INSULATING CONCRETE FORMS INSTALLATION MANUAL

October 2010

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CELBLOX® INSTALLATION MANUAL

This manual is intended to assist the contractor or installer on the proper installation techniques of CELBLOX® ICF construction. This manual assumes that general construction practices will be employed when building with CELBLOX®. All applicable building codes and regulations should be used in designing, engineering and constructing structures with CELBLOX®.

LIABILITY

Proper installation of CELBLOX® is the responsibility of the contractor. CelBlox, LLC accepts no liability for results as it has no control over the actual application or installation of the product. We reserve the right to change or modify the contents of this manual at any time. It is the responsibility of the contractor to obtain the most recent information available.

ACKNOWLEDGMENTS

Tables included in the appendix are from *PCA 100-2007, **Prescriptive Design of Exterior Concrete Walls for One- and Two-Family Dwelling**s.* They are copyrighted by and provided courtesy of the Portland Cement Association, Skokie, Illinois. It is recommended that residential builders obtain and utilize this publication in conjunction with this installation manual. This publication can be acquired from the PCA directly by calling 847.966.6200 or at www.cement.org.

APPROVALS & CODE COMPLIANCE

Use of CELBLOX® is approved under IRR Report to ensure compliance with both local and national building codes. These approvals are consistently updated and revised so please make certain you are referencing the most current version of the report on your permit submittal. CELBLOX® is also approved as a Wisconsin Building Product (approval 200710) and has Florida Product approval (4985).

A copy of this report can be obtained by contacting the CELBLOX® home office at 608-630-2205.

PRODUCT SPECIFICATIONS

CELBLOX® ICFs are used as a permanent formwork for structural concrete in below-grade and above-grade walls. CELBLOX® ICFs form a solid monolithic concrete wall of uniform thickness which can be designed for use in a great variety of construction projects.

Each CELBLOX® Insulating Concrete Form (ICF) consists of two 16”x48” expanded polystyrene (EPS) panels with variable core width hinged connectors from 4” to 12” and has 5.33 s/f or surface area. Embedded webs every 8” on center provide the furring strips needed for unlimited interior and exterior finishes. Each block weights about 6 pounds, making them easy to stage on the jobsite.

The CELBLOX® ICF system is shipped with hinged connectors folded flat to minimize freight costs and save space. On the job, the forms can be quickly popped open and are ready to stack.

90º and 45º blocks are available to speed construction and provide an exterior corner nailing strip.

In accordance with the International Building Code 2018, plain and reinforced walls constructed in accordance with Chapter 19 do not require a vapor retardant. CELBLOX® recommends that you check the local code requirements in your area to ensure compliance.

CELBLOX® ICFs can be used to construct fire rated wall assemblies with the following ratings based on concrete core thickness:

CONCRETE THICKNESS (inches)	**FIRE RESISTANCE RATING** (hours)
4” & 6”	2
8”, 10”, & 12”	4

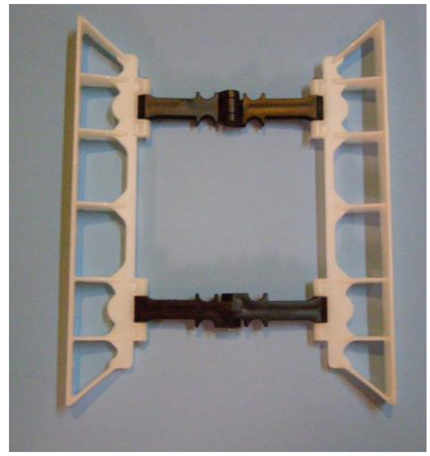
For further assistance or information, contact the CELBLOX® home office listed below.

CELBLOX®
1405 Laukant Street
Reedsburg, WI 53959
Phone: 608-630-2205
Fax: 608-524-2362
Website: www.celblox.com

FORMING SYSTEM COMPONENTS

CELBLOX® FORMING SYSTEM COMPONENTS

WEB DESIGN



Each web consists of a 1 1/2” wide outer flange that is connected through the EPS to two rows of hinged connectors on the inside of the panels.

Webs are spaced 8” on center for easy interior drywall and exterior finish attachment. The webs are recessed ¼” from the exterior surface of the EPS panel to eliminate heat which could crack stucco or acrylic stucco exterior finishes.

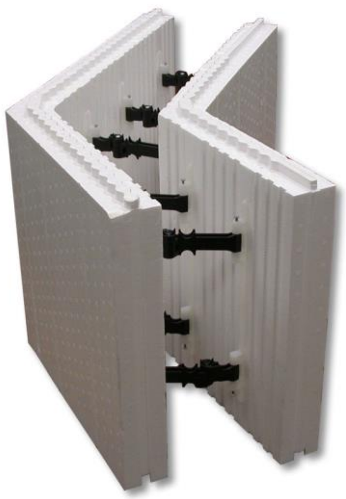
The web is full height minus ¼” to allow for utility placement. The open cavity allows free flow of concrete.

STRAIGHT PANEL

The CELBLOX® straight panel is 16” x 48.” Each straight block is assembled from two panels of 2 ½” thick EPS (expanded polystyrene) with a total insulating value of R-21.

The exterior of each panel is grooved in 1” increments with a wider groove indicating locations of the 8” on center webs making it easy to locate finish attachment points.

The top and bottom of each panel has a tongue & groove configuration to eliminate block movement during the concrete pour.

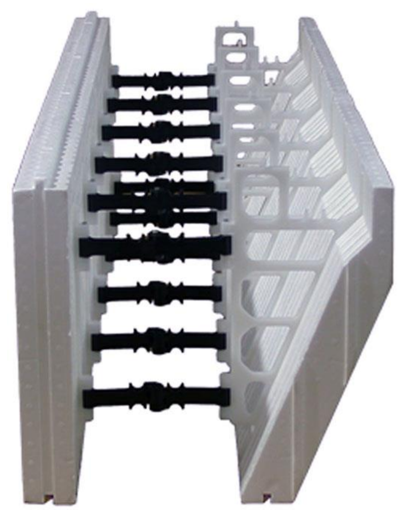


PRE-FORMED 45º CORNERS are available in core widths from 4” to 10”.

PRE-FORMED 90º CORNERS are available in core widths from 4” to12”.

BRICK LEDGE FORMS combine a straight panel and a preformed brick ledge panel to form a complete brick ledge block.

BRICK LEDGE RAILS are installed at the top of each brick ledge at top of the webs to strengthen and level the next course. (not shown)



TAPER TOP FORMS are designed for log houses, manufactured housing, basements with wood framing above, and stem walls for slab on grade. Rebar MUST be used in all applications and must be engineered and approved by local building officials.

INSULATING CONCRETE FORMS BENEFITS

CELBLOX® BENEFITS

QUICK CONSTRUCTION
Celblox ICF walls, due to minimal block weight and 16”x48” size, are less labor intensive to install, require fewer workers, and are ready to finish in less time than other wall systems.

MINIMAL WASTE
CELBLOX® ICFs are designed to reduce waste during construction and have a waste factor of 2-5% which is much lower than other wall materials. In addition, cut block can be re-used in other parts of the walls to minimize waste.

DURABILITY
Concrete is durable. The concrete inside a CELBLOX® wall cures chemically without any outside interference (temperature, moisture, wind) and is typically 50% stronger than the rated psi of the concrete used. ICF walls are six times stronger than reinforced block walls and ten times stronger than traditional wood-framed exterior walls used in standard construction.

MOLD, MILDEW, AND MOISTURE RESISTANCE
In wood-framed construction, mold can feed on the materials in the wall. In an ICF wall, EPS and concrete are both inorganic materials that do not provide moisture or a food source for mold or mildew, regardless of temperature and humidity. If a CELBLOX® ICF panel is completely saturated in water, it can only absorb .3% moisture by weight and Celblox ICF panels are extremely lightweight. In contrast, a typical electrical box opening in a wood framed wall will absorb 7.5 gallons of water each year through air leakage. Since CELBLOX® ICFs are closed cavity construction, there is no place for moisture to accumulate.

ENERGY EFFICIENCY
The thermal resistance of each 2 ½” CELBLOX® panel is R-10.5 and an R value of 22 when the wall is poured with concrete which has an R value of 1. However, *effective* performance is much better since the continuous EPS envelope eliminates air infiltration through the wall assembly and buffers the concrete against swings between inside and outside temperature. This “thermal mass effect” saves energy, improves building comfort, and allows reduction of up to 50% in HVAC requirements for the building. Energy savings for CELBLOX® ICFs wall range from 35-50%.

AIR INFILTRATION BARRIER
CELBLOX® ICF walls are an effective air barrier since concrete, when poured, forces air out of the cavity and fills all voids when consolidated. CELBLOX® ICF walls consistently show an air infiltration rate less than 0.01 cfm/ft^2. Depending on roof type and quality of sealing around doors and windows, CELBLOX® *structures* consistently show results of .5 to 2.5 ACH or less.

SOUND TRANSMISSION BARRIER
A typical interior stud wall with 2 sheets of 5/8” drywall has an STC of about 33. Adding insulation to the wall cavity increases the STC to 36-39. Replacing wood with metal studs in the assembly increases the STC to about 43-44. CELBLOX® ICF 8” core walls consistently achieve STC ratings of 55.

DISASTER RESISTANCE

CELBLOX® ICF walls can be engineered to withstand any form of severe weather, including tornados, hurricanes, and earthquakes.

TORNADO

In a tornado, the most vulnerable areas of a building are roof, walls, and windows. Even with fastened roofing systems and impact-resistant windows, these areas would still be vulnerable if the building takes a direct hit. Therefore, the safest option is to build an ICF "safe room" in the building where the entire room is ICFs with no windows.

HURRICANE

Hurricanes pose three main threats to a structure – strong winds, storm surge, and flying debris – and Celblox stands up well to all three.

Strong winds – Because each concrete filled 6" core form weighs about 400 pounds (75 pounds per square foot) this makes a CELBLOX® wall heavy enough to withstand strong winds.

Storm Surge - All the wall components above the footing are connected in a solid monolithic mass and eliminate flex, fatigue, and weak points.

Flying Debris – This is a major threat in hurricane areas because boards literally become missiles and can puncture even brick walls. A Texas Tech University test shot 2"x4"x8' studs at an ICF wall but did not penetrate them even at 100mph.

EARTHQUAKE

In ICF construction, the combination of concrete and steel provides the three most important properties for earthquake resistance: stiffness, strength, and ductility. CELBLOX® ICF walls are a composite system in which the concrete resists compression forces and rebar resists a tensile force produced by an earthquake since the concrete is cast around the bars and locks them into place. A study at Construction Technology Laboratories revealed that even a lightly reinforced concrete shear wall has over six times the racking load resistance as framed wall construction.

FIRE RESISTANCE

In fire wall tests, CELBLOX® stood exposure to intense flame without structural failure longer than did wood framed walls. The EPS used in CELBLOX® will not support combustion. Tests also show that CELBLOX® ICFs transmit an outside flame source less than that of most wood products.

Without drywall, CELBLOX® ICF walls have a two hour fire resistance rating (FRR) with a 4" or 6" concrete core and a four hour FRR with 8", 10", or 12" core.

AFFORDABILITY

Although CELBLOX® ICFs may increase the building cost by 2% to 4%, these costs can be offset by their ability to reduce HVAC equipment size (and cost) by up to 60%, save up to 50% of the energy costs over the lifetime of the structure, and qualify for insurance discounts of up to 20%.

FINANCIAL INCENTIVES

Commercial buildings placed in service by December 31, 2013 that achieve a 50% reduction in annual energy costs are eligible for a depreciation deduction of $1.80 per s/t under the U.S. Energy Policy Act. A database of state and federal financial incentive for Energy Efficiency can be accessed at www.dsireusa.org.

GREEN BUILDING & LEED

To promote green building, LEED was created by the USGBC as a sustainability rating system to encourage use of green building technologies and address energy use and CO^2 emissions.

LEED v3, the revised version of the LEED Rating System released in late 2009, incorporates:

- **LEED for New Construction** (and major renovations) of offices, schools, hotels, and multi-family more than four stories. This is the most commonly applied for certification
- **LEED for Schools** for design and construction of new or major renovations for academic buildings K-12
- **LEED for Core and Shell** for elements of speculative projects where the owner/developer may have limited or no control of tenant finish

CELBLOX® can contribute *significantly* in several credit areas:

CREDIT AREAS	NC	SCHOOLS	CORE & SHELL
Sustainable Sides	2	2	2
Water Efficiency	0	0	0
Energy & Atmosphere	19	19	21
Material & Resources	6	6	6
Indoor Environmental Quality	1	3	1
Innovation & Design	5	4	5
Regional Priority	2	2	2
TOTAL CELBLOX POINTS AVAILABLE	**35**	**36**	**37**

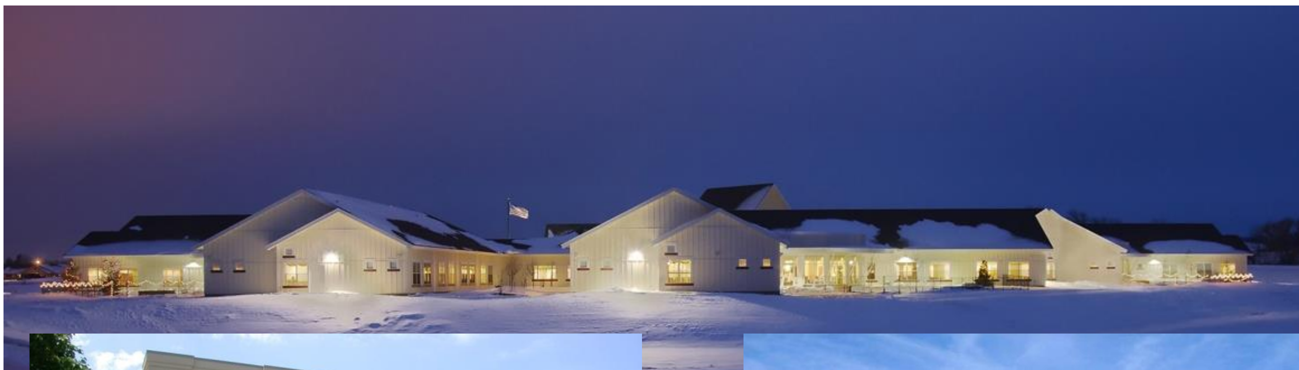
For more information on USGBC and LEED, visit their website as www.usgbc.org.

DESIGN

CELBLOX® can be used below and above grade in single and multi-story residential, commercial, institutional and industrial construction.

Because of the design flexibility of CELBLOX®, they will readily adapt to structures of any shape or size. CELBLOX® can be used to design arched openings, radius walls, turrets, curved exterior or interior walls, or multiple 45° angles or bay windows.

Structural details such as post-tensioned floor, sound barrier or fire resistant demising walls, and tall walls can be designed with CELBLOX®.



INSTALLATION GUIDELINES

MATERIAL ESTIMATING

CELBLOX® ICFs		FORMULA	SAMPLE CALCULATION	RESULT	
1.	Courses	Divide wall height in inches by 16	108" height / 16" block height	6.75	courses
2.	Number of courses	Add one more course, if unable to divide evenly by 16	6 courses + 1 course	7	courses
3.	Course Height	Multiple number of courses by 16 for inches/divide inches by 12 for feet	7 courses *16" = 112" 112" / 12" = 9.33 ft	9.33	feet
4.	Wall s/f w/o openings	Add exterior lineal feet of walls and multiply by course height (in feet)	30+30+60+60 = 180 lineal ft 180 x 9.33ft wall height	1679	wall s/f
5.	Opening s/f	Multiply width by height of each opening and add together	3x5 = 15s/f *10 windows= 150s/f 7x3 = 21s/f * 3 doors = 63 s/f 150 s/f windows + 63 s/f doors	213	opening s/f
6.	Total wall s/f with openings	Subtract opening s/f from wall s/f	1679 s/f wall - 213 s/f openings	1466	total wall s/f
7.	Total forms	Divide total wall s/f by 5.33 (s/f per block)	1466 wall s/f / 5.33 s/f	**275**	Total Forms
8.	Corners	Multiple number of structure corners by number of courses	6 corners * 7 courses	42	Corners
9.	Straight Forms	Subtract number of corner forms from total forms	275 forms - 42 corners	233	Straight Forms
10.	Form Check	Add straight forms to corner forms (should match Total forms above)	42 corners + 233 straight forms	**275**	Total Forms
11.	Waste Factor	Multiple Total forms by 2-5%, depending on skill level	275 * 2%	6	Extra Forms
TOTAL FORMS		**Add total forms and waste factor**	**275 + 6**	**281**	**Total Forms**

NOTE:
Placing block pieces back into the wall that are at least one web tall and two lines wide minimizes waste.

CONCRETE ESTIMATING

The amount of concrete needed for the wall pour can be estimated by multiplying the wall core (ft) x wall length (ft) x wall height (ft) and then dividing the sum by 27 (the number of cubic feet in a cubic yard) to obtain cubic yards.

Example: A 200 ft lineal wall that has an 8 ft height and a core thickness of 8".

8" WALL CORE EXAMPLE			
Wall Core (ft)	= 8" core / 12" (1 ft)	0.67	s/f
Wall Length x Core (ft)	= 200 (length) x .67 (core)	134.00	s/f
Wall Height x Length (ft)	= 8 ft (height) x 134 ft (length)	1072.00	s/f
Cubic yd concrete for wall	= s/f (1072) / 27 (cubic yd)	39.70	Cubic yds

INSTALLATION TOOLS & MATERIALS

Most tools used to install CELBLOX® are also used in standard construction and are easy to find materials.

RECIPROCATING SAW – for occasional cuts in forms

CIRCULAR SAW or **PORTABLE TABLE SAW** – for longer, straighter cuts through webs

KEYHOLE SAW – for small cuts and cutting holes in forms

HAND SAW – for vertical or horizontal cuts

DRILL – for attaching bracing, extra reinforcement, etc. to the forms with screws

WIRE TYING TOOL – speeds the wiring together of rebar
REBAR TIE WIRES – used to wire bars securely into precise positions

ZIP TIES (30" – 34") – for tying adjacent blocks together at critical points
BLOCK LOCK – for positive connection between blocks

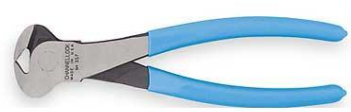
HOT KNIFE with ICF Attachments or
ROUTER or
ELECTRIC CHAIN SAW – for precise, clean utility cuts (optional)

REBAR CUTTER/BENDER – to cut bar to length and bending, if needed
LASER LEVEL – to check walls for plumb
TAPE MEASURE – to check dimensions

FOAM GUN with ***<u>low expansion</u>*** foam – for gluing and filling gaps

DUCT TAPE – to protect the top form crenellated tongue for stacking additional floors
LUMBER – for strapping and blow-out kit
CHALK LINE – to lay out first course and mark form cuts
PLUMBERS STRAPPING – for corner reinforcement

END CUTTER - for removing hinge nails, if needed



FOOTINGS

Getting the footing or slab as level as possible (preferably within +/- ¼”) will minimize any adjustment needed on the first course.

Width and depth of the footing will be specified by engineering specifications or local building codes, taking into account loads and soil types and conditions. It is the responsibility of the designer and/or end user to verify that structures built with CELBLOX® have been designed, engineered, and constructed in accordance with all applicable building codes and regulations.

Vertical dowels are inserted in the footing as specified to match vertical rebar spacing in the wall. If position is not shown on plan, consult the engineer or local building official, for correct placement. Dowels must extend vertically out of the footing to meet rebar overlap requirements (d_b*40). See appendix A for rebar schedule tables.

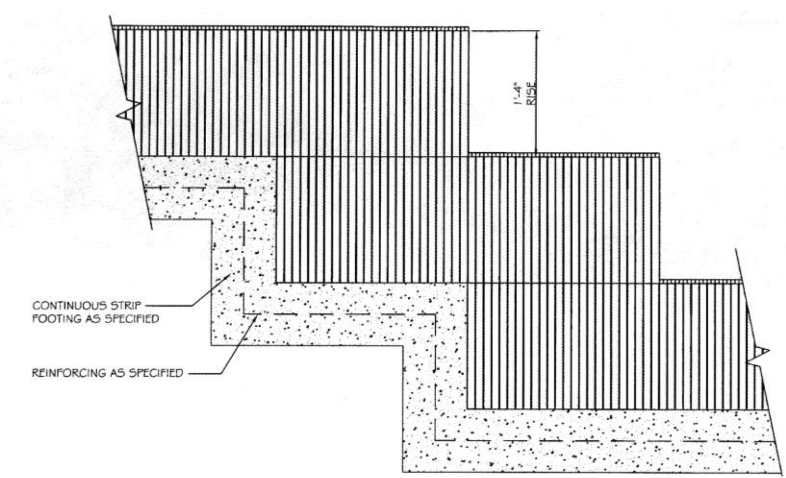
IMPORTANT NOTE

Rebar overlaps are typically 40 times bar diameter on each end (d_b * 40), based on the diameter of the smaller bar, if two different bar sizes are used.

Example: #4 rebar is ½” diameter. ½” x 40 = 20” overlap. Dowel length should be calculated using the same formula as overlap.

STEP FOOTINGS

Site conditions and local building code requirements will dictate step footing run.
When building step footings, if possible, consider using 16” increments to save time and eliminate block waste.

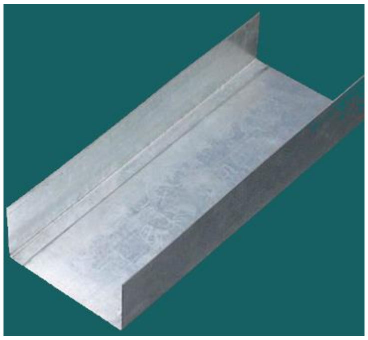


PVC COLLARS

Some state and local codes may require use of PVC collars to capture the vertical rebar, when inserted from above. Check with your local building official regarding requirements. If required, cut sections of 2” PVC pipe about 3 inches high and place over the dowel.

If collars are required by code in your area, be sure to place collars before stacking the first course.

LAYOUT GUIDELINES



Whether working off a footing or a slab, maintaining straight walls is important to the success of your project. Begin by snapping a chalk line where the outside of the CELBLOX® will sit on the footing.

Nailing 2”x2” lumber to the outside of the perimeter chalk line perpendicular to the sides of each corner will firmly locate where the corner CELBLOX® will sit. Make sure to remove this wood after the pour so it will not attract insects or create waterproofing issues later.

Alternately, a 2 ½” metal channel can be installed on the chalk line on the footing with a power nailer. When installing the first course, this channel will hold the ***outside*** panel of the block. For slab applications, the channel should be installed under the ***inside*** panel of the block to eliminate possible damage to the exterior edge of the slab.

Marking the location of your window and door openings on the footing will serve as a reminder of where to cut your forms as you build.

BLOCK STACKING METHODS

There are two stacking methods when making cuts to meet plan dimensions. The choice of which method to use depends on contractor preference. The contractor should measure the wall as it is built, by course, and make adjustments, as needed using either of these two options:

CORNER ADJUSTMENT

Block is stacked from corner to corner, placing a common seam at the corner, making the adjustment on each course. Make sure your cut is in the standard block next to the corner block. This will be a staggered seam because of the different configuration in right and left corner blocks.

COMMON SEAM ADJUSTMENT

This method is to stack from the corner to the center of the wall making a “common seam” in the middle of each wall, next to a window or door opening. The common seam is a vertical cut which is carried from the bottom to the top of the wall. It allows the wall to be adjusted in or out to meet the correct dimensions of the project and should be ½” wide. This seam will need to be carefully braced before the pour.

FIRST COURSE

Select one corner to start placing the forms. Place a corner form (right or left hand) at this corner and begin installation using the corner adjustment or common seam adjustment stacking option. Alternate right and left corners for each course.

Work around the foundation making cuts as necessary to maintain plan dimensions. Keep in mind – only ***straight*** forms should be cut. Cuts, when needed, should be made so the block can be placed without wedging it into the wall. Cuts, if possible, must have a web and tie assembly within 4" of the cut. Cuts wider than 4" and corner bracing are detailed in the bracing section.

If possible, make cut on the form's one inch lines as indicated on the face of the CELBLOX® by the thin line to keep tongue & groove in alignment. If adjustment is being made at the corner, the cut will be made and placed in the direction in which the wall is being stacked. If using the common seam, the vertical cut may be made on either side of the block. Making proper cuts when placing block will ensure that the webs remain on 8" centers uniformly, as indicated by the thick line, throughout the entire wall.

