Structural Calculations For:

Pallet Shelter V2

Prepared for: Pallet Shelter

Job #: 11776-2018-01-00

Date: June 8, 2023

SSF STRUCTURAL ENGINEERING

SEATTLE 2124 Third Ave, Suite 100, Seattle, WA 98121 O 206.443.6212

TACOMA 934 Broadway, Suite 100, Tacoma, WA 98402 O 253.284.9470

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General Building Narrative

The Pallet Shelter 70 and 120 are 70sqft (7'x10'x9') and 120sqft (7'x17'x9') emergency shelters intended for rapid deployment and supportive interim housing.

The general construction takes the form of composite reinforced foam wall and roof panels on a welded aluminum base. These panels are TransCore panels produced by Ridge Corporation. The Walls are joined at the corners with diagonal thru-bolts, and tied to the base with aluminum angles and screws. The roof is held down with tension rods from the roof to the base. The floor consists of a reinforced foam panel laid on the base frame.

Given the lightweight nature of the fully assembled structure, utilizing the CBC to determine seismic demands assuming an R value of 1.0, the prescriptive lateral forces of appendix P are significantly higher than that required per the California Building Code. As such, the structure has been designed elastically to resist the prescriptive lateral values.

Given the unique nature of construction and deployment, testing has been conducted to determine shear capacity in the roof and wall systems to transmit the prescriptive lateral forces as outlined in the California Building Code. Pallet has opted to conduct testing in accordance to ASTM E564-06. Testing was conducted on a full scale 70sqft shelter by attaching anchor plates to the roof panel, inboard of the wall line, and applying a tension force in line with the roof. This testing method captures the wall behaviors outlined in ASTM E564-06 as well as the shear transfer behavior between roof panel and walls through the keyed interlock.

During testing, we applied lateral testing loads up to 4300lbs and measured the panel displacement. This corresponds to a factor of safety of 6, with respect to the CBC Appendix P prescriptive loads, for the 70sqft units. This corresponds to a Factor of Safety of 3.7 for the 120sqft units. Maximum wall displacement observed was 1.0". After multiple rounds of testing, no permanent deformations or damage were observed on the subject unit. Testing was halted at 4300lbs due to concerns with the capacity of the testing aparatus.

Roof panel testing was conducted by loading the roof of the assembled structure with 50lb sandbags in 2 layers. Displacements were measured at each layer at the center of the panel. The first layer corresponded to a roof live load of 22psf, and the 2nd layer corresponds with a roof live load of 37psf. Lateral buckling of the front panel was also measured

In addition to the testing undertaken to determine lateral capacity, we are also utilizing material data of TransCore panels in determining capacities of the lightweight coverings to resist gravity floor loads of 40 pounds per square foot.

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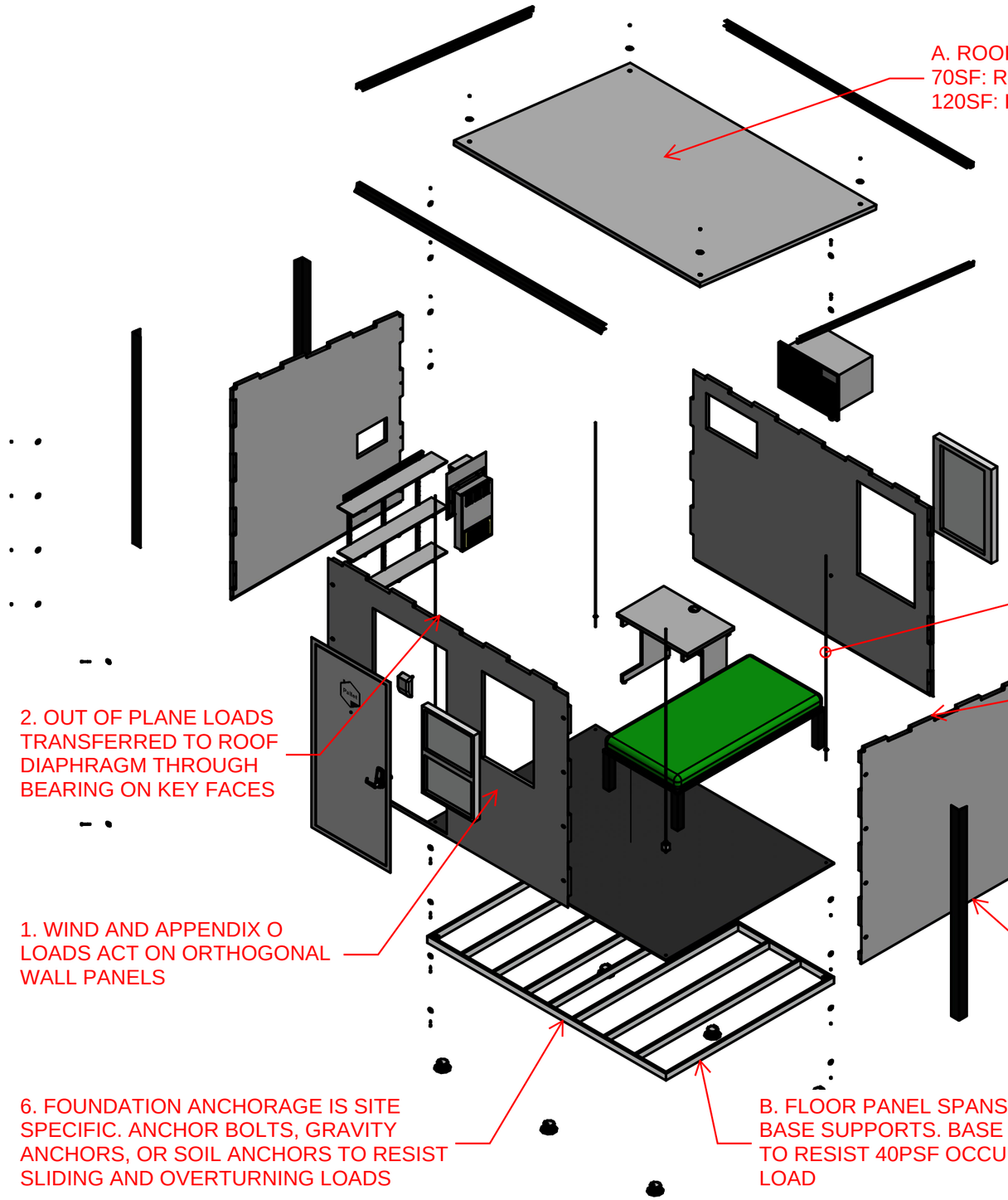
Project Title:	Date	SSF project no.
PALLET SHELTER V2 TESTING	##/##/2023	---
	Design: AGL	
Sheet Title:	Drawn: AGL	Sheet

REVISION HISTORY		
REV	DESCRIPTION	DATE
X1	Preliminary Release	



PARTS LIST			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1		Back Wall
2	1		Side Wall Right
3	1		Base Concept 2
4	1		Front Wall
5	1		Roof
6	1		Side Wall Left Assy [X3]
7	2		Sheet Metal Side Roof Trim
8	1		Sheet Metal Front Roof Trim
9	1		Sheet Metal Back Roof Trim
10	1		Front Left Corner Flashing
11	1		Front Right Corner Flashing
12	1		Back Left Corner Flashing
13	1		Back Right Corner Flashing
14	1		Bed
15	1		Desk Assy
16	1		Door Assy
17	1		Vandal Resistant Exterior Light
18	1		Egress Window
19	1		Single Hung Window
20	1		AC Heater Combo
21	6		Leveling Feet
22	4		3/8" Washer
23	8		3/8" Nut
24	32		Stamped Wall Washer
26	16		3"-5/16 Hex Bolt
27	16		5/16 Nut
28	4		Stamped Roof Washer

