OMEGA SQUARE ENGINEERING

CONSULTING STRUCURAL AND CIVIL ENGINEERS

7408 TEGNER DRIVE
ROSEMEAD, CA 91770

PHONE: (626) 376-5351
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Job	2014.001		date	7.22.2014	by	MC	Sheet	1	of	3

Subject: Spider Rax Black Widow and Red Widow Roof Mounting System for Pitched Rooftops (Hawaii)

STRUCTURAL TESTING AND ANALYSIS (STATIC LOAD RESULTS)

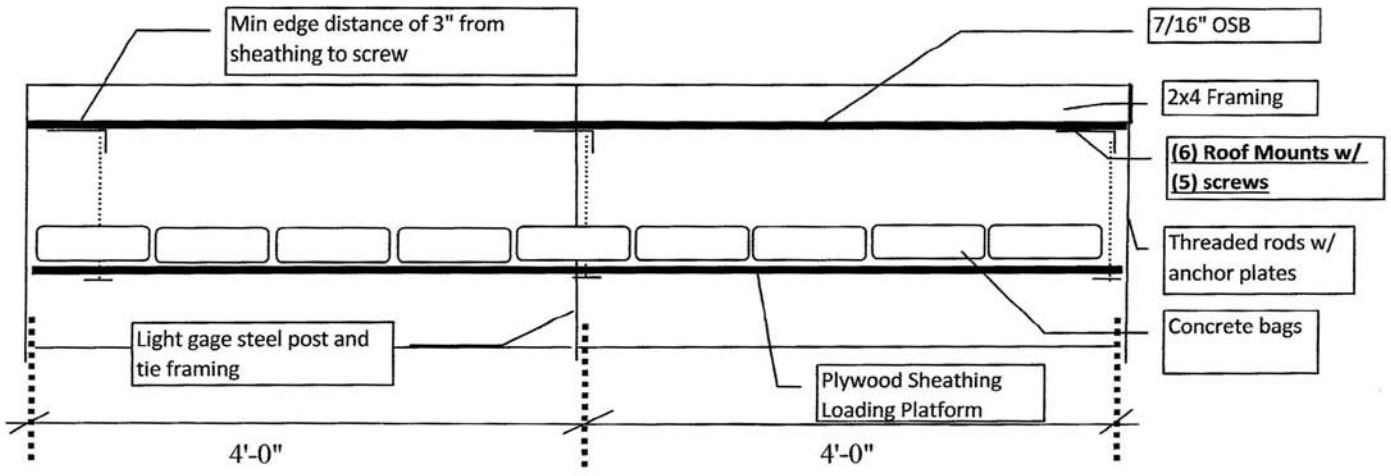
Project: Spider Rax Black Widow and Red Widow Roof Mounting System for Pitched Rooftops (Hawaii)
Location: State of Hawaii
Client: Spider Rax

Applicable Codes:
2012 International Building Code
ASCE 7-10 Minimum Design Loads for Buildings and Other Structures, by ASCE/SEI, 2010
2012 International Residential Code

Material Specifications for testing
7/16" thick OSB sheathing, 24/16 Panel Index. 4ft wide by 8ft long
Extruded Aluminum (See specifications). Includes bracket (foot/panel mount) and clamp
Kwikseal II Woodbinder #12 x2" screw (5 per mount). See specifications
#14 wood screw to connect 2x4 framing
2x4 Doug Fir-Larch framing
3/8" A307 Threaded rod, nut and washer
5/8" thick Plywood sheathing
Light gage steel framing (Posts, ties and clips)
90 lbs concrete mix bags (19 total)

Test Objectives
Roof mounts tested to verify capacity (and factor of safety) against pull out and lateral shear forces, as well as deflections.

