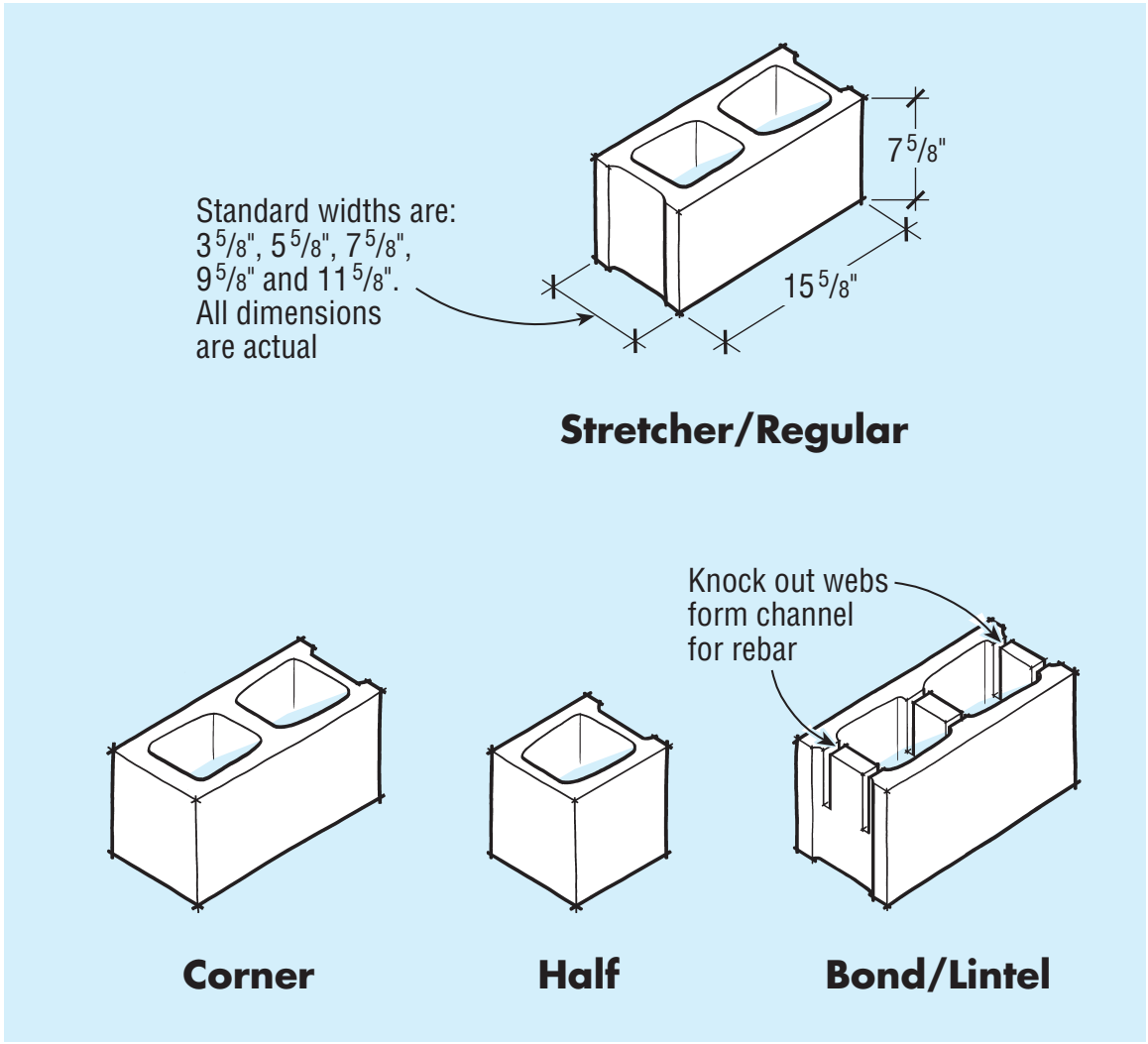
FOUNDATIONS
CONCRETE BLOCK

For block foundations, effective perimeter drainage is critical to reduce lateral soil pressures, especially for full basements (see Perimeter Foundation Drains). And block is also very porous, so waterproofing or dampproofing is important to control moisture intrusion (see Waterproofing and Dampproofing).

BLOCK TYPES

Most block basements are built with two-core or three-core hollow, loadbearing concrete masonry units (CMUs). Solid blocks are used to carry point loads and to cap foundations. **Figure A** shows some of the common types of block likely to be needed for building a block basement. Other specially shaped blocks are available for use in bond beams, joist and girder pockets, window and door openings, pilasters, and piers..

FIGURE A: COMMONLY USED MASONRY UNITS



Block Grades
When selecting block, choose blocks graded according to ASTM standards. Use only ASTM Grade N for foundations, not Grade S. Grade N has greater bearing strength and better resistance to frost action and moisture.

Block Types
Masonry units of ASTM Type I (moisture-controlled), rather than Type II, are recommended; Type I units are less susceptible to drying shrinkage and cracking.

Block Dimensions
Concrete block generally conforms to a modular system based on 4 in. or 8 in. Depth, height, and length of blocks are stated in full inches, but the actual dimensions are reduced by 3/8 in. or 5/8 in. to allow for the mortar joint. That way, walls can be designed in full lengths based on feet and inches (see Estimating Block), and block laid with mortar joints will fall out correctly when installed.

In describing block, the wall or block width is always named first, then the course or block height, and finally the length of the block. For example, an 8x8x16-in. unit is actually 75/8 in. thick, 75/8 in. high, and 155/8 in. long. Most block is available in half sizes, but odd lengths or heights may have to be cut on site.

MORTAR
Mortar serves to bond the units together, accommodate minor size variations between units, and create a seal against air and moisture. Mortar may also bond with reinforcing wire placed between courses.

Grout is different from mortar. Grout is used to fill block cores for reinforcement (see Grouting Block Foundations).

Mortar Ingredients
Mortar is made of Portland cement, hydrated lime, sand, and water. Portland cement gives mortar its compressive strength. The lime weakens the mix, but improves its workability and helps form a better seal. Sand provides strength and also reduces drying shrinkage. Water provides workability and enhances the bond to the block or brick.

