SBC ASSOCIATION

Research Report

Insulating Concrete Form Sill Plate Requirements

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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

Efficiency is a goal that most strive to achieve in the form of cost, fuel, energy, time and many other resources. The building industry has focused on various aspects of efficiency over the past several years. Many innovative solutions came from this initiative, one of which was Insulating Concrete Forms (ICFs).

ICFs are concrete forms constructed of rigid foam plastic, composite of cement and foam, composite of cement and wood chips, or other suitable insulation materials. The form shapes can vary based on material, structural requirements, and manufacturer. Concrete is poured into the insulating forms similar to traditional cast in place concrete, but instead of removing the forms after the concrete has cured, the form is left in place and acts as permanent insulation of the wall. ICFs save time and money for the contractor and the building owner.

Many builders have learned to incorporate ICFs into their designs. Various suppliers provide training, standard details, and technical support to get their product in the field. In addition to proprietary resources, the U.S. Department of Housing and Urban Development (HUD) sponsored the *Prescriptive Method for Insulating Concrete Forms in Residential Construction* which standardizes minimum requirements for basic ICF systems.

In an effort to standardize and simplify construction with ICF systems, some general detailing may be overdesigned. This Research Report will look specifically at the sill plate requirements according to the 2009, 2012, and 2015 *International Residential Code* (*IRC*) and *International Building Code* (*IBC*) and clarify if a sill plate is required in the following conditions:

- Flat truss bottom chord bearing on ICF wall.
- Flat truss top chord bearing on ICF wall.
- Roof truss bearing on ICF wall.

Key Definitions

Diaphragm[1] – A horizontal or nearly horizontal system acting to transmit lateral forces to the vertical resisting elements. Where the term "*diaphragm*" is used, it includes horizontal bracing systems.

Insulating Concrete Form (ICF)[1] – A concrete forming system using stay-in-place forms of rigid foam plastic insulation, a hybrid of cement and foam insulation, a hybrid of cement and wood chips, or other insulating material for constructing cast-in-place concrete walls.

Standard Truss[1] – Any construction that does not permit the roof/ceiling insulation to achieve the required R-value over the exterior walls**.**

Supports[1] – Devices for supporting, hanging and securing pipes, fixtures and equipment.

Background

The *Prescriptive Method for Insulating Concrete Forms in Residential Construction* (HUD) provides guidelines for the design and construction of one- and two-family residential dwellings using ICF. This prescriptive method references U.S. building codes, engineering standards, and practical construction techniques. The most recent edition of the document was edited in 2002 with the following changes:

- Improved lintel reinforcement and span tables.
- Expanded provisions covering high seismic hazard areas, specifically Seismic Design Category D (Seismic Zones 3 and 4).
- Inclusion of conversions between fastest-mile wind speeds and newer 3-second gust wind speeds.
- Expanded provisions recognizing 3,000 psi and 4,000 psi concrete compressive strengths and Grade 60 steel reinforcement.

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[1] 2015 *IRC Section R202*

- New connection details.
- New table formatting for above grade walls and required solid wall length to resist wind and seismic lateral loads.

The *IRC* discusses floor bearing conditions in Chapters 5, concrete wall systems in Chapter 6, and roof bearing conditions in Chapter 8. The main focus in each of these chapters will be the truss bearing requirements with respect to a sill plate. The specific references will be discussed in the Analysis section.

Chapter 5 of the *IRC* is more specific about joist/beam/girder bearing in the 2012 and 2015 editions than in the 2009 edition.

Sections of interest were changed in Chapter 6 of the *IRC* from R608 to R611 between the 2012 and 2015 editions. Specific wood species requirements were added in 2015. In the analysis section, the 2015 version will be discussed.

Chapter 8 of the *IRC* has been modified due to *ASCE 7* wind loading changes and *AF&PA/NDS* was changed to *AWC NDS*. Bearing information is added between the 2009 and 2012 editions, and considerable uplift information was added. The bearing requirements and roof tie-down requirements are basically the same in the 2012 and 2015 editions with some minor edits for clarity.

