QUAD-LOCK®

Insulating Concrete Forms

INSTALLATION MANUAL

June 2015

Welcome to Quad-Lock!

The most versatile and highest quality Insulating Concrete Forming System.

QUAD-LOCK Building Systems Ltd. was established in 1994 in Surrey, British Columbia, Canada. QUAD-LOCK® develops, manufactures and distributes its patented Insulating Concrete Form (ICF) system.

The QUAD-LOCK® System was conceived and engineered to reduce the cost and increase the versatility of cast in place concrete walls and help our environment by saving energy.

QUAD-LOCK® is a panel type ICF system consisting of Panels, Ties, Metal Tracks and Metal Brackets. QUAD-LOCK® panels are made with high density, fire retardant expanded polystyrene beads (EPS) and contain no formaldehyde, HFCs, CFCs or other harmful substances. Six panel types are currently available, 2¼" [58mm], 3⅛" [79mm], 4¼" [108mm] thick Panels. 2¼" [58mm], and 4¼" [108mm] thick Panels are each available with or without fastening strips molded into each panel. The 4" [102mm] thick Extra Panel is available to increase the insulation of the wall. These panels can be combined allowing unlimited wall configurations with the resulting R-values ranging from R-22 to R-59 [U-0.28 to U-0.10].

Plastic ties ingeniously connect the panels, help to secure the reinforcing steel in place, while also providing a means to anchor drywall, siding and temporary bracing. Ties are available in many lengths to form different wall thicknesses. The Metal Track is used to start and finish the wall and the Metal Brackets eliminate additional outside bracing at corners and angles. Metal Brackets come in a 90° version and in an adjustable version accommodating almost any angle.

The revolutionary QUAD-DECK® floor, roof, and tilt-up forming system is a "pan floor" form designed for both commercial and residential construction. QUAD-DECK® panels shape a series of T-beams every 24" [610mm] which integrate with a concrete slab. The resulting monolithic concrete structure now provides one-way span capacity and a shear plane, for superior structural performance.

The few components of the QUAD-LOCK® System ensure simplicity in design, construction and supply. Applications include load bearing walls, shear walls, fire resistant walls, basement walls, retaining walls, and foundation walls incorporated in residential, industrial and institutional construction. QUAD-LOCK® can easily be shaped to form the design elements of modern buildings – openings, corners, angles, curves and arches.

QUAD-LOCK® is dedicated to hiring only individuals with extensive, successful construction and sales experience to best serve your needs.

For assistance with this manual or the QUAD-LOCK® product, please contact the regional sales representative serving your area or contact our head office:

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QUAD-LOCK Building Systems is constantly reviewing manufacturing and construction methods to ensure a well-engineered, quality product at the lowest cost to customers. QUAD-LOCK Building Systems reserves the right to update this manual as appropriate and asks that you check online for the most recent version and request a printed copy, if needed.

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Warning about structural integrity:

DEFECTS IN THE REINFORCED CONCRETE CAN LEAD TO STRUCTURAL FAILURE AND BUILDING COLLAPSE. The concrete and reinforcement placed into Insulated Concrete Forms (ICFs) are the only structurally significant components and must be designed & built according to all locally applicable laws, building codes, and other regulations, standards, and best practices. Each building's construction team (owner, general contractor, architect, engineers) is responsible for adequate building design, installation, quality control, and safety. Inexperienced persons should not perform poured-in-place concrete construction. In the event of a conflict between this manual and the local building code, provisions of the local building code shall apply.

Warning about corrosion of metal components:

- QUAD-LOCK® metal parts are galvanized to minimize corrosion, however, please be aware that:
- Metal connectors, anchors, fasteners, and other metal components will corrode and lose load carrying capacity, if installed in corrosive environments.
- Many new types of treated wood are highly corrosive to metal components, especially lumber treated with ACQ (alkaline copper quaternary).
- QUAD-LOCK® recommends that metal components should NOT be used in contact with treated lumber in exterior applications or anywhere water is likely to be present (unless you ensure compatibility of your treated lumber with the metal components).
- For exterior applications, the project engineer should specify the type, size and spacing of corrosion resistant bolts, concrete anchors, and other metal fasteners.

Warning about material compatibility:

- QUAD-LOCK® Panels should not come into contact with solvents or petroleum based liquids as they may dissolve the EPS and thus affect the structural integrity of Panels. Please ensure that all sealants and primers are water based.

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Key to Symbols Found in the Quad-Lock Installation Manual

Light-bulb symbol indicates that the content is a *great idea for your ICF build*.

Book symbol indicates that the content is important for *building-code compliance*

Hazard symbol indicates that the content contains *a warning*.

Leaf symbol indicates that the content relates to *sustainability*

Hard hat symbol indicates that the content relates to *safety issues.*

Clock symbol indicates that the content contains *time-saving advice*

Dollar symbol indicates that the contents contains *money-saving advice*

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1 PRODUCT DESCRIPTION

1.1 QUAD-LOCK - THE MOST VERSATILE INSULATING CONCRETE FORMS

The Quad-Lock ICF system is known in the industry for its ability to easily adapt to the widest range of building design features and specifications.

Whether the plan calls for angles or radius walls to accent architecture or an enhanced insulation layer in the building envelope for low-energy designs, Quad-Lock has the solutions.

1.1.1 Four Common Components

The Quad-Lock System encompasses these components:

- **Panels** made of EPS, available in 3 thicknesses (2¼" [57mm], 3⅛" [79mm] and 4¼" [108mm]). Extra Panel (4" [102mm]) is available as insert panel to increase the insulation values.
- **Ties** made of High Density Polyethylene (HDPE) in 6 standard lengths plus Extender Ties and Brick Ledge Ties
- **Metal Corner Brackets** to eliminate bracing at corners, angles, T-intersections
- **Metal Track**, Flex-Track and Wire Top Ties for starting and finishing the wall assembly

Two Quad-Lock Panels form one *"Unit" or a pair,* each of which requires four Quad-Lock Ties. Each Unit and 4 ties will build 4 square feet of wall [.372 sq. meters].

For a listing of standard wall configurations please see Chapter 2, Table 2.3 on Page 24.

Panels made of Expanded Polystyrene (EPS) and Ties made of High Density Polyethylene (HDPE) create a Concrete Form that accommodates vertical and horizontal Reinforcing Steel as required.

Filling the cavity with concrete creates resilient, reinforced concrete walls with 2-4 hour Fire Resistance Ratings (FRR), low maintenance, and outstanding durability. The EPS Forming System stays in place to provide space to run small utilities, serve as backing for finishes, and incorporate superior, continuous insulation layers. The high insulation values, low air infiltration, and high thermal mass can achieve significant energy savings for building owners, operators, and tenants over the building's longer lifetime.

Temporary bracing is usually required only for vertical and horizontal alignment.

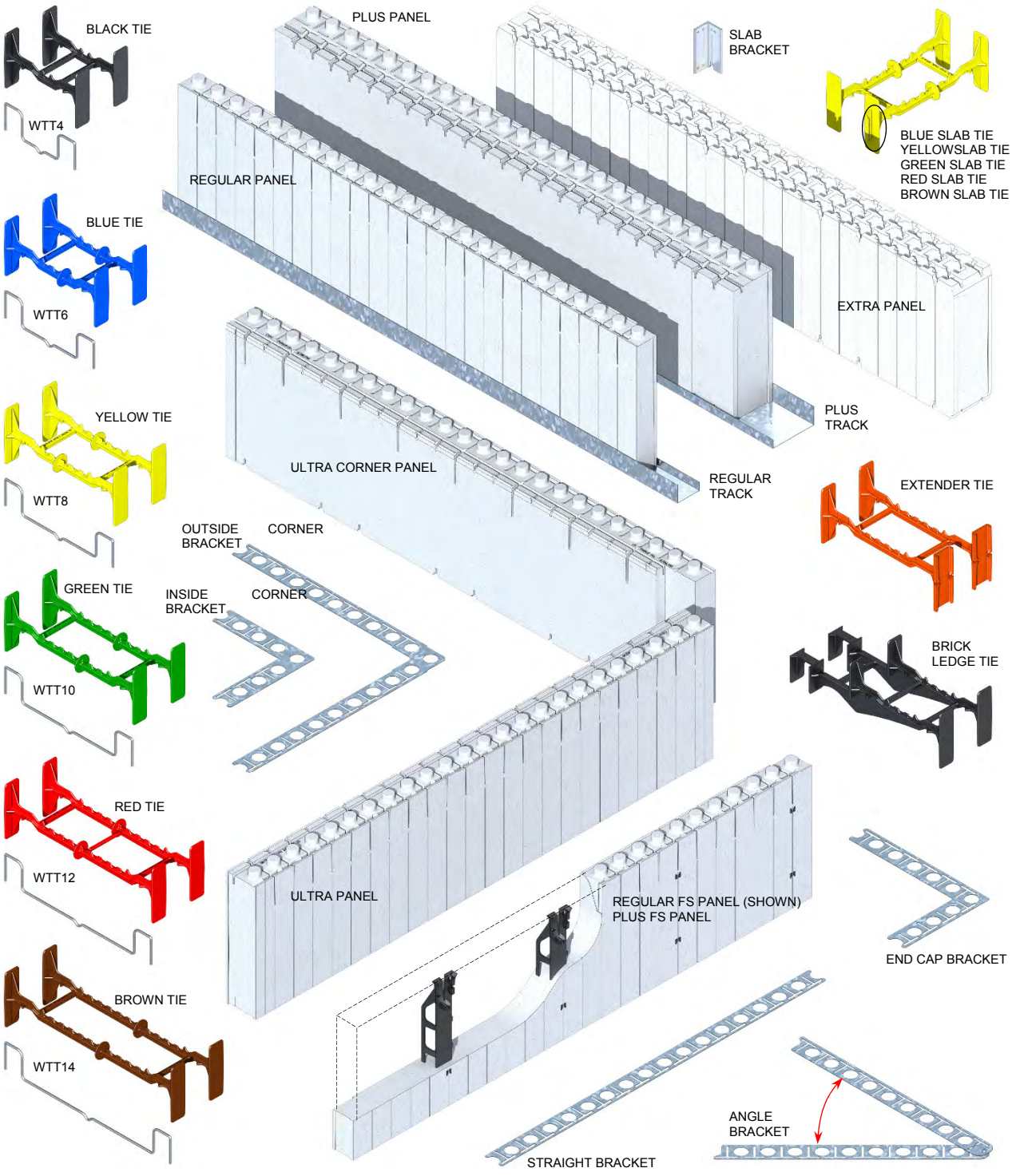


Figure 1: Quad-Lock Components

1.1.2 Quad-Lock Panels

Quad-Lock EPS panels are available in different thicknesses to allow flexibility in choice of insulating value, wall dimensions, and to optimize the thermal performance with additional exterior insulation depending on design and climate requirements.

1.1.2.1 Regular Panels

Regular Panels are 48" [1219mm] long, 12" [305mm] high, and 2¼" [57mm] thick with interlocks along the top and bottom of the panels.

Regular Panels are only recommended for use by experienced Quad-Lock installers.

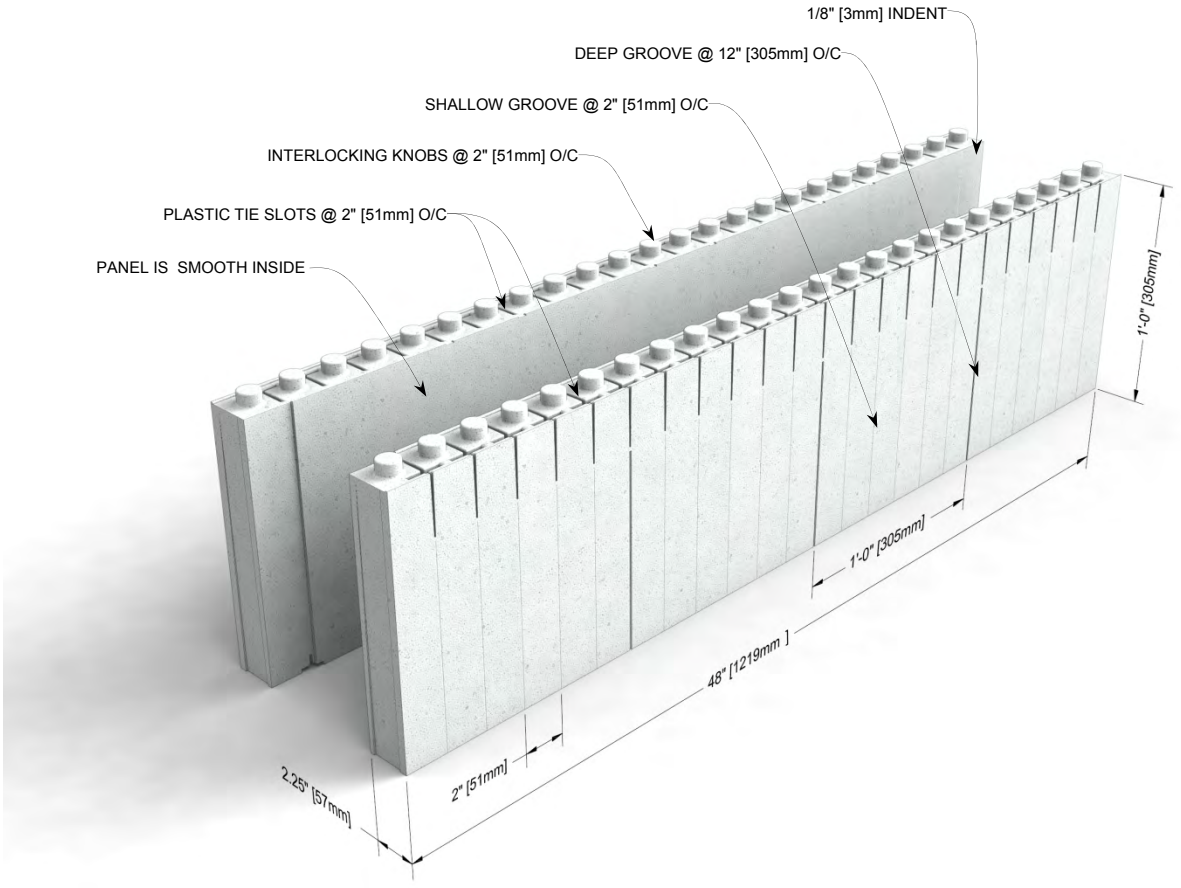


Figure 2: Quad-Lock Regular Panels

1.1.2.2 Ultra & Ultra Corner Panels

Ultra Panels and Ultra Corner Panels have been developed for walls requiring higher insulation values. Major dimensions for Ultra Panel are the same as for Regular Panels except for the thickness of 3⅛" [79mm]. **Corner panels** speed up installation by providing a recess for Ultra Panels to fit together.

Ultra Panels are about 20% stronger than Regular Panels with almost 30% more insulation value.

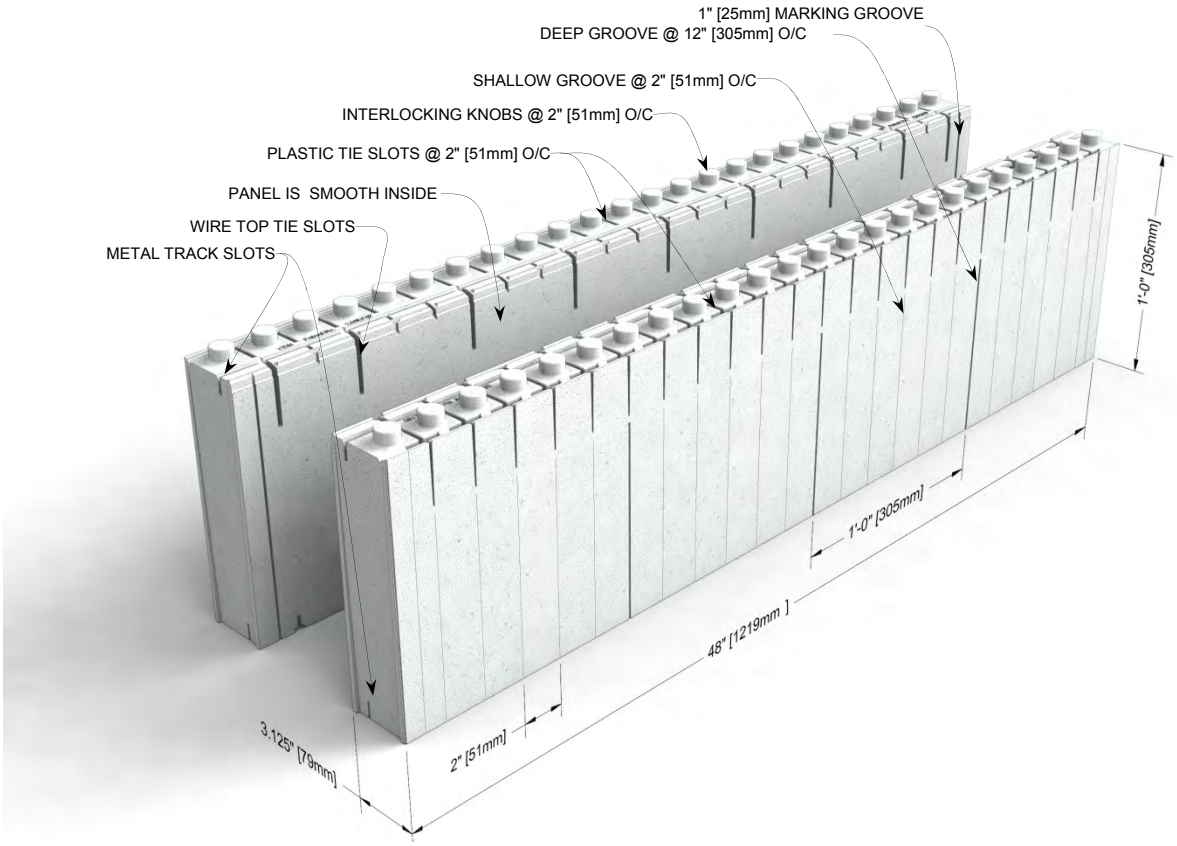


Figure 3: Quad-Lock Ultra Panels

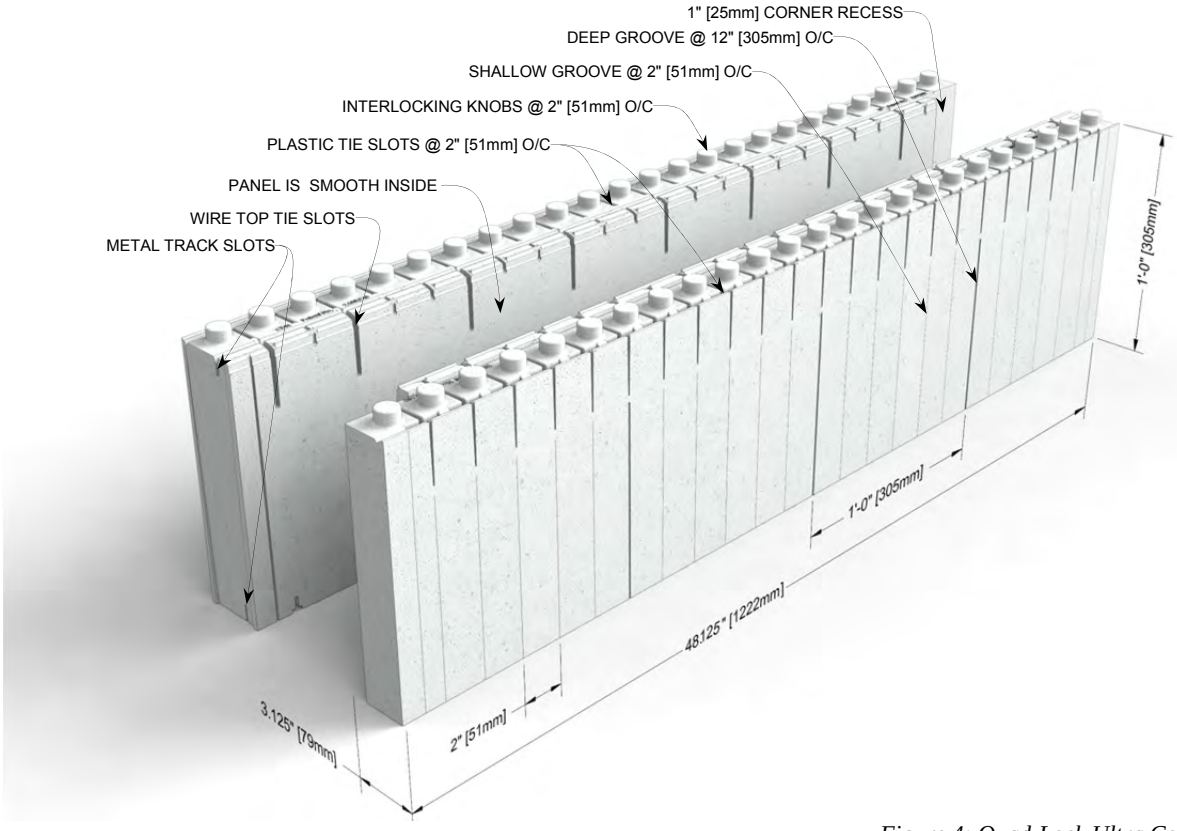


Figure 4: Quad-Lock Ultra Corner Panels

1.1.2.3 Plus Panels

Plus Panels have been developed for walls requiring even higher insulation values and wall transitions. Dimensions for Plus Panels are the same as Regular and Ultra Panels except for the thickness of 4¼" [108mm].

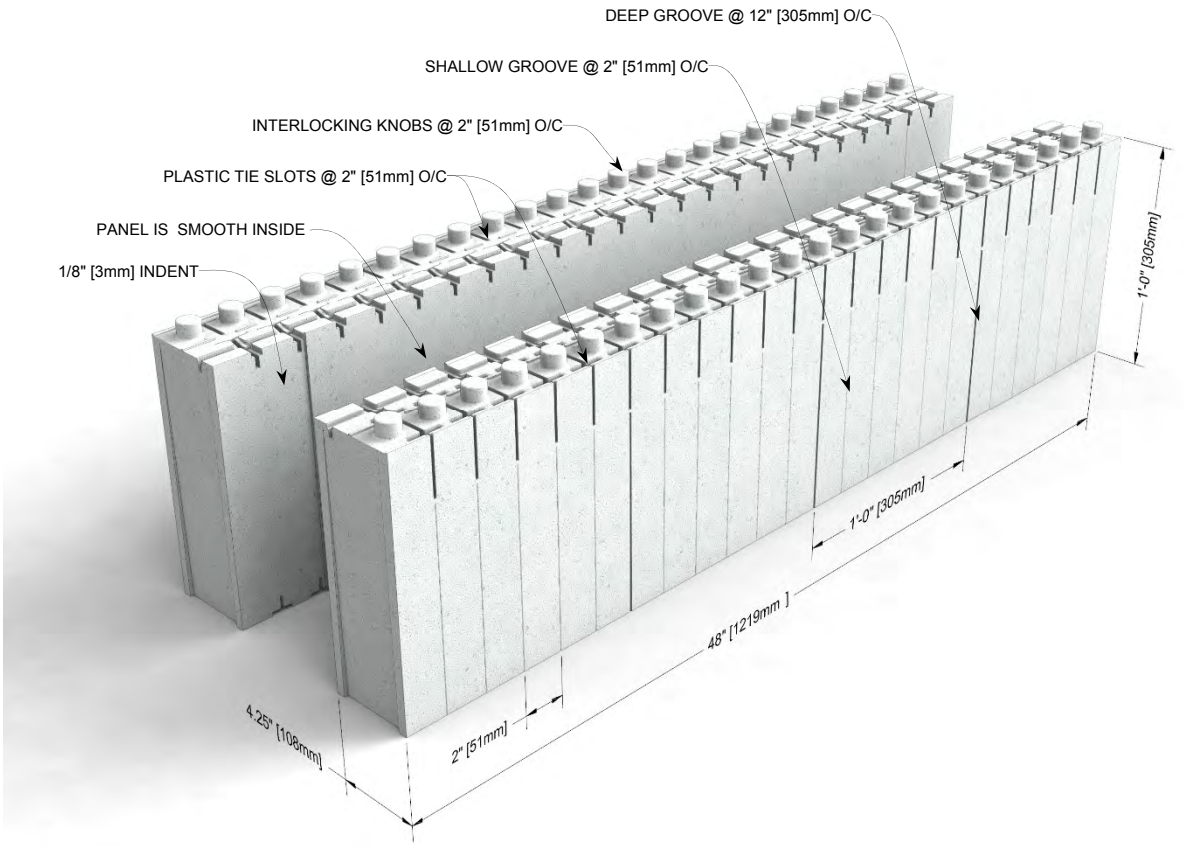


Figure 5: Quad-Lock Plus Panel

Building Tip:	**Use Quad-Lock Plus Panels for:** **1. Additional Insulation (usually on exterior of building) and to un-balance the insulation layers on the wall (Thermal Mass Optimization)** **2. Wall Width Transitions (e.g. from 8" to 6" concrete thickness, or** **3. Create a "belly band" (a raised horizontal relief detail between stories) for stucco application in multi-story applications.**

1.1.2.4 Fastening Strip (FS) Panels

Regular FS and **Plus FS Panels** are dimensionally identical to Regular Panel and Plus Panel except they contain fastenings strips molded into the panels which are located 2" [51mm] to the left of all deep grooves (every 12" [305mm]) and extend to the panel's surface in small spots for easy identification. Plastic ties are locked into the fastening strips to create an uninterrupted vertical fastening surface 1½" [38mm] wide (no breaks or gaps to complicate siding installation). The FS Panels can be used on one side or on both sides of the wall as needed. They provide a continuous anchoring point for exterior cladding/lapped siding (e.g. vinyl or fiber-cement siding) where needed.

Figure 6: Quad-Lock 2" FS Panel

Figure 7: Quad-Lock 4" FS Panel

Building Tips: **Use Quad-Lock FS Panels for attaching:**
1. Exterior Finishes requiring a continuous fastening surface*, or
2. Base Boards or Crown Molding using one row of FS Panels at the bottom or top of a wall, or
3. Soffit - Place a row of FS Panels even with the soffit elevation; Snap a line where the soffit joins the wall; Glue and screw a horizontal 2x4 [50mm x 100mm] backer on the FS Panels to support the soffit material where it intersects the wall. See Figure 122.
***Note: Check local building ordinances for regulations on drainage requirements behind exterior claddings. Direct application to ICFs may not be allowed in jurisdictions requiring "rain-screen" gap technology.**
See Chapter 10, Section 10.2.3.1 "Cladding Best Practices" on Page 186

1.1.2.5 Extra Panels

Extra Panels serve to increase the wall insulation levels on the exterior. Dimensions for Extra panels are 48" [1219mm] long, 12" [305mm] high, and 4" [102mm] thick with indents along the top and bottom to allow for plastic Tie legs and Tie water stops.

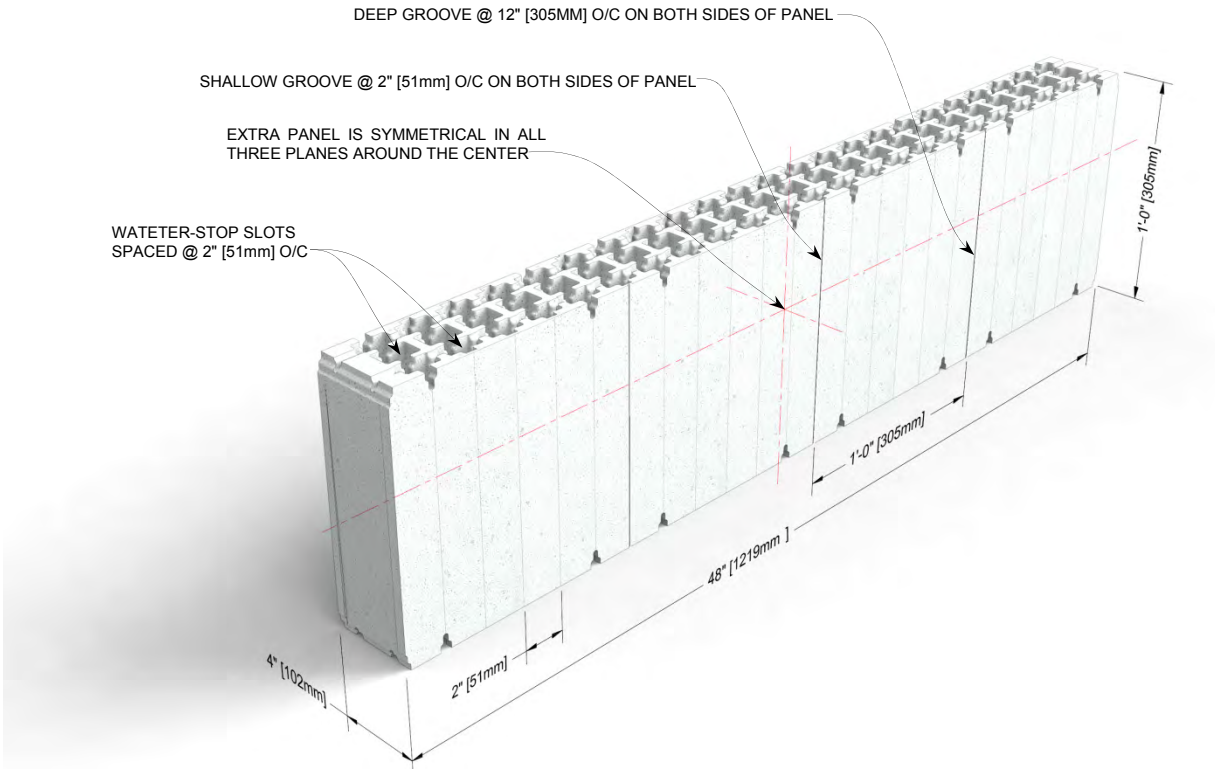


Figure 8: Quad-Lock EXTRA Panel

1.1.3 Panel Features and Properties

1.1.3.1 Tie Slots and Grooves in Panels

- All Panels (except EXTRA Panels) contain molded slots every 2" [51mm] to interlock panels with the Quad-Lock Ties, ensuring every panel will align with precision.
- Panels are lightly scored every 2" [51mm] to make measuring and cutting easy.
- Every 12" [305mm] panels have a heavier groove to mark the placement of the ties.
- Ultra Panels have a score mark on the inside of each panel located one inch from each end, to assist with trimming the panels at corners where no factory-recessed corner panel is available.

1.1.3.2 Panel Properties

Quad-Lock panels are made from Expanded Polystyrene (EPS) EPS is a foamed insulation that has a zero ozone depletion rating. EPS does not, and never did, contain CFCs or HCFCs. The Quad-Lock Panel is inert and chemically stable.

Table 1.1.3.2: Properties of Quad-Lock EPS panels are shown in the following table:

Panel Thickness	Nominal Density	Min. Density	EPS Board Type Classification	
			USA (ASTM C578)	**Canada** (CAN/ULC-S701)
Regular: 2¼" [57mm]	2 lb/ft³ [32 g/l]	1.8 lb/ft³ [28.8 g/l]	Type IX	Type 3
Ultra: 3⅛" [79mm]	1.5 lb/ft³ [24 g/l]	1.35 lb/ft³ [21.7 g/l]	Type II	Type 2
Plus: 4¼" [108mm]	1.5 lb/ft³ [24 g/l]	1.35 lb/ft³ [21.7 g/l]	Type II	Type 2
Extra: 4" [102mm]	1.25 lb/ft³ [20 g/l]	1.15 lb/ft³ [18 g/l]	Type VIII	Type 1

1.1.4 Quad-Lock HDPE Ties

1.1.4.1 Full Ties - Function, Positioning, Spacing and Sizes

Ties are placed at the intersection of the horizontal and vertical joints of all panels and every 12" [305mm] in-between, which are marked by the deeper, wider grooves in the panels. The ties are placed to align every 12" [305mm] vertically and horizontally in every wall.

Quad-Lock Ties:

- Lock-in the panels in 4 ways (hence "Quad-Lock"): across the cavity, across butt joints, vertically from one layer to the next, and against shear-forces along horizontal seams.
- Serve as an attachment point for bracing and finish materials.
- Help to position reinforcing steel using the ties' molded rebar chairs. (Always follow specifications from engineer of record, national building codes or local building codes)
- Help to secure corners, T-Walls, etc.
- Reduce risk of water migration along ties with a water stop.
- Allow unlimited concrete cavity size by combining Extender Ties with standard ties.

Ties are recessed from the outside surface of the panels to prevent thermal bridging and the telegraphing of dissimilar materials when finishing with stucco.

Ties are available in six different standard lengths and are color-coded for easy identification. Using ties of different lengths, up to six different wall widths are available and can be combined with Extender Ties to add 12" [305mm] to any standard tie length. Multiple Extender Ties can be joined to make wider cavities.

Quad-Lock Ties are molded of High Density Polyethylene (HDPE).

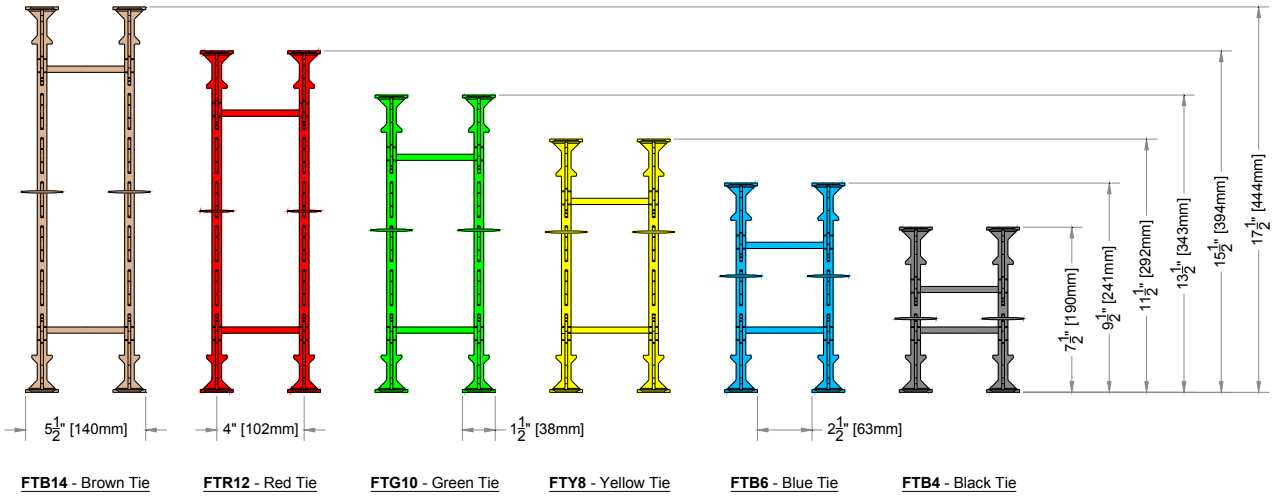


Figure 9: Quad-Lock Standard Ties – Dimensions

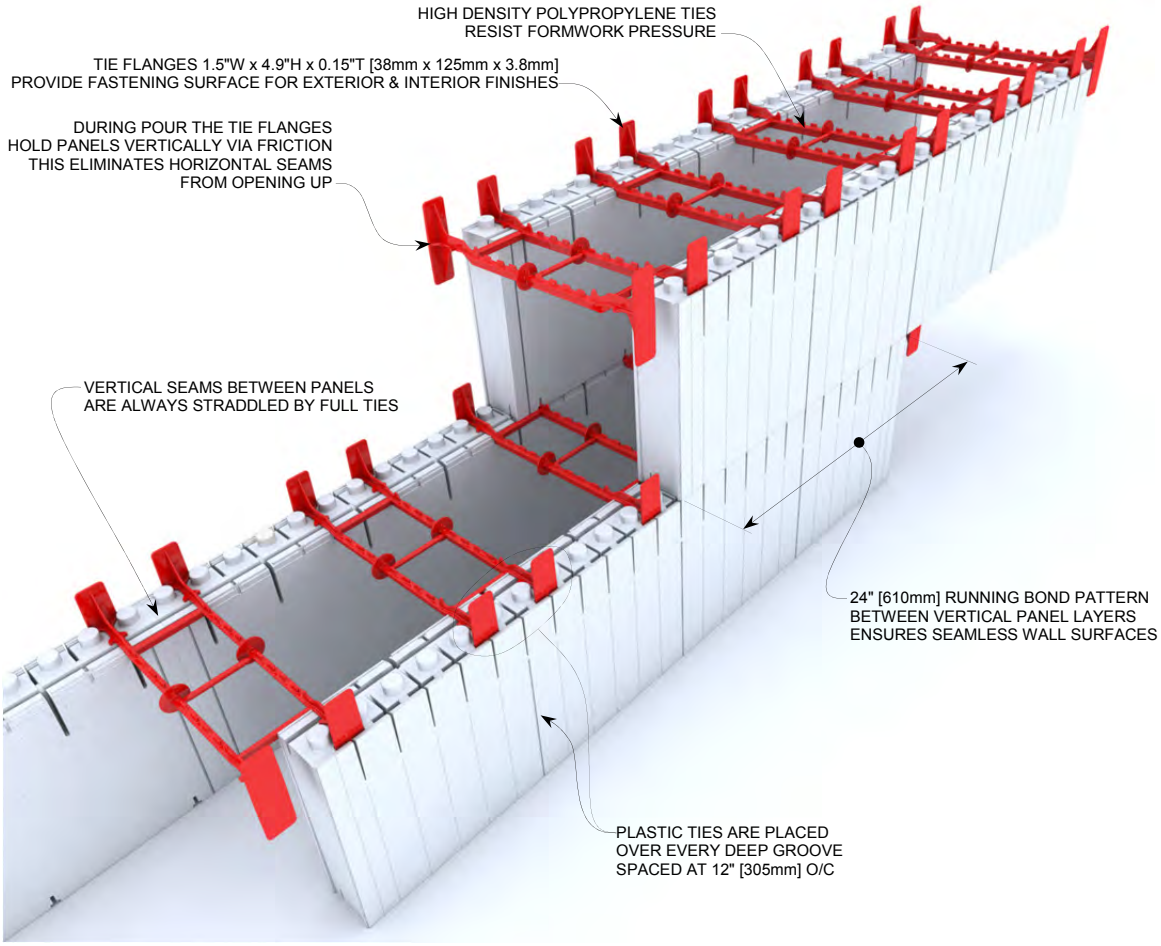


Figure 10: Quad-Lock Ties & Panels

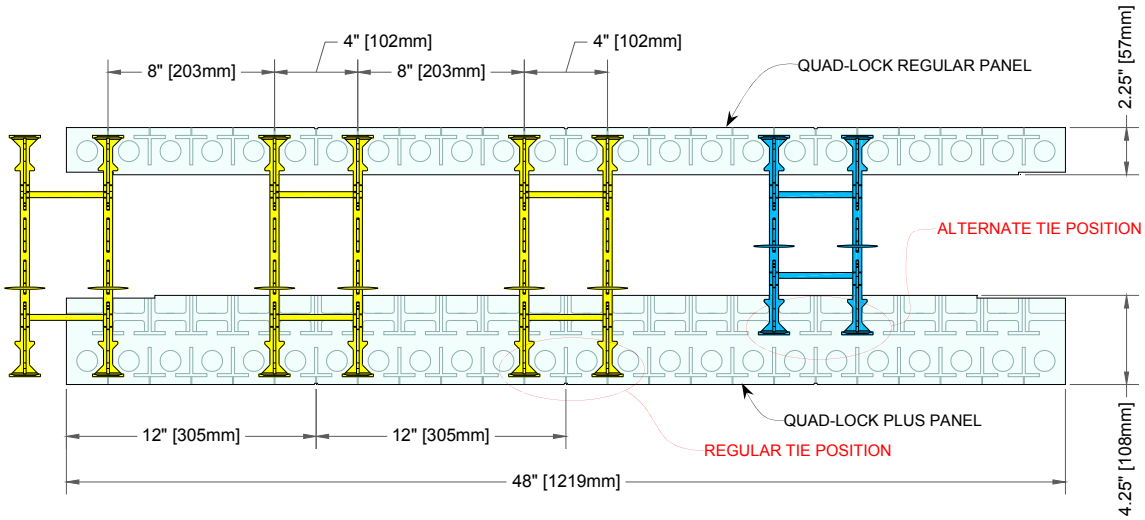


Figure 11: Quad-Lock Plus Panel - Positioning of Ties

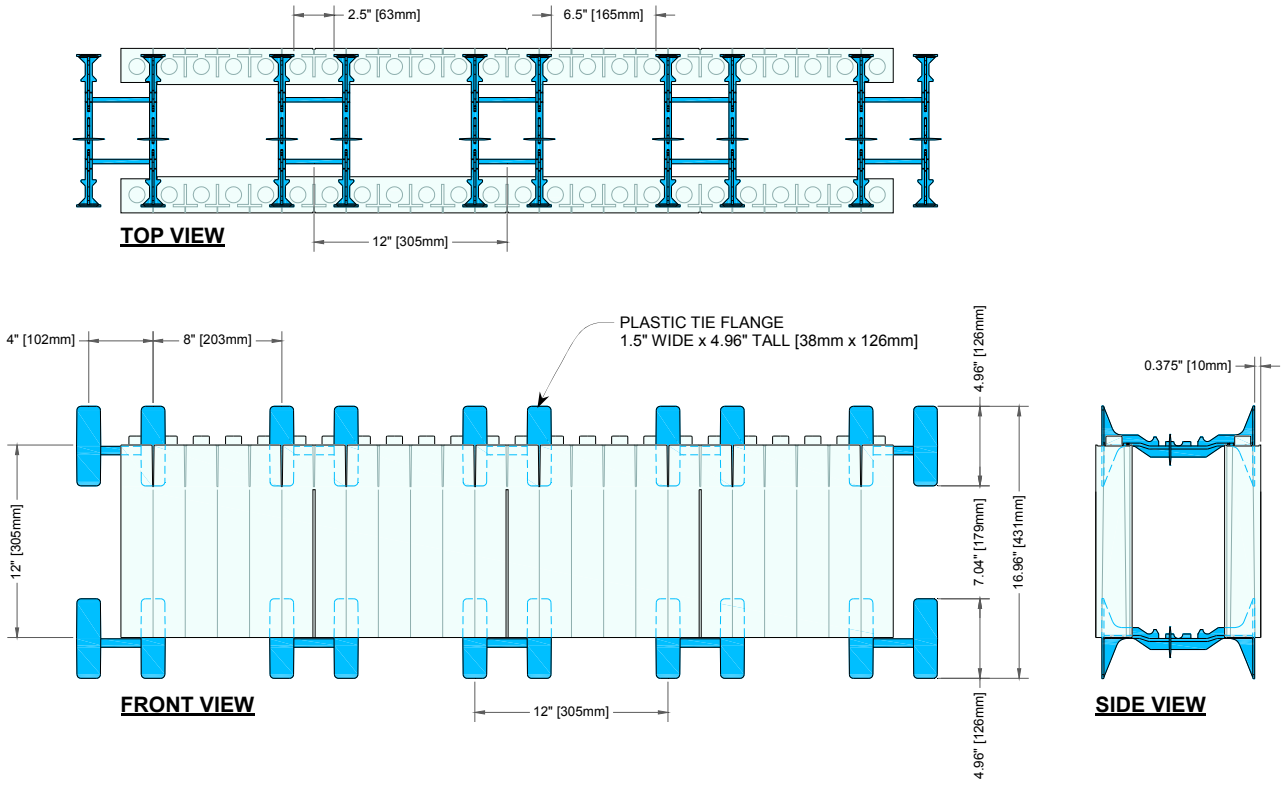


Figure 12: Tie Layout Dimensions

1.1.4.2 Extender Tie

The Quad-Lock Extender Tie allows design of almost any desired concrete thickness. Extender Ties interlock with regular Full Ties to add 12" [305mm] of concrete cavity. Combine multiple Extender Ties with Full Ties to create concrete cavities larger than 24" [610mm]. For more details, see Chapter 4 *"Special Wall Elements,* Section 4.6 *"Wide Walls"* on Page 82.

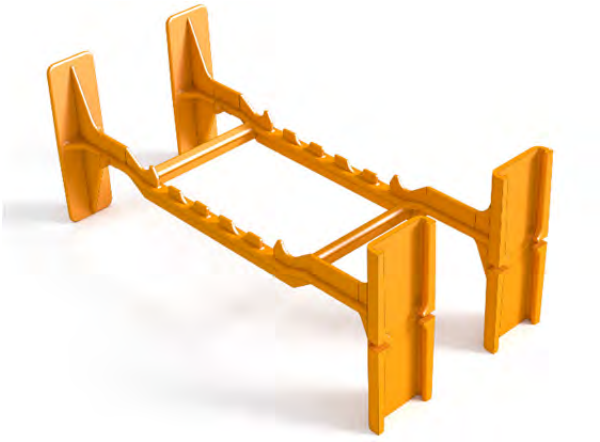


Figure 13: Quad-Lock Extender Tie

1.1.4.3 Brick Ledge Tie

Quad-Lock Brick Ledge Tie can be used with Regular Panels only to create a concrete ledge for brick or stone exterior finishes or as an interior support for floor joists. It transitions the wall from a 12" [305mm] concrete cavity to a 6" [150mm] cavity leaving a 3¾" [95mm] solid concrete supporting ledge. For more details, see Chapter 10, Section 10.2.4.1 "Brick Ledge Support" on Page 192.

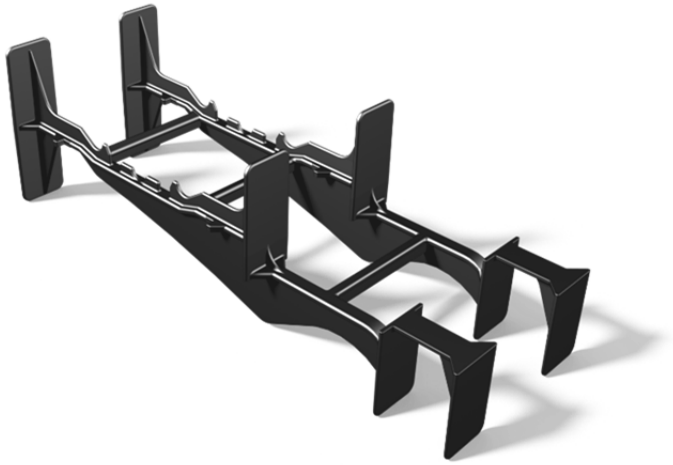


Figure 14: Brick Ledge Tie

1.1.4.4 Slab Tie & Slab Bracket System

Quad-Lock Slab Ties and aluminum Slab Brackets can support one outside row of Quad-Lock panels used as an edge-form during the pour of an interconnecting concrete slab. This means that a continuous layer of insulation is maintained at the outer edge of the slab, eliminating thermal bridging. The 1st course of the story above ties seamlessly into the panels below.

Some experts use the slab-ties and brackets for vertical bracing when pouring Quad-Lock walls and Quad-Deck in a monolithic pour. *See Chapter 7 "Wall-to-Floor Connections", Section 7.1.2 "Concrete Floor Connections" on Page 146.*

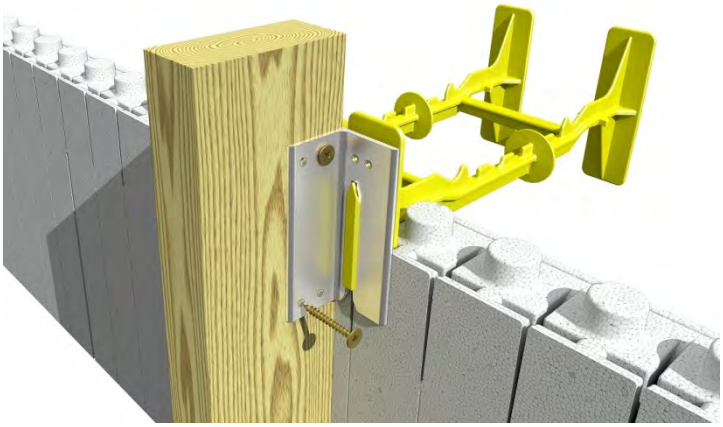


Figure 15: Slab Tie & Slab Bracket Assembly

1.1.5 Quad-Lock Wire Top Ties

1.1.5.1 Wire Top Ties

Quad-Lock Wire Top Ties are used in conjunction with the Metal Tracks to easily finish the top of Quad-Lock walls. They keep the top panels plumb, secure and in position to create a straight wall. They also provide easy placement of horizontal rebar close to the top of the wall. Wire Top Ties are made from 6 ga. galvanized steel wire and are bent to securely fit the contours of the panels and into the tie slots in the panel.

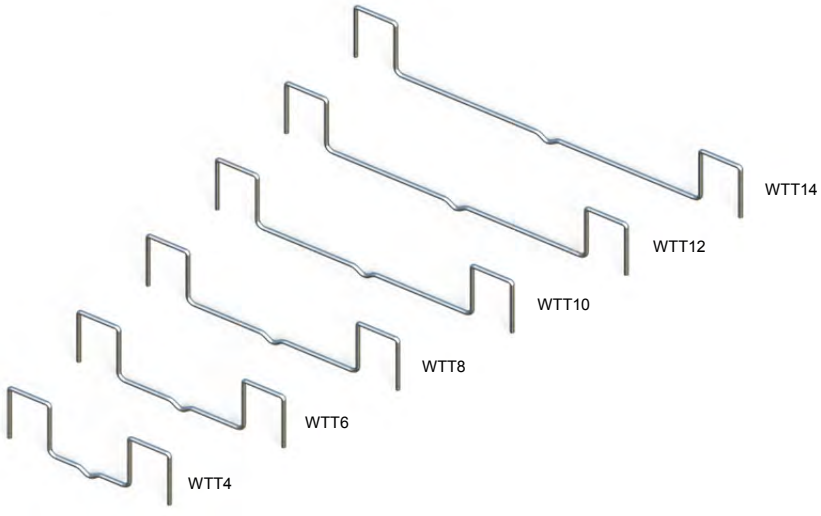


Figure 16: Wire Top Ties

Wire Top Ties are available in 6 lengths that correspond to the lengths of Black Ties through Brown Ties. Place a minimum of 4 Wire Top Ties per panel pair. For building cavities larger than that of a red tie, see Chapter 3, Section 3.9.6 "Finishing the Top of Walls" on Page 66.

1.1.6 Quad-Lock Metal Brackets

1.1.6.1 Corner Brackets:

Quad-Lock Corner Brackets allow for the safe, quick and secure assembly of 90° corners and can eliminate the need for any external corner bracing. They come in two configurations: the Inside Corner Bracket and the Outside Corner Bracket.

- Inside Corner Brackets are used on every row of the inside panels, with the exception of the top row, for 90° corners and on the inside corners of T-walls, columns and pilasters.
- Outside Corner Brackets are used on every row of the outside corner panels, again with the exception of the top row, as reinforcement for the back wall of T-walls, and for outside corners of pilasters and columns.

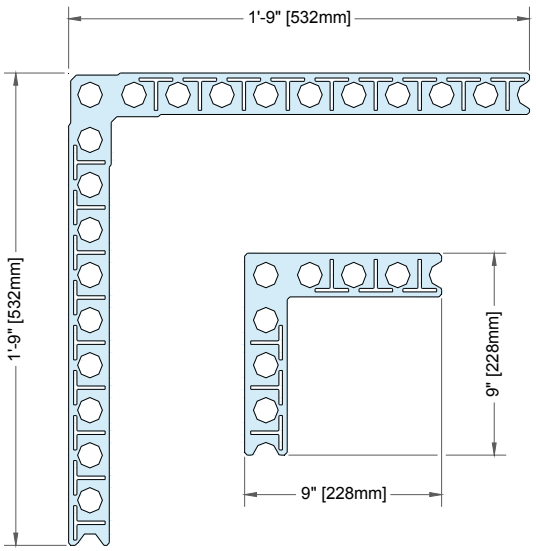


Figure 17: Inside and Outside Corner Brackets

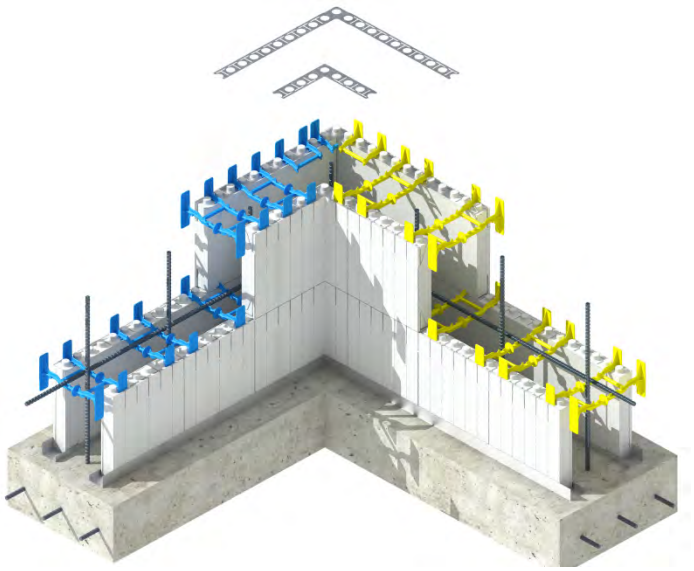


Figure 18: 90° Corner Assembly

Corner brackets are made of flat galvanized steel and are designed to fit over Quad-Lock Panels placed at 90° to one another. The brackets have holes that match the panels' foam interlock knobs, and slots that allow the ties and tie flanges to be inserted once the bracket has been placed over the panels.

When installed properly, the Corner Brackets combined with the ties and tie flanges alone will absorb the forces of the poured concrete at the recommended slump and pour rates, eliminating the need for structural corner bracing. Bracing may be needed only to assure plumb and alignment in relation to the rest of the wall. For details see Section 3.7 on Page 61.

Corner and Angle Brackets are recessed from the surface of the EPS panels to minimize thermal bridging and avoid flashing through stucco.

Note: For wider concrete cavities and thicker foam applications, it is advisable to extend the Outside Corner Brackets. See section below on Straight Brackets. See Chapter 4, Section 4.6 "Wide Walls" on Page 82.

1.1.6.2 Angle Brackets

Quad-Lock hinged Angle Brackets allow wall angles of almost any degree to be easily formed and braced. Once the two panel ends are mitered at the bi-section degree of the desired angle, the bracket folds out to match the angle of the wall.

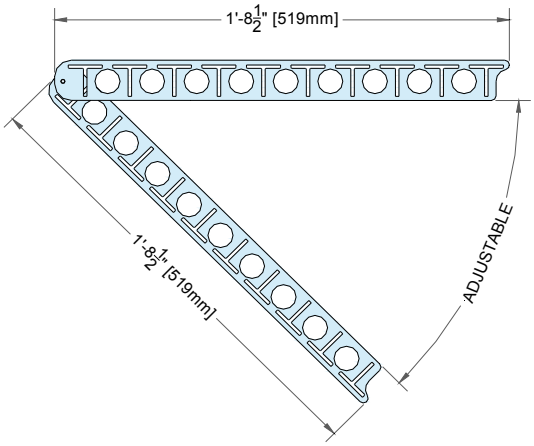


Figure 19: Angle Bracket

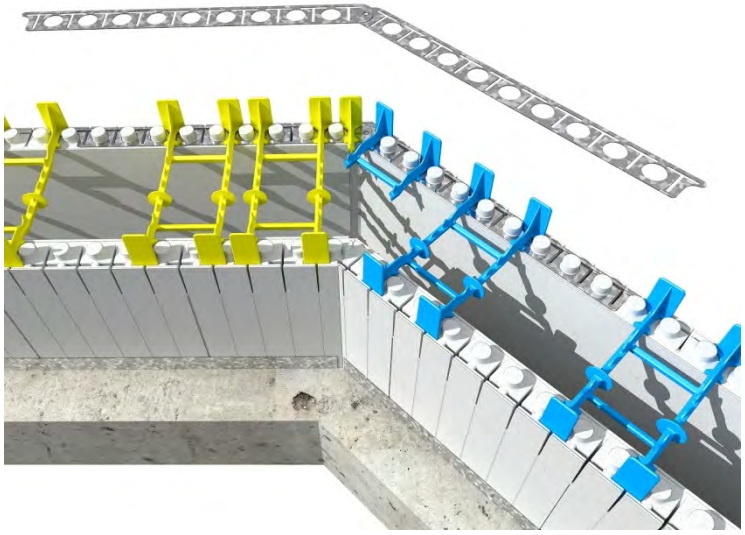


Figure 20: Assembly of Angle

Similar to the 90° Corner Bracket, ties are placed through the Angle Bracket and into the panel. Angle Brackets are only needed on the outside of the angle and will ensure that the wall is held together plumb and true without the need for extra bracing. For details see Chapter 4 – Special Wall Elements, Section 4.4 on Page 13.

1.1.6.3 End Cap Brackets

Quad-Lock End Cap Brackets have been specifically designed to replace lumber or plywood forms at wall ends (bulkheads) with EPS foam piece, leaving no exposed concrete. The End Cap Bracket is very similar to an Outside Corner Bracket and can be used for insulated wall ends ranging from 6" to 12" [150mm to 305mm] nominal cavity size. *See Chapter 4, Section 4.3 on Page 73 and Chapter 5, Section 5.1.3 on Page 102.*

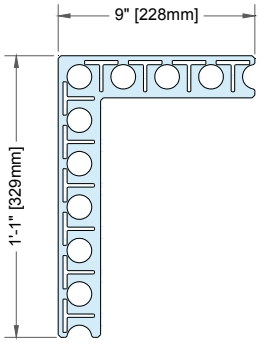


Figure 21: End Cap Bracket

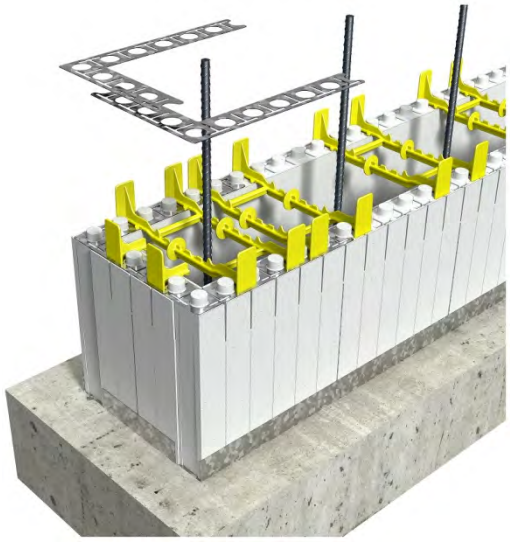


Figure 22: End Cap (Bulkhead) Assembly with End Cap Brackets

1.1.6.4 Straight Brackets

Quad-Lock Straight Brackets allows the installer to secure a 4-way wall intersection by placing pairs of 34 inch [86.3 cm] long Straight Brackets that span across intersecting walls. This provides a solid connection between two wall segments that have been interrupted by another wall plane.

Straight Brackets cut in half are used to extend the corner brackets on wide walls, where additional support is needed.

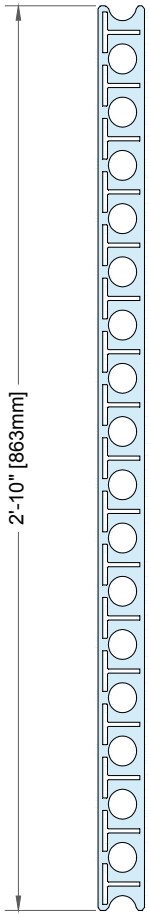


Figure 23: Straight Bracket

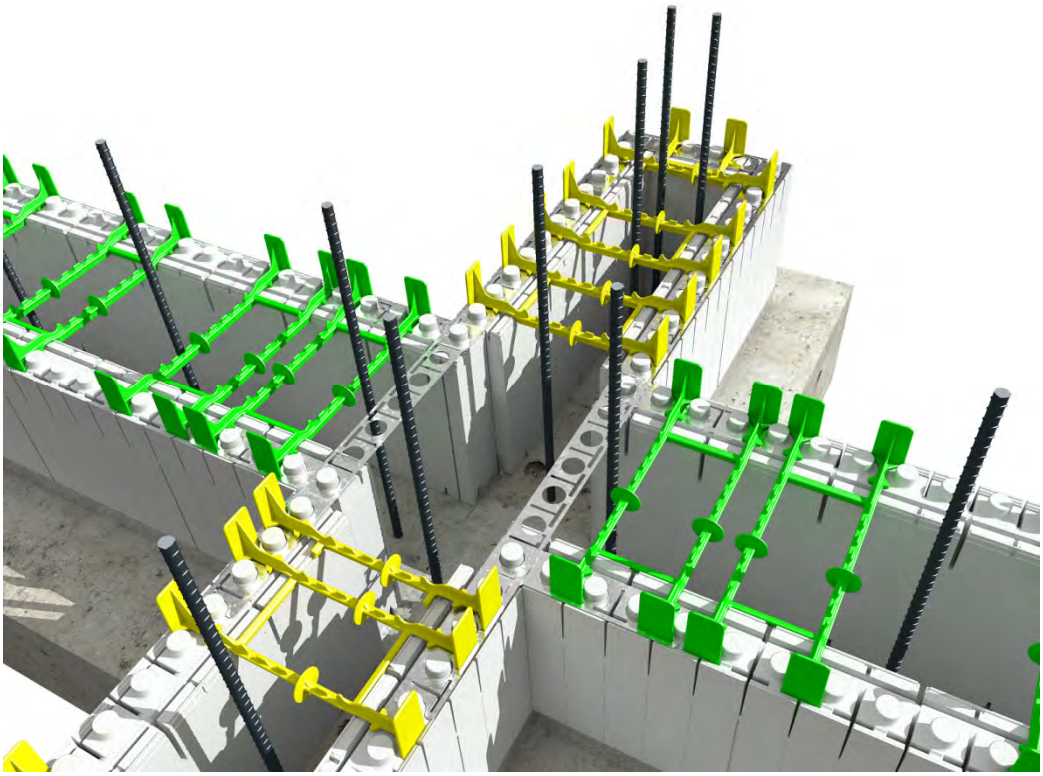


Figure 24: Straight Bracket on T Wall assembly

1.1.7 Quad-Lock Metal Track

Metal Track is used to start and finish a Quad-Lock wall. Quad-Lock provides a range of metal track styles to accommodate different wall assemblies.

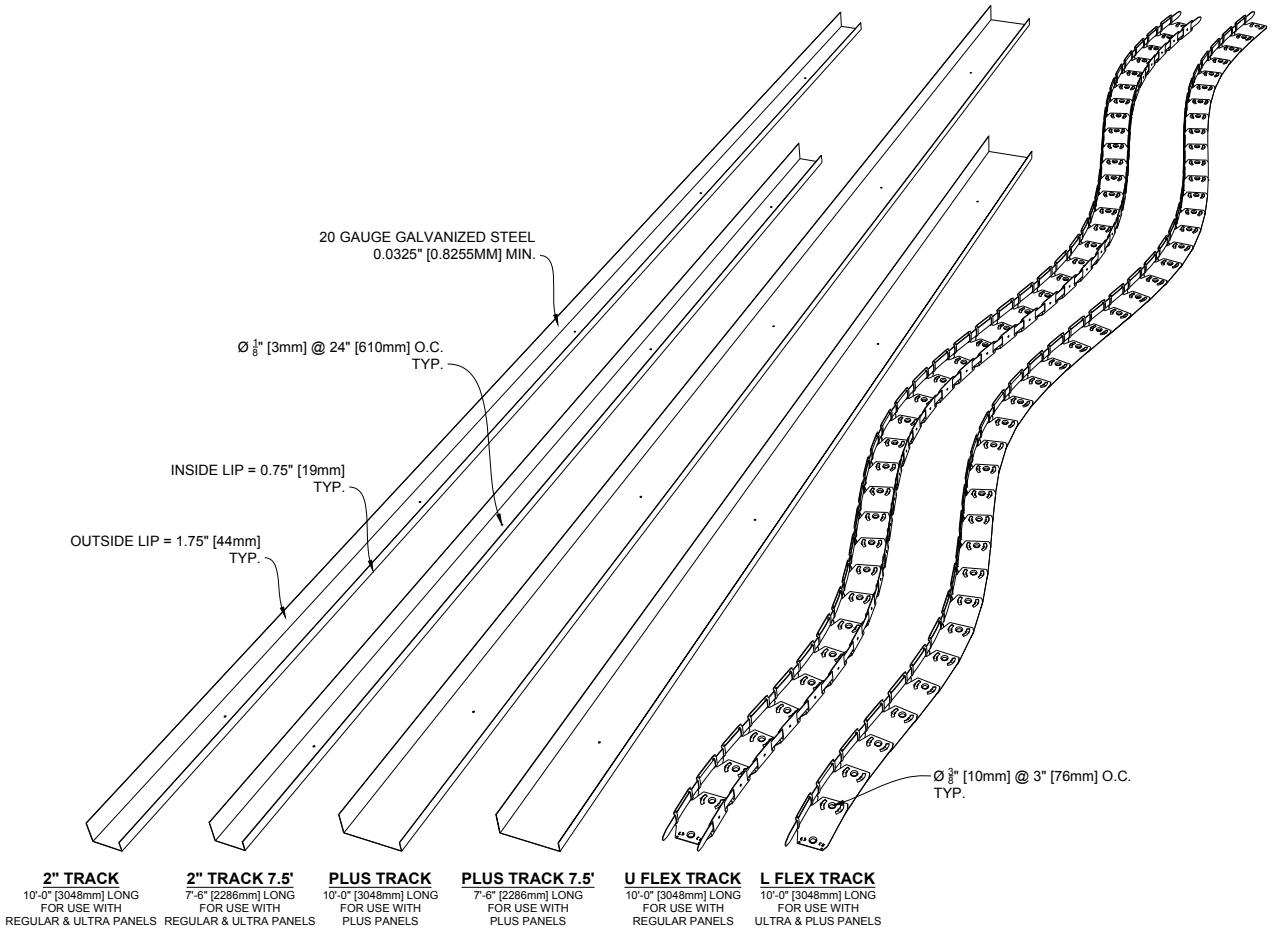


Figure 25: Different Types of Quad-Lock Metal Tracks

1.1.7.1 Metal Track

Quad-Lock Metal Track is made from 20-gauge galvanized steel and is pre-bent to fit the dimensions of the panels. The Metal Track is available in 2¼" [57mm] width for use with Regular or Ultra Panels or in 4¼" [108mm] width for use Quad-Lock Plus Panels and is pre-punched with marker holes every 24" [610mm] for fastening to concrete. Metal Track is used:

- On the bottom of the first course of panels to secure the bottom of the wall. They are fastened to the concrete footing or slab using a minimum of 1¼" [32mm] long fasteners.
- In conjunction with Wire Top Ties as the ladder brace to finish the top of the wall.
- To form bottom sill of window bucks.
- To form brick ledges in conjunction with Brick Ledge Ties (BLT) and Regular Panels.

1.1.7.2 Flex Tracks

Flex Track is used to secure radius walls for impressive architectural details. Draw the desired radius on the footing or slab, then use the “drill and pin” method to attach Flex Track to concrete. Flex Track must be used on both sides of the radius wall, just like regular track, with the taller flange to the outside, away from concrete.

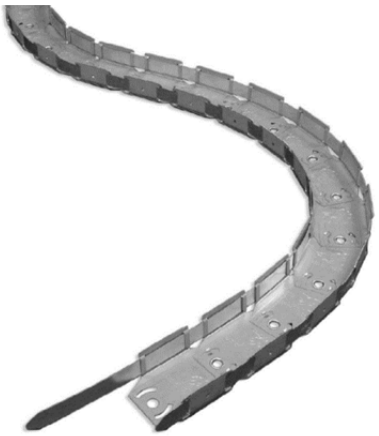


Figure 26: Radius U-Track for Regular Panels

Figure 27: Radius L-Track for Ultra and Plus Panels

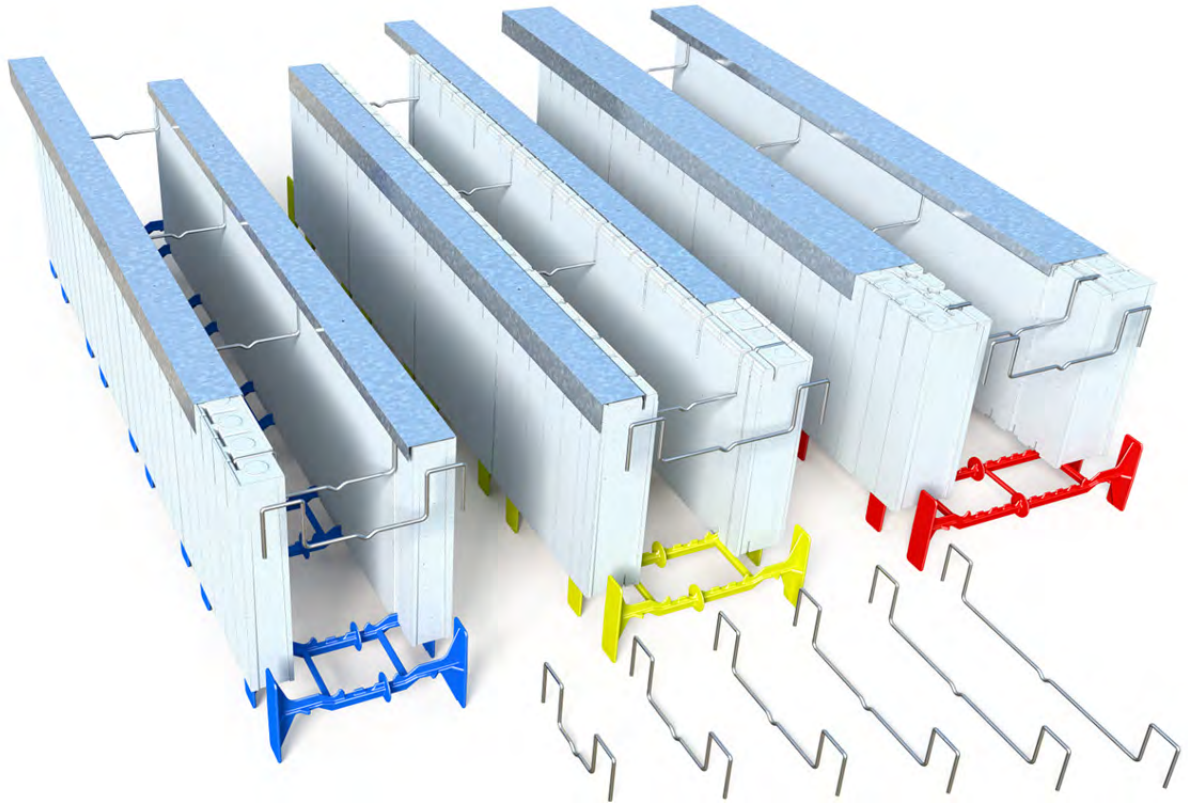


Figure 28: Wire Top Ties used with Metal Track

For details see Chapter 3, Section 3.9.6.1 “Wire Top Ties & Metal Track” on Page 66.

2 DESIGN CONSIDERATIONS

The following chapter outlines information pertaining to many common design concerns. It begins with an outline of how Quad-Lock ICF designs help to facilitate high priority design requirements in today's buildings. This is followed by a series of key topical summaries that may be critical to the design process.

2.1 QUAD-LOCK AND THE BUILDING SHELL

Building owners today place increasing importance on long-term performance (and protection) of their valuable assets in terms of durability, sustainability, and long-term cost of operation. Professional designers look to building science experts to provide proven construction details that insure that the customer's interests are best served.

The building science community's top experts offer some essential principles* to promote long-life, good energy performance, and survivability against disasters in built structures. Reinforced concrete buildings constructed with Insulating Concrete Forms are recognized as being among the best of means suited to achieve the levels of performance prescribed by building science experts.

The following table summarizes, in layman's terms, some of the latest building science principles** and how Quad-Lock ICFs meet those challenges:

Suggested Building Design Principle	Quad-Lock ICF/Concrete Offering
"Keep the rain out of the structure"	Properly constructed ICF walls have been independently demonstrated to be 100% air and water tight under the most demanding conditions, using appropriate forming and sealing techniques for window/door openings. Quad-Lock has co-sponsored some of the latest research on water and air intrusion in ICF walls.
"Keep the building from blowing away"	Reinforced concrete structures are arguably the most disaster resistant designs available in the industry. Properly constructed and detailed ICF structures can resist the highest wind loads in nature.
"Build with materials that can get wet"	Both concrete and foamed insulation materials (ICFs) are highly resistant to degradation by exposure to water. EPS retains insulating qualities when wet. Quad-Lock EPS has been independently tested and shown to be 100% resistant to mold growth
"Design assemblies to easily dry when they get wet"	Materials used in ICF-built concrete structures are (by their nature) moisture resistant as well as having been confirmed to possess adequate drying capacity in order to prevent damage from moisture*** Quad-Lock also offers up-to-date construction details that can enhance the drying capacity of cladding assemblies applied to ICFs.
"Elevate the structure when threatened by water"	Flood-resistant building designs incorporating Quad-Deck ICF suspended slabs have been the design of choice for replacement homes and schools following destruction of the original buildings by recent hurricane-driven flood events.
"Build with materials that won't burn"	Quad-Lock walls have been independently verified**** to provide 2 hr., 3 hr., and 4 hr. fire protection, depending on the concrete cavity size. Quad-Lock EPS and full scale Quad-Lock/Concrete structures have been tested to the latest safety standards in USA, Canada, and EU for smoke generation, flame-spread, toxicity, and the ability of finishes to stay in place during 15 min. fire exposure.

* Straube, J & Burnett, E (2005-Building Science Press) *"Building Science for Building Enclosures"*
**Lstiburek, J - Notes from Roundtable Discussion from "An Evening with Joseph Lstiburek", BC-BEC Sept 25 2013
*** Gadja, J & Van Geem, M (2002 Portland Cement Assn.) *"Moisture in ICF Walls"*

**** UL Canada, (2007, Project 05CA55130) *"Report on Concrete Wall System Incorporating ICFs for Use in Bearing Wall and Partition Systems",* (Test Standards: ASTM E119-07, CAN/ULC S101-04 and EN 1365-1)

2.2 DESIGN CONSIDERATION SUMMARY

Quad-Lock ICF walls are regarded in the same manner as other formed cast-in-place reinforced concrete wall in terms of structural design. National concrete design standards from American Concrete Institute (USA) and CAN/ULC (Canada) apply to Quad-Lock ICF walls.

The following is a brief outline of architectural and structural design considerations for Quad-Lock ICF projects. For more complete information, please contact Quad-Lock's Technical Department.

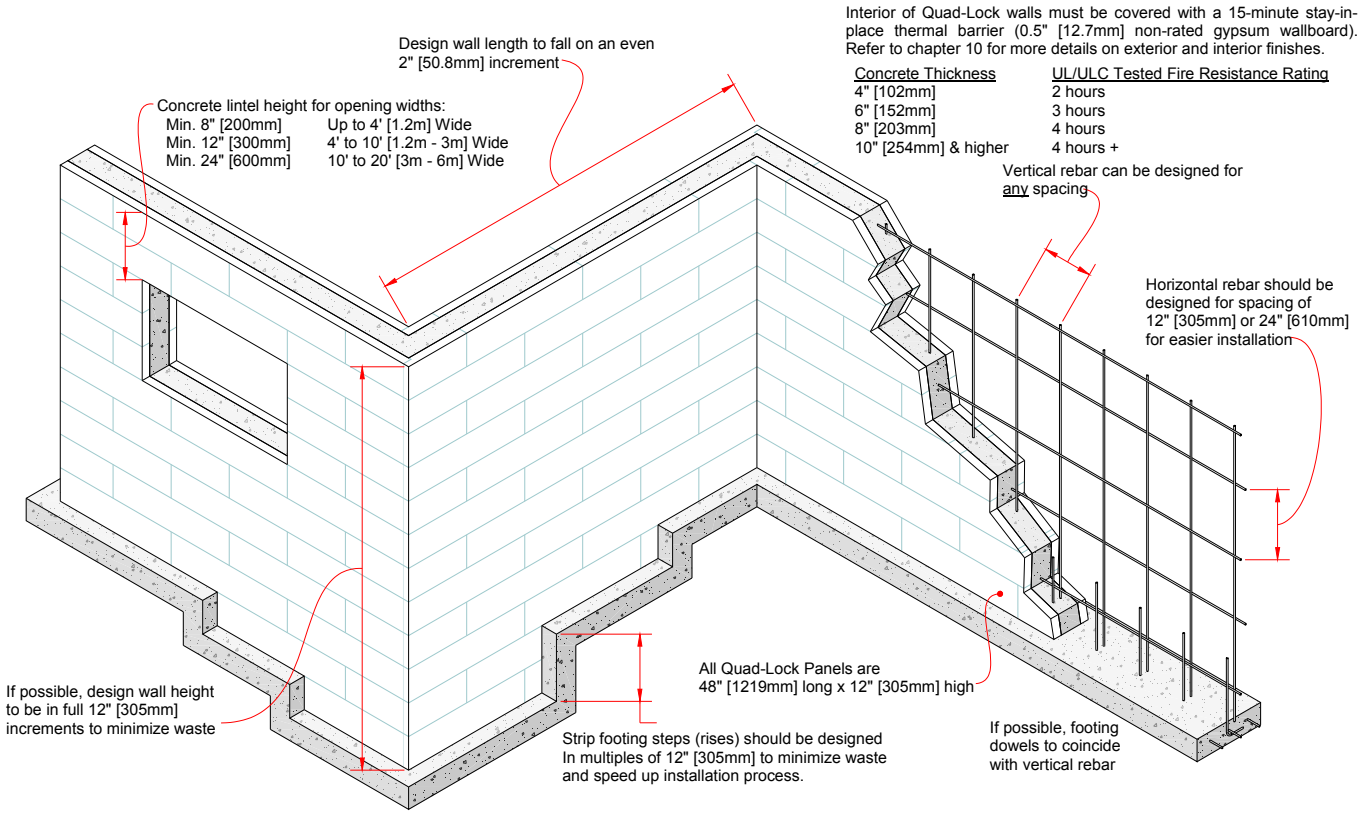


Figure 29: Design Considerations

2.2.1 Code Compliance & Fire Safety

The Quad-Lock wall system can be used for the construction of concrete walls when designed and constructed in accordance with national and local concrete building design criteria or recognized evaluation reports specific to Quad-Lock. *Contact Quad-Lock's Technical Department for more details on the regional and national evaluations*.

Quad-Lock products have been tested to required material safety standards and criteria for USA, Canada, UK, EU, and many other jurisdictions, including:

USA
ASTM E2634 *"Standard Specification for Flat Wall Insulating Concrete Form (ICF) Systems"* Quad-Lock products have been evaluated by ICC-ES and carry ESR-2157. *Contact Quad-Lock's Technical Department for more details.*

Canada
CAN/ULC-S717.1-12, *First Edition - Standard for Flat Wall Insulating Concrete Form (ICF) Units. Contact Quad-Lock's Technical Department for more details.*

2.2.1.1 Fire Resistance Rating

Quad-Lock walls poured with normal weight concrete have been evaluated for 2, 3 and 4 hour Fire Resistance Ratings by Underwriters Laboratories in USA and Canada. *See Quad-Lock's Code Evaluations, Approvals & Tests for details.*

2.2.1.2 Required Thermal Barrier

Most jurisdictions require foamed plastic insulation (EPS) to be covered by a rated 15-minute thermal barrier. *See Chapter 10, Section 10.1.1 for details.*

2.2.1.3 Combustible Construction Types

Quad-Lock ICFs are suitable for buildings classified as combustible construction. *Contact Quad-Lock's Technical Department for more details contained in ICC Evaluation Report ESR-2157.*

2.2.1.4 Non-Combustible Construction Types

Quad-Lock walls finished with approved acrylic stucco systems can serve in designs for non-combustible construction categories. Details are available in Quad-Lock's ICC Evaluation ESR-2157. *Contact Quad-Lock's Technical Department for more details.*

2.2.1.5 Sound Attenuation (STC)

Quad-Lock walls and deck have undergone testing under ASTM E-90 *Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements.* STC values of 50 and higher are documented. *Contact Quad-Lock's Technical Department for more details.*

2.2.2 Structural Design

Commercial buildings and certain residential buildings require a site-specific structural design plan which is stamped by the architect or engineer who is responsible for the design.

In some cases, residential projects (within certain size parameters) can be designed using only prescriptive provisions taken from national or regional codes without the need for a professional stamp.

Note: In general, Quad-Lock ICF wall forms are best suited for **12 inch [305mm] or 24 inch [610mm] spacing of horizontal bars** and they will accommodate any spacing of vertical reinforcing bars, though cost savings can be achieved when **stub steel / footing dowels coincide with vertical rebar**.

For more information about reinforcing bar placement see Chapter 8, Section 8.2 REINFORCING STEEL (Rebar)

2.2.2.1 Site Specific Structural Design

For all commercial and many residential buildings, a site-specific structural design must be developed by a licensed professional in the region where the building permit is being issued. The design is carried out using national standards and any additional local regulations concerning structural design.

USA
Concrete walls designed and constructed in accordance with the IBC must comply to Chapters 16 and 19. Footings and foundations must be designed and constructed in accordance with IBC Chapter 18.

Quad-Lock walls for residential buildings in high wind areas may be designed and constructed in accordance with the prescriptive provisions of Section 209 of the ICC Standard for Residential Construction in High Wind Areas (ICC 600-2008), subject to certain restrictions. *(See Quad-Lock's ICC Evaluation ESR-2157, Section 4.0)*

Canada
National Building Code of Canada: Concrete walls not covered by prescriptive provisions of Part 9 must be designed and constructed in accordance with Parts 3, 4, and 5 of the NBC or Provincial Building Code. Structural design must be carried out in accordance with CSA A23.3

2.2.2.2 Prescriptive Design Specifications for One and Two Family Homes

Building codes in both the USA and Canada contain concrete wall reinforcement tables that have been prepared for buildings with basements supporting light-frame construction *or* up to two-stories of concrete construction.

USA

International Residential Code (IRC) Chapters R404 "Foundations" and R611 "Exterior Concrete Wall Construction" allow builders to easily make reinforcement selections without site specific engineering. Note that certain size and span limitations apply to buildings constructed under these specifications.

IRC also permits design according to provisions of PCA100-2012 *"Prescriptive Design of Exterior Concrete Walls For One and Two Family Dwellings"*, 2nd Edition", by the Portland Cement Association. (Free download at www.cement.org).

When PCA 100, or the provisions of IRC sections are used to design concrete walls, project drawings, typical details and specifications are not required to bear the seal of the architect or engineer responsible for design, unless otherwise required by the jurisdiction having authority. Consult with the local building department regarding the applicability of prescriptive code provisions.

For designs exceeding applicability limits in the above documents, US designs shall be carried in accordance to ACI 318 and must bear the seal of the architect or engineer responsible for design

Canada

Part 9, Division B of the *National Building Code of Canada – 2010* contains prescriptive design provisions for residential structures for use in lieu of site-specific engineering. Included are reinforcing tables for foundation walls, above-grade walls and openings.

Footing sizes, lateral restraint, and roof attachment specifications are offered. Note: A limitation for use of prescriptive designs exists in Canadian seismic zones where spectral response acceleration [Sa (0.2)] exceeds 0.4.

Most Provincial building codes will mirror the National Code, with regional adaptations.

In the event of a conflict between this manual and the applicable building code, the provisions of the building code shall prevail in all cases.

Table 2.2.2: The following table summarizes applicable codes in North America

Building Element or Type	*Applicable Code or Standard (USA)*	*Applicable Code or Standard (Canada)*
Residential Basements and Foundations	**International Residential Code** ***Section R404*** **OR** **PCA 100-2012, *Prescriptive Design of Exterior Concrete Walls for One- and Two-Family Dwellings*** **OR** **Quad-Lock ICC Evaluation Report ESR-2157**	**National Building Code of Canada** ***Section 9.15*** **OR** **Current Provincial Building Code - Part 9** **OR** **Quad-Lock Canadian Engineering Report** *(Contact Quad-Lock's Technical Department for more details)*
Residential 1 and 2-Story Above Grade	**International Residential Code** ***Section R611*** **OR** **PCA 100-2012, Prescriptive Design of Exterior Concrete Walls for One- and Two-Family Dwellings** **OR** **Quad-Lock ICC Evaluation Report ESR-2157**	**If $Sa_{(0.2)}$ is 0.4 or lower use National Building Code of Canada Section 9.15** **If $Sa_{(0.2)}$ is above 0.4 and under 0.94 use Quad-Lock Canadian Engineering Report** **If Sa(0.2) is above 0.94 (very rare) consult a licensed structural engineer**
Multi-Family and Commercial Buildings	**International Building Code – Chapters 16 & 19; ACI 318**	**National Building Code of Canada - Part 4 and CSA A23.3**

2.2.3 Standard Specification Template (CSI)

Quad-Lock offers a standard specification template in CSI format for use by design professionals. The Quad-Lock CSI specification can be found in the Technical Library of Quad-Lock's website, www.quadlock.com.

2.2.4 Construction Details and Drawings

Quad-Lock Building Systems has developed generic construction details for the assembly of the Quad-Lock wall system illustrating numerous wall connections, reinforcing and finishing details. A complete library (including BIM templates) of these details is available (at no charge) in PDF and AutoCAD formats in the technical section of the Quad-Lock website, www.quadlock.com.

Designers are welcome to download Quad-Lock generic construction details for use in their own drawings. Additional design information can be added to reflect engineering and other project specifications.

2.2.5 Commercial and Multi-Family Buildings

Commercial and multi-family residential buildings not conforming to the above and constructed using Quad-Lock wall or deck forms, must be designed and engineered in accordance with Part 4 of the National Building Code of Canada or Chapters 16 & 19 "Concrete" of the International Building Code. *Contact Quad-Lock's Technical Department for more details.*

2.2.6 Disaster Resistant Structures

Buildings especially intended for disaster resistance should be designed in accordance with specific requirements outlined in the building codes and in publications offered by FEMA, ASCE, and other recognized bodies. *Contact Quad-Lock's Technical Department for more details.*

2.2.7 Swimming Pools, Cisterns, and Tanks

Insulated swimming pools, water cisterns, and agricultural tanks are often built with Quad-Lock ICFs. Chapter 13 on Page 211 expands on this topic.

2.2.8 Energy Management Planning

2.2.8.1 HVAC Considerations

High performance ICF buildings must be viewed differently than conventional wood, steel or masonry structures when designing and sizing HVAC systems. Relatively high, continuous insulation values, thermal mass and very low rates of air exchange must be factored into heating/cooling load calculations. Consequently, common "rules-of-thumb" for other types of buildings should not be used. Always consult local building codes for current minimum requirements that apply to your building type.

Please note the following points regarding HVAC design in ICF buildings:

- Air leakage rates of 0.5 to 1.5 (ACH50) are very common in blower door testing of new ICF buildings, compared to rates as high as 8 (ACH50) on older conventionally built structures, especially wood-framed.
- Due to very low rates of uncontrolled air exchange in ICF structures, Quad-Lock recommends the use of **mechanical ventilation** (e.g. fans or air-to-air heat exchangers) to maintain adequate indoor air quality. Note: To minimize pressure differentials in very airtight buildings, a "balanced" air-exchange design *(see example below)* is preferable to a "supply-only" or "exhaust-only" design .
- See HUD report "HVAC Sizing Methodology for Insulated Concrete Homes".

Due to longer curing periods of concrete within ICFs, some buildings initially require additional dehumidification, sometimes for up to 6-9 months after construction.

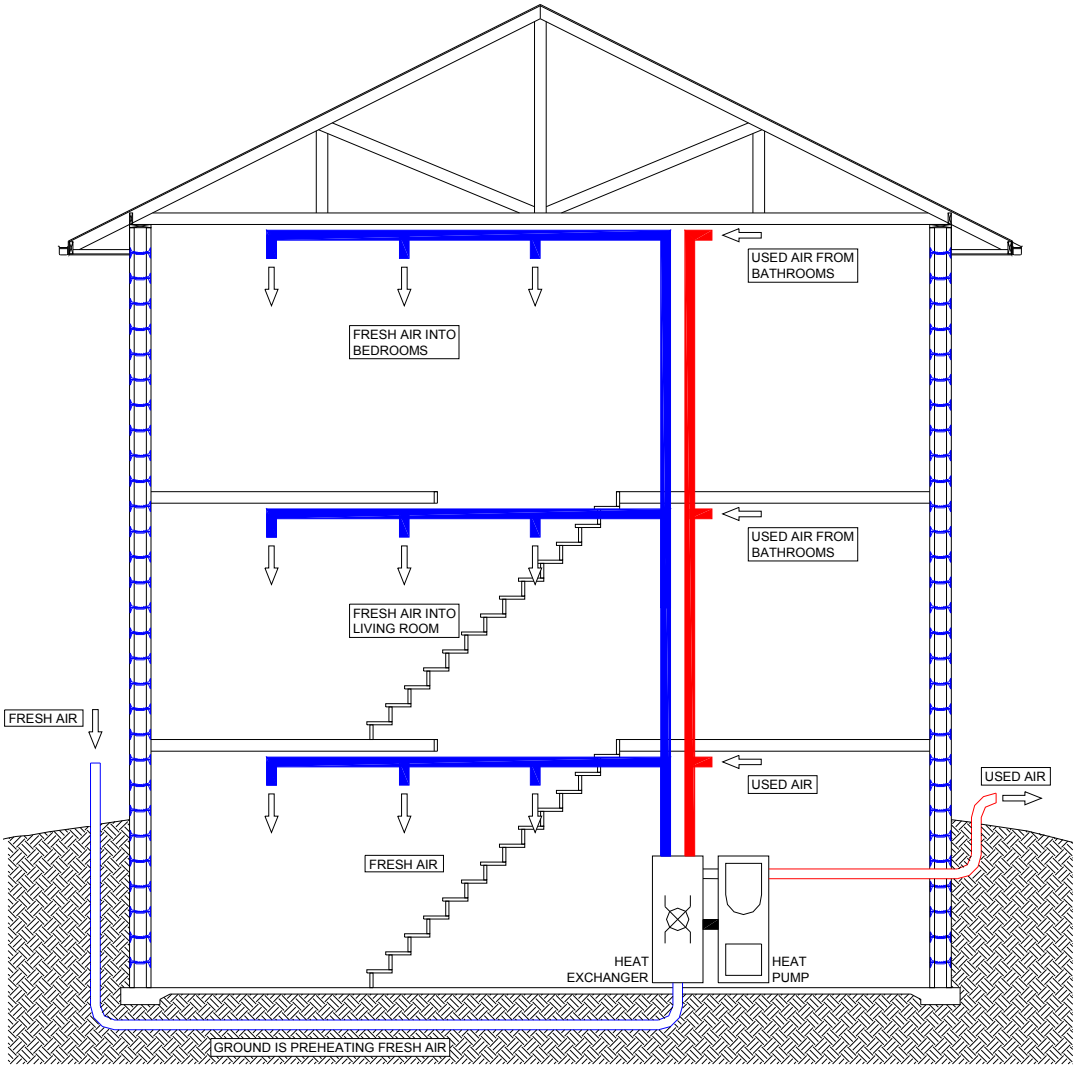


Figure 30: Typical "Passive House" Ventilation System

2.2.8.2 Whole Building Design, Energy Modeling

Every building should be considered from a 'whole system' perspective and designed using an integrated systems approach. E.g. depending on factors like site & location of the building and the prevailing climate, Passive Solar Building Design helps optimize a building's absorption and reflection of solar radiation through orientation, placement of windows and shading elements, and choice of finishes. Besides walls, roof and slab, windows also have a significant impact on energy-efficiency and they range widely in performance.

Many design professionals now offer energy modeling / simulation services that help in formulating an energy-efficient yet cost-effective building design. Energy modeling software allows the designer to compare the thermal, cost and other properties of building components, such as windows and doors. Quad-Lock's BIM library (Building Information Modeling) for walls, floors, and roofs is available for download on quadlock.com.

2.2.9 Interior and Exterior Finishes

Quad-Lock ICFs are meant to be protected from exposure on both the interior and exterior faces. *See Chapter 10 on Page 180 of this manual for installation instructions.*

2.2.9.1 Interior Finish Requirements

Most national building codes require that foam-plastic insulation be protected by a tested 15 minute thermal barrier in habitable spaces. (Exceptions exist for exposed attics and crawl spaces).

- In most instances, ½" [13mm] gypsum drywall is used to meet these requirements.
- Mechanical fastening of ½ gypsum drywall to Quad-Lock tie flanges has been tested under NFPA 286 and is approved as a 15 minute thermal barrier.

Contact Quad-Lock's Technical Department for more details.

2.2.9.2 Exterior Finish

A wide range of exterior finishes can be incorporated into a Quad-Lock building design, including face-sealed stucco finishes, lapped siding, sheet siding products, natural stone or brick, and many more. Key information is needed to develop a finish plan to suit the architectural design: Manufacturers fastening specifications, required shear and tensile loading, and maximum spacing of support elements are among the most important. *See Chapter 10 on Page 180 of this manual for more information.*

2.2.10 Mechanical-Electrical-Plumbing

A clear advantage of ICFs is the ability to create chase-ways through the EPS insulation to allow passage of conduit and piping. Depending on diameter, many utilities can be 100% contained in the cross-section of the insulation, sometimes without protection if adequate set-back exists. Details for installation of electrical and plumbing services is found in Chapter 12 on Page 203 of this manual.

2.2.11 Allowable Loads for Fasteners

In compliance with USA ICC-AC353, Quad-Lock has developed the following table, expressing *"allowable loads"* on plastic ties and fastenings strips. These are *"factored"* loads developed using the safety guidelines contained in the ICC acceptance criteria. http://www.icc-es.org/Criteria/criteria/index.cfm?list_all=yes

Table 2.2.11: Summary of Lateral and Tensile Fastener Load Testing*:

Lateral (Shear) Strength Evaluation			
Substrate	**Fastener Type**	**Average Ultimate Load (lbf)**	**Allowable Lateral Strength (lbf)**
Quad-Lock Tie Flanges	#9 Cement Board Fasteners	148.7	46.5
Quad-Lock Tie Flanges	#8 Drywall Screws	125.3	39.2
FS Fastening Strips	#9 Cement Board Fasteners	299.3	93.5

Withdrawal (Pullout) Strength Evaluation			
Substrate	**Fastener Type**	**Average Ultimate Load (lbf)**	**Allowable Withdrawal Strength (lbf)**
Quad-Lock Tie Flanges	#9 Cement Board Fasteners	121.6	24.3
Quad-Lock Tie Flanges	#8 Drywall Screws	120.9	24.2
FS Fastening Strips	#9 Cement Board Fasteners	181	36.2

**Testing performed in compliance to ASTM 2634-11 and ICC-ES Acceptance Criteria #353*

2.2.12 Insect Resistance

Quad-Lock products are not manufactured with borate or other insecticides. If used in areas where termites or other insects pose a threat to buildings, walls should be layered with rated termite-resistant membranes and flashings. See Page 99 in Chapter 4 for more details.

- Normal pest-control measures should always be followed near ICF buildings. *Contact Quad-Lock's Technical Department for more details.*

2.2.13 Damp Proofing/Waterproofing

Quad-Lock ICF walls must comply with local building codes regarding moisture resistance. In most cases below grade walls should be protected against damp or saturated soils. *Methods to apply damp proofing or water proofing are detailed in Chapter 9 "Damp Proofing and Water Proofing" on Page 175.*

2.3 CHOOSING THE CORRECT WALL CONFIGURATION

The Quad-Lock components you choose are dependent on the structural and thermal performance required in your building design specifications.

The wide range of panel & tie configurations and R-values (or U-values) offered allows construction of complex, multi-story structures able to resist severe loads while still offering the best thermal protection in the industry.

2.3.1 Wall Configuration Matrix: Insulation Value vs. Concrete Thickness

The following table plots insulation values of Quad-Lock panel layers over a variety of concrete wall thicknesses:

Table 2.3.1: Insulation Values & Configurations Versus Concrete Core Thickness*

Insulation Value	Inside Foam Thickness	Common Concrete Core Thicknesses*						Outside Foam Thickness
R-22 [U-0.28]	**2.25"** [57mm]	**3.75"** [95mm]	**5.75"** [146mm]	**7.75"** [197mm]	**9.75"** [248mm]	**11.75"** [298mm]	**13.75"** [349mm]	**2.25"** [57mm]
R-28 [U-0.21]	**3.125"** [79mm]	**4"** [102mm]	**6"** [152mm]	**8"** [203mm]	**10"** [254mm]	**12"** [305mm]	**14"** [356mm]	**3.125"** [79mm]
R-30 [U-0.20]	**2.25"** [79mm]	**3.75"** [95mm]	**5.75"** [146mm]	**7.75"** [197mm]	**9.75"** [248mm]	**11.75"** [298mm]	**13.75"** [349mm]	**4.25"** [108mm]
R-38 [U-0.15]	**4.25"** [108mm]	**3.75"** [95mm]	**5.75"** [146mm]	**7.75"** [197mm]	**9.75"** [248mm]	**11.75"** [298mm]	**13.75"** [349mm]	**4.25"** [108mm]
R-38 TMO [U-0.15 TMO]	**2.25"** [57mm]	**3.75"** [95mm]	**5.75"** [146mm]	**7.75"** [197mm]	**9.75"** [248mm]	**11.75"** [298mm]	**13.75"** [349mm]	**4" + 2.25"** [102mm + 57mm]
R-43 [U-0.14]	**3.125"** [79mm]	**4"** [102mm]	**6"** [152mm]	**8"** [203mm]	**10"** [254mm]	**12"** [305mm]	**14"** [356mm]	**4" + 3.125"** [102mm + 79mm]
R-45 [U-0.13]	**2.25"** [79mm]	**3.75"** [95mm]	**5.75"** [146mm]	**7.75"** [197mm]	**9.75"** [248mm]	**11.75"** [298mm]	**13.75"** [349mm]	**4" + 4.25"** [102mm + 108mm]
R-53 [U-0.11]	**4.25"** [108mm]	**3.75"** [95mm]	**5.75"** [146mm]	**7.75"** [197mm]	**9.75"** [248mm]	**11.75"** [298mm]	**13.75"** [349mm]	**4" + 4.25"** [102mm + 108mm]
R-53 TMO [U-0.11 TMO]	**4.25"** [108mm]	**3.75"** [95mm]	**5.75"** [146mm]	**7.75"** [197mm]	**9.75"** [248mm]	**11.75"** [298mm]	**13.75"** [349mm]	**4" + 4.25"** [102mm + 108mm]
R-59 [U-0.10]	**3.125"** [79mm]	**4"** [102mm]	**6"** [152mm]	**8"** [203mm]	**10"** [254mm]	**12"** [305mm]	**14"** [356mm]	**4" + 4" + 3.125"** [102mm + 102mm + 79mm]

* Shaded cells require the use of Extender Ties. See Chapter 4, Section 4.6.1 on Page 83 for more information.
* For **total wall thickness** add up the following: Inside Foam Thickness + Desired Concrete Core + Outside Foam Thickness layer(s). Also add in the interior and exterior wall finishes.

