The following pages are excerpted from the document entitled "READ THIS: Before You Design, Build or Renovate". Please go to our website to download the complete document.
Groundwater
The fundamental principles of groundwater control are to keep rainwater away from the foundation wall perimeter and to drain groundwater with sub-grade perimeter drains before it gets to the foundation wall. This applies to slabs, crawlspaces and basements (see Figures 8a, 8b and 8c) regardless of whether they are newly constructed or undergoing rehabilitation (see Figure 9).

Capillary Breaks Concrete and masonry are sponges – they can absorb or “wick” water due to capillarity (see Figure 10). This is the main reason that damp proofing (the black tar-like coating) is applied to exterior basement walls. The damp proofing fills in the pores in the concrete and masonry to reduce ground water absorption. The damp proofing is a capillary break. Under concrete floor slabs, the stone layer combined with polyethylene serves a similar function (they act as capillary breaks). Unfortunately, the capillary rise through footings is typically ignored. This can be a major problem if foundation perimeter wall are finished or insulated.

In new construction a capillary break should be installed on the top of the footing between the footing and the perimeter foundation wall (see Figure 11). This can be done by dampproofing the top of the footing or by installing a membrane at this location.

Interior Basement Insulation In new construction, and particularly in renovations, the interior insulation and finishing approach must take into account the moisture migrating up through the footing. This is best accomplished by installing vapor semi-permeable rigid foam insulation on the interior of the assembly to protect the interior finishes and to release the capillary water to the interior in a controlled manner—at a rate that does not damage interior finishes or lead to mold.

The best foams to use have a perm rating of greater than 1 perm for the thickness used. This means limiting extruded polystyrene insulation to less than 1-inch thickness for walls (when they are more than 1-inch thick they do not breathe sufficiently) and making sure that the rigid insulation is not faced with polypropylene skins or foil facings. Additionally, since foams need to be protected from fire, and this is often done with gypsum board, only latex paint should be used on interior gypsum finishes (since latex breathes). This breathability requirement for rigid foams limits the thickness and therefore the thermal resistance of the wall. If higher insulation levels are required, an interior insulated frame wall can be added (see Figure 20).

Slab-on-Grade Construction Capillary control also applies to slab-on-grade construction and crawlspaces (see Figure 12). Monolithic slabs need plastic ground covers that extend under the perimeter grade beam and upwards to grade. Additionally, the exposed portion of the slab edge that is exposed to the outside must be painted with latex paint to reduce water absorption and a capillary break must be installed under perimeter wall framing.

Interior perimeter drainage can also be used in new construction — particularly where impermeable rigid insulation is used on the interior of the foundation wall. This allows rigid insulation of greater than 1-inch to be used. And, if foil-faced rigid insulation is used — with the appropriate flame-spread and smoke-developed rating — it can be left exposed (i.e. interior gypsum board does not have to be installed as thermal barrier for fire protection. See Figure 14).

Also in renovations, the conditions under a slab may be difficult to determine, or once they are determined, it is found that a stone layer or polyethylene is not present. It may be necessary to provide “top side” control of water and vapor. This can be done several ways. If salts are not present in the ground, epoxy coatings or chemical sealers may be used. Salts lead to osmosis and osmotic pressures are typically greater than the bond strength of most coatings and sometimes exceed the cohesive strength of concrete (i.e. the coating is pushed off the slab or the concrete
spalls/flakes apart). If salts are present, spacer systems that provide vapor control and drainage can be used over the top of existing slabs (see Figure 16).

A “floating floor” (see Figure 15) can also be used where moisture flow upwards is small – or where a finished wood floor (or carpet) is to be installed over a slab. Rigid insulation and plywood are installed on the top of the slab. In this assembly extruded polystyrene should be limited to $\frac{\gamma}{4}$ - inch or less so that the slab can dry upwards (floors are different than walls with respect to permeability limits). Carpets should never be installed directly on below grade slabs unless slabs are insulated (below or on the top surface). Carpets on uninsulated slabs are cold resulting in sufficiently elevated relative humidities within the carpet to support dust mite and mold growth.

