Research Report

Truss Heel Heights and the Energy Requirements

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Structural Building Components Association (SBCA)

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- *IBC* Section 104.11.1 and Section 1703.4.2 – "**Research reports.** Supporting data, where necessary to assist in the approval of materials or assemblies not specifically provided for in this code, shall consist of valid research reports from *approved sources*."
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Introduction:

There has been a great deal of interest since the 2009 building code cycle in the requirements for building envelope energy efficiency. Anyone who has been watching the evening news on television, reading the newspapers or browsing the internet has seen countless news stories touting various green building techniques that can be used to reduce one's "carbon footprint."

The federal government, in an effort to wean U.S. consumers from reliance on foreign oil, has been actively pursuing a change in the culture to be more conservative with energy resources. Tax credits abound for those who purchase more energy efficient upgrades for their homes. Insulation, high efficiency windows and doors, heating and cooling equipment and caulking are just some of the purchases that qualify. Credits for hybrid vehicles and the "cash for clunkers" program are some of the government incentives meant to spur Americans into saving energy and to jumpstart the economy.

Of all these programs, the one that may have the greatest long-term effect is the mandate to increase energy efficiency standards used in the building codes. The American Clean Energy and Security Act (ACES) of 2009 established the 2006 *International Energy Conservation Code®* (*IECC*) as the residential standard benchmark against which future standards will be evaluated. The Act also provided funding for states that adopted the 2009 *IECC* or equivalent and mandated the 2012 edition to produce a 30% increase in nationwide overall energy savings over the requirements of the 2006 edition. This increases to 50% for the 2015 edition with an incremental savings target of 5% in each subsequent edition of the *IECC* after 50% target is reached.

One of the easiest ways to accomplish these energy saving goals is to increase the energy efficiency requirements of the building envelope. This Research Report will address the requirements of the 2009, 2012 and 2015 International Residential Code (*IRC*) and *IECC* as they impact ceiling insulation and truss heel heights.

Key Definitions:

Building Designer[1] – Owner of the Building or the Person that contracts with the Owner for the design of the Building Structural System and/or who is responsible for the preparation of the Construction Documents. When mandated by the Legal Requirements, the Building Designer shall be a Registered Design Professional.

Standard Truss[2] – Any construction that does not permit the roof/ceiling insulation to achieve the required R-value over the exterior walls**.** (Figure 1 and Figure 2 below are based on the *2012 & 2015 IRC* Commentary)

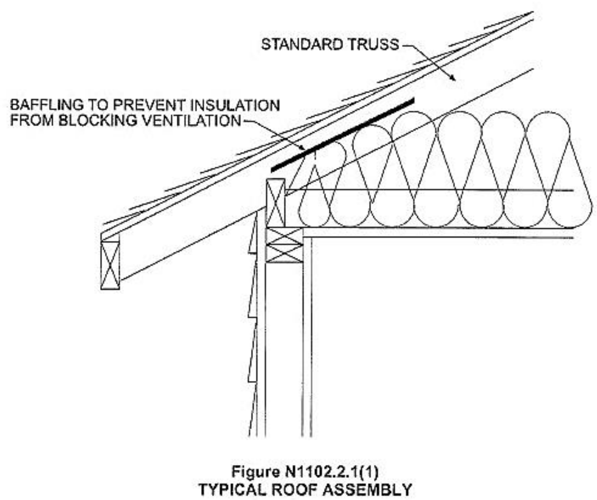

Figure 1: Standard Truss

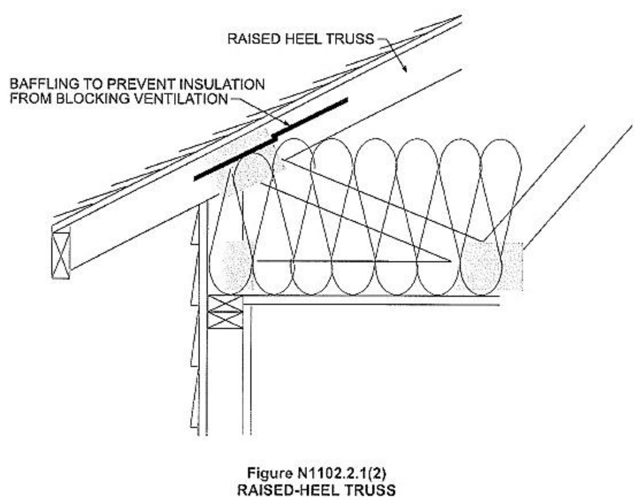

Figure 2: Raised-Heel Truss

Truss Heel Height – The vertical depth of the truss at the outside face of the bearing.

Standard Heel – Typical truss heel height is about 4".

Raised (Energy) Heel – Typical truss heel height is about 12" but may be designed to most any height per the Building Designer specification.

[1] TPI 1-2014
[2] 2015 *IRC Section R202*

Background:

Chapter 11 of the *IRC* deals with energy efficiency and is closely coordinated with Chapter 4 of the *IECC*. In the 2009 and 2012 editions, differences are present but are not relevant to the scope of this research report.

