CITY of NORTH OLMSTED

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Regulations for Residential Dampproofing (Waterproofing)

General Guidelines

- Dampproofing, colloquially called waterproofing by many contractors, is governed by the Residential Code of Ohio (RCO) and the requirements of the City of North Olmsted Engineering Department.
- The contractor is also responsible to do all of the following:
  - Verify that the drain tile/storm flow is open and unobstructed to the city storm sewer,
  - Provide a capped clean out to grade with access to the length of the wall along each wall being worked on, and
  - Have all work inspected before covering or backfilling and again at the completion of the work.

Submittal for Permit

- An application for permit accompanied by an accurate noted and dimensioned scale plan of the proposed work, including sections/details of the work if a foundation wall or any portion of a foundation wall is to be reconstructed, must be submitted and approved prior to a permit being issued. Attached are graphic examples of a wall section that may be noted and used in the application.
- If appurtenances, such as steps or a deck, must be removed to do the dampproofing work, a permit with a compliant drawing is required to reconstruct them unless they can be lifted out of and set back into place, such as a set of wood steps. All new or reconstructed work must comply with the current RCO.
- The application must be signed by the authorized parties.
- An estimated, but *reasonable* cost must be provided to report to the County.
- If a contractor is doing the work, they must be registered with the City and it is their responsibility to apply for and pick up the permit.

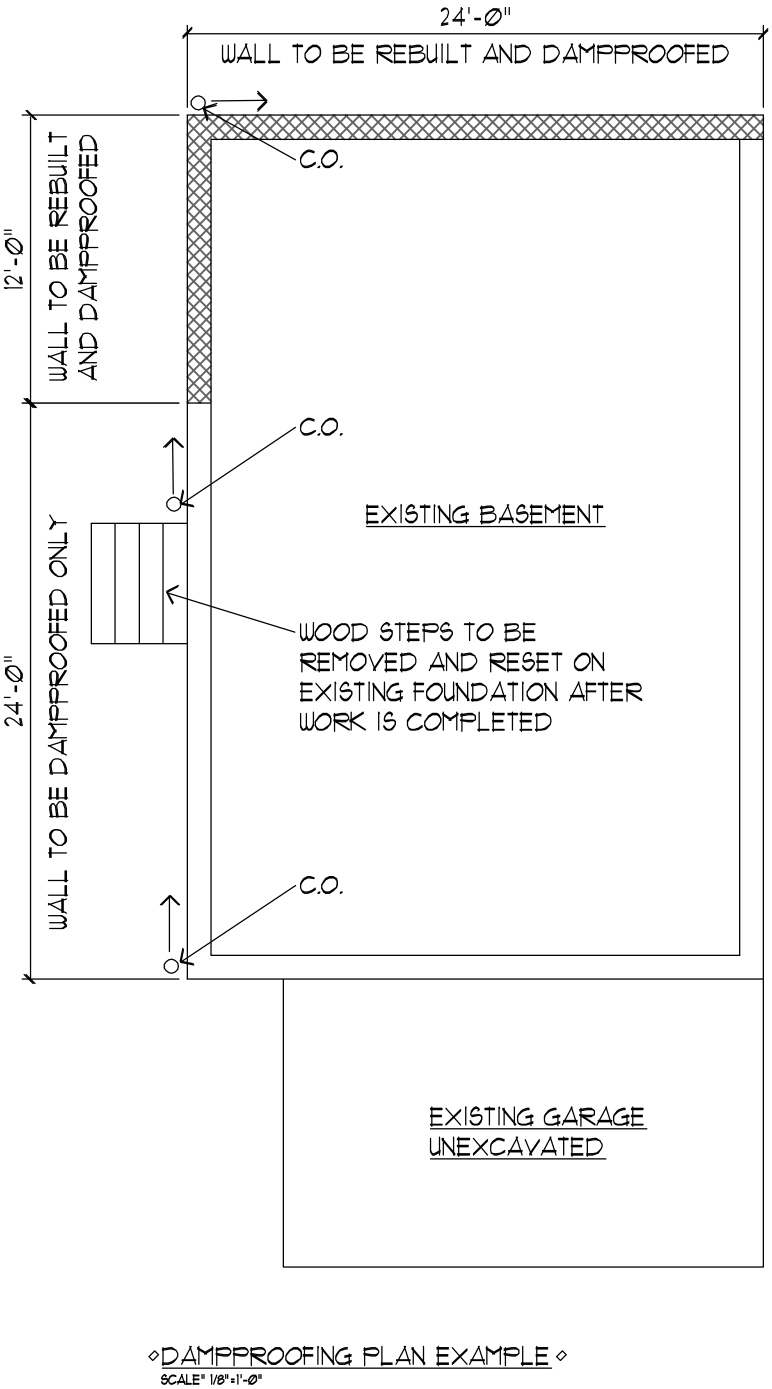
Recommendations for Homeowners and Contractors

- Attached are NCMA recommendations. It is also recommended that the gravel be placed to within 12" of grade with a filter fabric on top (and then planting soil or concrete walk over that) to encourage better drainage. A drainage panel (insulation panel) over the wall and before backfill should also be considered.
- After excavation, look over the wall to make sure that it is adequately cleaned, power washed and wire brushed to remove all loose material before the parging.
- Look over the parging before applying the bituminous dampproofing. Make sure that the parging is neat, smooth and of the appropriate thickness.
- During and after the bituminous application, make sure that it is applied per the recommendations of the manufacturer. These instructions should be with the material on site or available on line.
- Make sure that the drain tile is laid with the holes down, properly connected and wrapped in a filter fabric. Clean outs at each end or turn should be considered and at least one is required to access each wall section. Verify that remaining drain tile is clear and operational.
- Make sure that the ground surface/concrete is graded to drain away from the wall.