After the first course is laid completely around the foundation, measure each wall to ensure it is the required length and adjust as necessary. Set door bucks, if specified at this level, and plumb them with kickers.   Make sure the kickers are easy to adjust so they can be re-plumbed later if necessary.

All blocks in the first course should be tied with Zip Ties end to end to ensure alignment on subsequent courses. Zip Ties should be tied from the corner to the first web back on adjacent straight block on either side of corner. If using Block Lock on corners instead of Zip Ties, they should be snapped around the top pin bracket on each corner and the top pin bracket on the adjacent straight block.

REBAR PLACEMENT

Amount, size and position of rebar in the wall will be specified by the project engineer, building official, and/or code requirements.

Typical rebar overlaps are 40 times bar diameter on each end (d_b * 40) based on the diameter of the smaller bar (if two different bar sizes are used).

Example: #4 bar is ½" in diameter. ½" x 40 = 20 inches of overlap or as required by local codes. Dowel length into the footing should be calculated the same as overlap.

The first course horizontal rebar should be placed to the outside of the wall with the second course alternating to the inside. Rebar should continue to be alternated until the top of the wall is reached.   This will ensure maximum wall strength in the wall. Typical horizontal placement is every 16" or as required by local code or engineering.

See Appendix B for typical rebar placement tables.

NOTE
In all walls, rebar must be placed to allow a minimum of 1" concrete coverage between the bar and the forms.

SECOND COURSE

Starting at the same corner as the first course, work around the second course just like the first course. Corner blocks used for the second course should be opposite those used for the first course so the joints will be staggered 16" on center. Align webs on second and subsequent courses to match webs of first course.

Working around the second course, make all cuts to straight forms as outlined for the first course. Continue to use the adjustment location chosen on the first course.

Zip tie or use Block Lock to stabilize each corner block to the adjacent straight panels on all courses.

If you have reached the sill level for the windows, set the bucks and plumb them with kickers. Make sure the kickers are easy to adjust so they can be re-plumbed later if necessary.

If the plans call for horizontal rebar in the second course, set it now. Place the rebar to the inside of the wall to allow you to thread the vertical bar between the offset horizontal bars when you reach to top of the wall. Lap the rebar at least the required length (db*40) and place bars into the chairs on the connectors.

On the second course, after the lengths are checked and accurate, check **level** on each wall and shim or trim Celblox where necessary to level.

If the wall is too **high**, trim the bottom of the block with a keyhole saw and push block down into place.

If wall is too **low**, cut EPS shims from scrap block and shim until level. Use low expansion foam to fill in the void under the form.

After walls are level, apply a bead of minimally expansive foam at the intersection of the wall and the footing on both sides of the forms to prevent the forms from being inadvertently bumped out of place on the footing.

THIRD COURSE BRACING

Bracing is installed on all walls after the third course is stacked to provide access to upper courses and keep the wall aligned prior to and during the pour.

In most cases bracing is installed on the inside of the wall structure since this is where most wall construction occurs. However, it may also be installed on the outside of the wall when interior bracing is not feasible. (Example – radiant floor heating installation is complete and interior bracing would damage the product.)

Brace spacing will depend on the height and core size of the walls being constructed. These are typical bracing requirements:

WALL HEIGHT	MAXIMUM BRACE SPACING
8 foot	6 feet
10 foot	5 feet
12 foot	4 feet

When attaching the vertical bracing piece to the wall**,** use No. 8 x 2" pan head steel screws that are threaded all the way to the head of the screw. Screws should be attached to the center of the web, placed in the center of the screw slot and snug, not over tightened, so the head can "float" up or down slightly. Ensure that each course of CELBLOX® receives a screw. Drywall screws have been used very successfully for this but keep in mind that they are quite brittle (snap easily) and do not work as well as standard.

Secure the diagonal turnbuckle to the slab or soil making sure the turnbuckle is in the middle position so it can be adjusted in either direction as needed.

A component of any good bracing system is the scaffolding bracket which allows the crew to work safely at heights over four feet. Use quality dimensional lumber for your scaffolding planks and ensure that the planks overlap and are properly fastened at the corners to prevent accidents. Place a brace as close as possible to the corners while still allowing the scaffold planks to pass by each other. If scaffolding planks are 8' or more above the ground, OSHA requires attachment of toe boards and handrails. Check with OSHA for requirements.

There are a number of scaffolding companies who also manufacture bracing for tall walls. Consideration when purchasing these systems should include safety regulations, code compliance, and engineering requirements for the project.

WINDOW AND DOOR BUCKS

Bucks are required to maintain correct opening size, to contain concrete during the pour, and to mount windows and doors in the structure.

VINYL buck is a readily available product that can be purchased in a variety of standard widths. Radius, arched, and other shapes are available by special order. Assembly and installation instructions can be obtained from the manufacturer and should be delivered with the product.

Engineered **METAL** bucks (shown above) are available in any width and to accommodate any form width. They are much stronger than vinyl, are fire rated, and are specified in many commercial applications. They speed up construction since they supply the buck and finished framing. Some metal bucks may also include insulation to provide a thermal break.

Estimates for buck are based on lineal footage of all rough openings, with allowances for overlap. Although CELBLOX® recommends metal or vinyl buck systems, wood is an option. **WOOD** bucks can be manufactured on site. Complete instructions for building and installing wood bucks are included in Appendix A, Construction Techniques.

All window and door bucks should be assembled prior to assembling the walls. Off-site assembly is preferable since it will increase on-site productivity and keep the jobsite clean. If you can't build them off-site, build them in an out-of-the-way location prior to assembling the walls.

Place your door bucks first. As soon as the foundation is cured, mark the location of all doors and secure the pre-built door bucks into place. The CELBLOX® ICF walls can then be started.

Once walls have reached the level of the bottom of the window, mark the height of the window bottom on the wall and cut the EPS down to window height with a hand saw.

Lift the window buck into place. Ensure the buck is level, adjusting if necessary, prior to fastening it into place. Place kickers to keep the bucks plumb. Once the bucks are in place, continue building until the top of the buck is reached.

All bucks must be supported properly before filling walls with concrete.

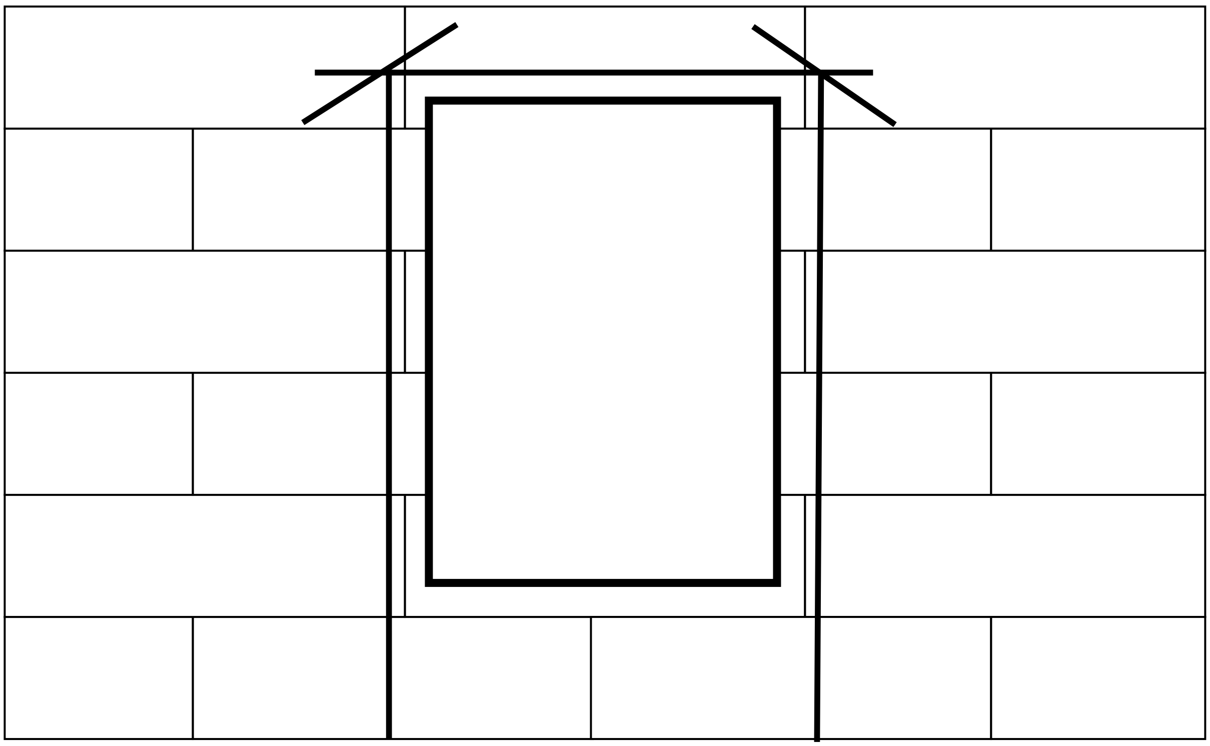
LINTELS REINFORCEMENT

Always check local building codes or engineering specifications for correct lintel reinforcement.

Horizontal rebar above opening typically will extend beyond the opening 40 times the bar diameter or as specified by local codes or engineering requirements. For example, #4 rebar would extend 20" beyond the opening.

45° diagonal rebar is installed as shown to divert load from lintel to sides of opening.

Lintel reinforcement will vary depending on opening size.



Charts for lintel widths up to 16'3" are included in the back of the installation manual. These charts are also available in *PCA 100-2007,* ***Prescriptive Design of Exterior Concrete Walls for One- and Two-Family Dwellings***, a publication available online from the Portland Cement Association (www.cement.org) or the National Association of Home Builders (www.nahb.org).

In addition to lintel reinforcement, the publication provides a general guideline for design, construction, and inspection of structures using ICF technology. This publication covers topics such as reinforcement tables, lintel span tables, percentage of solid wall length, connection requirements, and seismic design.

UPPER COURSES

Continue to stack CELBLOX® ICFs following rules for the second and third course.

TOP COURSE REBAR PLACEMENT

If plans call for horizontal rebar in the top course, set it now, making sure to maintain the staggered pattern.

When all CELBLOX® and rebar in the top course have been set, vertical rebar should be placed between the staggered horizontal rebar on centers to match dowel spacing in the footing or as required by local codes or engineering specifications.

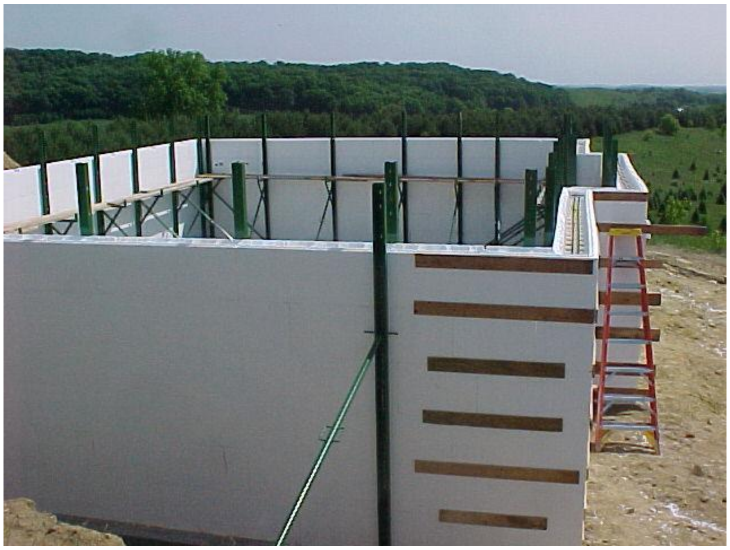
If sleeves were required for the footing rebar, be sure to position the vertical rebar inside the sleeves.

Tie each vertical to the horizontal rebar along the top or to a connector to hold it firmly in the center of the wall. Tying the verticals slightly off the bottom provides weight on the wall and helps to hold the forms firmly together.

If this is the top story of CELBLOX®, finish the vertical rebar three inches below the bottom of the sill plate or top of the wall.

If another story of CELBLOX® will be built on top, make sure to leave enough rebar extending beyond the top of the wall to maintain the minimum lap requirements (db*40).

ADDITIONAL STRAPPING



CORNERS
Additional strapping is necessary on all corners to keep them from shifting during the pour. If using CELBLOX® Block Lock, they should be snapped around the top pin bracket on each corner and the top pin bracket on the adjacent straight block. Corners may also be strapped by wrapping lumber or cut pieces of OSB or plywood completely around the corner and overlapping adjacent straight block two webs on either side of the corner.

Any jobsite manufactured angle must be strapped its entire height. To reinforce this angle, cut widths of OSB or plywood wide enough to cover two webs by the height of the wall and attach one to each side of the corner. Strap by securely screwing a piece of 2x lumber the height of the wall in the corner. The two pieces can also be connected using a piano hinge if you plan to save this strapping for use on subsequent projects. To apply, center the hinge on the cut seam and then screw into the webs on each side of the cut block. The strapping should be approximately 1” off the footing to allow the blocks in the angle to settle with the rest of the wall during the pour.

WINDOW & DOOR OPENINGS
Attach vinyl or metal bucks securely using the method recommended by the buck manufacturer. External wood bucks can be strapped by wrapping both sides of the window opening with dimensional lumber, OSB, or plywood strips screwed to the face of the wall and into the bucks. Internal bucks should be attached securely to the EPS with plastic washers and long screws. Wood bucks must be braced vertically and horizontally every 18” with 2x4 or wider lumber.

Arched openings must have a horizontal brace at the bottom of the radius, one vertical at the center, and two diagonally to hold the arch. The remainder of an arched window will be braced as standard opening.

T-WALL external strapping is critical. Use 2x6 or larger dimension lumber long enough to cover two webs or OSB or plywood with kickers.

PILASTERS are similar to T-walls and must be strapped in the same manner as T-walls. If constructing a pilaster using the T-wall method, additional support is needed on the end cap.

NON-STANDARD JOINTS are any vertical joints that are too close together or are not offset properly. Cuts wider than 4” should have strapping installed to span two webs in each direction and be installed on both sides. Scrap lumber, if long enough, or strips of OSB or plywood can be used for strapping these types of joints. The common seam, if used, should also be braced using this method.

RADIUS WALL STRAPPING

Fasten 1/8” hardboard strips to the inside and outside panel face with drywall screws flush to the bottom of each course. Ensure that the pieces are tight together and aligned at the top prior to fastening.

An ICF bracing system must also be installed on the radius.

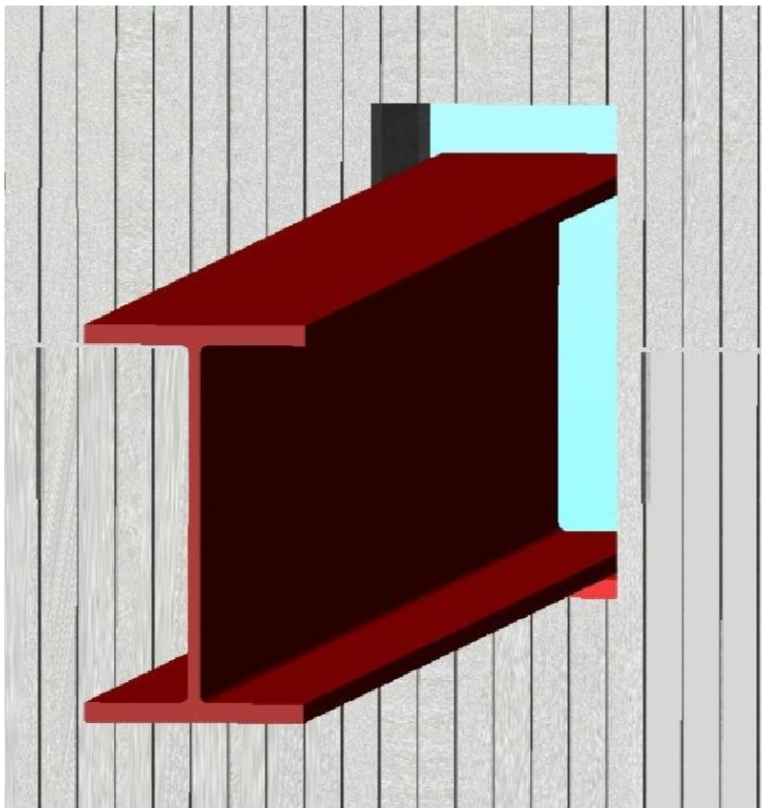
MECHANICAL INSERTS

Before pouring, place a sleeve for anything that will pass through the wall such as plumbing, electrical, water, sewer, outdoor faucets, gas lines, phone, cable, dryer vents, etc. The diameter of the PVC pipe should be slightly larger than what will pass through it and longer than the width of the wall. The PVC sleeves should be tilted slightly downward on the exterior of the wall to prevent water infiltration. After the pour is complete and the bracing system is being removed, trim the excess length of PVC flush with the forms.

If possible, the sub-contractors should be present when locations and sizes are determined. Alternatively, at the pre-planning meetings, subcontractors should mark location and size of all exterior penetrations needed for the project.

BEAM POCKETS

If the specifications call for steel beams or laminated floor joists to be placed on the concrete exterior wall a beam pocket will need to be installed. Consult your engineer for proper placement of bearing plate and size of beam.



1. Establish the beam elevation using a laser level and mark elevation on the interior of both walls
2. Measure beam dimension adding ½" all around to facilitate placement of beam
3. In one side of wall, cut opening on inside and outside EPS panels for beam placement after pour
4. On opposite wall, cut out EPS from inside of form only
5. Brace opening with ¾" plywood or 2x4 wood scraps to hold back concrete on both sides of the beam pocket
6. Secure bracing from inside with 2x4 scraps screwed into webs on either side of opening
7. If a bearing or weld plate is specified, insert after concrete has been poured but is still workable
8. Be sure include depth of bearing plate, if required, when measuring beam elevation

LEDGER ATTACHMENTS

Ledger attachments are installed after the top course and rebar is in place and before the concrete is placed. Check with the manufacturer for spacing and span specifications. These are two of several companies who manufacture ICF floor attachment systems:

ICF LEDGER CONNECTOR SYSTEM™ (ICFLC) by SIMPSON STRONG TIE

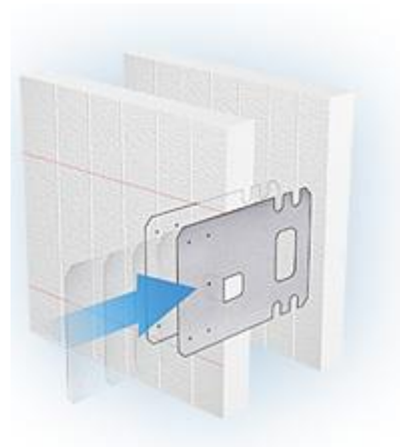
a. This system is a two-piece time and labor saving bracket and allows the ledge board to be set after pouring concrete. To install the first part of the ICFLC before the pour follow these steps:
b. Snap a chalk line on the wall at the appropriate location marking the top and bottom of the ledger board
c. Mark the required on center spacing (this can be done with a marker or by making an indentation in the EPS with the ICFLC bracket)
d. Make a vertical cut at the marked locations
e. Insert an ICFLC bracket through each cut
   i. If possible, the ICFLC should be centered on and screwed directly to a web
   ii. If unable to center on web, glue the exposed flange of the ICFLC to the EPS to hold it in place during concrete placement

f. After concrete is poured, the second part of the bracket can be installed
   I. Screw the ledger board to webs at proper level and height for temporary placement
   II. Slip the ICFLC-W underneath the wood ledger
   III. Attach the 6 screws, screwing through the ICFLC-W, ledger board and into the ICFLC

g. When installing a steel ledger, the ICFLC-W is eliminated. Place the steel ledger directly up against the ICFLC, making sure the ledger is level and at proper height, and attach the required number of screws through the steel ledger and into the ICFLC.

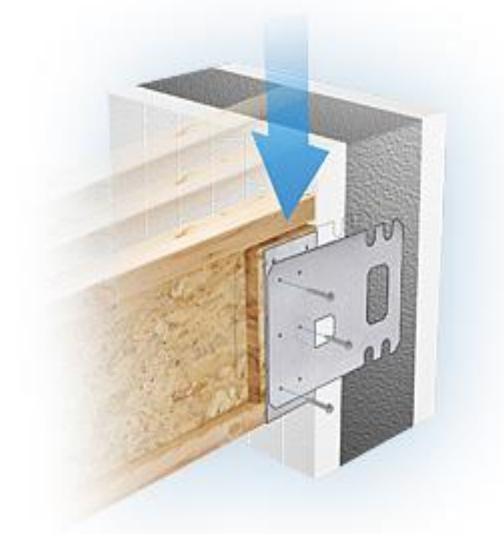
CF-CONNECTOR™ by ICF-CONNECT

1. The ICF-CONNECTOR™ is primarily used for hanging floor joists. However, it can also be used for exterior deck installations and fastening interior/exterior framed partition walls to ICF walls
2. It consists of two flat sheet plates, which can be roughly installed within the form AND
3. An adjustable stamped bearing bracket which is accurately fixed after the concrete pour by screwing six #10 self-tapping/self-drilling screws (1.5" in length (38mm) or equivalent to the joist width) into the joists as specified
4. Determine the lowest elevation at which the framing will be set in the wall
5. Apply a chalk line 1" above this lowest elevation line
6. Make vertical cuts on either side of the joist or truss unit location



7. Cut either from the top of the course down, or
8. Cut directly through the form to suit the height of the panel being installed
9. Do not extend the cut below the chalk line in order to provide intermediate support of the hanger brackets
10. Insert each of the 2 insert plates so that large hold perforations sit INSIDE the form cavity by
11. Either sliding them downward from the top of the form or
12. Inserting them horizontally through the form cuts

13. NOTE: Exact placement of insert plates is not crucial if all cuts are made at 90º to EPS face to ensure the bracket faces will always be in plane and in line with the face of the joist or truss frame
14. After the concrete has been placed and cured enough for hanging a floor or truss member, chalk a second line at either the top or bottom elevation of the joist to be installed with a laser or transit level
15. Fit the framing member stamped bearing bracket at the bottom end of the joist or truss
16. Slide the joist or truss member and stamped bearing bracket down between form insert plates ready for anchorage at the desired height
17. Once positioned so that the joist is in line with the final chalk line, fasten through both the plate and bracket perforations in an offset triangle fashion to ensure solid anchorage of the stamped bearing bracket into position

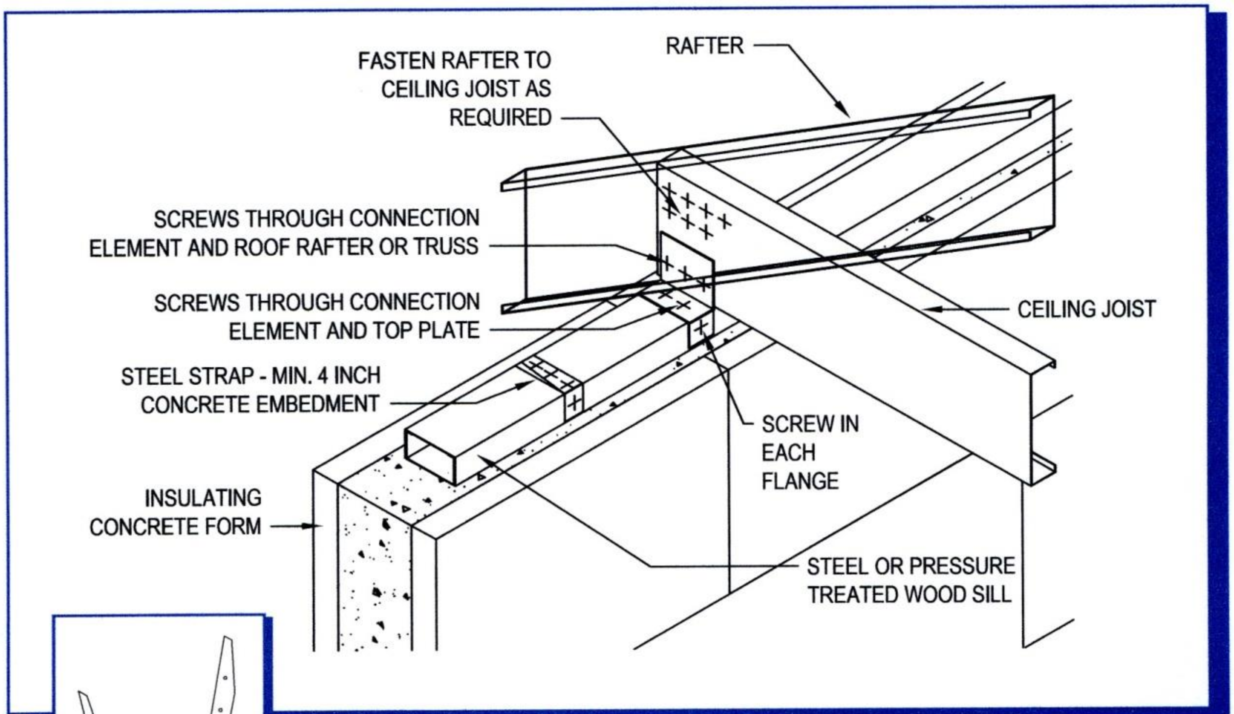


WALL TO ROOF CONNECTION

Basic Roof Connection Requirements

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

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



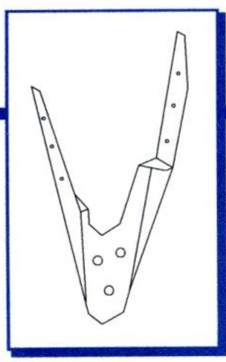


Figure 7.1. Steel Concrete Anchor Strap and Sill Plate Connection Method at Wall Parallel to Ridge

Refer to Table 7.2 for Required Installation Schedules

Concrete Anchor Steel Strap

This shows a steel frame roofing attachment to an ICF wall. This same method would be used for a wood framed roof also.