Mortar Types
Mortars are graded by type, based on the proportions of the ingredients (see **Figure B**). The five traditional mortar types are known as Type M, S, N, O, and K, in de-scend-ing order of compressive strength (using every other letter from the phrase "Mason Work"). Types with higher proportions of cement and lower proportions of lime have greater compressive strengths but are less workable.

FIGURE B: STANDARD MORTAR MIXES

Type	Cement	Lime	Sand	Compressive Strength (psi)
M	1	1/4	3	2,500
S	1	1/2	4	1,800
N	1	1	6	750
O	1	2	9	350
K	1	3	12	75

Use these ratios of ingredients for mixing different mortar types. Typically, one bag of materials (cement and lime) is equivalent to 1 cu. ft. of loose material (sand). The ratios of ingredients alter the compressive strength of the mortars, but also affect workability and bond strengths. As a rule of thumb, tensile strength is a little less than one-tenth the compressive strength.

For block joints: Many skilled masons prefer Type N (a.k.a. "6-1-1") for bonding block because it has better workability, allowing for a better-made joint and a better bond. The higher lime content also makes this mortar more "extensible," or flexible, in service.

For parging: Use Type M or S mortar for parging block prior to dampproofing (see **Parging Concrete Block** in Dampproofing).

Mortar Strength

Type M or Type S mortar is often specified for basement foundations because of its higher compressive strengths (**Figure C**). However, the compressive strength of the mortar is less important than the quality of the joint and strength of the bond. (Cutting the mortar's compressive strength in half lowers the compressive strength of the total wall assembly by only about 10%.) If lateral soil loads are a concern, no mortar will provide sufficient strength. Instead, the block cores should be filled with grout and rebar (see **Reinforcing Block Walls**).

FIGURE C: COMPRESSIVE STRENGTH OF MORTAR TYPES

Mortar Type	Average Compressive Strength at 28 Days (min. psi)
M	2,500
S	1,800
N	750
O	350

Mortar Water Content

Unlike concrete, which should be made with as little water as practical, mortar performs best when made with as much water as possible for a workable mix. Wetter mortar makes a stronger bond with the block, increasing the performance of the total wall system.

Site-Mixed Mortar

Mortar is usually mixed on site with water, Portland cement, lime, and sand. Site-mixing allows skilled masons to fine-tune the quality of the mortar, easing the labor and improving the quality of the job.

Pre-Bagged Mortar

Pre-bagged masonry cement mixes are available, with the cement and lime pre-proportioned so that only sand and water need to be added. If unskilled help is mixing the mortar, pre-bagged cements make it easier to get a uniform mix from batch to batch.

Bagged Material Weights

Bags of Portland cement, masonry cement, and lime all contain 1 cu. ft. of material per bag, although they weigh different amounts. Portland cement weighs almost 100 lbs./cu. ft.; lime weighs about 50 lbs./cu. ft.; and masonry cements— which are mixtures of Portland and lime—weigh somewhere in between, depending on the type.

FOOTINGS FOR BLOCK FOUNDATIONS

Footings for block walls do not differ much from cast footings for poured concrete walls (see **Footings**).

If block and other materials will be staged inside the building perimeter before footings are poured, take care that stored materials do not prevent you from checking cross- diagonals and measuring foundation widths.

SETTING BLOCK

As with concrete, mortar sets up best in humid climates with temperatures averaging above 40°F and below 70°F. In climate conditions above and below this, follow similar procedures described in **Hot-Weather Concrete** and **Cold-Weather Concrete**.

GROUTING BLOCK FOUNDATIONS

Grout is used to fill cores and bond beams for strength, along with appropriately sized and placed steel rebar. Grout is not the same as mortar. It is really a type of concrete, made with Portland cement, water, sand, and small crushed rock or pea gravel, but little or no lime. Grout typically reaches a compressive strength of 2,500 to 3,000 psi.

Ordering Ready-Mix Grout

Grout is best ordered from a ready-mix plant. A grout mix delivered by truck typically will be about an 8-bag concrete mix with maximum 1/2-in. gravel.

Site Mixed Grout

If mixing small batches of grout on site, make sure to mix the batch for at least five minutes. Place the grout soon after mixing. Discard any batch of grout that is not placed within 90 minutes.

