ER-87537

World Shelters

550 South G St., Suite 3
Arcata, CA 95521
USA

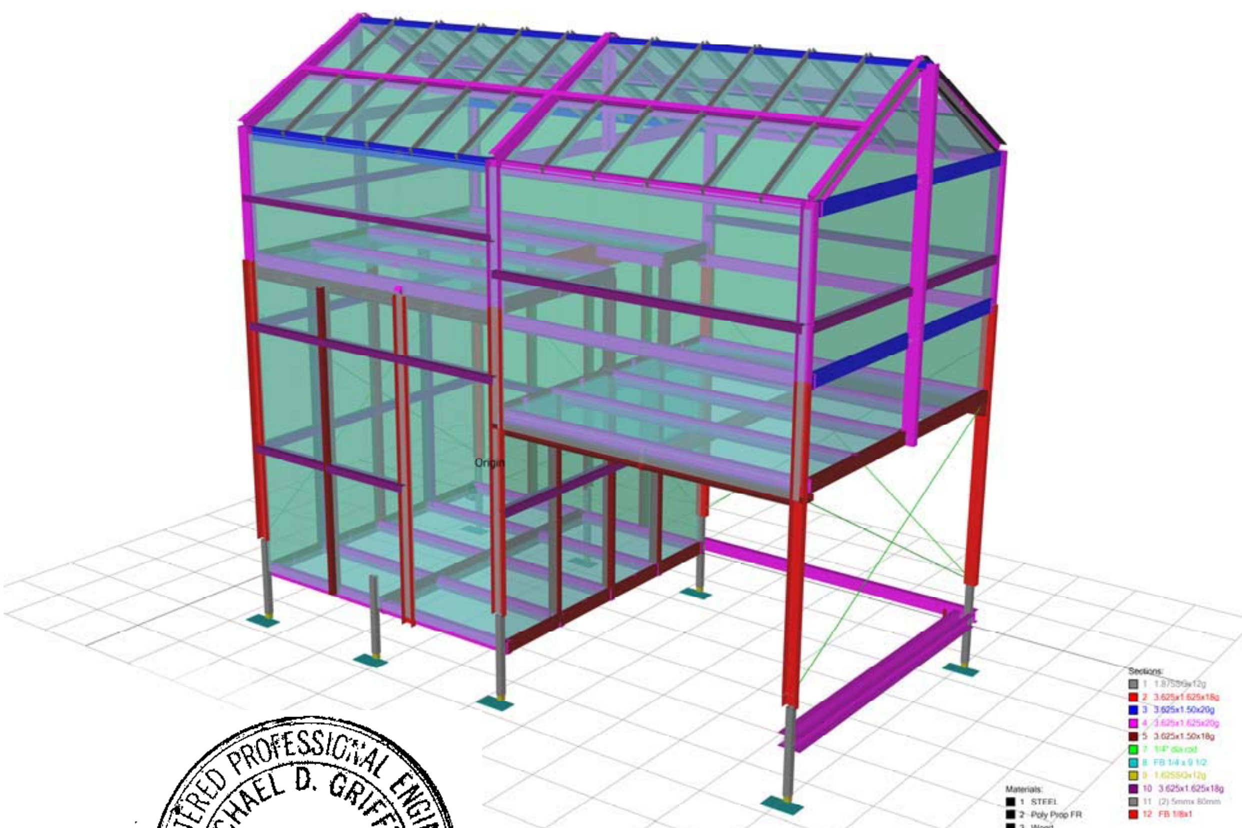
Telephone: +1-707-822-6600
Email: info @ worldshelters.org

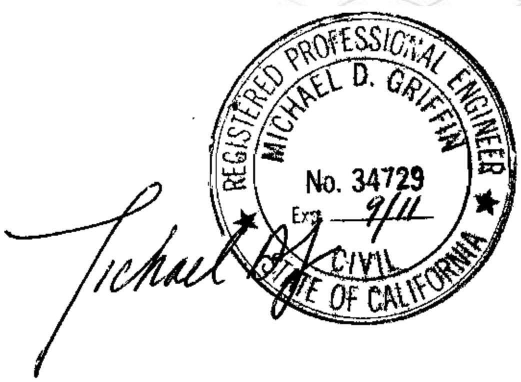
Two Story T Shelter

Engineering Review:

Shelter Structure

16 November 2010





engineering review

i n t e r n a t i o n a l

1.0 Introduction

This report summarizes an engineering review of the demonstration model two story transitional shelter. The hybrid design is a collaborative effort between World Shelters and Uber Shelters. The review includes the structural capacity for dead, live, wind and earthquake loading as they pertain to Port au Prince, Haiti. The three enclosed floor areas in plan total 192 ft^2 (17.8 m^2).

The structural frame is made up primarily of metal studs and tracks, floor levels of plywood along with roof and wall panels of flame retardant 5 mm thick corrugated polypropylene connected with metal fasteners.

2.0 Summary

The metal stud/track and plywood materials are defined in the 2006 International Building Code (2006 IBC). The materials used for the roofing and side panels are not defined so testing of panel strength and deflection has been performed to use in the evaluation. The limiting environmental loads have been determined to provide a 1.7 safety factor against panel buckling.

Resulting capacities of the system are:

Floor Live Load: -Lowest floor, 26 psf (equates to 1664 lbs/floor)
-2nd and 3rd floors, 22 psf (equates to 1408 lbs/floor)
(Requires 2nd and third floor track on one edge to have partial second track added).

Roof Live load: 10 psf, no changes required.

Wind load: Wind exposure C is assumed (Open terrain with scattered obstructions having heights generally less than 30 feet (9.1 m). This category includes flat open country, grasslands, and all water surfaces in hurricane-prone regions)

For Port au Prince, the design wind speed is 100 mph (160 km/hr) gust 50 year return period (from figure 3-8 of ARA report 18108-1). Various portions of the structure for the current demonstration model are not able to withstand the full design load. With adjustments, the structure can have increased capacity to be the full design value. A summary of the major component capabilities as-is and with adjustments follows:

Roof System: As designed, standing seam polypropylene roofing material design limit is 70 mph. By adding a mid supporting member, the span is reduced in half and the allowable design wind speed increases to 100 mph.

Vertical Studs: The studs without any cladding attachments must have a track attached to create a closed section to reduce torsional buckling for all load cases. Studs just above the top of telescoping Unistrut legs to which cross bracing is attached, local bending limits the design wind speed to 70 mph. Local stiffening or lowering bracing attachment along with other vertical stud stiffening locations, can increase capacity to 100 mph.

Cross Bracing: Attachment of cross bracing perpendicular to stud flange is of low load capacity. Local stiffening at 3 5/8" stud surfaces increases capacity to 100 mph. In addition, add 1/4" plate to transfer load to flanges for full capacity.

Telescoping Legs: Overall bending on 1 7/8" square Unistrut P9200 section cantilevered over 15", limits wind speed to 80 mph. With bracing at select locations to reduce the cantilever to 9" maximum, capacity increases to 100 mph. Base plate of 12" square x 1/4" plate provides bearing capacity for 100 mph design wind if located 12" below grade or sitting atop gravel/rubble that starts at 12" below grade.

Wall Cladding: Extruded Polypropylene 5mm flame retardant material folded beam capacity reduces capacity to 40 mph. By adding a stud at the current Polypropylene beam location, the design wind is increased to 80 mph. By adding additional vertical studs to decrease unsupported distance to about 24", the design capacity increases to 100 mph.

Anchors: Platipus Earth Anchor, 1 ton capacity located at 6 locations, limits design wind speed to 91 mph. Additional anchors at two corners would increase uplift capacity for a 100 mph wind speed. Lateral load at anchors for full 100 mph wind speed is as high as 780 lbs at center legs. Passive lateral capacity of type 5 clay soil is 100 psf/f. Platipus to verify lateral capacity of anchors.

3.0 Input Data

Documentation provided by World Shelters to conduct the structure analysis includes:

1. Panel construction of 5mm Polypropylene co-polymer with a density of 90 g/cc, tensile strength at yield of 4000 psi and elongation at yield of 10%.
2. Panel connection using no. 10 metal screws fasteners with fender washers on panel side, washer and lock nut on metal stud/track side.
3. Metal stud to track fastening using 3/8" diameter A307 bolts.

Assumptions made by Engineering Review International include:

1. Shelters are not placed adjacent to the top of escarpments, hills or ridges that could result in increased wind loading.
2. A safety factor of 1.7 against panel buckling has been used to determine panel loading capacities for wind.
3. Type 5 soil (clay, sandy clay) per IBC 2006 table 1804-2 assumed.
4. For earthquake loading, a soil site class D has been assumed with Ss = 124%, S1 = 56%. (Chapter 3, table 3-3 Ground Motion and Geological Hazards Assessment).

4.0 Loading

Using methods from the 2006 IBC and ASCE 7-05, the structure model is loaded with a 100 mph 3 second gust wind speed for wind exposure C. An enclosed structure is assumed so all windows and doors must remain closed during a high wind event. Wind loading on the shelter surface is approximated using ASCE Standard 7-05 and specifically figure 6-6 for Walls & Roofs of a gable/hip roof MWRS. A floor live load of 20 psf and roof live load of 10 psf is analyzed. Earthquake loading does not control the design but is included as a check.

The loading conditions modeled for the structure include:

11. D	Dead
12. D+Lf	Dead+Floor Live
13. D+Lr	Dead+Roof Live
14. D+0.75Lf+0.75 Lr	Dead+0.75 Floor Live + 0.75 Roof Live
15. D+Wxa	Dead+Wind Xa
16. D+Wxb	Dead+Wind Xb
17. D+Wya	Dead+Wind Ya
18. D+Wyb	Dead+Wind Yb
19. D+0.75Lf+0.75Lr+0.75Wxa	Dead+.75Floor Live+.75Roof Live+0.75Wind Xa
20. 0.6D+Wxb	0.6 Dead + Wind Xb
21. D+0.7Ex	Dead+0.7 Earthquake X
22. D+ 0.7Ey	Dead+0.7 Earthquake Y
23. D+0.75Lf+0.75Lr+0.525Ex	Dead+.75Floor Live+.75Roof Live+0.525 EQ X
24. 0.6D+0.7Ex	0.6 Dead + 0.7 Earthquake X

5.0 System Analysis

The analysis is completed using the program Spacegass which is described in Appendix B. A summary of the analysis model is included in Appendix C. The frame is modeled with steel metal studs and tracks with panel elements connected to the steel beam elements. In this finite element model, non linear affects of large displacements are accounted for. The 15/32 OSB floor has been modeled.

6.0 Conclusions

For the demonstration model evaluation period, certain stiffening items should be conducted before being inhabited. With the items completed below, the design wind speed capacity is 70 mph (roofing and vertical studs limiting):

1. The vertical studs without any cladding attachments must have a track attached to create a closed section to reduce torsional buckling.
2. Stiffen cross bracing attachment points at studs.
3. Add horizontal studs to folded beam locations.
4. Add 3.625x1.5x18 ga track at 2nd and 3rd floor sides where floor beam connects.

   Move 3rd floor beam to center.

Once the demonstration model evaluation period has been completed, other design items can be incorporated with inputs from shelter use to obtain the full design wind speed capacity of 100 mph or any reduced value deemed appropriate by the stake holders for the production design.

engineering review

i n t e r n a t i o n a l

Appendix A

Calculations:

- Loads
- Interim stiffening sketches for 70 mph design capacity
- Floor checks
- Cross Bracing checks
- Structure Anchoring Check

2388 Golf Course Rd, Bayside, CA 95524; phone 707.496-4893; fax 775.514.6382
mgriffin@engreview.com; www.engreview.com

engineering review
i n t e r n a t i o n a l

project no. 87537 date 11/16/10
by: MDG page 1 of 4
project Two Story T Shelter
subject LOADS

1. LIVE LOADS

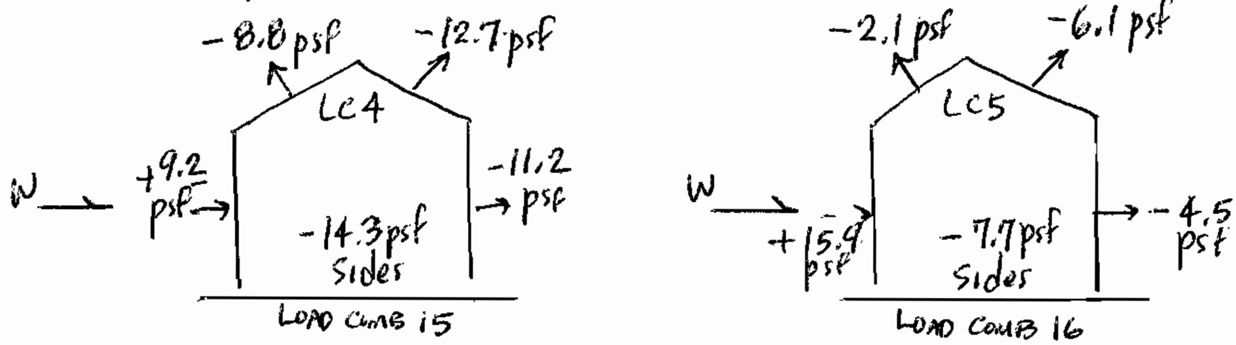
– FLOOR LOADS IBC 2006
TABLE 1607.1
SLEEPING AREAS 30psf

