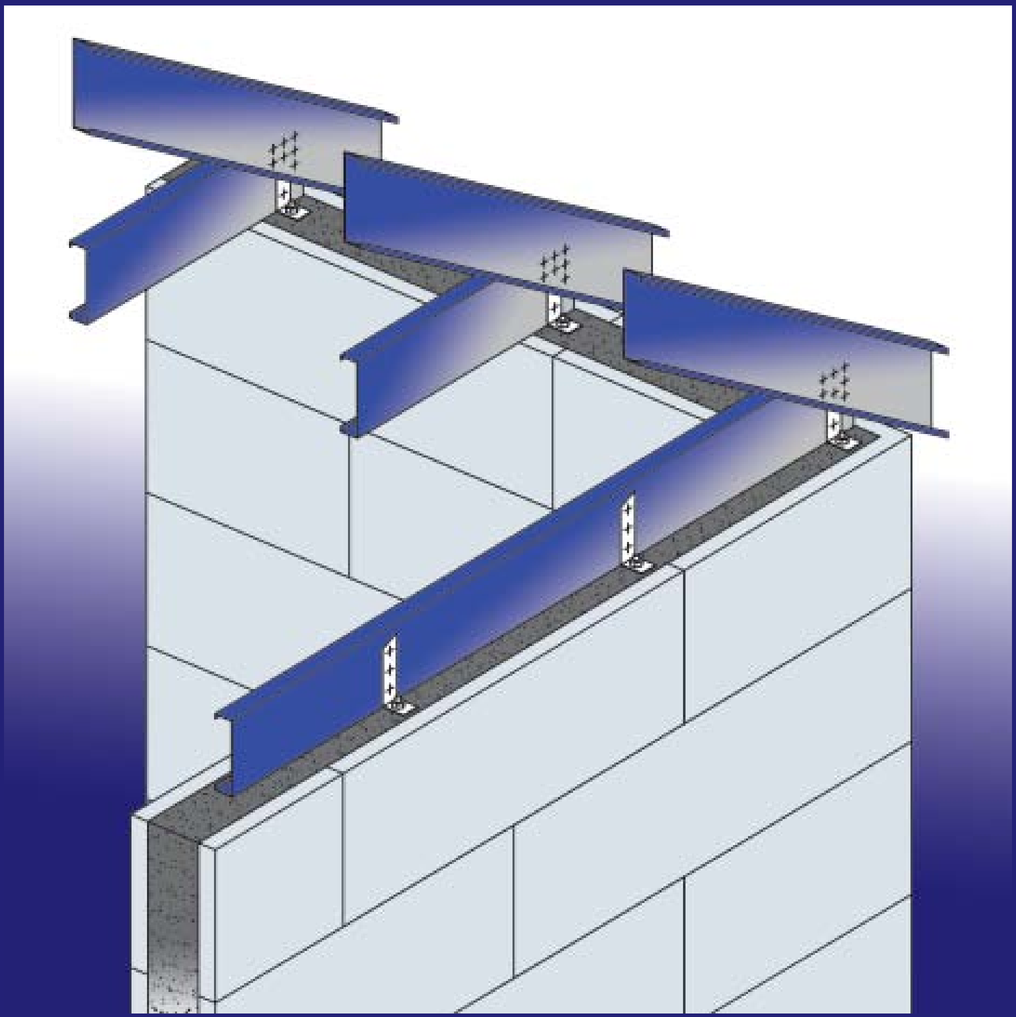
U.S. Department of Housing and Urban Development

Office of Policy Development and Research

Prescriptive Method for Connecting Cold-Formed Steel Framing to Insulating Concrete Form Walls in Residential Construction



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Prescriptive Method for Connecting

Cold-Formed Steel Framing to Insulating Concrete Form Walls

in Residential Construction

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Preface

In recent years construction of single-family homes with exterior walls of insulating concrete forms has grown rapidly. The use of cold-formed steel for the construction of residential interior walls, floors, and roofs has likewise grown rapidly. The reasons given for use of both materials include:

- Durability
- Strength
- Material consistency
- Price stability of material
- Ecological concerns

Yet builders who have combined insulating concrete forms and cold-formed steel framing in homes complain of a lack of information on making the connections. Many say that they believe they are employing overly involved and expensive methods. However, they are unwilling to employ simpler methods for fear that the connections might be inadequate.

This publication is intended to alleviate these problems by providing construction details and schedules for the connection of cold-formed steel frame walls, floor decks, and roofs to insulating concrete form exterior walls, based on engineering analysis and common building requirements. It is also intended to provide code officials and inspectors with the guidance necessary to perform their duties in home construction when these materials are used. Note that this publication is intended for use only by qualified industry professionals who can evaluate the applicability of its recommended details in specific projects and circumstances.

By facilitating the construction of houses from insulating concrete forms and cold-formed steel, HUD expands housing affordability and quality through competition from new methods and materials.

Acknowledgments

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This book is the third publication in a prescriptive method series produced by the U.S. Department of Housing and Urban Development on insulating concrete forms and cold-formed steel framing. We would like to thank all individuals involved in preparing those publications on which Chapters 2 and 3 are largely based.

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NUCONSTEEL, Co.
Quad-Lock, Inc
Reward Wall Systems, Inc.
Simpson Strong-Tie Co., Inc.

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Executive Summary

The *Prescriptive Method for Connecting Cold-Formed Steel Framing to Insulating Concrete Form Walls in Residential Construction* was developed as a guideline for the connection of cold-formed steel (CFS) frame assemblies and structures to insulating concrete form (ICF) exterior walls in the construction of single-family homes. These guidelines are only intended to apply subject to the limitation presented in Chapter 2. They are intended for use only by qualified industry professionals who can evaluate their applicability in specific projects and circumstances.

The common connections between cold-formed steel framing and insulating concrete form walls are:

- CFS interior walls to ICF exterior walls;
- CFS floor decks to ICF exterior walls;
- CFS roof structures to ICF exterior walls; and
- Upper-story CFS exterior walls to lower-story ICF exterior walls.

For each connection there are alternative connection methods that are believed to be economical and reliable. The chapters that follow contain recommended specifications for such connections.

Non-loadbearing interior CFS walls in many cases require no connection to the ICF exterior wall. Where the interior wall will be subject to high lateral forces or vibrations, a simple fastener to the ICF wall or to some form of plate fastened to the ties is recommended.

CFS floor decks include ledger tracks to which the joists are fastened. These ledger tracks may be fastened to the ICF exterior wall by means of anchor bolts or right angle ledger connectors. Within specified limits, the joists may be fastened to the tracks directly by means of self-tapping sheet metal screws.

The end joists of CFS floor decks are to be attached to the side walls of the building. This may be accomplished by means of anchor bolts.

In addition to floor decks consisting of CFS joists and plywood or OSB sheathing, there are several floor systems that create floor decks entirely of steel and concrete components. This document provides general descriptive information regarding several such systems.

CFS roof members (trusses or joists and rafters) may be connected to the ICF walls directly by means of embedded steel straps. Alternatively, they may be connected to a top plate by means of steel connection plates, and the plate connected to the ICF walls by means of embedded steel straps. As a third alternative, roofing members may be connected to the ICF wall directly be means of anchor bolts adhered into special holes drilled in the concrete after the concrete has cured.

The end roof members are to be connected to the ICF side walls at various intermediate

points. This may be accomplished by any of the same three methods that the other roof connections are made.

Upper-story CFS exterior walls may be connected to lower-story ICF exterior walls by means of anchor bolts through the bottom plate of the CFS wall.

Chapter 1

Introduction

The materials set forth herein are for general information only. They are not a substitute for competent professional assistance. Application of this information to a specific project or setting should be reviewed by a qualified individual. The authors believe that the information contained in this publication substantially represents industry practice and related scientific and technical information, but the information is not intended to represent an official position of any organization or to restrict or exclude any other construction or design technique. Anyone making use of the information set forth herein does so at his or her own risk and assumes any resulting liability.

Note that references made to other publications are in brackets [ ] throughout the body of this document. All references can be found in Chapter 8.

Chapter 2

General

Purpose

The purpose of this document is to provide a prescriptive method for the connection of cold-formed steel framing members and assemblies to exterior walls built of insulating concrete forms. These provisions include definitions, connection details, fastener schedules, and other related information appropriate for use by homebuilders, design professionals, and building code officials.

Approach

These requirements are based primarily on the American Iron and Steel Institute's (AISI) Specification for the *Design of Cold-Formed Steel Structural Members* [1] for steel member strength, on the American Concrete Institutes's (ACI) *Building Code Requirements for Structural Concrete* [2], on the *Structural Design of Insulating Concrete Form Walls in Residential Construction* [3] for concrete design and specification, and on the *Standard for Cold-Formed Steel Framing - Prescriptive Method for One and Two Family Dwellings* [29] for steel framing requirements. The provisions for building loads are based on the American Society of Civil Engineers' (ASCE) *Minimum Design Loads for Buildings and Other Structures* [4], the *International Building Code* [5], and the *International Residential Code* [6].

These provisions are intended to represent sound engineering and construction practice, taking into account the need for practical and affordable construction techniques for residential buildings. This document is not intended to restrict the use of sound judgment or exact engineering analysis of specific applications.

Scope

The provisions of this *Prescriptive Method* apply to the construction of detached one- and two- family dwellings, townhouses, and other attached single-family dwellings in compliance with the general limitations of Table 2.1. The limitations are intended to define the appropriate use of this document for most one- and two-family dwellings. Using insulating concrete forms and cold-formed steel systems with other construction materials in a single structure shall be in accordance with the applicable building code requirements for that material, the general limitations of Table 2.1, and relevant provisions of this document. An engineered design shall be required for applications that do not meet the limitations of Table 2.1.

The provisions of the *Prescriptive Method* shall not apply to irregular structures or portions of structures in Seismic Design Categories C, D_1, and D_2. Only such irregular portions of structures shall be designed in accordance with accepted engineering practice to the extent such irregular features affect the performance of the structure. A portion of the building shall be considered to be irregular when one or more of the following conditions occur:

- Exterior shear wall lines are not in one plane vertically from the foundation to the uppermost story in which they are required (i.e., cantilevers).
- A section of floor or roof is not laterally supported by shear walls on all edges.
- An opening in the floor or roof exceeds the lesser of 12 ft (3.7 m) or 50 percent of the least floor dimension.
- Portions of the floor are vertically offset.
- Shear walls (i.e. exterior ICF walls) do not occur in two perpendicular directions.
- Shear walls are constructed of dissimilar systems on any one story level.

TABLE 2.1
APPLICABILITY LIMITS

ATTRIBUTE	MAXIMUM LIMITATIONS
General	
Building Dimensions	60 feet with center bearing wall or beam 32 feet without center bearing wall or beam
Number of Stories	2 stories above grade with a basement
Design Wind Speed	130 mph (209 km/h) 3-second gust
Ground Snow Load	70 psf (3.4 kPa)
Seismic Design Category	A, B, C, D_1 and D_2 (Seismic Zones (0, 1, 2, 3, and 4)
Floors	
Floor Dead Load	10 psf (0.72 kPa)
First-Floor Live Load	40 psf (1.9 kPa)
Second-Floor Live Load (sleeping rooms)	30 psf (1.4 kPa)
Floor Clear Span (unsupported)	32 feet (9.8 m)
Walls - Concrete	
Unit Weight of Concrete	150 pcf (23.6 kN/m^3)
Wall Height (unsupported)	10 feet (3 m)
Walls - Cold-Formed Steel	
Wall Dead Load	10 psf (0.48 kN/m^2)
Load Bearing Wall Height	10 feet (3 m)
Roofs	
Roof and Ceiling Dead Load	15 psf (0.72 kPa)
Roof Live Load (ground snow load)	70 psf (3.4 kPa)
Roof Slope	3:12 to 12:12
Attic Live Load	20 psf (0.96 kPa)
Roof Clear Span (unsupported)	32 feet (9.8 m)

For SI: 1 foot = 0.3048 m; 1psf = 47.8804 Pa; 1 pcf = 157.0877 N/m^3 = 16.0179 kg/m^3; 1 mph = 1.6093 km/hr

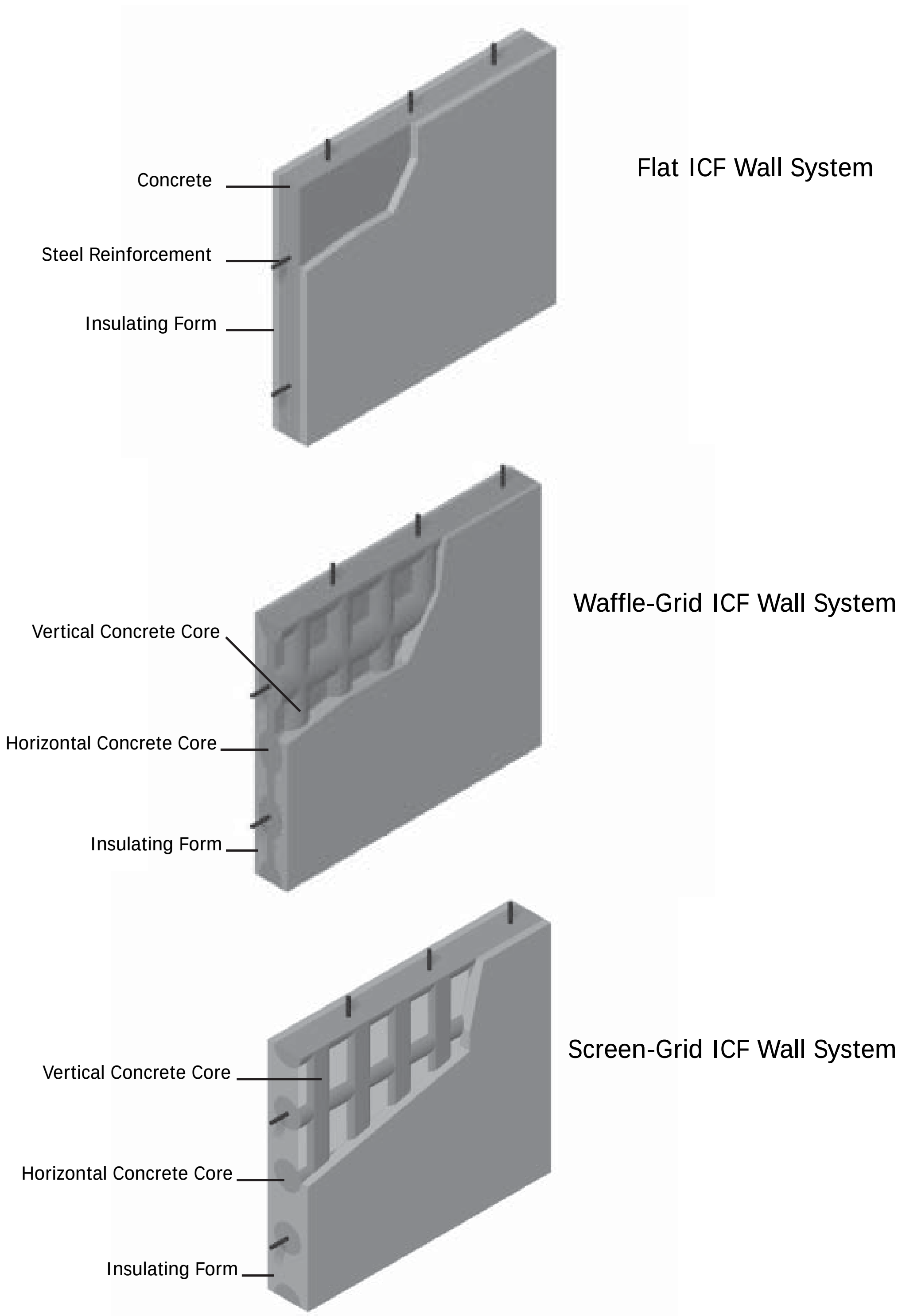


Figure 2.1. Insulating Concrete Form (ICF) Systems

Definitions

The following are definitions of key terms as they are used in this document. Figure 2.1 illustrates certain terms as referenced by these definitions.

Accepted Engineering Practice: An engineering approach that conforms with accepted principles, tests, technical standards, and sound judgment.

Anchor Bolt: A bolt, headed or threaded, used to connect a structural member of different material to a concrete member.

Approved: Reference to approval by the building code authority having jurisdiction. A rational design by a competent design professional shall constitute grounds for approval.

Attic: The enclosed space between the ceiling joists of the top-most floor and the roof rafters of a building not intended for occupancy but sometimes used for storage.

Authority Having Jurisdiction: The organization, political subdivision, office, or individual charged with the responsibility of administering and enforcing the provisions of applicable building codes.

Axial Load: The longitudinal force acting on a member. Examples are the gravity loads carried by columns or studs.

Backfill: The soil that is placed adjacent to completed portions of a below-grade structure (i.e., basement) with suitable compaction and allowance for settlement.

Basement: That portion of a building, which is partly, or completely below grade and which may be used as habitable space.

Bearing Stiffener: Additional material that is attached to the web to strengthen the member against web crippling. Also called a web stiffener.

Bond Beam: A continuous horizontal beam of concrete with steel reinforcement located in the exterior walls of a structure to tie the structure together and distribute loads.

Buckling: A kink, wrinkle, bulge, or otherwise loss of the original shape of a member due to compressive, bending, bearing, or shear loads.

Building: Any one- or two-family dwelling or portion thereof that is used for human habitation.

Building Length: The dimension of a building that is perpendicular to roof rafters, roof trusses, or floor joists (L).

Building Width: The dimension of a building that is parallel to roof rafters, roof trusses, or floor joists (W).

Ceiling Joist: A horizontal structural framing member that supports ceiling components and which may be subject to attic loads.

