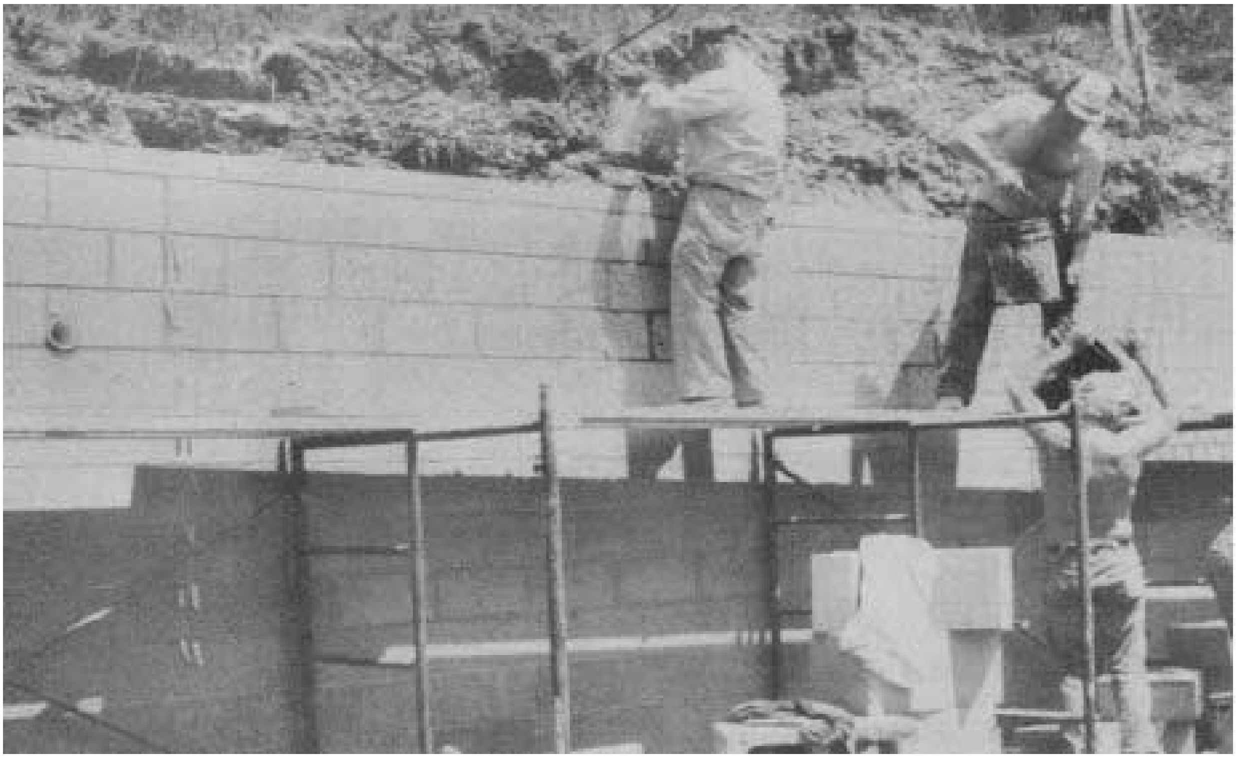


BUILDING ON BLOCK

by Robert VanLaningham

Details for sturdy and dry block foundations

A recent study conducted by the National Association of Home Builders found that about one out of every three homes built today includes a basement. The growing popularity of below-grade space is due to the increasing need for living, recreational, and storage space at an affordable cost. And with the scarcity and high cost of buildable land, the most affordable option is often to build down.

While above-grade residential space costs from $47 to $62 per square foot (1986 prices), below-grade space built from concrete masonry drops to $18 to $32 per square foot depending upon the level of insulation and special features. With proper design and construction, concrete masonry can provide an extremely affordable, comfortable, and dry living space at a lower cost than competitive materials.

Non-Reinforced Walls

A joint committee of the American Concrete Institute and the American Society of Civil Engineers has recently proposed values for the minimum wall thickness and maximum depth of unbalanced fill for non-reinforced concrete-masonry basement walls. These are shown in Table 1. The values are based more on observations of what works than on theoretical analyses. They are based on average conditions and assume earth pressures and compressive loads typical in light building construction. For above-average earth pressures, higher walls (more than 8 feet), or deeper fill, you will need to consider using a thicker wall section, a reinforced design, or lateral support such as crosswalls or pilasters.