WITH THE LIKELYHOOD OF MINIMAL FURNITURE, 22 → 26 psf gives 1408Lbs. → 1664 Lbs. of Live Load Capacity / Floor

– ROOF LOADS IBC 2006
TABLE 1607.1 20psf
Reducible to 12psf
canopies, fabric 5psf
10psf Capacity Appears Resonable

2. WIND LOADS

Assume exposure C, importance factor 1.0
100mph 3sec gust, Not on hill or ridge
ASCE 7-05 Figure 6-6, see Attached
SUMMARY pressures

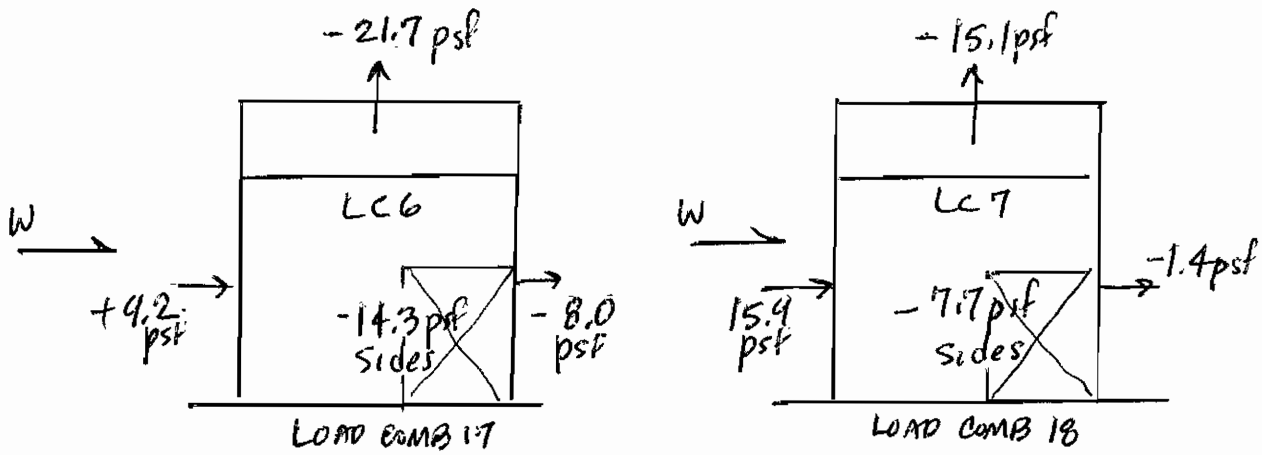


2388 Golf Course Rd, Bayside, CA 95524; phone 707.496-4893; fax 775.514.6382
mgriffin@engreview.com; www.engreview.com

engineering review
international

project no. 87537 date 11/16/10
by: MDG page 2 of 4
project TWO STORY T SHELTER
subject LOADS

3. CONT. (WIND)



4. EARTHQUAKE

$S_S = 124\%$ SOIL SITE CLASS D ASSUMED

$S_1 = 56\%$ see Attached 0.7g used

2388 Golf Course Rd, Bayside, CA 95524; phone 707.496-4893; fax 775.514.6382
mgriffin@engreview.com; www.engreview.com

6.5 METHOD 2- ANALYTICAL PROCEDURE

6.5.12. Design Wind Loads on Enclosed and Partially Enclosed Buildings. (all Heights)

MWFRS Velocity pressure q_z = $.00256\ K_z\ K_{zt}\ K_d\ V^2\ I_w$ (6-15)

Exposure C Roof Height h = 13.45 feet

Exposure coefficient K_z = Section 6.5.6.6, is obtained from Table 6-3, Case 2 for MWFRS

Topography factor K_{zt} = 1.00 6.5.7.2, Figure 6-2

Directionality factor K_d = 0.85 Table 6-4

Wind Speed V = 100 mph

Importance factor I_w = 1.00 Table 6-1

q_z = 21.76 K_z psf

Internal Pressure Coefficient (GC_{pi}) = ± 0.18 Figure 6-5 for Enclosed Building

Gust effect factor G = 0.85 6.5.8.1

Pressures for MWFRS p = $qGC_p - q_i(GC_{pi})$ (6-17)

Wall and Roof External pressure Coefficients C_p from Fig. 6-6 or 6-8

Wind Normal to Ridge (⊥ to 16) L/B = 0.50 h/L = 13.45/8 = 1.68 θ= 28.8

Windward wall C_p = 0.8 Windward roof C_p = -0.35

Leeward wall C_p = -0.500 for L/B = 0.50 Leeward roof C_p = -0.60

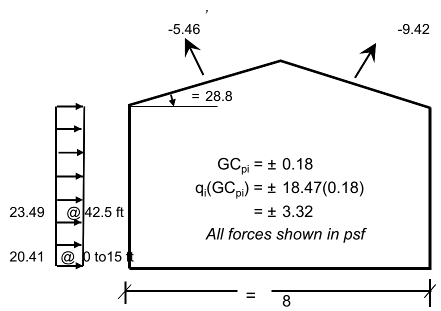
Side wall C_p = -0.7 or Roof C_p =

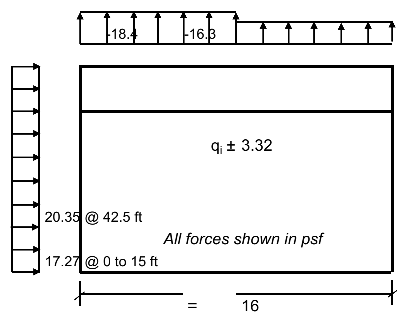
Wind Parallel to Ridge (⊥ to 8) L/B = 2.00

Windward wall C_p = 0.8 h/L = 13.45/16 = 0.84

Leeward wall C_p = -0.300 for L/B = 2.00 Roof C_p = -1.2 -1.0

Side wall C_p = -0.7 for dist 6.7 13.5





p = $qGC_p - q_i(GC_{pi})$ Eq. 6-15 For Exp C

where q = q_z for windward z_g = 900 ∝ = 9.5

q = q_h for leeward wall, side wall and roof @13.45 ft $K_z = 2.01(z/z_g)^{2/\alpha}$

q_i = q_h for enclosed building @13.45 ft K_z (min) $= 2.01(15/z_g)^{2/\alpha}$

Roof Ht, h = 13.45 ft				Normal to Ridge ⊥ to 16		Parallel to ridge ⊥ to 8		
	Height	K_h	q_h	C_p	q_hGC_p	C_p	q_hGC_p	
Leeward wall	all	0.849	18.47	-0.5	-7.85	-0.30	-4.71	
Side wall	all	0.849	18.47	-0.7	-10.99	-0.70	-10.99	
Roof	ww	-0.348				-1.17	-18.41	fr 0 - 6.7
	Lw	-0.600				-1.04	-16.27	fr >6.7
								fr 13.5-
								fr

				Wind Normal to Ridge			Wind Parallel to Ridge		
	z, Ht. (ft)	K_z	q_z	C_p	p =q_zGC_p	WW+LW	C_p	p =q_zGC_p	WW+LW
Windward wall	0 to 15	0.849	18.47	0.8	12.56	20.41	0.80	12.56	17.27
	15.0	0.849	18.47	0.8	12.56	20.41	0.80	12.56	17.27
	42.5	1.057	23.00	0.8	15.64	23.49	0.80	15.64	20.35
	60.0	1.137	24.73	0.8	16.82	24.67	0.80	16.82	21.53

IBC2006 (1613), ASCE 7-05 CHAPTER 11, 12, 13 SEISMIC DESIGN CRITERIA

Soil Site Class D — Table 20-3-1, Default = D

Response Spectral Acc. (0.2 sec) S_s = 125.00%g = 1.250g — Figure 22-1 through 22-14

Response Spectral Acc.(1.0 sec) S_1 = 56.00%g = 0.560g — Figure 22-1 through 22-14

Site Coefficient F_a = 1.000 — Table 11.4-1

Site Coefficient F_v = 1.500 — Table 11.4-2

Max Considered Earthquake Acc. S_{MS} = $F_a.S_s$ = 1.250 — (11.4-1)

Max Considered Earthquake Acc. S_{M1} = $F_v.S_1$ = 0.840 — (11.4-2)

@ 5% Damped Design S_{DS} = 2/3(S_{MS}) = 0.834 — (11.4-3)

S_{D1} = 2/3(S_{M1}) = 0.560 — (11.4-4)

Building Occupancy Categories: II, Standard — Table 1-1

Design Category Consideration: Flexible Diaphragm — with dist. between seismic resisting system >40ft

Seismic Design Category for 0.1sec: D — Table 11.6-1

Seismic Design Category for 1.0sec: D — Table 11.6-2

S1 < .75g: NA — Section 11.6

Since Ta < .8Ts (see below), SDC = D — Control (exception of Section 11.6 does not apply)

Comply with Seismic Design Category D — IRC, Seismic Design Category = D2 — T-R301.2.2.1.1

12.8 Equivalent lateral force procedure — H. STEEL SYSTEMS NOT SPECIFICALLY DETAILED FOR SEISMIC RESISTANCE, EXCLUDING CANTILEVER COLUMN SYSTEMS — T-12.2-

Seismic Force Resisting Systems: H. STEEL SYSTEMS NOT SPECIFICALLY DETAILED FOR SEISMIC RESISTANCE, EXCLUDING CANTILEVE

C_t = 0.02 — x = 0.75 — T-12.8-2

Building ht. H_n = 14.6 ft — Limited Building Height (ft) = NP

C_u = 1.400 for S_{D1} of 0.560g — Table 12.8-1

Approx Fundamental period, T_a = $C_t(h_n)^x$ = 0.149 — 12.8-7 — T_L = 8 Sec

Calculated T shall not exceed ≤ Cu.Ta = 0.209 — Use T = 0.149 sec.

0.8Ts = 0.8(S_{D1}/S_{DS}) = 0.537 — Control (exception of Section 11.6 does not apply)

Is structure Regular & ≤ 5 stories ? Yes — 12.8.1.3

Response Spectral Acc.(0.2 sec) S_s = 1.250g — *Max Ss ≤ 0.15g*

F_a = 1.00

@ 5% Damped Design S_{DS} = ⅔($F_a.S_s$) = 0.834g — (11.4-3)

Response Modification Coef. R = 3 — Table-12.2-1

Over Strength Factor Ω_o = 2.5 — foot note g

Importance factor I = 1 — Table 11.5-1

Seismic Base Shear V = $C_s W$

$C_s = \frac{S_{DS}}{R/I}$ = 0.278 — (12.8-2)

or need not to exceed, $C_s = \frac{S_{D1}}{(R/I).T}$ = 1.250 — For T≤ T_L — (12.8-3)

or $C_s = \frac{S_{D1}T_L}{T^2(R/I)}$ N/A — For T > T_L — (12.8-4)

C_s shall not be less than = 0.01 — (12.8-5)

Min C_s = $0.5S_1I/R$ N/A — For S_1 ≥ 0.6g — (12.8-6)

Use C_s = 0.278

Design base shear V = 0.278 W — **Control** — <=== Use 0.7 W

12.14 Simplified Seismic base shear: 13. Light-framed walls sheathed with wood structural panels rated for shear resistance or steel sheets — T-12.14

@ 5% Damped Design S_{DS} = 0.834 — SDC = D — Limitations: P

F = 1.1 — For two-story building — R = 6.5

$V = \frac{FS_{DS}(W)}{R}$ = 0.141 W

13.3 Seismic Demands on Nonstructural Components

$F_p = \frac{0.4a_pS_{DS}W_p(1+2z/h)}{(R_p/I_p)}$ — (13.3-1) — S_{DS} = 0.834

a_p = 1 — R_p = 2.5 — T-13.5-1 or 13.6-1

I_p = 1.0 — 13.1.3

z = 14 ft — h = 14 ft — F_p = 0.400 Wp

Max F_p = $1.6S_{DS}I_pW_p$ = 1.334Wp — (13.3-2)

Min F_p = $0.3S_{DS}I_pW_p$ = 0.250Wp — (13.3-3)

F_p = 0.400 Wp

12.11.1 Structural Walls and Their Anchorage

F_p = $0.40S_{DS}IW_w$ — 12.11.1

= 0.333(W)

12.11.2 Anchorage of Concrete or Masonry structural Walls (flexible diaphragm)

or F_p = $400S_{DS}I$ = 333 — shall be ≥ 280 #/ft

F_p = $0.8S_{DS}I(W_w)$ — (12.11.1)

= 0.667 Wp

Max Seismic Load E_M = $\Omega Q_E \pm 0.2S_{DS}D$ — (12.4.4), (12.4.5), (12.4,6), (12.4.7)

Where Ω_o = 2.5

$0.2S_{DS}D$ = 0.167(D)

Deflection Amplification factor C_d = 3

Nonbuilding structures, Section 15

Response Modification Coef. R = 3 — T-15.4-1 or T-15.4-2

Importance factor I = 1 — 15.4.1.1

For flexible nonbuilding, C_s = $S_{DS}I/R$ = 0.278

Min C_s = 0.03 — (15.4-1)

or C_s = $0.8\ S_1I/R$ = 0.149 — (15.4-2)