2.4 SUSTAINABILITY & BEST MATERIAL UTILIZATION PRACTICES

2.4.1 LEED and Other Sustainability Plans

Along with reinforced concrete, Quad-Lock and Quad-Deck can be major contributors to attaining the goals set forth in sustainability measures like LEED, Green Globe, Built-Green and others. Contact Quad-Lock's Technical Department for more information.

2.4.2 Minimizing Waste and Debris

Quad-Lock is recognized in the industry as being the most efficient ICF system on the market for, among other items, control of waste. This has beneficial effects on the overall material cost of the project, the labor and fees spent on waste disposal, and reducing the life cycle cost of the building from an environmental impact perspective.

- The design of the Quad-Lock system allows for later use of scrap generated in the building process.
- **Use the unique 2 inch [50mm] tie layout to your best advantage by integrating once-cut panels and ties into a second fitting.**

2.4.2.1 Re-Utilize Cut Panels

Cut pieces of Quad-Lock panels can be re-utilized by using the following techniques.

- Cut pieces of Quad-Lock panels should be stored in one or two central location(s) on the jobsite for later use.
- When a detail calls for a cut panel, the person making the cut should first check the scrap pile before reaching for a new panel. Since Quad-Lock's unique design allows placement of ties at any 2" [5cm] interval, ties can be placed to accommodate the detail.
- **Use 12 inch and 24 inch length panels anywhere in the normal 12 inch layout of ties.**
- Substitute short panels of 12" [30cm], 24" [60cm] or 36" [90cm] lengths in appropriate combinations for full 48" [1219mm] panels.
- Since the scrap is cut to 12" [30cm] intervals, each seam will be straddled by a tie, so the wall does not suffer a loss of strength. This will utilize the larger portion of cut panels on the site, if wisely managed.

Pieces shorter than 12" [30cm] are generally not used in the wall, because additional ties will be required to support them, leaving the job short of ties at the end.

- Small panel scraps may be used to fashion window openings using the Quad-Lock End Cap Bracket for fully insulated window openings.
- End caps on wall terminations can also be formed using End Cap Brackets and panel scrap.
- Smaller EPS panel pieces (not useable in the wall as forms) can be placed over water supply lines buried in the earth to prevent freezing, and to protect from backfill or seismic activity, or placed in attic space as additional insulation.

By following the re-purposing recommendations above, it is possible to finish a job with zero panel waste.

2.4.2.2 Re-Purpose Panel Bags

Full panel bags should be opened only at the ends with a razor knife to access panels. Bags are clearly marked "Do Not Cut" on the sides, as score marks in the panels within may weaken panels during the pour.

- Panel bags can be re-purposed for use throughout the job as trash bags for removal of light construction waste generated by other trades.
- Bags not re-used can be recycled wherever grocery bags and other plastics are accepted.

2.4.2.3 Plastic Ties

Plastic ties are easily cut with common pruning shears. Quad-Lock Ties come from the factory in pairs, connected with two plastic ribs.

- When cut apart at the ribs, the ties can operate independently as needed in the wall.
- Single ties are useable, even when placed in pairs instead of Full Ties.
- All intact single ties should be collected from the jobsite and used in the wall.

- Tie flanges are also useable at corners and T-walls. Any intact tie flange should be saved for use in building corners and T-walls. Excess plastic material can be cut away and the flange inserted into Corner Brackets or End Cap Brackets.
- Any cut pieces of ties that are not useable are recyclable at any location that accepts HDPE (high-density polyethylene) plastic materials.

2.4.2.4 Tie Boxes

Quad-Lock tie boxes are re-useable and/or recyclable. Waxed (winter) boxes make great storage or moving containers. Un-waxed (summer) boxes can be recycled anywhere cardboard is accepted.

- If a project is deemed environmentally sensitive, be sure to specify the un-waxed tie boxes for compliance to recyclability requirements.

2.4.2.5 Minimizing Debris from Cutting

On some sites, maximum containment of any construction debris is required. Quad-Lock experts have devised cutting methods to minimize the production and spread of EPS bead that can be generated by both hand and power saws. *See Chapter 3, Section* 3.5 CUTTING EPS PANELS, PLASTIC TIES, & METAL COMPONENTS *on Page 42 for more information.*

2.4.3 Recycling Categories

Save money and help protect the environment by reusing and recycling Quad-Lock components throughout the project.

Table 2.4.3 – How to Recycle Quad-Lock Components

How to Recycle Quad-Lock Components Off-Site		
Quad-Lock Panels	**6 - Polystyrene**	
Quad-Lock Ties	**2 – High Density Polyethylene**	
Quad-Lock FS strips	**7 - Other**	
Quad-Lock Panel Bags	**4 – Low Density Polyethylene**	
Quad-Lock Tie Boxes	**Recyclable Cardboard**	
Quad-Lock Metal Brackets	**Steel**	

3 BASIC QUAD-LOCK WALL ASSEMBLY

3.1 OVERVIEW

The following information has been developed to offer users a general guide to the assembly of Quad-Lock Insulating Concrete Forms. Since every building is different, not every situation or issue can be addressed here though our experience does provide much insight into the process. Experienced field sales professionals and the experts in Quad-Lock's Training and Technical Services Department are available to assist with special applications

***Note**: While ICFs make concrete forming a much easier and faster task, they do not build themselves. The critical component not included with any ICF system is your good building skill. Our Quad-Lock mantra ("Plumb, Straight, Square, and Level") applies to an ICF installation as much as any other construction undertaking. Care must be taken to meet all building plan and code specifications throughout the process, especially during placement of concrete. Persons not experienced with concrete placement are advised to out-source the task to an experience professional.*

3.2 PRE-PLANNING

3.2.1 Estimating

Your dealer can provide you with an accurate estimate on the amount and cost of the Quad-Lock product suitable for your construction project, provided they are supplied with a set of plans and a clear indication of what to estimate.

Your dealer needs to know the following:

- Total wall length and height.
- Specified/desired insulation value, below grade and above grade.
- Wall height and total length of each concrete cavity size (by building level or story)
- Number of corners, angles and T-walls, intersections and end walls on each level.
- The number and sizes of all openings in the walls, i.e. doors and windows.
- Fire resistance requirement (if any) noted in building plans

This information can then be entered into the specially designed Quad-Lock Estimating Program by your dealer.

3.2.2 Getting Started

The most successful and productive Quad-Lock projects come from careful planning of details at all stages. The following information has been compiled from many experienced construction professional sources and will help to insure success during a Quad-Lock installation.

3.2.2.1 Project Management

The project manager and job supervisor should carefully review the building plans to determine what needs to be done before assembly takes place. Below you will find detailed check-lists that have been developed by ICF industry experts.

Quad-Lock experts utilize the following methods:

- Prepare cut lists and pre-fabricate components wherever possible.
- Rebar should be cut to length, pre-bent, and delivered to where it will be installed.
- Check the plans and determine the spacing that is specified for all rebar. Adapt to 12" [305mm] horizontal spacing whenever possible.
- Consult with utility sub-contractors to determine where electrical and plumbing services will enter/leave the building
- Window and door bucks should be pre-assembled on- or off-site, and delivered to the site ready for installation.
- Panel measurements that repeat can be pre-cut prior to assembly, particularly for corners. (Mind the wind☺)

- Have materials stocked on the site. Panels, ties, brackets and track should all be placed where they will be assembled. This minimizes the amount of time spent walking back and forth to retrieve product.
- Pre-plan your site to make sure that everything runs smoothly. Ask these questions:

1. Where will the concrete truck sit? Are there any overhead or adjacent obstacles like wires and trees that might pose a hazard to the pumping equipment?
2. Where will materials be delivered and off-loaded?
3. What is the best access route on and off the site?
4. Where will waste be deposited?
5. Where can the crew park so they won't be in the way of delivery vehicles?

It is important for the project manager to ensure that tasks relating to ICF assembly are allocated properly and that personnel are trained and have the necessary tools on hand:

- Determine who is going to set the track, the panels and the ties.
- Workers should read assembly instructions on the sides of the tie boxes and also refer to the Quad-Lock Product Manual if they require more detailed instructions.
- Make sure there is a plan for the bracing system and ensure that all equipment has been ordered and is ready. Determine who will assemble it. Ensure there is adequate lumber on hand if wood bracing is needed.
- Make sure that the concrete and pump has been ordered and that it will be ready on pour day.
- Determine who will run the pour, and address quality issues like Plumb, Straight, Square and Level. Assign individual tasks like handling the pump and running the vibrator.
- If an inspection is needed at any stage ensure that inspectors are scheduled and on site at the appropriate times.

Attention to these details will save you time and money, and help to ensure a smooth running and high quality job.

Building Tip:	**The building site must be prepared, clean and well organized. Clear all excess building materials and debris away from the work area. If you have a below grade basement, make sure that the excavation is clear and that you have good access all around the perimeter. A minimum clearance of 3 feet [1m] is recommended for safety. Provisions for a sub-surface drainage system should be made for later installation.**

3.2.2.2 Building Checklist

- ☐ Building inspector briefed and agreed on building plans, tying of rebar, inspections, etc.
- ☐ Footings are poured, level and cleats are stripped
- ☐ Steps in footings are built in 12″ [305mm] increments
- ☐ Building lines are snapped; Metal Track is securely fastened to footings. Ensure you take into account the panel thickness
- ☐ All Quad-Lock material is on site
- ☐ Adequate bracing material is on site
- ☐ Steel reinforcing details and specifications checked; Crew members briefed on placement details
- ☐ Horizontal steel is pre-bent for each row; vertical steel is cut to length
- ☐ Each crew member is equipped with drywall saw or utility knife to cut panels and snips to cut ties.
- ☐ Hold down locations are marked and bolts and hardware on site.

Refer to the checklist below for a suggested tool list

3.3 TOOLS

3.3.1 Recommended Tools

Experience has clearly shown that having the right tools on the job can greatly impact both efficiency and quality of an ICF project. Each worker should be equipped with basic hand tools for cutting panels and ties and for performing other tasks that they are responsible for. Power tools are recommended to speed up cutting of components and for making more precise cuts at angles or radius bends.

A very basic tool kit is pictured below. Please see next section for a handy "Tool Checklist".


Fully Extendable Utility Knife


Keyhole Saw


Hand Saw


Tape Measure


48" [50-60cm] or Laser Level


Chalk-Line


String Line


Impact Driver


Pruning Shears

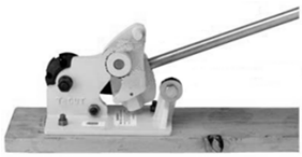

Rebar Cutter/Bender

Figure 31: Tools for the project

3.3.1.1 Other Equipment:

- Wire Twister
- Hammer
- Regular Pliers
- Ladders/Scaffolding
- Power Saw
- Gloves/Safety Goggles

3.3.1.2 Highly Recommended:

- Table Saw
- Compound Miter Saw (to cut panels for corners, angles etc.)

3.3.2 Tool Checklist

Each Crew Member:

- ❑ Extendable utility knife
- ❑ Keyhole saw and/or folding pruning saw
- ❑ Pruning shears
- ❑ Chalk line
- ❑ Felt pen to mark panels
- ❑ Hammer, measuring tape, and all other common tool belt items
- ❑ Hard hat, safety vest, & protective eye wear

On Site:

- ❑ Chop saw w/ carborundum blade; metal shears to cut track
- ❑ Roto-hammer or PAT device (+ fasteners) on site to fasten track to concrete
- ❑ 12” sliding miter saw [25cm] to pre-cut panels
- ❑ Rebar bender/cutter
- ❑ Cordless impact driver; Bits for all fasteners used at site
- ❑ Laser level and tri-pod; 6 ft. [2m] hand level; 2 ft. [.6m] hand level
- ❑ Mason’s string line
- ❑ Step ladders rated for employee weight and ladder tie-offs
- ❑ Tie wire, pre-made wire ties or plastic zip ties to secure rebar
- ❑ 100 ft. [30m] tape measure to check dimensions and square
- ❑ Sledge hammer (maul) to drive stakes
- ❑ Spray-foam adhesive and applicator gun; Gun cleaner
- ❑ Electrical cords with grounding, GFI between cord and tools
- ❑ Water for crew members (min. 1 gal/worker/day)

3.4 FOOTINGS AND BUILDING LAYOUT

3.4.1 Footings

When forming footings, ensure they are built level to within a tolerance of ¼" [7mm] and that they are troweled smooth. If the footings are not level and smooth, it will create unnecessary work later when it is time to position track. If your project has stepped footings, maintain elevation changes in 12" [305mm] or multiples thereof. This will minimize waste and speed up construction significantly.

- Check plan specifications for correct footing sizing. If necessary, consult local or national building codes which often give prescriptive information on footing sizes.
- When placing rebar dowels in your footings, take into account the panel thicknesses when establishing center of wall.
- A decision must be made whether to tie vertical reinforcing bars to the dowels extending out of the footing, or to drop the vertical bar into position later. If the latter method is chosen, provisions must be made during the assembly of the wall to correctly position and secure the horizontal and vertical bars within the wall cavity. *(See Chapter 8 Concrete & Reinforcing on Page 161)*

Building Tips:	**When pouring your footings:** **1. Level them to within a tolerance of ¼" [6mm].** **2. Trowel footings smooth to prevent rough surfaces.** **3. Ensure that all steps are 12" [305mm] or any multiple thereof to match the height of the panel.** **The few extra minutes spent ensuring your footings are level and smooth will save hours in setting up the wall!**

Note: ***ICF experts are all very particular about their footings and slabs. They know that if footings are out of specification, it will cost them time and money.***

3.4.1.1 Stepped Footing Detail

The illustration below shows a footing that is designed to be compatible with Quad-Lock 12 inch high panels. Steps heights should be either 12" [305mm] or 24 inches [610mm] (maximum step height unless otherwise allowed by project engineer).

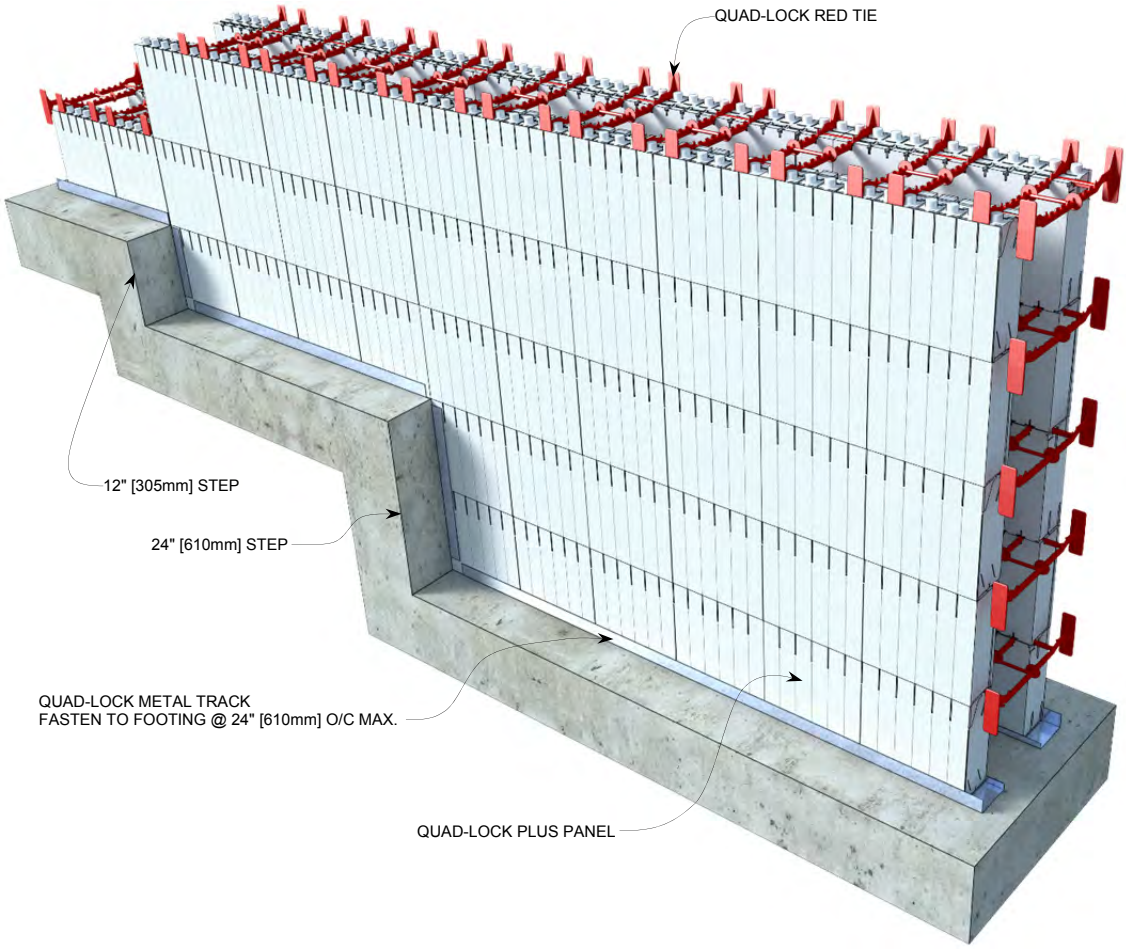


Figure 32: Stepped Footing

3.4.2 Problem Solving: Footings Are Out of Specification

If footings or slabs are constructed out of level or are inconsistent in elevation, corrective actions can be taken.

- Some ICF installers just fasten the track to the footing regardless of the error, and make the adjustment in the panel height.
- Some installers use a 'shim' under the track to correct low spots, and carve the panels to adjust for high spots. *(See Section 3.4.5.2 "Attachment of Track to Uneven Footing" on page 38)*

3.4.3 Adjusting Panels to Odd Footing Elevations:

If stepped footings have been formed to increments of other than 12" [305mm] as suggested in Section 3.4.1, panels on the lowest level must be ripped to bring succeeding courses into the next footing steps at the correct elevation.

3.4.3.1 Small Variations in Footing Elevations

If the height of a panel needs to be increased by ¾" [20mm] or less, then either spray foam or shims may be added into the track to elevate the panel to the desired height.

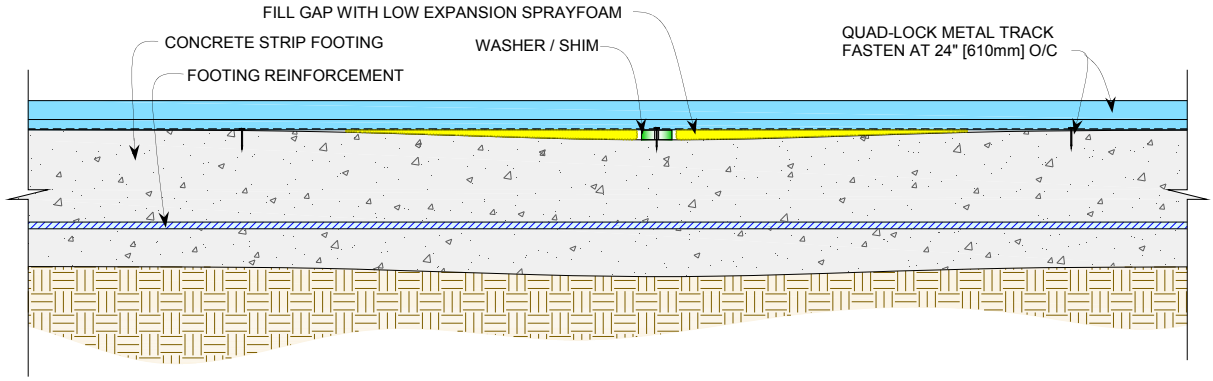


Figure 33: Dealing with Small Variations in Footing Elevations

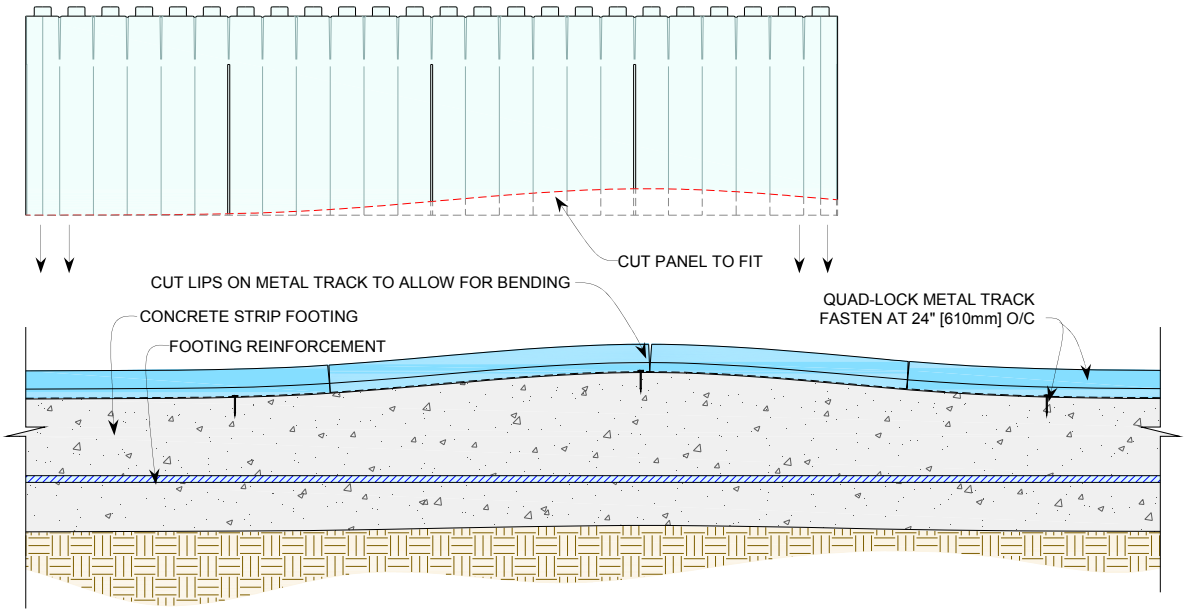


Figure 34: Adapting panels to inconsistencies in footing elevation

3.4.3.2 Adapting to Odd Footing Elevations

If the step in the footing is less than 12" [305mm], then rip the lowest row of panels by the difference between the actual footing step height and 12" [305mm].

- Rip the bottom of the panel and use the remaining top piece.
- Maintain your panel lay-out pattern started in lower courses by forming through succeeding incorrect footing elevations
- Notch full panels to match the shape of the footing as they span across the change in footing elevation.

If the height of a panel needs to be increased by 1" [25mm] or more, then tops and bottoms of full panels must be ripped and used to start the course. Ties may have to be clipped to fit into rips that are 2½" [64mm] or less.

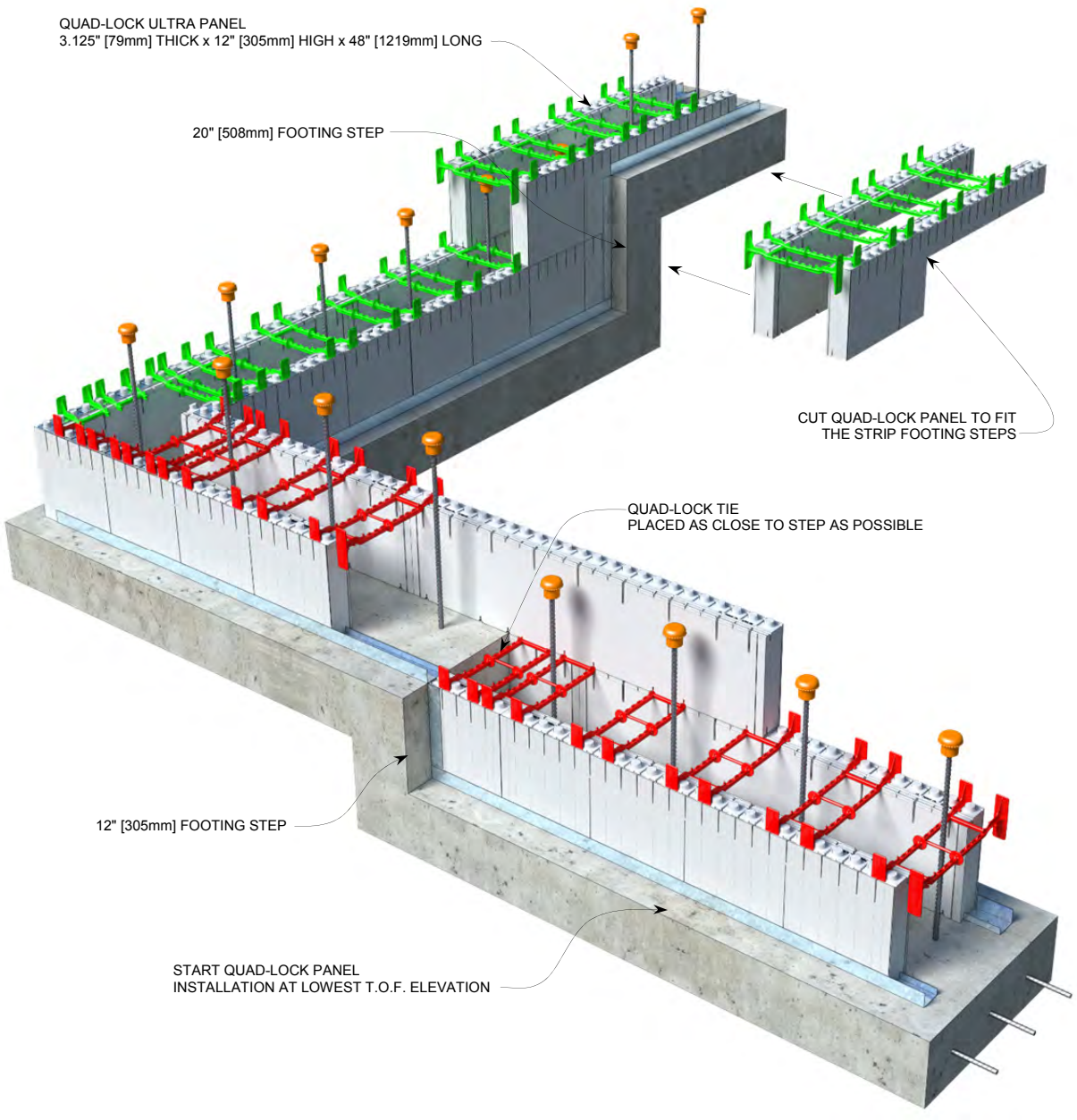


Figure 35: Adapting to Odd Footing Elevations

3.4.3.3 Taper Panels to Correct Out-Of-Level Footings

If footings or slab are out of level to the point where a correction must be made, Quad-Lock panels are easily cut to compensate for the out-of-level condition. A common condition would be where one corner of a building is lower than the rest. If this is the case, Quad-Lock panels can be custom-cut to taper into or out of a low area. The illustration below shows how this method can be used.

- The key is to find the lowest point and bring the panels back to a base elevation that works for the rest of the build.

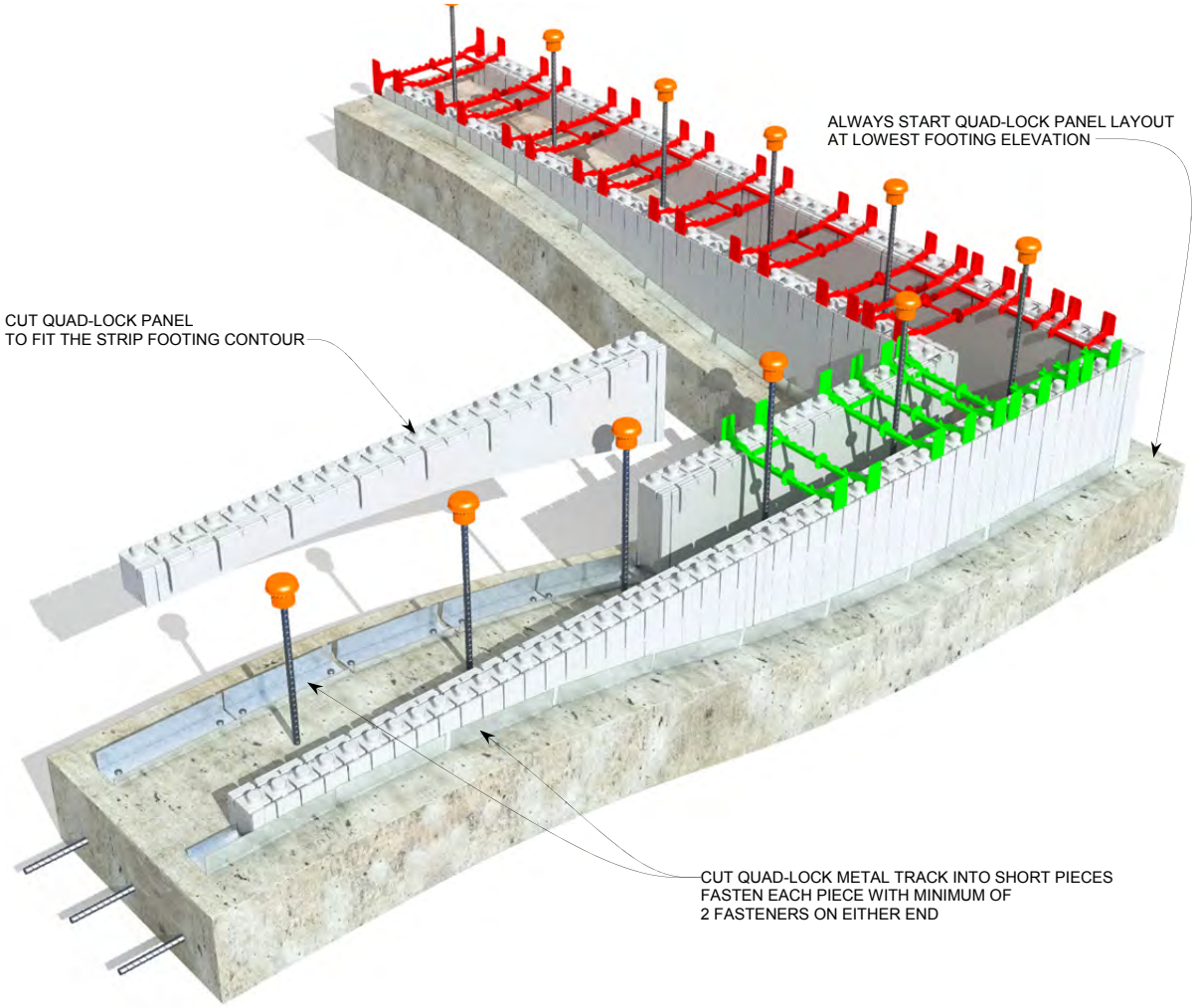


Figure 36: Panels Tapered to Compensate for out-of-level Footing

3.4.3.4 *Typical Footing-to-Wall Connections*

The construction details below are examples of typical connections between footings (or slabs) and ICF Wallis

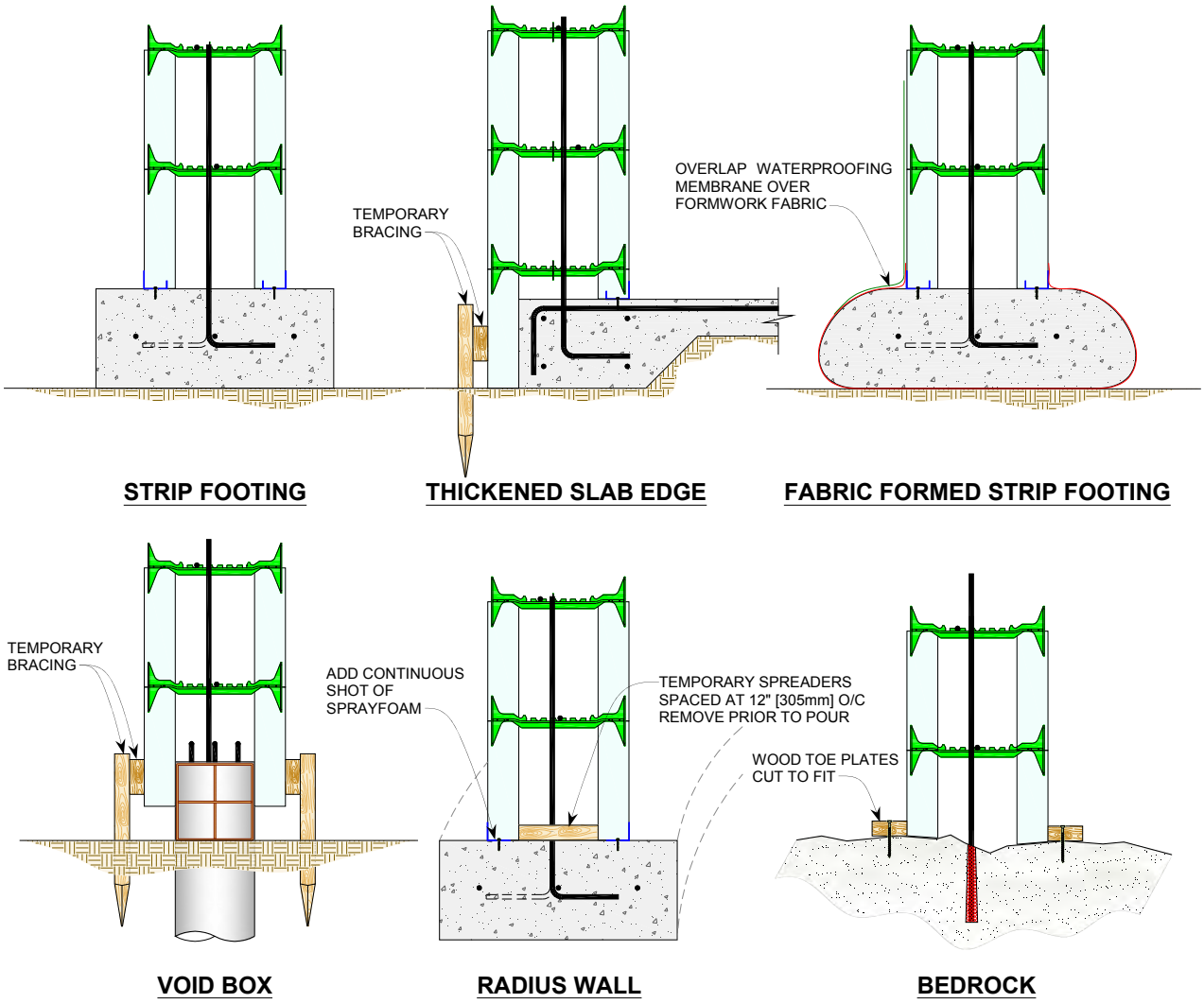


Figure 37: Typical Bottom of Wall Details

3.4.4 Applying Building Layout to Footings

One of the most critical steps in any building project is the layout of the building dimensions. Care must be taken to interpret building plans correctly and transfer that shape to the concrete footing or slab.

- **Caution:** A common mistake is to apply building footprint dimensions that have not been specifically designed for ICF construction. The thickness of the foam panels must be accounted for in the building design. If your plan has not been adjusted to accommodate ICF panels, a re-draw or other adjustment may be required.

3.4.4.1 *Set the Outermost Building Dimension ("Building Line")*

The outermost dimension of the building is commonly referred to as "building line". This dimension should be established first and marked on the footing using a chalk-line.

- Double check the plans to be sure that this line represents the outside of the ICF foam panel, and that the full width of the ICF wall (EPS panel + concrete + EPS panel) has been accounted for.
- Once the entire perimeter of the building has been established and marked on the footing or slab, any interior walls to be constructed with ICFs should also be marked in their correct position.
- It is not necessary to apply a second set of lines to indicate the inside face of the ICF wall. Section 3.5 will clearly explain how the metal track will be installed to correctly position the ICF panels on both faces of the wall.

3.4.4.2 Positioning of Door and Window Openings

After the building line has been completed, the positions of doors, windows or other openings should be marked clearly on the concrete.

- It is generally a good idea to mark both the outside dimensions and the centerline of the opening for later reference as the wall is erected.
- Sill height of windows may be noted on the surface of the EPS as the wall is erected.
- Many ICF experts set their door forms (also called 'buck-outs' in USA/Canada, or 'shuttering' in UK) just after the bottom metal track has been installed, and before any ICF panels have been installed. The ICF panels are then built around the door buck-outs.

3.4.5 Securing Metal Track

Metal tracks must be securely fastened to the footing on both sides of the Quad-Lock wall, starting with the outside (building line).

- At a minimum, fasten the track to the footing every 2 to 2½ feet [60-75 cm] and at the ends of each track
- Note the pre-punched holes every 2'-0" [61cm] which indicate the minimum spacing of fasteners required.
- Ensure track is fastened to concrete, and not to the outside of a form board, as form boards will easily come off the side of the footing.

3.4.5.1 Fastening to Concrete Footings, Concrete Slabs, Rock, or Cleats:

Depending on the intended use of the track, there are three main methods of fastening to base material.

- Nail through track with concrete nails, generally with a Powder Actuated Tool (PAT) into concrete slab or footing.
- Drill and anchor with fastener of choice (see below) into concrete slab or footing.
- Screw track to metal or wooden cleats over rock surfaces, or over open footings for a monolithic pour.

3.4.5.1.1 Method 1: Nail to Concrete with P.A.T.

Quad-Lock Metal Track can be nailed using a Powder Actuated Tool (PAT) to concrete slabs or footings. This method is generally recognized as one of the fastest ways to prepare the job for stacking Quad-Lock, but is among the highest cost, due to the cost of tools, pins, and shots. A 1 ¼" [32mm] PAT nail is best.

- Single-shot tools are time consuming and drive up labor costs as well.
- Strip-fed PATs are faster, but more costly to purchase.
- When using PAT on a slab, avoid "spalling" of the concrete, where the impact of the nail can crack the edge of a slab, rendering the nail useless.
- Be aware that PAT] nails can "curl" when they impact large aggregate, and thereby lose their holding power. In either case, the result is that the track is not properly fastened down, and can fail against concrete pressure.

Special care should be taken to check the track prior to placing Quad-Lock panels, if the PAT nailing method is used.

Figure 38: Fastening Track with Powder Actuated Tool (PAT)

3.4.5.1.2 Method 2 - Drill and Anchor

Experience has shown us that the “drill and anchor” method can actually be less expensive and time consuming than nailing with a PAT. Usually a 3/16" or ¼" hole is drilled through the track, after the track is set into position according to the building lines. Spacing of fasteners should be a minimum 24" [610mm] and maximum 30" [762mm]. Then, a fastener is inserted into the hole and tapped or screwed into place. These fasteners can include:

- A 3" [75mm] nail, augmented with a piece of tie wire
- A 1¼" [30mm] long “Zamac” (Available from Quad-Lock; see Product Catalog)
- A specially designed concrete screw (TapCon, or equivalent)

Any of these fasteners will yield a very secure fastening, and the act of drilling does not result in spalling of the concrete, or curling of the fasteners. The low cost of these fasteners brings down the average installed cost as well. Concrete drill bits are relatively low cost, and yield many holes for fastening. Hammer drills are commonly available for sale or rent.

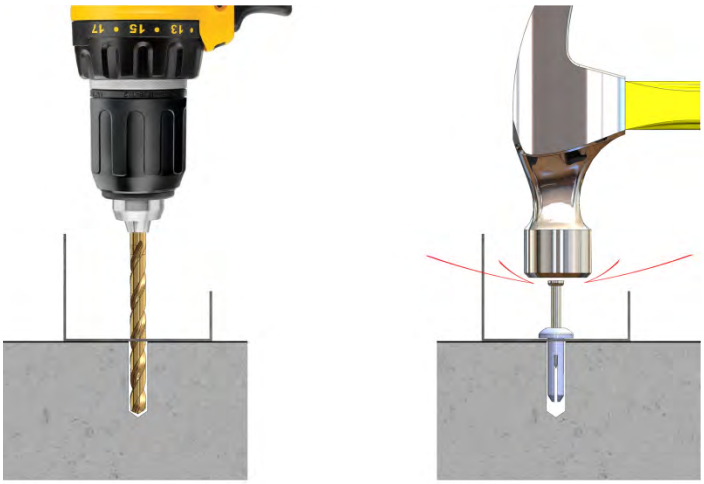


Figure 39: Installation of Hit-Anchors

3.4.5.1.3 Method 3 - Screw to Metal or Wood Cleats

In cases where a concrete slab or footing is not available, Metal Track can be screwed to metal or wood cleats to provide both proper spacing and lateral strength against form pressure. This may be the case with a monolithic pour of stem-walls and footings. Place Metal Track on top of wood or metal cleats fastened across footing forms at 3 foot (1 m) maximum intervals. Use self-tapping screws to penetrate Metal Track and into the cleat below.

3.4.5.2 Attachment of Track to Uneven Footings

If footings are slightly out of level, fasten track to the footings and stretch a string line slightly higher than 1 foot [30cm] above the highest point of the footing.

- Use the string line to set the first course level. Shim the panels in the track with scrap foam or spray foam and/or scribe/cut the bottoms of the panels to level your wall.

- If you have a very uneven footing surface, (like a rock surface) builders have successfully scribed the EPS panels to the shape of the rock and fastened 2x4 “toe plates” to the rock to contain the bottom of the panels. This methods may also be used when forming to bedrock or other areas where footings are not used. *See Section 3.4.7 below.*

3.4.6 Installing Quad-Lock on Bedrock

If approved by the engineer of record or local building code authorities, Quad-Lock Walls can be installed on bedrock without the need for a footing strip.

- Vertical reinforcing bars must be drilled and fixed into bedrock per engineering specifications. Quad-Lock panels can then be scribed to follow the shape of the natural rock formation.
- When 2 or more courses of panels are in place, bracing must be secured to the bedrock on each side of the wall line to keep the forms stable during the pour.
- Builders often use anchor bolts drilled through the toe-plates and into the bedrock at points where the lumber and bedrock come into contact with one another.

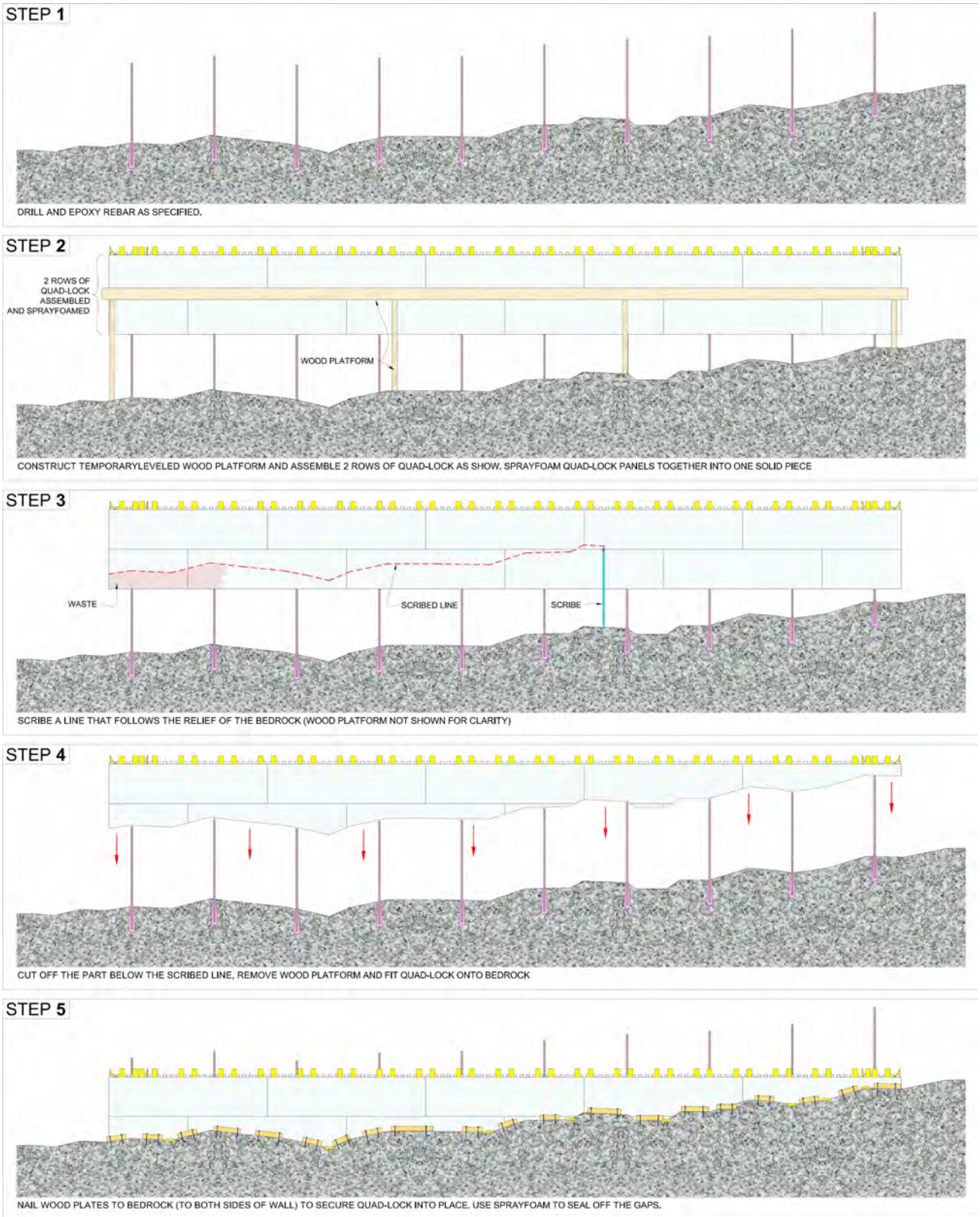


Figure 40: Quad-Lock Wall Installation on Bedrock

3.4.7 Proper Spacing of Metal Track

Critical to maintaining the shape of the wall is the initial placement of the Metal Track at the bottom of the wall. Usually, a chalk line is snapped to represent the outside perimeter of the building, or “building line”. Then, the outer row of track is fastened down by any of the above means.

The inside row of track can be located in the following manner:

- Fasten the outside row of track (“building line”),
- Cut a template from plywood that represents the inside-to-inside dimension of the track.
- Place the template on the footing to the inside of the outer track.
- Loose-lay pre-cut sections of the inner track.
- Slide the inside track against the template until it stops firmly against the outside (fastened) track.
- Fasten the inside track into position.

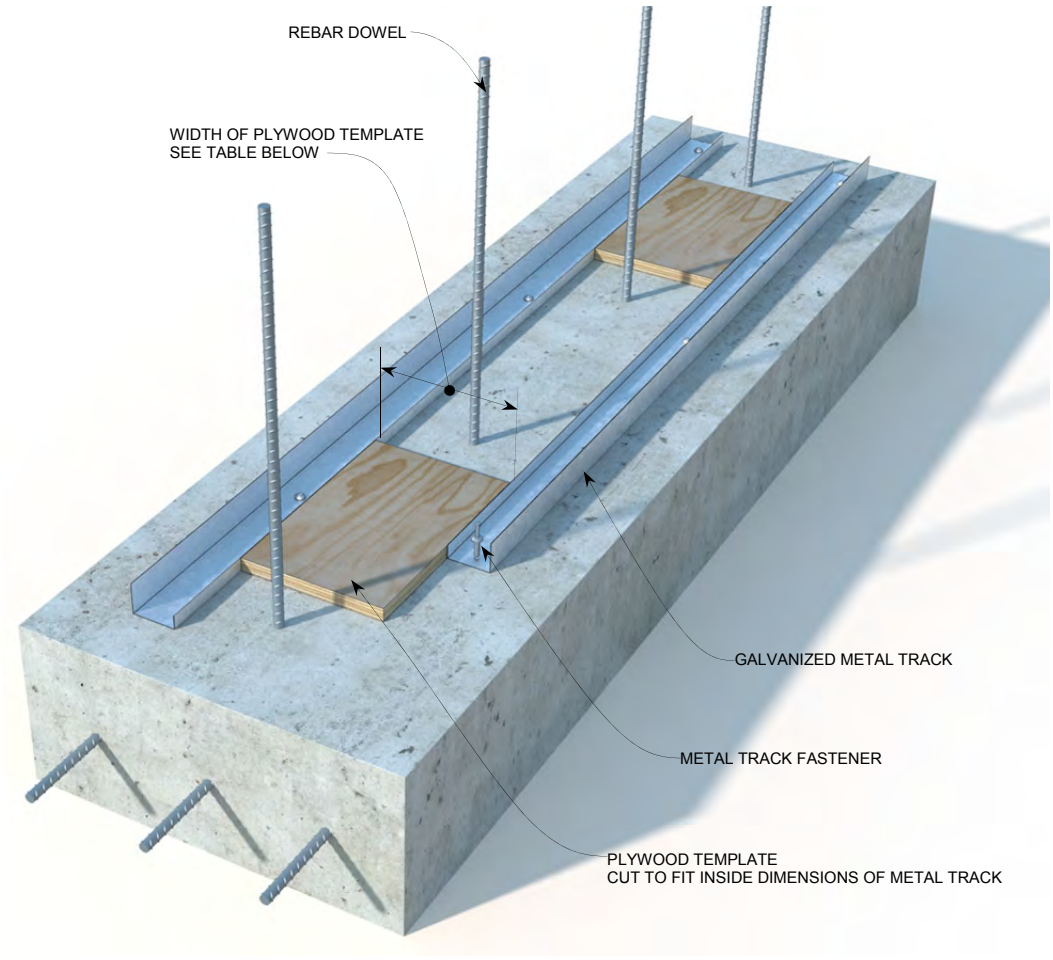


Figure 41: Plywood Templates fit to Wall Dimension

3.4.7.1 Table for Plywood Template Widths

Insulation Value	Tie Size					
	Black	Blue	Yellow	Green	Red	Brown
R-22 [U-0.28]	3 11/16" [94mm]	5 11/16" [144mm]	7 11/16" [195mm]	9 11/16" [246mm]	11 11/16" [297mm]	13 11/16" [348mm]
R-28 [U-0.21]	-	5 11/16" [144mm]	7 11/16" [195mm]	9 11/16" [246mm]	11 11/16" [297mm]	13 11/16" [348mm]
R-30 [U-0.20]	-	3 11/16" [94mm]	5 11/16" [144mm]	7 11/16" [195mm]	9 11/16" [246mm]	11 11/16" [297mm]
R-38 [U-0.15]	-	-	3 11/16" [94mm]	5 11/16" [144mm]	7 11/16" [195mm]	9 11/16" [246mm]
R-38 TMO [U-0.15 TMO]	-	5 11/16" [144mm]	7 11/16" [195mm]	9 11/16" [246mm]	11 11/16" [297mm]	13 11/16" [348mm]
R-43 [U-0.14]	-	-	-	9 11/16" 246mm	11 11/16" 297mm	13 11/16" 348mm
R-45 [U-0.13]	-	-	-	7 11/16" [195mm]	9 11/16" [246mm]	11 11/16" [297mm]
R-53 [U-0.11]	-	-	-	-	7 11/16" [195mm]	9 11/16" [246mm]
R-53 TMO [U-0.11 TMO]	-	-	-	-	11 11/16" [297mm]	13 11/16" [348mm]
R-59 [U-0.10]	-	-	-	-	-	13 11/16" 348mm

Building Tips:

Locate the outside building line and strike the chalk line. The building line is the outside of the foam. Remember to account for the 2¼" [57mm], 3 1/8" [79mm] or 4¼" [108mm] of foam on both sides of the wall.

The outside track should be installed first, using the building line struck on the footing. The Metal Track is then secured to the footing every 2-2½' [60-75cm].

After the outside track has been placed, use a plywood spacer to place the inside track. Cut templates in a "C" shape to match the outside-to-outside dimension of the foam panels. Cut inside track to length and loose-lay next to the outside track. Place the template over both tracks and pull the loose track firmly against the template. The inside track should now be in the proper position for fastening.

To avoid potential problems, the job supervisor should carefully check the attachment of Metal Track to the footing before walls are built.

If the wall runs off the side of the footing or the footing is not wide enough, strap ties or some other form of banding material can be used through the wall to connect the Metal Tracks/wood toe plates.

3.5 CUTTING EPS PANELS, PLASTIC TIES, & METAL COMPONENTS

3.5.1 Cutting EPS Panels

To cut Quad-Lock EPS Panels, a fully extendible utility knife, a regular handsaw or keyhole saw can be used. Table-mounted power saws are also a good way to pre-cut panels.

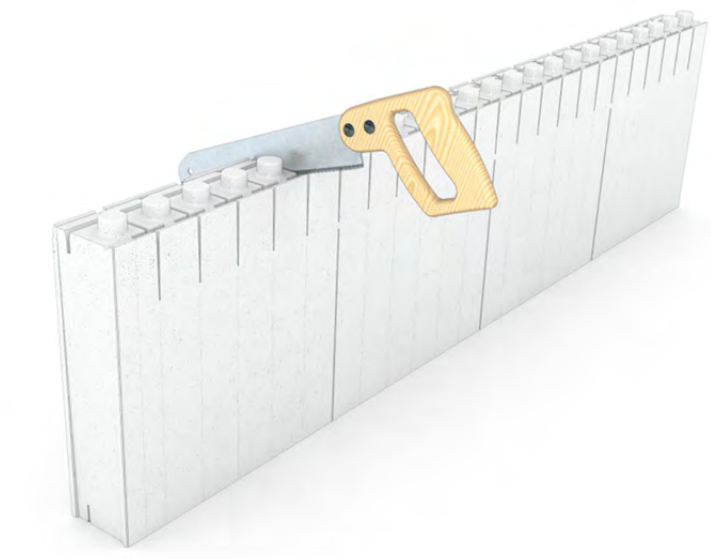


Figure 42: Cutting EPS Panels

- When using power saws use extreme caution since the EPS foam material offers very little resistance to high RPM saws and has a tendency to grab the blade if the cut is not perfectly straight.
- Some builders use an abrasive (carborundum) blade that is normally used for cutting steel. This eliminates the tiny beads of EPS that result from cutting through the panels with a typical saw blade.

Figure 43: Recommended Tools for Cutting EPS Panels

Building Tip:	**Clean and accurate panel cuts make for better results:** **1. Hand-saws or power saws make cleaner cuts than a utility knife, especially on thicker panels (though knives can be used)** **2. Keep a drywall rasp on your belt to clean up cut panel ends if necessary** **3. After cutting the panel in two pieces, scrub the two cut ends together to remove small amounts of residual material**

3.5.2 Cutting Plastic Ties

Use pruning shears to cut ties into “Flanges” or “Split Ties”:

- Flanges are used in conjunction with metal brackets in all corners and angles. Make sure to cut at the point indicated below.
- Split ties are used in tight radius walls, near odd wall joints, window and door openings, and bulkheads.

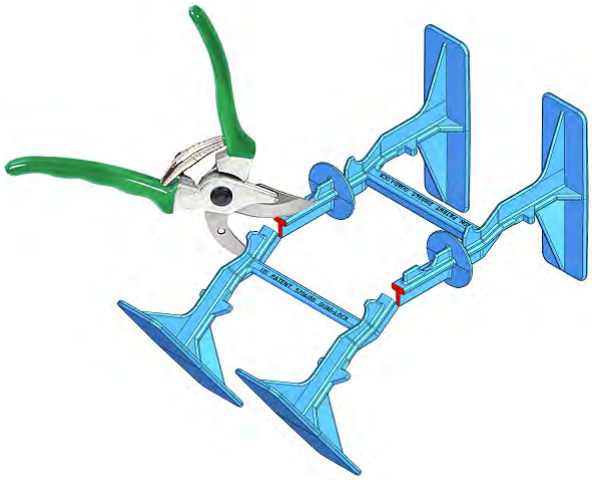


Figure 44: Cut Flanges

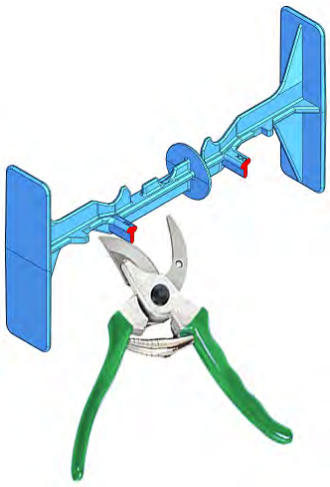


Figure 45: Split Tie

3.5.2.1 Cutting Metal Components

Cut Metal Track or Corner Brackets with metal shears or a chop saw with appropriate blade (e.g. carborundum).

3.6 START OF ASSEMBLY

All corners, T-wall connections, and angles should be installed first. While other forming methods may call for building into the corners, the design and precise layout of the Quad-Lock system is best suited for building from the corners to a common point in the middle of the wall. Odd dimensions can be taken into account by establishing a common seam at mid-point in the wall.

- If building dimensions are in 2 inch increments, Quad-Lock panels will likely be able to interlock when they meet in the middle of a wall line.
- If the wall length is not in 2 inch increments, then a common seam must be run up the entire wall height to allow for adjustment in wall dimension. See Section 3.8 for details on laying out a common seam.
- Quad-Lock Ties and Panels are designed to allow walls with different thickness to be joined at a corner (e.g. 8" [203mm] wall joining 6" [152mm] wall).

3.6.1 90 ^{o} Corner Assembly

First, note which Quad-Lock EPS panel thickness you are using (e.g.: 2", 3", 4" or a combination of thicknesses) and follow general techniques below for building all 90^{o} corners.

See detailed illustrations beginning on Page 51 for R-22, R-28, R-30, and R-38 corner assemblies. (U-0.28, U-0.21, U-0.20, and U-0.15)

3.6.1.1. General Guidelines for Building 90^{o} Corners

3.6.1.1.1 Outside Corner Panels

Begin by placing the outside panels as follows:

- Outside corner panels will ALWAYS be one of two lengths:
  - 48 inches [1219mm] on odd numbered rows *(Rows #1, 3, 5, 7, 9, & etc)*
  - 24 inches [610mm] on even numbered rows *(Rows #2, 4, 6, 8, 10, & etc)*

- Ultra Corner Panel users can cut one Ultra Corner Panel in half for the even numbered rows

- Lap the left panel over the right (as seen from the inside of the corner).
- Seat the first-row panels firmly into the Metal Track squarely against one another at the corner.
- Place the Outside Corner Bracket into position, as described later in Section 3.6.1.3 on Page 53.

Note**: **Ultra Panel users have a special outside corner panel available, which is the preferred method for this panel series. If not using the Ultra Corner Panel, refer to Section 3.6.1.4 Alternate Ultra Panel 90°Corner Method on Page 55 in this chapter.

3.6.1.1.2 Inside Corner Panels

Inside panels must be shortened at the corner to allow concrete and reinforcing to pass through the corner unobstructed. Installers may choose a simplified method for determining cut-length of inside panels or a "waste-optimized" version, both of which have been pre-calculated below.

3.6.1.1.2a Simplified Method for Inside Corner Panels

Lap the inner panels in the same direction as the outer panels.

- Use a simple formula for determining inside panel size as follows:
  - Cut each inside panel by a dimension equaling the wall cavity size plus either 2" [51mm] or 4" [102mm], depending on which panels you are using.

    Regular Panel Example: 8" [305mm] wall cavity size
    +2" [51mm] added to cavity size
    10" [356mm] cut from panel

  - For Regular Panels, the off-cut is cavity size + 2" .
  - For Ultra and Plus Panels, the off-cut is cavity size +4"
- Always cut the ends closest to the corner to keep lay-out marks on the panels matched to the outside panels.
- The objective is to keep the factory ends (away from the corner) exactly in line with each other

3.6.1.1.2b Waste-Optimized Method for Inside Corner Panels

- Certain (but not all) panel combinations can be "waste & cut optimized" by **reversing the lap of the inside panel pair.**
- Use Table 3.6.1.1b (below) to identify which panel combinations can be optimized.

Note**: **If cut dimensions do not appear on the line matching your panel and tie combination on Table 3.6.1.1(b), that means the Simplified Method works best in your particular case. Refer back to Table 3.6.1.1(a)

- Always cut the ends closest to the corner to keep lay-out marks on the panels matched to the outside panels.
- The objective is to keep the factory ends (away from the corner) exactly in line with each other.

3.6.1.1.3 Quick Reference to Most Common Panel/Tie Combinations

The four pairs of diagrams below illustrate cutting dimensions for the most common combinations of panels and ties.

- R-22, [U-0.28] 6" concrete cavity
- R-22, [U-0.28] 8" concrete cavity
- R-28, [U-0.21] 6" concrete cavity
- R-28, [U-0.21] 8" concrete cavity

Complete lists of cutting dimensions can be found in Tables 3.6.1.1a and 3.6.1.1b

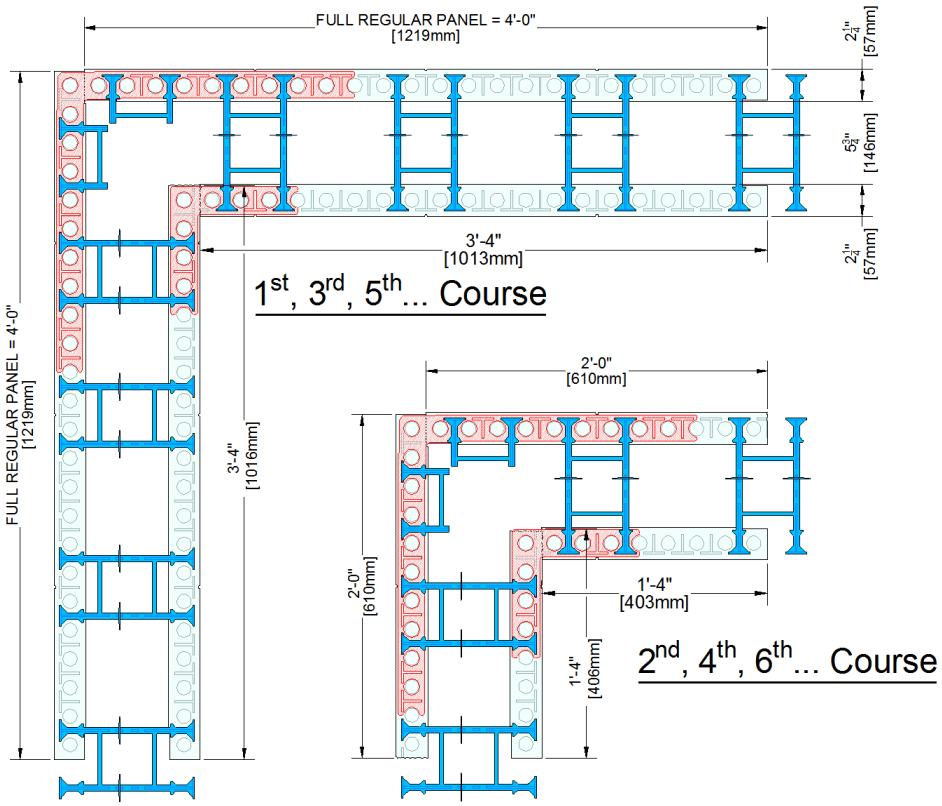


Figure 46: Panel/Tie Combination for R-22 [U-0,28] 6" Concrete Cavity

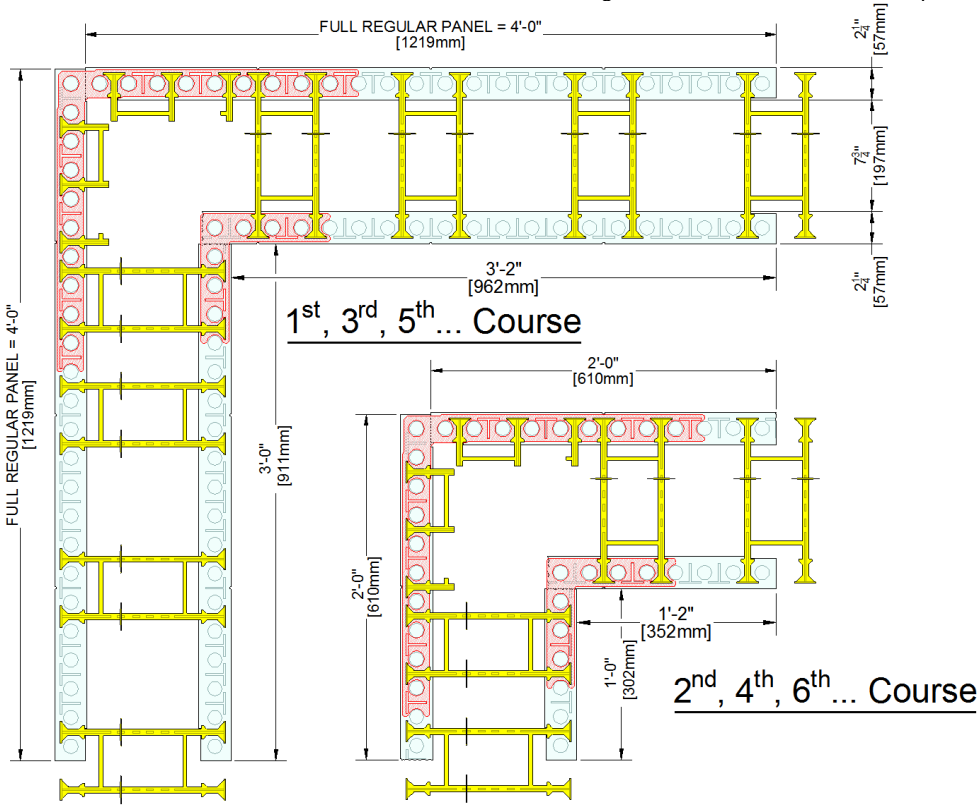


Figure 47: Panel/Tie Combination for R-22 [U-0,28] 8" Concrete Cavity

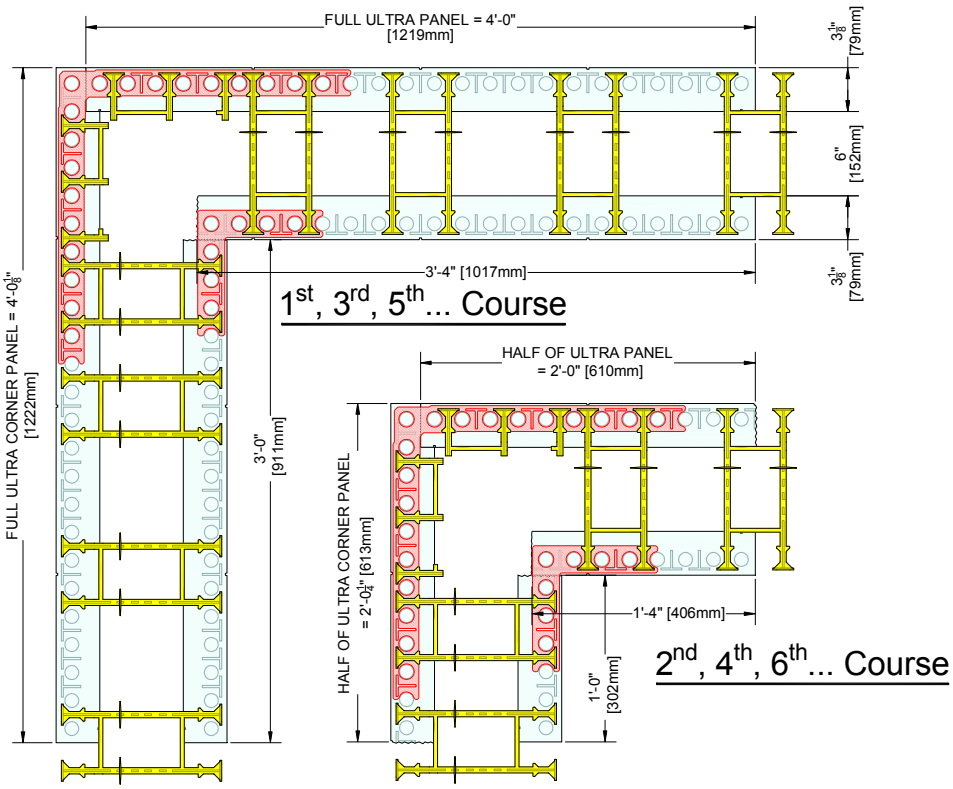


Figure 48: Panel/Tie Combination for R-28 [U-0,21] 6" Concrete Cavity

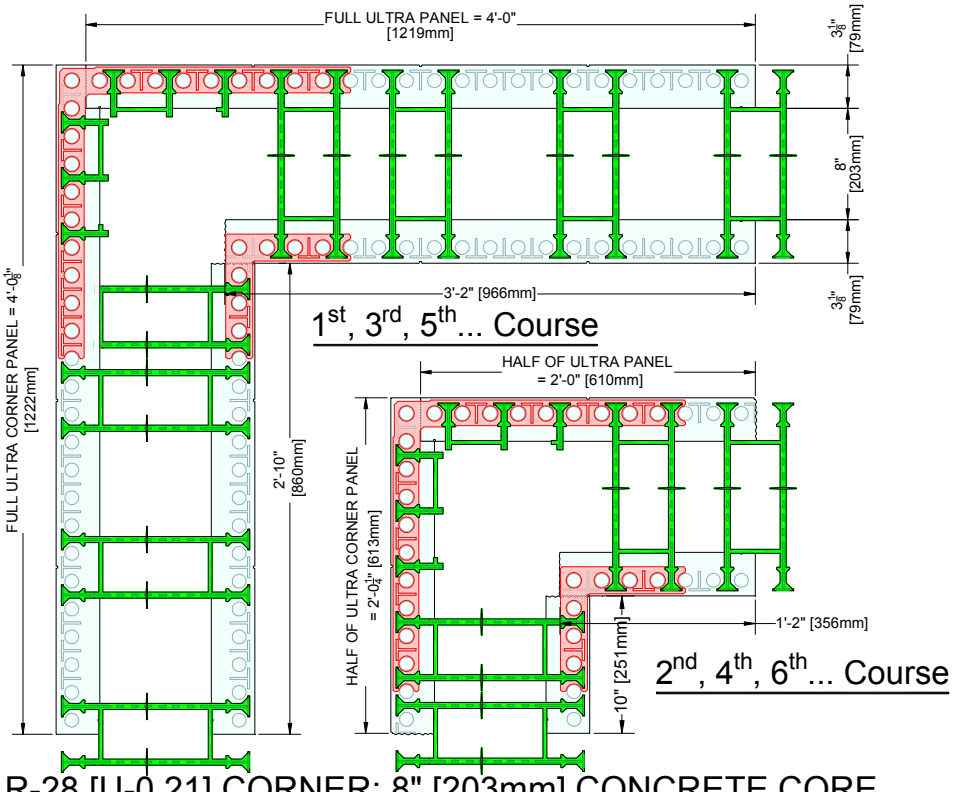


Figure 49: Panel/Tie Combination for R-28 [U-0,21] 8" Concrete Cavity

Table 3.6.1.1(a) Simplified Panel Cutting Method

This table helps to make the job of cutting inside panels easy by using consistent measurements for panel length. Users of this table can expect a slightly higher waste factor at the end of the job. Any panel scrap that is at least 12 inches [305mm] in length should be re-used in the project by placing them between two full ties.

Note: ***Most values in the "Inside Right" columns are indicated as the same as "Inside Left".***

Simplified Panel Cutting Method

Inside Panels Lapped Left over Right

Wall Insulation	Concrete Core	First Course Panels		Second Course Panels		Extend CBO's	Tie Color or Combination
		Inside Left	Inside Right	Inside Left	Inside Right		
R-22 [U-0.28]	3.75" [95mm]	42" [1067mm]	← Same as Inside Left	18" [457mm]	← Same as Inside Left	No	Black
	5.75" [146mm]	40" [1016mm]		16" [406mm]		No	Blue
	7.75" [197mm]	38" [965mm]		14" [356mm]		No	Yellow
	9.75" [248mm]	36" [914mm]		12" [305mm]		No	Green
	11.75" [298mm]	34" [864mm]		10" [254mm]		Yes	Red
	13.75" [349mm]	32" [813mm]		8" [203mm]		Yes	Brown
R-28 [U-0.21]	4" [102mm]	40" [1016mm]	← Same as Inside Left	16" [406mm]	← Same as Inside Left	No	Blue
	6" [152mm]	38" [965mm]		14" [356mm]		No	Yellow
	8" [203mm]	36" [914mm]		12" [305mm]		No	Green
	10" [254mm]	34" [864mm]		10" [254mm]		Yes	Red
	12" [305mm]	32" [813mm]		8" [203mm]		Yes	Brown
R-30 [U-0.20]	3.75" [95mm]	40" [1016mm]	42" [1067mm]	16" [406mm]	18" [457mm]	No	Blue
	5.75" [146mm]	38" [965mm]	40" [1016mm]	14" [356mm]	16" [406mm]	No	Yellow
	7.75" [197mm]	36" [914mm]	38" [965mm]	12" [305mm]	14" [356mm]	No	Green
	9.75" [248mm]	34" [864mm]	36" [914mm]	10" [254mm]	12" [305mm]	Yes	Red
	11.75" [298mm]	32" [813mm]	34" [864mm]	8" [203mm]	10" [254mm]	Yes	Brown
R-38 [U-0.15]	3.75" [95mm]	40" [1016mm]	← Same as Inside Left	16" [406mm]	← Same as Inside Left	No	Yellow
	5.75" [146mm]	38" [965mm]		14" [356mm]		No	Green
	7.75" [197mm]	36" [914mm]		12" [305mm]		Yes	Red
	9.75" [248mm]	34" [864mm]		10" [254mm]		Yes	Brown
	11.75" [298mm]	32" [813mm]		8" [203mm]		Yes	XT+Black
R-38 TMO [U-0.15 TMO]	3.75" [95mm]	38" [965mm]	← Same as Inside Left	14" [356mm]	← Same as Inside Left	No	Yellow
	5.75" [146mm]	36" [914mm]		12" [305mm]		No	Green
	7.75" [197mm]	34" [864mm]		10" [254mm]		Yes	Red
	9.75" [248mm]	32" [813mm]		8" [203mm]		Yes	Brown
R-43 [U-0.14]	4" [102mm]	36" [914mm]	← Same as Inside Left	12" [305mm]	← Same as Inside Left	No	Green
	6" [152mm]	34" [864mm]		10" [254mm]		Yes	Red
	8" [203mm]	32" [813mm]		8" [203mm]		Yes	Brown
R-45 [U-0.13]	3.75" [95mm]	36" [914mm]	38" [965mm]	12" [305mm]	14" [356mm]	No	Green
	5.75" [146mm]	34" [864mm]	36" [914mm]	10" [254mm]	12" [305mm]	Yes	Red
	7.75" [197mm]	32" [813mm]	34" [864mm]	8" [203mm]	10" [254mm]	Yes	Brown
R-53 [U-0.11]	3.75" [95mm]	36" [914mm]	← Same as Inside Left	12" [305mm]	← Same as Inside Left	Yes	Red
	5.75" [146mm]	34" [864mm]		10" [254mm]		Yes	Brown
	7.75" [197mm]	32" [813mm]		8" [203mm]		Yes	XT+Black
R-53 TMO [U-0.11 TMO]	3.75" [95mm]	34" [864mm]	← Same as Inside Left	10" [254mm]	← Same as Inside Left	Yes	Red
	5.75" [146mm]	32" [813mm]		8" [203mm]		Yes	Brown
	7.75" [197mm]	30" [762mm]		18" [457mm]		Yes	XT+Black
R-59 [U-0.10]	4" [102mm]	32" [813mm]	← Same as Inside Left	8" [203mm]	← Same as Inside Left	Yes	Brown
	6" [152mm]	30" [762mm]		18" [457mm]		Yes	XT+Black
	8" [203mm]	28" [711mm]		16" [406mm]		Yes	XT+Blue

Table 3.6.1.1(b) Waste & Cut Optimized Panel Cutting Method

This table helps more experienced installers to minimize the amount of off-cuts from panels that aren't easily re-used in the project.

The focus of this table is to:

- Re-use the off-cuts from inside panels on the bottom row for the row immediately above
- Retain sufficient length in off-cuts to enable re-use elsewhere in the job (minimum 12 in. [305mm])

Find the insulation value and cavity-size combination that you are using at the far left of the table. Look for cut-lengths in the middle two columns.

Note**:* ***If no values appear, it means that the Simplified Method is the most efficient manner of cutting the inside panels and refer back to Table 3.6.1.1(a).

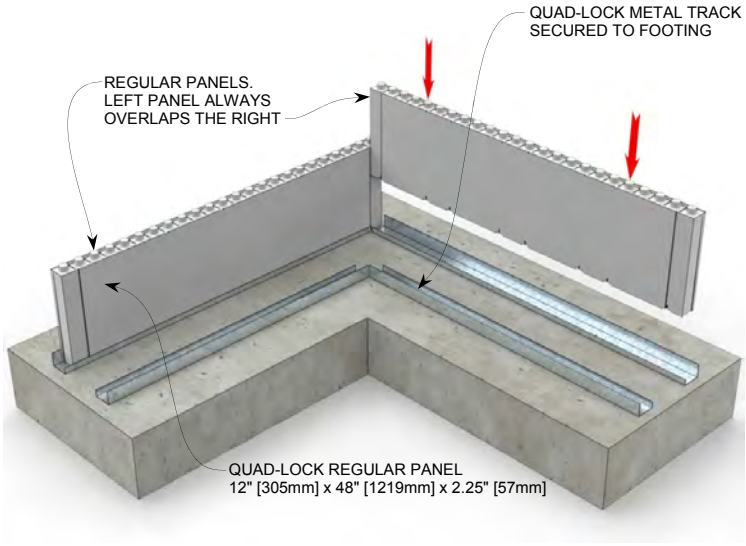
Optimized Cutting Method

Inside Panels Lapped Right Over Left

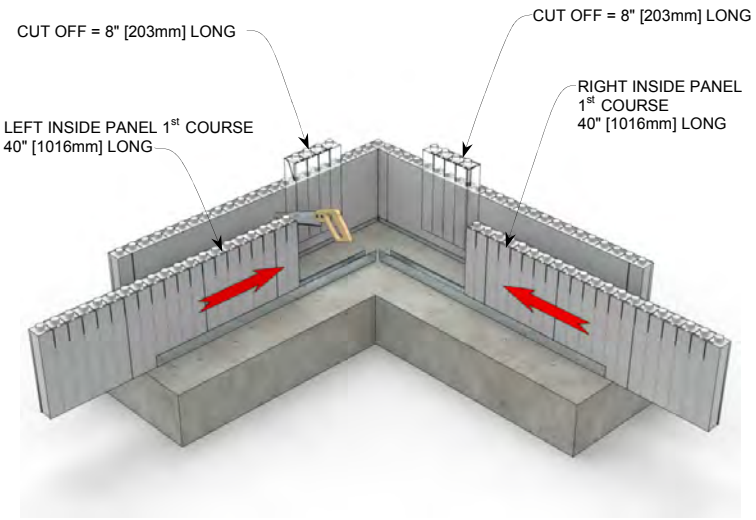
Wall Insulation	Concrete Core	First Course Panels		Second Course Panels		Extend CBO's	Tie Color or Combination
		Inside Left	Inside Right	Inside Left	Inside Right		
R-22 [U-0.28]	3.75" [95mm]					No	Black
	5.75" [146mm]					No	Blue
	7.75" [197mm]	36" [914mm]	40" [1016mm]	12" [305mm]	16" [406mm]	No	Yellow
	9.75" [248mm]					No	Green
	11.75" [298mm]	32" [813mm]	36" [914mm]	8" [203mm]	12" [305mm]	Yes	Red
	13.75" [349mm]					Yes	Brown
R-28 [U-0.21]	4" [102mm]					No	Blue
	6" [152mm]	36" [914mm]	40" [1016mm]	12" [305mm]	16" [406mm]	No	Yellow
	8" [203mm]					No	Green
	10" [254mm]	32" [813mm]	36" [914mm]	8" [203mm]	12" [305mm]	Yes	Red
	12" [305mm]					Yes	Brown
R-30 [U-0.20]	3.75" [95mm]	38" [965mm]	42" [1067mm]	14" [356mm]	20" [508mm]	No	Blue
	5.75" [146mm]	36" [914mm]	40" [1016mm]	12" [305mm]	18" [457mm]	No	Yellow
	7.75" [197mm]					No	Green
	9.75" [248mm]					Yes	Red
	11.75" [298mm]	30" [762mm]	34" [864mm]	6" [152mm]	12" [305mm]	Yes	Brown
R-38 [U-0.15]	3.75" [95mm]					No	Yellow
	5.75" [146mm]	36" [914mm]	40" [1016mm]	12" [305mm]	16" [406mm]	No	Green
	7.75" [197mm]					Yes	Red
	9.75" [248mm]	32" [813mm]	36" [914mm]	8" [203mm]	12" [305mm]	Yes	Brown
	11.75" [298mm]					Yes	XT+Black
R-38 TMO [U-0.15 TMO]	3.75" [95mm]	36" [914mm]	40" [1016mm]	12" [305mm]	16" [406mm]	No	Yellow
	5.75" [146mm]					No	Green
	7.75" [197mm]	32" [813mm]	36" [914mm]	8" [203mm]	12" [305mm]	Yes	Red
	9.75" [248mm]					Yes	Brown
R-43 [U-0.14]	4" [102mm]					No	Green
	6" [152mm]	32" [813mm]	36" [914mm]	8" [203mm]	12" [305mm]	Yes	Red
	8" [203mm]					Yes	Brown
R-45 [U-0.13]	3.75" [95mm]					No	Green
	5.75" [146mm]					Yes	Red
	7.75" [197mm]	30" [762mm]	34" [864mm]	6" [152mm]	12" [305mm]	Yes	Brown
R-53 [U-0.11]	3.75" [95mm]					Yes	Red
	5.75" [146mm]	32" [813mm]	36" [914mm]	8" [203mm]	12" [305mm]	Yes	Brown
	7.75" [197mm]					Yes	XT+Black
R-53 TMO [U-0.11 TMO]	3.75" [95mm]	32" [813mm]	36" [914mm]	8" [203mm]	12" [305mm]	Yes	Red
	5.75" [146mm]					Yes	Brown
	7.75" [197mm]					Yes	XT+Black
R-59 [U-0.10]	4" [102mm]					Yes	Brown
	6" [152mm]					Yes	XT+Black
	8" [203mm]	26" [660mm]	30" [762mm]	14" [356mm]	18" [457mm]	Yes	XT+Blue

3.6.1.2 R-22 [U-0.28] Regular Panel Corner Assembly

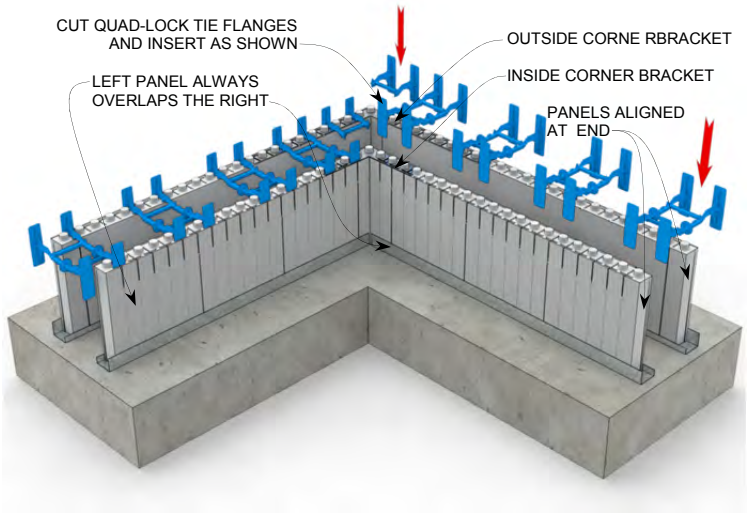
Keeping in mind the general techniques outlined above, corners built with Regular (2.25” [57mm]) Panels should follow the illustrated steps shown in the figures below.



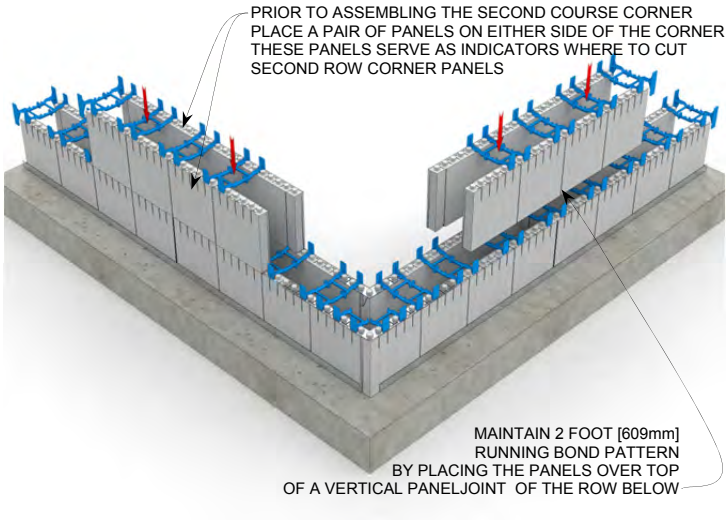
STEP 1 R-22 [U-0.28] 5.75" [146mm] Concrete Wall



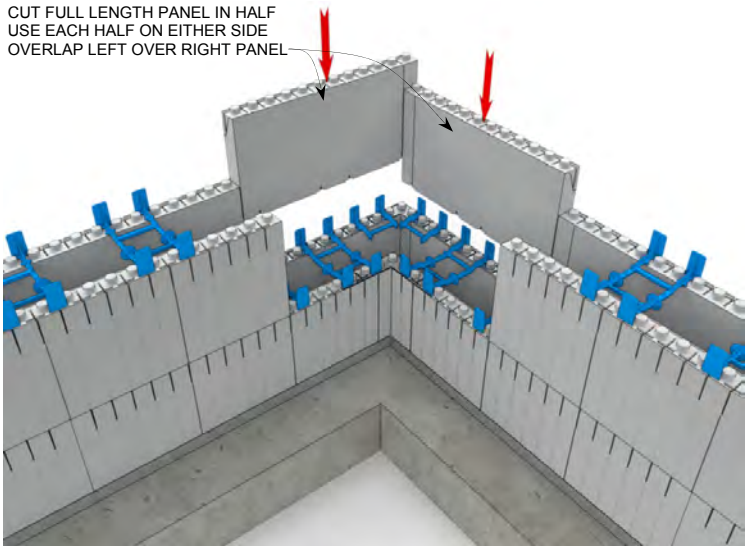
STEP 2 R-22 [U-0.28] 5.75" [146mm] Concrete Wall



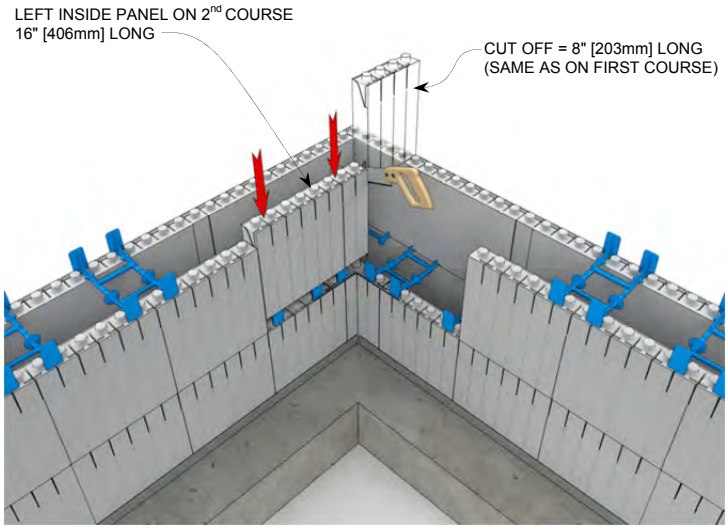
STEP 3 R-22 [U-0.28] 5.75" [146mm] Concrete Wall



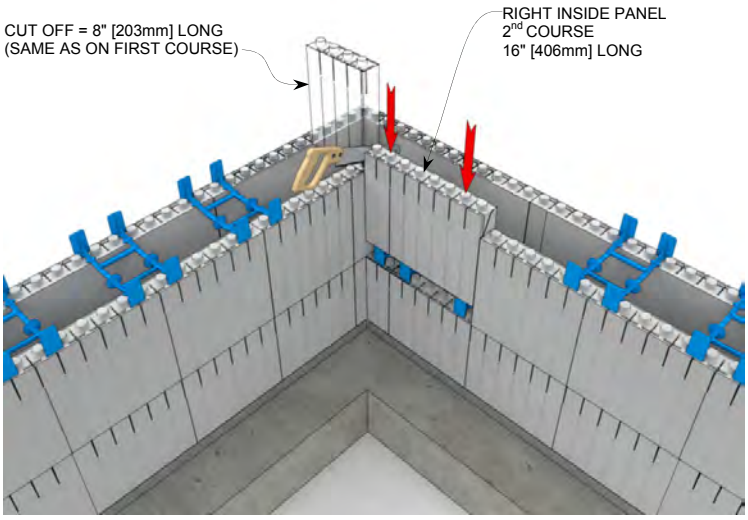
STEP 4 R-22 [U-0.28] 5.75" [146mm] Concrete Wall



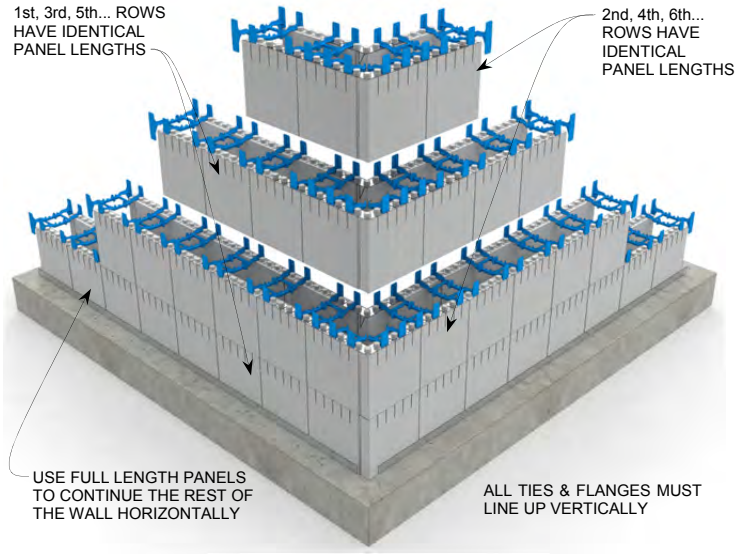
STEP 5 R-22 [U-0.28] 5.75" [146mm] Concrete Wall



STEP 6 R-22 [U-0.28] 5.75" [146mm] Concrete Wall



STEP 7 R-22 [U-0.28] 5.75" [146mm] Concrete Wall



STEP 8 R-22 [U-0.28] 5.75" [146mm] Concrete Wall

3.6.1.3 R-28 [U-0.21] Ultra Panel Corner Assembly

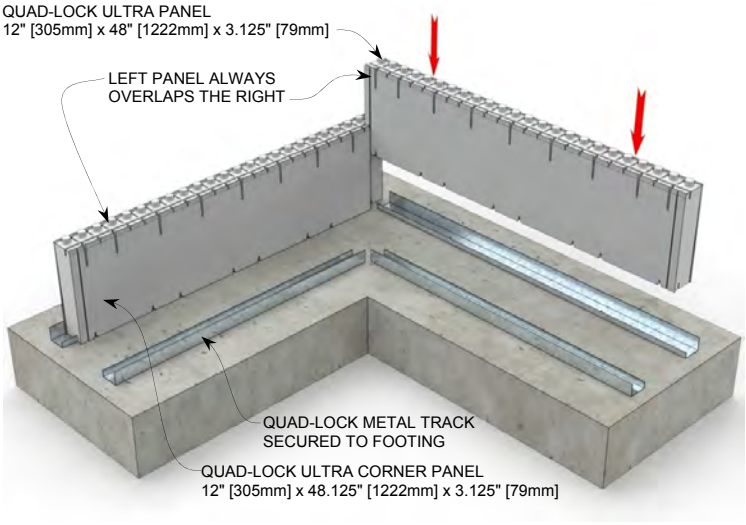
The new standard Quad-Lock R-28 wall employs a 3.125” [79mm] thick panel, which differs from earlier 2.25" [57mm] and 4.25" [108mm] models.

- The 3” thickness necessitates use of one of two measures when constructing 90 degree corners with the standard metal corner brackets.
  1. Use of the pre-formed Ultra Corner Panel, or;
  2. A 1 inch [25mm] cut-back on one corner panel (using the pre-formed line on the inside of the panel)

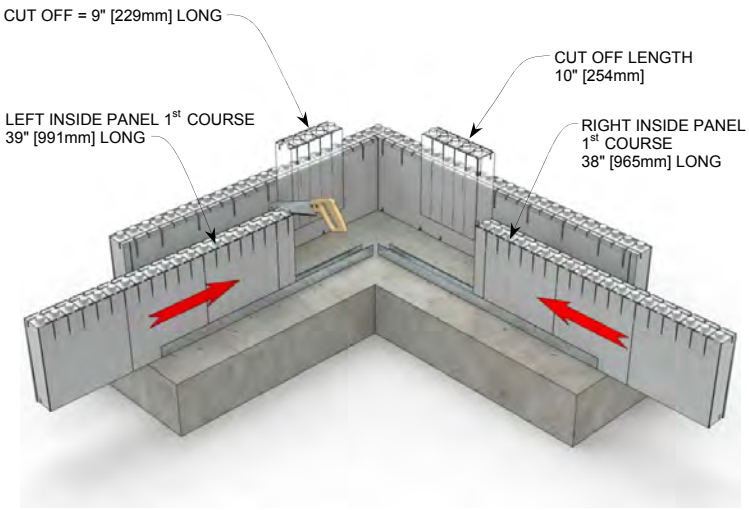
Experience has shown that using the Ultra Corner Panel yields a much more precise corner, and is the preferred method.

- QPX3 Corner Panels are specifically designed to accommodate the thicker foam with standard Quad-Lock Corner Brackets.
- QPX3 Corner Panels are recessed at only one end, which will necessitate a “left-over-right” lap pattern uniformly over the job.

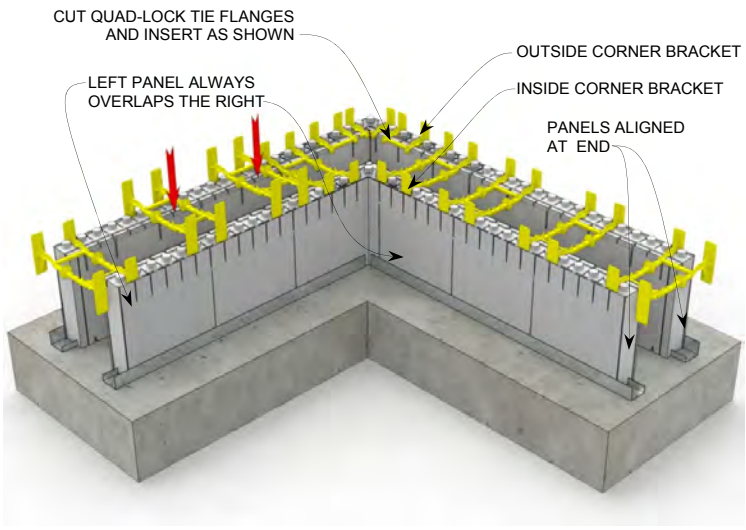
See the illustrated steps below.