In general, it's difficult to justify the use of reinforced masonry basement walls in residential construction except where seismic forces, extremely poor soil, or other unusual forces or conditions come into play.

Pilasters

Pilasters—essentially thickened wall sections—are often used to support heavy concentrated vertical loads and to provide lateral support for basement walls. They can be built of hollow or solid units. The hollow type can be filled with grout or concrete and can be reinforced. Generally, standard rules or code requirements are used to select the dimensions and spacing of non-reinforced pilasters used to stiffen walls. A suggested "rule of thumb" is that the pilaster projection should be not less than one-twelfth the pilaster height between supports and the width not less than one-tenth the wall length between

Table 1. Thickness of Foundation Walls

Foundation Wall Construction	Nominal Thickness (inches)	Maximum Depth of Backfill (Unbalanced)(1) (feet)
Masonry of hollow units, ungrouted	8	4
	10	5
	12	6
Masonry of solid units	8	5
	10	6
	12	7
Masonry of hollow units, fully grouted	8	7
	10	8
	12	8

(1) Based on 30 pounds per cubic feet

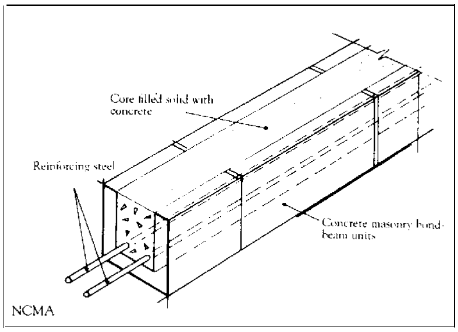


Figure 1. Bond beams are made from special masonry units filled with concrete or grout and reinforced with steel. They give increased strength and stiffness to the wall, thereby reducing cracks.

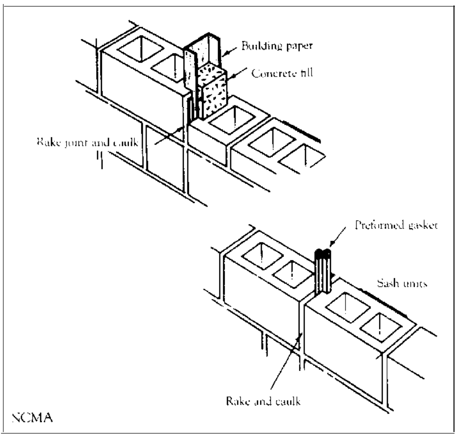


Figure 2. Control joints, such as the Michigan joint shown at left, reduce cracking by accommodating movement in the wall. Yet the joint transfers enough shear and flexural strength to keep the wall from being pushed in by earth pressures. Another version, shown at left below, uses a pre-formed star-shaped gasket.

pilasters or other vertical supports. Reinforced masonry pilasters can serve as full lateral supports for basement walls.

Bond Beams and Joint Reinforcement

Concrete-masonry walls can be made stronger and stiffer in the horizontal span by adding horizontal reinforcement in the walls, either in the form of bond beams or joint reinforcement.

In basement walls, bond beams are most effective when located at or near the top of the wall and built so they extend continuously around the foundation (see Figure 1). Used this way they act not only as edge-stiffening beams, but also serve to: (1) distribute concentrated loads over the wall length and thickness; (2) eliminate the need for separate lintels above openings just under the bond beam; and (3) prevent or minimize vertical crack development.

Horizontal joint reinforcement, like bond beams, can help prevent cracks. But it adds little horizontal strength.

Horizontal joint reinforcement (such as that made by Dur-O-Wal, Inc., Arlington Heights, Ill., and A.A. Wire Products Co., Chicago, Ill.), like bond beams, can help prevent cracks—but adds little horizontal strength. Its effect is limited by the amount of steel that can be embedded in the joints and the bond strength that can be developed between the mortar, the reinforcement, and the masonry units.

For that reason, it's generally best to ignore any theoretical increase in horizontal flexural strength due to joint reinforcement. Rather, your design should assume the wall is unreinforced. Bond beams, on the other hand, can contribute appreciably to wall strength and stiffness.