Changes were made to section and table numbering in the various editions of the *IRC* and *IECC*. The following Table illustrates the references for the section/table of interest for this research report (*IECC* section/table numbers are in parenthesis):

Section/Table Reference	2006	2009	2012	2015
Table: Insulation and Fenestration Requirements by Component	N1102.1 (402.1.1)	N1102.1 (402.1.1)	N1102.1.1 (R402.1.1)	N1102.1.2 (R402.1.2)
Section: Ceilings with attic spaces	N1102.2.1 (402.2.1)	N1102.2.1 (402.2.1)	N1102.2.2 (R402.2.2)	N1102.2.1 (R402.2.1)

There were no changes between the 2006 and 2009 editions regarding the requirements for ceiling insulation and ceilings with attic spaces, except that a sentence was added in the 2009 edition stating that the reductions did not apply to the U-factor or total UA alternatives.

In the 2012 edition there were changes to the ceiling R-Value requirements, increasing some from 30 to 38 and some from 38 to 49. In addition, the requirements for ceilings with attic spaces were revised in an effort to make them clearer.

In the 2015 edition no changes were made to either the ceiling R-Value requirements or the requirements for ceilings with attic spaces.

The following table illustrates some general insulation thicknesses to meet the 3 ceiling R-Value requirements (R-Values for similar products can vary greatly among manufacturers):

Insulation	R-Value per inch	R-30	R-38	R-49
Fiberglass blown	2.2 - 4.3	9"-10"	12"-14"	16"-18"
Fiberglass batt	3.1 - 3.4	9"-10"	12"-14"	16"-18"
Mineral wool blown	3.1 - 4.0	9"-10"	12"-14"	16"-18"
Cellulose blown	3.2 - 3.7	8"-9"	10"-12"	14"-16"
Open cell Spray Foam	3.5 - 3.6	8"-9"	11"-12"	14"
Closed cell Spray Foam	6.0 - 6.5	5"	6"-7"	8"-9"

In addition to the height of the insulation an air space for ventilation above the insulation is required in vented attics, which adds 1-2″ of additional height at the eaves.

The issue for this Research Report is not in regard to the R-Value for the ceiling requirements, rather, the application of the ceiling R-Value requirements when the roof framing may limit the height of the insulation at the outside face of the building. The ultimate aim is to answer the following questions:

- What happens at the outside of the wall where the vertical depth of the roof framing is typically less than the required depth of insulation?
- Does the depth of the framing need to increase?
- Does the building designer need to modify the profile of the building to accommodate this increased framing depth?

Analysis

Confusion as to the required height of the roof framing above the wall top plate at the eaves arises from the language in Section N1102.2.1 of the *2006 & 2009 IRC*, which states:

> **N1102.2.1 Ceilings with attic spaces.** When Section N1102.1 would require R-38 in the ceiling, R-30 shall be deemed to satisfy the requirement for R-38 wherever the full height of uncompressed R-30 insulation extends over the wall top plate at the eaves. Similarly R-38 shall be deemed to satisfy the requirement for R-49 wherever the full height of uncompressed R-38 insulation extends over the wall top plate at the eaves. [This reduction shall not apply to the U-factor alternative approach in Section N1102.1.2 (N1102.1.3) and the total UA alternative in Section N1102.1.3 (N1102.1.4)[3]].

[3] This last sentence was added in the 2009 edition.

In an effort to reduce the confusion, Section N1102.2.2 of the *2012 IRC* & Section N1102.2.1 of the *2015 IRC were* revised (underlined):

> **N1102.2.1 (R402.2.1) Ceilings with attic spaces.** Where Section N1102.1.2 would require R-38 insulation in the ceiling, <u>installing R-30 over 100 percent of the ceiling area requiring insulation</u> shall be deemed to satisfy the requirement for R-38 wherever the full height of uncompressed R-30 insulation extends over the wall top plate at the eaves. Similarly, where Section N1102.1.2 would require R-49 insulation in the ceiling<u>,</u> <u>installing R-38 over 100 percent of the ceiling area requiring insulation</u> shall be deemed to satisfy the requirement for R-49 insulation wherever the full height of uncompressed R-38 insulation extends over the wall top plate at the eaves. This reduction shall not apply to the U-factor alternative approach in Section R1102.1.4 and the total UA alternative in Section R1102.1.5.