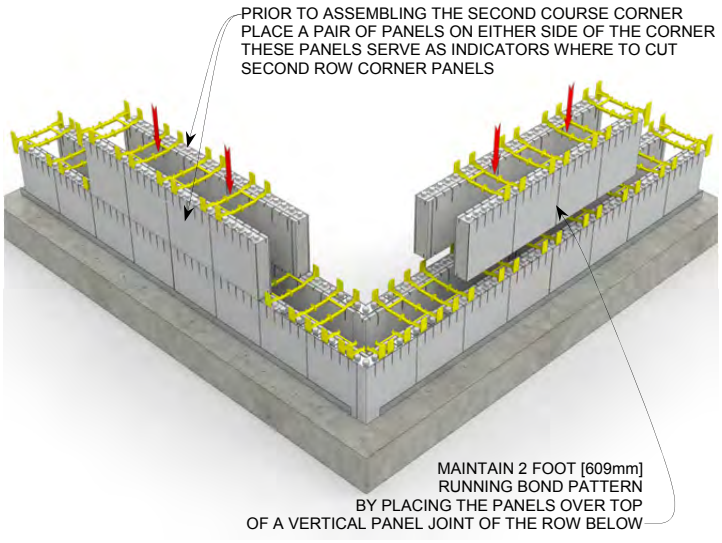
STEP 1 R-28 [U-0.21] 6" [152mm] Concrete Wall



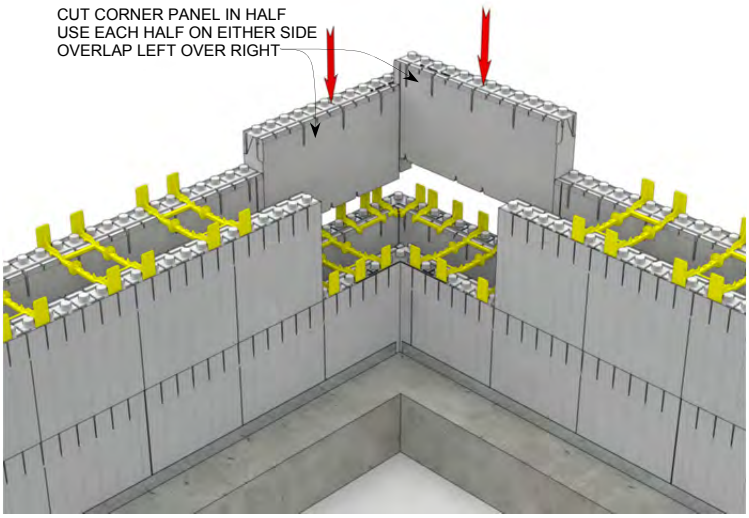
STEP 2 R-28 [U-0.21] 6" [152mm] Concrete Wall



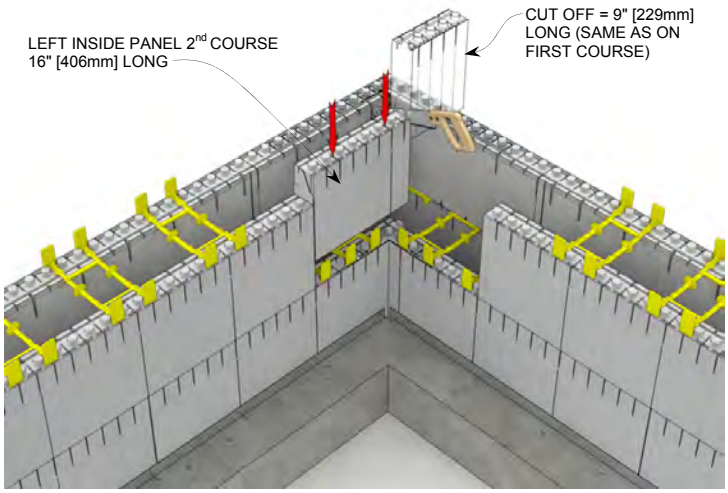
STEP 3 R-28 [U-0.21] 6" [152mm] Concrete Wall



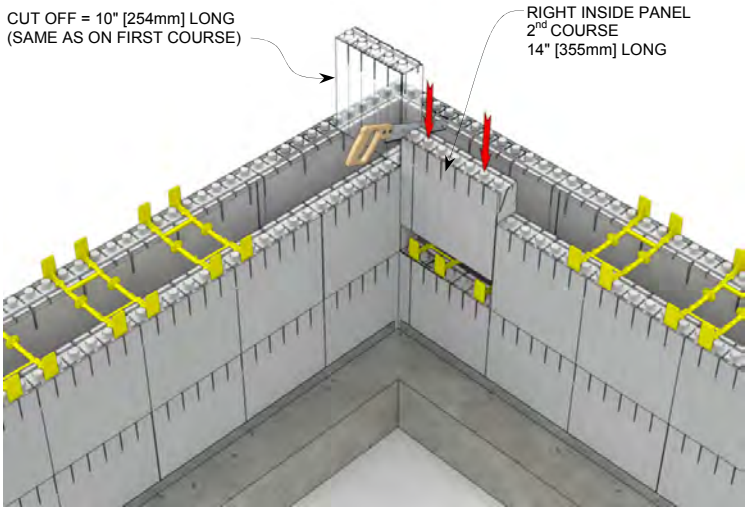
STEP 4 R-28 [U-0.21] 6" [152mm] Concrete Wall



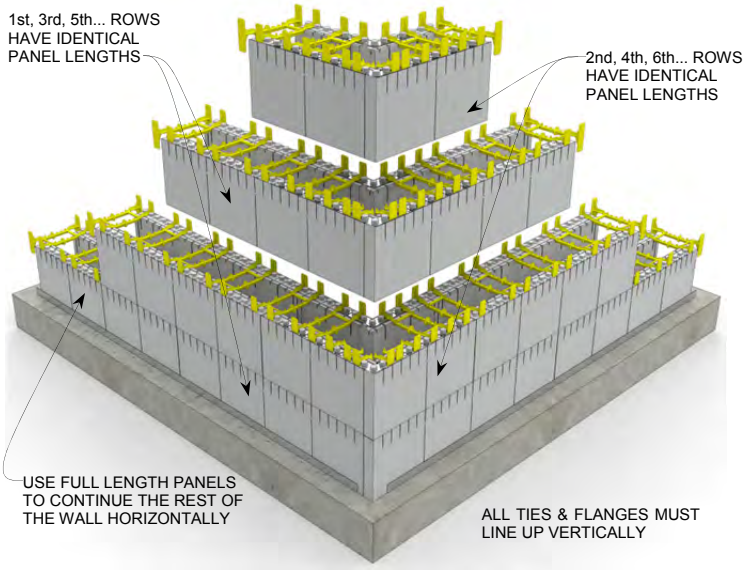
STEP 5 R-28 [U-0.21] 6" [152mm] Concrete Wall



STEP 6 R-28 [U-0.21] 6" [152mm] Concrete Wall



STEP 7 R-28 [U-0.21] 6" [152mm] Concrete Wall



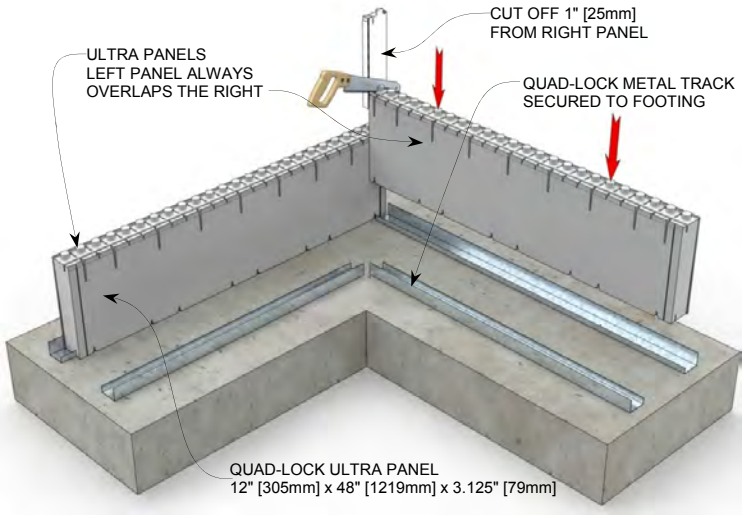
STEP 8 R-28 [U-0.21] 6" [152mm] Concrete Wall

3.6.1.4 R-28 [U-0.21] Alternate Ultra Panel 90° Corner Method

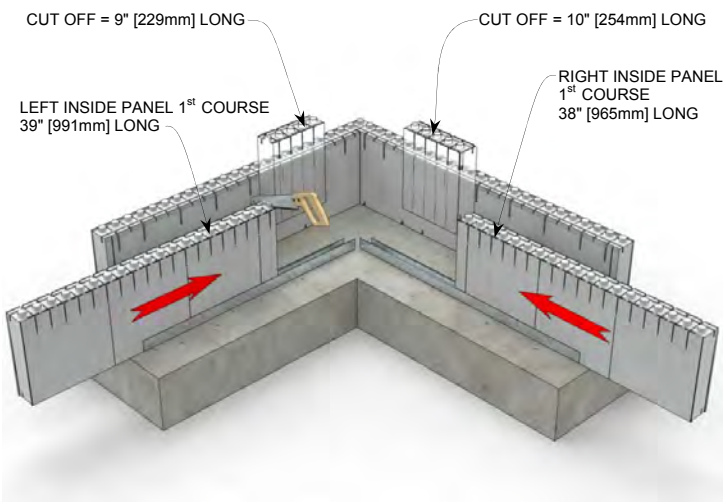
If installers choose not to use (or run out of) 3 inch Ultra Corner Panels, an alternate (but less tidy) method is as follows:

- Use a Straight Panel on the outside (lapped) panel.
- For the second (butting) panel, shorten a Straight Panel by 1 inch using the cut-line located on the inside face of the Ultra Straight Panel.
- Butt the cut end at the 90 degree turn and install the Outside Corner Bracket.

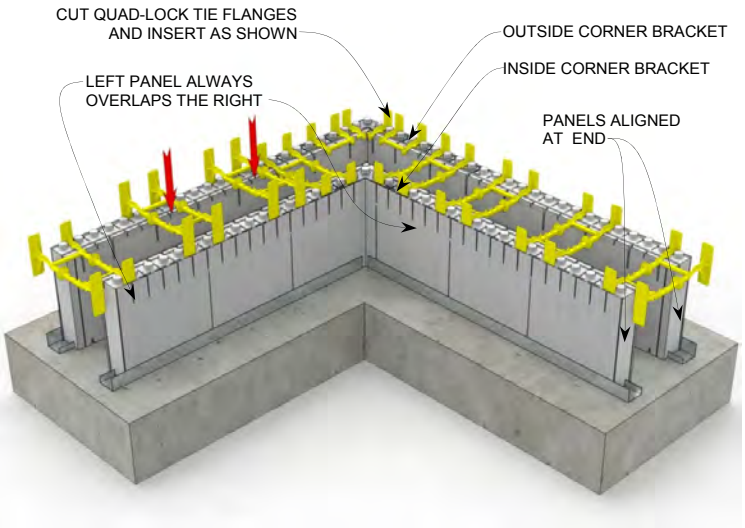
Either method will work, and can be used in combination with one another, however experience has shown that the factory recessed panel makes a neater and more precise corner. No specially-sized corner bracket is available for the 3 inch Ultra Panel, in keeping with Quad-Lock's philosophy of minimizing the number of parts necessary.



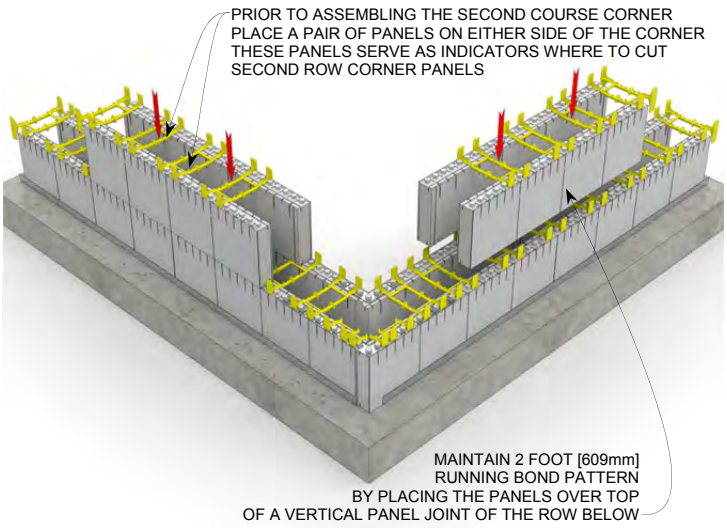
STEP 1 R-28 [U-0.21] 6" [152mm] Concrete Wall (Alternate Method)



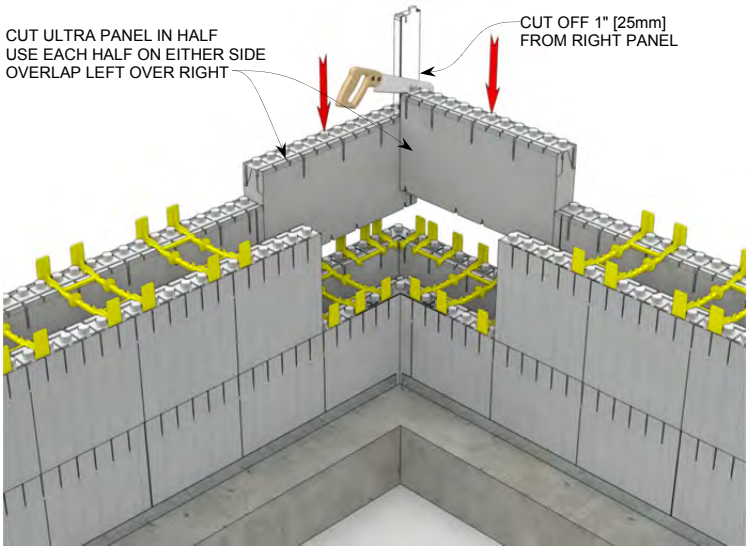
STEP 2 R-28 [U-0.21] 6" [152mm] Concrete Wall (Alternate Method)



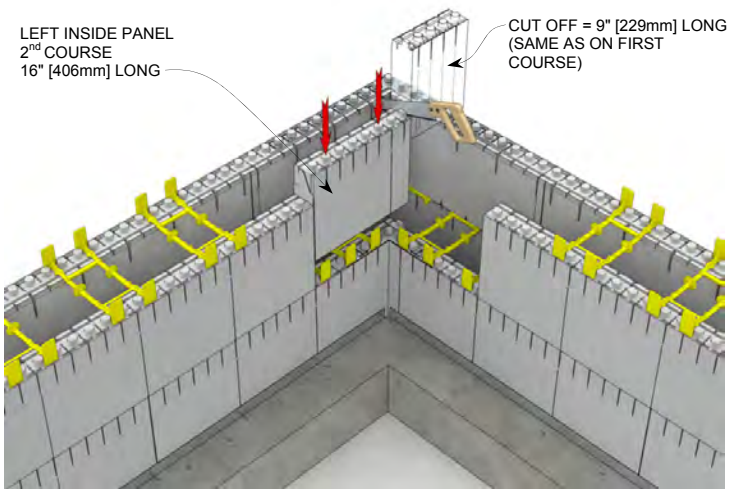
STEP 3 R-28 [U-0.21] 6" [152mm] Concrete Wall (Alternate Method)



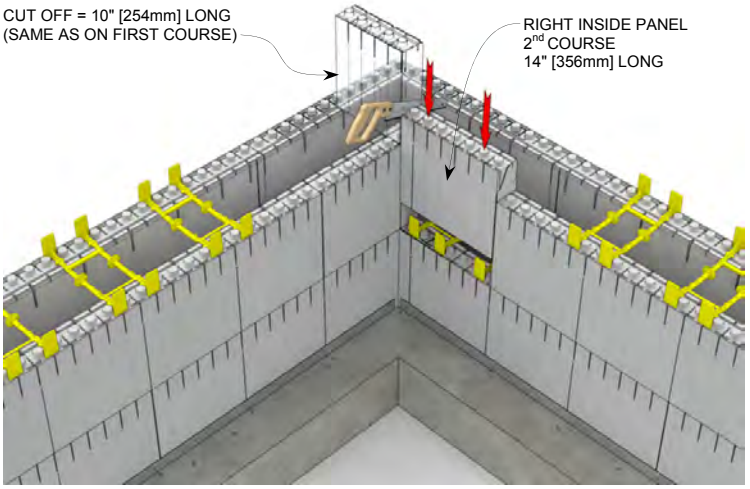
STEP 4 R-28 [U-0.21] 6" [152mm] Concrete Wall (Alternate Method)



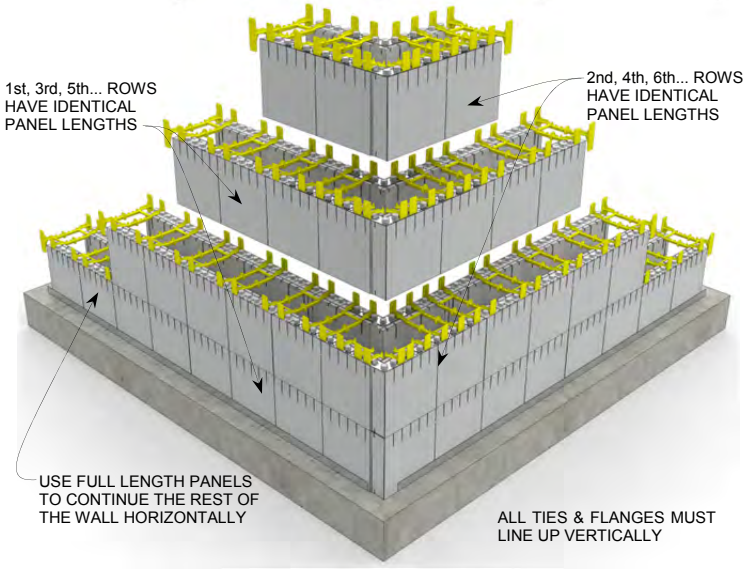
STEP 5 R-28 [U-0.21] 6" [152mm] Concrete Wall (Alternate Method)



STEP 6 R-28 [U-0.21] 6" [152mm] Concrete Wall (Alternate Method)



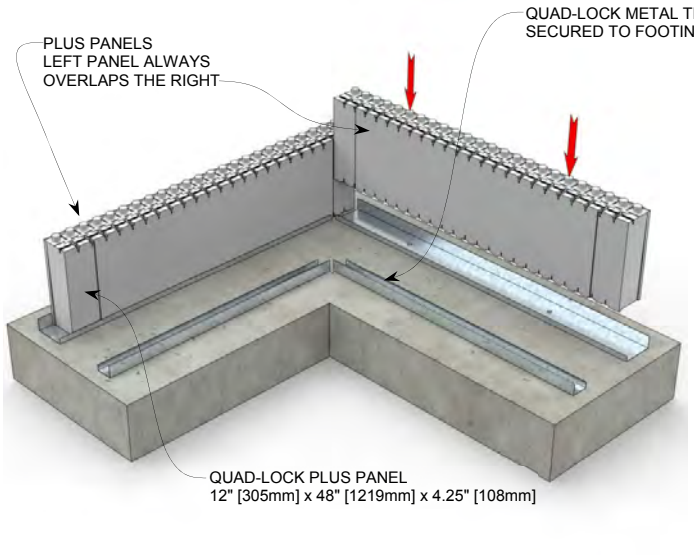
STEP 7 R-28 [U-0.21] 6" [152mm] Concrete Wall (Alternate Method)



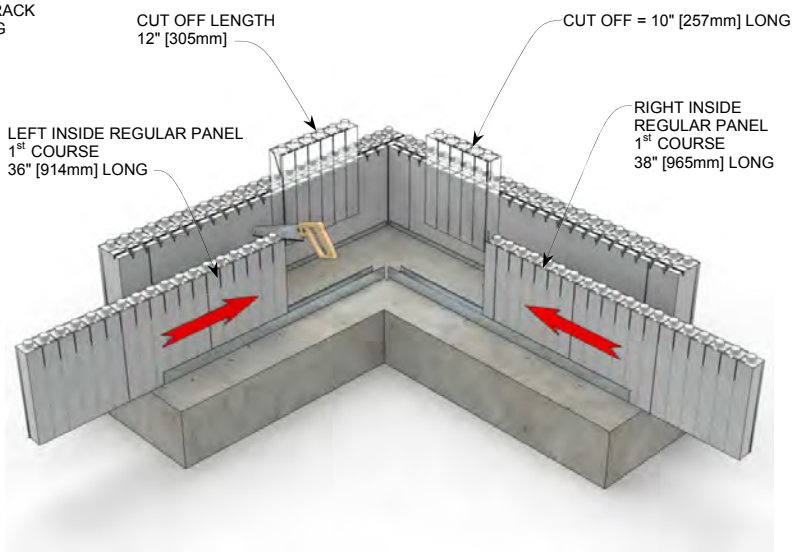
STEP 8 R-28 [U-0.21] 6" [152mm] Concrete Wall (Alternate Method)

3.6.1.5 R-30 [U-0.20] Plus & Regular Panel Corner Assembly

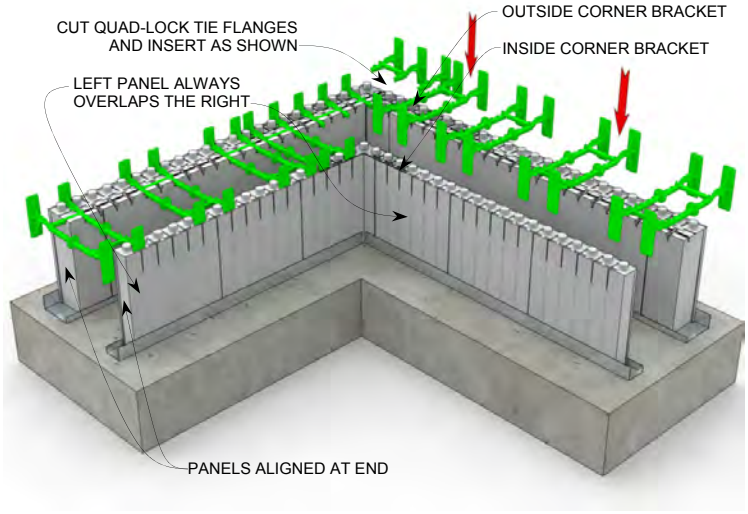
Keeping in mind the general techniques outlined in Section 3.7.1.1, corners built with Plus Panels in combination with Regular Panels will follow the illustrated steps shown below.



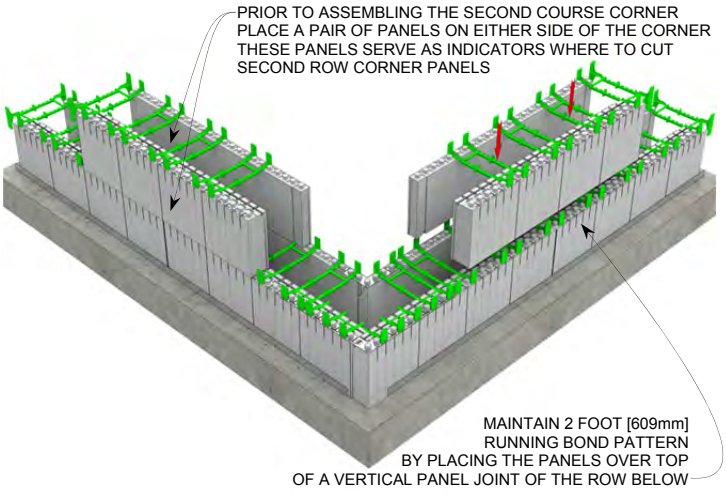
STEP 1 R-30 [U-0.20] 7.75" [197mm] Concrete Wall



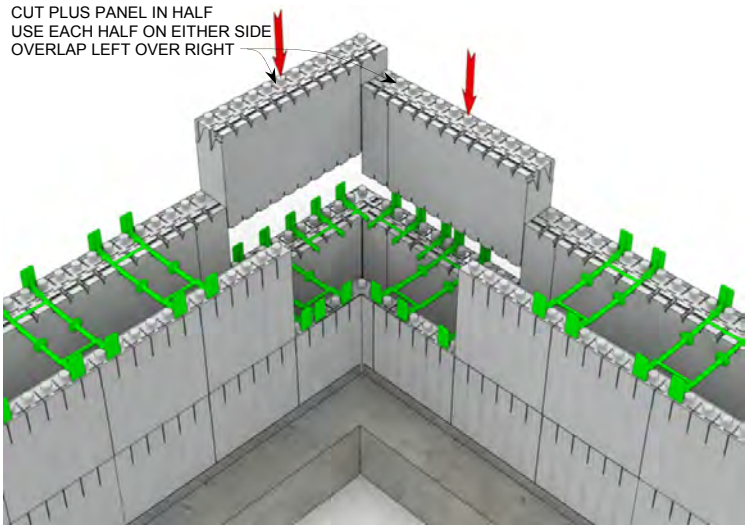
STEP 2 R-30 [U-0.20] 7.75" [197mm] Concrete Wall



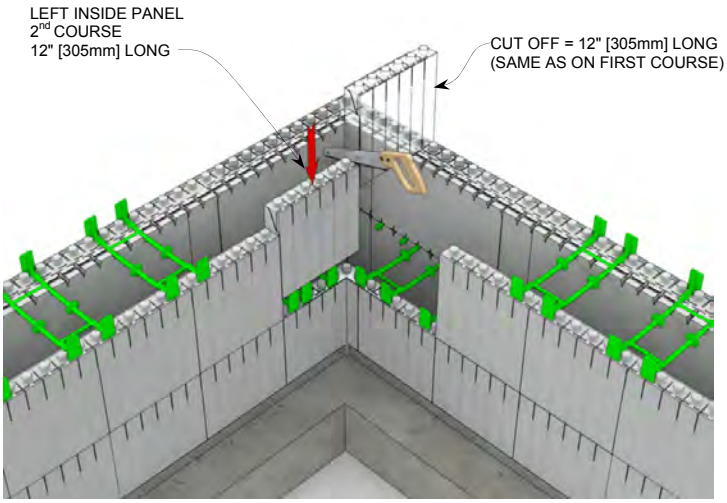
STEP 3 R-30 [U-0.20] 7.75" [197mm] Concrete Wall



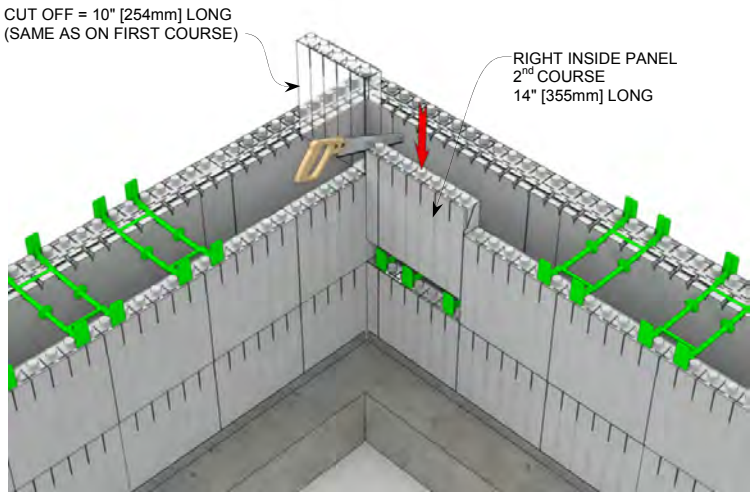
STEP 4 R-30 [U-0.20] 7.75" [197mm] Concrete Wall



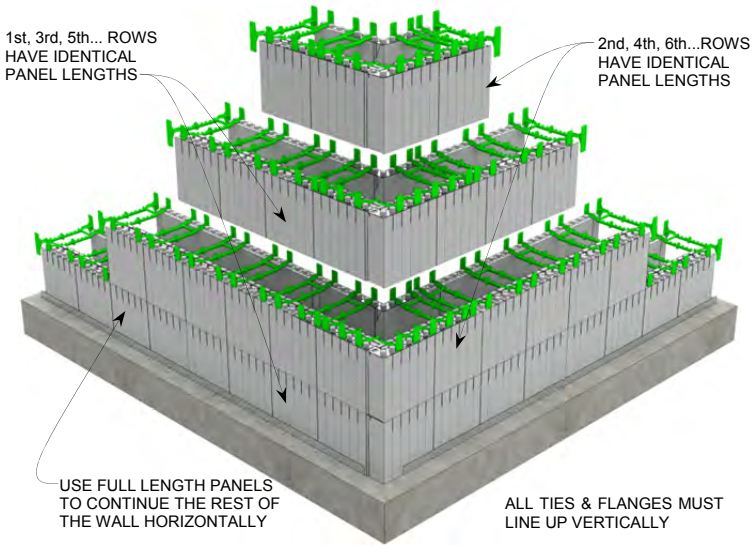
STEP 5 R-30 [U-0.20] 7.75" [197mm] Concrete Wall



STEP 6 R-30 [U-0.20] 7.75" [197mm] Concrete Wall



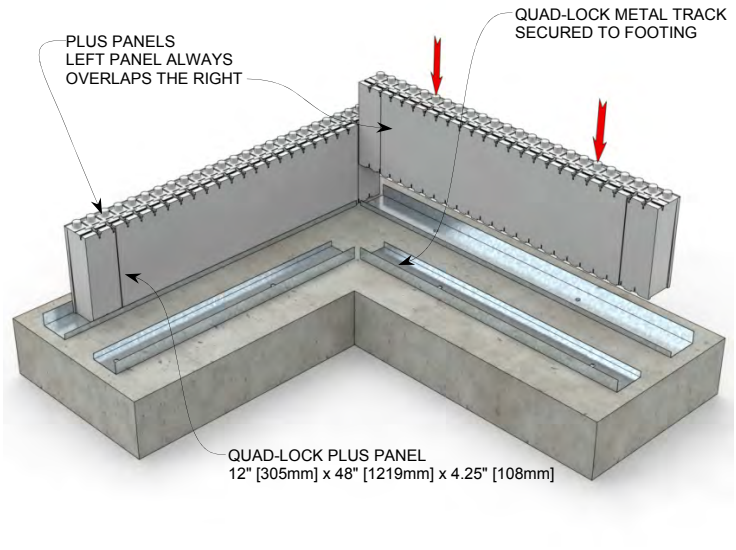
STEP 7 R-30 [U-0.20] 7.75" [197mm] Concrete Wall



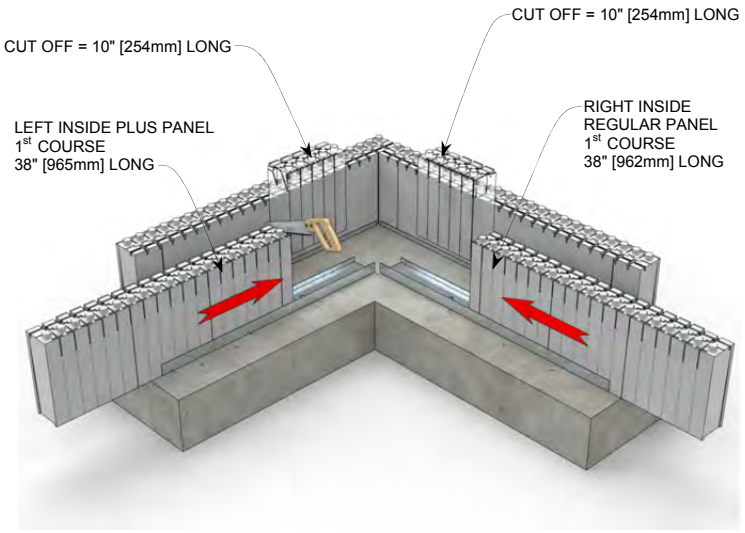
STEP 8 R-30 [U-0.20] 7.75" [197mm] Concrete Wall

3.6.1.6 R-38 [U-0.15] Plus Panel Corner Assembly

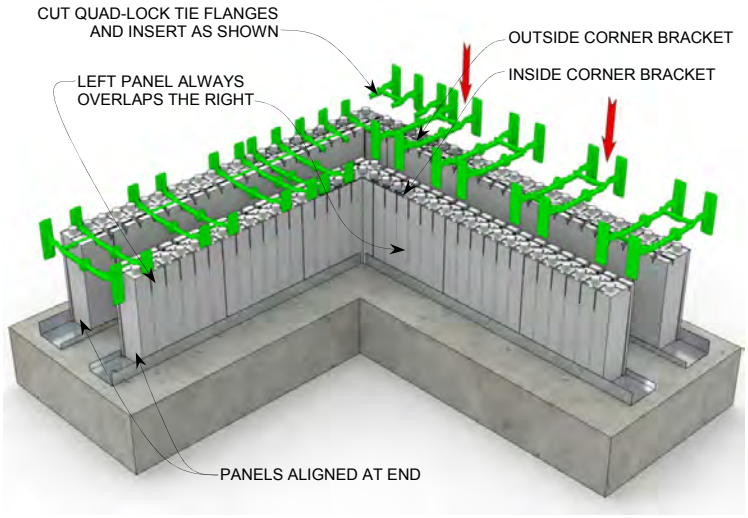
Keeping in mind the general techniques outlined in Section 3.7.1.1, corners built with Plus Panels will follow the illustrated steps shown below:



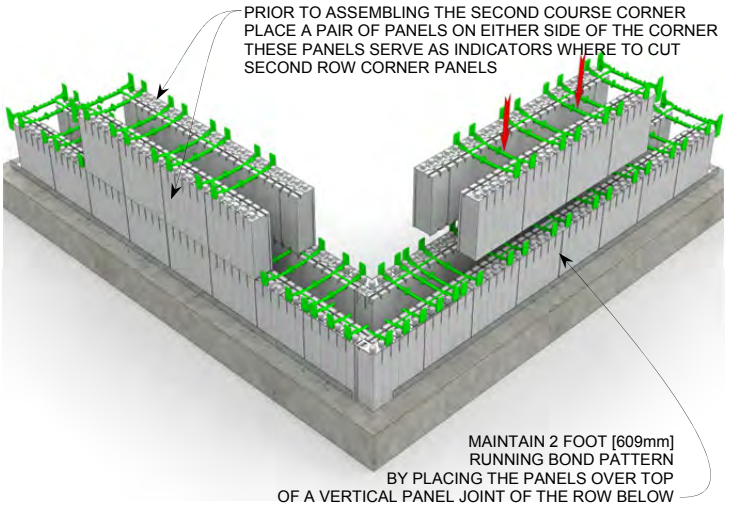
STEP 1 R-38 [U-0.15] 5.75" [146mm] Concrete Wall



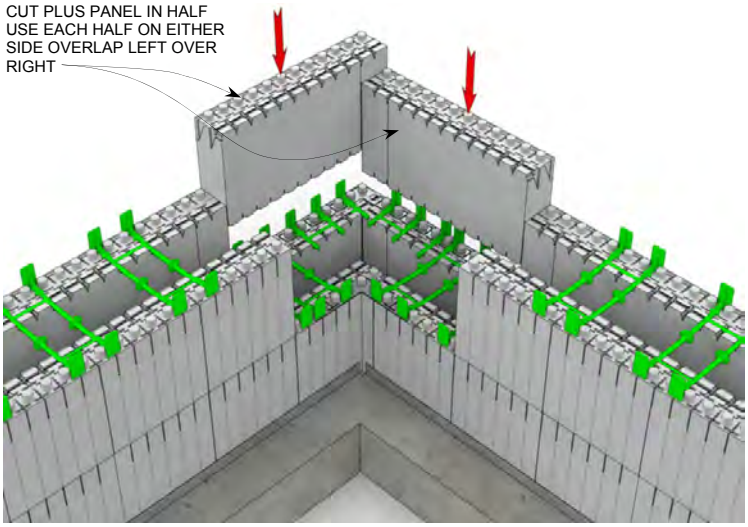
STEP 2 R-38 [U-0.15] 5.75" [146mm] Concrete Wall



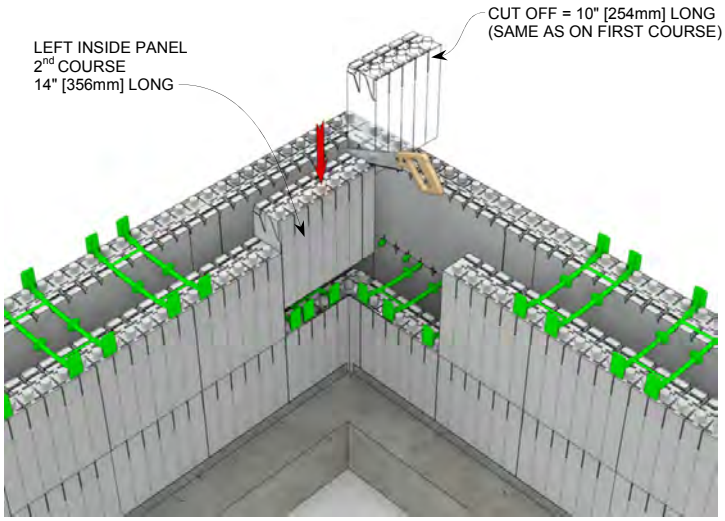
STEP 3 R-38 [U-0.15] 5.75" [146mm] Concrete Wall



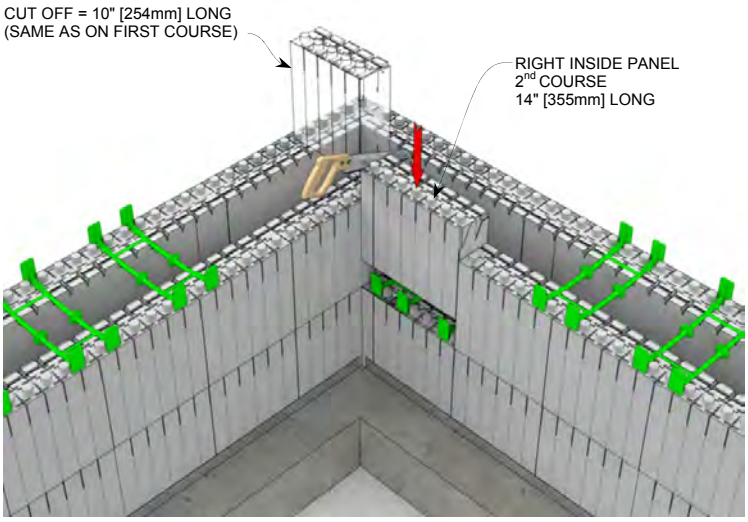
STEP 4 R-38 [U-0.15] 5.75" [146mm] Concrete Wall



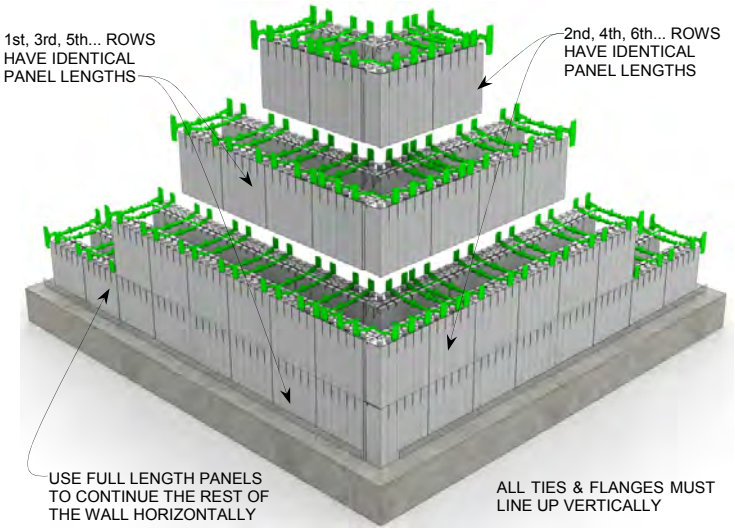
STEP 5 R-38 [U-0.15] 5.75" [146mm] Concrete Wall



STEP 6 R-38 [U-0.15] 5.75" [146mm] Concrete Wall



STEP 7 R-38 [U-0.15] 5.75" [146mm] Concrete Wall



STEP 8 R-38 [U-0.15] 5.75" [146mm] Concrete Wall

3.6.1.7 Placing 90° Corner Brackets and Ties (All Panel Sizes)

One of the most favored features of the Quad-Lock system is the Metal Corner Bracket system. Most corners do not require any external support to contain concrete or maintain the position of the panels. Exceptions may occur as described in Chapter 4 "Special Wall Elements" on Page 71.

- Place Inside and Outside Corner Brackets over the interlock knobs.
- Place a Full Tie as close to the corner as you can, making sure that the two flanges are both inserted in the inner corner bracket.
- Cut flanges from ties and insert them in the outer corner bracket as shown below, making sure that the slots closest to the corner have a flange.
- Insert a flange every 4" [10cm]. Extra flanges can be added around the heavy grooves, if needed for attachment.

IMPORTANT: The **cut tie flanges** placed into the corner brackets **are critical structural parts**. Do not forget them. The wider the panels AND the concrete cavity, the more cut-flanges should be inserted (every other tie slot)

Building Tip:	**Flanges for corners can be pre-cut to speed up construction.**

Building Tip:	**To expedite tie placement, work in pairs with one person placing ties on top of the wall and another inserting them into the panels.**

3.7 T-WALLS, JUNCTIONS, ANGLES & SPECIAL WALL ELEMENTS

See **Chapter 4 - Special Wall Elements** starting on page 71 for details on T-Wall junctions, Special Angles, Radius Walls, and more.

3.8 PLACING REINFORCING BAR (REBAR)

Note: ***A detailed discussion of concrete, concrete placement and reinforcing bar will be found in Chapter 8 on page 161. Readers are advised to consult that chapter before attempting to place concrete and reinforcing bar.***

3.8.1 Horizontal Rebar

3.8.1.1 Positioning Horizontal Rebar

Determine which molded rebar chair in the tie best suits the building plan's engineering specifications. Lay and secure the horizontal bars into that position around the entire wall.

- Make sure to have the appropriate minimum lap between bars and tie the splices.
- Insure that minimum concrete coverage can be maintained between rebar and form panels.
- Horizontal bar can be tied to the plastic ties.
- Consult building codes for permissibility of "non-contact lapped splices" where bars are overlapped the correct distance, but not tied to one another.
- **When tying bar laps, position horizontal bars one on top of the other in an "over-and-under" fashion (not side-by-side). Doing so will improve the flow of concrete.**

3.8.2 Vertical Rebar

A decision should have been made at the completion of the footings as to whether the vertical rebar should be pre-tied to dowels extending up from the footing or slab, or to drop the vertical rebar into the wall after the wall is assembled.

- Be sure that the vertical bars have the proper splice overlap with the dowels. Consult local building codes if unsure.

3.8.2.1 Pre-Tied Vertical Rebar

If the vertical bar has been pre-tied to the dowels, panels can easily be passed through the upright bars and properly positioned while working from one side of the wall.

- Quad-Lock ties can be either fit between bars at their proper spacing, or placed around the bar by cutting one of the two cross-members that connect the two halves of the tie.

3.8.2.2 Vertical Rebar Placed After Assembly

Prior to stacking panels AND if allowed by local building officials, slip a 4" [10cm] long piece of 1¼" – 1½" [32mm-38mm] plastic pipe over each vertical rebar dowel jotting out of the footing. This will be used later to secure vertical reinforcing bar that is dropped in from the top.

Building Tip: **Most building codes call for overlapped distance of minimum 40 times the bar diameter. This includes corners. Quad-Lock suggests that lapped splices always be tied in "over-and-under" fashion versus side-by-side. This presents a smaller surface for concrete to collect on, and makes pouring and consolidation easier.**

3.9 STRAIGHT WALLS

If you are reading this section first, please refer back to Section 3.7, which advises to start any project by building corners, angles, T-Walls and other special elements first, then working to a common mid-point in the wall. Installation of door bucks should take place before any panels are laid.

3.9.1 First Course

Having first constructed 90 degree corners, T-wall intersections and angles, the first course of panels can now be placed. The layout of the first course of panels and ties is very important, since it will serve as a reference for the rest of the wall installation.

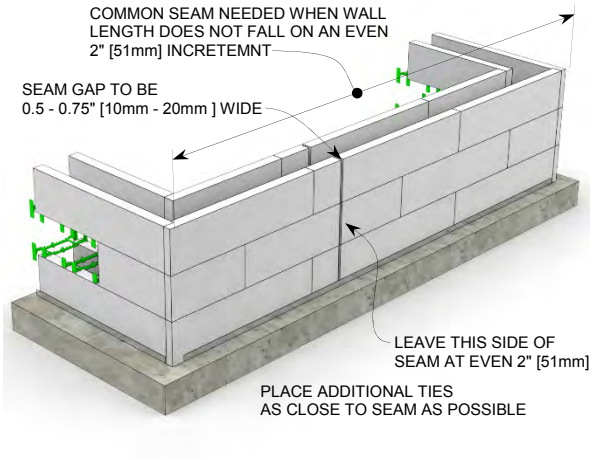
- Experienced ICF installers take a little extra time to insure that the first course layout is correct and repeatable. The value of the extra care invested at this point will become obvious as the job progresses.
- Place panel pairs into track along the wall line, keeping the panel ends even with one-another. (This way, one tie will protect both sides of the joint between panels)
- Work away from corners and T-walls and toward a central point.
- Be sure to tap the panels securely into the track below to maintain the correct wall elevation.

3.9.1.1 Adjusting Wall Length Using Common Seams

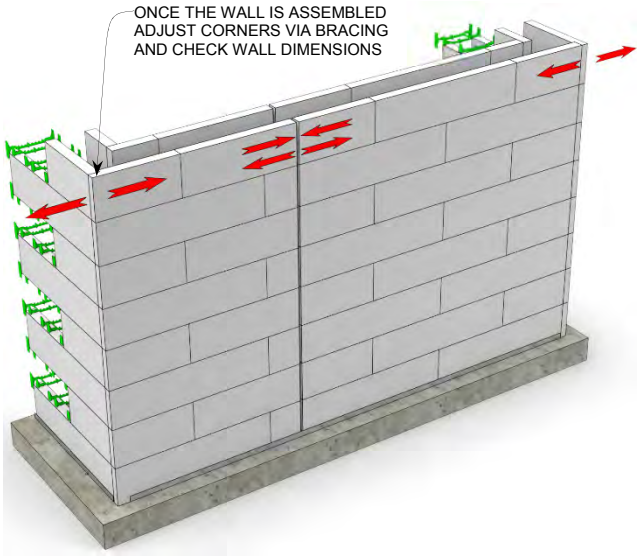
Confirm that the wall length is correct by measuring from end to end. If the measurement is an increment of 2 inches, any succeeding panel courses will overlap and no adjustment seam is necessary. If the measurement is other than a 2 inch increment, choose a convenient point to place a common adjustment seam that will extend up the entire height of the wall. **This is the point where an adjustment is made to fit the Quad-Lock panels to the actual building dimension.**

- Experienced installers make a door opening their first choice for positioning the common seam. Their second choice is a window opening. This reduces the amount of cutting & fitting necessary to form the common seam.
- To form the common seam:
  1. Measure each wall length to ensure that your building dimension is correct. Make adjustments, if necessary.
  2. After placing panels to within 1 panel-length of one another, measure the remaining gap and cut remaining two panels about ¼" [8mm] shorter than the measured gap. Cutting these panels too tightly may increase the wall length, and force the corners out of plumb. Be sure to keep the odd-dimension cuts on the same side of the adjustment seam, leaving the opposing side at factory dimensions.
  3. Since the adjustment seam is not on the 2" [5cm] layout pattern, cut the cross braces out of a tie to form two 'split ties' that operate independently of one another. Place one split tie on each side of the common seam, as near as possible to the seam.

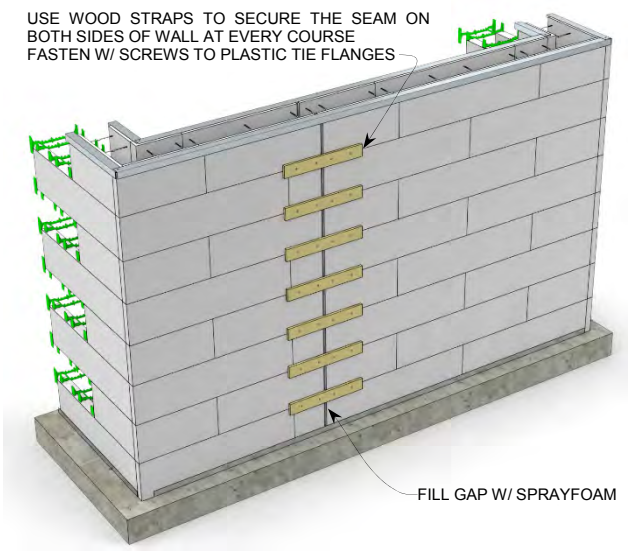
This seam will continue to the top of the wall and is secured later after aligning and plumbing the walls.



Step 1



Step 2



Step 3 A

Step 3 B

Now, in-fill between all pre-built corners, T-walls, and angles with first-course panels and prepare to place ties. If panels are properly cut and installed, the deeper grooves on both sides should be aligned with one another.

Building Tip:	**To save time in securing the common seam, a 24" (610 mm) wide strip of plywood can be laid vertically over the seam, and secured to tie flanges on either side of the seam. Otherwise, strips of plywood or 1x4 wood must be fastened individually across the seam.**

3.9.1.2 Tie Placement in First Course

- Place ties at maximum 12 inch [305mm] spacing along the entire length of the first course, using the deeper grooves in the panels as a layout mark.
- Center each tie over the deep grooves.
- When you reach a common seam, clip a full tie into two single ties and place them as close to either side of the common seam as possible.

Tie positioning in the first course is very important, as it will guide the tie placement during the entire installation.

After positioning first-row ties and before starting the second level, place horizontal reinforcing bar in its correct position on the first-row ties. ***(See Section 3.9)***

3.9.2 Second Course

3.9.2.1 Second Course Panels

Start the second row by finding the first butt-joint between pairs of first-row panels as you move away from the corner.

- Place a pair of full-length panels on the second row so the middle point of both panels lines up with the vertical joint in the panels below.
- There should be a half panel length (24" [61cm]) offset between the end of the panels in the first and second rows.
- Do the same on both sides of the corner.
- The outside corner panels for row two will always be half (24 inch [61cm]) panels.
- The length of the inside corner panels will vary, depending on the cavity size.

Offsetting joints between courses in this manner helps to keep walls straight by eliminating 'hinge-points'.

Build succeeding rows using the same layout pattern as rows one and two in alternating fashion. *No other cut pattern should be necessary after the first two rows are established!*

- **Exception:** An exception to this rule may be at very short wall runs (i.e. 'bay window' area) where offsetting joints may not be necessary or desirable. In fact, experts find it far simpler to cut each row of panels the same length, with joints stacked vertically. In these short-run areas, eliminate the offset and stack any joints vertically (if necessary). Be sure that ties are properly positioned over joints. If additional bracing on the wall seems necessary, then add it to the wall for stability.

3.9.2.1.1 Second Row Corner Brackets and Ties

Tie placement in row two (and above) **should always line up vertically with the ties in the first row.**

- This makes the job of the interior drywall installer much easier because ties are stacked vertically in line.
- Never leave more than 8" [20cm] or 4 interlock knobs between any two ties in straight walls (more ties may be needed for corners, T-walls, tight radii etc.; see details to follow).
- Place Corner Brackets, Full Ties and tie flanges in the same manner as the first row. Corner Bracket and tie placement should be exactly the same on every row.

Make note of all cut dimensions and prepare panels for the entire wall height. For instance, in an 8 ft. {2.44m] high wall, courses 1, 3, 5, and 7 will all be identical. Rows 2, 4, 6, and 8 will be identical.

Building Tip:	**One of the best tools on an ICF job is a permanent marker ("Sharpie") used for making notes on the surface of panels showing cut-length, location of ties, or other information for others.**

Building Tips:	**Minimize waste by cutting left over pieces of panel in 12" or 24" [30 or 60cm] lengths. These can be distributed throughout the wall in groups adding up to 48" [1219mm], rather than using full panels. When using smaller scraps, be certain that vertical joints fall between the two flanges of a full tie.** **Use the deeper grooves to locate tie placement every 12" [30cm] on center.** **Follow suggested stacking pattern to keep grooves and ties aligned for later reference by finish trades.**

3.9.3 Stacking Courses to Window Elevation

Place panels and ties for succeeding rows in alternating fashion to rows one and two.

- Check placement of ties by looking down the wall cavity to be certain that all ties are aligned vertically and none are missing.

3.9.3.1 Preparing for & Placing Window Buck-Outs

- Check the building plans for correct window elevations and stack panels/ties to a level at or slightly above bottom sill height specified.
- Mark elevation and positions of window openings. Cut panels to proper elevation and shape to receive pre-built window buck-outs. *See Chapter 5, Section 5.1.2 on page 102*).
- Place pre-built window buck-outs, level them, and secure with screws and Wind-Lock plastic washers.

3.9.4 Continuing to Top-of-Wall Elevation

When door and window openings have been confirmed and placed, continue stacking to top-of-wall elevation.

Note**:* ***Many experts fasten only the bottom of the window buck-out until the entire wall is completely stacked. While one worker racks the form into perfect square and confirms with a builder's square, another worker fastens panels with screws and Wind-Locks securely to the window frame.

- At a height of 4'-5' [120-150cm] in the build, stop construction and check for Plumb, Straight, Square and Level and install bracing (see Chapter 6, Section 6.1 on page 132)
- Check all walls with a level, tape measure, string line and laser level to make sure the building is the specified size and shape. Make adjustments where needed, and monitor as construction continues. (Note: Only rookies skip this step. This is NOT the time and place to cut corners)
- When building dimensions and wall alignment are checked, secure the common seams.
- Span the seam with 1x4 strapping on each row (or a full-height plywood ½ panel) secured to two ties on each side with screws at 12 inch intervals up the wall.
- Use spray foam to fill in the gap of the seam once the wall has been fully stacked, plumbed and secured in place. Make sure corners are in their correct and final position before foaming.

3.9.5 Top of Wall

3.9.5.1 Adjustment of Top-of-Wall Elevation

While all Quad-Lock Panels come from the factory in convenient 12" [305mm] heights, your plan may call for an elevation other than an even increment of 12" [305mm].

To adjust the final elevation of your wall, two methods are suggested: Either *start* the wall with a ripped (shorter) panel, or *finish* the wall with a ripped panel. The choice is yours, and should suit your situation.

3.9.5.1.1 Adjusting Wall Elevation at Bottom Course

Start the wall with a ripped panel whose height is calculated as follows:

- From the total wall height, subtract the largest available increment of 12" [305mm]. For example, if your finished wall height is called out at 9 ft. 4½" (112½" [2858mm]), subtract the 9 feet (108" [2743mm]), leaving 4½" [114mm]. The 4½" [114mm] remainder will be the elevation of your first course.
- Rip tops and bottoms of full panels to 4½" [114mm] on a table saw and install them in the Metal Track that has been secured to the footing or slab. *(Bottoms of panels can be inverted to accept the plastic ties, in order to conserve panel material. The lack of interlock knobs is of no consequence.)*
- Build the wall to full height using full panels, and the last row should bring the wall to the exact finished elevation.
- Remove the interlock knobs and place Wire Top Ties and track, or ladder brace.

Note**:* ***Ultra Panels: *When using ripped Ultra Panels with the Regular Track, a slot must be cut into the bottom of the Ultra Panel to accept the track. Set your table saw for a 2 ¼" [57mm] wide by 1" [25mm] high to make the cut.*

3.9.5.1.2 Adjusting Wall Elevation at Top Course

The alternate method is to start the wall with full 12" [305mm] high panels, and rip the top row of panels to attain the exact finished wall height.

- If the ripped panels are less than 4 inches [100mm] in height, just place Metal Track over the ripped panels with no cleats joining the panels across the wall . The 4 inch high panels *(without being abused!)* will maintain their position during the pour.
- If the ripped panels are higher than 4 inches, place track over the tops of ripped panels and substitute conventional wood cleats for Wire Top Ties. Wood cleats are screwed across the track at 3 to 4 foot [90-120cm] intervals to maintain spacing between the top panels.

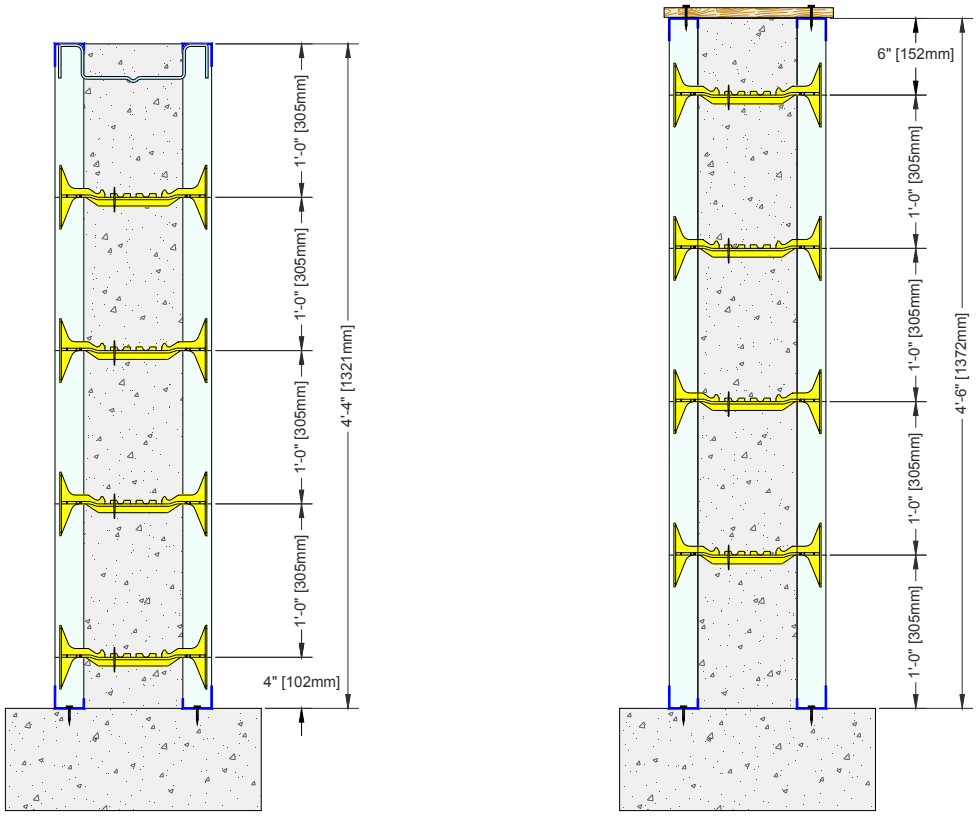


Figure 50: Panels Ripped to Adjust Wall Elevation

3.9.6 Finishing the Top of Walls

The Quad-Lock Metal Tracks and Wire Top Ties make finishing the top of walls easy when completing the top course of the wall. The Metal Tracks can also be connected using wood cleats. Another method to finish the top of walls is to use wood-ladder bracing (without Metal Track or Wire Top Ties).

When building cavities larger than that of a red tie or wall assemblies with Extra Panel, place metal track without Wire Top Ties and place a conventional wooden cleat across the cavity. Fasten wooden cleats to the metal track with screws long enough to penetrate both the cleat and metal track. A cordless screw-gun or impact driver will drive screws quickly. Use minimum ¾ inch [20mm] thick lumber or ½ inch [13mm] plywood ripped into strips. Space wooden cleats at 3 ft. to 4 ft. [1m to 1.3m] along the top of walls and where joints between metal track pieces occur.

Building Tip:	**ALWAYS remove the foam interlock knobs before placing track. Track will not fit properly over knobs left in place.** **When cutting foam knobs be sure to keep them from falling into the wall cavity. Debris at the bottom of the wall can be called as a code violation.**

3.9.6.1 Wire Top Ties and Metal Track

The combination of Metal Tracks and Wire Top Ties allows builders to save considerable time in both finishing and bracing of the wall and in troweling the top of the wall without having to work around wood cleats.

- Use a minimum of four Wire Top Ties per 48” [1219mm] panel pair: One as near to each end as possible, and two more evenly spaced along the length of the panel pair.
- Wire Top Ties also feature a bend that allows for the centerline placement of rebar at 3½" [9cm] below the top of the wall elevation (top of concrete).

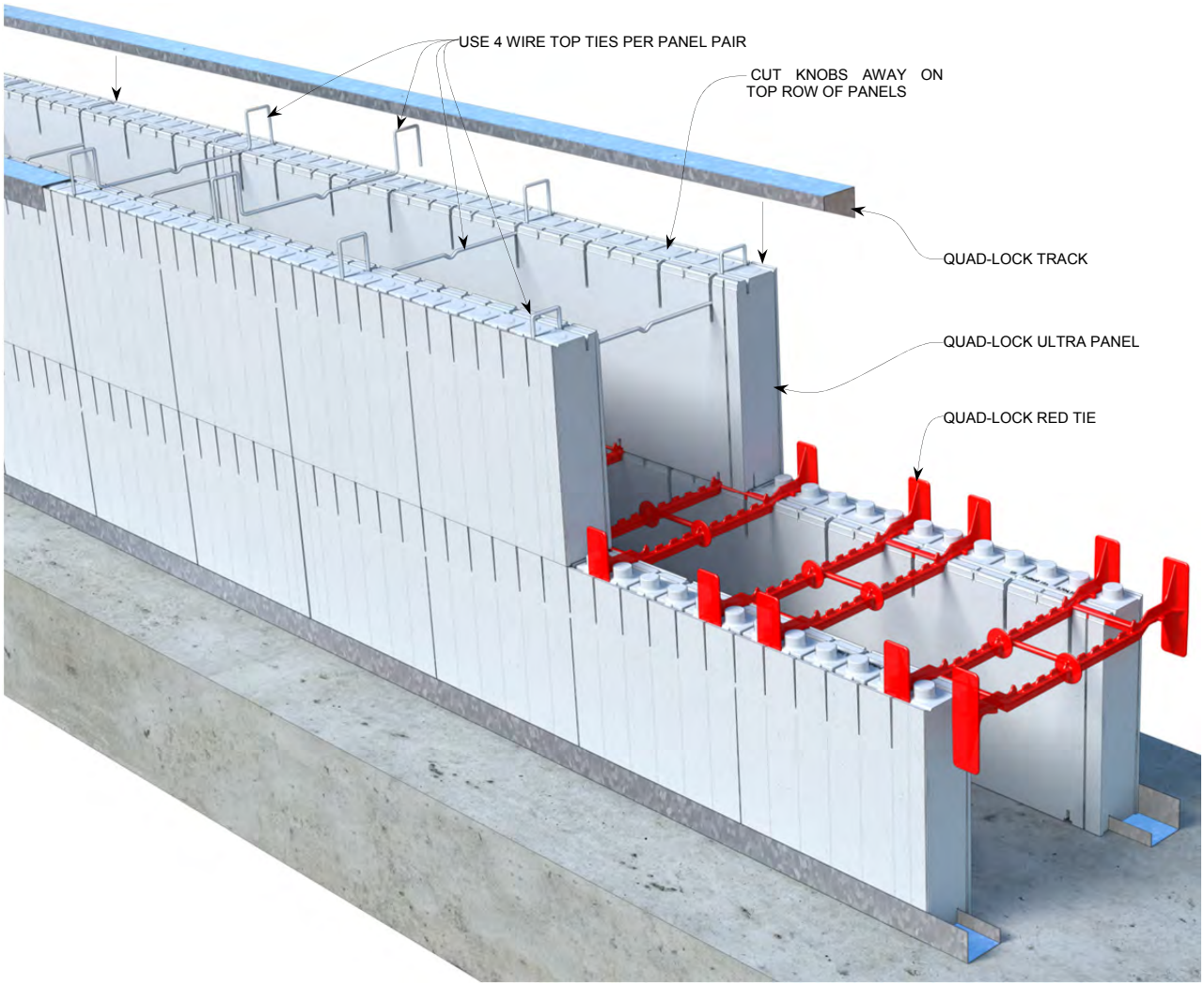


Figure 51: Finishing the Top of Walls with Metal Tracks and Wire Top Ties

3.9.6.2 Installing Wire Top Ties and Metal Track at Top-of-Wall

Install Wire Top Ties and Metal Track using the following steps:

- Remove all the foam interlock (round) knobs from the top panels.
- Place a minimum of four Wire Top Ties into the tie slots in the top of each panel, one at each panel’s ends and two spaced evenly at about 16 [406mm] inches apart.
- Install the Metal Track over the panels with the short leg of the track facing the concrete cavity. (Use a ‘rolling’ motion after you have caught the top of the panels with the longer (outside) leg of the track to easily position the track.)
- Seat the track firmly on the panels with a gloved hand or a hammer to insure that the correct wall elevation is maintained and to lock in the Wire Top Ties.
- At corners/angles/T-Walls etc., cut the Metal Track to overlap at the corner junction. Screw them together with one or two screws. Use a ¾" [2cm] long self-tapping sheet metal screw. **DO NOT SKIP THIS STEP!** This will keep the corners from spreading apart during the pour.

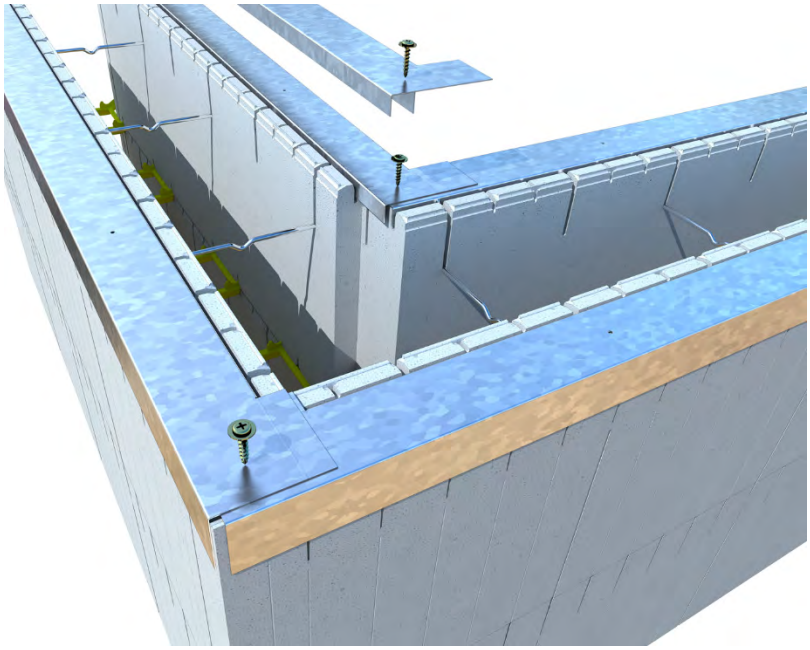


Figure 52: Overlapping metal track on top of corners

Note: ***It is not necessary to overlap the track along straight wall sections.***

The combination of Metal Track and Wire Top Ties will act as a 'spine' for the wall and assist in keeping the wall aligned during the pour.

Building Tip:	**In many regions, the Metal Track can be left in place. However, in cold climates, removing the top Metal Track can reduce the risk of condensation on the interior of the wall. If the building has proper ventilation / air exchanges, this is usually not necessary as the excessive moisture is being removed from the structure. If left unaddressed, excessive condensation combined with organic material such as drywall paper could result in the development of mold.**

Building Tip:	**When using ripped panels on the last course (where tie-slots have been removed), use wood cleats every 4 ft. [1.4m] instead of the Wire Top Ties to connect the Metal Track and maintain the proper cavity size. Remember to check the cavity measurement before you fasten cleats across the wall.**

3.9.6.3 Alternate "Ladder-Brace" Method

Early ICF installations were often done using a "ladder-brace" method, as are some shorter walls today.

- Space two pieces of 2x4 [50mmx100mm] lumber apart by the exact dimension (outside to outside) of your ICF wall. Use straight 10 ft. [3m] lumber or longer where possible. *(Find them in the aisle next to the Unicorns)*
- Fasten wood (1x4 [25mmx100mm]) cleats across the 2x4s, maintaining the ICF wall dimension along the entire length.
- Slip ladder-brace sections over the top-of-wall, with ends touching. Connect them with plywood gussets on each side.
- Brace to the ground and align the walls with turnbuckles.

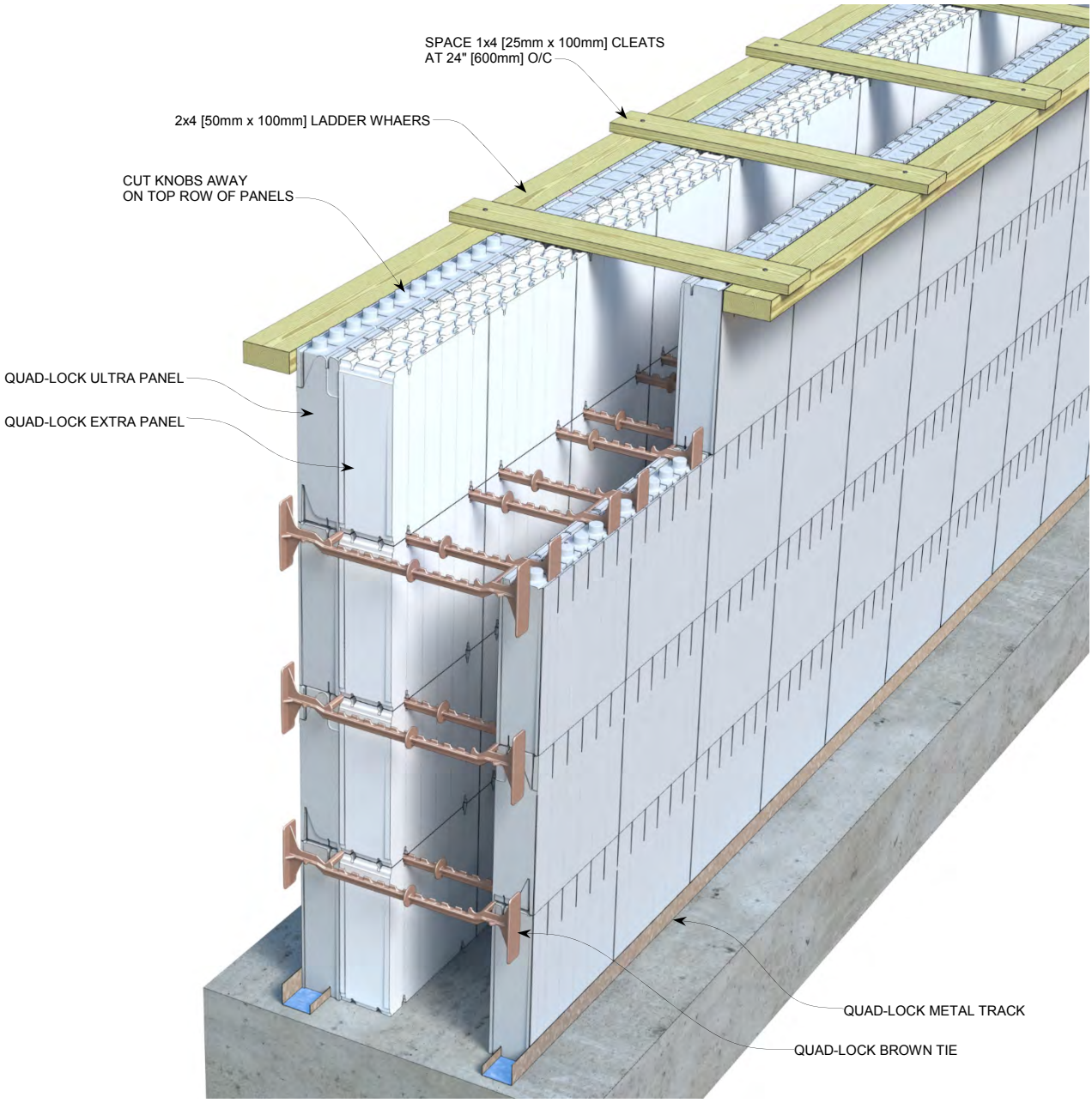


Figure 53: Finishing the Top of Walls with wood Ladder brace

Savings Tip:	**Eliminate the need for top-of-wall track and wire top ties by ripping 3" to 4" from the bottom of the first row panels. Save the 3" to 4" pieces in a location where they won't be damaged or discarded.** **Start the wall with the remaining 8" to 9" piece of panel (which brings the first tie row closer to the bottom of the wall and improves resistance against concrete pressure). Add rows of full panels and ties to the desired elevation, then cap the wall with the reserved 3" to 4" panel rips. The top row of panels should not need any track or ladder brace to resist concrete pressure. It is recommended that a wood or metal whaler (brace) be screwed horizontally to ties at the top of the wall to assist in aligning the wall.** **Before starting installation of panels, and if a more precise elevation adjustment is needed, trim the bottom panel again to yield the exact wall elevation when heights of all layers are added together.** **This method will require one additional row of ties, the cost of which is usually more than offset by the savings in track and wire top ties.**

3.9.7 Completing Wall Bracing and Reinforcing

3.9.7.1 Wall Bracing

Complete wall bracing by adding braces in areas that have not been previously addressed. *See Chapter 6, Section 6.1.2 for a detailed treatment of ICF wall bracing.*

- At this stage, make provisions for accessing the wall for pouring, preferably at an elevation no higher than your own rib-cage.
- Working at or above chest-height when pouring is dangerous, tiring, and time-consuming. Take the time to provide safe and convenient work platforms.

3.9.7.2 Installation of Rebar

If vertical reinforcing has not been placed and secured at the outset of the build, place pre-cut pieces of vertical rebar around the outside of the wall, within reach of crew members standing on inside scaffolding. *See Chapter 8, Section 8.2 for a detailed treatment of reinforcing in Quad-Lock walls.*

4 SPECIAL WALL ELEMENTS

4.1 COMMENTS ON SPECIAL WALL ELEMENTS

The previous chapter dealt only with the basics of a Quad-Lock ICF wall assembly. This chapter contains a more detailed treatment of the more complex wall elements that feature in many building designs, including angles, arches, and radii. These features add appeal and value to buildings, while Quad-Lock ICFs keep the cost of installation low and affordable.

The light weight, ease of cutting, and the design of Quad-Lock panels gives the installer a clear advantage over less advanced building methods, and indeed, other ICF systems.

- Keep in mind that the methods described below are a blend of ICF experience, common sense, and good old-fashioned journeyman carpenter techniques.
- In keeping with our guiding principles, we have endeavored to keep the same four common Quad-Lock components in use in combination with “off-the-shelf” materials, tools, and construction knowledge.

4.2 T-WALLS

Where two perpendicular walls meet, they form a T-Wall intersection. As with 90° corners, T-Walls should be constructed first. Walls of different concrete thicknesses can be joined at T-Wall intersections.

4.2.1 T-Wall Installation

Use full length panels to form the back of the T-wall.

- Avoid placing the panel joints in line with the T, where higher concrete pressures exist during concrete placement. Align the end of the panel/vertical joint with the outside edge of the intersecting wall.
- Place two panels for the intersecting wall so intersecting panels butt into the main wall.
- Place the smaller Inside Corner Bracket over the two resulting 90° corners.

Set the inside panels so as to butt into the intersecting wall, and maintain the normal layout with the outer panels, keeping their ends aligned. To secure the outside wall (see figures below), either install two Outside Corner Brackets so they span the concrete cavity, flip toward each other and overlap one on top of the other.

Place three Full Ties in the main and intersecting walls, filling the slots as close to the inside corners as possible.

Cut tie flanges and place between Full Ties at the center of the T into the overlapping Outside Corner Brackets, using one flange at least every 4" [10cm].

Place a Full Tie in the Corner Bracket at the top of the intersecting wall.

Second row panels should follow the normal 2 foot [61cm] offset with the middle of the panels falling on the joints of the panels below. Cut the last panel to allow for the T intersection. Start the second row of the intersecting wall with 2 foot [61cm] panels. Repeat the bracket the tie pattern from the first row. If you didn’t use the two Outside Corner Brackets across the cavity, brace the back side of the T with conventional bracing.

Note: ***Always pour concrete into the straight wall first and afterwards into the intersecting T-wall.***

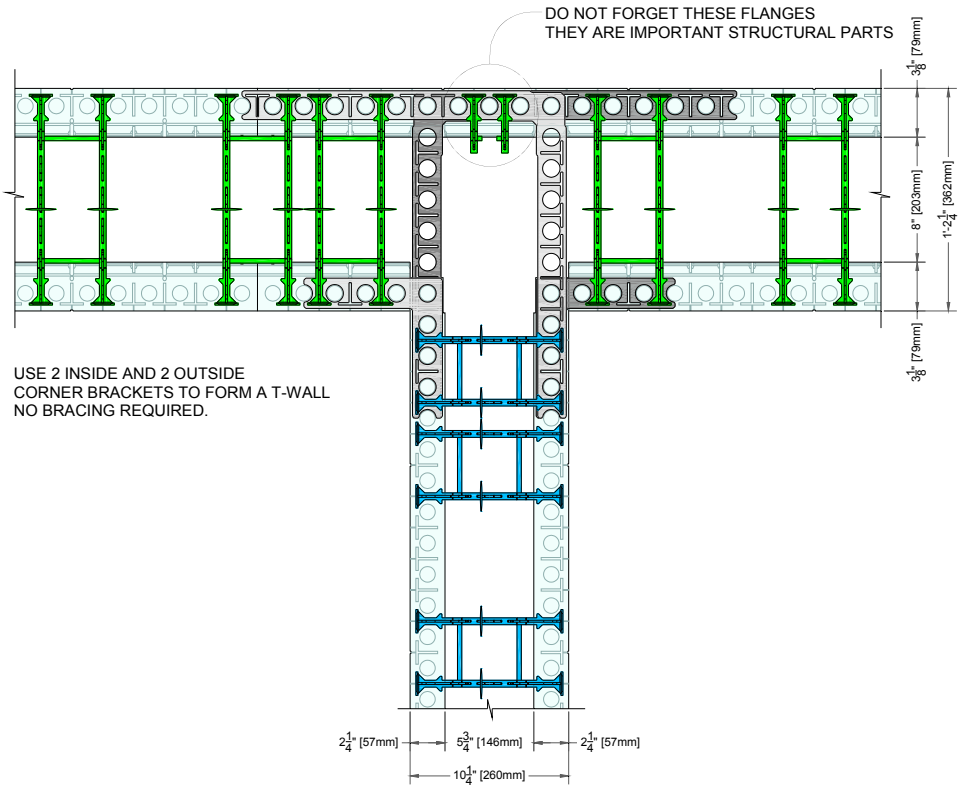


Figure 54: T-Wall Assembly w/ two Outside and two Inside Corner Brackets (plan view)

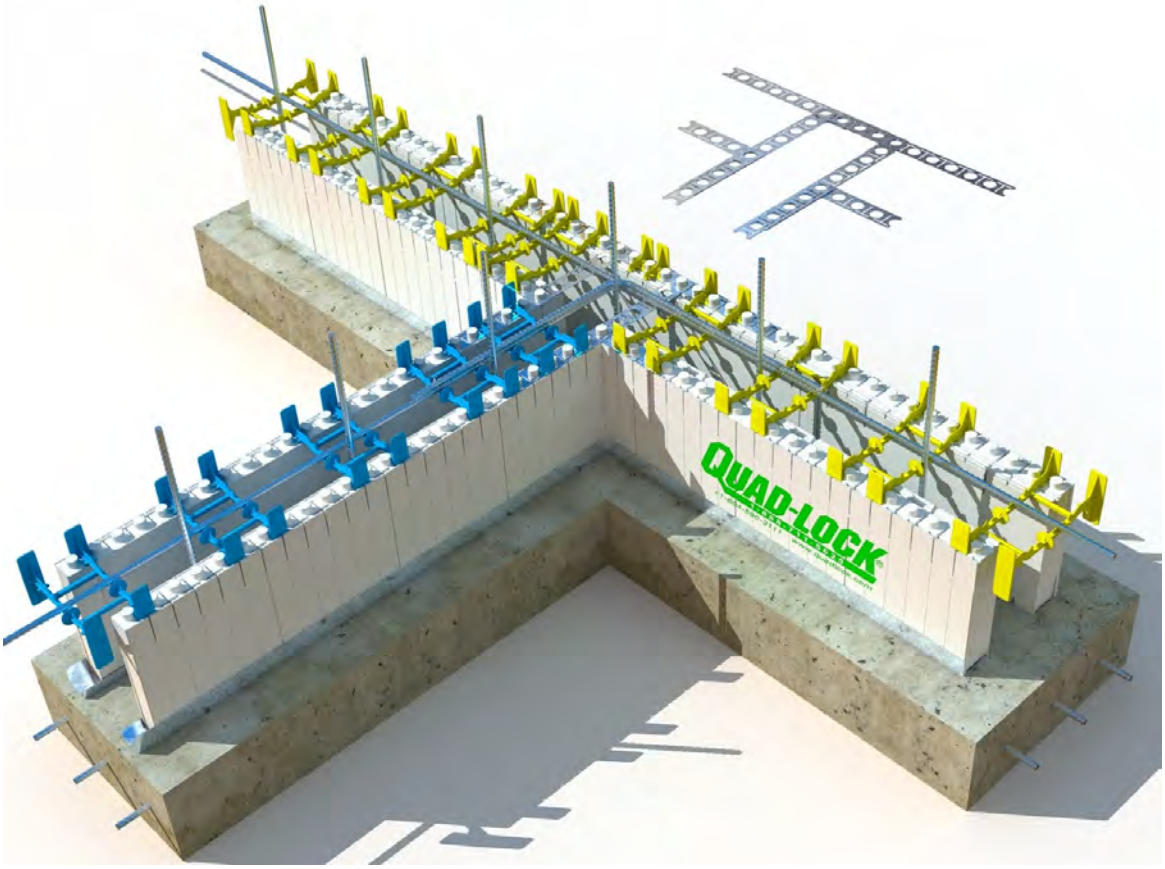


Figure 55: T-Wall Assembly with 2 Outside Corner Brackets and 2 Inside Corner Brackets (3D)

Building Tip:	**Position the panels that form the back of the T-Wall so a vertical seam will not align with the intersecting wall. Be sure to always brace the back side of any T-Wall intersection when not using the two outside corner brackets, as the ties are placed further apart at this location. Never direct the flow of the concrete during the pour into the backside of the T-Wall, i.e. pour the straight wall first then the intersecting wall.**

4.3 BULKHEADS

4.3.1 Forming Bulkheads

In some instances, a wall must terminate without a corner or angle. Quad-Lock recommends two methods for creating this wall termination, or "bulkhead":

- Rip dimension lumber to the exact wall cavity size and secure inside the cavity by driving wind-lock fasteners through the foam on each side and into the wood bulkhead material.
- Cut scrap panel pieces to the exact cavity size and insert them into the cavity at the end of the wall. Use overlapping Metal End Cap Brackets to lock the panels into place, then insert Full ties and tie flanges as shown in Figure 56 below.

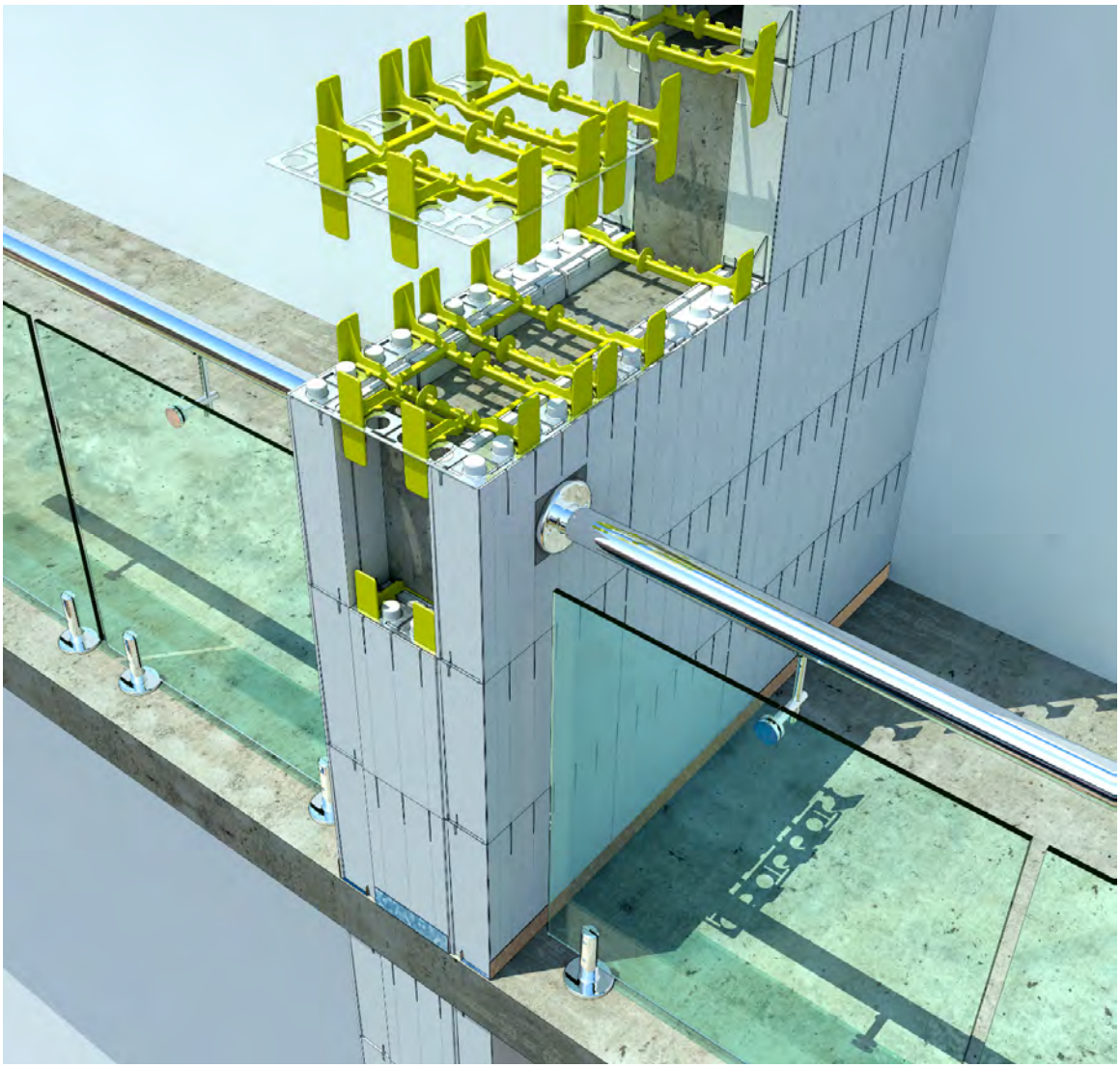


Figure 56: Bulkheads Formed with Quad-Lock End Cap Brackets

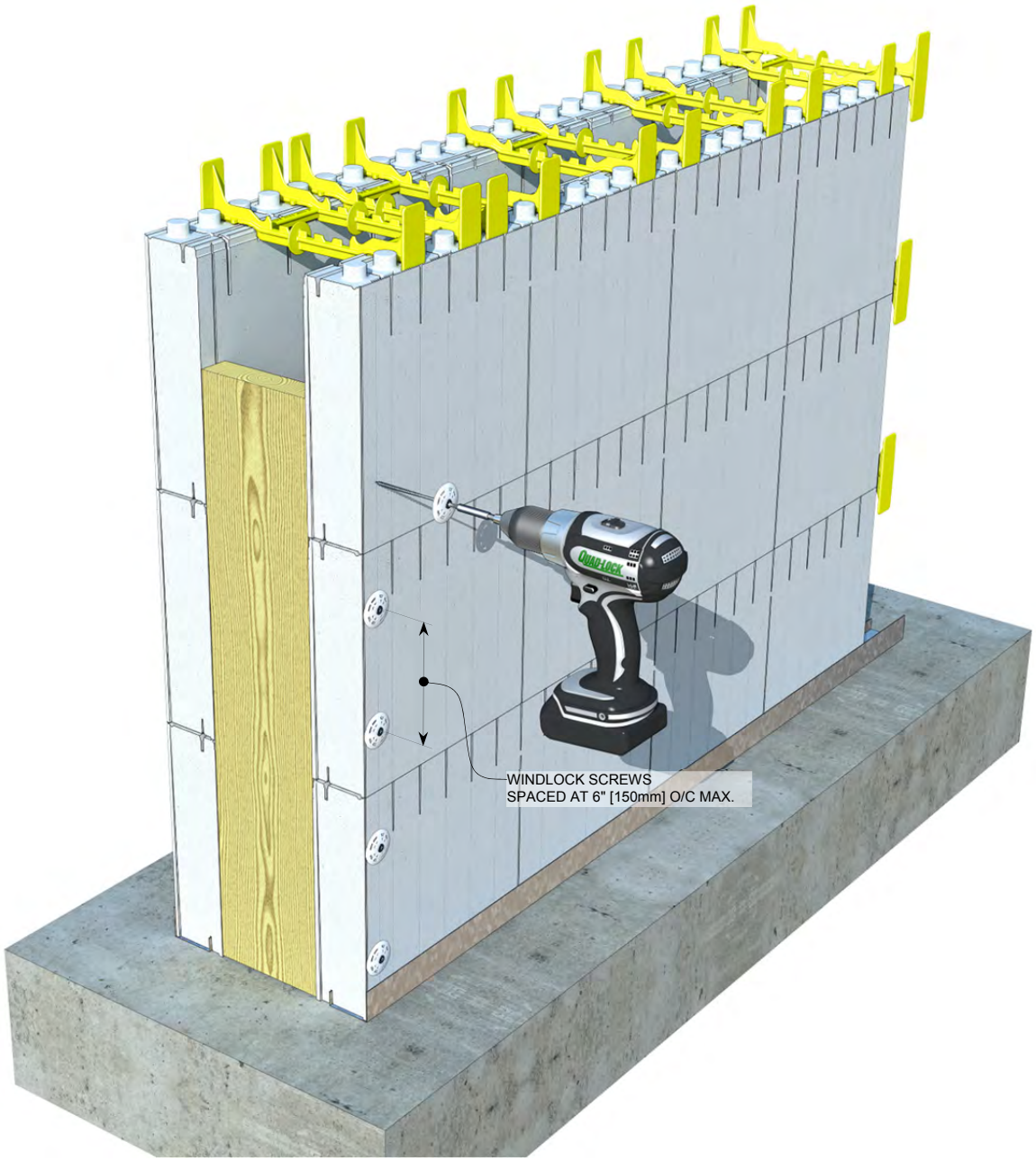


Figure 57: Bulkhead Formed with Lumber and Windlocks

Building Tips: **When using End Cap Brackets with Ultra Panels, cut foam cap pieces by starting layout in the middle of an interlock knob. This will insure compatible layout to the End Cap Brackets. When using Regular or Plus Panels, start layout midway between two interlock knobs.**

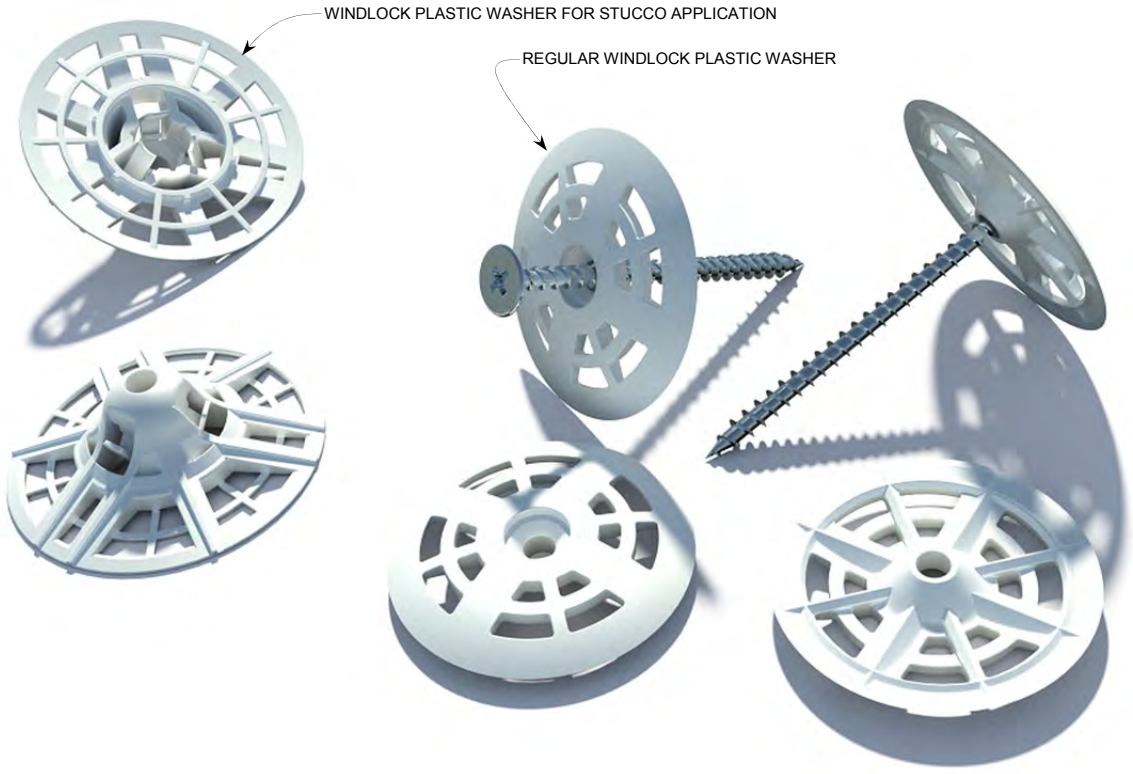


Figure 58: Wind-Lock (Plastic) Washers with Screws

4.4 ANGLES (OTHER THAN 90^{O})

In keeping with Quad-Lock's principle of maximum versatility with only four common components, customers are not limited to a pre-manufactured angle panel or tie. Instead, angles of almost any degree can be constructed with Quad-Lock articulating Angle Brackets and a bit of old-fashioned carpentry skill.

4.4.1 Building Non-90° Angles

The keys to constructing non-90° angles with Quad-Lock are:

- Use of the Quad-Lock articulating Angle Bracket.
- Panel ends mitered at the bi-section of the desired angle
- Miter cuts that pass through the center of any interlock knob in order to match the layout of the metal Angle Bracket.

Below are provided both the "journeyman" method of measuring, cutting and fitting the corner panels and a pre-calculated reference table showing cut-lengths for common angles.

Building Tip:	**Save time, materials, and cutting labor at bay windows by stacking butt-joints vertically between rows of panels instead of offsetting them by 24" per normal recommended procedure. Add an extra vertical brace at stacked joints to insure stability in the wall during pour.** **Yes, this breaks "the rules" as outlined earlier, but it is a proven time-saver in the field.**

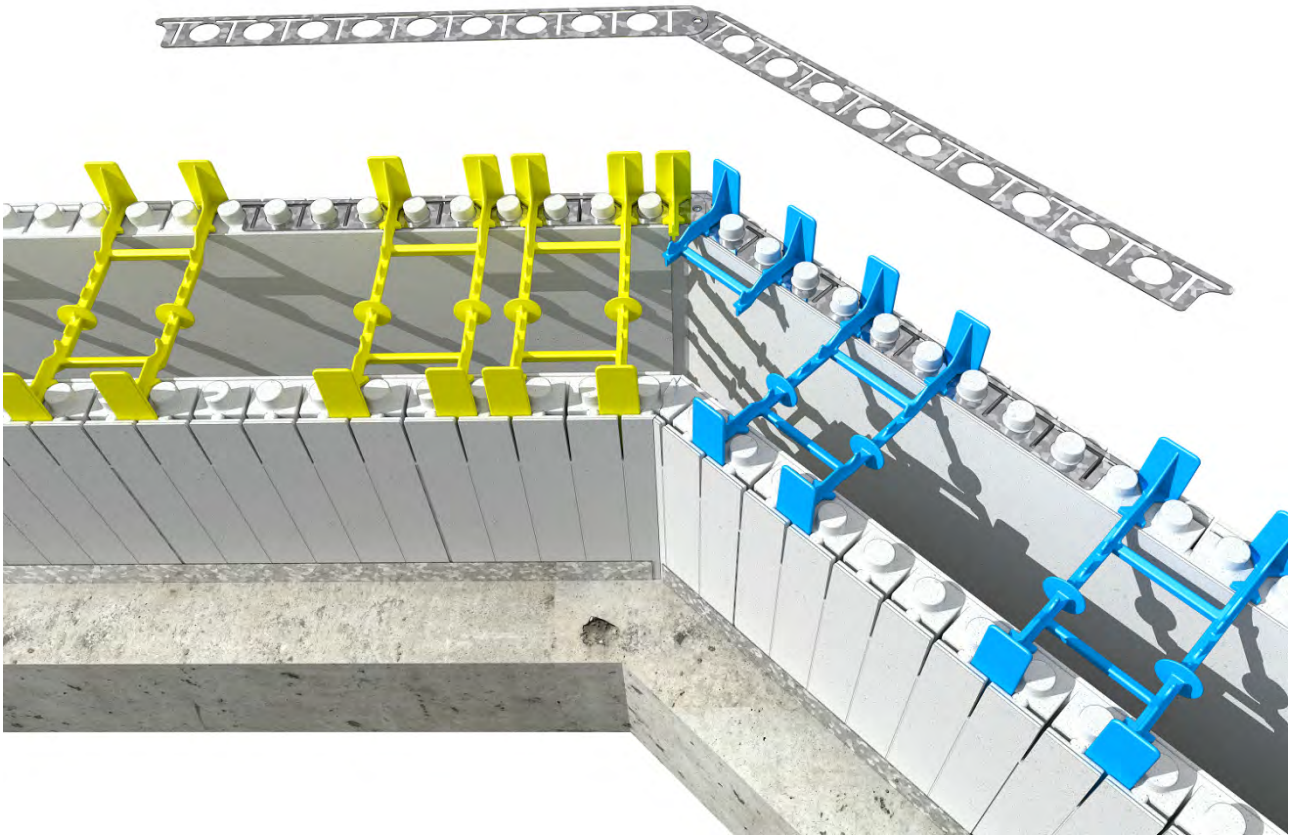


Figure 59: Assembly of Angles

4.4.1.1 Cutting Panels for Angles (Journeyman method)

4.4.1.1.1 Steps for cutting and assembling outside panels (Refer to Figure 60 below)

1. Determine the bi-section of the specified angle. *(Full specified angle divided by 2)*
2. Set your miter-saw at the bi-section angle and cut an opposing pair of outside panels, passing the cuts through the center of round interlock knobs.
3. Be sure that the panel ends away from the miter cut are on a factory 2 inch increment.
4. Place the outside panel pair in pre-positioned Metal Track at the intersection of the angle, matching the two halves of the angle cut.
5. Remove the center interlock knob formed by the two halves and open the articulating Angle Bracket to the desired angle.
6. Drop the bracket into place with the pivot point directly over the angle intersection. The interlock knobs of the two panels should match exactly the layout of the metal Angle Bracket

4.4.1.1.2 Steps for cutting and assembling inside panels (Refer to Figure 60 below)

1. Using a builder's square and from the factory ends of the outside panels, transfer the outside panel length across the wall to the inside face of the wall.
2. From that point, measure the distance back to the intersection of the angle (along the inside face of the wall).
3. You now have the "short-point" length of the mitered inside panel, *matching exactly the tie layout on the outside panels*.
4. Mark the 'short-point' dimension on two opposing panels and make the appropriate miter cut on each, using the same saw angle as on the outside panels.

