 12 | | | |
| | | 0.05 | 4.64 | 12 | -0.50 | 0.00 | 11 | 2.92 T | 4.64 | 11 |
| 27 | MAX | 0.69 | 0.00 | 11 | 2.35 | 0.00 | 11 | | | |
| | | -0.03 | 0.00 | 12 | 0.08 | 0.00 | 11 | 1.43 T | 0.00 | 12 |
| | MIN | 0.42 | 4.64 | 12 | -0.72 | 4.64 | 11 | | | |
| | | -0.05 | 4.64 | 11 | -0.13 | 4.64 | 11 | 2.19 T | 4.64 | 11 |
| 28 | MAX | 0.03 | 0.00 | 11 | 0.29 | 0.00 | 11 | | | |
| | | -0.01 | 0.00 | 12 | 0.00 | 0.00 | 11 | 0.96 T | 0.00 | 12 |
| | MIN | -0.03 | 4.64 | 12 | 0.17 | 1.93 | 12 | | | |
| | | -0.01 | 4.64 | 11 | -0.05 | 4.64 | 11 | 1.48 T | 4.64 | 11 |
| 29 | MAX | 0.51 | 0.00 | 11 | 2.06 | 0.00 | 11 | | | |
| | | -0.01 | 0.00 | 12 | 0.02 | 0.00 | 11 | 0.34 T | 0.00 | 12 |
| | MIN | 0.30 | 4.64 | 12 | -0.20 | 4.64 | 11 | | | |
| | | -0.01 | 4.64 | 11 | -0.02 | 4.64 | 11 | 0.54 T | 4.64 | 11 |
| 30 | MAX | 0.56 | 0.00 | 11 | 2.26 | 0.00 | 11 | | | |
| | | 0.00 | 0.00 | 12 | 0.04 | 0.00 | 11 | 0.17 T | 0.00 | 12 |
| | MIN | 0.33 | 4.64 | 12 | -0.21 | 4.64 | 11 | | | |
| | | -0.01 | 4.64 | 11 | 0.01 | 4.64 | 12 | 0.30 T | 4.64 | 11 |
| 31 | MAX | 0.75 | 0.00 | 11 | 2.74 | 0.00 | 11 | | | |
| | | 0.03 | 0.00 | 11 | 0.09 | 4.64 | 11 | 1.39 T | 0.00 | 12 |



| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | MIN | 0.46 | 4.64 | 12 | -0.62 | 4.64 | 11 | | | |
| | | 0.02 | 4.64 | 12 | -0.05 | 0.00 | 11 | 2.13 T | 4.64 | 11 |
| 32 | MAX | 0.36 | 0.00 | 11 | 2.18 | 0.00 | 11 | | | |
| | | -0.08 | 0.00 | 12 | 0.60 | 0.00 | 11 | 1.46 T | 0.00 | 12 |
| | MIN | 0.20 | 4.64 | 12 | 0.42 | 4.64 | 12 | | | |
| | | -0.11 | 4.64 | 11 | 0.05 | 4.64 | 12 | 2.27 T | 4.64 | 11 |
| 34 | MAX | 0.01 | 0.00 | 11 | 0.00 | 0.00 | 11 | | | |
| | | 0.00 | 0.00 | 12 | 0.00 | 0.00 | 11 | 3.65 C | 0.00 | 11 |
| | MIN | -0.01 | 6.28 | 11 | -0.01 | 3.14 | 11 | | | |
| | | 0.00 | 6.28 | 11 | 0.00 | 5.75 | 11 | 2.38 C | 6.28 | 12 |
| 35 | MAX | 0.01 | 0.00 | 11 | 0.00 | 0.00 | 11 | | | |
| | | 0.00 | 0.00 | 12 | 0.00 | 0.00 | 11 | 3.19 C | 0.00 | 11 |
| | MIN | -0.01 | 6.28 | 11 | -0.01 | 3.14 | 11 | | | |
| | | 0.00 | 6.28 | 11 | 0.00 | 5.75 | 11 | 2.08 C | 6.28 | 12 |
| 36 | MAX | 0.01 | 0.00 | 11 | 0.00 | 0.00 | 11 | | | |
| | | 0.00 | 0.00 | 12 | 0.00 | 0.00 | 11 | 2.02 C | 0.00 | 11 |
| | MIN | -0.01 | 6.28 | 11 | -0.01 | 3.14 | 11 | | | |
| | | 0.00 | 6.28 | 11 | 0.00 | 5.75 | 11 | 1.31 C | 6.28 | 12 |
| 37 | MAX | 0.01 | 0.00 | 11 | 0.00 | 0.00 | 11 | | | |
| | | 0.00 | 0.00 | 12 | 0.00 | 0.00 | 11 | 1.37 C | 0.00 | 11 |
| | MIN | -0.01 | 6.28 | 11 | -0.01 | 3.14 | 11 | | | |
| | | 0.00 | 6.28 | 11 | 0.00 | 5.75 | 11 | 0.88 C | 6.28 | 12 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 38 MAX | 0.01 | 0.00 | 11 | 0.00 | 0.00 | 11 | | | |
| | 0.00 | 0.00 | 12 | 0.00 | 0.00 | 11 | 0.64 C | 0.00 | 11 |
| MIN | -0.01 | 6.28 | 11 | -0.01 | 3.14 | 11 | | | |
| | 0.00 | 6.28 | 11 | 0.00 | 5.75 | 11 | 0.40 C | 6.28 | 12 |
| 39 MAX | 0.00 | 0.00 | 12 | 0.03 | 6.28 | 11 | | | |
| | 0.03 | 0.00 | 11 | 0.17 | 6.28 | 11 | 3.06 C | 0.00 | 11 |
| MIN | -0.01 | 6.28 | 11 | 0.00 | 1.05 | 12 | | | |
| | 0.02 | 6.28 | 12 | 0.00 | 0.00 | 12 | 2.00 C | 6.28 | 12 |
| 40 MAX | 0.00 | 0.00 | 12 | 0.05 | 6.28 | 11 | | | |
| | 0.06 | 0.00 | 11 | 0.23 | 6.28 | 11 | 2.94 C | 0.00 | 11 |
| MIN | -0.02 | 6.28 | 11 | -0.03 | 0.00 | 11 | | | |
| | 0.04 | 6.28 | 12 | -0.16 | 0.00 | 11 | 1.90 C | 6.28 | 12 |
| 41 MAX | 0.00 | 0.00 | 11 | 0.00 | 0.00 | 11 | | | |
| | 0.00 | 0.00 | 11 | 0.00 | 3.12 | 11 | 5.03 C | 0.00 | 11 |
| MIN | 0.00 | 3.40 | 11 | 0.00 | 1.70 | 11 | | | |
| | 0.00 | 3.40 | 12 | 0.00 | 3.40 | 12 | 3.38 C | 3.40 | 12 |
| 42 MAX | 0.00 | 0.00 | 11 | 0.00 | 0.00 | 11 | | | |
| | 0.00 | 0.00 | 11 | 0.00 | 3.12 | 11 | 4.33 C | 3.40 | 11 |
| MIN | 0.00 | 3.40 | 11 | 0.00 | 1.70 | 11 | | | |
| | 0.00 | 3.40 | 12 | 0.00 | 3.40 | 12 | 2.88 C | 0.00 | 12 |
| 44 MAX | 0.00 | 0.00 | 11 | 0.00 | 0.00 | 11 | | | |
| | 0.00 | 0.00 | 12 | 0.00 | 0.00 | 11 | 0.01 C | 3.40 | 11 |

STAAD SPACE -- PAGE NO. 11

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| MIN | 0.00 | 3.40 | 11 | 0.00 | 1.70 | 11 | | | |
| | 0.00 | 3.40 | 11 | 0.00 | 3.12 | 11 | 0.00 C | 0.00 | 12 |
| 46 MAX | 0.00 | 0.00 | 11 | 0.00 | 0.00 | 11 | | | |
| | 0.00 | 0.00 | 12 | 0.00 | 0.00 | 11 | 0.92 C | 3.40 | 11 |
| MIN | 0.00 | 3.40 | 11 | 0.00 | 1.70 | 11 | | | |
| | 0.00 | 3.40 | 11 | 0.00 | 3.12 | 11 | 0.61 C | 0.00 | 12 |
| 55 MAX | 1.16 | 0.00 | 11 | 2.97 | 0.00 | 11 | | | |
| | 0.00 | 0.00 | 12 | 0.01 | 0.00 | 11 | 1.09 C | 2.06 | 11 |
| MIN | 0.59 | 2.06 | 12 | 0.58 | 2.06 | 12 | | | |
| | 0.00 | 2.06 | 11 | 0.00 | 2.06 | 12 | 0.69 C | 0.00 | 12 |
| 56 MAX | 0.87 | 0.00 | 11 | 0.87 | 0.00 | 11 | | | |
| | 0.00 | 0.00 | 12 | 0.00 | 0.00 | 11 | 1.49 C | 11.34 | 11 |
| MIN | -0.72 | 11.34 | 11 | -1.84 | 6.61 | 11 | | | |
| | 0.00 | 11.34 | 11 | 0.00 | 11.34 | 12 | 0.74 C | 0.00 | 12 |
| 57 MAX | 1.94 | 0.00 | 11 | 3.88 | 0.00 | 11 | | | |
| | 0.00 | 0.00 | 11 | 0.00 | 11.34 | 11 | 0.75 T | 11.34 | 12 |
| MIN | -1.25 | 11.34 | 11 | -2.78 | 6.61 | 11 | | | |
| | 0.00 | 11.34 | 12 | -0.03 | 0.00 | 11 | 2.01 T | 0.00 | 11 |
| 58 MAX | -1.44 | 0.00 | 12 | 3.88 | 2.06 | 11 | | | |
| | 0.00 | 0.00 | 11 | -0.02 | 2.06 | 12 | 2.55 T | 2.06 | 12 |
| MIN | -2.72 | 2.06 | 11 | -1.14 | 0.00 | 11 | | | |
| | 0.00 | 2.06 | 12 | -0.03 | 0.00 | 11 | 4.04 T | 0.00 | 11 |
| 59 MAX | 2.32 | 0.00 | 11 | 5.79 | 0.00 | 11 | | | |
| | 0.00 | 0.00 | 11 | 0.00 | 13.40 | 11 | 0.27 T | 13.40 | 12 |
| MIN | -1.45 | 13.40 | 11 | -3.73 | 7.82 | 11 | | | |
| | 0.00 | 13.40 | 12 | -0.01 | 0.00 | 11 | 1.39 T | 0.00 | 11 |
| 60 MAX | 1.85 | 0.00 | 11 | 2.89 | 0.00 | 11 | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0.00 | 0.00 | 11 | 0.00 | 11.34 | 12 | 1.50 C | 11.34 | 11 |
| MIN | -1.34 | 11.34 | 11 | -3.19 | 6.61 | 11 | | | |
| | 0.00 | 11.34 | 12 | -0.01 | 0.00 | 11 | 0.47 C | 0.00 | 12 |
| 61 MAX | -1.02 | 0.00 | 12 | 2.89 | 2.06 | 11 | | | |
| | 0.00 | 0.00 | 11 | -0.01 | 2.06 | 12 | 0.61 T | 2.06 | 12 |
| MIN | -2.16 | 2.06 | 11 | -0.95 | 0.00 | 11 | | | |
| | 0.00 | 2.06 | 12 | -0.01 | 0.00 | 11 | 1.07 T | 0.00 | 11 |
| 62 MAX | 2.35 | 0.00 | 11 | 5.26 | 0.00 | 11 | | | |
| | 0.00 | 0.00 | 12 | 0.00 | 0.00 | 11 | 0.93 C | 13.40 | 11 |
| MIN | -1.56 | 13.40 | 11 | -4.17 | 7.82 | 11 | | | |
| | 0.00 | 13.40 | 11 | 0.00 | 13.40 | 11 | 0.04 T | 0.00 | 11 |
| 63 MAX | 2.28 | 0.00 | 11 | 5.24 | 0.00 | 11 | | | |
| | 0.00 | 0.00 | 12 | 0.01 | 0.00 | 11 | 1.19 C | 13.40 | 11 |
| MIN | -1.49 | 13.40 | 11 | -3.96 | 7.82 | 11 | | | |
| | 0.00 | 13.40 | 11 | 0.00 | 13.40 | 12 | 0.17 C | 0.00 | 12 |
| 64 MAX | -0.18 | 0.00 | 12 | 0.00 | 2.06 | 12 | | | |
| | 0.00 | 0.00 | 12 | 0.00 | 2.06 | 11 | 0.23 T | 2.06 | 12 |

STAAD SPACE -- PAGE NO. 12

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| MIN | -0.84 | 2.06 | 11 | -1.14 | 0.00 | 11 | | | |
| | 0.00 | 2.06 | 11 | 0.00 | 1.89 | 11 | 0.49 T | 0.00 | 11 |
| 65 MAX | 2.31 | 0.00 | 11 | 5.76 | 0.00 | 11 | | | |
| | 0.00 | 0.00 | 12 | 0.01 | 0.00 | 11 | 0.22 T | 13.40 | 12 |
| MIN | -1.46 | 13.40 | 11 | -3.74 | 7.82 | 11 | | | |
| | 0.00 | 13.40 | 11 | 0.00 | 13.40 | 12 | 1.32 T | 0.00 | 11 |
| 66 MAX | 2.34 | 0.00 | 11 | 6.15 | 0.00 | 11 | | | |
| | 0.00 | 0.00 | 12 | 0.03 | 0.00 | 11 | 1.24 T | 13.40 | 12 |
| MIN | -1.43 | 13.40 | 11 | -3.58 | 7.82 | 11 | | | |
| | 0.00 | 13.40 | 11 | 0.00 | 13.40 | 12 | 2.89 T | 0.00 | 11 |
| 67 MAX | 1.16 | 0.00 | 11 | 2.93 | 0.00 | 11 | | | |
| | 0.00 | 0.00 | 11 | 0.00 | 2.06 | 12 | 1.11 C | 2.06 | 11 |
| MIN | 0.59 | 2.06 | 12 | 0.56 | 2.06 | 12 | | | |
| | 0.00 | 2.06 | 12 | 0.00 | 0.00 | 11 | 0.70 C | 0.00 | 12 |
| 68 MAX | 0.87 | 0.00 | 11 | 0.84 | 0.00 | 11 | | | |
| | 0.00 | 0.00 | 11 | 0.00 | 11.34 | 12 | 1.51 C | 11.34 | 11 |
| MIN | -0.72 | 11.34 | 11 | -1.85 | 6.61 | 11 | | | |
| | 0.00 | 11.34 | 12 | 0.00 | 0.00 | 11 | 0.75 C | 0.00 | 12 |
| 69 MAX | 1.66 | 0.00 | 11 | 3.07 | 0.00 | 11 | | | |
| | 0.23 | 0.00 | 11 | 0.03 | 2.00 | 11 | 0.05 T | 0.00 | 12 |
| MIN | -0.14 | 4.00 | 11 | 0.01 | 3.67 | 11 | | | |
| | -0.22 | 4.00 | 11 | -0.20 | 0.00 | 11 | 0.07 T | 4.00 | 11 |
| 70 MAX | 2.09 | 0.00 | 11 | 0.14 | 0.00 | 11 | | | |
| | 0.33 | 0.00 | 11 | 0.17 | 3.00 | 11 | 0.02 T | 0.00 | 12 |
| MIN | 0.20 | 4.00 | 12 | -4.62 | 4.00 | 11 | | | |
| | -0.12 | 4.00 | 11 | -0.32 | 0.00 | 11 | 0.02 T | 4.00 | 11 |
| 71 MAX | 1.27 | 0.00 | 11 | -3.00 | 0.00 | 12 | | | |
| | 0.14 | 0.00 | 11 | 0.14 | 1.33 | 11 | 0.01 T | 0.00 | 11 |
| MIN | -0.52 | 4.00 | 11 | -6.30 | 2.67 | 11 | | | |
| | -0.31 | 4.00 | 11 | -0.28 | 4.00 | 11 | 0.01 T | 4.00 | 12 |
| 72 MAX | 0.61 | 0.00 | 11 | -3.22 | 4.00 | 12 | | | |
| | 0.32 | 0.00 | 11 | 0.16 | 3.00 | 11 | 0.00 C | 0.00 | 11 |

```
   MIN      -1.18   4.00    11       -6.40   1.33    11
            -0.13   4.00    11       -0.30   0.00    11       0.00 T   4.00   12

 73 MAX     -0.25   0.00    12        0.13   4.00    11
             0.12   0.00    11        0.16   1.00    11       0.01 C   0.00   11
   MIN      -2.16   4.00    11       -4.94   0.00    11
            -0.33   4.00    11       -0.33   4.00    11       0.00 C   4.00   12

 74 MAX      0.05   0.00    11        3.28   4.00    11
             0.18   0.00    11        0.06   1.67    11       0.04 T   0.00   12
   MIN      -1.74   4.00    11       -0.10   0.00    11
            -0.27   4.00    11       -0.26   4.00    11       0.05 T   4.00   11
 STAAD SPACE                                                  -- PAGE NO.   13


********** END OF FORCE ENVELOPE FROM INTERNAL STORAGE **********


 91. FINISH


          *********** END OF THE STAAD.Pro RUN ***********

            **** DATE= FEB 28,2007   TIME= 23:36:25 ****
```

| **_Truss Design** | Completed By | Revised By | DCN # | |
|---|---|---|---|---|
| Appendix 4.05 | Benoit | Glantz, Owens | S-40 | |
| *Conclusions: The following is the RISA output data to check the design of the Living Space truss with added wind load from distribution calculations as described in Appendix 3.03.* | | | | |