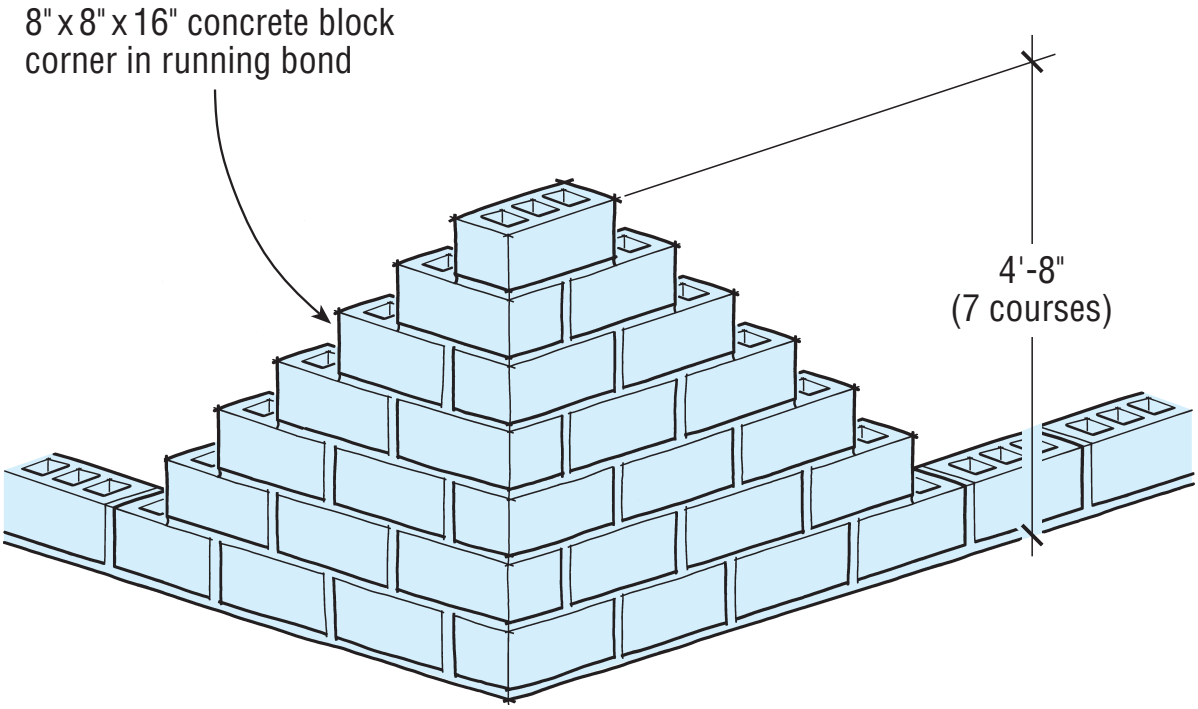
BLOCK CONSTRUCTION DETAILS

If you have control over design decisions, lay out the distances between corners and bump-outs, as well as the dimensions of door and window openings, in increments of 8- or 16-in. to match full- and half-block lengths.

Running Bond

Concrete blocks are designed to be laid in a running bond (sometimes called half-bond) pattern in which the vertical joint of two adjoining blocks falls over the center of the block below (**Figure D**).

FIGURE D: RUNNING BOND

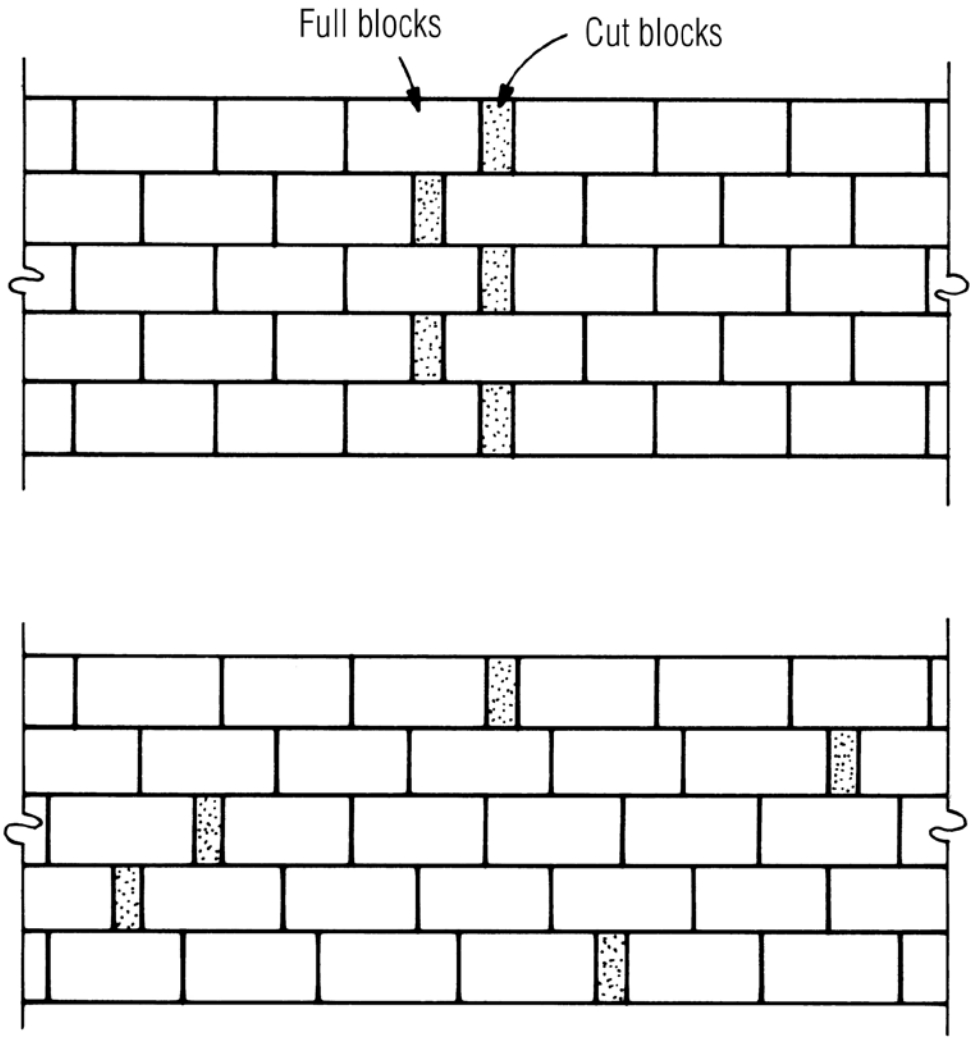


A running bond starts from the corner with each course offset by half a block from the one below it. By building up the corner first, a mason can establish the course heights and the plumb of the wall.

Cut Block Placement

If blocks must be cut, maintain a running bond by staggering cut blocks symmetrically (**Figure E**). Joints can be as close as 4 in. from a joint in the courses above and below and not affect the strength of the wall; but the appearance will suffer if the joints are off-center. Where portions of the wall will have cores filled with concrete, keep the half-bond dead accurate.