C-Shape: A cold-formed steel shape used for structural and non-structural framing members consisting of a web, two (2) flanges and two (2) lips (edge stiffeners).

Clip Angle: An L-shaped short piece of metal (normally with a 90-degree bend), typically used for connections.

Cold-Formed Sheet Steel: A process where light-gauge steel members are manufactured by (1) press-braking blanks sheared from sheets or cut length of coils or plates, or by (2) continuous roll forming of cold- or hot-rolled coils of sheet steel; both forming operations are performed at ambient room temperature, that is, without any addition of heat such as would be required for hot forming.

Compressive Strength: The maximum ability of concrete to resist a compressive load, usually measured in pounds per square inch (psi) or Pascals (Pa). The compressive strength is based on compression tests of concrete cylinders that are moist-cured for 28 days in accordance with ASTM C 31 [7] and ASTM C 39 [8].

Concrete Web: A concrete wall segment as per Figure 2.1, a minimum of 2 inches (51 mm) thick, connecting the vertical and horizontal concrete members (cores) of a waffle-grid ICF wall or lintel member. Webs may contain form ties but are not reinforced (i.e., vertical or horizontal reinforcement or stirrups).

Crawlspace: A type of building foundation that uses a perimeter foundation wall to create an under floor space which is not habitable.

Dead Load: Forces resulting from the weight of walls, partitions, framing, floors, ceilings, roofs, and all other permanent construction entering into, and becoming part of, a building.

Deflection: Elastic movement of a loaded structural member or assembly (i.e., beam or wall).

Design Professional: An individual who is registered or licensed to practice their respective design profession as defined by the statutory requirements of the state in which the project is to be constructed.

Design (or Basic) Wind Speed: Related to winds that are expected to be exceeded once every 50 years at a given site (i.e., 50-year return period). Wind speeds in this document are given in units of miles per hour (mph) by 3-second gust measurements in accordance with ASCE 7 [4].

Dwelling: Any building that contains one or two dwelling units for living purposes.

Edge Stiffener: The part of a C-shape framing member that extends from the flange as a stiffening element that extends perpendicular to the flange.

Endwall: The exterior wall of a building which is perpendicular to the roof ridge and parallel to floor framing, roof rafters, or trusses. It is normally the shorter dimension of a rectangular building's footprint.

Exposure Categories: Reflects the effect of the ground surface roughness on wind loads in accordance with ASCE 7 [4]. Exposure Category B includes urban and suburban areas, or other terrain with numerous closely spaced obstructions having the size of single-family dwellings or larger. Exposure Category C includes open terrain with scattered obstructions having heights generally less than 30 ft (9.1 m) and shorelines in hurricane prone regions. Exposure D includes open exposure to large bodies of water in non-hurricane-prone regions.

Flange: The portion of the C-shape framing member or track that is perpendicular to the web.

Flat Wall: A solid concrete wall of uniform thickness produced by ICFs or other forming systems.

Floor Joist: A horizontal structural framing member that supports floor loads and superimposed vertical loads.

Form Tie: The element of an ICF system that holds both sides of the form together. Form ties can be steel, solid plastic, foam plastic, a composite of cement and wood chips, a composite of cement and foam plastic, or other suitable material capable of resisting the loads created by wet concrete. Form ties remain permanently embedded in the concrete wall.

Foundation: The structural elements through which the load of a structure is transmitted to the earth.

Foundation Wall: The structural element of a foundation that transmits the load of a structure to the earth; includes basement, stem, and crawlspace walls.

Grade: The finished ground level adjoining the building at all exterior walls.

Ground Snow Load: Measured load on the ground due to snow accumulation developed from a statistical analysis of weather records expected to be exceeded once every 50 years at a given site.

Horizontal Reinforcement: Steel reinforcement placed horizontally in concrete walls to provide resistance to temperature and shrinkage cracking. In certain circumstances, horizontal reinforcement is required for additional strength around openings and in high loading conditions such as experienced in hurricanes and earthquakes.

In-Line Framing: A framing method where all vertical and horizontal load carrying members are aligned.

Insulating Concrete Forms (ICFs): A concrete forming system using stay-in-place forms of foam plastic insulation, a composite of cement and foam insulation, a composite of cement and wood chips, or other insulating material for constructing cast-in-place concrete walls. Some systems are designed to have one or both faces of the form removed after construction.

J Bolt: A threaded anchor bolt typically embedded in concrete with threads on one end and a crook in the shank at the other; used to connect a structural member of different material to a concrete member.

Lateral Load: A horizontal force, created by wind or earthquake, acting on a structure or its components.

Lateral Support: A horizontal member providing stability to a column or wall across its smallest dimension.

Ledger: A horizontal structural member fastened to a wall to serve as a connection point for other structural members, typically floor joists.

Lip: See edge stiffener.

Live Load: Any gravity load that is not permanently applied to a structure; typically transient and sustained gravity forces resulting from the weight of people and furnishings, respectively.

Material Thickness (Steel): The base metal thickness excluding any protective coatings. Thickness is now commonly expressed in mils (1/1000 of an inch).

Metallic Coated Steel: Steel that has a metallic coating for protection against corrosion. The level of protection provided is measured by the weight of the metallic coating applied to the surface area of the steel. Typical metallic coatings are galvanizing, galvalume, or galfan, which are zinc-based.

Mil: A unit of measurement equal to 1/1000 of an inch (e.g., 33 mil = 0.033 inch).

Multiple Span: The span made by a continuous member having intermediate supports.

Non-Structural Walls: Refer to walls.

Post-and-Beam Wall: A perforated concrete wall with widely spaced (greater than that required for screen-grid walls) vertical and horizontal concrete members (cores) with voids in the concrete between the cores created by the ICF form (i.e., flat, waffle-, or screen-grid as per Figure 2.1).

Ridge: The horizontal line formed by the joining of the top edges of two sloping roof surfaces.

Roof Snow Load: Uniform live load on the roof due to snow accumulation; roughly equivalent to 70 to 80 percent of the ground snow load in accordance with ASCE 7 [4].

Screen-Grid Wall: A perforated concrete wall with closely spaced vertical and horizontal concrete members (cores) with voids in the concrete between the members created by the ICF form as per Figure 2.1. It is also called an interrupted-grid wall or post-and-beam wall in other publications.

Seismic Load: The force exerted on a building structure resulting from seismic (earthquake) ground motions.

Seismic Design Categories: Designated seismic hazard levels associated with a particular level or range of seismic risk and associated seismic design parameters (i.e., spectral response acceleration and building importance). Seismic Design Categories A, B, C, D1, and D2 (Seismic Zones 0, 1, 2, 3, and 4) correspond to successively greater seismic design loads; refer to the IBC [5] and IRC [6].

Sill Plate: A horizontal member constructed of wood, steel, or other suitable material that is fastened to the top of a concrete wall, providing a suitable surface for fastening structural members constructed of different materials to the concrete wall.

Slab-on-Grade: A concrete floor, which is supported by, or rests on, the soil directly below.

Slump: A measure of consistency of freshly mixed concrete equal to the amount that a cone of uncured concrete sags below the mold height after the cone-shaped mold is removed in accordance with ASTM C 143 [9].

Smoke-Development Rating: The combustibility of a material that contributes to fire impact through life hazard and property damage by producing smoke and toxic gases; refer to ASTM E 84 [10].

Span: The clear horizontal distance between bearing supports.

Stem Wall: A below-grade foundation wall supported directly by the soil or on a footing. Wall thickness and height are determined as that which can adequately distribute the building loads safely to the earth.

Stirrup: Steel bars, wires, or welded wire fabric located perpendicular to horizontal reinforcement and extending across the depth of the member in concrete beams, lintels, or similar members subject to large shear loads.

Story: That portion of the building included between the upper surface of any floor and the upper surface of the floor next above, except that the top-most story shall be that habitable portion of a building included between the upper surface of the top-most floor and the ceiling or roof above.

Story Above-Grade: Any story with its finished floor surface entirely above grade except that a basement shall be considered as a story above-grade when the finished surface of the floor above the basement is (a) more than 6 feet (1.8 m) above the grade plane, (b) more than 6 feet (1.8 m) above the finished ground level for more than 50 percent of the total building perimeter, or (c) more than 12 feet (3.7 m) above the finished ground level at any point.

Strap: Flat or coiled sheet steel material typically used for bracing and blocking which transfers loads by tension and/or shear.

Stud: Vertical structural element of a wall assembly, which supports vertical loads and/or transfers lateral loads.

Townhouse: Attached single-family dwelling units constructed in a row with each unit separated by fire walls at property lines.

Track: A framing member consisting of only a web and two (2) flanges. Track depth measurements are taken to the inside of the flanges.

Truss: A coplanar system of structural members joined together at their ends usually to construct a series of triangles that form a stable beam-like framework.

Vertical Reinforcement: Steel reinforcement placed vertically in concrete walls to strengthen the wall against lateral forces and eccentric loads. In certain circumstances, vertical reinforcement is required for additional strength around openings.

Waffle-Grid Wall**:** A solid concrete wall with closely spaced vertical and horizontal concrete members (cores) with a concrete web between the members created by the ICF form; refer to Figure 2.1. The thicker vertical and horizontal concrete cores and the thinner concrete webs create the appearance of a breakfast waffle. It is also referred to as an uninterrupted-grid wall in other publications.

Wall Height: The clear vertical distance between the finished floor and the finished ceiling. Where a finished floor does not exist (i.e., crawlspace), the wall height is the clear vertical distance between the interior finish grade and the finished ceiling.

Walls (steel):

> *Structural or Load Bearing:* Wall systems subject to loads that exceed the limits for a non-structural system.
>
> *Non-Structural or Non-Load Bearing:* Wall systems that are limited to a lateral (transverse) load of not more than 5 psf (240 Pa), a superimposed vertical load per member, exclusive of sheathing materials, of not more than 100 lb/ft (1460 N/m), or a superimposed vertical load per member of not more than 200 lbs (890 N).

Web: That portion of a framing member that connects the flanges.

Web Crippling: The localized permanent (inelastic) deformation of the web member subjected to concentrated load or reaction at bearing supports.

Web Stiffener: Additional material that is attached to the web to strengthen the member against web crippling. Also called a bearing stiffener.

Wind Exposure: refer to *Exposure Categories.*

Wind Load: The force or pressure exerted on a building structure and its components resulting from wind. Wind loads are typically measured in pounds per square foot (psf) or Pascals (Pa).

Wind Speed: Wind speed is the design wind speed related to winds that are expected to be exceeded once every 50 years at a given site (i.e., 50 year-return period). Wind speeds in this document are given in units of miles per hour (mph) by "3-second gust" measurements (refer to Table 2.2 to convert to fastest-mile wind speed).

TABLE 2.2
EQUIVALENT BASIC WIND SPEEDS (mph)[1]

Fastest Mile	70	75	80	85	90	100	110
3-Second Gust	85	90	100	105	110	120	130

For SI: 1 mph = 1.609 km/hr = 0.447 m/sec
[1] Linear interpolation is permitted.

Yield Strength: A characteristic of the basic strength of the steel material defined as the highest unit stress that the material can endure before permanent deformation occurs as measured by a tensile test in accordance with ASTM A 370 [11].

Chapter 3

Materials, Shapes, and Standard Sizes

Insulating Concrete Forms

Connections between Insulating Concrete Form (ICF) systems and Cold-Formed Steel (CFS) framing in accordance with this document shall comply with the shapes and minimum concrete cross-sectional dimensions required in this section. Connections not in compliance with this section shall be used in accordance with the manufacturer's recommendations and as approved.

Flat ICF Wall Systems

Flat ICF wall systems shall comply with Figure 3.1 and shall have a minimum concrete thickness of 5.5 inches (140 mm) for basement walls and 3.5 inches (89 mm) for above-grade walls.

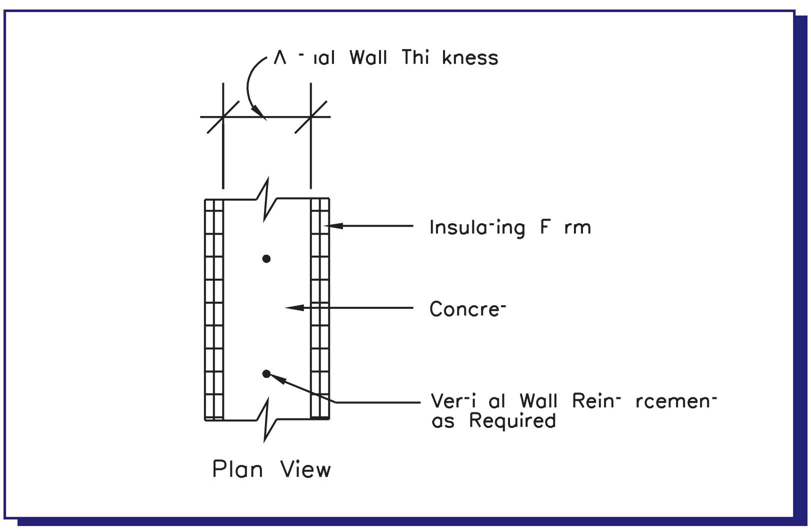


Figure 3.1. Flat ICF Wall Systems

Waffle-Grid ICF Wall Systems

Waffle-grid ICF wall systems shall have a minimum nominal concrete thickness of 6 inches (152 mm) for the horizontal and vertical concrete members (cores). The actual dimension of the cores shall comply with the dimensional requirements of Table 3.1 and Figure 3.2.

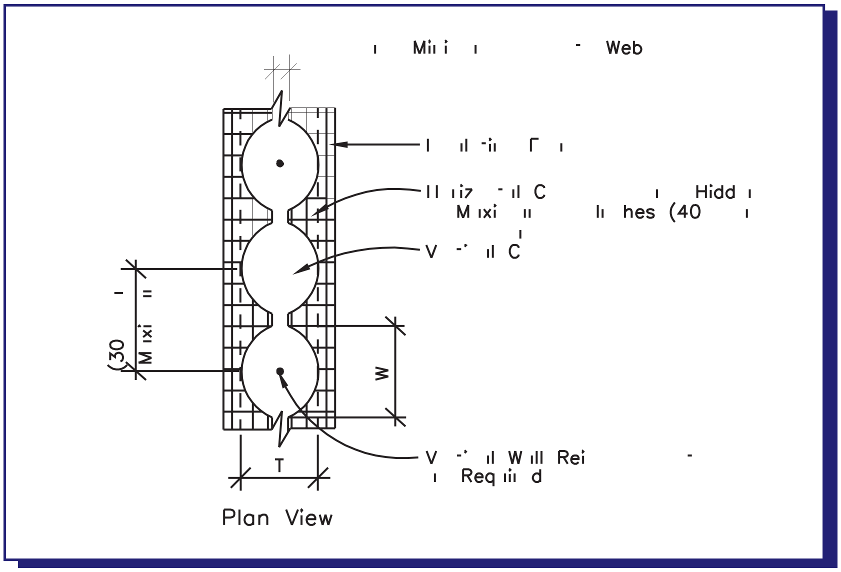


Figure 3.2. Waffle-Grid ICF Wall Systems

Screen-Grid ICF Wall Systems

Screen-grid ICF wall systems shall have a minimum nominal concrete thickness of 6 inches (152 mm) for the horizontal and vertical concrete members (cores). The actual dimensions of the cores shall comply with the dimensional requirements of Table 3.1 and Figure 3.3.

TABLE 3.1
DIMENSIONAL REQUIREMENTS FOR CORES AND WEBS IN WAFFLE- AND SCREEN- GRID ICF WALLS

Nominal Size, (in)	Minimum Width of Vertical Core, (in)	Minimum Thickness of Vertical Core, (in)	Maximum Spacing of Vertical Cores, (in)	Maximum Spacing of Horizontal Cores, (in)	Minimum Web Thickness, (in)
Waffle-Grid					
6	6.25	5	12	16	2
8	7	7	12	16	2
Screen-Grid					
6	5.5	5.5	12	16	0

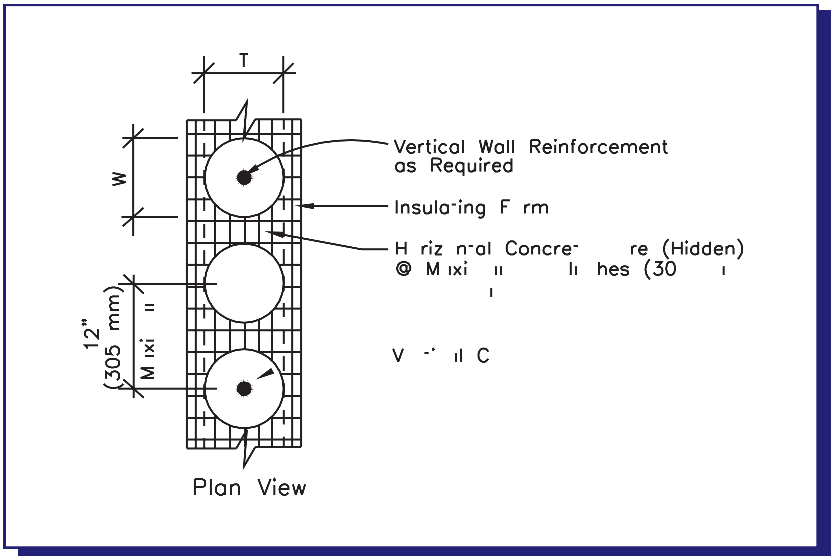


Figure 3.3. Screen-Grid ICF Wall Systems

Form Materials

Insulating concrete forms shall be constructed of rigid foam plastic meeting the requirements of ASTM C 578 [12], a composite of cement and foam insulation, a composite of cement and wood chips, or other approved material. Forms shall provide sufficient strength to contain concrete during the concrete placement operation. Flame-spread rating of forms shall be less than 75 and smoke-developed rating of forms shall be less than 450 tested in accordance with ASTM E 84 [10].