The *IBC* sections regarding floor and roof anchorage have not changed from 2009 to 2015. The information provided in the *IBC* is minimal, while the *IRC* goes into more detail. The *Prescriptive Method for Insulating Concrete Forms in Residential Construction* will be used for conceptual guidance only, as the publication is no longer current. As a result, the *IRC* will be used as the primary resource throughout this Research Report.

Analysis

The necessity of a sill plate at truss bearing on an ICF wall is in question. The primary structural functions of a sill plate are bearing, hold-down, and diaphragm chord. The sill plate also acts as a barrier against decay from termites and moisture when pressure-preservative treated lumber is used. Beyond specific code requirements, it is important to verify all sill functions are accounted for through alternative means before eliminating the sill plate.

Chapter 6 of the IRC gives an overview of floor to concrete connections in section R608.9.2. Roof system connection options are outlined similarly in R608.9.3.

> **R608.9.2 Connections between concrete walls and light-framed floor systems.** Connections between concrete walls and light-framed floor systems shall be in accordance with one of the following:
>
> 1. For floor systems of wood frame construction, the provisions of Section R608.9.1 and the prescriptive details of Figures R608.9(1) through R608.9(4), where permitted by the tables accompanying those figures. Portions of connections of wood-framed floor systems not noted in the figures shall be in accordance with Section R502, or AWC WFCM, if applicable. Wood framing members shall be of a species having a specific gravity equal to or greater than 0.42.
> 2. For floor systems of cold-formed steel construction, the provisions of Section R608.9.1 and the prescriptive details of Figures R608.9(5) through R608.9(8), where permitted by the tables accompanying those figures. Portions of connections of cold-formed steel framed floor systems not noted in the figures shall be in accordance with Section R505, or AISI S230, if applicable.
> 3. Proprietary connectors selected to resist loads and load combinations in accordance with Appendix A (ASD) or Appendix B (LRFD) of PCA 100.
> 4. An engineered design using loads and load combinations in accordance with Appendix A (ASD) or Appendix B (LRFD) of PCA 100.
> 5. An engineered design using loads and material design provisions in accordance with this code, or in accordance with ASCE 7, ACI 318, and AWC NDS for wood frame construction or AISI S100 for cold-formed steel frame construction.

Since a truss system is not within the referenced prescriptive details, the proprietary connectors or engineered design are the two remaining options for wood truss systems bearing on ICF walls. If a proprietary bolt is used to connect a truss to an ICF wall, the minimum bearing requirements for the truss can be taken from the *IRC* for joists, beams, girders, rafters, and ceiling joists in R502.6 and R802.6. The options of direct bearing or the use of a sill plate are presented when bearing on masonry or concrete (underlined):

> **R502.6 Bearing.** The ends of each joist, beam or girder shall have not less than 1 1/2 inches (38 mm) of bearing on wood or metal and not less than 3 inches (76 mm) on masonry or concrete except where supported on a 1-inch by 4-inch (25 mm by 102 mm) ribbon strip and nailed to the adjacent stud or by the use of approved joist hangers. The bearing on masonry or concrete shall be direct, or a sill plate of 2-

inch-minimum (51 mm) nominal thickness shall be provided under the joist, beam or girder. The sill plate shall provide a minimum nominal bearing area of 48 square inches (30 865 mm^2).

R802.6 Bearing. The ends of each rafter or ceiling joist shall have not less than 1 1/2 inches (38 mm) of bearing on wood or metal and not less than 3 inches (76 mm) on masonry or concrete. The bearing on masonry or concrete shall be direct, or a sill plate of 2-inch (51 mm) minimum nominal thickness shall be provided under the rafter or ceiling joist. The sill plate shall provide a minimum nominal bearing area of 48 square inches (30 865 mm^2).

The 3" minimum bearing requirement on concrete may not be met depending on the ICF wall configuration. The *IRC* provides three examples of wall systems that are commonly used and the minimum parameters for each in Section R608.3:

R608.3 Concrete wall systems. Concrete walls constructed in accordance with these provisions shall comply with the shapes and minimum concrete cross-sectional dimensions of Table R608.3.