FIGURE E: CUT BLOCK PLACEMENT

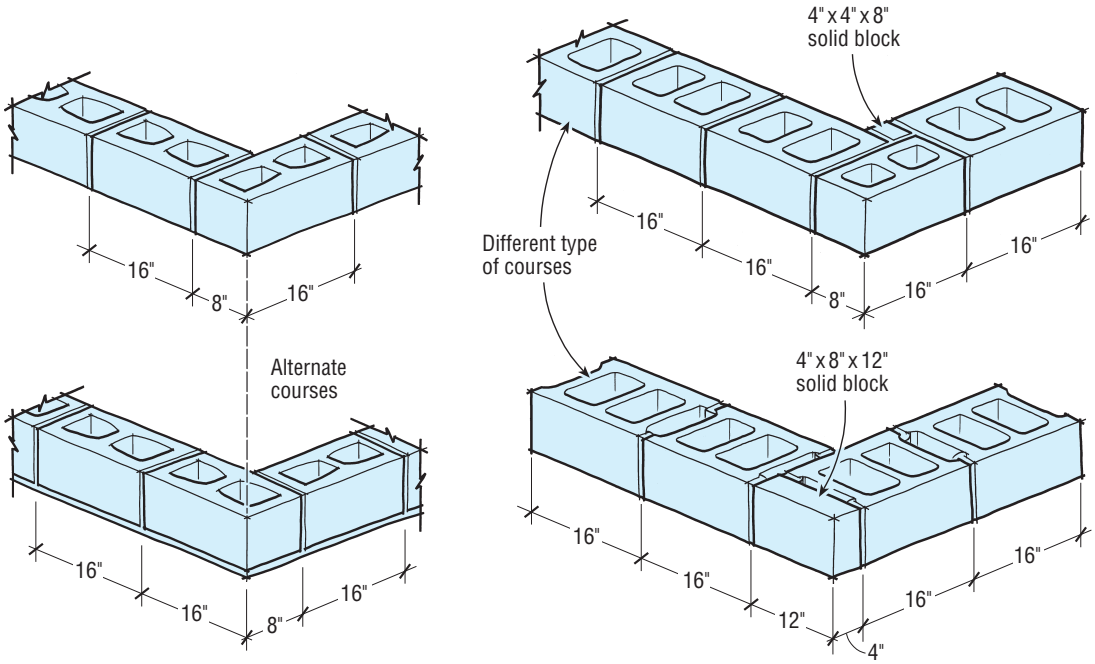


If the length of a wall doesn't divide evenly into full blocks, align cut blocks in succeeding courses (**at top**). This keeps the cores lined up and looks much better than random placement (**at bottom**).

Building Block Corners

Corners are a key detail in a block basement, and must be built to maintain a modular layout. With 8-in. block, weaving block at corners establishes the 8-in. running bond and keeps the cores in two-core block in line (**Figure F**). For 10- and 12-in. block, a number of techniques can be used to lay out corners (**Figures G and F**); the simplest method uses special corner block.

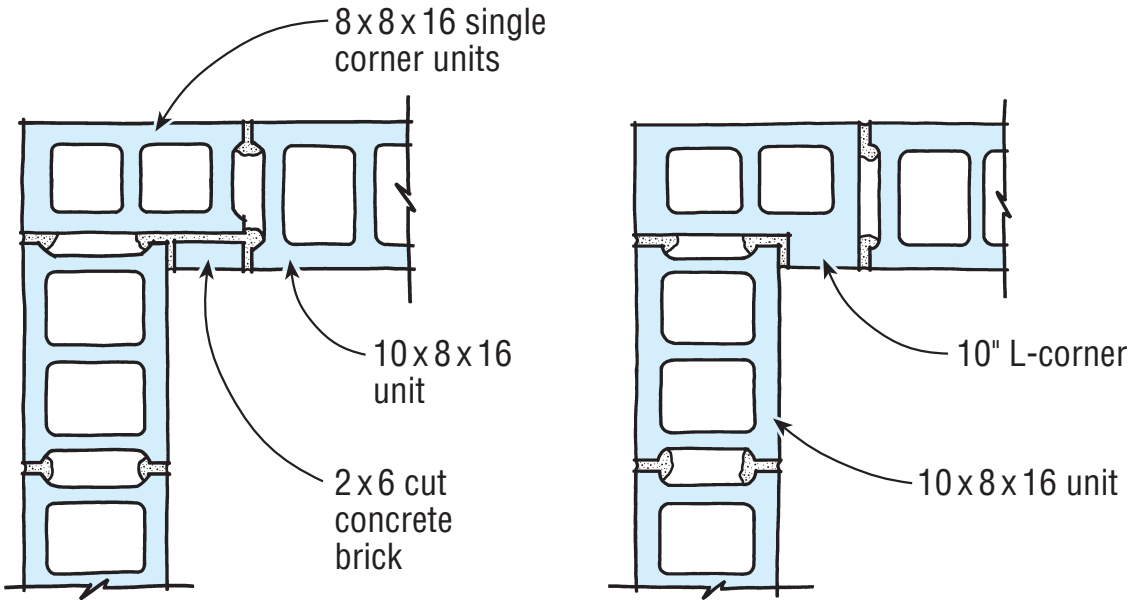
FIGURE F: CORNER LAYOUT FOR BLOCK



8-Inch Block **12-Inch Block**

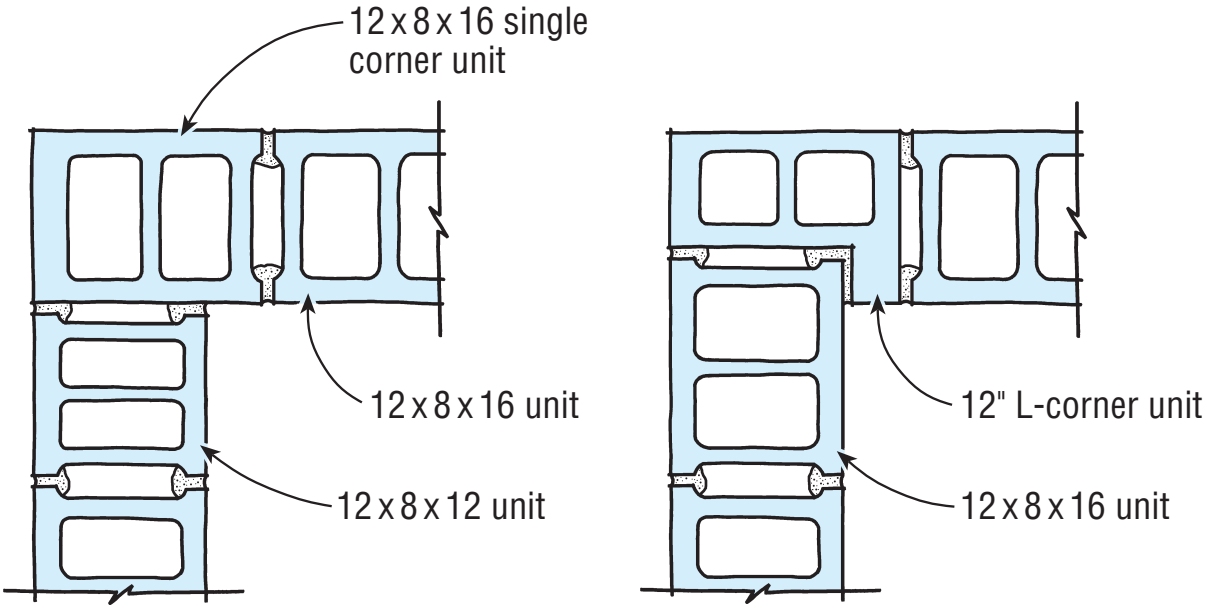
Maintain a running bond with standard block by weaving corners in alternate courses.