Concrete Materials

Concrete Mix

Ready-mixed concrete for ICF walls shall meet the requirements of ASTM C 94 [13]. Maximum slump shall not be greater than 6 inches (152 mm) as determined in accordance with ASTM C 143 [9]. Maximum aggregate size shall not be larger than 3/4 inch (19 mm).

Exception: *Maximum slump requirements may be exceeded for approved concrete mixtures resistant to segregation, meeting the concrete compressive strength requirements, and in accordance with the ICF manufacturer's recommendations.*

Compressive Strength

The minimum compressive strength of concrete, f_c', shall be 2,500 psi (17.2 MPa) at 28 days as determined in accordance with ASTM C 31 [7] and ASTM C 39 [8]. For Seismic Design Categories D_1 and D_2 the minimum compressive strength of concrete f_c', shall be 3,000 psi.

Reinforcing Steel

Reinforcing steel used in ICFs shall meet the requirements of ASTM A 615 [14], ASTM A 616 [15], ASTM A 617 [16], or ASTM A 706 [17]. The minimum yield strength of the reinforcing steel shall be Grade 40 (300 MPa). Reinforcement shall be secured in the proper location in the forms with tie wire or other bar support system such that displacement will not occur during the concrete placement operation. Steel reinforcement shall have a minimum 3/4-inch (19-mm) concrete cover. Horizontal and vertical wall reinforcement shall not vary outside of the middle third of beams, columns, lintels, horizontal and vertical cores, and flat walls for all wall sizes.

Cold-Formed Steel

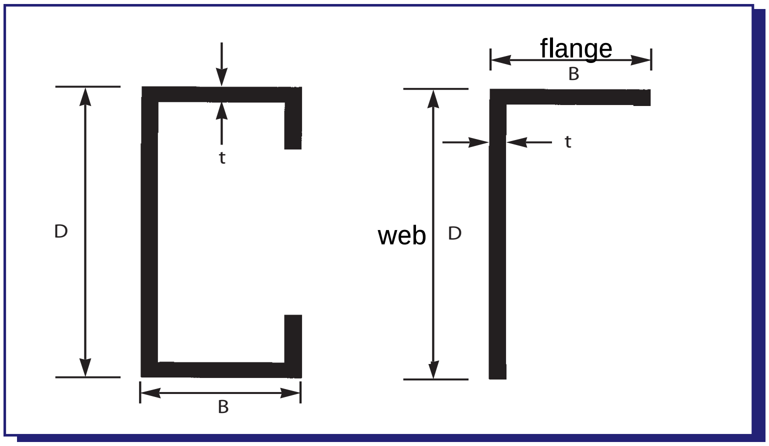
Material

Structural and non-structural framing members utilized in steel construction shall be cold-formed to chape from sheet steel complying with the requirements of ASTM A1003/A1003M [23].

Corrosion Protection

Structural and non-structural framing members utilized in steel construction shall have a minimum metallic coating complying with the requirements of ASTM A1003/A1003M [23]. Unless additional corrosion protection is provided, framing members shall be located within the building envelope and adequately shielded from direct contact with moisture from the ground or the outdoor climate. Dissimilar metals shall not be used in direct contact with steel framing members. Steel framing members shall not be embedded in concrete, unless approved for that purpose.

Fasteners shall have rust inhibitive coating suitable for the installation in which they are being used, or be manufactured from material not susceptible to corrosion.



Member Designation

Member Designation

The standard designator defined in this section is used to identify framing members used in cold-formed steel construction. The designator consists of the following sequential codes:

A three or four-digit numerical indicating member web depth in 1/1000 inch. A letter indicating:

S = Stud or joist framing member which have lips
T = Track section
U = Channel or stud framing section which do not have lips
F = Furring channels
L = Angle or L-header

A three-digit numerical indicating flange width in 1/100 inch, followed by a dash. A two or three-digit numerical indicating base metal thickness in 1/1000 inch (mils).

Example: Designation for a 5 1/2"-16 gauge C-shape with 1 5/8" flanges:
550S162-54

550 S 162 -54

Minimum base metal thickness in mils (0.054 in. = 54 mils)
1 5/8" flange width in 1/100th inches
Stud or joist with flange stiffeners
5 1/2" member depth in 1/100th inches (outside-to-outside dimension)

Example: Designation for an 8"-18 gauge L-Header with 1 1/2" short leg:
2-800L150-43

800 L 150 -43

Minimum base metal thickness in mils (0.043 in. = 43 mils)

1 1/2" width of short leg of angle in 1/100th inches

Angle or L-header

8" long leg of angle depth in 1/100th inches (outside-to-outside dimension)

Physical Dimensions

Cold-formed structural steel members shall comply with Figure 3.5 and the dimensional requirements specified in Table 3.2. Tracks shall comply with Figure 3.4 and shall have a minimum of 1-1/4 inch (32 mm) flanges. Members with different geometrical shapes shall not be used with these provisions without the approval of a design professional. Dimensional tolerances shall be in accordance with ASTM C955 [22] for load bearing members and ASTM C645 [21] for non-structural members.

TABLE 3.2
COLD-FORMED STEEL MEMBER SIZES

Member Designation[1]	Web Depth[2] (inches)	Minimum Flange Width[2,3] (inches)
350S162-t	3.5	1.625
550S162-t	5.5	1.625
800S162-t	8	1.625
1000S162-t	10	1.625
1200S162-t	12	1.625
350T125-t	3.5	1.25
550T125-t	5.5	1.25
800T125-t	8	1.25
1000T125-t	10	1.25
1200T125-t	12	1.25
600L150-t	6	1.50
800L150-t	8	1.50
1000L150-t	10	1.50

For SI: 1 inch = 25.4 mm.
[1] "t" indicates the bare metal thickness of the steel, expressed in mils.
[2] Web represents long leg size and flange represents short leg size for L-header angles.
[3] Maximum flange width is 2 inches; minimum lip size is 0.5 inches.

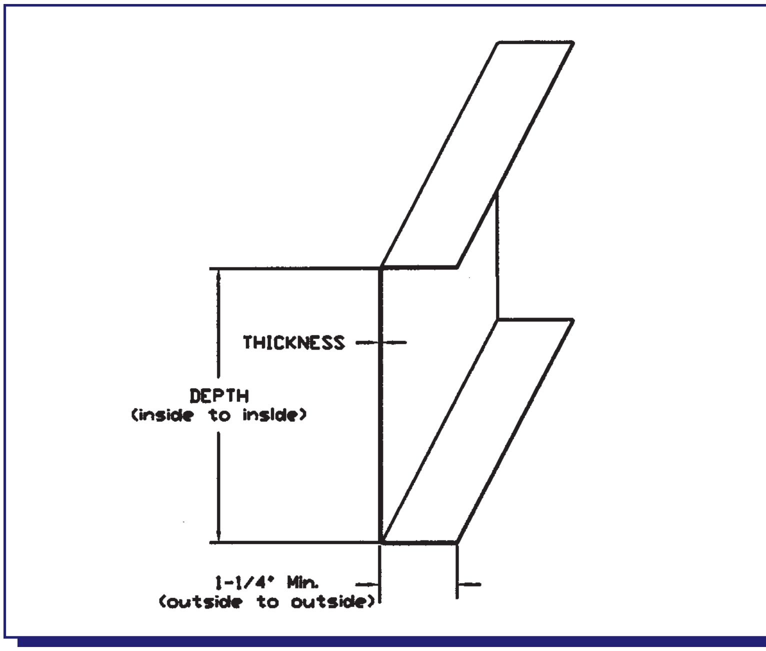


Figure 3.4. Track Section Dimensions

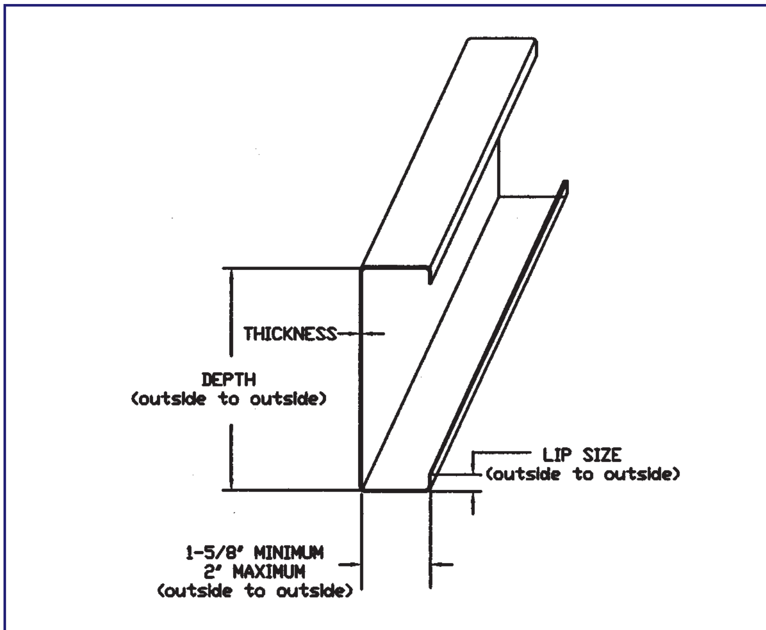


Figure 3.5. C-Shape Section Dimensions

Base Metal Thickness

The material thickness of framing members, in their end-use, shall meet or exceed the minimum base metal thickness values given in Table 3.3.

TABLE 3.3
MINIMUM BASE METAL THICKNESS OF COLD-FORMED STEEL MEMBERS

Designation (thickness in mils)	Minimum Base Metal Thickness, Inches (mm) [1]	Old Reference Gauge Number [2]
18	0.0179 (0.455)	25
27	0.0269 (0.683)	22
30	0.0296 (0.752)	20 - Drywall [1]
33	0.0329 (0.836)	20 - Structural [1]
43	0.0428 (1.09)	18
54	0.0538 (1.37)	16
68	0.0677 (1.72)	14
97	0.0966 (2.45)	12
118	0.1180 (3.00)	10

[1] Design thickness should be the minimum base metal thickness divided by 0.95.
[2] Gauge thickness is an obsolete method of specifying sheet and strip steel thickness. Gauge numbers are only a very rough approximation of steel thickness and shall not be used to order, design or specify any sheet or strip steel product.
[3] Historically, 20 gauge material has been furnished in two different thicknesses for structural and drywall (non-structural) applications.

Bend Radius

The maximum bend radius shall be the greater of the following:

- 3/32 inch (2.4 mm), or
- two times the material thickness (2t) but not greater than 1/8 inch (3.2 mm).

Yield Strength

The yield strength of steel members shall be determined in accordance with ASTM A370 [11]. Unless otherwise specified as 50 ksi (345 MPa), the minimum yield strength (or yield point) of cold-formed steel C-shapes, tracks, flat straps, and other members shall be 33 ksi (228 MPa).

Product Identification

Framing members used in steel construction shall be identified with a ledgible sticker, stamp, stencil, or embossment, spaced a maximum of 48 inches (1220 mm) on center and located on the web of the framing member, in accordance with one of the following standards:

ASTM C645 (Non-structural framing members only)
ASTM C955 (Structural framing members only)
ASTM A1003/A1003M (Framing members not described in ASTM C645 or C955)

Performance of Steel in Homes

Steel-framing members located in an indoor atmosphere (such as wall and floor framing) have a very low rate of corrosion. Studies showed that the corrosion of zinc is lower than 0.1 µm per 3-year period in houses located in different rural, urban, marine, and industrial atmospheres. It can be concluded that a typical G40 zinc coated steel (10 µm = 0.39 mils) should outlast the life expectancy of a residential building.

Galvanized Steel in Contact With Building Materials

Contact With Other Metals

An electrochemical reaction occurs between dissimilar metals or alloys that can cause corrosion of one metal and protection of the other when they are in contact. This reaction will only occur when the dissimilar metals are connected in an electrolyte medium (such as moisture). In normal indoor environments, moisture levels are usually very low, and consequently, the galvanic action between dissimilar metals is much lower than those occurring in outdoor environments. Steel framing members are generally coated with zinc or aluminum alloy. Both zinc and steel will react adversely with brass and copper used for plumbing installations—this is known as a “galvanic reaction” or “galvanic corrosion” and can lead to durability problems just like other forms of corrosion. Steel Framing Alliance publication NT16-97, *Durability of Cold-Formed Steel Framing Members,* [24] provides detailed information on galvanized coatings in contact with building materials. Steel framing members can be easily isolated from other metals by plastic insulators or grommets.

Contact With Mortar and Plaster

Fresh mortar and plaster may attack zinc and zinc alloy coating when damp, but corrosion ceases when the materials dry.

Contact With Wood

Metallic coated steel does not react with dry wood. Dry pressure-treated lumber is also not corrosive to zinc, and no special requirements are needed to fasten steel to wood framing. Galvanized nails and screws have been successfully used to join wood and steel materials for years.

Contact With Drywall and Insulation Products

Drywall, mineral wool, cellulose, and rigid foam insulating products do not react with galvanized steel.

Contact With Concrete

Good quality chloride-free concrete is not corrosive to zinc once it has cured.

Bearing Stiffeners

A bearing stiffener (also referred to as web stiffener) shall be fabricated from a minimum 33 mil (0.84 mm) C-shaped member or 43 mil (1.09 mm) track member. Each stiffener shall be fastened to the web of the member it is stiffening with a minimum of four No. 8 screws equally spaced. Bearing stiffeners shall extend across the depth of the web and shall be installed on either side of the member.

Clip Angles

Clip angles shall have a minimum size of 2 inches x 2 inches by 33 mil (51 mm x 51 mm x 0.84 mm), unless otherwise noted. All clip angle materials shall comply with the following sections: “Structural Members,” “Yield Strength,” and “Corrosion Protection.”

Fasteners

Fastening cold-formed steel framing members can be accomplished using different methods and techniques. The most common methods of fastening steel to steel are accomplished by screwing, welding, clinching, and nailing. Self-drilling, tapping screws are the most prevalent fasteners. Other fastening techniques, such as the use of pneumatically driven fasteners, powder-actuated fasteners, crimping, clinching, or welding, shall be permitted when approved. Screws are typically applied with a positive-clutch electric screw gun.

Screws

Holes are not typically drilled in steel framing before installing the screws. Therefore, self-drilling, self-tapping screws are the most common fasteners used to frame steel members. Screws are available in diameters ranging from No. 6 to No. 14, with No. 6 to No. 10 being the most common. Lengths typically vary from 1/2 inch (12 mm) to as much as 3 inches (76 mm) depending on the application. Screws are generally 3/8 inch (9.5 mm) to 1/2 inch (12.7 mm) longer than the thickness of the connected materials so that a minimum of three threads shall extend beyond the connected material. It is important that the drill point be as long as the material thickness being fastened to drill effectively. The correct fastener type and length for each application should be selected by consulting the screw manufacturer's specifications and catalogs.

Point Types

Two specific point types are commonly used, as shown in Figure 3.6:

- Self-Drilling Screws: Externally threaded fasteners with the ability to drill their own hole and form, or "tap," their own internal threads without deforming their own thread and without breaking during assembly. These screws are used with 33 mil (0.84 mm) steel or thicker.
- Self-Piercing Screws (sharp point): Externally threaded fasteners with the ability to pierce relatively thin steel material. They are commonly used to attach rigid materials, such as gypsum wallboard, to 33 mil (0.84 mm) or thinner steel.

For drill point screws, the total thickness of steel determines the point style of the screw to use. The larger the point style number and the larger the screw diameter, the more material the screw is capable of penetrating. Screw sizes should be selected based on the total thickness of the steel layers. While point styles 1, 4, and 5 are available, the most common are point styles 2 and 3.

Figure 3.6. Screw Point Type

Body Diameter

The body diameter of a screw is related to the nominal screw size as shown in Table 3.4. All connections shall be made with minimum of a No. 8 screw, except when attaching gypsum wallboard using a No. 6 screw.

TABLE 3.4
SCREW BODY DIAMETER

Screw Nominal Size	Nominal Screw Diameter, d, in.
No. 6	0.1380
No. 8	0.1640
No. 10	0.1900
No. 12	0.2160
1/4"	0.2500

For SI: 1 inch = 25.4 mm.

Length

The length of a screw is measured from the bearing surface of the head to the end of the point as shown in Figure 3.7. For example, the length of a flat or countersunk head is measured from the top of the head to the end of the point. A pan head screw length is measured from under the head (bearing surface) to the end of the point.

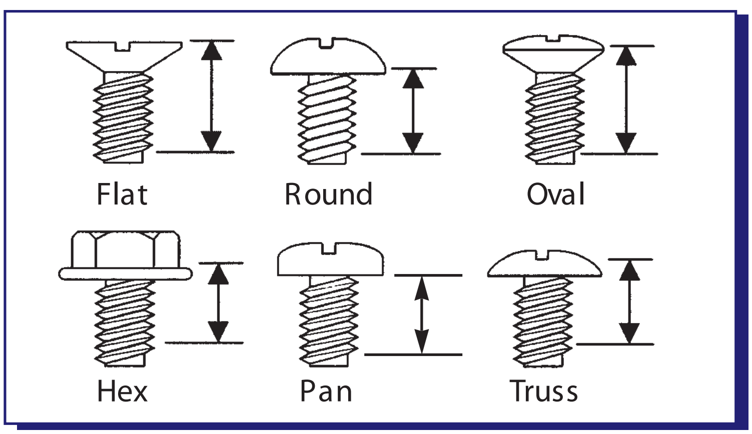


Figure 3.7. Screw Length Measurements
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The length of self-drilling screws may require special consideration since some designs have an unthreaded pilot section or reamer with wings between the threads and the drill point as shown in Figure 3.7. These features may be necessary for certain applications, such as applying wood sheathing to a steel floor joist. The long pilot point or reamer (see Figure 3.8) is required to allow the screw to drill through the material before engaging the threads. If the threads engage before the pilot hole is drilled completely, a gap may result in the connection. This can result in a squeaky connection or “screw-pops” through certain finish materials.