NOT TO SCALE

WHERE USED	xxxxx

DRAWN BY	JordanBarde
DATE	6/1/2023
CHECKED BY	
DATE	
MFG CHECKED BY	
DATE	
APPROVED BY	
DATE	

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ± 1/16
ANGULAR ± 1°
X.X ± .06
X.XX ± .03
X.XXX ± .01

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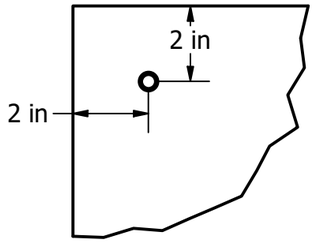
TITLE
Shelter 70

PART NUMBER	REV
	X1

WorkInProgress | SHEET 1 OF 1

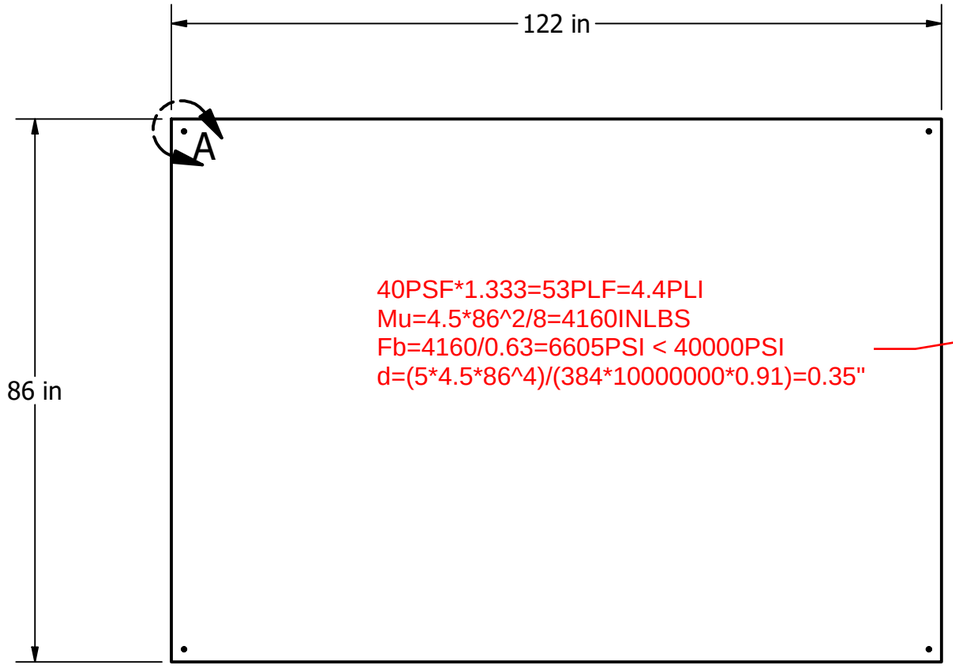
REVISION HISTORY		
REV	DESCRIPTION	DATE
X1	Preliminary Release	



DETAIL A

Note: Aluminum Rectangular Tube
3" x 1" x 0.125" T6 6061

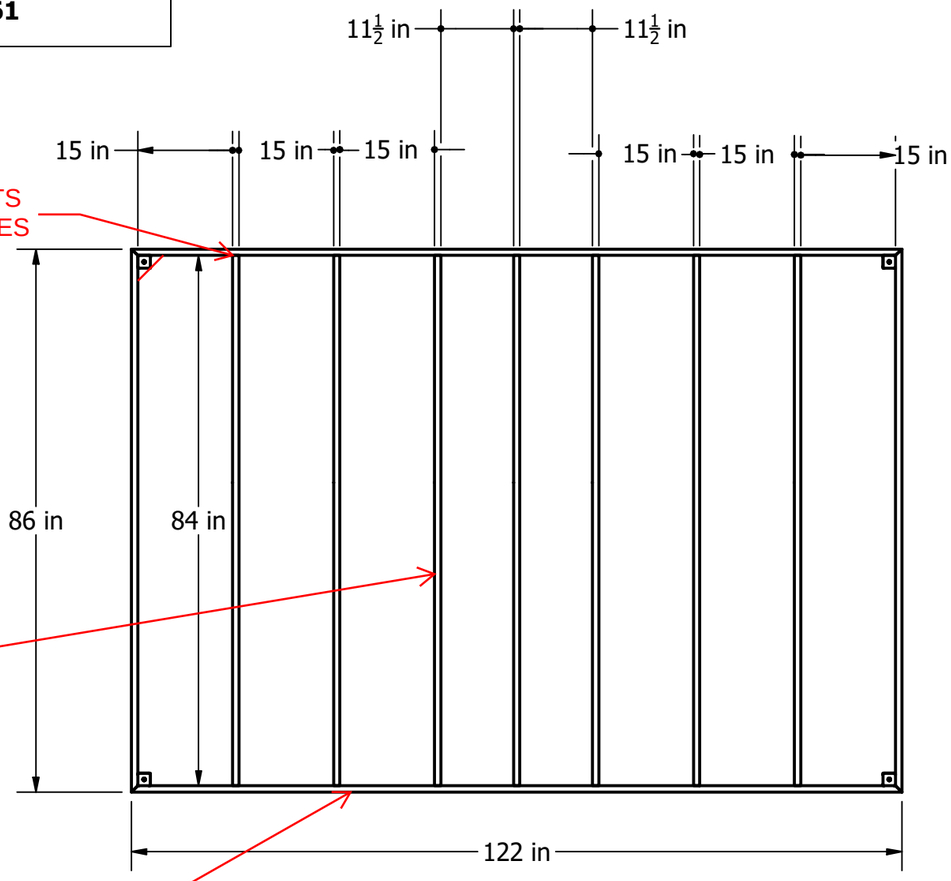
Sx=0.63IN3
Ix=0.91IN3
fb=40KSI



40PSF*1.333=53PLF=4.4PLI
Mu=4.5*86^2/8=4160INLBS
Fb=4160/0.63=6605PSI < 40000PSI
d=(5*4.5*86^4)/(384*10000000*0.91)=0.35"

3 SUPPORTS (OR BEARING ON SOIL)
40PSF*7/2=140PLF=11.7PLI
Mu=12*61^2/8=5581NLBS
Fb=5581/0.63=8860PSI < 40000PSI
d=(5*12*61^4)/(384*10000000*0.91)=0.24"

ALL CORNER AND JOINTS
ARE WELDED BOTH SIDES



PRELIMINARY

NOT TO SCALE

WHERE USED	xxxxx

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DATE	
APPROVED BY	
DATE	

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ± 1/16
ANGULAR ± 1°
X.X ± .06
X.XX ± .03
X.XXX ± .01

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TITLE
Base Concept 2

PART NUMBER

REV
X1

WorkInProgress

SHEET 1 OF 1

1 | Product Description and Application

TransCore® panels are resilient, lightweight, abrasion and puncture resistant, recyclable, engineered thermoplastic composite sandwich panels. TransCore® panels are used for a variety of building material applications such as floors, walls, doors, or interior finish panels, with a composition to meet requirements for ASTM E84 standards. TransCore® panels are engineered with high glass content skins that are thermally fused to a resilient thermoplastic core to provide durability, stiffness, and adequate screw withdrawal properties. The construction also provides an insulation value up to 3.4R per inch at the lowest weight possible. The product is hydrophobic, resists corrosion, mildew, degradation, and can be easily cleaned.

Surface options of TransCore® panels offer a variety of benefits. Royal Watson® includes Surlok® adhesive bonding technology, optimized for polyurethane paints, glues, and foam systems while providing long-lasting UV stability a glossy white finish. BioStat® technology is built into the Royal Watson® exterior providing a surface that meets the FDA requirements for direct food contact.

TransCore® panel engineering and manufacturing is done completely in house by Ridge Corporation, the configurations are designed to reach appropriate specifications per application. Please reach out to Ridge Corporation for additional configuration and supplementary test data availability.