Michelle Benoit S-40
L.S. Truss

## Envelope LRFD Steel Code Checks

| Member | Shape | Code C... | Loc[ft] | lc | Shear C... | Loc[ft] | Dir | lc | phi*Pnc [k] | phi*Pnt [k] | phi*Mn y-... | phi*Mn z-... | Cb | LRFD E... |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M1 | HSS6X4X4 | .819 | 14.367 | 2 | .023 | 32 | y | 2 | 30.142 | 177.795 | 22.204 | 29.372 | 1 | H1-1a |
| M2 | HSS6X4X4 | .440 | 3.918 | 2 | .006 | 28.082 | y | 2 | 30.142 | 177.795 | 22.204 | 29.372 | 1 | H1-1a |
| M3 | HSS4X2X2 | .368 | 3.5 | 2 | .021 | 0 | y | 2 | 42.989 | 54.074 | 3.332 | 5.724 | 1 | H1-1a |
| M4 | HSS4X2X2 | .312 | 0 | 2 | .017 | 0 | y | 2 | 42.989 | 54.074 | 3.332 | 5.724 | 1 | H1-1a |
| M5 | HSS4X2X2 | .158 | 0 | 2 | .012 | 0 | y | 2 | 42.989 | 54.074 | 3.332 | 5.724 | 1 | H1-1b |
| M6 | HSS4X2X2 | .095 | 0 | 2 | .007 | 0 | y | 2 | 42.989 | 54.074 | 3.332 | 5.724 | 1 | H1-1b |
| M7 | HSS4X2X2 | .027 | 0 | 2 | .001 | 0 | y | 3 | 42.989 | 54.074 | 3.332 | 5.724 | 1 | H1-1b |
| M8 | HSS4X2X2 | .095 | 0 | 2 | .007 | 0 | y | 2 | 42.989 | 54.074 | 3.332 | 5.724 | 1 | H1-1b |
| M9 | HSS4X2X2 | .158 | 0 | 2 | .012 | 0 | y | 2 | 42.989 | 54.074 | 3.332 | 5.724 | 1 | H1-1b |
| M10 | HSS4X2X2 | .312 | 0 | 2 | .017 | 0 | y | 2 | 42.989 | 54.074 | 3.332 | 5.724 | 1 | H1-1a |
| M11 | HSS4X2X2 | .368 | 3.5 | 2 | .021 | 0 | y | 2 | 42.989 | 54.074 | 3.332 | 5.724 | 1 | H1-1a |
| M12 | HSS4X2X2 | .283 | 0 | 2 | .004 | 0 | y | 2 | 34.329 | 54.074 | 3.332 | 5.724 | 1 | H1-1a |
| M13 | HSS4X2X2 | .123 | 0 | 2 | .003 | 0 | y | 2 | 34.329 | 54.074 | 3.332 | 5.724 | 1 | H1-1b |
| M14 | HSS4X2X2 | .080 | 0 | 2 | .002 | 0 | y | 2 | 34.329 | 54.074 | 3.332 | 5.724 | 1 | H1-1b |
| M15 | HSS4X2X2 | .030 | 0 | 2 | .000 | 0 | y | 2 | 34.329 | 54.074 | 3.332 | 5.724 | 1 | H1-1b |
| M16 | HSS4X2X2 | .030 | 5.315 | 2 | .000 | 0 | y | 2 | 34.329 | 54.074 | 3.332 | 5.724 | 1 | H1-1b |
| M17 | HSS4X2X2 | .080 | 5.315 | 2 | .002 | 0 | y | 2 | 34.329 | 54.074 | 3.332 | 5.724 | 1 | H1-1b |
| M18 | HSS4X2X2 | .123 | 5.315 | 2 | .003 | 0 | y | 2 | 34.329 | 54.074 | 3.332 | 5.724 | 1 | H1-1b |
| M19 | HSS4X2X2 | .283 | 5.315 | 2 | .004 | 0 | y | 2 | 34.329 | 54.074 | 3.332 | 5.724 | 1 | H1-1a |

## Envelope Member Section Deflections

| Member | Sec | | x [in] | lc | y [in] | lc | z [in] | lc | x Rotate [ra... | lc | (n) L/y Ratio | lc | (n) L/z Ratio | lc |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M1 | 1 | max | .029 | 2 | -.001 | 5 | 0 | 1 | 0 | 1 | NC | 5 | NC | 1 |
| | | min | .001 | 6 | -.011 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| | 2 | max | .002 | 3 | -.033 | 6 | 0 | 1 | 0 | 1 | NC | 6 | NC | 1 |
| | | min | -.002 | 4 | -.217 | 2 | 0 | 1 | 0 | 1 | 1861.948 | 2 | NC | 1 |
| | 3 | max | -.002 | 5 | -.001 | 6 | 0 | 1 | 0 | 1 | NC | 6 | NC | 1 |
| | | min | -.029 | 2 | -.011 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| M2 | 1 | max | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | NC | 1 | NC | 1 |
| | | min | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | NC | 1 | NC | 1 |
| | 2 | max | .001 | 3 | -.033 | 6 | 0 | 1 | 0 | 1 | NC | 6 | NC | 1 |
| | | min | -.001 | 4 | -.215 | 2 | 0 | 1 | 0 | 1 | 1788.051 | 2 | NC | 1 |
| | 3 | max | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | NC | 1 | NC | 1 |
| | | min | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | NC | 1 | NC | 1 |
| M3 | 1 | max | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | NC | 1 | NC | 1 |
| | | min | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | NC | 1 | NC | 1 |
| | 2 | max | 0 | 5 | 0 | 6 | 0 | 1 | 0 | 1 | NC | 6 | NC | 1 |
| | | min | -.006 | 2 | -.014 | 2 | 0 | 1 | 0 | 1 | 3090.301 | 2 | NC | 1 |
| | 3 | max | -.001 | 5 | -.001 | 6 | 0 | 1 | 0 | 1 | NC | 6 | NC | 1 |
| | | min | -.011 | 2 | -.029 | 2 | 0 | 1 | 0 | 1 | 1470.571 | 2 | NC | 1 |
| M4 | 1 | max | -.011 | 6 | .005 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| | | min | -.082 | 2 | 0 | 5 | 0 | 1 | 0 | 1 | NC | 5 | NC | 1 |
| | 2 | max | -.012 | 6 | 0 | 6 | 0 | 1 | 0 | 1 | NC | 6 | NC | 1 |
| | | min | -.087 | 2 | -.01 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| | 3 | max | -.013 | 6 | -.001 | 6 | 0 | 1 | 0 | 1 | NC | 6 | NC | 1 |
| | | min | -.092 | 2 | -.025 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| M5 | 1 | max | -.022 | 6 | .006 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| | | min | -.151 | 2 | 0 | 5 | 0 | 1 | 0 | 1 | NC | 5 | NC | 1 |
| | 2 | max | -.022 | 6 | 0 | 6 | 0 | 1 | 0 | 1 | NC | 6 | NC | 1 |
| | | min | -.154 | 2 | -.006 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| | 3 | max | -.023 | 6 | 0 | 6 | 0 | 1 | 0 | 1 | NC | 6 | NC | 1 |
| | | min | -.157 | 2 | -.018 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| M6 | 1 | max | -.029 | 6 | .004 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| | | min | -.196 | 2 | 0 | 5 | 0 | 1 | 0 | 1 | NC | 5 | NC | 1 |
| | 2 | max | -.03 | 6 | .001 | 6 | 0 | 1 | 0 | 1 | NC | 6 | NC | 1 |


10/2/06

## *Envelope Member Section Deflections (Continued)*

| Member | Sec | | x [in] | lc | y [in] | lc | z [in] | lc | x Rotate [ra... | lc | (n) L/y Ratio | lc | (n) L/z Ratio | lc |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | min | -.198 | 2 | -.003 | 3 | 0 | 1 | 0 | 1 | NC | 3 | NC | 1 |
| | 3 | max | -.03 | 6 | 0 | 6 | 0 | 1 | 0 | 1 | NC | 6 | NC | 1 |
| | | min | -.2 | 2 | -.009 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| M7 | 1 | max | -.033 | 6 | .001 | 4 | 0 | 1 | 0 | 1 | NC | 4 | NC | 1 |
| | | min | -.215 | 2 | -.001 | 3 | 0 | 1 | 0 | 1 | NC | 3 | NC | 1 |
| | 2 | max | -.033 | 6 | .002 | 4 | 0 | 1 | 0 | 1 | NC | 4 | NC | 1 |
| | | min | -.216 | 2 | -.002 | 3 | 0 | 1 | 0 | 1 | NC | 3 | NC | 1 |
| | 3 | max | -.033 | 6 | .002 | 4 | 0 | 1 | 0 | 1 | NC | 4 | NC | 1 |
| | | min | -.217 | 2 | -.002 | 3 | 0 | 1 | 0 | 1 | NC | 3 | NC | 1 |
| M8 | 1 | max | -.031 | 6 | 0 | 6 | 0 | 1 | 0 | 1 | NC | 6 | NC | 1 |
| | | min | -.196 | 2 | -.004 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| | 2 | max | -.031 | 6 | .003 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| | | min | -.198 | 2 | -.001 | 5 | 0 | 1 | 0 | 1 | NC | 5 | NC | 1 |
| | 3 | max | -.031 | 6 | .009 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| | | min | -.2 | 2 | 0 | 5 | 0 | 1 | 0 | 1 | NC | 5 | NC | 1 |
| M9 | 1 | max | -.024 | 6 | 0 | 6 | 0 | 1 | 0 | 1 | NC | 6 | NC | 1 |
| | | min | -.151 | 2 | -.006 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| | 2 | max | -.025 | 6 | .006 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| | | min | -.154 | 2 | 0 | 5 | 0 | 1 | 0 | 1 | NC | 5 | NC | 1 |
| | 3 | max | -.025 | 6 | .018 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| | | min | -.157 | 2 | .001 | 5 | 0 | 1 | 0 | 1 | NC | 5 | NC | 1 |
| M10 | 1 | max | -.013 | 5 | 0 | 6 | 0 | 1 | 0 | 1 | NC | 6 | NC | 1 |
| | | min | -.082 | 2 | -.005 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| | 2 | max | -.014 | 5 | .01 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| | | min | -.087 | 2 | 0 | 5 | 0 | 1 | 0 | 1 | NC | 5 | NC | 1 |
| | 3 | max | -.015 | 5 | .025 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| | | min | -.092 | 2 | .002 | 5 | 0 | 1 | 0 | 1 | NC | 5 | NC | 1 |
| M11 | 1 | max | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | NC | 1 | NC | 1 |
| | | min | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | NC | 1 | NC | 1 |
| | 2 | max | 0 | 6 | .014 | 2 | 0 | 1 | 0 | 1 | 3090.301 | 2 | NC | 1 |
| | | min | -.006 | 2 | .001 | 5 | 0 | 1 | 0 | 1 | NC | 5 | NC | 1 |
| | 3 | max | -.001 | 6 | .029 | 2 | 0 | 1 | 0 | 1 | 1470.571 | 2 | NC | 1 |
| | | min | -.011 | 2 | .002 | 5 | 0 | 1 | 0 | 1 | NC | 5 | NC | 1 |
| M12 | 1 | max | .029 | 2 | .01 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| | | min | .002 | 6 | 0 | 6 | 0 | 1 | 0 | 1 | NC | 6 | NC | 1 |
| | 2 | max | .04 | 2 | -.004 | 5 | 0 | 1 | 0 | 1 | NC | 5 | NC | 1 |
| | | min | .004 | 6 | -.029 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| | 3 | max | .051 | 2 | -.009 | 6 | 0 | 1 | 0 | 1 | NC | 6 | NC | 1 |
| | | min | .007 | 6 | -.065 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| M13 | 1 | max | .079 | 2 | -.008 | 5 | 0 | 1 | 0 | 1 | NC | 5 | NC | 1 |
| | | min | .01 | 6 | -.053 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| | 2 | max | .087 | 2 | -.014 | 6 | 0 | 1 | 0 | 1 | NC | 6 | NC | 1 |
| | | min | .011 | 6 | -.088 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| | 3 | max | .095 | 2 | -.018 | 6 | 0 | 1 | 0 | 1 | NC | 6 | NC | 1 |
| | | min | .013 | 6 | -.117 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| M14 | 1 | max | .117 | 2 | -.017 | 6 | 0 | 1 | 0 | 1 | NC | 6 | NC | 1 |
| | | min | .015 | 6 | -.107 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| | 2 | max | .122 | 2 | -.021 | 6 | 0 | 1 | 0 | 1 | NC | 6 | NC | 1 |
| | | min | .017 | 6 | -.132 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| | 3 | max | .126 | 2 | -.023 | 6 | 0 | 1 | 0 | 1 | NC | 6 | NC | 1 |
| | | min | .018 | 6 | -.15 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| M15 | 1 | max | .139 | 2 | -.023 | 6 | 0 | 1 | 0 | 1 | NC | 6 | NC | 1 |
| | | min | .019 | 6 | -.145 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| | 2 | max | .14 | 2 | -.025 | 6 | 0 | 1 | 0 | 1 | NC | 6 | NC | 1 |
| | | min | .02 | 6 | -.158 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| | 3 | max | .141 | 2 | -.025 | 6 | 0 | 1 | 0 | 1 | NC | 6 | NC | 1 |