Building Tip:	**A 12 inch sliding compound miter saw works best to easily and accurately cut the panels. First determine the bi-section of the angle (degree of wall angle divided by two), then set your sliding miter saw to the bi-section angle.**

4.4.1.2 Other Keys to Building Angled Corners

- As with radius walls, check plumb on each course installation. An out-of-plumb angle walls will not adjust if pushed in, because the panels have to get shorter to do so. Thus, it is important to monitor plumb during construction.
- Metal Angle Brackets need ONLY be placed on the outside row of panels. The inside panels are in compression and have ties right at the end, near the joint, and therefore require no Metal Angle Bracket. Be sure to place extra flanges in the outside panels at the joint, as shown below.
- If more assistance is required than the instructions above, the chart below explains how to cut the "inside" panels to build different angles:

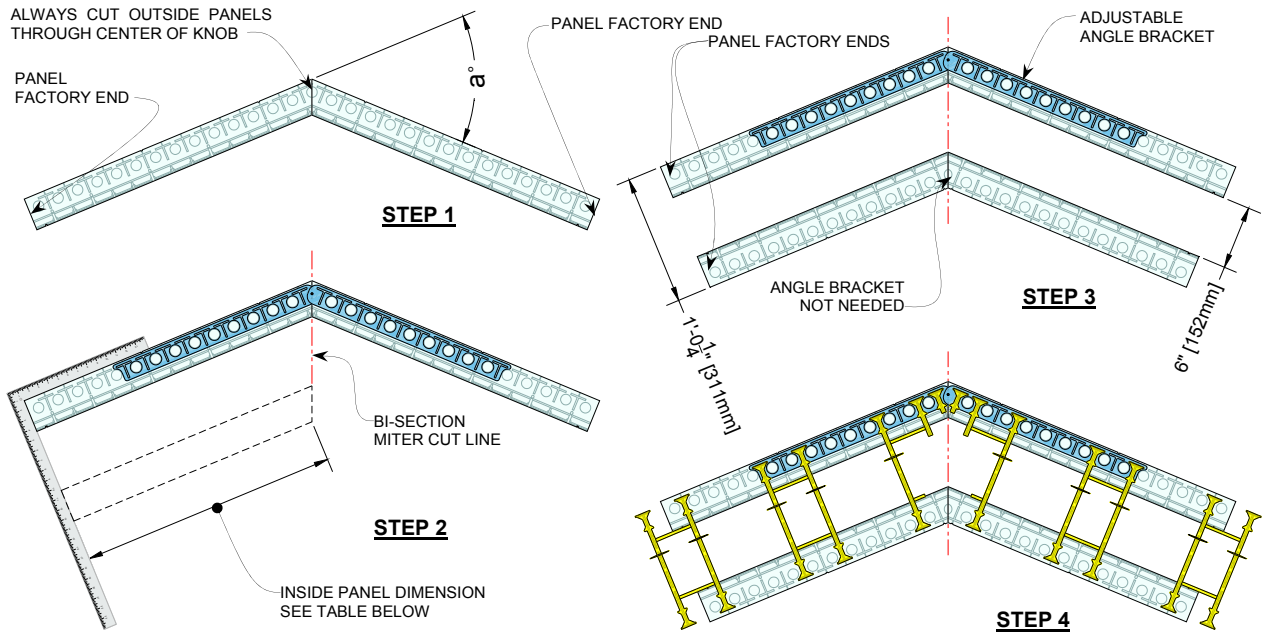


Figure 60: Angled Wall Cutting, Bracket & Tie Placement (Imperial)

Table 4.4.1 Cutting End Distance C

	Cutting End Distance C					
Angle α°	**4" Black Ties**	**6" Blue Ties**	**8" Yellow Ties**	**10" Green Ties**	**12" Red Ties**	**14" Brown Ties**
7.5°	1-7/16" 37mm	1-5/8" 41mm	1-3/4" 44mm	1-7/8" 47mm	2" 51mm	2-1/8" 54mm
15°	1-15/16" 49mm	2-3/16" 56mm	2-7/16" 63mm	2-3/4" 69mm	3" 76mm	3-1/4" 83mm
22.5°	2-7/16" 61mm	2-13/16" 72mm	3-3/16" 82mm	3-5/8" 92mm	4" 102mm	4-7/16" 112mm
30°	2-15/16" 74mm	3-7/16" 88mm	4" 101mm	4-1/2" 115mm	5-1/16" 128mm	5-9/16" 142mm
37.5°	3-7/16" 87mm	4-1/8" 104mm	4-3/4" 121mm	42497 139mm	6-1/8" 156mm	6-13/16" 173mm
45°	3-15/16" 100mm	4-3/4" 121mm	5-5/8" 142mm	6-7/16" 163mm	7-1/4" 185mm	8-1/16" 206mm
52.5°	4-1/2" 115mm	5-1/2" 140mm	6-1/2" 165mm	7-1/2" 190mm	8-7/16" 215mm	9-7/16" 240mm
60°	5-1/8" 130mm	6-1/4" 159mm	7-7/16" 189mm	8-9/16" 218mm	9-3/4" 247mm	10-7/8" 277mm
67.5°	5-3/4" 146mm	7-1/8" 180mm	42589 214mm	9-3/4" 248mm	11-1/8" 282mm	12-7/16" 316mm
75°	6-7/16" 164mm	8" 203mm	9-9/16" 242mm	11-1/16" 281mm	12-5/8" 320mm	14-1/8" 359mm
82.5°	7 4/16 184mm	9 229mm	10 12/16 273mm	12 8/16 318mm	14 4/16 362mm	16 407mm
90°	CBO & CBI	CBO & CBI	CBO & CBI	CBO & CBI	CBO & CBI	CBO & CBI
97.5°	9-1/8" 232mm	11-3/8" 290mm	13-11/16" 348mm	15-15/16" 406mm	18-1/4" 463mm	20-1/2" 521mm
105°	10-5/16" 261mm	12-7/8" 327mm	15-1/2" 394mm	18-1/8" 460mm	20-11/16" 526mm	23-5/16" 592mm
112.5°	11-11/16" 296mm	14-11/16" 372mm	17-5/8" 448mm	20-5/8" 524mm	23-5/8" 600mm	26-5/8" 676mm
120°	13-5/16 339mm	16-13/16" 427mm	20-1/4" 515mm	23-3/4" 603mm	27-3/16" 691mm	30-11/16" 779mm
127.5°	15-7/16" 392mm	19-1/2" 495mm	23-9/16" 598mm	27-5/8" 701mm	31-11/16" 804mm	35-3/4" 907mm
135°	18-3/16" 462mm	23" 585mm	27-7/8" 708mm	32-11/16" 830mm	37-1/2" 953mm	42-5/16" 1076mm

How to read the table for our example: You want to mark the Cut- line "A" on the exposed surface (with grooves) of the panel next to the inside seam of a 45° angle:

1. Look up column A of the "Nominal Concrete" 10" field
2. Go down to 45° row and find 6⅜"

4.5 RADIUS WALLS

The independent panel and tie design of the Quad-Lock ICF system makes it the clear choice for radius walls.

- Radii as small as 2' [60cm] can be built by making saw cuts on the compressive side of the panels.
- A sliding compound-miter saw with cut depth control is most effective.
- A Flex Track is used at the bottom of the first course of panels.
- Low-expansion polyurethane foam adhesive (e.g. Enerfoam) can be sprayed in each horizontal panel seam to make the radius rigid and to reduce bracing requirements.
- Brace the radius more frequently than straight walls (see Chapter 6, Section 6.2.4 “Bracing Radius Walls” on Page 136). **It is highly recommended that you read the section on bracing radius walls BEFORE you begin placing panels and ties.**

4.5.1 Configuring Panels for Radius Walls

Use the following suggestions to fashion panels for radius walls:

- Make sure to cut the compressive sides of the panels and that the cuts are centered over the interlock knobs between the groves; NOT over the 2" [5cm] groves in the panels.
- For tight radii, always make a cut at both ends of the panels over the first knob (between the panel’s end and the first groove).
- Use a rasp to bevel panel ends where they butt to other panels. Remove enough foam to create a normal-width joint line between panels.

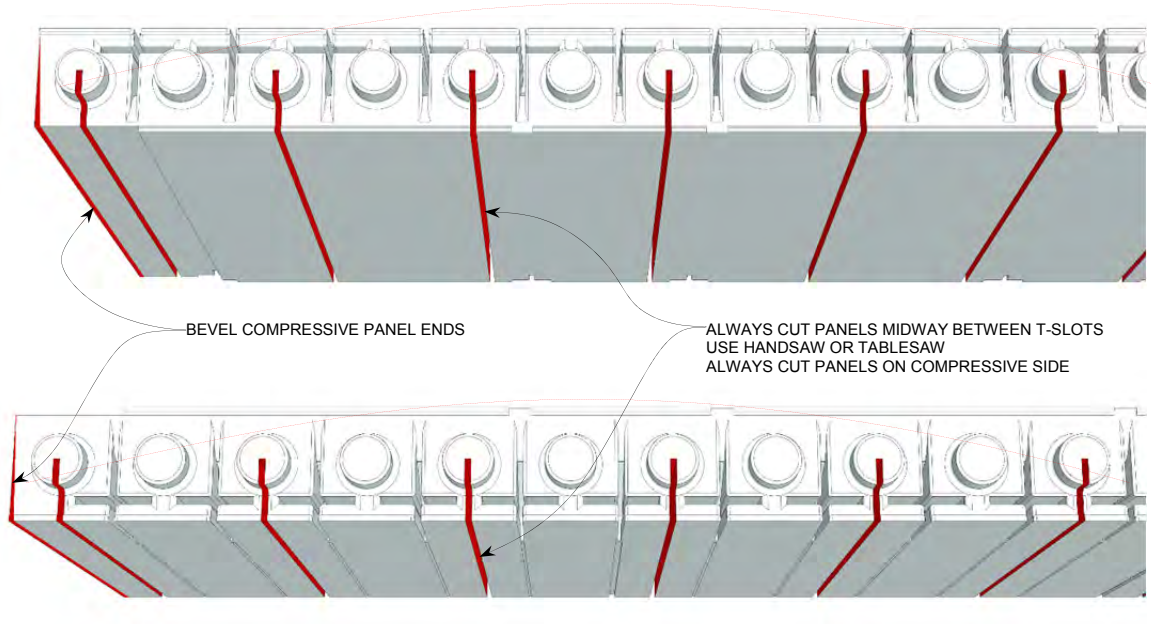


Figure 61: Radius Wall – Panels Cuts

4.5.1.1 Cut Locations & Spacing

Cuts should be placed 4" [102mm] to 12" [305mm] apart for most radii.

- The smaller the radius, the more cuts need to be made. The larger the radius, the fewer cuts need to be made. When the radius is over 30 feet [10m], no cuts are needed, and the Panels will bend sufficiently in stock condition.

4.5.1.2 Cut Depths

- 1⅛" to 1¼" [29-32mm] is the suggested cut-depth for Regular Panels
- 1 7/8” to 2” [48mm-51mm] deep is the suggested cut-depth for Ultra Panels
- 3⅛" to 3¼" [79-83mm] is the suggested cut-depth for Plus Panels.

***Note**: All three of the above will leave approximately 1⅛" to 1¼" [29-32mm] of panel thickness intact. Double check your first cuts to insure that this is the case before scoring additional panels.*

The key is the width of each cut, and how much material is being removed to facilitate the bend on the inside face of the radius.

Wider cuts will allow the panel to bend more. In some cases, a double saw blade can be used. This is particularly important when making radius walls with the Ultra and Plus Panels, which may require quite wide cuts in order to bend. (On the order of ¼" [6mm] to ⅜" [9mm])

It is also recommended to slightly bevel the ends of each panel at butt-joints between panels. Use a rasp, saw, or knife to remove a small amount of material. This will improve the fit of panels in the radius wall.

***Note*:** As the panels are stacked, check plumb at each course. The panels will naturally want to lean "out". As with angled walls, an out-of-plumb radius wall cannot easily be pushed "in", as the panels need to compress to do so. Only glue seams after you are certain of the panel length. Seat the panel on the bottom ties, leaving a 1" [25mm] gap; apply low-expansion polyurethane spray foam and press the panel down. This will prevent the wall to "grow" while building up. It will also make bracing redundant in radius walls up to 4' [120cm] high.

4.5.2 Ties for Radius Walls

The ties in radius walls will not always line up in a uniform fashion (like straight walls) because of the different length of the inside and outside rows of panels.

- Ties can be bent slightly or split apart to make them fit. Because of this the resulting cavity may appear to be a little smaller than specified, however, the pressure of the concrete during concrete placement will push it back out into place.

4.5.2.1 Ties for Wide Radius Walls

Full ties can be used for radii of 7½' [2.25m] and above.

- Ensure that a space no more than 4 interlock knobs (8" [20cm]) exists between full ties and that all vertical (butt) joints between panels have a tie on each side, as close to the joint as possible.

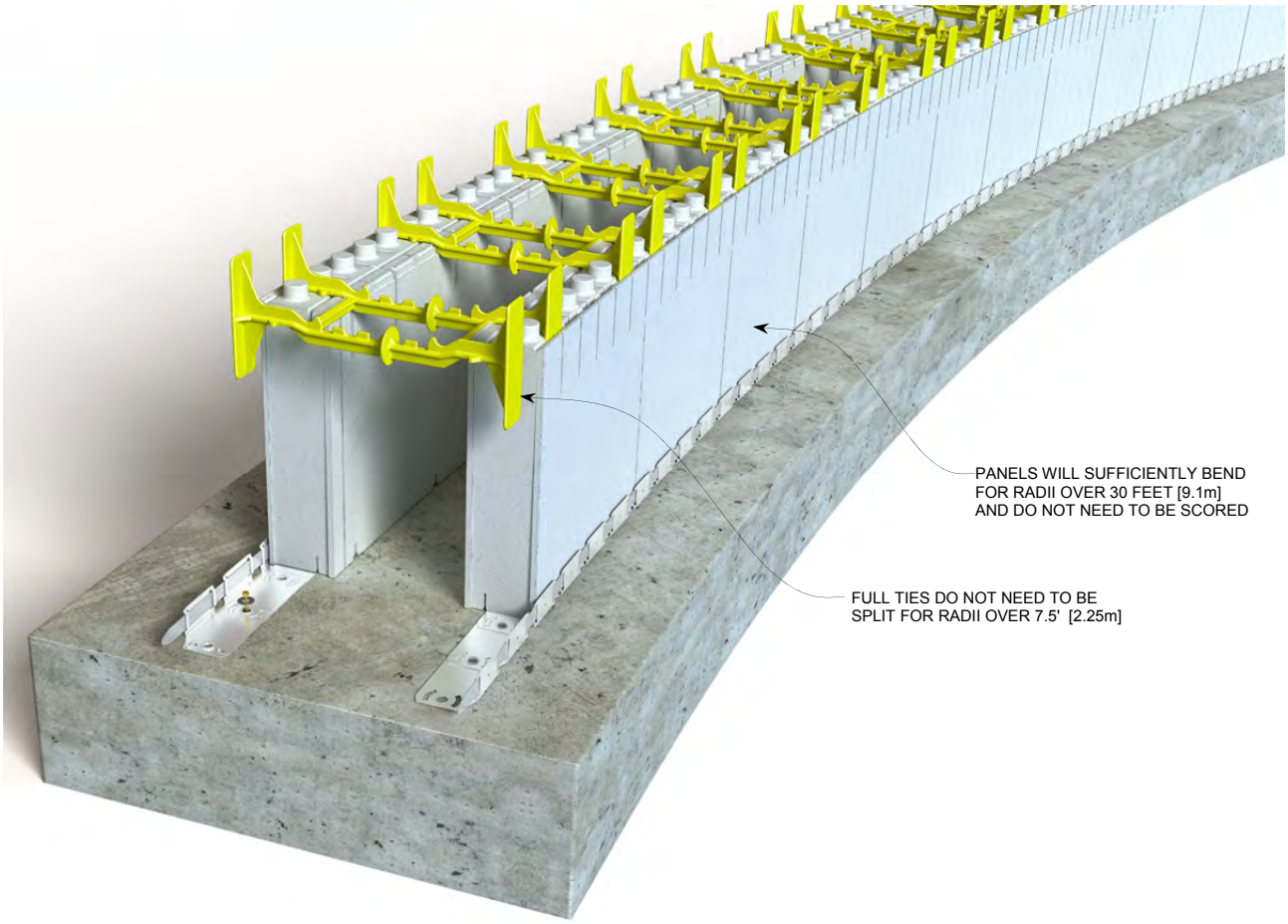


Figure 62: Radius Wall (wide radius)

4.5.2.2 Ties for Tight Radius

Split ties need to be used instead of Full Ties for radii of 7½' [225cm] or less ("tight radius").

- Ensure that no more than 3 knobs or 6" [15cm] are between split ties (counted on the outside row) and that all vertical joints between panels have a split tie on each side, as close to the joint as possible.

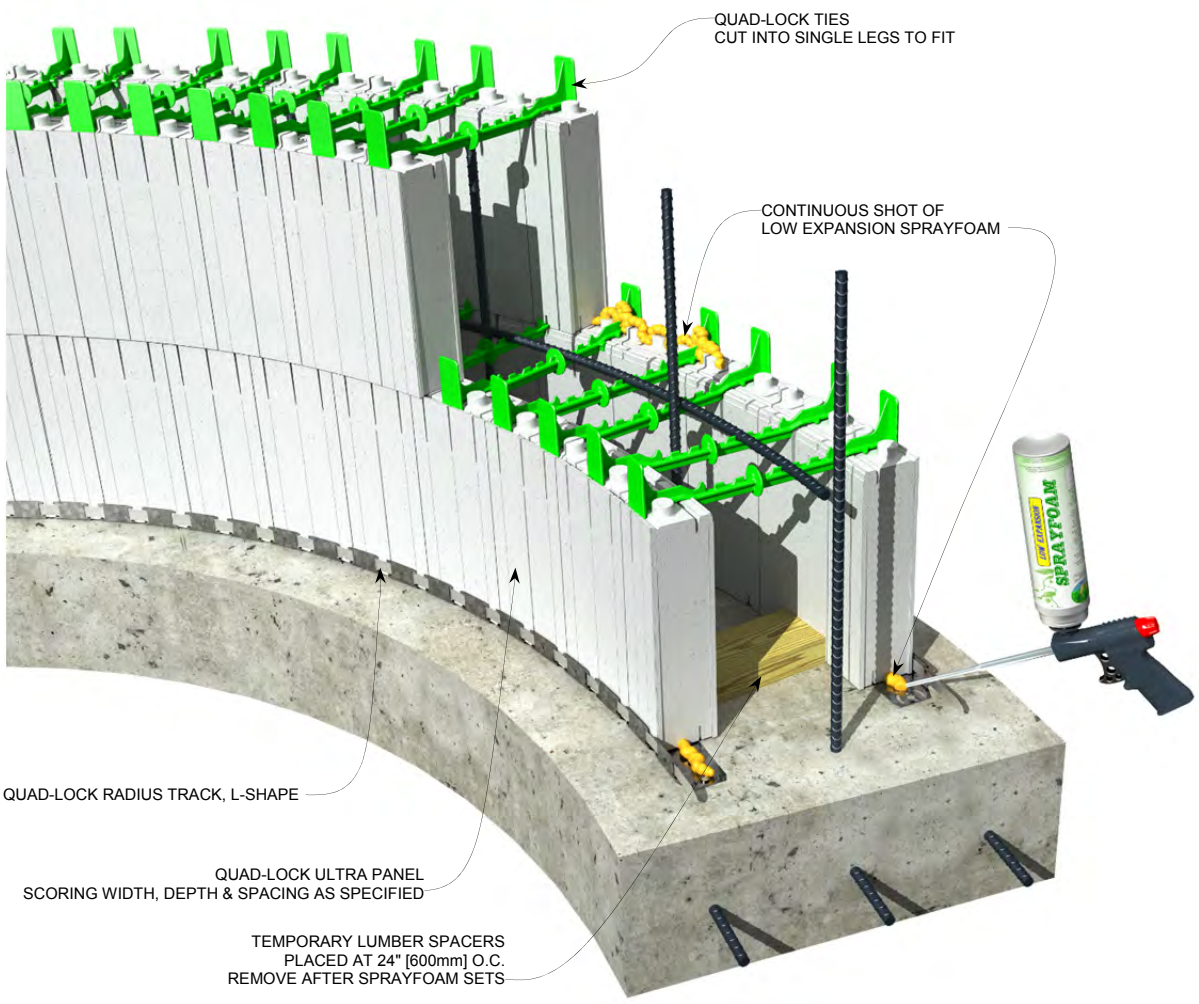


Figure 63: Radius Wall (tight radius)

4.5.3 Joining Straight Walls to Radius Walls

Where a straight wall joins a radius wall, use metal Angle Brackets to span the transition between the straight wall and the radius wall.

- It may be necessary to trim the end of the bracket on the radius portion as the radius moves away from the line of the bracket. Just catch as many slots as possible with tie flanges on the radius side of the transition.

4.5.4 Bracing Radius Walls

Brace radius walls with vertical braces and diagonal adjusters similar to straight walls, but usually installed on the outside of the radius to counteract the natural tendency of the radius wall to lean outward. *See Chapter 6, Section 6.3 "Accessing Walls for Pouring" on Page 139*

4.6 WIDE WALLS

Quad-Lock is un-matched in its ability to create walls and special elements of varying cavity sizes over a wide range of insulation values. Either of those variables may call for an increased tie-length.

- Depending on the insulation value selected, concrete cavity widths of 4" [102mm], 6" [152mm], 8" [203mm], 10" [254mm], 12" [305mm], and 14"[355mm] can be constructed using a single Full Tie.

- For projects requiring a wall thickness larger than these standard widths, Full Ties may be combined with XT-Extender Ties.
- Special building elements that need even wider sizes can be constructed by attaching a second XT-Extender Tie to the other end of the Full Tie.

4.6.1 Quad-Lock Extender Tie

Quad-Lock Extender Tie allows builders to create walls of almost any desired concrete thickness.

- Extender Ties are designed to interlock with regular Full Ties to add exactly 12" (305mm) of concrete cavity size.
- They are differentiated by their orange color, and the interlock system on one pair of flanges.

4.6.1.1 Assembling Extender Ties

To assemble Quad-Lock Extender Ties and Full Ties, follow these steps:

- Slide the flanges of a Full Tie into the receiving flanges of an XT-Extender Tie, and tap into place with a hammer, or tap the assembly against a hard surface.
- The Full Tie flanges will “click” into place and cannot be forced out of position by falling concrete during placement. Be sure to seat the Full Tie flanges completely into the XT-Extender tie receiving flanges.

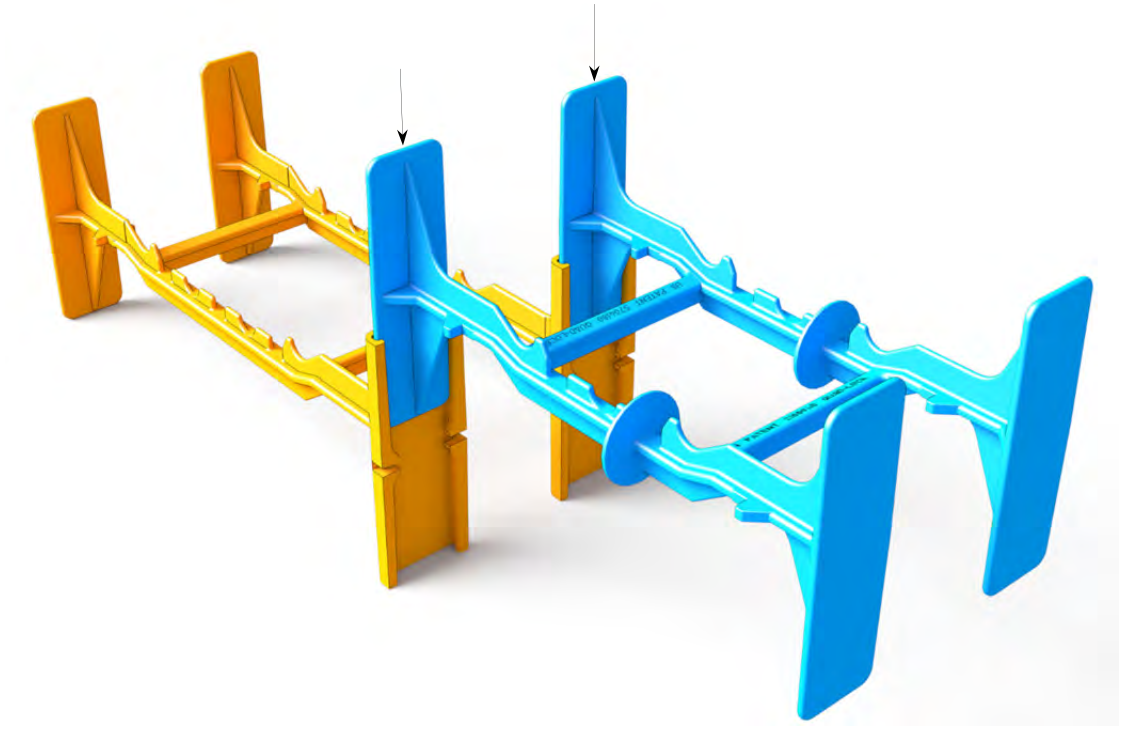


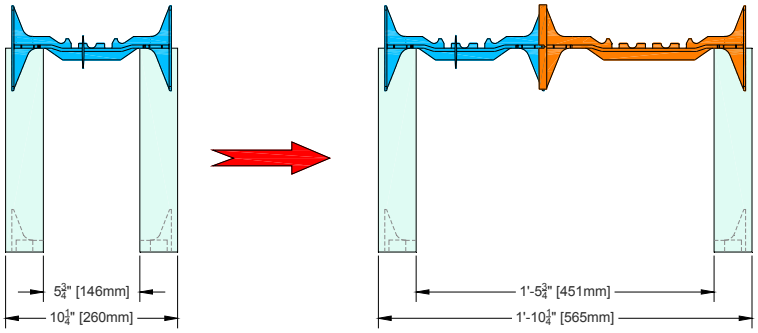
Figure 64: Assembling Extender Ties)

4.6.1.2 Placing Assembled Extender Ties

Once assembled, use the combination ties to form walls with cavities sized according to the chart above.

- Place at the normal recommended 12" (305mm) horizontal and vertical spacing.
- Secure horizontal rebar to vertical rebar with plastic zip ties to keep added weight off longer ties, which may cause deflection.
- Wider wall cavities may generate higher formwork pressure when poured with concrete. Pay close attention to mix design and minimize the amount of water in the mix. *See Chapter 8 “Concrete and Rebar” on Page 161*

R-22
[U-0.28]



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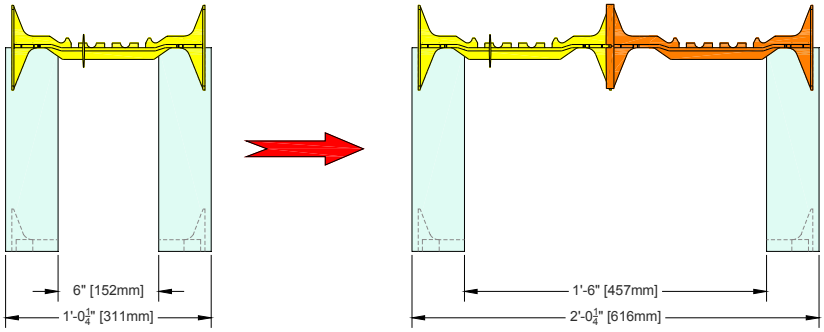

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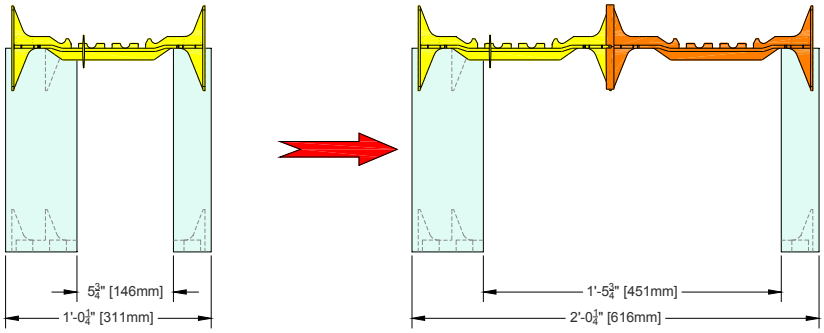

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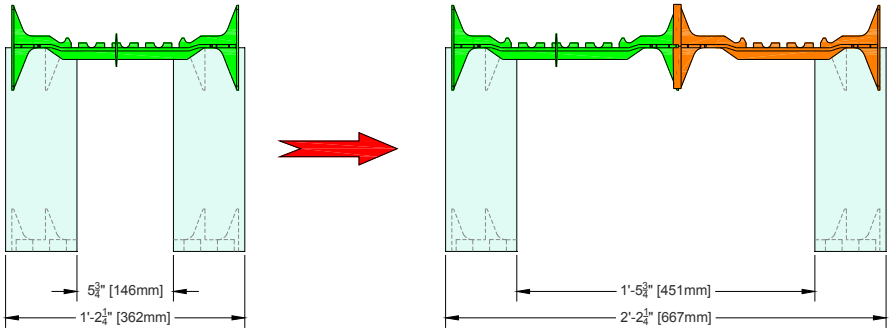


4.6.2 Wide Wall Corners

As both cavity size and foam thickness increases, the full ties supporting corners move further away from the intersection of the outside panels, placing more stress on the corner bracket assembly. This means that additional support must be added to the corners and the corner bracket assembly as the cavity size and/or the foam thickness increases.

- There are three measures that can be taken to supplement the standard corner bracket assembly:

1. *Extend the corner brackets* - The standard Quad-Lock Outside Corner Bracket can be extended by overlapping either a Straight Bracket, or ½ of an Outside corner bracket that has been cut at the 90 degree angle. When overlapping brackets, Quad-Lock suggests that three T-slots be overlapped, and that at least two cut flanges be inserted at the overlap.
2. *Add more tie flanges* - Adding more cut tie flanges has been shown to increase the strength of the corner assembly, when used in conjunction with extension of the metal corner brackets.
3. *Addition of external bracing* - In some cases, it may be prudent to support the outside corner with lumber or metal braces, or by securing plywood panels to the wall and each other in an 'L' fashion. If securing plywood panels or strapping directly to the wall forms, be sure to fasten far enough away from the corner so as to reach the first two full ties in the wall.

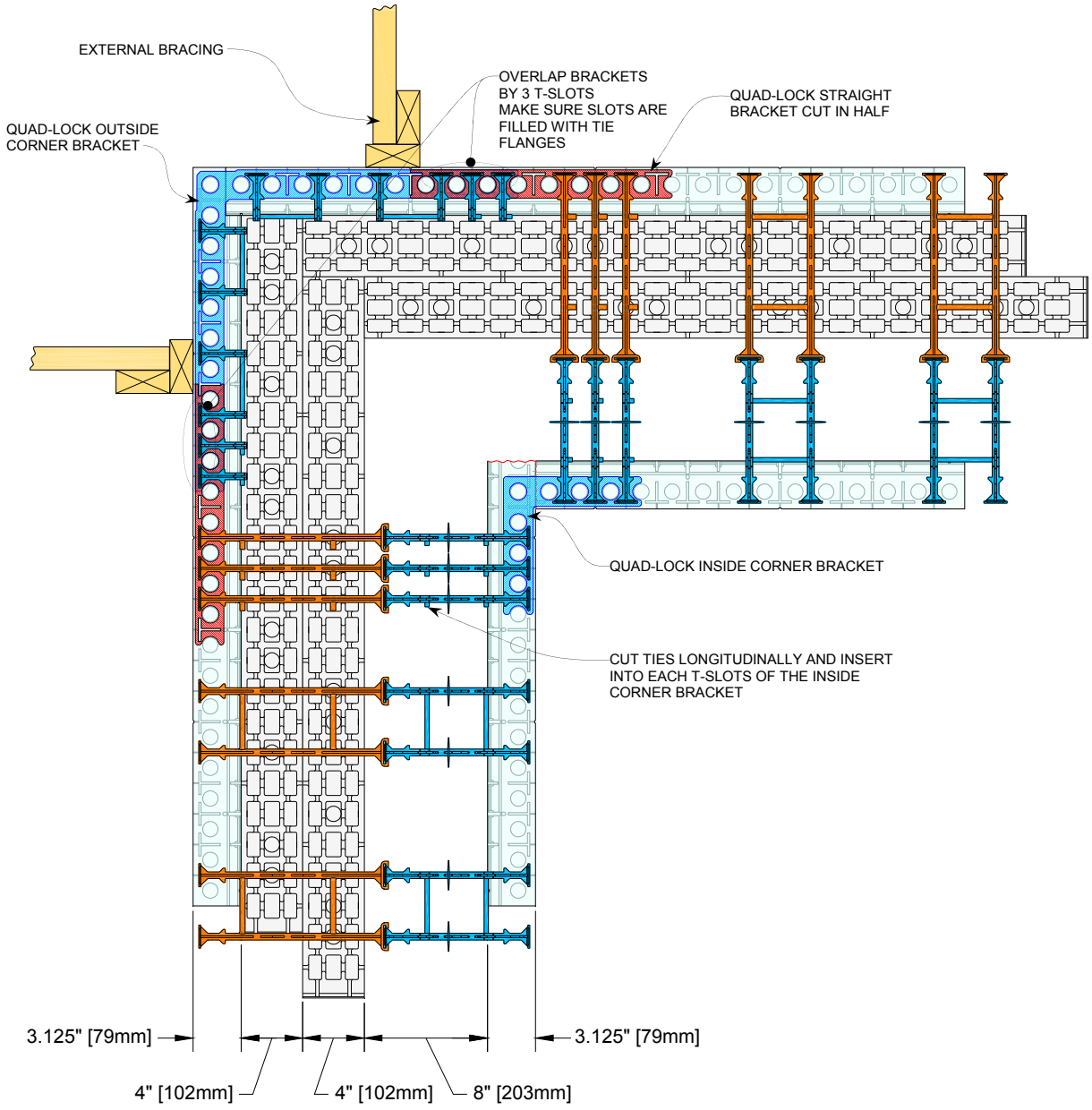


Figure 65: Extender Tie Assembly for Corners

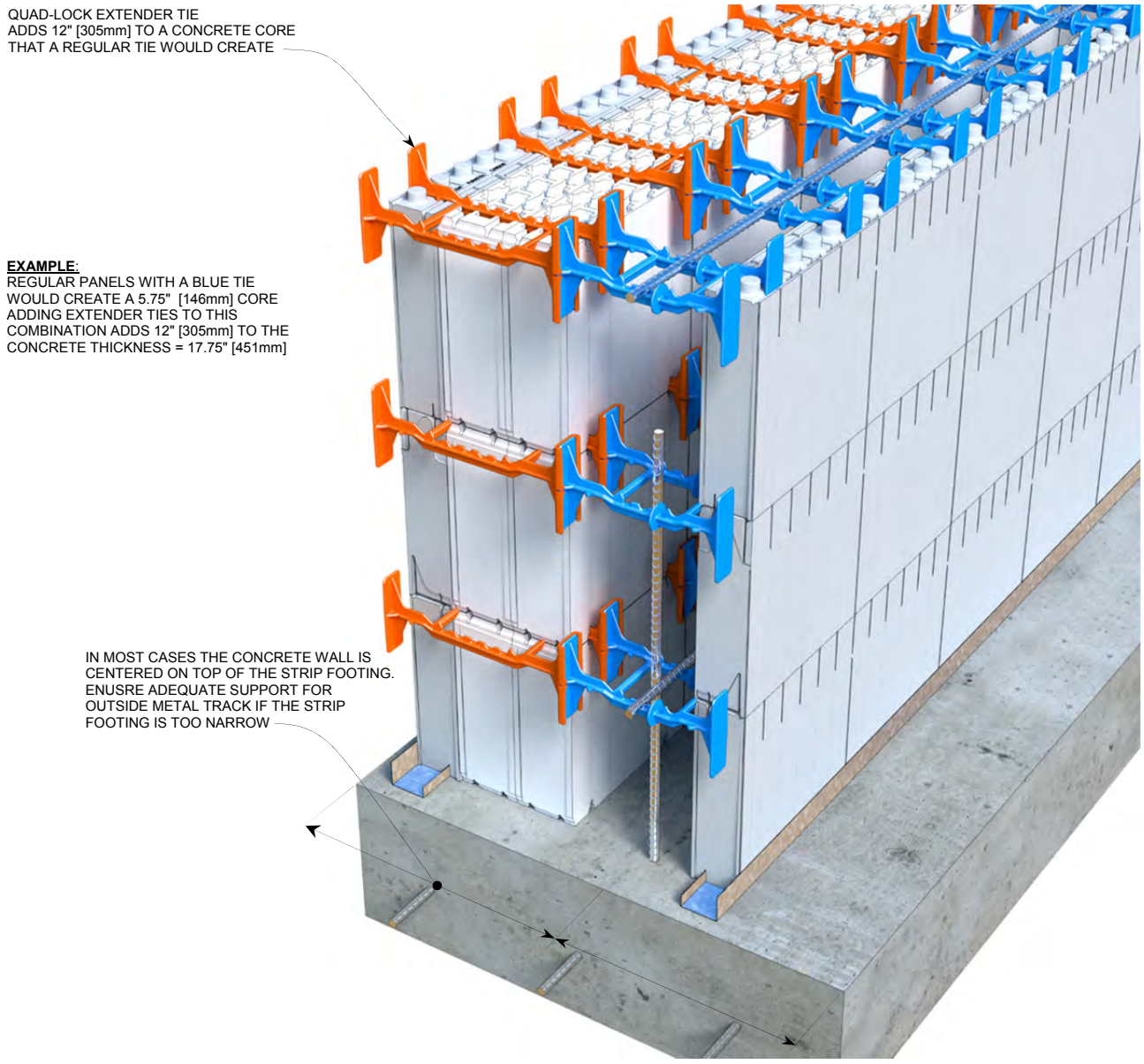


Figure 66: Extender Tie Assembly (20" [508mm] cavity shown)

Building Tip:	**Assemble fewer XT-Extender Ties + Full Ties than you think you will need for the job. Toward the end of the installation, make up the balance of the ties when you have an accurate count of what is required. Any extra assembled ties will be difficult to disassemble.**

4.7 PILASTERS AND SQUARE COLUMNS

If the building design calls for the support of heavy beams, posts, or other elements, a pilaster or column may be required at specified points along the wall line. While installers may choose to form these elements conventionally with ply forms, they also have the option of using Quad-Lock ICF components because:

- Ties can be threaded through reinforcing bar cages that are commonly used in these instances.
- Overlapping metal corner brackets insure a rigid corner construction.

Both methods of forming pilasters & columns are shown below.

4.7.1 Building Pilasters with Quad-Lock Components

4.7.1.1 Cutting Panels for Pilasters

Use the following suggested steps to cut panels for pilasters:

1. From the building plans, determine the center line of the pilaster.
2. Determine whether the pilaster must be centered on the wall-line or offset, and cut one or both sides accordingly.
3. From centerline, cut back the panels ½ of the total pilaster width + (panel width) in either direction along the wall line. This will result in a cut out that is larger than the pilaster, and will allow the intersecting panels to lap inside the main wall line.
4. To insure that metal brackets fit properly, adjust the pilaster width up to the nearest factory 2” [51mm] increment on either side.
5. Cut one panel to size equaling the called-out pilaster width and rounding up to the nearest even 2" [51mm] increment. This will serve as the end panel that is parallel to the wall line.
6. Cut two side panels by adding 4" [102mm] to the called out pilaster depth, rounding up to the nearest 2" [51mm] increment. These will be the sides of the pilaster, and must run inside the main wall line, and lap past the parallel end panel. (See diagram below.) *It is important to lap these panels inside the main wall line to place them in compression against the main wall to better resist concrete pressure*.

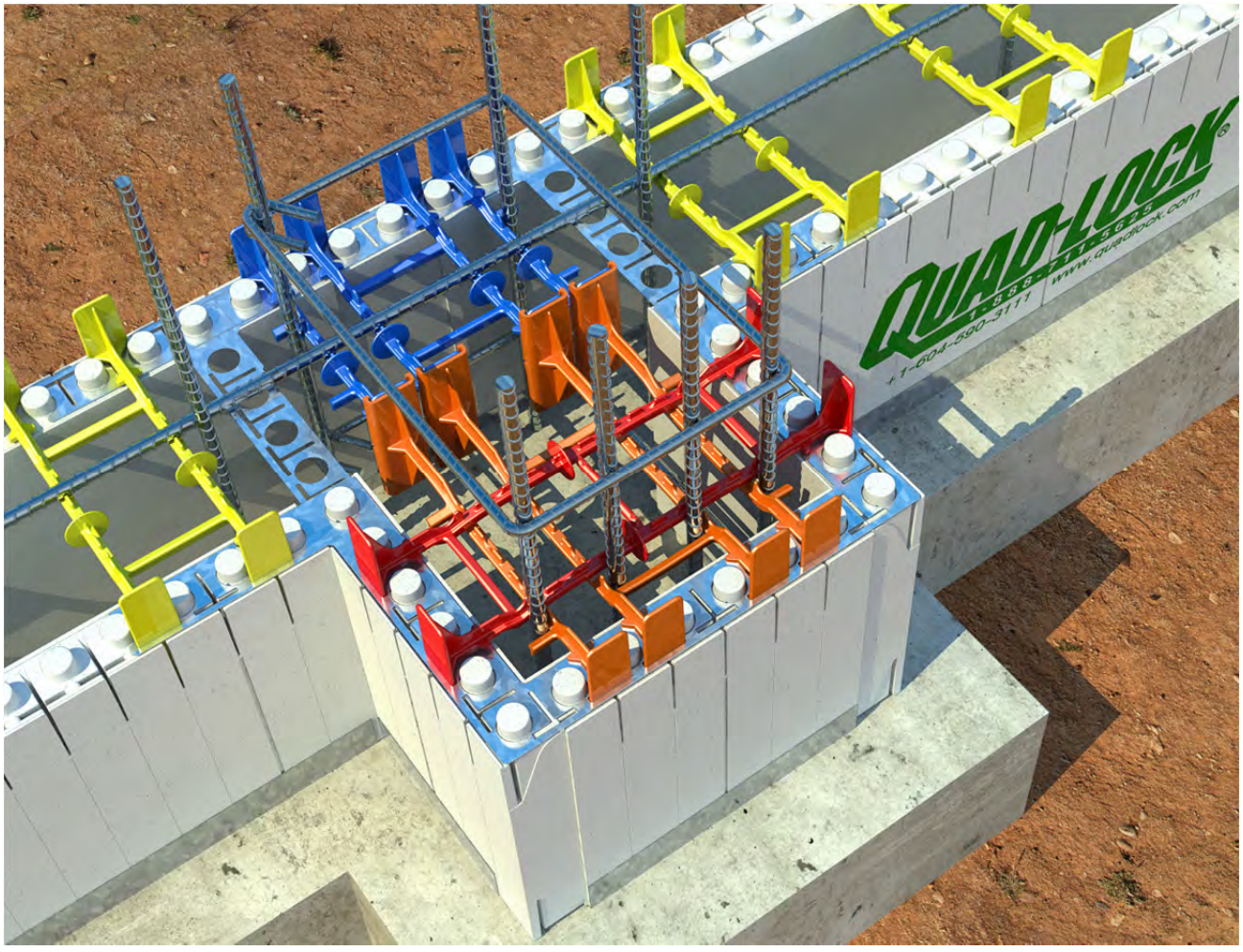


Figure 67: Pilaster Built with Quad-Lock Components

4.7.1.2 Placing Metal Corner Brackets for Pilasters

Use the following suggested steps to place Metal Corner Brackets for pilasters:

1. Place Inside Corner Brackets at the two inside corners.
2. Place two Outside Corner Brackets on the outside corners of the pilaster, over-lapping in the middles.
3. Place two more Outside Corner Brackets in the opposite direction, similar to T-wall construction and lap toward each other. This will secure the outside panel and reduce the need for bracing. (See T-wall diagram in the previous section).

4.7.1.3 Placing Ties for Pilasters

In general terms, it is best to cut ties apart into split ties for this application. This will allow ties to easily fit around rebar cages.

- Ties will span the width of the column only, and the depth (transverse to the main wall) of the pilaster will be secured by metal brackets and cut flanges.
- Two "cross ties" (see Figure 67) should be placed over the top of transverse ties to support the sides of the pilaster.
- Place cut flanges in slots not used by full-width ties to secure the metal brackets together, in at least every other slot. This will provide the rigidity necessary to resist concrete pressure.

4.7.1.4 Larger Pilasters

If the pilaster is wider than a single Full Tie length, connect a standard sized Full Tie to a 12" [305mm] XT-Extender Tie to equal the width of the pilaster, to the nearest 2" [51mm] increment.

4.7.1.5 Bracing Pilasters

While ties and metal brackets will contain concrete within the pilaster, the whole assembly must be braced and held in position.

- Secure vertical bracing to the outside of the pilaster to insure that it remains in plumb and doesn't shift during the pour. *See Chapter 6, Section on Accessing Walls for Pouring on Page 139.*

4.7.1.6 Pouring Pilasters

As with T-walls, pour concrete into the main wall next to the pilaster, and let concrete flow into the pilaster.

- Properly flowing (slumped) concrete is critical for elements like pilasters that contain more steel reinforcing.
- Begin consolidation by vibrating the steel cage. If (and as) necessary, carefully insert the vibrator down into the pilaster until concrete is properly consolidated.
- Re-tempering (adjustment) to concrete slump may be necessary to minimize the need for mechanical vibration. *See Chapter 8 "Concrete and Reinforcing", Section 8.1.2 "Pumping and Other Concrete Placement Suggestions" on Page 162.*

4.7.2 Building Pilasters with Conventional Plywood Forms

4.7.2.1 Cutting Quad-Lock panels for ply-formed pilaster

Use the following suggested steps to cut Quad-Lock ICF panels for integration with plywood forms:

1. From the building plans, determine the center line of the pilaster.
2. Determine whether the pilaster must be centered on the wall-line or offset, and cut one or both sides of the ICF panels accordingly.
3. From centerline, cut back the ICF panels ½ of the total pilaster width in either direction along the wall line. This should be the called-out width of the pilaster.
4. Plywood forms are now secured to the ICF wall by screwing the panels or bracing members attached to panels directly to the tie flanges in the Quad-Lock wall. (See Options A, B, &C below)
5. Add cross-ties made from 3/8" [10 mm] minimum dia. threaded rod by drilling holes in ply forms and lumber supports at maximum 2 ft. [60 cm] vertical intervals, depending on ply thickness.

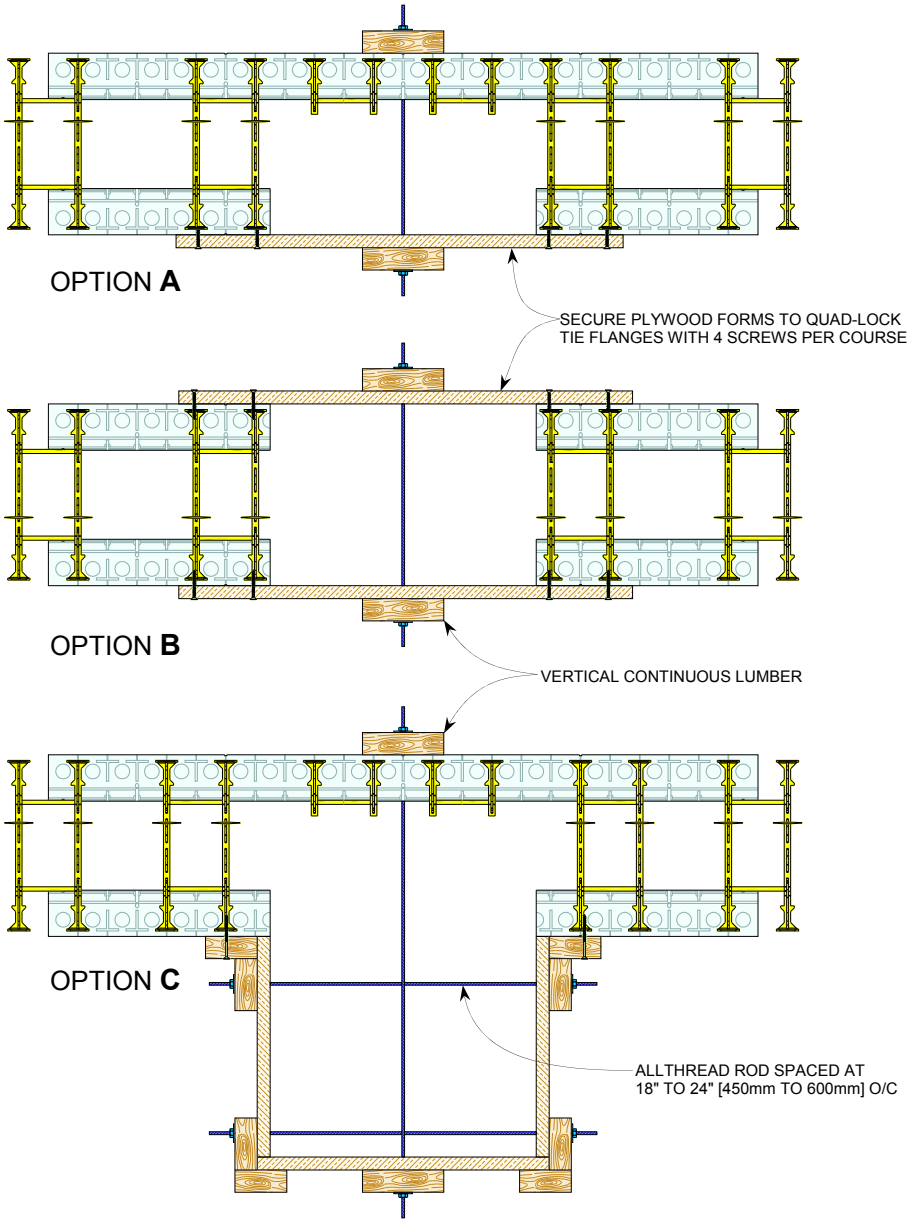


Figure 68: Pilasters formed with Plywood & Threaded Rod

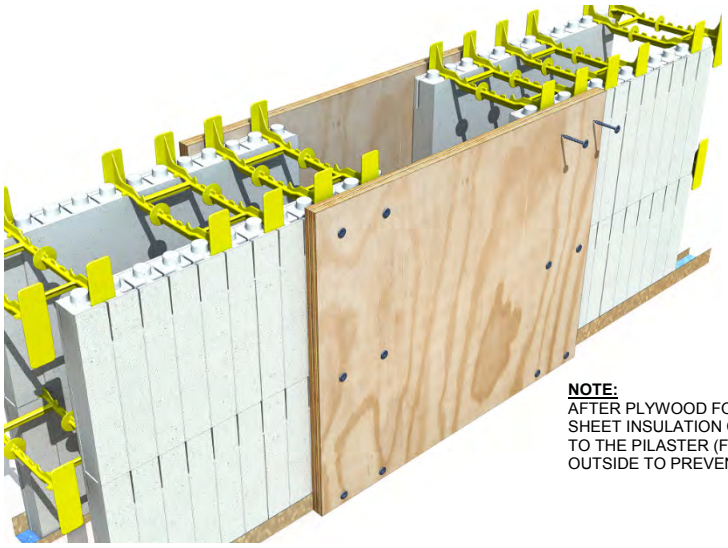


Figure 69: Pilaster formed with Plywood

4.8 MULTI-STORY WALLS

Quad-Lock ICFs are ideally suited to multi-story building designs. Integration between Quad-Lock walls and Quad-Deck (or other) concrete floors, as well as wood or steel floor systems, is detailed in *Chapter 7 "Floor, Roof, and Wall Connections" on Page 140.*

- Multi-story ICF walls are generally built one story-height at a time, even if there are clear-spanning wall elevations without intersecting floors.
- Use identical assembly methods as single-story builds in clear-wall areas, corners, windows, doors, & etc. The exception comes at the transition between stories, where floors intersect with walls. See *Chapter 7 "Floor, Roof, and Wall Connections" on Page 140.*

4.8.1 Building Multi-Story Walls

The key to a multi-story ICF build is in planning the integration of lower story walls to floor diaphragm and then floor-diaphragm to upper story walls. The following suggestions will help with that transition:

- Build lower story walls to an elevation slightly above that of the floor connection, making a wall-width transition if necessary.
- Install floor ledger or hardware for later use in making a floor connection, and brace securely into position.
- Pour lower story walls to an elevation at or just above floor level, but just short (6" [15cm] or so) of the top of the highest row of panels.
- Take care to keep the top edges of panels and ties protected and free from concrete spills, which will obstruct the fit of upper panels and ties.
- Make sure that vertical reinforcing steel extends up far enough to develop a proper lapped splice with steel in the upper wall. (Usually about bar diameter x 40)
- Ensure that concrete is well consolidated around ledger bolts or hardware.

4.9 TALL WALLS

When wall heights exceed 1 full story (about 10 ft. or 3 meters), considerations must be made for stabilizing and aligning the walls as well as proper placement of the concrete in taller structures.

4.9.1 Bracing Tall Walls

A plan for stabilizing, aligning and accessing tall-wall ICFs should be developed and approved well in advance of the build. As wall height increases, so do concerns for quality, accuracy, and above all crew safety. *See Chapter 6, Section 6.2.5 "Bracing Tall Walls" on Page 136.*

4.9.2 Pouring Concrete in Tall Walls

4.9.2.1 Limitations on Free-Fall of Concrete

While ACI and other standards no longer limit the free-fall of concrete, site-specific engineering specifications may dictate a maximum distance that concrete may be dropped.

- If no such limitation is in place, then walls can be filled from the top.
- One way to limit the free-fall distance is to pour from the side of the wall. (See Section 4.8.2.4 for description)

4.9.2.2 Rate of Pour

An important consideration when filling tall walls is the "rate-of-pour", or lift height.

- Pressure on concrete forms is mainly governed by the height of the liquid head of concrete: i.e.; the higher the lift, the greater the pressure on the forms.
- Quad-Lock recommends maximum lift heights of 4 ft over the space of 1 hour, though many factors (like temperature) can influence concrete behavior. Lift height combined with impact of concrete that falls a greater distance can put added pressure on ICF forms.

4.9.2.3 Cold Joints

If tall walls are not poured in consecutive lifts, "cold-joints" in the concrete will probably result and may (or may not) be of concern to the project engineer. Check with the project engineer for specifications on placement of cold joints and any additional reinforcement that may be required. Typical reinforcing for cold-joints is shown in the figure below.

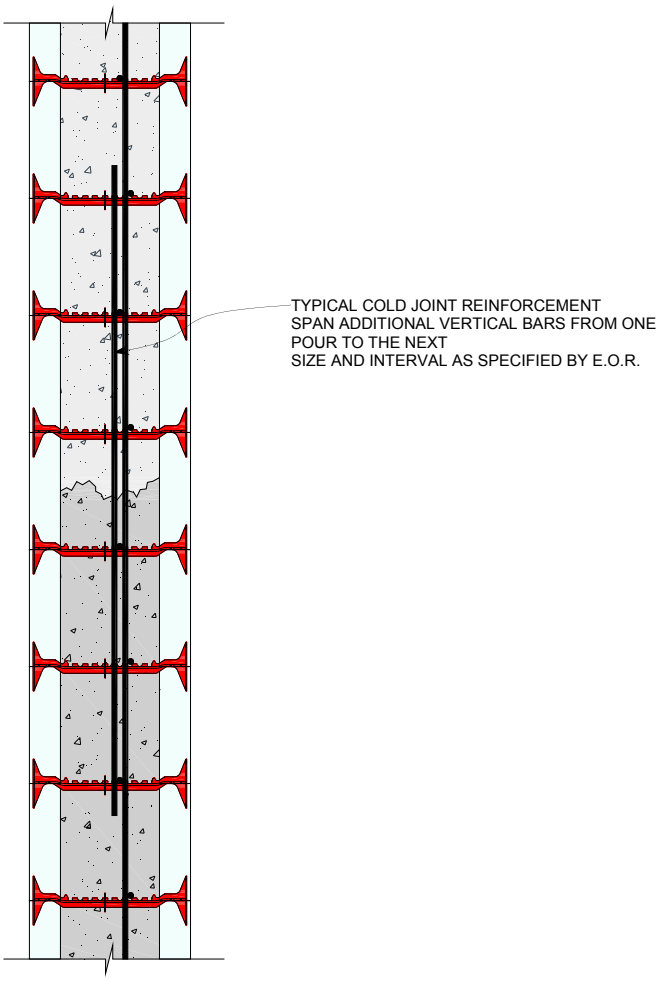


Figure 70: Cold Joint Reinforcement

4.9.2.4 Side-Pour Method

If conditions and/or specifications require minimizing the free-fall of concrete, Quad-Lock recommends that 6" [15cm] diameter access ports be cut in the wall at about 6' [1.8m] intervals (make sure to not cut areas that have ties). Pour the wall from the side until the concrete reaches the level of the cut-outs. Steel should be vibrated from the top of the wall to ensure consolidation of concrete. Save the foam cut-outs and put them back in the wall, bracing them by screwing plywood over the holes and into ties. Continue with the pour from the top (or the next set of access ports), as soon as you are able to place concrete without excessive fall, which may cause segregation of the concrete.

4.10 GABLE ENDS

Quad-Lock can easily be incorporated into building above grade projects that require gabled roof ends.

4.10.1 Forming Quad-Lock ICF Gable Ends

Follow these steps to form gable ends with Quad-Lock ICFs.

- Stagger forms as usual, up to the highest point of the roofline. (See Figure Below)
- Next determine your roof's pitch and snap a chalk line on the side of the panels.
- Cut panels to form the gable. Ensure to take into account the thickness of the plate/board on the top of the wall.

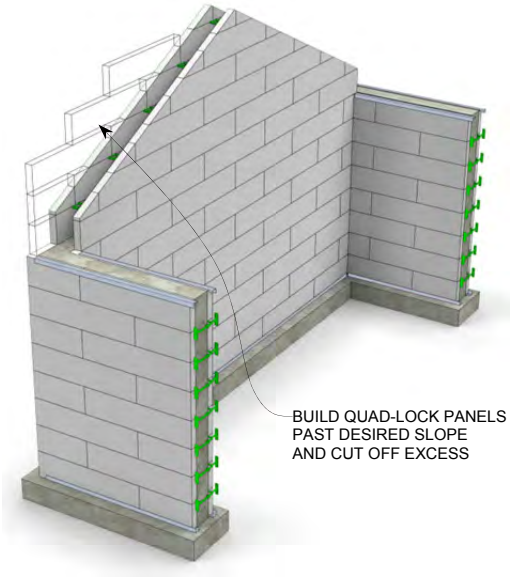
4.10.1.1 Low-Pitched Roof Lines

For low pitch roofs, a simple ladder brace (see detail) may be sufficient and concrete may be troweled to the pitch of the roof.

4.10.1.2 Higher Pitched Roof Lines

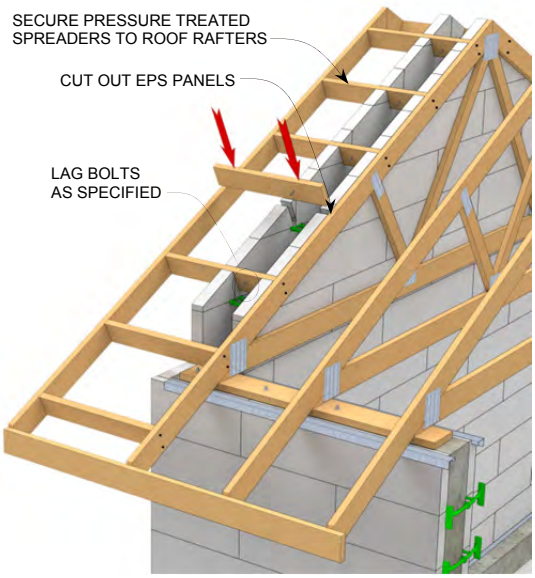
For higher pitched roofs, a plywood cap with 2 x 4 rails may need to be secured to the top of the wall to contain the concrete.

- Cut holes at 4' [1.2m] on center to fill the wall with concrete.
- Pour slowly and avoid the use of mechanical vibration equipment in this case. Rod the concrete by hand or very carefully with a small mechanical pencil vibrator.
- Concrete should not exceed the recommended slump of 6" [15cm].

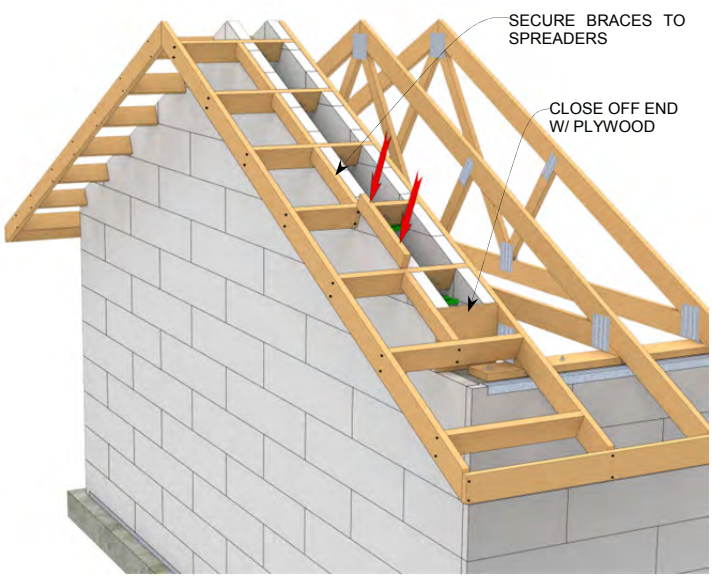


STEP 1 Gable Slope

STEP 2 Installing Roof Rafters



STEP 3 Overhang Installation



STEP 4 Securing Top Foam - Ready for Pour

Figure 71: Gable Forming

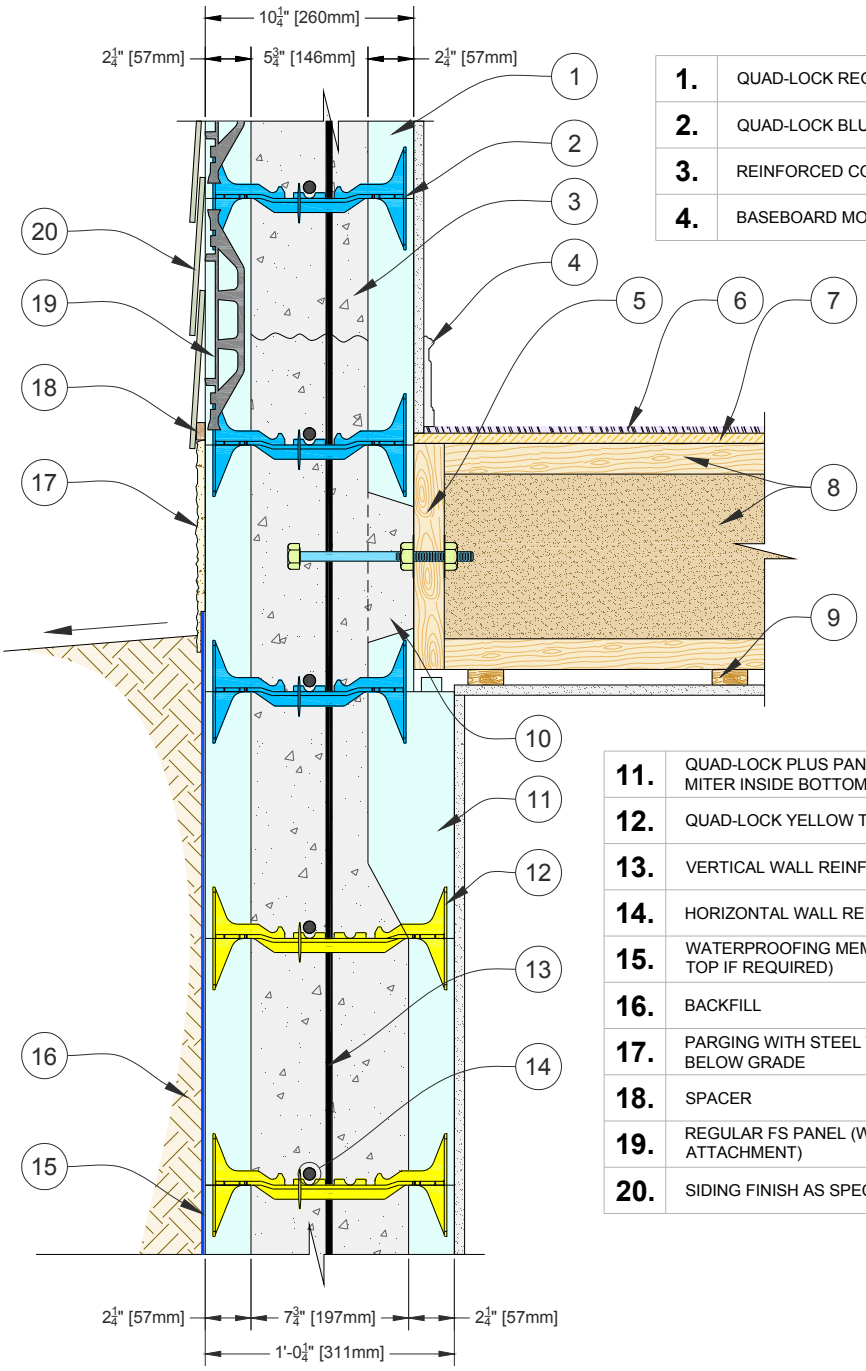
4.11 WALL WIDTH TRANSITIONS

Wall width transitions are easily accomplished using the Quad-Lock Plus Panels on the transition layer. When incorporating wall width transitions in your project for transitioning from one wall thickness to another, it is important to follow suggestions that follow.

4.11.1 Vertical Wall Transitions

- A wall width transition generally occurs where a floor ties into a wall or from one story to the next. A good practice is to build a maximum of 2' [60cm] above the transition, while making accommodations for the floor connection.
- Pour a maximum of 16" [40cm] above the transition, with floor ledger attachment accessories already in place. When the concrete is sufficiently cured, install the floor system, which can then serve as a platform to build the next story of concrete walls.
- **IMPORTANT**: Always cover (protect) ties, slots, and foam interlocks during the pour if you intend on building walls higher. Concrete spilled on the panels and ties will prevent a proper fit on the next row. Use pieces of Quad-Lock Metal Track, or plastic rain gutter as a shield. Slide them along the wall under the concrete pump hose as you pour.
- To step out, place a Plus Panel with the inner row of tie slots lined up with the ties below, and place the next larger tie size in the outer row of slots at the top of the Plus panel. Next, place a Regular Panel on the wider tie and continue the wall at the new cavity width.
- To ensure good consolidation, cut the bottom inside edge of the Plus Panel at a 45° angle to permit better concrete flow.

4.11.1.1 Wall Width Transition using Quad-Lock Plus Panels (w/ Ledger Board Connection)



1.	QUAD-LOCK REGULAR PANEL
2.	QUAD-LOCK BLUE TIE
3.	REINFORCED CONCRETE CORE
4.	BASEBOARD MOLDING TRIM
5.	LEDGER BOARD WITH BOLTS AS SPECIFIED
6.	FLOOR FINISH
7.	SUBFLOOR
8.	WOOD JOISTS AS SPECIFIED
9.	FURRING FOR CEILING FINISH ATTACHMENT AS SPECIFIED
10.	PRIOR TO POURING THE CONCRETE REMOVE EPS FOAM AROUND EVERY J-BOLT AND CLOSE OFF WITH LEDGER BOARD WITH PRE-INSTALLED BOLTS FASTEN LEDGER BOARD TO QUAD-LOCK PLASTIC TIES POUR CONCRETE MIX MINIMUM 6" [150mm] ABOVE THE FLOOR LEVEL
11.	QUAD-LOCK PLUS PANEL FOR WALL TRANSITION MITER INSIDE BOTTOM EDGE FOR BETTER CONCRETE FLOW
12.	QUAD-LOCK YELLOW TIE
13.	VERTICAL WALL REINFORCEMENT AS SPECIFIED
14.	HORIZONTAL WALL REINFORCEMENT AS SPECIFIED
15.	WATERPROOFING MEMBRANE (INSTALL DRAINAGE BOARD ON TOP IF REQUIRED)
16.	BACKFILL
17.	PARGING WITH STEEL WIRE MESH MIN. 6" [150mm], EXTEND 2"-3" BELOW GRADE
18.	SPACER
19.	REGULAR FS PANEL (WITH FASTENING STRIPS FOR SIDING ATTACHMENT)
20.	SIDING FINISH AS SPECIFIED

Figure 72: Wall Width Transition & Ledger Connection

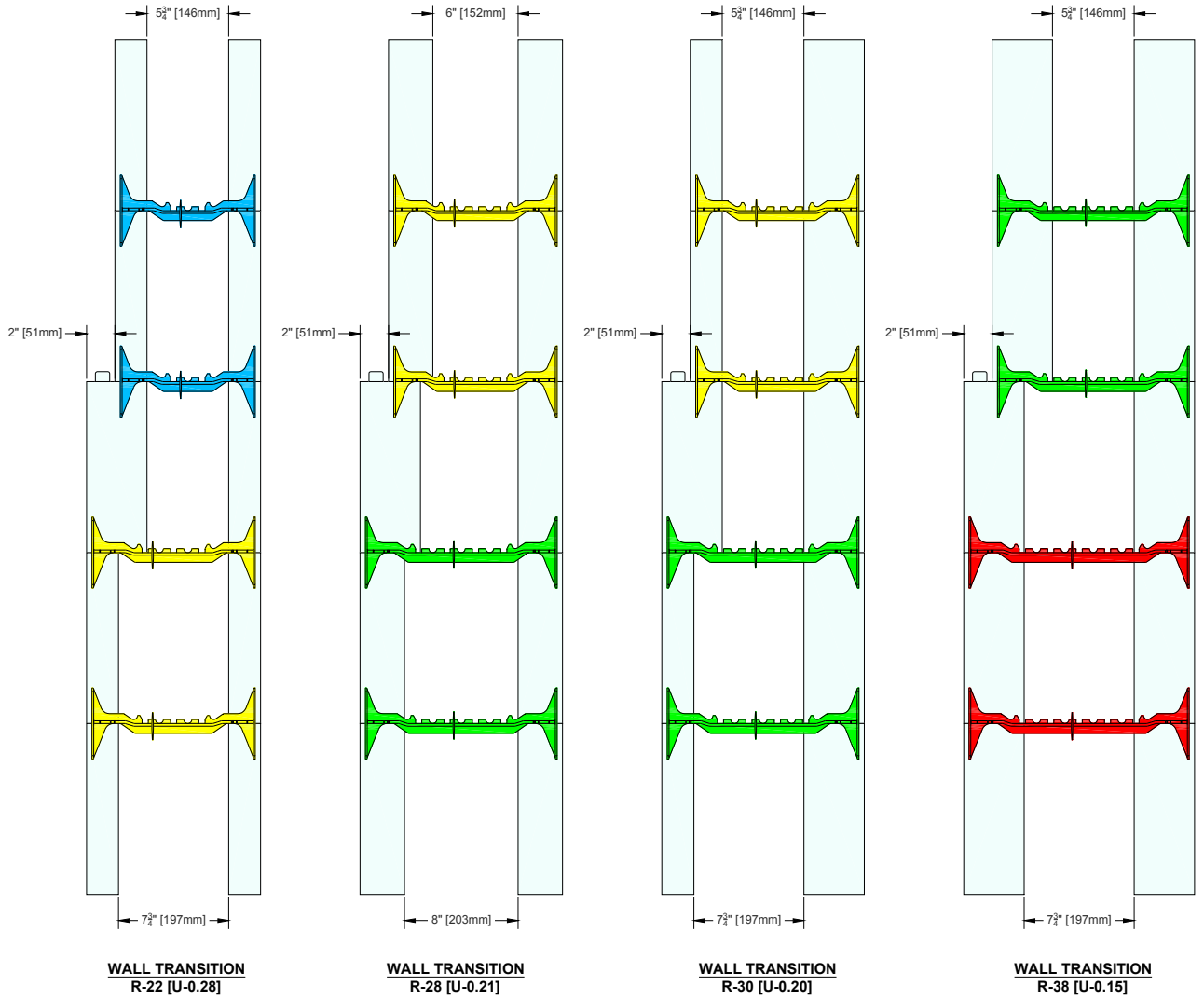


Figure 73: Wall Width Transition using Quad-Lock Plus Panels

4.11.2 Horizontal Wall Transitions

Wall-width transitions along a horizontal line are easily made by simply changing the length of Quad-Lock Full Tie to suit the design need.

- In-fill the gap left at the transition point by cutting scrap panels to fit at 90o to the wall line (shown below in Figure Figure 74: Horizontal (plan view) Wall Width Transition)
- Assemble a “Z” shaped brace and fasten to the ties that are next to the transition. (shown below in Figure 68)
- Insure proper alignment by attaching a diagonal brace to the transition assembly and using the usual equipment and procedures to align the wall. *See Chapter 6, Section 6.2.2.2 “Adjustable Diagonal Braces” on Page 135.*

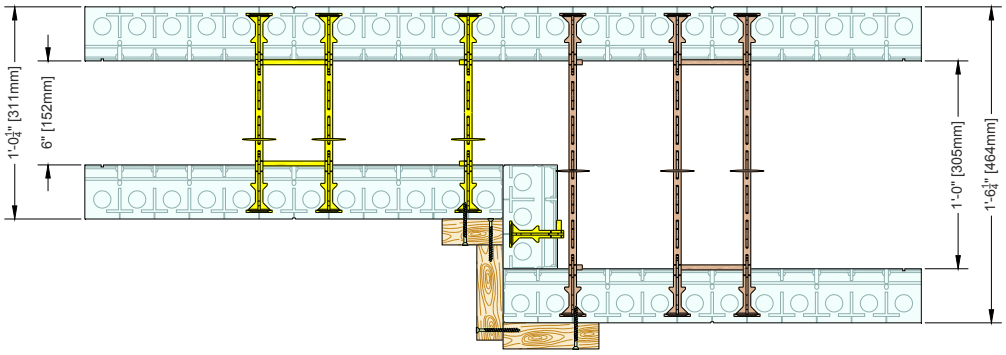


Figure 74: Horizontal (plan view) Wall Width Transition

4.12 DOUBLE WALLS/COMMON WALLS

Double Walls or Common Walls are easily built using a Quad-Lock Plus Panels in the middle and offsetting the ties for the two sides of the walls. Push down and fully seat the ties that are placed in the Plus Panel the opposite direction from normal factory layout.

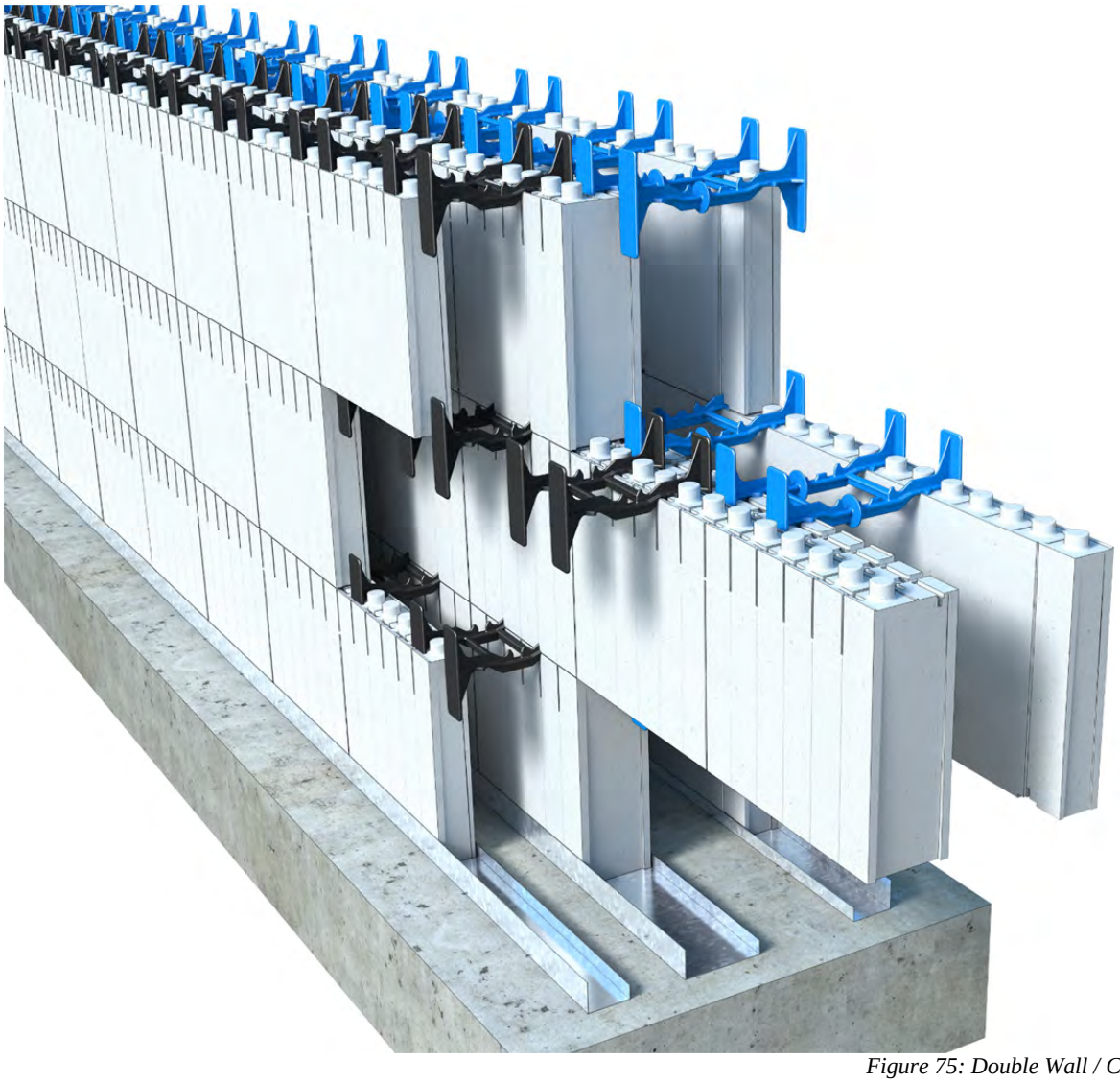


Figure 75: Double Wall / Common Wall

4.13 FOUNDATION AND BASEMENT WALLS

"Foundation" walls and *"Basement"* walls are treated by most building codes as one building type. Variations come with differing wall heights and depth of back-fill supported by the wall. Other factors, like soil pressure, may also have an effect on the cavity size and reinforcing in the wall.

If the Quad-Lock system is chosen as an alternate or a substitute to a conventionally formed foundation or basement wall, design professionals should ensure to account for the 2¼" [57mm] , 3 1/8" [79mm] or 4¼" [108mm] thickness of the EPS panels at the footing and sill plate elevations. **Check building plans carefully to assess whether or not this step has been done in advance**, since the plans may not have been drawn with ICFs in mind.

- ICF foundation wall design is generally governed by the same structural guidelines as conventional cast in place concrete walls.
- A detail for the transition between the ICF foundation wall and the structure above should be in place before construction begins. *See Chapter 7 "Floor, Roof, and Wall Connections" on Page 140*

Note**: Building codes in the USA and Canada have prescriptive design specifications which may be used without the need for site specific engineering.* ***See Chapter 2, Section 2.2.2 "Prescriptive Design Specifications for One and Two Family Homes"

4.13.1 Venting for Crawlspaces

Use off-the-shelf plastic foundation vents sized or adapted to the outer dimensions of the Quad-Lock wall, and foam into place prior to pour. Be sure to consolidate concrete under vents.

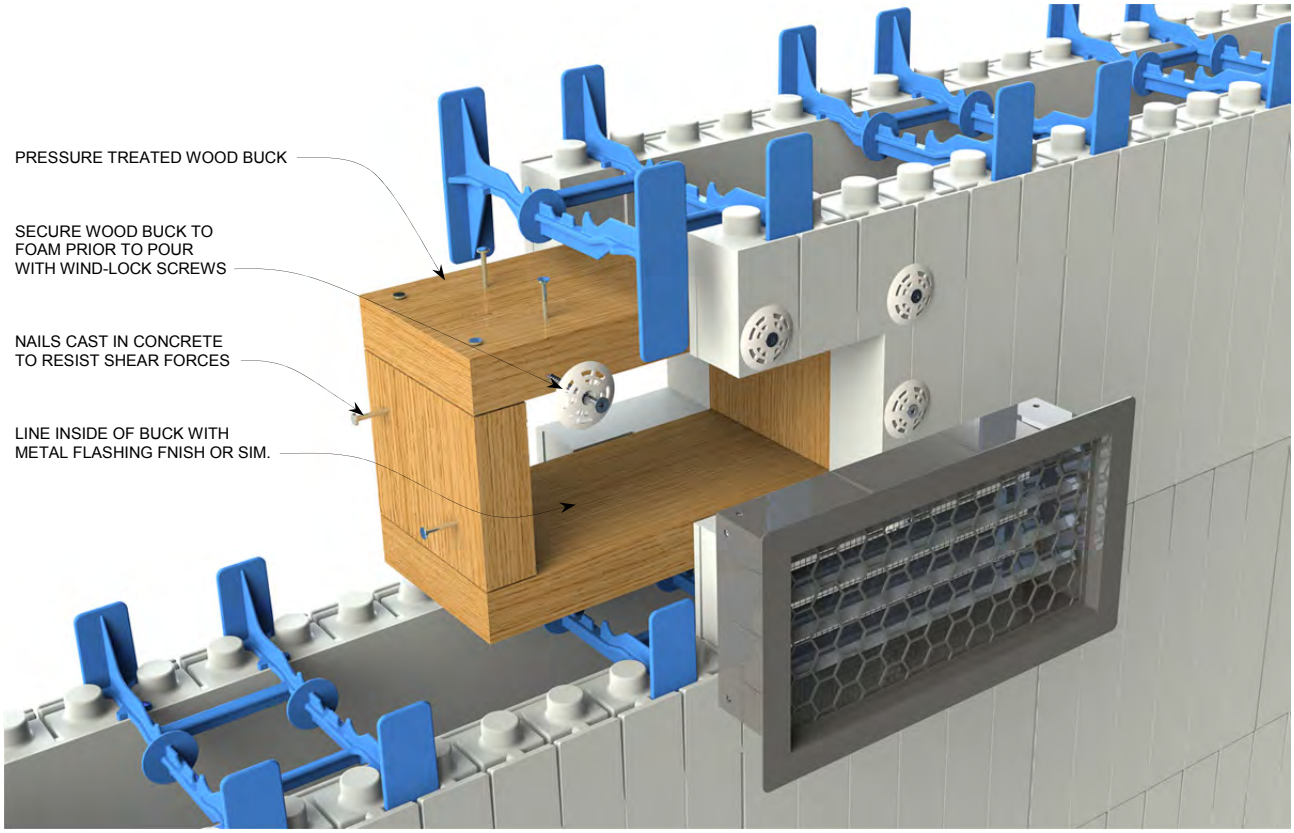


Figure 76: Vent Wall Penetration

4.13.2 Termite Protection for Foundation Walls

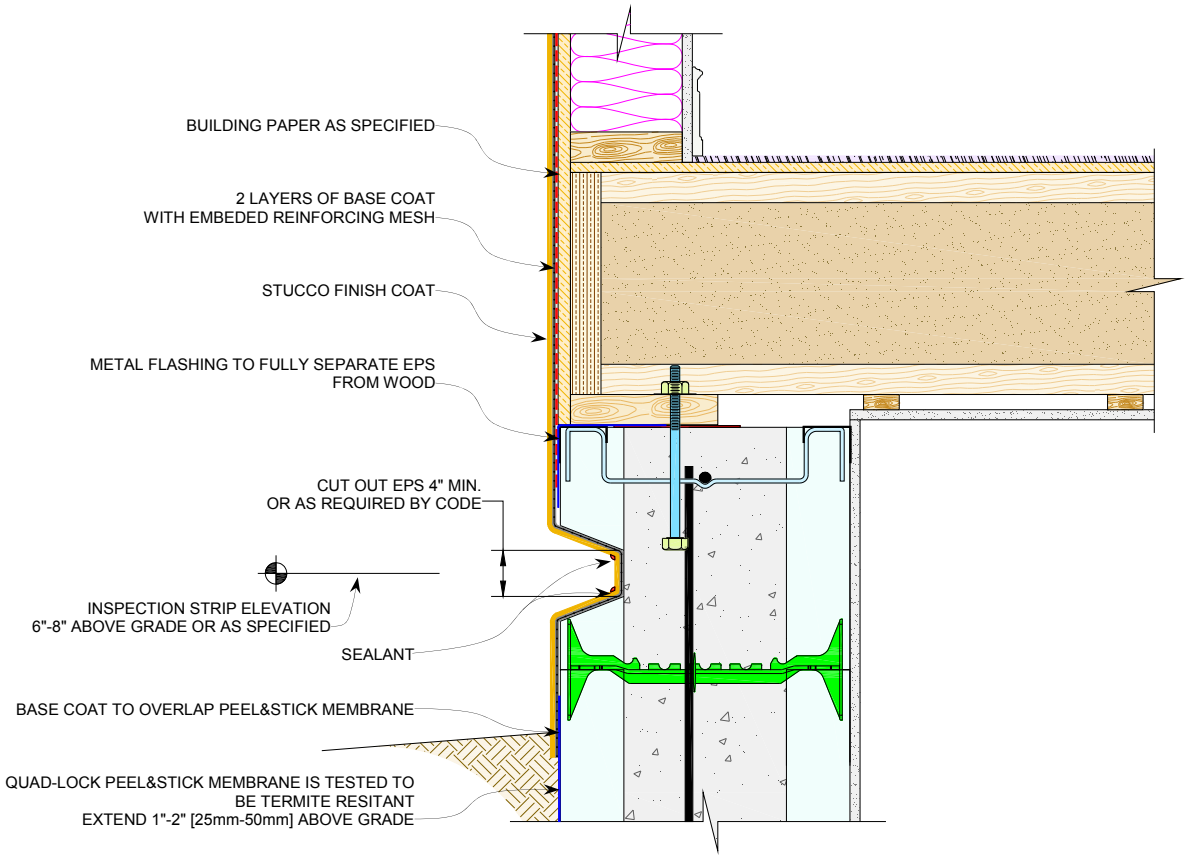
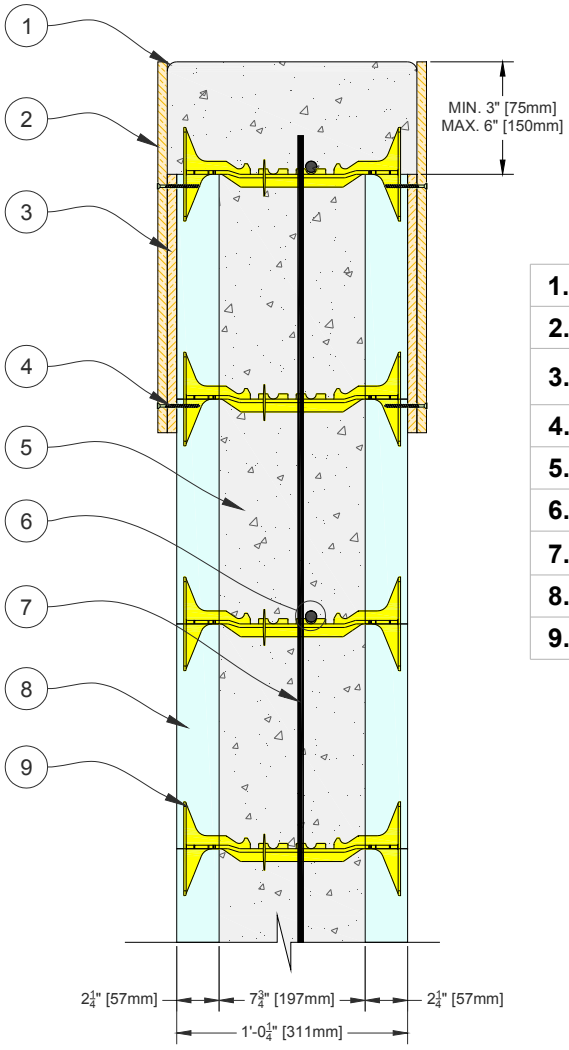


Figure 77: Termite Protection for Foundation Walls

4.14 SOLID WALL CAP

In cases where a solid concrete cap is needed on top of a Quad-Lock wall, such as with retaining walls and some foundation walls, screw plywood strips to the Metal Track as a form and screed line. Brace as needed.



1.	BEVEL ALL EXPOSED CONCRETE EDGES
2.	SECOND PLYWOOD FORM LAYER
3.	PLYWOOD FORM SPACER LAYER (CREATES SPACE FOR WALL FINISHES)
4.	FASTEN FORMS TO QUAD-LOCK PLASTIC TIE FLANGES
5.	REINFORCED CONCRETE CORE
6.	HORIZONTAL WALL REINFORCEMENT AS SPECIFIED
7.	VERTICAL WALL REINFORCEMENT AS SPECIFIED
8.	QUAD-LOCK PANEL
9.	QUAD-LOCK YELLOW TIE

Figure 78: Forming for Solid Wall Cap

4.15 MONOLITHIC POURS

The light weight nature of the Quad-Lock system makes it suitable for the simultaneous monolithic pour of the footing and wall. A monolithic pour is used to eliminate the need for multiple trips by the pumping equipment and to eliminate the cold joint between the footing and wall.

4.15.1 Setting Up for a Monolithic Pour

- Use 2x material for footing forms, and at least 50% more stakes than normal. If the wall is higher than 4' [1.2m), make the footing extra wide to allow pouring from each side (between the wall and footing forms). Before the final grade is set, cut rot resistant wood or metal spreaders and attach them to the 2x footing forms at maximum 3' [1m] intervals.
- Set the footing forms to grade and secure into place with stakes. Strike the building line on top of the 1x4 spreaders with a chalk line.

- Now fasten the Metal Track to the wood or metal spreaders using the chalk line as a guide with screws through the Metal Track. A self tapping screw works best. Cut wooden spacers to set the inside track, and fasten to the 1 x 4 spreaders.
- Now set the Quad-Lock Panels into the track in the same fashion you would on a pre-poured footing.
- Brace the wall as you normally would by screwing bracing to the ties.
- On walls 4' [1.2m] high and under, fill the footing from the top of the wall. On walls higher than that, fill the footing first from the sides, pouring through the gap left between the Quad-Lock Panels and the footing forms.
- Space the arrival of concrete trucks to allow a few extra minutes of set time for the footings before pouring the walls. When the footings begin to set, continue the pour in the walls.

Building Tip: **Cut short lengths of steel framing studs to serve as spreaders for footing forms in a mono-pour. Cut the legs of the "C" shaped stud pieces about 1½ inches back from each end, and flatten the stud so it can be screwed or nailed to the wooden footing forms on either side. Now snap building lines, and place the Quad-Lock metal track on top of the steel-stud spreaders. Fasten to the steel stud spreaders with sheet-metal screws.**

The "C" shape of the metal stud will act like a truss, and give good support to the wall forms placed above. (See Figure *79*).

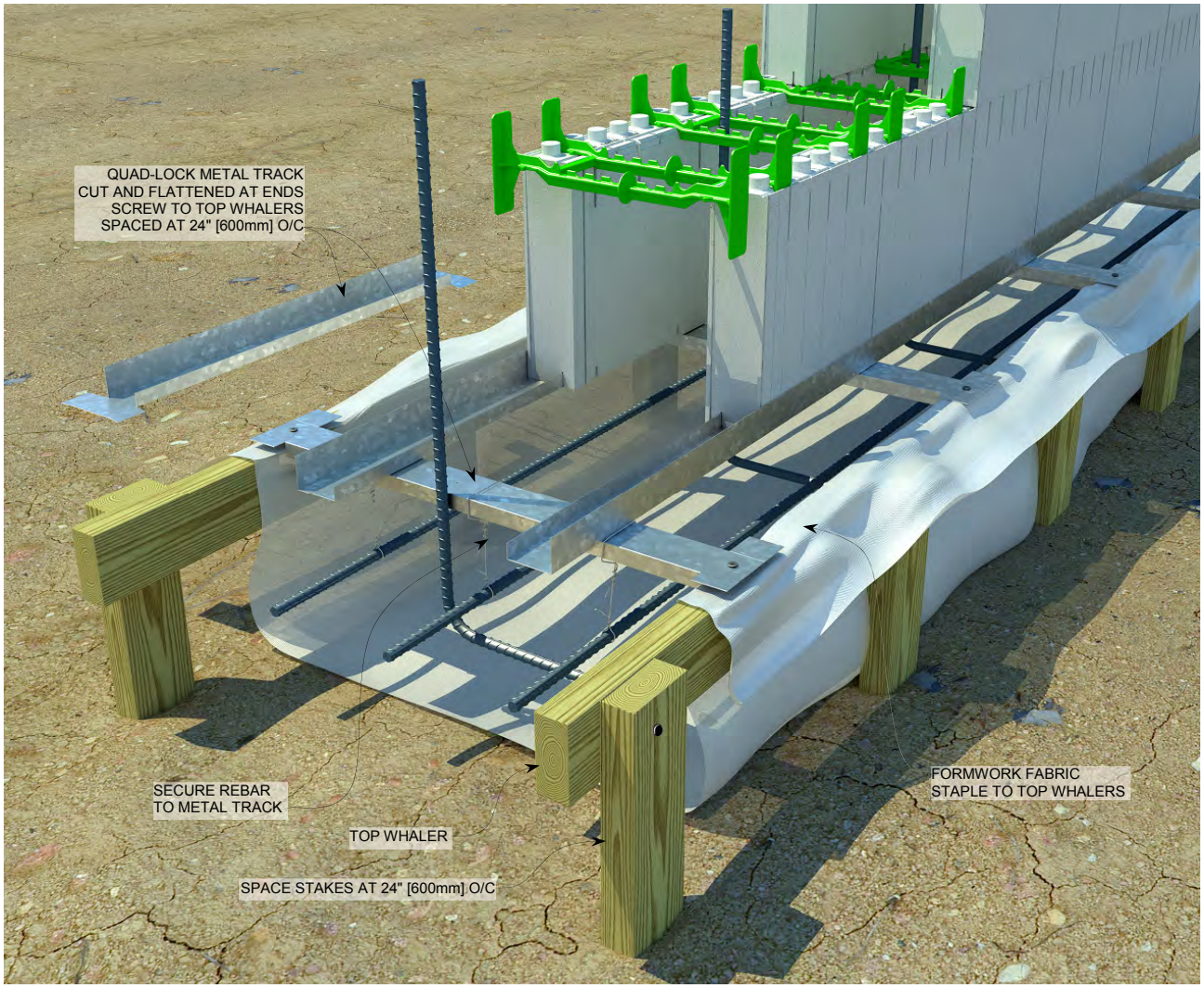


Figure 79: Typical Monolithic Footing / Wall Set Up

5 WINDOW & DOOR OPENINGS

5.1 FENESTRATION: CONDITIONS & METHODS FOR ICFS

Window and door *(fenestration)* openings are a feature of nearly every building project, and are a critical building element where several components must be fitted together in a very exacting manner. Efficiency and life-span of the building depend on proper detailing and construction of openings because of the potential for unwanted passage of air and water around the window or door assembly. Most building codes require that building assemblies be kept dry by proper detailing of openings made in the building shell.

5.1.1 Factors Influencing Fenestration

The manner in which window and door openings are constructed in Quad-Lock ICF walls is a function of six issues:

- The position in which the window or door is required to remain, in relation to the center-line of the wall.
- How the window/door frame is to be attached to the wall.
- The size specification of the actual window versus the rough opening size.
- The desired architectural detail for finishing the interior and exterior of the opening.
- The integration of concrete, forming materials, and window seal to insure a continuous watertight plane is extended from concrete core to window or door.
- Creating a water seal around the window or door as well as drainage ("drying") capacity.

Ongoing research suggests that wood forms left in ICF walls may be susceptible to shrinkage as moisture leaves the wood material, creating a potential pathway between concrete and forms left in place. Quad-Lock suggests that measures to protect against ingress of unwanted moisture and air leakage are always taken. These include flashing that bridges potential gaps, sealing membranes applied to the opening, or other measures that have been identified in research reports and testing.

Building Tip:	**Develop a detailed plan for window and door installation well in advance that considers all of the above issues. Lack of preparation in this phase can cause unnecessary delays or even long-term failures in the building shell.**

5.1.2 Sizing and Positioning of the Opening

Depending on the style of architecture, windows and doors may be flush to the outside of the building, or recessed into the opening.

- Know in advance exactly where the window or door is to be positioned, and make the necessary provisions to place the window or door assembly.

Building Tip:	**Actual window size and rough-opening size are different from each other, depending on the type and brand of window used. Confirm with the window manufacturer what the rough-opening sizes must be.**

5.1.3 Formwork for ICF Wall Rough Openings (R/O's)

Depending on exposure conditions on the site, forming of window and door penetrations may follow one of the following methods.

1. *Treated wood* may be left in the wall permanently.
2. *Plastic forms* or *composite forms* may be left in the wall permanently
3. Temporary forms, removed to leave the concrete core exposed.

Higher wind and rain exposure will require a more robust window/door connection plan. Independent research has demonstrated that continuation of the (watertight) plane of the concrete core across to a direct connection with window frames is the most effective at resisting wind-driven water. *(See below.)*

A description of commonly utilized methods follows:

5.1.3.1 Method 1: Forming R/O's with Permanent Treated Wood Buck-Outs

In many areas, it is acceptable to leave pressure treated wood in the wall in contact with the concrete. Different configurations of forming can be chosen depending on the style and positioning of the window and exterior finishes.

The following points are important when using permanent wood buck-outs:

5.1.3.1.1 "Internal" Wood Buck-out

For windows that are recessed from the exterior face of the building, an internal buck-out may be sufficient to accommodate window installation and finishes, like stucco or EIFS.

