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PREVENTING WATER PENETRATION IN BELOW-GRADE CONCRETE MASONRY WALLS

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

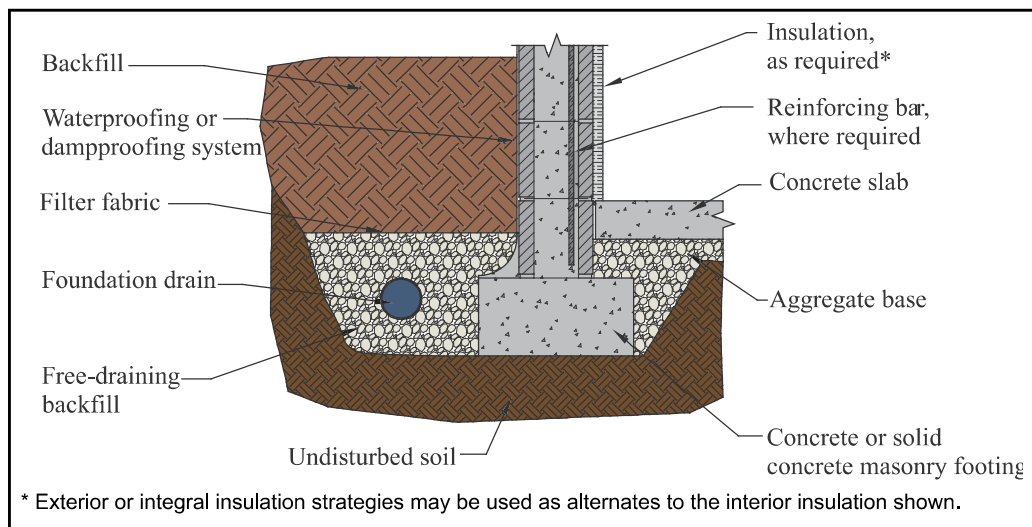


Figure 1—Typical Footing Detail

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 dampproofing material is approved for direct application to the masonry, masonry walls are required to have not less than $\frac{3}{8}$ 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 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;
 - $\frac{1}{8}$ 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/yd² (16 N/m²) of acrylic modified cement;
- $\frac{1}{8}$ 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, 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 $\frac{3}{8}$ 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.

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*, CMU-MAN-002-01, Concrete Masonry & Hardscapes Association, 2001.
5. *Acceptance Criteria for Cold, Liquid-Applied, Below-Grade, Exterior Damproofing and Waterproofing Materials*, ICC ES AC29. International Code Council, 2011.
6. *Acceptance Criteria for Rigid, Polyethylene, Below-Grade, Damproofing and Wall Waterproofing Material*, ICC-ES AC114. International Code Council, 2011.
7. *Concrete Masonry Basement Wall Construction*, [TEK 03-11](#), Concrete Masonry & Hardscapes Association, 2001.

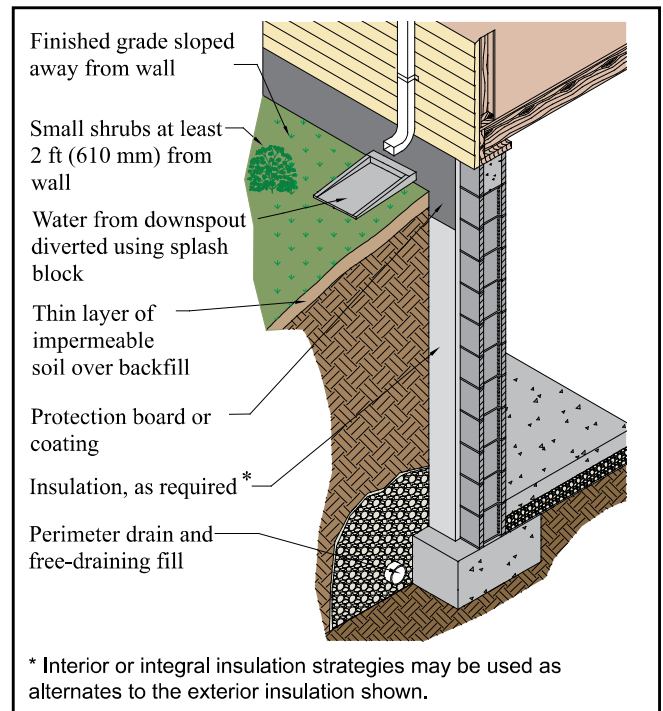


Figure 2—Landscape Elements for Draining Water Away From Foundation Walls

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