## Envelope Member Section Deflections (Continued)

| Member | Sec | | x [in] | lc | y [in] | lc | z [in] | lc | x Rotate [ra... | lc | (n) L/y Ratio | lc | (n) L/z Ratio | lc |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | min | .02 | 6 | -.162 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| M16 | 1 | max | -.023 | 6 | -.024 | 6 | 0 | 1 | 0 | 1 | NC | 6 | NC | 1 |
| | | min | -.141 | 2 | -.162 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| | 2 | max | -.022 | 5 | -.023 | 6 | 0 | 1 | 0 | 1 | NC | 6 | NC | 1 |
| | | min | -.14 | 2 | -.158 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| | 3 | max | -.022 | 5 | -.021 | 6 | 0 | 1 | 0 | 1 | NC | 6 | NC | 1 |
| | | min | -.139 | 2 | -.145 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| M17 | 1 | max | -.02 | 5 | -.023 | 6 | 0 | 1 | 0 | 1 | NC | 6 | NC | 1 |
| | | min | -.126 | 2 | -.15 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| | 2 | max | -.019 | 5 | -.02 | 6 | 0 | 1 | 0 | 1 | NC | 6 | NC | 1 |
| | | min | -.122 | 2 | -.132 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| | 3 | max | -.018 | 5 | -.016 | 6 | 0 | 1 | 0 | 1 | NC | 6 | NC | 1 |
| | | min | -.117 | 2 | -.107 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| M18 | 1 | max | -.015 | 5 | -.018 | 6 | 0 | 1 | 0 | 1 | NC | 6 | NC | 1 |
| | | min | -.095 | 2 | -.117 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| | 2 | max | -.013 | 5 | -.013 | 6 | 0 | 1 | 0 | 1 | NC | 6 | NC | 1 |
| | | min | -.087 | 2 | -.088 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| | 3 | max | -.011 | 5 | -.007 | 6 | 0 | 1 | 0 | 1 | NC | 6 | NC | 1 |
| | | min | -.079 | 2 | -.053 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| M19 | 1 | max | -.008 | 5 | -.01 | 6 | 0 | 1 | 0 | 1 | NC | 6 | NC | 1 |
| | | min | -.051 | 2 | -.065 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| | 2 | max | -.005 | 5 | -.004 | 6 | 0 | 1 | 0 | 1 | NC | 6 | NC | 1 |
| | | min | -.04 | 2 | -.029 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| | 3 | max | -.003 | 5 | .01 | 2 | 0 | 1 | 0 | 1 | NC | 2 | NC | 1 |
| | | min | -.029 | 2 | 0 | 5 | 0 | 1 | 0 | 1 | NC | 5 | NC | 1 |

## Envelope Member Section Forces

| Member | Sec | | Axial[k] | lc | y Shear[k] | lc | z Shear[k] | lc | Torque[k-ft] | lc | y-y Momen... | lc | z-z Momen... | lc |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M1 | 1 | max | 10.315 | 2 | 1.578 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | 1.144 | 2 |
| | | min | .156 | 6 | .248 | 5 | 0 | 1 | 0 | 1 | 0 | 1 | .149 | 5 |
| | 2 | max | 23.681 | 2 | 1.172 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | .013 | 6 |
| | | min | 3.39 | 6 | -.543 | 3 | 0 | 1 | 0 | 1 | 0 | 1 | -.045 | 2 |
| | 3 | max | 10.315 | 2 | -.245 | 6 | 0 | 1 | 0 | 1 | 0 | 1 | 1.144 | 2 |
| | | min | 1.001 | 5 | -1.578 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | .148 | 6 |
| M2 | 1 | max | 12.451 | 2 | .438 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | .825 | 2 |
| | | min | .569 | 5 | .066 | 5 | 0 | 1 | 0 | 1 | 0 | 1 | .104 | 5 |
| | 2 | max | -1.888 | 6 | .078 | 4 | 0 | 1 | 0 | 1 | 0 | 1 | -.17 | 6 |
| | | min | -9.552 | 2 | -.149 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | -.996 | 2 |
| | 3 | max | 12.451 | 2 | -.063 | 6 | 0 | 1 | 0 | 1 | 0 | 1 | .825 | 2 |
| | | min | .572 | 6 | -.438 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | .103 | 6 |
| M3 | 1 | max | 10.047 | 2 | -.061 | 5 | 0 | 1 | 0 | 1 | 0 | 1 | -.104 | 5 |
| | | min | 1.303 | 5 | -.483 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | -.825 | 2 |
| | 2 | max | 10.047 | 2 | -.061 | 5 | 0 | 1 | 0 | 1 | 0 | 1 | .02 | 2 |
| | | min | 1.303 | 5 | -.483 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | .003 | 6 |
| | 3 | max | 10.047 | 2 | -.061 | 5 | 0 | 1 | 0 | 1 | 0 | 1 | .865 | 2 |
| | | min | 1.303 | 5 | -.483 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | .111 | 5 |
| M4 | 1 | max | 8.686 | 2 | -.051 | 5 | 0 | 1 | 0 | 1 | 0 | 1 | -.091 | 5 |
| | | min | 1.097 | 5 | -.398 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | -.708 | 2 |
| | 2 | max | 8.686 | 2 | -.051 | 5 | 0 | 1 | 0 | 1 | 0 | 1 | -.002 | 6 |
| | | min | 1.097 | 5 | -.398 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | -.012 | 2 |
| | 3 | max | 8.686 | 2 | -.051 | 5 | 0 | 1 | 0 | 1 | 0 | 1 | .685 | 2 |
| | | min | 1.097 | 5 | -.398 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | .087 | 5 |
| M5 | 1 | max | 6.18 | 2 | -.031 | 5 | 0 | 1 | 0 | 1 | 0 | 1 | -.055 | 5 |
| | | min | .695 | 5 | -.276 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | -.492 | 2 |
| | 2 | max | 6.18 | 2 | -.031 | 5 | 0 | 1 | 0 | 1 | 0 | 1 | -.001 | 6 |

## *Envelope Member Section Forces (Continued)*

| Member | Sec | | Axial[k] | lc | y Shear[k] | lc | z Shear[k] | lc | Torque[k-ft] | lc | y-y Momen... | lc | z-z Momen... | lc |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | min | .695 | 5 | -.276 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | -.008 | 2 |
| | 3 | max | 6.18 | 2 | -.031 | 5 | 0 | 1 | 0 | 1 | 0 | 1 | .475 | 2 |
| | | min | .695 | 5 | -.276 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | .052 | 5 |
| M6 | 1 | max | 3.667 | 2 | -.014 | 5 | 0 | 1 | 0 | 1 | 0 | 1 | -.025 | 5 |
| | | min | .294 | 5 | -.167 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | -.299 | 2 |
| | 2 | max | 3.667 | 2 | -.014 | 5 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 5 |
| | | min | .294 | 5 | -.167 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | -.008 | 2 |
| | 3 | max | 3.667 | 2 | -.014 | 5 | 0 | 1 | 0 | 1 | 0 | 1 | .284 | 2 |
| | | min | .294 | 5 | -.167 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | .024 | 5 |
| M7 | 1 | max | 2.36 | 2 | .013 | 3 | 0 | 1 | 0 | 1 | 0 | 1 | .023 | 3 |
| | | min | .375 | 5 | -.013 | 4 | 0 | 1 | 0 | 1 | 0 | 1 | -.023 | 4 |
| | 2 | max | 2.36 | 2 | .013 | 3 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 5 |
| | | min | .375 | 5 | -.013 | 4 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 6 |
| | 3 | max | 2.36 | 2 | .013 | 3 | 0 | 1 | 0 | 1 | 0 | 1 | .021 | 4 |
| | | min | .375 | 5 | -.013 | 4 | 0 | 1 | 0 | 1 | 0 | 1 | -.021 | 3 |
| M8 | 1 | max | 3.667 | 2 | .167 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | .299 | 2 |
| | | min | .298 | 6 | .012 | 6 | 0 | 1 | 0 | 1 | 0 | 1 | .022 | 6 |
| | 2 | max | 3.667 | 2 | .167 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | .008 | 2 |
| | | min | .298 | 6 | .012 | 6 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 6 |
| | 3 | max | 3.667 | 2 | .167 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | -.02 | 6 |
| | | min | .298 | 6 | .012 | 6 | 0 | 1 | 0 | 1 | 0 | 1 | -.284 | 2 |
| M9 | 1 | max | 6.18 | 2 | .276 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | .492 | 2 |
| | | min | .696 | 6 | .029 | 6 | 0 | 1 | 0 | 1 | 0 | 1 | .052 | 6 |
| | 2 | max | 6.18 | 2 | .276 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | .008 | 2 |
| | | min | .696 | 6 | .029 | 6 | 0 | 1 | 0 | 1 | 0 | 1 | .001 | 5 |
| | 3 | max | 6.18 | 2 | .276 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | -.049 | 6 |
| | | min | .696 | 6 | .029 | 6 | 0 | 1 | 0 | 1 | 0 | 1 | -.475 | 2 |
| M10 | 1 | max | 8.686 | 2 | .398 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | .708 | 2 |
| | | min | 1.1 | 6 | .049 | 6 | 0 | 1 | 0 | 1 | 0 | 1 | .087 | 6 |
| | 2 | max | 8.686 | 2 | .398 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | .012 | 2 |
| | | min | 1.1 | 6 | .049 | 6 | 0 | 1 | 0 | 1 | 0 | 1 | .002 | 5 |
| | 3 | max | 8.686 | 2 | .398 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | -.083 | 6 |
| | | min | 1.1 | 6 | .049 | 6 | 0 | 1 | 0 | 1 | 0 | 1 | -.685 | 2 |
| M11 | 1 | max | 10.047 | 2 | .483 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | .825 | 2 |
| | | min | 1.306 | 6 | .061 | 6 | 0 | 1 | 0 | 1 | 0 | 1 | .103 | 6 |
| | 2 | max | 10.047 | 2 | .483 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | -.003 | 5 |
| | | min | 1.306 | 6 | .061 | 6 | 0 | 1 | 0 | 1 | 0 | 1 | -.02 | 2 |
| | 3 | max | 10.047 | 2 | .483 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | -.11 | 6 |
| | | min | 1.306 | 6 | .061 | 6 | 0 | 1 | 0 | 1 | 0 | 1 | -.865 | 2 |
| M12 | 1 | max | -1.617 | 5 | -.012 | 5 | 0 | 1 | 0 | 1 | 0 | 1 | -.038 | 5 |
| | | min | -12.983 | 2 | -.098 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | -.279 | 2 |
| | 2 | max | -1.617 | 5 | -.012 | 5 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 6 |
| | | min | -12.983 | 2 | -.098 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | -.018 | 2 |
| | 3 | max | -1.617 | 5 | -.012 | 5 | 0 | 1 | 0 | 1 | 0 | 1 | .243 | 2 |
| | | min | -12.983 | 2 | -.098 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | .028 | 5 |
| M13 | 1 | max | -1.046 | 5 | -.008 | 5 | 0 | 1 | 0 | 1 | 0 | 1 | -.028 | 5 |
| | | min | -9.337 | 2 | -.067 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | -.21 | 2 |
| | 2 | max | -1.046 | 5 | -.008 | 5 | 0 | 1 | 0 | 1 | 0 | 1 | -.003 | 6 |
| | | min | -9.337 | 2 | -.067 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | -.032 | 2 |
| | 3 | max | -1.046 | 5 | -.008 | 5 | 0 | 1 | 0 | 1 | 0 | 1 | .145 | 2 |
| | | min | -9.337 | 2 | -.067 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | .013 | 5 |
| M14 | 1 | max | -.453 | 5 | -.004 | 5 | 0 | 1 | 0 | 1 | 0 | 1 | -.018 | 5 |
| | | min | -5.629 | 2 | -.044 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | -.158 | 2 |
| | 2 | max | -.453 | 5 | -.004 | 5 | 0 | 1 | 0 | 1 | 0 | 1 | -.005 | 6 |
| | | min | -5.629 | 2 | -.044 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | -.042 | 2 |
| | 3 | max | -.453 | 5 | -.004 | 5 | 0 | 1 | 0 | 1 | 0 | 1 | .074 | 2 |

## *Envelope Member Section Forces (Continued)*

| Member | Sec | | Axial[k] | lc | y Shear[k] | lc | z Shear[k] | lc | Torque[k-ft] | lc | y-y Momen... | lc | z-z Momen... | lc |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | min | -5.629 | 2 | -.044 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | .002 | 5 |
| M15 | 1 | max | .212 | 5 | .001 | 5 | 0 | 1 | 0 | 1 | 0 | 1 | -.008 | 5 |
| | | min | -1.571 | 2 | -.009 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | -.087 | 2 |
| | 2 | max | .212 | 5 | .001 | 5 | 0 | 1 | 0 | 1 | 0 | 1 | -.009 | 6 |
| | | min | -1.571 | 2 | -.009 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | -.062 | 2 |
| | 3 | max | .212 | 5 | .001 | 5 | 0 | 1 | 0 | 1 | 0 | 1 | .003 | 6 |
| | | min | -1.571 | 2 | -.009 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | -.037 | 2 |
| M16 | 1 | max | .201 | 6 | .009 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 5 |
| | | min | -1.571 | 2 | 0 | 6 | 0 | 1 | 0 | 1 | 0 | 1 | -.037 | 2 |
| | 2 | max | .201 | 6 | .009 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | -.01 | 5 |
| | | min | -1.571 | 2 | 0 | 6 | 0 | 1 | 0 | 1 | 0 | 1 | -.062 | 2 |
| | 3 | max | .201 | 6 | .009 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | -.008 | 6 |
| | | min | -1.571 | 2 | 0 | 6 | 0 | 1 | 0 | 1 | 0 | 1 | -.087 | 2 |
| M17 | 1 | max | -.455 | 6 | .044 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | .074 | 2 |
| | | min | -5.629 | 2 | .004 | 6 | 0 | 1 | 0 | 1 | 0 | 1 | .003 | 6 |
| | 2 | max | -.455 | 6 | .044 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | -.006 | 5 |
| | | min | -5.629 | 2 | .004 | 6 | 0 | 1 | 0 | 1 | 0 | 1 | -.042 | 2 |
| | 3 | max | -.455 | 6 | .044 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | -.018 | 6 |
| | | min | -5.629 | 2 | .004 | 6 | 0 | 1 | 0 | 1 | 0 | 1 | -.158 | 2 |
| M18 | 1 | max | -1.048 | 6 | .067 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | .145 | 2 |
| | | min | -9.337 | 2 | .008 | 6 | 0 | 1 | 0 | 1 | 0 | 1 | .014 | 6 |
| | 2 | max | -1.048 | 6 | .067 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | -.004 | 5 |
| | | min | -9.337 | 2 | .008 | 6 | 0 | 1 | 0 | 1 | 0 | 1 | -.032 | 2 |
| | 3 | max | -1.048 | 6 | .067 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | -.027 | 6 |
| | | min | -9.337 | 2 | .008 | 6 | 0 | 1 | 0 | 1 | 0 | 1 | -.21 | 2 |
| M19 | 1 | max | -1.626 | 6 | .098 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | .243 | 2 |
| | | min | -12.983 | 2 | .013 | 6 | 0 | 1 | 0 | 1 | 0 | 1 | .029 | 6 |
| | 2 | max | -1.626 | 6 | .098 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | -.001 | 5 |
| | | min | -12.983 | 2 | .013 | 6 | 0 | 1 | 0 | 1 | 0 | 1 | -.018 | 2 |
| | 3 | max | -1.626 | 6 | .098 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | -.038 | 6 |
| | | min | -12.983 | 2 | .013 | 6 | 0 | 1 | 0 | 1 | 0 | 1 | -.279 | 2 |

| **_SIP Design** | Completed By | Revised By | DCN # | |
|---|---|---|---|---|
| Appendix 4.06 | MURUS | Glantz, Owens | | |

*Conclusions: The following is a description of the loads used to assess the deflection seen in the SIPs for the roof design of the home. MURUS has used a 30psf snow load (please note this load is less than the 35psf used throughout the rest of the structural design, however, is an acceptable number for the State College and DC region) and additional 15psf as designated for dead load. The mechanical core roof is a green roof and loads are adjusted to account for this.*

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**E-mail: info@murus.com**
**www.murus.com**

March 2, 2007

Sally,

This is in response to your email to Chris Bloom and me today. This is revised for a snow load of 30psf. The 2X Lumber that we use in our calculations is mixed southern pine no. 2 or better. This is different than we gave you in our most recent phone conversation. The span that is input to our panel program is along the horizontal. Sorry I didn't mention that in the last letter.