CELBLOX® PRE-POUR CHECKLIST

SQUARE, PLUMB, AND LEVEL	
Are walls and corners, square and level?	
Are walls plumb everywhere?	
Is the top of the wall level?	
Are window and door bucks level, plumb, and square?	
Are all bucks diagonally braced to maintain square during the pour?	
Is each buck securely connected to the block?	
PLANNING	
Does the layout match the plans everywhere?	
Have you received building department inspection & approval, if required?	
Have you received engineering inspection and approval, if needed?	
Do you have enough manpower scheduled for the pour date?	
Is the pump (if any) ordered and scheduled?	
Is the concrete ordered and quantity verified?	
Is there adequate room for pump (if any), concrete trucks, and ground crew?	
Has the immediate surrounding area been checked for high voltage lines?	
Have you planned the position of anchor bolts or straps, if any, at the top of the wall?	
REBAR	
Is all vertical and horizontal rebar installed and tied as specified?	
Are dowels ready to insert in concrete at top of wall if planning another level?	
STRAPPING	
Have all outside corners been strapped?	
Have all cut block pieces and potential weak spots been strapped from both sides?	
Are all jobsite manufactured angles strapped from both sides?	
Are all T-walls and pilasters strapped properly?	
Are all lintels properly strapped?	
Have you protected the top of the wall with tape if you are planning another level?	
PENETRATIONS	
Have beam pockets been installed in correct locations?	
Are all mechanical penetration sleeves in place and securely glued?	
Are all anchor bolts or brackets for interior walls in place?	
Is the ledger or ledger connections (if any) in place and securely fastened?	
Are all weld plates in place as specified on plan?	
SUPPLIES	
Do you have pieces of plywood or scrap lumber on hand if needed during the pour?	
Do you have enough anchor bolts or straps on hand for the top of the wall?	
Do you have a laser level or enough string ready for plumbing the wall during pour?	
Do you have a concrete vibrator ready to consolidate walls?	

CONCRETE PLACEMENT EQUIPMENT

A **boom pump truck** is the recommended method for concrete placement in CELBLOX® ICF walls since it is easy to maneuver and requires less labor during the pour. A boom pump should be ordered with a line reduction to a 3” flexible hose to improve the handling capacity of the hose. Most pump trucks have remote controls and the driver should be where he can easily hear your instructions.

Line pumps are smaller portable units that are either truck-mounted or placed on a trailer. They typically pump concrete at lower volumes than boom pumps and are used most often for smaller projects such as swimming pools and single family home concrete slabs. Although they are often less expensive, you will need additional labor on the job to help move the line during the pour.

A **conveyor** may be standard equipment on some concrete trucks. Although this is not a recommended method, it could be used to pour retaining walls but you must still request a reduction to 3”. Since the truck will need to be moved continuously, you should be aware of longer truck time costs and consolidation issues. A conveyor has limited ability to pump concrete uphill, may not be able to reach second level or higher walls, and often cannot reach areas on a single story either. One advantage of the conveyer is that, if needed, the flow of concrete can be stopped more quickly than with a boom pump.

Walls that are either at or below grade, such as stem walls or a basement, can be done from the **concrete truck chute**. However, you should be aware of consolidation concerns. Since the truck will need to be moved a number of times, cost of truck time and labor may increase.

CONCRETE RECOMMENDATIONS

When the walls are built and ready to pour, the amount of concrete should be re-estimated. **DO NOT RELY ON ORIGINAL ESTIMATES** since changes may have been made in the field that affect the project layout.

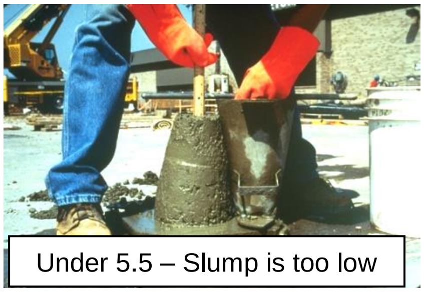
Refer to earlier section on concrete estimating or use this quick method to re-estimate the number of cubic yards needed:

1. Count the number of blocks in the wall
    a. Divide by 15 for 4” walls
    b. Divide by 10 for 6” walls
    c. Divide by 7.5 for 8” walls
    d. Divide by 6 for 10” walls
    e. Divide by 5 for 12” walls
2. Add one yard to finish off the top of the wall
3. Add one yard for pump truck

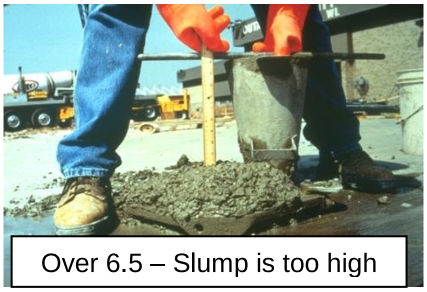
CELBLOX® ICF wall concrete must have a compressive strength of 3000 PSI at 28 days or as specified by the structural engineer, architect, or local building codes. You may also consult the concrete supplier to see if an ICF mix is available.

Aggregate size is important and is specific to wall thickness. The concrete supplier will provide the proper size based on the wall cavity information you provide them.

Slump should to be between 5.5” and 6.5” unless otherwise specified by the structural engineer. Slump is measured by pouring concrete into a cone, consolidating it with a rod, turning it out on a flat surface, and removing the cone from the concrete. Hold a horizontal rod across the upside down cone for level. Measure distance to the top of the concrete to ascertain slump.


Under 5.5 – Slump is too low


5.5 to 6.5 – Slump is correct

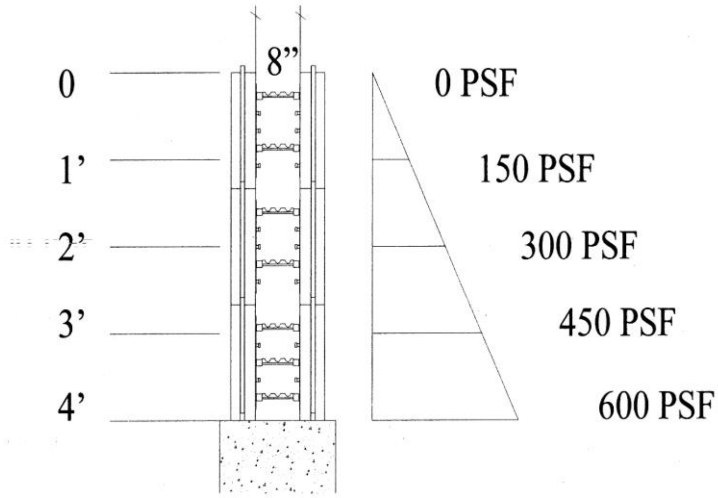

Over 6.5 – Slump is too high

CONCRETE PRESSURE

During the pour, concrete exerts hydrostatic pressure outward on the forms. CELBLOX® is designed to withstand this pressure but you should be aware of several factors that can increase the pressure of concrete against the forms.

FORCE OF FALLING CONCRETE

Maximum outward pressure is greatest on the bottom course of each lift. As the concrete begins to stiffen, the pressure exerted gradually decreases. CELBLOX® ICF forms are designed to withstand a maximum of **600 PSF** (pounds per square foot). To minimize pressure CELBLOX® recommends pouring in four foot lifts and using a reducer hose on the boom pump or a 3" line on any pump. Not following these recommendations may increase the pressure on the forms and cause form failure.



VIBRATION

Using a vibrator with 1" diameter or less can increase pressure on the CELBLOX® forms. When walls are being vibrated, maximum pressure will occur at the bottom of the forms so they should be watched carefully.

ADDING WATER TO THE CONCRETE

Adding water to concrete on the job is not recommended. This will increase pressure and may weaken the quality of the concrete below what is required. According to the PCA rule of thumb, adding one gallon of water per cubic yard **reduces** concrete strength by 150 psi.

CONCRETE TEMPERATURE

In cold weather, hot water is typically added to the concrete mix at the plant. However, trip duration and pumping time may drop the temperature of the concrete to the point that lifts need to be adjusted to approximately half height to compensate for the added time it will take for the concrete to set up.

> **NOTE**
> Because pressure will increase in a 4" wall faster than a wider dimension wall, a slower pour is recommended when pouring a 4" cavity wall.

Concrete is a caustic product and is capable of causing severe burns or injuries. Wear eye protection, gloves, and clothes that cover exposed skin on arms and legs.

CONCRETE PLACEMENT

Each complete pass around the wall is a "lift." Maximum lifts of four feet are recommended for most applications. When pouring in temperatures below 30º, lift height should be reduced because concrete set time is reduced. Lift height is also dependent on crew experience so using experienced help is recommended.

After each lift, check laser or string line and adjust the braces as needed to keep walls plumb.

While concrete is being poured there should be two people (four for commercial jobs), one on the interior and one on the exterior of the wall being poured to monitor for weak spots. If a weak area is noticed, screw scrap plywood or lumber across webs closest to the area.

The starting point of the pour should be near the center of the wall or at least four feet from a corner. Begin placing concrete by swinging the concrete hose in a back and forth motion while moving around the wall. This movement allows concrete pressure to be evenly dispersed over several feet. In each lift, fill wall spaces first and then pour into sill areas ensuring that they are completely filled.

When pouring a corner, stop concrete placement 2-3' from either side of the corner. Swing the hose to either side and through the corner allowing the concrete pressure to be dispersed away from the corner. T-walls and pilasters are also filled using this method.

Continue around remaining walls, working in a consistent direction (clockwise or counter clockwise). After each lift, check all dimensions, including diagonals and adjust as necessary Continue lifts as outlined above as many times as necessary to fill walls.

Consolidate concrete in each lift using a 1" or less internal vibrator. Consolidate from the bottom up being careful not to over vibrate and increase pressure on the forms. One second per foot of concrete, in and out in a continuous motion, is code compliant.

If another story of CELBLOX® will be built on top of the first one, concrete should be kept at least 4" below the top of the wall with enough rebar extending to allow for overlap on the next course. Insert dowels for vertical rebar as specified by engineer, architect, and/or local codes before concrete sets. If a roof or frame walls will go on top, remove the tongue from top course and trowel the concrete smooth inserting anchor bolts or straps as required for roof trusses or top plate.

BLOWOUT

Blowouts rarely happen but are possible if the rate of placement has been too fast, or the concrete is too wet. Contrary to the name given them, blow outs are more of an annoyance than a catastrophe as the name might imply.

If a blowout occurs, either move to a different location on the wall or stop the flow of concrete while the crew repairs the wall. Clean the concrete out of the hole made so the blown out portion of the EPS will fit back in the hole. Use either plywood or dimensional lumber to secure the EPS back into place and support the pressure of pouring. Keep in mind that you must support both sides of the blowout. Repair should cover at least two webs on either side of the blowout.

BRACING & STRAPPING REMOVAL

Allow at least one day for concrete to set up before removing strapping. Bracing and scaffolding should not be removed until concrete has reached adequate strength, at least 24 hours but usually 3-5 days.

WATERPROOFING

Any waterproofing product used must be EPS compatible because solvent-based products will damage the EPS. Costs vary from product to product and type chosen will depend on project cost constraints. For whatever type of waterproofing used, ensure that the product meets local building codes and follow manufacturer's installation recommendations.

CELBLOX® performs favorably with PLATON and can be ordered when placing your block order. There are many other products available that work equally well such as water based coatings that are easily applied with sprayers. All membrane waterproofing products should have a drain board or protective cover to eliminate damage from backfill.

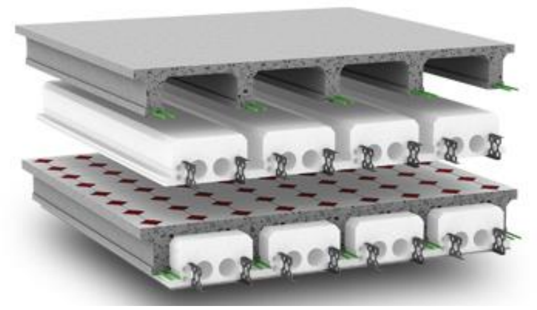
The footing must be wrapped with the waterproofing product and drain tile should be installed next to – NOT ON TOP – of footing.

BACKFILL

For below grade walls, it is recommended that walls sit at least 7-10 days before backfilling.

FLOORING SYSTEMS

All types of flooring systems can be installed with CELBLOX®. Although CELBLOX® does not sell or promote any particular system these are some types of systems available:



Insul-Deck is an EPS insulated floor system with pre-molded access chases, steel beams, and furring strips in the form which makes utilities easier to install. The energy efficiency range is R-10 to R-25 depending on panel thickness. Spans from 30 to 40' are possible using post-tensioning methods. More information is available at www.insul-deck.org. This system typically has a 4-6" concrete slab poured on top.

NON-INSULATED CONCRETE FLOORING SYSTEMS

Post Tension slabs. Thinner floors are possible with savings in concrete and steel and carry the same load capacity as standard floors. Larger spans are possible.

Steel Truss is a composite steel joist system that uses normal weight concrete. It is possible to achieve sound deadening to STC57 and these floors are UL rated.

Precast Hollow Core floors do not require fireproofing due to their natural fire resistance and are usually certified by an Independent Third Party for fire resistance. They provide runs for electrical, HVAC, and plumbing with early design coordination. Long spans can be designed that need no intermediate support. These floors provide an immediate work platform when installed.

Pan Deck floor can span large areas, depending on floor thickness and rebar configuration. They are poured with normal weight concrete and shored from below during the pour.

WOOD FLOORING SYSTEMS

Engineered truss joist are extremely strong, lightweight, and easy to cut on site. Each piece is consistently true to size and is produced using 50% less timber. They resist shrinking, crowning, twisting, and warping which means quieter floors and fewer callbacks.

Open web floor trusses allow longer spans than traditional dimensional lumber. Their open design provides easy placement of mechanical systems and save time as there are no soffits to build around. They have greater lower level design flexibility.

Dimensional Lumber is prone to warping and is not always dimensionally true in depth. Spans are more limited than other flooring systems.

Steel Joists have consistent quality as there is no regional variance in composition. There is usually a 2% waste factor versus 20% for dimensional lumber. They will not burn and have improved fire safety compliance with local codes and fire regulations. They are lightweight and do not expand or contract with the seasons.

INTERIOR WALL FRAMING ATTACHMENT

Interior walls can be attached to exterior CELBLOX® walls either flush to the face of the wall or with a recessed channel.

FLUSH TO FACE OF WALL
If the interior wall lines up with webs, the wall can be screwed directly to the webs using screws that reach approximately one inch into the web.

If wall does not line up with webs, Tapcons can be attached by drilling through the stud, EPS, and into the concrete. Another method is to screw 6”x24” sheet metal strips horizontally across the webs and then attaching the wall to the sheet metal strips.

RECESSED CHANNEL
Treated lumber must be used when installing a wall in a recessed channel. To install, establish placement of the wall and remove EPS to match wall width. Insert treated stud into opening and attach with wedge anchors, Tapcons, or power fasteners.

ELECTRICAL

Electrical wiring runs in both interior and exterior CELBLOX® walls can be cut with a hot knife, router, or electric chain saw to remove EPS at the specified location. Angle the channel so it has a lip on the bottom to hold the cable in place or spot glue with EPS compatible foam. Check local codes to determine wire depth requirements from the wall surface, including drywall.   Horizontal runs are easier to cut at the intersection of the panels as the webs are purposely recessed ¼” from the top and bottom of the panels.

Electrical box locations can be cut by removing the EPS with a hot knife or router. Boxes can then be screwed to webs using glue or screws or installed in concrete using glue or concrete anchors.

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PLUMBING

Plumbing channels are made in CELBLOX® walls the same as electrical runs. Pipes up to 2 ½” can be recessed in the wall. Larger pipe may require furring out. To protect pipe from being accidentally pierced by a nail or screw, install a nail plate over the pipe.

CABINETS & FIXTURES

To surface mount heavy items, such as cabinets, mount 5/8" or thicker plywood or OSB slightly smaller than outline of the cabinet and attach it in numerous places to the webs before mounting the cabinet. The plywood or OSB should be installed prior to drywall installation. The plywood provides a continuous fastening point for the cabinets and serves as the thermal barrier in lieu of gypsum.

If cabinets are very heavy, CELBLOX® recommends that they be attached directly to the concrete. Prior to drywall installation, remove EPS and nail 2"x4" lumber (with the 4" dimension flat against the wall) to the concrete making a solid surface to attach the cabinets to later.

The Grappler is available from Wind-Lock. It is a 4"x8" mesh that is pushed into the ICF wall prior to drywall installation and becomes a locking washer with 175 pounds per screw of holding power after drywall is in place. It can secure lightweight fixtures such as thermostats, smoke detectors, and towel bars. Screws can be easily backed out with no major holes to repair.

For curtain rods and other attachments, there are numerous specialty products in the marketplace geared towards building with Insulating Concrete Forms. Contact CELBLOX® or your CELBLOX® distributor for more information.

INTERIOR FINISHES

Due to national fire code requirements, the most common interior finish is gypsum board installed and finished over all exposed EPS. CELBLOX® webs on 8" centers provide double the nailing capacity of wood framed walls for gypsum board applications. For installation of ½" interior drywall, CELBLOX® recommends a #6x1 5/8" coarse thread drywall screw that allows the required ¼ inch penetration into the webs.

A number of alternate products have been developed that can make interior ICF wall finishing easier, faster, and more cost effective than in the past. These options are often healthier, more durable, and offer an unlimited variety of styles, textures, and colors for interior walls.

A one or two-coat hard veneer plaster product features fire resistance, no VOC emissions, abuse and indent resistance, and is highly resistant to mold and mildew. It can be sprayed or troweled directly over EPS without installation of reinforcing mesh or gypsum board. The base coat itself can be finished with textured rollers and paints, making it a very durable and economical replacement for gypsum board. Its primary purpose is to increase durability making it a useful product for all abrasion or abuse prone areas in buildings.

Clay plasters are another option which can be applied over gypsum board or directly to the EPS. If drywall is not used, it requires a layer of sanded basecoat to be applied first. It is a natural product composed of marble dust, potters' clays, and mineral pigments. The two coat application is only 1/16" thick which does not require any sanding.

A third option is acrylic stucco manufactured specifically for interior finishes. Like most exterior acrylic stuccos, it is applied directly to the EPS, and no drywall is needed. It is cement-based and requires a second coat of the same product to finish the wall. It is available in a variety of colors and textures.

EXTERIOR FINISHES

All exterior finishes, except brick, can be applied to the EPS following local building codes and manufacturers' recommendations. A brick ledge form must be installed when building CELBLOX® walls in order to hold the weight of the brick. Installation details for the brick ledge are included in Appendix B.

Vinyl or hardboard siding products are attached to the CELBLOX® webs in the same way as to frame construction. CELBLOX® webs are marked using a thick line on the outside of the form. The webs are on 8" centers and 1 ½" wide. The webs are marked using a thick line on the outside Consult the manufacturer of the siding for specific installation instructions, fastener type, and fastener length. If using nails to install product, wear appropriate safety eye protection and use caution.

Cement-based stucco or acrylic-based products are typically reinforced with fiberglass mesh. They are durable and resist cracking in both hot and cold climates. For proper installation requirements, consult the manufacturer of the product you choose.

Fiber cement siding, due to its weight, should be installed using screws. CELBLOX® recommends using a Type 'S' #10 x 1 5/8" or similar non-corrosive screw on 8" or 16" centers, depending on siding exposure and wind load.

APPENDIX A

CONSTRUCTION DETAILS

WOOD BUCK CONSTRUCTION AND INSTALLATION

When making wood bucks, using pressure-treated (ACQ) lumber is preferable. If pressure-treated lumber is not used, a moisture barrier **must** be applied to the side that will be in contact with the concrete.

There are three main methods of constructing wood door and window bucks:

1. **EXTERNAL**- Run 2x pressure treated lumber buck across the width of the ICF wall
   The 2x buck is placed so that the ends are flush with both faces of the ICF wall. The 2x will vary in size depending on the form width. 8" core and wider walls will need additional 2x attached to match full wall width. The top and sides will be solid boards. The bottom may be two narrower 2x pieces flush with each side of wall or solid board with 5" holes drilled to allow space for concrete placement. Bucks are fastened to the ICF wall with a frame of 1x4s or other lumber attached to both sides of the buck. When building this buck, the lintel (top board) rests over the jamb and the sill plate(s) (bottom boards) sit inside the jamb.

2. **INTERNAL**- Inset or recess the pressure treated buck into the cavity of the form
   This method is often used for projects with a stucco exterior finish or when thermal bridging is a concern. It uses less material than the first method and is useful when the total wall thickness exceeds 11 inches. 2x treated lumber is cut to the width of the concrete cavity and is placed flush into the cavity of the form. Long screws with a large plastic washer (such as Wind-Lock Buck Plate) ensure that the screw doesn't go completely through the EPS when securing the buck. Insert screws a maximum of 6" on center. Trim excess EPS AFTER the buck has been secured.

3. **COMBINATION**- Use plywood in combination with 2x cleats
   This method provides a wider flange for fastening around the opening and uses less lumber than both of the other methods. However, it may take more time to assemble. In this method, a 2x6 ripped in half is fastened to ¾" pressure-treated plywood. A slot in the bottom or sill of the buck must be built to allow for proper placement and consolidation of the concrete below the opening. Position buck in place with wood framing on both sides.

After the bucks are assembled:

1. Measure the diagonals of all window and door bucks to ensure they are square, and brace them with 2x lumber horizontally and vertically at the half way point of the buck **or** every 18" if wider or taller than 2 feet. This will keep the buck secure in its dimension when the concrete is poured and will be removed later. Bracing the bucks diagonally in all four corners is an additional step that can be taken to ensure the bucks stay square.

2. Number the bucks to keep the jobsite organized and eliminate the possibility of error.

3. Set anchor bolts, nails, or screws in the exterior of the assembled buck a W-pattern that are long enough to extend into the interior of the cavity of the wall and allow for concrete coverage. Use only hardware that is compatible with the pressure treated lumber. These anchors will secure the buck to the concrete and minimize warping.

When setting the bucks in the wall:

.

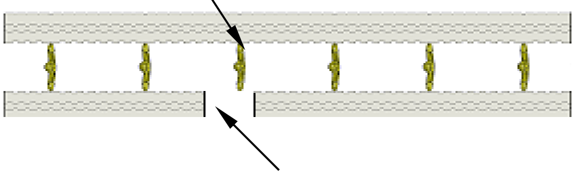
1. Set the buck in place and hold it in position with kickers. Ensure the kickers are easy to adjust in order to plumb the buck.

2. Follow installation instructions as outlined above for each type of buck.

3. Courses that go over the lintel (top of buck) should be trimmed on the bottom so that a ¼"gap is left between the lintel and block. This allows for settling during the pour.