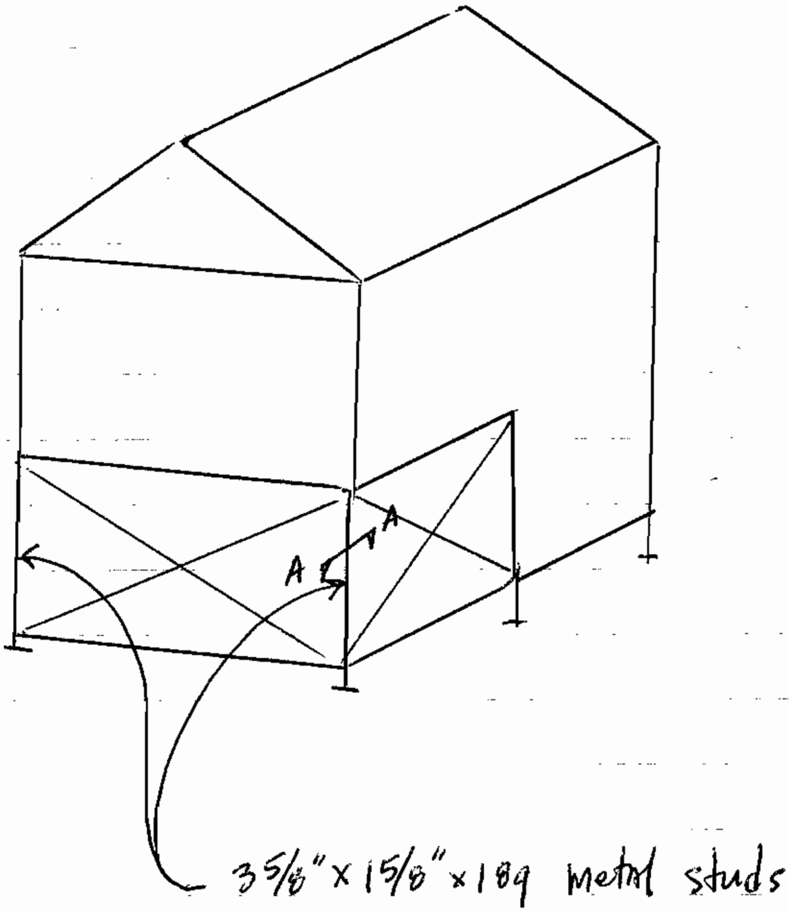
V = 0.278 W

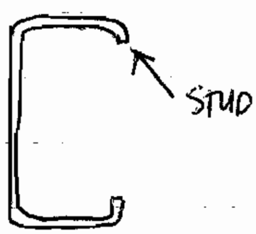
For rigid nonbuilding, C_s = $0.3\ S_{DS}\ I$ — (15.4-5)

= 0.250 W

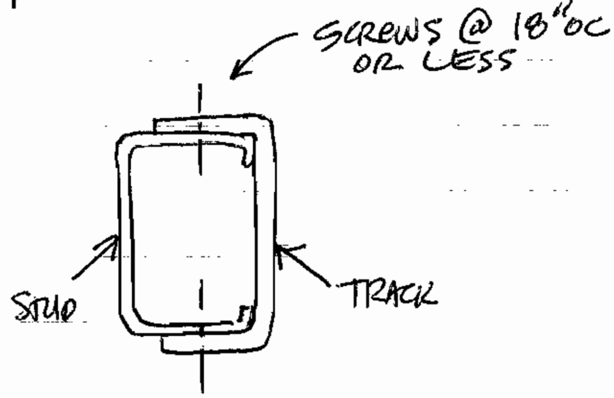
INTRIM STIFFENING 2010-11-10.

1. VERTICAL STUDS WITHOUT CLADDING ATTACHMENTS





current
SECTION A-A

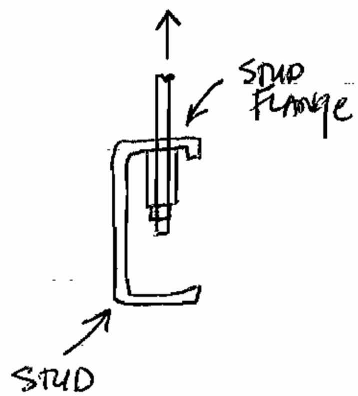


REVISED
SECTION A-A
(BETWEEN CROSS BRACE CONN.)

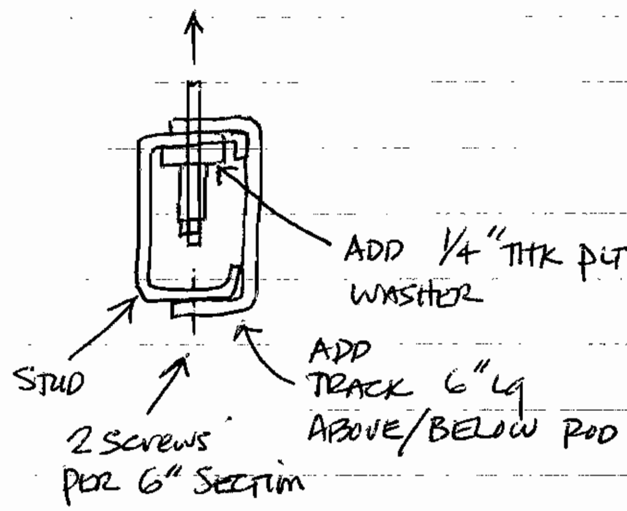
INTERIM STIFFENING 2010-11-10

2. STIFFEN CROSS BRACING ATTACHMENT POINTS AT STUDS

A. ATTACHMENT TO STUD FLANGE

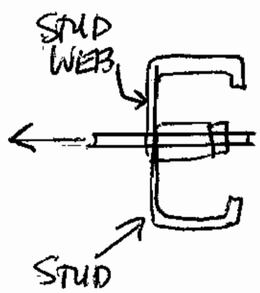


EXISTING

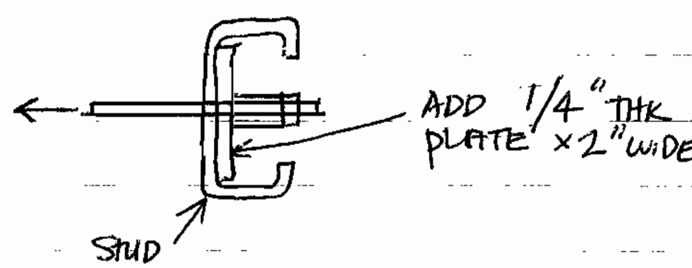


MODIFIED

B. ATTACHMENT TO STUD WEB



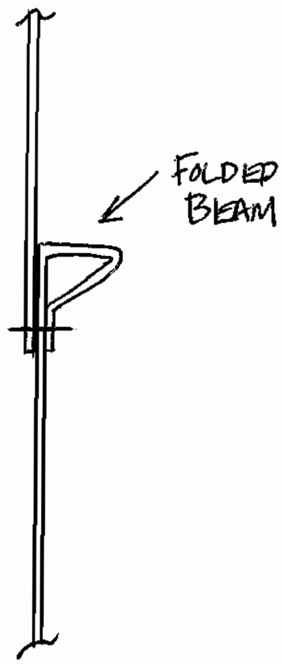
EXISTING



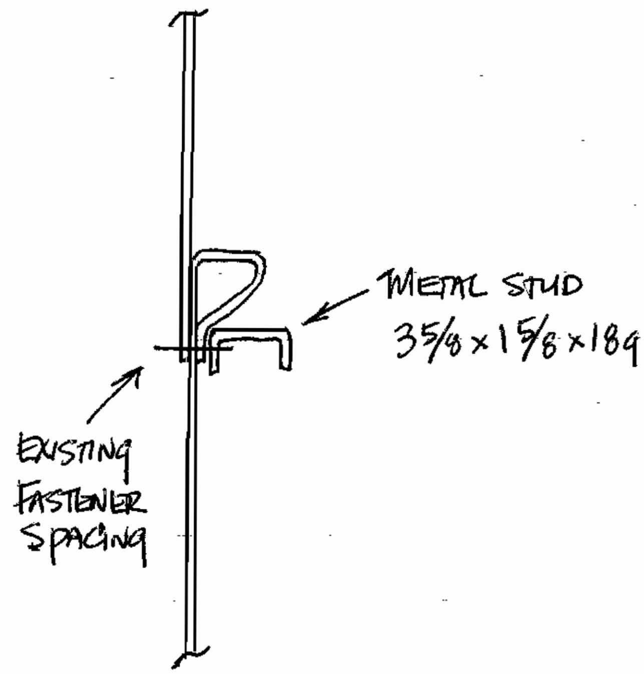
MODIFIED

INTERIM STIFFENING 2010-11-16

3. ADD HORIZONTAL METAL STUDS TO FOLDED BEAM LOCATIONS

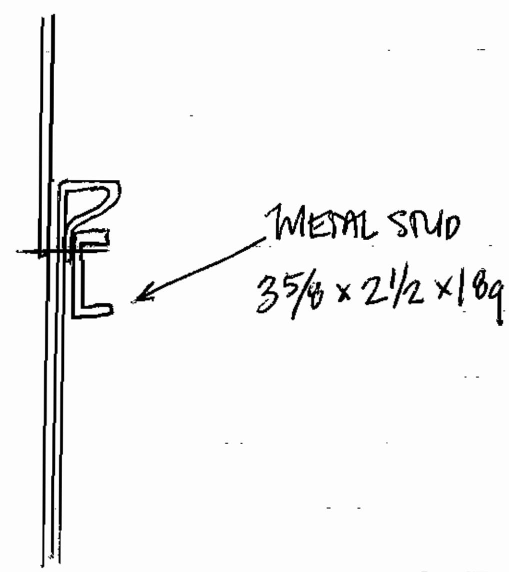


EXISTING



MODIFIED

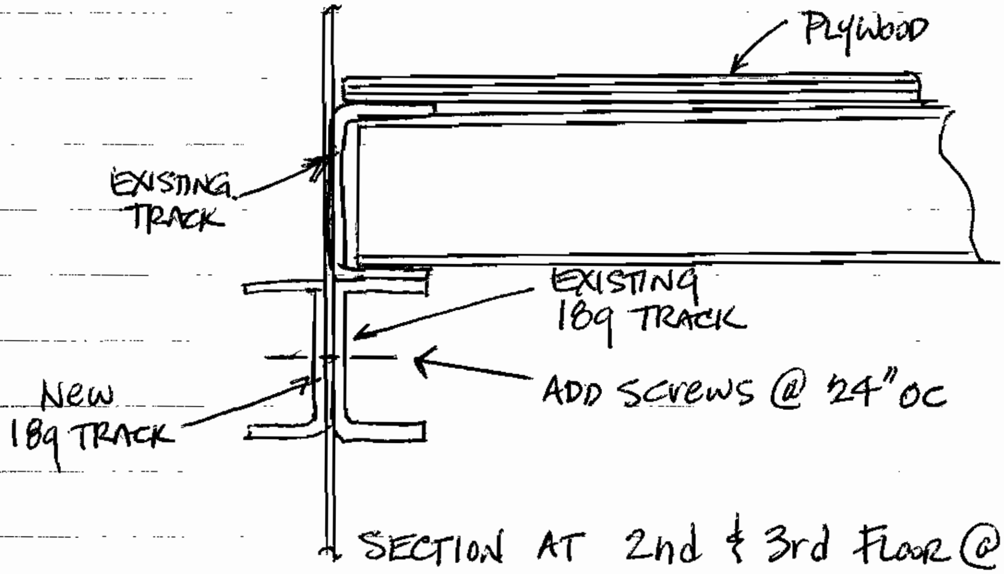
OR



MODIFIED

INTERIM STIFFENING 2010-11-16

4. BOLT TOGETHER STUD & TRACK @ 2nd & 3rd FLOORS



SECTION AT 2nd & 3rd FLOOR @ WALL

engineering review
international

project no. 87537 date 11/4/10
by: MDG page 1 of 3
project 2 Story T-Shelter
subject FLOORS

1. 15/32 CDX FLOORS, 5PLY

SUPPORTED ~ 24" OC

15/32 BENDING CAPACITY = 67 psf
L/240 " = 51 psf

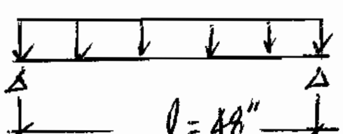
DEAD LOAD 1.4 psf plywood
0.6 psf metal studs
2.0 psf – say 5psf possible

LIVE LOAD 30psf IBC 2006
Residential Habitable Attics & SLEEPING AREAS

D+L = 35psf < 51psf ✓OK

2. FIRST FLOOR METAL STUDS / RAILS

– 3 5/8" x 1 5/8" x 20g metal stud
ASSUME F_y = 33 ksi



$W = \frac{35 \times 2'}{12} = 5.833$ Lb/in

$I_{x-33} = 0.551 \text{ in}^4$
$S_{x-33} = 0.292 \text{ in}^3$
$M_{a-33} = 5.77$ K-in
$V_{a-33} = 1039$ Lbs.

V = 140 Lbs. ✓OK

$M = \frac{wl^2}{8} = \frac{5.833(48)^2}{8} = 1.68$ K-in < 5.77 K-in ✓OK

– 3 5/8" x 1 1/2" x 18g metal track
ASSUME F_y = 33 ksi

$W = \frac{35 \times 2'}{12} = 5.83$ Lb/in

$M = \frac{5.83 \times 96^2}{8} = 6.72$ K-in
> 5.04 K-in

$I_{x-33} = 0.574 \text{ in}^4$
$S_{x-33} = 0.255 \text{ in}^3$
$M_{a-33} = 5.04$ K-in
$V_{a-33} = 1777$ Lbs.