2 | Physical and Technical Data

Layup	Nominal Thickness	Nominal Weight	Nominal Skin Thickness	Nominal Foam Core Density[1]	Typical Compression Strength[3] (ASTM D365)	Typical Flexural Stiffness (EI)/in Width (ASTM D3043 3PT 22" Span, 3" x 24")
	in *mm*	lbs/ft² *kg/m²*	in *mm*	lbs/ft³ *kg/m³*	psi *kPa*	lbsF-in *Nm*
WW01701404R064CC FLOOR	0.563 *14.3*	0.77 *3.76*	0.044 *1.1*	4.0 *64*	50 *344*	7,585 *856*
WW04804808R140CC WALL	1.429 *36.3*	1.6 *7.83*	0.044 *1.1*	8.7 *140*	84 *580*	47,512 *5,368*
WW06205008R140CC ROOF	1.921 *48.8*	1.96 *9.58*	0.044 *1.1*	8.7 *140*	148 *1,020*	77,066 *8,708*

[1]Compression strength values listed are based off the core's strength assuming equal loading. The value listed does not reflect ultimate compression strength. The thermoplastic foam nature of the product will continue to compress while simultaneously increasing compression force without catastrophic failure.

3 | Material Specifications and Information

3.1 Part Number Specification | Cut Sheet: WW01701404R064CC -HHHHLLLL

Examples: WW01701404R064CC-092D1560

$HHHH_2$	Width/Height Code	i.e., 92.25"=092D , 110"=1100
LLLL	Length Code	i.e., 76"=0760 , 228.5"=228H

Note 2: Last character in these segments of the part number reference a fraction code below
A=1/16", B=1/8", C=3/16", D=1/4", E=5/16", F=3/8", G=7/16", H=1/2", J=9/16", K=5/8", L=11/16", M=3/4", N=13/16", P=7/8", Q=15/16", 0=0"

3.2 Composition | TransCore® composite panels consist of continuous E-glass fiber reinforcement saturated in a polypropylene copolymer thermoplastic resin matrix. The core is comprised of a thermoplastic closed cell foam thermally fused to the skins. The Royal Watson® surface composition meets the FDA and USDA/FSIS requirements for direct food contact.

3.3 Finished Panel Tolerances | Finished panel sizes are subject to the following tolerances unless otherwise specified:

Thickness (t):	±0.045" (±1.2mm)
Areal Weight:	± 0.2 lb/ft^2 (0.98 kg/m^2)
Width (w):	± 1/8"
Length (L):	•L ≤ 12' ± 1/8" • 12' ≤ L < 24' ± 1/4" • L ≥ 24' ± 1/2"
Squareness:	•1/8" in 48" of width• 1/4"" Diagonal variation up to 24' •1/2"" Diagonal variation over 24' •± 3/8" Bow over length
Standards:	•Flat sheet widths up to 115" •Custom CNC Profiles up to 114" x 59' with +/- 1/16" dimensional tolerances

3.4 Packaging and Shipping | Depending on the nature of the order and required shipping method, TransCore® products are provided cut to size. Product is shipped flat on wood pallets or flatbed wrapped by protective plastic and reinforced occasionally with Styrofoam and wood dunnage unless other arrangements are previously agreed upon.

3.5 Fabrication and Installation Recommendations | Safety: Always use safety glasses during fabrication of TransCore®. Wear gloves and dust masks where applicable. Cutting/Drilling: Use carbide tipped and coated saw blades, router bits, and drill bits for best results. Cleaning: TransCore® materials can be cleaned with mild detergents, water, and 50/50 isopropyl alcohol mixtures. Other solvents may be used, but it is recommended to test their effects on the surface of the material to ensure colorfastness as well as no degradation effects to the surface or adhesion properties. Power washers can be utilized with a minimum 40° fan wash tip with 2800 psi or less units. Adhesion to TransCore® can be affected by the cleanliness of the Royal Watson® surface. Clean surface with above guidance for best results.

3.6 Storage | It is recommended to store TransCore® materials indoors and keep clean and dry for proper installation. Take care when handling and processing TransCore®.

3.7 Quality, Product Use, and Liability | TransCore® composite structural panels do not provide a class A surface, but do provide a clean, uniform colored panel appearance. However, due to material composition and our continuous manufacturing process some small irregularities in surface and edge continuity may be present. These standard cosmetic imperfections due to our process will not affect the functionality or performance of the product and include, but are not limited to, small fiber alignment separations, slight tape overlaps and gaps, surface depressions, core weld and joint lines, impressions caused from changes in manufacturing equipment textures, and minor thermal shrinkage or warpage effects which may be present on either side of the material. If there are any questions regarding the standard non-conforming specifications, additional testing information or otherwise agreed upon terms, please contact Ridge Corporation. Ridge Corporation can only be held liable for the material and workmanship of the product and freight, but not any labor, handling, or installation costs incurred.

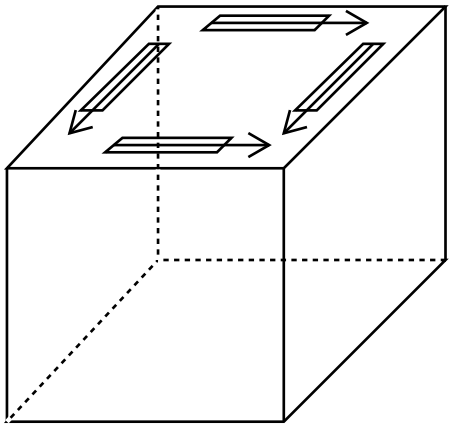
All information included herein is believed to be accurate and is supported by sound engineering testing and development. Ridge Corporation recommends the user test the material for their specific application in order to determine if the product will be functional. Ridge Corporation cannot be found liable for the use of the product or the information presented herein for any infringement by a third party as to the intellectual or industrial property or rights of others by the purchaser.

LATERAL LOAD TESTING STRAP ATTACHEMENTS

#8 x 1-1/4" WOOD SCREW - MIN ULTIMATE SHEAR LOAD: 200 LBS
USE FACTOR OF SAFETY (FS) = 2
ALLOWABLE SHEAR CAPACITY = 200/2=100 LBS/SCREW

5/16" THRU BOLT IN SINGLE SHEAR - MIN ULTIMATE LOAD 900LBS
USE FS=2
ALLOWABLE SHEAR CAPACITY = 450LBS

TESTING LATERAL LOADS
CBC APPENDIX P: 15PSF
ANTICIPATED HIGH WIND LOAD: 50PSF
(Exposure C, V=200mph)



TEST SETUP:
ATTACH TEST BRACKET TO ROOF PANEL
TEST PULL STRUCTURE TO MAXIMUM DEFLECTION
TEST PULL TO DESTRUCTION

MAXIMUM LATERAL LOADS FOR TESTING
STRUCTURE HEIGHT: 9'0"
LONG DIMENSION: 10'0"
SHORT DIMESION: 7'0"

CBC APPENDIX P: Vbase = 9'0" * 10'0" * 15PSF = 1350 LBS
Vroof = 1350/2 = 675 LBS

HIGH WIND: Vbase = 90 * 50 = 4500 LBS
Vroof = 4500/2 = 2250 LBS

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Wind Design - MWFRS

ASCE 7 Chapter 27 - Directional Procedure

Design Method	Strength

Wind Coefficients

Exposure	C	
V=	155	mph
K_d=	0.85	Table 26.6-1
K_h=	0.85	Table 26.10-1
K_e=	1.00	Table 26.9-1
G=	0.85	26.9.4

Transverse Wind Pressures

L/B = 0.70 h/L = 1.29

Pressure Coefficients from Figure 27.3-1:

Bldg Face	C_p
Windward Wall	0.8
Leeward Wall	-0.50
Windward Roof	-1.3 / -0.18
Leeward Roof	-0.70