FIGURE G: CORNER LAYOUT FOR 10-IN. BLOCK



Standard Corner Construction **Special L-Corner Construction**

FIGURE H: CORNER LAYOUT FOR 12-IN. BLOCK



Standard Corner Construction

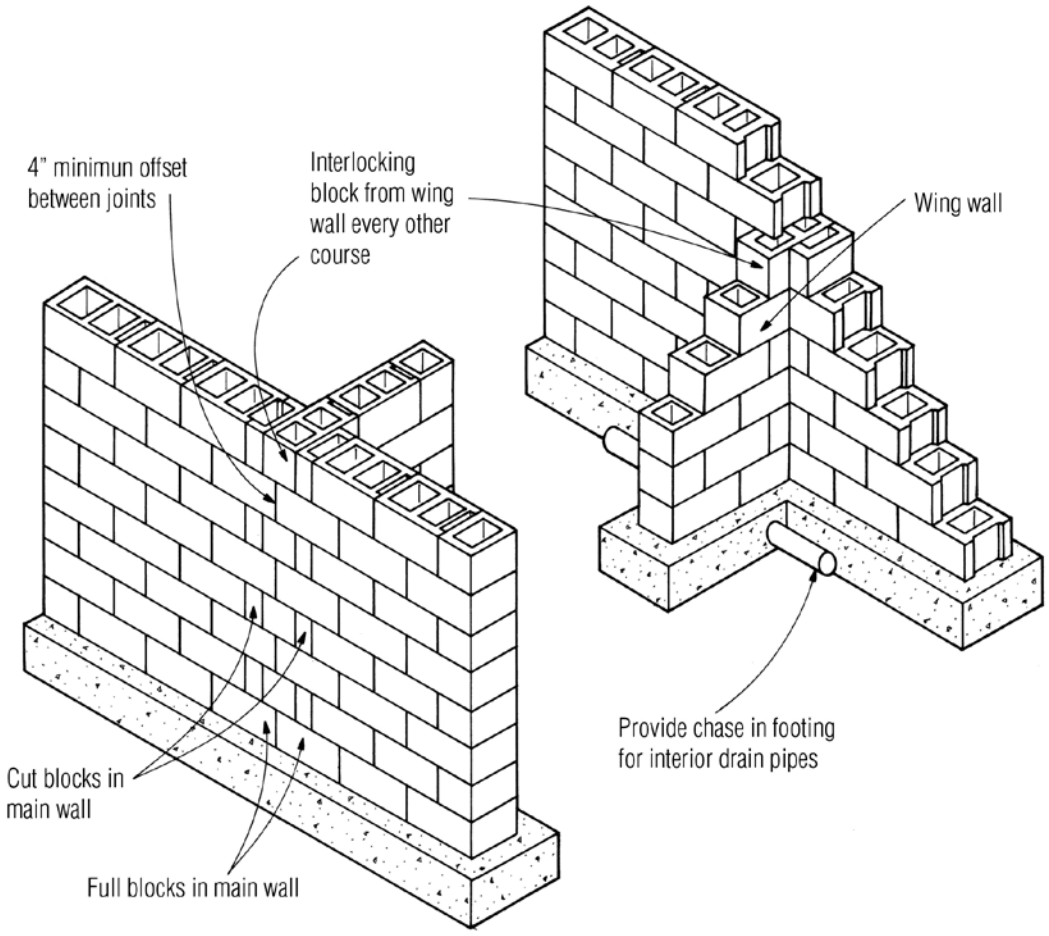
Special L-Corner Construction

Concrete Block Intersections

Wall intersections add strength to help resist soil pressure. Buttresses or "wing walls" can be built to stiffen main walls even if no partition is called for (**Figure I**).

Weave alternate courses together just as in building a corner, and grout all cores and reinforce with steel.

FIGURE I: INTERSECTING BLOCK WALLS



Where block walls join, the blocks must intersect on alternating courses. Fill the cores with grout and rebar running through the intersecting blocks to pin the walls -together.