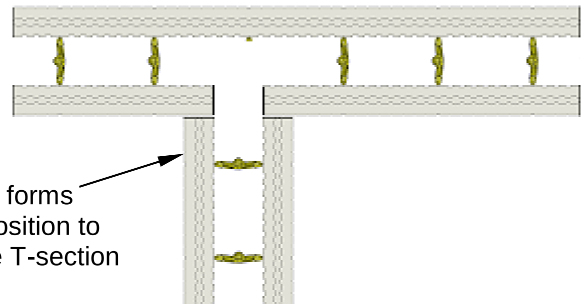
T-WALLS

1. Remove this tie from top to bottom of wall. Replace hinge nail to hold zip ties.



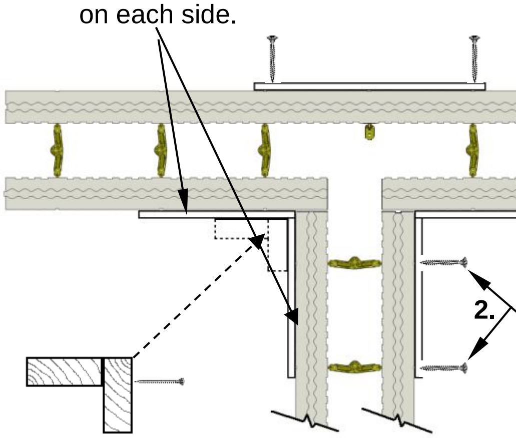
2. Cut out vertical opening at desired location of T-wall.

3. Place forms into position to create T-section



T-WALL BRACING

1. Attach plywood or OSB the full height of the wall and wide enough to overlap at least two webs on each side.

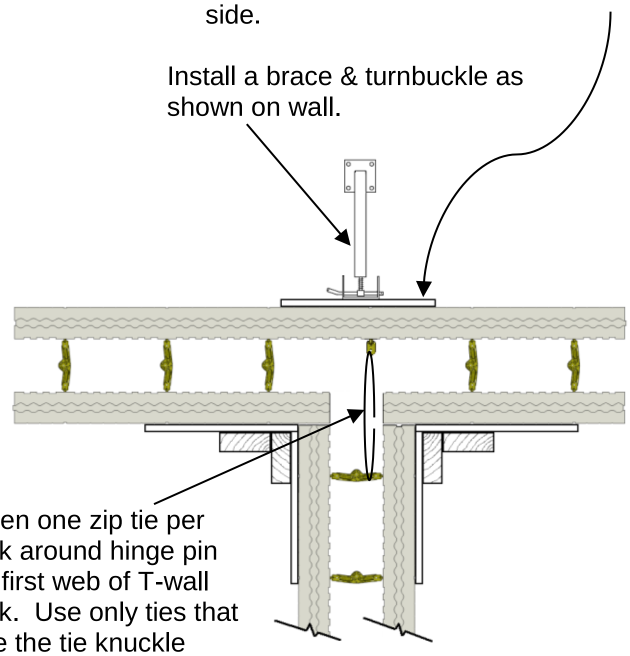


2. Place screws in webs as shown, in each course of the wall.

3. Place dimensional lumber into corners as shown and screw the assembly into plywood or OSB.

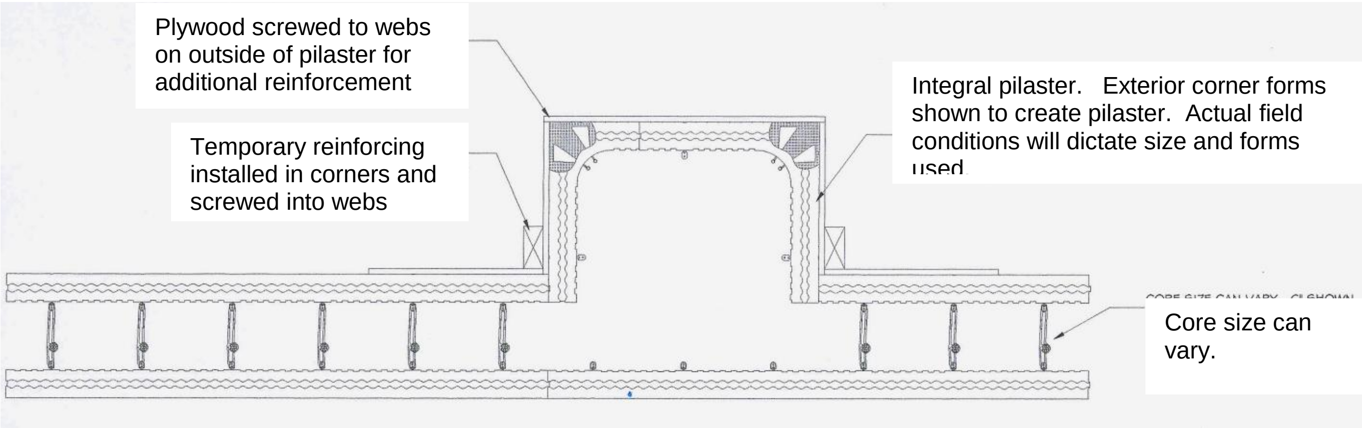
4. Attach plywood or OSB the full height of wall and wide enough to overlap at least two webs on each side. Alternately, attach dimensional lumber on each block the full height of the wall to overlap at least two webs on each side.

Install a brace & turnbuckle as shown on wall.



5. Fasten one zip tie per block around hinge pin and first web of T-wall block. Use only ties that have the tie knuckle facing the outside wall.

PILASTERS



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Pilasters are commonly used to provide a break in long, straight walls and give them vertical support. They may be specified in below grade walls to compensate for backfill pressure.

Pilaster size and footing depth must be designed, engineered, and constructed in accordance with all applicable building codes and regulations.

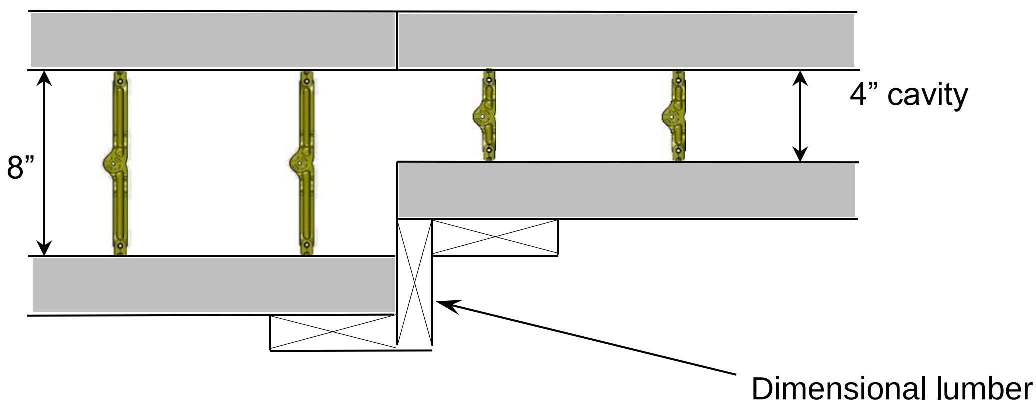
A load-bearing structural pilaster can be assembled using two CELBLOX® exterior corner forms as shown above.

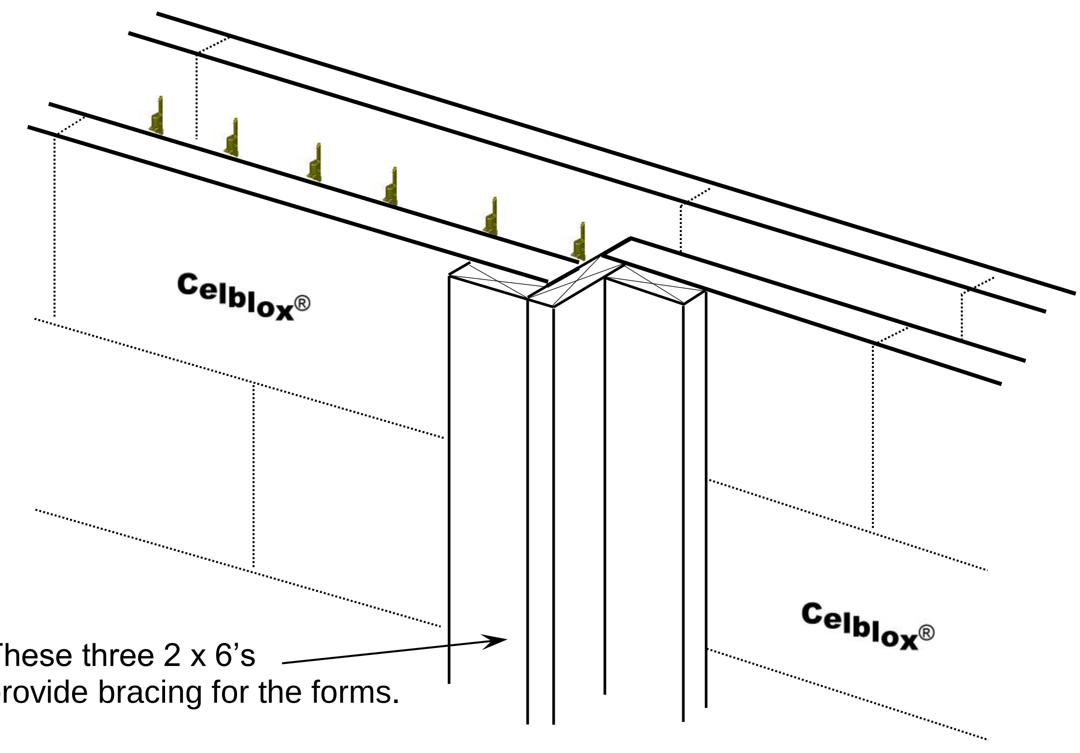
A pilaster to compensate for below-grade backfill pressure can be built using the T-wall method and cutting pieces of panels to make the end caps. All pilasters must be braced and supported similar to T-walls. (Refer to Reinforcement section for further details)

Pilasters normally are constructed on long wall applications to create additional strength in the concrete wall.

8" TO 4" HORIZONTAL WALLTRANSITION

Top View

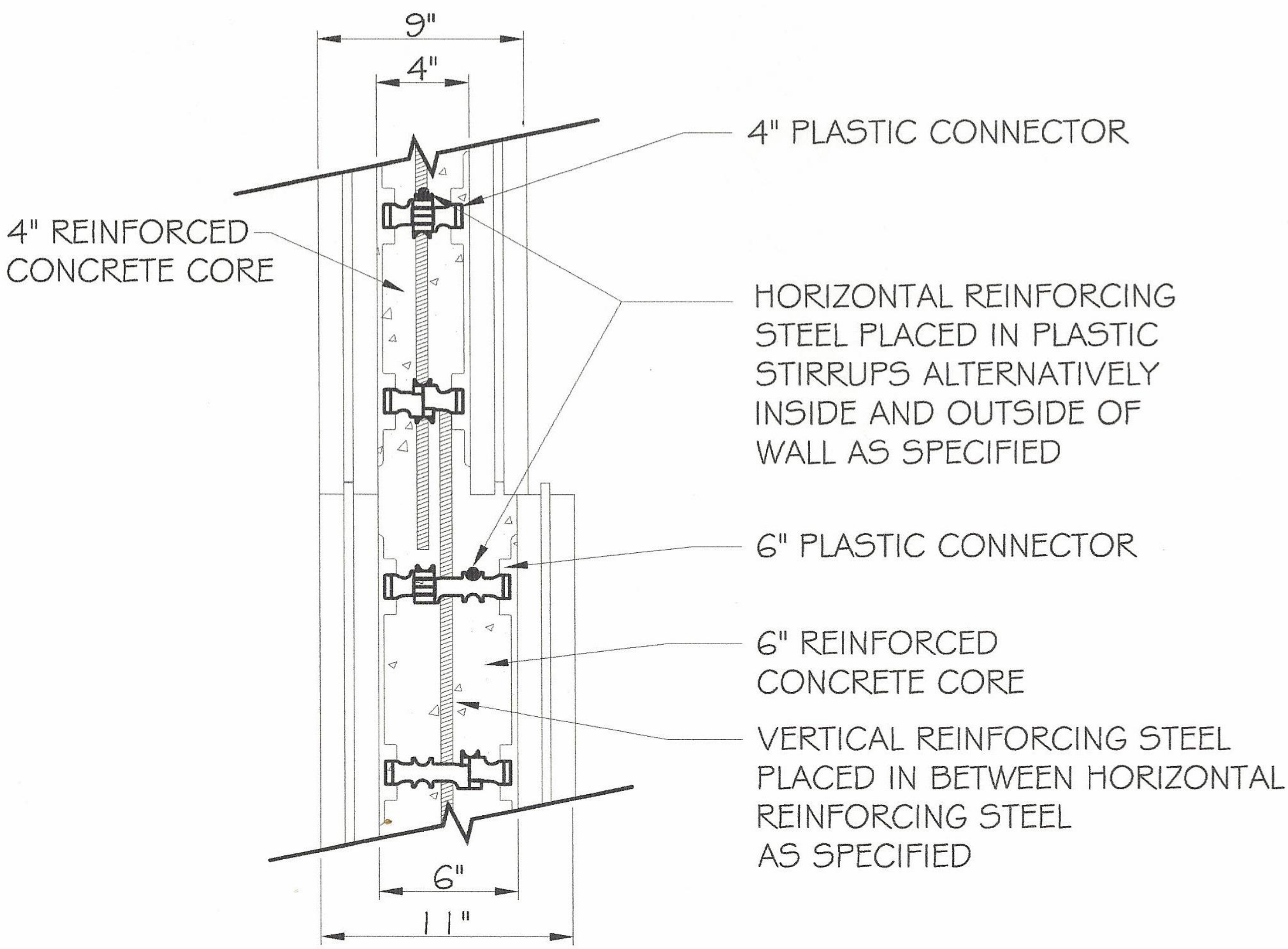




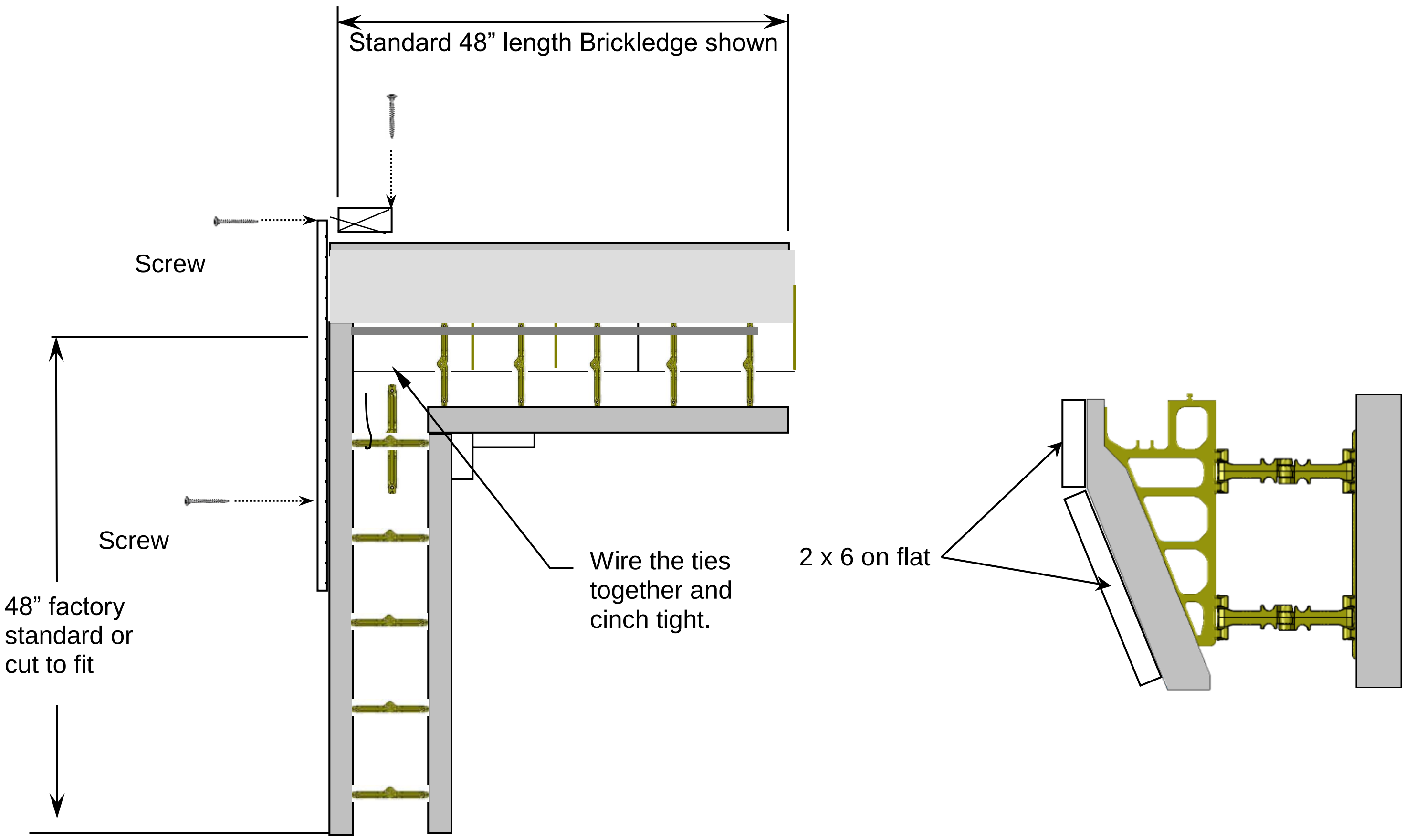
These three 2 x 6's provide bracing for the forms.

If wider width than dimensional lumber is needed to attach to the webs, use OSB or plywood behind the dimensional lumber.

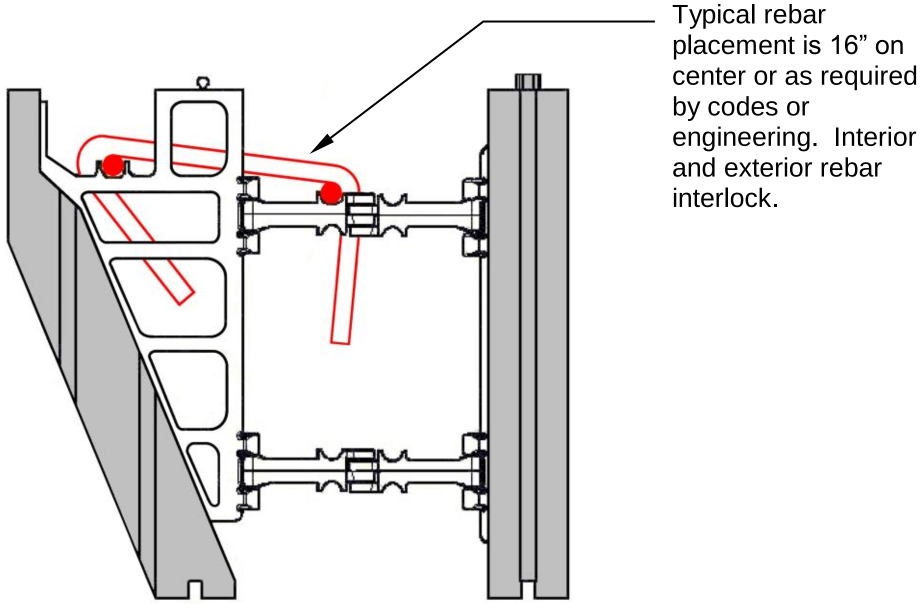
6" to 4" VERTICAL WALL TRANSITION



BRICK LEDGE FLUSH WITH END OF WALL



BRICKLEDGE REBAR PLACEMENT



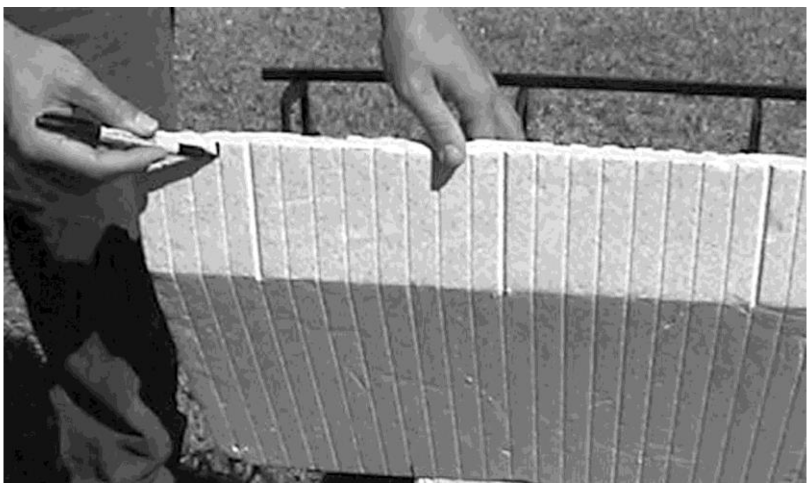
BRICK LEDGE MITERED CORNER

CELBLOX® brick ledge units hold more concrete than a straight form. Be sure to adjust the concrete estimate when brick ledge is used on the job.

One yard of concrete fills:

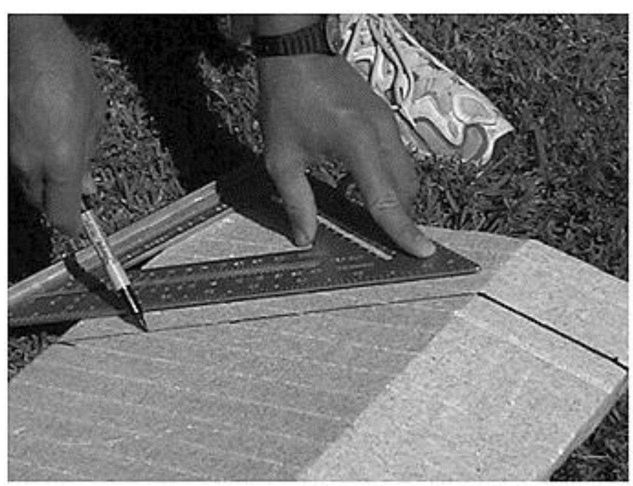
CORE SIZE	# BLOCK FILLED WITH ONE CUBIC YD	# CUBIC YD PER BLOCK
4”	8.5	.118
6”	6.5	.151
8”	5.5	.184

MARKING THE BRICK LEDGE FOR MITERING CORNER



1. Place the CELBLOX® Brick Ledge panel over the corner block, lining up the third web of the brick ledge with the first web of the corner block.
2. Make a mark on the Brick Ledge panel where it lines up over the “point” of the 90º form.
3. Count 5 bars outside the first mark and make a mark at the top of the panel. This mark represents the outermost portion of the Brick Ledge Corner
4. Using a marker, draw a line down the “flat face” of the Brick Ledge panel, stopping where the “angled face” begins.
5. Draw a line from the bottom of the line on the “flat face” to the first mark that was made on the bottom of the panel (a straight edge works well).

It is useful to mark the bottom of the panel at a 45º angle. When properly marked, the angle will be going away from the corner.



CUTTING THE BRICK LEDGE PANEL

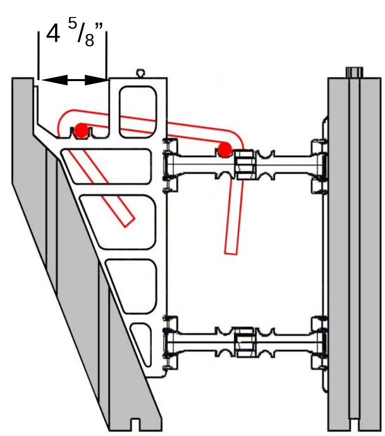
Use either a good quality handsaw or, if using a reciprocating saw, use a metal cutting blade to cut through the plastic webs.
Mark and cut the panel before attaching the connectors.