Living Space:

Input - Panel: 6 5/8" OSB/OSB PUR with (2) 2X splines
Loading: simple span; 3:12 slope; 12ft horizontal span; 15psf DL; 30psf SL

Results - Total load deflection over span = 1/261
Live load deflection over span = 1/391
Normal stress in OSB skins = ± 213psi < 780psi allowable
Shear stress in core = 1.8psi < 6psi allowable

Breezeway:

Input - Panel: 4 5/8" OSB/OSB PUR with (2) 2X splines
Loading: overhang; 2:12 slope; 4ft horizontal span; 3ft-9in horizontal overhang; 15psf DL; 30psf SL

Results - Total load deflection over span = 1/268
Live load deflection over span = 1/402
Normal stress in OSB skins = ± 173psi < 780psi allowable
Shear stress in core = 0.9psi < 6psi allowable

Mechanical Core:

Input - Panel: 6 5/8" OSB/OSB PUR with no splines
Loading: simple span; 0:12 slope; 7ft span; 15psf DL; 30psf SL

Results - Total load deflection over span = 1/349
Live load deflection over span = 1/524
Normal stress in OSB skins = ± 288psi < 780psi allowable
Shear stress in core = 1.9psi < 6psi allowable

Thanks,

Joshua R. Sherman
Structural Engineer

**_THE MURUS COMPANY_**
**_P.O. BOX 220, 3234 ROUTE 549_**
**_MANSFIELD, PA 16933_**
**_(570) 549-2100 (570) 549-2101 FAX_**
**E-mail: info@murus.com**
**www.murus.com**

March 4, 2007

Steve,

This is in response to your email to Chris Bloom today. This is revised for dead load of 40 PSF and a Snow load of 35 PSF on the Mechanical Core roof.

Living Space:

Input - Panel: 6 5/8" OSB/OSB PUR with (2) 2X splines
Loading: simple span; 3:12 slope; 12ft horizontal span; 15psf DL; 30psf SL

Results - Total load deflection over span = 1/261
Live load deflection over span = 1/391
Normal stress in OSB skins = ± 213psi < 780psi allowable
Shear stress in core = 1.8psi < 6psi allowable

Breezeway:

Input - Panel: 4 5/8" OSB/OSB PUR with (2) 2X splines
Loading: overhang; 2:12 slope; 4ft horizontal span; 3ft-9in horizontal overhang; 15psf DL; 30psf SL

Results - Total load deflection over span = 1/268
Live load deflection over span = 1/402
Normal stress in OSB skins = ± 173psi < 780psi allowable
Shear stress in core = 0.9psi < 6psi allowable

Mechanical Core:

Input - Panel: 6 5/8" OSB/OSB PUR with single 2X splines
Loading: simple span; 0:12 slope; 7ft span; 40psf DL; 35psf SL

Results - Total load deflection over span = 1/346
Live load deflection over span = 1/707
Normal stress in OSB skins = ± 148psi < 780psi allowable
Shear stress in core = 1.7psi < 6psi allowable

Thanks,

Joshua R. Sherman
Structural Engineer

murus
STRUCTURAL INSULATING PANELS

3234 Route 549, PO Box 220
Mansfield, PA 16933
(570) 549-2100 Fax: (570) 549-2101

***Letter of Transmittal***

To: Engineering Projects Inc.
1903 East College Avenue
State College, PA 16801

Date: June 19, 2007
Attention: Brennan Glantz, PE
Re: PSU - Solar Decathlon

**We are sending you:**

☐ Attached ☐ Prints ☐ Panel Layout ☐ Preliminary Plans
☐ Design Plans ☐ Final Design Plans ☐ Final Drawings ☐ Pre-Cut Drawings
☐ Change Order ☐ Samples X Other: Stamped Roof Panel Span Calculations

| Copies | Date | No | Revision | Description |
|---|---|---|---|---|
| 4 | 5/31/07 | Page 1 of 1 | NA | Roof Panel Span Calculations |
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**THESE ARE TRANSMITTED AS CHECKED BELOW:**

☐ For Approval ☐ Approved as Submitted ☐ Resubmit ☐ Copies for Approval
☐ For your use ☐ Approved as Noted ☐ Submit X Copies for Distribution
☐ As requested ☐ Returned for corrections ☐ For review and comment
☐ Prints returned after loan to us ☐ Other:

Remarks: These are stamped panel span calculations from our P.E. Please let me know if you need anything else.

Copy To: File

Signed: Joshua Sherman

JAMES R. FRANDSEN P.E.
Licensed Professional Engineer

P.O. Box 426 • 3310 Route 352 • Big Flats • New York 14814
Phone: (607) 562-3560 • Fax: (607) 562-8105

Roof Panel Span Calculations May 31, 2007

The following is input and output from the computer program used to calculate deflection and stresses in Murus structural insulating panels. The headings (Living Space, Breezeway, and Mechanical Core) correspond to the area on the Penn State – Solar Decathlon architectural drawings that the analyzed roof is covering.

Living Space:

Input - Panel: 6 5/8" OSB/OSB PUR with (2) 2X splines
Loading: simple span; 3:12 slope; 12ft horizontal span; 15psf DL; 30psf SL

Results - Total load deflection over span = 1/261
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Breezeway:

Input - Panel: 4 5/8" OSB/OSB PUR with (2) 2X splines
Loading: overhang; 2:12 slope; 4ft horizontal span; 3ft-9in horizontal overhang; 15psf DL; 30psf SL

Results - Total load deflection over span = 1/268
Live load deflection over span = 1/402
Normal stress in OSB skins = ± 173psi < 780psi allowable
Shear stress in core = 0.9psi < 6psi allowable

Mechanical Core:

Input - Panel: 6 5/8" OSB/OSB PUR with single 2X splines
Loading: simple span; 0:12 slope; 7ft span; 40psf DL; 35psf SL

Results - Total load deflection over span = 1/346
Live load deflection over span = 1/707
Normal stress in OSB skins = ± 148psi < 780psi allowable
Shear stress in core = 1.7psi < 6psi allowable

COMMONWEALTH OF ... REGISTERED PROFESSIONAL JAMES R. FRANDSEN ENGINEER No.

6-12-07

JAMES R. FRANDSEN P.E.
Licensed Professional Engineer

P.O. Box 426 • 3310 Route 352 • Big Flats • New York 14814
Phone: (607) 562-3560 • Fax: (607) 562-8105

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Normal stress in OSB skins = ± 148psi < 780psi allowable
Shear stress in core = 1.7psi < 6psi allowable

COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL
JAMES R. FRANDSEN
ENGINEER
No.

6-12-07



MORNINGSTAR

JAMES R. FRANDSEN P.E.
Licensed Professional Engineer

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Phone: (607) 562-3560 • Fax: (607) 562-8105

Roof Panel Span Calculations May 31, 2007

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COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL
JAMES R. FRANDSEN
ENGINEER
No. PE027973

6/2/07

JAMES R. FRANDSEN P.E.
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Roof Panel Span Calculations May 31, 2007

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COMMONWEALTH OF PENNSYLVANIA
REGISTERED
PROFESSIONAL
JAMES R. FRANDSEN

6-12-07

# Appendix 5.0X

Specs and Structural Reports

| **_Code Compliance List** | Completed By | Revised By | DCN # | |
|---|---|---|---|---|
| Appendix 5.01 | Gimbert | Glantz, Owens | | |
| *Description: The following is a list of codes references by the PSU Solar Decathlon team to complete the structural design of the MorningStar Home.* | | | | |

## _Code Reference List

1 *IBC_2006*
The International Bulding Code

2 *IRC_2006*
The International Residential Code

3 *ASCE7-05*
Wind analysis, braking restrictions and seismic loads were designed based on this version of ASCE7-05

4 *HUD_4-1-06 Edition*
Housing and Urban Development Code

5 *2007 Solar Decathlon Code*
*See following pages for specific structural compliances.*

6 *SC & RA oversize /Overweight permit Manual*
See following pages for specific reference on Pennsylvania, Maryland and District of Columbia.

# 5 2007 Solar Decathlon Code

### 5.4 *Changes In Elevation*

All changes in elevation (including even minor changes in areas such as door thresholds) must be considered along an accessible route. Changes not exceeding 0.25 in. (0.635 cm) are acceptable. Elevation changes between 0.25 in. (0.635 cm) and 0.5 in. (1.27 cm) shall be beveled at a maximum of 1:2. Any higher change in elevation exceeding 0.50 in. (1.27 cm) shall be by a ramp with a maximum slope of 1:12 (ADAAG, Sec. 4.5.2).

### 5.5 *Doors and Door Approaches*

All doors shall comply with ADAAG Section 4.13 (ANSI A117.1-2003 Section 404). Doors that can be fixed in an open position may be accepted as part of the accessible route if 32-in. (81.3-cm) minimum clearance is provided through the door opening with the door secured in the fully open position.

## 6. Structural

The structural drawings and calculations included in the construction drawings and specifications set must be stamped by a licensed professional engineer (P.E.). Obtaining the P.E. stamp is the responsibility of the teams, not the Organizers. The Organizers will submit stamped structural drawings and calculations to the NPS for final approval. It is strongly recommended that teams involve a licensed structural engineer throughout the design process, because he or she could require structural design changes that could affect other aspects of the house. In addition to meeting applicable IRC requirements, special attention must be given to the structural design challenges unique to the Solar Decathlon. These challenges include, but are not limited to, the following:

- Increased live loads because of public access to houses
- Necessity for tie-downs because of the lack of a permanent foundation (tie-downs must not penetrate more than 18 in. (45.7 cm) into the National Mall topsoil)
- Use of low-impact footings to protect the National Mall grass
- Unique wind loading conditions because of roof-mounted solar systems
- Increased dead loads because of unusual mechanical and electrical equipment, such as batteries and water storage.

### 6.1 *Prescriptive Requirements*

Structural systems shall be designed in accordance with the appropriate prescriptive provisions of the IRC. See alternate materials provisions in Section 6.6. For structural framing, a one-line structural plan view drawing is required at a minimum. Successive plan sheets shall be provided and shall include foundation footings, floor framing, wall locations, and roof framing. All structural components shall be listed including sizes, species and grade, and repetitive spacing (on-center distances). Include details on connections between joists and beams, floor systems and foundations, walls and floors, rafters and beams, etc. Specify proprietary hangers or other mechanical connections. (IRC, Sec.R301.1)

### *6.2 Design Loads*

The following minimum loads must be used in the structural design:

- Wind: 60 mph (26.8 m/s) (3-second gust), exposure category C (if tie-downs are not used, you must show that there is no overturning or uplifting with a safety factor of 2)
- Railings: 200-lb (890-N) concentrated load applied in any direction at any point at the top of the rail
- Interior Floor, Decks, Ramps: 50 psf (2.39 kPa) live load
- Roof: 20-psf (0.958-kPa) live load
- Soil: 1500-psf (71.8-kPa) load-bearing pressure on top of the soil
- Additional structural design requirements at the post-Event house location (to be determined by the engineer of record).

Structural plans shall indicate the design loads (e.g., 50 psf [2.39 kPa] floors, 100 psf [4.78 kPa] means of egress components, 20 psf [0.958 kPa] snow roof live load) and the location, size, and weight of special loads such as liquid storage tanks, mass or trombe walls, and battery storage racks (IRC, Sec. R310.2).

### *6.3 Exterior Construction*

Structural plans shall include design details for any exterior appurtenances such as decks, stairs, ramps, awnings, canopies, and roof projections (IRC, Sec. R301.1).

### *6.4 Specific Point Loads*

Provide wind-analysis calculations for point-load connections demonstrating the components' abilities to withstand 60-mph (26.8-m/s), exposure category C wind conditions. Provide point-load connection details for all solar panel connections to demonstrate that the connections will resist uplift (IRC, Sec. R301.1).

### *6.5 Foundation Details*

Provide a foundation plan for temporary set up on the National Mall. Plans shall include location and size of all pad footings and required tie-down anchors (e.g., type, number, and installation configuration) to prevent wind uplift or over-turning (IRC, Sec. R401.1 and

R401.2). Please provide consideration for sloping or variable site conditions. The surface of each assigned site on the Mall may vary up to 18 in. (46 cm.) depending upon location.

### *6.6 Alternate Materials*

Alternate materials are permitted as follows.

- Engineered Lumber (e.g., TJIs, LPIs, and BCIs) pursuant to specific manufacturer's design data. The product selected must carry a current International Code Council (ICC) Evaluation Services report. See http://www.icc-es.org/.
- Structurally insulated panel systems (SIPS) pursuant to specific manufacturer's design data. The product selected must carry a current ICC Evaluation Services report. Also be advised that foam plastics must be thermally isolated from the interior of the dwelling (see Section 4.6 for more details).
- Engineered trusses (floor or roof) must be designed in accordance with IRC Sections R502.11 or R802.10 as appropriate. Individual truss reports shall be provided for review and shall bear the seal of a registered design professional (IRC, R104.11).
- Other alternate materials may be permitted if approved pursuant to IRC Section 104.11. It is the responsibility of the applicant to provide adequate proof to document the alternate as meeting the intent of the prescriptive code requirements. The Organizers reserve the right to deny any alternate for failure to clearly demonstrate code equivalence.

### *6.7 Structural Steel*

Provide structural details for load-carrying structural steel assemblies. Include welded or bolted connections within the assembly and where attached to other structures (IRC, R301.1.3).

## 7. Electrical

### *7.1 General Requirements*

The provisions of the 2005 National Electrical Code will supersede the limited prescriptive electrical requirements contained in Chapters 33-42 of the 2006 International Residential Code.