$\frac{5.04}{6.72} \times 35 = 26$ psf capacity

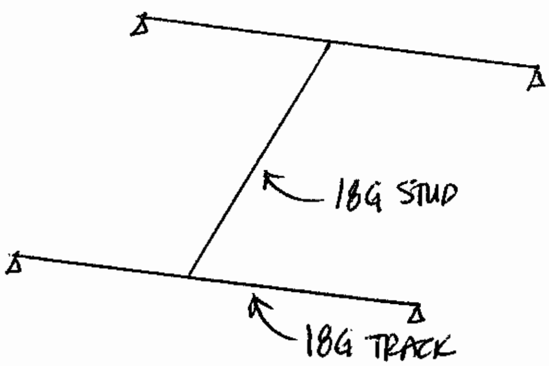
2388 Golf Course Rd, Bayside, CA 95524; phone 707.496-4893; fax 775.514.6382
mgriffin@engreview.com; www.engreview.com

engineering review
international

project no. 87537 date 11/4/10
by: mog page 2 of 3
project 2 STORY T-shelter
subject FLOORS

3. 2nd FLOOR METAL STUDS + FRAME BELOW

metal studs @ 24' oc and 4' span okay from 2.
1×4 WOOD STUDS @ MID JOINT SPLICE (Not structural)
– BELOW DECK, FOLLOWING FRAME



corner load @ 35psf

$$\frac{8^2 \times 35psf}{4} = 560 lbs/corner$$

3/8"φ BOLT ON 18GA THK
single shear cap. = 2.4 d t Fu/2
= 2.4(0.375).0451(45)/2 = 913 lb. ✓ok

$$V = \frac{11.67 \text{ lb/in} \times 96"}{2} = 560 lbs. < 1777 lbs. \checkmark ok$$

– FOR STUD: $w = \frac{(D+L) \times 4'}{12}$

$$M = \frac{wl^2}{8} \leq 8{,}460 \text{ lb-in}$$

$$\frac{(D+L) \times 4'}{12} \frac{(96)^2}{8} \leq 8{,}460 \text{ lb-in}$$

D+L MAX. = 22.0 psf CAPACITY D+L < 35psf

↑ Controls

– FOR TRACK:

$$M = \frac{PL}{4} \qquad P = \frac{wl}{2} \text{ (from stud)}$$

$$\frac{(D+L) \times 4}{12} \times \frac{96}{2} \times \frac{96}{4} \leq 5.04 \text{ k-in}$$

D+L MAX. = 13.1 psf CAPACITY D+L

ADD SECOND 18g TRACK @ EXTERIOR 26psf capacity

engineering review
international

project no. 87537 date 11/4/10
by: MDG page 3 of 3
project 2 story T-Shelter
subject FLOORS

4. 3rd FLOOR METAL studs

identical to 2nd floor except opening

- Add exterior 18ga TRACK
- Controling is center 18g stud, 22psf Live

2388 Golf Course Rd, Bayside, CA 95524; phone 707.496-4893; fax 775.514.6382
mgriffin@engreview.com; www.engreview.com

engineering review
international

project no. 87537 date 11/16/10
by: MDG page 1 of 1
project 2 STORY T-SHELTER
subject CROSS BRACING CHECK

1. 1/4"φ ROD

$F_{MAX.}$ = 825 lbs. LC 16 #406 100 mph

ROD CAPACITY A307 STEEL, TENSION

$\frac{0.25^2\pi}{4} \times 22ksi = 1{,}080lb.$ ✓ OK

2. ROD ATTACHMENT TO STUD WEB

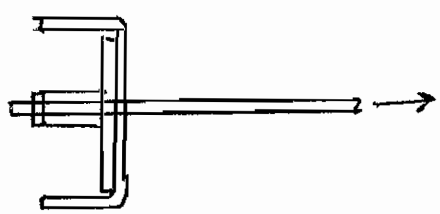


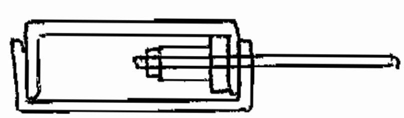
PLATE BENDING cos45°

$f_b = \frac{825lb/2 \times 1.77"}{t^2 \times 2"/6} \le 27ksi$

$t_{min} = 0.24"$

use 1/4" THK × 2" WIDE × 3 1/2" Lg

3. ROD ATTACHMENT TO STUD FLANGE



use SAME 1/4" THK PLATE × 2" WIDE × 1 1/2" Lg

2388 Golf Course Rd, Bayside, CA 95524; phone 707.496-4893; fax 775.514.6382
mgriffin@engreview.com; www.engreview.com

engineering review
international

project no. 87537 date 11/16/10
by: MOG page 1 of 1
project 2 STORY T-SHELTER
subject ANCHOR LEGS

1. SOIL BEARING pressure

Fm downward = 1393 Lbs. MAX. LC 19 # 293

12" SQ PLATE bearing = $\frac{1393 \text{ Lb.}}{1 \text{ ft}^2}$ = 1393 psf
< 1500 psf ✓ OK

2. PLATYPUS ANCHOR – 1 ton

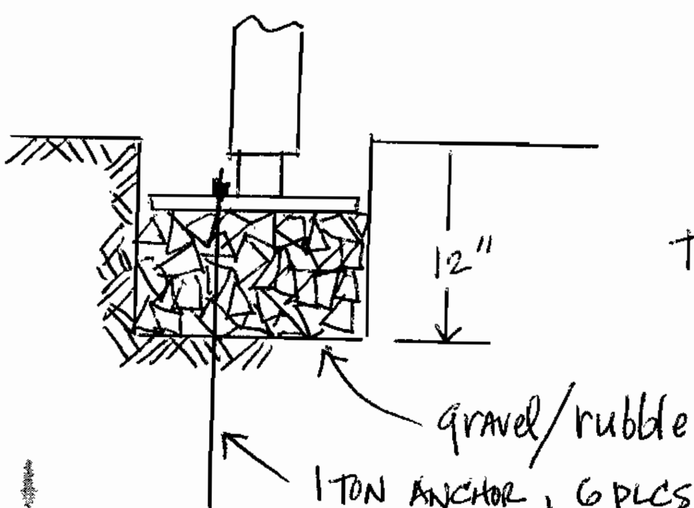
MAX. UPLIFT = 1563 Lbs.

SWL FOR ANCHOR = $\frac{2000 \text{ Lbs.}}{1.5}$ = 1333 Lbs.

FOR SINGLE ANCHOR @ 6 PLCS.

MAX. WIND SPEED $\left[\frac{1333}{1563} \times 100^2\right]^{1/2}$ = 92 mph

USE 2 ANCHORS @ 2 PLCS FOR FULL 100 mph



TYP. LEG ANCHORING

Appendix B

Analysis Program description - SPACEGASS

TITLE: 3D or 2D general frame analysis and steel design. ACCESSIBILITY: Any computer running Windows 95, 98, NT, 2000 or ME.

MAINTENANCE: Integrated Technical Software

CAPABILITY: Analyses 3 dimensional frames with straight prismatic members. Capacity is theoretically unlimited but depends on the available memory in the computer. Units may be any consistent set. Input methods include graphical input, datasheet input, free format text file input, standard structure input and CAD input.

Features include linear and non-linear static analysis, dynamic frequency analysis, dynamic response analysis, buckling analysis, master-slave constraints, tension-only members, compression-only members, cable members, 3D member offsets, extensive data generation facilities, non-sequential numbering, automatic re-numbering, elastic supports, complete or partial member end fixity, comprehensive data checking for inconsistencies and instabilities and wavefront analysis method with wavefront optimizer.

Permissible loading conditions include any combination of concentrated and distributed forces and moments on nodes and members, thermal loads, self weight, and prescribed node displacements. Numerous primary and combination load cases can be analyzed in a single run. Frames or sub-frames can be moved, rotated, copied or mirrored. Section and material properties can be input manually or can be read directly from a library. Data can be transferred into or from a CAD program such as AutoCAD via DXF files.

Integrated steel member design modules for the latest codes including AISC-LRFD (17), AISC-ASD (16), EUROCODE 3 (18), AS1250 (3), AS4100 (4), SABS0162 (5), BS5950 (6), NZS3404 (7), AS3990 (11) and AS/NZS4600 (13). Selected members or the entire frame can be designed or checked in accordance with the appropriate code.

Integrated steel connection design and drafting module for AS4100 (4). Connections can be designed and connection drawings can be viewed, printed or exported to DXF files.

Integrated concrete design module for AS3600 (14). Selected members or the entire frame can be designed or checked in accordance with the code.

INPUT: Node coordinates, member connectivity and fixity, node restraints, section and material properties, master-slave constraints, member offsets, node loads, prescribed displacements, member concentrated and distributed loads, self weight, combination load cases, load case titles, lumped masses, dynamic response spectra, steel member design data, steel connection design data and concrete design data.

OUTPUT: Printout of all input data plus displacements, forces, moments, reactions, stresses, equilibrium summary, bill of materials, centre of gravity coordinates, dynamic

engineering review

i n t e r n a t i o n a l

natural frequencies and mode shapes, buckling load factors and member effective lengths, steel member design results, steel connection design results and concrete design results. Output can be chosen selectively and can be limited to user defined nodes, members, load cases, member design groups and connections. Results envelopes can be produced. Deflections, forces and moments can be output at numerous points along members (not just at the end nodes). Graphical output on screen, printer or plotter includes the frame geometry, loading diagrams, deformed geometry, bending moment diagrams, shear force diagrams, axial force diagrams, stress diagrams, dynamic mode shapes, buckling mode shapes, 3D full member geometry with hidden line removal, steel connection drawings, concrete column interaction diagrams.

METHOD: Stiffness analysis method using wavefront equation solver with optimization.

LANGUAGE: Fortran and C.

AUTHORS: Integrated Technical Software

DOCUMENTATION: Comprehensive user manual with worked examples.

INFORMATION: www.spacegass.com

ABSTRACT BY: Integrated Technical Software

engineering review

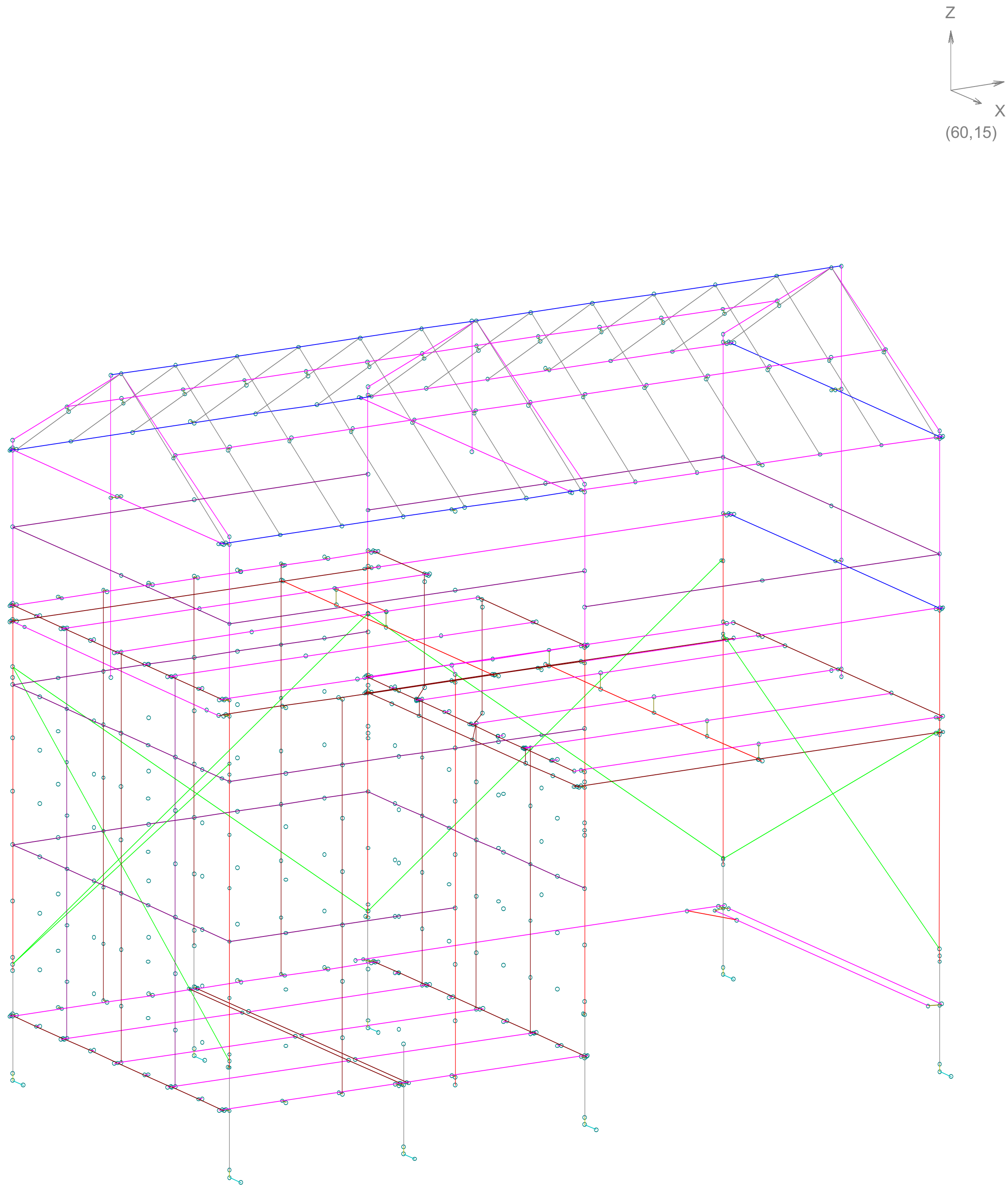
i n t e r n a t i o n a l

Appendix C

Spacegass Model, STS-04.sg

- Model images with property and support node number locations
- Model deflected shape for Wind
- Input/Output Summary of Model with Reactions