**Exterior Drainage** It is always better to intercept groundwater before it gets to a foundation wall. Exterior perimeter drainage is always preferable to interior perimeter drainage.

However, in renovations, exterior perimeter drainage may not be present or may not be practical or possible. In such cases, interior perimeter drainage can be used and connected to an interior sump pump. Interior sump pits/crocks must be fitted with airtight gasketed covers to prevent soil gas entry. This interior perimeter drainage may be combined with an interior drainage layer. Where an interior drainage layer is used, it must be gas tight and vapor tight relative to the interior (see Figure 13). Another technique is to use an exterior impermeable material to minimize rain and groundwater entering below grade spaces (see Figure 9).
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**Figure 8b**
Groundwater control with crawlspace

- Keep rain water away from the foundation perimeter
- If the interior crawlspace is lower than the exterior grade, a sub-grade perimeter footing drain is necessary as in a basement foundation
- The crawlspace in this configuration is conditioned space; it is part of the “interior” of the building and should be heated, cooled and ventilated as part of the building’s heating, cooling and ventilating strategy

**Figure 8c**
Groundwater control with slabs

- Keep rain water away from the foundation perimeter
- Do not place sand layer over polyethylene vapor barrier under concrete slab
- Where vinyl flooring is installed over slabs, a low water-to-cement (w/c) ratio (≤ 0.45 or less is recommended) to reduce water content in the concrete; alternatively, the slab should be allowed to dry (less than 0.3 grams/24 hrs/ft²) prior to flooring installation

**Figure 9**
Using an impermeable skirt outside

- Prevents saturation of ground adjacent to existing foundation

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**Polyethylene “skirt” (minimum 10 mil) or membrane roofing extending 6 to 10 feet from foundation perimeter**

**Breathing gap can be coated with cement “parge” coat and painted with latex paint to reduce water absorption but still permit drying to exterior**

**Leave gap between top of “skirt” and top of foundation wall (minimum 12”) to allow foundation wall to dry out**

**New 3” concrete slab**

**Polyethylene vapor barrier; turned up at wall**

**Granular drainage pad (coarse gravel, no fines)**

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**Conditioned space**

**Ground slopes away from the foundation**

**Figure 8b**
Groundwater control with crawlspace

**Figure 8c**
Groundwater control with slabs

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**Polyethylene vapor barrier in direct contact with concrete slab**

**Capillary break under plate**

**Conditioned space**

**Polyethylene ground cover acting as both an air barrier and a vapor barrier**

**Ground slopes away from the foundation**

**Figure 8b**
Groundwater control with crawlspace

**Figure 8c**
Groundwater control with slabs

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**Granular drainage pad (coarse gravel, no fines)**

**Figure 8b**
Groundwater control with crawlspace

**Figure 8c**
Groundwater control with slabs
Figure 10
Capillary rise through basement footing

Figure 11
Capillary break over footing
- Concrete wall cold, can only dry to the interior if interior assemblies are vapor semi-permeable (permeance greater than 1 perm — i.e. unfaced extruded polystyrene less than 1-inch thick); mold possible if interior assemblies do not permit drying
- Cold concrete wall must be protected from interior moisture-laden air in winter and in summer
- Basement floor slab can dry to the interior
- Thicker foam can be used if drainage is provided between the foam and the foundation wall (see Figure 14)

Figure 12
Capillary control for monolithic slab
- Never install a sand layer between a polyethylene ground cover and a slab; the sand layer becomes wet and holds water indefinitely; the sand can only dry upwards, not downwards, due to the polyethylene
Figure 13
Interior drainage: Renovation
• Interior membrane waterproofing must be gas tight and vapor tight relative to the interior

Figure 14
Interior drainage: New construction
• Interior rigid insulation must be gas tight and vapor tight relative to the interior
• This can also be a retrofit approach
Basements  Basements should be designed to dry to the interior (see Figure 20). These principles are often in conflict with some common misapplied energy conservation and moisture control practices – for example the use of sheet polyethylene as an interior vapor barrier.