All houses must meet all applicable electrical requirements stated in the 2005 National Electric Code (NEC2005). Particular attention should be paid to Articles 690, 480, 445, 250, 310, 400, and 240, which refer to photovoltaic system design, storage batteries, generators, grounding, conductors for general wiring, flexible cords and cables, and over-current protection devices, respectively. Teams are also encouraged to follow the guidelines in the following publication: Wiles, John C. (2006). *Photovoltaic Power Systems and the 2005*

# 6 SC & RA oversize / Overweight permit Manual

# PENNSYLVANIA

**CONTACT:**
Central Permit Office
Keystone Building
P.O. Box 8210
Harrisburg, PA 17105-8210
Website: www.dot.state.pa.us → More Links→ Permits → Hauling Permits

Hours: 8:00 am - 4:30 pm
(717) 787-4680 (General Information Only)
Online Permitting: www.dot1.state.pa.us
(Must register with Central Permit Office)

## LEGAL LIMITS

| | |
|---|---|
| GVW | 80,000 |
| o (steer) | 20,000 |
| o | 20,000 |
| oo | 34,000 |
| ooo | 42,000 |

—— Federal Bridge Formula applies to combination vehicles registered and weighing more than 73,280

| | |
|---|---|
| 2-axle truck | 38,000 |
| 3-axle truck | 58,400 |
| 4-axle truck | 73,280 |

TOLERANCE 3% scale tolerance on GVW when axle weighed (not allowed on Interstate if weighed on stationary scales)

| | | |
|---|---|---|
| WIDTH | 8' | nondesignated hwys |
| | 8'6" | designated hwys |
| HEIGHT | 13'6" | |
| LENGTH | 40' | single unit |
| | 53' | semitrailers (53', kingpin setting to center of axle group not to exceed 41') |
| | 28'6" | doubles |
| | 65' | auto transporter |
| | 75' | stinger steered |
| OVERHANG | 3' | front |
| | 6' | rear divisible loads; no rear restriction for non-divisible loads not exceeding 70' |
| TIRE WIDTH | 800 lbs per inch width | |

## SPECIAL PERMIT LIMITS

| | |
|---|---|
| o | 27,000 |
| oo | 52,000 |
| ooo | 63,000 |
| oooo | 72,000 |
| 5 axles | 116,000 |
| 6 axles | 127,000 |
| 7 axles | 136,000 |
| 8 axles | 136,000 |

| | | |
|---|---|---|
| WIDTH: | 16' | |
| HEIGHT: | 14'6" | depends on route |
| LENGTH: | 160' | |

## TYPES OF PERMITS

**Single Trip** — Nondivisible Oversize and/or Overweight Vehicle and/or Load

**Seasonal** — Commodity Specific (cranes, building structural components, implements of husbandry, military convoy)

**Annual** — Commodity Specific (glass, coal, ash, oil, fiberboard, wooden structures, live domestic animals, animal feed, SME (Special Mobile Equipment) on freeways, articles in course of manufacture, crossings, containerized cargo)

## FEES

**Single Trip** — $25 if under or equal to 14' wide, if over 14' wide the fee is $50; plus $.03 cents per ton mile (Note: this applies to all single trip) for all weight in excess of motor carrier's registered weight. A 3-day extension requested because of weather problems or breakdown may be obtained at no charge.

**Seasonal** — $25 to several thousand dollars, based on weight, distance and duration allowed for commodity.

**Annual** — $200 to several thousand dollars, based on weight and distance allowed for commodity.

## ESCORTS AND SIGNS

All escorts must have insurance in the amount of one million dollars and list the state as additional insured.

**Labeling** — All vehicles and loads of excessive size must be marked with red or fluorescent orange flags not less than 18" square. Signs with the words "OVERSIZE LOAD" must be placed on the front and rear of the vehicle, and on both the front and rear of pilot cars when escorts are required. The sign attached to a permitted vehicle or load must have dimensions of at least 7' x 18", with 10" black letter with a 2 inch letter stroke on a yellow background.

**Escort Vehicles and Personnel** — Pilot cars must have revolving or flashing amber lights on top of the car. One rear escort is required for vehicles over 90' in **length.** Vehicles over 13' in **width** must have one rear escort on roads with two or more lanes which carry traffic in the same direction. The escort vehicle must lead the overwidth vehicle on highways having only one lane which carries traffic in the same direction. Vehicles with loads over 14'6" in **height** must have a pilot car preceding the vehicle by 1,000–3,000' and equipped with a height pole.

Escorts may be required in some urbanized areas. In addition, Pennsylvania state escorts will be necessary for hauling super loads. State escort fees are assessed by PA State Police.

## CONTACTS

City of Philadelphia — Must have a permit to operate on city streets. Permits are available from 9:00 am to 3:30 pm. The fee is $15.

Oversize vehicles may not travel along Traffic Route 209 in Monroe and Pike Counties between I-80 and the Pennsylvania-New York border unless approval is obtained from the National Park Service (570) 588-6344.

Operators must receive approval when operating permitted loads in the following jurisdiction

**ALLEGHENY COUNTY**
Pittsburgh Traffic Department
(412) 255-2853
Allegheny County Roads Permit
(412) 350-5469

**DAUPHIN COUNTY**
Harrisburg/Sgt. Butler
(717) 255-3131

**ELK COUNTY**
St. Mary's Borough Police
(814) 772-0000

**RIDGWAY BOROUGH POLICE**
(loads over 12' wide)
(814) 772-0775

**LEBANON COUNTY**
City Engineer
(717) 273-6711 x426

**CITY OF GROVE CITY**
Police Department
(724) 458-7925

**CITY OF MERCER**
Police Department
(724) 662-6110

**CITY OF PHILADELPHIA**
(215) 686-5546
(height and weight only)

**CITY OF YORK**
Office of Public Works
(717) 849-2245

**BOROUGH OF SLIPPERY ROCK**
Police Department
(724) 794-6388

**CLEARFIELD COUNTY**
Houtzdale Boro Police
(800) 689-3535

**DELAWARE RIVER PORT AUTHORITY**
(609) 968-2093

**BURLINGTON COUNTY BRIDGE COMMISSION**
(609) 829-1900

**DELAWARE RIVER JOINT TOLL BRIDGE COMMISSION**
(215) 295-5061 (ext 230)

# MARYLAND

CONTACT:
State Highway Administration
Hauling Permits Section
7491 Connelley Drive
Hanover, MD 21076

**Hours: 7:30 am – 4:30 pm** **(410) 582-5712**

## LEGAL LIMITS

| | | |
|---|---|---|
| GVW | 73,000 | 80,000 |
| o (steer) | 12,000 | 12,000 |
| o | 22,400 | 20,000 |
| oo | 36,000 | 34,000 |
| ooo | 36,000 | 42,000 (must have more than 8' between axles) |

-Federal Bridge Formula applies

TOLERANCE: None.

| | | |
|---|---|---|
| WIDTH | 8' | (nondesignated highways) |
| | 8'6" | (designated hwys.) |
| HEIGHT | 13'6" | |
| LENGTH | 40' | single unit |
| | NR | overall length |
| | 53' | semitrailer w/41' kingpin |
| | 28' | doubles (designated hwys) |
| | 65' | autotransporter (designated highways) (3' front, 6' rear overhang) |
| | 75' | autotransporter (stinger-steered, designated highways) |
| OVERHANG | 3' | front, boat/autocarrier |
| | 4' | rear, boat/autocarrier |

## SPECIAL PERMIT LIMITS

| | |
|---|---|
| o | 27,000 |
| oo | 52,000 |
| ooo | 62,000 |
| GVW | 120,000 |
| | 150,000 |

TRUNNION AXLES: 27,000 lbs.
WIDTH 15'11"
HEIGHT 15'11"
LENGTH 120' (kingpin to rear axle limit of 41' on modular homes only)

## GENERAL PERMIT RESTRICTIONS

Permits are valid for five days, daylight hours. Travel allowed one-half hour after sunrise and one-half hour before sunset. No travel is permitted on Sunday, nor after noon on Saturday. See "Types of Permits" for valid length of permits.

As a general rule, operators may not obtain permits for divisible loads.

Insurance credit bond required to be on file, with amount depending on amount of business (but not less than $3,000); required to have performance bond liability insurance of at least $10,000.

## FEES

**Blanket** — $50 (30-day permit); $500 (annual).

**Book** — $300.

**Special Hauling** — $30 up to 45 tons, plus $5 for each additional ton; $5 fee for 3-day extension.

**Excessive** — Composed of engineering fees (number of structures crossed multiplied by $8/structure) and administrative costs; $20 per structure if over 200,000 GVW plus administrative costs. Permit request can take 5-10 business days to process. For multiple moves identical in travel and load, engineering fees will be assessed generally once for a six month period; permit and administrative charges will be assessed each time a permit is activated.

Structural survey done as a part of the engineering fee good for six months. District engineer may decide that Administration personnel must monitor move, at a rate of $200 a day. If required, state police officer to escort at $250 per move. All fees must be prepaid, and engineering fee will be paid regardless of use or nonuse of permit. Posted bonds required to cover administrative costs or insurance liability (additional to regular insurance bond).

## ESCORTS AND SIGNS

**Labeling** — Any load over 9' in width must have a wide load sign on the front and rear of the vehicle. Wide load or oversize load signs must appear in black letters not less than 10" high and have a brush stroke of not less than 1.625" wide. Background is yellow. Banner dimensions of 1.5' x 7'.

Red or orange fluorescent flags must be at least 18" square and must be placed on all extremities of the load.

Escort vehicle shall display a sign on the roof of the vehicle that is at least 5' long, 12" high with letters 8" high.

**Escort Vehicles and Personnel** — One escort required for load over 13' in width. 85' in **length** equal to or over 14'6" in **height** (pole vehicle) and/or **gross weight** exceeding 60 tons. Two escorts required for load equal to or over 14' in **width**, 140' in **length** or traveling on roads too narrow for other traffic to pass or for which traffic must be diverted. Police escort required for loads equal to or over 16' in **width** or over 65 tons GVW.

Escort vehicles travel no more than 200' to the front or rear of the permitted vehicle. Single escort must follow the load on any four-lane road and precede the load on a two-lane road.

Escorts-A single or double private escort or Maryland State Police escort may be added at any time at the discretion of the Maryland Hauling Permits Unit for safety.

## FINES

**Overdimension Only**: $100 per violation.

**Overweight Fines**: Statutory weight limit of 79,000 lbs. is allowed, as is the statutory plus a loading error or tolerance of 1,000 lbs. on only one weight limit (axle or gross); whichever excess is greater.

| | |
|---|---|
| 0–5,000 lbs. overweight | 5 cents per pound or $50 (whichever is greater) |
| over 5,000 | 12 cents per pound |

4) William Preston Lane, Jr. Memorial Bridge (Bay Bridge —U.S. 50/301)
5) Francis Scott Key Bridge (I-695)
6) John F. Kennedy Memorial Highway (I-95 toll road)
7) Ft. McHenry Tunnel (I-95 Tunnel)

**Baltimore Harbor Tunnel** - No Permit Loads

**Harry Nice Bridge** (US Route 301) — Vehicles over 12' in width are prohibited without prior special written permission from the Bridge Superintendent; moves over 14'6" in height are prohibited.

**Ft. McHenry Tunnel** — Lies within the city limits, so that vehicle operators must obtain a city permit (see below) before crossing. Travel restrictions include 55 tons GVW, 14'6" height, and 11' width (no length limit specified).

**Baltimore City Permit** — Fee of $30 for the first 45 tons, with an added $5 fee additional ton. No engineering fee is charged, but permittees may be requested to have a survey done prior to the granting of the permit. For further information, call (410) 396-3333.

**Moving heavy equipment at railroad crossing.**

**(a) Application of Section** — Unless a person has complied with this section, he may not drive or move on or across any railroad grade crossing any power shovel, derrick, roller, crawler-type tractor, or other equipment or structure that has:

(1) A normal operating speed of 10 miles an hour or less; or

(2) A vertical body or load clearance, measured above the level surface of a roadway, of less than;
  (i) One-half inch for each foot of the distance between any two adjacent axles; or

(1) A normal operating speed of 10 miles an hour or less; or

(2) A vertical body or load clearance, measured above the level surface of a roadway, of less than;
  (i) One-half inch for each foot of the distance between any two adjacent axles; or
  (ii) 9 inches.

**(b) Notice of Intended Crossing** — Before any person drives or moves any equipment described in subsection (a) of this section on or across any railroad grade crossing, the person shall:

(1) Notify an agent of the railroad of his intention; and

(2) Afford the railroad reasonable time to provide proper protection at the crossing.

**(c) Duty to Stop, Look, and Listen** — When the person approaches the crossing he:

(1) Shall stop within 50' but not less than 15' from the nearest rail in the crossing.

(2) While stopped, shall listen and look in both directions along the track for any approaching or passing railroad train and for any signals indicating the approach or passage of a railroad train; and

(3) May not proceed until he can do so safely.

**(d) Obedience to Signals** —

(1) The person may not proceed if a warning is given by an automatic signal, crossing gaflagman, or otherwise of the immediate approach or passage of a railroad train.

(2) If the railroad provides a flagman, the person may proceed over the crossing only at the direction of the flagman.

# DISTRICT OF COLUMBIA

CONTACT:
Department of Public Works
614 H Street, N.W.
Washington, DC 20001

**hours: 9:00 am - 3:00 pm** **(202) 727-7050**

## LEGAL LIMITS

| | |
|---|---|
| GVW | 80,000 |
| o (steer) | 20,000 |
| o | 20,000 |
| oo | 34,000 |
| ooo | 42,000 |

—Federal Bridge Formula applies

TOLERANCE: 1,000 lbs.

| | | |
|---|---|---|
| WIDTH: | 8' | (nondesignated highways) |
| | 8'6" | (designated highways) |
| HEIGHT: | 13'6" | |
| LENGTH: | 40' | single unit |
| | 48' | trailer |
| | 28' | doubles |
| | 55' | overall |
| | 55' | autotransporter |
| OVERHANG: | 3' | front |
| | 5' | rear |

## SPECIAL PERMIT LIMITS

| | | |
|---|---|---|
| o | 31,000 | |
| oo | 62,000 | depends |
| ooo | 93,000 | on |
| oooo | 124,000 | spacings, |
| 5 axles - | 155,000 | lbs. per |
| 6 axles - | 186,000 | inch |
| 7 axles - | 217,000 | tire |
| 8 axles - | 248,000 | width |

| | | |
|---|---|---|
| WIDTH: | 20' | wider limits possible |
| HEIGHT: | depends on routes | |
| LENGTH: | depends on routes | |

## GENERAL PERMIT RESTRICTIONS

Permits are valid for five days. Travel is permitted from sunrise to sunset seven days a week.

Divisible load permits are not available.

***Insurance*** — proof of insurance coverage not required to be on file; must have coverage meeting federal standards ($750,000 - $5,000,000, depending on commodity and hazardous nature).

| **_Product List** | Completed By | Revised By | DCN # | |
|---|---|---|---|---|
| Appendix 5.02 | Gimbert | Glantz, Owens | | |
| *Description: The following list all codes the PSU Solar Team Structural team complied to through the design of the MorningStar Home.* | | | | |

## *_Product List*

*SIPs [Murus]*

Structural Insulating Panels consist of a layer of rigid insulation sandwiched between two layers of Oriented Strand Board to provide structural capacity. The # 2145 panel has an overall thickness of 4-5/8" and weight of 3.75 lb/sf and is used as roof material over the breezeway. The remainder of the home consists of the # 2165 panel that has an overall thickness of 6-5/8" and a weight of 4.15 lb/sf.

*Diamond Pier [Pin Foundations Inc.]:*

The Diamond Pier is a bearing system and performs much like a spread footing. The entire system pushes against the soil as one unit, creating two A-frames per pier through which the load is directly transferred to the soil. The DP-50 has a maximum capacity of 4,000 lbs. The DP-100 has a maximum capacity of 8,000 lbs.

*Tie Rods: [Simpson Strong-Tie]*

Simpson has a large variety of tie rods available.

*Structural Steel, A-36, A-500:*

One of the world's most recycled products; steel is a locally available and recognized material and its process of production is proven to have less embodied energy than concrete. A-36 grade pieces include all angles, plates and bars. Structural steel members; A-500 grade pieces include all HSS tubing within the design.

*Steel Bolts, A-325:*

Steel bolts used in various connections throughout the house. Most bolts used are 1/2" diameter.

*Structural Wood, No.1 S-P-F, No. 2 Southern Pine*

One of the world's most widely used products throughout history. Wood is available locally and is a highly sustainable, natural product.