Location and Building Dimensions

Calculate Kzt?	Yes	
Kzt	1.00	
Roof Type	Monoslope	
Roof Slope - Transverse Dir	10	degrees
Roof Slope - Long Dir	0	degrees
Ground to top of roof	10	ft
Bot of roof to top of roof	2	ft
Mean Roof Height, h	9	ft
Short Plan Dimension	7	ft
Long Plan Dimension	10	ft
Parapet ?	No	
Ground to top of parapet		ft
Average Parapet Height		ft

Velocity Pressure at Mean Roof Height, q_h =	44.3	psf

Wall Pressures (Unfactored): Strength

Ht	K_z	q_z	$P_{ww\ walls}$	$P_{lwwalls}$	**P_{walls} (psf)**
0-15	0.85	44.34	30.15	18.82	**49.0**
15-20	0.9	46.95	31.93	18.82	**50.8**
20-25	0.94	49.04	33.35	18.82	**52.2**
25-30	0.98	51.13	34.77	18.82	**53.6**
30-40	1.04	54.26	36.89	18.82	**55.7**
41-50	1.09	56.87	38.67	18.82	**57.5**
51-60	1.13	58.95	40.09	18.82	**58.9**
61-70	1.17	61.04	41.51	18.82	**60.3**
71-80	1.21	63.13	42.93	18.82	**61.7**
81-90	1.24	64.69	43.99	18.82	**62.8**
91-100	1.26	65.73	44.70	18.82	**63.5**

Roof Pressures (Unfactored) Strength

Windward		Leeward	**Horiz Proj (psf)**
Max	Min		
-6.8	-48.9	-26.4	**19.57**

THIS CALCULATION SERVES TO BACK CALCULATE THE BASIC WIND SPEED FROM THE MAXIMUM DESIGN LATERAL LOADS USED. NO ADDITIONAL WIND SPEED UP FACTORS (Kzt) WERE TAKEN INTO CONSIDERATION

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LATERAL LOAD TESTING STRAP ATTACHEMENTS

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ALLOWABLE SHEAR CAPACITY = 200/2=100 LBS/SCREW

5/16" THRU BOLT IN SINGLE SHEAR - MIN ULTIMATE LOAD 900LBS
USE FS=2
ALLOWABLE SHEAR CAPACITY = 450LBS

TESTING BRACKET DESIGN

VROOF MAX = 2250LBS
2 LINES OF RESISTANCE = 1125 LBS/WALL
FSdemand = 2
Fbracket = 2250 LBS

OF SCREWS = 2250/100 = 23 (USE 24)
OF BOLTS = 2250/450 = 5 BOLTS

BRACKET THICKNESS
((2250#/0.75)/58000PSI)/1"=0.05" - USE 1/4" PLATE MIN

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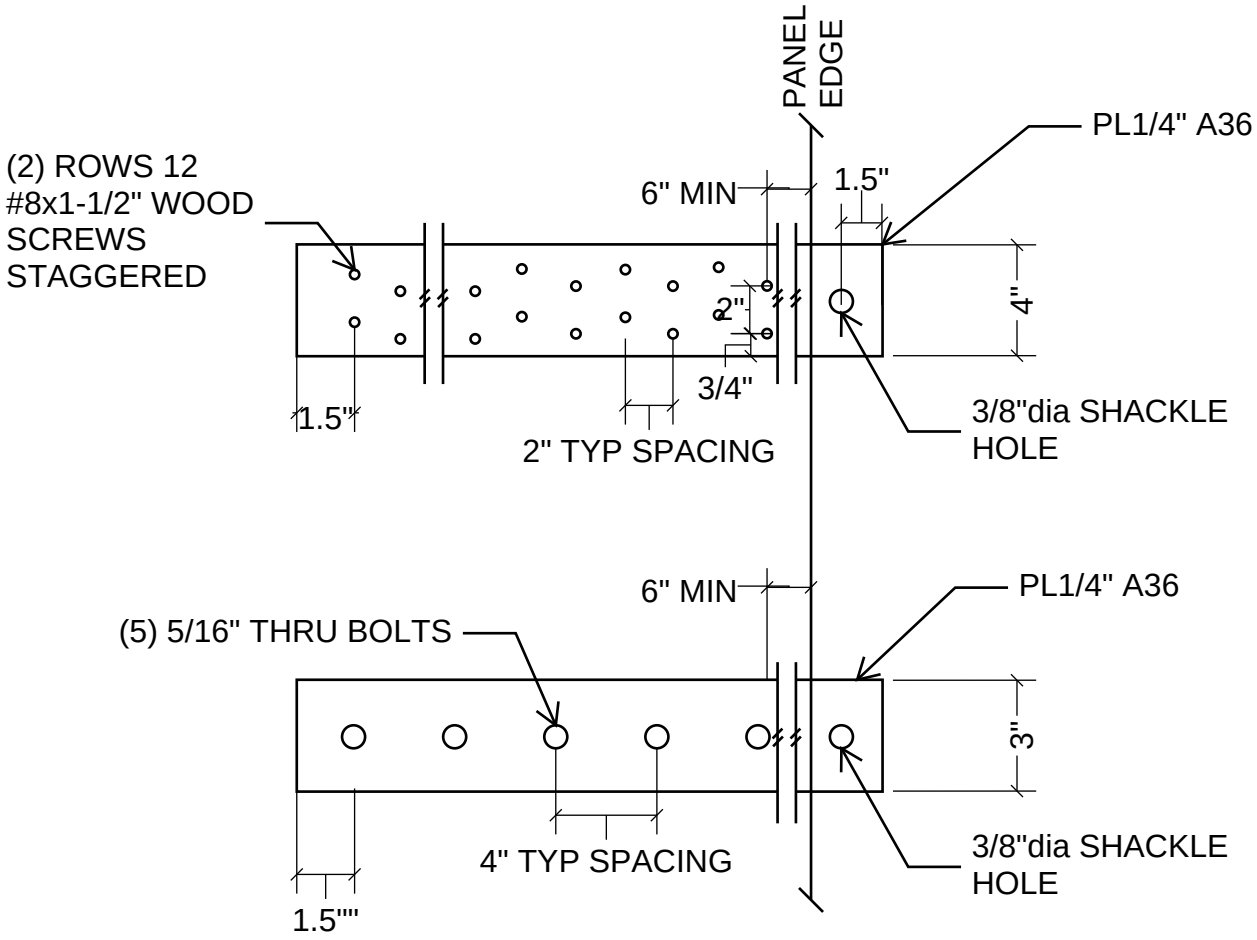
LATERAL LOAD TESTING STRAP ATTACHEMENTS



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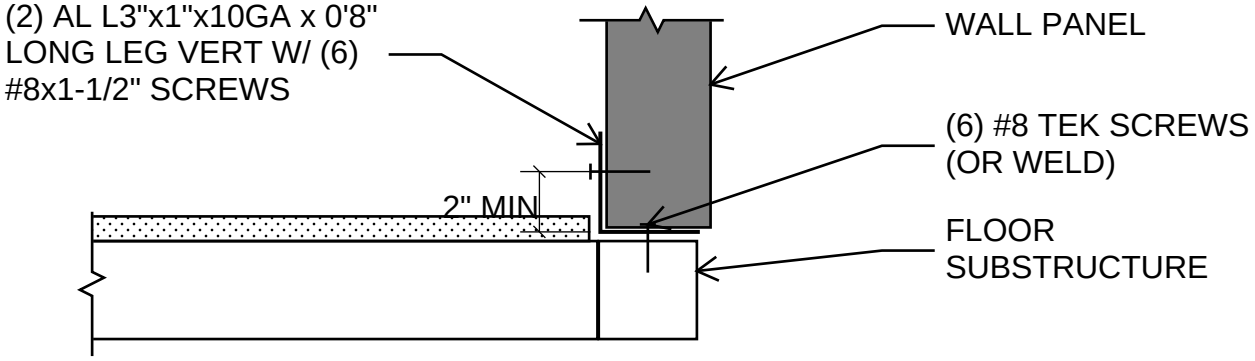
WALL BASE ANCHORAGE - MINIMUM CAPACITY