Block Construction Details

Reinforcing Block Walls

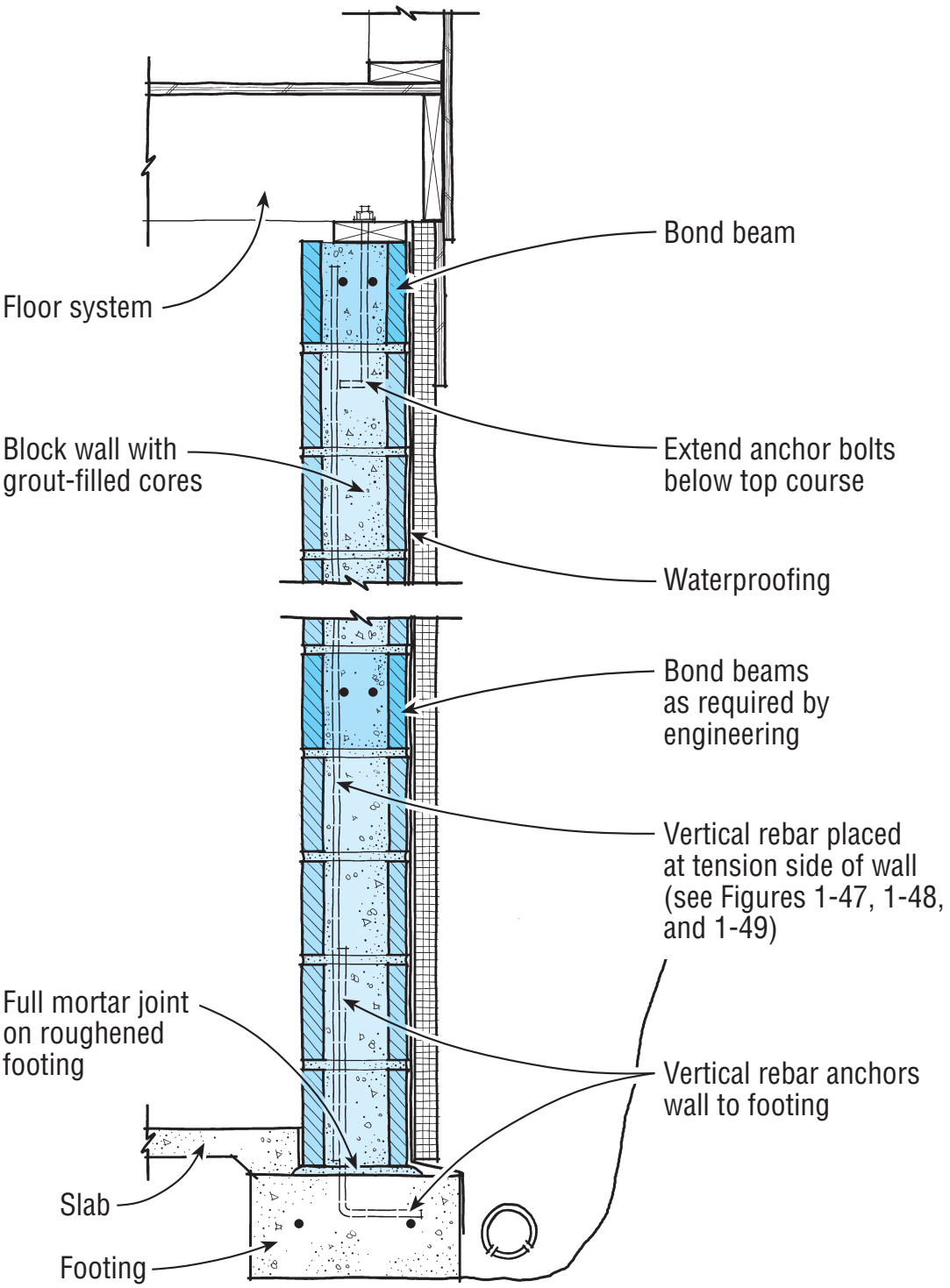
REINFORCING BLOCK WALLS

Follow general guidelines for reinforcing foundations (see **Rebar**).

Rebar placed in grouted cores adds significant stiffness and strength to masonry basement walls. Place rebar towards the inside face of full-height foundation walls, and tie it securely into the footing (**Figure J**).

For appropriate sizing and spacing of rebar in masonry foundations, follow the minimum code requirements shown in **Figures** in **Sizing and Spacing in Walls**.

FIGURE J: REINFORCING BLOCK WALLS

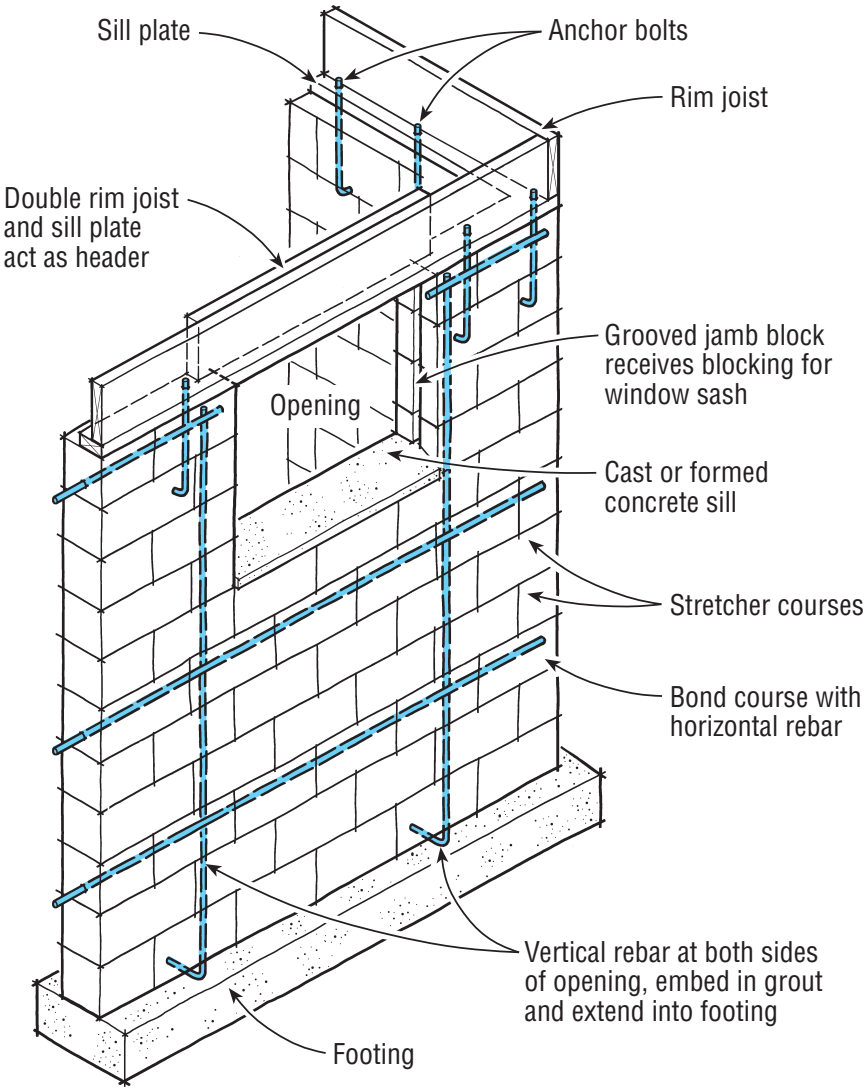


Reinforcing for block walls consists primarily of vertical rebar embedded in columns of grout-filled cores to the full-height of the foundation wall. Rebar must tie to the footing, and anchor bolts must extend below the top course of block.