Attachments

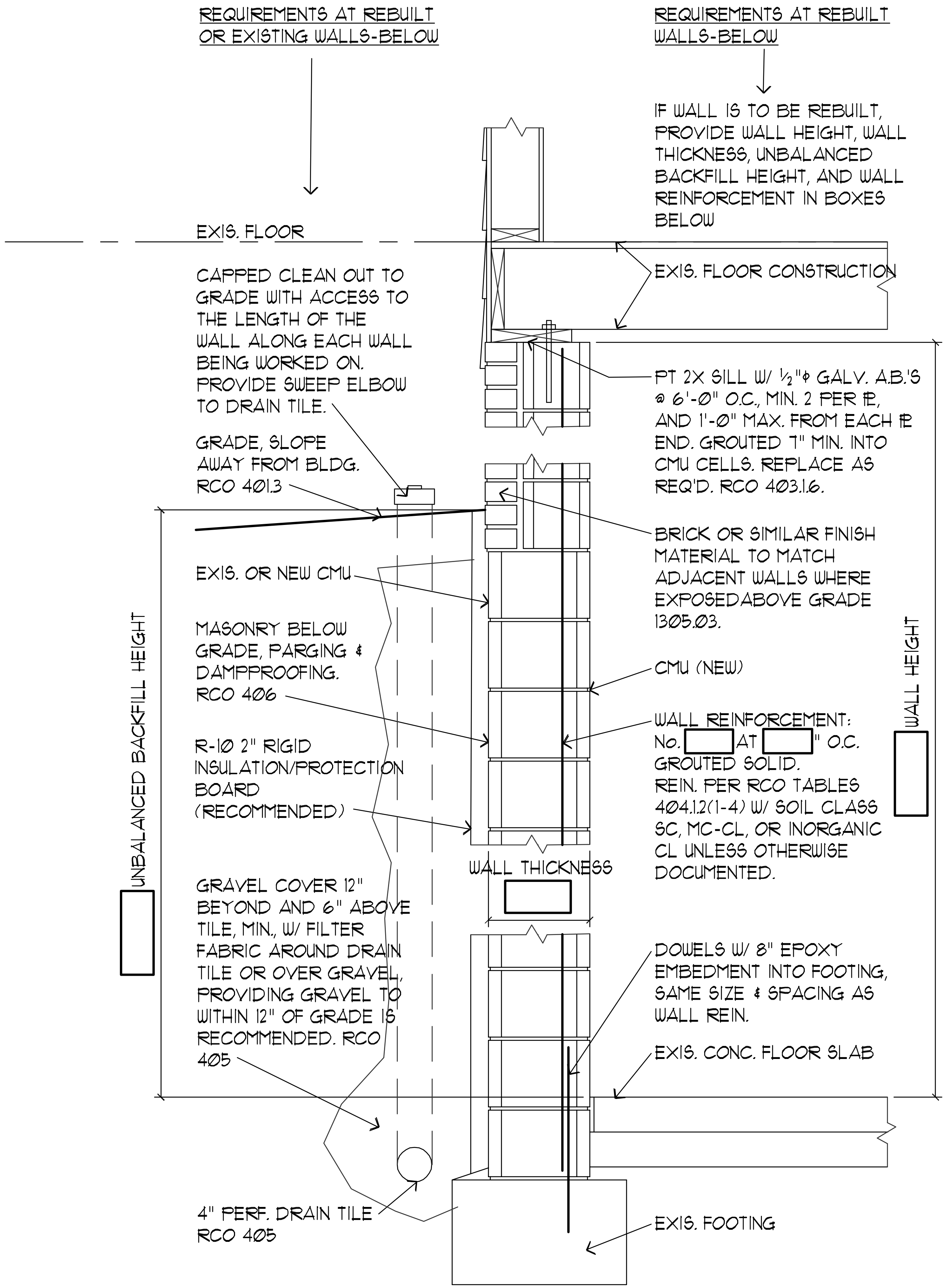
- Plan Example
- Typical section for markup of dampproofing and wall reconstruction requirements and recommendations
- NCMA TEK 19-03B2 Preventing Water Penetration in Below-Grade Concrete Masonry Walls and NCMA TEK 03-11 Concrete Masonry Basement Wall Construction

Nothing contained herein shall be construed to change or modify the pertinent Ordinances or codes.



DAMPPROOFING PLAN EXAMPLE

SCALE" 1/8"=1'-Ø"



DAMPPROOFING SECTION

SCALE: ¾"=1'-0"

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PREVENTING WATER PENETRATION IN BELOW-GRADE CONCRETE MASONRY WALLS

TEK 19-3B

Water Penetration Resistance (2012)

INTRODUCTION

Concrete masonry has traditionally been the material of choice for foundation wall construction. State-of-the-art waterproofing, dampproofing, and drainage systems applied to concrete masonry provide excellent protection from water penetration, ensuring protection for building contents and comfort for occupants.

Protecting below-grade walls from water entry involves installing a barrier to water and water vapor. Below grade moisture tends to migrate from the damp soil to the drier area inside the basement. An impervious barrier on the exterior wall surface can prevent moisture entry. The barrier is part of a comprehensive system to prevent water penetration, which includes proper wall construction and the installation of drains, gutters, and proper grading.

WATERPROOFING AND DAMPPROOFING

Building codes (refs. 1, 2) typically require that basement walls be dampproofed for conditions where hydrostatic pressure will not occur, and waterproofed where hydrostatic pressures may exist. Dampproofing is appropriate where groundwater drainage is good, through granular backfill into a subsoil drainage system.

Hydrostatic pressure may exist due to a high water table or due to poorly draining backfill, such as heavy clay soils. Materials used for waterproofing are generally elastic, allowing them to span small cracks and accommodate minor movements.

When choosing a system, consideration should be given to the degree of resistance to hydrostatic head of water, absorption characteristics, elasticity, stability in moist soil, resistance to mildew and algae, and impact, puncture and abrasion resistance.

WATERPROOF AND DAMPPROOF SYSTEMS

Waterproof and dampproof systems must be continuous to prevent water penetration. Similarly, the barrier is typically carried above the finished grade level to prevent water entry between the barrier and the foundation wall. Cracks exceeding $^1/_4$ in. (6 mm) should be repaired before applying a waterproof or dampproof barrier. Repair of hairline cracks is typically not required, as most barriers will either fill or span small openings. In addition, most waterproofing and dampproofing systems should be applied to clean, dry walls. In all cases, manufacturer's directions should be carefully followed for proper installation.

Particular attention should be paid to wall penetrations and to re-entrant corners at garages, porches, and fireplaces. Because differential movement often occurs at these intersections, stretchable membranes are often used to span any potential cracks. Alternately, the main wall in some cases can be coated prior to constructing the cross wall provided that structural adequacy is maintained.

Coatings are sprayed, trowelled, or brushed onto below-grade walls, providing a continuous barrier to water entry. Coatings should be applied to clean, structurally sound walls. Walls should be brushed or washed to remove dirt, oil, efflorescence, or other materials which may reduce the bond between the coating and the wall.

Sheet membranes and panels are less dependent on workmanship and surface preparation than coatings. Many membrane systems are better able to remain intact in the event of settlement or other foundation wall movement. Seams, terminations, and penetrations must be properly sealed.

Prescriptive Systems

Both the *International Building Code* (IBC) (ref. 1) and the *International Residential Code* (IRC) (ref. 2) include prescriptive methods for waterproofing and dampproofing. Except where a damproofing material is approved for direct application to the masonry, masonry walls are required to have not less than $^3/_8$ in. (9.5 mm) portland cement parging applied to the exterior of the wall before applying dampproofing. The following materials are specified in the IBC as acceptable

Related TEK:
3-11

Keywords: basements, basement walls, coatings, dampproofing, moisture, waterproofing

waterproofing and dampproofing materials:
- two-ply hot-mopped felts;
- 6 mil (0.006 in.; 0.152 mm) or greater polyvinyl chloride;
- 40 mil (0.040 in.; 1.02 mm) polymer-modified asphalt;
- 6 mil (0.006 in.; 0.152 mm) polyethylene; or
- other approved methods or materials capable of bridging nonstructural cracks.