DESIGN BASE SHEAR: 1125 LBS
SCREW CAPACITY: 100LBS/SCREW (FS=2)
USE (12) #8x 1-1/2" SCREWS



HOLDOWN ANCHORAGE

DESIGN SHEAR: 1125 LBS
OVERTURNING: 1125*9/7 = 1446LBS
As min = 0.05 in
USE 3/8" MIN THREADED ROD: Ae=0.07 IN2

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GRAVITY TEST LAYOUT

REVISION HISTORY		
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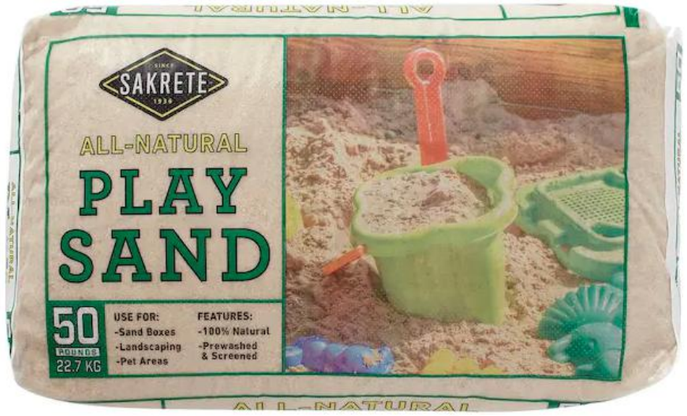
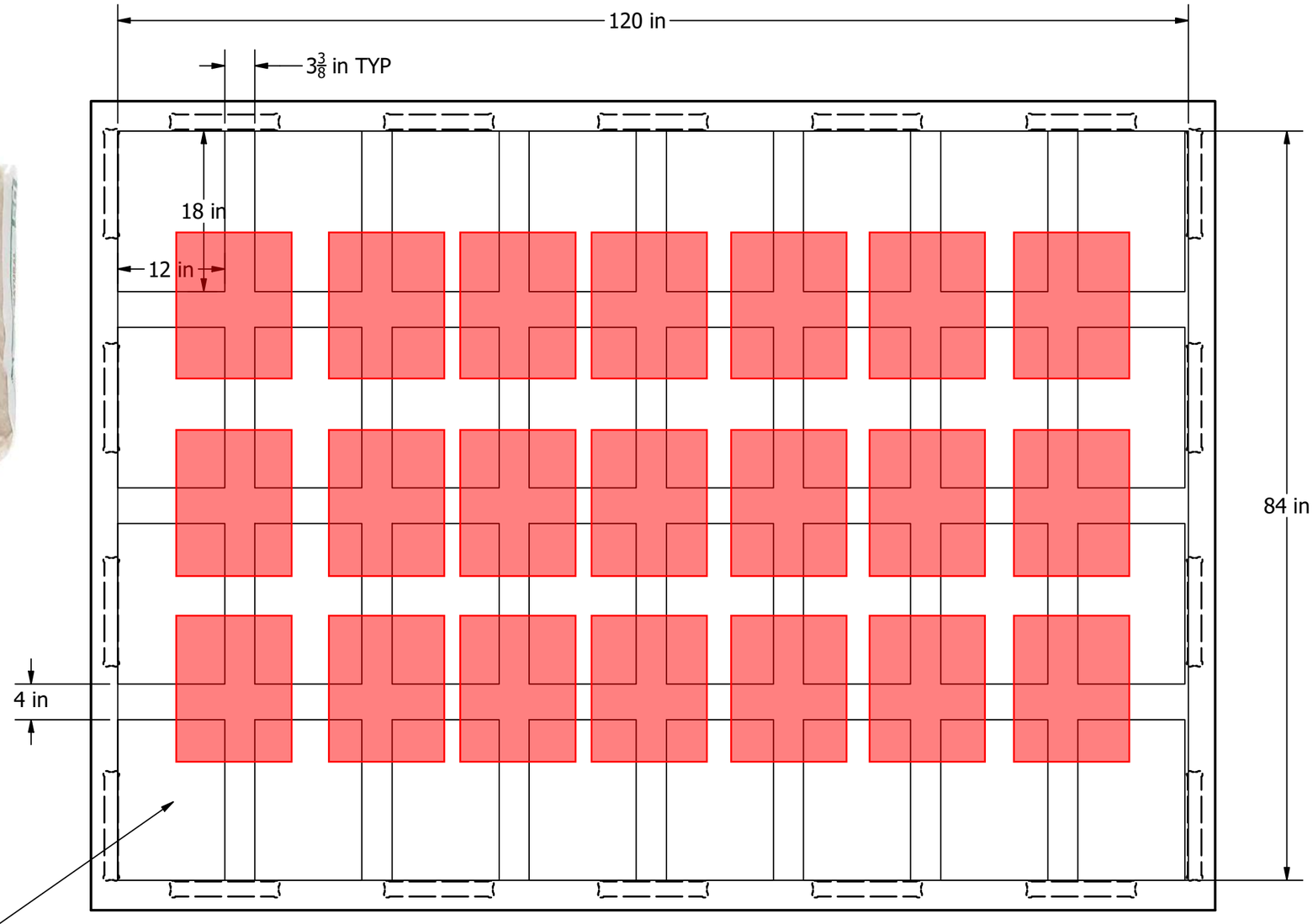


Note: ***84" x 120" is exposed internal floor space dimension***

32 bags * 50 lb = 1,600 lbs.

Actual bag weights range anywhere from 48-51 lbs.



PRELIMINARY

1st LAYER ACHIEVES 22PSF ROOF LOADING EQUIVALENT.
2ND LAYER ADDS 21 BAGS = 1050 LBS
ACHIEVES 37PSF ROOF LOADING EQUVALENT

Pallet™

DRAWN BY	JordanBarde
DATE	5/17/2023
CHECKED BY	
DATE	
MFG CHECKED BY	
DATE	
APPROVED BY	
DATE	

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ± 1/16
ANGULAR ± 1°
X.X ± .06
X.XX ± .03
X.XXX ± .01

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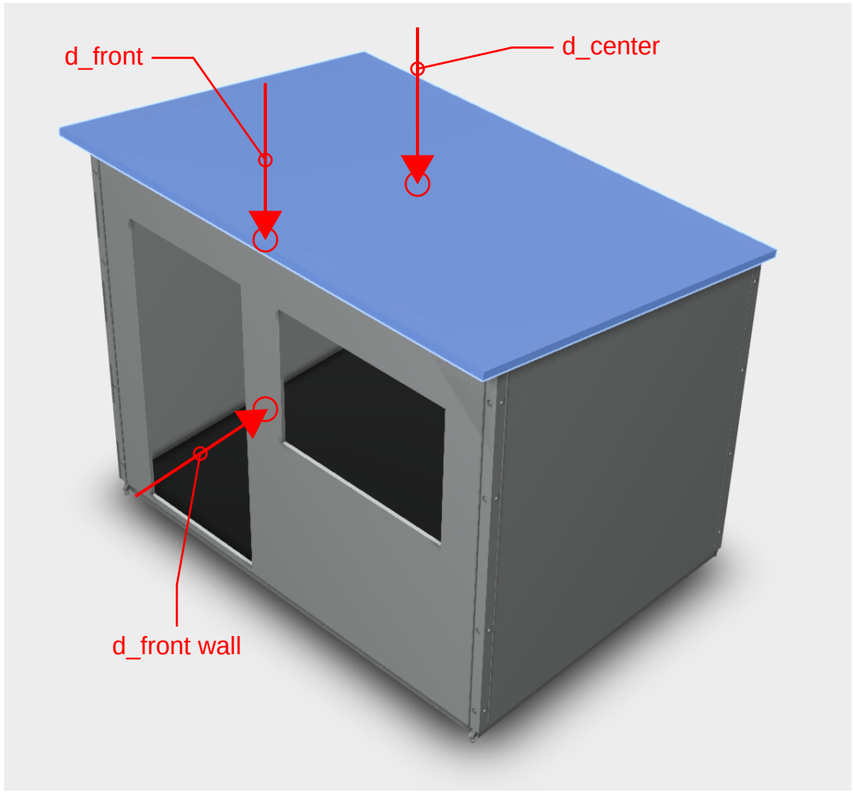
TITLE
Roof