When considering the use of bond beams and joint reinforcement in foundation walls, remember that neither will add appreciably to the strength of the walls in the vertical span.

Openings

Portions of masonry walls that lie below-grade face relatively small changes in moisture and temperature. Above-grade sections, however, see wide variations, and therefore build up tensile stresses. These stresses can cause cracks to radiate from the corners of window and door openings.

To prevent such cracking, strengthen around the openings with horizontal joint reinforcement. For window openings, install the reinforcement in the two courses immediately above and below the openings, extending it at least 24 inches beyond the jambs in each direction. For a door opening in a walk-out basement, run the reinforcing along the entire wall at every other course. Interrupt the reinforcing only at a control joint, which you should locate at one side of the door opening and extend from the jamb to the top of the wall.

Expansion and Control Joints

Avoid using expansion and control joints in basement construction when possible because they weaken the walls in the horizontal span and increase the possibility of leakage. Fortunately, these joints are rarely needed in masonry foundation walls because the earth contact keeps movement due to thermal and moisture change in such walls quite low.

In most cases, you can control cracking with a bond beam or horizontal joint reinforcement at or near the top of the walls. Where you must use control joints, make sure they are designed to transfer shear across the joint so earth pressure cannot push the wall in at that point. Also design the joint to protect against leaks. The Michigan joint (Figure 2) accomplishes both these goals. Other methods use special preformed gaskets, or blocks shaped to interlock.

Moisture Protection

Moisture protection is a primary concern with concrete block foundation walls. Moisture tends to migrate from damp soil to the dry interior surfaces of basement walls. In general, a solid, non-porous barrier is needed to divert water away from the exterior face of the wall. Any coatings put on the interior surface of the wall must be permeable to permit moisture that gets in the wall to evaporate. Otherwise water pressure can build up within the wall causing spalling on the interior.

Two types of barriers are generally applied to exterior wall surfaces to protect basements from moisture: dampproofing and waterproofing.

Dampproofing commonly refers to coatings that prevent the passage of water vapor through walls and restricts the flow of liquid water that is under slight pressure. The effectiveness of dampproofing methods is somewhat limited.

Waterproofing refers to coatings or materials that prevent moisture from penetrating in either its vapor or liquid form.

The two terms—dampproofing and waterproofing—are often used interchangeably, giving the owner or occupant the false impression that dampproofing will afford the same degree of protection as waterproofing.

If the native soil is well-drained or if the basement will be used only for storage, dampproofing may be adequate. However, if the soil is poorly drained or if the basement is to be used for recreational or living purposes, waterproofing techniques are recommended to insure a dry environment.

Dampproofing. Parging, grout-coating, and asphalt coating are considered acceptable coatings for dampproofing.

1. Parging (plastering) consists of a ½-inch-thick coat of Portland cement and sand mix (1:2½ by volume), or Type M mortar, applied in two ¼-inch layers.

To prevent excessive moisture absorption from the parge coat and thus assure better bonding, the masonry surface should he cleaned and sprayed (not soaked) with water immediately before parging.

Roughen the first coat when partially set, allow it to harden fro 24 hours, and then moisten it before applying the second coat. Trowel the second coat to a dense, tight surface and form into a cove on the footing to prevent water from accumulating at the juncture between the wall and the footing. The final coat should be moist cured for at least 48 hours before backfilling.

2. Cement-grout coats are applied in two thick applications by brushing with a stiff-bristle brush. Grout consists of equal parts by volume of Portland cement and fine sand (passing No. 30 sieve) mixed with water to a thick, creamy consistency and stirred frequently to prevent segregation.

The first coat should be moist cured for at least 24 hours and dampened immediately before the second coat is applied. Curing of the second coat should also be continued 24 hours.

3. Asphalt coatings, applied hot or cold, may be either sprayed, brushed, or troweled. Troweling is the preferred method. Hot asphalts tend to become brittle and crack upon cooling, while cold asphalt coatings are not capable of bridging normal structural cracks. Both will function satisfactorily, however, when used in accordance with the manufacturers' instructions.

With moderately wet soils, more stringent measures may be needed. For example, you can apply two brush coats of bituminous coatings over parging. Over cement-coated grouts, you can trowel on one heavy coat of cold fiber-reinforced asphaltic mastic.