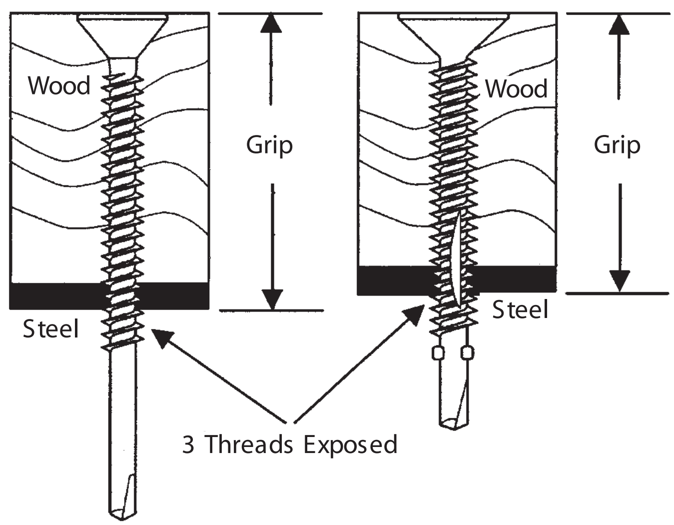

Figure 3.8. Screw Grip Range
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Thread

Self-piercing and self-drilling screws intended for cold formed steel applications generally have a coarse thread (e.g., 10-16 x 5/8 HWH SD indicates a 10 diameter, 16 threads per inch, 5/8" length, hex washer head, self-drilling screw). Self-drilling screws with fine threads are permitted. Manufacturer recommendations should be followed.

Corrosion Resistance

Common platings for corrosion resistance include zinc (mechanical galvanizing), phosphate and oil, and zinc with a yellow dichromate finish (gold color appearance). Self-drilling screws are typically zinc plated.

Screw Head Types

The screw head locks the screw in place and prevents it from sinking into the fastened material, and it draws the fastened material together. Common head styles include flat, oval, wafer, truss, modified truss, hex washer, pan, round washer, and pancake. See Figure 3.9. The specified style shall be determined by the application, preference, and availability. However, hex head screws are typically used for heavier structural connections. Round washer screws are typically used for general framing connections. Low profile heads are used on surfaces to be finished with gypsum board. And bugle head screws are typically used to attach sheathing products.

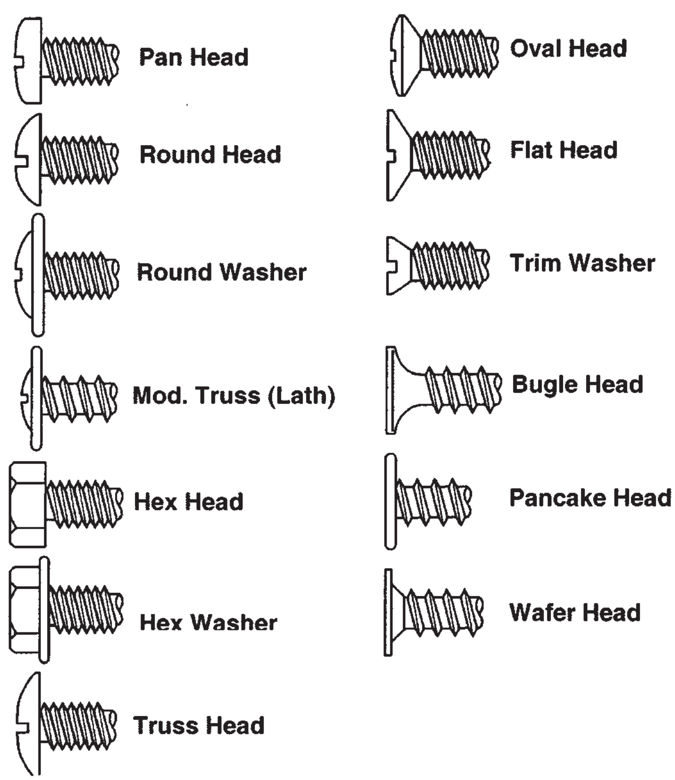

Figure 3.9. Screw Head Types
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Drive Types

Availability and preference determines drive types. Common drive types are shown in Figure 3.10.

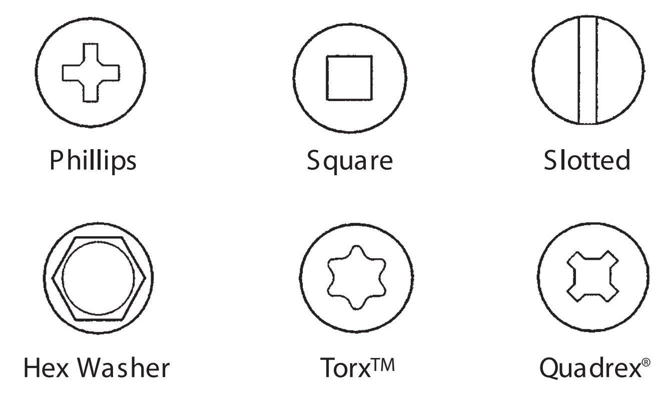

Figure 3.10. Screw Drive Types
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Screw Requirements

For all connections, screws shall extend through the steel a minimum of three exposed threads as shown in Figures 3.11 and 3.12. Screws shall penetrate individual components of a connection without causing permanent separation between the components. Screws shall be installed in a manner such that the threads and holes are not stripped. Self-drilling tapping screws shall have a coating of 3 microns of zinc, or satisfy a 24-hour salt spray test (ASTM F1941) [25] or equivalent corrosion protection. Where No. 8 screws are specified in a steel-to-steel connection, the required

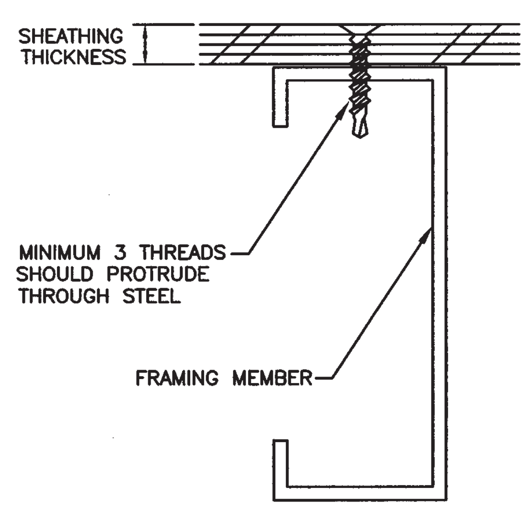

Figure 3.11 Floor Sheathing-to-Steel Connection
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number of screws in the connection is permitted to be reduced in accordance with the reduction factors in Table 3.6 when larger screws are used or when one of the sheets of steel being connected is thicker than 33 mils (0.84 mm). When applying the reduction factor, the resulting number of screws shall be rounded up.

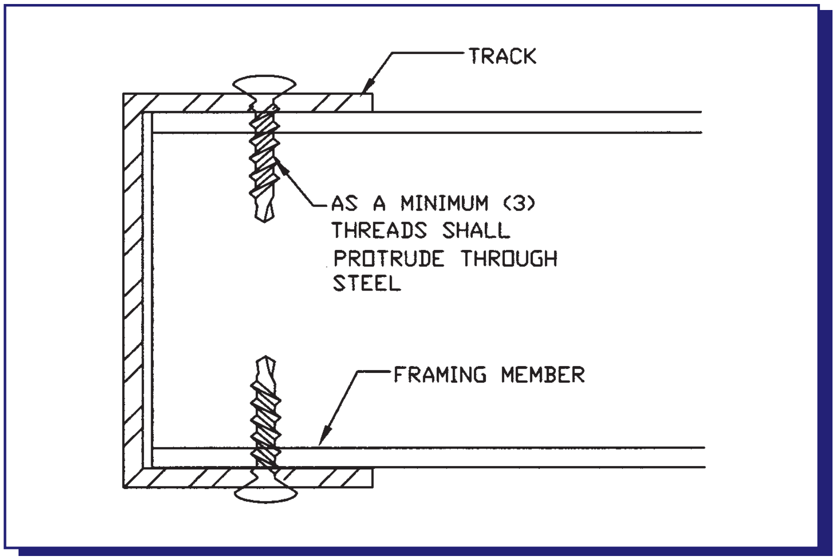

Figure 3.12. Steel-to-Steel Screw Connection
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TABLE 3.5
SCREW SUBSTITUTION FACTOR

Screw Nominal Size	Thinnest Connected Steel Sheet (mil)	
	33	43
No. 8	1.0	0.67
No. 10	0.93	0.62
No. 12	0.86	0.56

For SI: 1 inch = 25.4 mm.

Steel-to-Steel Connections

Screws for steel-to-steel connections shall be installed with a minimum edge distance and center to center spacing of 1/2 inch (13 mm), and shall be self-drilling tapping in compliance with SAE J-78 [26].

Structural Sheathing to Steel Connections

Structural sheathing shall be attached to steel framing (i.e., studs and joists) with minimum No. 8 self-drilling tapping screws in compliance with SAE J-78 [26]. Screws attaching structural sheathing to steel joists and wall framing shall have a minimum head diameter of 0.292 inch (7 mm) with countersunk heads and shall be installed with a minimum edge distance of 3/8 inch (9 mm).

Gypsum Board to Steel Connections

Gypsum board shall be attached to steel framing with minimum No. 6 screws conforming to ASTM C954 [27] and shall be installed in accordance with the applicable building code requirements for interior wall and ceiling finishes.

Drive Pins and Nails

Pneumatic pins and nails are specifically designed with spiral grooves or knurls on the nail shaft to penetrate the steel. Drive pins and nails are typically used with airguns. Drive pins and nails are primarily used in attaching wood sheathing to wall and roof framing. Care should be taken and manufacturer's recommendations should be followed carefully when fastening subflooring to joists using drive pins and nails, in order to prevent the assembly from creating noise.

Bolts

Bolts are used in cold-formed steel framing when required to anchor a floor or a wall to foundations. The most common anchors used in steel construction are anchor bolts, mudsill anchors, anchor straps, mushroom spikes, and powder-actuated anchors. Bolts shall meet or exceed the requirements of ASTM A307 [28]. Washers and nuts shall be properly installed and tightened. Bolts connecting steel framing to concrete shall have bolt holes spaced no closer than three bolt diameters on center. The distance from the center of the bolt hole to the edge of the connecting member shall not be less than one and one-half bolt diameters.

Chapter 4

ICF-to-Steel Floor Connection Methods

Introduction

Cold-formed steel floor framing shall be connected to ICF exterior walls in accordance with this section. Cold-formed steel framing members and insulating concrete form walls shall comply with the provisions of Chapter 2.

Construction of ICF walls shall be in accordance with the International Residential Code [6] Section R611. Construction of cold-formed steel floors shall be in accordance with the AISI Standard for Cold-Formed Steel Framing - Prescriptive Method for One and Two Family Dwellings [29] Section D.

> ***Connection Tip***
>
> In many cases one may connect the floor joist to the track with only fasteners through the top and bottom flanges. For the situations in which this is allowed refer to the AISI Standard for Cold-Formed Steel Framing - Prescriptive Method for One and Two Family Dwellings [29] Section D.

Table 4.1 is used to obtain applicable design velocity pressure for the building. Tables 4.2 through 4.4 are used to determine required connector schedules.

Ends of the steel floor joists shall have square end cuts and shall be seated tight and squarely against the tracks with a maximum gap tolerance of 1/8 inch (3.2 mm) between the end of the floor joist and the web of the track.

In some cases it might be difficult to reinforce the floor joist to ledger track connection with a steel clip angle or a web stiffener, because concrete behind the ledger may interfere with the fasteners running through the ledger. In those cases, one may connect the joist to the track with fasteners through the top and bottom flanges and omit the clip angle or bearing stiffener. However, doing so is limited to the floor members and span distances specified in the AISI Standard for Cold-Formed Steel Framing - Prescriptive Method for One and Two Family Dwellings [29] Section D.

In the cases where the floor framing is placed on top of the ICF exterior walls, bearing stiffeners or clip angles shall be installed on the floor joists in accordance with the AISI Standard for Cold-Formed Steel Framing - Prescriptive Method for One and Two Family Dwellings [29] Section D.

Several alternative floor systems are described further in this chapter.

Applicability Limits

The data provided here apply to buildings within the limits of the “Scope” section in Chapter 2, where Table 2.1 shall apply.

Connectors, as required in this section, shall be provided to ensure a continuous path capable of transferring out-of-plane and in-plane loads from the ICF walls and the steel floor framing to the foundation.

Concrete anchor connectors and bolts must always be embedded within the applicable limits in the ICF wall specified within this chapter.

Floor Connection Requirements

Anchor Bolt

Anchor bolts shall be secured in place before the concrete pour. The concrete should have no voids and be allowed to flow to the inside face of the ICF form at the backing points. The minimum area of the concrete backing shall be 4 inches (101.6 mm) wide by 6 inches (152.4 mm) high centered for each anchor bolt.

Anchor bolts shall be located at the predetermined connection locations as required for the steel ledger. The anchor bolts shall be minimum 1/2 inch (12.7 mm) diameter, Grade A307, anchor bolts embedded in the ICF in accordance with Figure 4.1. Connection of the steel ledger to the ICF shall be with minimum 1-1/4 inch (31.75 mm) diameter washers and nuts .The diameter of the pre-drilled holes in the steel ledger is permitted to be oversized by not greater than 1/8 inch (3.17 mm) of the diameter of the anchor bolt. A washer shall always be used between the nut and the connected steel member.

Anchor bolts shall be installed in accordance with Table 4.2. Anchor bolts shall have a minimum 4 inch (178 mm) concrete embedment into the wall not taking into consideration the concrete pad. The minimum distance to the concrete edge shall be 2.5 inches (63.5 mm).

Bolts shall be located not more than 12 inches (305 mm) from wall corners, wall ends or joints in the ledger track.

In Seismic Design Categories C, D_1 and D_2 additional anchorage capacity between the ICF load bearing wall and the floor diaphragm shall be provided as per Table 4.3. The anchorage mechanisms shall be installed at a maximum spacing of 6 feet (1.8 m) on center for Seismic Design Category C and 4 feet (1.2 m) on center for Seismic Design Categories D_1 and D_2.

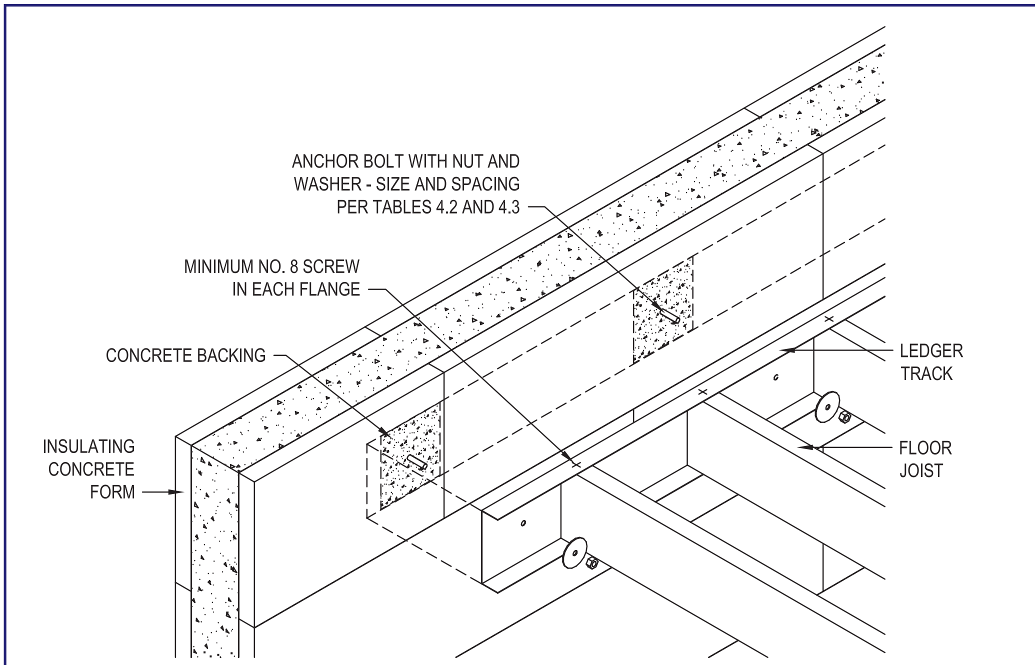


Figure 4.1. Anchor Bolt to Ledger Track Connection

Refer to Table 4.2 for Required Installation Schedules

Right Angle Steel Plate

The right angle ledger connector shall be secured in place before the concrete pour.

A minimum 54 mil (16 gauge) right angle steel plate shall be used. For the ledger connector with the exposed portion of plate being a minimum 2 inch (50.8 mm) by 10 inch (254 mm) to allow for fastening to ledger track as per Figure 4.2. The right angle ledger connector shall be sized and spaced as per manufacturer's data.

Concrete embedment of the connector shall be a minimum 4 inches (178 mm) deep. Connectors shall be located not more than 12 inches (305 mm) from wall corners or wall ends.

Minimum 3 1/4-inch (6.35 mm) screws (shown) or 4-No. 12 self drilling screws shall connect the ledger track to the right angle ledger connector plate.