PART NUMBER	REV
Roof[SNOW_TEST]	X1
WorkInProgress	SHEET 1 OF 1

NOT TO SCALE

WHERE USED	xxxxx



FOR THE 70SQFT UNIT, THE ROOF PANEL ACTS AS A 2-WAY SLAB. THE REPORTED TEST VALUES BELOW ARE ONLY VALID FOR THIS CONFIGURATION

DEFLECTIONS AT THE FRONT WALL WERE TAKEN TO ADDRESS CONCERNS FOR BUCKLING AT THE CENTER PIER BETWEEN THE WINDOW AND DOOR. WE FIND THESE RESULTS GENERALLY ACCEPTABLE. ADDITIONAL REINFORCEMENT MAY BE REQUIRED WHERE ROOF SNOW/LIVE LOADS EXCEED 40PSF.

Layer	Total Weight (lb.)	lbs/sqft	Bag Count	Range	$\delta_{roof,center}$(in)	$\delta_{roof,front}$(in)	$\delta_{front\ wall}$(in)
1	1578	22.54	32	23-54	0.53125	0.03125	0.09375
2	1033	37.30	21	2-22	0.96875	0.125	0.21875

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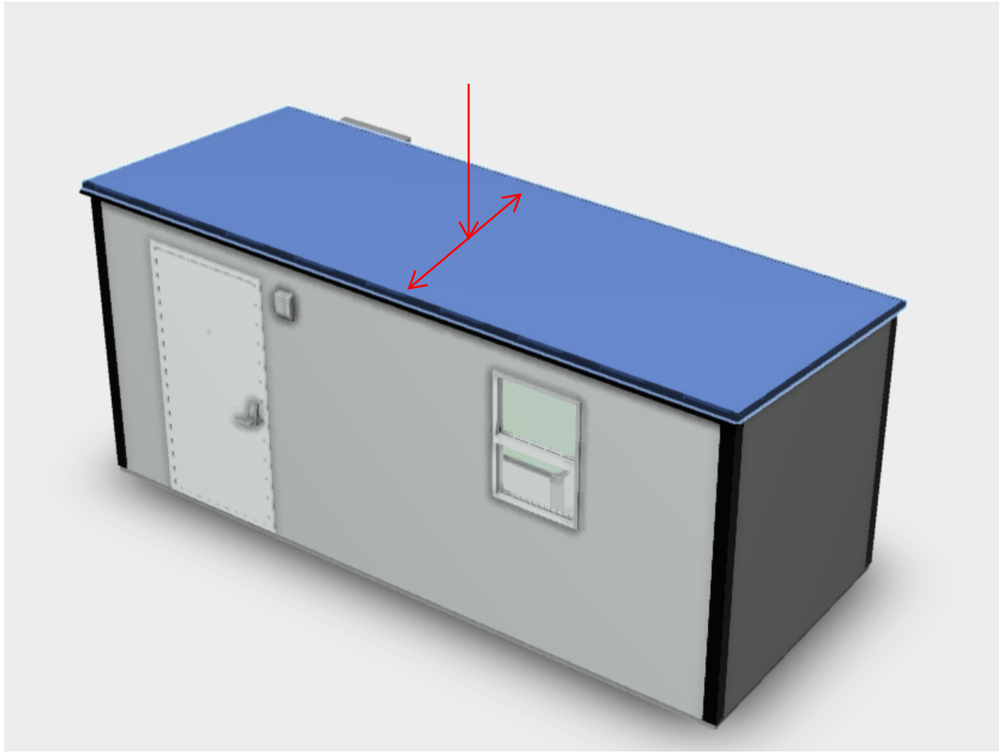
FOR THE FOR THE 120SQFT UNIT, THE ROOF PANEL PRIMARILY ACTS IN 1-WAY FLEXURE. THE TEST DATA BELOW IS BASED ON THE ROOF PANEL IN A SIMPLY SUPPORTED CONFIGURATION.



WeightTotal	w (psf)	δTotal
1546	22.1	0.625
2562	36.6	1.1875

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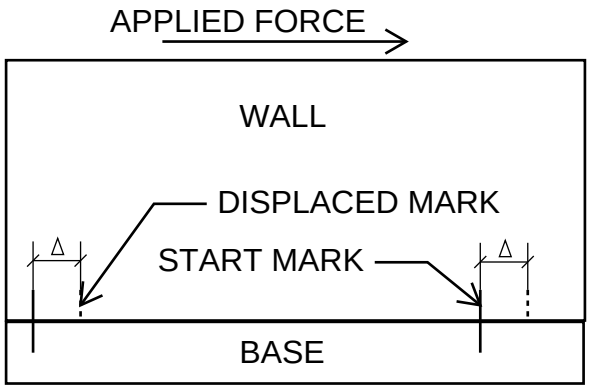
Sheet

LATERALTEST MEASUREMENTS - REFERENCE ASTM E564-06

7.2.3: SEAT ALL CONNECTIONS WITH A 10% INITIAL LOAD. HOLD LOAD FOR 5 MIN. REMOVE LOAD AND TAKE INITIAL READINGS BEFORE STARTING TEST. APPLY LOADS IN 1/3 INCREMENTS. MAINTAIN TENSION FOR 5 MINUTES BEFORE MEASURING DISPLACEMENT

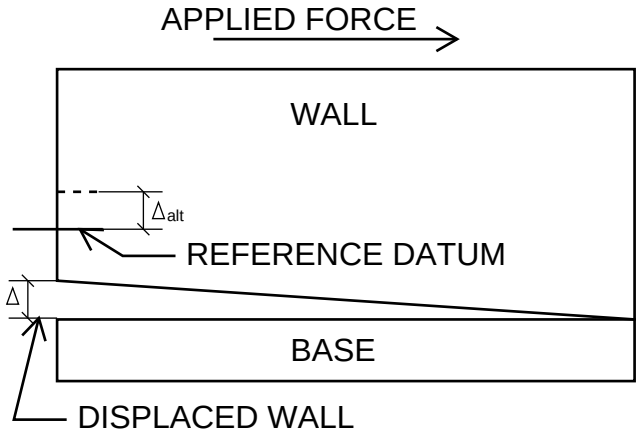
7.3.3.1: SLIP AT THE BASE

MARK 2 LOCATIONS ON THE BASE AND BOTTOM OF WALL PANEL. MEASURE DISPLACEMENT OF MARK AT EACH INCREMENT



7.3.3.2: UPLIFT AT TENSION WALL END

MEASURE SEPARATION OF WALL END FROM BASE. ALTERNATIVELY, SET A DATUM WITH REFERENCE TO THE BASE/FLOOR. MARK THE WALL AT THE STARTING DATUM AND MEASURE VERTICAL DISPLACEMENT OF MARK W.R.T. DATUM



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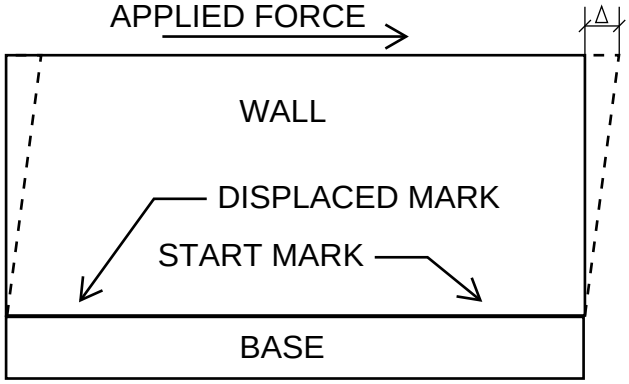
TEST MEASUREMENTS - REFERENCE ASTM E564-06

7.3.3.3: DISPLACEMENT AT TOP OF WALL

ESTABLISH A VERTICAL DATUM. MEASURE DISPLACEMENT AT THE TOP CORNER OF EACH WALL IN THE DIRECTION OF FORCE.