In addition, the IRC includes the following materials for concrete and masonry foundation waterproofing:
- 55 pound (25 kg) roll roofing;
- 60 mil (1.5 mm) flexible polymer cement;
- $^1/_8$ in. (3 mm) cement-based, fiber-reinforced, waterproofing coating; or
- 60 mil (1.5 mm) solvent-free liquid-applied synthetic rubber.

Both the IBC and IRC list the following materials as acceptable for dampproofing only (note—any of the waterproofing materials are acceptable for dampproofing):
- bituminous material;
- 3 lb/yd^2 (16 N/m^2) of acrylic modified cement;
- $^1/_8$ in. (3.2 mm) coat of surface-bonding mortar complying with ASTM C887 (ref. 3); or
- other approved methods or materials.

The following discusses details of some of the prescriptive code methods for waterproofing and dampproofing.

Rubberized Asphalt Systems

A wide variety of rubberized and other polymer-modified asphalt waterproofing systems are available. Most of these are applied as sheet membranes, although some are available as liquid coatings. These systems provide a continuous barrier to water with the ability to elastically span small holes or cracks.

Rubberized asphalt sheet membranes are applied over a primer, which is used to increase adhesion of the sheet. The membrane is adhesive on one side and protected by a polyethylene film on the other. Adjacent pieces of membrane must be lapped, and the top and bottom edges sealed with mastic to provide continuous protection from water entry. After the membrane is placed on the wall, the surface is rolled with sufficient pressure to ensure adequate adhesion.

Rubberized asphalt is also available in a form that can be melted at the jobsite, then spread to completely cover foundation walls. Liquid coatings can be applied by airless spray, roller, or brush. Both the liquid-applied and sheets are covered with a protection board, which protects from construction traffic and during backfilling.

Cementitious Coating Systems

Cement-based coatings are typically trowelled onto concrete masonry walls or brushed on using a coarse-fibered brush. The coatings sufficiently fill block pores, small cracks, and irregularities. Some cementitious coatings are modified with various polymers to increase elasticity and water penetration resistance.

Elastomeric Systems

Elastomeric materials are acrylic-based products which provide a flexible barrier to water penetration for below grade walls. Elastomerics are available as liquid coatings and as sheet membranes. The sheets are attached with adhesive, and may be reinforced with fabric to further increase tensile strength and resistance to tears and punctures. Liquid coatings can be applied by airless spray, roller, or brush.

Other Waterproofing and Dampproofing Systems

The systems listed above (and within the building codes) are only some of the materials and systems available; several others are discussed below. See *Basement Manual—Design & Construction Using Concrete Masonry* (ref. 4) for more detailed information.

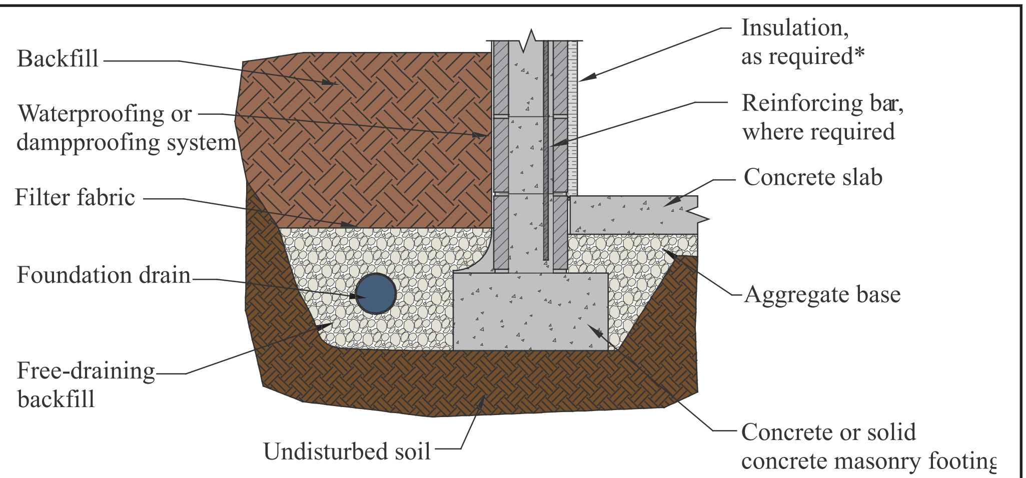
Parging and Bituminous Coating Systems

Where drainage is good, a dampproof coating of parging with a permanent bituminous coating has proven to be satisfactory. A portland cement and sand mix (1:3.5 by volume), or Type M or S mortar may be used for the parge coat. The parge coat should be beveled at the top to form a wash, and thickened at the bottom to form a cove between the wall base and top of footing, as shown in Figure 1.

To further increase water penetration resistance, a bituminous coating is applied over the parging. Coal tar or asphalt based bitumens are available in solvent for hot application, or in emulsions for application at ambient temperatures. These coatings can be sprayed, brushed, or trowelled onto the finish coat of parging.

Bentonite Panel Systems

Bentonite is a mineral that swells to many times its original size when wet. Waterproofing panels incorporate dry bentonite encased in kraft paper or fabric. After installation, the bentonite swells up the first time it is exposed to water,



* Exterior or integral insulation strategies may be used as alternates to the interior insulation shown.

Figure 1—Typical Footing Detail

expanding between the foundation wall and the backfill, and forming an impervious barrier. The swelling seals small cracks in the foundation wall or punctures in the panels themselves.

To prevent premature hydration bentonite panels must be protected from moisture until they are properly installed and the foundation wall has been backfilled.

Other Systems

There are several systems for which Acceptance Criteria, developed by the ICC Evaluation Service, exist. Cold, liquid-applied, below-grade exterior dampproofing and waterproofing materials should demonstrate compliance with ICC ES AC29 (ref. 5). For rigid, polyethylene, below-grade dampproofing and waterproofing materials, compliance should be shown to ICC-ES AC114 (ref. 6).

Some systems fulfill the requirements of both waterproofing/dampproofing and wall insulation. These systems, however, may not be specified directly in the building code or have an Acceptance Criteria. In these cases, materials should be evaluated both for general waterproofing (or dampproofing) characteristics (such as resistance to hydrostatic pressure, etc.) as well as for criteria specific to the material or system. The Acceptance Criteria listed above can be used as a baseline for a material, although not all requirements may apply to all materials. An engineering evaluation of the product testing results can demonstrate acceptable performance for use as dampproofing or waterproofing.

DRAINAGE

Draining water away from basement walls significantly reduces the pressure the basement wall must resist. This reduces both the potential for cracking and the possibility of water penetration into the basement if there is a failure in the waterproof or dampproof system.