Generally speaking, dampproofmg materials should not be applied when the ambient air temperature is below

Dampproofing is not waterproofing. It blocks the flow of water vapor and water under slight pressure. But it won't hold off water under sustained pressure.

40°F or the masonry surface is above 90°F, unless they are specifically formu-

Waterproofing. If you're working in very poorly drained and highly impermeable soils, and want the space fit for habitable use, you'll need a proven waterproofing barrier. To be effective, the barrier material must form a continuous blanket or enclosure with no leakage at joints or laps. Materials that can satisfy the above requirements include composite sheet membranes, synthetic rubber sheet membranes, surface bonding materials, and bentonite.

1. Composite sheet membranes, such as bituthene, are sheets of polyethylene, polyvinylchloride, or glass fabric coated with rubberized asphalt usually 50 mils thick. The membrane is available in sheet or roll form in widths of 3 to 4 feet.

Install sheets horizontally starting from the footings, with each successive sheet overlapping the previous sheet a minimum of 2 inches to direct water toward the drain. Because positive contact is mandatory to keep water from

membrane to the surface where required, and also to eliminate potential leakage paths for moisture that has managed to infiltrate between the membrane and the wall.

3. Surface-bonding materials are proprietary mortar systems which combine glass fibers with Portland Cement and other additives. The surface to be coated should be dampened lightly prior to application. The mortar is troweled smooth to an average thickness of 1/8 inch. Power sprayers can be used to apply coatings on large projects, although final troweling is still required for proper fiber orientation. Consult the manufacturer's instructions regarding curing.

For optimum protection, apply a bituminous coating such as asphalt or pitch after the surface-bonding material has been allowed to dry.

4. Bentonite exists as a natural clay that swells from 16 to 22 times its original volume when in contact with water. Once the clay expands, it becomes impervious to the penetration of additional water.

True waterproofing requires a continuous barrier against water. This system uses spray-on bentonite (Bentonize), a clay that expands when wet sealing off all leaks.

getting between the membrane and the wall, a primer must be applied to the masonry surface prior to installation. The laps must also be completely sealed to prevent leakage.

When the composite sheet membrane contains polyethylene, you must backfill as soon as possible to prevent deterioration from exposure to ultraviolet light.

2. Synthetic-rubber sheet membranes, consisting of two or more plies and having uniform, controlled thicknesses, may be installed fully bonded to the masonry surface or laid loose (unbonded) according to the manufacturer's recommendations. Proper sealing of laps is critical and often difficult under job conditions.

Synthetic rubber sheet membranes are available in sheets sized up to 20x100 feet and are more specifically identified as: Butyl rubber (polyisobutylene), EPDM (Ethylene Propylene Diene Monomer), and Neoprene (Polychloroprene).

Both sheet membranes and synthetic rubber membranes require special precautions during construction. The exterior face of the masonry wall must be aligned as carefully as possible; the units must be free from cracks, chips and other imperfections; and the mortar joints should be finished flush with the face of the wall. These steps are necessary to allow full bonding of the

Bentonite is available in two forms: cardboard panels filled with bentonite, or as a spray-on material.

a) Cardboard panels are nailed to the masonry surface. The cardboard decomposes rapidly when in contact with water, so the panels must be protected from rain until completion of backfilling. When the cardboard decomposes, the bentonite expands between the masonry and the earth and forms an effective water barrier.

b) Spray-on bentonite (Bentonize) consists of bentonite mixed with a mastic binder that enables the material to stick to the masonry surface. The recommended application is 3/8 inch thick. Backfilling must be completed before rainfall to prevent the material from being washed from the surface.

Because damage can render any waterproofing barrier ineffective, it is important to protect the barrier during installation and backfilling, and from later protrusions into the soil, such as from roots. You should protect the waterproofing with a covering such as fiber board, roofing felt, cement-asbestos board, or similar durable materials.

No system will work well under all conditions. Seek advice about which system is best for your situation from an experienced waterproofing contractor. Whenever possible, find a contractor experienced in the installation of the type of barrier selected.