Reinforcing Openings in Block Foundations

To prevent cracking at stress points near openings, place reinforcing steel, as shown in **Figure K.**

FIGURE K: REINFORCED OPENING IN A BLOCK FOUNDATION



In addition to the vertical rebar specified by code (figures, "Foundation Wall Reinforcements"), additional rebar embedded in grout should surround window openings. In an opening at the top of a foundation wall, the sill plate and floor framing act as a header and tie together the top sections of the block

Anchoring Floor Framing to Block Foundations

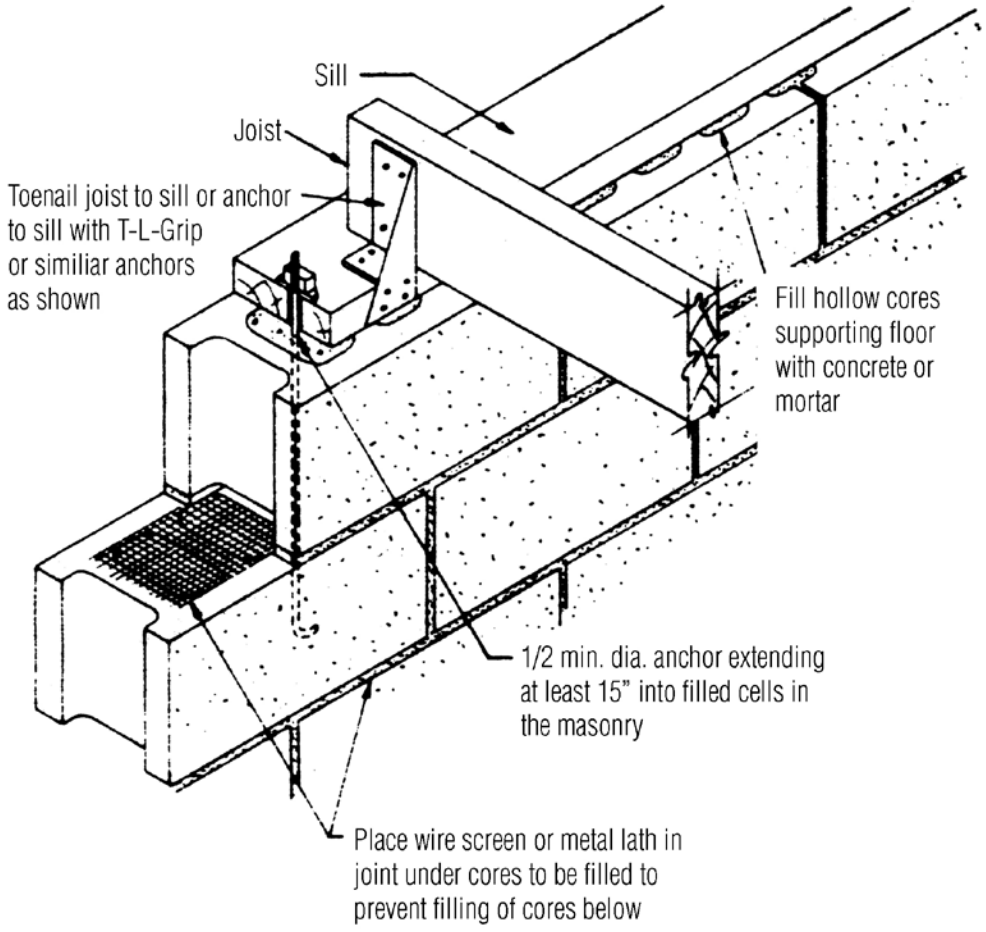
In most block foundations, the floor framing acts as a critical brace to stabilize the top of the block wall. First-floor decks must be securely tied to the block:

- Anchor bolts should be embedded at least 12 in. into grouted cores. Ideally, the core with the anchor bolt should be fully grouted down to the footing, contain vertical rebar, and be tied to the footing with a rebar dowel (**Figure J**).
- Floor joists must be securely fastened to the sill plate with toenails or clips (**Figure L**).
- Bracing or blocking on joists parallel to foundation wall must extend three joists back from the wall (**Figure M**).

Bond Beams

In tall foundation walls (8 ft. or higher) a bond beam running along the top course is recommended to tie walls together, particularly in poor soil conditions. On wet sites and in seismic zones, an engineer may also specify bond beams for lateral support midway in the foundation wall elevation (**Figure L**).