- Size the buck-out material so it fits snugly between the ICF panels.
- Attach a water-stop rail that carries across the head and down the jambs at center of wall, on the concrete side.
- Wrap the buck-out with adhesive membrane material toward the exterior face and back around the inside face of the wood where the window will attach and seal. (See figure below.)
- Secure the ICF panels to the wood with Wind-Lock washers and decking screws

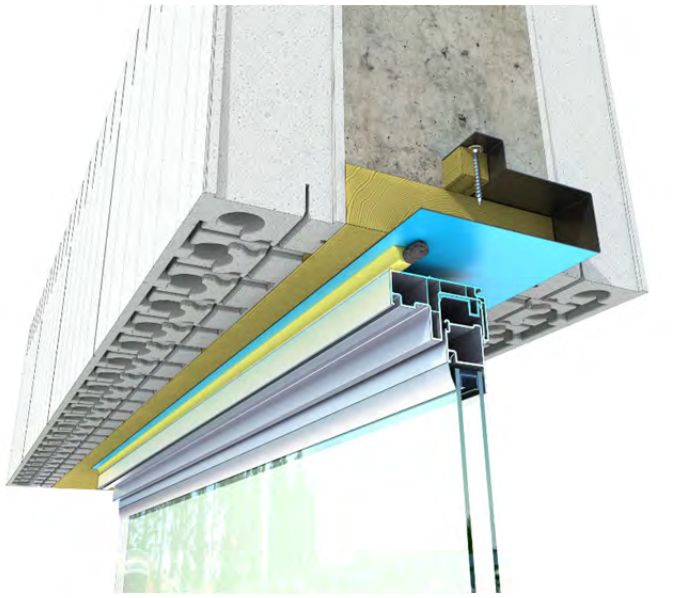


Figure 80: Internal Wood Buck-out in position between ICF panels

5.1.3.1.2 "Hybrid" Wood Buck-out

When attachment to the exterior face of the window opening is required (flanged windows or wood trim), Quad-Lock recommends a "hybrid" buck-out configuration that preserves the insulating layer on the interior, AND offers a nailing surface on the exterior.

- Size the buck-out material so it carries to the exterior face of the ICF panel.
- Attach a water-stop rail that carries across the head and down the jambs at center of wall, on the concrete side.
- Wrap the buck-out with adhesive membrane material toward the exterior face and back around the inside face of the wood where the window will attach and seal. (See figures below.)

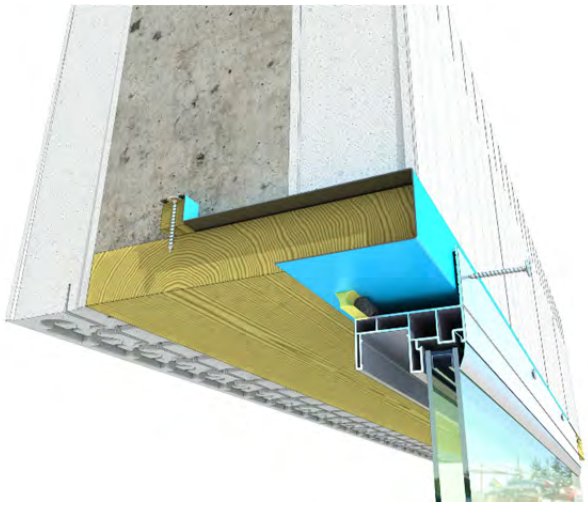


Figure 81: Hybrid Wood Buck-out extends to exterior face of ICF wall

5.1.3.1.3 Water-stop and flashing for buck-outs left in place

Quad-Lock recommends that a water-stop and self-adhesive membrane flashing be added to the buck-out to preserve continuity of the water-resistant concrete-core to the point where the window-seal takes over. This addition helps to intercept unwanted water that may enter the wall assembly above the window or door opening and finds its way through joints between ICF panels in the event that exterior claddings may be damaged or fail. The figures below show water-stop and buck flashing for both internal and hybrid buck-outs:

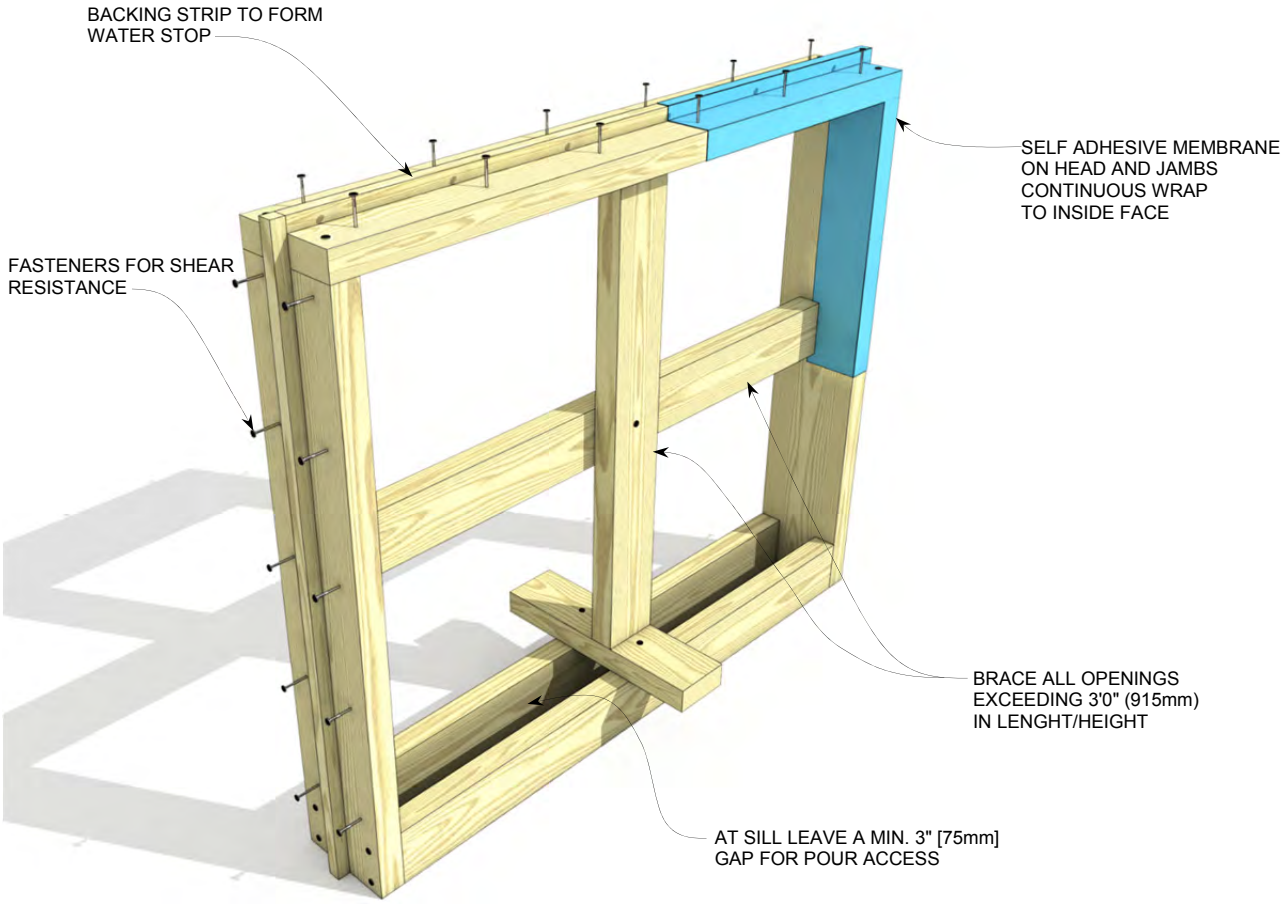
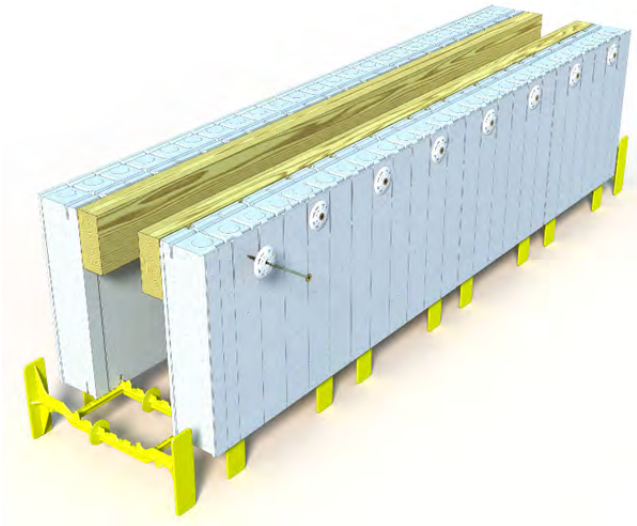


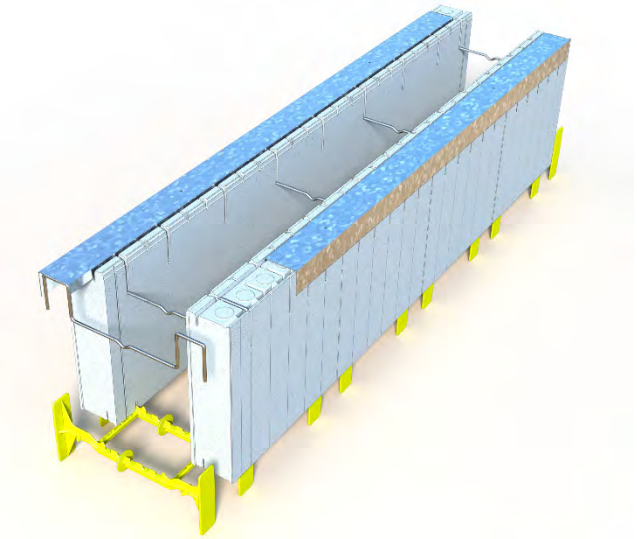
Figure 82: Internal Wood Buck-out with backing strip added to concrete side (lined with Peel & Stick waterproofing membrane)

5.1.3.1.4 Options for Sill Forming (Bottom of Window)

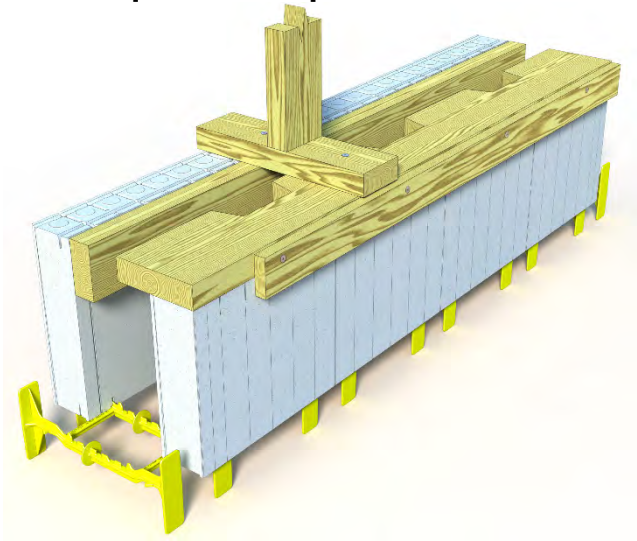
- For the bottom, or sill, (internal buck-out) use two 2x4s on edge to create an opening to pour through, instead of full cavity width lumber. Fasten the panels to the wood with Wind-Locks and screws. For the hybrid buck-out option, turn the exterior facing 2x4 flat to extend to the exterior face of the build.
- An alternate method for the sill is to use Quad-Lock Metal Track to form the sill instead of wood. This leaves the sill 100% open for rebar placement, pouring and consolidation of concrete. If the window elevations matches the top of a full panel, Quad-Lock Wire Top Ties may be utilized. If the elevation is cut to suit, place the metal track over the panels and secure with conventional cleats across the wall.
- If using a Hybrid buck, turn the exterior 2x on its side as shown, to provide support on concrete



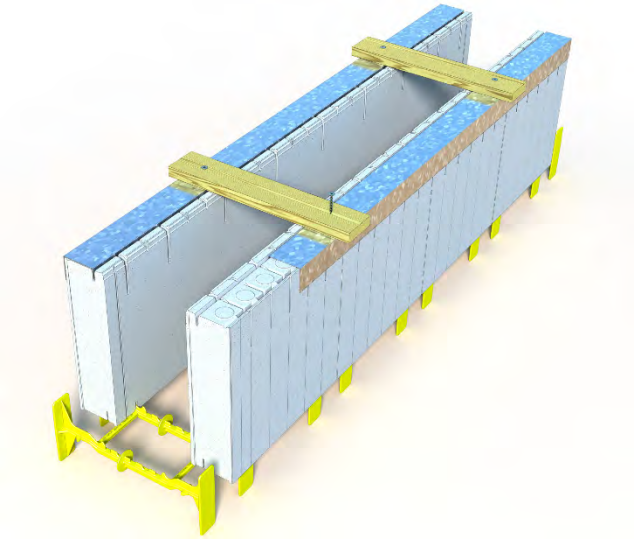
Double 2x4 [50mm x 100mm] secured with Wind-Locks



Quad-Lock Metal Track with Wire Top Ties



Hybrid Sill - Cut out holes to provide access for pouring



Quad-Lock Metal Track with Cleats

Figure 83: Options for Forming Sill Bucks: Wood or Metal Track with Wire Top Ties

Building Tip: **Pre-assemble all door and window bucks for the job. Pull cross dimensions to insure that the buck is square and nail a brace on to hold it in square. Nail two pieces of scrap lumber across the sill to hold the buck in position when you set it in the wall. Number the bucks and have them available for placement in the wall when the proper wall height is reached.**

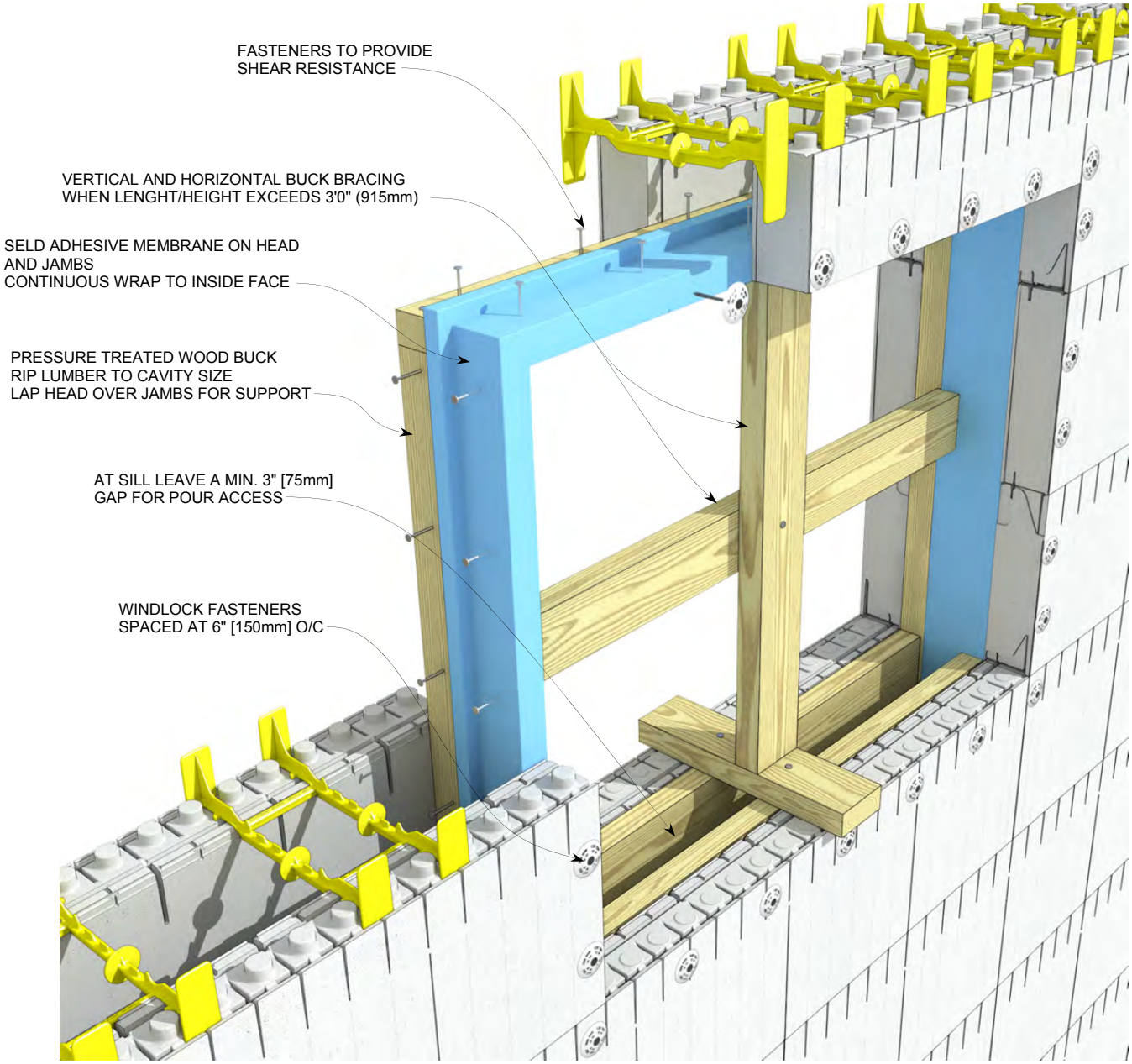


Figure 84: Internal buck-out with water-stop flashing, bracing, and ICF panels fastened to wood members

5.1.3.1.5 Full-Width (External) Wood Buck-Outs

While popular in early ICF installations, window and door buck-outs that span the entire wall width (called external bucks) and are permanently left in place are no longer recommended by Quad-Lock. This style of buck-out creates a thermal bridge that compromises the integrity of the thermal envelope and has been shown to be very susceptible to wind-driven water and air leakage.

- A full-width buck-out is recommended for temporary use only. Full-width wood forms should be removed to expose the concrete core according to Method 3, unless protected by a flashing mechanism that provides continuity between the concrete core and the window seal.

5.1.3.2 Method 2: Forming R/O's with Permanent Plastic or Composite Frames

Many builders use specially designed plastic frame material that is fashioned into full wall width frames which both form the concrete and serve as an attachment point for windows and doors.

- EPS panels must be cut precisely to size for the plastic frames to fit over the panel edges, and fastened into place with spray foam adhesive.
- Care must be taken that the inside of the frames are adequately braced to resist bowing during the concrete pour. Always check frames for plumb, square, and level. *(Then check them again)*
- Research has highlighted the importance of sealing the corner connections of plastic forming systems against wind-driven water intrusion. *Ask the frame manufacturer about "welding" the corners or other available sealing methods.* Properly installed, braced and sealed, plastic window and door forms can be a good choice for ICF projects when suited to on-site exposure conditions.

5.1.3.3 Method 3: Forming R/O's with Exposed Concrete Face

For some designs, it is not desirable to leave material (wood or plastic) in the window/door rough opening, leaving access to the exposed concrete core. A full-width, removable form can be secured in place during concrete placement and stripped afterward.

- Use dimension lumber, plywood (or a combination of the two) to build a form matching the desired window or door rough opening size and shape.
- The form should span across the entire wall width from inside face to outside face of EPS.
- Treat the temporary form with form-release agent on the side exposed to concrete.

5.1.3.3.1 Alternate Method for Exposed Concrete Openings

- Build a *Method 1- Internal Wood Buck-Out*, decreasing the size of the buck-out to make the outside surface of the wooden form match the desired concrete rough opening size.
- No nails are placed into the concrete side of the form, but the wood is treated with a release agent.
- The completed form is installed per "Method 1" above, running panels past the wood and securing with screws.
- Following the pour, screws and Wind-Locks are removed.
- Foam is cut with a circular saw in line with the edge of the concrete.
- The entire form assembly is removed, cleaned, and saved for later use.

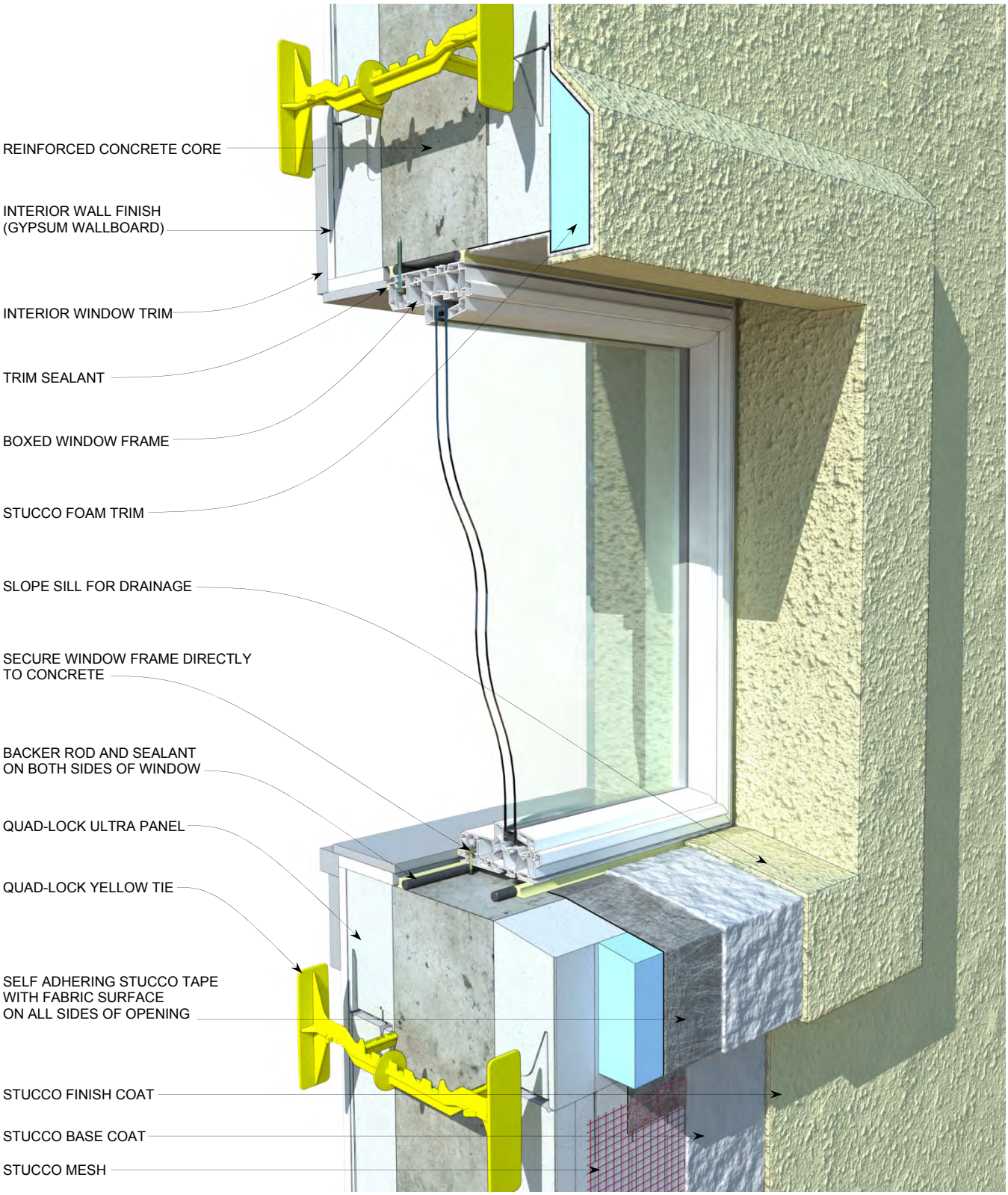


Figure 85: Direct to Concrete Window Assembly

Building Tip:	**Choose a method of forming windows and doors that best suits the climate conditions that your building is likely to face over the long term. Follow the principle of capturing water and draining it to the exterior.**

5.1.4 Steps for Placing Rough Opening Forms in ICF Walls

Having stacked wall panels to a level just above window sill-height, it is now time to place your window openings.

1. Determine the exact sill height and mark it on the inside panels.
2. Center the opening according to the plans, and cut the foam (using a hand saw) to the required height, and according to your choice of buck-out.
3. Repeat the cut on the outside panels.
4. Lift the pre-fabricated buck-out assembly into position, and have a crew member tack it into place using Wind-Lock style fasteners and appropriately sized screws. Use cross-blocking to keep internal bucks from falling into the cavity.
5. Check the sill for level and adjust. When level, secure the sill into place with screws and plastic Wind-Lock washers.
6. Continue building the wall around the window bucks. Run panels just past the inside of the bucks. Place split ties as close to the buck as possible within the wall cavity.
7. Fasten EPS panels to form material using Wind-Locks and screws at maximum 6" [152mm] centers.
8. Make sure that you have access to the wall cavity through the sill, to ensure concrete consolidation.
9. Trim away excess foam with a hand saw. Reduce waste by saving all your leftover pieces that are 12" [305mm] long for re-use.

5.1.5 Common Window Installation Details

The following details are a few of the most common window installation methods used in ICF construction. Many more details are found on the Quad-Lock website in the technical section.

As stated in the beginning paragraph of this section, window and door openings are a critical part of every building. Check with your design professional and local building department to determine the suitability of any plan for installing windows and doors in your region and local area weather conditions.

5.1.5.1 Legend for Labeling Found on Details

Used this legend to identify numerically labeled components on all 13 of the following window installation drawings.

1	Stucco Finish Coat
2	Base Coat
3	Self-Adhering Stucco Tape with Fabric Surface
4	Self-Adhering Waterproofing Membrane
5	Pressure Treated Wood Buck
6	Foam Stucco Trim
7	Backer Rod and Sealant
8	Flanged Window Frame
9	Shims
10	Sealant for Interior Window Trim
11	Interior Wall Finish (Gypsum Wallboard)
12	1x1 [20mm x 20mm] Backing Strip to Create Water-stop
13	Interior Window Trim
14	Cut Saw Kerf and Insert Flashing with Sealant
15	Lapped Siding Fasten to Furring
16	Furring Strips - Fasten to Quad-Lock Ties
17	Starter Strip
18	Sealant
19	Siding Trim
20	Through Wall Flashing as per Code or as Specified
21	ICF Brick Tie - Size and Spacing as Specified
22	Air Space as Specified
23	Brick Veneer
24	Lintel Steel Angle as Specified
25	Boxed Window Frame
26	Brick Tie as Specified
27	Precast Sill
28	Trim
29	Sill Trim

5.1.5.2 Selected Quad-Lock ICF Window Assembly Details

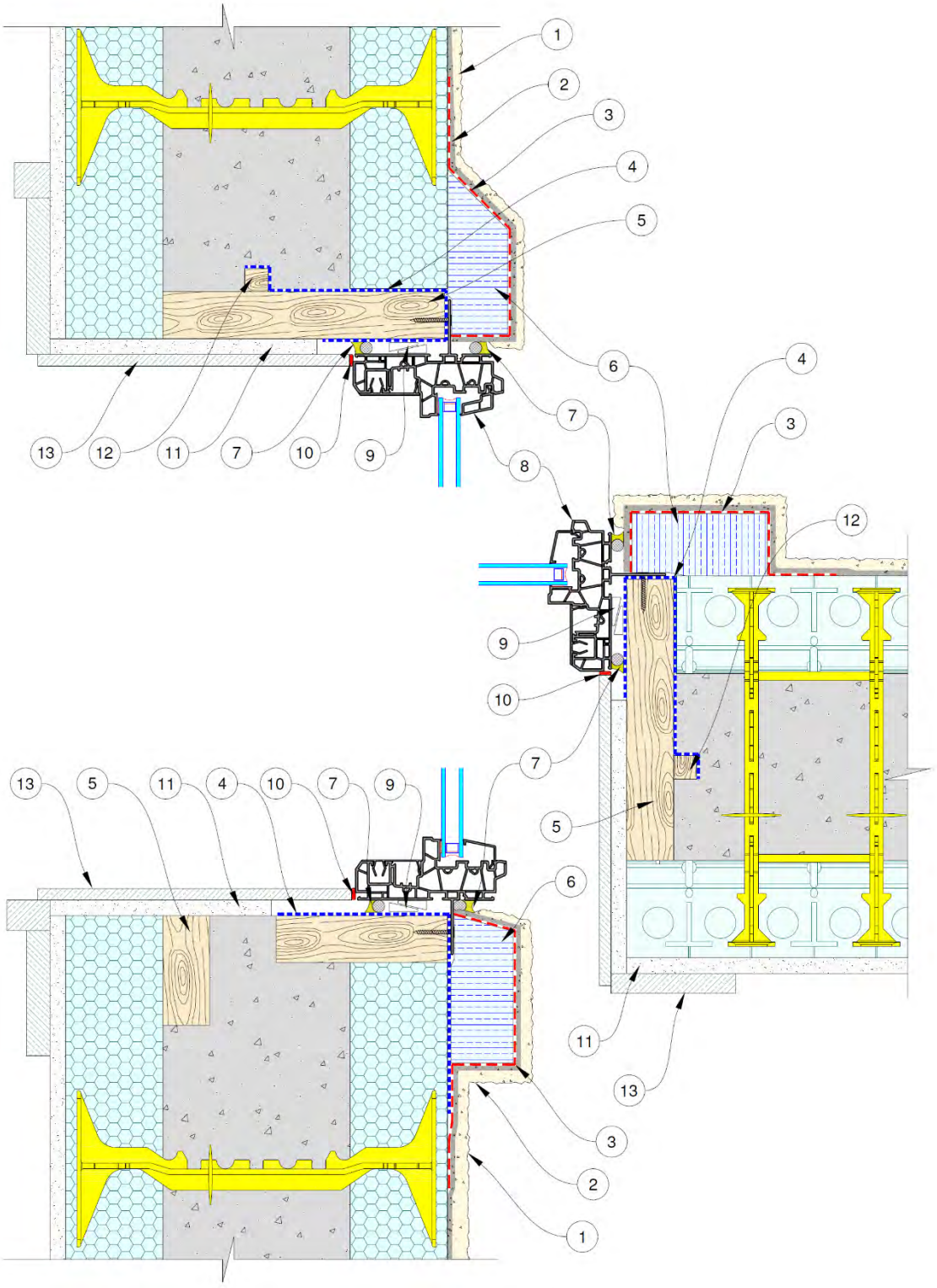


Figure 86: ICF Window Assembly: Wood buck-out, Flanged window flush to exterior, EIFS/Stucco lamina

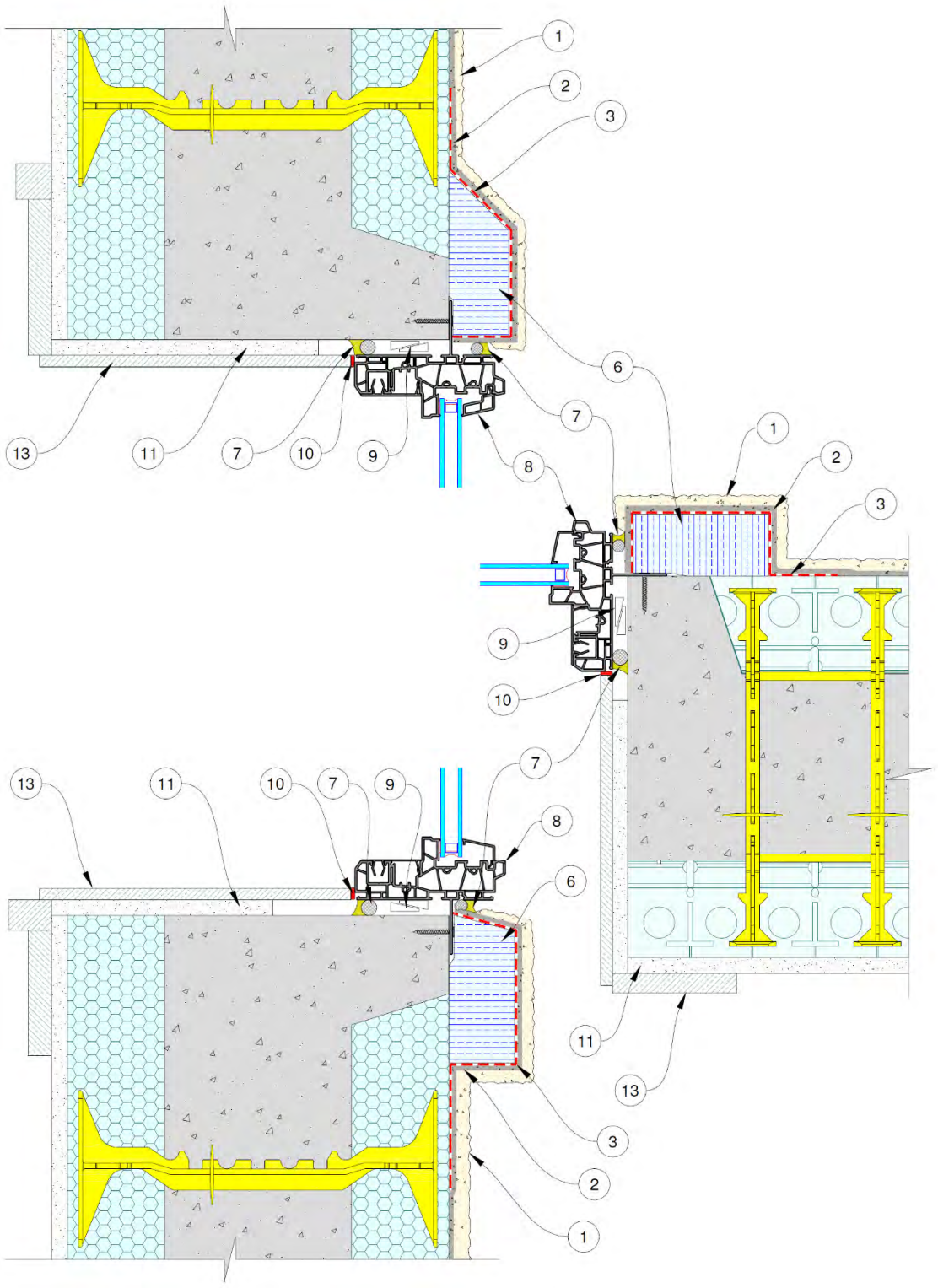


Figure 87: ICF Window Assembly: Direct to concrete, Flanged window flush to exterior, EIFS/Stucco lamina

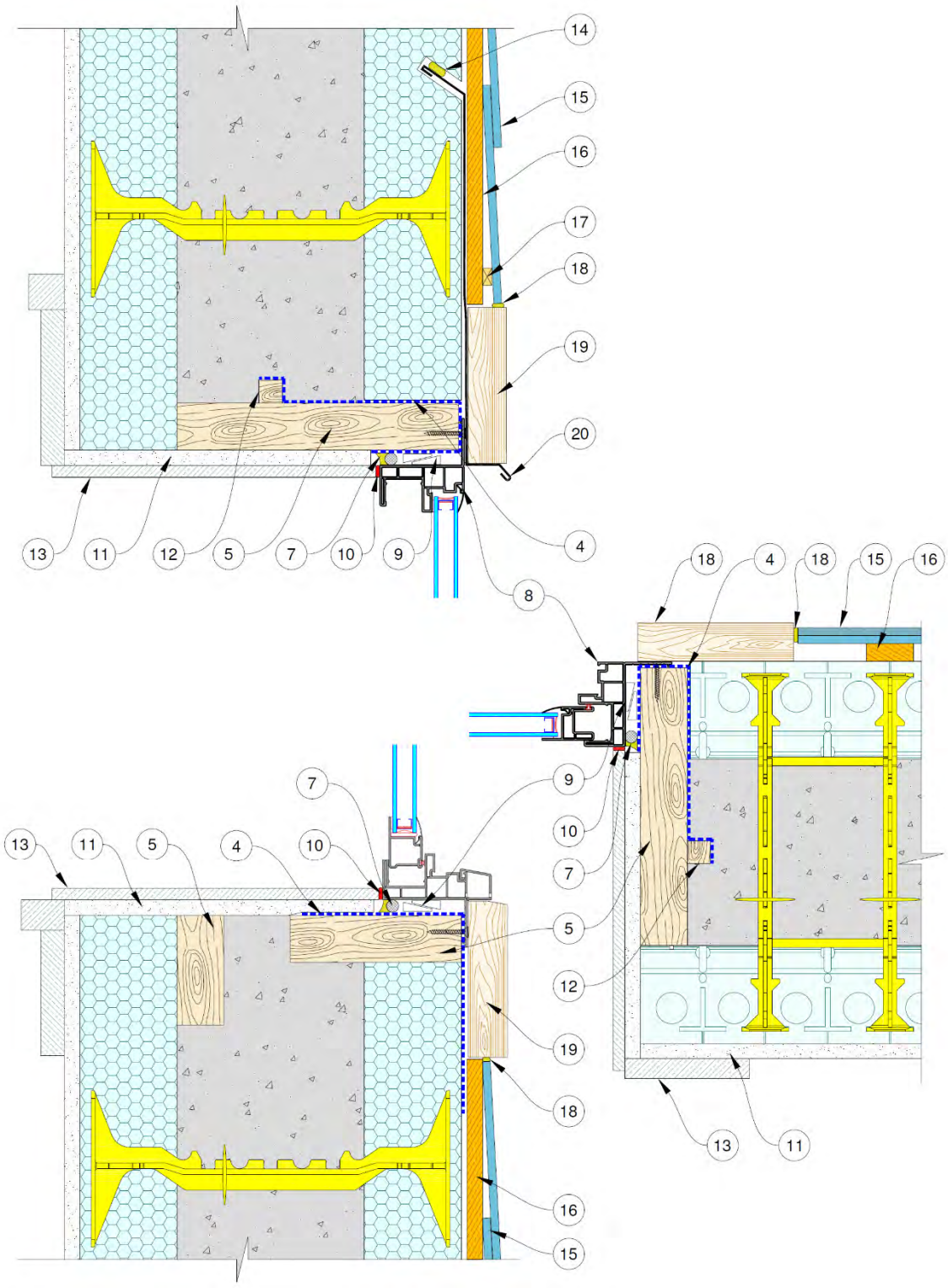


Figure 88: ICF Window Assembly - Wood buck-out, Flanged window flush to exterior, Lapped siding

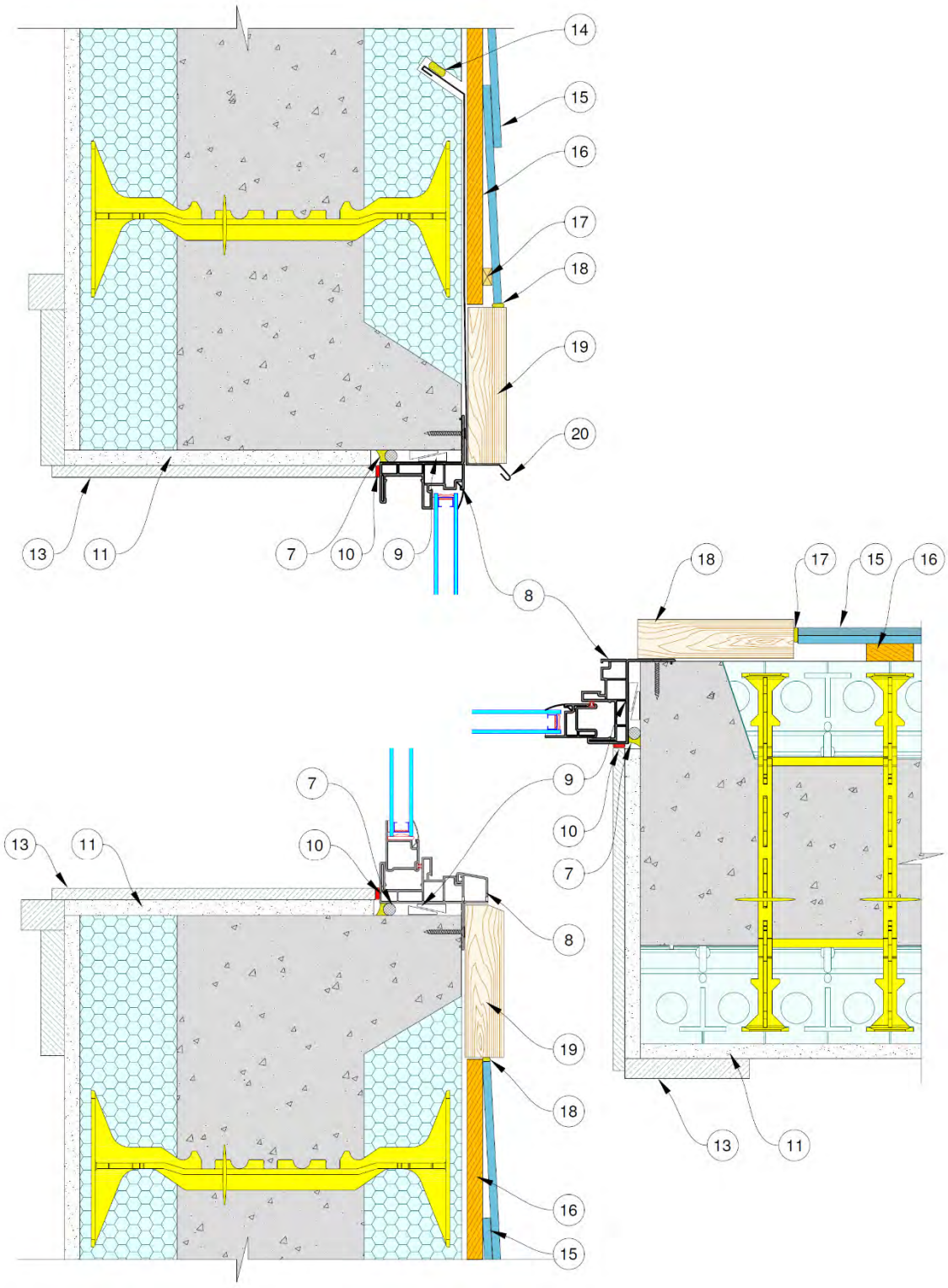


Figure 89: ICF Window Assembly - Direct to concrete, Flanged window flush to exterior, Lapped siding

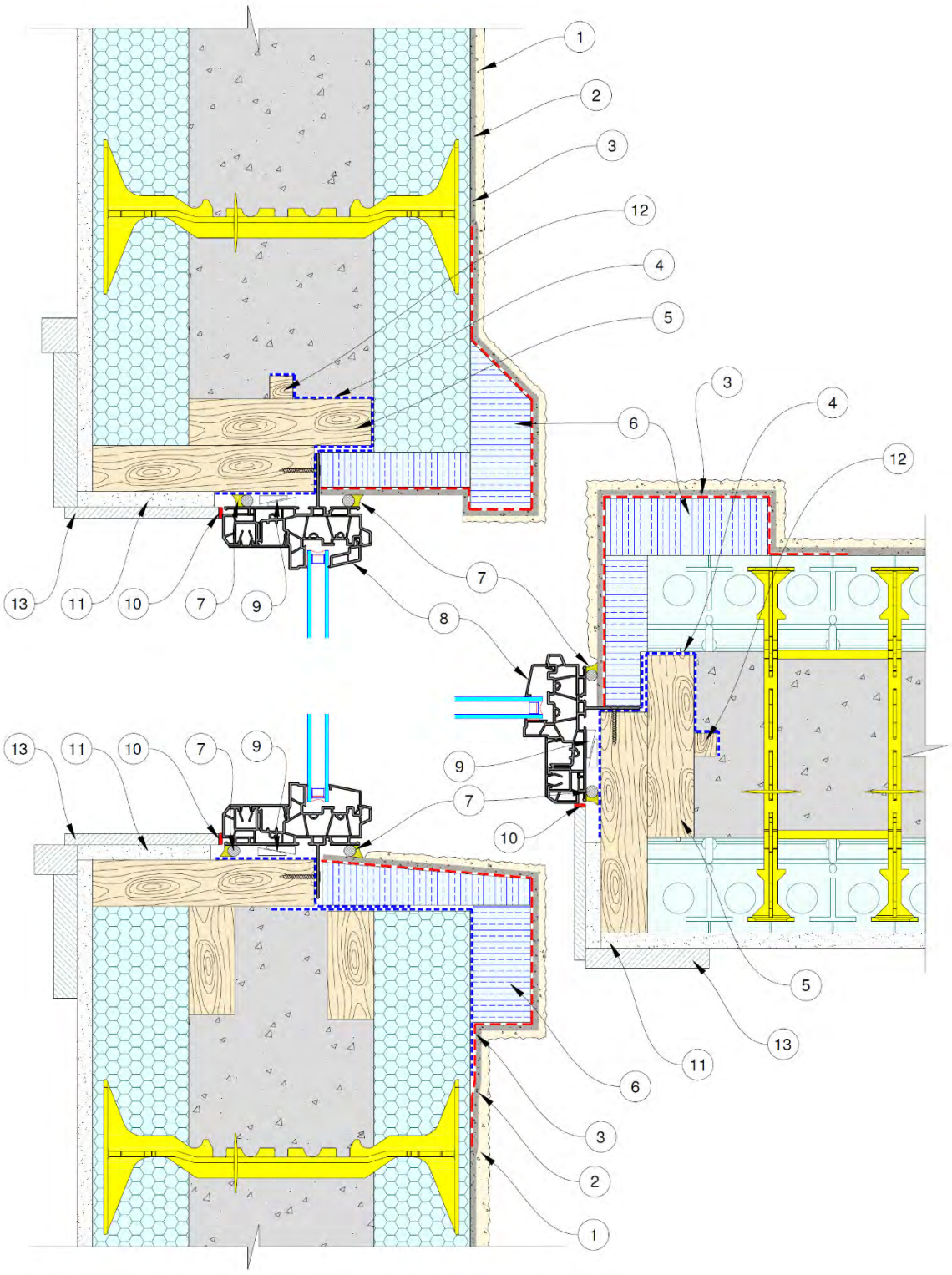


Figure 90: ICF Window Assembly - Wood buck-out, Flanged window centered, EIFS/Stucco lamina

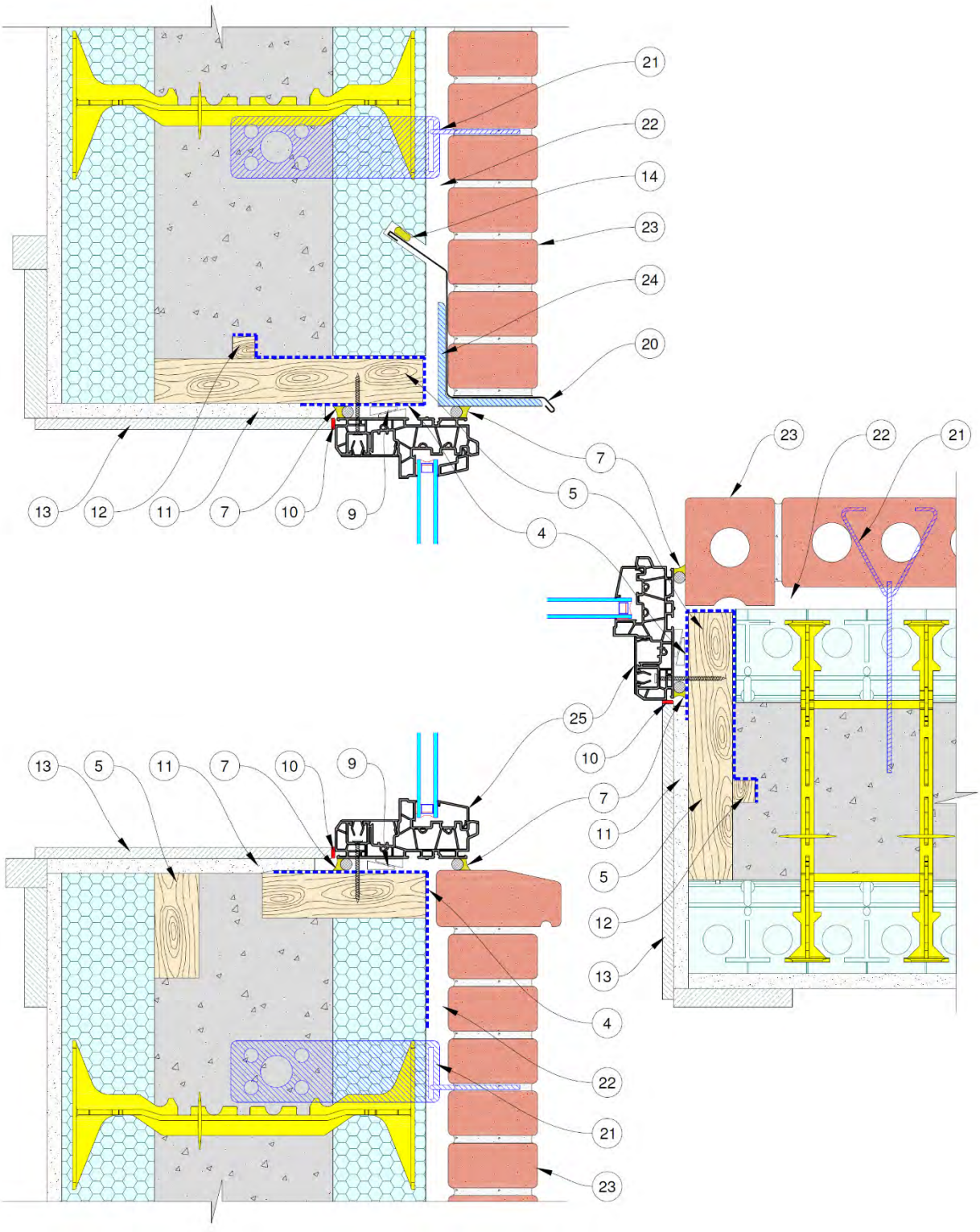


Figure 91: ICF Window Assembly - Wood buck-out, Boxed window flush, Brick veneer

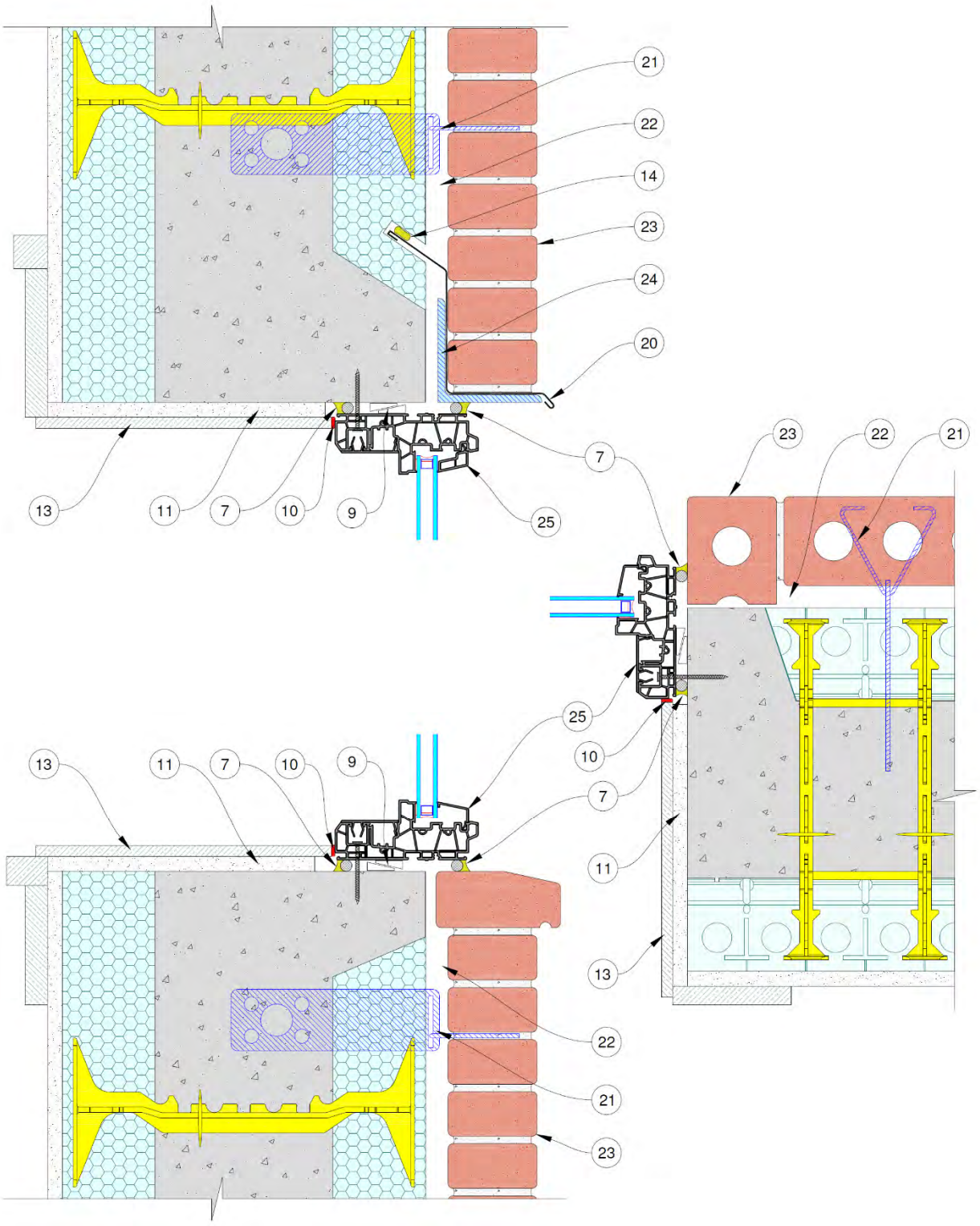


Figure 92: ICF Window Assembly - Direct to concrete, Boxed window flush, Brick veneer

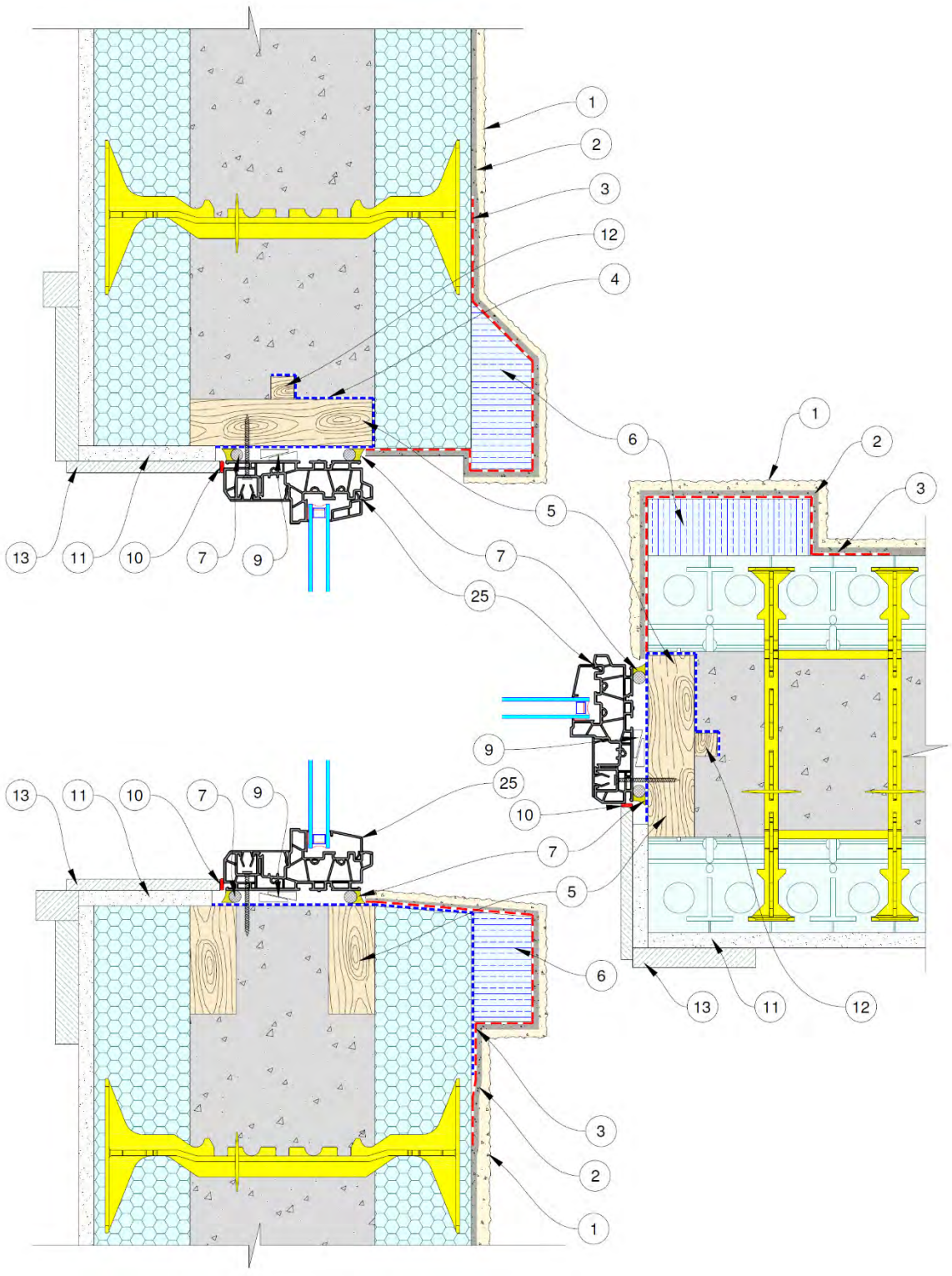


Figure 93: ICF Window Assembly - Wood buck-out, Boxed window centered, EIFS/Stucco lamina

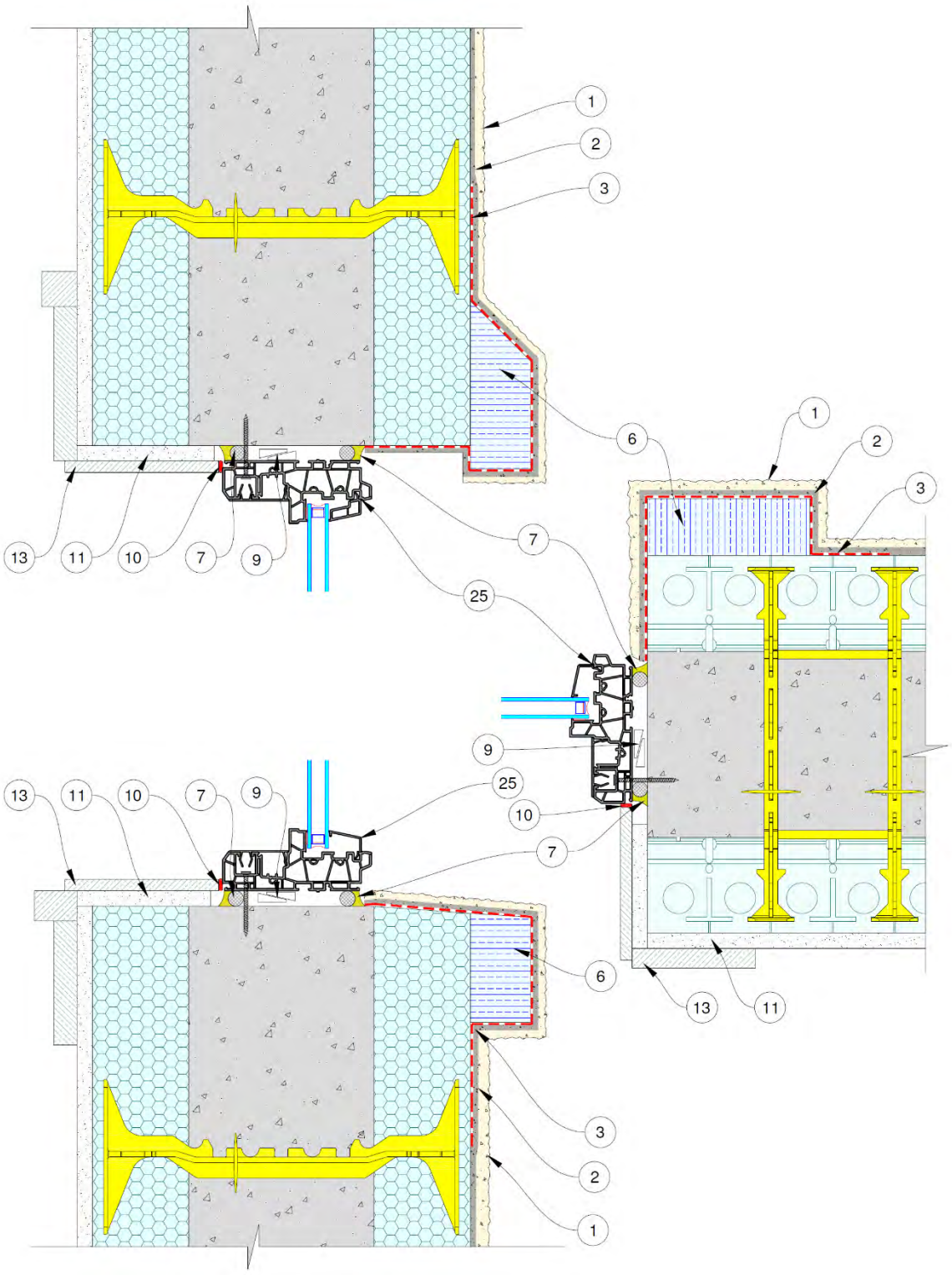


Figure 94: ICF Window Assembly - Direct to concrete, Boxed window centered, EIFS/Stucco lamina

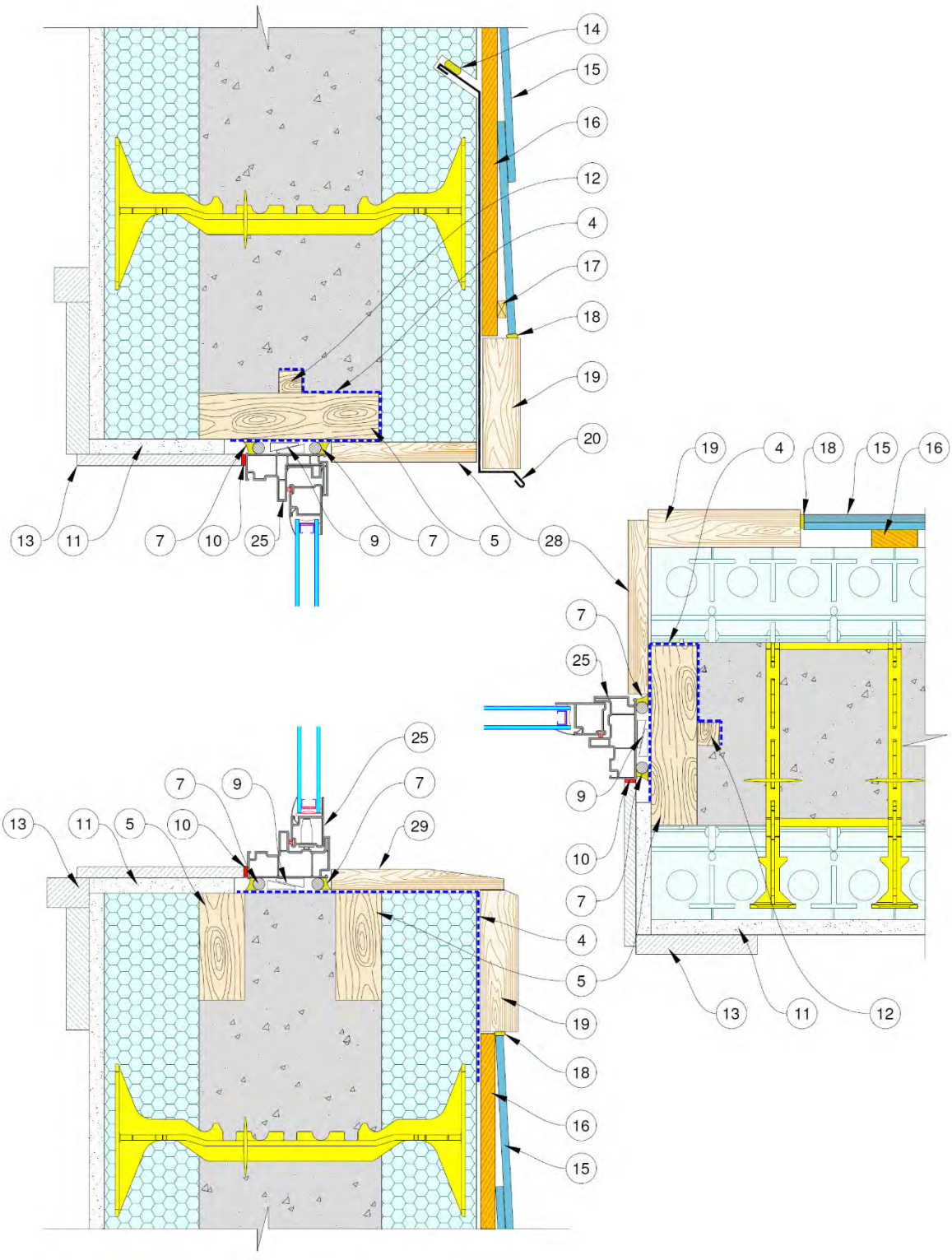


Figure 95: ICF Window Assembly - Wood buck-out, Boxed window centered, Lapped siding

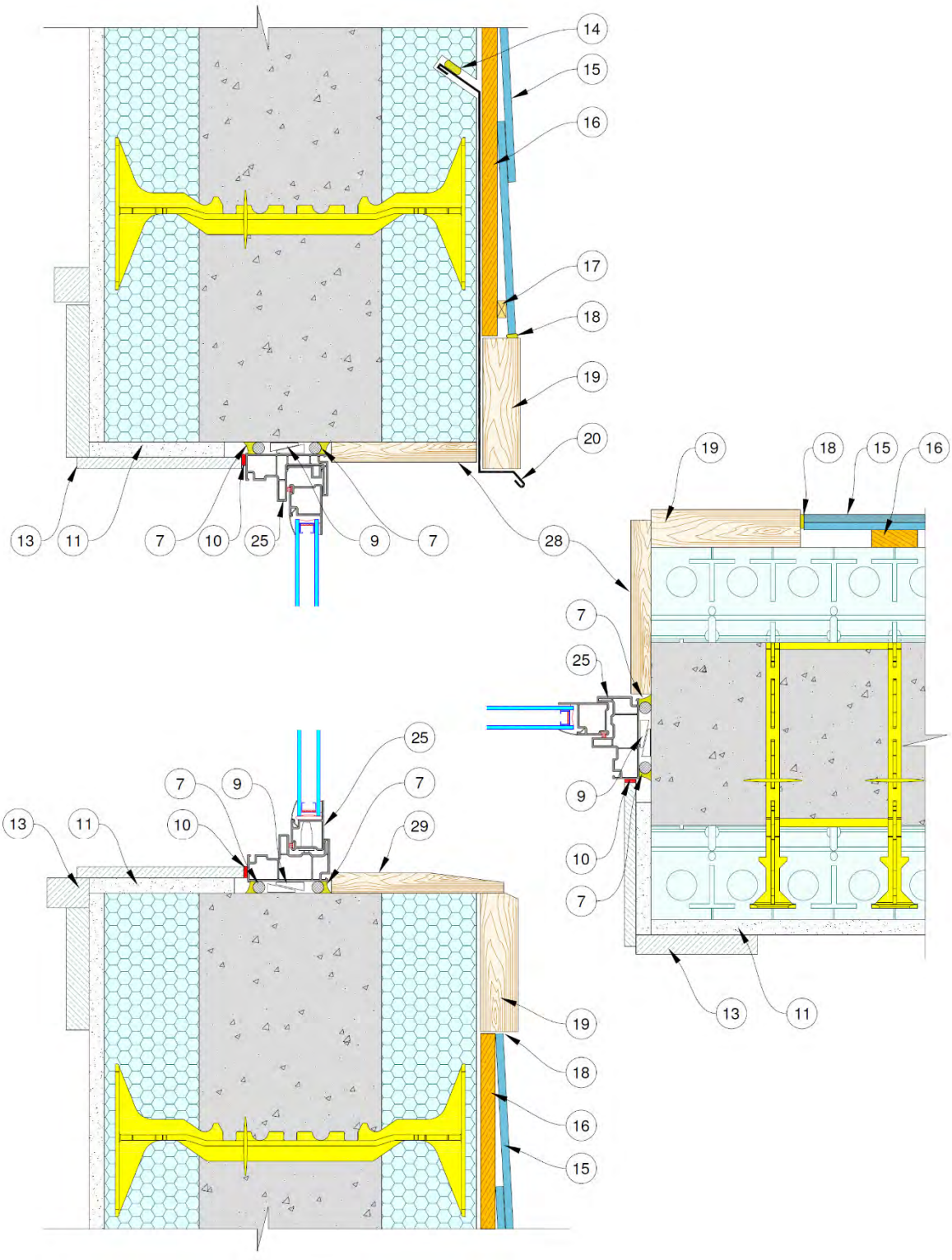


Figure 96: ICF Window Assembly - Direct to concrete, Boxed window centered, Lapped siding

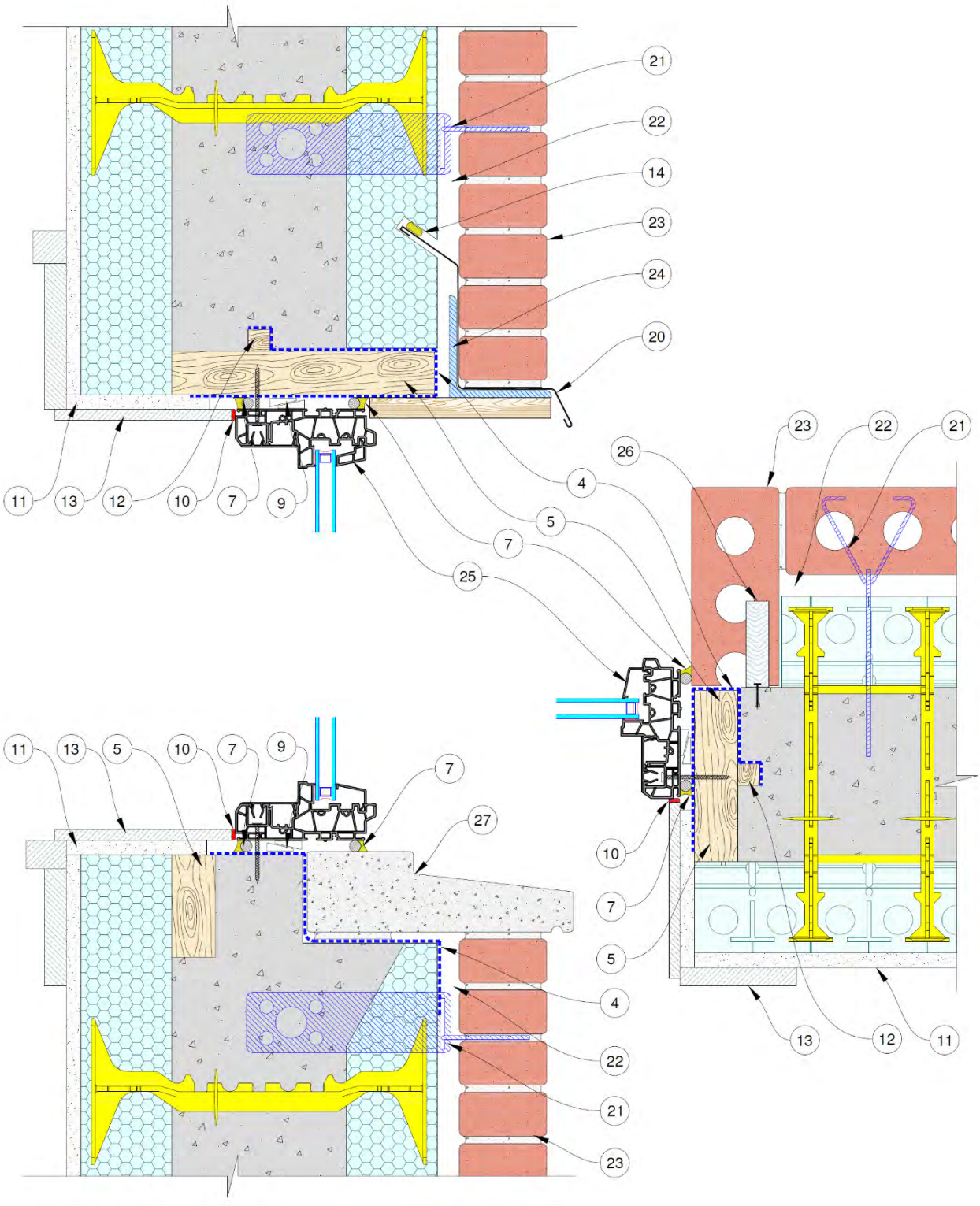


Figure 97: ICF Window Assembly - Wood buck-out, Boxed window centered, Brick veneer

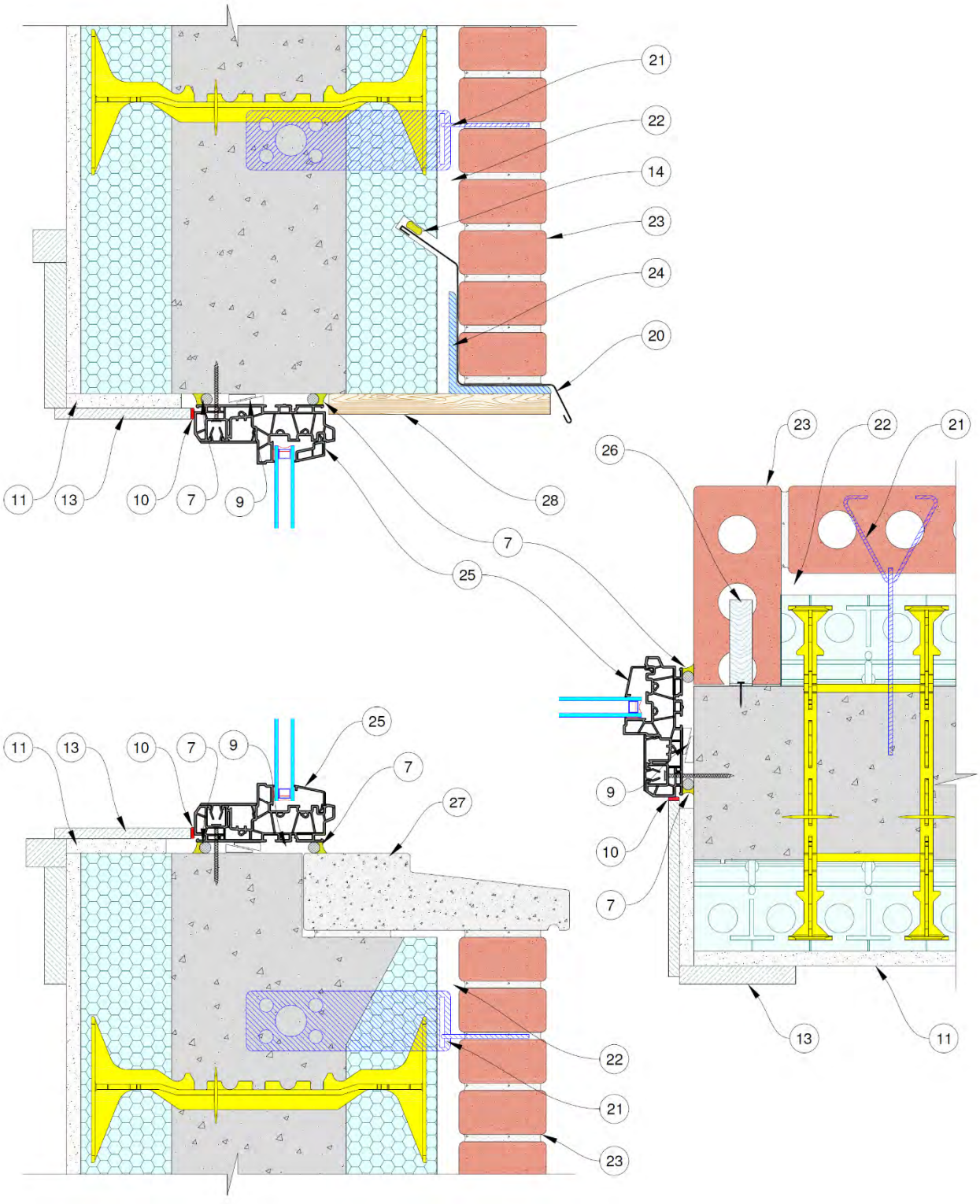


Figure 98: ICF Window Assembly - Direct to concrete, Boxed window centered, Brick veneer

5.1.6 Arched Window Openings

Form arched window openings by using multiple layers of flexible material for the top or “head” of the buck-out. Expert ICF installers use scored plywood strips or flexible plastic strips. A template (or “jig”) is created on a sheet of plywood that defines the shape of the arch. Multiple layers of form material are laminated together, using the template as a guide. The arched piece is then joined to the sides and sill of the buck-out.

Additional braces are used in a “wagon-wheel” pattern to support the arch.

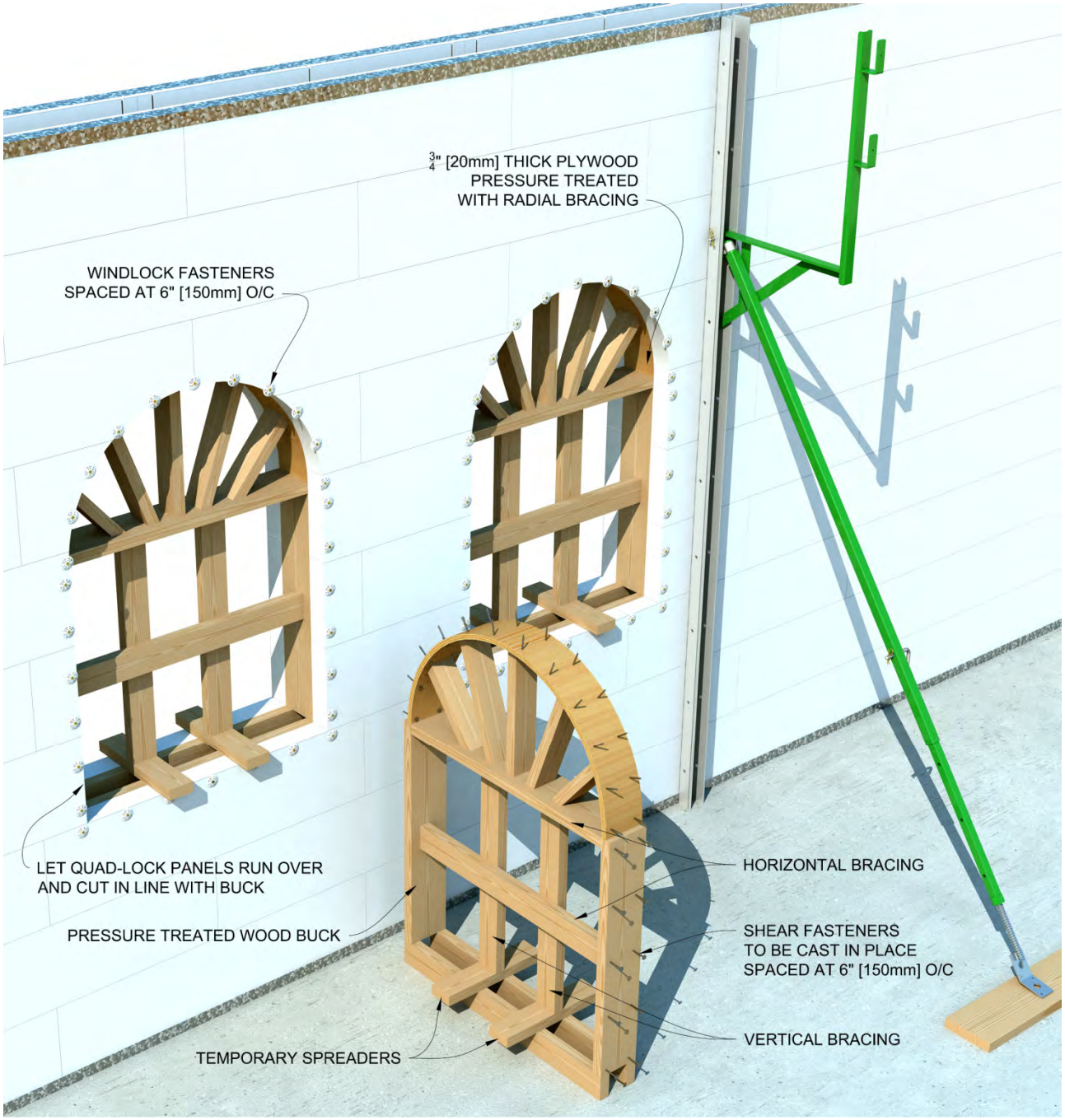


Figure 99: Arched Openings

5.1.7 Forming Openings in High-R *(Low –U)* Walls

Wide wall assemblies present special challenges to ICF installers that can be overcome with the right materials and techniques.

- In the case of wide-wall assemblies, Quad-Lock suggests that the temporary full-width forming technique be used. See Section 5.1.3.1.5 “Full-Width (External) Wood Buck-Outs” on Page 106.
- Heavier forming materials, like Laminated Veneer Lumber (LVL) or 1 inch [25 mm] form ply should be used in place of lighter materials.
- An exterior and interior frame should be attached to the inside and outside face of the form to stabilize the ICF panels and keep the entire form assembly in place during the pour.
- Variations on this technique that prevent thermal bridging & etc. can be incorporated to suit the individual design. A full discussion of these variations is beyond the scope of this manual. Contact the Training & Technical Services Dept. at Quad-Lock to discuss specific details.

The figure below is representative of our suggested forming for wider, high-R value walls.

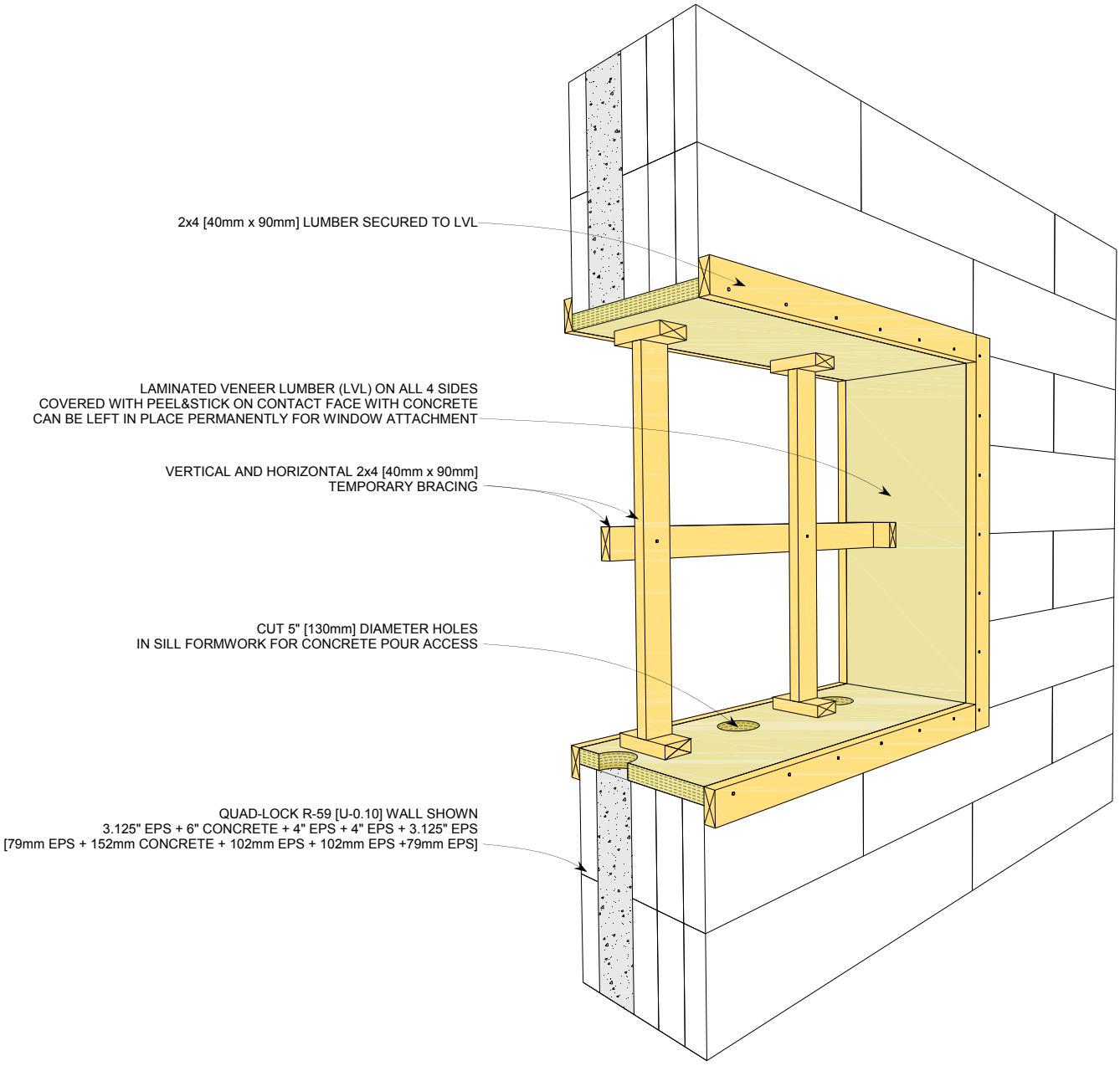


Figure 100: Forming an Opening on Quad-Lock R-59 [U-0.10] Wall

5.1.8 Storm or Typhoon Shutters

Many hurricane-prone coastal or island communities are now requiring storm or typhoon shutters on the exterior openings of buildings. In this case, it is wise to have a concrete surface to mount the shutter directly to, rather than reaching through the EPS panels with long fasteners into the concrete. Long fasteners that penetrate the foam are subject to a "cantilever" condition that will put large amounts of shear stress on them, and are therefore not advisable.

A form must be constructed that is a hybrid of the Internal Wood Buck described above, and an External Wood Buck made from plywood. This hybrid form will allow the concrete to flow to the outside of the building in a band along the /header and sill of the window or door, to which storm shutters can be properly attached. External plywood form components should be made large enough to be screwed to tie flanges above and below the opening. See diagram for suggestions on construction of a hybrid form.

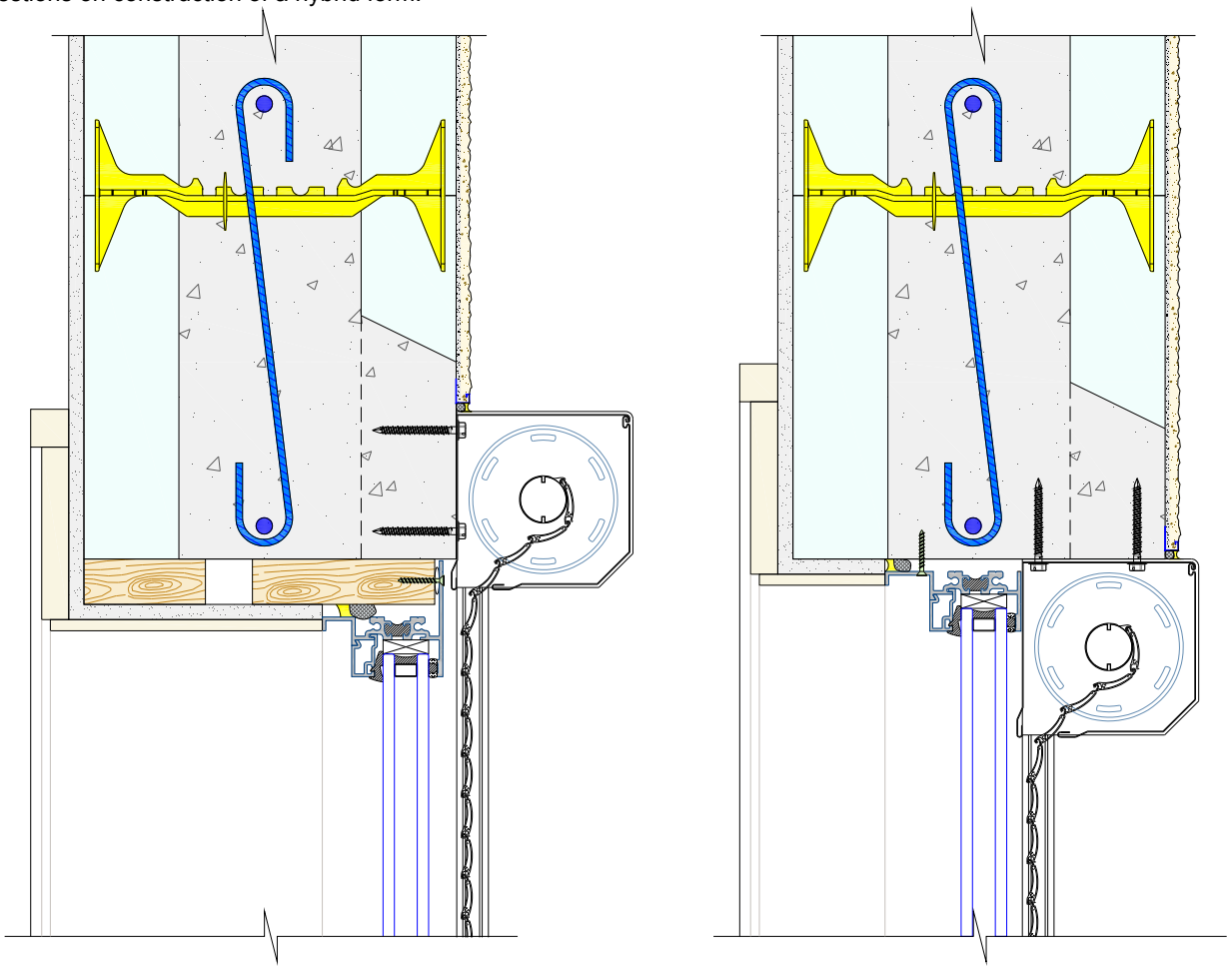


Figure 101: Attachment of Roll-Up Storm Shutter

5.1.9 Window Openings at Corners

When window and door openings occur in locations close to corners, the corners may tend to act more like columns and require additional tie-backs. When an opening is less than 4 feet [1.2m] from a corner, span a 2x from the corner across the opening and well into the wall beyond at about 3 ft. [90cm] O.C. vertically. Screw through the 2x into the tie flanges to anchor the corner back to the rest of the wall on the other side of the opening.

Note: *Canadian prescriptive residential codes [NBCC 9.20.17.4(1)] now requires openings in load bearing exterior walls to be 1200mm [3 ft. 11 in.] from internal or external corners.*

5.1.10 Door Openings

5.1.10.1 Forming Door Openings

Door openings are formed in similar fashion to window openings, but at an earlier stage in the build. Door buck-outs should be placed before or along with the bottom row of panels. This insures that panels on each level are long enough to attach to the forming material of the door.

1. Determine the required rough opening size of the specified door. Add to the rough opening height the thickness of any material that will be added to the entry area. Examples are slabs, door sills, concrete topping layers over slabs, tile, sound barrier materials, wood floors, & carpet.
2. Cut the two vertical side members to match the calculated rough opening size.
3. Cut the head piece of the form to match the rough opening width plus the width of the vertical leg material.
4. Fasten the head piece over the two legs in order to transfer the weight supported by the head onto the two sides.
5. On the footing or slab, mark the center of the door opening, as indicated on the plans.
6. Mark the full width of the door rough opening on the footing or slab, using the centerline mark as a reference point. These marks will indicate where the inside face of the buck-out should be positioned.
7. Place the pre-assembled buck-out on the marks and attach a diagonal brace to secure it to the ground.
8. Using a level and builder's square, bring the buck-out as close to it's final position as possible. Secure the diagonal brace from the inside face of one leg to the ground and a diagonal brace across a top corner to maintain square.
9. Brace the door buck-out vertically and horizontally, leaving no more than about 2 ft. [600mm] of clear span in the forming material. Plastic buck-outs may need additional bracing to maintain their shape.