Footings

Place concrete-masonry foundation walls on cast-in-place concrete or solid, interlocking concrete-masonry units (known as footer block). Generally, footings should be twice as wide as the wall thickness for average soil conditions. With poor soils or silt, or excessive loads, wider and thicker footings may be required. Similarly, if the soil under the footing varies greatly in compressibility, it's a good idea to put some longitudinal reinforcement in the footing, lest differential settlement cause cracking.

Always place footings on firm, undisturbed soil below the level of frost penetration. Backfill any excavations under the footing level, such as trenches for sewer, water, or other utilities, with a well-compacted gravel or crushed stone. Reinforce concrete footings where they cross such trenches or other unstable soil areas. Where tile drains are installed around the perimeter of footings, make sure the bottom of the drain is well above the level of the base of the footing to avoid the possibility of washing out, or undermining, the soil under the footing.

The top of the footing should be level and clean. Remove all dirt, mud, and water to provide a good bond with the mortar. After the corners of the basement have been accurately located on the footing, you can snap a chalk line to locate the wall.

Except with exceptionally well-drained subsoil, use a drain tile. But never connect downspouts to this tile. Unfortunately, when the time comes to install the drain tile, the side slopes of the excavation will generally have crumbled and filled in next to the footing where the tile should go. If this happens, take the time to dig out around the footing — making sure the bottom of the tile lies below the top of the footing.

As another precaution against leaks, it is important to create a cove of mortar at the bottom of the wall (Figure 3) to keep water from collecting there.

Wall Construction

Place the first course of concrete masonry on the footing in a full bed of mortar. Remaining courses may be laid up with mortar on the "face shell" only (the outer two faces of the block, not the webs). Mortar joints should be 3/8-inch thick, and should be firmly compacted with a 5/8-inch-diameter rounded tool after the mortar has stiffened. Joints in areas to be plastered, however, may be struck flush.

To insure adequate distribution of concentrated loads from joists, beams, or other members, build the bearing course in hollow-unit walls of solid masonry. Most regulations require a solid-masonry bearing course 4 inches thick under floor slabs, joists, beams, or girders. Alternatives for the top course include filling the cores of hollow units with concrete or mortar (Figure 4), or using a reinforced bond beam.

Anchorage

Where the first-floor joists laterally support the tops of the basement walls, the ends of the joists should be securely anchored to the walls. Anchorage should be minimally at every fourth joist or every 6 feet. Similarly, joists or beams parallel to foundations walls should be anchored to the walls with metal anchors at spacings not exceeding 8 feet with the anchors engaging at least three parallel joists (see Figure 5).

Crosswalls and partitions in basements must also be anchored to the exterior basement walls if they are to serve as lateral supports for the exterior wills. Where two walls connect at a corner, lay them up in a true masonry bond to insure that the walls will act together and mutually support one another in resisting lateral loads.

Where loadbearing walls intersect other than at corners, one wall should be terminated at the face of the other and the walls tied together by means of metal ties (Figure: 6). These should be

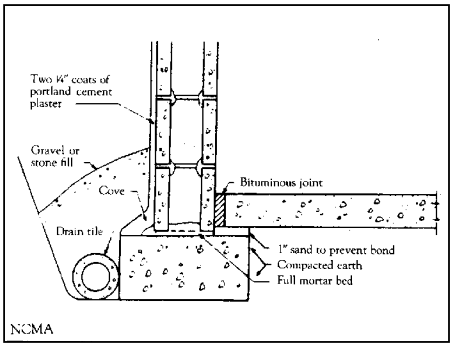


Figure 3. *At the bottom of the wall, form the mortar into a cover to shed water from the footing/wall joint.*

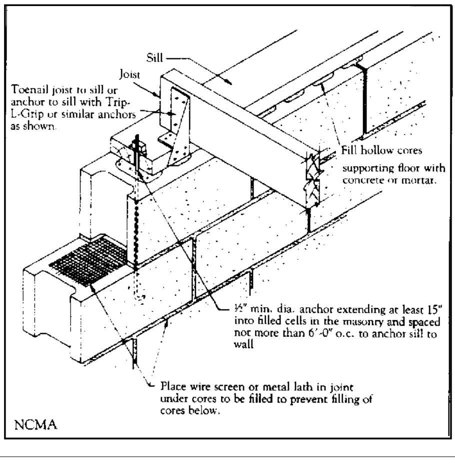


Figure 4. *In order to distribute the loads from joists and beams, the bearing course of block should either be 4-inch-thick solid masonry, or concrete-filled hollow units, as shown. Also, joists should be securely anchored to provide lateral support to walls.*

