Provisions of Building Code For Wind Uplift Pressure

In general, determination of wind uplift pressures applicable for residential building design is most often based on standard provisions of the building code.

However, when roof geometry is more complicated than that relatively simple "standard" roof shapes shown in the code, careful evaluation is necessary to correctly determine wind pressures, unless a conservative approach is taken.

Standard building code provisions (such as Figure R301.2(8) in IRC 2003) used for determining wind uplift pressures on roof surfaces are taken directly from the general ASCE 7 design standard that forms the basis for all typical building design loads.

However, the IRC building code includes a basic requirement at the beginning of Chapter 3 (R301.2.1.1; IRC 2006) that requires the use of one of the listed reference codes when design wind speed is equal to or greater than the specified value (110 mph in IRC 2000 & 2003; 100 mph in IRC 2006).

- ➡ Since design wind speed for Sun City is 130 mph, provisions of the IRC code for wind design are not applicable. One of the reference codes must be used.

Without going into too much detail, there is a problem with strictly applying the code-specification for use of "one of" the specified reference codes. Essentially, use of more than one code is necessary to perform wind load design when the use of prescriptive IRC provisions is not allowed. For example, when using the ASCE 7 reference code, the NDS code must also be used for wood design.

For further discussion, evaluation of wind uplift pressures in this report is based on ASCE 7-05.

Use of standard code provisions (ASCE 7-05) is strictly allowed only when the building and roof geometry conforms to conditions of the code (6.4.1.2 for components and cladding wind pressure).

However, even if the building might be considered to satisfy basic conditions, the roof may not completely conform with the relatively simple geometry shown in standard diagrams. For such condition (which happens frequently), "engineering judgement" must be employed.

Due to the various intersecting ridge lines and sloping surfaces (planes), roof geometries of Sun City houses do not conform with standard diagrams that define zones of wind uplift pressures on roof surfaces.

The "simplified" Method 1 is most appropriate for design of residential buildings. Therefore, Figure 6-3 of ASCE 7-05 is applicable.

Determination Of Areas For Zone 2 Pressure

Of the four roof diagrams in Figure 6-3, the Gable Roof with slope between 7 and 45 degrees is most applicable.

- ☑ For conservative approach, each ridge line should be considered the ridge of a gable roof.

Therefore, Zone 2 ("End Zone") pressures apply along each side of the ridge line and along each free edge of the roof.

Outstanding issue is whether Zone 2 pressures should also apply along valley lines. The code does not provide much guidance. However, in Figure 6-13 (Multispan Gable Roofs) Zone 2 and Zone 3 wind pressures are shown along low edges of the "module", meaning that these pressures apply along valley lines. The same principle is shown in Figure 6-15 (Sawtooth Roofs).

Therefore, unless published research results show otherwise, a conservative approach warrants use of Zone 2 pressures along valley lines, especially for relatively small roof areas such as formed by valley truss sets.

Largest Zone 3 ("Corner Zone") pressures are generally not applicable, although Zone 3 does apply where ridge line ends at edge of roof.

Width ("a") of each Zone 2 strip is in the range of 3 to 4 feet for Sun City houses, based on standard code provisions (note 5a of Figure 6-3).

Even if some interior connections are reasonably considered to be subjected to Zone 1 pressures (entirely or partially), there will be many connections subjected to uplift force that is primarily (or completely) due to Zone 2 pressures.

Another reason to use Zone 2 pressures (per ASCE 7-2005) is the much larger Zone 2 pressures required by the IRC building code (for roof slope between 10 and 30 degrees) compared to corresponding pressures required by ASCE 7-2005. There is no explanation for the large difference in either code.

- ☑ For the various valley truss roof areas (shown on roof framing plans with calculations by Mr. Thom), and applying Zone 2 pressures along valley lines, it is reasonable to conclude that valley truss connections should be designed for Zone 2 pressures exclusively.

Mean Roof Height

Mean roof height is necessary to determine the Adjustment Factor, if Exposure Category C is applicable. Calculation to the nearest foot is more than adequate accuracy.

Mean roof height is the vertical distance from grade (ground) to average height of the roof.

For one-story house, top of wall is taken as 9 feet above grade.

For main roof at 5.5 to 12 roof slope, and 54 feet from front to back walls, ridge is about 12 feet above the wall. Therefore, mean roof height is 15 feet (9 feet + 12 feet / 2).

Exposure Category

Use of Exposure Category B is generally appropriate for houses within the interior of a large development. However, careful study of actual site conditions should be performed for houses within 1,500 feet (about 3 tenths of a mile) of the outer edges of the development.

- For houses that are less than 1,500 feet from outer edge of the development, Exposure Category C would be applicable unless the surrounding area (outside development) has similar building density or is covered with large trees ("wooded").

Future development might reasonably be taken into account. However, unless such additional development is well under way, a conservative approach is warranted.

If Exposure Category C is applicable, wind uplift pressures would have to be increased by the Adjustment Factor at end of Figure 6-3. For mean roof height of 15 feet, pressure must be increased 21% (Adjustment Factor = 1.21).