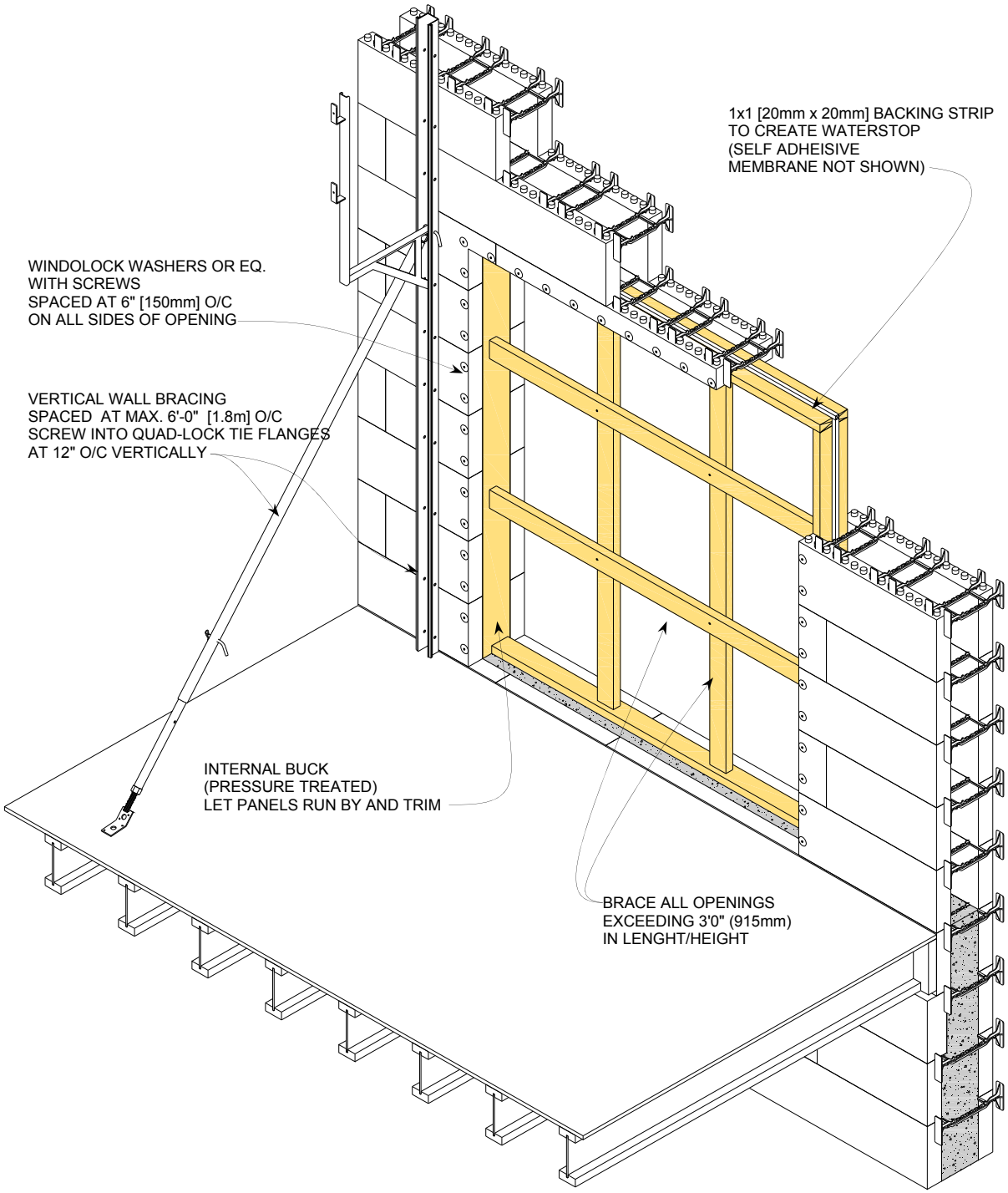
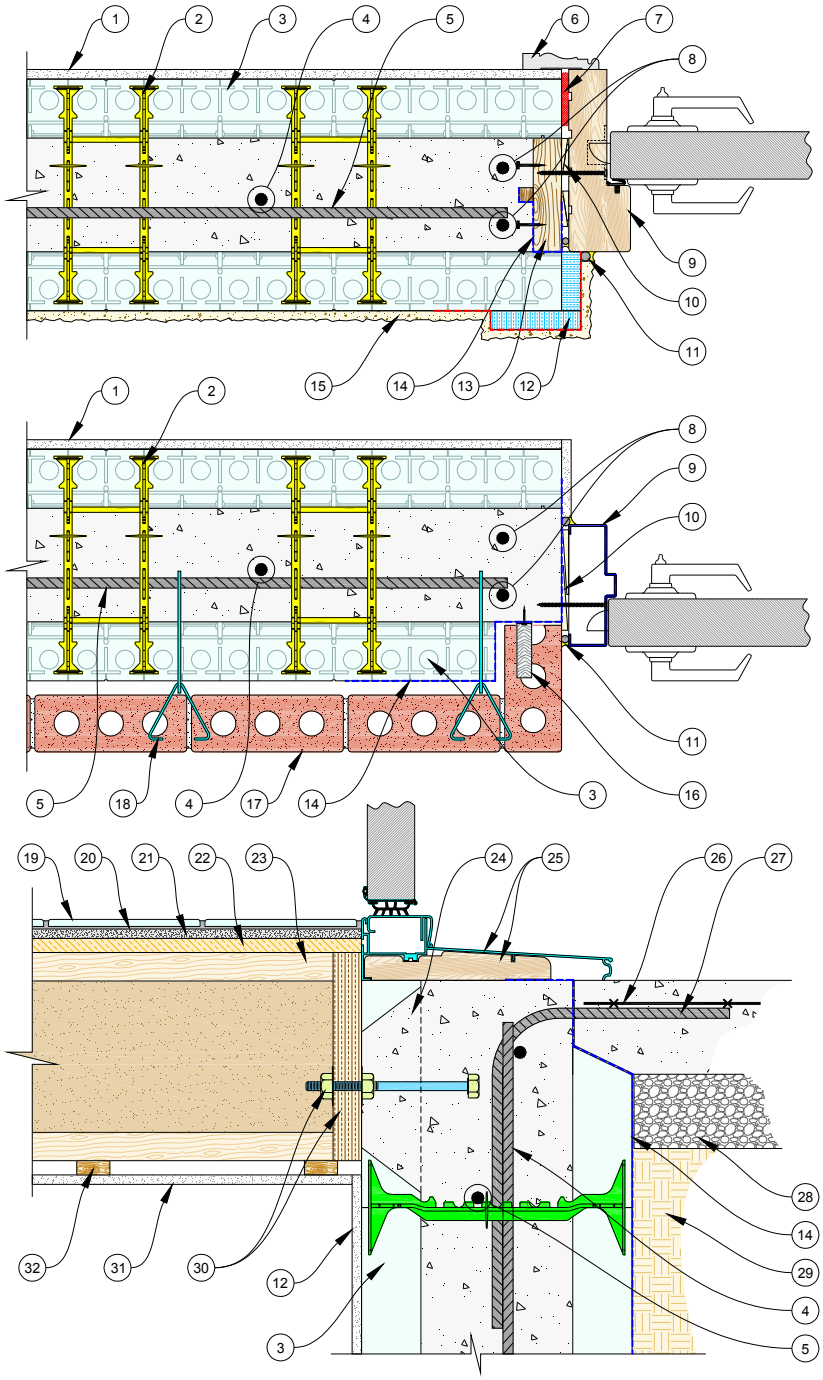


Figure 102: Door Rough Opening

Building Tip: **For multi-story projects where same-sized door openings repeat, expert builders will cut a plywood template to match the exact size of the rough opening. The template is fastened to the inside of the buck-out to serve as a shear plane that keeps the buck-out perfectly in square. They may cut an access hole in the middle of the plywood just large enough to allow workers to pass through the opening during the pour. The plywood template can be re-used multiple times.**



1.	INTERIOR WALL FINISH - FASTEN TO PLASTIC TIE FLANGES
2.	QUAD-LOCK YELLOW TIE
3.	QUAD-LOCK ULTRA PANEL
4.	VERTICAL WALL REINFORCEMENT
5.	CONCRETE ANCHOR BOLT (IF REQUIRED)
6.	DOOR TRIM
7.	SEAL TAPE
8.	JAMB REINFORCEMENT
9.	DOOR JAMB
10.	SHIMS
11.	CAULKING WITH BACKER ROD
12.	STUCCO FOAM TRIM - COVERED WITH STUCCO TAPE
13.	PRESSURE TREATED WOOD BUCK WITH NAILS OR LAG BOLTS
14.	PEEL&STICK FLASHING
15.	EXTERIOR WALL FINISH - STUCCO
16.	STANDARD BRICK TIE
17.	BRICK VENEER
18.	ICF BRICK TIE - INSERTED PRIOR TO POUR AT SPECIFIED INTERVALS
19.	FLOOR TILE FINISH
20.	TILE GROUT
21.	CEMENT BACKER BOARD
22.	SUBFLOOR
23.	WOOD I-JOISTS
24.	CUT OUT EPS TO ALLOW CONCRETE TO COME TO SURFACE AT BOLT LOCATIONS
25.	DOOR THRESHOLD - FASTEN TO CONCRETE
26.	EXTERIOR SLAB REINFORCEMENT AS SPECIFIED
27.	REBAR DOWELS AS SPECIFIED
28.	ZERO COMPACTION SAND OR GRAVEL
29.	BACKFILL
30.	LEDGER BOARD WITH STUDDED BOLTS AS SPECIFED
31.	CEILING FINISH
32.	FURRING FOR CEILING FINISH

Figure 103: Exterior Door at Jamb(Residential and Commercial) and Threshold

1.	QUAD-LOCK YELLOW TIE
2.	BRICK VENEER
3.	ICF BRICK TIE
4.	CUT SAW KERF, INSERT FLASHING AND CAULK AS SHOWN
5.	CONCRETE ANCHOR BOLT (IF REQUIRED)
6.	STEEL ANGLE
7.	CUT OUT EPS TO ALLOW CONCRETE TO COME TO SURFACE AT BOLT LOCATIONS
8.	LINTEL REINFORCEMENT AS SPECIFIED
9.	TRIM
10.	REINFORCED CONCRETE CORE
11.	QUAD-LOCK ULTRA PANEL
12.	INTERIOR WALL FINISH - FASTEN TO PLASTIC TIE FLANGES
13.	SIMPSON ICFVL AT REQUIRED SPACING **OR** REMOVE EPS & BUILD OUT W/ WOOD **OR** BRING CONCRETE TO SURFACE
14.	FASTEN SLIDING TRACK TO SIMPSON ICFVL
15.	HORIZONTAL WALL REINFORCEMENT
16.	VERTICAL WALL REINFORCEMENT
17.	CORNER BRICK
18.	JAMB REINFORCEMENT
19.	PEEL&STICK FLASHING
20.	WOOD BUCK WITH NAILS OR LAG BOLTS
21.	CAULKING WITH BACKER ROD
22.	EXPANSION JOINT

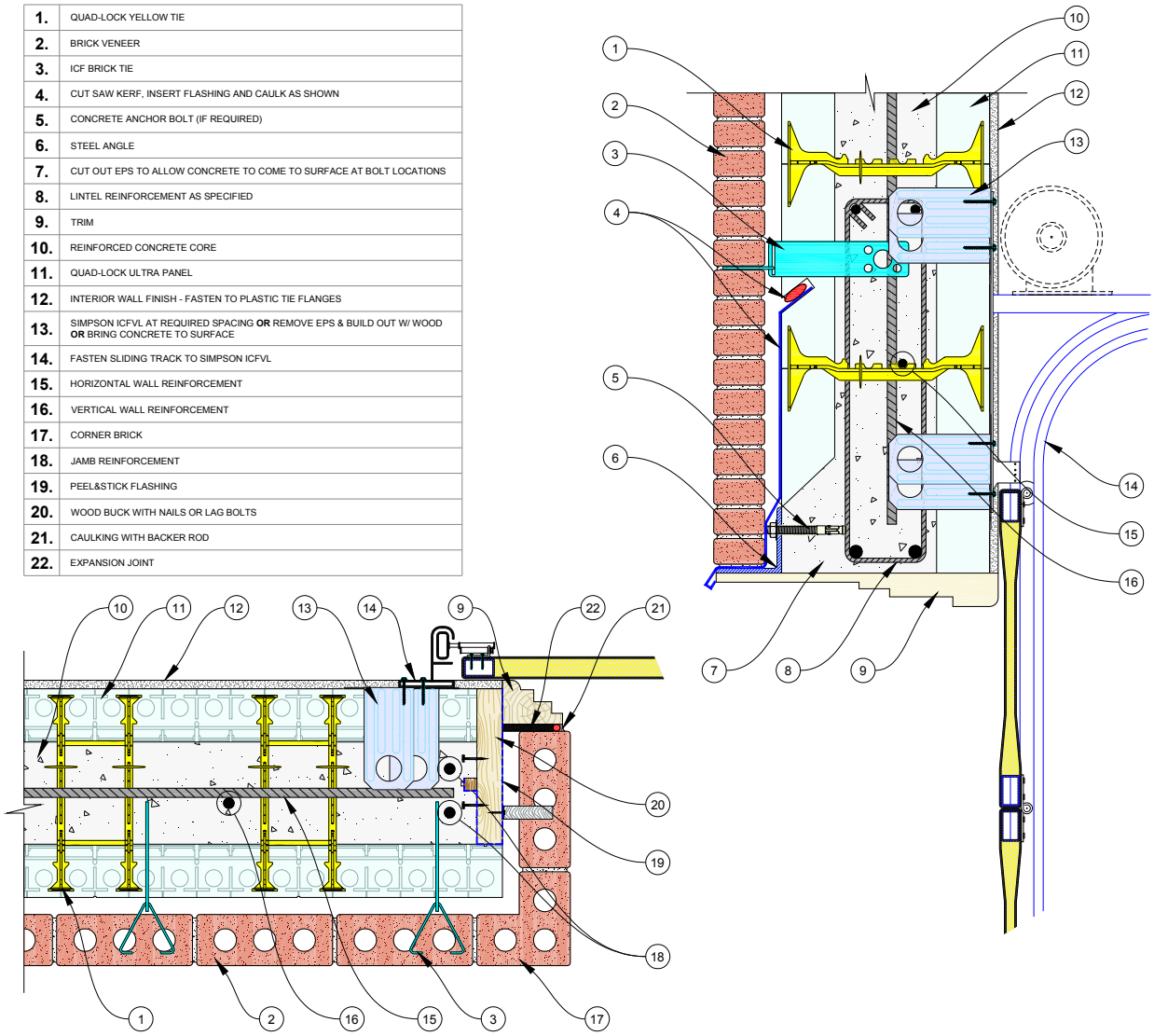


Figure 104: Garage Door at Jamb and Head (Brick Finish)

5.1.11 Window, Door and Penetrations Checklist

Pre-Construction

- ❑ Window and door rough opening sizes confirmed (Called-out size? Over-sized?) Ductwork and mechanical opening sizes confirmed.
- ❑ Electrical and plumbing supply entry points located
- ❑ Floor elevations and finishes accounted for in placement of opening elevations
- ❑ Finish details checked and provisions for finish attachment made during pour if possible

At the Site:

- ❑ Rough opening sizes checked; Elevations checked
- ❑ Panels secured to internal buck-outs with screws and Wind-Locks (both sides). Fill gaps with spray foam to meet full wall cavity dimension if necessary.
- ❑ Openings checked for plumb, straight, square and level
- ❑ Openings braced horizontally and vertically (if over 3 ft. in size)
- ❑ Sills open to allow concrete pour & consolidation (Always pour sills first!)
- ❑ Block-outs or sleeves in place for utility entry (water supply, waste lines, gas supply, electrical supply, furnace flues, HVAC)
- ❑ Lintel dimensions and reinforcement confirmed
- ❑ Attachment points for garage doors or other heavy hardware placed (Simpson ICFVL or equivalent) Confirm attachment points for items like kitchen cabinets, flat screen TV, & etc.
- ❑ FS panels in place to fasten soffit supports or baseboard trim, other finish items

6 BRACING & ACCESSING WALLS

Quad-Lock recommends the use of a pre-fabricated, re-useable metal alignment and scaffolding system. Metal Bracing systems are available up to 30 feet [9m] high. Most Quad-Lock dealers have these systems for rent or sale. If you do not have access to a Metal Bracing system you will need to construct bracing using lumber and turnbuckles available from most rental yards. *(See figure below.)*

***SAFETY NOTE**: Most national and regional safety standards require fall protection or guardrails for work platforms over 6 ft. [1.8 m] in height. In addition, guardrails generally must be a minimum 39" [991mm] in height, and be able to withstand 200 lbs [91kg] of lateral pressure. Consult your regional government safety officials for current regulations, and be sure your bracing system is constructed with these regulations in mind. Modern ICF wall bracing systems offer guard rail attachments that are designed to be in compliance with national safety regulations. In the event of a conflict between this manual and the applicable local regulations, local regulations will prevail in all cases.*

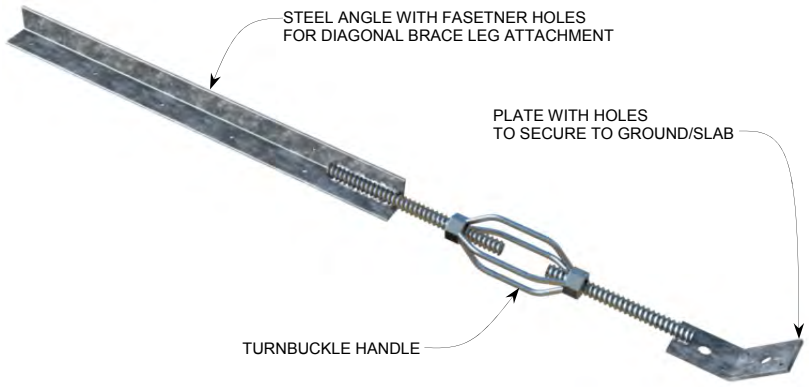


Figure 105: Typical Form Aligner (Turnbuckle) Device

6.1 GENERAL COMMENTS ON ICF BRACING

Remember these points about bracing a Quad-Lock wall:

- Braces typically need only be used on one side of the wall
- Vertical braces are there to plum, align, and straighten the wall, not hold concrete in the wall
- Braces are easier to “push” than to “pull” once the concrete is in the wall. Cheat the center of the wall slightly in towards the bracing, and push it into position immediately after concrete is poured.
- Do not over-span lumber used for platforms. Generally, 6 ft. [2m] is a maximum desired span for 2x lumber.
- Screw braces (metal or wood) into every tie flange on 12" [305mm] centers.
- Remove braces only after concrete has attained sufficient strength (See Chapter 8, Cure Time and Removal of Bracing on Page 164).
- Do not rely on bracing to support a foundation or basement wall against backfill. (See Chapter 8, Section 8.1.4.1 “Cure Time and Back-Filling” on Page 164)
- Adequately brace all Window and Door Bucks
- Always assure alignment along top of walls using Metal Tracks, hoizontal whalers or a combination of thereof.

6.2 BRACING INSTALLATION

6.2.1 Foundation and Crawl-Space Walls

6.2.1.1 Bracing Foundation Walls

If building a stem wall up to 4' [1.2m] high, vertical bracing is usually not required. Simply place a diagonal brace every 6' [2.0m] and secure it to the ground and to the top track or ladder brace at the top of the wall. Often times, short foundation walls are filled in one pass and can be easily aligned before the concrete sets.

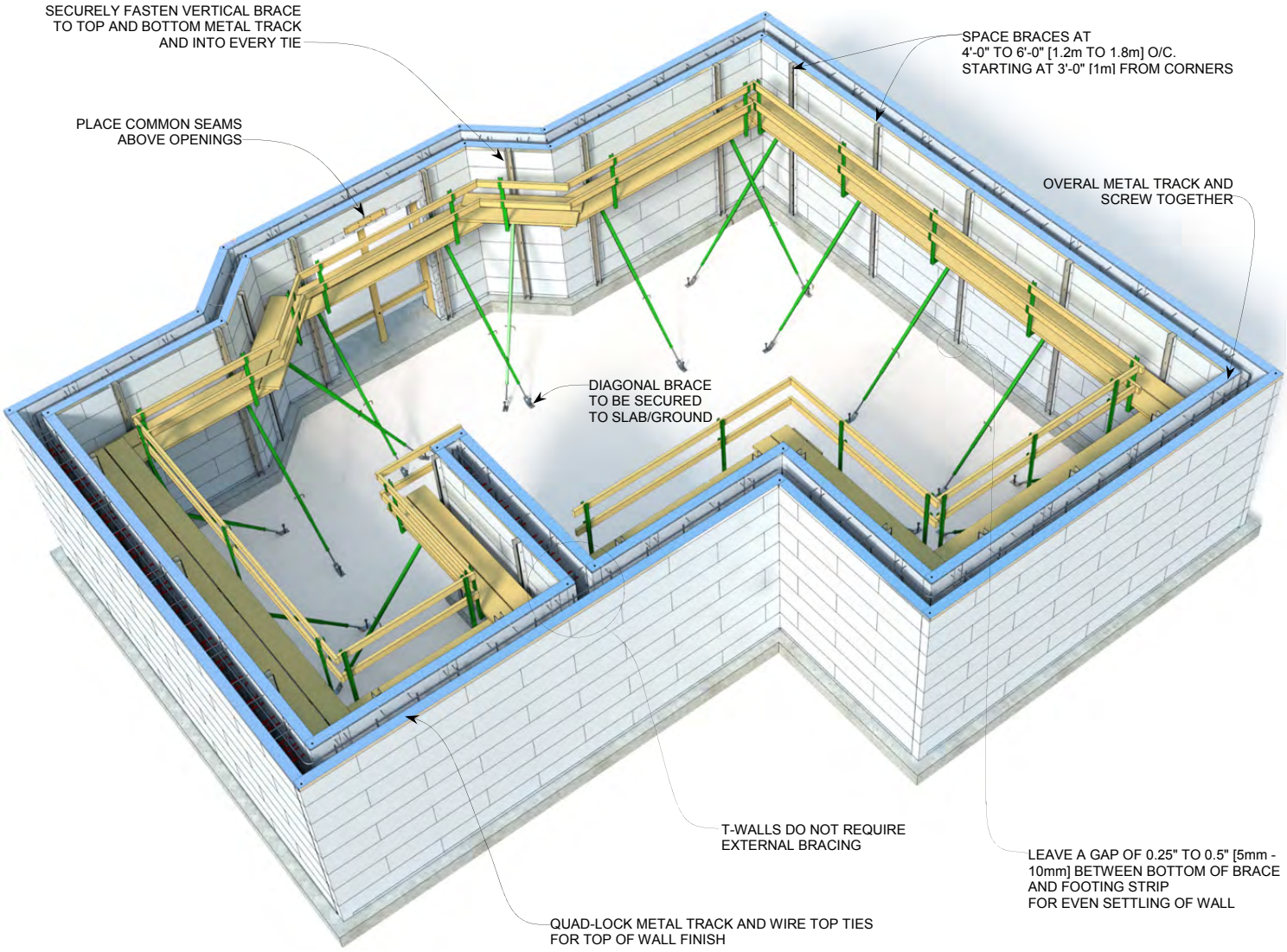


Figure 106: Metal Bracing System

6.2.2 Basement and Above-Grade Walls

6.2.2.1 Bracing Assembly

Many people assume (in error) that bracing is necessary to hold concrete in the wall. The Quad-Lock system is designed to hold concrete via its own internal support mechanism. Vertical bracing is used to a) bring the wall into 'plumb', b) control any deflection (bowing) in the ICF wall and c) straighten the wall along the entire length. A vertical bracing assembly consists of a vertical member (or 'strong-back') and a diagonal member that is anchored to both the vertical member and the ground. The diagonal leg usually has a turnbuckle device at one end or the other to allow adjustment in length.

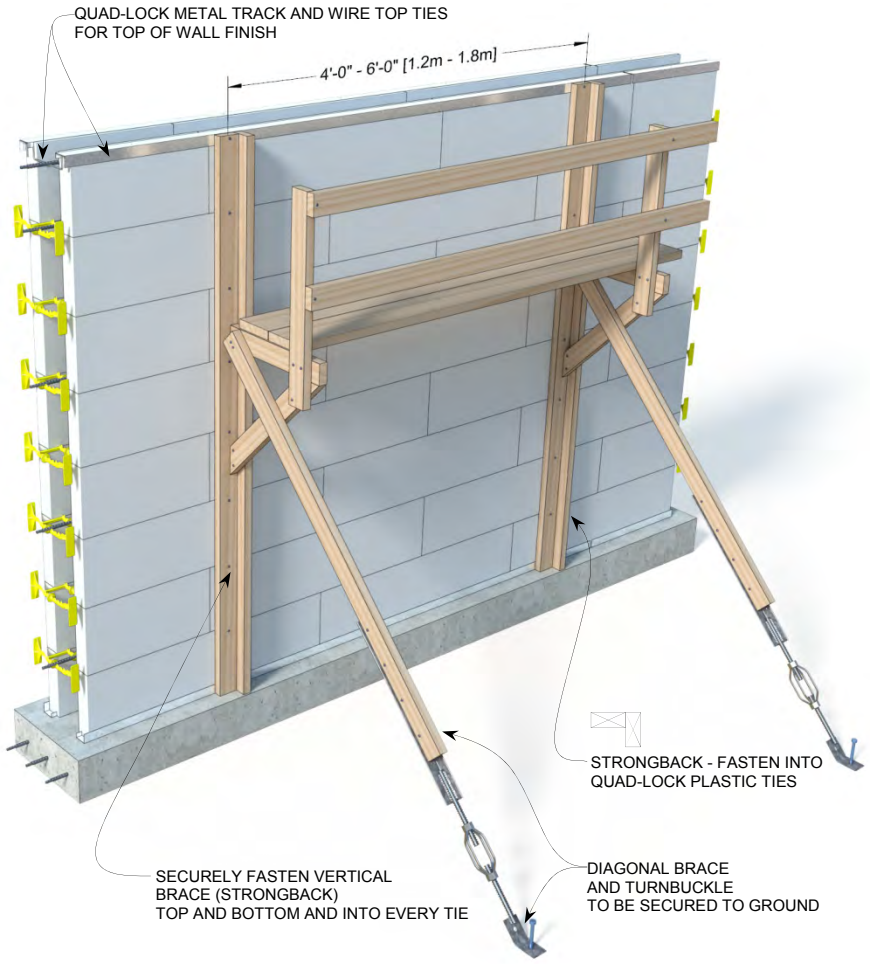


Figure 107: Site Constructed Wood Wall Bracing

6.2.2.1.1 Vertical Strong-Backs

When you have built as high as you can comfortably reach from the ground, vertical 'strong-back' braces can be attached to the wall. Strong-backs can be fashioned from dimension lumber screwed together in an 'L' shape, or use a commercially available steel or aluminum ICF bracing system.

Brace only from one side of the wall (preferably the inside) unless conditions require additional braces on the opposite side of the wall. Screw bracing members to tie flanges using #10 sheet-metal or wood screws every 12 inches [610mm]. Start your bracing layout 3' [1m] from all 90° corners, angles, T-Walls etc. Fasten a vertical brace to each row of ties using screws.

Ensure that the surface of the EPS is pulled tightly against the vertical brace, but take care not to over-drive and strip the screws in the plastic. Again, fasten vertical bracing to each row of ties.

6.2.2.2 Adjustable Diagonal Braces

Diagonal braces are used to steady the top of the wall against the ground, and to provide a means of adjusting alignment of the wall. Expert ICF installers use a turnbuckle device at one end of the diagonal brace. When installing diagonal braces, have one crew member use a level to rough plumb the wall. Remember to adjust turnbuckles so they will have adequate travel for fine tuning the wall later.

Place braces all the way around walls **every 4 - 6 feet [1.2-1.8m]**. Door openings and larger window openings should have a vertical brace on either side of the opening. Larger window openings should also have a vertical brace in the center of the opening to keep the lintel (header) properly aligned.

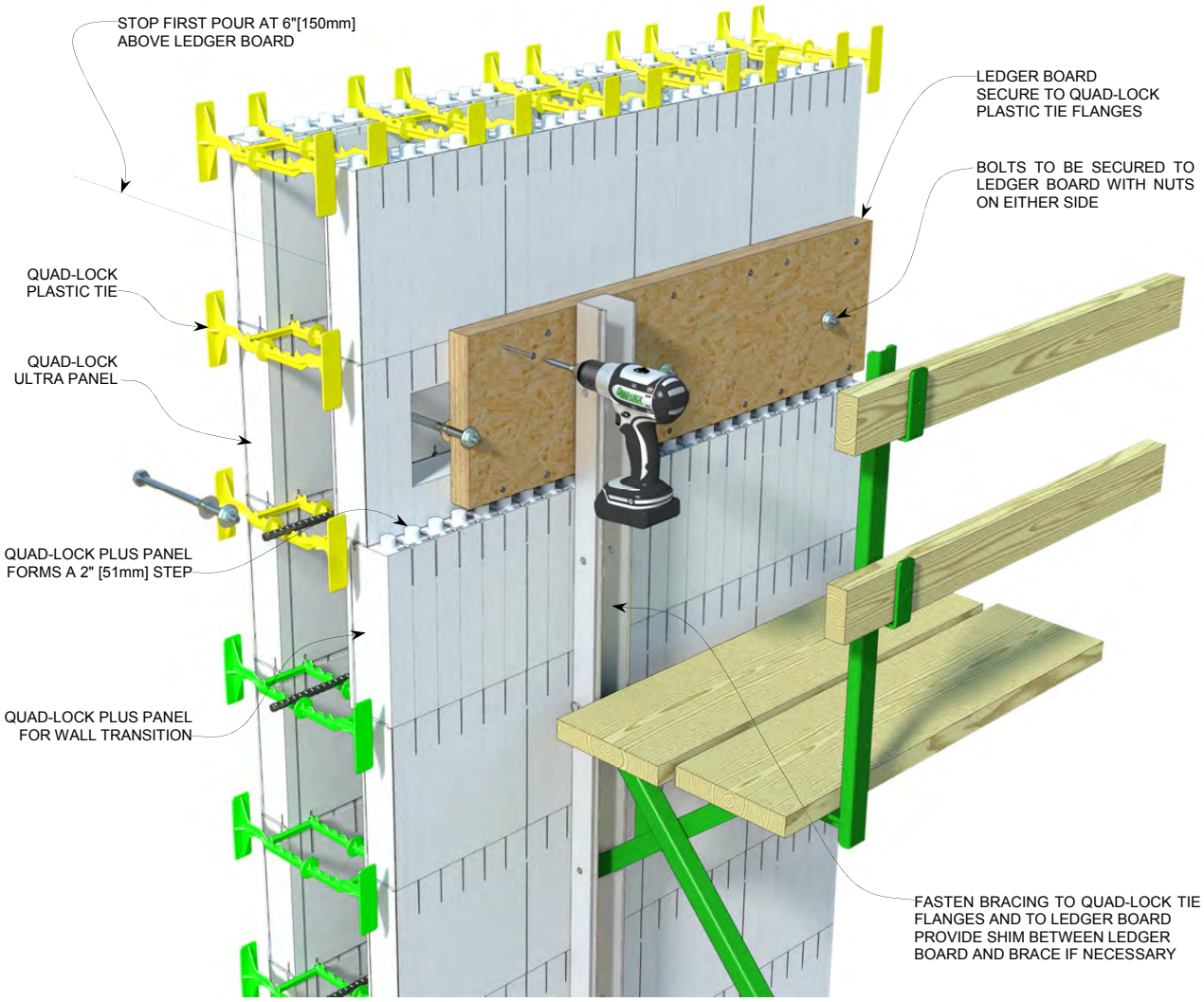


Figure 108: Wall Bracing with Ledger Board in Place

6.2.2.3 Bracing at Corners

The unique Quad-Lock Corner Bracket system does an excellent job of containing concrete at corners and maintaining the 90° shape of the corner. However, if the footings are out of level or if care has not been taken to bring the corners straight up (plumb), some bracing on outside corners may be necessary.

- For first-story corners, place brace assemblies on the outside of the corner and push it into plumb.
- For second-story (or higher) walls, brace assemblies will have to be attached to the inside of the corner. Place vertical strong-backs within about 16 inches [40cm] of the corner on each face. Be certain to screw vertical strong-backs to tie flanges at each row, 12 in. [305mm] on center. Use turnbuckles attached to both diagonal braces to draw the corner into plumb.

- Bracing at T-Walls and Pilasters
- T-Walls and Pilasters should have a set of vertical bracing on both sides of the intersection within 3 ft. [1m] .
- For T-walls the 'leg' of the T should also be braced within 3'-0" [1m] of the intersection.
- At T-Walls, if you are not using overlapping Outside Corner Brackets to contain the T-intersection *(see Chapter 4, Section 4.2.1 on Page 71),* place a brace at the outside of the T, and in line with the leg of the T.

6.2.3 Bracing Angled Walls

6.2.3.1 Single Story Angles

On the outside of the angle place a brace on both sides of the angle at a maximum of 1 foot [30cm] from the apex of the corner. Using diagonal braces with turnbuckles, push (or pull) the corner assembly into plumb.

6.2.3.2 Multi-Story Angles

Like 90° corners, multi-story angles will have to be braced from the inside and 'pulled' into position.

- The best option might be to rip two pieces of dimension lumber to form the exact angle of the wall.
- Screw the two beveled pieces of lumber together, then fasten the assembled vertical brace to tie flanges on the inside face of the angled corner.
- Use a single diagonal brace and turnbuckle to pull the corner into plumb.

6.2.4 Bracing Radius Walls

Radius walls should have additional bracing, depending on the severity of the radius, usually a maximum of 4 ft. [1.2m] spacing between vertical braces.

- The smaller the radius, the more bracing should be used. In general, reduce spacing to 4 feet [1.2m] on center or less, if more cuts have been made for tighter radii.
- Experts find it more effective to place radius bracing on the outside of the radius, pushing (rather than pulling) against the natural tendency of the wall to lean outward.
- No later than the completion of row #2, stand your vertical braces along with their adjustable diagonal braces. Adjust all braces into perfect vertical (plumb) position.

IMPORTANT:	**An un-braced radius wall naturally tends to lean away from the bend. Contain this tendency with vertical braces set into position no later than completion of the second course of radius panels. Use the vertical braces as a "template" to bring the wall up straight.** **A radius wall built out-of-plumb will be nearly impossible to bring into alignment, since the inside of the wall needs to get shorter to do so!**

6.2.5 Bracing Tall Walls

6.2.5.1 Proprietary ICF Bracing Systems

Most commercial grade wall bracing systems have brackets available that will allow the extension of the vertical bracing members from the first 10' [3m] section.

- Leave the first level bracing in place, and extend upward into your next pour with the extension brackets.
- Extra long lateral turnbuckle braces are also available to allow fine adjustments on taller walls. Remember that working platforms over 6 feet in height must have guardrails attached in most jurisdictions.
- Modern ICF bracing systems are equipped with railing adaptors that are in compliance with local and national safety standards.

Figure 109: Bracing Tall Walls

6.2.5.2 Adapting to Conventional Scaffold Equipment

Some systems have adaptors that will fasten the vertical strong-backs laterally to conventional scaffolding which is erected next to the wall. Other systems are designed to fit on top of conventional scaffold brackets and moved from story to story as the building progresses. Contact the Quad-Lock Training and Technical Services Dept. for details on bracing options.

If conditions and/or specifications require minimizing the free-fall of concrete, Quad-Lock recommends that 6" [15cm] diameter access ports be cut in the wall at about 6' [1.8m] intervals (make sure to not cut areas that have ties). Pour the wall from the side until the concrete reaches the level of the cut-outs. Steel should be vibrated from the top of the wall to ensure consolidation of concrete. Save the foam cut-outs and put them back in the wall, bracing them by screwing plywood over the holes and into ties. Continue with the pour from the top (or the next set of access ports), as soon as you are able to place concrete without excessive fall, which may cause segregation of the concrete.

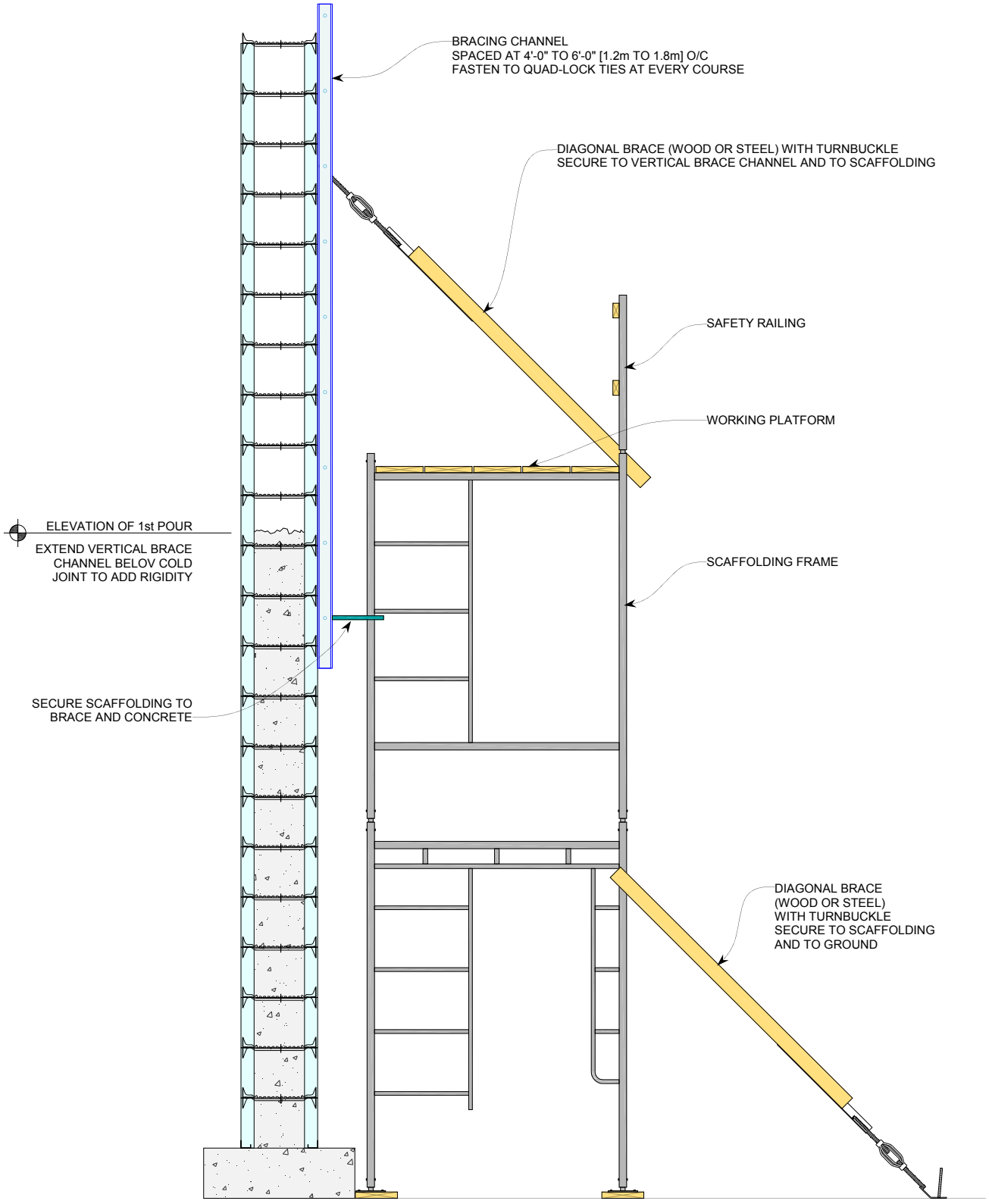


Figure 110: Bracing Tall Walls with Scaffolding

6.3 ACCESSING WALLS FOR POURING

6.3.1 Scaffold and Railings

Besides a means of stabilizing & aligning the wall during the pour, a way to access the top of wall should be provided. The usual way to do so is to provide a walkway for crew members, either incorporated into the bracing mechanism or separately supported on scaffolding.

- Some jurisdictions require that the scaffold that supports the crew and the adjustment mechanism for the wall are separate entities. If this is the case, an additional set of scaffolding must be built on the opposite side of the wall.
- In all cases, be certain of the safety regulations in your area and take precautions to protect the safety of crew members while building and pouring an ICF structure.
- Place your scaffolding and railings, and double check that every component is complete, securely fastened, and able to support the weight of crew members and their equipment.

Building Tip:	**With Metal Bracing Systems, place screws at the top of the provided slots and do not over tighten. This will allow the wall to settle evenly when concrete is placed.**

6.3.2 Bracing and Alignment Checklist

Pre-construction:

- ❑ Estimate for number of bracing sets completed; (1 set every 6 ft.[2m)] + 1 at each corner) Additional braces as needed at openings, angles, etc.
- ❑ Wall elevations checked to confirm adequate brace height.
- ❑ Plan in place to secure diagonal turnbuckles to ground or to floor surface.
- ❑ Wood materials available for additional brace fabrication and safety rails; Pre-drill verticals at 12” o.c. [30cm o.c.].
- ❑ Metal track ordered for bottom and top of wall. Include Wire Top Ties for top of wall.
- ❑ Building lines snapped on footings or slab to indicate outside of foam panels.

Metal Track:

- ❑ Chop saw and/or metal shears on site to cut track.
- ❑ Roto-hammer or PAT device (+ fasteners) on site to fasten track to concrete. (PAT requires ear protection and safety goggles)
- ❑ Metal track fastened on building lines for outside and inside panels; Space tracks with wood spacers cut slightly shorter than actual cavity width. Fasten to concrete with PAT or drilled anchors at max. 24” to 30” [60 to 75cm] + 12” [30cm] from each end of track.
- ❑ Metal track thoroughly checked for secure fastening around entire perimeter.
- ❑ At top of wall, remove interlock knobs; place metal track and wire top ties over panel edges.

Bracing:

- ❑ Vertical bracing strong-backs placed when wall reaches maximum 5 ft. [1.5m].
- ❑ Braces secured to each tie flange with fasteners specified by brace manufacturer.
- ❑ Diagonal turnbuckle braces adjusted to allow adequate adjustment length on threaded portion (in or out) when placed at **maximum 45 degree angle** to vertical strong-back.
- ❑ Long walls over-adjusted slightly towards bracing units to compensate for natural tendency to lean out during pour.
- ❑ Matching thickness wood blocks attached to each side of all corners (top of wall) to accommodate string line. String line in place & tight to check alignment.
- ❑ Common seams secured with plywood cleats AFTER corners are plumbed. Spray foam in remaining gap.
- ❑ Scaffold planks, safety rails, ladders and restraints installed according to governing safety regulations for your region.

7 FLOOR, ROOF & WALL CONNECTIONS

7.1 QUAD-LOCK WALL-TO-FLOOR CONNECTIONS

Quad-Lock walls can accommodate nearly any wall-to-floor connection detail, including:

- Dimensional lumber
- Engineered wood joist
- Steel joist
- Heavy timber
- Suspended concrete poured-in place slab or hollow-core plank
- Concrete T-beam slab construction.

7.1.1 Ledger Connections for Wood Floors

Ledgers may be attached to vertical wall faces using appropriately sized bolts or proprietary ledger bracket designs. Building codes may contain specific requirements for the style, sizing, and spacing of hardware designed to support floor ledgers.

- Manufacturers of proprietary ledger support hardware should provide technical specifications, including building code evaluations.
- Be sure that any hardware used in your project is acceptable under codes recognized in your local jurisdiction

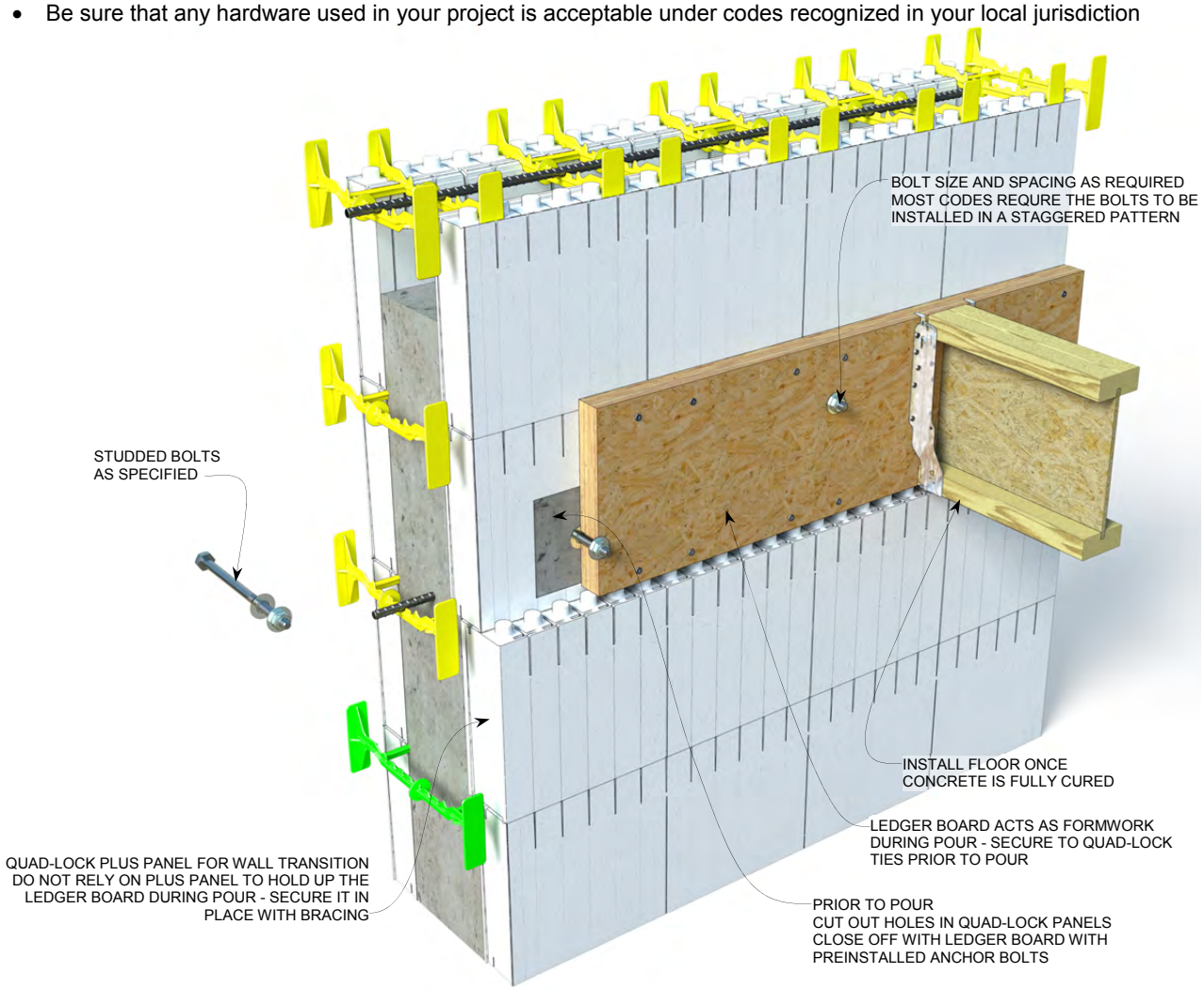


Figure 111: Installation of Floor Ledger Board

7.1.1.1 ICF Ledger Connectors (ICFVL)

One readily available proprietary solution is the ICF Ledger Connector System from Simpson Strong Tie Co. When approved by the local building official, the system provides easy, quick and versatile installation of ledgers for use with Quad-Lock Regular Panels and Ultra Panels. *(Note that there is a limitation on the depth of ICF foam allowable for ICFVL brackets. Contact Simpson Strong-Tie for details)*

- ICFVL Ledger brackets can also be used for the attachment of interior walls, overhead garage door hardware, or other heavy items.
- Quad-Lock recommends that the ICFVL, ICFVL-W, ICFVL-CW and their associated fasteners **should NOT be used in contact with treated lumber**, in exterior applications, or anywhere water is likely to be present.

7.1.1.1.1 Installation of ICFVL Connectors

To install the ICFVL brackets:

1. Using a laser level, strike a chalk line on the wall indicating the elevation of the ledger, usually the top of floor or roof joists.
2. Mark the positions of the ICFVL brackets below the chalk line elevation.
3. Insert the fixed portion of the ledger bracket through the foam, either at a vertical seam, or through a cut made with a drywall saw.
4. Set additional brackets using spacing determined by the project engineer.
5. After the concrete is poured, re-check the elevation mark and re-chalk if necessary.
6. Transfer the layout pattern of ICFVL brackets to the ledger material, then fasten the 'J' shaped portion of the bracket to the ledger board according to the layout.
7. Using the chalk line as the guide for elevation, screw the ledger assembly to the plastic ties.
8. Cut and fasten some 2x4 supports that extend from the bottom of the ledger down to the concrete footing or slab to insure that the elevation is maintained during the installation of screws, joist hangers and other floor components.
9. Fasten the assembled ledger to the fixed ICFVL brackets using self-tapping screws provided. *Note: Pre-drilling the ICFVL brackets is highly recommended!*

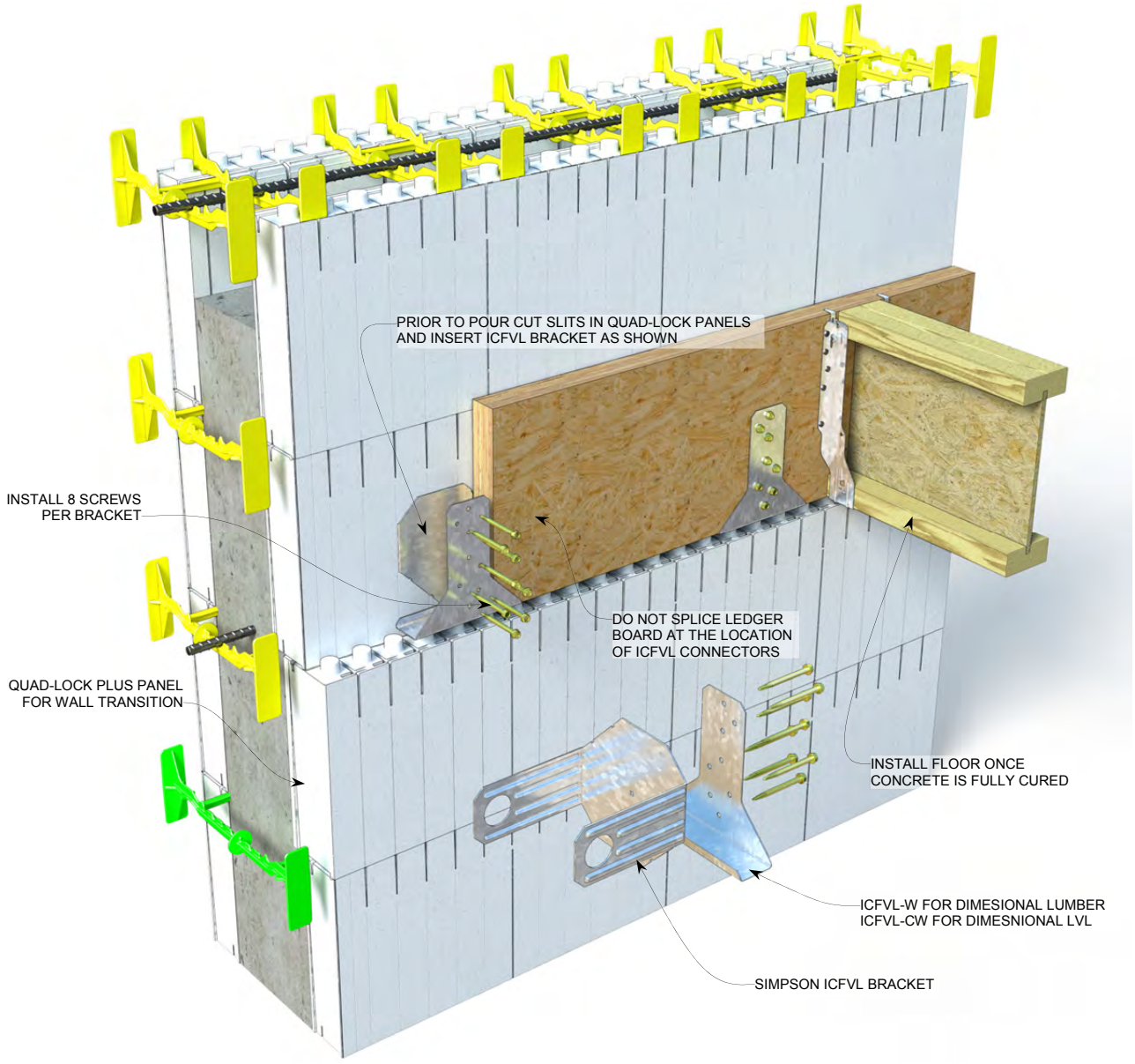
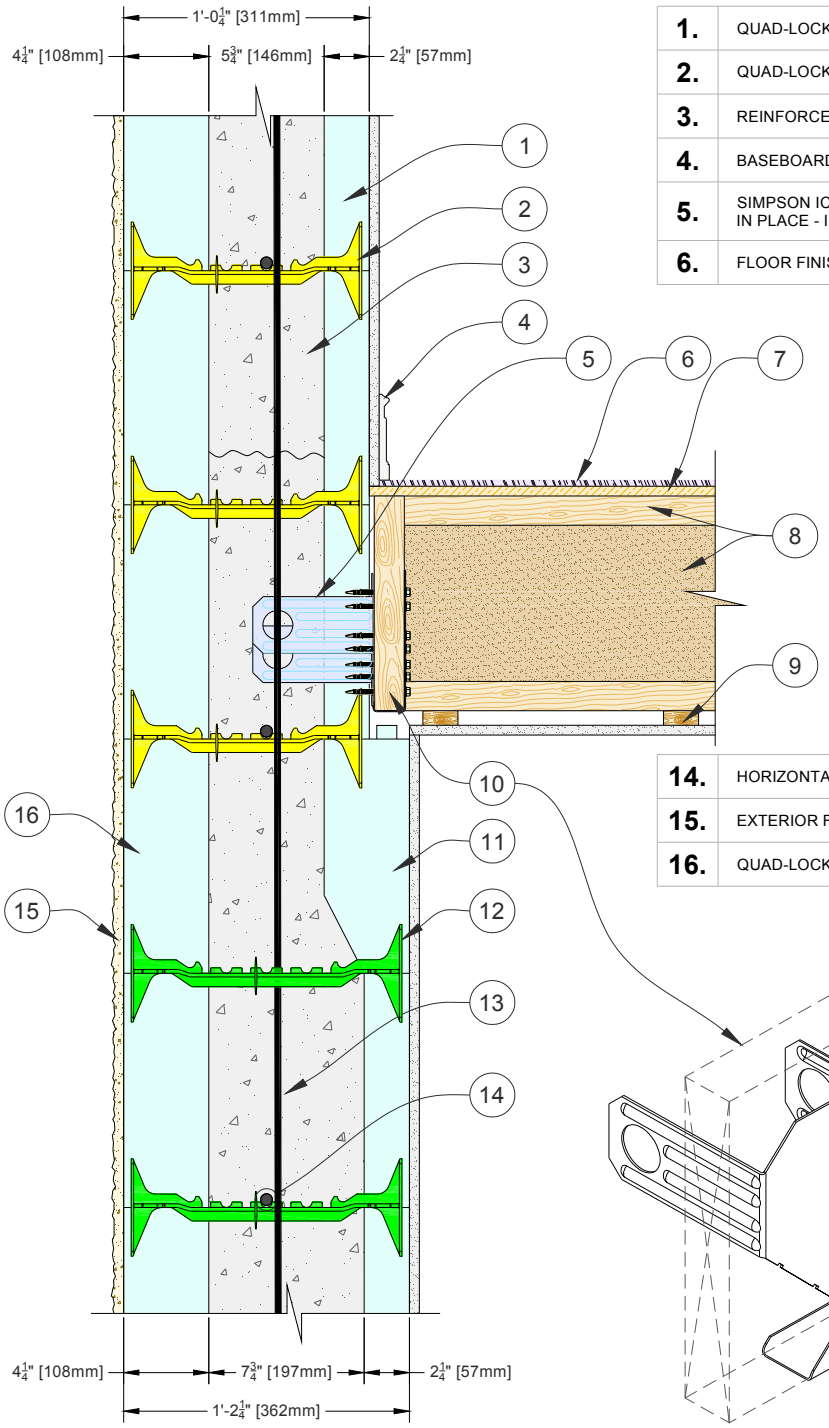


Figure 112: Installation of Floor Ledger with ICFVL Bracket System



1.	QUAD-LOCK REGULAR PANEL
2.	QUAD-LOCK YELLOW TIE
3.	REINFORCED CONCRETE CORE
4.	BASEBOARD MOLDING TRIM
5.	SIMPSON ICFVL (OR EQ.) GALVANIZED STEEL BRACKETS CAST IN PLACE - INSERT THROUGH FOAM PRIOR TO POUR
6.	FLOOR FINISH
7.	SUBFLOOR
8.	WOOD I-JOISTS
9.	FURRING FOR CEILING FINISH ATTACHMENT AS SPECIFIED
10.	WHEN CONCRETE IS CURED ATTACH LEDGER BOARD TO ICFVL BRACKETS USING EIGHT TAPCON SCREWS PROVIDED BY SIMPSON TOGETHER WITH LEDGER HANGERS ICFVL-W/CW MATCH ICFVL BRACKET SPACING
11.	QUAD-LOCK PLUS PANEL FOR WALL TRANSITION (TAPER INSIDE BOTTOM EDGE FOR BETTER CONCRETE FLOW)
12.	QUAD-LOCK GREEN TIE
13.	VERTICAL WALL REINFORCEMENT AS SPECIFIED
14.	HORIZONTAL WALL REINFORCEMENT AS SPECIFIED
15.	EXTERIOR FINISH AS SPECIFIED
16.	QUAD-LOCK PLUS PANEL

Figure 113: Ledger Installation using ICF Ledger Connectors

7.1.1.2 Ledger Boards Cast-in-Place with Bolts

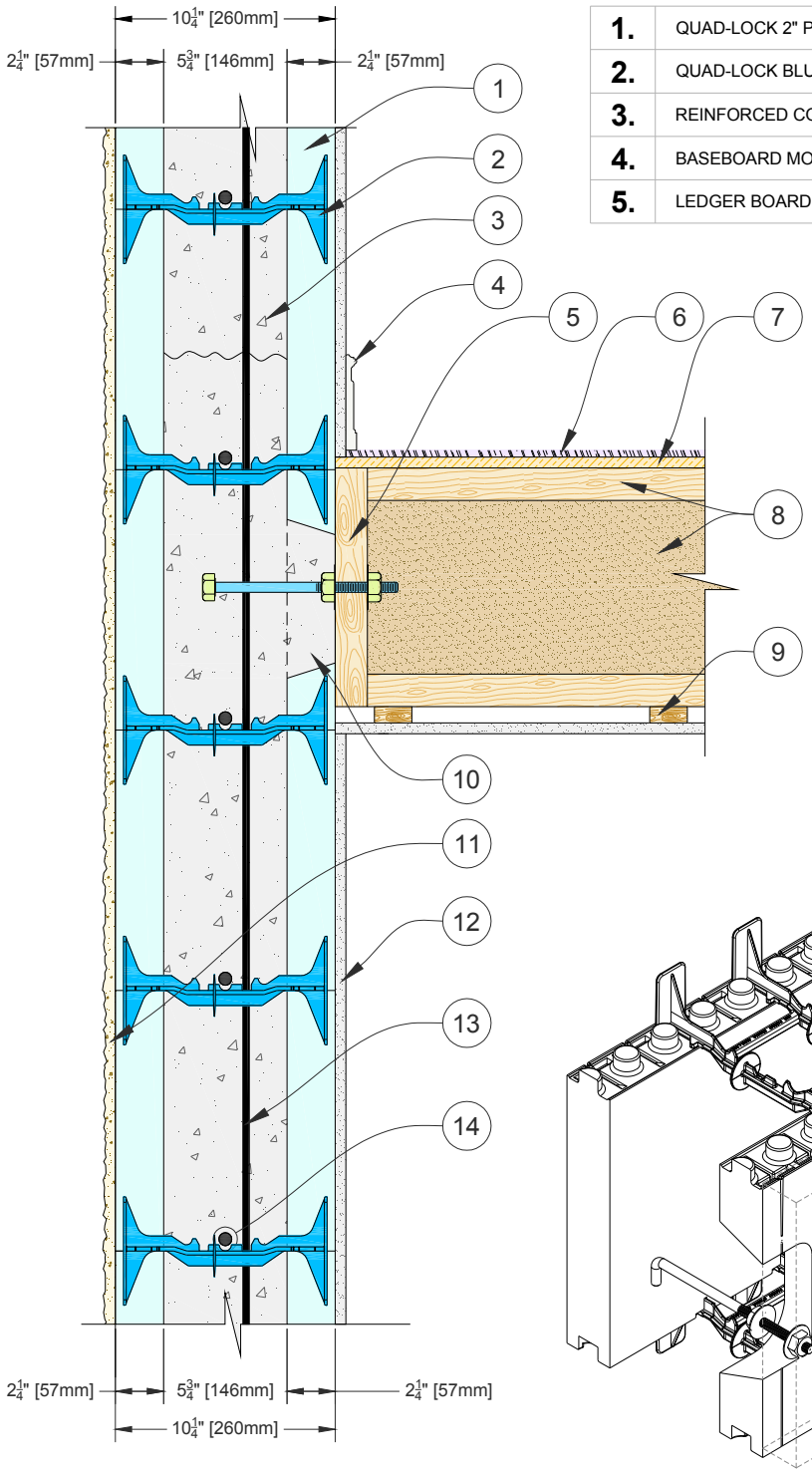
Another common method of ledger attachment is to cast the assembled ledger and anchor bolts in place while pouring the wall. To pre-set wood or steel ledgers, cut holes in panels at each anchoring location (avoiding the ties). *(See Figure 108 below.)*

- Ledger sizing, bolt pattern and spacing should be determined by a professional engineer and/or applicable building codes.
- Brace and level ledgers prior to placement of concrete.
- Quad-Lock recommends that each hole be cut to match the height ledger materials.

***Note**: Residential building codes in the USA have disallowed the use of "J-Bolts" used for hanging floor ledgers in vertical application, and now specify use of certain bolts with heads, or threaded rod with hex or square nuts. Check local, state, and national codes for details.*

US residential building codes also require minimum-sized cut-outs to allow concrete to surround the anchor-bolt and remain flush to the face of the EPS. Anchor bolts should always be positioned in the center of the cut-out. The following table shows the minimum hole diameter, depending on which Quad-Lock panel is used:

Panel Name & Thickness	Minimum Hole Diameter Required
Regular Panel	5.5 [140mm]
Ultra Panel	7.25 [184mm]
Plus Panel	9.5 [241mm]



1.	QUAD-LOCK 2" PANEL
2.	QUAD-LOCK BLUE TIE
3.	REINFORCED CONCRETE CORE
4.	BASEBOARD MOLDING TRIM
5.	LEDGER BOARD WITH J-BOLTS AS SPECIFIED
6.	FLOOR FINISH
7.	SUBFLOOR
8.	WOOD I-JOISTS AS SPECIFIED
9.	FURRING FOR CEILING FINISH
10.	PRIOR TO POURING THE CONCRETE REMOVE EPS FOAM AROUND BOLT LOCATIONS AND CLOSE OFF WITH LEDGER BOARD WITH PRE-INSTALLED J-BOLTS FASTEN LEDGER BOARD TO QUAD-LOCK PLASTIC TIES
11.	EXTERIOR WALL FINISH
12.	INTERIOR WALL FINISH
13.	VERTICAL REINFORCEMENT
14.	HORIZONTAL REINFORCEMENT

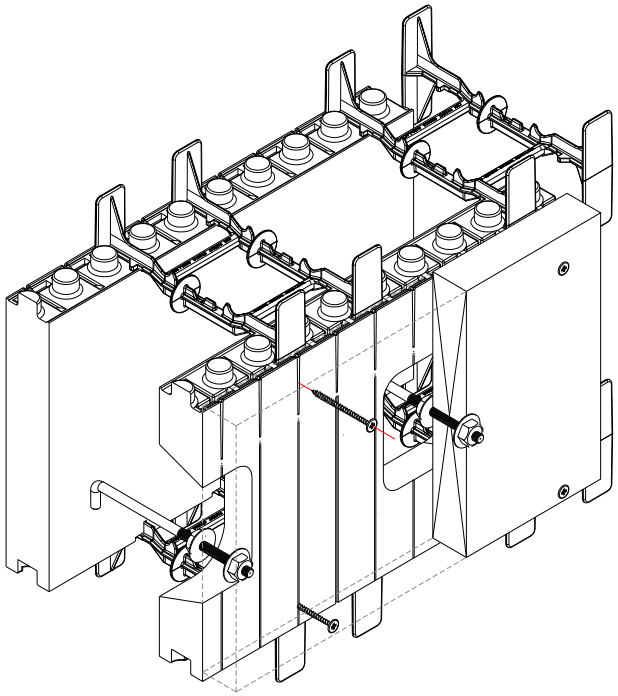


Figure 114: Typical Ledger Board Connection w/ Anchor Bolts

7.1.2 Concrete Floor Connections

When it is necessary to connect a poured-in-place concrete suspended slab to a Quad-Lock wall, the connection must be planned carefully in advance. The project engineer should be involved in the planning and must approve final details for any steel reinforcing connecting walls to the slab.

The elevation of the slab must be carefully calculated, and provisions made for forming the slab with Quad-Deck, or conventional suspended slab forming and shoring.

7.1.2.1 Quad-Lock Panels as Slab Edge Forms

Building science experts have identified un-insulated wall-to-floor connections as a major source of heat loss and gain in buildings. Quad-Lock Panels may be used as the "edge form" to both form and insulate around the perimeter of the slab where it intersects the exterior walls. This can occur at a flat-roof to wall connection, a parapet wall to roof connection, or an intermediate floor to wall connection (Figure 116).

To create Quad-Lock edge-form panels, follow these steps:

1. Install Quad-Lock Slab Ties (at 12" [305mm] or 24" [610mm] horizontal intervals) two courses down from the top-of-slab elevation. Build one additional full row, including ties.
2. Place a single panel on the outside of the top full row to act as the slab-edge form.
3. Brace with 2x4s attached to the Slab Ties with Quad-Lock Slab Brackets (Figure 116). Vertical braces should extend upward to the top-of-slab level, and downward at least 3 ft. [1m] below the bracket connection.
4. Screw a horizontal whaler on the tops of the vertical 2x4 braces to help align the wall.
5. Metal Track can be placed (temporarily) over the top panel edge to make the edge even more rigid.

As concrete is poured into the wall and encases the Slab Ties, they form a solid attachment point for the vertical 2x4 braces. The Slab Tie acts as a fulcrum as concrete pressure is exerted against the edge form panels, and the 2x4 brace is prevented from rotating around that attachment by the solid concrete wall below.

If the above method is used, the entire structure can be assembled using each succeeding floor as a work platform, without having to work on the outside of the building. This is a major advantage on multi-story construction.

Note: Vertical 2x4 [50mm x 100mm] braces used in conjunction with Quad-Lock Slab Ties and Slab Tie Brackets have NOT been certified to be in compliance with OSHA or other safety requirements to be used as guardrails or other fall protection. Guardrails generally must be a minimum height of 39" [991mm] and be able to withstand 200lbs [91kg] of lateral force. Consult your regional government safety officials for current requirements on scaffolding, guardrails, and fall protection.

Figure 115: Slab Tie & Slab Bracket

7.1.2.1.1 Slab Tie Placement

Slab Ties are placed at maximum 24" [610mm] on center, two panel layers below top of slab leaving one row of un-cut Full Ties above that row where the Slab ties are placed. *Note: cutting the ties in the row above the slab ties dramatically increases the concrete pressure on the two top panels. Refer to construction details on the Quad-Lock web site for proper installation.*

7.1.2.1.2 Slab Bracket Installation

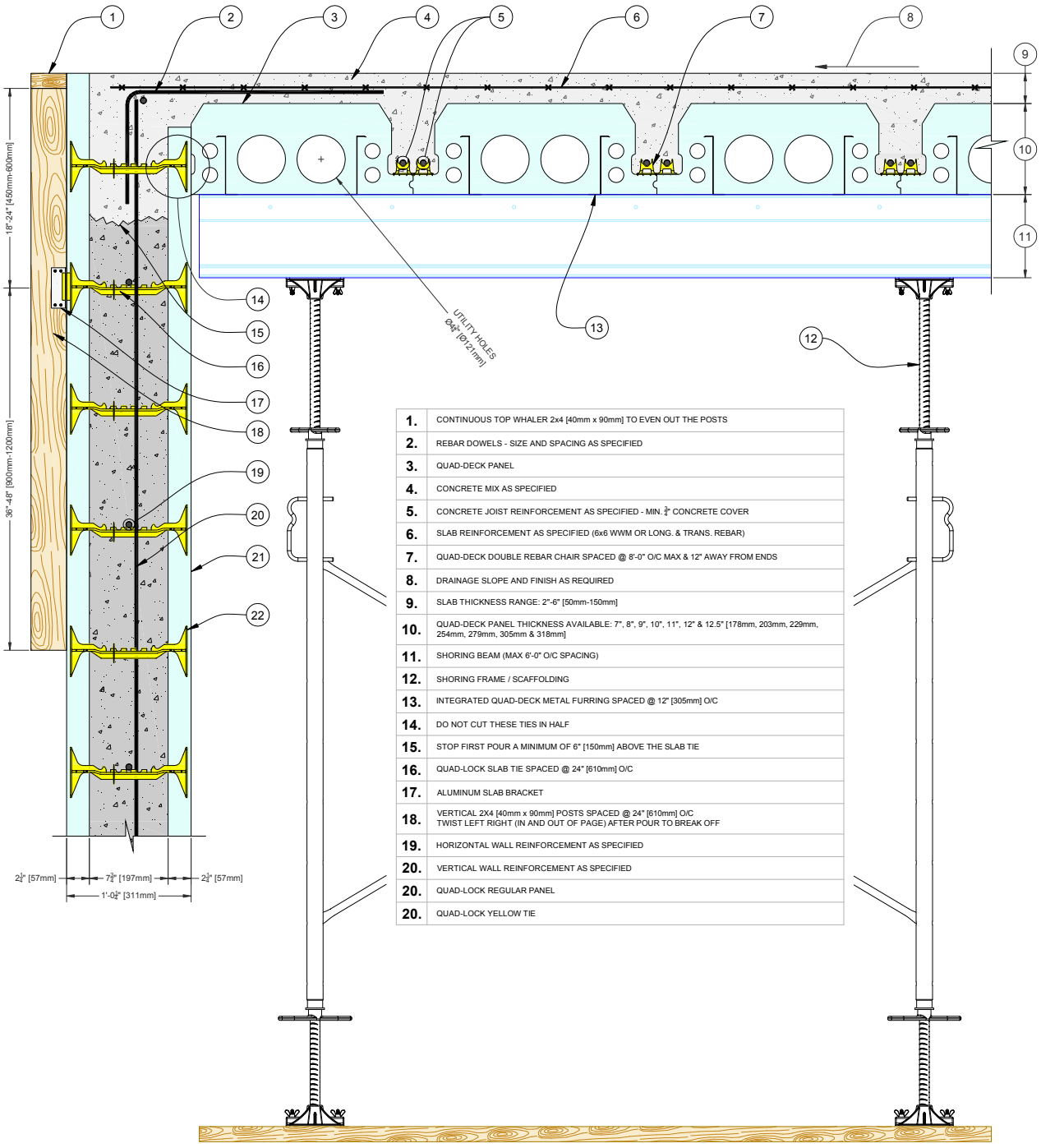
Slab Brackets are affixed to 5 to 6 ft. [1.5m to 1.8m] lengths of 2x4 [610mm x 1219mm] or 2x6 [610mm x 1829mm], at a level placing the top of the brace 1½" [38mm] below the top of the uppermost panel. The Slab Bracket/brace assembly is then positioned by sliding it over the plastic flange protruding from the face of the wall. For best results, a horizontal whaler is then screwed to the top of each vertical brace at slab elevation.

***Note**: Leaving long 2x4 braces in position for extended periods may cause them to warp and break the plastic extrusion away from the tie flange.*

7.1.2.1.3 Removal of Slab Bracing

To remove braces after they have served their purpose, tilt them sideways using a sharp motion and break the plastic extrusions off the ties. Reuse the lumber posts with the Slab Brackets on the next floor or project.

7.1.2.2 Quad-Lock Wall to Quad-Deck Floor

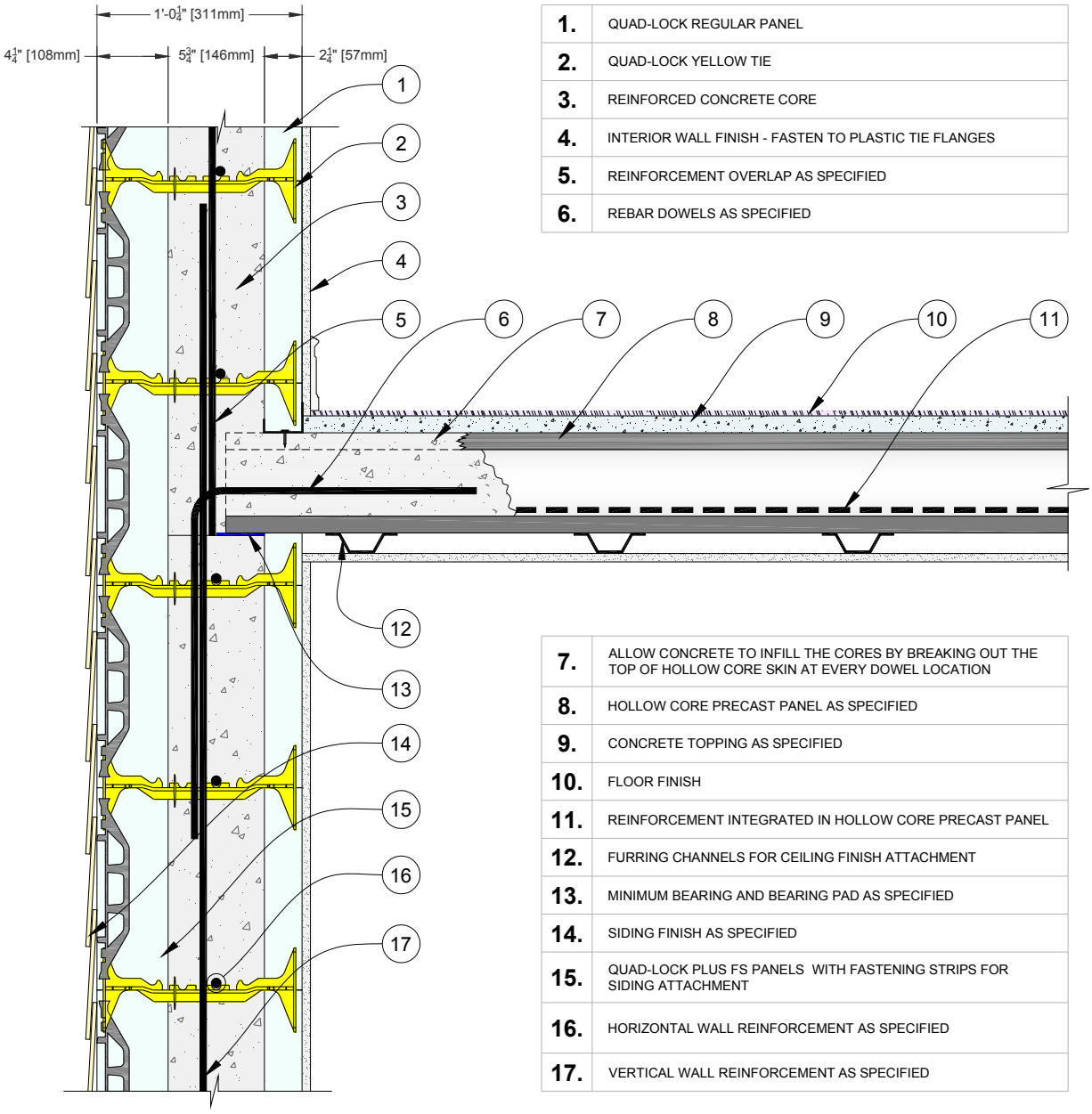


1.	CONTINUOUS TOP WHALER 2x4 [40mm x 90mm] TO EVEN OUT THE POSTS
2.	REBAR DOWELS - SIZE AND SPACING AS SPECIFIED
3.	QUAD-DECK PANEL
4.	CONCRETE MIX AS SPECIFIED
5.	CONCRETE JOIST REINFORCEMENT AS SPECIFIED - MIN. ¾" CONCRETE COVER
6.	SLAB REINFORCEMENT AS SPECIFIED (6x6 WWM OR LONG. & TRANS. REBAR)
7.	QUAD-DECK DOUBLE REBAR CHAIR SPACED @ 8'-0" O/C MAX & 12" AWAY FROM ENDS
8.	DRAINAGE SLOPE AND FINISH AS REQUIRED
9.	SLAB THICKNESS RANGE: 2"-6" [50mm-150mm]
10.	QUAD-DECK PANEL THICKNESS AVAILABLE: 7", 8", 9", 10", 11", 12" & 12.5" [178mm, 203mm, 229mm, 254mm, 279mm, 305mm & 318mm]
11.	SHORING BEAM (MAX 6'-0" O/C SPACING)
12.	SHORING FRAME / SCAFFOLDING
13.	INTEGRATED QUAD-DECK METAL FURRING SPACED @ 12" [305mm] O/C
14.	DO NOT CUT THESE TIES IN HALF
15.	STOP FIRST POUR A MINIMUM OF 6" [150mm] ABOVE THE SLAB TIE
16.	QUAD-LOCK SLAB TIE SPACED @ 24" [610mm] O/C
17.	ALUMINUM SLAB BRACKET
18.	VERTICAL 2X4 [40mm x 90mm] POSTS SPACED @ 24" [610mm] O/C TWIST LEFT RIGHT (IN AND OUT OF PAGE) AFTER POUR TO BREAK OFF
19.	HORIZONTAL WALL REINFORCEMENT AS SPECIFIED
20.	VERTICAL WALL REINFORCEMENT AS SPECIFIED
20.	QUAD-LOCK REGULAR PANEL
20.	QUAD-LOCK YELLOW TIE

Figure 116: Quad-Deck Concrete Floor Construction Details

Building Tip:	When using the slab bracket and tie system to brace the perimeter panels, longer 2x4 braces may tend to warp if left in place for extended periods. This can put enough strain on the ties to break off the extrusion that holds the aluminum bracket against the wall. Try to place the vertical braces as near to pouring time as possible.

7.1.2.3 Quad-Lock Wall to Hollow-Core Precast Panels

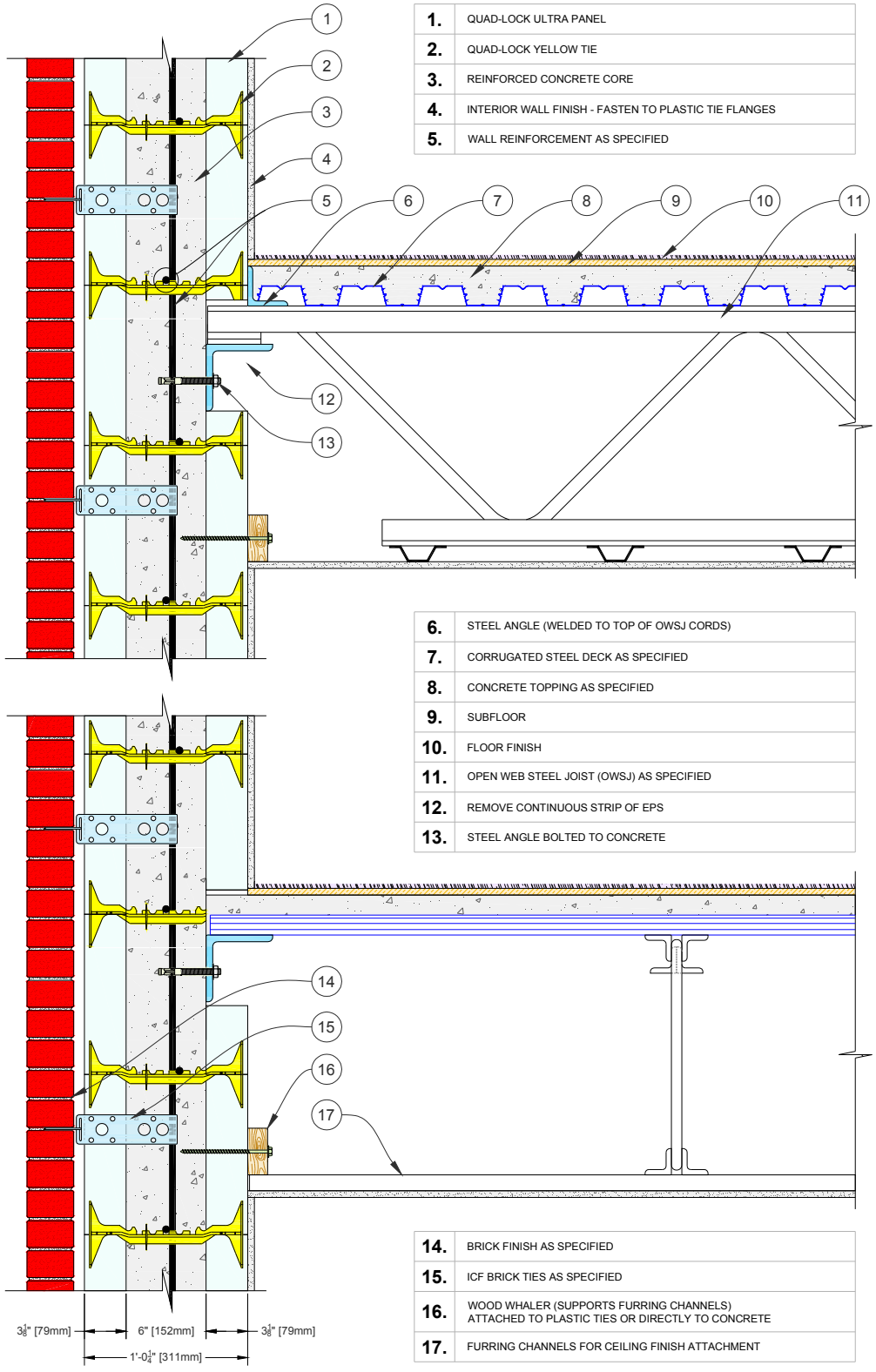


1.	QUAD-LOCK REGULAR PANEL
2.	QUAD-LOCK YELLOW TIE
3.	REINFORCED CONCRETE CORE
4.	INTERIOR WALL FINISH - FASTEN TO PLASTIC TIE FLANGES
5.	REINFORCEMENT OVERLAP AS SPECIFIED
6.	REBAR DOWELS AS SPECIFIED
7.	ALLOW CONCRETE TO INFILL THE CORES BY BREAKING OUT THE TOP OF HOLLOW CORE SKIN AT EVERY DOWEL LOCATION
8.	HOLLOW CORE PRECAST PANEL AS SPECIFIED
9.	CONCRETE TOPPING AS SPECIFIED
10.	FLOOR FINISH
11.	REINFORCEMENT INTEGRATED IN HOLLOW CORE PRECAST PANEL
12.	FURRING CHANNELS FOR CEILING FINISH ATTACHMENT
13.	MINIMUM BEARING AND BEARING PAD AS SPECIFIED
14.	SIDING FINISH AS SPECIFIED
15.	QUAD-LOCK PLUS FS PANELS WITH FASTENING STRIPS FOR SIDING ATTACHMENT
16.	HORIZONTAL WALL REINFORCEMENT AS SPECIFIED
17.	VERTICAL WALL REINFORCEMENT AS SPECIFIED

Figure 117: Typical Hollow Core Precast Floor Slab Connection

7.1.3 Alternate Floor Connections

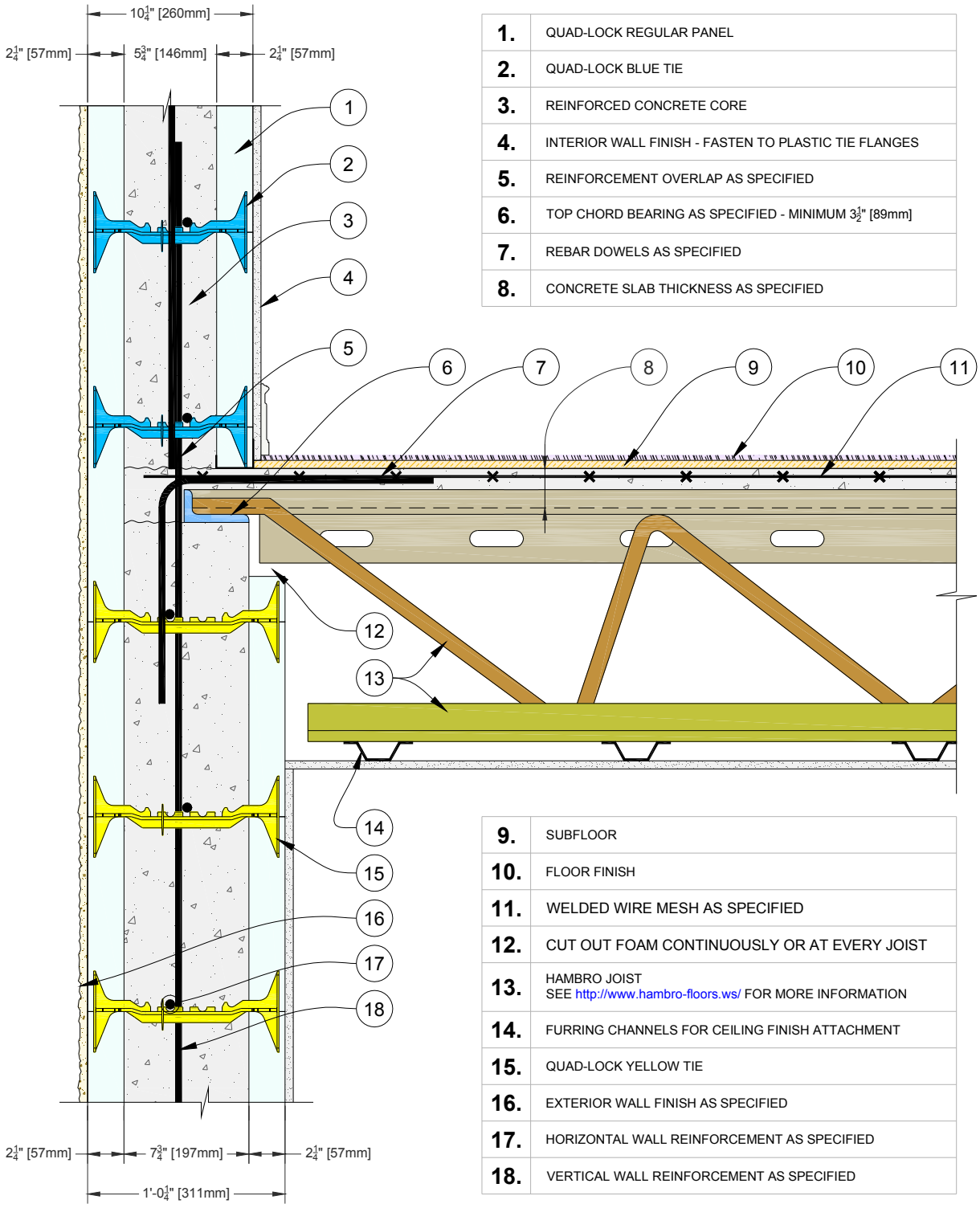
7.1.3.1 Quad-Lock Wall to Composite Steel Deck and Joists



1.	QUAD-LOCK ULTRA PANEL
2.	QUAD-LOCK YELLOW TIE
3.	REINFORCED CONCRETE CORE
4.	INTERIOR WALL FINISH - FASTEN TO PLASTIC TIE FLANGES
5.	WALL REINFORCEMENT AS SPECIFIED
6.	STEEL ANGLE (WELDED TO TOP OF OWSJ CORDS)
7.	CORRUGATED STEEL DECK AS SPECIFIED
8.	CONCRETE TOPPING AS SPECIFIED
9.	SUBFLOOR
10.	FLOOR FINISH
11.	OPEN WEB STEEL JOIST (OWSJ) AS SPECIFIED
12.	REMOVE CONTINUOUS STRIP OF EPS
13.	STEEL ANGLE BOLTED TO CONCRETE
14.	BRICK FINISH AS SPECIFIED
15.	ICF BRICK TIES AS SPECIFIED
16.	WOOD WHALER (SUPPORTS FURRING CHANNELS) ATTACHED TO PLASTIC TIES OR DIRECTLY TO CONCRETE
17.	FURRING CHANNELS FOR CEILING FINISH ATTACHMENT

Figure 118: Typical Quad-Lock wall Connection to Composite Concrete and Steel Deck Slab Floor with Steel Joists

7.1.3.2 Quad-Lock Wall to Hambro® Composite Floor System



1.	QUAD-LOCK REGULAR PANEL
2.	QUAD-LOCK BLUE TIE
3.	REINFORCED CONCRETE CORE
4.	INTERIOR WALL FINISH - FASTEN TO PLASTIC TIE FLANGES
5.	REINFORCEMENT OVERLAP AS SPECIFIED
6.	TOP CHORD BEARING AS SPECIFIED - MINIMUM 3½" [89mm]
7.	REBAR DOWELS AS SPECIFIED
8.	CONCRETE SLAB THICKNESS AS SPECIFIED

9.	SUBFLOOR
10.	FLOOR FINISH
11.	WELDED WIRE MESH AS SPECIFIED
12.	CUT OUT FOAM CONTINUOUSLY OR AT EVERY JOIST
13.	HAMBRO JOIST SEE http://www.hambro-floors.ws/ FOR MORE INFORMATION
14.	FURRING CHANNELS FOR CEILING FINISH ATTACHMENT
15.	QUAD-LOCK YELLOW TIE
16.	EXTERIOR WALL FINISH AS SPECIFIED
17.	HORIZONTAL WALL REINFORCEMENT AS SPECIFIED
18.	VERTICAL WALL REINFORCEMENT AS SPECIFIED

Figure 119: Typical Hambro Composite Floor System Connection

7.2 WOOD FRAMING ON TOP OF QUAD-LOCK WALL CONNECTION

When Quad-Lock walls are used as a basement or foundation only, many design options are available depending on requirements of (and interfacing with) the building elements above.

- Quad-Lock may be used in conjunction with all conventional building methods. Ledgers, joists, trusses and rafters of wood or steel may be attached to the Quad-Lock walls. Quad-Lock recommends having an Engineer review specific applications.

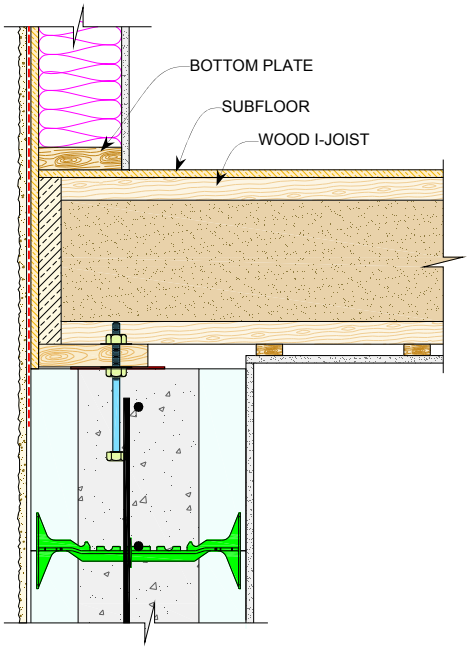
7.2.1 Positioning the Framed Structure on Quad-Lock Foundation Walls

Important! A decision must be made during the design phase and prior to construction as to how to transition from a Quad-Lock ICF basement or foundation wall to a wood or steel-framed building above.

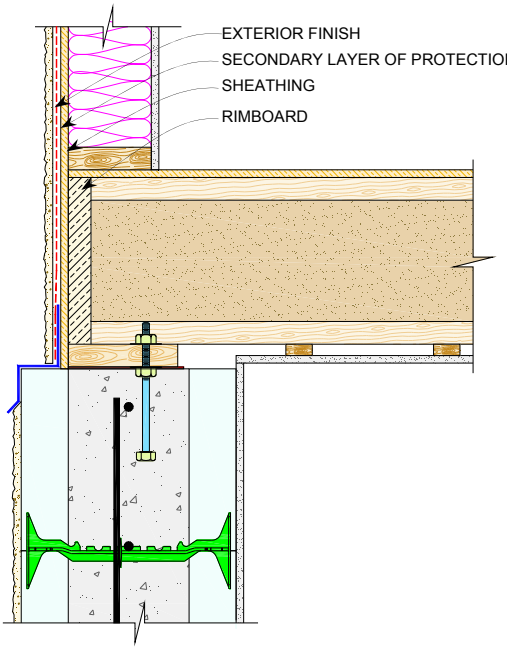
- In general, building owners prefer the exterior face of the foundation to be flush to the building line of the structure above, before claddings or finishes are applied. This may entail developing a slight cantilever of the sill plate attached to concrete out over the exterior foam layer.
- Though details are shown, few owners opt for the foundation insulation layer to extend past the building line of the structure above. Keeping the face of the ICF in line with the sheathing of the framed building is the preferred option by most builders.

7.2.1.1 Positioning of the Sill Plate

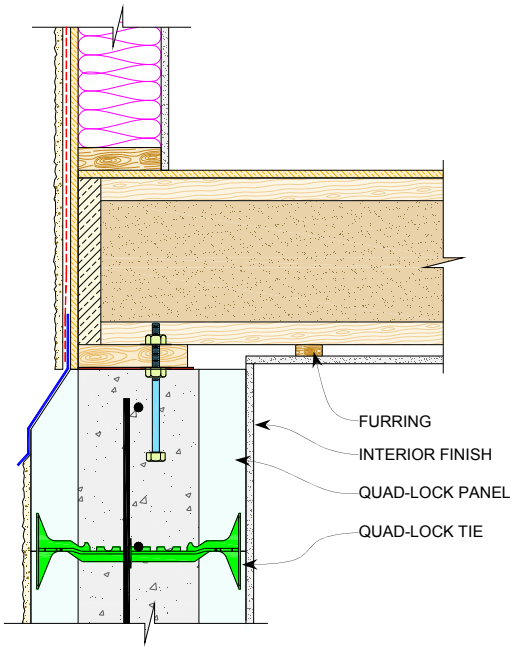
Typical details are offered below that outline different options for setting the sill-plate to support the framed floor and walls above.



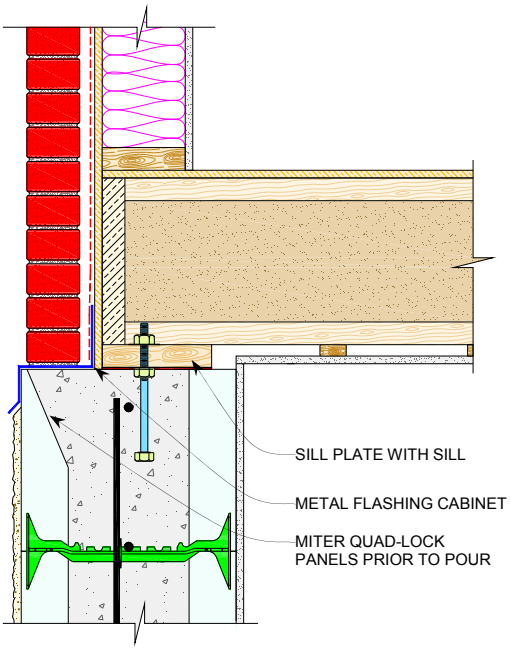
CANTILEVERED PLATE



100% BEARING WITH FLASHING

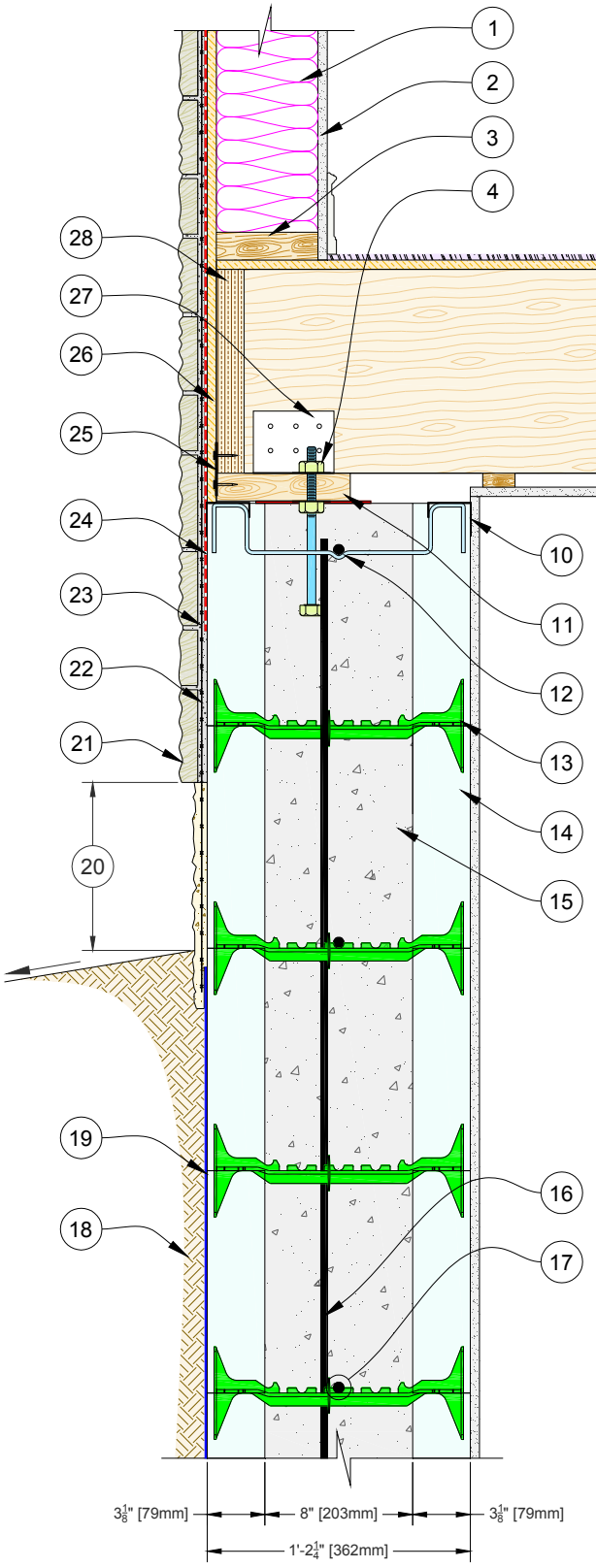


100% BEARING WITH FLASHING



100% BEARING WITH FLASHING

Figure 120: Sill Plate Options



1.	STUDS AND INSULATION
2.	INTERIOR FINISH
3.	BOTTOM PLATE
4.	ANCHOR BOLTS AS SPECIFIED
5.	FLOOR FINISH AS SPECIFIED
6.	SUBFLOOR
7.	WOOD JOISTS AS SPECIFIED
8.	FURRING FOR CEILING FINISH ATTACHMENT
9.	CEILING FINISH AS SPECIFIED
10.	QUAD-LOCK METAL TRACK
11.	SILL PLATE WITH SILL SEALER
12.	QUAD-LOCK WIRE TOP TIE
13.	QUAD-LOCK GREEN TIE
14.	QUAD-LOCK ULTRA PANEL
15.	REINFORCED CONCRETE CORE
16.	VERTICAL WALL REINFORCEMENT AS SPECIFIED
17.	HORIZONTAL WALL REINFORCEMENT AS SPECIFIED
18.	BACKFILL
19.	WATER-PROOFING OR DAMP-PROOFING AS SPECIFIED
20.	PARGING HEIGHT AS SPECIFIED
21.	STONE VENEER FINISH AS SPECIFIED
22.	WIRE MESH FOR MORTAR REINFORCEMENT - FASTEN TO QUAD-LOCK PLASTIC TIE FLANGES
23.	MORTAR
24.	SECONDARY LAYER OF PROTECTION (BUILDING PAPER - BRING OVER FOAM SURFACE FOR TIGHT SEAL)
25.	METAL TRANSITION STRIP AS REQUIRED
26.	SHEATHING - EXTERIOR OF SHEATHING FLUSHED WITH EXTERIOR OF QUAD-LOCK FOAM
27.	TENSION TIE AS REQUIRED
28.	RIMBOARD

Figure 121: Typical Wall to Floor & Framing Connection

7.3 QUAD-LOCK WALL-TO-ROOF CONNECTIONS

A critical detail affecting the durability of any structure is the connection of the walls to the roof assembly.

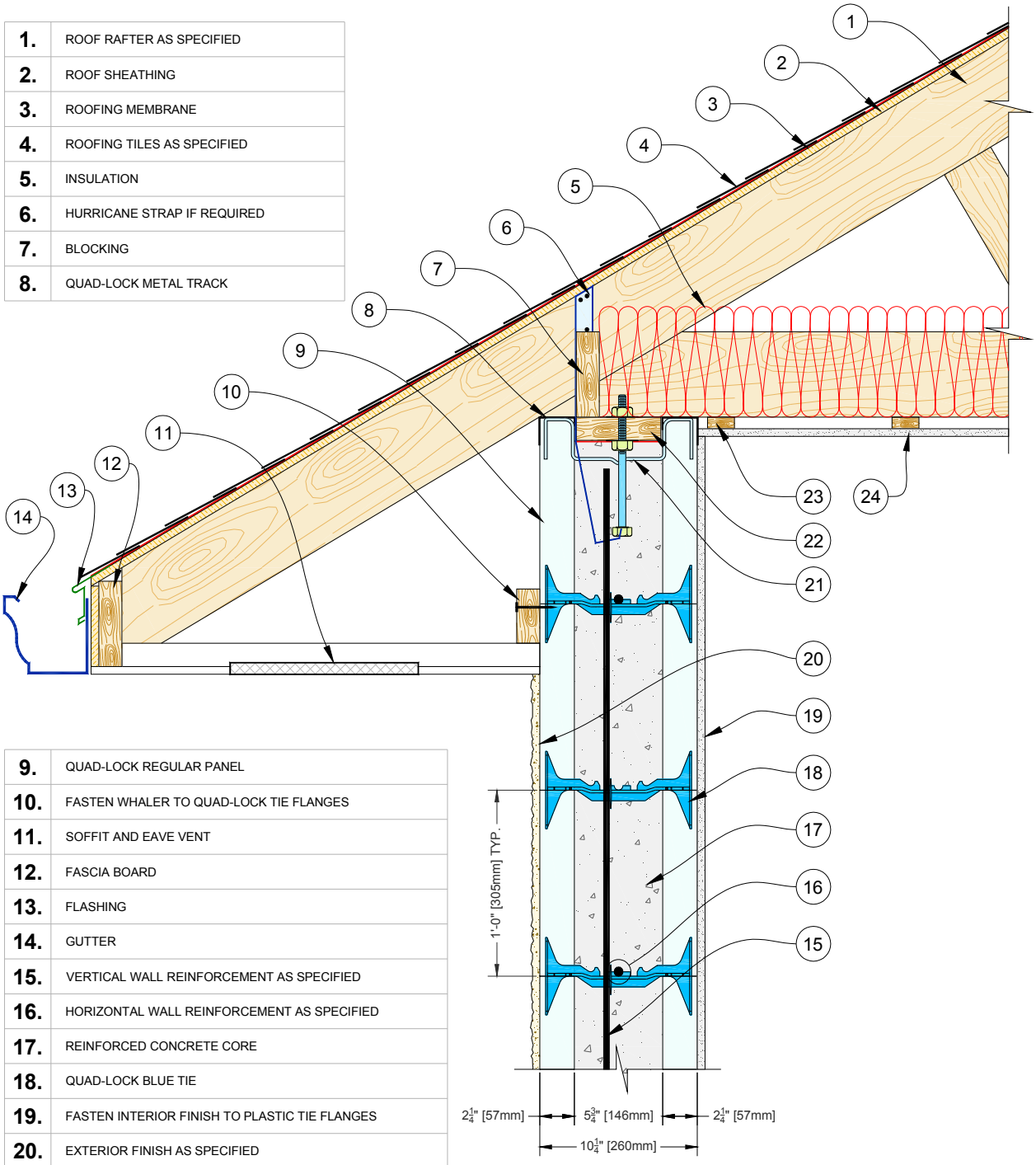
- Choice of connection methods will depend on the amount of load expected to be placed on the building, given the environmental factors in the area, like wind speed, wind exposure, and seismic threat.
- If a building is being designed for disaster resistance, there may be other factors to consider, such as the potential for hurricanes, tornados, typhoons, flooding, tidal wash, tsunami, earth slides and others.

Quad-Lock recommends that the choice of wall-to-roof connection be made in consultation with a licensed engineer with specific knowledge of the conditions in the area.

7.3.1 Quad-Lock Wall to Rafters or Trusses

Typical details for connecting either rafters or manufactured trusses to Quad-Lock walls are shown below.