1. Cut upside down resting with exterior face of panel towards you
2. Place on level surface such as dirt or grass to prevent unwanted movement during cutting.
3. Use the line on the bottom of the panel as a guide for the 45º angle that must be maintained during the entire cut.
4. While maintaining the 45º angle, follow the diagonal line marked on the sloped face of the panel.
5. Note: As this portion is cut, a web will need to be cut.
6. When reaching web, use a minimal amount of downward pressure while maintain high “rpm’s”
7. When you reach the vertical line on the flat face of the form, maintain the saw blade angle and your cut should follow the vertical line to completion.
8. After cutting the two Brick Ledge panels needed to form the corner, set them in place over the lower course of forms, prior to assembly with the standard panels (for the opposite side). The accuracy of the cut will show at this time. Use a square to check square of the corner.
9. If the cut does not match perfectly:
   a. Angle was too shallow in which case you need to re-cut the ends of the panels in place until perfect.
   b. Angel was too deep and a shim may be cut from scrap material to hold panels the correct distance from each other.
10. Use 4 pieces of 1-2” wide plumbers’ strapping tape, each a minimum of 24” long to hold the brick ledge panels together at the seam of the corner pieces
    a. Measure down from the top of the panel and place one piece of tape at 2”, 6”, 10” and 14”
    b. Position the tape with equal amounts of tape on each side of the two brick ledge panels

REBAR IN THE BRICK LEDGE

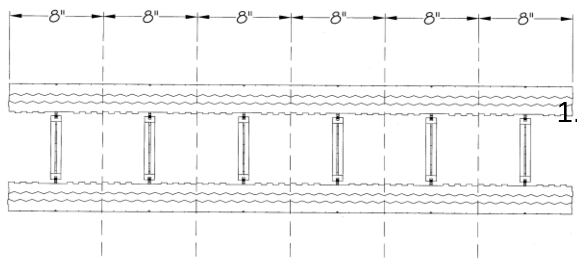
Horizontal rebar in the brick ledge is typically #4 bar and stirrups are typically #3 bar on 8” centers unless specified by local code or engineering. Be sure to install the stirrups so they tie the brick ledge reinforcing back to the wall reinforcing.

BRICK TIES are screwed to webs with #10 coarse thread screws because they have the greatest holding capacity.

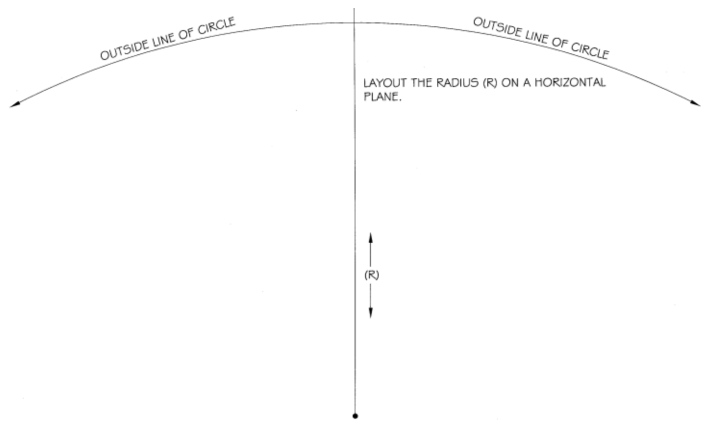


RADIUS WALLS

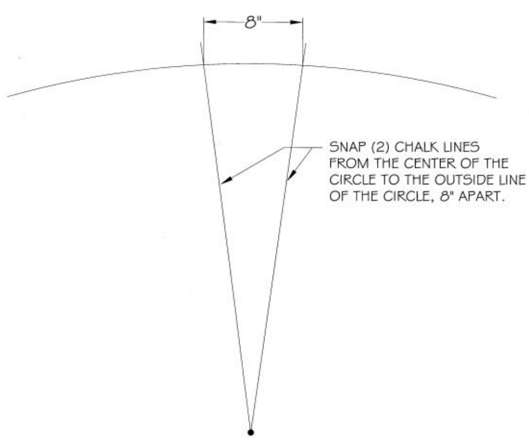
These instructions are intended to assist the installer in an effective and time efficient fabrication of the radius wall forms. Proper bracing, reinforcing, and placement of concrete is the responsibility of the contractor. All radius dimensions are to the outside face of the CELBLOX® ICF.



1. 1. Cut straight panels into 8” increments. When cutting, make sure you keep the web centered in the 8”



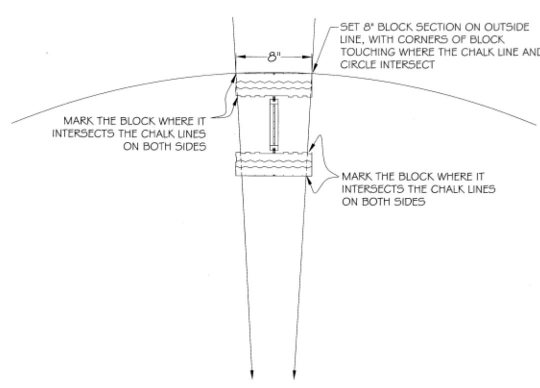
2. Mark the outside of the radius on the footing or slab. If site conditions do not permit the radius to be marked on the footing or slab, any horizontal surface will do.



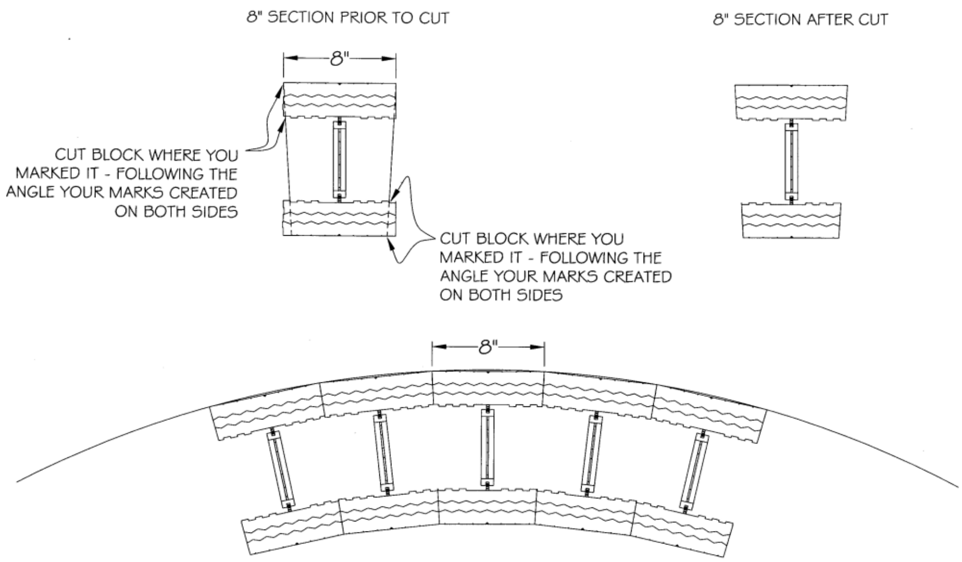
3. From the center of the circle, snap a chalk line extending beyond the mark for the outside of the radius.

4. Measure from first chalk line, 8” horizontally and make a mark

5. From the center of the circle, snap another chalk line at the 8” mark.

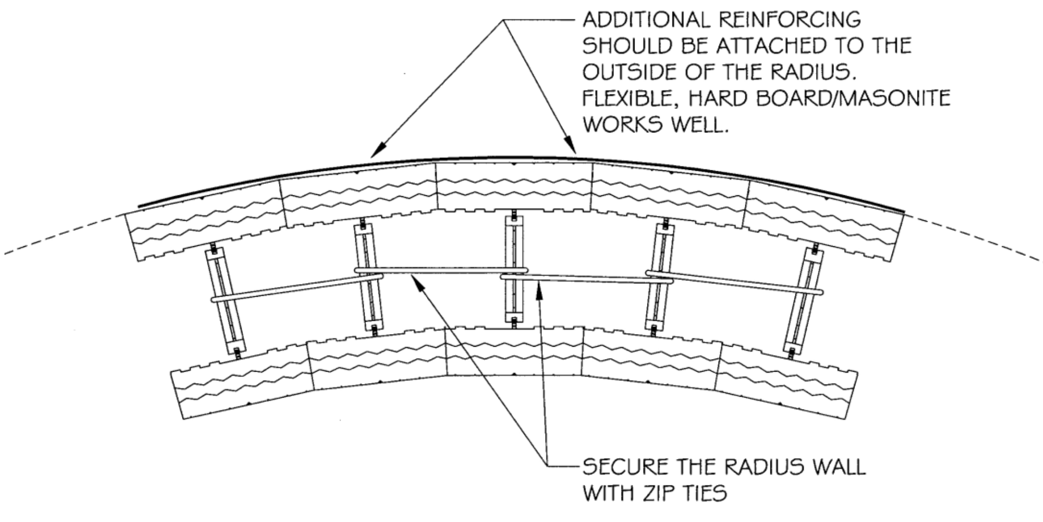


6. Set one of the 8” block sections on the outside radius line.
7. Make sure the outside corners of the block are at the intersection of the chalk lines and the radius line.
8. Mark the block where it touches the chalk line.
9. Cut the block where you marked it, following the angle your marks created
10. This will be the miter cut you use to make remaining cuts for the entire radius wall



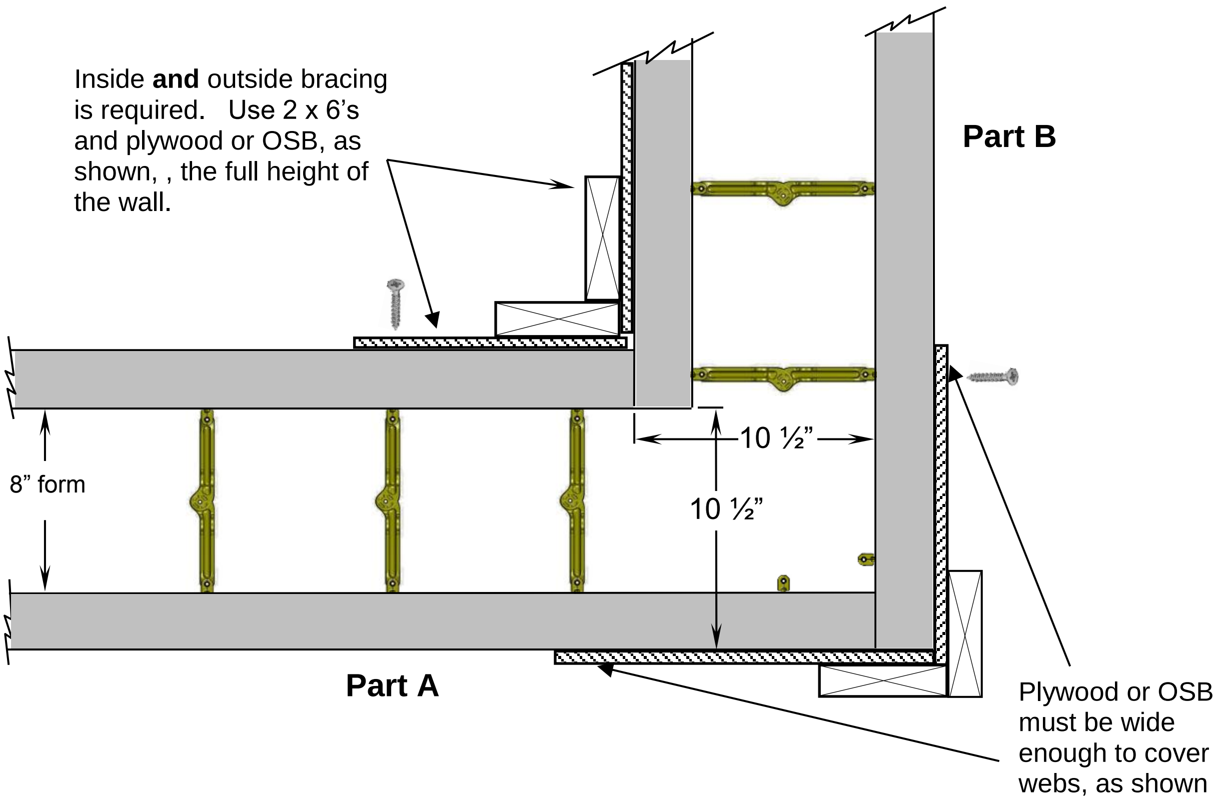
11. Repeat Step 9 until the correct number of blocks has been cut to complete the wall.

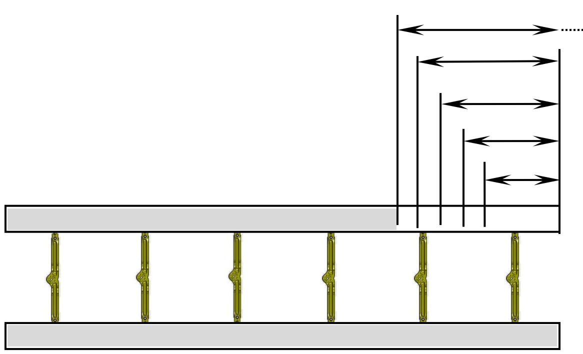
12. Stack forms, aligning webs vertically.
13. Zip tie the blocks together.
14. Additional reinforcing in the form of flexible, hardboard Masonite should be attached to the inside and outside of the wall.
15. Bracing on the interior of the wall should be the same spacing as typical bracing.



FABRICATING 90° CORNERS FROM STRAIGHT CELBLOX

If 90° corners are unavailable on the jobsite and needed immediately, they can be fabricated from standard 4ft. straight sections as shown below.

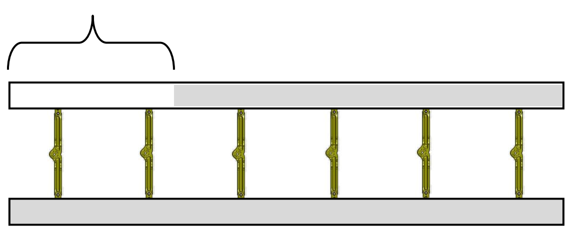




Cut off 14 ½" for a 12" thick wall.
" 12 ½" " 10" "
" **10 ½"** " **8"** "
" 8 ½" " 6" "
" 6 ½" " 4" "

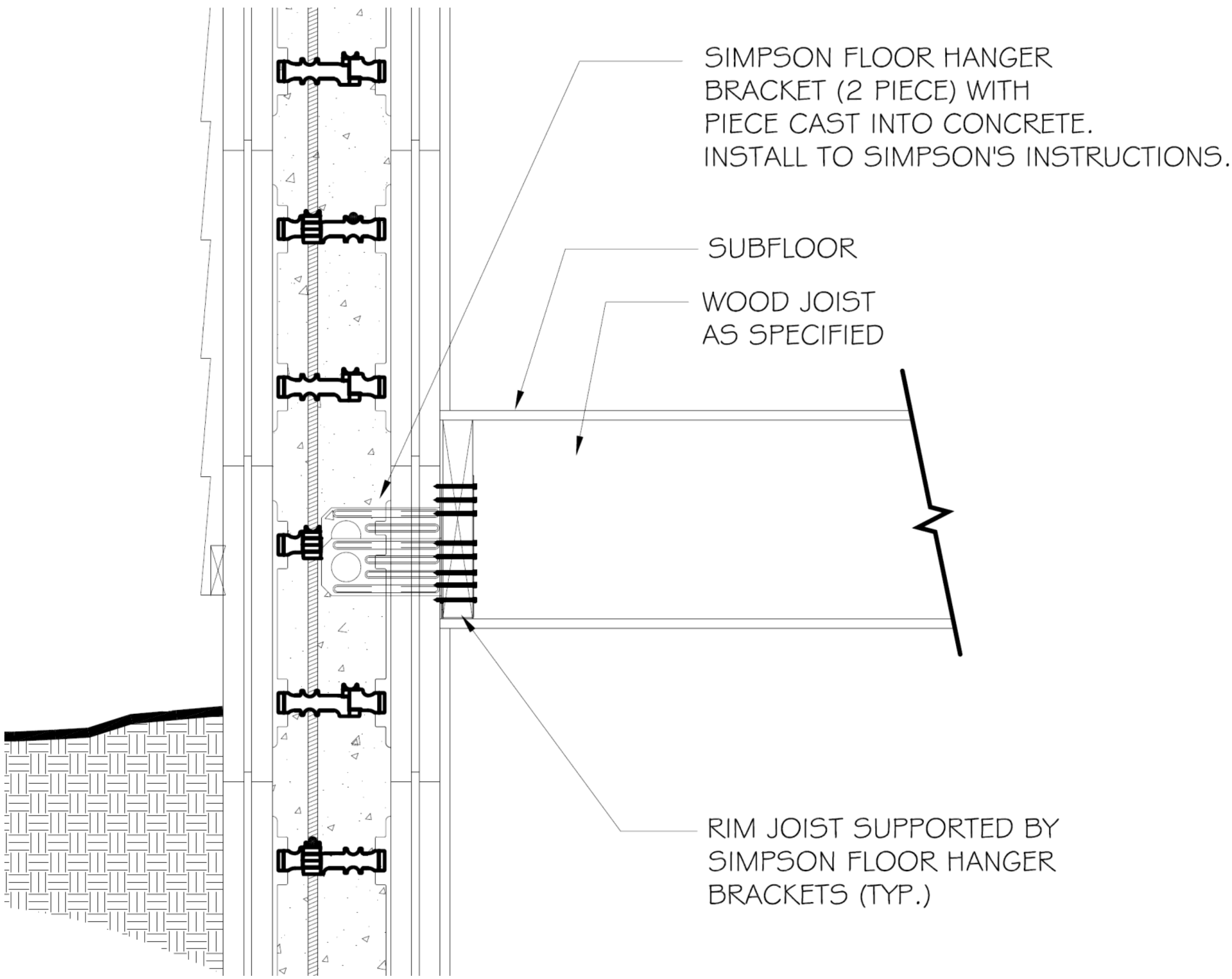
Part A

Use same dimensions as Part **A**



Part B

SIMPSON FLOOR HANGER DETAIL



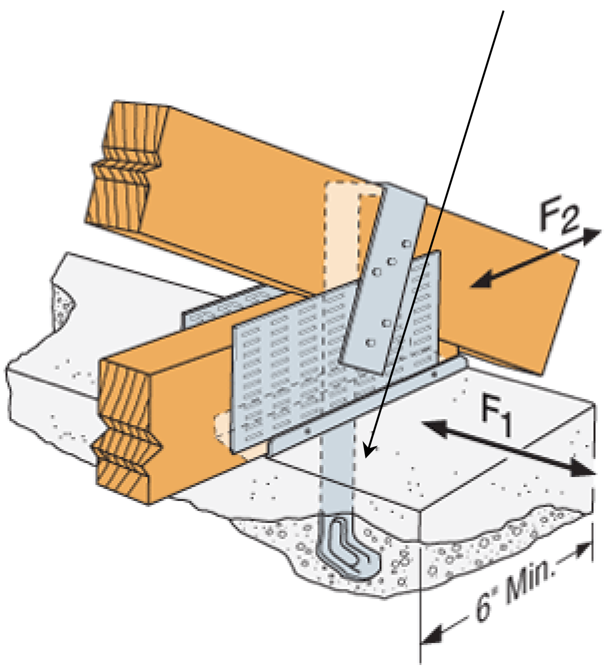
HURRICANE STRAPS

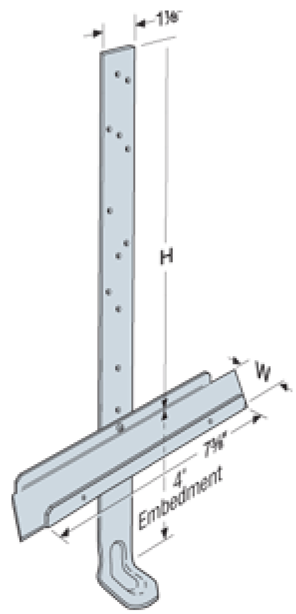
Hurricane straps are typically made of galvanized steel and are provided with a series of nail holes.

If required by local code or engineering, these straps are typically installed as shown. A strap is required for each truss.

Follow local codes for nail specification and nail quantity to be used at each truss.

Accurately embed strap into wet concrete a minimum of 4” at location of each truss.

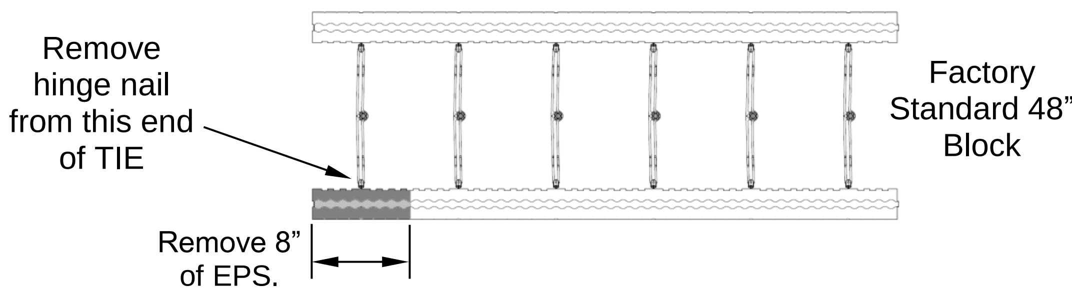




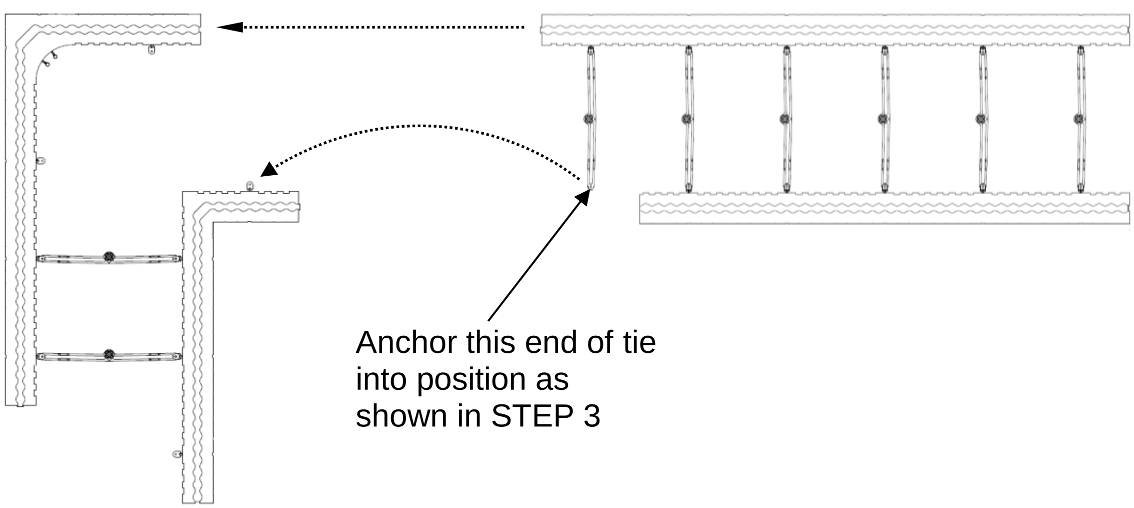
12” CORNER INSTALLATION

Additional reinforcing is necessary on all corners to keep them from shifting during the pour. If using CELBLOX® Block Lock, they should be snapped around the top pin bracket on each corner and the top pin bracket on the adjacent straight block. Corners can also be reinforced by wrapping lumber or cut pieces of OSB or plywood completely around the corner and overlapping adjacent straight block two webs on either side of the corner.

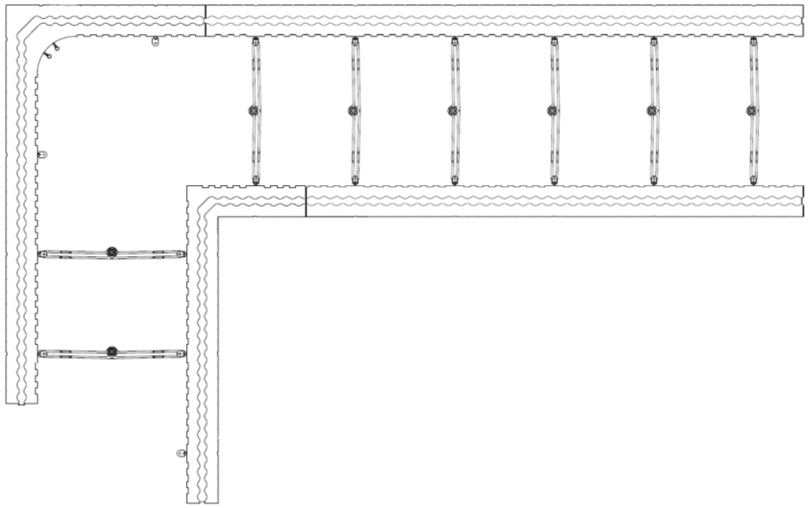
Step 1



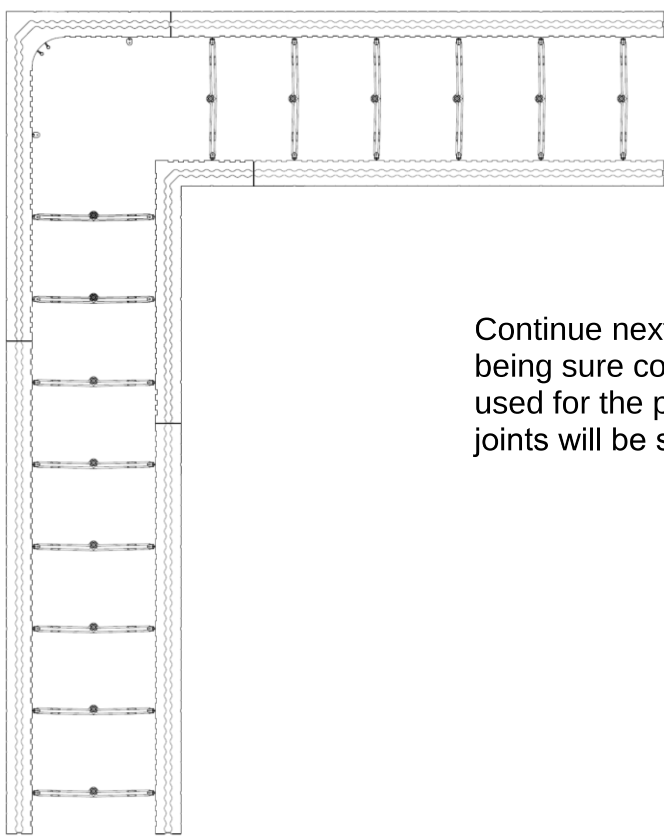
Step 2



Step 3



Step 4



Continue next course in same manner being sure corners are opposite those used for the previous course so the joints will be staggered 16” on center.