Test setup (Pull out forces)
2x4 doug fir framing is attached to light gage steel framing. OSB Sheathing is attached to 2x4 doug fir framing
Mounts are attached to OSB sheathing with WoodBinder Kwikseal II #12 screws, 3in min from edge of OSB
Threaded rod is connected to roof mount and attached to plywood sheathing loading platform



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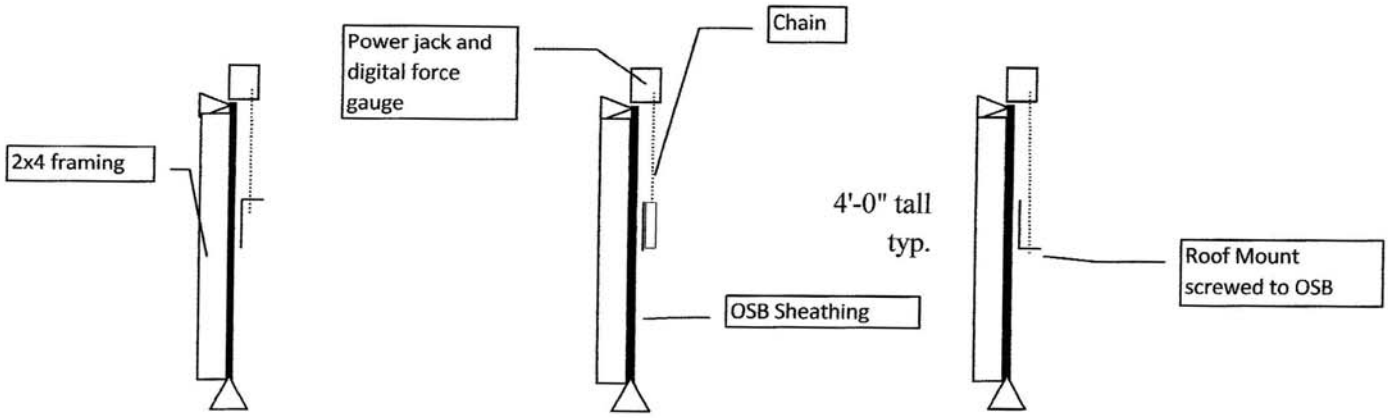
Location: State of Hawaii
Client: Spider Rax

Test procedure and results (Pull out forces)

The test setup was loaded with concrete mix bags up to failure. Concrete mix bags were placed on the plywood sheatthing platform at a rate of 1 bag per minute. Each bag weighs 90 lbs. The total load on the system before failure was equivalent to 55 lbs/ft^2. The maximum roof mount deflection recorded was 0.25" at a point before failure.

Test setup (Lateral Shear forces for individual mount)

2x4 framing is braced vertically. OSB sheathing is attached to 2x4 framing. Hydraulic jack and digital force gauge were connected to roof mount with a chain. Roof mount was attached to OSB sheathing with Kwikseal screws. Roof mount was attached in (3) different configurations.



Test procedure and results (Lateral Shear forces per individual mount)

East test setup configuration was loaded at a rate of 100 lbs/min with a hydraulic jack and verified with a digital force gauge. The average shear load was 1191 lbs. per mount.

Design Assumptions and conclusions (Based on ASCE 7-10, Chapter 30, Part 1)

1 Basic Wind Speed for Risk Category II per ASCE 7-10 (Strength level, excluding Special Wind Regions)
2 Maximum mean roof height of no more than 30'-0" as defined by ASCE 7-10
3 Exposure Category B, C or D as defined by ASCE 7-10
4 Dry service conditions (proper water proofing to be installed)
5 Roof sheathing minimum thickness of 7/16" OSB. Panel Index 24/16, with rafters spaced at 16" o.c. max.
6 Four PV mounts per PV module, such that adjacent modules share two PV mounts
7 Array may be located within zones 1, 2 for hip or gable roofs with a min pitch of 7° to a maximum pitch of 45°
8 Snow load of 0 lbs/ft^2
9 Fasteners installed per manufactured specifications
10 **(5) fasteners per mount**
11 Structure is considered an enclosed building

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Job	2014.001		date	7.22.2014	by	MC	Sheet	3	of	3

Subject: Spider Rax Black Widow and Red Widow Roof Mounting System for Pitched Rooftops (Hawaii)

Design Assumptions

13 Analysis of the mount is based upon the maximum effects of either the largest gravity loads or wind uplift loads. The point loads (either positive or negative) can act in either direction depending on the type of loading (i.e. wind, snow… etc)
14 Modules may be installed in landscape or portrait orientation
15 Modules may have maximum dimensions of 39" in width and 77" in length
16 Terrain Topographic factor Kzt = 1.0

Omega Square Engineering has reviewed the Spider Rax Black and Red Widow Roof Mounting system with ***testing data and analytical procedures****, and certifies that the roof mounts, as specified above in the design assumptions, can withstand a wind pressure equivalent to a wind speed (strenght level) of approximately* ***180mph**.***
The mounting fasteners performed as expected against axial and shear forces in the OSB.