Perforated pipe or drain tiles laid with open joints have proven to be effective at collecting and transporting water away from foundation walls. The invert of drain pipes should be below the top of the floor slab elevation, as shown in Figure 1. The backfill drain should be connected to solid piping to carry the water to natural drainage, a storm sewer, or a sump. For adequate drainage, drains should slope at least $^3/_8$ in. in 10 ft (10 mm in 3 m).

Drain tile and perforated pipes are typically laid in crushed stone to facilitate drainage. At least 2 in. (51 mm) of washed gravel or free-draining backfill (containing not more than 10% material finer than a No. 4 sieve) should be placed beneath perforated pipes. Drain tiles laid with open joints are more effective when laid on the undisturbed soil where the water begins to accumulate. At least 6 to 12 in. (152 to 305 mm) of the same stone should cover the drain and should extend 12 in. (305 mm) or more beyond the edge of the footing. To prevent migration of fine soils into the drains, filter fabrics are often placed over the gravel.

Drainage pipes may also be placed beneath the slab and connected to a sump. In some cases, pipes are cast in or placed on top of concrete footings at 6 to 8 ft (1.8 to 2.4 m) o.c. to help drain water from the exterior side of the foundation wall.

The backfill material itself also significantly affects water drainage around the wall. The backfill material should be well-draining soil free of large stones, construction debris, organic materials, and frozen earth. Saturated soils, especially saturated clays, should generally not be used for backfill, since wet materials significantly increase the hydrostatic pressure on foundation walls. The top 4 to 8 in. (102 to 203 mm) of backfill should be low permeability soil so rain water is absorbed into the backfill slowly.

The finished grade should be sloped away from the foundation at least 6 in. within 10 ft (152 mm in 3 m) from the building, as shown in Figure 2. If the ground naturally slopes toward the building, a shallow trench or swale can be installed to direct water runoff away from the building.

Finally, gutters and downspouts should be installed to minimize water accumulation near the foundation. Water exiting downspouts should be directed away from foundation walls using plastic drainage tubing or splash blocks. Roof overhangs, balconies, and porches also shield the soil from direct exposure to rainfall.

CONSTRUCTION

Methods of construction can also impact the watertightness of foundation walls. Properly tooled mortar joints help prevent cracks from forming, and contribute to the watertightness of the finished work. Concave-shaped mortar joints are most effective for resisting water entry. Tooling the mortar compresses the surface to make it more watertight, and also reduces leakage by filling small holes and other imperfections. On the exterior face of the wall, mortar joints may be struck flush if parging will be applied.

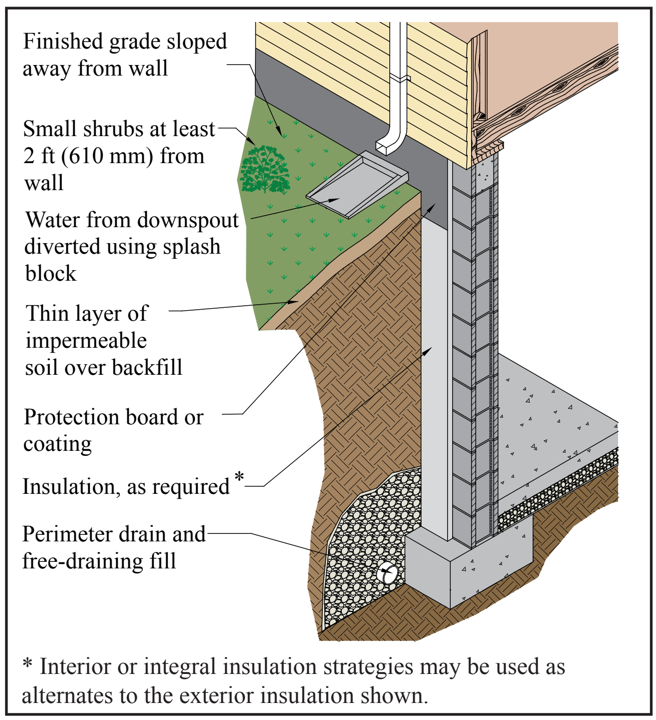


Figure 2—Landscape Elements for Draining Water Away From Foundation Walls

The drainage and waterproof or dampproof system should be inspected prior to backfilling to ensure they are properly placed. Any questionable workmanship or materials should be repaired at this point, because repair is difficult and expensive after backfilling.

Backfilling methods are important, since improper backfilling can damage foundation walls or the dampproof or waterproof system. Foundation walls should either be properly braced or should have the first floor in place prior to backfilling so the wall is supported against the soil load.

Final grade should be 6 to 12 in. (152 to 305 mm) below the top of the waterproof or dampproof membrane, and should slope away from the foundation wall. In no case should the backfill be placed higher than the design grade line.

These topics are covered in more detail in ref. 7.

LANDSCAPING

Landscaping directly adjacent to the building impacts the amount of water absorbed by the foundation backfill. Particular care should be taken when automatic sprinklers are installed adjacent to foundation walls. Whenever possible, large-rooting shrubs and trees should be placed 10 to 15 ft (3 to 4.6 m) away from foundation walls. Smaller shrubs should be kept at least 2 to 3 ft (0.6 to 0.9 m) from walls. Ground covers help prevent erosion and can extend to the foundation. These elements are illustrated in Figure 2.

Asphalt and concrete parking lots, sidewalks, building aprons, stoops and driveways prevent direct absorption of water into soil adjacent to the foundation, and should be installed to slope away from the building.

REFERENCES

1. *International Building Code*. International Codes Council, 2012.
2. *International Residential Code for One- and Two-Family Dwellings.* International Code Council, 2012.
3. *Standard Specification for Packaged, Dry, Combined Materials for Surface Bonding Mortar*, ASTM C887-05(2010) . ASTM International, Inc., 2010.
4. *Basement Manual—Design & Construction Using Concrete Masonry*, TR-68B. National Concrete Masonry Association, 2001.
5. *Acceptance Criteria for Cold, Liquid-Applied, Below-Grade, Exterior Dampproofing and Waterproofing Materials*, ICC ES AC29. International Code Council, 2011.
6. *Acceptance Criteria for Rigid, Polyethylene, Below-Grade, Dampproofing and Wall Waterproofing Material,* ICC-ES AC114. International Code Council, 2011.
7. *Concrete Masonry Basement Wall Construction*, TEK 3-11. National Concrete Masonry Association, 2001.

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CONCRETE MASONRY BASEMENT WALL CONSTRUCTION

TEK 3-11
Construction (2001)

Keywords: basements, basement wall, bracing, construction details, construction techniques, corners, details, foundation walls, grout, insulation, mortar, plain concrete masonry, reinforced concrete masonry, surface bonding, unreinforced concrete masonry, waterproofing

INTRODUCTION

Basements allow a building owner to significantly increase usable living, working, or storage space at a relatively low cost. Old perceptions of basements have proven outdated by state-of-the-art waterproofing, improved drainage systems, and natural lighting features such as window wells. Other potential benefits of basements include room for expansion of usable space, increased resale value, and safe haven during storms.