*Structural Wood, LVL:*

Laminated Veneer Lumber is made from several thin layers of wood veneer sandwiched together with glue. It has a much higher load bearing capacity than regular lumber and can be customized in sizes that regular lumber cannot.

murus
STRUCTURAL INSULATING PANELS

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**Homeowners**
SIP Overview
General Features & Benefits
PUR Features & Benefits
EPS Features & Benefits
Pre-cutting
Green Building
Timber Frame & Log Home Use
Recent Residential Projects
SIPS Technical Information
FAQs - PUR
FAQs - EPS
Mechanical Ventilation Information
Murus Brochure (PDF)

**Builders**

**Architects & Engineers**

Homeowners > SIPs Technical Information >

**THE MURUS OSB-2100PUR**
**STRUCTURAL INSULATING PANEL**
**(OSB/PUR Foam Core/OSB)**

| # | 2145 | 2155 | 2165 |
|---|---|---|---|
| Overall Thickness: | 4-5/8" | 5-5/8" | 6-5/8" |
| Thickness Tolerance: | +/- 1/8" | * | * |
| Width: | 48" | * | * |
| Width Tolerance: (Finish Size) | +0/-1/8" | * | * |
| Standard Lengths: (Feet) | 4', 6', 8', 9', 10', 12', 14', 16', 18', 20', 22', 24' | * | * |
| Length Tolerance: | +/- 1/4" | * | * |
| Weight: | 3.95 lb/sf | 4.15 lb/sf | 4.35 lb/sf |
| **Insulating Core** | | | |
| Type: | Polyurethane closed cell foam | | |
| Thickness: | 3-11/16" | 4-11/16" | 5-11/16" |
| Density: | 2.2 lb/cu.ft. | * | * |
| R-value | 6.76 per inch thickness | * | * |
| Insulating Core Properties | [4]Design Values | | |
| K Factor: (aged foam) | .14 | ASTM C-518 | |
| Compressive Strength: | 26 psi | ASTM D1621-94 | |
| Compressive [1]MOE: | 936 psi | ASTM D1621-94 | |
| Shear Strength: | 22 psi | ASTM C-273 | |
| Shear Modulus: | 192 psi | ASTM C-273 | |
| Flexure [2]MOR ([3]MD): | 39 psi | ASTM C203-92 | |
| Flexure Modulus ([3]MD): | 794 psi | ASTM C203-92 | |
| Tensile Strength: | 43 psi | ASTM D1623-78 | |
| Tensile Modulus: | 1133 psi | ASTM D1623-78 | |
| MVT/ Perm Inches: | <2.0 | ASTM E-96 | |
| Foam Fire Rating: | Class 1 | **ASTM E-84 | |
| Flame Spread: | 18 | **ASTM E-84 | |
| Smoke Developed | 270 | **ASTM E-84 | |

[1]**MOE:** Modulus of Elasticity [2]**MOR:** Modulus of Rupture [3]**MD:** Machine Direction [4]**Design Values** are mean derived from multiple specimens
*Specification or value is the same as the OSB 2145 Panel
**ASTM E-84 is not necessarily a representation of performance in an actual fire.
Class 1 is the highest rating available for combustible materials.

| |
|---|
| **Outside Skins** |
| Type: APA or equivalent rated oriented strand board (OSB) |
| Grade: Exposure-1 |
| Thickness: 7/16" |

**PUR Technical Specifications**

THE MURUS OSB-2100PUR
STRUCTURAL INSULATING PANEL
(OSB/PUR Foam Core/OSB)

THE MURUS PTP-2100PUR
STRUCTURAL INSULATING PANEL
(PTP/PUR Foam Core/PTP)

THE MURUS CLAD-2100PUR
STRUCTURAL INSULATING PANEL
(OSB/PUR Foam Core/OSB/Pine Cladding)

THE MURUS T-1-11-2100PUR
INSULATING PANEL
(OSB/PUR Foam Core/OSB/T-1-11)

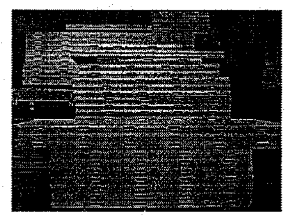
THE MURUS BB-2100PUR
INSULATING PANEL
(OSB/PUR Foam Core/Blueboard)

THE MURUS CB-2100PUR
INSULATING PANEL
(Cement Board/PUR Foam Core/Cement Board)

THE MURUS CP-2100PUR
INSULATING PANEL
(OSB/PUR Foam Core/Sound Board)

THE MURUS PTP/FB-2100PUR
INSULATING PANEL
(PTP/PUR Foam Core/FB)

THE MURUS FB-2100PUR
INSULATING PANEL
(OSB/PUR Foam Core/FB)



**The Murus Company**
PO Box 220 . 3234 Route 549 . Mansfield, PA . 16933
Phone: 570-549-2100 Fax: 570-549-2101
Email: info@murus.com

1. Polyurethane closed cell foam – minimum of 2.2 pcf insulation meeting manufacturer quality standards
2. OSB – an APA performance rating mark shall be identified on the panel, with an Exposure 1 durability rating; minimum physical properties shall be tested and described in APA PRP-108. 7/16" thickness is standard.
3. Cam locks – if required, shall be installed in the panel during the manufacturing process.
4. Wiring chases – if required, shall be formed into the panel during the manufacturing process.

B. Fasteners – shall be galvanized ring shank panel nails, or panel screws, as specified by panel manufacturer, for attachment of panel to frames, roofs, and corners. All fasteners to be sized and provided by manufacturer and installed per manufacturer's requirements.

C. Foam sealant – a sealant compatible with all components of the panel and adjacent materials, provided by manufacturer.

D. Construction adhesive – adhesive for installing dimensional lumber to be supplied by contractor.

E. Install foam sealant and adhesive per manufacturer's instructions.

F. Dimensional Lumber – SPF #2 kiln-dried or better, or pre-engineered equivalent supplied by contractor.

*2.02 Performance Characteristics*

A. Sizes – Murus polyurethane SIPs are available in sizes from 4' x 4' to 4' x 24'.

B. Thermal characteristics

| Typical R-values | |
|---|---|
| Murus polyurethane SIP thickness (inches) | R-value |
| 4 5/8" | 26 |
| 5 5/8" | 33 |
| 6 5/8" | 40 |

C. Panel Dimensional Tolerances – shall comply with values listed in the manufacturer's Quality Control Manual.

D. Structural Testing – Each panel type shown on the drawings shall meet or exceed performance standards, values, manufacturer's load design charts, and applicable technical data reports when tested in accordance with:

1. Transverse Load – Test method: ASTM E72
2. Combined Axial and Bending – Test method: ASTM E72
3. ASTM E84 Surface burning characteristics for the rigid insulation core.
4. ASTM E84 Surface burning characteristics conducted for the interior and exterior surfaces of the finished panel.

*2.03 Manufacturers/Contractors*

A. All components called for in this section to be supplied by the panel manufacturer shall be obtained from the selected manufacturer.

**SPECIFICATION:**

**Part 1 – General**

*1.01 Description of Work*

A. Provide all materials, labor, and equipment to install Murus Polyurethane SIPs.

B. Murus Polyurethane Structural Insulating Panels (SIPs) are engineered products consisting of approved oriented strand board (OSB) and third party certified rigid polyurethane foam insulation core.

C. Murus polyurethane SIPs are installed using patented cam lock connectors and approved fasteners supplied by the manufacturer, combined with dimensional plates, nailers, headers and sills, supplied by contractor, as detailed in manufacturer's installation details.

*1.02 Related Documents*

The general provisions of the contract and Division 1, General Supplementary and Special Conditions apply to the work specified in this section.

*1.03 Submittals*

A. Provide evidence of compliance with code requirements as an alternate method of construction.

B. Each Murus Polyurethane SIP installation drawing shall be reviewed by and sealed by a registered professional engineer qualified to perform such work.

Manufacturer shall verify that panels have been tested in accordance with ASTM E72, ASTM E84, and any other applicable tests.

*1.04 Quality Assurance*

A. Provide evidence of third party inspection and labeling of all insulation used in the manufacture of panels. Manufacturer's listing programs shall cover both flame and physical properties.

B. Panel manufacturer will provide lamination and R-value warranty documents for building owner acceptance and execution upon request. Manufacturer's standard forms will be submitted.

*1.05 Product Delivery, Storage and Handling*

A. All panels shall be stored in manufacturer's original packaging in a protected area and elevated to prevent ground contact.

B. Prior to installation, panels shall be covered and protected from exposure to sunlight and moisture.

C. After installation, panels shall be covered to prevent contact with water and /or moisture on all exposed panel edges and faces.

**Part 2 – Products**

*2.01 Description of Work*

A. Murus Polyurethane Structural Insulating Panel (SIP) - A stress skin panel manufactured using the proprietary manufacturing method of Uniform Dispersion Molding (UDM) consisting of the following:

## Part 3 – Installation

*3.01 General*

A. The contractor shall inspect conditions of substrate, grade and other conditions, which may affect the proper installation of panels. *Any* adverse conditions are to be reported in writing to the construction manager. Do not proceed with the installation until adverse conditions are corrected.

B. Installation shall be in strict accordance with manufacturer's published instructions, details, and the drawings that are part of the contract documents for this project. Any conflicts between these documents shall be resolved in writing. All plans shall be reviewed by a registered professional engineer and shall be signed and sealed. Deviations from standard detail and load design values shall be calculated and signed and sealed by a registered professional engineer.

*3.02 Protection*

A. When storing panels, do not allow them to come into contact with the ground. Stored panels must remain dry and in the manufacturer's original packaging. Do not allow panels to be stored in an unsupported manner. Improper storage may cause tolerance problems in the field.

B. Roof panels must be fully protected from weather by roofing materials or other means to provide temporary protection at the end of the day, or when rain or snow is imminent.

C. Remove and replace Insulating wall or roof panels, which have become excessively wet or damaged before proceeding with installation of additional panels or other work.

D. The construction manager, or his designee, shall remove all refuse created by the installation of work in this section.

| **_NREL Approval of MURUS SIP** | Completed By | Revised By | DCN # | |
|---|---|---|---|---|
| Appendix 5.03 | Tom Meyers | Glantz, Owens | | |
| *Conclusions: The use of Murus PUR SIP panels was approved by NREl and the Solar Decathlon committee.* | | | | |

**APPROVED**
***By Thomas Meyers at 7:56 pm, May 21, 2007***

**Date:** **May 21st, 2007**
**From:** **Sally J. Gimbert**
PSU Solar D Structural Team
**To:** **Thomas Meyers**
Building Code Official
2007 Solar Decathlon

It is the intention of the Penn State Solar Decathlon Team, through this written statement, to request **approval for the use of an alternative material**, the **Murus SIP system**, pursuant the **IRC R104.11**.

We understand that the Solar Decathlon accepts and approves the use of materials based on codes stipulated in the 2006 IBC and IRC. We understand that under the provisions provided by the IRC / IBC that the Murus SIP panel system is classified as an alternative material.

The provisions of R104.11 state that alternative materials must meet requirements of the IRC 2006 code with respect to quality, strength, effectiveness, fire resistance, durability and safety. It is not the intent of the code to limit the use of novel materials, but to verify its safe and reasonable use for the general public.

We also understand that the Solar Decathlon Committee will automatically accept a product that carries an ICC Evaluation Report.

The panels provided by the Murus Company have been evaluated for residential construction based on an ICC Legacy Report. Please see the enclosed copy of this. This legacy report ensures compliance of the SIP system with the 1996 BOCA National Building Code. Currently, Murus is in the process of updating their ICC report to reflect any improvements or changes made to the code since its original authentication.

The Penn State Solar Decathlon Team requests approval of the Murus SIP system for use as the main structural and envelope component of their 2007 Solar Decathlon entry. Approval of this system would be consistent with previous action taken by the Cornell University team and the Murus Company.

Enclosure, Murus ICC Legacy Report

| _ICC Report from MURUS | Completed By | Revised By | DCN # | |
|---|---|---|---|---|
| Appendix 5.04 | MURUS | Glantz, Owens | | |
| *Conclusions:* | | | | |

# LEGACY REPORT

97-36

*Reissued June 1, 2003*

**ICC Evaluation Service, Inc.**
www.icc-es.org

**Business/Regional Office** ■ 5360 Workman Mill Road, Whittier, California 90601 ■ (562) 699-0543
**Regional Office** ■ 900 Montclair Road, Suite A, Birmingham, Alabama 35213 ■ (205) 599-9800
**Regional Office** ■ 4051 West Flossmoor Road, Country Club Hills, Illinois 60478 ■ (708) 799-2305

**Legacy report on the BOCA® *National Building Code*/1999**

**DIVISION: 06—WOOD AND Plastics**
**Section: 06120—Structural Panels**

**EVALUATION SUBJECT:**

**MURUS PANELS**

**MANUFACTURER:**

**THE MURUS COMPANY**
**P.O. BOX 220**
**MANSFIELD, PA 16933**

**EVALUATION SCOPE**

**Compliance with the following code:**

BOCA® *National Building Code*/1999

- Section 1603.1 General
- Section 1708.1 Where required
- Section 1710.3.1 Test procedure
- Section 2305.7 Wind bracing
- Section 1404.2 Durability
- Section 2603.2 Labeling
- Section 2603.3 Surface burning characteristics
- Section 2313.2 Sandwich panels
- Section 1704.3 Labeling

**DESCRIPTION**

The Murus Panel is a composite panel used for exterior wall and roof applications. The Murus Panel, when used as an exterior wall panel, is used either as a curtain wall panel, which resists transverse loads only, or an exterior wall panel, which resists axial and transverse loads. The composite panel is 4 1/2 inches thick, 4 feet wide and is available in various lengths. See Figure 1 of this report for a diagram of the Murus Panel.

- Table 1 of this report contains allowable transverse loads and spans for the Murus Panel.
- Table 2 of this report contains allowable loads and spans for Murus Panels subjected to uniform tranverse and concentric axial loads.
- Table 3 of this report contains allowable loads and spans for Murus Panels subjected to uniform tranverse and axial loads with an eccentricity of 3/4 in.
- Table 4 of this report contains the allowable horizontal racking load of the Murus Panel, with and without openings.

■ **Panel Components**

- **Core:** The foam plastic core consists of one of two available foam plastic systems which are as follows: Flexible Products CIP 1416-HC#2 and Flexible Products PPG 442-22D. The Flexible Products CIP 1416-HC#2 core is made up of a rigid urethane foam which consists of an isocyanurate and polyol catalyst blend. The Flexible Products PPG 442-22D core is made up of a rigid urethane foam which consists of an isocyanurate and a resin component blend. The foam plastic cores have a density of 2.2 pounds per cubic feet.
- **Exterior skins:** Each face of the Murus Panel consists of 7/16-inch exterior grade, Exposure 1, Oriented Strand Board (OSB) complying with the United States Department of Commerce PS 2-95 (DOC PS 2-95).
- **Joinery:** The Murus Panel has a tongue-and-groove edge. The connection between the panels is made with a cam lock system, which consists of two parts, as shown in Figure 2 of this report. The cam lock is located along the vertical edge of the Murus Panel at 2-foot intervals, beginning 1 foot from the top or bottom of the panel. Two Murus panels are secured together by aligning two Murus Panels with cam locks next to each other, with spray foam applied to the tongue (or groove) of one panel, and rotating the cam turning gear in the cam lock with a hex head wrench. After the connection is completed, spray foam is applied in the exterior channel between the two panel skins. The excess foam is removed prior to the application of the exterior wall covering.

**CONDITIONS OF USE**

This report is limited to the applications and products as stated in this report. The ICC-ES Subcommittee on National Codes intends that the report be used by the code official to determine that the report subject complies with the code requirements specifically addressed, provided that this product is installed in accordance with the following conditions:

- Murus Panels shall be installed in accordance with this report and the manufacturer's instructions. Where the manufacturer's installation instructions differ from this report, this report shall be null and void.
- Murus Panels shall be limited to use as an exterior wall or roof panel in Type 5 construction.
- The use of Murus Panels in fireresistance rated wall or roof assemblies is beyond the scope of this report.