Sincerely

Manuel Chan, PE SE

This engineering report verifies that Omega Square Engineering has provided independent observation for loads testing as described in this report. The results of this load test reflect actual deflection values and are generally accepted as the industry standard for testing module mounting systems. Omega Square Engineering does not field check installations or verify that the mounting system is installed as described in this engineering report.

Omega Square Engineering does not express an opinion as to the load bearing characteristics of the structure the mounting system/modules are being installed on.

Installer shall verify proper flashing and/or protection to weather of the roof mount after installation. Omega Square Engineering does not express an opinion of the after installation conditions of the equipment.

** *As described on Figure 26.5-1A of the ASCE7-10 Standard for Min. Design Loads for Buildings & other Structures Values are nominal design 3-second gust wind speed in miles per hour*

Attachments:
1 Related ASCE 7-10 tables and figures
2 Black and Red Widow Roof Mount specifications
3 Kwikseal II Wood Binder fastener specifications

ASCE 7-10 TABLES

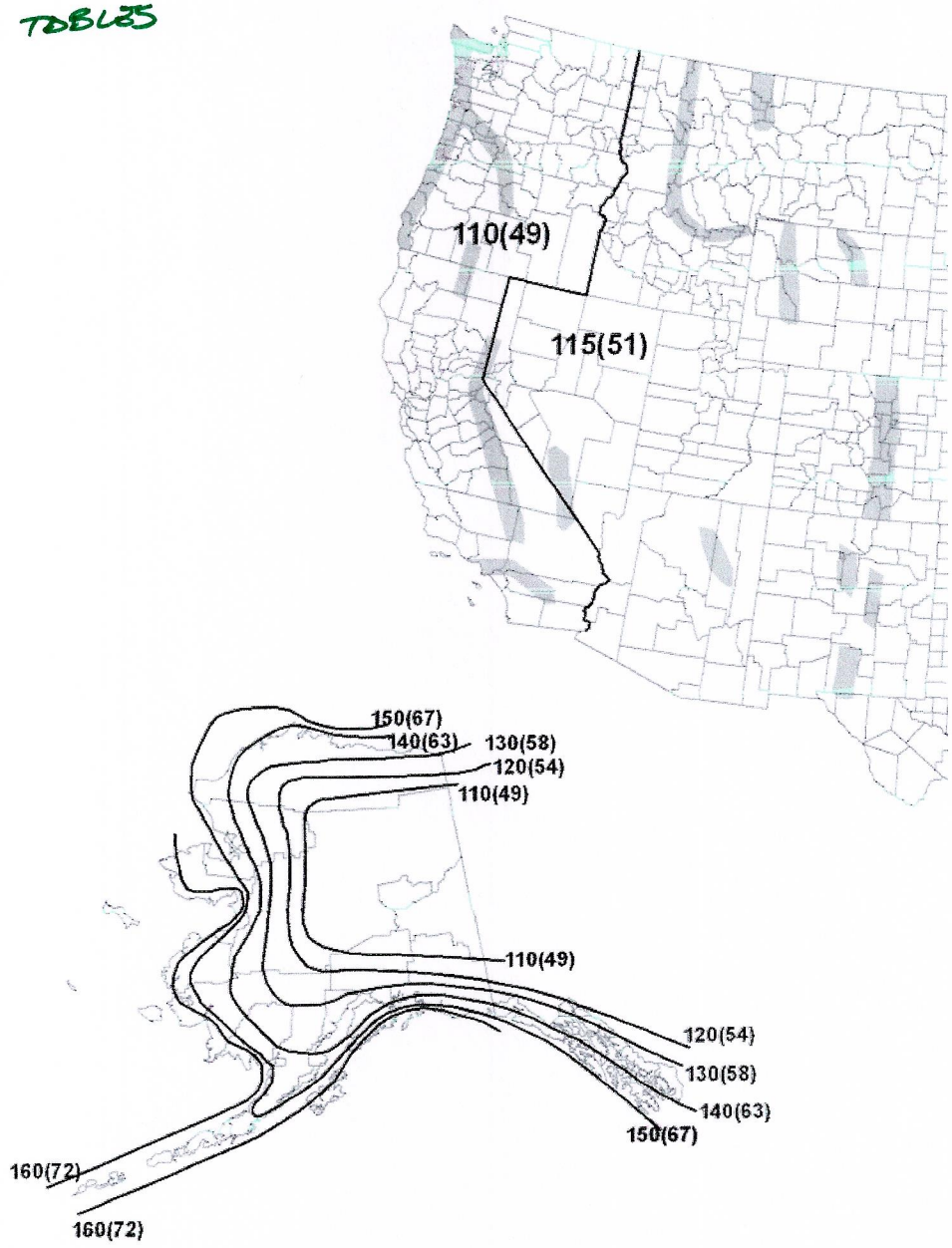

Figure 26.5-1A Basic Wind Speeds for Occupancy Category II Buildings and Other Structures.

Notes:

1. Values are nominal design 3-second gust wind speeds in miles per hour (m/s) at 33 ft (10m) above ground for Exposure C category.
2. Linear interpolation between contours is permitted.
3. Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.
4. Mountainous terrain, gorges, ocean promontories, and special wind regions shall be examined for unusual wind conditions.
5. Wind speeds correspond to approximately a 7% probability of exceedance in 50 years (Annual Exceedance Probability = 0.00143, MRI = 700 Years).

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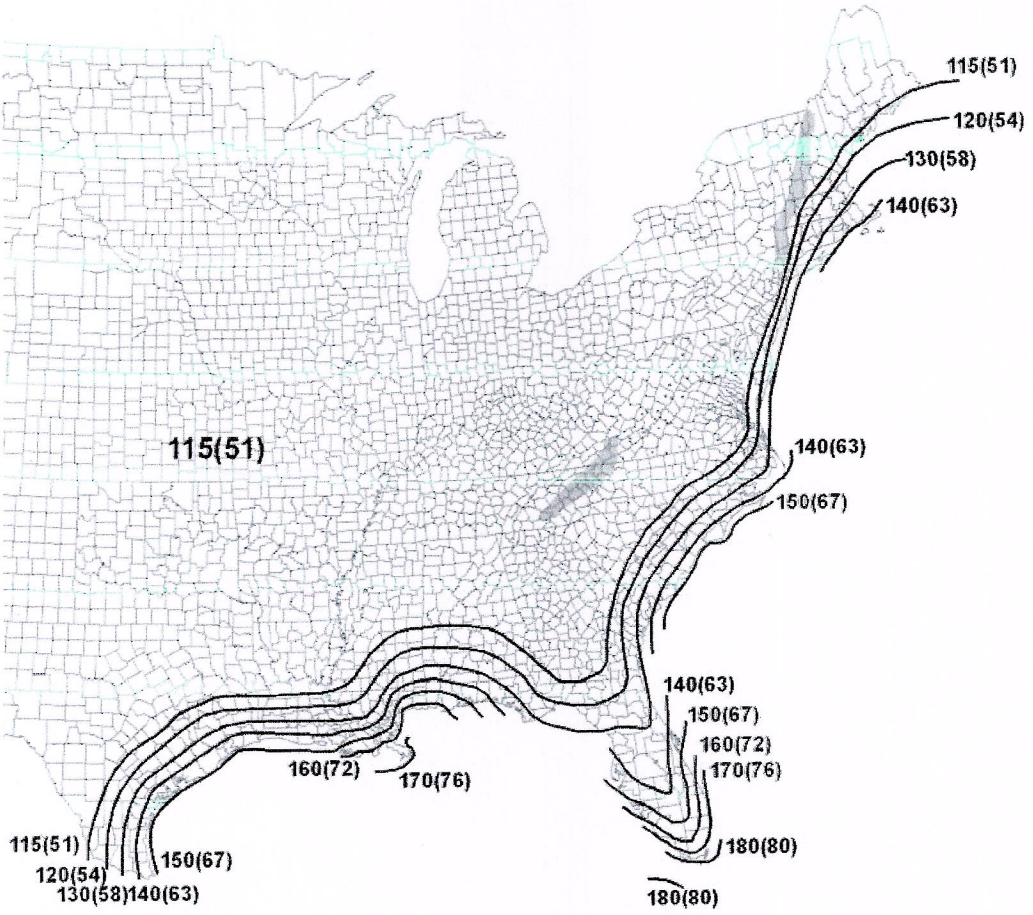
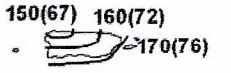


