Background Information

Initial Awareness

In May of 2007 the writer (John F Mann, PE) became aware of problems with roof truss connections while reading an article (online) published April 22, 2007 in the Island Packet newspaper (http://www.lowcountrynewspapers.net/archive/node/31127). The article described problems with connections of "valley" roof trusses installed on houses in the Sun City development in Bluffton, South Carolina.

Previous Comments

After email message and phone discussion about issues discussed in the article, the reporter (Ginny Skalski) provided specific information about valley truss connections for further review. In May of 2007, the writer submitted (via email) preliminary comments based on available information. As far as the writer is aware, those comments were not used by the Island Packet for further reports.

In September of 2007 the writer posted, on the Island Packet web site, several extensive comments about roof truss design in general and the specific problems discovered in Sun City. Those comments, which were viewed by many readers, do not appear to be available any longer on the Island Packet site.

In November 2009, the writer posted extensive comments, on the Island Packet web site, in response to another Island Packet article ("Trusses improperly fastened on homes"; 11-15-09).

Also in November 2009, the writer submitted (via email) a letter to editor of the Island Packet, with the basic advice that "Concerned homeowners should hire an independent, qualified professional engineer, licensed in South Carolina, to evaluate design and construction of the entire roof truss system." There is no indication that the letter was published.

In May 2010, the writer posted comments on the Island Packet web site in response to a letter, published in the Island Packet (4-28-10), by Ryan Rasmussen, identified (at end of letter) as "national engineering manager" of PulteGroup. The writer also sent an email message to two Island Packet reporters with comments about recent articles they had each recently written (separately) about roof truss installations in Sun City. No response was received from reporters.

Conditions & Conventions Of Report

Limits of Evaluation

This evaluation is focused on design of valley truss connections. Construction is discussed primarily to the extent that construction tolerances must be considered for design.

As-built valley trusses and connections are discussed briefly (see Photo 1), to show how design instructions have been implemented.

Evaluation is limited to building elements and conditions described in this report, based on available information as referenced.

Basis of Evaluation

Relevant articles published in the Island Packet since April 2007 have been used for general reference.

The following documents, provided in May of 2007 by the Island Packet reporter, have been used as reference for this evaluation;

1. Letter of July 7, 2005 (1 page), by Charles G Thom, Jr., PE, to Johnny McGill of Del Webb Communities Inc, about "Valley Set Installation". Attached are two copies of a truss connection drawing by Truswal, and two later letters (2-13-07 & 3-8-07) by Mr. Thom to Mr. McGill.

2. Set of calculations by Charles G Thom, Jr. PE, with dates of 2-12-07 (3 pages + attachments) and 3-7-07 (4 pages + attachments). Attachments include copies of roof truss framing plans with hand-written notes.

3. Letter to editor (Island Packet), dated 4-27-07, by Charles G Thom, Jr, PE.

The following documents, provided recently (via email) by Professional Home Inspections (PHI), have been used as reference;

1. Truss diagram for valley truss (V4E; Job 8351B) by Truswal (Arlington, TX), along with truss placement (layout) plan. Truswal is noted as source of design software.

2. Truss diagram for valley truss (V06; Job 309751) by Builders FirstSource (Sumter SC), with truss placement plan. MiTek is noted as source of design software.

3. Copy of sheet S2.0 from set of building design plans, with "Roof Framing Plan" and general notes for roof framing construction.

4. Copy of sheet S4.1 from set of building design plans ("Current Release Date: 6/30/09") with various roof framing details, including "Valley Set To Roof Truss Connection".

PHI has also supplied (via email) several digital photos, taken during recent inspections, showing roof truss conditions, as well as basic descriptions of observed conditions.

Design Standards & References

Structural analysis performed for this evaluation is based on the following standard references;

- NDS-2005; National Design Specification for Wood Construction, by American Forest & Paper Assocation (AF&PA)

- Technical Report 12 (1999); "General Dowel Equations For Calculating Lateral Connection Values", by American Wood Council of AF&PA

- IRC-2006; International Residential Code, by International Code Council

- ANSI / TPI 1-2002; National Design Standard for Metal Plate Connected Wood Truss Construction

Earlier versions of these standard codes may also be referenced, as noted in discussion.

Additional engineering references may also be noted in discussion.

Information Not Available

The following basic information has not been available for this evaluation;

1. Complete set of building design plans
2. Design diagrams for main roof trusses
3. Name of professional engineer that may have been responsible for design of roof trusses and valley truss connections shown on the referenced Truswal connection drawing
4. Details of business relationships relative to construction of houses in the Sun City development

Arrangement & Conventions of Report

Evaluation of available information is provided separately, after description of the information.

Text highlighted with an arrow ➡ generally denotes a deficiency or major problem.

Text emphasized with checkmark ☑ generally signifies a positive result or work required to improve a deficient condition.

Terms & Names Used In Report

The following terms and names used in this report are defined as follows;

Main (base) truss:	Roof truss, supported on exterior walls, that forms main roof structure. These trusses (termed "base" trusses on Truswal connection drawing) support "valley" trusses.
Valley truss:	Relatively short roof support panel, fabricated by roof truss manufacturer and installed on top of main roof trusses to form architectural features or to fill in behind a truss girder. The so-called "valley truss" is not a truss as generally defined in structural engineering texts since there are no sloped web members (only verticals). Although this assembly should more logically be termed a roof support panel, the term "valley truss" is used in this report to maintain consistency with standard industry terminology.
Engineer for builder:	Charles G Thom, Jr., PE
Pulte Homes / PulteGroup:	Company that built houses in Sun City (per published reports).
Del Webb:	Company noted on various building plan sheets and in letter of July 7, 2005 by Mr. Thom.