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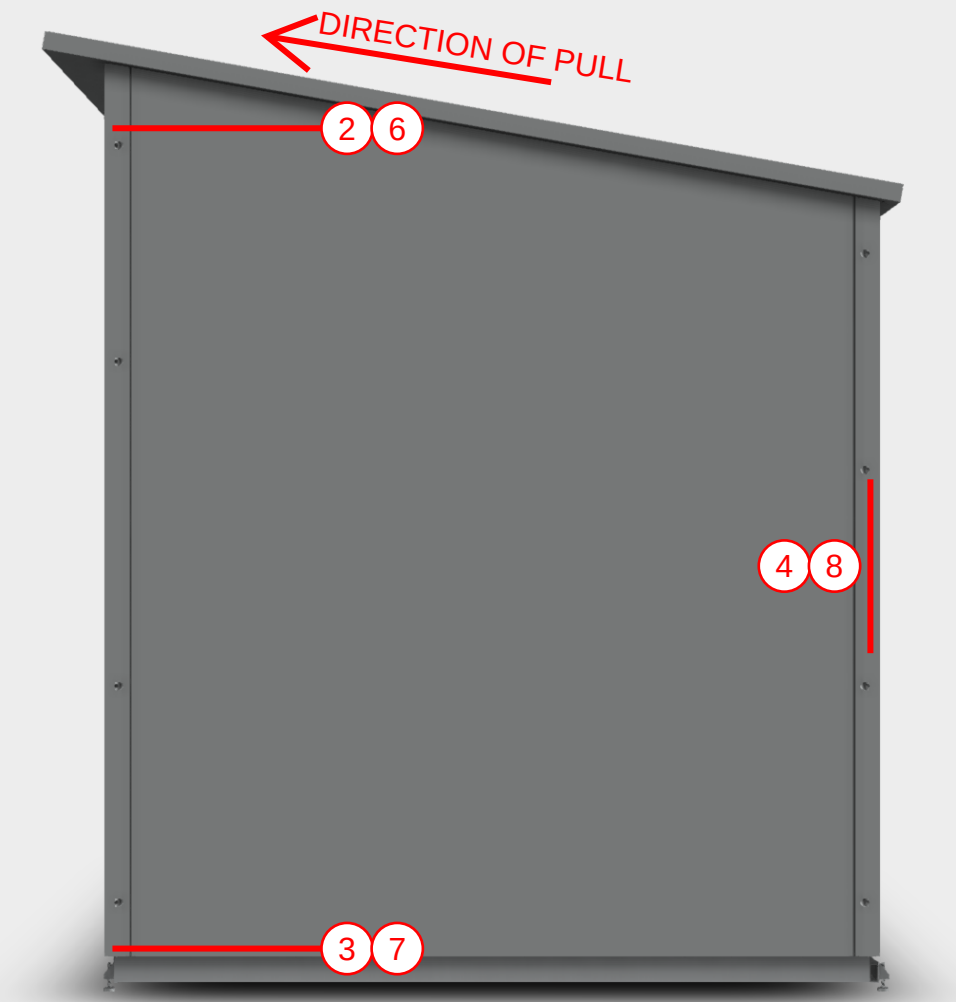
TEST MEASUREMENTS - KEY PLAN

TRANSVERSE LOADING



TEST LOCATIONS 5-8 OCCUR ON OPPOSITE WALL

TEST LOCATIONS 3&7 MEASURE SLIP OF THE BASE CONNECTION

TEST LOCATIONS 1&5 AND 2&6 MEASURE DISPLACEMENT OF THE WALL AT MID HEIGHT AND TOP OF WALL RESPECTIVELY, INCLUDING BASE CONNECTION SLIP

TEST LOCATIONS 4&8 MEASURE UPLIFT OF REAR CORNER UNDER LOAD

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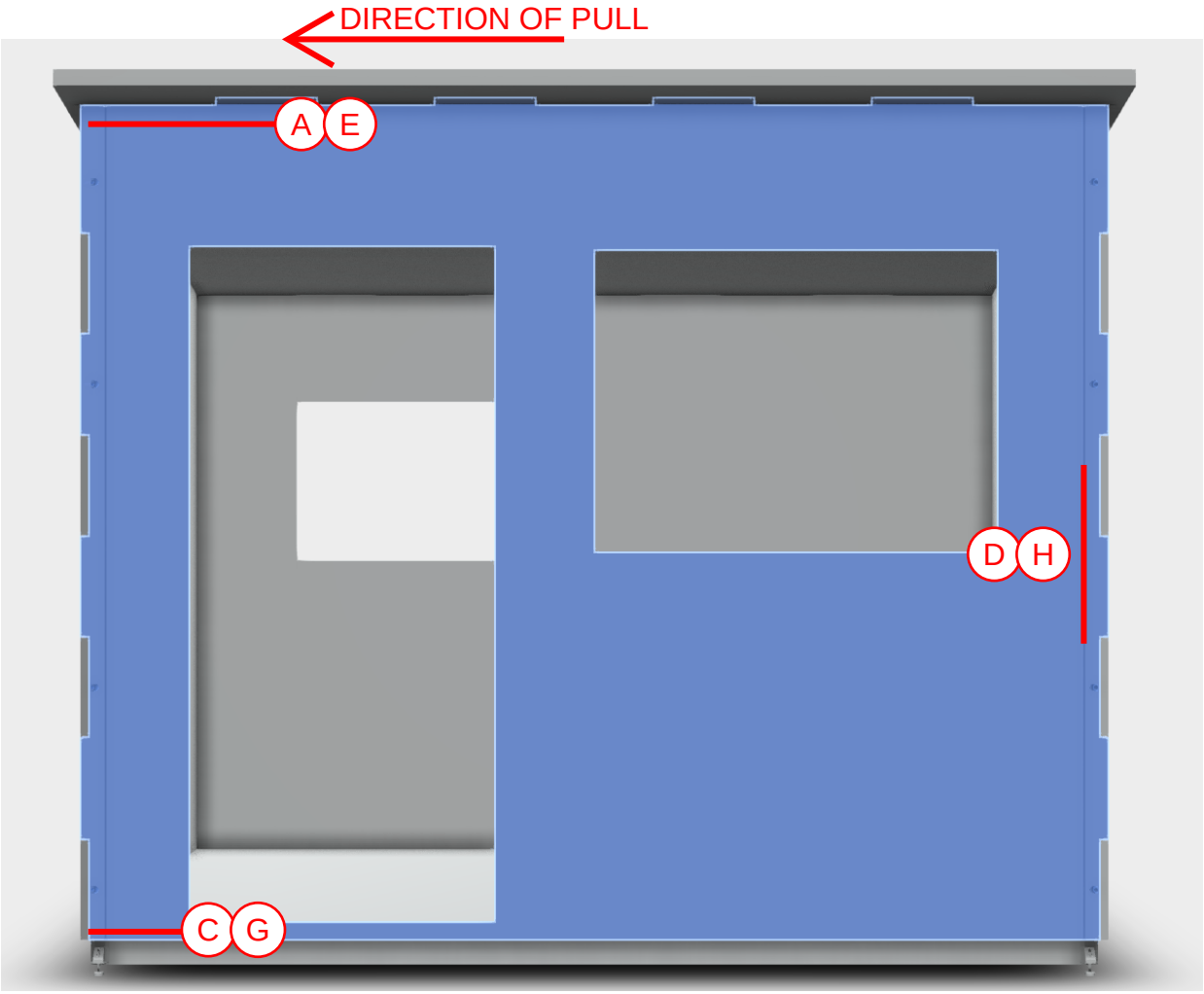
TEST MEASUREMENTS - KEY PLAN