Special Wind Region

Location	Vmph	(m/s)
Guam	195	(87)
Virgin Islands	165	(74)
American Samoa	160	(72)
Hawaii – Special Wind Region Statewide	130	(58)



Puerto Rico

Figure 26.5-1A (*Continued*)

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Wind Directionality Factor, K_d

Table 26.6-1

Structure Type	Directionality Factor K_d*
Buildings	
Main Wind Force Resisting System	0.85
Components and Cladding	0.85
Arched Roofs	0.85
Chimneys, Tanks, and Similar Structures	
Square	0.90
Hexagonal	0.95
Round	0.95
Solid Freestanding Walls and Solid Freestanding and Attached Signs	0.85
Open Signs and Lattice Framework	0.85
Trussed Towers	
Triangular, square, rectangular	0.85
All other cross sections	0.95

*Directionality Factor K_d has been calibrated with combinations of loads specified in Chapter 2. This factor shall only be applied when used in conjunction with load combinations specified in Sections 2.3 and 2.4.

Main Wind Force Resisting System and Components and Cladding		All Heights
Table 26.11-1	Internal Pressure Coefficient, (GC_{pi})	Walls & Roofs
Enclosed, Partially Enclosed, and Open Buildings		

Enclosure Classification	(GC_{pi})
Open Buildings	0.00
Partially Enclosed Buildings	+0.55 -0.55
Enclosed Buildings	+0.18 -0.18

Notes:

1. Plus and minus signs signify pressures acting toward and away from the internal surfaces, respectively.
2. Values of (GC_{pi}) shall be used with q_z or q_h as specified.
3. Two cases shall be considered to determine the critical load requirements for the appropriate condition:
   (i) a positive value of (GC_{pi}) applied to all internal surfaces
   (ii) a negative value of (GC_{pi}) applied to all internal surfaces

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Main Wind Force Resisting System – Part 1	All Heights
Velocity Pressure Exposure Coefficients, K_h and K_z	
Table 27.3-1	

Height above ground level, z		Exposure		
ft	(m)	B	C	D
0-15	(0-4.6)	0.57	0.85	1.03
20	(6.1)	0.62	0.90	1.08
25	(7.6)	0.66	0.94	1.12
30	(9.1)	0.70	0.98	1.16
40	(12.2)	0.76	1.04	1.22
50	(15.2)	0.81	1.09	1.27
60	(18)	0.85	1.13	1.31
70	(21.3)	0.89	1.17	1.34
80	(24.4)	0.93	1.21	1.38
90	(27.4)	0.96	1.24	1.40
100	(30.5)	0.99	1.26	1.43
120	(36.6)	1.04	1.31	1.48
140	(42.7)	1.09	1.36	1.52
160	(48.8)	1.13	1.39	1.55
180	(54.9)	1.17	1.43	1.58
200	(61.0)	1.20	1.46	1.61
250	(76.2)	1.28	1.53	1.68
300	(91.4)	1.35	1.59	1.73
350	(106.7)	1.41	1.64	1.78
400	(121.9)	1.47	1.69	1.82
450	(137.2)	1.52	1.73	1.86
500	(152.4)	1.56	1.77	1.89

Notes:

1. The velocity pressure exposure coefficient K_z may be determined from the following formula:

   For $15 \text{ ft.} \le z \le z_g$ $\quad K_z = 2.01\ (z/z_g)^{2/\alpha}$

   For $z < 15$ ft. $\quad K_z = 2.01\ (15/z_g)^{2/\alpha}$

2. α and z_g are tabulated in Table 26.9.1.
3. Linear interpolation for intermediate values of height z is acceptable.
4. Exposure categories are defined in Section 26.7.