In Seismic Design Categories C, D_1 and D_2 additional anchorage capacity between the ICF load bearing wall and the floor diaphragm shall be provided as per Table 4.3. The anchorage shall be installed at a maximum spacing of 6 feet (1.8 m) on center for Seismic Design Category C and 4 feet (1.2 m) on center for Seismic Design Categories D_1 and D_2.

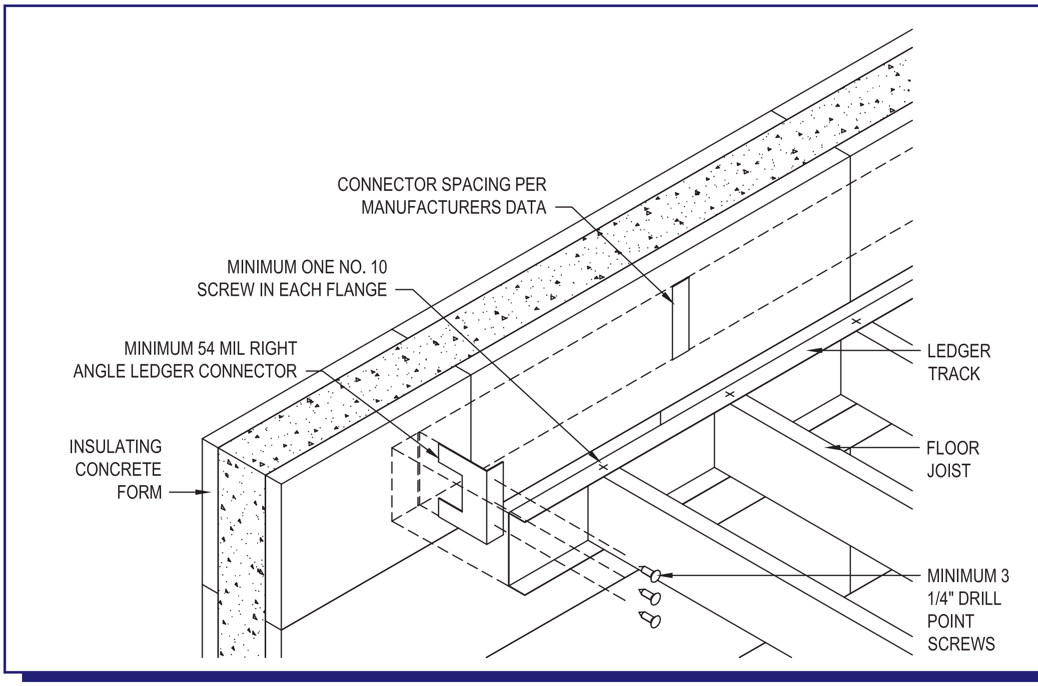


Figure 4.2. Right Angle Plate to Ledger Track Connection

Connection at End Floor Joist

Anchor bolts shall be secured in place before the concrete pour. The concrete should have no voids and be allowed to flow to the inside face of the ICF form at the backing points. The minimum area of the concrete backing shall be 4 inches (101.6 mm) wide by 6 inches (152.4 mm) high centered for each anchor bolt.

Anchor bolts shall be located at the predetermined connection locations as required for the steel ledger. The anchor bolts shall be minimum 1/2 inch (12.7 mm) diameter, Grade A307, anchor bolts which are to be embedded in the ICF in accordance with Figure 4.3. Connection of the steel ledger to the ICF shall be with minimum 1-1/4 inch (31.75 mm) diameter washers and nuts. The diameter of the pre-drilled holes in the steel ledger is permitted to be oversized by not greater than 1/8 inch (3.17 mm) of the diameter of the anchor bolt. A washer shall always be used between the nut and the connected steel member.

Anchor bolts shall be installed in accordance with Table 4.4. Anchor bolts shall have a minimum 4 inch (178 mm) concrete embedment into the wall not taking into consideration the concrete pad. The minimum distance to the concrete edge shall be 2.5 inches (63.5 mm).

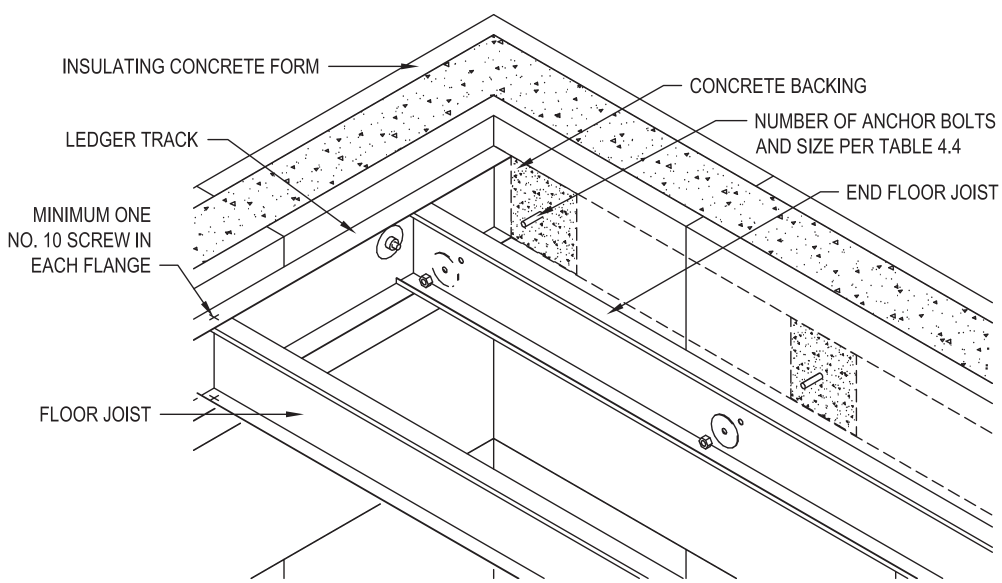


Figure 4.3. Connection at End Floor Joist

Refer to Table 4.4 for Required Installation Schedules

Bolts shall be located not more than 12 inches (305 mm) from wall corners or wall ends.

In Seismic Design Categories C, D_1 and D_2 additional anchorage capacity between the ICF load bearing wall and the floor diaphragm shall be provided as per Table 4.3. The anchorage shall be installed at a maximum spacing of 6 feet (1.8 m) on center for Seismic Design Category C and 4 feet (1.2 m) on center for Seismic Design Categories D_1 and D_2.

TABLE 4.1
LATERAL VELOCITY PRESSURE FOR DETERMINATION OF ICF-TO-FLOOR CONNECTION REQUIREMENTS [1]

Wind Speed (mph)	Velocity Pressure (psf)		
	Exposure [2]		
	B	C	D
85	12	16	19
90	13	17	21
100	16	22	26
110	19	27	31
120	22	32	37
130	27	37	43
140	31	42	50

For SI: 1 psf = 0.0479 kN/m^2; 1 mph = 1.6093 km/hr.

[1] Table values are based on ASCE 7-98 Figure 6-4 wind velocity pressures for low-rise buildings using a mean roof height of 35 ft (10.7 m).
[2] Exposure as defined in Chapter 2.

TABLE 4.2
MAXIMUM CONNECTOR SPACING
AT STEEL LEDGER TRACK TO ICF WALL CONNECTION [1, 2]

Design Velocity Pressure, (psf)		20	25	30	35	40	45	50
Ledger Track Thickness, (mil)	Floor Span, (ft)[3]	Maximum Connector Spacing Along Wall at Ledger Track, (in) [4]						
43 mil (18 gauge)	8	12	10	DR	DR	DR	DR	DR
	16	12	10	DR	DR	DR	DR	DR
	24	12	10	DR	DR	DR	DR	DR
	30	12	10	DR	DR	DR	DR	DR
54 mil (16 gauge)	8	14	12	10	10	10	DR	DR
	16	14	12	10	10	10	DR	DR
	24	14	12	10	10	10	DR	DR
	30	14	12	10	10	10	DR	DR
68 mil (14 gauge)	8	20	18	16	16	14	14	12
	16	20	18	16	16	14	14	12
	24	20	18	16	16	14	14	12
	30	20	18	16	16	14	14	12
97 mil (12 gauge)	8	38	34	30	28	26	26	24
	16	36	34	30	28	26	26	24
	24	26	24	24	22	22	22	20
	30	20	20	18	18	18	16	16

For SI: 1 psf = 0.0479 kN/m^2; 1 ft = 0.3048 m; 1 in = 25.4 mm; 1 mil = 0.0254 mm.

[1] Minimum ledger track flange width shall be 2.00 inches (41.28 mm).
[2] Interpolation is permitted between floor spans.
[3] Floor span corresponds to the clear span of the floor structure (i.e. joists or trusses) spanning between load bearing walls or beams.
[4] Connectors shall extend through the ledger to the center of the flat ICF wall thickness or the center of the horizontal or vertical core thickness of the waffle-grid or screen-grid ICF system.

DR - Indicates Design Required

TABLE 4.3
ADDITIONAL CAPACITY REQUIRED (plf) FOR LEDGER TRACK TO ICF WALL CONNECTION IN DESIGN CATEGORIES C, D_1 AND D_2

Nominal ICF Wall Thickness, (in)	Seismic Design Category		
	C	D_1	D_2
4	193	320	450
6	303	502	708
8	413	685	965
10	523	867	1223

For SI: 1 psf = 0.0479 kN/m^2; 1 mph = 1.6093 km/hr.

1. Table values are based on IBC Equation 16-63 using a tributary wall height of 11 feet (3,353 mm).
2. Table values may be reduced by 30 percent to determine minimum allowable stress design values for anchors.

TABLE 4.4
MINIMUM NUMBER OF ANCHOR BOLTS REQUIRED ALONG END FLOOR JOIST TO ICF SIDE WALL CONNECTION [1]

Design Velocity Pressure, (psf)		20	25	30	35	40	45	50
Anchor Bolt Diameter, (in)	Building Side Wall Length, (ft)	Number of Shear Connectors Needed Along Side Wall at End Floor Joists						
1 / 2	16	3	3	4	4	5	5	6
	24	4	4	5	6	7	7	8
	32	5	6	7	8	9	10	11
	40	6	7	8	9	11	12	13
	50	7	8	10	11	13	15	16
	60	8	10	12	14	16	17	19
5 / 8	16	1	2	2	2	2	2	3
	24	2	2	2	3	3	3	4
	32	2	3	3	3	4	4	5
	40	3	3	4	4	5	5	6
	50	3	4	4	5	6	6	7
	60	4	4	5	6	7	7	8

For SI: 1 psf = 0.0479 kN/m^2; 1 ft = 0.3048 m; 1 in = 25.4 mm.

[1] Anchor bolts shall extend through the ledger to the center of the flat ICF wall thickness or the center of the horizontal or vertical core thickness of the waffle-grid or screen-grid ICF system.

Steel-and-Concrete Floors

Several floor systems constructed of cold-formed steel and concrete are currently available for use in place of conventional floors built of joists topped with wood-based sheathing. As with other assemblies built of ICFs and CFS framing, these steel-and-concrete floors promise such benefits as:

- Durability
- Strength
- Consistency of material
- Price stability of material
- Ecological benefits

They also offer additional advantages in use, including:

- Increased sound attenuation between stories
- Suitability for in-floor radiant heating

Following are overview descriptions of steel-and-concrete floor systems. They do not comply within the applicability limits set forth in Table 2.1, therefore prescriptive requirements are not provided in this document. Detailed design specifications and product information are available from their manufacturers.

Concrete - Topped Steel Deck

The concrete-topped steel deck (Figure 4.4-A) is one of the simplest floors built of CFS and concrete.

With a concrete-topped steel deck, the floor sheathing consists of a shallow corrugated steel sheet typically 9/16" thick, topped with a relatively thin layer of concrete. The concrete layer may be as thin as 1.5". The floor framing is conventional CFS frame. However, it must be designed to bear the additional dead load from the relatively heavy steel-and-concrete composite sheathing. Lateral support consistent with the weight of the materials must also be installed. No concrete reinforcement is required, unless desired to minimize cracking.

The work of assembling the steel framing proceeds similarly to that for a conventional CFS floor deck. The steel sheet is fastened to the joists over the entire floor area, with the corrugations oriented perpendicular to the joists. After the sheet is in place, the concrete is placed on top using conventional concrete placement and finishing methods.

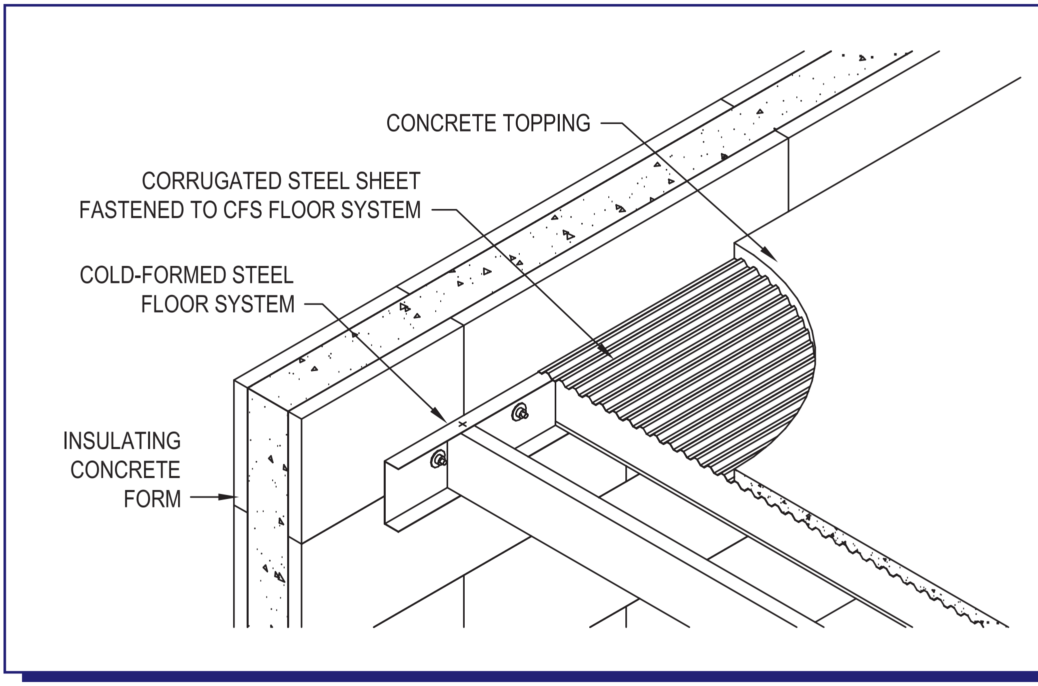


Figure 4.4-A. Concrete-topped Steel Deck

Foam/CFS Concrete Form Deck

Foam/CFS concrete form decks (Figure 4.4-B) use many of the same materials and methods as ICF wall construction. In this regard, they may be readily adopted by ICF crews. They also have the unique feature of providing a thick layer of foam. This provides insulation, which may be useful when the floor separates two different heating/cooling zones. Accommodating items installed in the floor space (i.e., utility lines and recessed lights) involves cutting away sections of the foam. Wallboard may be fastened on the underside of the joists.

The floor forms consist of foam panels in a variety of lengths. The panels include recesses to create beam pockets that run the entire length of the panel. Within the foam are also hollow cylindrical cores and CFS joists that run the panel length. The cores provide a convenient location for running utility lines. The joists support the panels during concrete placement and cure. Steel rebar is set in the beam pockets and welded wire steel mesh goes within the upper layer of concrete. Some of the rebar is tied into the ICF wall.

Installers set the floor form panels on top of the inner foam shell of the ICF form wall. It is necessary to have an outer shell around the panels to create an edge form for the concrete. This may be accomplished by cutting the inner shell off the next

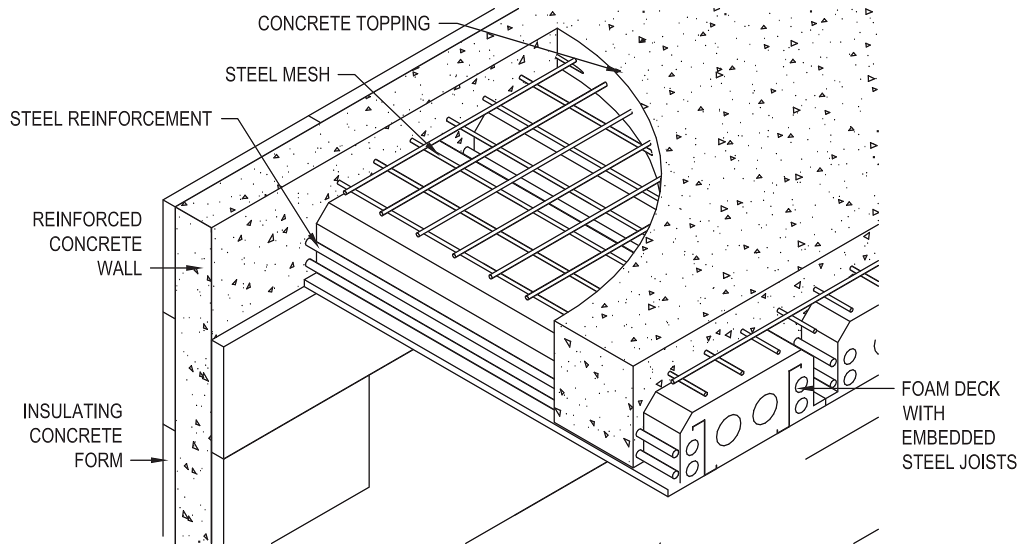


Figure 4.4-B. Foam / CFS Concrete Form Deck

course of ICF blocks and setting them in place. Temporary bracing is set beneath the panels at intervals of about 6 feet. The rebar and mesh go in place on top of rebar chairs. Concrete placement and finishing proceed according to the conventional methods for floor slabs. Crews may readily walk on the form deck throughout construction so long as they avoid certain weak spots, like the bottom of the beam pockets.