LONGITUDINAL LOADING



TEST LOCATIONS E-H
OCCUR ON OPPOSITE WALL

TEST LOCATIONS C-G MEASURE SLIP OF THE BASE CONNECTION

TEST LOCATIONS B&F AND A&E MEASURE DISPLACEMENT OF THE WALL AT MID HEIGHT AND TOP OF WALL RESPECTIVELY, INCLUDING BASE CONNECTION SLIP

TEST LOCATIONS D&H
MEASURE UPLIFT OF REAR CORNER UNDER LOAD

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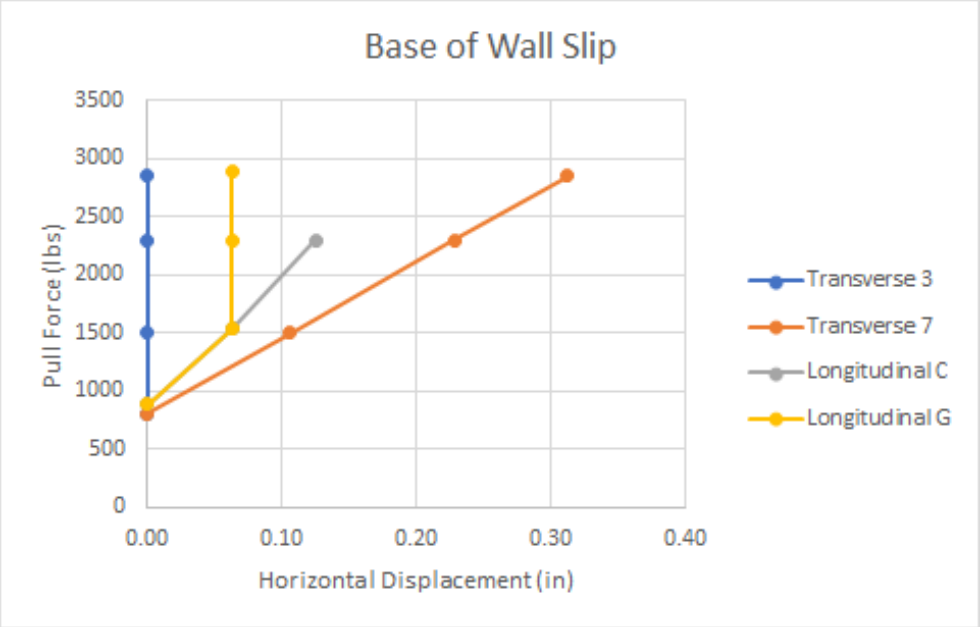
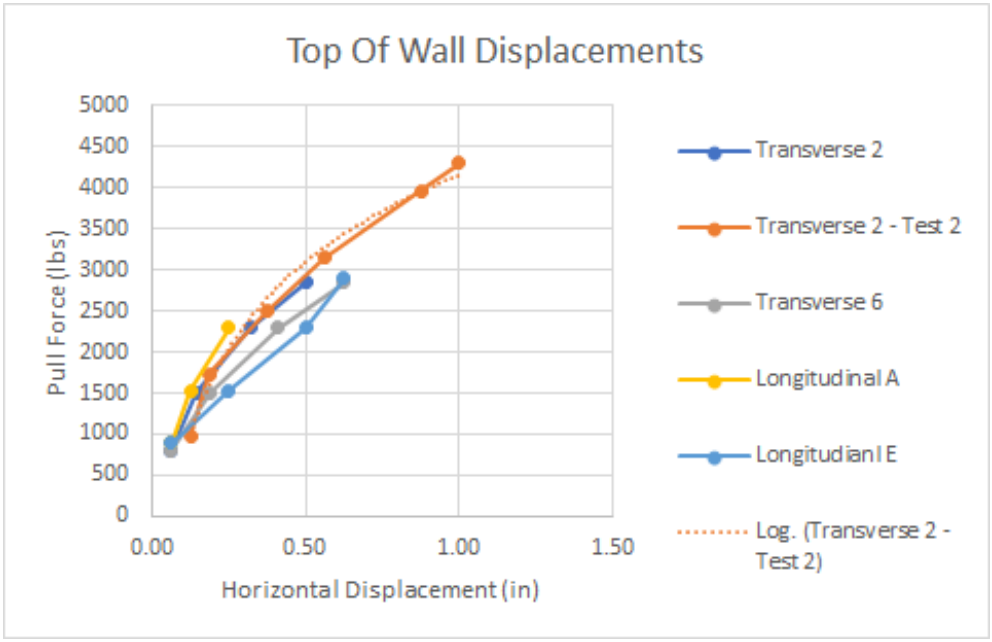
TEST MEASUREMENTS - RESULTS



THE ABOVE GRAPH RECORDS THE SLIP BETWEEN THE BASE OF THE WALL PANEL AND THE FLOOR PANEL. THE VERTICAL PLOTS OF LOCATIONS 3 AND G INDICATE THAT ALL SLIP WAS TAKEN OUT OF THE CONNECTION TO THE BASE AND THE PANEL HAD NOT YIELDED. LOCATION C IS MISSING A READING DUE TO ACCIDENTAL MOVEMENT OF THE MEASURMENT APPARATUS, INVALIDATING THE FINAL READING



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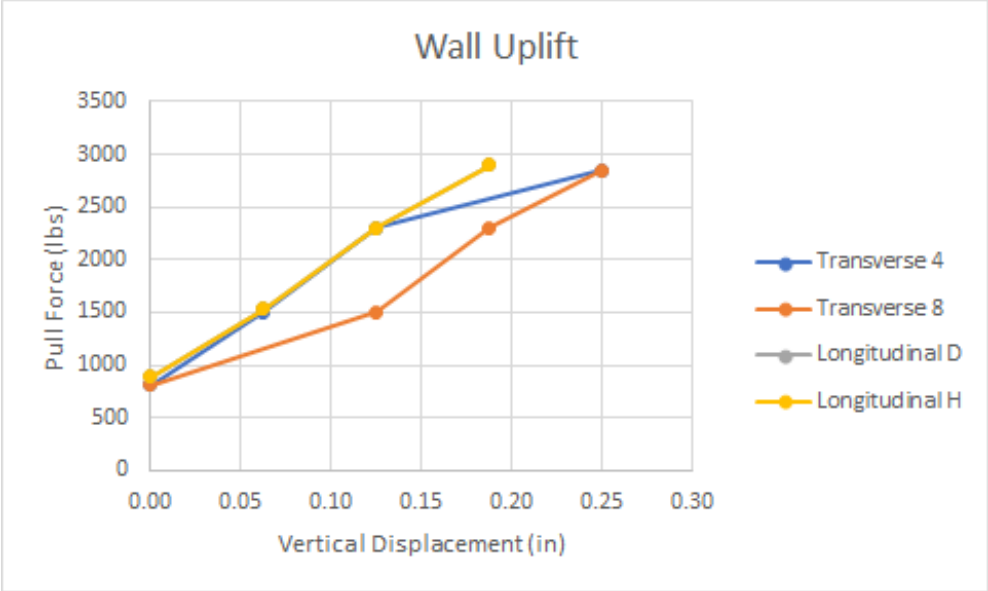
TEST MEASUREMENTS - RESULTS



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