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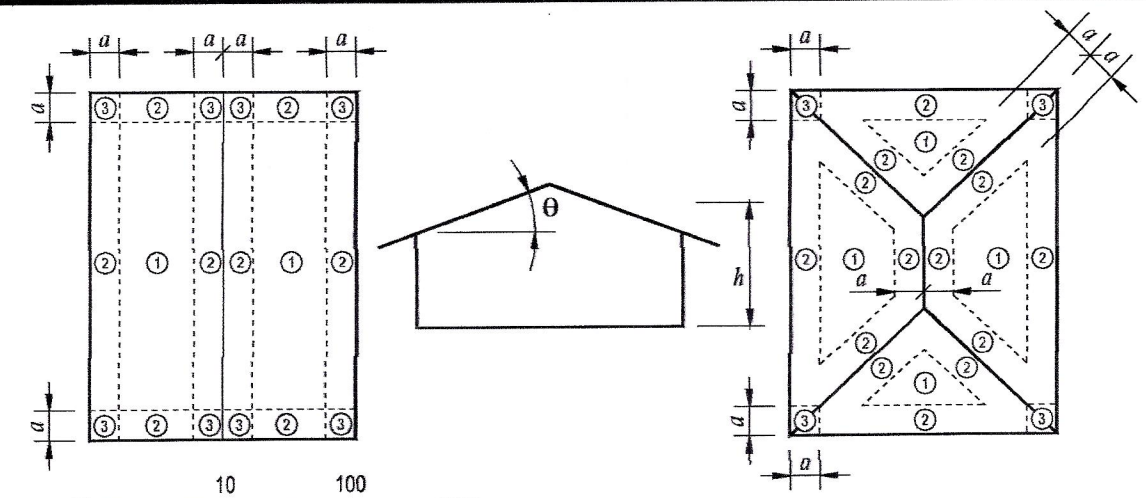
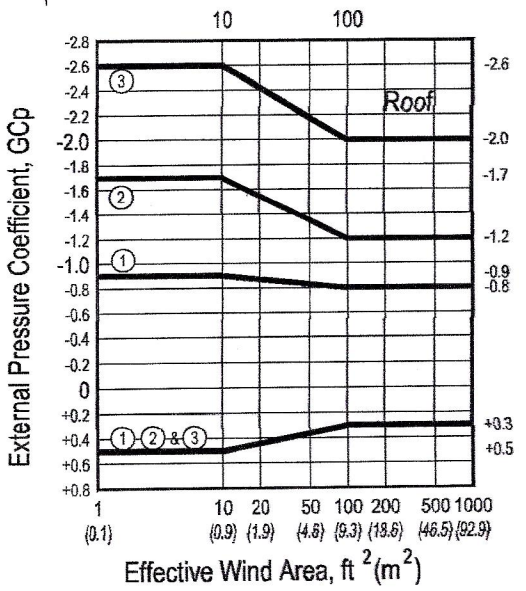
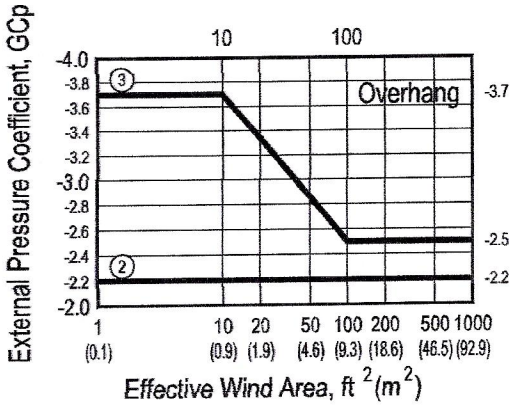
Components and Cladding		h ≤ 60 ft.
Figure 30.4-2B	External Pressure Coefficients, GC_p	Gable/Hip Roofs 7°< θ ≤ 27°
Enclosed, Partially Enclosed Buildings		