R608.3.1 Flat wall systems. Flat concrete wall systems shall comply with Table R608.3 and Figure R608.3(1) (Figure 1) and have a minimum nominal thickness of 4 inches (102 mm).

R608.3.2 Waffle-grid wall systems. Waffle-grid wall systems shall comply with Table R608.3 and Figure R608.3(2) (Figure 2) and shall have a minimum nominal thickness of 6 inches (152 mm) for the horizontal and vertical concrete members (cores). The core and web dimensions shall comply with Table R608. 3. The maximum weight of waffle-grid walls shall comply with Table R608.3.

R608.3.3 Screen-grid wall systems. Screen-grid wall systems shall comply with Table R608.3 and Figure R608.3(3) (Figure 3) and shall have a minimum nominal thickness of 6 inches (152 mm) for the horizontal and vertical concrete members (cores). The core dimensions shall comply with Table R608.3. The maximum weight of screen-grid walls shall comply with Table R608.3.

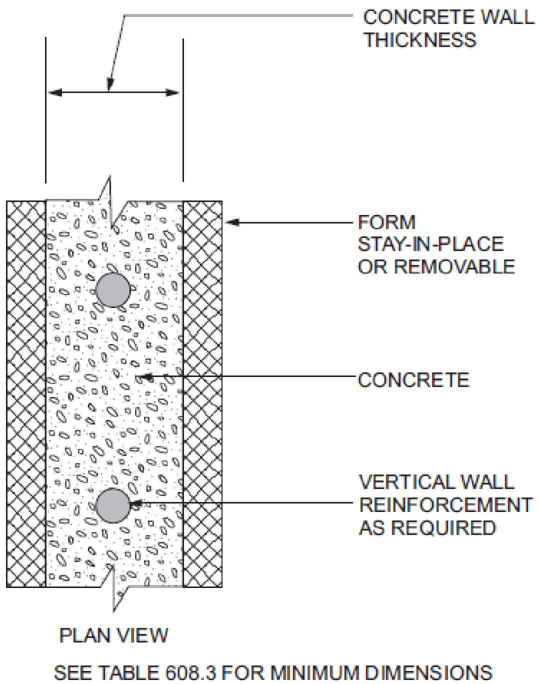

FIGURE R608.3(1)
FLAT WALL SYSTEM

Figure 1

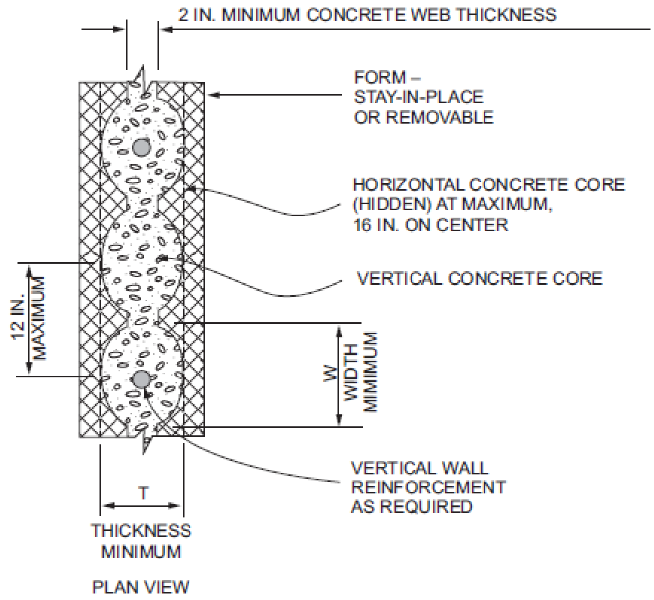

FIGURE R6083(2)
WAFFLE-GRID WALL SYSTEM

Figure 2

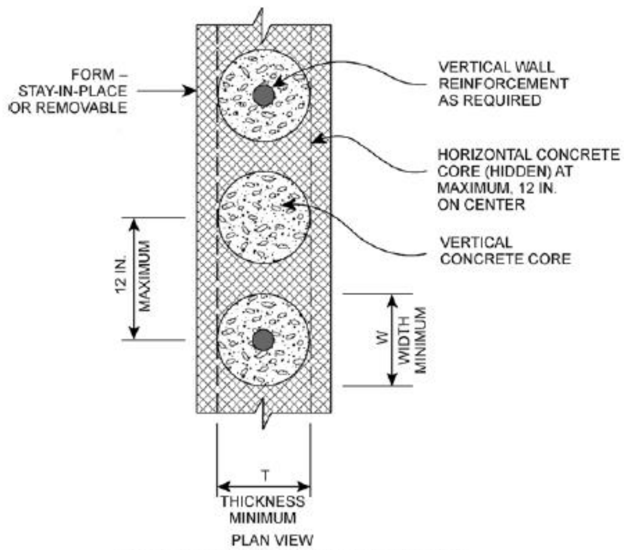