7.3.1.1 Typical Roof Rafter or Truss - Low Uplift Connection



1.	ROOF RAFTER AS SPECIFIED
2.	ROOF SHEATHING
3.	ROOFING MEMBRANE
4.	ROOFING TILES AS SPECIFIED
5.	INSULATION
6.	HURRICANE STRAP IF REQUIRED
7.	BLOCKING
8.	QUAD-LOCK METAL TRACK
9.	QUAD-LOCK REGULAR PANEL
10.	FASTEN WHALER TO QUAD-LOCK TIE FLANGES
11.	SOFFIT AND EAVE VENT
12.	FASCIA BOARD
13.	FLASHING
14.	GUTTER
15.	VERTICAL WALL REINFORCEMENT AS SPECIFIED
16.	HORIZONTAL WALL REINFORCEMENT AS SPECIFIED
17.	REINFORCED CONCRETE CORE
18.	QUAD-LOCK BLUE TIE
19.	FASTEN INTERIOR FINISH TO PLASTIC TIE FLANGES
20.	EXTERIOR FINISH AS SPECIFIED
21.	QUAD-LOCK WIRE TOP TIE
22.	SILL PLATE WITH SILL SEALER AND ANCHOR BOLTS
23.	FURRING FOR CEILING FINISH ATTACHMENT
24.	CEILING FINISH AS SPECIFIED

Figure 122: Typical Roof Rafter or Truss - Low Uplift Connection

7.3.1.2 Typical Cantilevered Joist Connection

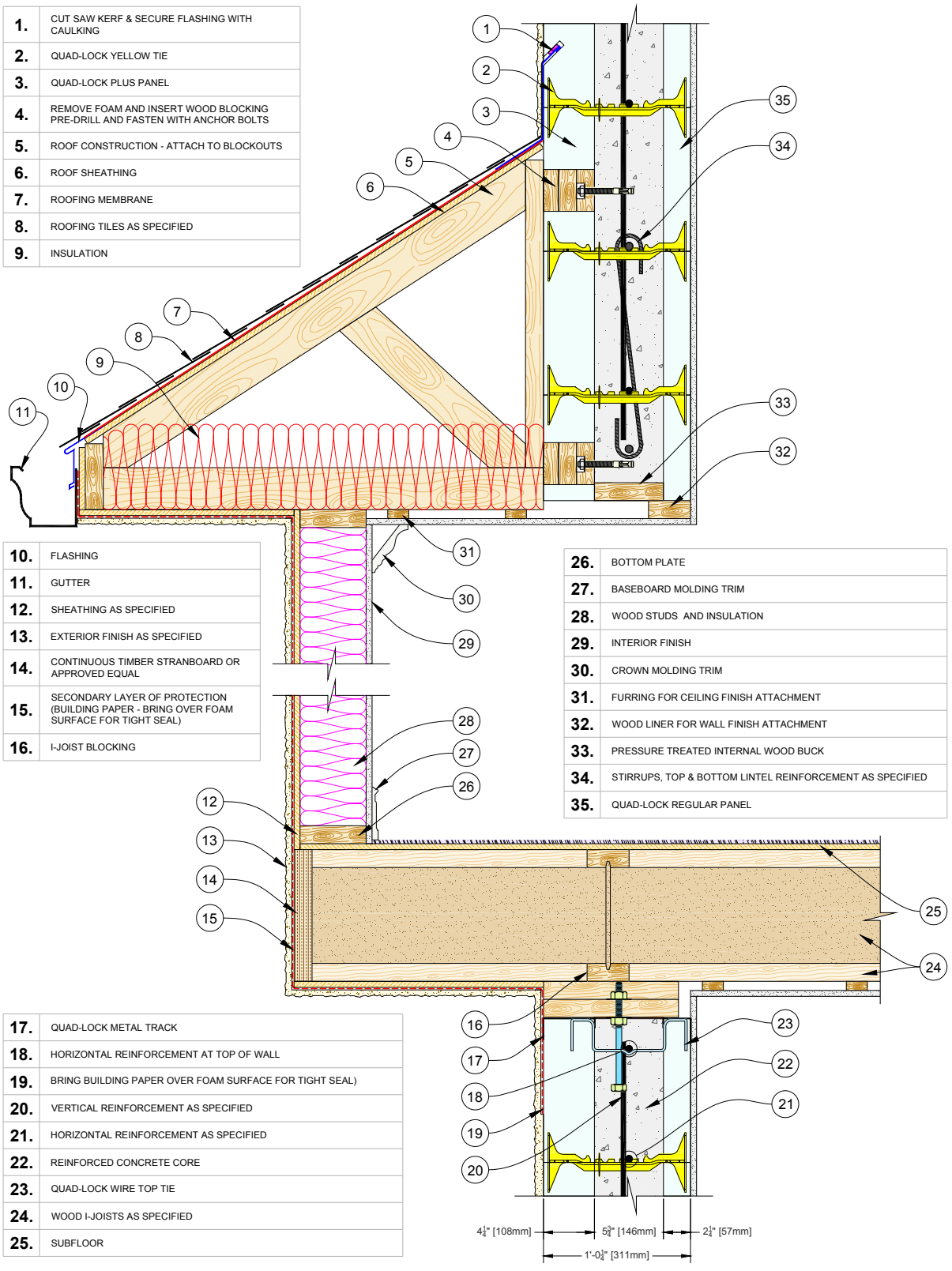


Figure 123: Cantilevered Joist Connection

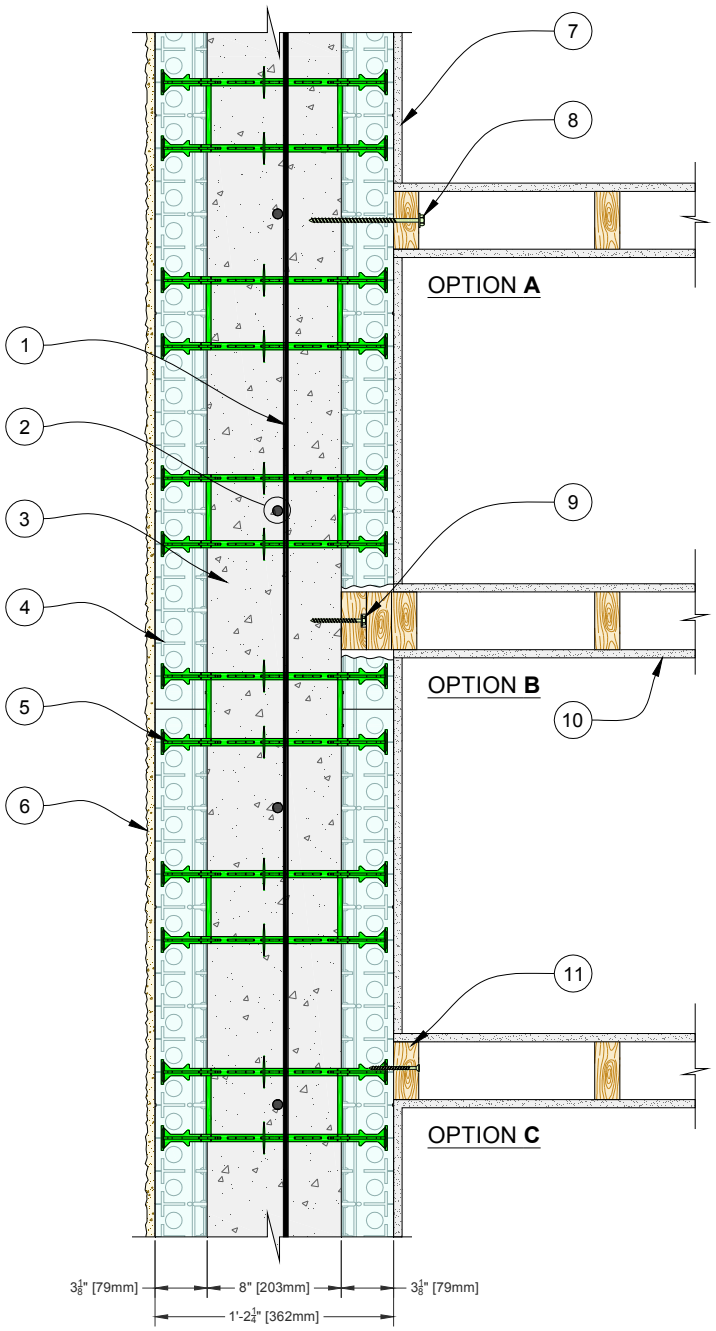
7.4 CONNECTION BETWEEN ICF AND OTHER WALLS

7.4.1 Interior Partition Wall Connection

Connection of interior walls to Quad-Lock ICF walls should take into consideration the stresses and conditions likely to be imposed on the interior partition, and the choice of connection method to the ICF wall made accordingly.

- Is the interior wall a bearing or non-bearing wall?
- Is there any requirement for the interior wall to serve as fire separation between rooms or units?

Methods shown below can be used for the attachment of interior walls.



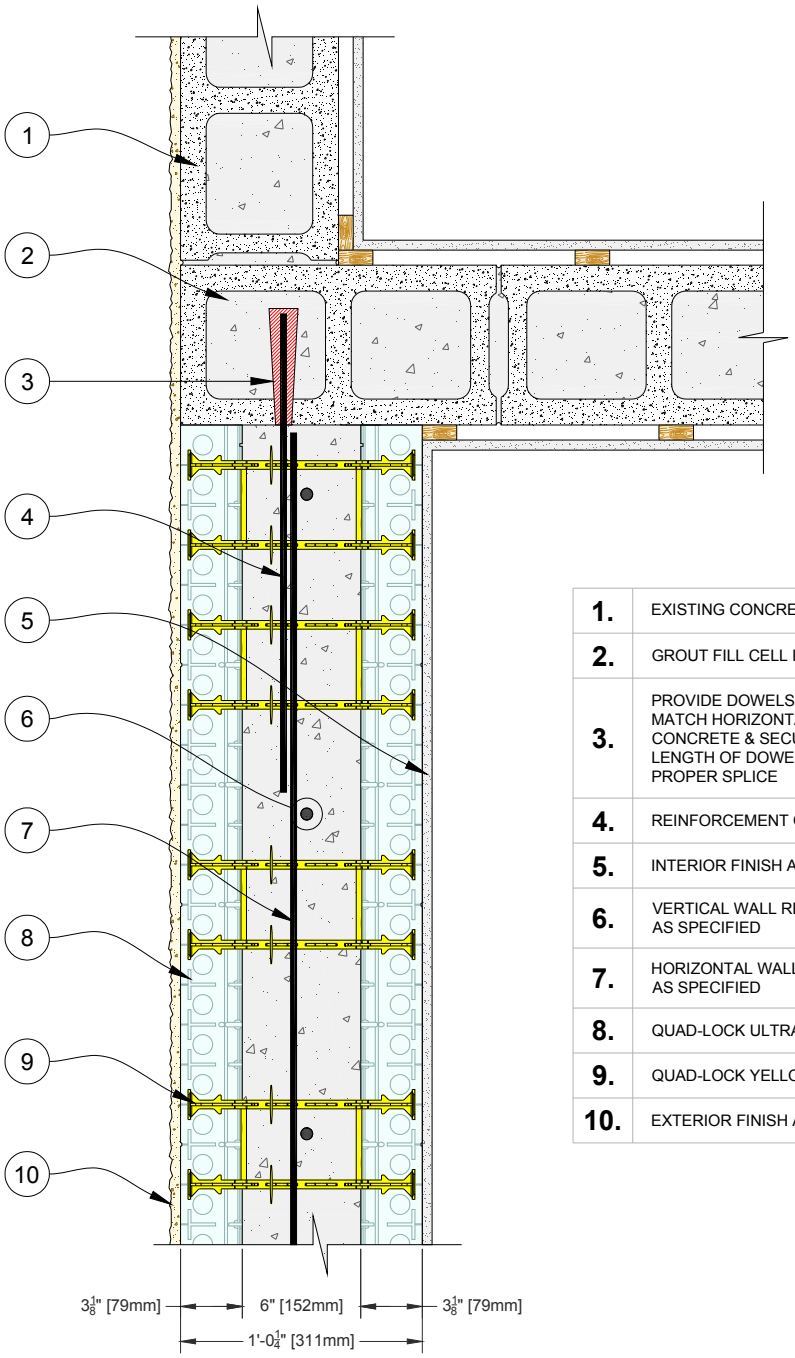
1.	HORIZONTAL WALL REINFORCEMENT AS SPECIFIED
2.	VERTICAL WALL REINFORCEMENT AS SPECIFIED
3.	REINFORCED CONCRETE CORE
4.	QUAD-LOCK ULTRA PANEL
5.	QUAD-LOCK GREEN TIE
6.	EXTERIOR FINISH AS SPECIFIED
7.	INTERIOR FINISH AS SPECIFIED
8.	MASONRY SCREW OR ANCHOR AS SPECIFIED
9.	REMOVE FOAM AND FASTEN DIRECTLY TO CONCRETE WITH MASONRY SCREW OR ANCHOR AS SPECIFIED
10.	INTERIOR PARTITION WALL
11.	GLUE TO QUAD-LOCK PANELS WITH WATER BASED GLUE AND SCREW TO QUAD-LOCK PLASTIC TIE FLANGES

Figure 124: Typical Interior Partition Wall Connections (plan view)

7.4.1.1 Connection to Existing Concrete Walls

When connecting a new ICF wall to an existing masonry or poured concrete wall, anchorage of the new wall to the old can be provided by rebar dowels drilled and anchored into the existing wall. Mechanical or adhesive anchorage systems can be used.

- Leave adequate length of rebar exposed to form the proper overlap (development length) for a splice in horizontal rebar (usually 40 x bar diameter)
- Using the first row Quad-Lock ties as a benchmark, space the dowels at 12 inches [305mm] vertically up the existing wall, in line with the center of the new ICF wall.



1.	EXISTING CONCRETE BLOCK (CMU) WALL
2.	GROUT FILL CELL IF VOID
3.	PROVIDE DOWELS BETWEEN WALLS TO MATCH HORIZONTAL REBAR DRILL TO CONCRETE & SECURE W/ EPOXY GROUT LENGTH OF DOWEL SUFFICIENT TO DEVELOP PROPER SPLICE
4.	REINFORCEMENT OVERLAP AS SPECIFIED
5.	INTERIOR FINISH AS SPECIFIED
6.	VERTICAL WALL REINFORCEMENT AS SPECIFIED
7.	HORIZONTAL WALL REINFORCEMENT AS SPECIFIED
8.	QUAD-LOCK ULTRA PANEL
9.	QUAD-LOCK YELLOW TIE
10.	EXTERIOR FINISH AS SPECIFIED

Figure 125: Typical Connection to Existing Concrete Wall (Plan View)

7.4.1.2 Connection to Existing Wood-Framed Wall

***Note**: Due to the extreme difference in mass (weight) between ICF concrete walls and wood-framed walls, it is Quad-Lock's recommendation that any new concrete structure be self-supporting and act independently of the wood structure.*

To create an interface between a wood structure and a Quad-Lock ICF wall, securely fasten a piece of lumber, ripped to the exact width of the concrete cavity, to the wood structure. The Quad-Lock panels can now butt into the existing structure and be fastened to the ripped lumber with Wind-Lock fasteners and screws. Be sure to place a Full Tie as close to the interface as possible to stabilize the panels and provide a fastening point on the exterior.

8 CONCRETE & REINFORCING

Important Note to Reader
Concrete, its mixing and its placement are some of the most critical issues affecting the success of an ICF building project. We cannot over-emphasize the importance of proper concrete mix design, slump characteristics, and good placement and consolidation techniques by experienced hands. While the erection of lightweight and versatile EPS formwork may be accomplished by those possessing a wide range of skills, concrete placement is a difficult (and often dangerous) undertaking which is best left to those with experience.

Quad-lock Building Systems, Ltd. offers a materials warranty on its products (see Page iii of this manual), but does not warrantee the workmanship demonstrated by those erecting the forms or placing reinforcing steel, concrete, or finish materials in or on them.

Variables Affecting Concrete
While humble in appearance, concrete is actually a very complex system and is affected by many factors between the time it is mixed at the plant and finally cured at your jobsite. Weather, local materials, age of the concrete, method of placement, and speed of placement are only a few of the variables affecting the properties of concrete during the pour. Experienced concrete hands usually know what to expect when certain sets of these variables are present and work accordingly to produce the required results. Those not familiar with conditions that affect concrete are advised to engage the services of a party has that knowledge and experience.

Know the Code
Building codes are quite specific about requirements for concrete and concrete reinforcement. These standards should be known ahead of time, and followed strictly. Quad-Lock has provided code references for many of the latest codes concerning concrete construction and ICFs in particular. Ask your local building department which building codes and standards apply to your project.

8.1 CONCRETE

The following information is sourced from the most reliable sources known to the authors as of the date of publication and is intended only as a set of general guidelines. *In the event of a conflict between this manual and the applicable local regulations, local regulations will prevail in all cases.*

Concrete shall be designed, mixed, placed, cured and tested in accordance with applicable codes, e.g. CAN3-A438, “Concrete Construction for Housing and Small Buildings” (Canada), or ACI 318 “Building Code Requirement for Reinforced Concrete” (US). The concrete shall be designed to be durable enough to withstand the expected exposure conditions. In particular, concrete for Quad-Lock walls shall conform to the following:

- **Slump**: As of 2009, US residential code requires a MIMIMUM 6 inch slump, which can exceed 8 inches if approved by the building official. Quad-Lock recommends a 6" [152mm] slump, measured in accordance with CSA Standard CAN3 - A23.2, Slump of Concrete / ASTM Standard C143 [11], Test Method for Slump of Hydraulic Cement Concrete.
- **Admixtures**: To achieve a greater slump, it is recommended to add a super-plasticizing admixture conforming to ASTM Standard C494.
- **Compressive Strength**:
  - Canadian building codes require the minimum strength of reinforced concrete to be 17 Mpa in accordance with requirements CSA Standard A23.1.
  - US residential codes (2012) for concrete walls require between 2500 and 3000 psi and in accordance with ASTM Standard C-94[13], depending on weather exposure.
  - Quad-Lock in all cases recommends a minimum 20.4Mpa/3000 psi mix for best flow characteristics during pouring.
- **Aggregate**: US residential codes (2012) contain specific maximum aggregate size requirements, generally expressed as three-fourths of the clear spacing between reinforcing bars or between the bar and the side of the form.

  Quad-Lock recommends a maximum sized coarse aggregate of 3/8” [10 mm] for optimum flow and consolidation. Use of larger aggregate will increase the potential for voids and rock-pockets in the wall. Quad-Lock also recommends the use of natural round stone (if available) versus crushed aggregate to optimize flow and

consolidation. Always pay close attention to slump characteristics during the pour, regardless of whether using round or crushed aggregate.

- **Placement**: Place concrete in continuous 'lifts', where the first lift should be approximately 1' to 2.5' [30-75 cm] in height. Continue with 2-4' [60-120cm] 'lifts'. The wall should be filled with concrete in such a manner as to prevent 'cold joints'. See table below for rates of pour under different conditions.
- **Consolidation**: Use an internal pencil vibrator unless concrete slump exceeds 8 in. [203mm] and is approved by the building official. Even if permitted otherwise, hand-rodding and external vibration are not recommended as a primary means of consolidating concrete in Quad-Lock walls.

Important Note: **Concrete Slump:**
Controlling concrete slump is critical. Excessively high slump ("wet concrete") will cause problems with ICFs, especially in cold weather when set-times are extended. Too low slump ("dry" concrete") will cause voids and rock-pockets.

To increase slump BEFORE offloading begins, add plasticizer or water SPARINGLY without exceeding allowable water/cement ratio. Have the operator go to mixing speed for 30 to 40 revolutions. Now check slump again, repeating the process if necessary. Depending on the plasticizing agent, you now have about 45 minutes to offload the concrete.

8.1.1 Delivery of Concrete

- Schedule arrival of concrete loads to adequately allow time to empty each load without significant overlap and waiting time.
- Site supervisor should collect delivery tickets and verify batch time and transit time. Concrete that is 2 hours or more from batch time should not be used.
- Site supervisor should verify compressive strength and aggregate size of delivered concrete.
- Any addition of water or plasticizer to concrete should be noted on the delivery slip, and initialed by the site supervisor.
- If re-tempering of plasticized concrete mix is required AFTER off-loading has begun, use only plasticizer to adjust the slump, not water. Note all changes to the mix on the delivery ticket.

Building Tip: Always check the delivery slips for each truck delivered by the concrete supplier and compare the batching time versus the time-on-site. If you are in danger of exceeding that critical 2 hour time window, send the load back to the supplier.

8.1.2 Pumping and Other Concrete Placement Suggestions

Concrete may be placed by any conventional method in accordance with national standards and local building codes. If using a boom type concrete pump, follow these general tips for pouring ICF walls:

- Use a 3" [76mm] or smaller diameter hose to control the flow of the concrete as it comes out of the pumping equipment. (See reducing hose specification to follow)
- Take your time and pour conservatively. A 20 to 30 minute offload of a full load (13 cu. yards [10 cu. meters]) of concrete is normal. Pouring in an aggressive manner will cause problems.
- Be sure to have sufficient vibrators & experienced operators on hand to keep pace with the placement by pump handlers, especially if multiple pumps are operating.
- Concrete should be placed as nearly as practical to its final position, to avoid segregation due to rehandling or flowing.
- Avoid use of "S" bends at the end of the hose as they pose a danger to placement crew members.
- Friction generated as the concrete moves through the pumping equipment can cause a noticeable loss of slump. Adjust slump in the mixer truck to account for some expected loss of slump by the time the concrete is discharged from the hose. This will vary depending on the pumping equipment and temperature conditions.

Note: *Quad-Lock recommends that local and national safety guidelines for concrete pumping be strictly followed, such as those published by the American Concrete Pumping Association.*
(See www.concretepumpers.com/content/safety)

8.1.3 Begin the Pour

Start by placing concrete under the windows through openings in sills. Fill as much concrete as possible until sill height is reached. Use the vibrator to insure no voids remain in the wall under window openings.

If enough time has passed and concrete under windows has begun to set, begin pouring from top of wall. (Otherwise, you may have to cap window sills with plywood to avoid spillover) Start near a corner and work around the perimeter. Under normal circumstances, place 1' to 2' [30-60 cm] of concrete in the first lift. The second and consecutive lifts should follow the pour rates in the table below, depending on site conditions.

Table 8.1.3 – Maximum Rate of Pour

		Maximum Rate of Pour			
		Wall Assemblies with Regular Panels		Wall Assemblies with Ultra and Plus Panels	
Ambient Temperature	Concrete Mix Temperature	6" [150mm] Concrete Core and Thinner	8" [200mm] Concrete Core and Thicker	6" [150mm] Concrete Core and Thinner	8" [200mm] Concrete Core and Thicker
104°F [40°C]	90°F [32°C]	3 ft [1.2m] / hr	2 ft [1.2m] / hr	4 ft [1.2m] / hr	2 ft [1.2m] / hr
	80°F [27°C]		1 ft [1.2m] / hr	3 ft [1.2m] / hr	
	70°F [21°C]	2 ft [1.2m] / hr			
86°F [30°C]	90°F [32°C]	3 ft [1.2m] / hr	2 ft [1.2m] / hr	4 ft [1.2m] / hr	3 ft [1.2m] / hr
	80°F [27°C]				
	70°F [21°C]				
68°F [20°C]	70°F [21°C]	3 ft [1.2m] / hr	2 ft [1.2m] / hr	4 ft [1.2m] / hr	4 ft [1.2m] / hr
	60°F [16°C]				3 ft [1.2m] / hr
	50°F [10°C]	2 ft [1.2m] / hr	1 ft [1.2m] / hr	3 ft [1.2m] / hr	2 ft [1.2m] / hr
50°F [10°C]	70°F [21°C]	4 ft [1.2m] / hr	3 ft [1.2m] / hr	4 ft [1.2m] / hr	4 ft [1.2m] / hr
	60°F [16°C]	3 ft [1.2m] / hr	2 ft [1.2m] / hr		
	50°F [10°C]				3 ft [1.2m] / hr
32°F [0°C]	60°F [16°C]	4 ft [1.2m] / hr	3 ft [1.2m] / hr	4 ft [1.2m] / hr	4 ft [1.2m] / hr
	50°F [10°C]				
14°F [-10°C]	60°F [16°C]	4 ft [1.2m] / hr	4 ft [1.2m] / hr	4 ft [1.2m] / hr	4 ft [1.2m] / hr
	50°F [10°C]		3 ft [1.2m] / hr		
-4°F [-20°C]	60°F [16°C]	4 ft [1.2m] / hr	4 ft [1.2m] / hr	4 ft [1.2m] / hr	4 ft [1.2m] / hr
	50°F [10°C]				

If you're continuing up with panels and ties later, make sure to cover the tops of the panels. If not using Metal Track on the top of the wall, nail two 1 x 4s at a 90° angle, place them over ties and move them along as you pour. Pour only to the middle of the top row of panels. (10 ft. long pieces of plastic rain guttering are another way to shield the top of panels against concrete.)

If you're not continuing up, trowel the top and set anchor bolts or threaded rod. **After pouring the concrete, immediately check the alignment of the wall; Make adjustments as necessary before concrete has fully set.**

8.1.3.1 Notes on Consolidation / Vibration:

You MUST ensure concrete is properly consolidated. A mechanical vibrator is recommended.

- Use a small diameter mechanical vibrator (¾" – 1¼" [19mm – 32mm]).
- Adequately consolidate the concrete, but do not over-vibrate. Over-vibraton can cause segregation in the concrete and/or form failure.
- External vibration (tapping wall with a wood block and hammer or Wallbrator) provides limited consolidation and is not recommended.

- Do not use the vibrator to move concrete laterally in the wall. This can result in segregation of the concrete components and negatively impact the compressive strength of the concrete.
- Concrete 'build up' on rebar can be removed using the vibrator or by shaking the vertical rebar. Horizontal rebar laps should be tied in an "over-and-under" fashion to present a smaller target for the concrete.
- Standard concrete with a slump of 6" [152mm] can be used to make Quad-Lock walls free of voids, especially if internal vibration is used. Slump loss is expected during off-loading, especially in hot weather. Water added to the mix will decrease concrete strength and should be done sparingly, within the limits of the mix design.

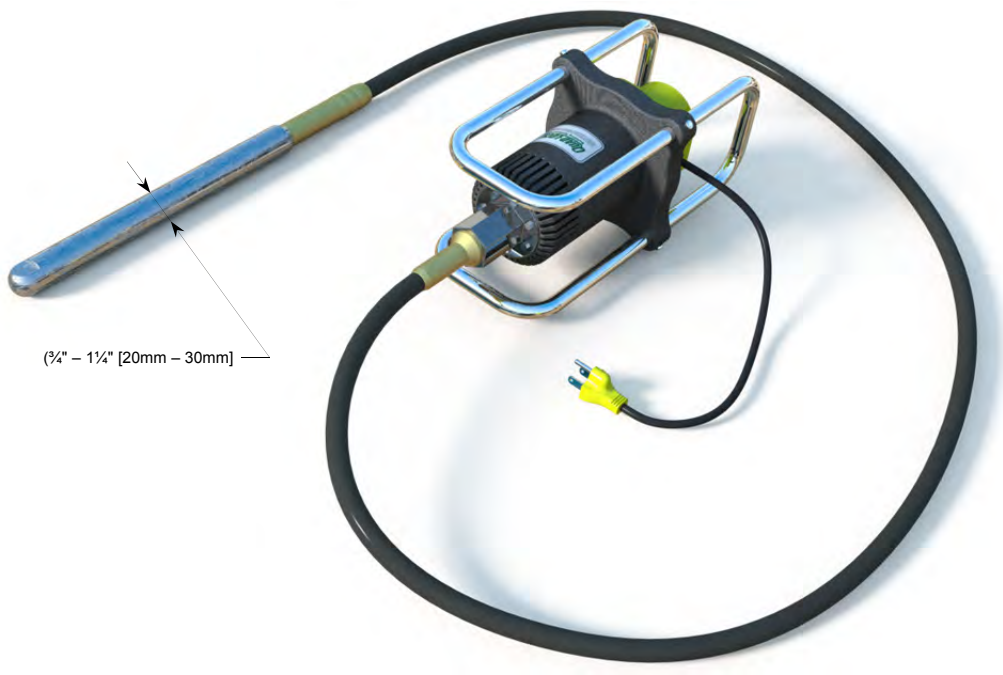


Figure 126: Internal Concrete Vibrator

8.1.4 Curing Concrete

Concrete will attain its initial compressive strength in Quad-Lock walls in the same fashion as other conventional forming systems. What is different about the cure obtained in Quad-Lock forms is that water does not evaporate as quickly as with other forming systems; thus, the higher amount of moisture available to complete the hydration process can result in 50% to 70% higher compressive strengths after time passes.

8.1.4.1 Cure Time and Removal of Bracing

For single-story wall heights, 48 to 72 hours is adequate time for the concrete to achieve safe compressive strength levels to allow bracing removal. Bracing for taller walls should be removed at the instruction of the project Engineer of Record. (See Chapter 6, Section 6.1 "General Comments on ICF Bracing" on Page 132 for more details)

8.1.4.2 Cure Time and Back-Filling

For back filling, the ready-mixed concrete producer's guidelines should be followed to obtain about an 80% cure prior to commencement of back-filling. (See Chapter 6, Section 6.1 "General Comments on ICF Bracing" on Page 132 for more details)

- Intermediate floor diaphragms MUST be installed before back-filling.

8.1.5 Using Pozzolan Additives (Fly Ash and Blast Slag):

Substitution of fly ash or blast slag in the concrete mix used in Quad-Lock walls is perfectly acceptable, even in relatively high percentages, and Quad-Lock encourages this practice. This is especially true in instances where the building owners must use recycled materials or post-industrial waste as an objective in their building design.

- The addition of fly ash or blast slag will affect slump, cure time, and initial compressive strength. Be sure to take this into account when using these materials as a substitute for cement.

- Introduction of pozzolans to the concrete mix generally makes the mix more flowable, which is advantageous in ICF construction. However, this will affect the dosage of plasticizers or other agents used to improve flow characteristics. Care must be taken not to exceed the required slump at the time of pour.

***Note**: When using fly ash or blast slag in suspended floor applications with Quad-Deck, it is critical that the engineer of record is aware of the addition of these materials, as rates of cure may be affected.*

8.1.6 Cold Weather Concreting

Quad-Lock walls can be poured in freezing weather under certain conditions. Concrete requires a certain minimum temperature to begin the chemical reaction required to begin the curing process. Mix designs with higher cement content can be placed at lower ambient air temperatures. Consult the table below for minimum temperature conditions.

Concrete must arrive at the site sufficiently warm to be placed at or above this minimum. It is advisable to include air entrainment in the mix design, if concrete is expected to be exposed to freezing temperatures. Under these conditions, the insulating qualities of the Quad-Lock Panels should sufficiently insulate the concrete long enough for the curing process to complete.

Cover the tops of the walls with insulation immediately after the pour to protect from freezing. Exposed steel anchor bolts needed to be insulated to prevent freezing damage to the concrete. Cold temperatures will retard early strength gains of concrete and extend curing times. Consult your ready mix supplier or local cement association representative for more details on cold weather concreting.

Minimum ambient air temperature for Quad-Lock Walls formed with **Regular or Ultra Panels** on just one or on both sides of wall. Surface temperature maintained at 50°F (10°C) for 3 days.

Quad-Lock Wall Concrete Core Thickness (nominal)	**Cement Content**			
	300 lb/yd³ 178 kg/m³	**400 lb/yd³ 237 kg/m³**	**500 lb/yd³ 296 kg/m³**	**600 lb/yd³ 356 kg/m³**
6" [150mm]	33°F [1°C]	27°F [-3°C]	21°F [-6°C]	16°F [-9°C]
8" [200mm]	26°F [-3°C]	18°F [-8°C]	10°F [-12°C]	3°F [-16°C]
10" [250mm]	19°F [-7°C]	9°F [-13°C]	-1°F [-18°C]	-11°F [-24°C]

1999-09-14 *Compiled by Hubert Kustermann*, Quad-Lock Building Systems Ltd.*

Minimum ambient air temperature for Quad-Lock Walls formed with **Plus Panels (including Extra Panels)** on both sides of Concrete Core. Surface temperature maintained at 50°F (10°C) for 3 days.

Quad-Lock Wall Concrete Core Thickness (nominal)	**Cement Content**			
	300 lb/yd³ 178 kg/m³	**400 lb/yd³ 237 kg/m³**	**500 lb/yd³ 296 kg/m³**	**600 lb/yd³ 356 kg/m³**
6" [150mm]	13°F [-11°C]	2°F [-17°C]	-11°F [-24°C]	-22°F [-30°C]
8" [200mm]	-1°F [-18°C]	-15°F [-26°C]	-32°F [-36°C]	-49°F [-45°C]
10" [250mm]	-15°F [-26°C]	-32°F [-36°C]	-52°F [-47°C]	-75°F [-59°C]

1999-09-14 *Compiled by Hubert Kustermann*, Quad-Lock Building Systems Ltd.*
**Diploma of Engineering- Technical University of Munich*

These tables are derived by an interpolation of the values shown in Table 7.3.2 of the "Practitioners Guide to Cold Weather Concreting" in "Manual of Concrete Practice"

8.1.6.1 Background Information on Cold Weather Concreting

Depending on the amount of cement content, the chemical process of hydration (hardening) of the cement is producing heat. That energy cannot escape due to the insulating properties of the Quad-Lock forms and insulation on the top of walls. The heat will keep the concrete at temperatures that not only prevent it from freezing, but also ensure proper curing of the freshly poured concrete, as long as the actual ambient temperatures will be above the minimum temperatures shown in the table above.

Example: You want to pour an 8" [20cm] R-22 Quad-Lock wall using concrete with a cement content of 500 lb/yd³. The weather forecast is predicting low temperatures of 5ºF [-15ºC] over the next days.

Can you pour? Look up the table under "Cement Contents 500 lb/yd³" and across 8" [20cm] and find 10ºF [-12ºC] as the minimum allowable ambient temperature.

Answer: You cannot pour! However, if you were using concrete with a cement content of 600 lb/yd³, the pour will become possible, since the minimum allowable temperature will be lower than the temperature forecasted (3ºF [-16ºC] versus 5ºF [-15ºC]).

8.1.6.2 General Cold Weather Concreting Guidelines:

- Use air-entrained concrete when exposure to moisture and freezing and thawing conditions are expected.
- Keep surfaces in contact with concrete free of ice and snow and at a temperature above freezing prior to placement.
- Place and maintain concrete at the recommended temperature.
- Place concrete at the lowest practical slump.
- Limit rapid temperature changes when protective measures are removed.
- Contact your Ready Mix Producer to discuss heating water and aggregates
- Order an accelerating admixture
- Increase cement content in the mix or using Type III Cement.
- Pour during the warmest part of the day.
- Avoid delays; Take advantage of heat generated by chemical reaction in the previous lift.
- Avoid “shocking” concrete by pouring over reinforcing bar that is at excessivly low temperatures.

8.1.7 Hot Weather Concreting:

Hot weather conditions can present challenges when pouring any ICF. “Hot Weather” may include any or all of the following:

- High ambient temperatures
- Low relative humidity
- Wind velocity
- Solar radiation

Note the following suggestions when building in sustained hot weather conditions:

8.1.7.1 Avoiding Heat Build-Up in EPS Form Panels and Reinforcing Steel

Expanded Polystyrene is a thermoplastic and will become more flexible as temperatures increase. Concrete pressure may cause undesired deflection in forms that are too warm.

- It is advisable to pour in the coolest conditions available (early in the morning) and/or to spray forms down with a water mist that will evaporate and carry away some heat from the forms. Effect of Hot Reinforcing Bar
- If reinforcing bar is allowed to heat up inside the forms, the stored heat will tend to accelerate the curing of concrete residue that may build up on the bar during the pour. In successive lifts, this residue may become an obstruction in the wall, and increase the risk of voids.

Again, an early-morning pour is suggested to minimize the temperature of both forms and rebar. Vibration of the bar between lifts is also recommended.

Daytime temperatures may be another reason to employ the “side-pour” method recommended for tall walls.

- Many builders cut holes in the side of the forms to accommodate filling by the pump through the holes, thus by-passing the upper layers of reinforcing bar.
- Foam cut-outs are then attached to plywood and placed back into the wall, screwing the plywood onto the tie flanges.

8.1.7.2 "Hot" Concrete

Concrete that is already beginning to set at the time of delivery is referred to as a "hot load". Since the concrete curing process is chemical reaction activated (and accelerated) by heat, it is best not to allow the mix to gain temperature during transport. This is problematic at more remote sites that are a long distance from the concrete plant, or routes that may encounter heavy urban traffic. There may be an hour or more of transport time, during which the concrete will begin its curing process. Add another 30 minutes or more for off-loading, and the concrete may be already setting during the pour, which will cause many problems.

8.1.7.3 Emergency Measures for Hot Conditions

It may be advisable to keep additional packets of plasticizer or set-retarder on site for emergencies, especially in the hottest conditions. Some concrete producers are able to add chilled water or ice to the mix to lower initial mix temperatures, but if delays occur, a backup plan may be needed to save the load and the equipment.

8.1.7.4 Site-mixed Concrete

One solution to the problem of hot conditions is "site-mixed concrete", wherein all the dry components are delivered in separate bins on a specialized mix truck and combined with water on site. The mixed concrete is literally seconds old when it is placed in the pump truck, and the concrete has a much longer life in its plastic (liquid) state, before curing begins. Call your local concrete producers to find this type of ("volumetric") equipment, often companies that specialize in small "yard-at-a-time" deliveries.

8.1.7.5 General Hot Weather Concreting Guidelines

- Pour early in the morning to take advantage of cooler ambient temperatures.
- Spray a water mist over forms and rebar to help dissapate stored heat.
- Avoid build-up of concrete on hot rebar by vibrating rebar between lifts, or bypassing upper rebar by pouring from side of wall.
- "Site-mix" concrete that must be transported long distances (or in heavy traffic).
- Keep plasticizer or set-retarder on site for emergencies.
- Order chilled water or ice added to the mix at the batch plant, if available.
- Use placement techniques and slump that will allow the fastest practical placement of concrete.

See ACI 305 "Hot Weather Concreting" for more detailed information on hot weather concreting.

8.2 REINFORCING STEEL (REBAR)

The Quad-Lock system has been designed to accommodate horizontal reinforcing steel placement in the molded "rebar chairs" on the Quad-Lock Ties. The system is ideally suited for even 12" [30cm] increments horizontally. Vertical reinforcing steel of almost any spacing can be accommodated in the Quad-Lock system.

8.2.1 Securing Reinforcing Steel in Quad-Lock Walls

The design and placement of reinforcing steel in the Quad-Lock system should be in accordance with local building codes or an approved site-specific design by a professional structural engineer. For additional reinforcing steel design guidelines contact Quad-Lock's Technical Department. Prescriptive reinforcing designs can be found in the IRC (USA), the NBC (Canada) and other national building codes.

8.2.1.1 Positioning Rebar

North American building codes require reinforcing bar to be 'secured' into position to prevent displacement during the pouring of concrete. Molded rebar chairs found on Quad-Lock ties aid in the correct positioning of rebar according to code or engineering specifications. Rebar can be fastened to the plastic ties, other rebar, or both to insure that the correct positioning is maintained. The following sections outline the basic methods for placement of rebar in Quad-Lock ICF walls. In all cases, the objective is to limit displacement of rebar during the pour to code-prescribed maximums like those shown in Section 8.2.1.2

8.2.1.1.1 Off-set Rebar Position

Rebar positioning within the wall is critical to the structural design, and prescribed in the structural design documents. For example, above-grade walls not subject to high wind or seismic loads may be allowed to have rebar simply centered in the wall cavity. Buildings subject to high wind, seismic forces, or soil pressures may have the rebar off-set to the tension side of the wall, e.g. **towards the INTERIOR for basements**. See "Position of Reinforcement within Quad-Lock Walls" Figure below.

Regardless of the position in the wall, installers must maintain the minimum concrete cover around each bar per local building codes and exposure conditions. E.g. per ACI 318 for walls not exposed to weather nor earth, at least ¾ inch [20mm] concrete cover is required for bars smaller than 1 inch [25mm].

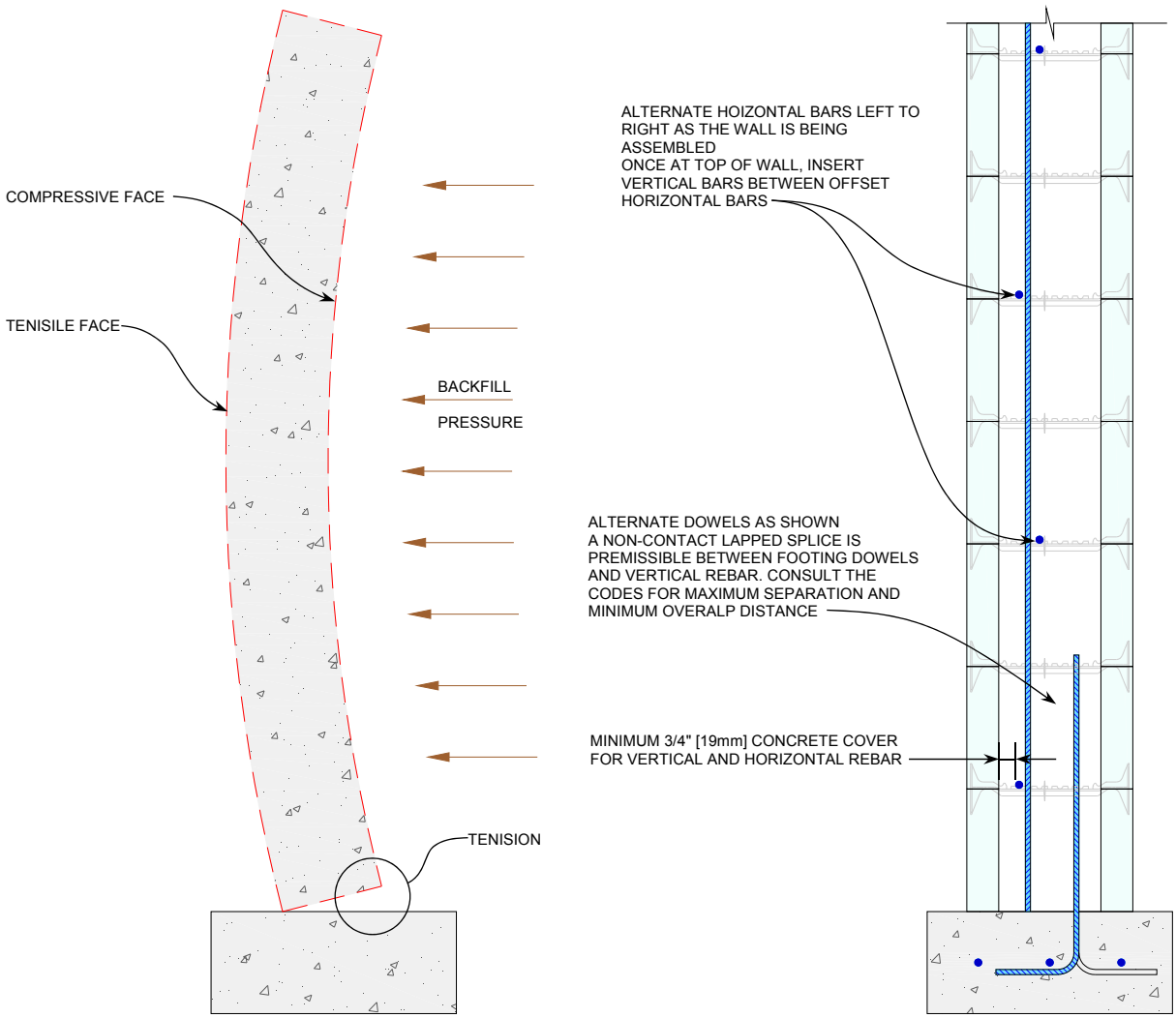


Figure 127: Position of Reinforcement within Quad-Lock Walls

8.2.1.1.2 Securing Vertical Reinforcing Bar

Vertical reinforcing bars may be secured into position in various ways, depending on the height of the walls and the structural requirements. Three basic methods are as follows:

Method 1. **Single story-height walls; Footing dowels and vertical bar spacing match**

Vertical rebar in single-story height walls can be pre-positioned by tying vertical bars to footing dowels IF the spacing of the dowels and vertical bar are the same. ICF panels and ties can then be positioned around the pre-tied bars, adding horizontal bars to each succeeding course.

Alternately, many experienced ICF installers find it more cost-effective to place the vertical bars after the ICFs and horizontal rebar has been built to full storey height.

To secure vertical rebar cut short (4" [102mm]) pieces of plastic pipe 1¼" to 1½" [32 to 38mm] in diameter and drop them over the rebar stubs that are sticking up out of the footing. Do not place the vertical steel at this point. Build the Quad-Lock wall, placing horizontal steel only as you build. (Use the "Rebar Weave" method described in Section 8.2.1.1.3) When the wall is at the desired height, slip pre-cut vertical rebar into the plastic pipe next to the stub steel, and secure at the top of the wall by tying vertical bars to horizontal bars.

Vertical rebar is now constrained at top and bottom of the wall, as well as by the off-set horizontal bars, which are themselves fixed to the plastic ties. Quad-Lock suggests that the local building department is consulted prior to starting the project to determine the acceptability of the above method.

Method 2. **Tall walls & higher loading requirements; Footing dowels and vertical bar spacing match**
When wall heights exceed a single story or if higher loading conditions exist, pre-tying vertical bars to extended footing dowels may be the best option.

During construction of the footing or slab, place dowels at the specified length and spacing called out by the Engineer of Record, taking into account the total wall width including two layers of EPS and the concrete cavity. Cut vertical reinforcing bars to length, or to a length that would permit a lapped splice somewhere in the wall height. Tie vertical bars to footing dowels. Stabilize the vertical bars by tying temporary (light weight) horizontal bars to the verticals, beginning about 6 ft. [2 m] above the footing or slab. Use the called-out spacing for the vertical bars.

After vertical rebar is spaced and stabilized, begin assembly of the ICF wall components by working around the vertical bars. Place horizontal reinforcing at each course of the ICF forms, securing the horizontal bar to the vertical bars. Pay close attention to keeping the wall aligned and in a vertical plane (plumb) so you do not have to work against the rebar to straighten the wall prior to pouring.

Method 3. **Tall walls and single-story walls: Footing dowels and vertical bar spacing do not match**

In cases where the spacing of the footing dowels and vertical rebar does not match, it may be necessary to provide "sleeves" in the concrete as follows:

While laying out the building lines and positioning for the Quad-Lock ICF panels, chalk an additional line to represent the position of the vertical bar in the cavity space. Place metal tracks and the first row of Quad-Lock panels & ties in the normal fashion.

After completing ICF row #1, use a rotary concrete drill with a long bit to place min. 2" [50mm] deep holes in the concrete, using the pre-snapped line as a guide. Space the holes at the called-out distance from the approved plans, making them slightly larger than the vertical bar itself. These holes now will provide a "sleeve" to secure vertical rebar that is inserted into the wall. Depending on the height of the wall, vertical bar placement may occur mid-way during the installation of the Quad-Lock ICFs or after the top elevation has been reached. In the case of walls exceeding one story, it may be necessary to secure the vertical bars to horizontal bars more frequently to resist displacement.

8.2.1.1.3 Rebar Weave

One way to keep vertical rebar in position is to "weave" it between horizontal bars that have been staggered in position as they are placed at each course of ICF panels and ties. (See Figure 127: Position of Reinforcement within Quad-Lock Walls above) Pre-cut vertical rebar is dropped into position from the top of the wall between the off-set lines of horizontal rebar, which are secured to the plastic ties. An example is shown in Figure 128: Rebar "Weave" below.

Note: The off-set between horizontal bars should be close enough to restrict the movement of vertical bar to the allowable limits shown in Table 8.2.1.2 below.

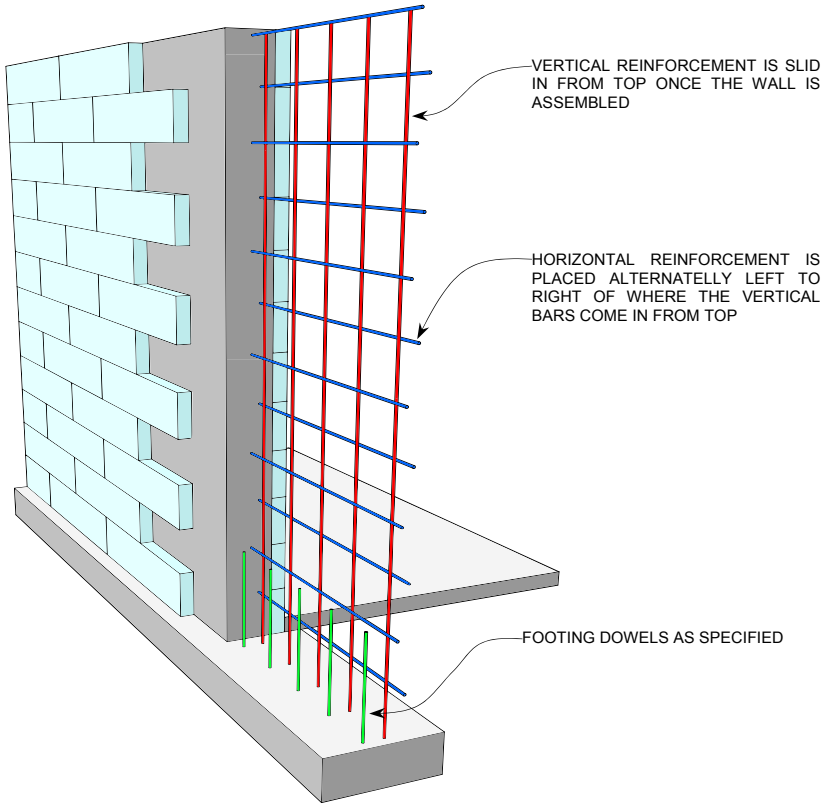


Figure 128: Rebar "Weave"

8.2.1.1.4 Lapped splicing of horizontal & vertical rebar

Splices between sections of horizontal & vertical rebar must be made by overlapping the two bars by a prescribed distance. Generally, for bars under 1" [25mm] in diameter, this distance is calculated by multiplying the bar diameter by 40. For example, the minimum lap for ½" [13mm] rebar is 20 inches [51 cm]. More lap is permissible, but not less. The two lapped bars may be tied and in contact with each other, or separated by a specified maximum distance.

8.2.1.1.5 Non-contact lapped splices of rebar

Most building codes allow "non-contact" (un-tied) lapped splices between bars running in a single direction, as long as certain minimum overlap lengths and maximum spacing between bars are met. For example, the 2012 IRC, Section 611.5.4 outlines the conditions under which non-contact lapped splices may be employed: overlap a minimum of 40db, where db is the diameter of the smaller bar. The maximum distance between noncontact parallel bars at a lap slice shall not exceed 8db.

Builder's Tip:	**Horizontal bar splices (except at corners or similar) are often well suited for non-contact lapped splices, especially where they coincide with a common seam in the ICF formwork. This allows for some adjustment of the formwork before, during, and right after the pour. Quad-Lock recommends that sufficient spacing between the non-contact spliced bars be maintained for course aggregate to easily fit in-between those bars.**

8.2.1.2 Allowable Variation in Rebar Position

Building codes may allow a small amount of variation in the positioning of rebar, usually driven by the total width of the wall cavity. Examples are shown in Table 8.2.1.2 below for Quad-Lock wall cavities according to the allowable variation permitted under the US 2012 IRC. Be certain to secure rebar in such a manner as to not exceed these allowable amounts of variation.

Table 8.2.1.2 Allowable Variation in Rebar Position

Wall Cavity Size	Maximum Allowable Variation in Rebar Position
3.75 inches [95mm]	0.375 inches (3/8”) [10mm]
4.0 inches [102mm]	0.375 inches (3/8”) [10mm]
5.75 inches [147mm]	0.575 inches (9/16”) [14mm]
6 inches [152mm]	0.625 inches (5/8”) [16mm]
7.75 inches [197mm]	0.75 inches (3/4”) [19mm]
8 inches [203mm]	0.81 inches (13/16”) [21mm]
9.75 inches [248mm]	0.975 inches (1”) [25mm]
10 inches [254mm]	1.00 inches (1”) [25mm]
11.75 inches [298mm]	1.17 inches (1 1/8”) [30mm]
12 inches [305mm]	1.19 inches (1 3/16”) [31mm]
13.75 inches [349mm]	1.37 inches (1 3/8”) [35mm]

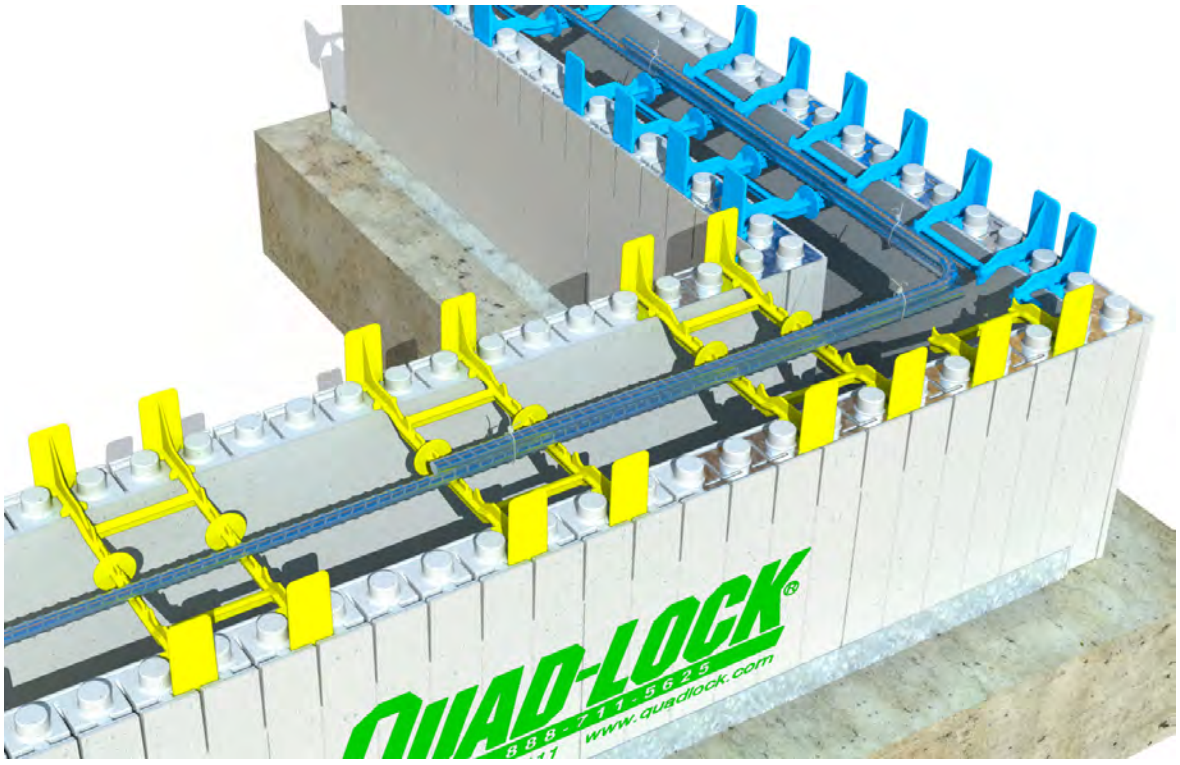


Figure 129: Sample Rebar Placement at Corners & T-Walls

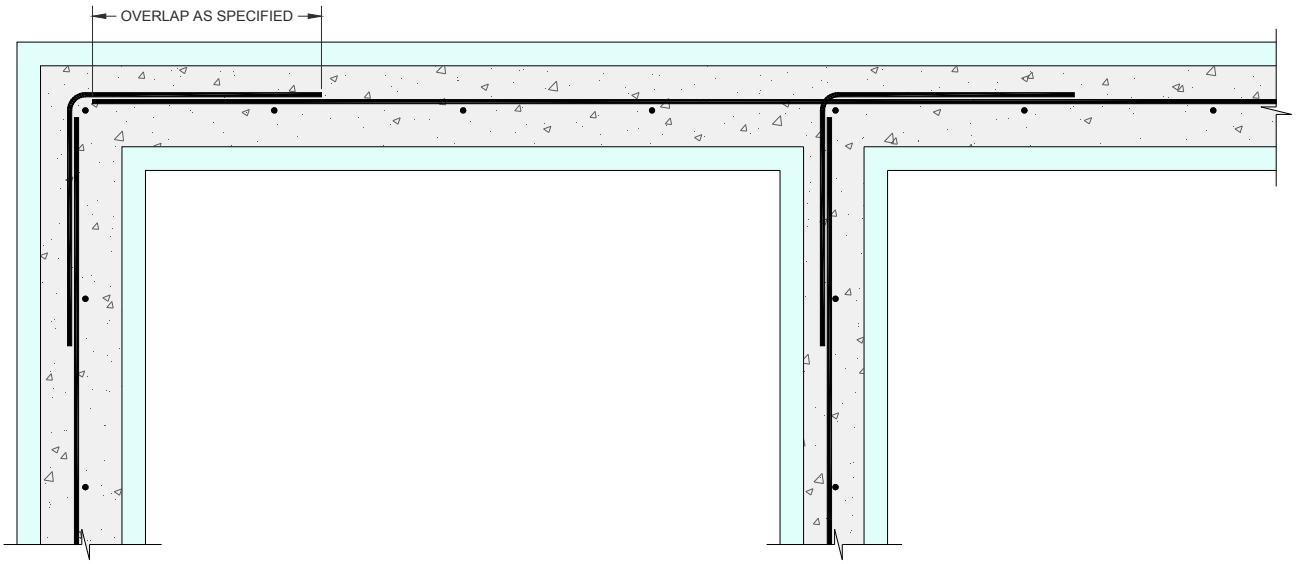


Figure 130: Typical Lap Patterns at Corners & T-Walls

Building Tips: **If the specified spacing for horizontal bar is not a 12" [305mm] increment, contact the project engineer and request a change. Alternate positioning of horizontal rebar (see figures below) to allow vertical bar to fit between horizontal runs at center of wall.**

From the building plans, pre-plan the layout of the horizontal and vertical steel. Pre-cut pieces off-site and have them delivered. This includes horizontal steel, vertical steel and 90° bends.

To secure vertical rebar (and if permitted by building officials), cut short (4" [102mm]) pieces of plastic pipe 1¼" to 1½" [32 to 38mm] in diameter and drop them over the rebar stubs that are sticking up out of the footing. Do not place the vertical steel at this point. Build the Quad-Lock wall, placing horizontal steel only as you build. When the wall is at the desired height, slip pre-cut vertical rebar into the plastic pipe next to the stub steel, and secure at the top of the wall.

Consult your local Building Official, Engineer and/or Quad-Lock Representative for accepted methods.

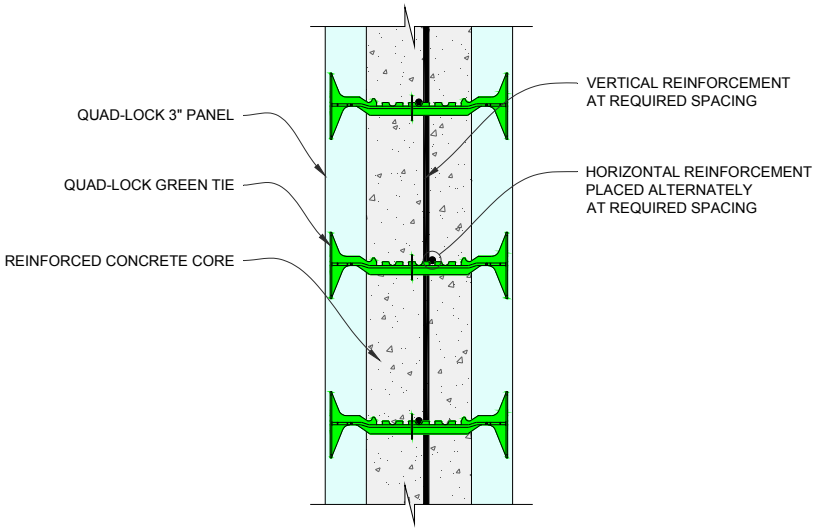


Figure 131: Rebar Placement

8.2.2 Typical Wall Opening & Lintel Reinforcement

An example of footing, wall and opening reinforcement is shown below. The expected wind and seismic risks in your area will determine how much reinforcing is required, as well as the number of stories in the structure. Follow the structural design requirements set out by the Engineer of Record for the project, or the prescriptive requirements contained in your local building code, if applicable.

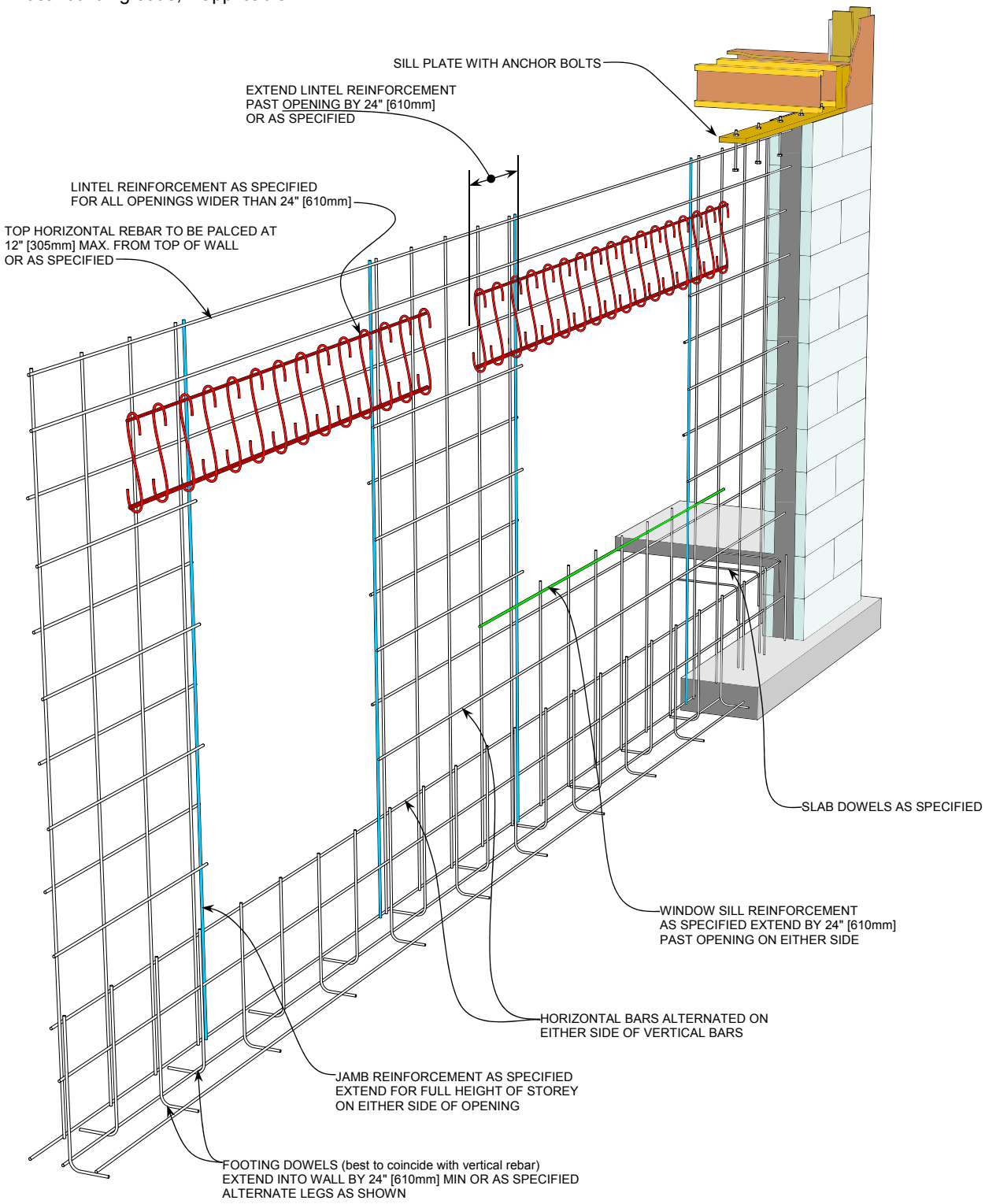


Figure 132: Typical Wall Opening Reinforcement

METHOD A - Lintel Reinforcement	METHOD B - Lintel Reinforcement	Alternate to **METHOD A - Lintel Reinforcement**
1 top bar and 1 or 2 bottom bars with S-stirrups ; Typically specified on openings up to 12 feet [3.6m] in span	2 top bars and 2 or 4 bottom bars with O-stirrups Typically specified for lintels up to 20 feet [6.1m] in span	**WARNING** - use only if approved by the Engineer of Record. Typically a single #3 [10M] bar bent to shape for easier installation

Figure 133: Typical Lintel Reinforcement

8.2.3 Concrete Pre-Pour Checklist

Concrete Order:

- ❑ Confirm required compressive strength (psi or KPa) from plans or engineering specifications.
- ❑ Aggregate size confirmed: 3/8" (10mm)
- ❑ Concrete mix ordered at low slump (3" to 4" [75mm to 100mm]) with water; Add plasticizer later.
- ❑ Chemical admixtures (Plasticizer; water reducer) ordered to increase slump (6" [150mm]) at time of delivery to site.
- ❑ If ordering fly ash or blast slag, change quantity of plasticizer or water reducer to suit.

At the Site:

- ❑ Digital photos taken of rebar placement for archive.
- ❑ Additional chemical admixture available at site for emergency use. (Plasticizer or other)
- ❑ Concrete truck delivery spaced to allow time for placement and initial set of 1st lift.
- ❑ Slump cone and cylinder molds for quality control; Clean-out pit for driver use.
- ❑ Delivery tickets saved by site superintendent.

Hot Weather:

- ❑ Chemical admixture available at site for emergency use (Plasticizer).
- ❑ Chilled water or ice added to mix.
- ❑ Chemical retarder added to mix.
- ❑ Forms & rebar sprayed with water to reduce internal temperature.
- ❑ Prepare for "side-pour" method on tall walls to reduce concrete build-up on rebar.

Cold Weather:

- ❑ Forms and rebar clean and free of snow or ice build-up; Provide covers for top of wall.
- ❑ Hot water added to concrete mix at ready-mix plant
- ❑ Accelerator added to first load (or subsequent loads as necessary).

9 DAMP PROOFING & WATERPROOFING

Most building codes require protection of below-grade concrete walls against subterranean moisture, either in bulk form (water-saturated soils) or vapor (damp soils). **These conditions are quite different, and require very different protection measures.**

- The local building department will usually call for either “water-proofing” or “damp-proofing” of below-grade concrete walls. A call to the building department, ahead of time, to establish which measure is required, will save time, expense, and a possible inspection failure.

9.1 DAMP PROOFING

For soil conditions that are never prone to saturation by water and the resulting hydrostatic pressure, damp-proofing measures may be adequate. As a rule, all below-grade concrete walls should be isolated from damp soils. While conventionally formed, un-insulated concrete walls are usually coated with a petroleum-based emulsion, ICF walls are not well-suited for this method.

- Quad-Lock recommends the installation of a dimpled drain board product that will both isolate the EPS from damp soils and provide a drainage pathway for ground water that may be present in soils from time to time. (see product list below).
- If rolled-on or sprayed-on emulsion products are used, they should be applied in multiple layers that bridge all seams and gaps. These products often require a fabric or mesh as reinforcement, and should be clearly recommended for application over EPS by the manufacturer.
- Be sure to backfill with clean, free-draining backfill material that does not contain clay or organic material.

Figure 134: Damp Proofing with Drainage/Dimple Board

9.2 WATERPROOFING

When the Quad-Lock Building System is used for below grade occupied areas or connected to these areas in soils prone to water saturation and the presence of hydrostatic pressure, the application of exterior waterproofing is necessary.

In addition, always ensure that below grade Quad-Lock walls are not subject to excessive hydrostatic pressure by following usual and customary building practices, including but not limited to:

- Proper collection and diversion of rainwater from roofs and surrounding areas.
- Proper construction of footing drains, with rated piping, drainage materials and filter fabric.
- Proper grading of soils away from the building.
- Use of rated free draining backfill material with known flow rates.
- Proper compaction methods during backfill to prevent settling after the fact.

9.2.1 Applied Waterproofing Membranes

Membrane-type waterproofing products are available as self-adhesive “peel and stick” type (recommended), roll-on, or spray-on type. Spray-on or roll-on membranes may not adequately bridge joints and other gaps in the foam, unless rated to do so.

- Quad-Lock recommends the use of self-adhesive membranes in almost every instance where hydrostatic pressure is ever likely to occur.
- Quad-Lock also recommends a drainage/protection board layer to adequately drain the soil, and to protect the membrane from backfill materials.

9.2.1.1 Application of Self Adhesive Membrane

Always follow manufacturer’s installation instructions for application to EPS surfaces. Quad-Lock recommends that a compatible primer be applied to the surface of EPS before installation of membranes.

The following is a general set of installation instructions for self-adhesive membranes over EPS:

9.2.1.1.1 General Instructions for Installing Self Adhesive (“Peel and Stick”) Membrane

1. All surfaces must be smooth, dry and free of dust, water or any other substance which may hinder adhesion.
2. Concrete (footing) must be cured a minimum of seven (7) days and an adhesion test is recommended before membrane application. Ensure the footing is clean and dry.
3. For membrane applications at temperatures below -5°C (23°F) contact your local peel & stick representative.
4. A water-based or rubber-based primer may be used. See manufacturer’s recommendations.
5. All penetrations (pipes, etc.) through the waterproofing membrane, should be pre-treated with an application of liquid membrane/sealant.
6. All inside corners (vertical and horizontal, e.g. along footing) must be pre-stripped with a 6" [152mm] width of membrane centered on the corner. This membrane must be installed in direct contact with the substrate not leaving any voids under the membrane strip.
7. All outside corners must be pre-treated with a 6" [15cm] width strip of membrane centered on the corner.
8. For vertical applications, align the first strip of membrane to one of the grooves in the Quad-Lock Panel. At the top edge of the strip remove approximately 6" [15cm] of the silicone release paper and adhere the membrane to the surface. Affix the remaining portion of the strip by removing the silicone release paper. During application, pass hand over the surface to remove any trapped air and wrinkles. Apply pressure with a hand roller over the membrane to ensure good initial adhesion.
9. Subsequent rolls must be installed in the same way and should be aligned with the preceding roll with a lap of at least 2½" [65mm]. End laps must overlap at least 6" [152mm]. Avoid wrinkles in the membrane at the overlaps (roll the seams with laminate or J-roller).
10. Seal all leading edges (e.g. at top and bottom) and all horizontal overlaps with sealant.
11. Protect the membrane to avoid damage from other trades, construction materials, and backfilling. Use a rated drainage board layer. Consult your Quad-Lock dealer for ideas.

Figure 135: Water Proofing with Protection Board

Figure 136: Water Proofing with Peel&Stick

Building Tip:	**Pre-cut peel-and-stick membrane into desired lengths and attach it vertically. Reach around either side of the membrane and remove the backing as you install. Avoid removing all of the backing prior to installation. Always overlap the joints and follow the manufacturer's recommendations on the use of a protection board before backfilling.**

9.2.2 Internal Membranes

Additives for concrete that provide a measure of water-resistance via the concrete structure itself have come into wider recognition and use in recent years. These additives are generally non-reactive with EPS and can be used in ICF walls and suspended floors or roofs. Note the following when using waterproofing additives for concrete:

- Limitations may exist on the size of void (crack) that a given product will protect. Carefully read manufacturer's instructions and warranty information.
- Admixtures will often change the slump and/or curing characteristics of concrete. Set times may be retarded.
- Admixtures must be WELL blended into concrete mix. Follow all recommended mixing procedures.

9.2.3 Water Management Products Compatible with Quad-Lock EPS

Below is a list of readily available waterproofing and damp-proofing products that have been screened for compatibility with EPS. Check warranty terms with the manufacturer prior to applying it to the Quad-Lock Panels. Quad-Lock Building Systems does not extend any warranties on waterproofing capacity offered by the Quad-Lock forming system or the concrete within. This can only be provided by manufacturers of systems applied to Quad-Lock walls, or added to the concrete used to pour them.

9.2.3.1 Table of Water Management Products Compatible with Quad-Lock EPS

PRODUCT NAME	MANUFACTURER	TYPE	APPLICATION
Quad-Lock Peel & Stick	Quad-Lock Building Systems Ltd. www.quadlock.com 888-711-5625	Waterproofing Membrane	Self-Adhesive
Blueskin WP-200	Henry Co. 800-486-1278 www.henry.com	Waterproofing Membrane	Self-Adhesive
Aquatac Emulsion Primer	Henry Co. 800-486-1278 www.henry.com	Water-based primer for self-adhesive membranes	Liquid applied
Hi-Tac Adhesive and Primer	Henry Co. 800-486-1278 www.henry.com	Rubber-based adhesive and primer for self-adhesive membranes	Liquid applied
Colphene ICF	Soprema Inc. 800-567-1492 www.soprema.ca	Waterproofing Membrane	Self-Adhesive
Elastocol Stick H2O	Soprema Inc. 800-567-1492 www.soprema.ca	Water-based primer for self-adhesive membranes	Liquid applied
Resisto ICF Membrane	Resisto 877-478-8408 www.resisto.ca	Waterproofing Membrane	Self-Adhesive
Resisto H2O Primer	Resisto 877-478-8408 www.resisto.ca	Water-based primer for self-adhesive membranes	Liquid applied
Jiffy Seal 140/160	Protecto Wrap Co. 800-759-9727 www.protectowrap.com	Waterproofing Membrane	Self-Adhesive
Universal Water Based Primer	Protecto Wrap Co. 800-759-9727 www.protectowrap.com	Water-based primer for self-adhesive membranes	Liquid applied
Bituthene 4000 Bituthene 3000	W.R. Grace & Co. 617-876-1400	Waterproofing Membrane	Self-Adhesive
Melrol Melgard	W.R. Meadows Co. 708-683-4500	Waterproofing Membrane	Self-Adhesive
Delta-MS Clear	Cosella-Dörken Products, Inc. www.cosella-dorken.com	Drainage Board	Mechanically Fastened
System Platon	Armtec 800-265-7622 www.armtec.com	Damp-proofing Membrane	Mechanically Fastened
Aqua-Barrier FP	IKO Group 800-661-1034 www.iko.com	Waterproofing Membrane	Self-Adhesive
Insul-Mastic 7101	Innovative Manufacturing 604-522-2811 www.innovativemfg.ca	Emulsion for Damp Proofing or Waterproofing	Liquid Applied Membrane + Mesh
Krystol Internal Membrane (KIM)	Kryton Canada Corporation 800-267-8280 www.kryton.com	Hydrophilic crystalline admixture	Blend into concrete
Xypex C-series	Xypex Chemical Corporation 800-961-4477 www.xypex.com	Hydrophilic crystalline admixture	Blend into concrete

10 WALL FINISHING

10.1 INTERIOR WALL FINISHES

10.1.1 Requirement for Thermal Barrier

Most model building codes around the world (Including USA, Canada, UK, and others) require thermal protection of foamed plastics used in construction, including Expanded Polystyrene like that used in Quad-Lock and other ICF systems. The most common requirement is for a *"15 minute thermal barrier"* to be installed over foam insulation in all habitable areas of the structure. Again, most commonly, the most widely recognized is the application of ½" [13mm] of gypsum drywall which is then tested to verify that the assembly is adequately protected for 15 minutes.

Quad-Lock has satisfied the requirements for most model building codes, including requirements governing the application of a 15 min. thermal barrier to foamed plastic insulation. Be sure to consult the Quad-Lock website for the most up-to-date information concerning code compliance. www.quadlock.com

Quad-Lock is often asked if other materials can be used to satisfy the 15 minute thermal barrier requirement. The answer is "yes", but only if the material has undergone specific fire testing according to standards recognized by the building code that governs your region, and is approved by your local building official.

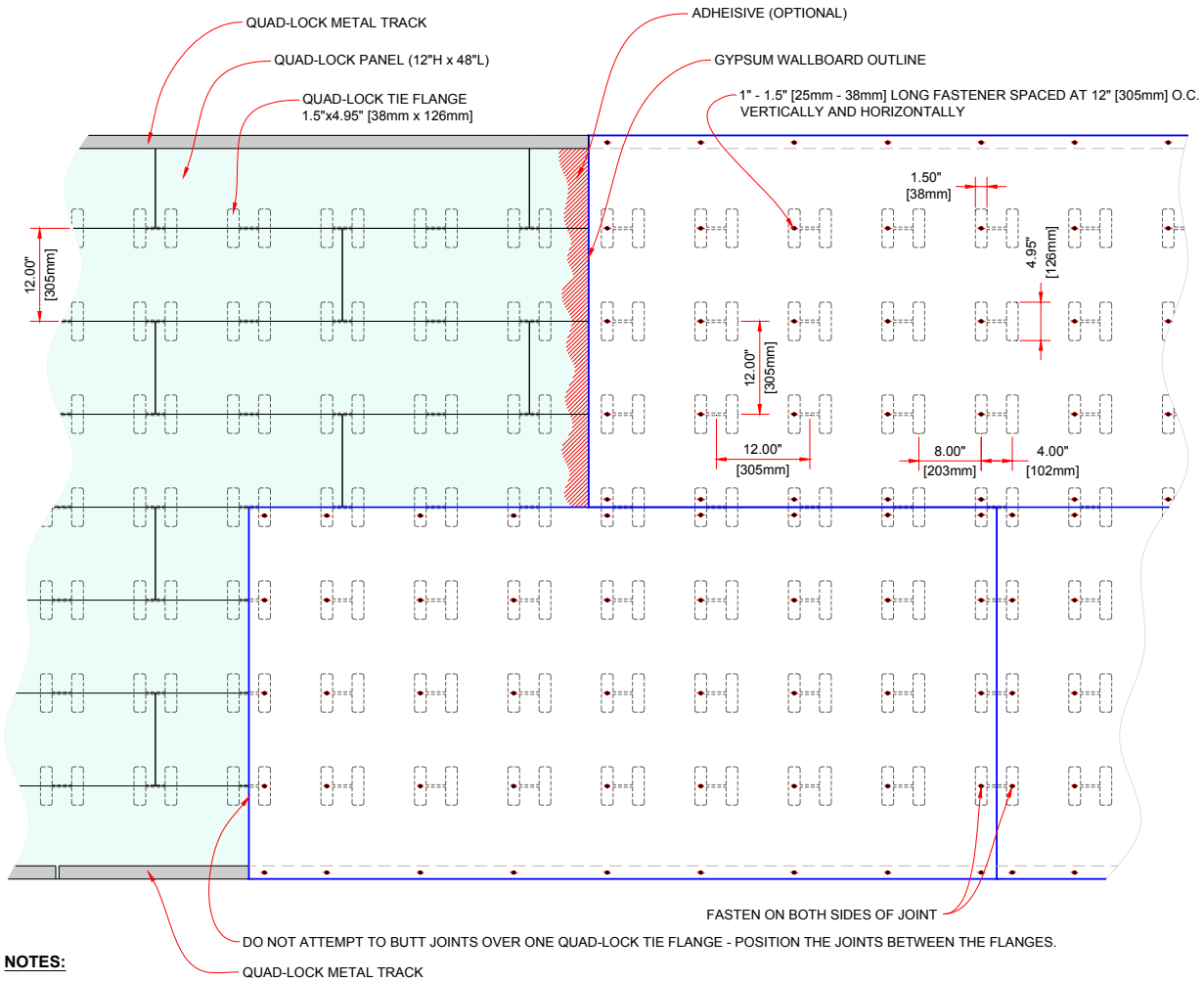
10.1.2 Drywall / Gypsum Finish

Gypsum board may be mechanically fastened directly to the surface of Quad-Lock panels and ties with drywall / gypsum screws only. Fasten into regularly-spaced tie flanges on a pattern that meets or exceeds the minimum requirements in your building code. US codes require screws vertically and horizontally at 12 inch [305mm] maximum spacing.

The gypsum wallboard should be taped and filled to provide a continuous thermal barrier.

10.1.2.1 Fastening Gypsum Drywall to Quad-Lock ICF Walls

The following details are minimum requirements for the attachment of drywall. An approved EPS compatible adhesive can be used in conjunction with drywall screws.



NOTES:

NAILS ARE NOT RECOMMENDED

STUD-FINDERS ARE USED TO LOCATE THE TIE FLANGES IF THEY ARE NOT POSITIONED REGULARLY

ALTERNATIVELY A COMBINATION OF MECHANICAL FASTENING AND ADHEISIVE IS PERMITTED GIVEN THAT THE ADHEISEIVE IS WATER BASED (EPS COMPATIBLE)

Figure 137: Drywall Attachment (elevation view)

10.1.2.2 Adhesives and Sealants for Attaching to Quad-Lock Walls

Quad-Lock endorses only the use of approved adhesives. Read the labels on adhesives to ensure compatibility with EPS ("foam compatible"). If questions arise concerning compatibility, contact the adhesive manufacturer.

Most distributors of Quad-Lock products sell adhesives that are chemically compatible and may carry an evaluation report from a national code body.

Table 10.1.2.2 - Suggested Adhesive Products for Quad-Lock Walls

PRODUCT	MANUFACTURER	USE	TYPE
LIQUID NAILS	Macco Adhesives Mississauga, ON L4T 4E5 905-731-9455	DRYWALL TO EPS	MASTIC
MD 200	Macklanberg-Duncan 4041 N. Santa Fe Oklahoma, City, OK 73118 405-528-4411	DRYWALL TO EPS	MASTIC
ACE Light Duty Construction Adhesive	Private Label by ACE Hardware 800-347-4583	DRYWALL TO EPS	MASTIC
EAGLE GRIP Foamboard Construction Adhesive	Marketed by Palmer G. Lewis Co. Auburn, WA	DRYWALL TO EPS	MASTIC
PL 300	Canadian Adhesives 420 Ave. Marien Montreal, PQ H1B 4V6	DRYWALL TO EPS	MASTIC
TOUCH 'N SEAL Panel Bond	Convenience Products 866 Horan Dr. Fenton, MO 63026 800-325-6180	EPS to EPS, DRYWALL TO EPS	ALL SEASON SPRAY FOAM
TOUCH 'N SEAL No-Warp Window and Door Insulating Sealant	Convenience Products 866 Horan Dr. Fenton, MO 63026 800-325-6180	MINIMAL EXPANSION WINDOW & DOOR SEALER	ALL SEASON SPRAY FOAM
FOAM 2 FOAM	Wind-Lock 1055 Leiscz's Bridge Rd Leesport, PA 19533 800-872-5625	EPS to EPS, DRYWALL TO EPS	SPRAY FOAM
Dow ENERFOAM	Wind-Lock 1055 Leiscz's Bridge Rd Leesport, PA 19533 800-872-5625	EPS to EPS, DRYWALL TO EPS	SPRAY FOAM
Dow GREAT STUFF PRO	Wind-Lock 1055 Leiscz's Bridge Rd Leesport, PA 19533 800-872-5625	MINIMAL EXPANSION WINDOW & DOOR SEALER	SPRAY FOAM
TBD	Henkel-Loctite	EPS to EPS, DRYWALL TO EPS, MGO BOARD TO EPS	MASTIC

Note: All adhesives used in conjunction with EPS must be "Foam" compatible. If compatibility is unknown, contact the adhesive manufacturer.

10.2 EXTERIOR WALL FINISHES

10.2.1 Preparing the Exterior Wall for Finish

10.2.1.1 Building Paper Exemption

Quad-Lock ICF walls are classified in most building codes as *"masonry or concrete"* structures, and are generally exempt from any requirement for a *"secondary plane of weather protection"*, like building paper or synthetic membranes. It is therefore not necessary to wrap the building in building paper or membrane (such as Tyvek® or others).

10.2.1.2 Improving Bond with Face-Sealed Finishes

If direct-applying a face-sealed finish, like an acrylic-modified stucco or EIFS product, it is recommended that the surface of the foam be roughened with a rasp to improve the bond between EPS and the finish material. Conventional cementitious stucco should have a suitable wire-lath mechanically fastened to tie flanges with Wind-Lock fasteners and exterior rated screws.

10.2.2 Hard-Coat Stucco, Acrylic and Exterior Insulated Finish Systems (EIFS)

The Quad-Lock building system is "stucco ready" for most exterior insulated finish systems (EIFS). The Quad-Lock Panel is the same material as foam board sheathing, and is installed in accordance with most EIFS manufacturers' specification. All finish and trim details should be approved by the Stucco/EIFS supplier or manufacturer. Consult the stucco manufacturer of choice or the Quad-Lock representative for the use of other products.

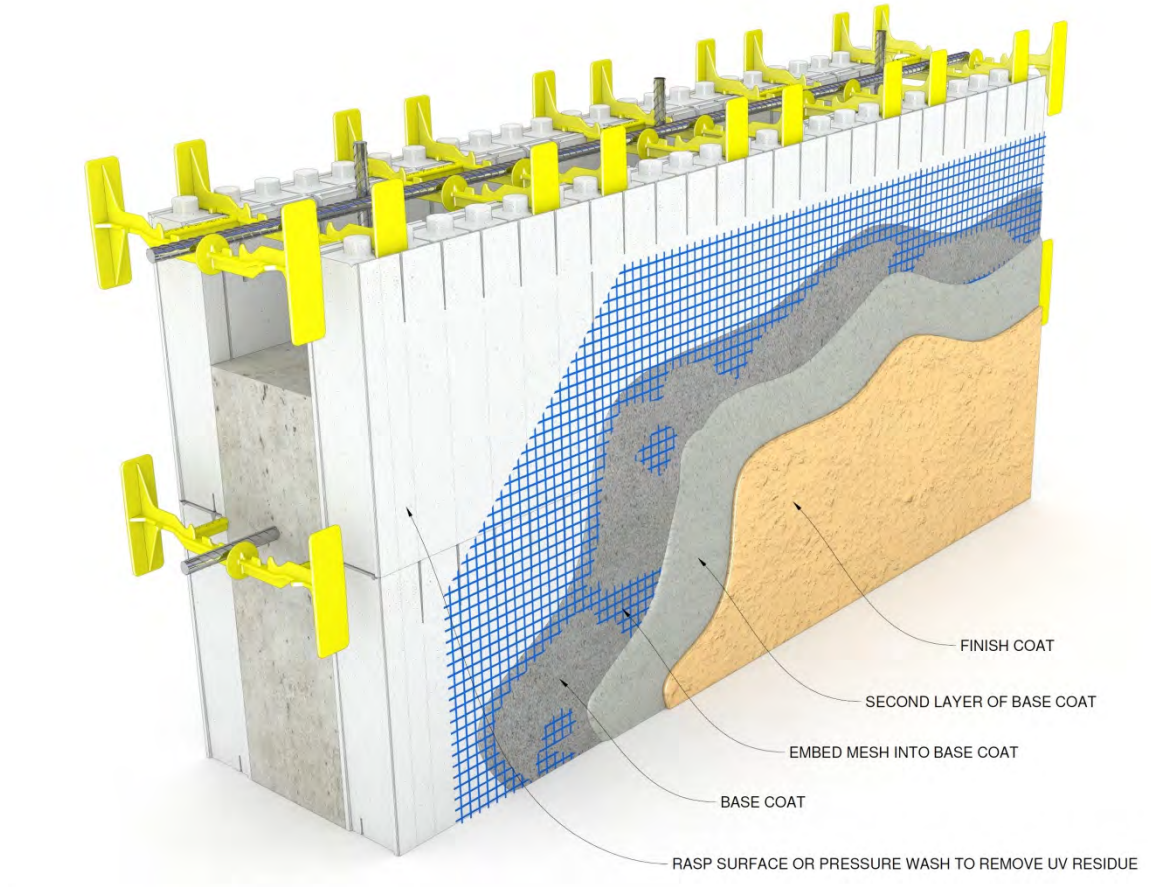


Figure 138: Stucco

10.2.2.1 Table for Cementitious Hard-Coat Finishes

PRODUCT	MANUFACTURER	TYPE	APPLICATION
SIDER-CRETE	Sider-Crete, Inc. Hawkinsville, GA	Hard-coat cementitious stucco	Spray, Trowel User applied
FRS (Fiberglass Reinforced Stucco) and FOAMCOAT	Quick-Crete Co. 1790 Century Circle NE Atlanta, GA 30345 404-634-9100	Fiberglass Reinforced Polymer Coating	Hand, Hopper, or Air. User applied
MONOCOUCHE	Monochouche Render Systems 46B North St. Thame OX9 3BH 0844 272 1467	1 day stucco 2 step polymer coating	Spray, Trowel User applied
THORO FIBER BASED COAT	Thoro System Products 8570 Phillips Hwy #108 Jacksonville, FL 32256 800-327-1570	Fiberglass Reinforced Surface Bonding Mortar	Hand, Air User Applied
WESTERN ONE KOAT	Western Stucco Products PO Box 968 - 6101 N. 53rd Glendale, AZ 95311 623-937-9141	Acrylic based cement	Hand, Air User applied
RUB CRETE	CONSPEC 636 S. 66th Terrace Kansas City, KS 66111 877-266-7732	Polymer Coating	Trowel, Spray User applied
STO FAST SET DRY ADHESIVE / BASE	STO Finish Systems Division PO Box 44609 Atlanta, GA 30336-5609 800-221-2397 | 404-346-3666	Acrylic Based Plaster	Trowel User applied
WALLEASE BASE COAT	El Rey Stucco Company Inc. 3830 Singer Blvd NE, Suite 2020 Albuquerque, NM 87109 505-873-1180 | 505-338-3448	Cement Based Plaster	Trowel
Great-Wall	Imasco Minerals Inc. 19287 - 98A Avenue Surrey, BC V4N 4C8 604-888-3848	Cementitious, fibre reinforced base coat	Hand or Machine User Applied

10.2.2.2 Table for Acrylic Stucco (EIFS)

PRODUCT	MANUFACTURER	TYPE	APPLICATION
Core-Factor	Imasco Minerals Inc. 19287 - 98A Avenue Surrey, BC V4N 4C8 604-888-3848	E.I.F.S.*	Hand or Machine - 3 year warranty or with an approved applicator 5 yr warranty
Dryvit	Dryvit Systems Inc. PO Box 1014 West Warnick, RI 02893 800-556-7752	E.I.F.S.*	Hand or Air Proprietary –Approved Applicators
Stucco-O-Flex series #200	Perma-Chink Systems Inc. 17635 N.E. 67th Ct. Redmond, WA 98052 800-548-1231 | 425-885-6050	E.I.F.S.*	Hand or Air Trowel, Roll
Preswitt	Preswitt Mfg. Ltd. 5721 Production Way Langley, BC 604-533-3368	E.I.F.S.*	Hand or Air User Applied
STO	STO Industries Inc. PO Box 44609 Atlanta, GA 30336-5609 404-346-3666	E.I.F.S.*	Hand or Air
Senergy	Senergy Systems Inc. 10245 Centurion Parkway N Jacksonville, FL 32256 800-221-9255	E.I.F.S.*	Hand or Air User Applied Local Training Available
Uni-Tex 100/200	United Paint & Coatings E. 19011 Cataldo Greenacres, WA 99016 800-541-4383 | 509-926-7143	E.I.F.S.*	Hand or Air User Applied Local Training Available
System 3	Parex, Inc. 1870 Stone Mt. Lithonia Rd. Atlanta, GA 30074 770-482-7872	E.I.F.S.* full synthetic or cementitious	Parex Trained Applicators Local Training Available
Energex	E.I.F.S. Inc. 65 Davids Dr. Hauppauge, NY 11788 800-777-6596 | 631-231-1300	E.I.F.S.*	Hand or Air Certified Applicators + Training Available
PermaFlex	El Rey Stucco Company Inc. 3830 Singer Blvd NE, Suite 2020 Albuquerque, NM 87109 505-873-1180 | 505-338-3448	E.I.F.S.*	Approved Applicator

*E.I.F.S. = Exterior Insulated Finish System

10.2.3 Cladding Products

Various types of exterior cladding (siding) can be attached to the Quad-Lock System. The Quad-Lock FS Panel provides built in Fastening Strips, for a continuous vertical point of attachment every 12" [30cm] on center.

- Consult the siding manufacturer's specifications for fastener spacing, and wind load requirements.
- Always be sure to use an exterior rated screw fastener that complies with the siding manufacturer's information.

Note: ***Nailing into Quad-Lock FS strips is not an acceptable alternative, as the nails do not generate enough holding power in the FS strips. Use exterior-rated screws only.***

10.2.3.1 Cladding Best-Practice

Many building jurisdictions are now requiring implementation of “gap technology” or “rain-screen” as a means of promoting drying capacity in the building shell. (See Option B below.) This means that a narrow ‘gap’ is required behind cladding materials to facilitate gravity-flow of unwanted water that may penetrate the primary cladding layer.

- In addition to providing drainage capacity, this gap is seen by some designers as a way to dissipate heat that may build up in cladding materials that are applied directly to ICF walls. Excessive heat build-up may expand the cladding materials enough to cause unsightly buckling when butt-joints are forced together. The gap technology is seen as a way to ventilate behind claddings.

10.2.3.1.1 Creating the Rain-Screen Gap

To create a rain-screen gap, vertical or horizontal furring material can be screwed to Quad-Lock Ties every 12" [305mm] or 24" [610mm]. Siding material can then be attached to these external furring strips. The thickness of the furring material depends on the required width of the rain-screen gap. A common gap width requirement is 3/8” [10mm].

Thought not all building codes require a rain-screen gap, Quad-Lock supports the technology and recommends its use. Consult the project architect or a building envelope engineer to evaluate conditions on your project.

10.2.3.2 Cladding Details

The following details are examples of how exterior cladding (siding) products can be fastened to Quad-Lock ICF walls.