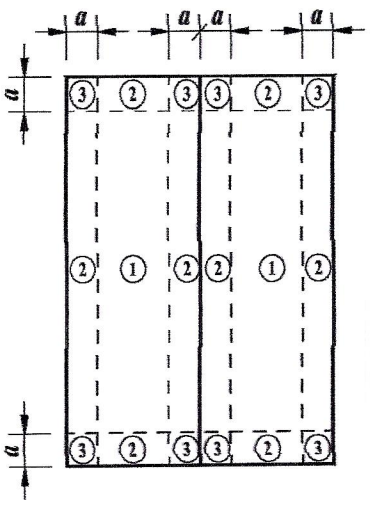


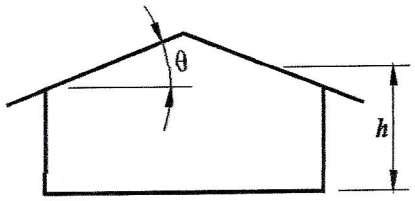


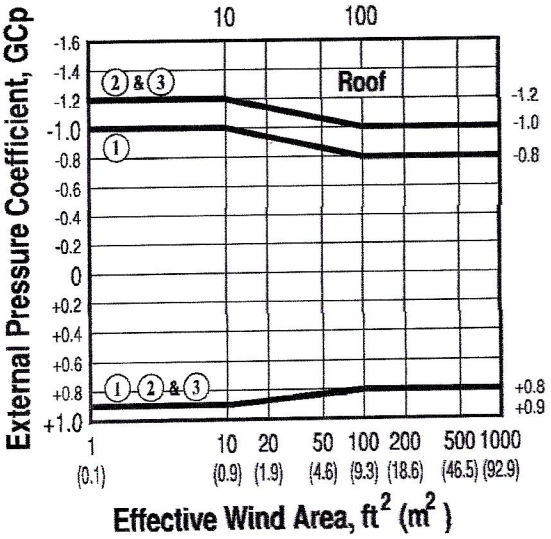
Notes:

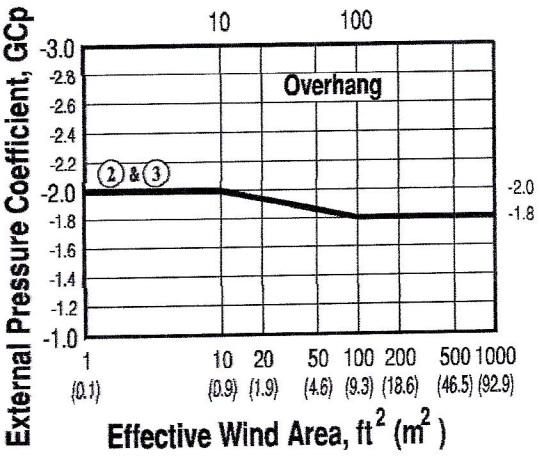
1. Vertical scale denotes GC_p to be used with q_h.
2. Horizontal scale denotes effective wind area, in square feet (square meters).
3. Plus and minus signs signify pressures acting toward and away from the surfaces, respectively.
4. Each component shall be designed for maximum positive and negative pressures.
5. Values of GC_p for roof overhangs include pressure contributions from both upper and lower surfaces.
6. For hip roofs with 7° < θ ≤ 27°, edge/ridge strips and pressure coefficients for ridges of gabled roofs shall apply on each hip.
7. For hip roofs with θ ≤ 25°, Zone 3 shall be treated as Zone 2.
8. Notation:
   - *a*: 10 percent of least horizontal dimension or 0.4h, whichever is smaller, but not less than either 4% of least horizontal dimension or 3 ft (0.9 m).
   - *h*: Mean roof height, in feet (meters), except that eave height shall be used for θ ≤ 10°.
   - θ: Angle of plane of roof from horizontal, in degrees.