FIGURE R608.3(3)
SCREEN-GRID WALL SYSTEM

Figure 3

In addition to the various form layouts, the concrete thickness and insulation thickness can vary. These are all factors that will affect the ability for a truss to successfully bear on the wall.

The *Prescriptive Method for Insulating Concrete Forms in Residential Construction* adds a prescriptive outline for attaching the floor system and roofs to the ICF wall in Sections 6.2.1 and 6.3, respectively. The floor connection description implies that it is acceptable to connect to the sill plate or the floor, but the roof only explains connection to the sill plate (underlined):

6.2.1 Floor on ICF Wall Connection (Top-Bearing Connection)

Floors bearing on ICF walls shall be constructed in accordance with 6.2 (Figure 4) or 6.3 (Figure 5). The wood sill plate or floor system shall be anchored to the ICF wall with 1/2-inch- (13-mm-) diameter bolts placed at a maximum spacing of 6 feet (1.8 m) on center and not more than 12 inches (305mm) from joints in the sill plate. . .

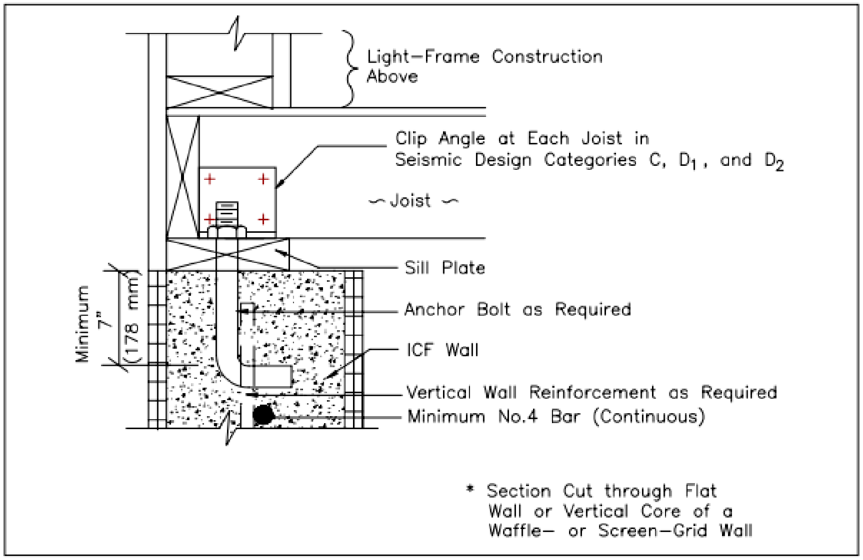

Figure 6.2 Floor on ICF Wall Connection (Top-Bearing Connection)