The logic for this revision is provided by the Commentary to Section N1102.2.2 of the *2012 IRC* & Section N1102.2.1 of the *2015 IRC*, which states:

> The required ceiling R-value found in the code is based on the assumption that standard truss or rafter construction was being used. When raised-heel trusses or other methods of framing that would not permit the ceiling insulation to be installed to its full depth over the entire area are used, then the code would permit the installation of a lower R-value insulation. The general assumption is that ceiling insulation will be compressed at the edges and, if the special construction techniques are used, that the level of insulation required can be reduced.
>
> Insulation installed in a typical roof assembly will be full height throughout the center portions of the assembly and will taper (be compressed) at the edges as the roof nears the top plate of the exterior wall system [see Commentary Figure N1102.2.1 (I)]. The slope of the roof causes this tapering, which is further amplified by any baffling installed to direct ventilation air from the eave vents up and over the insulation. Because of this tapering, the installed R-value near the plate lines will be less than the rated R-value for the insulation. This is caused by compression (compressed insulation has a lower R-value than insulation installed to its full thickness) and the limited space between the floor of the attic and the roof sheathing near the exterior plate line. Thus, a typical installation, on average, will have a lower R-value than that of the rated insulation. Because of this, the code will allow installation of a lower insulation value if it can be installed full thickness, to its rated R-value, over the plate line of the exterior wall. This allowance recognizes that a partial thermal "bypass" has been made more efficient by using insulation with the full R-value at the eaves. The full insulation R-value is sometimes achieved by what is termed an "energy truss" or "advanced framing." This can be achieved by using an oversized truss or raised-heel truss as shown in Commentary Figure N1102.2.1(2). Another way to achieve the full R-value would be by use of insulation with a higher R-value per inch at the eaves. The use of the options permitted by this section allows substituting R-30 for R-38 insulation, and R-38 may be substituted for R-49 insulation to meet the requirements of the code. When using the conditioned attic requirements of the code, the same option of using a reduced R-value would apply if the insulation was installed directly under the roof deck, rather than on the attic floor (see commentary, Section R806.4). The insulation would be permitted to meet the lesser R-value, presuming the full R-value was met over the eaves. Of course, this situation would also presume that the attic space beneath the insulation was not vented. Note that this text applies only to the R-value portion of the code; there is no reduction in requirements if the U-factor alternative or the total UA alternative is used. In those cases, the reduced thickness must be accounted for in the calculations. In addition, if the residence had more than one separate attic space, it is possible this section could apply to one attic space, but not another.

<u>Conclusion:</u>

It is important to understand that the ceiling insulation R-Value requirements in the table assume that the insulation for some portion of the ceiling space is lower than the requirement. There is no requirement to meet the table R-Value requirements across the entire ceiling, as long as the requirement is met on the majority of the ceiling. The requirements do not provide specific ratios.

From the *IRC* definition of a standard truss it is clear that all editions of the *IRC* recognize roofs framed using standard rafter or truss construction, which, in most parts of the United States, result in vertical depth of the framing at the outside face of the wall of as little as 4". The commentary is clear that the table values are based on standard rafter or truss framing. The ceiling R-values in the *IRC*, therefore, are not intended to be the minimum R-values for the attic space directly above an exterior wall but rather the rated R-value for the majority of the attic space.

The exception in Section N1102.2.1, allowing R-30 where R-38 is required or R-38 where R-49 is required is a trade-off to the initial requirement. If uncompressed insulation at the exterior wall top plate can be achieved then the R-value for the remaining portion of the ceiling area can also be reduced. In theory, maintaining a constant, but lower, R-value across the entire attic area, will provide comparable overall energy efficiencies to a system with a higher R-value in-bound from the exterior walls and a lower R-value at the walls. Note that there is no similar exception given for the R-30 requirement in zone 1 to reduce the R-Value requirement if 100% of the ceiling area can be covered with a lesser R-Value.

This interpretation given in the commentary goes back to the *2000* & *2003 IRC* editions which included the following:

> **N1102.1.2 Ceilings.** The required "Ceiling R-value" in Table N1102.1 assumes standard truss or rafter construction and shall apply to all roof/ceiling portions of the building thermal envelope, including cathedral ceilings. Where the construction technique allows the required R-value of ceiling insulation to be obtained over the wall top plate, R-30 shall be permitted to be used where R-38 is required and R-38 shall be permitted to be used where R-49 is required.

The basic concepts for applying R-value requirements of the *IRC* to attic spaces of a building are not actually different in any editions of the code. The only substantial change is that the magnitude of the required R-value has increased in some climate zones.

The building designer is responsible for ensuring the building meets overall energy efficiencies required in the code and to communicate those requirements to the truss designer through the construction documents.

With this information in mind, we can answer the questions posed earlier:

- What happens at the outside of the wall where the vertical depth of the roof framing is typically less than the required depth of insulation?
  - Nothing. The amount of insulation R-value over the remaining area has been increased to account for this very situation.
- Does the depth of the framing need to increase?
  - No, not as long as the required insulation R-value is covering most of the ceiling area.
- Does the building designer need to modify the profile of the building to accommodate this increased framing depth?
  - No, as there is no need for increased framing depth.

"Component Performance" versus the "Prescriptive" approach for the entire building is also a means to achieve objectives for minimal insulation levels over exterior walls. When all of the components of the building envelop come into play, it expands the opportunity for successful tradeoffs.

References:

International Energy Conservation Code, 2009, 2012, and 2015 by the International Code Council

International Residential Code, 2006, 2009, 2012 and 2015, by the International Code Council

TPI 1 – 2007, by the Truss Plate Institute

BCSI (Building Component Safety Information), June 2011 by Structural Building Components Association (SBCA) and Truss Plate Institute (TPI)