2388 Golf Course Rd, Bayside, CA 95524; phone 707.496-4893; fax 775.514.6382
mgriffin@engreview.com; www.engreview.com



Sections:
1 1.875SQx12g
2 3.625x1.625x18g
3 3.625x1.50x20g
4 3.625x1.625x20g
5 3.625x1.50x18g
6 link
7 1/4" dia rod
8 FB 1/4 x 9 1/2
9 1.625SQx12g
10 3.625x1.625x18g
11 (2) 5mmx 80mm
12 FB 1/8x1

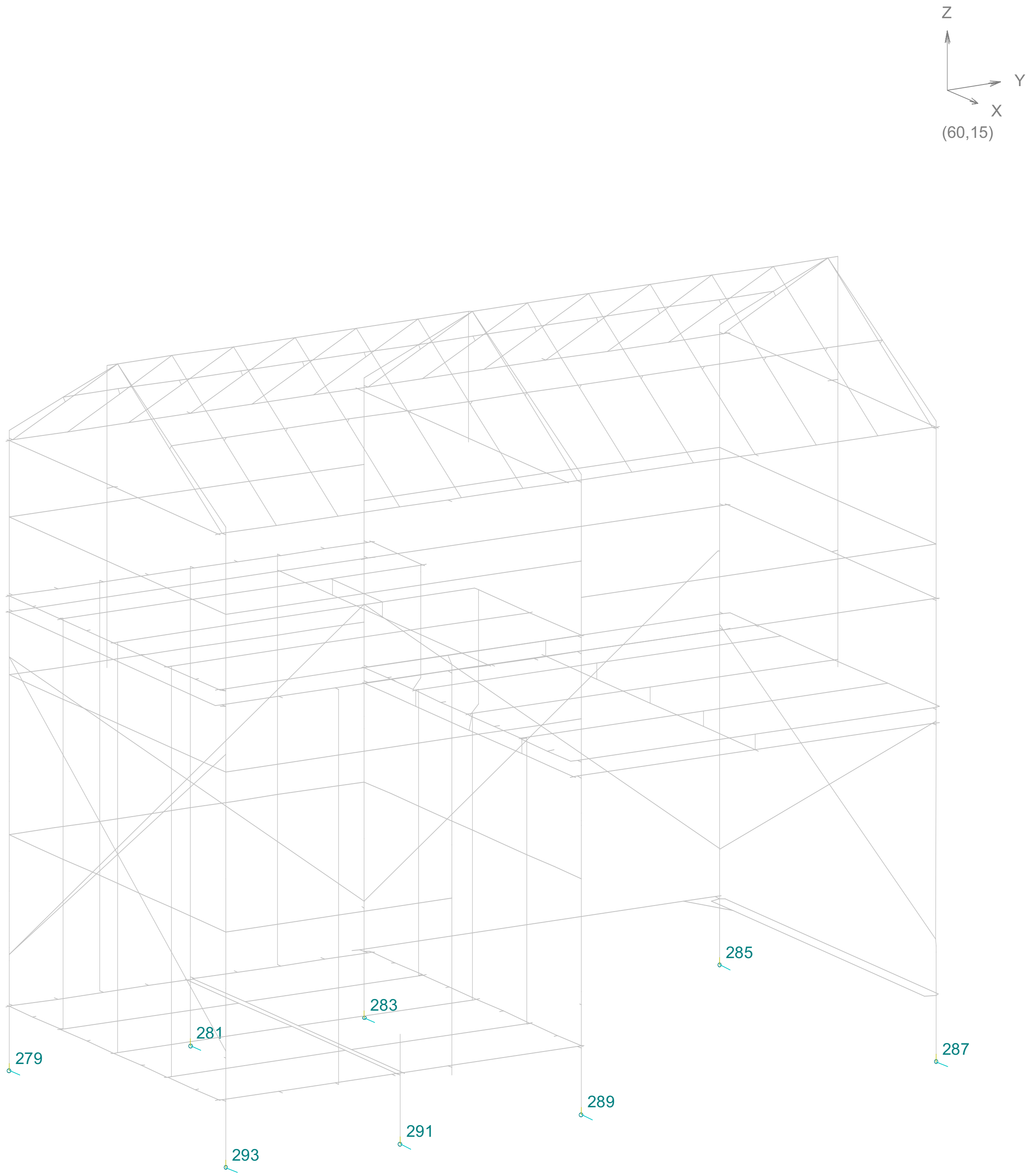
Materials:
1 STEEL
2 Poly Prop FR
3 Wood

Properties

Job: C:\Users\Public\Documents\ERi Projects\39-Worl...\5 Computer Models\STS-04
Units - Len: in, Sec: in, Mat: Psi, Dens: lb/in^3, Temp: Fahrenheit, Force: lb, Mom: lbin, Mass: lb, Acc: g's, Trans: in, Stress: Psi
Scales - Frame: 1:35, Load: None, Disp: None, Moment: None, Shear: None, Axial: None, Torsion: None

SPACE GASS 10.81b - ENGINEERING REVIEW INTERNATIONAL

16 Nov 2010, 7:21 pm



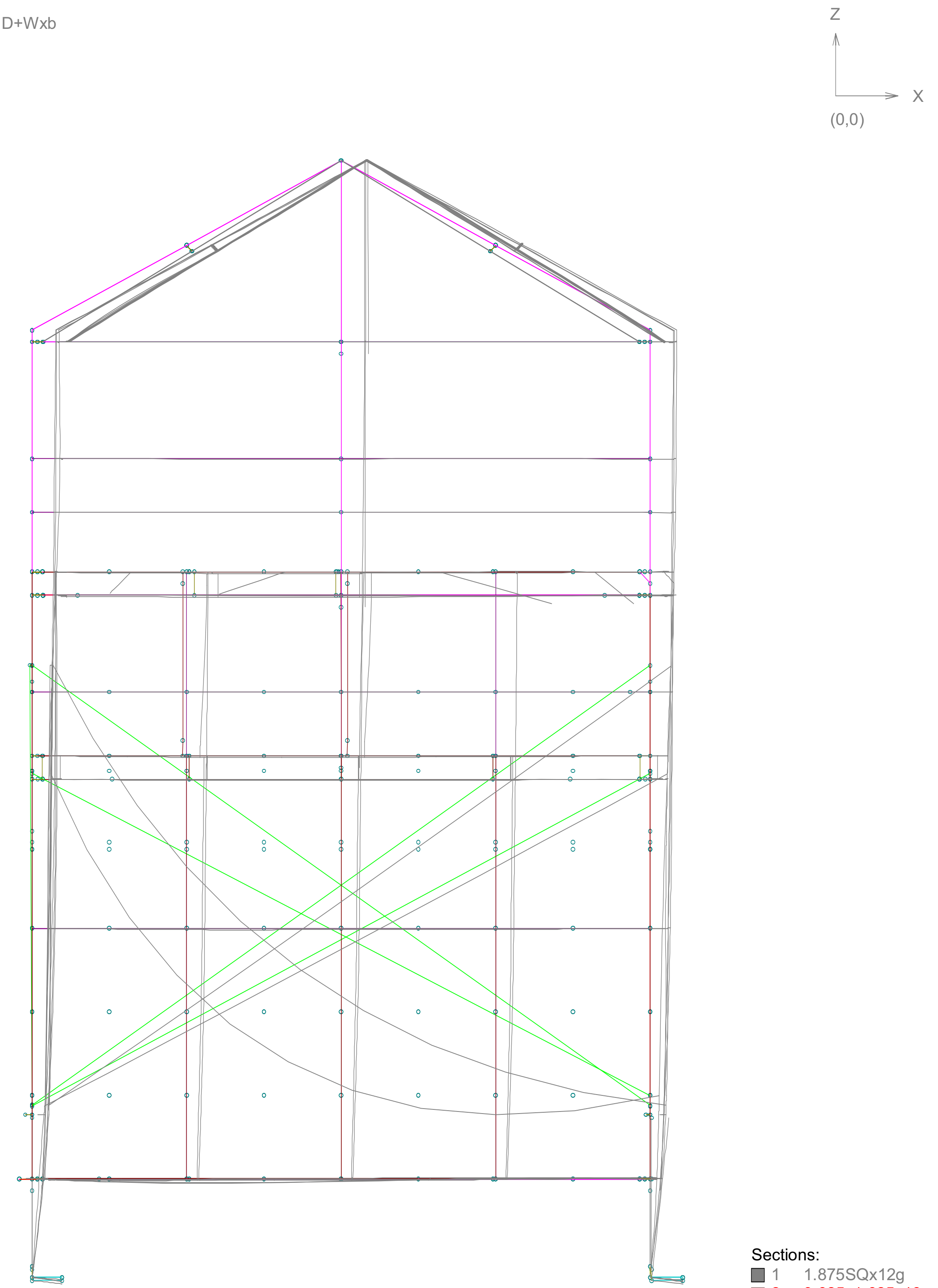
Support Nodes

Materials:
1 STEEL
2 Poly Prop FR
3 Wood

Sections:
8 FB 1/4 x 9 1/2
9 1.625SQx12g

Job: C:\Users\Public\Documents\ERi Projects\39-Worl...\5 Computer Models\STS-04
Filter: supports
Units - Len: in, Sec: in, Mat: Psi, Dens: lb/in^3, Temp: Fahrenheit, Force: lb, Mom: lbin, Mass: lb, Acc: g's, Trans: in, Stress: Psi
Scales - Frame: 1:35, Load: None, Disp: None, Moment: None, Shear: None, Axial: None, Torsion: None

Load cases:
16 (SW) D+Wxb



Sections:
1 1.875SQx12g
2 3.625x1.625x18g
3 3.625x1.50x20g
4 3.625x1.625x20g
5 3.625x1.50x18g
6 link
7 1/4" dia rod
8 FB 1/4 x 9 1/2
9 1.625SQx12g
10 3.625x1.625x18g
11 (2) 5mmx 80mm
12 FB 1/8x1

Materials:
1 STEEL
2 Poly Prop FR
3 Wood

Wind deflection x 10

Job: C:\Users\Public\Documents\ERi Projects\39-Worl...\5 Computer Models\STS-04
Units - Len: in, Sec: in, Mat: Psi, Dens: lb/in^3, Temp: Fahrenheit, Force: lb, Mom: lbin, Mass: lb, Acc: g's, Trans: in, Stress: Psi
Scales - Frame: 1:25, Load: None, Disp: 10, Moment: None, Shear: None, Axial: None, Torsion: None

SPACE GASS 10.81b - ENGINEERING REVIEW INTERNATIONAL
Job: C:\Users\Public\Documents\ERi Projects\39-World...\5 Computer Models\STS-04
Designer: Date: 16 Nov 2010, 7:23 PM Page: 1

ANALYSIS STATUS REPORT

Job name STS-04
Location ...... C:\Users\Public\Documents\ERi Projects\39-World Shelters\87...