- The design loads on the system shall not exceed those given in Tables 1, 2, 3 and 4 of this report. Design values are for normal duration under dry use conditions and temperatures less than 160°F.
- Openings in the Murus Panels shall be limited to the sizes given in Figures 6 and 7 of this report. Openings larger than those shown in Figures 6 and 7 are beyond the scope of this report.
- The routing of chaseways into the Murus Panel wall for electrical, plumbing, HVAC or other purposes is beyond the scope of this report.
- A top in-let plate, as shown in Figure 3 of this report, shall be provided along the top edge of all Murus wall panels. The top in-let plate shall be installed in such a manner as to be continuous through the vertical panel joints. The top in-let plate shall consist of 2-inch by 4-inch dimension lumber. The plate shall be located in a 1 1/2-inch-deep routed channel at the top of the panel with spray foam applied between the foam core and the in-let plate. The OSB faces of the Murus Panel shall be secured to the top plate with 8d nails at 4 inches on center. The fasteners on the OSB faces shall be staggered from each other.
- A bottom in-let plate, as shown in Figure 4 of this report, shall be provided along the bottom edge of all Murus wall panels. The bottom in-let plate shall consist of 2-inch by 4-inch dimension lumber. The foam core of the panel shall be routed to completely embed the in-let plate in the panel, so that the OSB faces of the panel will bear completely on the surface which supports the Murus Panels. The in-let plate is to be fastened securely to the supporting structure as required by the approved construction documents. The void in the Murus Panel is sprayed with foam, as described above, prior to placing the panel over the in-let plate. The Murus Panel is then secured to the in-let plate on both faces with 8d nails at 4 inches on center. The fasteners on the OSB faces shall be staggered from each other.
- Openings in the Murus Panels for door and windows shall be rough framed with 2-inch by 4-inch dimension lumber embedded into the foam core of the panel in the same manner as the top and bottom in-let plates. The lumber framing shall be provided on all sides of the opening, as shown in Figure 5 of this report, and shall be secured to the OSB faces of the panel on both sides with 6d nails at 8 inches on center, staggered.
- The manufacturer shall provide the user of this report with instructions for the erection of Murus Panels. These instructions shall include, but not be limited to, details of panel to panel and panel to other building components interfaces.
- This report is subject to periodic re-examination. For information on the current status of this report, contact the ICC-ES.

## ITEMS REQUIRING VERIFICATION

The following items are related to the use of the report subject, but are not within the scope of this evaluation. However, these items are related to the determination of code compliance:

✔ Product identification consistent with this report.

✔ Special inspections in accordance with Section 1705.0 of the BOCA® *National Building Code*/1999, and consistent with the following:

- **SPECIAL INSPECTIONS**

Special inspections are required for the installation of Murus Panels, in that it is work which is of an unusual design wherein installation, fabrication, erection and placement of components requires special expertise to ensure adequacy. Therefore, the Committee's evaluation of Murus Panels is based upon monitoring and control of the installation of Murus Panels through the use of special inspections in accordance with Section 1705.0 of the BOCA® *National Building Code*/1999. The following items shall be inspected:

- **Bottom in-let plates, top in-let plates and preparation of rough openings for doors and windows**
  - Foam core of panel properly routed (not over routed) to receive 2-in by 4-in nailer
  - Condition of foam core (clean and dry)
- **Application of foam spray**
  - Sufficient quantity of spray applied
  - Ambient temperature/substrate temperature
  - Appropriate mix proportions of foam
  - Label on ingredients
- **Framing of door and window openings**
  - Framing full length on all sides of the opening
  - Framing properly lapped
- **Fastening of panel to in-let plates and opening framing**
  - Size of fasteners
  - Spacing of fasteners
  - Fasteners on both sides of panel
- **Cam locks**
  - Properly secured, as required by the manufacturer's installation instructions

✔ Thermal barrier separation, when required, in accordance with Section 2603.4 of the BOCA® *National Building Code*/1999.

✔ Where installed in roofing applications, roof covering complies with the applicable provisions of Chapter 15 of the BOCA® *National Building Code*/1999.

✔ Where installed in exterior wall applications, exterior wall covering complies with the applicable provisions of Chapter 14 of the BOCA® *National Building Code*/1999.

## INFORMATION SUBMITTED

### STRUCTURAL

- "Structural Evaluation of the Murus Stress-Skin Urethane Sandwich Panel," by Harvey B. Manbeck, P.E., Ph.D, of the NAHB/NRC Designated Housing Research Center at Penn State, dated August 1991, containing the following:
  - Results of adhesion testing of the OSB facers and the foam plastic core material when subjected to ASTM Standard C481-62 Aging Cycle A.
  - Results of flatwise tension testing in accordance with ASTM C297.
  - Results of edgewise compression testing in accordance with ASTM C364.
  - Results of flatwise compression testing in accordance with ASTM C365.
  - Results of flexural testing in accordance with ASTM C393.
  - Results of transverse and compression testing ir dance with ASTM E72.

The results of the above test are the basis for Tables 1 through 3 of this report.

- Results of horizontal racking testing in accordance with a modified version of ASTM E72 performed on Murus Panels with and without door and window openings. The modification was that no stud framing was provided, and the panels were 10 feet high rather than 8 feet high. The panels were secured to the base beam and top beam of the test assembly with #6 sheetrock screws at 8 inches on center. The results of the testing are given in Table 4 of this report. The door and window openings tested are shown in Figures 6 and 7 of this report.

- Report No. 30, "Creep Behavior of the Murus Stress-Skin Urethane Composite Sandwich Panel," by Harvey B. Manbeck, P.E., Ph.D, of the NAHB/NRC Designated Housing Research Center at Penn State, dated January 1993, containing results of testing in accordance with Section 1710.3.1 of the BOCA® *National Building Code*/1999.

- Celotex Corporation Testing Services, MTS Job No. 258498, dated June 3, 1998 and June 29, 1998, containing results of tensile, compressive, flexural and shear testing of the CIP 14-8557(PPG 442-22D) foam plastic in accordance with ASTM D1623, ASTM D1621, ASTM C203 and ASTM C273. The results indicate that the CIP 14-8557(PPG 442-22D) foam plastic has structural properties at least equivalent to the CIP 1416-HC#2 foam plastic.

**FOAM PLASTIC**

- Omega Point Laboratories, Report No. 8926-98159, dated March 2, 1995, containing results of testing of the Flexible Products CIP 1416-HC#2 foam plastic in accordance with ASTM E84 at a thickness of 1 in and 5 3/4 in.

- Omega Point Laboratories, Report Nos. 9056-103120 and 9056-103121, dated May 11, 1998, containing results of testing of the Flexible Products CIP 14-8557(PPG 442-22D) foam plastic in accordance with ASTM E84 at a thickness of 5 3/4 in.

**LABELING**

- The Murus Company, *Quality Control Manual*, dated March 1999, Revision D, signed by representatives of the Murus Company and PFS Corporation, containing procedures for the manufacture of the Murus Panel, in-house plant inspections, and product labeling.

**APPLICATION FOR PERMIT**

To aid in the determination of compliance with this report, the following represents the minimum level of information to accompany the application for permit:

- The language "See ICC-ES Legacy Report No. 97-36" or a copy of this report;

- Manufacturer's name.

- Product model name and number.

- Design calculations and details for construction utilizing Murus Panels shall be furnished to the code official verifying compliance with this report. The individual preparing such documents shall be competent and qualified in the application of the structural design principals involved, and shall possess the registration or license in accordance with the professional registration laws of the state in which the project is constructed. The calculations shall include, but not be limited to, the following:
  - The minimum required design loads for the building for the building system, consistent with the requirements of Chapter 16 of the BOCA® *National Building Code*/1999.
  - The allowable design loads of the panels, consistent with this report.
  - The ability of all connections between the panel and adjacent building components to transfer all the imposed design loads to the building foundation and footing system.
  - Details of panel openings, consistent with this report.

- Statement of Special Inspections

**PRODUCT IDENTIFICATION**

- Murus Panels or product packaging shall be marked at the plant with the identifying language "See ICC-ES Legacy Report No. 97-36."

- Additionally, each panel shall bear a label containing the manufacturer name, product name, and identification of the inspection agency, PFS Corporation.

*This report is subject to re-examination in one year.*

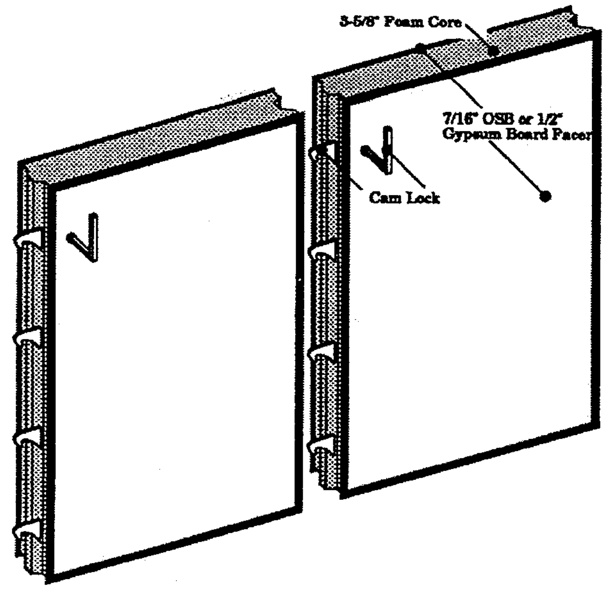



**FIGURE 1—*MURUS PANELS**

The panels are 48 inches wide. Cam Locks, if provided, are located 1 ft. from the top and bottom and at 2 ft. intervals in between.

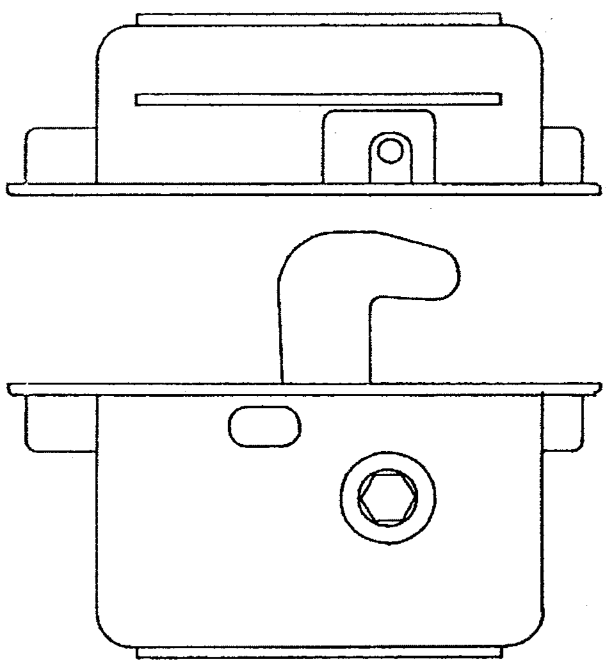


**FIGURE 2*—CAM LOCK**

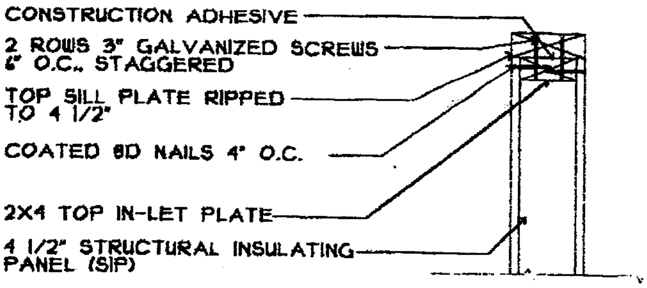



FIGURE 3*—TOP IN-LET PLATE

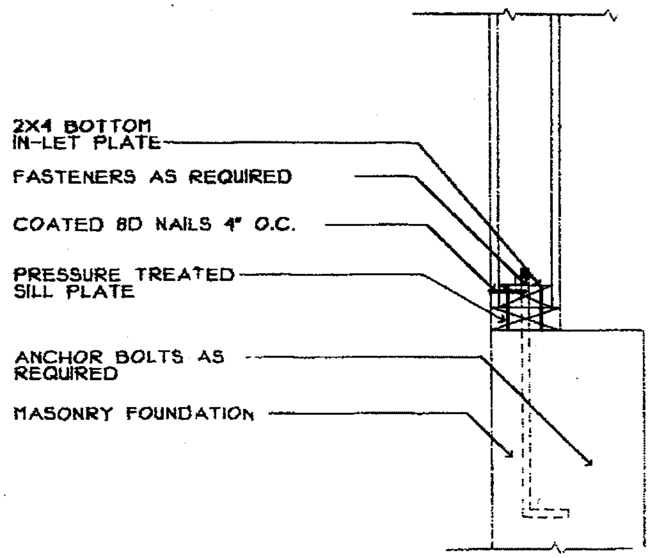



FIGURE 4*—BOTTOM IN-LET PLATE

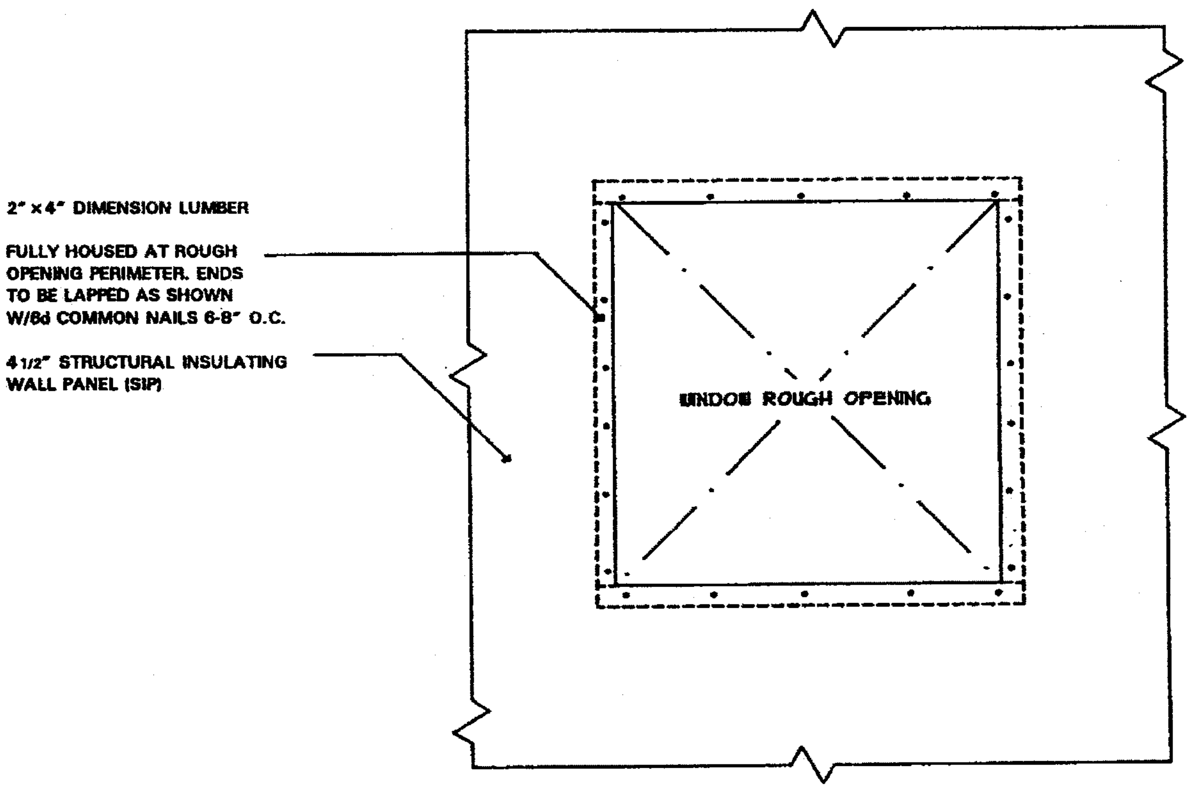



FIGURE 5*—FRAMING AT ROUGH OPENINGS FOR WINDOWS AND DOORS

**TABLE 1**
**TRANSVERSE LOAD-SPAN TABLE FOR THE MURUS PANEL**
**(Customary Units)**

| UNIFORM TRANSVERSE LOAD [1] (psf) | ALLOWABLE PANEL SPAN [2,3,4] (ft - in) DEFLECTION LIMITS | | | |
|---|---|---|---|---|
| | L/180 | L/240 | L/360 | L/480 |
| 5 | 20'-8" | 18'-9" | 16'-4" | 14'-9" |
| 10 | 16'-4" | 14'-9" | 13'-0" | 11'-9" |
| 15 | 14'-3" | 13'-0" | 11'-4" | 10'-3" |
| 20 | 13'-0" | 11'-9" | 10'-3" | 9'-4" |
| 25 | 12'-1" | 11'-0" | 9'-7" | 8'-8" |
| 30 | 11'-4" | 10'-3" | 9'-0" | 8'-2" |
| 35 | 10'-9" | 9'-9" | 8'-7" | 7'-9" |
| 40 | 10'-3" | 9'-4" | 8'-2" | 7'-6" |
| 45 | 9'-11" | 9'-0" | 7'-10" | 7'-2" |
| 50 | 9'-7" | 8'-8" | 7'-7" | 6'-11" |
| 55 | 9'-3" | 8'-4" | 7'-4" | 6'-8" |
| 60 | 9'-0" | 8'-2" | 7'-2" | 6'-6" |
| 65 | 8'-9" | 8'-0" | 7'-0" | 6'-3" |
| 70 | 8'-7" | 7'-9" | 6'-9" | 6'-2" |
| 75 | 8'-4" | 7'-7" | 6'-8" | 6'-0" |
| 80 | 8'-2" | 7'-5" | 6'-9" | 5'-11" |