CFS Joist / Concrete Composite

This system combines concrete and special CFS joists (Figure 4.4-C) in a structural composite connection. It requires no permanent form material. It also requires no steel reinforcement beyond a layer of welded wire mesh. Because the joists have large cutouts, utility lines may run in either direction. Strapping is generally attached to the bottoms of the joists as a substrate for the connection of wallboard.

The CFS joists are placed at four foot intervals, except where floor dimensions require closer spacing. The joists have deformed flanges along their top edges. The concrete encases the flanges, creating a connection between concrete and steel that results in a structural composite. Welded wire steel mesh within the concrete layer reinforces the concrete between the joists and controls cracking.

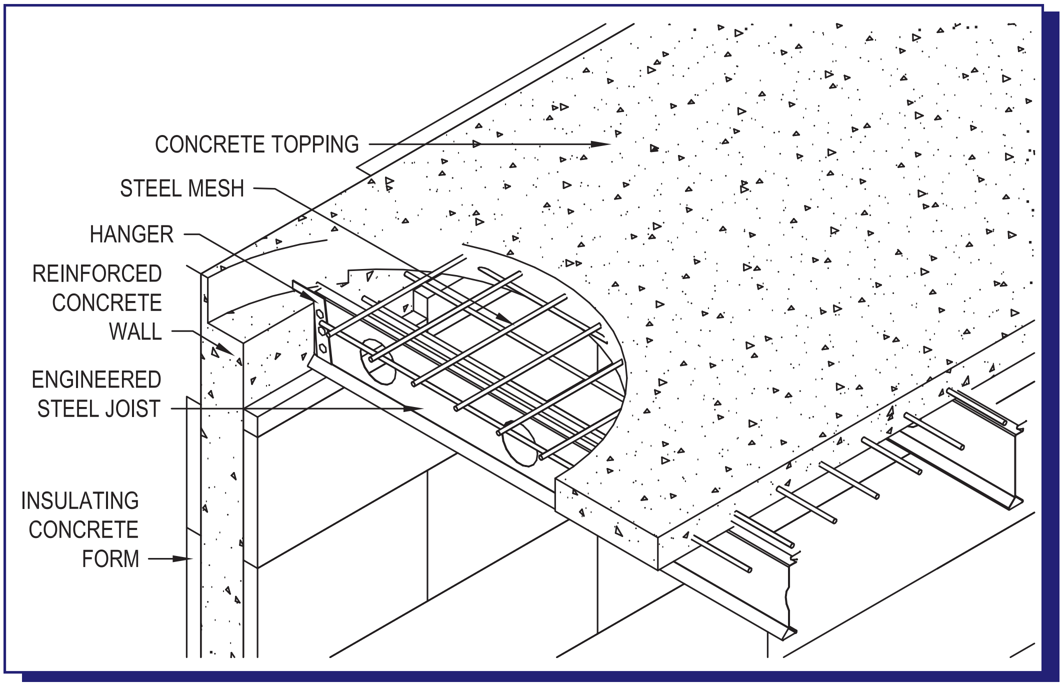


Figure 4.4-C. CFS Joist/Concrete Composite

The joists are cut to length, heavy steel "hangers" are attached to each joist end. The hangers project a few inches past the end of the joist. They rest on the top of the concrete wall, suspending the joists in position during construction. Standard plywood sheets are set between the joists and rest on special steel "roll bars". The roll bars run perpendicular to the joists and bear on them. The crew drapes welded wire steel mesh over the deformed flanges across the entire floor. Concrete placement and finishing are performed according to conventional methods. After the concrete has cured, the crew removes the roll bars and plywood from underneath.

Chapter 5

ICF-to-Steel Non-Structural Wall Connection Methods

Connection Tip

Make sure to fasten the top and bottom tracks to the ceiling and floor near their ends where they meet the ICF wall. If a particular interior wall might be subject to high side loads or heavy vibration, consider adding extra studs to the wall or using fasteners to attach the end stud to the ICF wall to prevent drywall cracks.

Introduction

Interior walls are typically designed to span vertically between the floor and the ceiling and are independent of the exterior wall. Therefore, any connection of the interior walls to the exterior ICF wall serves no structural purpose. The only issue that may deserve consideration is that the interior finish (usually drywall) must be attached to solid elements that do not move away from each other which may cause the finish to crack. This may be especially applicable if the interior wall is subjected to high lateral loads or vibration.

Therefore, a satisfactory connection depends on:

(1) arranging adequate connection points between the wall and the ceiling/floor above and below;

(2) using adequate fasteners at these connection points;

Fastener and framing schedules for cold-formed steel frame construction are provided in the AISI Standard for Cold-Formed Steel Framing - General Provisions [30] Section C2 and are not repeated herein.

Applicability Limits

All details, recommendations, and specifications presented here apply only to non-load bearing walls. Non-load bearing walls are partition walls that are not used to support floor, roof, or other horizontal framing members.

All details presented here apply only to structures in compliance with Chapter 2, General.

Basic Interior Wall Requirements

Steel framing members shall comply with ASTM C645 [21]. All interior walls considered are subject to 5 psf (0.24 kN/m^2) lateral load. The wall stud requirements are: minimum base metal thickness of 18 Mils (0.45 mm), minimum yield strength of 33 ksi (228 kPa), sections minimum lip size of 3/16 inch (5 mm).

Construction Details

The details provided here (Figure 5.1) should be used for information only. Refer to the Builders' Steel Stud Guide [31] for specific framing requirements.

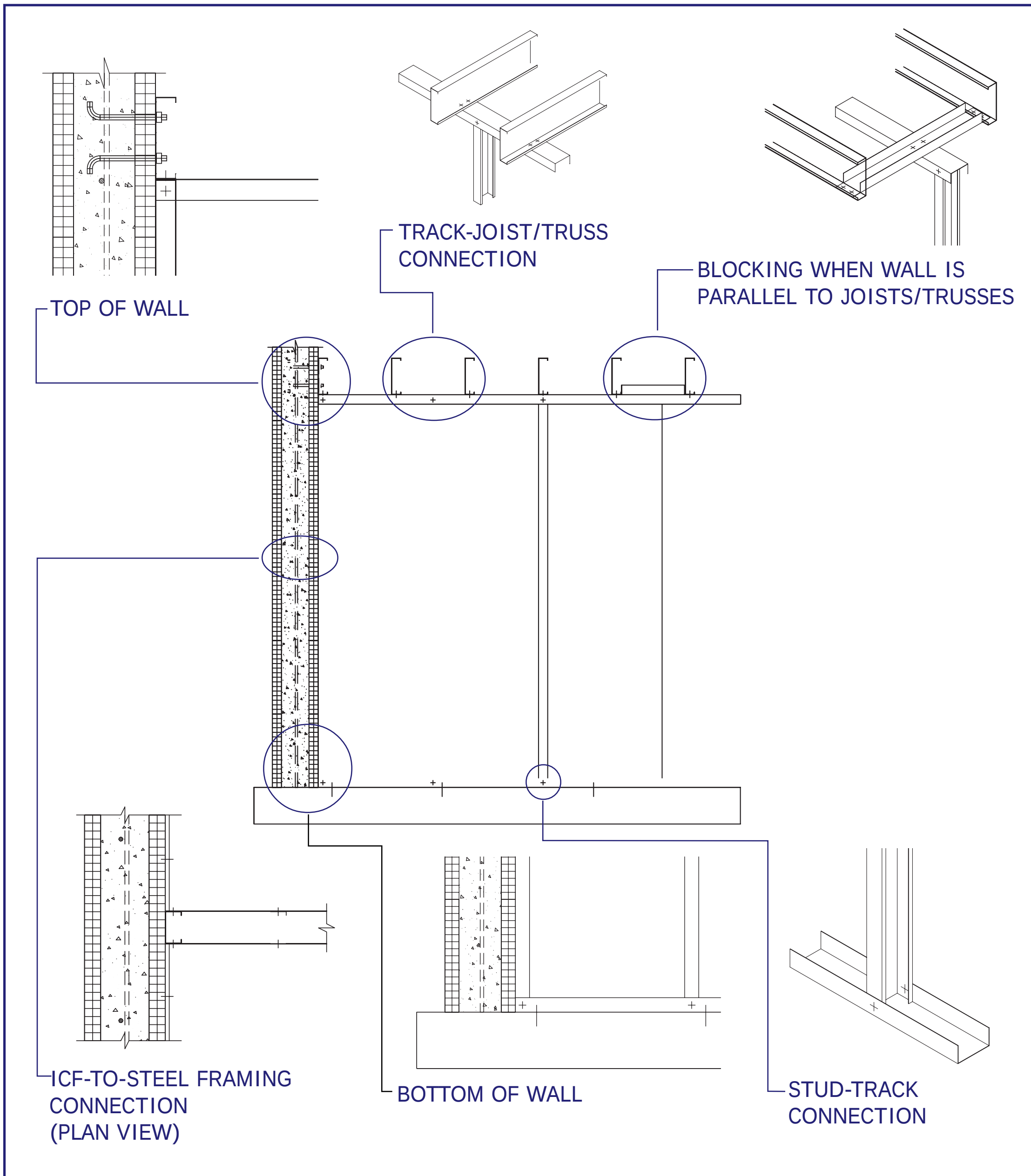


Figure 5.1. Typical ICF-to-Light Gauge Steel Wall Connection Details

Chapter 6

ICF-to-Steel Exterior Wall Connection Methods

Connection Tip

Structural cold-formed steel walls in regions with basic wind speed greater than or equal to 90 mph (145 km/hr) or in Seismic Design Category D_1 or greater shall be installed utilizing a wood sill plate with a steel plate or uplift strap connection at the base of the steel wall.

Introduction

Cold-formed steel exterior walls shall be connected to ICF exterior walls according to this section. Cold-formed steel framing members shall comply with the provisions of Chapter 2.

Construction of ICF walls shall be in accordance with the AISI Standard for Cold-Formed Steel Framing - Prescriptive Method for One and Two Family Dwellings [29]. Construction of cold-formed steel walls shall be in accordance with the International Residential Code [6] Section R603.

Table 6.1 is used to obtain applicable design velocity pressure for the building location. Tables 6.2 and 6.4 are used to determine required connector schedules and Table 6.3 to obtain required connector capacity.

Applicability Limits

The data provided here apply to buildings within the limits of the "Scope" section in Chapter 2, where Table 2.1 shall apply.

Connectors, as required in this section, shall be provided to ensure a continuous path capable of transferring shear and uplift loads from steel framing to the foundation. Steel straps or anchors must always be embedded within the applicable limits in the ICF wall.

Exterior Wall Connection Requirements

Direct Track to ICF Wall Connection

Use direct track to ICF wall anchorage as shown in Figure 6.1 in areas with wind speeds less than 100 mph (113 km/hr).

A minimum 1/2 inch (12.7 mm) diameter Grade A 307 anchor bolt is to be embedded in the concrete at the top of the wall and used to fasten down the bottom wall track in accordance with Figure 6.1. A minimum 6 inch (152 mm) long stud blocking with the same minimum thickness as a wall stud shall be installed inside the track at each anchor bolt connection. The track to stud blocking connection shall be made with minimum four No. 8 screws in each flange.

Anchor bolts shall be installed in accordance with Table 6.2. Anchor bolts shall have a minimum 7 inch (178 mm) concrete embedment with a minimum distance to the concrete edge of 2.5 inches (63.5 mm) or be placed in the middle one-third of the concrete wall.

Bolts shall be located not more than 12 inches (305 mm) from wall corners or wall ends.

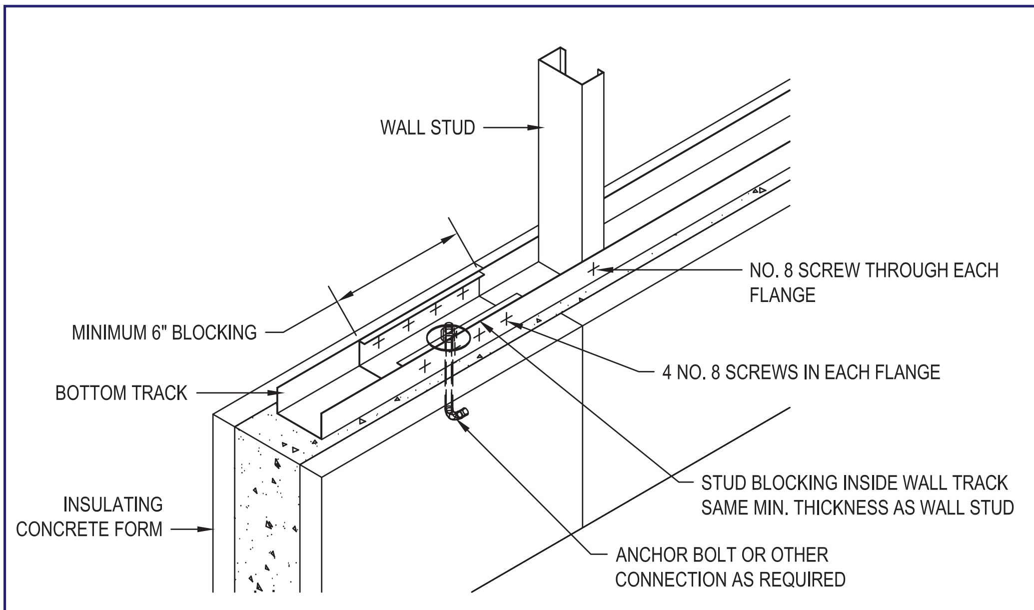


Figure 6.1. Direct Track to ICF Wall Connection

Refer to Table 6.2, 6.3, and 6.4 for Required Installation Schedules

Track to ICF Wall Connection with Wood Sill and Steel Plate

A minimum 1/2 inch (12.7 mm) diameter Grade A 307 anchor bolt is to be embedded in the concrete at the top of the wall and used to secure the bottom wall track in accordance with Figure 6.2. Bolts hold down the track and wood sill to the wall. The sill shall be connected to the track with 1-1/4 inch (32 mm) by 33 mil (0.88 mm) minimum steel plates with four 10d or six 8d common nails in the sill and four No. 8 screws in the track.

Anchor bolts shall be installed in accordance with Table 6.2. Anchor bolts shall have a minimum 7 inch (178 mm) concrete embedment with a minimum distance to the concrete edge of 2.5 inches (63.5 mm) or be placed in the middle one-third of the concrete wall.

Bolts shall be located not more than 12 inches (305 mm) from wall corners or wall ends.

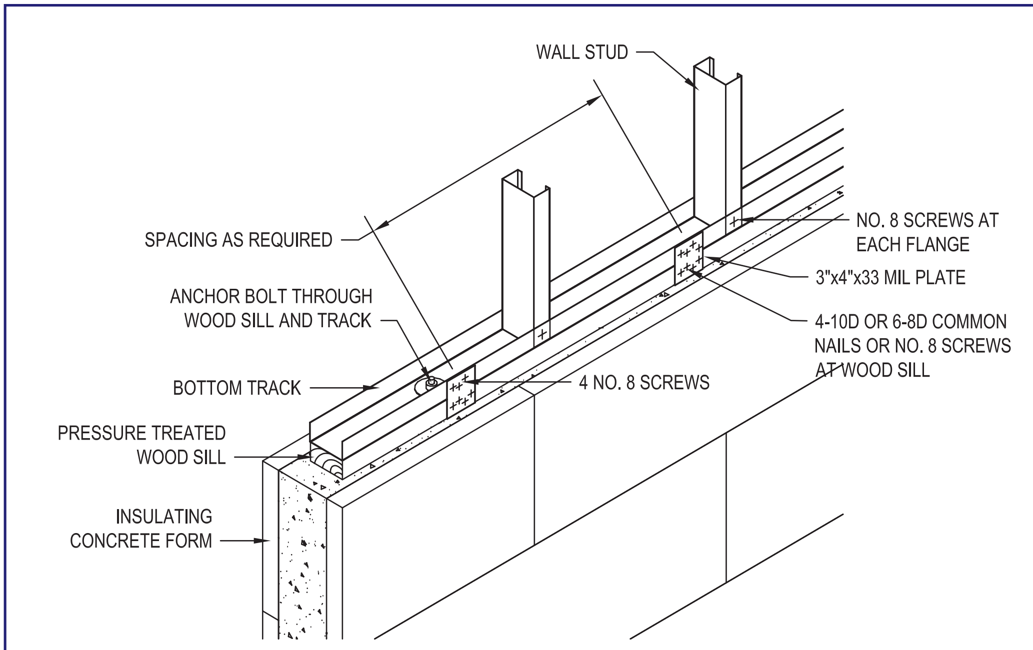


Figure 6.2. Track to ICF Wall Connection with Wood Sill and Steel Plate

Refer to Table 6.2, 6.3, and 6.4 for Required Installation Schedules

Track to ICF Wall Connection with Wood Sill and Uplift Strap

A minimum 1/2 inch (12.7 mm) diameter Grade A 307 anchor bolt is to be embedded in the concrete along the top of the wall and used to secure the bottom wall track and wood sides to the wall in accordance with Figure 6.3. Bolts hold down the track and wood sill. The sill shall be connected to the track with 33 mil (0.88 mm) minimum steel strap with No. 8 screws in accordance with Table 6.4 in the track flanges. Steel strap capacity shall be in accordance with Table 6.3.

Anchor bolts shall be installed in accordance with Table 6.2. Anchor bolts shall have a minimum 7 inch (178 mm) concrete embedment with a minimum distance to the concrete edge of 2.5 inches (63.5 mm) or be placed in the middle one-third of the concrete wall.

Bolts shall be located not more than 12 inches (305 mm) from wall corners or wall ends.