Figure 4

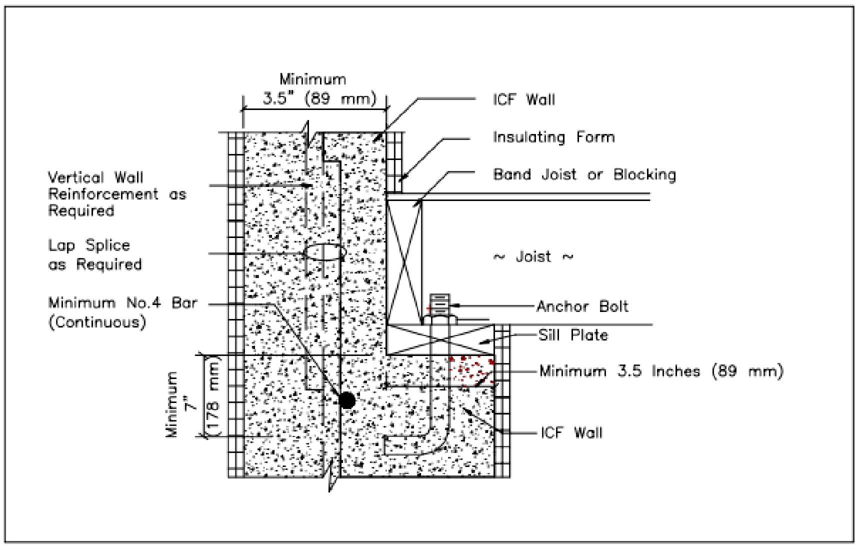

Figure 6.3 Floor on ICF Wall Connection (Top-Bearing Connection)
(Not Permitted is Seismic Design Categories C, D_1, or D_2 Without Use of Out-of-Plane Wall Anchor in Accordance with Figure 6.5)

Figure 5

6.3 ICF Wall-to-Roof Connection

Wood sill plates attaching roof framing to ICF walls shall be anchored to the ICF wall in accordance with Table 6.3 and Figure 6.8 (Figure 6). Anchor bolts shall be located in the middle one-third of the flat ICF wall thickness or the middle one-third of the vertical core thickness of the waffle-grid and screen-grid ICF wall system and shall have a minimum embedment of 7 inches (178 mm). Roof framing attachment to wood sill plates shall be in accordance with the applicable building code. . .

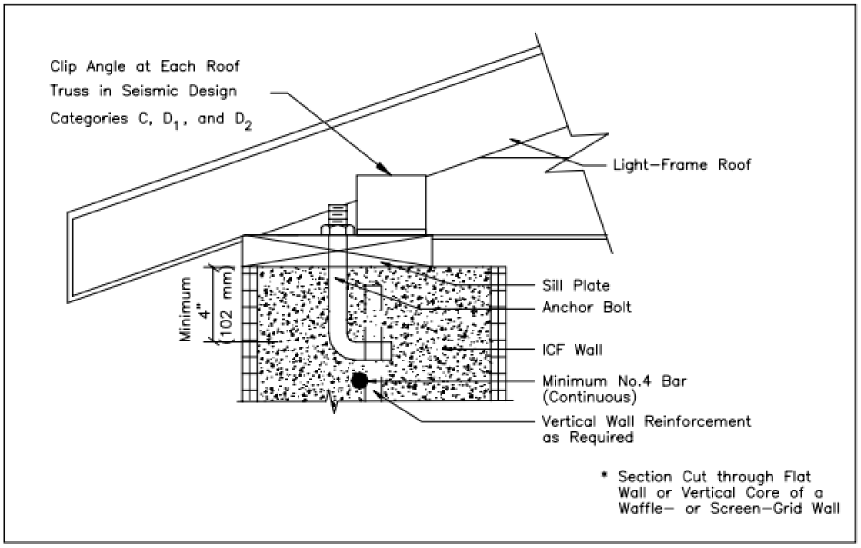

Figure 6.8 Top Wood Sill Plate-ICF Wall System Connection

Figure 6

The publication goes on to outline connection requirements for higher wind and seismic conditions. Ledger connections are also discussed, but do not fall within the scope of this Research Report.