Historically, plain (unreinforced) concrete masonry walls have been used to effectively resist soil loads. Currently, however, reinforced walls are becoming more popular as a way to use thinner walls to resist large backfill pressures. Regardless of whether the wall is plain or reinforced, successful performance of a basement wall relies on quality construction in accordance with the structural design and the project specifications.

MATERIALS

Concrete Masonry Units

Concrete masonry units should comply with *Standard Specification for Loadbearing Concrete Masonry Units*, ASTM C 90 (ref. 8). Specific colors and textures may be specified to provide a finished interior to the basement. Drywall can also be installed on furring strips, if desired. A rule of thumb for estimating the number of concrete masonry units to order is 113 units for every 100 ft² (9.3 m²) of wall area. This estimate assumes the use of 3/8 in. (9.5 mm) mortar joints.

Mortar

Mortar serves several important functions in a concrete masonry wall; it bonds the units together, seals joints against air and moisture penetration, and bonds to joint reinforcement, ties, and anchors so that all components perform as a structural element.

Mortar should comply with *Standard Specification for Mortar for Unit Masonry*, ASTM C 270 (ref. 9). In addi-

Table 1—Mortar Proportions by Volume (Ref. 12)

Mortar	Type	Proportions by volume (cementitious materials): Portland cement or blended cement[a]	Masonry cement M	Masonry cement S	Masonry cement N	Mortar cement M	Mortar cement S	Mortar cement N	Hydrated lime or lime putty[a]	Aggregate measured in a damp, loose condition
Cement-lime	M	1	—	—	—	—	—	—	1/4	Not less than 2 1/4 and not more than 3 times the sum of the separate volumes of cementitious materials.
	S	1	—	—	—	—	—	—	over 1/4 to 1/2	
	N	1	—	—	—	—	—	—	over 1/2 to 1 1/4	
	O	1	—	—	—	—	—	—-	over 1 1/4 to 2 1/2	
Mortar cement	M	1	—	—	—	—	—	1	—	
	M	—	---	—	—	1	—	—	—	
	S	1/2	—	—	—	—	—	1	—	
	S	—	—	—	—	—	1	—	—	
	N	—	—	—	—	—	—	1	—	
Masonry cement	M	1	—	—	1	—	—	—	—	
	M	—	1	—	—	—	—	—	—	
	S	1/2	—	—	1	—	—	—	—	
	S	—	—	1	—	—	—	—	—	
	N	—	—	—	1	—	—	—	—	
	O	—	—	—	1	—	—	—	—	

[1] When plastic cement is used in lieu of portland cement, hydrated lime or putty may be added, but not in excess of one tenth of the volume of cement.

tion, most building codes require the use of Type M or S mortar for construction of basement walls (refs. 2, 4, 5, 9, 13), because Type M and S mortars provide higher compressive strengths. Table 1 lists mortar proportions.

Typical concrete masonry construction uses about 8.5 ft^3 (0.24 m^3) of mortar for every 100 ft^2 (9.3 m^2) of masonry wall area. This figure assumes 3/8 in. (9.5 mm) thick mortar joints, face shell mortar bedding, and a 10% allowance for waste.

Grout

In reinforced concrete masonry construction, grout is used to bond the reinforcement and the masonry together. Grout should conform to *Standard Specification for Grout for Masonry*, ASTM C 476 (ref. 10), with the proportions listed in Table 2. As an alternative to complying with the proportion requirements in Table 2, grout can be specified to have a minimum compressive strength of 2000 psi (13.8 MPa) at 28 days. Enough water should be added to the grout so that it will have a slump of 8 to 11 in. (203 to 279 mm). The high slump allows the grout to be fluid enough to flow around reinforcing bars and into small voids. This initially high water-to-cement ratio is reduced significantly as the masonry units absorb excess mix water. Thus, grout gains high strengths despite the initially high water-to-cement ratio.

Table 2—Grout Proportions by Volume (Ref. 10)

Type	Proportions by volume (cementitious materials): portland cement or blended cement	Proportions by volume (cementitious materials): hydrated lime or lime putty	Aggregate measured in a damp, loose condition: Fine	Aggregate measured in a damp, loose condition: Coarse
Fine Grout	1	0 to 1/10	2¼ to 3 times the sum of the volumes of the cementitious materials	
Coarse Grout	1	0 to 1/10	2¼ to 3 times the sum of the volumes of cementitious materials	1 to 2 times the sum of the volumes of cementitious materials

CONSTRUCTION

Prior to laying the first course of masonry, the top of the footing must be cleaned of mud, dirt, ice or other materials which reduce the bond between the mortar and the footing. This can usually be accomplished using brushes or brooms, although excessive oil or dirt may require sand blasting.

Masons typically lay the corners of a basement first so that alignment is easily maintained. This also allows the mason to plan where cuts are necessary for window openings or to fit the building's plan.

To make up for surface irregularities in the footing, the first course of masonry is set on a mortar bed joint which can range from 1/4 to 3/4 in. (6.4 to 19 mm) in thickness. This initial bed joint should fully bed the first course of masonry units, although mortar should not excessively protrude into cells that will be grouted.

All other mortar joints should be approximately 3/8 in. (9.5 mm) thick and, except for partially grouted masonry, need only provide face shell bedding for the masonry units. In partially grouted construction, webs adjacent to the grouted cells are mortared to restrict grout from flowing into ungrouted cores. Head joints must be filled solidly for a thickness equal to a face shell thickness of the units.

Tooled concave joints provide the greatest resistance to water penetration. On the exterior face of the wall, mortar joints may be cut flush if parging coats are to be applied.

When joint reinforcement is used, it should be placed directly on the block with mortar placed over the reinforcement in the usual method. A mortar cover of at least 5/8 in. (15.9 mm) should be provided between the exterior face of the wall and the joint reinforcement. A mortar cover of 1/2 in. (12.7 mm) is needed on the interior face of the wall. For added safety against corrosion, hot dipped galvanized joint reinforcement is recommended.

See Figures 1-4 for construction details.

Reinforced Masonry

For reinforced masonry construction, the reinforcing bars must be properly located to be fully functional. In most cases, vertical bars are positioned towards the interior face of basement walls to provide the greatest resistance to soil pressures. Bar positioners at the top and bottom of the wall prevent the bars from moving out of position during grouting. A space of at least 1/2 in. (12.7 mm) for coarse grout and 1/4 in. (6.4 mm) for fine grout should be maintained between the bar and the face shell of the block so that grout can flow completely around the reinforcing bars.

As mix water is absorbed by the units, voids can form in the grout. Accordingly, grout must be puddled or consolidated after placement to eliminate these voids and to increase the bond between the grout and the masonry units. Most codes permit puddling of grout when it is placed in lifts less than about 12 in. (305 mm). Lifts over 12 inches (305 mm) should be mechanically consolidated and then reconsolidated after about 3 to 10 minutes.