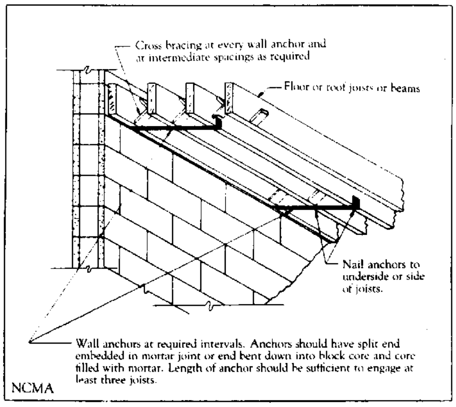


***Figure 5.** Joists parallel to a block wall should be anchored at a minimum of every eight feet. Anchors should engage at least three joists.*

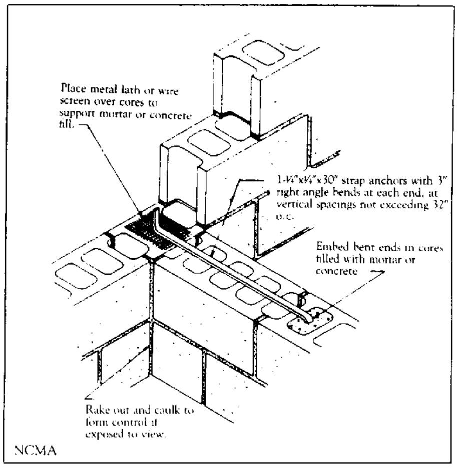
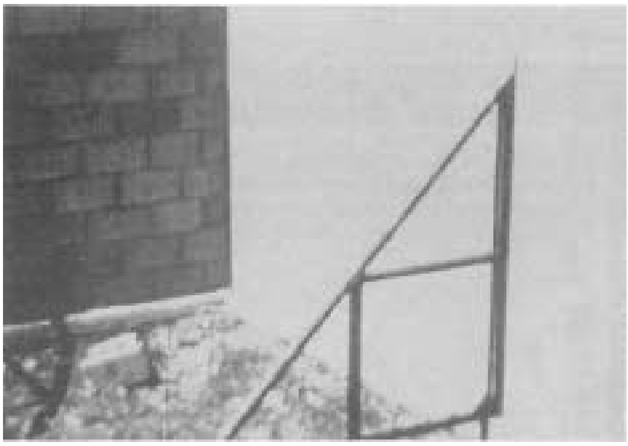


***Figure 6.** Where loadbearing walls intersect, tie them together with metal tie bars. This provides the tensile and shear strength of a true masonry bond, but allows for some movement at the joint.*



NCMA

Don't backfill a block wall unless the floor joists are in or the walls are securely braced with temporary supports.

sized and spaced to provide tensile and shearing resistance theoretically equivalent to what a masonry-bonded connection would provide. At the same time, this type of joint can function as a control joint, since the metal tie bars permit some slight longitudinal movement of the walls. To permit this movement the mortar in the joint should be raked out to a depth of about 3/4 inch and filled with plastic caulking compound.

You can use essentially the same detail to tie nonbearing partitions to exterior basement walls. But you can substitute strips of metal lath, galvanized hardware cloth, or prefabricated wire ties in alternate courses for the metal tie bars. In earthquake-prone areas, these connections require special attention.

Bracing and Backfilling

If you backfill before installing the first floor, make sure you adequately brace the basement wall to provide lateral support. It is also important to place backfill in shallow lifts and properly compact it. Take care to prevent damaging the moisture barrier (see "Moisture Protection") during the backfilling operation.

Also, never operate heavy equipment any closer to a wall than the distance equal to the height of the fill or risk collapsing the wall. For example, don't try to use a front-end loader to compact the backfill.

In summary, the need for increased space at a reasonable cost is becoming greater each day in the residential market. Basements provide the most affordable means to fulfill this need. Concrete block with all its attributes — versatility, quality, durability, speed of erection, and low cost — is well suited for the job. ■

Robert VanLaningham is an engineer with the National Concrete Masonry Association in Herndon, Va.