Length units	in
Section property units	in
Material strength units	Psi
Mass density units	lb/in^3
Temperature units	Fahrenheit
Force units	lb
Moment units	lbin
Mass units	lb
Acceleration units	g's
Translation units	in
Stress units	Psi

Nodes	695	(32765)
Members	794	(32765)
Plates	297	(32765)
Restrained nodes	8	(32765)
Nodes with spring restraints	0	(32765)
Section properties	12	(999)
Material properties	3	(999)
Constrained nodes	0	(32765)
Member offsets	0	(32765)
Node loads	0	(32765)
Prescribed node displacements	0	(32765)
Member concentrated loads	0	(32765)
Member distributed forces	0	(32765)
Member distributed torsions	0	(32765)
Thermal loads	0	(32765)
Member prestress loads	12	(32765)
Plate pressure loads	1155	(32765)
Self weight load cases	3	(999)
Combination load cases	14	(999)
Load cases with titles	23	(999)
Lumped masses	0	(32765)
Spectral load cases	0	(999)
Static analysis	Y	
Dynamic analysis	N	
Response analysis	N	
Buckling analysis	Y	
Ill-conditioned	N	
Non-linear convergence	Y	
Frontwidth	921	
Total degrees of freedom	4128	
Static load cases	9	(999)
Mass load cases	3	(999)

STEEL DESIGN STATUS REPORT

Members with design data	196	(32765)
Member design or check	C	AISC-ASD
Connections with design data	0	(32765)
Connection design	N	

NODE RESTRAINTS (lb/in,lbin/rad)

(F=Fixed, R=Released, S=Spring, *=General)

Node	Rest Code	X Axial Stiffness	Y Axial Stiffness	Z Axial Stiffness	X Rotation Stiffness	Y Rotation Stiffness	Z Rotation Stiffness
279	FFFRRR						
281	FFFRRR						
283	FFFRRR						
285	FFFRRR						
287	FFFRRR						
289	FFFRRR						
291	FFFRRR						
293	FFFRRR						

SECTION PROPERTIES (in,in^2,in^4,deg)

Sect	Section Name	Mark	Angle Type	Flipped	Source
1	1.875SQx12g	S1	Not applicable	No	Unistrut
2	3.625x1.625x18g	S2	Not applicable	No	Mstuds
3	3.625x1.50x20g	S3	Not applicable	No	Mstuds
4	3.625x1.625x20g	S4	Not applicable	No	Mstuds
5	3.625x1.50x18g	S5	Not applicable	No	Mstuds
6	link	S6	Not applicable	No	Standard shape
7	1/4" dia rod	S7	Not applicable	No	Plates
8	FB 1/4 x 9 1/2	S8	Not applicable	No	Plates
9	1.625SQx12g	S9	Not applicable	No	Unistrut
10	3.625x1.625x18g	S10	Not applicable	No	Mstuds
11	(2) 5mmx 80mm	S11	Not applicable	No	U-Dome
12	FB 1/8x1	S12	Not applicable	No	Plates

Sect	Area of Section	Torsion Constant	Y-Axis Mom of In	Z-Axis Mom of In	Y-Axis Shr Area	Z-Axis Shr Area	Princ Angle
1	7.4340E-01	5.8225E-01	3.8953E-01	3.8953E-01	INFINITE	INFINITE	0.00
2	3.3982E-01	2.2870E-04	1.4102E-01	7.4401E-01	INFINITE	INFINITE	0.00
3	2.2683E-01	8.9900E-05	4.9699E-02	4.6416E-01	INFINITE	INFINITE	0.00
4	2.6143E-01	1.0370E-04	1.0904E-01	5.7567E-01	INFINITE	INFINITE	0.00
5	2.9472E-01	1.9810E-04	6.4125E-02	5.9951E-01	INFINITE	INFINITE	0.00
6	7.3631E-01	6.5002E-01	3.2501E-01	3.2501E-01	INFINITE	INFINITE	0.00
7	4.9087E-02	3.8350E-04	1.9170E-04	1.9170E-04	INFINITE	INFINITE	0.00
8	2.3750E+00	4.8659E-02	1.2369E-02	1.7862E+01	INFINITE	INFINITE	0.00
9	6.3840E-01	3.6874E-01	2.4700E-01	2.4700E-01	INFINITE	INFINITE	0.00
10	3.3982E-01	2.2870E-04	1.4102E-01	7.4401E-01	INFINITE	INFINITE	0.00
11	1.2403E+00	5.9065E-02	1.6029E-02	1.0253E+00	INFINITE	INFINITE	0.00
12	1.2500E-01	5.9980E-04	1.6280E-04	1.0417E-02	INFINITE	INFINITE	0.00

Sect	Section Shape	D	B/Bt	Bb/Hf	Tw	Tf
6	CHS	2.00			0.12	

MATERIAL PROPERTIES (Psi,lb/in^3,strain/degF)

Matl	Material Name	Young's Modulus	Poisson's Ratio	Mass Density	Coeff of Expansion	Concrete Strength
1	STEEL	2.9000E+07	0.25	2.8356E-01	6.500E-06	
2	Poly Prop FR	6.0000E+04	0.30	6.9560E-03	0.000E+00	
3	Wood	1.5000E+06	0.30	2.0255E-02	0.000E+00	

SELF WEIGHT (g's)

Load Case	X-Axis Accel'n	Y-Axis Accel'n	Z-Axis Accel'n
1	0.00	0.00	-1.00
8	0.70	0.00	0.00
9	0.00	0.70	0.00

COMBINATION LOAD CASES

Load case 11: D

1.000 * Load case 1: Dead

Load case 12: D+Lf

1.000 * Load case 1: Dead
1.000 * Load case 2: Floor Live

Load case 13: D+Lr

1.000 * Load case 1: Dead
1.000 * Load case 3: Roof Live

Load case 14: D+0.75Lf+0.75Lr

1.000 * Load case 1: Dead
0.750 * Load case 2: Floor Live
0.750 * Load case 3: Roof Live

Load case 15: D+Wxa

1.000 * Load case 1: Dead
0.826 * Load case 4: Wind Xa

Load case 16: D+Wxb

1.000 * Load case 1: Dead
0.826 * Load case 5: Wind Xb

Load case 17: D+Wya

1.000 * Load case 1: Dead
0.826 * Load case 6: Wind Ya

Load case 18: D+Wyb

1.000 * Load case 1: Dead
0.826 * Load case 7: Wind Yb

Load case 19: D+0.75Lf+0.75Lr+0.75Wxa

1.000 * Load case 1: Dead
0.750 * Load case 2: Floor Live
0.750 * Load case 3: Roof Live
0.620 * Load case 5: Wind Xb

Load case 20: 0.6D+Wxb

0.600 * Load case 1: Dead
0.826 * Load case 4: Wind Xa

Load case 21: D+0.7Ex

1.000 * Load case 1: Dead
0.700 * Load case 8: Earthquake X

Load case 22: D+0.7Ey

1.000 * Load case 1: Dead
0.700 * Load case 9: Earthquake Y

Load case 23: D+0.75Lf+0.75Lr+0.75x0.7Ex

1.000 * Load case 1: Dead
0.750 * Load case 2: Floor Live
0.750 * Load case 3: Roof Live
0.525 * Load case 8: Earthquake X

Load case 24: 0.6D+0.7Ex

0.600 * Load case 1: Dead
0.700 * Load case 8: Earthquake X

LOAD CASE TITLES

Load Case	Title
1	Dead
2	Floor Live
3	Roof Live
4	Wind Xa
5	Wind Xb
6	Wind Ya
7	Wind Yb
8	Earthquake X
9	Earthquake Y
11	D
12	D+Lf
13	D+Lr
14	D+0.75Lf+0.75Lr
15	D+Wxa
16	D+Wxb
17	D+Wya
18	D+Wyb
19	D+0.75Lf+0.75Lr+0.75Wxa
20	0.6D+Wxb
21	D+0.7Ex

Load Case	Title
22	D+0.7Ey
23	D+0.75Lf+0.75Lr+0.75x0.7Ex
24	0.6D+0.7Ex

NODE REACTIONS (lb,lbin)

Load case 11 (Non-linear): D
Non-linear effects: P-Δ, P-δ, 3 Iterations, 99.936% Convergence

Node	X-Axis Force	Y-Axis Force	Z-Axis Force	X-Axis Moment	Y-Axis Moment	Z-Axis Moment
279	10.04	4.42	144.55	0.00	0.00	0.00
281	3.05	-1.13	116.94	0.00	0.00	0.00
283	8.93	0.59	214.60	0.00	0.00	0.00
285	21.04	-4.58	122.95	0.00	0.00	0.00
287	-23.31	-0.34	126.38	0.00	0.00	0.00
289	-1.03	-2.32	203.82	0.00	0.00	0.00
291	-8.57	1.10	85.86	0.00	0.00	0.00
293	-10.17	2.26	159.60	0.00	0.00	0.00
Load	0.00	0.00	-1174.70	0.00	0.05	0.00
Reac	0.00	0.00	1174.70	0.00	0.00	0.00

Frame -3.496E-11 3.740E-09 0.000E+00
Nodes 1.719E-07 4.546E-08 5.625E-06 1.423E-08 1.528E-07 1.161E-09

Load case 12 (Non-linear): D+Lf
Non-linear effects: P-Δ, P-δ, 3 Iterations, 99.988% Convergence

Node	X-Axis Force	Y-Axis Force	Z-Axis Force	X-Axis Moment	Y-Axis Moment	Z-Axis Moment
279	9.15	9.44	542.31	0.00	0.00	0.00
281	17.73	-6.84	508.85	0.00	0.00	0.00
283	57.85	-13.06	912.54	0.00	0.00	0.00
285	16.30	-1.61	436.93	0.00	0.00	0.00
287	-25.72	-4.07	449.05	0.00	0.00	0.00
289	-10.19	-11.05	896.43	0.00	0.00	0.00
291	-51.32	10.76	439.38	0.00	0.00	0.00
293	-13.80	16.42	611.28	0.00	0.00	0.00
Load	0.00	0.00	-4796.76	-0.07	0.78	0.00
Reac	0.00	0.00	4796.76	0.00	0.00	0.00

Frame -1.481E-07 -4.368E-07 0.000E+00
Nodes 8.615E-08 5.432E-07 1.499E-05 4.977E-08 3.450E-07 6.632E-09

Load case 13 (Non-linear): D+Lr
Non-linear effects: P-Δ, P-δ, 3 Iterations, 99.986% Convergence

Node	X-Axis Force	Y-Axis Force	Z-Axis Force	X-Axis Moment	Y-Axis Moment	Z-Axis Moment
279	10.18	4.60	270.83	0.00	0.00	0.00
281	3.82	-0.75	163.29	0.00	0.00	0.00
283	11.87	-1.38	496.98	0.00	0.00	0.00
285	20.70	-4.06	272.51	0.00	0.00	0.00
287	-22.99	-0.59	274.80	0.00	0.00	0.00
289	-1.63	-3.29	495.74	0.00	0.00	0.00
291	-12.10	2.12	116.84	0.00	0.00	0.00
293	-9.84	3.35	292.85	0.00	0.00	0.00
Load	0.00	0.01	-2383.85	0.00	0.05	0.00
Reac	0.00	-0.01	2383.85	0.00	0.00	0.00

Frame -4.295E-08 -7.916E-08 0.000E+00
Nodes 1.772E-07 5.656E-07 6.243E-06 2.577E-08 2.091E-07 6.426E-09

Load case 14 (Non-linear): D+0.75Lf+0.75Lr
Non-linear effects: P-Δ, P-δ, 3 Iterations, 99.986% Convergence

Node	X-Axis Force	Y-Axis Force	Z-Axis Force	X-Axis Moment	Y-Axis Moment	Z-Axis Moment
279	9.47	8.31	537.54	0.00	0.00	0.00
281	14.64	-5.15	445.66	0.00	0.00	0.00
283	47.80	-11.12	949.97	0.00	0.00	0.00
285	17.21	-1.98	470.48	0.00	0.00	0.00
287	-24.83	-3.32	479.71	0.00	0.00	0.00
289	-8.35	-9.59	942.30	0.00	0.00	0.00
291	-43.29	9.13	374.24	0.00	0.00	0.00
293	-12.65	13.71	598.21	0.00	0.00	0.00
Load	0.00	0.01	-4798.10	-0.05	0.60	0.00
Reac	0.00	-0.01	4798.10	0.00	0.00	0.00

Frame 2.065E-07 -1.434E-07 0.000E+00
Nodes 1.731E-07 1.745E-06 9.683E-06 7.466E-08 3.359E-07 3.093E-09

Load case 15 (Non-linear): D+Wxa
Non-linear effects: P-Δ, P-δ, 3 Iterations, 99.966% Convergence

Node	X-Axis Force	Y-Axis Force	Z-Axis Force	X-Axis Moment	Y-Axis Moment	Z-Axis Moment
279	-336.74	-41.26	-1505.05	0.00	0.00	0.00
281	-267.22	-38.76	30.78	0.00	0.00	0.00
283	-738.63	-36.96	-379.87	0.00	0.00	0.00
285	-162.99	-26.96	-881.46	0.00	0.00	0.00
287	-480.46	-5.78	929.57	0.00	0.00	0.00
289	-360.73	-120.27	476.85	0.00	0.00	0.00
291	-21.96	-171.47	175.49	0.00	0.00	0.00
293	-414.12	-157.56	1027.20	0.00	0.00	0.00
Load	2782.84	599.01	126.49	-0.02	0.02	0.82
Reac	-2782.84	-599.01	-126.49	0.00	0.00	0.00

Frame 0.000E+00 0.000E+00 0.000E+00
Nodes 4.449E-05 1.121E-04 2.609E-06 3.410E-06 1.520E-06 3.725E-07

Load case 16 (Non-linear): D+Wxb
Non-linear effects: P-Δ, P-δ, 3 Iterations, 99.956% Convergence

Node	X-Axis Force	Y-Axis Force	Z-Axis Force	X-Axis Moment	Y-Axis Moment	Z-Axis Moment
279	-332.49	38.61	-1153.94	0.00	0.00	0.00
281	-228.28	58.13	78.36	0.00	0.00	0.00
283	-741.38	60.95	-375.05	0.00	0.00	0.00
285	-168.68	29.05	-885.14	0.00	0.00	0.00
287	-492.53	-3.60	1012.95	0.00	0.00	0.00
289	-362.72	-45.68	422.34	0.00	0.00	0.00
291	-40.79	-62.64	356.15	0.00	0.00	0.00
293	-414.98	-72.46	1221.32	0.00	0.00	0.00
Load	2781.86	-2.35	-676.99	-0.01	0.00	1.12
Reac	-2781.86	2.35	676.99	0.00	0.00	0.00

Frame 0.000E+00 2.384E-07 0.000E+00
Nodes 2.564E-05 4.103E-06 9.825E-07 9.067E-08 1.073E-06 1.410E-07

Load case 17 (Non-linear): D+Wya
Non-linear effects: P-Δ, P-δ, 3 Iterations, 99.997% Convergence