Basic Scope & Description Of Structural Evaluation

Valley Trusses

As shown on copies of several roof framing plans (from building design plans) attached to letters by engineer for builder, so-called "valley trusses" are installed on top of, and perpendicular to, underlying roof trusses that form the main roof structure (see Photo 1). Such method of construction, known as "overframing", has become widely used to reduce labor compared to site-built ("stick") roof framing using sawn lumber.

The term "truss" is actually a misnomer (commonly used) since the valley "truss" (with only vertical webs) is not a structural truss. The term "valley roof support panel" (similar to wall panel) would be more appropriate. However the term "valley truss" is used in this report to remain consistent with industry terminology and avoid confusion with prior reports.

Overframed valley trusses form a small gable-shaped roof area that has a constantly varying overall width. The "valley" designation results from the two roof valley lines that occur after valley trusses are installed on the main roof structure.

Valley trusses are typically intended primarily as an architectural feature. However, when roof sheathing is omitted underneath, valley trusses may have to provide essential lateral bracing for top chords of main roof trusses (supporting valley trusses).

As for any building element, proper support (to resist forces in all directions) is essential to ensure safety and durability, especially for items that may have to resist relatively large forces ("loads"), such as wind force during a hurricane.

Wind Uplift

Wind causes uplift pressure on roof surfaces unless the roof slope is relatively steep. For structural design and analysis of residential buildings, determination of wind uplift pressure is generally based on standard code provisions using values from code tables.

If roof framing elements are not tied down to resist wind uplift forces, such elements can be torn away from the building. During storms with intense winds, the entire roof has been effectively pulled upwards and off of the supporting walls by wind uplift force.

Structural Design Requirements

Buildings designed in accordance with standard building codes must be designed to resist design loads specified by the code. These loads are generally determined by code authors using historical data and statistical methods to develop expected probability of occurrence.

Design wind loads are typically based on historical wind speed data for a specific area, combined with more general engineering knowledge obtained through testing or modeling.

Design capacity of a building element, to resist any specific force or load, is generally based on conservative estimations of material properties obtained by testing.

Design capacity is always less than "ultimate" or "failure" capacity, which is the capacity that results in failure of the structural element. Although failure is often considered to be collapse, failure can also be defined as loss of intended function using specific criteria or limits.

Essentially, design capacity (also known as allowable capacity) is set at a level less than failure capacity to ensure an appropriate margin of safety, often termed "safety factor".

Margin of safety used to develop design requirements in building codes is intended to guard against the following basic potential problems that could cause structural failure, either individually or in concert;

1. Variety of errors and oversights that are inherent in the design and construction process, including calculation errors.

2. Variability in expected design properties of materials that may result in less capacity than calculated for code-specified properties.

3. Overload condition at any time during expected life of the structure, compared to loads used for design.

Expectations & Understanding Of Design and Construction

The knowledge that failure capacity is much greater than standard design capacity is all-too-often used by builders, even if only in a very general sense, to reduce quality of building construction specified on plans, or by the code, without informing code officials or buyers.

Prospective buyers of new homes almost always expect a new home to satisfy all requirements of the building code. They also mistakenly believe that issuance of a certificate of occupancy by the governing code official represents a certification or "guarantee" of proper design and construction. Such mistaken belief is typically reinforced by builders in an attempt to escape responsibility for any construction defects.

➡ Home owners generally do not think to wonder how code officials, who are almost universally not licensed architects or engineers, could "approve" structural design without being qualified for the task.

Many owners of new homes seek to have the builder repair any visible defects. However, the vast majority of owners do not realize that there can be defects with structural design of the house, typically because they have been fooled (most often by the builder) into believing that code officials "approve" the design, but also because they do not appreciate that structural design defects commonly exist without showing up as a physical problem for many years.

Many home owners do not know that licensed design professionals (architect, engineer) are supposed to be responsible for structural design. They assume that the builder is responsible for all design functions, if they even realize that design is a separate function from construction.

To the extent that prospective home buyers understand what an architect does, home buyers and owners generally assume that an architect is qualified to perform structural design.
Some architects are qualified for structural design of relatively simple framing elements. However, many architects are not qualified to perform more complex structural design functions, especially dealing with wind forces. Many architects today are not qualified to design truss connections or permanent truss bracing.

More than a few homeowners express indifference when informed of defects with structural design and construction, taking the position that if there is no visible damage now, there must not be a "real" problem. Some even take offense at the message bearer.

Structural Analysis

Structural analysis involves engineering evaluation of an existing (or proposed) building, building element or condition.

Design standards for new construction may be appropriate and used for analysis, especially for relatively new homes.

Less conservative standards may be warranted, depending on several factors, including age of the house.

Detailed analysis typically requires engineering calculations, generally using standard methods and code provisions. However, standard methods do not cover every situation. Basic principles of physics must then be applied. Load testing might also be warranted.