INSTALLATION OF METAL TIES IN 12” CORNERS

Walls over 12’ in height require the use of optional metal ties to supplement support from inside and outside of the wall. There are two types of “straps”, as seen in the photographs, which are inserted into place in the field.

This type strap, CELBLOX® BlockLock, is used to bridge

TAPER TOP

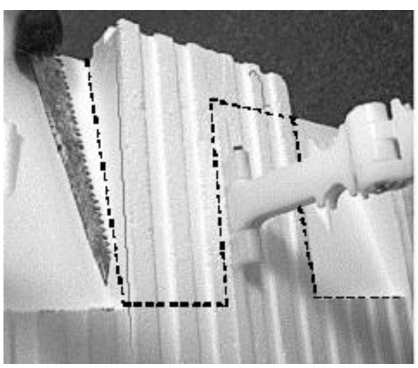
CELBLOX® Taper Top forms can be used to provide support when installing traditional wood-framing above CELBLOX® ICF foundation walls. The taper top form can also be used for log homes, manufactured housing, and stem walls for slab on grade.

The CELBLOX® Taper Top will be the top course of the CELBLOX® ICF walls and the Taper Top edge will face the *outside* of the ICF walls.

Before pouring, trim off outside interlock tongue on the CELBLOX® Taper Top to ensure a smooth finish for your upper walls.

It is preferred that all flooring systems be attached using ledger attachments as outlined on Pages 32 and 33. Although the CELBLOX® Taper Top has been used to provide a ledge to set flooring systems, unless horizontal rebar is tied back to the main portion of the wall, there will be a shear point and the wall will not meet load requirements for flooring attachments. Rebar placement must be specified by local codes or engineering requirements if the Taper Top is used for this application.

The Taper Top edge of the block is turned to the *inside* of the ICF wall when being used as a ledger attachment. When this course is stacked, the interlock tongue on the inside of the wall can be trimmed off before pouring the wall. **Do not** trim off the outside interlock tongue if you plan to use CELBLOX® for the next floor.



Depending upon spacing of the flooring, you may have to cut the EPS on the tapered side of the CELBLOX® prior to the pour, as detailed. This allows the concrete to flow in and create a ledge to the floor system to sit on.

Use a keyhole saw to cut away EPS indicated by dotted lines.

Do **not** cut into imbedded plastic parts.

APPENDIX B
REINFORCEMENT SCHEDULES

Tables included in Appendix B are from *PCA 100-2007,* ***Prescriptive Design of Exterior Concrete Walls for One- and Two-Family Dwelling****s.* They are copyrighted by and provided courtesy of the Portland Cement Association, Skokie, Illinois. They are to be used only within the assumptions and restrictions laid out in these documents. Local building codes or engineering designed for a specific construction project supersedes these tables. If your project does not fall within the design parameters of these tables, you must consult an engineer.

It is recommended that residential builders obtain and utilize this publication in conjunction with this installation manual. This publication can be acquired from the PCA directly by calling 847.966.6200 or at www.cement.org.

TABLE 3.1
MINIMUM WIDTH OF CONCRETE FOOTINGS FOR CONCRETE WALLS (INCHES)

Max. number of stories[5]	Max. roof span[6] (ft)	Max. floor span[7] (ft)	Minimum load-bearing value of soil[8] (psf)											
			1500		2000		2500		3000		3500		4000	
			Ground snow load[9] (psf)											
			30	70	30	70	30	70	30	70	30	70	30	70
Group 1 – 4-inch flat, 6-inch waffle-grid, or 6-inch screen-grid wall thickness[10]														
One story	32	20	20	24	15	18	12	14	10	12	9	10	8	9
		32	22	26	17	19	13	15	11	13	10	11	8	10
	40	20	22	26	16	19	13	16	11	13	9	11	8	10
		32	24	28	18	21	14	17	12	14	10	12	9	10
Two story	32	20	27	30	20	23	16	18	14	15	12	13	10	11
		32	31	34	23	25	19	20	16	17	13	15	12	13
	40	20	29	33	21	25	17	20	14	16	12	14	11	12
		32	32	36	24	27	19	22	16	18	14	15	12	14
Group 2 – 6-inch flat or 8-in waffle-grid wall thickness[10,11]														
One story	32	20	22	25	16	19	13	15	11	12	9	11	8	9
		32	23	27	18	20	14	16	12	13	10	11	9	10
	40	20	23	27	17	20	14	16	12	14	10	12	9	10
		32	25	29	19	22	15	17	12	15	11	12	9	11
Two story	32	20	30	33	22	25	18	20	15	16	13	14	11	12
		32	33	36	25	27	20	22	17	18	14	16	13	14
	40	20	31	35	23	26	19	21	16	18	13	15	12	13
		32	35	39	26	29	21	23	17	19	15	17	13	14
Group 3 – 8-inch flat wall thickness[10,12]														
One story	32	20	25	28	19	21	15	17	12	14	11	12	9	11
		32	27	30	20	23	16	18	13	15	11	13	10	11
	40	20	26	30	20	23	16	18	13	15	11	13	10	11
		32	28	32	21	24	17	19	14	16	12	14	11	12
Two story	32	20	34	38	26	28	21	23	17	19	15	16	13	14
		32	38	41	29	31	23	25	19	21	16	18	14	15
	40	20	36	40	27	30	21	24	18	20	15	17	13	15
		32	39	43	30	33	24	26	20	22	17	19	15	16
Group 4 – 10-inch flat wall thickness[10]														
One story	32	20	28	32	21	24	17	19	14	16	12	14	11	12
		32	30	33	23	25	18	20	15	17	13	14	11	13
	40	20	30	34	22	25	18	20	15	17	13	14	11	13
		32	32	36	24	27	19	21	16	18	14	15	12	13
Two story	32	20	39	43	29	32	24	26	20	21	17	18	15	16
		32	43	46	32	35	26	28	22	23	19	20	16	17
	40	20	41	45	31	34	24	27	20	22	17	19	15	17
		32	44	48	33	36	27	29	22	24	19	21	17	18
Additional footing width for masonry veneer[4,13,14]														
One story			5		3		3		2		2		2	
Two story			6		5		4		3		3		2	

NOTES FOR TABLE 3.1

1. Minimum footing thickness shall be the greater of: the projection of the footing beyond the face of the concrete wall, one-third of the footing width, 6 inches, and 11 inches where vertical wall reinforcement is required to extend into the footing in accordance with Section 6.2.
2. Footings shall have a width that allows for a nominal 2-inch projection from either face of the concrete in the wall to the edge of the footing. Where masonry veneer is supported directly on the footing, the required projection shall be measured from the face of the veneer.
3. Tabulated footing widths are based on the weight of concrete walls as indicated in Table 2.1, plus an allowance of 2 psf for interior wall finish and 11 psf for exterior wall finish. Where two or more wall types are grouped, the greatest weight of all those in the group was used.
4. Masonry veneer is not permitted for multiple dwellings assigned to Seismic Design Category C and all buildings assigned to Seismic Design Category D0, D1 or D2.
5. Basement walls shall not be considered as a story in determining footing widths, because table values assume the building has a basement. Where the building does not have a basement and the height of the foundation wall measured from the top of the footing to the top of the first floor does not exceed 5 feet, footing widths are permitted to be reduced 10%. This reduction also applies to the additional footing width for masonry veneer.
6. For roof spans of less than 32 feet, use footing width for 32 feet roof span. For roof spans between 32 and 40 feet, use footing width for 40 feet roof span, or determine footing width by interpolation.
7. For floor spans of less than 20 feet, use footing width for 20 feet floor span. For floor spans between 20 and 32 feet, use footing width for 32 feet floor span, or determine footing width by interpolation.
8. To determine required footing width for soil bearing values of greater than 2,500 psf that are not shown in the table, multiply the footing width for 1,500 psf soil by 1,500 and divide by the load bearing value of he soil for which the footing width is desired.
9. For ground snow loads between 20 and 70 psf, use footing widths shown for 70 psf or determine by interpolation.
10. See Table 2.1 for tolerance from nominal thickness permitted for flat walls, and thicknesses and dimensions of waffle- and screed-grid walls.
11. Tabulated footing widths based on use of 6-inch nominal flat or 8-inch nominal waffle-grid foundation wall and above-grade wall. Where an 8-inch or 10-inch nominal flat foundation wall is used with an above-grade 6-inch nominal flat or 8-inch nominal waffle-grid wall, use footing width required for 8-inch or 10-inch nominal flat wall, or interpolate midway between footing widths required for the foundation wall and above-grade wall.
12. Tabulated footing widths based on use of an 8-inch nominal flat foundation wall and above-grade wall. Where a 10-inch nominal flat foundation wall is used with an above-grade 8-inch nominal flat wall, use footing width required for a 10-inch nominal flat wall, or interpolate mid-way between footing widths required for the 10-inch nominal flat foundation wall and an 8-inch nominal flat above-grade wall.
13. Where masonry veneer is installed, the tabulated additional footing width is based on an installed weight of 40 psf for the veneer, minus 11 psf to compensate for the exterior finish of 11 psf which is already included. See Note 3.
14. It is assumed that the masonry veneer is supported directly on the footing.

Table 3.12

MINIMUM VERTICAL REINFORCEMENT FOR 6, 8, 10, AND 12 INCH NOMINAL FLAT BASEMENT WALLS

Maximum wall height (ft)	Maximum unbalanced backfill height[7] (ft)	Minimum vertical reinforcement – bar size No. and spacing (in.)											
		Maximum design lateral soil load											
		30 psf/ft				45 psf/ft				60 psf/ft			
		Minimum nominal wall thickness, (in.)											
		6	8	10	12	6	8	10	12	6	8	10	12
5	4	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
6	4	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
	5	NR	NR	NR	NR	NR	NR[12]	NR	NR	4@35	NR[12]	NR	NR
	6	NR	NR	NR	NR	5@48	NR	NR	NR	5@36	NR	NR	NR
7	4	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
	5	NR	NR	NR	NR	NR	NR	NR	NR	5@47	NR	NR	NR
	6	NR	NR	NR	NR	5@42	NR	NR	NR	6@43	5@48	NR[12]	NR
	7	5@46	NR	NR	NR	6@42	5@46	NR[12]	NR	6@34	6@48	NR	NR
8	4	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
	5	NR	NR	NR	NR	4@38	NR[12]	NR	NR	5@43	NR	NR	NR
	6	4@37	NR[12]	NR	NR	5@37	NR	NR	NR	6@37	5@43	NR[12]	NR
	7	5@40	NR	NR	NR	6@37	5@41	NR[12]	NR	6@34	6@43	NR	NR
	8	6@43	5@47	NR[12]	NR	6@34	6@43	NR	NR	6@27	6@32	6@44	NR
9	4	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
	5	NR	NR	NR	NR	4@35	NR[12]	NR	NR	5@40	NR	NR	NR
	6	4@34	NR[12]	NR	NR	6@48	NR	NR	NR	6@36	5@39	NR[12]	NR
	7	5@36	NR	NR	NR	6@34	5@37	NR	NR	6@33	6@38	5@37	NR[12]
	8	6@38	5@41	NR[12]	NR	6@33	6@38	5@37	NR[12]	6@24	6@29	6@39	4@48[13]
	9	6@34	6@46	NR	NR	6@26	6@30	6@41	NR	6@19	6@23	6@30	6@39
10	4	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
	5	NR	NR	NR	NR	4@33	NR[12]	NR	NR	5@38	NR	NR	NR
	6	5@48	NR[12]	NR	NR	6@45	NR	NR	NR	6@34	5@37	NR	NR
	7	6@47	NR	NR	NR	6@34	6@48	NR	NR	6@30	6@35	6@48	NR[12]
	8	6@34	5@38	NR	NR	6@30	6@34	6@47	NR[12]	6@22	6@26	6@35	6@45[13]
	9	6@34	6@41	4@48	NR[12]	6@23	6@27	6@35	4@48[13]	DR	6@22	6@27	6@34
	10	6@28	6@33	6@45	NR	DR	6@23	6@29	6@38	DR	6@22	6@22	6@28

For SI: 1 inch = 25.4 mm; 1 foot = 0.3048 m; 1 psf/ft = 0.1571 kN/m²/m

NOTES FOR TABLE 3.1.2

1. Table values are based on reinforcing bars with a minimum yield strength of 60,000 psi.
2. Vertical reinforcement with a yield strength of less than 60,000 psi and/or bars of a different size than specified in the table are permitted in accordance with Section 2.5.7 and Table 2.3.
3. NR indicates no vertical wall reinforcement is required, except for 6-inch nominal walls formed with stay-in-place forming systems in which case vertical reinforcement shall be #4@48 inches on center.
4. Allowable deflection criterion is ***L***/240, where ***L*** is the unsupported height of the basement wall in inches.
5. Interpolation shall not be permitted.
6. Where walls will retain 4 feet or greater of unbalanced backfill, they shall be laterally supported at the top and bottom before backfilling.
7. Refer to Chapter 1 for the definition of unbalanced backfill height.
8. Vertical reinforcement shall be located to provide a cover of 1.25 inches measured from the inside face of the wall. The center of the steel shall not vary from the specified location by more than the greater of 10% of the wall thickness and 3/8-inch.
9. Concrete cover for reinforcement measured from the inside face of the wall shall not be less than ¾-inch (19mm). Concrete cover for reinforcement measured from the outside face of the wall shall not be less than 1 ½ inches for #5 bars and smaller, and not less than 2 inches (51mm) for larger bars.
10. DR means design is required in accordance with the applicable building code, or where there is no code in accordance with ACI 318.
11. Concrete shall have a specified compressive strength of not less than 2,500 psi (17.2MPa) at 28 days, unless a higher strength is required by Note 12 or 13.
12. The minimum thickness is permitted to be reduced 2 inches, provided the minimum specified compressive strength of concrete is 4,000 psi.
13. A plain concrete wall with a minimum nominal thickness of 12 inches is permitted, provided the minimum specified compressive strength of concrete is 3,500 psi.
14. See Table 2.1 for tolerance from nominal thickness permitted for flat walls.

TABLE 3.7
MINIMUM VERTICAL REINFORCEMENT FOR 8-INCH NOMINAL FLAT CONCRETE BASEMENT WALLS

Maximum unsupported wall height (ft)	Maximum unbalanced backfill height[7] (ft)	Minimum vertical reinforcement – bar size No. and spacing (in.)		
		Maximum design lateral soil load		
		30 psf/ft	45 psf/ft	60 psf/ft
8	4	NR	NR	NR
	5	NR	NR	NR
	6	NR	NR	6@37
	7	NR	6@36	6@35
	8	6@41	6@35	6@26
9	4	NR	NR	NR
	5	NR	NR	NR
	6	NR	NR	6@35
	7	NR	6@35	6@32
	8	6@36	6@32	6@23
	9	6@35	6@25	6@18
10	4	NR	NR	NR
	5	NR	NR	NR
	6	NR	NR	6@35
	7	NR	6@35	6@29
	8	6@35	6@29	6@21
	9	6@34	6@22	6@16
	10	6@27	6@17	6@13

1. Table values are based on reinforcing bars with a minimum yield strength of 60,000 psi, concrete with a minimum specified compressive strength of 2,500 psi, and vertical reinforcement being located at the centerline of the wall. See Section 3.3.
2. Vertical reinforcement with a yield strength of less than 60,000 psi and/or bars of a different size than specified in the table are permitted in accordance with Section 2.5.7 and Table 2.3.
3. NR indicates no vertical reinforcement is required.
4. Deflection criterion is L/240, where L is the height of the basement wall in inches.
5. Interpolation shall not be permitted.
6. Where walls will retain 4 feet or greater of unbalanced backfill, they shall be laterally supported at the top and bottom before backfilling.
7. Refer to Chapter 1 for the definition of unbalanced backfill height.
8. See Sections 3.2.3, 3.2.4, and 3.2.5 for minimum reinforcement required for basement walls supporting above-grade concrete walls.
9. See Table 2.1 for tolerance from nominal thickness permitted for flat walls.

TABLE 3.5
MINIMUM HORIZONTAL REINFORCEMENT FOR CONCRETE BASEMENT WALLS

Maximum unsupported height of basement wall-feet (meters)	Location of horizontal reinforcement
≤ 8 (2.4)	One No. 4 bar within 12 inches (305 mm) of the top of the wall story and one No. 4 bar near mid-height of the wall story
> 8 (2.4)	One No. 4 bar within 12 inches (305 mm) of the top of the wall story and one No. 4 bar near third points in the wall story

1. Horizontal reinforcement requirements are for reinforcing bars with a minimum yield strength of 40,000 psi and concrete with a minimum concrete compressive strength of 2,500 psi.

2. See sections 3.2.3, 3.2.4, and 3.2.5 for minimum reinforcement required for basement walls supporting above-grade concrete walls.

TABLE 4.1
MINIMUM VERTICAL REINFORCEMENT FOR FLAT ABOVE-GRADE WALLS

Max. number of stories[5]	Max. roof span[6] (ft)	Max. floor span[7] (ft)	Minimum load-bearing value of soil[8] (psf)											
			1500		2000		2500		3000		3500		4000	
			Ground snow load[9] (psf)											
			30	70	30	70	30	70	30	70	30	70	30	70
Group 1 – 4-inch flat, 6-inch waffle-grid, or 6-inch screen-grid wall thickness[10]														
One story	32	20	20	24	15	18	12	14	10	12	9	10	8	9
		32	22	26	17	19	13	15	11	13	10	11	8	10
	40	20	22	26	16	19	13	16	11	13	9	11	8	10
		32	24	28	18	21	14	17	12	14	10	12	9	10
Two story	32	20	27	30	20	23	16	18	14	15	12	13	10	11
		32	31	34	23	25	19	20	16	17	13	15	12	13
	40	20	29	33	21	25	17	20	14	16	12	14	11	12
		32	32	36	24	27	19	22	16	18	14	15	12	14
Group 2 – 6-inch flat or 8-in waffle-grid wall thickness[10,11]														
One story	32	20	22	25	16	19	13	15	11	12	9	11	8	9
		32	23	27	18	20	14	16	12	13	10	11	9	10
	40	20	23	27	17	20	14	16	12	14	10	12	9	10
		32	25	29	19	22	15	17	12	15	11	12	9	11
Two story	32	20	30	33	22	25	18	20	15	16	13	14	11	12
		32	33	36	25	27	20	22	17	18	14	16	13	14
	40	20	31	35	23	26	19	21	16	18	13	15	12	13
		32	35	39	26	29	21	23	17	19	15	17	13	14
Group 3 – 8-inch flat wall thickness[10,12]														
One story	32	20	25	28	19	21	15	17	12	14	11	12	9	11
		32	27	30	20	23	16	18	13	15	11	13	10	11
	40	20	26	30	20	23	16	18	13	15	11	13	10	11
		32	28	32	21	24	17	19	14	16	12	14	11	12
Two story	32	20	34	38	26	28	21	23	17	19	15	16	13	14
		32	38	41	29	31	23	25	19	21	16	18	14	15
	40	20	36	40	27	30	21	24	18	20	15	17	13	15
		32	39	43	30	33	24	26	20	22	17	19	15	16
Group 4 – 10-inch flat wall thickness[10]														
One story	32	20	28	32	21	24	17	19	14	16	12	14	11	12
		32	30	33	23	25	18	20	15	17	13	14	11	13
	40	20	30	34	22	25	18	20	15	17	13	14	11	13
		32	32	36	24	27	19	21	16	18	14	15	12	13
Two story	32	20	39	43	29	32	24	26	20	21	17	18	15	16
		32	43	46	32	35	26	28	22	23	19	20	16	17
	40	20	41	45	31	34	24	27	20	22	17	19	15	17
		32	44	48	33	36	27	29	22	24	19	21	17	18
Additional footing width for masonry veneer[4,13,14]														
One story			5		3		3		2		2		2	
Two story			6		5		4		3		3		2	

NOTES FOR TABLE 4.1

1. **Table 4.1** is based on ASCE 7 components and cladding wind pressures for an enclosed building using a mean roof height of 35 ft (10.7 m), interior wall area 4, an effective wind area of 10 ft^2 (0.9 m^2), and topographic factor, K_{zt}, and importance factor, *I*, equal to 1.0.
2. Table is based on concrete with a minimum specified compressive strength of 2,500 psi (17.2 MPa). See Section 4.1.4 for minimum strength of concrete for buildings assigned to Seismic Design Category D_0, D_1, or D_2.
3. See Section 4.1.7 for location of reinforcement in wall.
4. Deflection criterion is ***L**/240*, where ***L*** is the unsupported height of the wall in inches.
5. Interpolation shall not be permitted.
6. See Section 4.1.3 for minimum grade, and size and spacing of vertical wall reinforcement for multiple dwellings assigned to Seismic Design Category C, and all buildings assigned to Seismic Design Category D_0, D_1, or D_2. The more stringent provisions of that section or this table shall apply.
7. Where No 4 reinforcing bars at a spacing of 48 inches (12.19 mm) are specified in the table, bars with a minimum yield strength of 40,000 psi (280 MPa) or 60,000 psi (420 MPa) are permitted to be used.
8. Other than for No. 4 bars spaced at 48 inches (1219 mm) on center, table values are based on reinforcing bars with a minimum yield strength of 60,000 psi (420 MPa). Vertical reinforcement with a yield strength of less than 60,000 psi (420 MPa) and/or bars of a different size than specified in the table are permitted in accordance with Section 2.5.7 and Table 2.3.
9. **Top** means gravity load from roof and/or floor construction bears on top of wall
10. **Side** means gravity load from floor construction is transferred to wall from a wood ledger or cold-formed steel track bolted to side of wall.
11. Where floor framing members span parallel to the wall, the ***top*** bearing condition is permitted to be used.
12. **DR** indicates design required.

Requirements for Lintels and Reinforcement Around Openings

7.1 REINFORCEMENT AROUND OPENINGS

Reinforcement shall be provided around openings in walls equal to or greater than 2 feet (610 mm) in width in accordance with this section and Figure 7.1, in addition to the minimum wall reinforcement required by Chapters 3, 4 and 5. Vertical wall reinforcement required by this section is permitted to be used as reinforcement at the ends of solid wall segments required by Section 5.2.2.2 provided it is located in accordance with Section 7.1.2. Wall openings shall have a minimum depth of concrete over the width of the opening of 8 inches (203 mm) in flat walls and waffle-grid walls, and 12 inches (305 mm) in screen-grid walls. Wall openings in waffle-grid and screen-grid walls shall be located such that no less than one-half of a vertical core occurs along each side of the opening.

7.1.1 Horizontal Reinforcement

Lintels complying with Section 7.2 shall be provided above wall openings equal to or greater than 2 feet (610 mm) in width.

> **Exception:** Continuous horizontal wall reinforcement placed within 12 inches (305 mm) of the top of the wall story as required in Chapters 3 and 4 is permitted to be used in lieu of top or bottom lintel reinforcement required by Section 7.2 provided that the continuous horizontal wall reinforcement meets the location requirements specified in Figures 7.3, 7.4, and 7.5 and the size requirements specified in Tables 7.3 through 7.25.