1. Uniform load for normal load durations only.
2. Values given are for full (four foot) panel widths with facing strands oriented parallel to the panel span assuming proper end support and connections. The transverse load-carrying capacity of panels that contain openings is beyond the scope of this report.
3. Values given are computed from the continuous span uniform deflection equation using the flexural stiffness parameter $(EI)_g$ developed from the full scale transverse panel assembly test of the Murus Panel (ASTM E72-80).
4. Design values are for normal load duration under dry use conditions and temperatures less than 160°F.

**TABLE 2**
**ALLOWABLE AXIAL LOAD/UNIT WIDTH FOR THE MURUS PANEL WITH NO ECCENTRICITY**
**(Customary Units)**

| TRANSVERSE LOAD[1] psf | ALLOWABLE AXIAL LOAD[*1, 2, 3, 4] lb/ft | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | PANEL LENGTHS ft | | | | | | | | | | |
| | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 0 | 9025 | 8720 | 8165 | 7250 | 5870 | 4640 | 3755 | 3105 | 2610 | 2220 | 1915 |
| 2 | 8975 | 8630 | 8030 | 7075 | 5690 | 4470 | 3600 | 2955 | 2460 | 2080 | 1775 |
| 4 | 8920 | 8540 | 7900 | 6905 | 5510 | 4310 | 3445 | 2805 | 2315 | 1940 | 1635 |
| 6 | 8865 | 8455 | 7765 | 6740 | 5340 | 4150 | 3295 | 2660 | 2175 | 1800 | 1500 |
| 8 | 8815 | 8365 | 7640 | 6575 | 5170 | 3990 | 3145 | 2515 | 2035 | 1660 | 1365 |
| 10 | 8760 | 8275 | 7510 | 6415 | 5005 | 3840 | 3000 | 2375 | 1900 | 1530 | 900* |
| 12 | 8710 | 8190 | 7380 | 6255 | 4840 | 3690 | 2855 | 2235 | 1765 | 1240* | 35* |
| 14 | 8655 | 8100 | 7255 | 6100 | 4685 | 3540 | 2715 | 2100 | 1630 | 435* | NP |
| 16 | 8600 | 8015 | 7130 | 5950 | 4530 | 3395 | 2575 | 1965 | 1180* | NP | NP |
| 18 | 8550 | 7925 | 7010 | 5800 | 4375 | 3250 | 2440 | 1835 | 440* | NP | NP |
| 20 | 8495 | 7840 | 6885 | 5650 | 4230 | 3110 | 2305 | 1665* | NP | NP | NP |
| 22 | 8445 | 7755 | 6765 | 5505 | 4080 | 2975 | 2170 | 990* | NP | NP | NP |
| 24 | 8390 | 7670 | 6645 | 5365 | 3940 | 2835 | 2040 | 310* | NP | NP | NP |
| 26 | 8340 | 7585 | 6525 | 5220 | 3795 | 2705 | 1910 | NP | NP | NP | NP |
| 28 | 8285 | 7500 | 6410 | 5085 | 3655 | 2570 | 1590* | NP | NP | NP | NP |
| 30 | 8235 | 7415 | 6295 | 4945 | 3520 | 2440 | 975* | NP | NP | NP | NP |

* Load limited by L/240 deflection criterion

NP = Not Permitted

1. Uniform transverse and axial loads are for normal load durations only.
2. Values given are for full (four foot) panel widths with facing strands oriented parallel to the panel span assuming proper end support and connections. The load-carrying capacity of panels that contain openings is beyond the scope of this report.
3. Values given are computed from the combined load case and limiting deflection criterion using the flexural stiffness parameter $(EI)_g$ developed from the full-scale transverse panel assembly test of the Murus Panel (ASTM E72-80), $F_c$ developed from the compression edgewise test of the Murus Panel (ASTM C364-61), $F_b$ from published data for Oriented Strand Board.
4. Design values are for dry end use conditions and temperatures less than 160°F.

**TABLE 3**
**ALLOWABLE AXIAL LOAD/UNIT WIDTH FOR THE MURUS PANEL WITH A 0.75-IN. ECCENTRICITY**

| TRANSVERSE LOAD[1] psf | ALLOWABLE AXIAL LOAD*[1, 2, 3, 4] lb/ft | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | PANEL LENGTHS ft | | | | | | | | | | |
| | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 0 | 4925 | 4605 | 4245 | 3835 | 3340 | 2930 | 2570 | 2260 | 1990 | 1765 | 1565 |
| 2 | 4895 | 4560 | 4190 | 3765 | 3260 | 2840 | 2475 | 2155 | 1885 | 1655 | 1455 |
| 4 | 4870 | 4520 | 4135 | 3695 | 3180 | 2755 | 2380 | 2055 | 1780 | 1545 | 1345 |
| 6 | 4845 | 4482 | 4080 | 3625 | 3100 | 2665 | 2285 | 1955 | 1680 | 1440 | 1130* |
| 8 | 4815 | 4440 | 4025 | 3555 | 3020 | 2575 | 2190 | 1860 | 1575 | 1170* | 760* |
| 10 | 4790 | 4400 | 3970 | 3490 | 2945 | 2490 | 2095 | 1760 | 1335* | 840* | 385* |
| 12 | 4760 | 4355 | 3915 | 3420 | 2865 | 2405 | 2005 | 1630* | 1045* | 510* | NP |
| 14 | 4735 | 4315 | 3860 | 3350 | 2785 | 2320 | 1915 | 1380* | 755* | 180* | NP |
| 16 | 4705 | 4275 | 3805 | 3280 | 2710 | 2235 | 1820 | 1128* | 460* | NP | NP |
| 18 | 4680 | 4235 | 3750 | 3215 | 2630 | 2150 | 1640* | 875* | 170* | NP | NP |
| 20 | 4650 | 4195 | 3695 | 3145 | 2555 | 2065 | 1420* | 620* | NP | NP | NP |
| 22 | 4625 | 4155 | 3640 | 3080 | 2480 | 1980 | 1205* | 365* | NP | NP | NP |
| 24 | 4595 | 4115 | 3585 | 3010 | 2400 | 1895 | 990* | 115* | NP | NP | NP |
| 26 | 4570 | 4070 | 3530 | 2945 | 2325 | 1770* | 775* | NP | NP | NP | NP |
| 28 | 4540 | 4030 | 3475 | 2880 | 2250 | 1585* | 555* | NP | NP | NP | NP |
| 30 | 4515 | 3990 | 3420 | 2810 | 2175 | 1405* | 340* | NP | NP | NP | NP |

* Load limited by L/240 deflection criterion

NP = Not Permitted

1. Uniform transverse and axial loads are for normal load durations only.
2. Values given are for full (four foot) panel widths with facing strands oriented parallel to the panel span assuming proper end support and connections. The load-carrying capacity of panels that contain openings is beyond the scope of this report.
3. Values given are computed from the combined load case and limiting deflection criterion using the flexural stiffness parameter $(EI)_g$ developed from the full-scale transverse panel assembly test of the Murus Panel (ASTM E72-80), $F_c$ developed from the compression edgewise test of the Murus Panel (ASTM C364-61), $F_b$ from published data for Oriented Strand Board, and an eccentricity of 0.75 inch, the same as required in the compression test of the Murus Panel (ASTM E72-80).
4. Design values are for dry end use conditions and temperatures less than 160°F.

**TABLE 4**
**HORIZONTAL RACKING RESISTANCE OF MURUS PANELS**

| Panel Assembly | Allowable Racking Resistance [1] | |
|---|---|---|
| | lbs | plf |
| Full Panel Assemblies | 430 | 53.75 |
| Panel with Door Opening[2] | 400 | 50 |
| Panel with Window Opening[2] | 430 | 53.75 |

1. The connection at the head and sill of the panel shall conform to Figures 3 and 4 of this report.
2. The size of the door and window openings shall not exceed those shown in Figures 6 and 7 of this report, and the opening shall be rough framing with 2x4 dimension lumber, as shown in Figure 5 of this report.
3. The values in this table were obtained from panels attached with sheet rock screws at 8 inch on center.

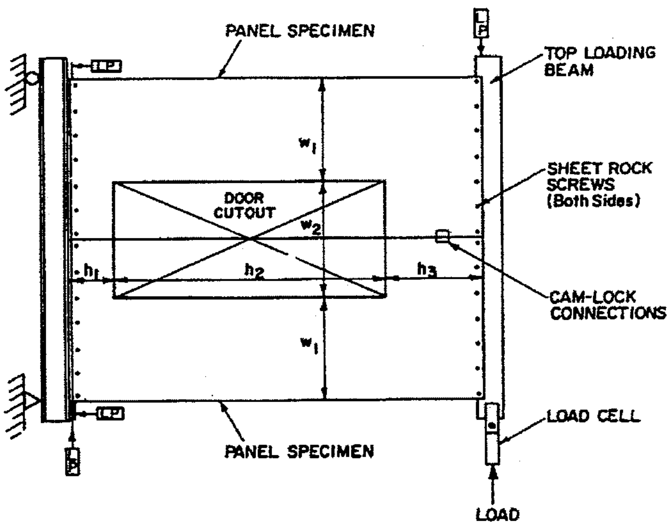



**FIGURE 6***
**PANEL TESTED WITH DOOR OPENING**

$h_1$ = 12 inches (30 cm)
$h_2$ = 84 inches (210 cm)
$h_3$ = 24 inches (60 cm)
$w_1$ =29 1/4 inches (74 cm)
$w_2$ = 37 1/2 inches (95 cm)

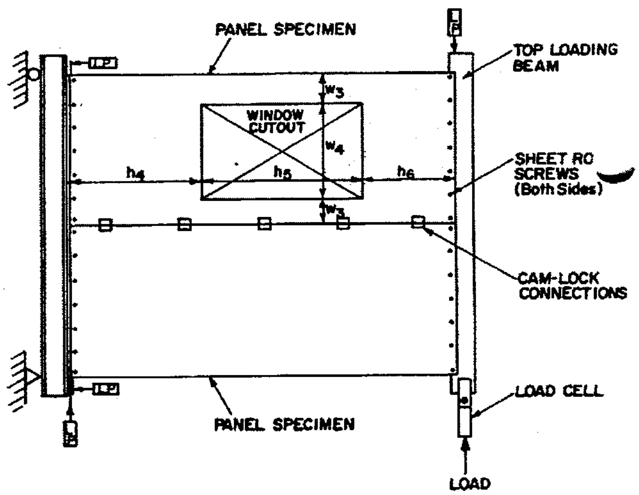



**FIGURE 7***
**PANEL TESTED WITH WINDOW OPENING**

$h_4$ = 42 inches (107 cm)
$h_5$ = 54 inches (137 cm)
$h_6$ = 24 inches (60 cm)
$w_3$ = 8 inches (20 cm)
$w_4$ = 32 inches (81 cm)

*THESE DRAWINGS ARE FOR ILLUSTRATION PURPOSES ONLY. THEY ARE NOT INTENDED FOR USE AS CONSTRUCTION DOCUMENTS FOR THE PURPOSE OF DESIGN, FABRICATION OR ERECTION.

**murus**
STRUCTURAL INSULATING PANELS

# LIMITED WARRANTY

## MURUS PUR (POLYURETHANE) STRUCTURAL INSULATING PANELS (SIPs)

## OSB-2100PUR ~ CLAD-2100PUR ~ PTP-2100PUR ~ T-1-11-2100PUR ~ CB-2100PUR

**Delamination:** Murus PUR SIPs are warranted not to delaminate for the life of the panel provided said SIPs were specified, utilized and installed in a correct and proper manner, in accordance with 1) the standards and specifications established by The Murus Company's Installation Manual and 2) standard building practices, and: wherein said delamination interferes with and/or impairs the ability of the SIPs to perform as intended by The Murus Company.

**Materials and Workmanship:** Murus PUR SIPs are warranted against defects in materials and/or workmanship for a period of ten (10) years from the date of manufacture provided said SIPs were specified, utilized and installed in a correct and proper manner, in accordance with 1) the standards and specifications established by The Murus Company's Installation Manual, and 2) standard building practices, and: wherein said defects interfere with and/or impair the ability of the SIPs to perform as intended by The Murus Company.

This warranty is extended only to the original purchaser or the original property owner where Murus SIPs were installed, and is otherwise non-transferable.

**Definitions:** Delamination is defined as visible separation of the bond of the foam core from the surface of the panel skin. Life is defined as a period of time while the building structure is in good condition and sound, and the SIP is in good condition and is still useful.

**Exceptions:** This warranty does not cover delamination or defects due to:

- Fire, floods, natural disaster or any acts of God.
- Improper handling, storage, use or installation.
- Water or moisture damage.
- Faulty construction, settling of the building foundation, or movement of the structure.

**The Murus Company's Commitment:** If Murus PUR SIPs are found to delaminate or be defective in materials and/or workmanship during the warranty period(s) as listed above, The Murus Company will provide to the purchaser or original property owner, replacement SIPs as originally purchased.

Notification of claims to The Murus Company must be made in writing immediately upon detection or perception of defective SIPs. The Murus Company reserves the right to inspect the said defective SIPs by an authorized representative prior to the settlement of any claim.

The Murus Company's sole responsibility for delamination and/or defects in materials or workmanship is as set forth in this warranty and The Murus Company will not be responsible for incidental, indirect or consequential damages.

For questions concerning this warranty, contact The Murus Company Customer Service at (570) 549-2100; P.O. Box 220, 3234 Route 549, Mansfield, PA 16933.

This warranty is subject to local, state, federal and statues, regulations and alike.

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