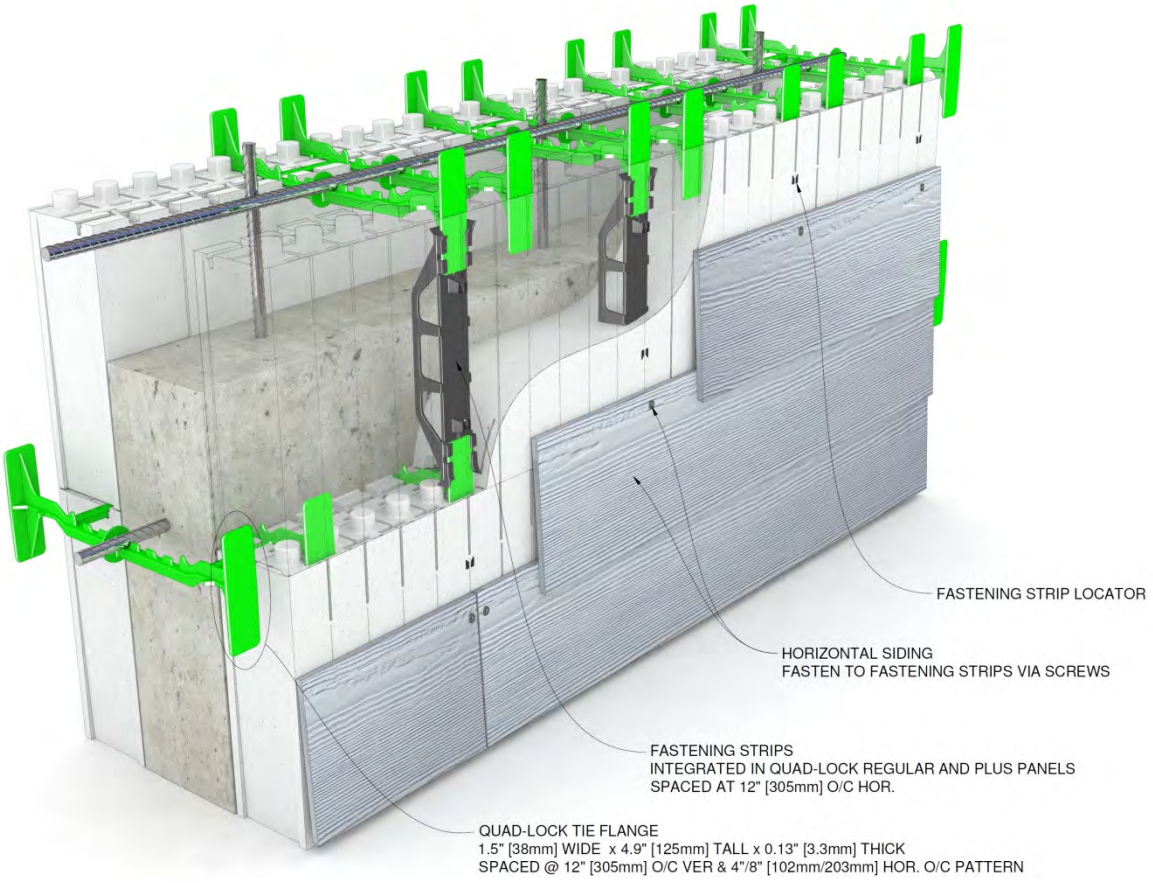


Figure 139: Cladding Details

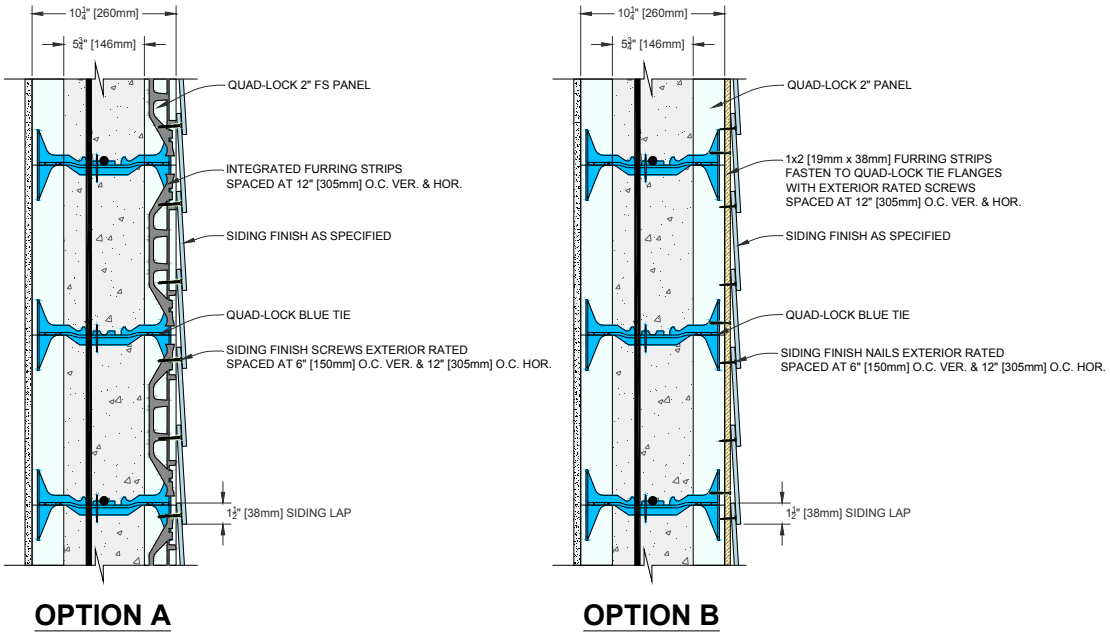


Figure 140: Cladding Detail Options

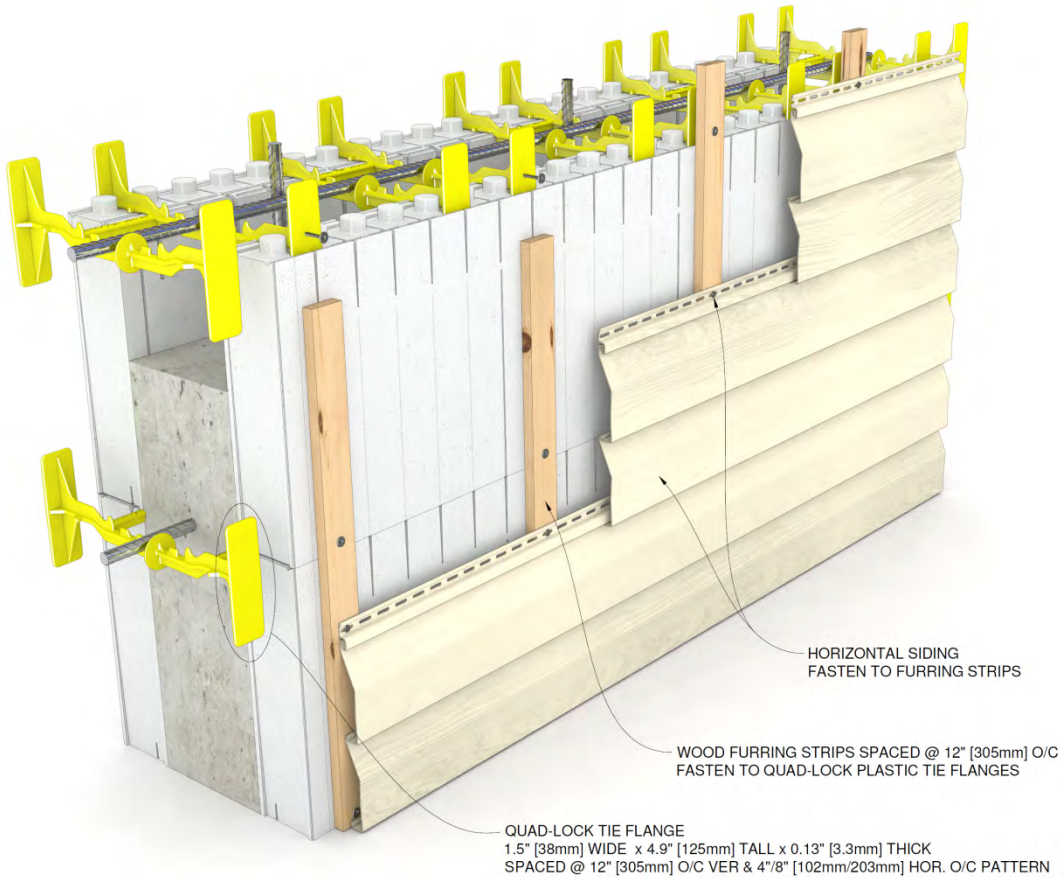


Figure 141: Siding Attachment with external furring strips

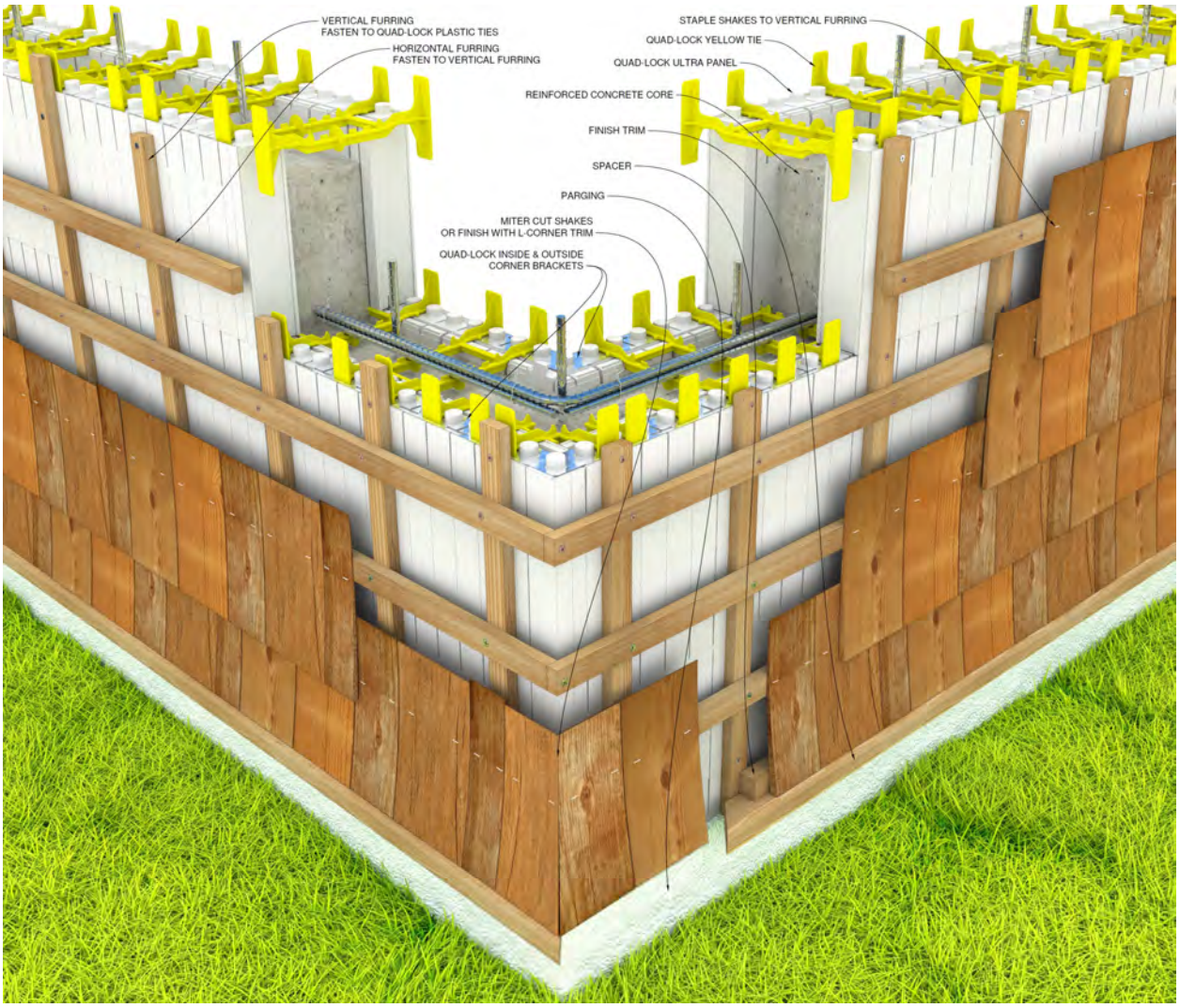


Figure 142: Shake & Shingle finish with external vertical and horizontal furring strips

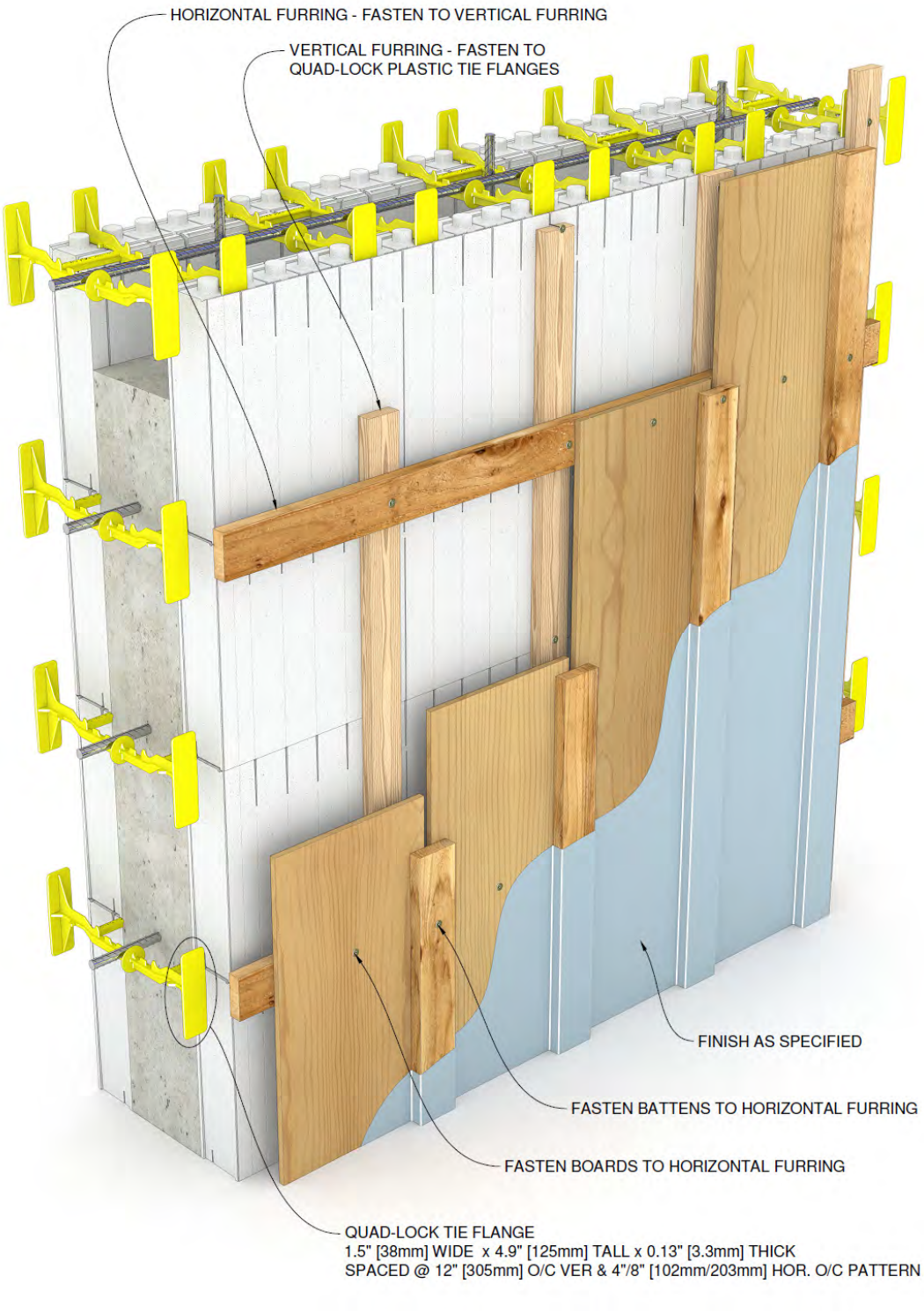


Figure 143: Board & Batten finish with external vertical and horizontal furring strips

Section 10.2.3.2.1: Attaching Corner Trim for Lapped Siding Finish

To provide a fastening surface on Quad-Lock corners, it is recommend that the corners be strapped with 14 gauge (0.0641" [1.63mm]) aluminum or 22 gauge (0.0336" [0.85mm]) galvanized steel straps 4" high by 12" each way [100mm x 300mm] at every course. A minimum of 4 screws is recommended per strap (2 on either side). Refer to Figures below for installation details.

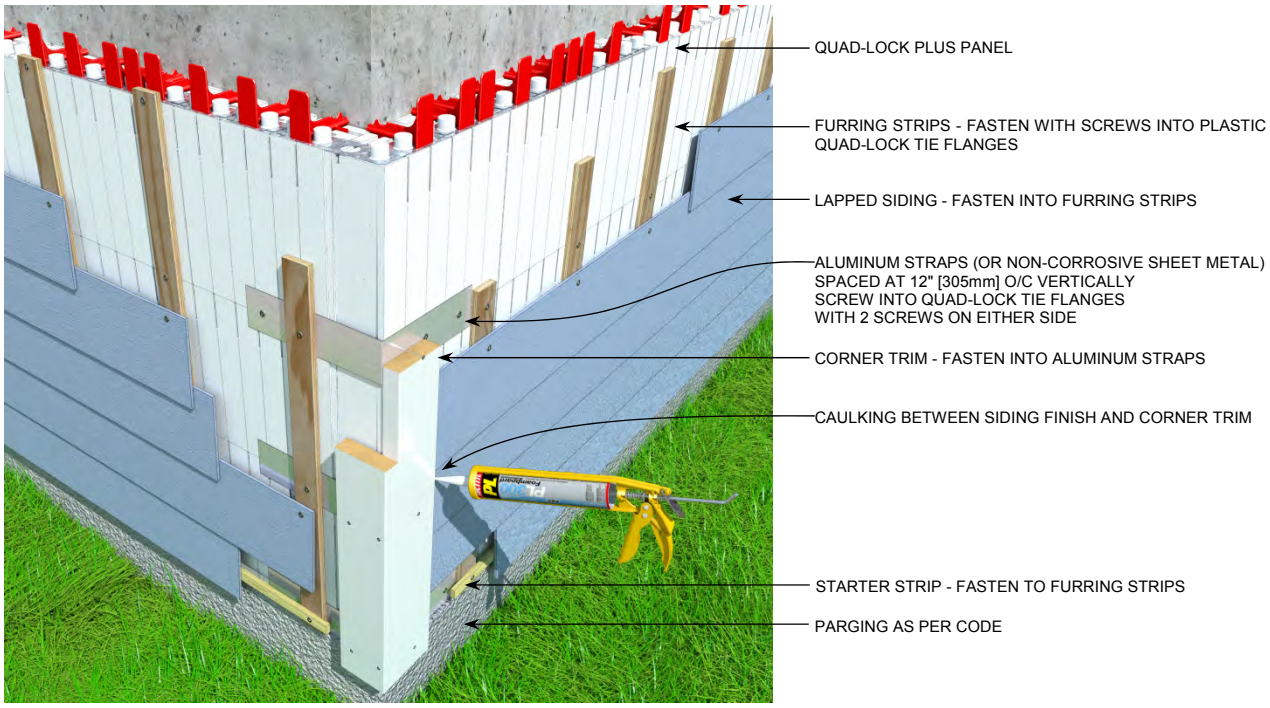


Figure 144: Corner Trim Attachment for Lapped Siding with Rain-Screen

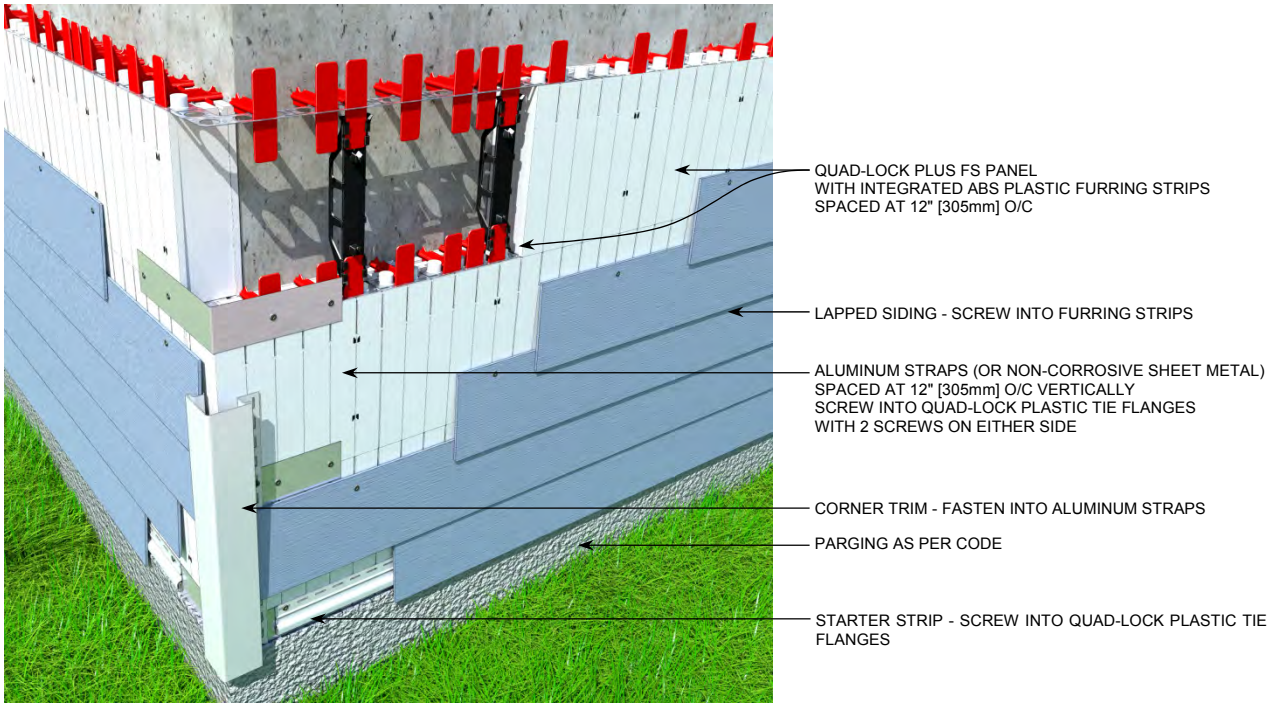


Figure 145: Corner Trim Attachment with Siding Directly Applied to Quad-Lock

10.2.4 Brick and Stone

Metal ties may be inserted through the vertical and/or horizontal joints of the Quad-Lock Panels for proper anchoring of stone or brick veneer into the concrete wall. The following details illustrate several options for the construction of ledges for brick and stone.

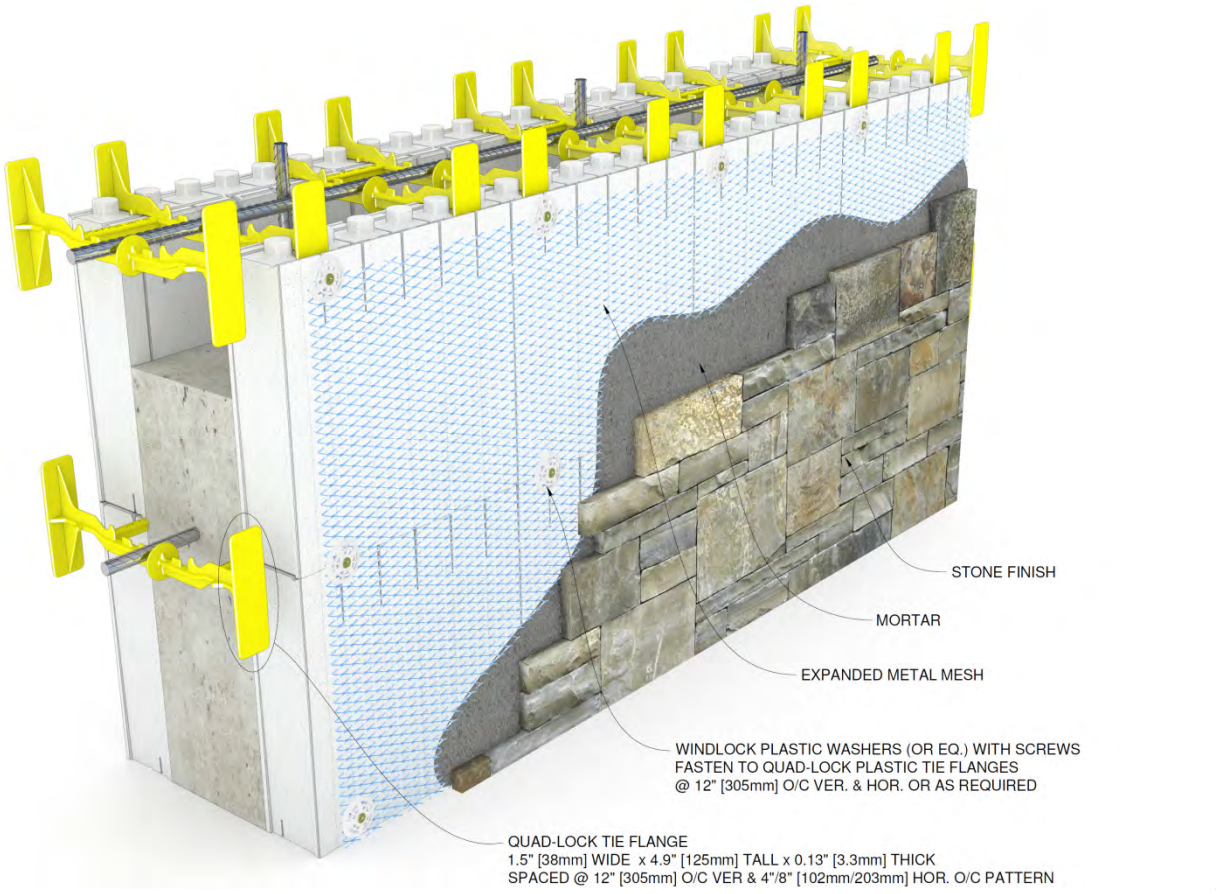


Figure 146: Stone

10.2.4.1 Brick Ledge Support

Brick Ledges can be built using an off the shelf steel angel either bolted to concrete or supported with Fero Brackets, by transitioning wall widths or by using temporary plywood formwork. In addition, it is common for the top of a basement wall to provide support to both the wood floor and the brick finish. Please note that a brick ledge support is recommended for all finishes exceeding 20psf [100kg/m^2].

10.2.4.1.1 Option 1: Steel Angle Bolted to Concrete

Cut out holes of required min. diameter at required spacing and close off with plywood prior to concrete pour to provide a concrete surface for attaching the steel angle. Drill into concrete and secure the angle with anchor bolts. Refer to Section 7.1.1.2 for the required minimum hole diameter. This is a very popular method to form brick ledges due to its simplicity and relatively low material cost.

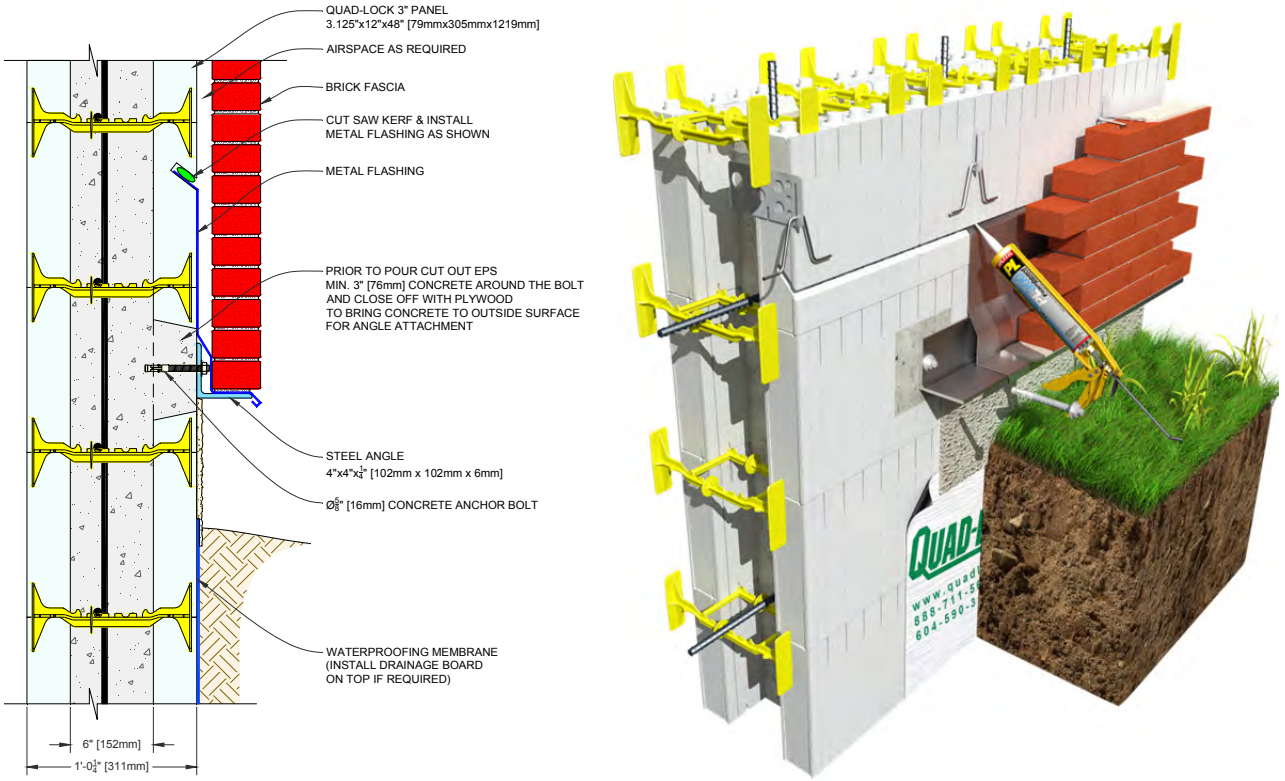
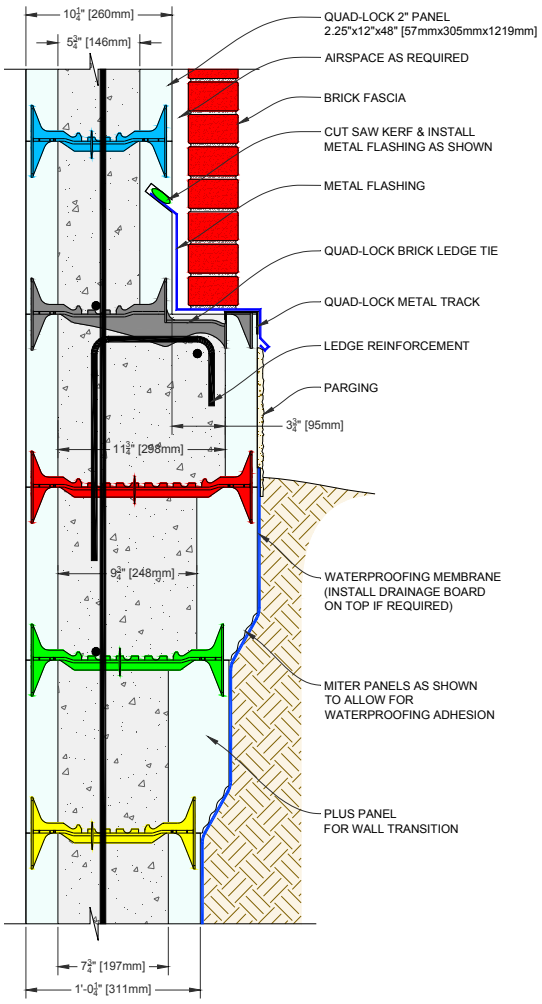


Figure 147: Brick Ledge with Steel Angle Bolted to Concrete

10.2.4.1.2 Option 2: Multiple Transitions with Brick Ledge Tie

Quad-Lock Brick Ledge Tie can be used only on R-22 wall assemblies (Regular Panels that are 2.25" [57mm] thick) and only to transition from 11.75" concrete to 5.75" concrete core leaving a 3.75" [95mm] bearing surface for brick and air space.



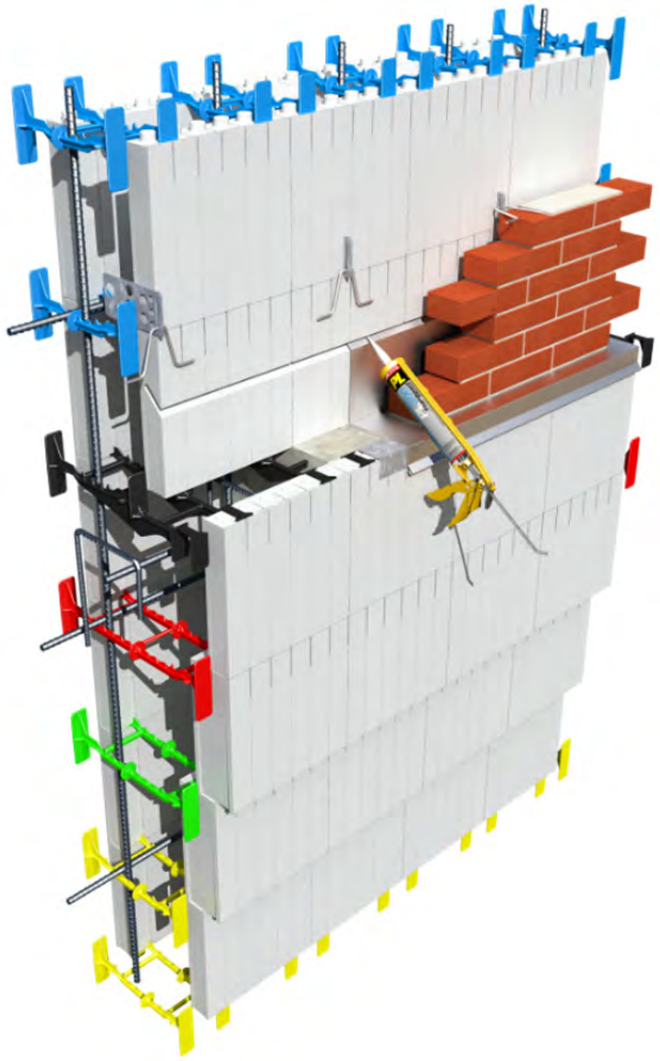


Figure 148: Brick Ledge with Quad-Lock Brick Ledge Tie

10.2.4.1.3 Option 3: Fero-Angle Support Technology

The Fero Angle Support Technology ("FAST"™ by Fero Corporation) can be used to support masonry veneer of all types. It can also be used to support granite panels and precast concrete. The system is ideal to accommodate construction tolerances because it can provide for adjustability in all directions and it is available in a wide range of sizes. Contact Fero for bracket size and spacing which varies upon EPS thickness as well the veneer weight and height. The brackets can be further filled with sprayfoam to virtually eliminate the thermal bridging effect.

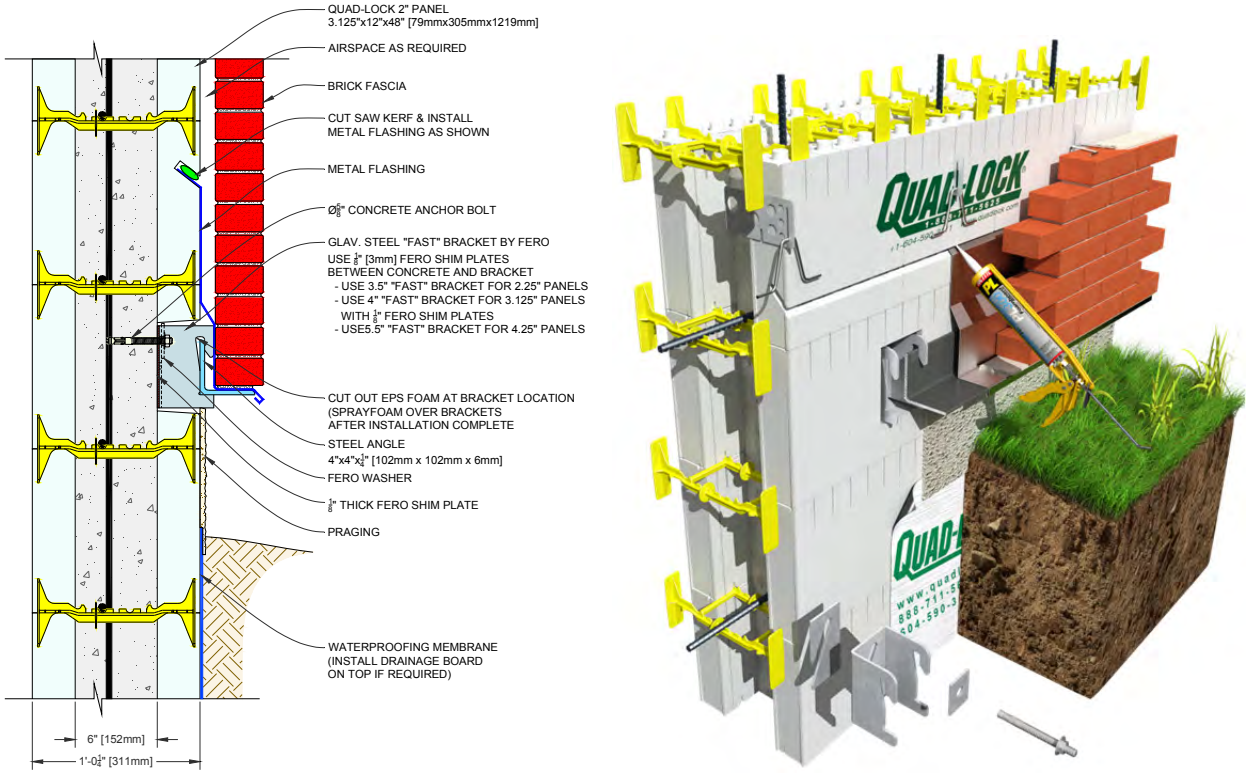


Figure 149: Steel Angle Brick Ledge Supported with Fero Brackets

10.2.4.1.4 Option 4: Temporary Plywood Form

Temporary plywood forms can be used to form a brick ledge by screwing the plywood to the Quad-Lock Ties as shown below. Stack one additional Quad-Lock Panel on the wall's other side. Brace that panel with vertical braces and adequately brace the plywood forms to contain the concrete during the first concrete pour. The first pour stops at the level of the top of the plywood form. After sufficient curing, Metal Track is secured to the resulting concrete step. The Quad-Lock Panels need to be ripped horizontally and set into the track to match the height of the opposing panel.

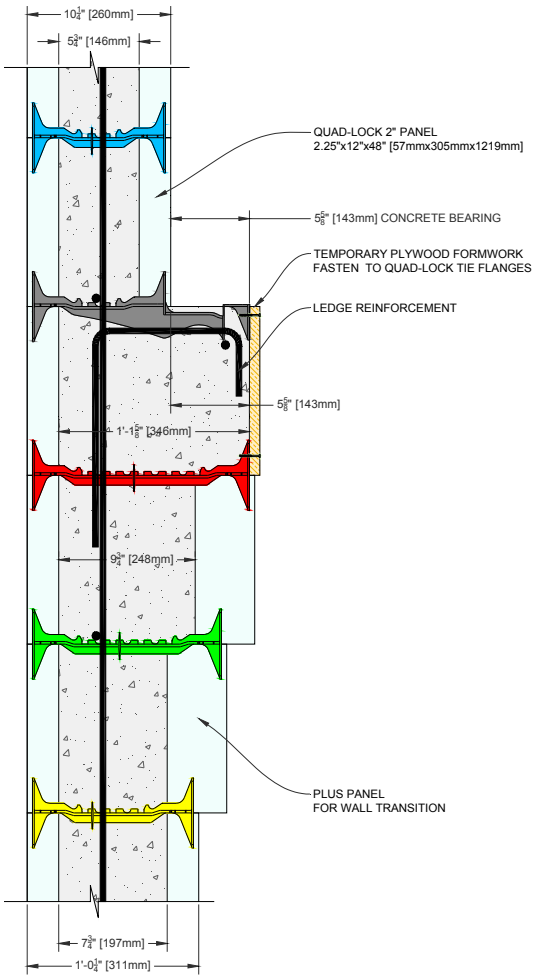
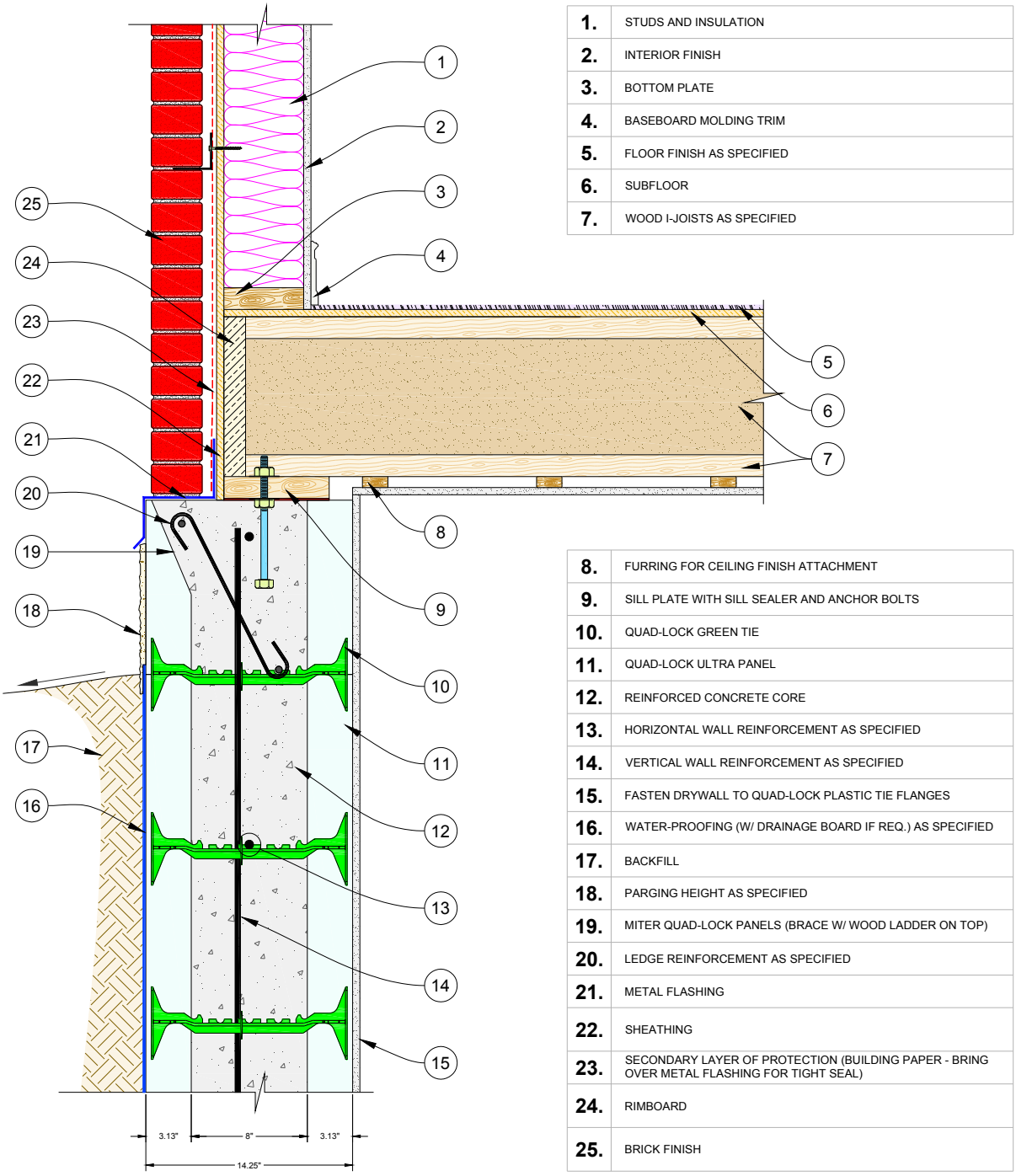


Figure 150: Brick Ledge Formed with Temporary Plywood Forms

10.2.4.1.5 Option 5: Top of Wall Brick Ledge

Miter cut the Top Panels to provide extra bearing surface for brick finish.



1.	STUDS AND INSULATION
2.	INTERIOR FINISH
3.	BOTTOM PLATE
4.	BASEBOARD MOLDING TRIM
5.	FLOOR FINISH AS SPECIFIED
6.	SUBFLOOR
7.	WOOD I-JOISTS AS SPECIFIED
8.	FURRING FOR CEILING FINISH ATTACHMENT
9.	SILL PLATE WITH SILL SEALER AND ANCHOR BOLTS
10.	QUAD-LOCK GREEN TIE
11.	QUAD-LOCK ULTRA PANEL
12.	REINFORCED CONCRETE CORE
13.	HORIZONTAL WALL REINFORCEMENT AS SPECIFIED
14.	VERTICAL WALL REINFORCEMENT AS SPECIFIED
15.	FASTEN DRYWALL TO QUAD-LOCK PLASTIC TIE FLANGES
16.	WATER-PROOFING (W/ DRAINAGE BOARD IF REQ.) AS SPECIFIED
17.	BACKFILL
18.	PARGING HEIGHT AS SPECIFIED
19.	MITER QUAD-LOCK PANELS (BRACE W/ WOOD LADDER ON TOP)
20.	LEDGE REINFORCEMENT AS SPECIFIED
21.	METAL FLASHING
22.	SHEATHING
23.	SECONDARY LAYER OF PROTECTION (BUILDING PAPER - BRING OVER METAL FLASHING FOR TIGHT SEAL)
24.	RIMBOARD
25.	BRICK FINISH

Figure 151: Quad-Lock Wall Tapering out at Top to Provide Support for Brick Finish

10.2.5 Covering a Wall in Zero Clearance Condition

Fiber-Cement siding is applied to Quad-Lock wall as the forms are installed, then poured in place to remain as protection of building exterior.

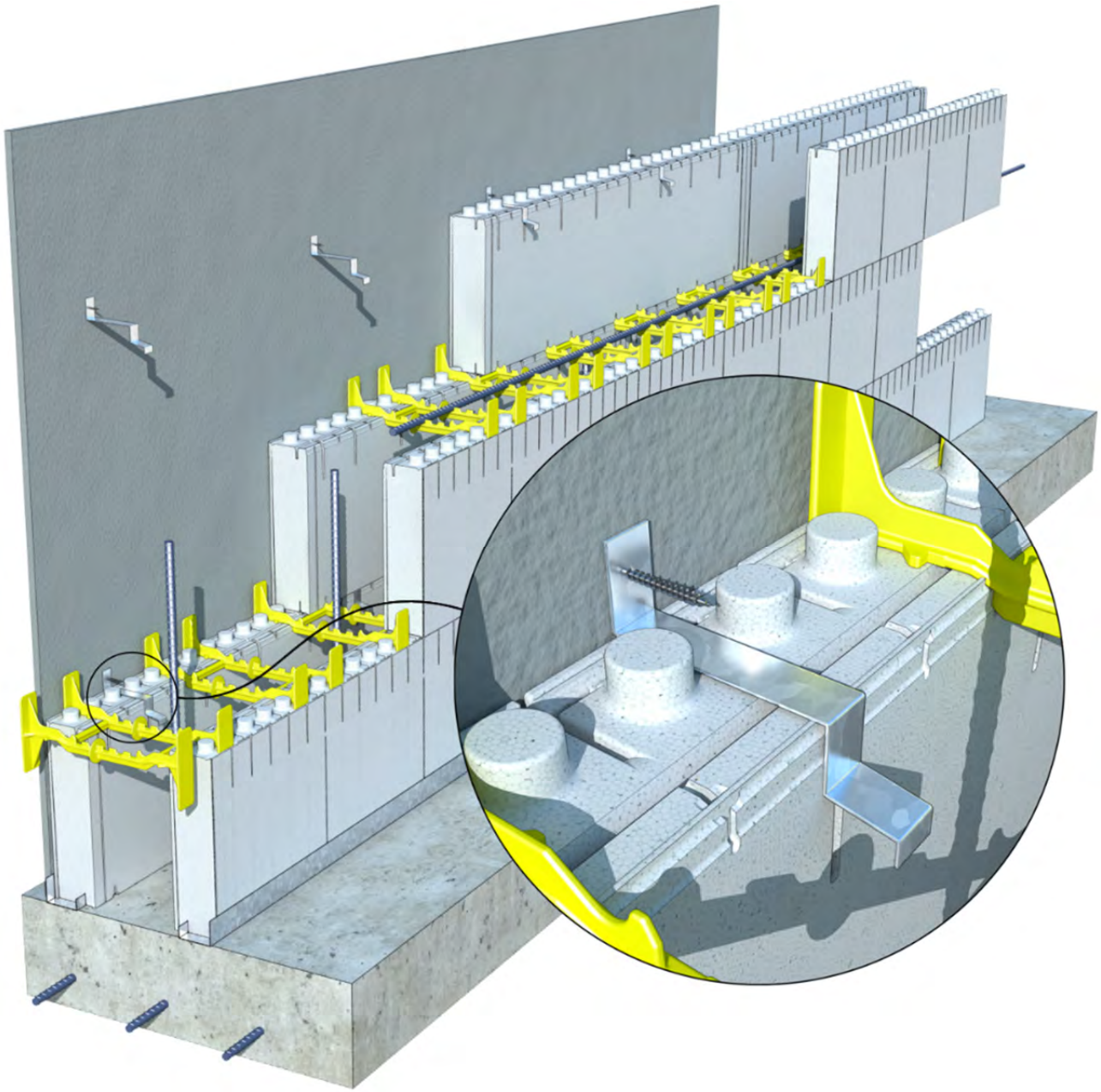


Figure 152: Installing Quad-Lock Walls With no Accesses From Exterior

Figure 153: Common Brick Ties

Use the the following steps to install Quad-Lock when no access to wall from exterior to install exterior finish.

1. Prior to assembling the Quad-Lock wall, strike lines on a fiber-cement panel that match the elevation of Quad-Lock panel horizontal joints. Use these lines as a reference for attaching angled metal clips or brick-ties that will hold the board in place during pour. The clips should be galvanized and of adequate gauge to resist shear and pullout forces. The clips protrude into concrete cavity and are cast in the concrete.
2. Depending on resistance required, metal ties can be placed every 12" or 24" [305mm or 610mm] o/c vertically. Horizontal spacing is not limited but usually varies between 12" or 24" [305mm or 610mm] o/c.
3. Once the first row of Quad-Lock Panels are installed, insert the fiber cement boards with brick ties extending over the first-row panels.
4. Once ready to install the row of panels directly beaneth the clips, twist clips so they a are not in the way and slide in Quad-Lock Panels.
5. Repeat the process untill the wall is finished.
6. Consider using sprayfoam or based primer for places along the walls where clips are hard to install (e.g. corners).

11 FASTENING TO QUAD-LOCK WALLS

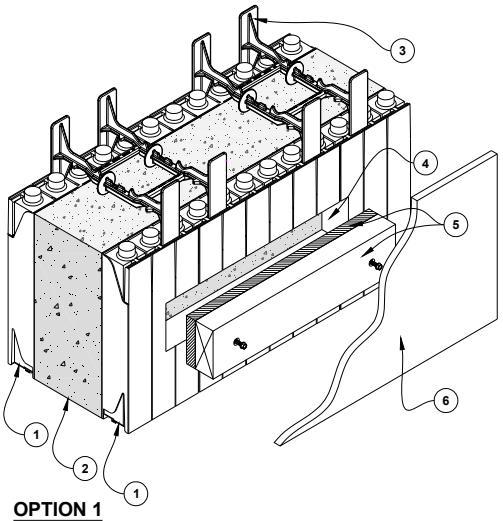
11.1 METHODS FOR FASTENING TO QUAD-LOCK WALLS

The best advice any expert ICF builder will give is to *"PLAN AHEAD!"* when it comes to fastening to ICF walls. This is due to the fact that some of the best methods involve casting concrete in a certain manner, or casting hardware into concrete for later use.

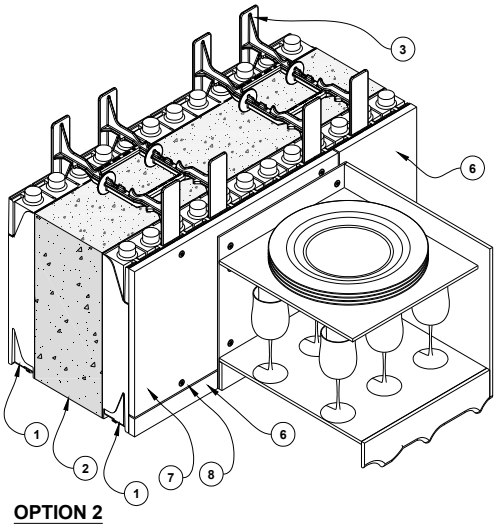
Think ahead into the finishing phases of your building and anticipate the needs generated by certain accessories and equipment.

11.1.1 Fastening for Heavy Items:

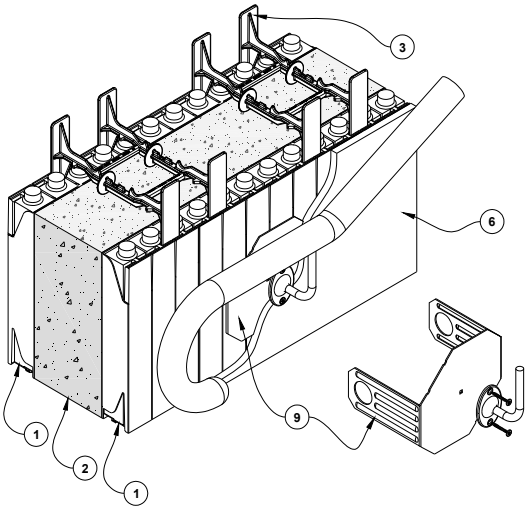
Quad-Lock Ties can support most finish materials quite adequately. However, for heavier items it will be necessary to fasten directly to the concrete to incorporate more solid attachment surfaces. This can be achieved by embedding hardware in the concrete or by making the concrete directly available for fastening.



OPTION 1
Suggested for: flat screen tv's, handrails, etc..



OPTION 2
Suggested for: kitchen kabintes



OPTION 3
Suggested for: point loads such as haindrails or stair stringers.

1.	QUAD-LOCK PANEL
2.	REINFORCED CONCRETE CORE
3.	QUAD-LOCK TIE
4.	REMOVE QUAD-LOCK EPS AFTER CONCRETE CONSOLIDATES
5.	USE A COMBINATION OF PLYWOOD AND LUMBER INFILL TO FORM ATTACHMENT SURFACE (ANCHOR TO CONCRETE)
6.	GYPSUM WALL BOARD
7.	FASTEN PLYWOOD BASE TO QUAD-LOCK PLASTIC TIE FLANGES @ 12" [305mm] O/C VER. & HOR.
8.	JOINT BETWEEN PLYWOOD AND (GWB) TO BE FLUSHED AND HIDDEN BEHIND CABINETS
9.	SIMPSON ICFVL ATTACMENT BRACKET (TO BE CAST IN PLACE)
	OPTION 4 (NOT SHOWN) WOULD BE TO BRING CONCRETE TO THE SURFACE OF THE FOAM BY CUTTING OUT Ø6" [150mm] HOLES AT REQUIRED SPACING IN THE FOAM PRIOR TO POUR AND CLOSE THEM OF WITH TEMPORARY PLYWOOD FASTENED TO QUAD-LOCK TIE FLANGES.

Figure 154: Attaching Heavy Items

11.1.1.1 Metal Bracket Embedded in Concrete

For some items, it may be advisable to cast a metal bracket into the wall, *(like the Simpson ICFVL)* to provide an attachment point to carry very heavy or dynamic loads. See graphic below. Consider using this method at the following locations:

- Garage door hardware attachments (tracks and operator)
- Closet-rods in large walk-in closets
- Rods for heavier window-coverings and shades
- Shelving and wall-mount fixtures for electronics
- Security cameras and lighting
- Exterior signage
- Fences or security gates
- Fire extinguishers
- Tracks for store-front windows
- Deck hardware

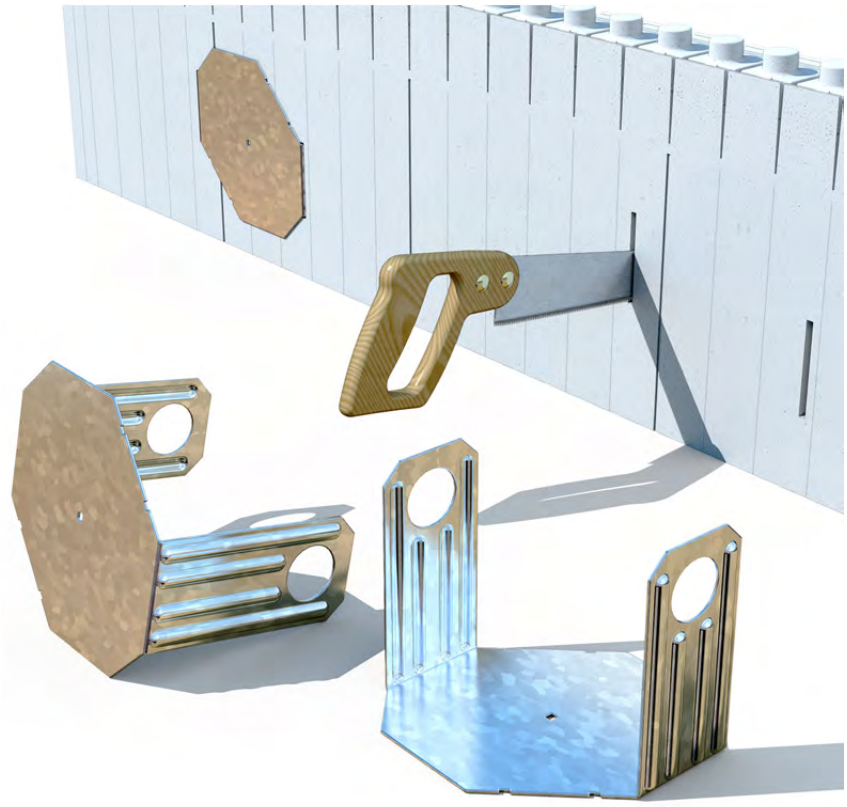


Figure 155: Attaching Extremely Heavy Items or Dynamic Loads

11.1.1.2 Exposed Concrete at Surface of Foam

Many fastening needs can be satisfied by bringing concrete out to the surface of the ICF panel.

- Make a hole (usually 4" to 6" [10 cm to 15cm] in diameter) in the Quad-Lock panel at the desired location for fastening.
- Prior to pour, cover the hole with a small plywood panel that is secured to tie flanges.
- Consolidate concrete well at these locations to insure that concrete reaches the surface of the foam panel.
- Fasten heavy items directly to the exposed concrete with a suitable drilled-in concrete anchor.

This method can be used for heavy items like those listed above in Section 11.1.1.1.

11.1.1.3 Substitute Plywood Behind Cabinets

One way to make cabinet installation quick and easy is to substitute a layer of plywood for gypsum drywall at areas that will be covered by the cabinets.

- With a chalk line, mark the exact cabinet locations on the EPS foam surface before the installation of drywall.
- Pre-cut minimum ½" [13 mm] plywood (depending on drywall thickness) to fit within the chalked area behind cabinets. Leave the plywood about ½ inch [12mm] short of the cabinet line.

- Just before installing the ply layer, apply an EPS-compatible adhesive to the ICF panels to increase the bond between the wall and the plywood
- Fasten to the wall plywood with screws to each available tie-flange.

  NOTE: Consult table in Section 2.2.11 Allowable Loads for Fasteners on Page 23). Use an adequate number of screws to hold the anticipated load. Butt drywall up to the plywood, and fasten normally by screwing to the plastic tie flanges.
- To mount cabinets on the wall, screws are driven through the backs of the cabinets and into the plywood mounted securely to the Quad-Lock wall. Again, use an adequate number of screws to hold the anticipated load generated by the cabinets AND their contents.

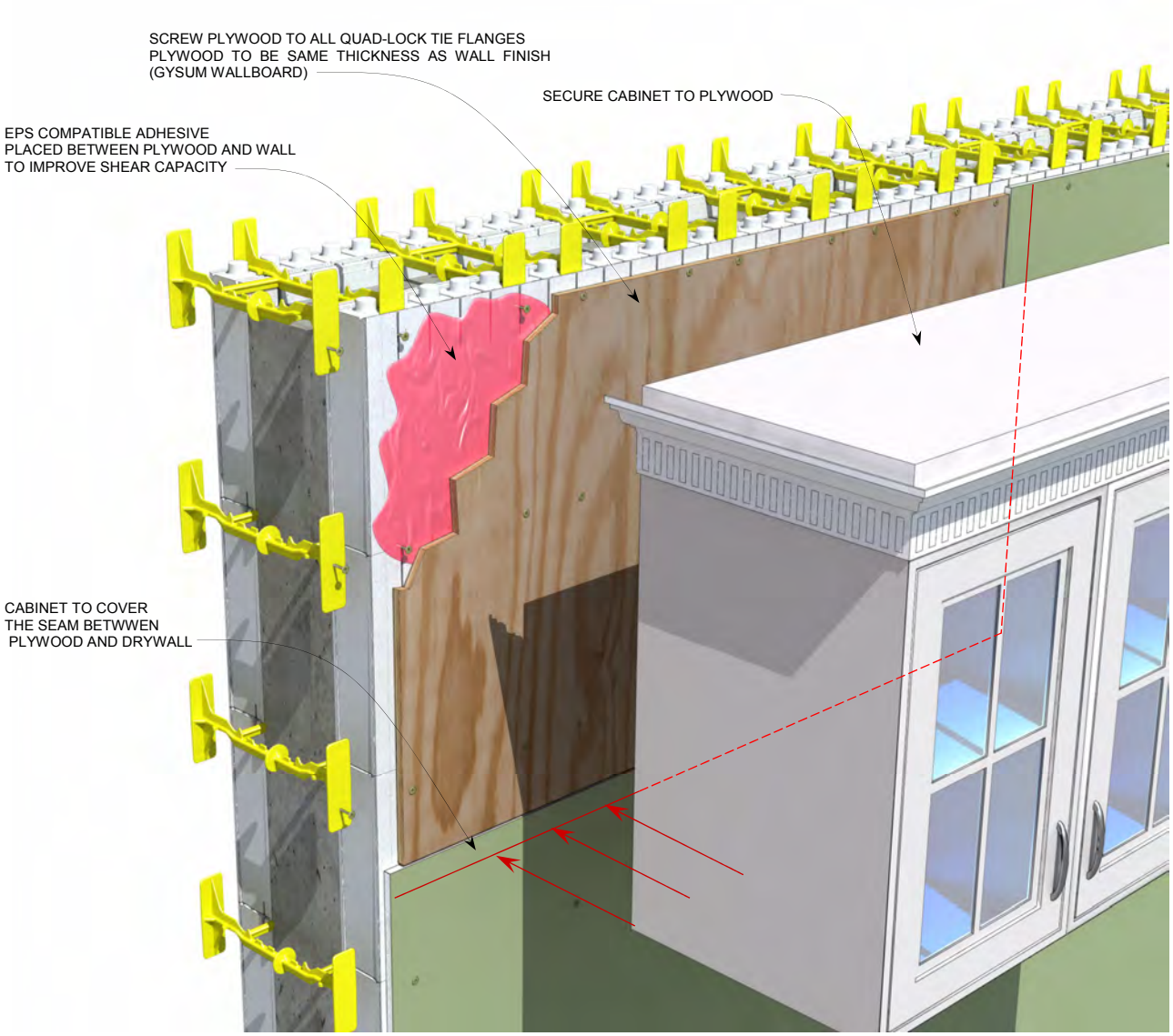


Figure 156: Attaching Heavy Items using Plywood behind Cabinets

11.1.1.4 Screws for Concrete

A wide range of concrete fasteners are available for builders, including special screws designed for use in concrete. Pre-drilled holes (matched to the diameter of the screw shank) allow the screw to bite into the concrete and provide a secure fastening for plumbing fixtures and many other features.

When using screws to fasten to ICF walls, be sure to take the thickness of the foam into consideration.

- Screws that “cantilever” through foam may be subject to deflection under heavy loads. In that case, it may be best to bring the concrete to the surface of the foam, as described above.

11.1.2 Attachment of Fixtures and Accessories

11.1.2.1 Medium-Duty Fastening

11.1.2.1.1 Metal Lath Behind Drywall

For medium-duty fastening needs, use expanded-metal lath behind gypsum drywall to provide a means to spread the load across a wider area. Use a lath with a small enough gauge to engage screws that are driven through gypsum drywall.

- Press strips of metal lath into the ICF foam where medium-duty fastening needs are anticipated.
- Cover the lath with gypsum drywall, fastened to the wall with spray-foam adhesive and screws.
- Mark the area where the lath sits behind the drywall for later reference.
- Mount curtain rods, bath accessories, and other furnishings with screws through the drywall and metal lath.

11.1.2.2 Light-Duty Fastening

Common drywall anchors can be used to hang accessory fixtures, much like cavity wall construction.

- The depth of the anchor must be limited to the depth of the EPS panel, however, or concrete will prevent full insertion into the wall.
- Examples of common anchors are as follows:

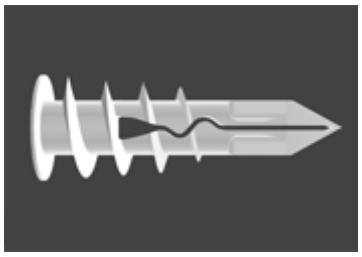


Figure 157: Toggler brand “Snapskru”

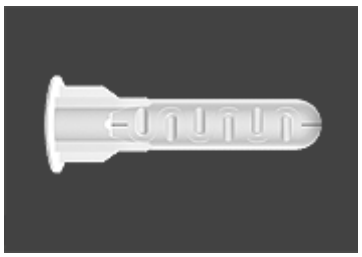


Figure 158: Alligator brand Solid Wall Anchor

12 ELECTRICAL & PLUMBING SERVICES

12.1 ELECTRICAL AND COMMUNICATIONS UTILITIES

Concrete walls formed and insulated by the Quad-Lock ICF system will accommodate electrical wiring and fixtures after the pour by cutting chases in the foam for wiring and boxes.

While the notion of setting conduit in the wall cavity prior to the pour sounds appealing, field experience has shown that the after-pour method for placement of wiring runs, boxes, and fixtures is far more successful and allows much more flexibility. Experience has shown that pre-installed electrical boxes and conduit add congestion that may result in poor consolidation (voids) in concrete. Quad-Lock no longer recommends placement of electrical boxes and conduit in ICF wall cavities prior to the concrete pour

Note: **CONFIRM THE FOLLOWING MATERIALS AND METHODS WITH LOCAL BUILDING OFFICIALS BEFORE BUILDING**

12.1.1 Recommended Tools

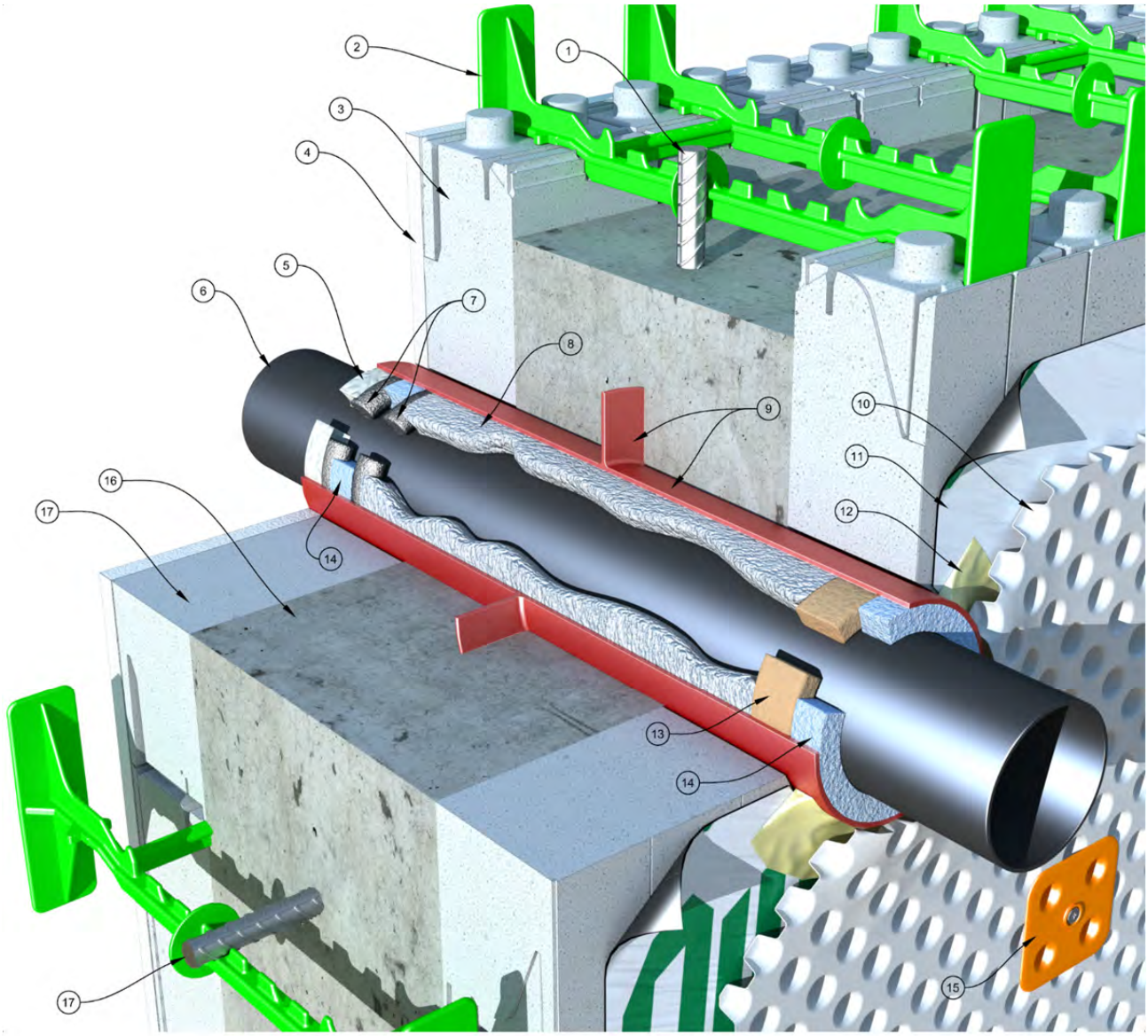
Field experience has also shown that several tools are useful in placement of electrical wiring and boxes in Quad-Lock forms. These include:

- Hot Knife kit *(supplied by Wind-Lock www.wind-lock.com, Demand Product www.demandproducts.com, or other)*
- Electric chain saw for wiring runs
- Drywall saw
- Small roto-hammer drill
- Concrete screws

12.1.2 Access for Services (Pre-pour)

Penetrations through walls for service access should be provided prior to pouring concrete by inserting a sleeve in a hole cut in the Quad-Lock forms which is large enough to accommodate the wire or conduit necessary for service. Usually this sleeve is a piece of PVC, ABS, or other plastic pipe.

- Mark the desired location for the service entrance by using the sleeve for a template and draw the shape of the sleeve on the wall surface.
- Using a drywall saw, cut a hole to accommodate the sleeve on both sides of the wall, and insert sleeve material.
- Use spray foam to secure the sleeve into place for the concrete pour.
- Make sure that your sleeve material is compatible with other wiring or conduit that is to pass through the sleeve.
- When wire or conduit is in place, use spray foam to fill the sleeve and secure wire or conduit.



1.	VERTICAL WALL REINFORCEMENT
2.	QUAD-LOCK GREEN TIE
3.	QUAD-LOCK ULTRA PANEL
4.	INTERIOR WALL FINISH - FASTEN TO PLASTIC TIE FLANGES
5.	SEALANT
6.	PIPE
7.	BACKER RODS
8.	GROUT / URETHANE CRACK INJECTION FOAM (E.G. DENEF)
9.	SLEEVE WITH WATERSTOP (SECURE TO QUAD-LOCK PANELS PRIOR TO POUR WITH SPRAYFOAM)

10.	DIMPLEBOARD/PROTECTION BOARD (IF REQUIRED)
11.	QUAD-LOCK PEEL&STICK WATERPROOFING MEMBRANE
12.	LIQUID WATERPROOFING SEAL MIN. ½" WIDE x ½" TALL [12mm x 12mm]
13.	BENTONITE ROD
14.	STIFF MIX CRYSTALLINE BASED WATERPROOFING (E.G. XYPEX)
15.	PROTECTION BOARD WASHER AND NON-CORROSIVE FASTENER (FASTEN TO QUAD-LOCK PLASTIC TIE FLANGES)
16.	8" [203mm] THICK CONCRETE CORE
17.	HORIZONTAL WALL REINFORCEMENT

Figure 159: Plumbing / Electrical Wall Penetration

Building Tip:	**Cut teeth in one end of a PVC pipe matching the desired hole size and "screw" it through the wall to create the wall penetration. Reuse that piece for other holes.**

12.1.3 Electrical Panel Placement:

Electrical panels can be placed on top of the foam or against concrete after the foam has been removed.

***Note**: It is suggested that electrical panels not be placed in the forms prior to pour in order to cast in place. Efforts to do so have not been successful.*

12.1.3.1 Surface-Mount for Panel Boxes

If a "surface-mount" of the electrical panel is desired, use a method similar to that suggested for cabinets:

- Cut a piece of ½" [13mm] to ¾" [19mm] plywood to match the size of the panel.
- Use a compatible adhesive or spray foam to glue the plywood to the surface of the foam, and also screw the plywood to the flanges of plastic ties.
- A #8 or #10 screw has about 30 lbs of shear value per fastener, so use a fastener count that exceeds the load to be placed on it.
- When the plywood is secured, mount the electrical panel to the plywood with screws, or as recommended.
- For excessively heavy panels, it may be desirable to use anchor bolts to connect directly to the concrete. Support the box temporarily, and "through-drill" through the box, the foam panel, and into the concrete. Set anchor bolts into the holes and set nuts as directed.

12.1.3.2 Flush-Mount for Panel Boxes (Direct-to-Concrete)

If a "flush-mount" is desired, pre-planning is required to substitute Quad-Lock Plus Panels at the location where the electrical panel is to be mounted.

- The 4¼" [108mm] thick Plus Panels can be cut away from the mounting area to allow a recessed installation of the panel.
- Direct connection to the concrete with anchor bolts or concrete screws is recommended.

12.1.4 Switch and Outlet Box Placement

Quad-Lock recommends installation of electrical boxes after the pour by cutting away the EPS insulation and exposing the concrete.

- Boxes should be sized to be deep enough to both connect to concrete and sit higher than the surface of the foam by the thickness of the finish material (usually gypsum wallboard or stucco). Example: In the case of a 3 1/8" [79mm] Ultra Panel, the box must be 3 5/8" [92 mm] deep to touch the concrete and remain flush to ½" [13mm] gypsum wallboard attached to the foam.

12.1.4.1 After-Pour Box Installation:

Have the electrician mark the exact location of all electrical boxes.

- Use the box as a template and use a felt pen to draw the shape of the box on the wall.
- Use an electric hot knife or hand saw to cut the foam away to accommodate the box.
- Place the box in the hole and secure into place by drilling a hole through the box and into concrete with a hammer drill.
- Use a concrete screw fastener (TapCon or equivalent) to affix the box firmly to concrete.
- If the box does not sit higher than the plane of the foam, use a "mud ring" to extend the box.

Inspectors generally discourage "shooting" boxes onto concrete with P.A.T. fastening devices, and will not approve adhesive caulk or spray foam as a method to secure boxes. Wiring and Conduit Runs:

12.1.4.2 After-Pour Wiring Installation

Wiring runs can be made after concrete is poured by removing foam insulation to form a chase way. Conduit, sheathed cable, or unsheathed cable (such as Type NM, if permitted) can be placed in the chase way and secured either to concrete or with spray foam insulation.

- CONSULT LOCAL CODE REQUIREMENTS FOR SET-BACK AND PROTECTION REQUIREMENTS. Many national codes require a minimum 1½" [38mm] setback from the surface of the foam.

- Regular Quad-Lock panels (2¼" [57mm] thick) and Ultra Panels (3 1/8" [79mm] thick) can be cut back to concrete to easily provide a set-back of 1½" [38mm] or more.
- Quad-Lock Plus Panels are 4¼" [108mm] thick, and can be cut open to easily accommodate conduit runs up to 3¾" [95mm] in diameter.
- When placing wire, conduit, or sheathed cable in the chase way, secure into place with daubs of spray foam at 3 ft. [1m] intervals, allowing the cable to be open for inspection. After inspection, chase ways can be filled with spray foam to preserve the insulation value of the wall. Spray foam and other adhesives must be rated for contact with polystyrene. Consult the Quad-Lock list of approved companion products contained in this manual.

***Note**: Some jurisdictions and certain building use classifications will require mechanical fastening of conduit to concrete with approved clips.*

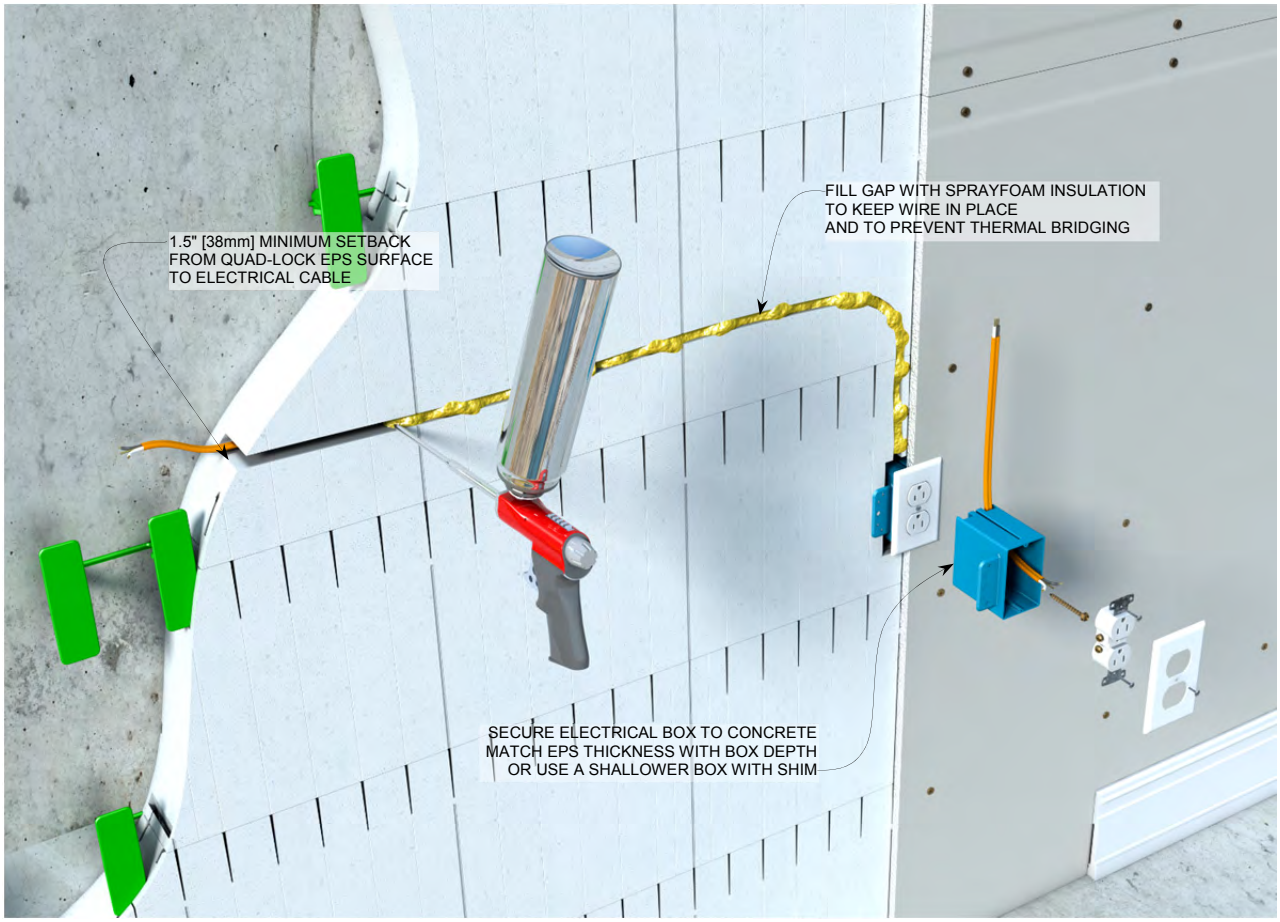


Figure 160: Installation of Electrical Boxes and Wiring

12.1.5 Wiring and Fixtures in Quad-Deck

An in-depth discussion of placement of services in Quad-Deck is outside the scope of this manual readers should consult the Quad-Deck Installation Manual. However, please note the following brief comments:

12.1.5.1 Installation of Wiring in Quad-Deck:

Installation of conduit in Quad-Deck can be accomplished prior to pouring concrete by cutting a shallow channel into the surface of the Quad-Deck panels. Spray foam the conduit into place. It is permissible for conduit runs to pass through the T-beams, so long as it does not displace reinforcing steel. Conduit should be sleeved with oversized pipe when passing through T-beams.

12.1.6 Recessed Lighting:

If recessed lighting is used in a Quad-Deck floor or in a Quad-Lock wall, it is recommended that light cans are cut into the Quad-Deck or Quad-Lock. Low voltage or LED fixtures should be used to minimize heat buildup inside the can.

12.1.7 Fixtures

12.1.7.1 Mounting Electrical Fixtures:

Small fixtures can be mounted on finished walls using appropriately sized drywall anchors. Larger fixtures should be fastened to expansion anchors set through the foam panels and into the concrete Plumbing

12.2 PLUMBING SERVICES

Plumbing pipes and fixtures may be installed in conjunction with Quad-Lock in several ways (similar to Electrical Installation / previous section):

12.2.1 Pre-Pour Preparations

Like pre-installed electrical boxes and conduit, Quad-Lock does not recommend placing plumbing supply or drain lines in un-poured wall cavities. Instead, preparation of chase-ways to accommodate installation of these lines is recommended. The exception to this is service access sleeves that pass directly through the cross-section of the wall. (See “Service Access” below.)

12.2.1.1 Plumbing Chases

If larger diameter piping won’t fit in the cross-section (width) of EPS panels, a larger chase must be provided.

- Plumbing chases can be created by using oversized plastic pipes cut lengthwise in half. Wire the pipe into place with the cut face in contact with inside face of the wall cavity.
- On the outside of the panel, wrap the wire around a small piece of wood to keep the wire from cutting into the foam.
- Mark the location of the chase pipe on the outside of the wall with a felt pen for cutting after the concrete pour.

Building Tip:	**Chases may also be created by adding foam thickness along the line where the plumbing will travel. For instance, cut 1 ft. pieces of 4” Quad-Lock Panels and substitute them (vertically aligned) for smaller panels as the wall is stacked. This will create an area where a 4 ¼” deep chase can be cut vertically into the wall, accommodating a 3” vent line.**

12.2.1.2 After-Pour Plumbing Placement:

Supply pipe (and smaller diameter drain lines and vents) may be set in grooves or chases routed in the foam after placement of the concrete.

- Pipe locations must conform to the minimum setback requirements of applicable building code unless protective measures are utilized.
- Anchor plumbing directly to the concrete as required.
- After inspection, spray foam may be used to refill the grooves. Anchor plumbing fixtures directly to the concrete or to blocking attached to concrete.

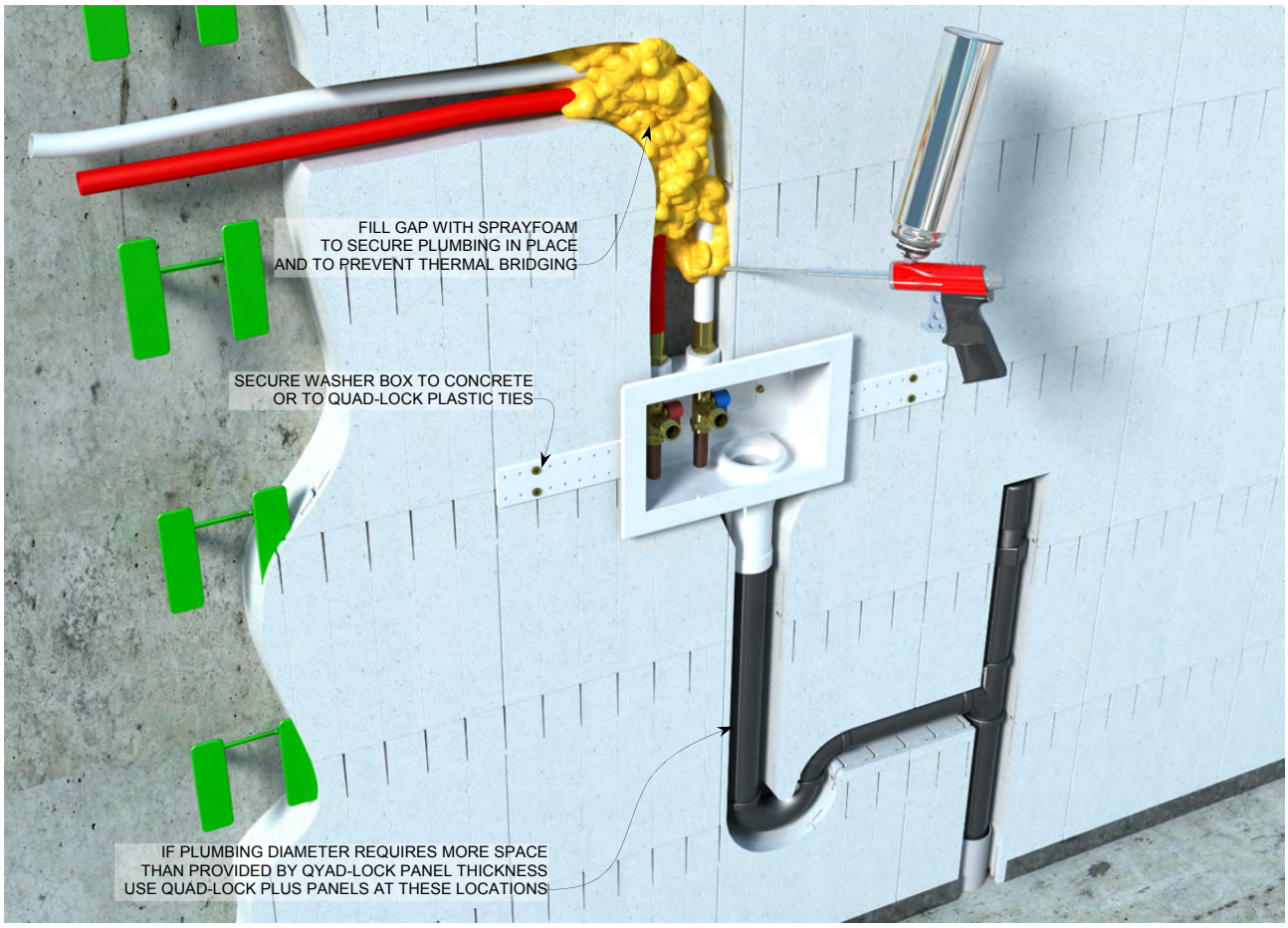
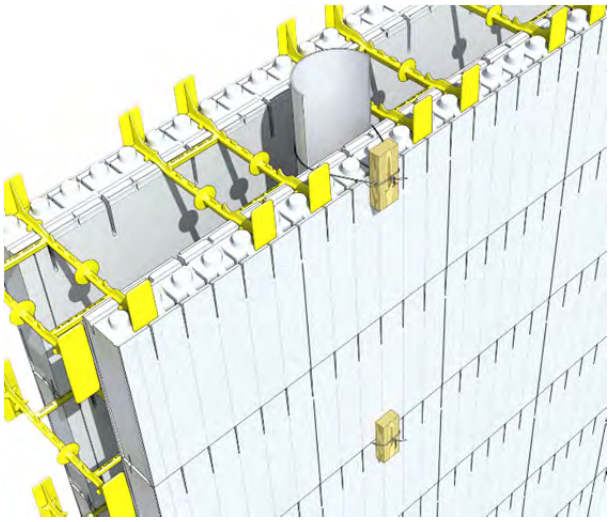


Figure 161: Plumbing Installation (After-Pour Method)

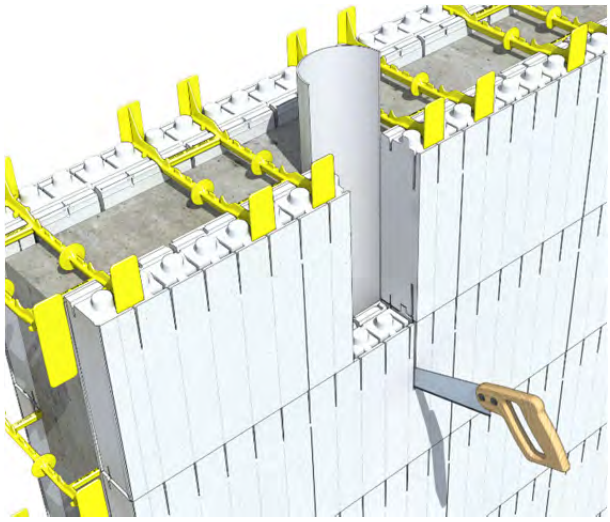
12.2.2 Service Access

Penetrations through walls for service access should be provided prior to pouring concrete.

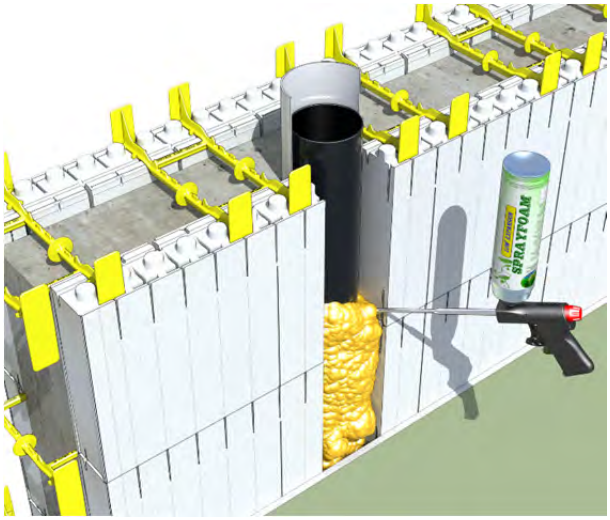
- Insert oversized sleeves through holes cut in the Quad-Lock forms, large enough to accommodate the supply or drain pipe required for service. Usually this sleeve is a piece of PVC, ABS, or other plastic pipe.
- Mark the desired location for the service entrance by using the sleeve for a template and draw the shape of the sleeve on the wall surface. Using a drywall saw, cut a hole to accommodate the sleeve on both sides of the wall, and insert sleeve material.
- Use spray foam to secure the sleeve into place for the concrete pour.
- MAKE SURE THAT YOUR SLEEVE MATERIAL IS COMPATIBLE WITH OTHER PIPING THAT IS TO PASS THROUGH THE SLEEVE.
- When service piping is in place, use spray foam to fill the sleeve and secure piping



Step 1. Tie Sleeve to Quad-Lock EPS prior to pour.



Step 2. Cut out EPS Panels to expose the blocked out area.



Step 3. Install plumbing, sprayfoam prior to installing wall finish.

Figure 162: Steps for creating Service Access

12.2.3 Mounting Plumbing Fixtures

Provisions for mounting and securing of plumbing fixtures (sinks, toilets, urinals) to walls should be considered well ahead of time, and certainly prior to pouring concrete. Consult manufacturers' specifications for all plumbing fixtures to determine exact requirements for proper mounting. Fastener type and size are the most important, followed by loading specifications (if given) and suggested substrates (concrete or wood framing).

- If fastening to concrete is required, a decision must be made whether to fasten through foam and into the concrete wall (after the pour), or to bring the concrete out to the face of the EPS panels to offer a solid surface in which to fasten.
- If concrete must be brought flush to the surface of the foam, prior to pouring concrete measure the exact intended position of the fixture and mark fastening points on the wall with a felt-pen. Now mark a larger area surrounding the fastening points to represent the area of exposed concrete desired. Cut the foam away and place a ¾" plywood panel to cover the hole(s), fastening the plywood securely to ties on all sides with screws. The plywood now serves as a form to stop the concrete when it is flush to the surface of the EPS panel.
- Alternately, water-resistant wood blocking may be attached to concrete to provide a substrate into which fasteners for the fixture may be driven. Remove the EPS foam back to concrete to accommodate the wood block size. Use a combination of lumber or plywood that, when layered, will equal the depth of the EPS panel when fastened to the

wall. Use anchor bolts or appropriately-sized concrete screws to fasten the wood assembly to the concrete wall, leaving it flush to the surface of the EPS. Fasten the fixture directly to the wood block.

Gypsum drywall or other finishes can be applied over the top of either concrete or wood blocking that has been left flush with the surface of Quad-Lock EPS panels, using either screws or adhesive.

Building Tip:	**Where laundry supply, larger vents, and other deep plumbing fixtures are required, substitute pieces of Quad-Lock PLUS Panels for Quad-Lock 2¼" [57mm] Regular Panels or QPX3 Panels 3 1/8" [79mm] thick to create an extra deep (4¼" [107mm]) chase. Place PLUS Panel pieces flush to the rest of the wall surface, creating a short section of concrete where the concrete wall section is 2" [51mm] thinner than the rest of the wall. Then, the 4¼" [107mm] PLUS Panels can be cut away to permit installation of fixtures. This method should not create structural problems, as long as normal rebar placement is maintained, and the area of thinner cross section is limited. If there is a question, consult the project engineer for authorization.**

13 QUAD-LOCK SWIMMING POOLS, CISTERNS & TANKS

13.1 SWIMMING POOLS

Quad-Lock Insulating Concrete Forms are ideal for the construction of swimming pools for a number of key reasons, including:

- Flexibility to form any shaped pool
- Insulation to save energy and lower operating costs
- Adaptability to structural designs to resist heavy hydraulic loads
- Built-in substrate for waterproof architectural finishes

Quad-Lock walls are usually built on a pre-poured footing to match the desired shape of the pool structure. Tops of pool walls are usually a solid concrete cap, as described in *Chapter 4, Section 4.14*.

The figure below details a common ICF pool design.

13.1.1 Swimming Pool Design Considerations

Like any specialty structure, a swimming pool must be designed to perform the tasks that it is being asked to do: i.e.; contain a heavy hydrostatic load, adapt to equipment used to circulate and condition water, accommodate fixtures like ladders, and to present the desired architectural look.

Quad-Lock recommends that all local, regional, and national building codes pertaining to swimming pool construction be followed. An example of a comprehensive pool code (International Swimming Pool and Spa Code) can be found online at: http://publicecodes.cyberregs.com/icod/ispsc/index.htm Unless using prescriptive provisions of a local building code, Quad-Lock recommends the involvement of a structural engineer in the design of swimming pools.

- Follow detailed instructions for construction of radius walls contained in Chapter 4 this manual if your pool features a rounded shape.
- Be sure to add a small rounded fillet (using base-coat material) where the pool walls meet the slab at a 90 degree angle.

13.2 STORAGE TANKS AND CISTERNS

Storage tanks for water reserves (potable water, fire-suppression, irrigation or other) or for containment of agricultural waste should be constructed in a similar fashion to swimming pools, but taking into consideration the special conditions brought about by individual uses.

- Structural design must be adequate to support expected loads whether the tank is full or empty.
- Coatings or membranes used to contain liquids must be compatible with EPS and able to provide long-term service while in contact with the contents of the tank.
- Piping or other systems must be properly detailed and sealed to prevent leakage out of or into the tank.
- Tanks for containing liquids other than those discussed above (industrial chemicals & etc.) must be designed by an engineering specialist that is well versed in the properties of and conditions created by the chemical in question.

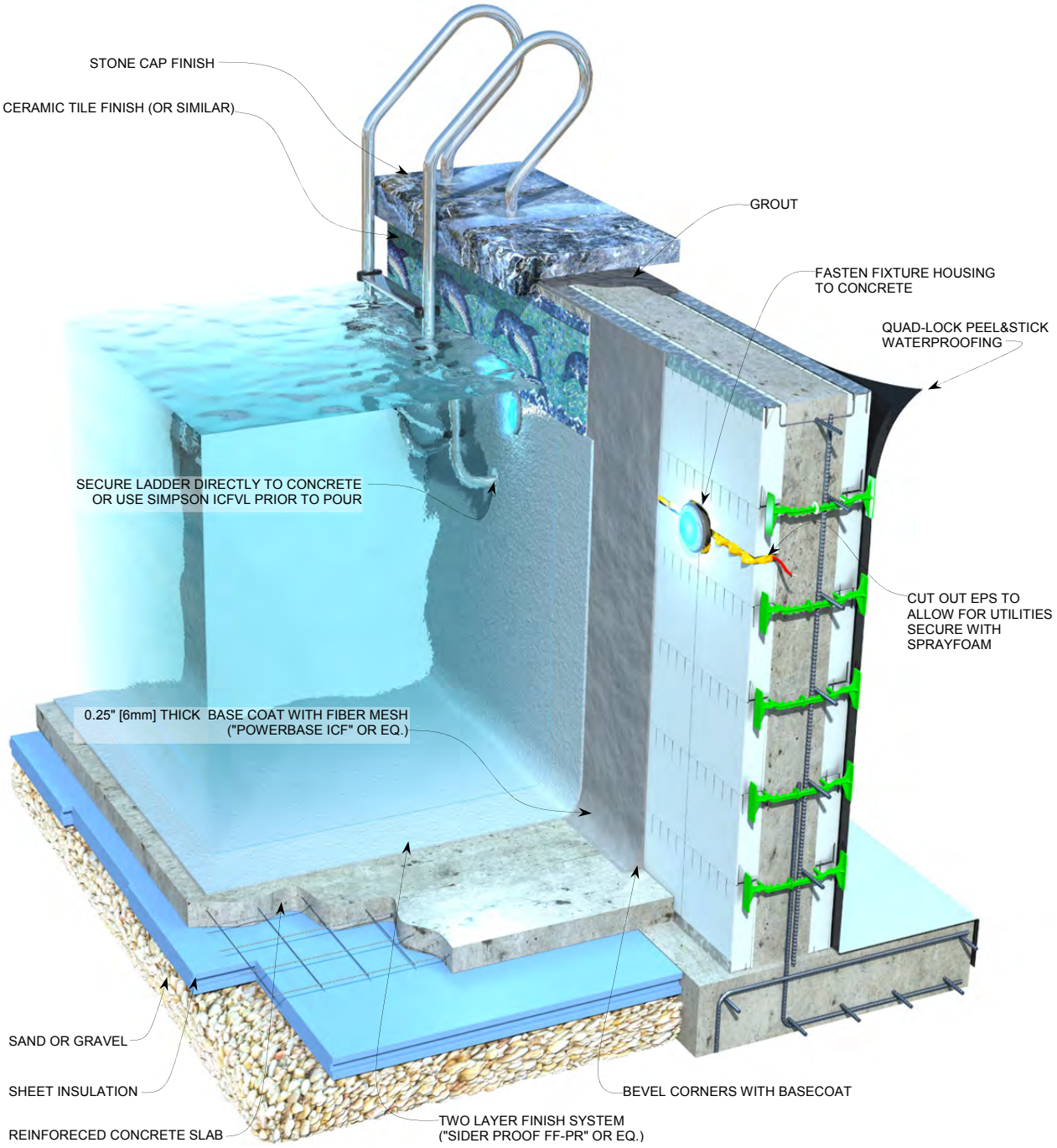


Figure 163: Typical Swimming Pool Wall section

14 COMPLIMENTARY PRODUCTS

14.1 COMPLIMENTARY PRODUCTS

Quad-Lock has identified a number of products and services that developers, builders and homeowners have used successfully in completion of their ICF projects.

These products and services include (but are not limited to) the following listed items:

Product/Service Name	Manufacturer/Vendor	Type	Application
Exterior Hard-Coat Stucco Swimming Pool Finish System	Sider-Crete www.sider-crete.com	Hard-coat stucco basecoat and acrylic seal & finish coat	Spray or hand applied basecoat; Spray or hand-applied finish coat; Roll-on seal coat for pools
Spray-on Insulation System	ICYNENE 800-758-7325 or 905-363-4040 inquiry@icynene.com www.icynene.com	Soft foam insulation and air barrier for moisture and thermal management in wall, floor, and roof systems	Spray formula or Pour-fill for existing construction
ICF Accessories and Tools	Wind-Lock 800-872-5625 800-854-6614 Fax wlsupport@wind-lock.com www.wind-lock.com	Construction accessories and specialty tools for ICF construction and EIFS installation	Retail and wholesale supply via distribution, phone, and internet
Engineering Services	Various providers in USA, Canada, and Int'l (Contact Q/L Tech. Dept.) 888-711-5625	Site specific engineering and consulting services	Site specific engineering and consulting services
Giraffe Wall Bracing	GiraffeBracing™ 888-778-2285 www.giraffebracing.com	Giraffe wall bracing system for ICF walls and deck systems.	Retail and wholesale supply via distribution, phone, and internet
Panel Jack Wall Bracing	ReechCraft, Inc 888-600-6160 | 701-232-6666 Fax www.reechcraft.com	Panel Jack wall bracing system for ICF forms	Retail and wholesale supply via distribution, phone, and internet
Shoring and Scaffolding	Formwork Exchange/Shore-All	Complete line of shoring and scaffold accessories for all types of construction; sale and rental	Retail sales; Rentals
Shoring and Scaffolding	ThyssenKrupp Safway Scaffold (USA and Canada) www.safway.com 800-558-4772	Complete line of shoring and scaffold accessories for all types of construction; sale and rental	Retail sales; Rentals
KIM 300 Waterproofing Concrete Admixture	Kryton International, Inc 800-267-8280 or 604-324-8280 www.kryton.com	Krystol internal membrane; crystalline self-sealing concrete waterproofer	Powder form concrete admixture added on-site
Xypex Waterproofing Concrete Admixture	Xypex Chemical Corp. 800-961-4477 or 604-273-5265 info@xypex.com www.xypex.com	Xypex C-1000 crystalline self-sealing concrete waterproofer	Powder form concrete admixture added on-site

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