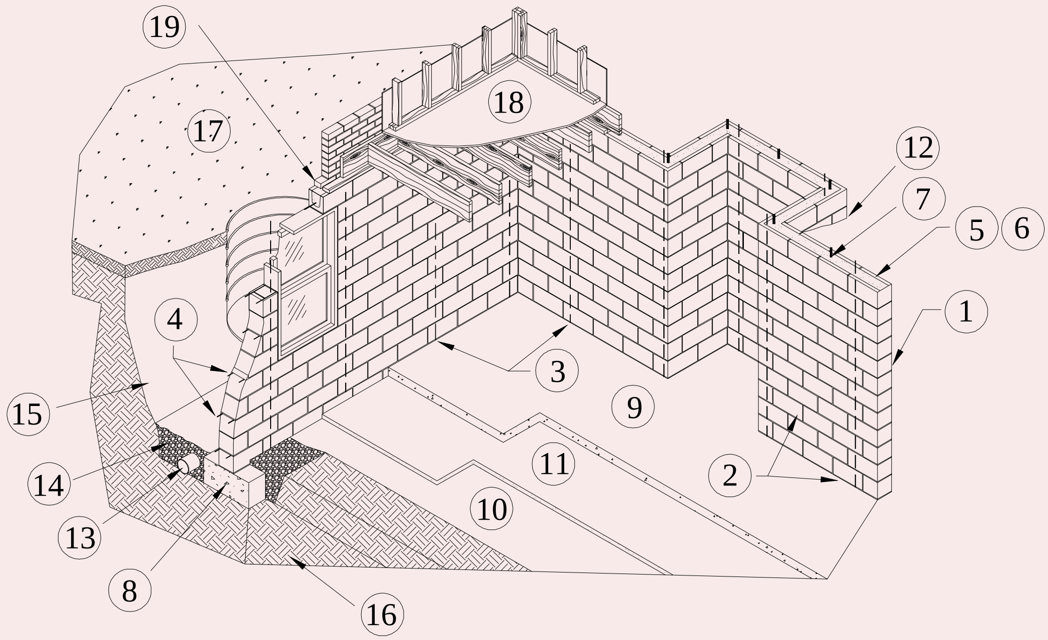
Surface Bonding

Another method of constructing concrete masonry walls is to dry stack units (without mortar) and then apply surface bonding mortar to both faces of the wall. The surface bonding mortar contains thousands of small glass fibers. When the mortar is applied properly to the required thickness, these fibers, along with the strength of the mortar itself, help produce walls of comparable strength to conventionally laid plain masonry walls. Surface bonded walls offer the benefits of excellent dampproof coatings on each face of the wall and ease of construction.

Dry-stacked walls should be laid in an initial full mortar bed to level the first course. Level coursing is maintained by using a rubbing stone to smooth small protrusions on the block surfaces and by inserting shims every two to four courses.

Water Penetration Resistance

Protecting below grade walls from water entry involves installation of a barrier to water and water vapor. An imper-



1. Concrete masonry units, typically 8-in. units. Larger sizes may be required in for some soil and backfill height conditions.
2. Mortar, generally Type S. Joints should be tooled for improved impermeability unless the exterior side is parged.
3. Vertical reinforcing bars, if required. Reinforcement should be placed adjacent to openings, in corners and at a maximum spacing determined from a structural analysis. Positioners hold the vertical bars in proper position.
4. Joint reinforcement or horizontal reinforcing bars to aid in control of shrinkage cracking and in Seismic Design Categories C, D, E, and F. See TEK 14-18 (ref. 7) for more information on seismic reinforcement requirements.
5. Grout of 2,000 psi (13.8 MPa) minimum compressive strength in cores containing reinforcement. Consolidate grout by puddling or vibration to reduce voids.
6. Solid grouted and reinforced top course to distribute loads from the walls above and increase soil gas and insect resistance.
7. Anchor bolts. Typically 7 in. (178 mm) long, $1/2$ in. (12.7 mm) diameter anchor bolts are spaced no more than 4 ft (1.2 m) on center. Anchor bolts significantly increase earthquake and high wind resistance.
8. Concrete footing. Footings distribute loads to the supporting soil. Concrete should have a minimum strength of 2500 psi (17.2 MPa) and be at least 6 in. (152 mm) thick, although many designers prefer footings to be as thick as the wall thickness and twice as wide as the wall thickness. Incorporating two #4 bars (or larger) increases the ability to span weak spots.
9. Concrete slab, typically minimum 2500 psi (17.2 MPa), 4 in. (101 mm) thick. Contraction joint spacing should not exceed about 15 ft (4.6 m). Welded wire fabric located near the center of the slab increases strength and holds unplanned shrinkage cracks tightly together. Welded wire fabric should be cut at contraction joints.
10. Aggregate base. A 4 to 6 in. (102 to 152 mm) base of washed aggregate ($3/4$ to $1\,1/2$ in. (19 to 38 mm) diameter) distributes slab loads evenly to the underlying soil, provides a level, clean surface for slab placement, and allows for inclusion of a soil gas depressurization system.
11. Vapor retarder. Continuous or lapped sheets of 6 mil (152 mm) polyethylene, PVC or equivalent reduce rising dampness and block soil gas infiltration through the slab. Vapor retarders can be placed on top of the aggregate base to increase the effectiveness of the soil gas barrier system, or under the aggregate to reduce concrete placement and curing difficulties.
12. Waterproof or dampproof membrane. Dampproof where hydrostatic pressure will not occur. Where ground water levels are high, soil drainage is slow, or where radon gas levels are high, consideration of waterproof membranes such as rubberized asphalt, polymer-modified asphalt, butyl rubber and/or drainage boards should be considered.
13. Foundation drain. Perforated pipe collects and transports ground water away from the basement. Drains should be located below the top of the slab and should be sloped away from the building to natural drainage, a storm water sewer, or a sump.
14. Free draining backfill. At least 12 in. (305 mm) of washed gravel or other free draining backfill material should be placed around drains to facilitate drainage. Cover the top of the gravel with a filtering geotextile to prevent clogging.
15. Backfill. Backfill should be placed after wall has gained sufficient strength and is properly braced or supported.
16. Undisturbed soil. Soil beneath footings and slabs should be undisturbed or compacted.
17. Top of grade. Surrounding soil should slope away from building to drain water away from walls. The top 4 to 8 in. (102 to 203 mm) of soil should be of low permeability so that water is absorbed slowly into the soil.
18. Floor diaphragm. A floor diaphragm supports the tops of masonry walls and distributes loads from the superstructure to them.
19. Flashing. Flashing should be installed at the top of basement walls to prevent water from entering the wall.