An aerial view of Sun City (per Google Maps; see link below) clearly shows open space all around the development and even within the development.

http://maps.google.com/maps?f=s&utm_campaign=en&utm_source=en-ha-na-us-sk-gm&utm_medium=ha&utm_term=map

Almost all of these open spaces are covered with trees. Unless trees immediately adjacent to the development are relatively small (short), Exposure Category B is applicable.

However, open space north of the development, along Sgt William Jasper Blvd, is open land except for a relatively narrow strip of trees along north side of Fording Island Road (Route 278). Exposure Category C is therefore applicable for houses along north side of Fording Island Road.

Further evaluation of site conditions around the development may be warranted.

Resistance From Dead Load

Weight of permanent materials ("dead" load) may be considered to resist wind uplift pressure.

However, standard code provisions for load combinations allow the use of only 60-percent of dead load as resistance (see ASCE 7-05; 2.4.1, load combination 7).

Although actual weight of materials can be used for design, a conservative approach is warranted when using dead load to offset the primary design loading. Use of weights from Table C3-1 in ASCE 7-05 is one reasonable method.

For typical residential construction with asphalt roof shingles, the following dead loads from Table C3-1 of ASCE 7-05 are appropriate;

Asphalt roof shingles	2.0 psf
Roof sheathing; 1/2-inch plywood	1.6 psf
Total on truss top chord	3.6 psf

Uniform load on the truss top chord is then 3.6 psf times 2 feet truss spacing, or 7.2 PLF.

Weight of the valley truss is most reasonably considered to be only the weight of 2x4 top chord and 2x4 bottom chord, or 2.2 PLF, which is equivalent to 1.1 psf.

Total dead load is then 9.4 PLF. Allowable dead load (at 60%) is 5.6 PLF, which can be rounded up to 6.0 PLF. However, rounding up eliminates any further increase due to slope of the roof.

This allowable dead load of 6.0 PLF (equivalent to 3.0 psf for 2-foot truss spacing) is less than the 5.36 psf used in calculations by Mr. Thom.

Required Design Uplift Force

Structural analysis calculations have been performed for this evaluation to determine wind uplift forces for valley truss connections.

Uplift force is calculated for the most conservative position of valley trusses, as shown on the Truswal connection drawing, with vertical webs directly over main roof trusses.

- ☑ Key feature that determines tributary area for any connection is the 4-feet spacing of the valley truss vertical webs.

Tributary area for each connection is then spacing of valley trusses (2.0 feet) times spacing of vertical webs (4.0 feet), or 8.0 square feet.

- ➡ Tributary area of 8.0 sf, for position of valley truss that results in the largest (most conservative) value of uplift force for each connection, is double the 4.0 sf tributary area used by engineer for builder in calculations, as noted in his letter of February 13, 2007.

As previously noted, for wind speed of 130 mph, design for wind must be based on one of the reference codes specified in the IRC (Chapter 3). For this analysis, ASCE 7-2005 is used to determine wind uplift pressures.

A value of 3.0 psf is used for dead load, per calculations performed for this report.

As explained in Note 1 of Figure 6-3 (ASCE 7-2005), wind uplift pressure is applied normal (perpendicular) to the roof surface. Vertical component of this pressure must therefore be calculated to determine vertical uplift force applied by each vertical web of the valley truss to the underlying main truss.

For wind uplift pressures based on tributary area of 10 square feet, and Exposure Category B, required design uplift forces are calculated as follows;

For the 6 on 12 roof slope (of valley trusses), design uplift force (VF1);

Cos (26.4 deg) = 0.894

Zone 2; VF1 = (0.894 x 48.4 psf - 3.0 psf) x 8 square feet = 322 lbs
Zone 1; VF1 = (0.894 x 27.8 psf - 3.0 psf) x 8 square feet = 175 lbs

For the 7 on 12 roof slope (of valley trusses), design uplift force (VF1);

COS (30.6 deg) = 0.864

Zone 2; VF1 = (0.864 x 35.6 psf - 3.0 psf) x 8 square feet = 222 lbs
Zone 1; VF1 = (0.864 x 30.4 psf - 3.0 psf) x 8 square feet = 186 lbs

For Exposure Category C, with mean roof height of 15 feet, uplift force is larger. Gross wind pressures must be multiplied by the Adjustment Factor of 1.21 before deducting dead load.

For the 6 on 12 roof slope (of valley trusses), design uplift force (VF1);

Zone 2; VF1 = (0.894 x 1.21 (58.7 psf) - 3.0 psf) x 8 square feet = 395 lbs
Zone 1; VF1 = (0.894 x 1.21 (27.8 psf) - 3.0 psf) x 8 square feet = 217 lbs

For the 7 on 12 roof slope (of valley trusses), design uplift force (VF1);

Zone 2; VF1 = (0.864 x 1.21(35.6 psf) - 3.0 psf) x 8 square feet = 274 lbs
Zone 1; VF1 = (0.864 x 1.21(30.4) psf - 3.0 psf) x 8 square feet = 230 lbs

Wind uplift pressures from Figure 6-3 of ASCE 7-2005 are the same three of the corresponding pressures from IRC 2003. However, for 6:12 roof slope and Zone 2, the 48.4 psf pressure from ASCE 7-2005 is significantly less than the corresponding 58.7 psf pressure per IRC.