Openings equal to or greater than 2 feet (610 mm) in width shall have a minimum of one No. 4 bar placed within 12 inches (305 mm) of the bottom of the opening. See Figure 7.1.

Horizontal reinforcement placed above and below an opening shall extend beyond the edges of the opening the dimension required to develop the bar in tension in accordance with Section 2.5.4.

7.1.2 Vertical Reinforcement

In all buildings where the factored roof uplift force from Table 7.1A is less than or equal to 800 plf (11.68 kN/m) and the opening width is equal to or greater than 2 feet (610 mm) and less than or equal to 18 feet (5.5 m), not less than one No. 4 bar (Grade 40 (280 MPa)) shall be provided on each side of the opening. Where the roof uplift force from Table 7.1A is greater than 800 plf (11.68 kN/m) and the opening width is greater than 6 feet (1.8 m), vertical reinforcement shall be provided on each side of openings in accordance with Table 7.1B.

In multiple dwellings assigned to Seismic Design Category C, and all buildings assigned to Seismic Design Category D_0, D_1 or D_2, vertical reinforcement shall comply with the above requirements, but shall not be less than 2 No. 4 bars (Grade 60) or one No. 5 bar (Grade 60 (420 MPa)). See Section 4.1.3.

The vertical reinforcement required by this section shall extend the full height of the wall story and shall be located within 12 inches (305 mm) of each side of the opening. The vertical reinforcement required on each side of an opening by this section is permitted to serve as reinforcement at the ends of solid wall segments in accordance with Section 5.2.2.2, provided it is located as required by the applicable detail in Figure 5.1. Where the vertical reinforcement required by this section is used to satisfy the requirements of Section 5.2.2.2 in waffle- and screen-grid walls, a concrete flange shall be created at the ends of the solid wall segments in accordance with Table 5.4B, footnote 9. In the top most story, the reinforcement shall terminate in accordance with Section 4.1.6.

7.1.3 Wall Segments in Seismic Design Categories C, D_0, D_1 and D_2

For multiple dwellings assigned to Seismic Design Category C and all buildings assigned to Seismic Design Category D_0, D_1 or D_2, wall segments with a length of less than 24 inches (610 mm), shall be provided with not less than No. 3 ties in accordance with Figure 7.2. Ties shall be terminated at each end with a standard hook conforming to Figure 2.6.

Exception: Ties need not be provided in wall segments where flat walls are used to provide all of the required solid wall length.

Ties shall start at ***d***/4 but not more than 3 inches (76 mm) from the top and bottom of the wall segment. Ties shall be spaced at ***d***/2, but not more than 6 inches (152 mm) on center along the height of the wall segment. Where necessary to provide a minimum cover of 1½ inches (38 mm) on all sides of ties, screen- and waffle-grid forms shall be modified by removal of form material, or replaced by flat forms. Ties required by this section are permitted to be used to satisfy the horizontal reinforcement requirements of Section 4.1.3.

7.2 LINTELS

Lintels shall be provided over all openings equal to or greater than 2 feet (610 mm) in width. Lintels with uniform loading shall conform to Sections 7.2.1, 7.2.2, and 7.2.3 or Section 7.2.4. Lintels supporting concentrated loads, such as from roof or floor beams or girders, shall be designed in accordance with the applicable building code, or if there is no code in accordance with ACI 318.

7.2.1 Lintels Designed for Gravity Load-Bearing Conditions

Where a lintel will be subjected to gravity load condition 1 through 5 of Table 7.2, the clear span of the lintel shall not exceed that permitted by Tables 7.3 through 7.16. The maximum clear span of lintels with and without stirrups in flat walls shall be determined in accordance with Tables 7.3 through 7.10, and constructed in accordance with Figure 7.3. The maximum clear span of lintels with and without stirrups in waffle-grid walls shall be determined in accordance with Tables 7.11 through 7.14, and constructed in accordance with Figure 7.4. The maximum clear span of lintels with and without stirrups in screen-grid walls shall be determined in accordance with Tables 7.15 and 7.16, and constructed in accordance with Figure 7.5. The clear span of a lintel subjected to gravity loading conditions and uplift loading conditions (see Section 7.2.2) shall not exceed the smaller of the spans determined for the two conditions.

Where required by the applicable table, No. 3 stirrups shall be installed in lintels at a maximum spacing of ***d***/2 where ***d*** equals the depth of the lintel, ***D***, less the cover of the concrete as shown in Figures 7.3, 7.4, and 7.5. The smaller value of *d* computed for the top and bottom bar shall be used to determine the maximum stirrup spacing. Where stirrups are required in a lintel with a single bar or two bundled bars in the top and bottom, they shall be fabricated like the letter "c" or "s" with 135-degree standard hooks at each end that comply with Section 2.5.5 and Figure 2.6 and installed as shown in Figures 7.3 through 7.5. Where two bars are required in the top and bottom of the lintel and the bars are not bundled, the bars shall be separated by a minimum of 1 inch (25 mm), and stirrups shall be fabricated with 90- or 135-degree standard hooks that comply with Section 2.5.5 and Figure 2.6 and installed as shown in Figures 7.3 and 7.4. For flat, waffle-grid and screen-grid lintels, stirrups are not required in center distance, ***A***, portion of spans in accordance with Figure 7.1 and Tables 7.3 through 7.16, and Tables 7.19 through 7.25.

7.2.2 Lintels Designed for Uplift Loading Conditions

Where the roof uplift force in Table 7.1A exceeds 600 plf (8.76 kN/m), the clear span of a lintel in the top story of a two-story building or first story of a one story building supporting roof framing members shall not exceed that permitted by Tables 7.19 through 7.25 based on the uplift force from Table 7.1A. Where the roof uplift force in Table 7.1A exceeds 600 plf (8.76 kN/m), the clear span of a lintel in the first story of a two-story building or basement of a one-story building supporting an exterior wall of light framed construction which supports roof framing members shall not exceed that permitted by Tables 7.19 through 7.25 based on the uplift force from Table 7.1A. Where the roof uplift force in Table 7.1A exceeds 965 plf (14.09 kN/m), the clear span of a lintel in the first story of a two-story building or basement of a one-story building supporting an exterior wall of concrete construction which supports roof framing members shall not exceed that permitted by Tables 7.19 through 7.25 based on the uplift force from Table 7.1A, less the factored dead load in the table below. If the net uplift force is less than or equal to 600 plf (8.76 kN/m) after subtracting the value from the table below from the force from Table 7.1A, the lintel is not required to be designed for uplift loads.

Wall Group[1] of concrete wall in story above supported by lintel	Factored dead load to be subtracted from force determined from Table 7.1A (plf)
1	325
2	505
3	690
4	875

For SI: 1 plf = 0.0146 kN/m.
1. See Table 2.1 for types of walls within a group.

The maximum clear span of lintels with and without stirrups in flat walls for uplift loading conditions shall be determined in accordance with Tables 7.19 through 7.22, and constructed in accordance with Figure 7.3. The maximum clear span of lintels with and without stirrups in waffle-grid walls for uplift loading conditions shall be determined in accordance with Tables 7.23 and 7.24, and constructed in accordance with Figure 7.4. The maximum clear span of lintels with and without stirrups in screen-grid walls for uplift loading conditions shall be determined in accordance with Table 7.25, and constructed in accordance with Figure 7.5. The clear span of a lintel subjected to uplift loading conditions and gravity loading conditions (see Section 7.2.1) shall not exceed the smaller of the spans determined for the two conditions.

7.2.3 Bundled Bars in Lintels

It is permitted to bundle two bars in contact with each other in lintels if all of the following are observed:

1. Bars no larger than No. 6 are bundled.
2. Where the wall thickness is not sufficient to provide not less than 3 inches (76 mm) of clear space beside bars (total on both sides) oriented horizontally in a bundle, the bundled bars shall be oriented in a vertical plane.
3. Where vertically oriented bundled bars terminate with standard hooks to develop the bars in tension beyond the support (see Section 2.5.4), the hook extensions shall be staggered to provide a minimum of one inch (25 mm) clear spacing between the extensions.
4. Bundled bars shall not be lap spliced within the lintel span and the length on each end of the lintel that is required to develop the bars in tension.
5. Bundled bars shall be enclosed within stirrups throughout the length of the lintel. Stirrups and the installation thereof shall comply with Section 7.2.1.

7.2.4 Lintels Without Stirrups Designed for Non Load-Bearing Conditions

The maximum clear span of lintels without stirrups designed for nonload-bearing conditions of Table 7.2 shall be determined in accordance with this section. The maximum clear span of lintels without stirrups in flat walls shall be determined in accordance with Table 7.17, and the maximum clear span of lintels without stirrups in walls of waffle-grid or screen-grid construction shall be determined in accordance with Table 7.18.

7.2.5 Lintels in Seismic Design Categories C, D_0, D_1 and D_2

For multiple dwellings assigned to Seismic Design Category C and all buildings assigned to Seismic Design Category D_0, D_1 or D_2, lintels with a depth, ***D***, less than 24 inches (610 mm) shall be provided with not less than No. 3 stirrups in accordance with Figure 7.2. Stirrups shall be terminated at each end with a standard hook conforming to Figure 2.6.

> **Exception:** Stirrup reinforcing for lintels where flat walls are used to provide all of the required solid wall length need only comply with Section 7.2.1.

Stirrups shall start at ***d***/4, but not more than 3 inches (76 mm) from each end of the lintel. Stirrups shall be spaced at ***d***/2, but not more than 6 inches (152 mm) on center across the entire length of the lintel. Where necessary to provide a minimum cover of 1½ inches (38 mm) on all sides of stirrups, screen- and waffle-grid forms shall be modified by removal of form material, or replaced by flat forms. Stirrups required by this section are permitted to be used to satisfy the stirrup requirements of Section 7.2.1.

Table 7.2. Lintel Design Loading Conditions[1,2,4]

Description of loads and openings above influencing design of lintel			Design loading condition[3]
Opening in wall of top story of two-story building, or first story of one-story building			
Wall supporting loads from roof, including attic floor, if applicable, and	top of lintel equal to or less than **W**/2 below top of wall		2
	top of lintel greater than **W**/2 below top of wall		NLB
Wall not supporting loads from roof or attic floor			NLB
Opening in wall of first story of two-story building where wall immediately above is of concrete construction, or opening in basement wall of one-story building where wall immediately above is of concrete construction			
LB ledger board mounted to side of wall with bottom of ledger less than or equal to **W**/2 above top of lintel, and	top of lintel greater than **W**/2 below bottom of opening in story above		1
	top of lintel less than or equal to **W**/2 below bottom of opening in story above, and	opening is entirely within the **footprint** of the opening in the story above	1
		opening is partially within the **footprint** of the opening in the story above	4
LB ledger board mounted to side of wall with bottom of ledger more than **W**/2 above top of lintel			NLB
NLB ledger board mounted to side of wall with bottom of ledger less than or equal to **W**/2 above top of lintel, or no ledger board, and	top of lintel greater than **W**/2 below bottom of opening in story above		NLB
	top of lintel less than or equal to **W**/2 below bottom of opening in story above, and	opening is entirely within the **footprint** of the opening in the story above	NLB
		opening is partially within the **footprint** of the opening in the story above	1
Opening in basement wall of two-story building where walls of two stories above are of concrete construction			
LB ledger board mounted to side of wall with bottom of ledger less than or equal to **W**/2 above top of lintel, and	top of lintel greater than **W**/2 below bottom of opening in story above		1
	top of lintel less than or equal to **W**/2 below bottom of opening in story above, and	opening is entirely within the **footprint** of the opening in the story above	1
		opening is partially within the **footprint** of the opening in the story above	5
LB ledger board mounted to side of wall with bottom of ledger more than **W**/2 above top of lintel			NLB
NLB ledger board mounted to side of wall with bottom of ledger less than or equal to **W**/2 above top of lintel, or no ledger board, and	top of lintel greater than **W**/2 below bottom of opening in story above		NLB
	top of lintel less than or equal to **W**/2 below bottom of opening in story above, and	opening is entirely within the **footprint** of the opening in the story above	NLB
		opening is partially within the **footprint** of the opening in the story above	1
Opening in wall of first story of two-story building where wall immediately above is of light framed construction, or opening in basement wall of one-story building, where wall immediately above is of light framed construction			
Wall supporting loads from roof, second floor and top-story wall of light-framed construction, and	top of lintel equal to or less than **W**/2 below top of wall		3
	top of lintel greater than **W**/2 below top of wall		NLB
Wall not supporting loads from roof or second floor			NLB

1 **LB** means load bearing, **NLB** means non-load bearing, and **W** means width of opening.
2 **Footprint** is the area of the wall below an opening in the story above, bounded by the bottom of the opening and vertical lines extending downward from the edges of the opening.
3 For design loading condition "NLB" see Tables 7.17 and 7.18. For all other design loading conditions see Tables 7.3 through 7.16.
4 A NLB ledger board is a ledger attached to a wall that is parallel to the span of the floor, roof or ceiling framing that supports the edge of the floor, ceiling or roof.

TABLE 7.17
MAXIMUM ALLOWABLE CLEAR SPANS FOR FLAT LINTELS WITHOUT STIRRUPS IN NON-LOAD-BEARING WALLS

Lintel Depth[6], *D* (in.)	Number of bars and bar size	Steel yield strength, f_y (psi)	Nominal Wall Thickness (inches)							
			4		6		8		10	
			Construction of wall above lintel							
			Concrete wall	Light framed gable	Concrete wall	Light framed gable	Concrete wall	Light framed gable	Concrete wall	Light framed gable
			Maximum clear span of lintel (ft-inches)							
8	1 – #4	40,000	10-11	11-5	9-7	11-2	7-10	9-5	7-3	9-2
		60,000	12-5	11-7	10-11	13-5	9-11	13-2	9-3	12-10
	1 – #5	40,000	12-7	11-7	11-1	13-8	10-1	13-5	9-4	13-1
		60,000	DR	DR	12-7	16-4	11-6	14-7	10-9	14-6
	2 – #4 1 – #6	40,000	DR	DR	12-0	15-3	10-11	15-0	10-2	14-8
		60,000	DR	DR	DR	DR	12-2	15-3	11-7	15-3
	2 – #5	40,000	DR	DR	DR	DR	12-7	16-7	11-9	16-7
		60,000	DR	DR	DR	DR	DR	DR	13-3	16-7
	2 – #6	40,000	DR	DR	DR	DR	DR	DR	13-2	17-8
		60,000	DR	DR	DR	DR	DR	DR	DR	DR
12	1 – #4	40,000	11-5	9-10	10-6	12-0	9-6	11-6	8-9	11-1
		60,000	11-5	9-10	11-8	13-3	10-11	14-0	10-1	13-6
	1 – #5	40,000	11-5	9-10	11-8	13-3	11-1	14-4	10-3	13-9
		60,000	11-5	9-10	11-8	13-3	11-10	16-0	11-9	16-9
	2 – #4 1 – #6	40,000	DR	DR	11-8	13-3	11-10	16-0	11-2	15-6
		60,000	DR	DR	11-8	13-3	11-10	16-0	11-11	18-4
	2 – #5	40,000	DR	DR	11-8	13-3	11-10	16-0	11-11	18-4
		60,000	DR	DR	11-8	13-3	11-10	16-0	11-11	18-4
16	1 – #4	40,000	13-6	13-0	11-10	13-8	10-7	12-11	9-11	12-4
		60,000	13-6	13-0	13-8	16-7	12-4	15-9	11-5	15-0
	1 – #5	40,000	13-6	13-0	13-10	17-0	12-6	16-1	11-7	15-4
		60,000	13-6	13-0	13-10	17-1	14-0	19-7	13-4	18-8
	2 – #4 1 – #6	40,000	13-6	13-0	13-10	17-1	13-8	18-2	12-8	17-4
		60,000	13-6	13-0	13-10	17-1	14-0	20-3	14-1	
	2 – #5	40,000	13-6	13-0	13-10	17-1	14-0	20-3	14-1	
		60,000	DR	DR	13-10	17-1	14-0	20-3	14-1	
20	1 – #4	40,000	14-11	15-10	13-0	14-10	11-9	13-11	10-10	13-2
		60,000	15-3	15-10	14-11	18-1	13-6	17-0	12-6	16-2
	1 – #5	40,000	15-3	15-10	15-2	18-6	13-9	17-5	12-8	16-6
		60,000	15-3	15-10	15-8	20-5	15-9		14-7	20-1
	2 – #4 1 – #6	40,000	15-3	15-10	15-8	20-5	14-11		13-10	
		60,000	15-3	15-10	15-8	20-5	15-10		15-11	
	2 – #5	40,000	15-3	15-10	15-8	20-5	15-10		15-11	
		60,000	15-3	15-10	15-8	20-5	15-10		15-11	
24	1 – #4	40,000	16-1	17-1	13-11	15-10	12-7	14-9	11-8	13-10
		60,000	16-11	18-5	16-1	19-3	14-6	18-0	13-5	17-0
	1 – #5	40,000	16-11	18-5	16-3	19-8	14-9	18-5	13-8	17-4
		60,000	16-11	18-5	17-4		17-0		15-8	
	2 – #4 1 – #6	40,000	16-11	18-5	17-4		16-1		14-10	
		60,000	16-11	18-5	17-4		17-6		17-1	
	2 – #5	40,000	16-11	18-5	17-4		17-6		17-4	
		60,000	16-11	18-5	17-4		17-6		17-8	

For SI: 1 inch = 25.4 mm; 1 psf = 0.0479 kN/m^2; 1 ft = 0.3048 m; Grade 40 = 280 MPa; Grade 60 = 420 MPa

1 See Table 2.1 for tolerances permitted from nominal thickness.
2 Table values are based on concrete with a minimum specified compressive strength of 2,500 psi (17.2 MPa). See note 5.
3 Deflection criterion is *L*/240, where *L* is the clear span of the lintel in inches, or ½-inch (13 mm), whichever is less.
4 Linear interpolation between lintels depths, *D*, is permitted provided the two cells being used to interpolate are shaded.
5 Where concrete with a minimum specified compressive strength of 3,000 psi (20.7 MPa) is used, spans in cells that are shaded shall be permitted to be multiplied by 1.05.
6 Lintel depth, *D*, is permitted to include the available height of wall located directly above the lintel, provided that the increased lintel depth spans the entire length of the lintel.
7 DR indicates design required
8 The maximum clear opening width between two solid wall segments shall be 18 feet (5.5 m). See Section 5.2.1. Lintel spans in table greater than 18 feet are shown for interpolation and information purposes only.

NOTES FOR TABLES 7.19 through 7.22

1. See Table 2.1 for tolerances permitted from nominal thickness.
2. Table values are based on concrete with a minimum specified compressive strength of 2,500 psi. See notes 10 and 12.
3. Table values are based on uniform loading. See Section 7.2 for lintels supporting concentrated loads.
4. Deflection creterion is ***L***/240, where ***L*** is the clear span of the lintel in inches, or ½-inch, whichever is less.
5. Linear interpolation is permitted between roof uplift forces and between lintel depths.
6. The maximum clear span of a lintel shall not exceed 18 feet. Tabular values greater than 18 feet are provided for purposes of interpolation.
7. Lintel depth, ***D***, is permitted to include the available height of wall located directly above the lintel, provided that the increased lintel depth spans the entire length of the lintel.
8. Stirrups shall be fabricated from reinforcing bars with the same yield strength as that used for the main longitudinal reinforcement.
9. Allowable clear span without stirrups applicable to all lintels of the same depth, D. Top and bottom reinforcement for lintels without stirrups shall not be less than the least amount of reinforcement required for a lintel of the same depth and loading conditions with stirrups. All other spans require stirrups spaced at not move than ***d***/2.
10. Where concrete with a minimum specified compressive strength of 2,000 psi is used, clear spans for lintels without stirrups shall be permitted to be multiplied by 1.05. If the increased span exceeds the allowable clear span for a lintel of the same depth and loading condition with stirrups, the top and bottom reinforcement shall be equal to or greater than that required for a lintel of the same depth and loading condition that has an allowable clear span that is equal to or greater than that of the lintel without sitrrups that has been increased.
11. Center distance, ***A***, is the center portion of the span where stirrups are not required. This is applicable to all longitudinal bar sizes and steel yield strengths.
12. Center distance, ***A***, shall be permitted to be multiplies by 1.10 where concrete with a moinimum specified compressive strength of 3,000 psi is used.
13. The maximum clear opening width between two solid wall segments shall be 18 feet. See Section 5.2.1 Lintel spans in table greater than 18 feet are shown for interpretation and informational purposes only.

Table 7.20
Maximum Allowable Clear Spans for 6-inch Nominal Thick Flat Lintels in Top Story Walls Subject to Roof Uplift Forces [1,2,3,4,5,6,13]

TABLE 7.1.9
MAXIMUM ALLOWABLE CLEAR SPANS FOR 4-INCH NOMINAL THICK FLAT LINTELS IN TOP STORY WALS SUBJECT TO ROOF UPLIFT FORCES [1,2,3,4,5,6,13]

Lintel Depth[7], *D* (in.)	Number of bars and bar size in top and bottom of lintel	Steel yield strength[8], f_y (psi)	Factored roof uplift force from Table 7.1A (plf)								
			600	800	1000	1200	1400	1600	1800	2000	2200
			Maximum clear span of lintel for uplift forces (ft-inches)								
8	Span without stirrups[9,10]		5-6	4-1	3-3	2-8	2-3	2-0	2-0	2-0	2-0
	1 – #4	40,000	8-3	7-1	6-4	5-9	5-4	5-0	4-8	4-5	4-3
		60,000	9-10	8-5	7-6	6-10	6-4	5-11	5-4	4-9	4-4
	1 – #5	40,000	10-0	8-7	7-8	7-0	6-5	6-0	5-4	4-9	4-4
	Center distance *A*[11,12]		5-6	4-1	3-3	2-8	2-3	2-0	2-0	2-0	2-0
12	Span without stirrups[9,10]		4-8	3-5	2-9	2-3	2-0	2-0	2-0	2-0	2-0
	1 – #4	40,000	10-11	9-5	8-4	7-7	7-0	6-7	6-2	5-10	5-7
		60,000	13-2	11-4	10-1	9-2	8-6	7-11	7-5	7-1	6-9
	1 – #5	40,000	13-5	11-6	10-3	9-4	8-8	8-1	7-7	7-2	6-10
		60,000	16-1	13-10	12-3	11-2	10-4	9-8	8-11	8-0	7-3
	2 – #4 1 – #6	40,000	15-0	12-11	11-6	10-5	9-8	9-0	8-6	8-0	7-3
		60,000	17-10	15-4	13-8	12-5	11-5	10-1	8-11	8-0	7-3
	Center distance *A*[11,12]		4-8	3-5	2-9	2-3	2-0	2-0	2-0	2-0	2-0
16	Span without stirrups[9,10]		6-9	4-11	3-11	3-2	2-9	2-4	2-1	2-0	2-0
	1 – #4	40,000	13-2	11-3	10-0	9-1	8-5	7-10	7-5	7-0	6-8
		60,000	16-0	13-8	12-2	11-1	10-2	9-6	8-11	8-6	8-1
	1 – #5	40,000	16-4	13-11	12-5	11-3	10-5	9-8	9-2	8-8	8-3
		60,000		16-10	14-11	13-7	12-6	11-8	11-0	10-5	9-11
	2 – #4 1 – #6	40,000	18-3	15-8	13-44	12-8	11-8	10-10	10-3	9-8	9-3
		60,000			16-8	15-2	14-0	13-0	12-3	11-4	10-3
	2 – #5	40,000			17-0	15-5	14-3	13-3	11-9	10-7	9-7
	Center distance *A*[11,12]		6-9	4-11	3-11	3-2	2-9	2-4	2-1	2-0	2-0
20	Span without stirrups[9,10]		8-10	6-5	5-1	4-2	3-6	3-1	2-9	2-5	2-3
	1 – #4	40,000	15-2	13-0	11-6	10-5	9-7	9-0	8-5	8-0	7-7
		60,000	18-6	15-9	14-0	12-8-	11-8	10-11	10-3	9-9	9-3
	1 – #5	40,000	18-10	16-1	14-3	12-11	11-11	11-1	10-6	9-11	9-5
		60,000		19-5	17-3	15-8	14-5	13-5	12-8	12-0	11-5
	2 – #4 1 – #6	40,000		18-1	16-0	14-6	13-5	12-6	11-9	11-2	10-7
		60,000			19-4	17-6	16-2	15-1	14-2	13-5	12-9
	2 – #5	40,000			19-8	17-10	16-5	14-10	13-1	11-9	10-8
		60,000						18-4	16-4	14-8	13-3
	2 – #6	40,000				20-0	17-0	14-10	13-1	11-9	10-8
	Center distance *A*[11,12]		8-10	6-5	5-1	4-2	3-6	3-1	2-9	2-5	2-3
24	Span without stirrups[9,10]		11-1	8-0	6-3	5-2	4-4	3-10	3-4	3-0	2-9
	1 – #4	40,000	17-1	14-6	12-10	11-8	10-9	10-0	9-5	8-11	8-6
		60,000	20-9	17-8	15-7	14-2	13-1	12-2	11-5	10-10	10-4
	1 – #5	40,000		18-0	15-11	14-5	13-4	12-5	11-8	11-0	10-6
		60,000			19-4	17-6	16-2	15-0	14-2	13-5	12-9
	2 – #4 1 – #6	40,000		20-3	17-11	16-3	15-0	13-11	13-1	12-5	11-8
		60,000					18-1	16-10	15-10	15-0	14-3
	2 – #5	40,000					18-5	16-4	14-5	12-11	11-8
		60,000							18-3	16-4	14-10
	2 – #6	40,000					18-9	16-4	14-5	12-11	11-8
	Center distance *A*[11,12]		11-1	8-0	6-3	5-2	4-4	3-10	3-4	3-0	2-9