Figure 1— Basement/Foundation Wall (Ref. 1)

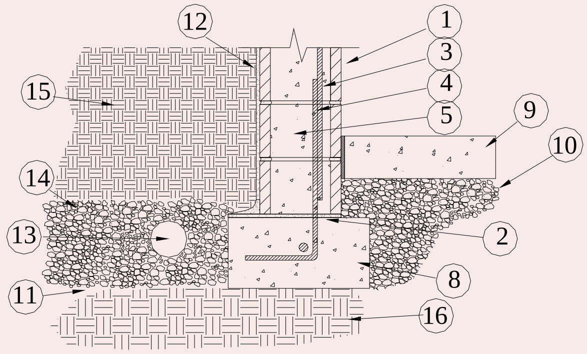


Figure 2—Typical Footing Detail (Ref. 1)

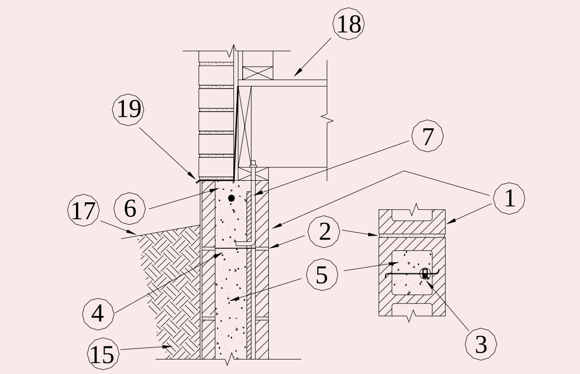


Figure 3—Typical Floor Connection (Ref. 1)

vious barrier on the exterior wall surface can prevent moisture entry. The barrier is part of a comprehensive system to prevent water penetration, which includes proper wall construction and the installation of drains, gutters, and proper grading.

Building codes (refs. 2, 4 , 5, 9, 13) typically require that basement walls be dampproofed for conditions where hydrostatic pressure will not occur, and waterproofed where hydrostatic pressures may exist. Dampproofing is appropriate where groundwater drainage is good, for example where granular backfill and a subsoil drainage system are present. Hydrostatic pressure may exist due to a high water table, or due to poorly draining backfill, such as heavy clay soils. Materials used for waterproofing are generally elastic, allowing them to span small cracks and accommodate minor movements.

When choosing a waterproof or dampproof system, consideration should be given to the degree of resistance to hydrostatic head of water, absorption characteristics, elasticity, stability in moist soil, resistance to mildew and algae, impact or puncture resistance, and abrasion resistance. A complete discussion of waterproofing, dampproofing, and drainage systems is included in TEK 19-3A (ref. 6).

All dampproofing and waterproofing systems should be applied to walls that are clean and free from dirt, mud and other materials which may reduce bond between the coating and the concrete masonry wall.

Draining water away from basement walls significantly reduces the pressure the walls must resist and reduces the possibility of water infiltration into the basement if the waterproofing (or dampproofing) system fails. Perforated pipe has historically proven satisfactory when properly installed. When placed on the exterior side of basement walls, perforated pipes are usually laid in crushed stone to facilitate drainage. To prevent migration of fine soil into the drains, filter fabrics are often placed

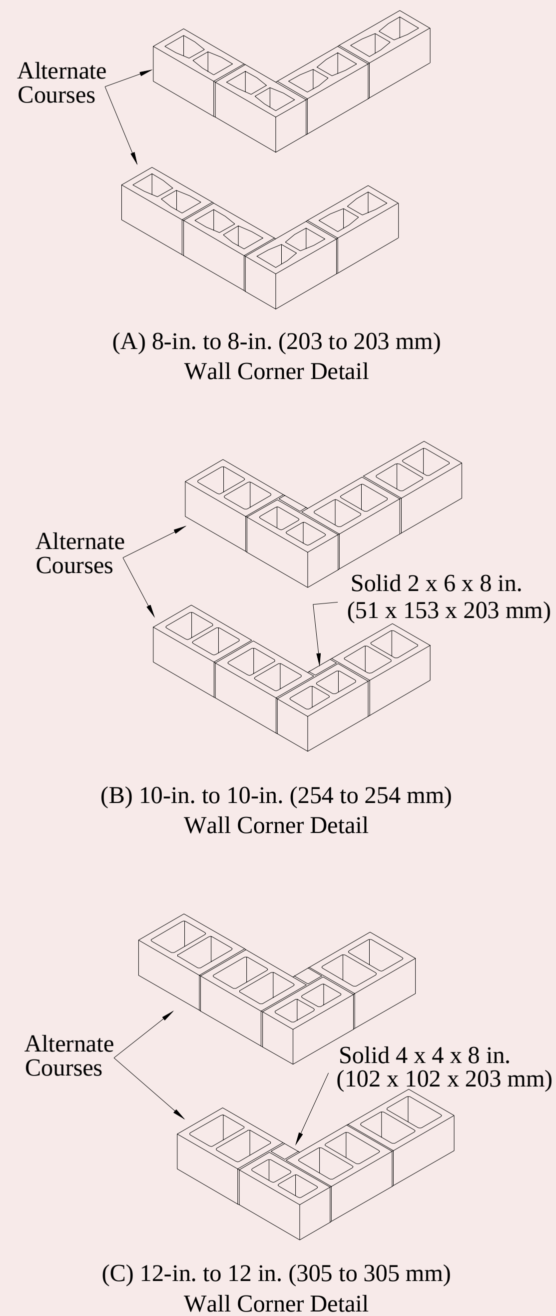


Figure 4—Standard Corner Layout Details

over the gravel.

Drainage pipes can also be placed beneath the slab and connected into a sump. Pipes through the footing or the wall drain water from the exterior side of the basement wall.

The drainage and waterproofing systems should always be inspected prior to backfilling to ensure they are adequately placed. Any questionable workmanship or materials should be repaired at this stage since repairs are difficult and expensive after backfilling.

Backfilling

One of the most crucial aspects of basement construction is how and when to properly backfill. Walls should be properly braced or have the first floor in place prior to backfilling. Otherwise, a wall which is designed to be supported at the top may crack or even fail from the large soil pressures. Figure 5 shows one bracing scheme which has been widely used for residential basement walls. More substantial bracing may be required for high walls or large backfill pressures.