Node	X-Axis Force	Y-Axis Force	Z-Axis Force	X-Axis Moment	Y-Axis Moment	Z-Axis Moment
279	4.62	-219.40	-880.56	0.00	0.00	0.00
281	-98.16	-275.12	-17.59	0.00	0.00	0.00
283	13.29	-274.50	88.62	0.00	0.00	0.00
285	48.08	-159.05	91.93	0.00	0.00	0.00
287	-6.66	-9.36	-131.67	0.00	0.00	0.00
289	1.03	-230.78	231.39	0.00	0.00	0.00
291	42.64	-308.51	-362.33	0.00	0.00	0.00
293	-6.90	-243.61	-472.41	0.00	0.00	0.00
Load	2.05	1720.32	1452.62	-0.01	0.09	-1.12
Reac	-2.05	-1720.32	-1452.62	0.00	0.00	0.00

Frame -2.384E-07 -1.221E-04 0.000E+00
Nodes 7.112E-08 4.601E-05 1.174E-05 2.248E-06 2.692E-07 1.576E-07

Load case 18 (Non-linear): D+Wyb
Non-linear effects: P-Δ, P-δ, 3 Iterations, 99.997% Convergence

Node	X-Axis Force	Y-Axis Force	Z-Axis Force	X-Axis Moment	Y-Axis Moment	Z-Axis Moment
279	2.29	-220.40	-799.88	0.00	0.00	0.00
281	-69.12	-275.97	29.93	0.00	0.00	0.00
283	13.08	-275.59	263.15	0.00	0.00	0.00
285	47.38	-157.44	192.18	0.00	0.00	0.00
287	-5.53	-10.40	-30.89	0.00	0.00	0.00
289	-3.06	-243.01	365.35	0.00	0.00	0.00
291	25.15	-297.37	-212.48	0.00	0.00	0.00
293	-11.30	-242.18	-456.56	0.00	0.00	0.00
Load	1.10	1722.37	649.19	0.00	0.07	-1.09
Reac	-1.10	-1722.37	-649.19	0.00	0.00	0.00

Frame 0.000E+00 0.000E+00 0.000E+00
Nodes 5.445E-07 7.518E-05 2.009E-06 1.474E-06 6.400E-08 7.222E-07

Load case 19 (Non-linear): D+0.75Lf+0.75Lr+0.75Wxa
Non-linear effects: P-Δ, P-δ, 3 Iterations, 99.956% Convergence

Node	X-Axis Force	Y-Axis Force	Z-Axis Force	X-Axis Moment	Y-Axis Moment	Z-Axis Moment
279	-245.82	34.06	-437.17	0.00	0.00	0.00
281	-159.50	39.83	416.32	0.00	0.00	0.00
283	-515.16	34.54	505.97	0.00	0.00	0.00
285	-125.23	23.49	-291.68	0.00	0.00	0.00
287	-378.27	-5.79	1149.74	0.00	0.00	0.00
289	-277.57	-42.29	1108.51	0.00	0.00	0.00
291	-65.96	-39.23	580.08	0.00	0.00	0.00
293	-318.77	-42.84	1393.07	0.00	0.00	0.00
Load	2086.28	-1.76	-4424.84	-0.05	0.56	0.84
Reac	-2086.28	1.76	4424.84	0.00	0.00	0.00

Frame 0.000E+00 -3.576E-07 0.000E+00
Nodes 3.720E-05 6.262E-07 8.719E-06 1.261E-07 9.718E-07 3.387E-07

Load case 20 (Non-linear): 0.6D+Wxb
Non-linear effects: P-Δ, P-δ, 3 Iterations, 99.972% Convergence

Node	X-Axis Force	Y-Axis Force	Z-Axis Force	X-Axis Moment	Y-Axis Moment	Z-Axis Moment
279	-338.02	-42.49	-1563.01	0.00	0.00	0.00
281	-268.18	-38.51	-14.11	0.00	0.00	0.00
283	-741.97	-36.92	-465.72	0.00	0.00	0.00
285	-166.13	-25.89	-930.99	0.00	0.00	0.00
287	-476.35	-5.58	878.72	0.00	0.00	0.00
289	-360.51	-119.33	395.59	0.00	0.00	0.00
291	-18.86	-171.76	140.89	0.00	0.00	0.00
293	-412.82	-158.53	962.25	0.00	0.00	0.00
Load	2782.84	599.01	596.37	-0.02	0.00	0.82
Reac	-2782.84	-599.01	-596.37	0.00	0.00	0.00

Frame 0.000E+00 0.000E+00 0.000E+00
Nodes 4.846E-05 5.277E-06 1.063E-05 3.609E-07 1.507E-06 1.120E-07

Load case 21 (Non-linear): D+0.7Ex
Non-linear effects: P-Δ, P-δ, 4 Iterations, 99.995% Convergence

Node	X-Axis Force	Y-Axis Force	Z-Axis Force	X-Axis Moment	Y-Axis Moment	Z-Axis Moment
279	-60.21	10.72	-74.05	0.00	0.00	0.00
281	-60.64	9.32	106.35	0.00	0.00	0.00
283	-135.00	10.44	111.48	0.00	0.00	0.00
285	-30.97	-1.28	-40.90	0.00	0.00	0.00
287	-110.31	-1.20	292.46	0.00	0.00	0.00
289	-72.54	-10.26	278.07	0.00	0.00	0.00
291	-18.42	-8.89	146.79	0.00	0.00	0.00
293	-87.50	-8.86	354.50	0.00	0.00	0.00
Load	575.60	0.00	-1174.70	0.00	0.05	0.00
Reac	-575.60	0.00	1174.70	0.00	0.00	0.00

Frame 0.000E+00 6.822E-08 0.000E+00
Nodes 4.204E-06 2.091E-06 5.787E-06 8.216E-08 1.549E-07 3.364E-08

SPACE GASS 10.81b - ENGINEERING REVIEW INTERNATIONAL
Job: C:\Users\Public\Documents\ERi Projects\39-World...\5 Computer Models\STS-04
Designer: Date: 16 Nov 2010, 7:23 PM Page: 3

Load case 22 (Non-linear): D+0.7Ey
Non-linear effects: P-Δ, P-δ, 3 Iterations, 99.927% Convergence

Node	X-Axis Force	Y-Axis Force	Z-Axis Force	X-Axis Moment	Y-Axis Moment	Z-Axis Moment
279	6.54	-72.72	-95.86	0.00	0.00	0.00
281	0.27	-91.91	113.22	0.00	0.00	0.00
283	8.42	-93.38	367.16	0.00	0.00	0.00
285	28.92	-54.77	214.52	0.00	0.00	0.00
287	-18.21	-11.61	142.74	0.00	0.00	0.00
289	-5.99	-83.61	366.02	0.00	0.00	0.00
291	-7.72	-87.61	77.97	0.00	0.00	0.00
293	-12.22	-79.98	-11.07	0.00	0.00	0.00
Load	0.00	575.60	-1174.70	0.00	0.05	0.00
Reac	0.00	-575.60	1174.70	0.00	0.00	0.00

Frame	1.191E-08	0.000E+00	0.000E+00			
Nodes	2.385E-07	1.798E-05	1.675E-06	5.635E-07	1.292E-07	4.897E-08

Load case 23 (Non-linear): D+0.75Lf+0.75Lr+0.75x0.7Ex
Non-linear effects: P-Δ, P-δ, 4 Iterations, 99.996% Convergence

Node	X-Axis Force	Y-Axis Force	Z-Axis Force	X-Axis Moment	Y-Axis Moment	Z-Axis Moment
279	-43.28	13.01	374.01	0.00	0.00	0.00
281	-33.18	2.75	437.64	0.00	0.00	0.00
283	-60.29	-3.70	871.81	0.00	0.00	0.00
285	-22.23	0.57	346.47	0.00	0.00	0.00
287	-89.96	-3.98	605.28	0.00	0.00	0.00
289	-61.48	-15.55	998.80	0.00	0.00	0.00
291	-50.32	1.57	420.46	0.00	0.00	0.00
293	-70.96	5.33	743.64	0.00	0.00	0.00
Load	431.70	0.01	-4798.10	-0.05	0.60	0.01
Reac	-431.70	-0.01	4798.10	0.00	0.00	0.00

Frame	0.000E+00	-9.453E-08	0.000E+00			
Nodes	3.049E-06	2.383E-07	1.292E-05	9.822E-08	4.928E-07	3.938E-08

Load case 24 (Non-linear): 0.6D+0.7Ex
Non-linear effects: P-Δ, P-δ, 4 Iterations, 99.996% Convergence

Node	X-Axis Force	Y-Axis Force	Z-Axis Force	X-Axis Moment	Y-Axis Moment	Z-Axis Moment
279	-62.64	9.51	-132.37	0.00	0.00	0.00
281	-61.72	9.82	60.85	0.00	0.00	0.00
283	-138.31	10.65	26.31	0.00	0.00	0.00
285	-35.99	0.08	-91.28	0.00	0.00	0.00
287	-104.90	-1.01	242.34	0.00	0.00	0.00
289	-72.02	-9.52	196.77	0.00	0.00	0.00
291	-15.06	-9.52	112.42	0.00	0.00	0.00
293	-84.97	-10.02	289.77	0.00	0.00	0.00
Load	575.60	0.00	-704.82	0.00	0.03	0.00
Reac	-575.60	0.00	704.82	0.00	0.00	0.00

Frame	0.000E+00	-1.369E-07	0.000E+00			
Nodes	1.223E-06	1.852E-06	3.494E-06	5.753E-08	7.089E-08	8.387E-08

BILL OF MATERIALS (in,in^2,lb)