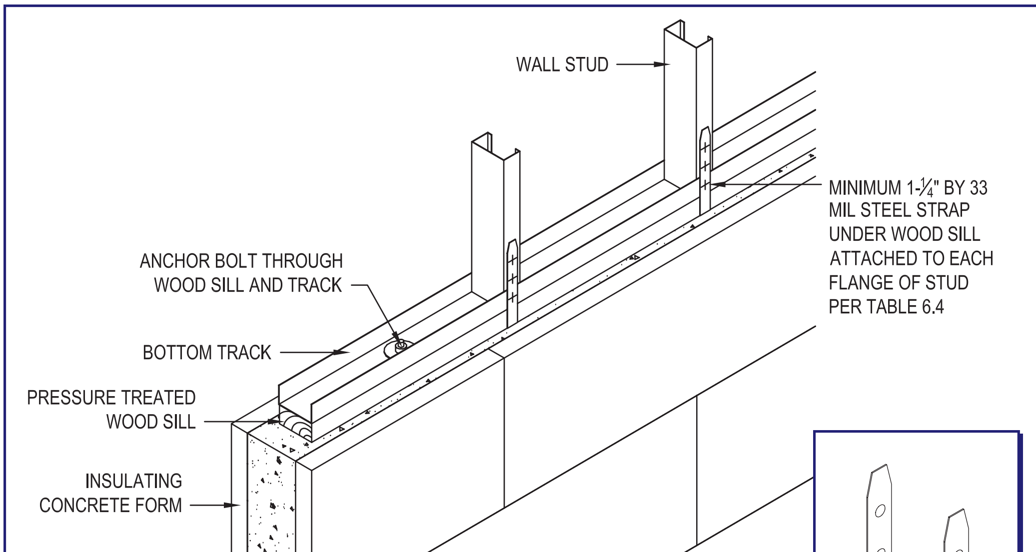
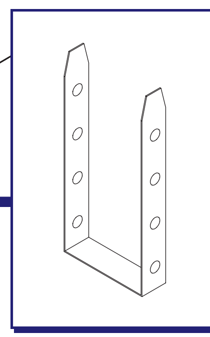


Figure 6.3. Track to ICF Wall Connection with Wood Sill and Uplift Strap

Refer to Table 6.2, 6.3, and 6.4 for Required Installation Schedules



Uplift Steel Strap

TABLE 6.1
LATERAL WIND VELOCITY PRESSURE FOR DETERMINATION OF ICF-TO-EXTERIOR STEEL WALL CONNECTION REQUIREMENTS [1]

Wind Speed (mph)	Velocity Pressure (psf) Exposure [2]		
	B	C	D
85	12	16	19
90	13	17	21
100	16	22	26
110	19	27	31
120	22	32	37
130	27	37	43
140	31	42	50

For SI: 1 psf = 0.0479 kN/m^2; 1 mph = 1.6093 km/hr.

[1] Table values are based on ASCE 7-98 Figure 6-4 wind velocity pressures for low-rise buildings using a mean roof height of 35 ft (10.7 m).
[2] Exposure Categories as defined in Chapter 2.

TABLE 6.2
BASIC ICF-TO-EXTERIOR STEEL WALL CONNECTION REQUIREMENTS [1, 2, 3]

Framing Condition	Design Velocity Pressure (psf) and Seismic Design Category				
	less than 15 or SDC3 A, B, C	15	20	25	more than 25
Direct Track to ICF Wall as per Figure 6.1	1/2" minimum diameter anchor bolt at 6' o.c.	1/2" minimum diameter anchor bolt at 6' o.c.	1/2" minimum diameter anchor bolt at 4' o.c.	1/2" minimum diameter anchor bolt at 4' o.c.	1/2" minimum diameter anchor bolt at 4' o.c.
Wall Bottom Track to ICF Wall as per Figure 6.2	Steel plate at 4' o.c. with 4 No. 8 screws and 4-10d or 6-8d common nails	Steel plate at 4' o.c. with 4 No. 8 screws and 4-10d or 6-8d common nails	Steel plate at 3' o.c. with 4 No. 8 screws and 4-10d or 6-8d common nails	Steel plate at 2' o.c. with 4 No. 8 screws and 4-10d or 6-8d common nails	Steel plate at 2' o.c. with 4 No. 8 screws and 4-10d or 6-8d common nails
Wind Uplift Connector Capacity for 16" Stud Spacing	N/A	N/A	N/A	N/A	65 lbs. per foot of wall length
Wind Uplift Connector Capacity for 24" Stud Spacing	N/A	N/A	N/A	N/A	100 lbs. per foot of wall length

For SI: 1 inch = 25.4 mm, 1 mph = 1.61 km/hr, 1 foot = 0.3048 m, 1 lb. = 4.4 N.

[1] Anchor bolts shall have a minimum 7 inch (178 mm) concrete embedment with a minimum distance to the concrete edge of 2.5 inches (63.5 mm).
[2] Bolts shall be located not more than 12 inches (305 mm) from wall corners or wall ends.Use the greater of the wind speed and exposure or the seismic zone for a given site.
[3] All screw sizes shown are minimums.

TABLE 6.3
ICF-TO-EXTERIOR STEEL WALL UPLIFT CONNECTION CAPACITY AT EACH FRAMING MEMBER [1, 2]

Design Velocity Pressure, (psf)		20	25	30	35	40	45	50
Framing Spacing, (in)	Roof Span, (ft)	Sill Plate to Wall Framing Uplift Connection Capacity, (lbs)						
12	24	74	152	230	308	386	464	542
	28	87	178	269	360	451	542	633
	32	99	203	307	411	515	619	723
16	24	99	203	306	410	514	618	721
	28	115	236	358	479	600	721	842
	32	132	270	409	547	685	824	962
19.2	24	119	244	369	493	618	743	868
	28	139	284	430	576	721	867	1012
	32	159	325	492	658	824	991	1157
24	24	149	305	461	617	773	929	1085
	28	174	356	538	720	902	1084	1266
	32	198	406	614	822	1030	1238	1446

For SI: 1 inch = 25.4 mm, 1 foot = 0.3048 m, 1 mph = 1.61 km/hr.

[1] Uplift requirements assume a roof/ceiling dead load of 10 psf (2/3x15psf) (0.479 kN/m^2).
[2] Uplift connection requirements shall be permitted to be multiplied by 0.70 for framing not located within 8 feet (2,438 mm) of building corners.

TABLE 6.4
TOTAL NUMBER OF NO. 8 SCREWS IN FLANGES OF WALL STUD TO STEEL STRAP CONNECTION [1, 2, 3]

Design Velocity Pressure, (psf)		20	25	30	35	40	45	50
Framing Spacing, (in)	Roof Span, (ft)	Total Number of No. 8 Screws in Each End of Steel Strap						
12	24	1	1	1	1	2	2	2
	28	1	1	1	2	2	2	2
	32	1	1	1	2	2	2	3
16	24	1	1	1	2	2	2	3
	28	1	1	2	2	2	3	3
	32	1	1	2	2	3	3	3
19.2	24	1	1	2	2	2	3	3
	28	1	1	2	2	3	3	4
	32	1	2	2	3	3	4	4
24	24	1	1	2	2	3	3	4
	28	1	2	2	3	3	4	4
	32	1	2	2	3	4	4	5

For SI: 1 inch = 25.4 mm, 1 foot = 0.3048 m, 1 mph = 1.61 km/hr.

[1] Uplift requirements assume a roof/ceiling dead load of 10 psf (2/3x15psf) (0.479 kN/m^2).
[2] Uplift connection requirements shall be permitted to be multiplied by 0.70 for framing not located within 8 feet (2,438 mm) of building corners.
[3] The number of screws is based on standard No. 8 screw capacity and minimum steel thickness of 33 mils. Use *Table 3.5 Screw Substitution Factor* to reduce screw quantities.

Chapter 7

ICF-to-Steel Roof Connection Methods

Introduction

Roof members may consist of roof trusses or conventional framing (e.g. joist and rafters). Connection of either type of member to the ICF wall is by the same methods.

A CFS steel or wood sill plate may be fastened to the top of the ICF wall, and in turn the roof framing members fastened to the sill plate. A second method for securing the roof framing to the ICF wall is through the use of steel straps. This second method has the potential of being a labor saving method over the conventional sill plate connection. However, it requires knowing the precise positions of the roof members in advance and placing the straps accordingly before or during the pour. As a third option, adhesive-anchored fasteners may be added to the concrete after it has cured. This is typically most useful for replacing any connectors that should have been embedded in the wet concrete but were left out, misplaced or misaligned.

> ***Connection Tip***
>
> Be sure to allow for the thickness of the wall when setting the dimensions of the roofing members. For example, a top plate usually does not extend all the way to the outside edge of the ICF wall. Therefore a rafter that does not allow for this may clear the plate but contact the concrete or foam, requiring removal of some material.

Table 7.1 is used to obtain applicable design velocity pressure for the building location. Tables 7.2 to 7.5 are used to determine required connector schedules.

Applicability Limits

The data provided here apply to buildings within the limits of the "Scope" section in Chapter 2, where Table 2.1 shall apply. Homes with larger floor dimensions or greater roof pitches will experience greater total loads on their roofs and therefore may require roof-to-wall connections with greater capacities. Engineers' design in such situations is recommended.

The connections discussed in this section are designed for two purposes:

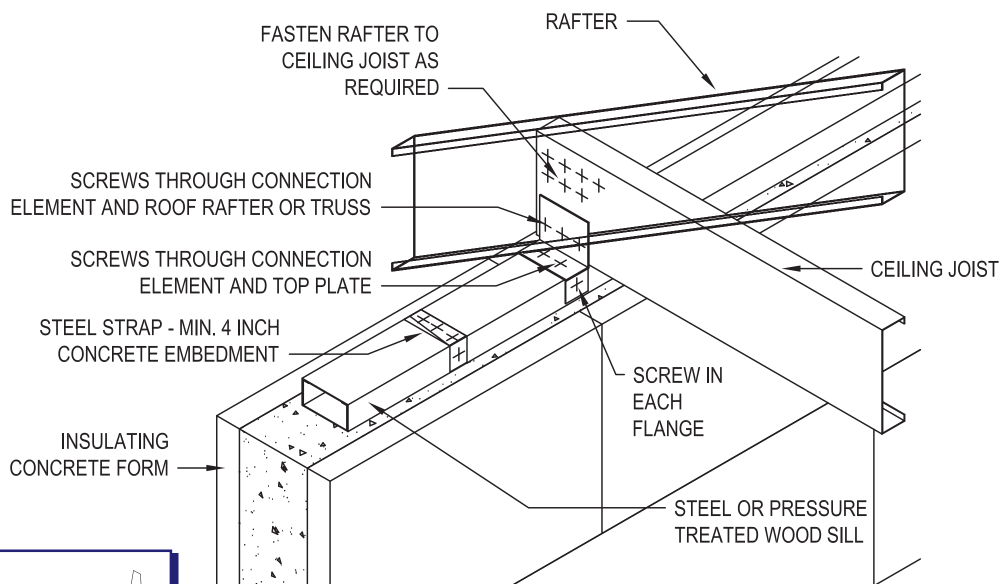
(1) to "hold down" the roof that is subjected to wind uplift, and

(2) to transfer lateral (wind and seismic) loads to the shear walls. (Gravity loads, dead and live loads, are assumed to be transferred by bearing on the ICF wall and, therefore, do not depend on connectors.)

Basic Roof Connection Requirements

Top Sill Plate Connected to ICF Wall With Concrete Anchor Steel Straps

Steel straps are embedded in the concrete at the top of the wall and used to fasten



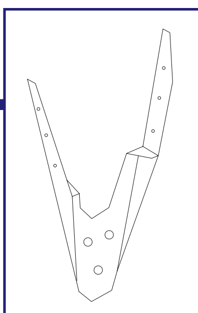


Figure 7.1. Steel Concrete Anchor Strap and Sill Plate Connection Method at Wall Parallel to Ridge

Refer to Table 7.2 for Required Installation Schedules

Concrete Anchor Steel Strap

down a steel or treated wood plate in accordance with Figure 7.1. Steel connectors attach the roof members to the plate. This method does not require the precise positions of the roof members to be known before the concrete pour.

Note that steel plates are created by mating a steel stud and a like-sized steel track to create a box profile, and connecting the two pieces with a screw along either edge every 12 inches (305 mm).

Concrete anchor steel straps shall be installed as per Table 7.2. Anchor straps shall have a minimum 4 inch (102 mm) concrete embedment with minimum distance to the concrete edge of 2 inches (51 mm) or be placed in the middle one-third of the concrete wall and have a minimum thickness of 0.43 mills (18-gauge).

On a wall perpendicular to the ridge the anchor strap schedule should be in accordance with Figure 7.2 and Table 7.2. Anchor straps shall have a minimum 4 inch (102 mm) concrete embedment with distance to the concrete edge of 2 inches (51 mm) and minimum thickness of 43 mills (18-gauge).

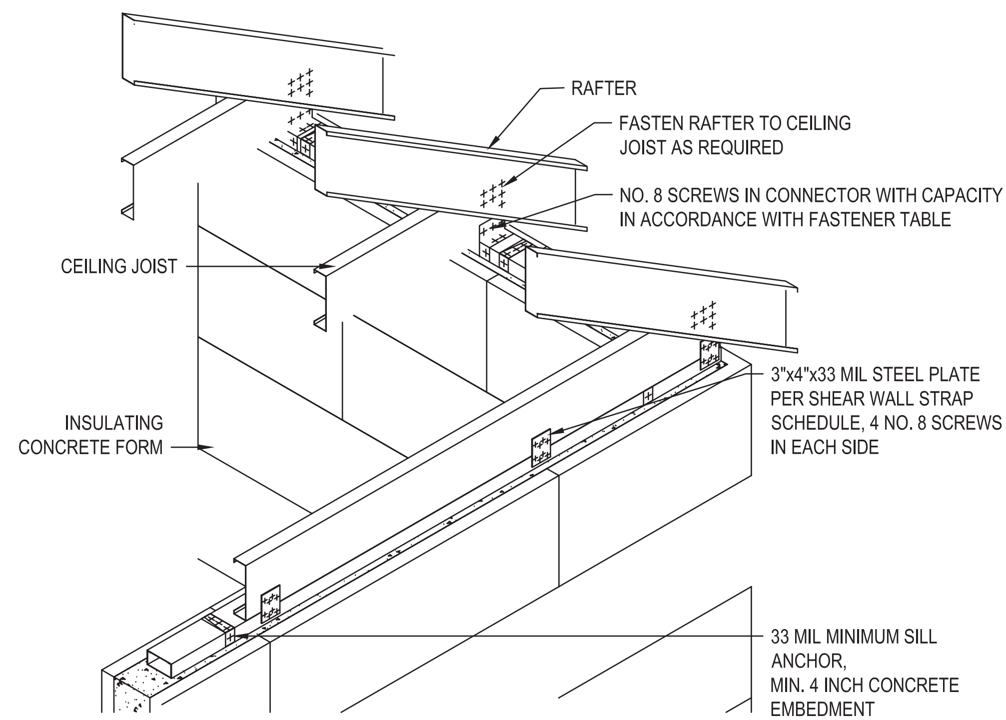


Figure 7.2. Steel Concrete Anchor Strap and Sill Plate Connection Method at Wall Perpendicular to Ridge

Refer to Table 7.2 for Required Installation Schedules

Straps shall be located not more than 12 inches (305 mm) from wall corners or wall ends.

The roof members are connected to the plate in accordance with Figures 7.1 and 7.2 with steel connectors with capacities as per Table 7.3. These are screwed or nailed through prepunched holes to the plate and to the roof member.

Embedded Steel Strap

A steel strap with deformed embedmend end is embedded into the ICF concrete wall at the location of each CFS framing member, which is then fastened directly to the roof framing member in accordance with Figure 7.3. This method uses a minimum of materials and labor, but requires knowing the precise location of each roof member before the concrete pour. If by chance the strap for a particular roof member is missing or in the wrong location, that member may be connected to the wall by means of a bolt embedded in the concrete with epoxy adhesive (described later). However, these post-pour embedments add back time and cost.

Straps shall have a minimum 4 inch (102 mm) concrete embedment with a minimum

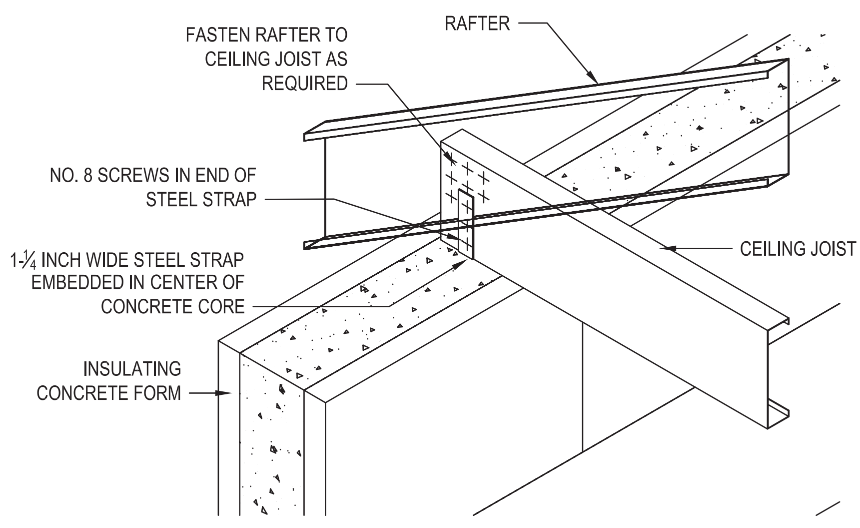


Figure 7.3. Steel Strap Connection at Wall Parallel to Ridge
Refer to Table 7.4 for Required Installation Schedules

distance to the concrete edge of 2 inches (51 mm). Each strap shall be fastened to roof framing member with No. 8 screws in accordance with fastener schedule in Table 7.4.