FIGURE L: TYING BLOCK TO FLOOR FRAMING

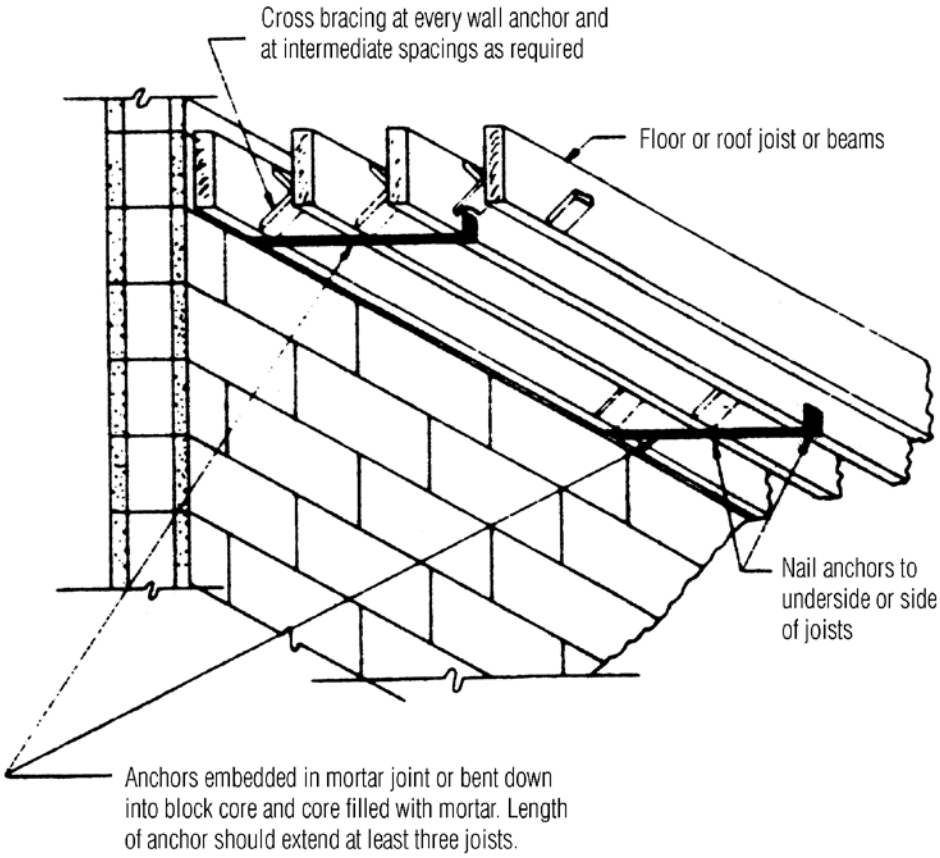


In order to distribute the loads from joists and beams, the bearing course of block should either be capped by 4-in.-thick solid masonry, or anchored into concrete-filled (grouted) block cores.

Reinforcing Block Walls

To form bond beams, place rebar and pour grout in the channel made by knocking out the webs in special bond-beam block. Use two #4 bars in 8-ft. walls and two #5 bars in 10- or 12-ft. walls. Lap bars at joints, and bend bars around corners by at least 24 bar diameters..

FIGURE M: BRACING BLOCK WALLS



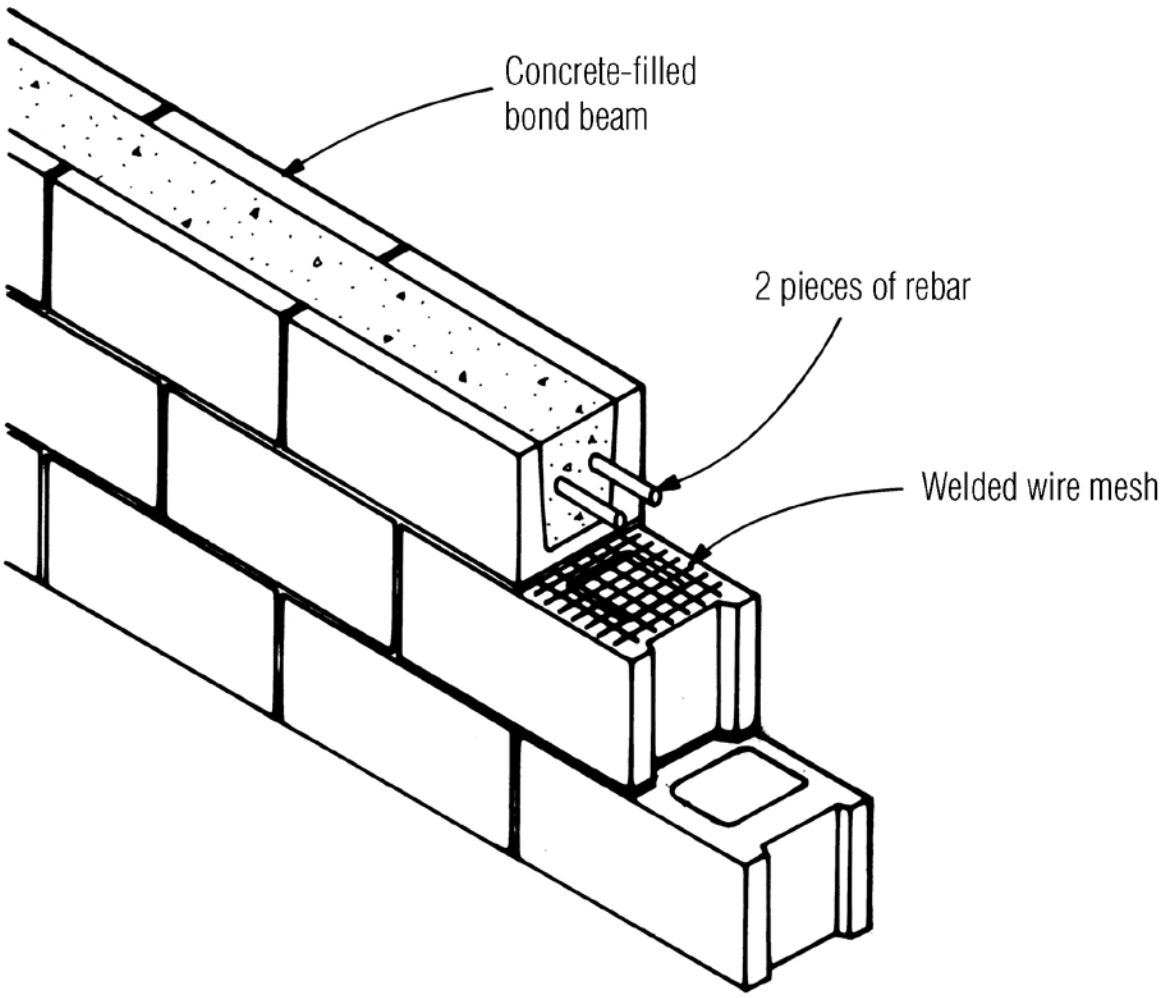
Joists running parallel to a block wall should be braced every 8 ft. The bracing (or joist blocking) should span at least three joists.

Joint Reinforcement

Wire-mesh joint reinforcement is used to help reduce the size of cracks, but it does not add appreciable structural strength. Typically, mesh is placed in the mortar joints every second or third course (**Figure N**).

FIGURE N: BOND BEAM

Reinforcing Block Walls



To strengthen a block wall against lateral pressure, place a -horizontal bond beam halfway up the wall.