Memb	Sect	Qty	Section Name	Unit Length	Total Length	Unit Mass	Total Mass
1	1	4	1.875SQx12g	10.13	40.51	2.13	8.54
2	2	4	3.625x1.625x18g	1.49	5.95	0.14	0.57
3	3	1	3.625x1.50x20g	2.62	2.62	0.17	0.17
4	4	12	3.625x1.625x20g	27.86	334.30	2.07	24.78
5	2	2	3.625x1.625x18g	1.87	3.74	0.18	0.36
6	4	7	3.625x1.625x20g	1.81	12.69	0.13	0.94
7	10	20	3.625x1.625x18g	12.20	244.06	1.18	23.52
8	1	2	1.875SQx12g	9.63	19.26	2.03	4.06
9	1	2	1.875SQx12g	10.19	20.38	2.15	4.30
10	4	12	3.625x1.625x20g	14.19	170.25	1.05	12.62
11	4	1	3.625x1.625x20g	41.94	41.94	3.11	3.11
12	4	1	3.625x1.625x20g	1.87	1.87	0.14	0.14
13	4	2	3.625x1.625x20g	45.35	90.69	3.36	6.72
14	4	1	3.625x1.625x20g	30.55	30.55	2.26	2.26
15	4	25	3.625x1.625x20g	0.78	19.56	0.06	1.45
16	5	18	3.625x1.50x18g	0.81	14.62	0.07	1.22
17	4	1	3.625x1.625x20g	1.56	1.56	0.12	0.12
18	6	2	link	2.72	5.44	0.57	1.14
19	6	2	link	1.32	2.63	0.27	0.55
20	4	1	3.625x1.625x20g	9.79	9.79	0.73	0.73
21	4	1	3.625x1.625x20g	96.00	96.00	7.12	7.12
22	6	29	link	1.26	36.67	0.26	7.66
23	6	2	link	2.04	4.08	0.43	0.85
24	5	6	3.625x1.50x18g	10.58	63.47	0.88	5.30
25	4	1	3.625x1.625x20g	0.61	0.61	0.05	0.05
26	4	2	3.625x1.625x20g	0.40	0.81	0.03	0.06
27	4	3	3.625x1.625x20g	0.20	0.59	0.01	0.04
28	4	4	3.625x1.625x20g	1.75	7.01	0.13	0.52
29	5	9	3.625x1.50x18g	23.19	208.69	1.94	17.44
30	4	1	3.625x1.625x20g	2.06	2.06	0.15	0.15
31	6	33	link	1.62	53.62	0.34	11.20
32	2	4	3.625x1.625x18g	1.62	6.50	0.16	0.63
33	6	7	link	3.69	25.80	0.77	5.39
34	4	8	3.625x1.625x20g	46.19	369.50	3.42	27.39
35	5	5	3.625x1.50x18g	1.81	9.06	0.15	0.76
36	3	4	3.625x1.50x20g	0.89	3.58	0.06	0.23
37	6	27	link	1.71	46.08	0.36	9.62
38	3	2	3.625x1.50x20g	0.81	1.62	0.05	0.10
39	4	3	3.625x1.625x20g	0.87	2.62	0.06	0.19
40	2	4	3.625x1.625x18g	0.87	3.49	0.08	0.34
41	4	1	3.625x1.625x20g	0.82	0.82	0.06	0.06
42	4	3	3.625x1.625x20g	23.92	71.76	1.77	5.32
43	2	2	3.625x1.625x18g	22.38	44.75	2.16	4.31
44	6	1	link	0.20	0.20	0.04	0.04
45	6	1	link	0.81	0.81	0.17	0.17
46	7	2	1/4" dia rod	119.85	239.70	1.67	3.34
47	2	2	3.625x1.625x18g	1.18	2.36	0.11	0.23
48	2	3	3.625x1.625x18g	1.70	5.10	0.16	0.49
49	2	1	3.625x1.625x18g	3.07	3.07	0.30	0.30
50	7	2	1/4" dia rod	115.56	231.12	1.61	3.22
51	7	1	1/4" dia rod	115.49	115.49	1.61	1.61
52	6	1	link	0.42	0.42	0.09	0.09
53	6	2	link	0.65	1.29	0.14	0.27
54	6	1	link	1.10	1.10	0.23	0.23
55	4	4	3.625x1.625x20g	46.28	185.14	3.43	13.72
56	5	2	3.625x1.50x18g	24.77	49.53	2.07	4.14
57	5	2	3.625x1.50x18g	1.87	3.75	0.16	0.31
58	5	1	3.625x1.50x18g	3.39	3.39	0.28	0.28
59	5	1	3.625x1.50x18g	3.24	3.24	0.27	0.27
60	5	2	3.625x1.50x18g	3.69	7.37	0.31	0.62
61	5	1	3.625x1.50x18g	3.82	3.82	0.32	0.32
62	6	1	link	1.85	1.85	0.39	0.39
63	2	2	3.625x1.625x18g	11.06	22.12	1.07	2.13
64	2	1	3.625x1.625x18g	25.39	25.39	2.45	2.45
65	2	6	3.625x1.625x18g	3.68	22.11	0.36	2.13
66	4	2	3.625x1.625x20g	17.88	35.76	1.33	2.65
67	8	4	FB 1/4 x 9 1/2	4.71	18.84	3.17	12.69
68	8	3	FB 1/4 x 9 1/2	5.17	15.50	3.48	10.44
69	8	1	FB 1/4 x 9 1/2	4.94	4.94	3.33	3.33
70	9	8	1.625SQx12g	1.69	13.52	0.31	2.45
71	10	8	3.625x1.625x18g	14.69	117.50	1.42	11.32
72	10	1	3.625x1.625x18g	3.18	3.18	0.31	0.31
73	10	3	3.625x1.625x18g	11.21	33.63	1.08	3.24
74	10	4	3.625x1.625x18g	46.19	184.75	4.45	17.80
75	10	4	3.625x1.625x18g	48.81	195.25	4.70	18.81
76	10	1	3.625x1.625x18g	33.62	33.62	3.24	3.24
77	10	1	3.625x1.625x18g	47.19	47.19	4.55	4.55
78	11	52	(2) 5mmx 80mm	27.58	1434.31	0.24	12.37
79	12	1	FB 1/8x1	13.80	13.80	0.49	0.49
80	1	3	1.875SQx12g	13.87	41.62	2.92	8.77
81	2	2	3.625x1.625x18g	2.55	5.10	0.25	0.49
82	2	2	3.625x1.625x18g	1.58	3.17	0.15	0.30
83	3	1	3.625x1.50x20g	2.68	2.68	0.17	0.17
84	3	5	3.625x1.50x20g	14.19	70.94	0.91	4.56
85	2	9	3.625x1.625x18g	13.20	118.78	1.27	11.45
86	4	4	3.625x1.625x20g	18.50	73.99	1.37	5.49
87	2	1	3.625x1.625x18g	51.49	51.49	4.96	4.96
88	1	1	1.875SQx12g	12.00	12.00	2.53	2.53
89	1	1	1.875SQx12g	1.87	1.87	0.39	0.39
90	1	2	1.875SQx12g	14.37	28.75	3.03	6.06
91	4	2	3.625x1.625x20g	26.93	53.87	2.00	3.99
92	1	2	1.875SQx12g	13.81	27.62	2.91	5.82
93	3	1	3.625x1.50x20g	1.12	1.12	0.07	0.07
94	4	2	3.625x1.625x20g	28.68	57.35	2.13	4.25
95	4	1	3.625x1.625x20g	40.06	40.06	2.97	2.97
96	4	1	3.625x1.625x20g	25.39	25.39	1.88	1.88
97	3	1	3.625x1.50x20g	13.06	13.06	0.84	0.84
98	4	1	3.625x1.625x20g	9.95	9.95	0.74	0.74
99	4	3	3.625x1.625x20g	1.68	5.05	0.12	0.37
100	4	31	3.625x1.625x20g	0.97	30.07	0.07	2.23
101	5	6	3.625x1.50x18g	0.41	2.44	0.03	0.20
102	5	8	3.625x1.50x18g	24.00	192.00	2.01	16.05
103	5	12	3.625x1.50x18g	12.20	146.44	1.02	12.24
104	5	6	3.625x1.50x18g	11.80	70.78	0.99	5.92
105	4	3	3.625x1.625x20g	0.16	0.47	0.01	0.04
106	4	1	3.625x1.625x20g	8.19	8.19	0.61	0.61
107	4	1	3.625x1.625x20g	86.21	86.21	6.39	6.39
108	4	1	3.625x1.625x20g	1.35	1.35	0.10	0.10
109	4	1	3.625x1.625x20g	0.55	0.55	0.04	0.04
110	6	1	link	0.87	0.87	0.18	0.18
111	5	4	3.625x1.50x18g	46.19	184.75	3.86	15.44
112	2	3	3.625x1.625x18g	0.06	0.18	0.01	0.02
113	5	5	3.625x1.50x18g	1.00	5.00	0.08	0.42
114	5	1	3.625x1.50x18g	0.93	0.93	0.08	0.08
115	2	1	3.625x1.625x18g	50.02	50.02	4.82	4.82
116	2	2	3.625x1.625x18g	2.79	5.59	0.27	0.54
117	2	1	3.625x1.625x18g	23.19	23.19	2.23	2.23
118	4	2	3.625x1.625x20g	47.94	95.88	3.55	7.11
119	2	1	3.625x1.625x18g	23.13	23.13	2.23	2.23
120	2	2	3.625x1.625x18g	24.00	48.00	2.31	4.63
121	5	2	3.625x1.50x18g	10.92	21.85	0.91	1.83
122	5	1	3.625x1.50x18g	10.62	10.62	0.89	0.89
123	5	4	3.625x1.50x18g	14.69	58.75	1.23	4.91
124	3	4	3.625x1.50x20g	47.11	188.42	3.03	12.12
125	4	1	3.625x1.625x20g	92.38	92.38	6.85	6.85
126	3	2	3.625x1.50x20g	1.00	2.00	0.06	0.13
127	4	3	3.625x1.625x20g	47.16	141.47	3.50	10.49
128	4	1	3.625x1.625x20g	47.10	47.10	3.49	3.49
129	4	1	3.625x1.625x20g	11.72	11.72	0.87	0.87
130	4	1	3.625x1.625x20g	94.23	94.23	6.99	6.99
131	3	2	3.625x1.50x20g	2.75	5.50	0.18	0.35
132	5	2	3.625x1.50x18g	23.00	46.00	1.92	3.84
133	4	2	3.625x1.625x20g	5.51	11.02	0.41	0.82
134	2	1	3.625x1.625x18g	47.94	47.94	4.62	4.62
135	2	1	3.625x1.625x18g	23.94	23.94	2.31	2.31
136	5	1	3.625x1.50x18g	69.38	69.38	5.80	5.80
137	4	5	3.625x1.625x20g	35.16	175.80	2.61	13.03
138	4	6	3.625x1.625x20g	11.30	67.78	0.84	5.02
139	4	1	3.625x1.625x20g	23.00	23.00	1.71	1.71
140	2	2	3.625x1.625x18g	11.12	22.23	1.07	2.14
141	7	1	1/4" dia rod	115.61	115.61	1.61	1.61
142	10	8	3.625x1.625x18g	11.80	94.38	1.14	9.09
143	2	1	3.625x1.625x18g	4.17	4.17	0.40	0.40
144	2	1	3.625x1.625x18g	0.22	0.22	0.02	0.02
145	2	1	3.625x1.625x18g	14.33	14.33	1.38	1.38
146	2	2	3.625x1.625x18g	1.35	2.69	0.13	0.26
147	7	1	1/4" dia rod	110.10	110.10	1.53	1.53
148	7	1	1/4" dia rod	110.89	110.89	1.54	1.54
149	10	8	3.625x1.625x18g	11.30	90.38	1.09	8.71
150	4	1	3.625x1.625x20g	33.62	33.62	2.49	2.49
151	5	1	3.625x1.50x18g	11.59	11.59	0.97	0.97
152	5	1	3.625x1.50x18g	22.19	22.19	1.85	1.85
153	2	2	3.625x1.625x18g	8.25	16.50	0.79	1.59
154	5	1	3.625x1.50x18g	23.94	23.94	2.00	2.00
155	5	1	3.625x1.50x18g	24.06	24.06	2.01	2.01
156	4	2	3.625x1.625x20g	1.12	2.25	0.08	0.17
157	2	2	3.625x1.625x18g	10.10	20.19	0.97	1.95
158	2	11	3.625x1.625x18g	12.46	137.01	1.20	13.20
159	2	1	3.625x1.625x18g	26.40	26.40	2.54	2.54
160	2	2	3.625x1.625x18g	15.30	30.59	1.47	2.95
161	10	1	3.625x1.625x18g	45.63	45.63	4.40	4.40
162	4	2	3.625x1.625x20g	9.44	18.88	0.70	1.40
163	4	2	3.625x1.625x20g	13.13	26.25	0.97	1.95
164	4	2	3.625x1.625x20g	8.44	16.87	0.63	1.25
165	3	15	3.625x1.50x20g	16.00	240.00	1.03	15.44
166	4	24	3.625x1.625x20g	16.00	384.00	1.19	28.47
167	3	2	3.625x1.50x20g	11.44	22.88	0.74	1.47
168	3	1	3.625x1.50x20g	12.56	12.56	0.81	0.81
169	4	1	3.625x1.625x20g	84.19	84.19	6.24	6.24
170	4	1	3.625x1.625x20g	83.24	83.24	6.17	6.17
171	5	2	3.625x1.50x18g	0.58	1.17	0.05	0.10
172	4	6	3.625x1.625x20g	11.80	70.78	0.87	5.25
173	4	3	3.625x1.625x20g	14.69	44.06	1.09	3.27
174	10	1	3.625x1.625x18g	58.75	58.75	5.66	5.66
175	3	1	3.625x1.50x20g	3.44	3.44	0.22	0.22
176	6	2	link	1.00	2.00	0.21	0.42
177	10	1	3.625x1.625x18g	45.19	45.19	4.35	4.35

Memb	Sect	Qty	Section Name	Unit Length	Total Length	Unit Mass	Total Mass
178	4	1	3.625x1.625x20g	10.89	10.89	0.81	0.81
179	4	1	3.625x1.625x20g	11.09	11.09	0.82	0.82
180	4	2	3.625x1.625x20g	10.62	21.25	0.79	1.58
181	4	2	3.625x1.625x20g	34.22	68.44	2.54	5.07
182	4	1	3.625x1.625x20g	24.53	24.53	1.82	1.82
183	4	1	3.625x1.625x20g	2.43	2.43	0.18	0.18
184	4	3	3.625x1.625x20g	0.94	2.82	0.00	0.01
185	4	1	3.625x1.625x20g	1.17	1.17	0.09	0.09
186	4	1	3.625x1.625x20g	1.46	1.46	0.11	0.11
187	4	1	3.625x1.625x20g	1.60	1.60	0.12	0.12
188	4	1	3.625x1.625x20g	1.25	1.25	0.09	0.09
189	4	1	3.625x1.625x20g	1.04	1.04	0.08	0.08
190	5	3	3.625x1.50x18g	11.22	33.67	0.94	2.81
191	5	1	3.625x1.50x18g	3.57	3.57	0.30	0.30
192	5	23	3.625x1.50x18g	13.20	303.55	1.10	25.37
193	5	15	3.625x1.50x18g	12.46	186.83	1.04	15.61
194	5	4	3.625x1.50x18g	18.98	75.92	1.59	6.35
195	5	6	3.625x1.50x18g	13.63	81.81	1.14	6.84
196	5	1	3.625x1.50x18g	15.30	15.30	1.28	1.28
197	10	6	3.625x1.625x18g	13.20	79.19	1.27	7.63
198	10	6	3.625x1.625x18g	12.46	74.73	1.20	7.20
199	10	2	3.625x1.625x18g	18.98	37.96	1.83	3.66

Plate	Qty	Thickness	Total Area	Total Mass
1	1	0.20	149.09	0.20

Total mass = 809.41
Centre of gravity = 46.52,82.89,71.33

BUCKLING LOAD FACTORS

Load Case	Mode	Load Factor	Tolerance	Iterations	Node at Max Trans	Node at Max Rotn
11	1	208.47	0.007812	23	102 (X)	604 (Y)
12	1	59.17	0.007812	19	23 (X)	674 (Y)
13	1	97.47	0.007812	21	82 (X)	604 (Y)
14	1	56.82	0.007812	19	82 (X)	674 (Y)
15	1	13.12	0.007812	15	344 (Z)	344 (Y)
16	1	12.61	0.007812	15	344 (Z)	344 (Y)
17	1	70.29	0.007812	21	462 (X)	676 (Y)
18	1	81.25	0.007812	21	343 (Y)	674 (Y)
19	1	16.52	0.007812	17	344 (Z)	344 (Y)
20	1	13.01	0.007812	15	344 (Z)	344 (Y)
21	1	46.95	0.007812	19	344 (Z)	344 (Y)
22	1	59.06	0.007812	19	674 (Y)	674 (Y)
23	1	51.91	0.007812	19	82 (X)	395 (Z)
24	1	45.64	0.007812	19	343 (Z)	344 (Y)