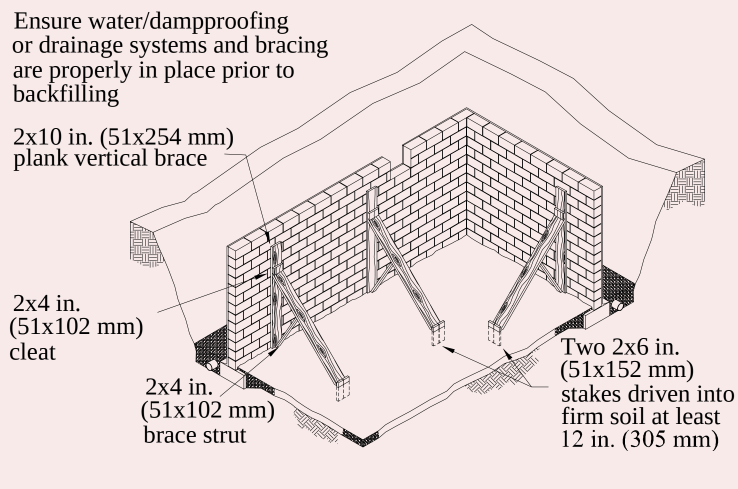


Figure 5—Typical Bracing for Concrete Masonry Basement

The backfill material should be free-draining soil without large stones, construction debris, organic materials, and frozen earth. Saturated soils, especially saturated clays, should generally not be used as backfill materials since wet materials significantly increase the hydrostatic pressure on the walls.

Backfill materials should be placed in several lifts and each layer should be compacted with small mechanical tampers. Care should be taken when placing the backfill materials to avoid damaging the drainage, waterproofing or exterior insulation systems. Sliding boulders and soil down steep slopes should thus be avoided since the high impact loads generated can damage not only the drainage and waterproofing systems but the wall as well. Likewise, heavy equipment should not be operated within about 3 feet (0.9 m) of any basement wall system.

The top 4 to 8 in. (102 to 203 mm) of backfill materials should be low permeability soil so rain water is absorbed into the backfill slowly. Grade should be sloped away from the basement at least 6 in. (152 mm) within 10 feet (3.1 m) of the building. If the ground naturally slopes toward the building, a shallow swale can be installed to redirect runoff.

Construction Tolerances

Specifications for Masonry Structures (ref. 8) specifies tolerances for concrete masonry construction. These tolerances were developed to avoid structurally impairing a wall because of improper placement.

1. Dimension of elements in cross section or elevation ....-1/4 in. (6.4 mm), +1/2 in. (12.7 mm)
2. Mortar joint thickness: bed............±1/8 in. (3.2 mm)
   head...................-1/4 in (6.4 mm), +3/8 in. (9.5 mm)
3. Elements

a. Variation from level: bed joints................................
   ±1/4 in. (6.4 mm) in 10 ft (3.1 m), ±1/2 in. (12.7 mm) max
   top surface of bearing walls...................................
   ±1/4 in.(6.4 mm), +3/8 in.(9.5 mm), ±1/2 in.(12.7mm) max
b. Variation from plumb...........±1/4 in. (6.4 mm) 10 ft (3.1 m)
   ....±3/8 in. (9.5 mm) in 20 ft (6.1 m)
   ....±1/2 in. (12.7 mm) maximum
c. True to a line.............±1/4 in. (6.4 mm) in 10 ft (3.1 m)
   ....±3/8 in. (9.5 mm) in 20 ft (6.1 m)
   ....±1/2 in. (12.7 mm) maximum
d. Alignment of columns and bearing walls (bottom versus top)....................................±1/2 in (12.7 mm)

4. Location of elements

a. Indicated in plan...........±1/2 in (12.7 mm) in 20 ft (6.1 m)
   ....±3/4 in. (19.1 mm) maximum
b. Indicated in elevation
   ....±1/4 in. (6.4 mm) in story height
   ....±3/4 in. (19.1 mm) maximum

Insulation

The thermal performance of a masonry wall depends on its R-value as well as the thermal mass of the wall. R-value describes the ability to resist heat flow; higher R-values give better insulating performance. The R-value is determined by the size and type of masonry unit, type and amount of insulation, and finish materials. Depending on the particular site conditions and owner's preference, insulation may be placed on the outside of block walls, in the cores of hollow units, or on the interior of the walls.

Thermal mass describes the ability of materials like concrete masonry to store heat. Masonry walls remain warm or cool long after the heat or air-conditioning has shut off, keeping the interior comfortable. Thermal mass is most effective when insulation is placed on the exterior or in the cores of the block, where the masonry is in direct contact with the interior conditioned air.

Exterior insulated masonry walls typically use rigid board insulation adhered to the soil side of the wall. The insulation requires a protective finish where it is exposed above grade to maintain durability, integrity, and effectiveness.

Concrete masonry cores may be insulated with molded polystyrene inserts, expanded perlite or vermiculite granular fills, or foamed-in-place insulation. Inserts may be placed in the cores of conventional masonry units, or they may be used in block specifically designed to provide higher R-values.

Interior insulation typically consists of insulation installed between furring strips, finished with gypsum wall board or panelling. The insulation may be fibrous batt, rigid board, or fibrous blown-in insulation.

DESIGN FEATURES

Interior Finishes

Split faced, scored, burnished, and fluted block give owners and designers added options to standard block surfaces. Colored units can be used in the entire wall or in sections to achieve specific patterns.

Although construction with staggered vertical mortar joints (running bond) is standard for basement construction, the appearance of continuous vertical mortar joints (stacked bond pattern) can be achieved by using of scored units or reinforced masonry construction.

Natural Lighting

Because of the modular nature of concrete masonry, windows and window wells of a variety of shapes and sizes can be easily accommodated, giving basements warm, natural lighting. For additional protection and privacy, glass blocks can be incorporated in lieu of traditional glass windows.

REFERENCES

1. *Basement Manual-Design and Construction Using Concrete Masonry*, TR-68A, National Concrete Masonry Association, 2001.
2. *BOCA National Building Code.* Country Club Hills, IL: Building Officials and Code Administrators International, Inc. (BOCA), 1999.
3. *Building Code Requirements for Masonry Structures*, ACI 530-02/ASCE 5-02/TMS 402-02. Reported by the Masonry Standards Joint Committee, 2002.
4. *International Residential Code*. Falls Church, VA: International Code Council, 2000.
5. *International Building Code*. Falls Church, VA: International Code Council, 2000.
6. *Preventing Water Penetration in Below-Grade Concrete Masonry Walls*, TEK 19-3A. National Concrete Masonry Association, 2001.
7. *Seismic Design Provisions for Masonry Structures*, TEK 14-18, National Concrete Masonry Association, 1996.
8. *Specifications for Masonry Structures*, ACI 530.1-02/ASCE 6-99/TMS 602-02. Reported by the Masonry Standards Joint Committee, 2002.
9. *Standard Building Code*. Birmingham, AL: Southern Building Code Congress International, Inc. (SBCCI), 1999.
10. *Standard Specification for Grout for Masonry*, ASTM C 476-01. American Society for Testing and Materials, 2001.
11. *Standard Specification for Load-Bearing Concrete Masonry Units*, ASTM C 90-01. American Society for Testing and Materials, 2001.
12. *Standard Specification for Mortar for Unit Masonry*, ASTM C 270-00. American Society for Testing and Materials, 2000.
13. Uniform *Building Code*. Whittier, CA: International Conference of Building Officials (ICBO), 1997.