Components and Cladding		*h ≤ 60 ft.*
Figure 30.4-2C	**External Pressure Coefficients GC_p**	**Gable Roofs $27° < \theta \leq 45°$**
Enclosed, Partially Enclosed Buildings		









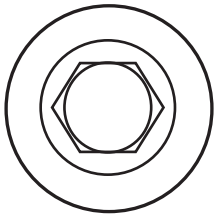
Notes:

1. Vertical scale denotes GC_p to be used with q_h.
2. Horizontal scale denotes effective wind area, in square feet (square meters).
3. Plus and minus signs signify pressures acting toward and away from the surfaces, respectively.
4. Each component shall be designed for maximum positive and negative pressures.
5. Values of GC_p for roof overhangs include pressure contributions from both upper and lower surfaces.
6. Notation:
   - a: 10 percent of least horizontal dimension or 0.4h, whichever is smaller, but not less than either 4% of least horizontal dimension or 3 ft (0.9 m).
   - h: Mean roof height, in feet (meters).
   - θ: Angle of plane of roof from horizontal, in degrees.

KWIKSEAL II WoodBinder®

Features and Benefits

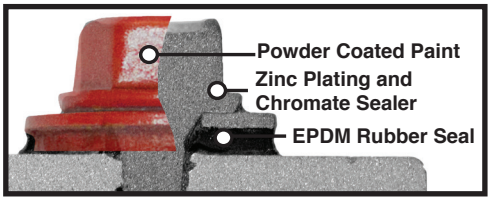
- Fastener is designed to attach steel roofing & siding used in post-frame & residential metal roofing applications.
- Threads transition from fine to coarse to generate superior holding strength in various wood substrates.
- Sharp Point & pronounced lead thread consistently drills high tensile 29 & 26 gauge steel with no “point walking.”
- Type 17 point reduces metal shavings that can embed themselves in the rubber washer.
- EPDM rubber is vulcanized to a galvanized steel washer to form an excellent seal even when driven at an angle.



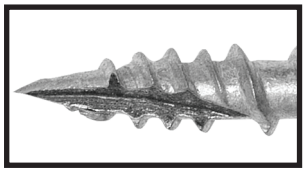
POWDER COATED

HEAD STYLE
1/4” HWH
POINT DIAMETER
30º Sharp Point Type 17
MAJOR DIAMETER
.210/.200
MINOR DIAMETER
.130/.126
BONDED WASHER DIAMETER
.472
HEAD ACROSS FLATS
.247/.244
ULT. TENSILE STRENGTH
1904 LBS.
MIN. TORSIONAL STRENGTH
60 IN-LBS.
NOM. SHEAR STRENGTH
1547 LBS.

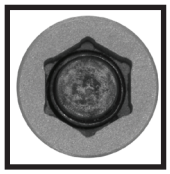
Sharp Point Type 17



Hex Washer Head with EPDM rubber washer provides a watertight seal on roof applications. Sealtite sockets are designed to allow for the added thickness of the powder coat.

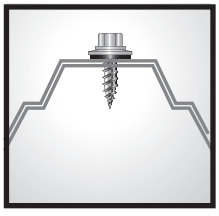


The combination of the Type 17 point & transition thread from fine to coarse generates superior drill speed in metal & holding strength in wood substrates.



ST Magnetic Sockets are available for powder coated fasteners.

APPLICATIONS



SIZE	CARTON QTY.	WEIGHT/M
10 x 1”	3000	7.8
10 x 1 1/2”	2500	9.9
10 x 2”	2000	12.2
10 x 2 1/2”	1500	14.3
10 x 3”	1000	17.2
12 x 3/4” Stitch	2500	8.8

NOTES: All strength values shown below are ultimate values, expressed in LBS. Apply an appropriate safety factor to obtain design limits.

PULL OUT STRENGTH
LBS. ULT.

SUBSTRATE	PENETRATION	VALUE
3/4” PLY		707
5/8” PLY		590
1/2” PLY		400
7/16” OSB		310
2 X Y. PINE*	1”	1052
2 X Y. PINE*	FULL	1552
2 X SPF*	1”	492
2 X SPF*	FULL	1042
2 X OAK	1”	1894

* Y.PINE (Yellow Pine) * SPF (Spruce Pine Fir)

PULL OVER STRENGTH
LBS. ULT.

SUBSTRATE	GAUGE	THICKNESS	VALUE
AZ55 Galvalume	29	.015	378
AZ55 Galvalume	26	.019	629
AZ55 Galvalume	24	.024	721

FOR PROPER APPLICATION, THE USE OF IMPACT DRIVERS ARE NOT RECOMMENDED FOR POWDER COATED OR ANY WET PAINTED FASTENER

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