Connection of the end roof member to wall perpendicular to the ridge shall be in accordance with Figure 7.4 and Table 7.5.

Straps shall be located not more than 12 inches (305 mm) from wall corners or wall ends.

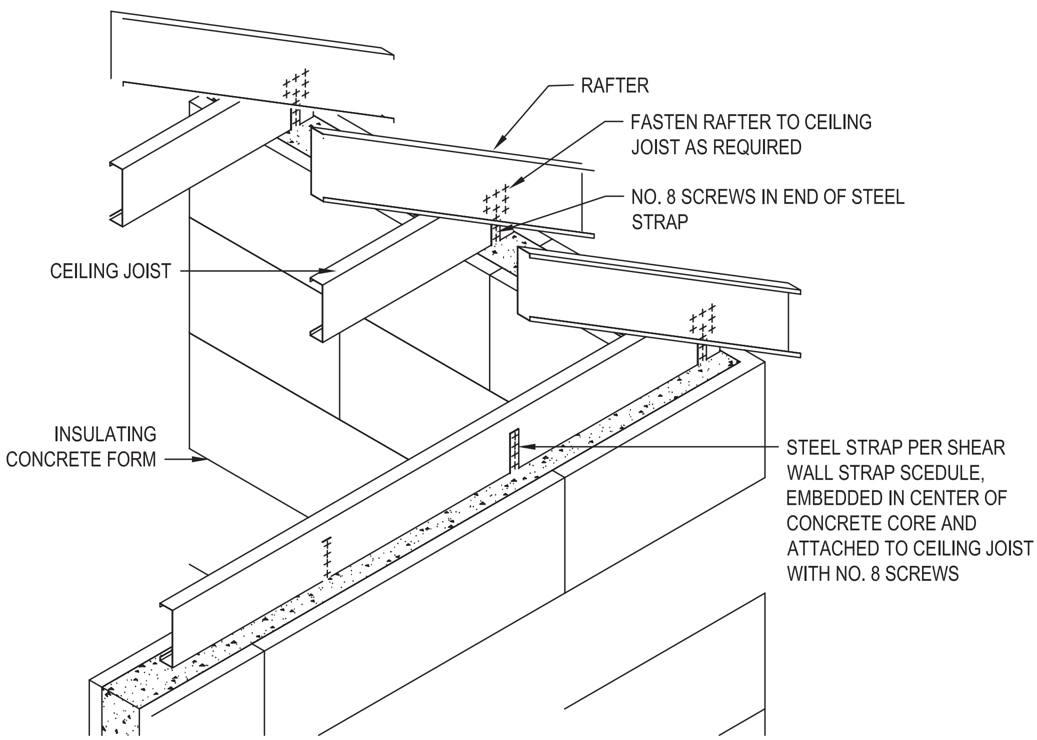


Figure 7.4. Steel Strap Connection Method at End Roof Joist to Wall Perpendicular to Ridge

Refer to Table 7.5 for Required Installation Schedules

Right-Angle Steel Strap With Epoxy Anchor Bolt

After the concrete has cured, a hole is drilled in the top of the wall at the location of each roof member in accordance with Figure 7.5. A bolt is placed inside each hole and secured to the concrete with epoxy adhesive. A steel strap connects the bolt to the roof member. This method generally entails more labor and higher material cost than others. However, it is useful to replace a connector that should have been embedded in the wet concrete but was omitted or placed in the wrong position.

Anchor bolts shall have a minimum 7 inch (178 mm) concrete embedment with a minimum distance to the concrete edge of 2.5 inches (63.5 mm). A minimum 1/2 inch (12.7 mm) diameter Grade A 307 anchor bolts should be used. Each strap shall be fastened to the roof member with No. 8 screws in accordance with the fastener schedule in Table 7.4.

Connection of the end roof ceiling joist to the wall perpendicular to the ridge (shear wall) shall be in accordance with Figure 7.6 and Table 7.5.

Straps shall be located not more than 12 inches (305 mm) from wall corners or wall ends.

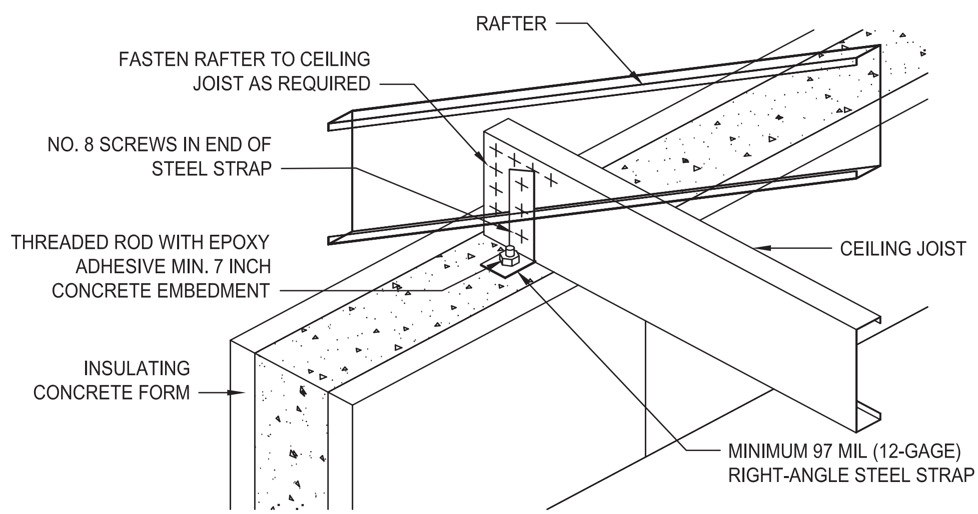


Figure 7.5. Steel Strap Connection With Epoxy Anchor at Wall Parallel to Ridge

Refer to Table 7.4 for Required Installation Schedules

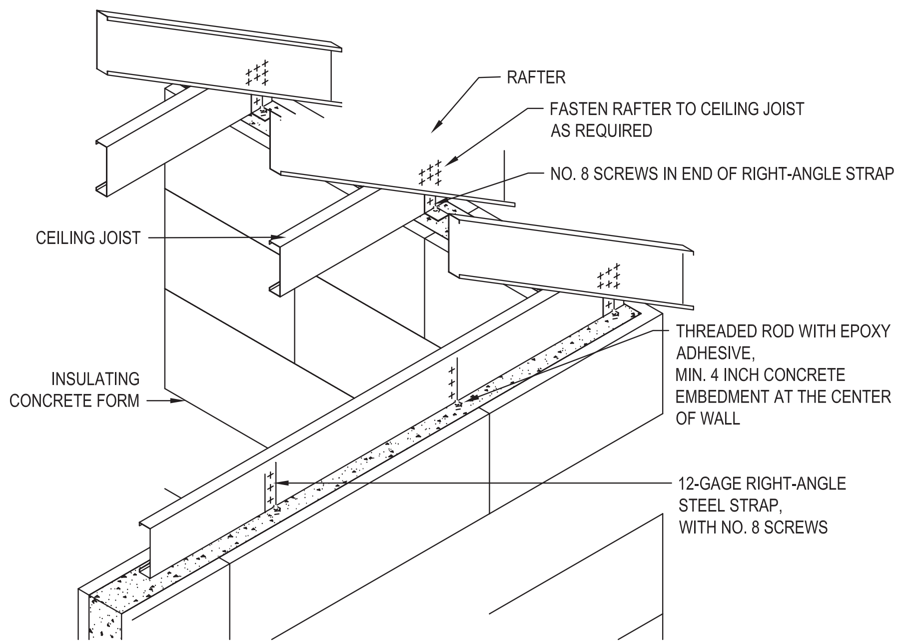


Figure 7.6. Steel Strap With Epoxy Anchor Connection Method at End Roof Joist to Wall Perpendicular to Ridge

Refer to Table 7.5 for Required Installation Schedules

TABLE 7.1
LATERAL WIND VELOCITY PRESSURE FOR DETERMINATION OF ICF-TO-STEEL ROOF CONNECTION REQUIREMENTS [1]

Wind Speed (mph)	Velocity Pressure (psf)		
	Exposure [2]		
	B	C	D
85	12	16	19
90	13	17	21
100	16	22	26
110	19	27	31
120	22	32	37
130	27	37	43
140	31	42	50

For SI: 1 psf = 0.0479 kN/m^2; 1 mph = 1.6093 km/hr.

[1] Table values are based on ASCE 7-98 Figure 6-4 wind velocity pressures for low-rise buildings using a mean roof height of 35 ft (10.7 m).
[2] Exposure Categories as defined in Chapter 2.

TABLE 7.2
CONCRETE ANCHOR STEEL STRAP SPACING TO CONNECT SILL PLATE TO ICF WALL [1, 2]

Wind Pressure, (psf)	20	25	30	35	40	45	50
Roof Span, (ft)	Concrete Anchor Strap Spacing on Sill Plate at Wall Parallel to Ridge, (ft-in)						
24	4-10	2-6	1-10	1-6	1-2	1-0	1-0
28	3-4	2-2	1-8	1-2	1-0	1-0	0-10
32	3-0	2-0	1-4	1-2	1-0	0-10	0-8

For SI: 1 inch = 25.4 mm, 1 mph = 1.61 km/hr, 1 foot = 0.3048 m, 1 lb. = 4.4 N.

[1] Straps shall have a minimum 4 inch (178 mm) concrete embedment with a minimum distance to the concrete edge of 2.5 inches (63.5 mm).
[2] Straps shall be located not more than 12 inches (305 mm) from wall corners or wall ends.Use the greater of the wind speed and exposure or the seismic zone for a given site.

TABLE 7.3
ROOF FRAME TO SILL PLATE REQUIRED UPLIFT CONNECTION CAPACITY [1, 2]

Design Velocity Pressure, (psf)		20	25	30	35	40	45	50
Framing Spacing, (in)	Roof Span, (ft)	Sill Plate to Rafter or Truss Uplift Connection Capacity, (lbs)						
12	24	204	282	360	438	516	594	672
	28	238	329	420	511	602	693	784
	32	272	376	480	584	688	792	896
16	24	271	375	479	583	686	790	894
	28	317	438	559	680	801	922	1043
	32	362	500	638	777	915	1053	1192
19.2	24	326	451	576	701	826	950	1075
	28	381	526	672	818	963	1109	1254
	32	435	602	768	934	1101	1267	1434
24	24	408	564	720	876	1032	1188	1344
	28	476	658	840	1022	1204	1386	1568
	32	544	752	960	1168	1376	1584	1792

For SI: 1 inch = 25.4 mm, 1 foot = 0.3048 m, 1 mph = 1.61 km/hr.

[1] Uplift requirements assume a roof/ceiling dead load of 10 psf (2/3x15psf) (0.479 kN/m^2).
[2] Uplift connection requirements shall be permitted to be multiplied by 0.70 for framing not located within 8 feet (2,438 mm) of building corners.

TABLE 7.4
FASTENER SCHEDULE FOR STEEL STRAPS AT ICF WALL [1, 2, 3, 4]

Design Velocity Pressure, (psf)		20	25	30	35	40	45	50
Framing Spacing, (in)	Roof Span, (ft)	Steel Strap Schedule and Number of #8 Screws in End of Strap to Roof Rafter or Truss						
12		18-gauge	18-gauge	18-gauge	18-gauge	18-gauge	18-gauge	18-gauge
	24	2	2	3	3	4	4	5
	28	2	3	3	4	4	5	5
	32	2	3	3	4	5	5	6
16		18-gauge	18-gauge	18-gauge	18-gauge	18-gauge	18-gauge	18-gauge
	24	2	3	3	4	5	5	6
	28	2	3	4	5	5	6	7
	32	3	4	4	5	6	7	8
19.2		18-gauge	18-gauge	18-gauge	18-gauge	18-gauge	16-gauge	16-gauge
	24	2	3	4	5	6	6	7
	28	3	4	5	5	6	7	8
	32	3	4	5	6	7	8	9
24		18-gauge	18-gauge	18-gauge	18-gauge	16-gauge	14-gauge	14-gauge
	24	3	4	5	6	7	8	9
	28	3	5	6	7	8	9	10
	32	4	5	6	8	9	10	11

For SI: 1 inch = 25.4 mm, 1 foot = 0.3048 m, 1 mph = 1.61 km/hr.

[1] Uplift requirements assume a roof/ceiling dead load of 10 psf (2/3x15psf) (0.479 kN/m^2).
[2] Uplift connection requirements shall be permitted to be multiplied by 0.70 for framing not located within 8 feet (2,438 mm) of building corners.
[3] The number of screws is based on standard No. 8 screw capacity and minimum steel thickness of 33 mils. Use *Table 3.5 Screw Substitution Factor* to reduce screw quantities.
[4] Gauge numbers in the body of the table refer to the gauge of the steel strap. Use *Table 3.3 Base Metal Thickness of Cold-Formed Steel Members* to convert steel thickness in mils.

TABLE 7.5
STEEL STRAP SPACING TO CONNECT END ROOF TRUSS OR JOIST TO ICF WALL PERPENDICULAR TO RIDGE [1,2]

Wind Pressure, (psf)	20	25	30	35	40	45	50
Roof Span, (ft)	Concrete Anchor Strap Spacing on Sill Plate at Wall Parallel to Ridge, (ft-in)						
24	4-10	2-6	1-10	1-6	1-2	1-0	1-0
28	3-4	2-2	1-8	1-2	1-0	1-0	0-10
32	3-0	2-0	1-4	1-2	1-0	0-10	0-8

For SI: 1 inch = 25.4 mm, 1 mph = 1.61 km/hr, 1 foot = 0.3048 m, 1 lb. = 4.4 N.

[1] Straps shall have a minimum 4 inch (178 mm) concrete embedment with a minimum distance to the concrete edge of 2.5 inches (63.5 mm).
[2] Straps shall be located not more than 12 inches (305 mm) from wall corners or wall ends.Use the greater of the wind speed and exposure or the seismic zone for a given site.

Chapter 8

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Appendix, Metric Conversion

The following list provides the conversion relationship between U.S. customary units and the International System (SI) units. A complete guide to the SI system and its use can be found in ASTM E 380, Metric Practice.

To convert from	to	multiply by
Length		
inch (in)	micrometer (mm)	25,400
inch (in)	millimeter (mm)	25.4
inch (in)	centimeter (cm)	2.54
inch (in)	meter (m)	0.0254
foot (ft)	meter (m)	0.3048
yard (yd)	meter (m)	0.9144
mile (mi)	kilometer (km)	1.6
Area		
square foot (sq ft)	square meter (sq m)	0.0929
square inch (sq in)	square centimeter (sq cm)	6.452
square inch (sq in)	square meter (sq m)	0.00064516
square yard (sq yd)	square meter (sq m)	0.8391
square mile (sq mi)	square kilometer (sq km)	2.6
Volume		
cubic inch (cu in)	cubic centimeter (cu cm)	16.387064
cubic inch (cu in)	cubic meter (cu m)	0.00001639
cubic foot (cu ft)	cubic meter (cu m)	0.02831685
cubic yard (cu yd)	cubic meter (cu m)	0.7645549
Force		
kip (1000 lb)	kilogram (kg)	453.6
kip (1000 lb)	Newton (N)	4,448.222
pound (lb)	kilogram (kg)	0.4535924
pound (lb)	Newton (N)	4.448222
Stress or pressure		
kip/sq inch (ksi)	megapascal (Mpa)	6.894757
kip/sq inch (ksi)	kilogram/square centimeter (kg/sq cm)	70.31
pound/sq inch (psi)	kilogram/square centimeter (kg/sq cm)	0.07031
pound/sq inch (psi)	pascal (Pa)*	6,894.757
pound/sq inch (psi)	megapascal (Mpa)	0.00689476
pound/sq foot (psf)	kilogram/square meter (kg/sq m)	4.8824
pound/sq foot (psf)	pascal (Pa)	47.88

* A pascal equals 1000 Newton per square meter

To convert from	to	multiply by
Mass (weight)		
pound (lb) avoirdupois	kilogram (kg)	0.4535924
ton, 2000 lb	kilogram (kg)	907.1848
grain	kilogram (kg)	0.0000648
Mass (weight) per length		
kip per linear foot (klf)	kilogram per meter (kg/m)	0.001488
pound per linear foot (plf)	kilogram per meter (kg/m)	1.488
Moment		
1 foot-pound (ft-lb)	Newton-meter (N-m)	1.356
Mass per volume (density)		
pound per cubic foot (pcf)	kilogram per cubic meter (kg/cu m)	16.01846
pound per cubic yard (lb/cu yd)	kilogram per cubic meter (kg/cu m)	0.5933
Velocity		
mile per hour (mph)	kilometer per hour (km/hr)	1.60934
mile per hour (mph)	kilometer per second (km/sec)	0.44704
Temperature		
degree Fahrenheit (°F)	degree Celsius (°C) $t_C = (t_F - 32)/1.8$	
degree Fahrenheit (°F)	degree Kelvin (°K) $t_K = (t_F + 59.7)/1.8$	
degree Kelvin (°F)	degree Celsius (°C) $t_C = (t_K - 32)/1.8$	

The prefixes and symbols below are commonly used to form names and symbols of the decimal multiples and submultiples of the SI units.

Multiplication Factor	Prefix	Symbol
1,000,000,000 = 10^9	giga	G
1,000,000 = 10^6	mega	M
1,000 = 10^3	kilo	k
0.01 = 10^{-2}	centi	c
0.001 = 10^{-3}	milli	m
0.000001 = 10^{-6}	micro	m
0.000000001 = 10^{-9}	nano	n

Notes

Notes