The proprietary or engineered connection will also need to meet uplift requirements provided in *IRC* Section R802.11.1:

> **R802.11.1 Uplift resistance.** Roof assemblies shall have uplift resistance in accordance with Sections R802.11.1.1 and R802.11.1.2.
>
> Where the uplift force does not exceed 200 pounds (90.8 kg), rafters and trusses spaced not more than 24 inches (610 mm) on center shall be permitted to be attached to their supporting wall assemblies in accordance with Table R602.3(1).
>
> Where the basic wind speed does not exceed 115 mph, the wind exposure category is B, the roof pitch is 5:12 or greater, and the roof span is 32 feet (9754 mm) or less, rafters and trusses spaced not more than 24 inches (610 mm) on center shall be permitted to be attached to their supporting wall assemblies in accordance with Table R602.3(1).
>
> **R802.11.1.1 Truss uplift resistance**. Trusses shall be attached to supporting wall assemblies by connections capable of resisting uplift forces as specified on the truss design drawings for the ultimate design wind speed as determined by Figure R301.2(4)A and listed in Table R301.2(1) or as shown on the construction documents. Uplift forces shall be permitted to be determined as specified by Table R802.11, if applicable, or as determined by accepted engineering practice.
>
> **R802.11.1.2 Rafter uplift resistance.** Individual rafters shall be attached to supporting wall assemblies by connections capable of resisting uplift forces as determined by Table R802.11 or as determined by accepted engineering practice. Connections for beams used in a roof system shall be designed in accordance with accepted engineering practice.

Sill plates may allow the number of pull-out point load anchorage locations to be reduced by increasing the spacing between anchorage locations. The sill plate must have sufficient to transfer the uplift forces from the trusses to the anchorage points. Without the sill plate, the truss spacing will be the minimum anchorage spacing available.

The sill plate typically acts as a continuous chord for the structure's lateral diaphragm. Without the sill, other load paths will need to be reviewed to verify continuity, tensile capacity, and compression capacity. In a typical floor system similar to Figure 4, the bottom plate of the wall above may be an option. In Figure 5, the band joist may work as the chord, but blocking is not acceptable due to its discontinuity, similar to Figure 6, which may be why the prescriptive method recommends a sill plate for roof trusses.

Where wood is in contact with concrete or has exposure to termites, decay is a concern. A sill plate will commonly be pressure-preservative treated to serve as a barrier while also meeting structural needs. If the treated sill plate is not utilized, alternative options to prevent decay are discussed extensively in R317 and R318 of the *IRC*.

A final item to keep in mind is the design assumptions of top chord bearing trusses. The industry standard for the gap between the edge of the truss web and the edge of bearing is ½" maximum. With the insulation acting as a non-load bearing gap between the edge of the truss web and edge of bearing, the ½" maximum is exceeded. The truss top chord must be designed to span the non-load bearing gap created by the insulation, see Figure 7.