Lintel Depth[7], *D* (in.)	Number of bars and bar size in top and bottom of lintel	Steel yield strength[8], f_y (psi)	Factored roof uplift force from Table 7.1A (plf)								
			600	800	1000	1200	1400	1600	1800	2000	2200
			Maximum clear span of lintel for uplift forces (ft-inches)								
8	Span without stirrups[9,10]		8-10	6-6	5-2	4-3	3-8	3-2	2-10	2-6	2-3
	1 – #4	40,000	8-6	7-3	6-6	5-11	5-5	5-1	4-9	4-6	4-4
		60,000	10-3	8-9	7-10	7-1	6-7	6-1	5-9	5-5	5-2
	1 – #5	40,000	10-5	8-11	7-11	7-3	6-8	6-3	5-10	5-7	5-3
		60,000	12-5	10-8	9-6	8-8	8-0	7-5	7-0	6-8	6-4
	2 – #4 1 – #6	40,000	11-7	10-0	8-10	8-1	7-5	6-11	6-6	6-2	5-11
	Center distance ***A***[11,12]		8-10	6-6	5-2	4-3	3-8	3-2	2-10	2-6	2-3
12	Span without stirrups[9,10]		7-8	5-7	4-5	3-7	3-1	2-8	2-4	2-2	2-0
	1 – #4	40,000	11-3	9-7	8-6	7-9	7-2	6-8	6-3	5-11	5-8
		60,000	13-8	11-8	10-4	9-5	8-8	8-1	7-7	7-3	6-10
	1 – #5	40,000	13-11	11-11	10-7	9-7	8-10	8-3	7-9	7-4	7-0
		60,000	16-10	14-5	12-9	11-7	10-8	10-0	9-4	8-10	8-5
	2 – #4 1 – #6	40,000	15-8	13-4	11-10	10-9	9-11	9-3	8-9	8-3	7-10
		60,000	18-10	16-1	14-3	12-11	11-11	11-2	10-6	9-11	9-5
	2 – #5	40,000	19-2	16-4	14-6	13-2	12-2	11-4	10-8	10-1	9-7
		60,000		19-5	17-3	15-8	14-5	13-6	12-8	12-0	11--5
	2 – #6	40,000		19-2	17-0	15-5	14-2	13-3	12-4	11-1	10-1
	Center distance ***A***[11,12]		7-8	5-7	4-5	3-7	3-1	2-8	2-4	2-2	1-11
16	Span without stirrups[9,10]		11-2	8-1	6-3	5-2	4-5	3-10	3-4	3-0	2-9
	1 – #4	40,000	13-8	11-7	10-3	9-4	8-7	8-0	7-6	7-1	6-9
		60,000	16-8	14-1	12-6	11-4	10-5	9-9	9-2	8-8	8-3
	1 – #5	40,000	17-0	14-5	12-9	11-6	10-8	9-11	9-4	8-10	8-5
		60,000	20-7	17-6	15-5	14-0	12-11	12-0	11-3	10-8	10-2
	2 – #4 1 – #6	40,000	19-1	16-3	14-4	13-0	12-0	11-2	10-6	9-11	9-5
		60,000		19-7	17-4	15-8	14-6	13-6	12-8	12-0	11-5
	2 – #5	40,000		20-0	17-8	16-0	14-9	13-9	12-11	12-3	11-7
		60,000				19-2	17-8	16-6	15-6	14-8	13-11
	2 – #6	40,000				18-10	17-4	16-2	14-5	12-11	11-9
	Center distance ***A***[11,12]		11-2	8-1	6-3	5-2	4-5	3-10	3-4	3-0	2-9
20	Span without stirrups[9,10]		14-11	10-8	8-3	6-9	5-9	5-0	4-5	3-11	3-6
	1 – #5	40,000	19-9	16-8	14-8	13-3	12-2	11-4	10-8	10-1	9-7
		60,000		20-3	17-10	16-1	14-10	13-10	13-0	12-3	11-8
	2 – #4 1 – #6	40,000		18-9	16-6	14-11	13-9	12-9	12-0	11-4	10-10
		60,000				18-1	16--8	15-6	14-7	13-9	13-1
	2 – #5	40,000				18-6	17-0	15-10	14-10	14-1	13-4
		60,000						19-1	17-11	16-11	16-1
	2 – #6	40,000						18-9	16-7	14-10	13-5
		60,000								18-4	16-7
	Center distance ***A***[11,12]		14-11	10-8	8-3	6-9	5-9	5-0	4-5	3-11	3-6
24	Span without stirrups[9,10]		19-1	13-5	10-4	8-5	7-1	6-2	5-5	4-10	4-4
	1 – #5	40,000	22-4	18-9	16-5	14-10	13-8	12-8	11-11	11-3	10-8
		60,000				18-1	16-7	15-5	14-6	13-8	13-0
	2 – #4 1 – #6	40,000			18-7	16-9	15-4	14-3	13-5	12-8	12-1
		60,000					18-8	17-4	16-4	15-5	14-8
	2 – #5	40,000					19-0	17-9	16-7	15-8	14-11
	2 – #6	40,000							18-9	16-9	15-2
	Center distance ***A***[11,12]		19-1	13-5	10-4	8-5	7-1	6-2	5-5	4-10	4-4

Lintels without stirrups shown in shaded cells shall have top and bottom reinforcement from this table that permits a lintel with stirrups of the same depth and loading condition to have a clear span that is equal to or greater than the span of the lintel without stirrups.

Table 7.20
Maximum Allowable Clear Spans for 8-inch Nominal Thick Flat Lintels in Top Story Walls Subject to Roof Uplift Forces [1,2,3,4,5,6,13]

Lintel Depth[7], *D* (in.)	Number of bars and bar size in top and bottom of lintel	Steel yield strength[8], f_y (psi)	Factored roof uplift force from Table 7.1A (plf)								
			600	800	1000	1200	1400	1600	1800	2000	2200
			Maximum clear span of lintel for uplift forces (ft-inches)								
8	Span without stirrups[9,10]		12-5	9-1	7-2	5-11	5-0	4-4	3-10	3-6	3-2
	1 – #4	40,000	8-8	7-5	6-7	6-0	5-6	5-2	4-10	4-7	4-4
		60,000	10-6	9-0	7-11	7-3	6-8	6-3	5-10	5-6	5-3
	1 – #5	40,000	10-8	9-2	8-1	7-4	6-9	6-4	6-0	5-8	5-5
		60,000	12-10	11-0	9-9	8-10	8-2	7-8	7-2	6-10	6-6
	2 – #4 1 – #6	40,000	12-0	10-3	9-1	8-3	7-7	7-1	6-8	6-4	6-0
		60,000	14-4	12-3	10-10	9-11	9-1	8-6	8-0	7-7	7-3
	2 – #5	40,000	14-7	12-6	11-1	10-1	9-3	8-8	8-2	7-9	7-4
	Center distance ***A***[11,12]		12-5	9-1	7-2	5-11	5-0	4-4	3-10	3-6	3-2
12	Span without stirrups[9,10]		10-11	7-10	6-2	5-0	4-3	3-9	3-3	2-11	2-8
	1 – #4	40,000	11-7	9-10	8-8	7-10	7-3	6-9	6-4	6-0	5-9
		60,000	14-1	11-11	10-7	9-7	8-10	8-3	7-9	7-4	6-11
	1 – #5	40,000	14-4	12-2	10-9	9-9	9-0	8-4	7-10	7-5	7-1
		60,000	17-5	14-9	13-1	11-10	10-11	10-2	9-6	9-0	8-7
	2 – #4 1 – #6	40,000	16-2	13-8	12-1	11-0	10-1	9-5	8-10	8-5	8-0
		60,000	19-6	16-7	14-8	13-3	12-3	11-5	10-8	10-2	9-8
	2 – #5	40,000	19-11	16-11	14-11	13-6	12-5	11-7	10-11	10-4	9-10
		60,000		20-3	17-11	16-3	14-11	13-11	13-1	12-4	11-9
	2 – #6	40,000		19-11	17-7	15-11	14-8	13-8	12-10	12-2	11-7
	Center distance ***A***[11,12]		10-11	7-10	6-2	5-0	4-3	3-9	3-3	2-11	2-8
16	Span without stirrups[9,10]		16-2	11-5	8-10	7-3	6-1	5-3	4-8	4-2	3-9
	1 – #4	40,000	14-1	11-11	10-6	9-5	8-8	8-1	7-7	7-2	6-10
		60,000	17-3	14-6	12-9	11-6	10-7	9-10	9-3	8-9	8-4
	1 – #5	40,000	17-7	14-9	13-0	11-9	10-10	10-1	9-5	8-11	8-6
		60,000	21-4	18-0	15-10	14-4	13-2	12-3	11-6	10-10	10-4
	2 – #4 1 – #6	40,000	19-9	16-8	14-8	13-3	12-2	11-4	10-8	10-1	9-7
		60,000		20-3	17-10	16-1	14-9	13-9	12-11	12-3	11-7
	2 – #5	40,000			18-2	16-5	15-1	14-0	13-2	12-5	11-10
		60,000					18-2	16-11	15-11	15-0	14-3
	2 – #6	40,000				19-5	17-10	16-7	15-7	14-9	13-11
		60,000							18-8	17-8	16-9
	Center distance ***A***[11,12]		16-2	11-5	8-10	7-3	6-1	5-3	4-8	4-2	3-9
20	Span without stirrups[9,10]		22-0	15-4	11-9	9-7	8-0	6-11	6-1	5-5	4-11
	1 – #5	40,000	20-7	17-2	15-1	13-7	12-5	11-7	10-10	10-3	9-9
		60,000		20-11	18-4	16-6	15-2	14-1	13-2	12-6	11-10
	2 – #4 1 – #6	40,000		19-4	17-0	15-3	14-0	13-0	12-3	11-6	11-0
		60,000				18-7	17-0	15-10	14-10	14-0	13-4
	2 – #5	40,000				18-11	17-5	16-2	15-2	14-4	13-7
		60,000							18-4	17-4	16-6
	2 – #6	40,000						19-2	18-0	17-0	16-2
	Center distance ***A***[11,12]		22-0	15-4	11-9	9-7	8-0	6-11	6-1	5-5	4-11
24	Span without stirrups[9,10]			19-7	14-11	12-0	10-1	8-8	7-7	6-9	6-1
	1 – #5	40,000		19-5	16-11	15-3	13-11	12-11	12-1	11-5	10-10
		60,000				18-7	17-0	15-9	14-9	13-11	13-3
	2 – #4 1 – #6	40,000			19-2	17-2	15-9	14-7	13-8	12-11	12-3
		60,000					19-2	17-9	16-7	15-8	14-11
	2 – #5	40,000						18-1	17-0	16-0	15-2
	Center distance ***A***[11,12]			19-7	14-11	12-0	10-1	8-8	7-7	6-9	6-1

Lintels without stirrups shown in shaded cells shall have top and bottom reinforcement from this table that permits a lintel with stirrups of the same depth and loading condition to have a clear span that is equal to or greater than the span of the lintel without stirrups.

Table 7.20
Maximum Allowable Clear Spans for 10-inch Nominal Thick Flat Lintels in Top Story Walls Subject to Roof Uplift Forces [1,2,3,4,5,6,13]

Lintel Depth[7], ***D*** (in.)	Number of bars and bar size in top and bottom of lintel	Steel yield strength[8], f_y (psi)	Factored roof uplift force from Table 7.1A (plf)								
			600	800	1000	1200	1400	1600	1800	2000	2200
			Maximum clear span of lintel for uplift forces (ft-inches)								
8	Span without stirrups[9,10]		8-10	6-6	5-2	4-3	3-8	3-2	2-10	2-6	2-3
	1 – #4	40,000	8-6	7-3	6-6	5-11	5-5	5-1	4-9	4-6	4-4
		60,000	10-3	8-9	7-10	7-1	6-7	6-1	5-9	5-5	5-2
	1 – #5	40,000	10-5	8-11	7-11	7-3	6-8	6-3	5-10	5-7	5-3
		60,000	12-5	10-8	9-6	8-8	8-0	7-5	7-0	6-8	6-4
	2 – #4 1 – #6	40,000	11-7	10-0	8-10	8-1	7-5	6-11	6-6	6-2	5-11
	Center distance ***A***[11,12]		8-10	6-6	5-2	4-3	3-8	3-2	2-10	2-6	2-3
12	Span without stirrups[9,10]		7-8	5-7	4-5	3-7	3-1	2-8	2-4	2-2	2-0
	1 – #4	40,000	11-3	9-7	8-6	7-9	7-2	6-8	6-3	5-11	5-8
		60,000	13-8	11-8	10-4	9-5	8-8	8-1	7-7	7-3	6-10
	1 – #5	40,000	13-11	11-11	10-7	9-7	8-10	8-3	7-9	7-4	7-0
		60,000	16-10	14-5	12-9	11-7	10-8	10-0	9-4	8-10	8-5
	2 – #4 1 – #6	40,000	15-8	13-4	11-10	10-9	9-11	9-3	8-9	8-3	7-10
		60,000	18-10	16-1	14-3	12-11	11-11	11-2	10-6	9-11	9-5
	2 – #5	40,000	19-2	16-4	14-6	13-2	12-2	11-4	10-8	10-1	9-7
		60,000		19-5	17-3	15-8	14-5	13-6	12-8	12-0	11--5
	2 – #6	40,000		19-2	17-0	15-5	14-2	13-3	12-4	11-1	10-1
	Center distance ***A***[11,12]		7-8	5-7	4-5	3-7	3-1	2-8	2-4	2-2	1-11
16	Span without stirrups[9,10]		11-2	8-1	6-3	5-2	4-5	3-10	3-4	3-0	2-9
	1 – #4	40,000	13-8	11-7	10-3	9-4	8-7	8-0	7-6	7-1	6-9
		60,000	16-8	14-1	12-6	11-4	10-5	9-9	9-2	8-8	8-3
	1 – #5	40,000	17-0	14-5	12-9	11-6	10-8	9-11	9-4	8-10	8-5
		60,000	20-7	17-6	15-5	14-0	12-11	12-0	11-3	10-8	10-2
	2 – #4 1 – #6	40,000	19-1	16-3	14-4	13-0	12-0	11-2	10-6	9-11	9-5
		60,000		19-7	17-4	15-8	14-6	13-6	12-8	12-0	11-5
	2 – #5	40,000		20-0	17-8	16-0	14-9	13-9	12-11	12-3	11-7
		60,000				19-2	17-8	16-6	15-6	14-8	13-11
	2 – #6	40,000				18-10	17-4	16-2	14-5	12-11	11-9
	Center distance ***A***[11,12]		11-2	8-1	6-3	5-2	4-5	3-10	3-4	3-0	2-9
20	Span without stirrups[9,10]		14-11	10-8	8-3	6-9	5-9	5-0	4-5	3-11	3-6
	1 – #5	40,000	19-9	16-8	14-8	13-3	12-2	11-4	10-8	10-1	9-7
		60,000		20-3	17-10	16-1	14-10	13-10	13-0	12-3	11-8
	2 – #4 1 – #6	40,000		18-9	16-6	14-11	13-9	12-9	12-0	11-4	10-10
		60,000				18-1	16--8	15-6	14-7	13-9	13-1
	2 – #5	40,000				18-6	17-0	15-10	14-10	14-1	13-4
		60,000						19-1	17-11	16-11	16-1
	2 – #6	40,000						18-9	16-7	14-10	13-5
		60,000								18-4	16-7
	Center distance ***A***[11,12]		14-11	10-8	8-3	6-9	5-9	5-0	4-5	3-11	3-6
24	Span without stirrups[9,10]		19-1	13-5	10-4	8-5	7-1	6-2	5-5	4-10	4-4
	1 – #5	40,000	22-4	18-9	16-5	14-10	13-8	12-8	11-11	11-3	10-8
		60,000				18-1	16-7	15-5	14-6	13-8	13-0
	2 – #4 1 – #6	40,000			18-7	16-9	15-4	14-3	13-5	12-8	12-1
		60,000					18-8	17-4	16-4	15-5	14-8
	2 – #5	40,000					19-0	17-9	16-7	15-8	14-11
	2 – #6	40,000							18-9	16-9	15-2
	Center distance ***A***[11,12]		19-1	13-5	10-4	8-5	7-1	6-2	5-5	4-10	4-4

Lintels without stirrups shown in shaded cells shall have top and bottom reinforcement from this table that permits a lintel with stirrups of the same depth and loading condition to have a clear span that is equal to or greater than the span of the lintel without stirrups.

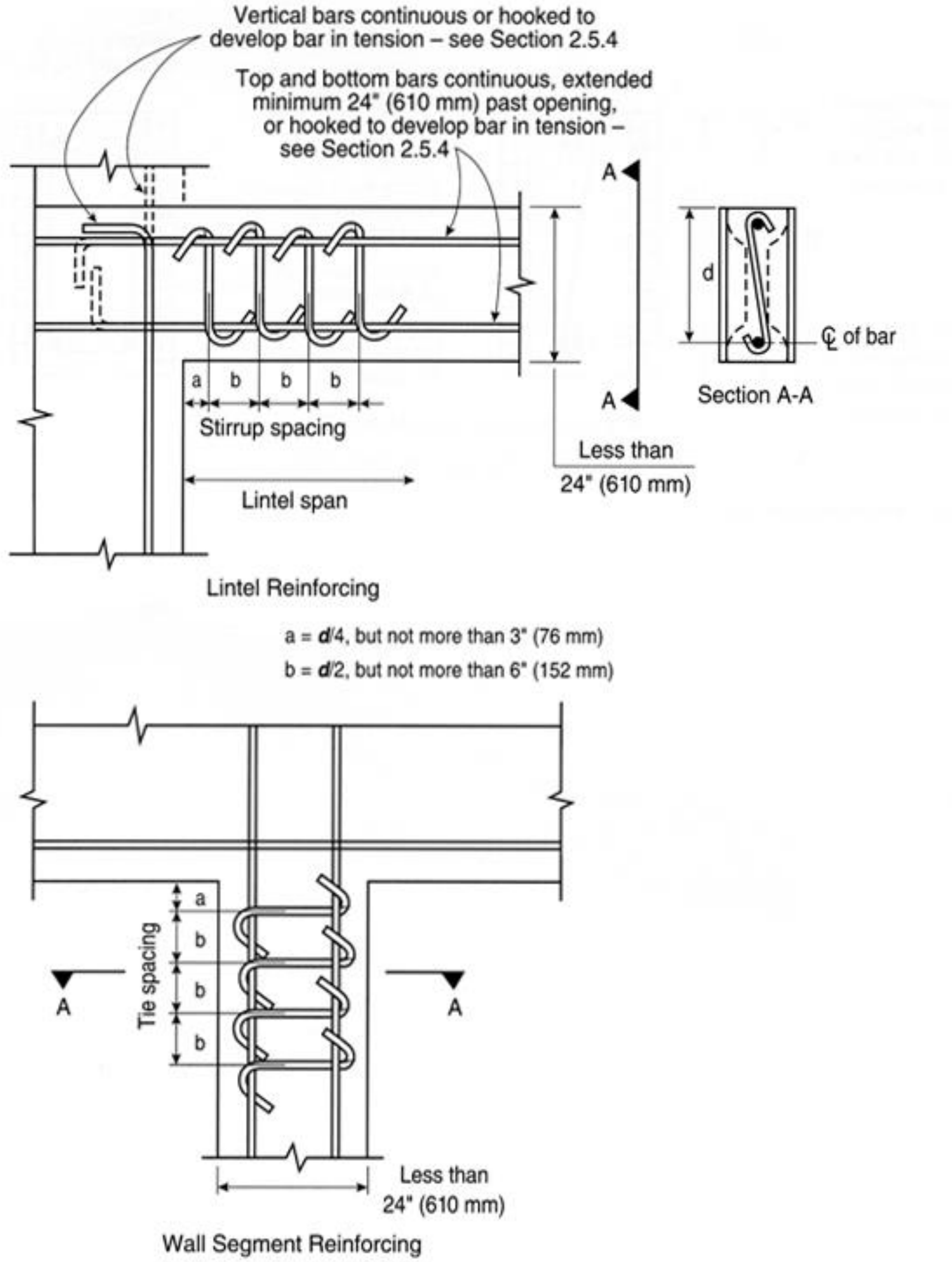


Figure 7.2. Lintel and wall segment reinforcing for Seismic Design Categories C, D_0, D_1 and D_2.

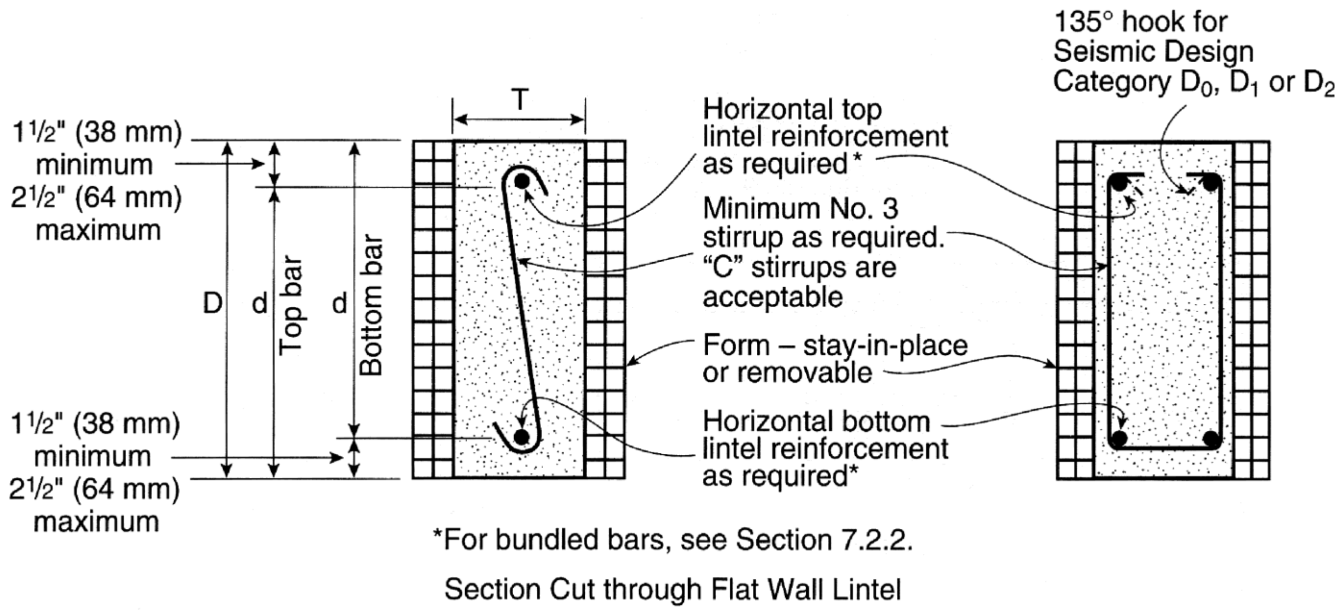


Figure 7.3. Flat lintel construction.