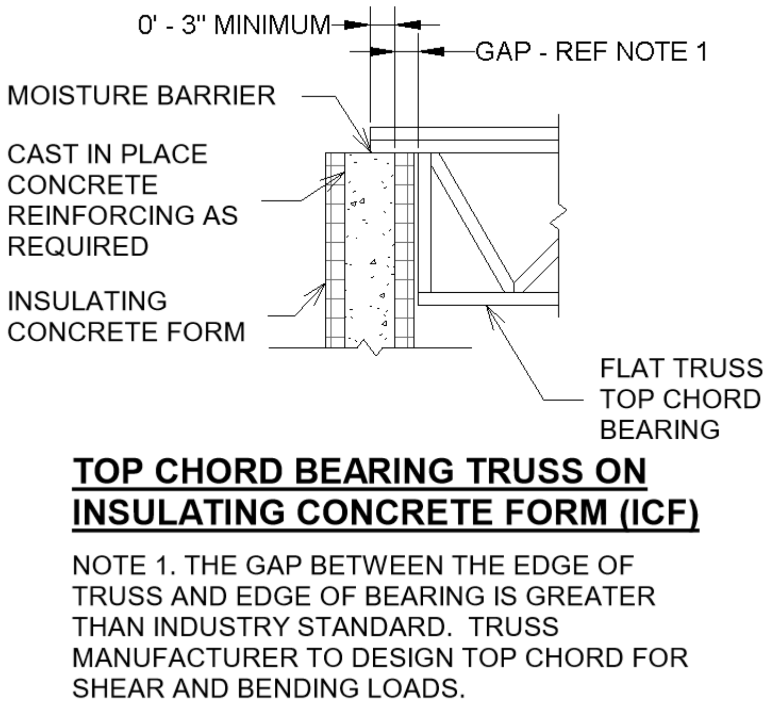

Figure 7

Conclusion

In order to meet the minimum bearing thickness requirement of 3", the concrete within the form must be a minimum of 3" wide. The flat wall system has a minimum thickness of 4", which is acceptable for one truss to bear on, but not two trusses at the same location. The trusses in this application would need to be staggered. Since the minimum waffle-slab web thickness of 2" is less than the allowable minimum bearing, a sill plate may be required for thin waffle-slab configurations. The screen-grid does not provide continuous concrete bearing, so a sill plate will be required for these forms. In addition, the sill plate may require additional plies in order to span between concrete cores.

The three basic truss bearing conditions on ICF walls are flat truss bottom chord bearing, flat truss top chord bearing, and roof truss bearing. Each condition comes with various factors to be considered based on code requirements and industry standards.

Flat Truss Bottom Chord Bearing

Refer to Figure 4 and Figure 5 for the conceptual layout of a flat truss bottom chord bearing on ICF. Without the sill plate, 3" min of bearing on concrete can be achieved. Uplift is not typically a concern at the floor elevation, but needs to be checked to ensure a complete load path to the foundation. Uplift connections at the roof intersection would require a proprietary or engineered tie-down connection. The sill is sometimes used as a diaphragm chord element. Without the sill, an alternative load path will need to be designed at floor and roof conditions. Finally, decay prevention must be accounted for through means discussed in R317 and R318 of the *IRC*.

Flat Truss Top Chord Bearing

Refer to Figure 7 for the proposed layout without a sill plate. Bearing, uplift, lateral load and decay are issues that can be solved, similar to the flat truss bottom chord bearing. The primary issue with the top chord bearing is the gap discussed in the Analysis section. The insulating form does not have bearing capacity, so a sill would be required for a truss that is designed based on industry standards of maximum ½" gap. The sill should be checked to make sure it is adequate to distribute the load to the concrete. Without the sill, the truss will need to be specially designed to span the large gap or the insulating form will need to be removed with the consent of the wall manufacture.

Roof Truss Bearing

The prescriptive method for roof trusses does not provide an option of direct connection to ICF. While bearing, uplift, and decay can be addressed similar to flat trusses, the lateral system does not provide many alternative load paths. The sheathing could be an option for light loading, the concrete could be designed to utilize the concrete reinforcing, or a proprietary solution could be used.

Provided bearing, uplift, lateral, and decay are accounted for through proprietary or engineered design, Table 1 shows the acceptability of the truss to ICF bearing connection without a sill plate.

Table 1. Sill Plate Requirements

		Insulating Concrete Form (ICF) Shapes		
		Flat Wall System	**Waffle-Grid System**	**Screen-Grid System**
Truss Bearing	**Flat Truss -Bottom Chord Bearing**	Acceptable without sill.	Acceptable without sill if wall web >3”.	Sill required.
	Flat Truss -Top Chord Bearing	Acceptable without sill if truss is designed to span gap.	Acceptable without sill if wall web >3” and truss designed to span gap.	Sill required.
	Roof Truss- Bottom Chord Bearing	Not recommended without sill, but acceptable if lateral load path is designed.	Not recommended without sill, but acceptable if lateral load path is designed and wall web >3”.	Sill required.

References

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

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

Prescriptive Method for Insulating Concrete Forms in Residential Construction, Second Edition, by the U.S. Department of Housing and Urban Development Office of Policy Development and Research