Sheet polyethylene (or vapor barriers) should never be installed on the interior of interior basement insulation assemblies or on the interior of interior insulation in below grade wall assemblies

Figure 18
Classic flow-through wall assembly

- Permeable interior surface and finish and semi-permeable exterior sheathing and permeable building paper drainage plane
- Ventilation provides interior air change (dilution) and also limits the interior moisture levels during heating
- Air conditioning/dehumidification limits the interior moisture levels during cooling

Figure 19
Masonry wall with interior rigid insulation and stucco

- The vapor semi-permeable rigid insulation and interior latex paint permit drying to the interior
- Vapor semi-permeable rigid insulation (1 perm or greater) used on the interior should be unfaced or faced with permeable skins; foil facings and polypropylene skins should be avoided
- Avoid use of metal furring or “hat” channels due to thermal bridging and impermeability; use only wood furring
- Wood furring should be installed over rigid insulation; rigid insulation should not be installed between wood furring, but should be installed directly on interior of masonry
- The exterior latex paint permits drying to the exterior
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in any climate as it prevents drying to the interior. The exception to this interior vapor barrier in basements rule is where drainage is provided between the interior vapor barrier and the assembly (i.e. exterior to the vapor barrier – see Figure 13 — Interior Drainage: Renovations and Figure 14 — Interior Drainage: New construction).

Impermeable interior finishes should be avoided, such as vinyl wall coverings or oil (alkyd) based paints. In a similar vein, vinyl floor coverings should be avoided on basement floor slabs or on slab-on-grade construction unless a low water-to-cement ratio concrete is used (less than 0.45) installed directly over a polyethylene vapor barrier – and only where slab edges are protected from capillary water (see Figure 13 – Capillary Control For Monolithic Slab).

Figure 20
Internally insulated concrete basement with wood siding above
• Concrete wall cold; can only dry to the interior if interior assemblies are vapor semi-permeable; low likelihood of mold
• Cold concrete wall must be protected from interior moisture-laden air in winter and in summer
• Basement floor slab is warm, can dry to the ground (since there is no under slab vapor diffusion retarder) as well as to the interior; lowest likelihood of mold
Air

Air transports pollutants and moisture. In order to control pollutant movement you must first control air. But in order to control air you must first enclose air. That means getting rid of the big holes. Once we get rid of the big holes, identify the building “boundaries” (and get an “enclosure”), we can control air movement within a home and between the home and the outside.

Then we can concentrate on the cold surfaces (get rid of them by insulating them) or make sure that the indoor air or the outdoor air never gets to the cold surfaces. Why do we not want air seeing cold surfaces? Because we do not want condensation. Condensation, especially the kind we don’t see, can cause mold and destroys buildings.

Finally, we can limit indoor humidity and airborne pollutants by controlling air change between the interior and exterior. Dilution is the solution to indoor pollution that cannot otherwise be prevented or removed near the source.

But none of this is possible until we first get rid of the big holes and identify the building boundaries.

Big Holes - Building Boundaries

The biggest holes in buildings often occur between basements, crawlspace and living areas. Other major holes include bathtubs on exterior walls, ductwork in attic spaces or exterior walls, soffits, recessed lights, plumbing chases and chimneys.

Basements  These areas are part of a home, within the building boundary – despite repeated attempts over the years to disconnect them. They should be designed and constructed to be dry and conditioned. This is particularly important for basements because mechanical systems are always located in basements. Do not install mechanical systems outside of a home in unconditioned space unless there is no practical alternative. If a basement is being used for storage or as living space, it needs to be kept dry to avoid mold and dust mites.

Basements should be insulated on their perimeters – they should not be insulated between floors. Ceiling basement insulation is a bad idea, especially, if the basement is wet. If the basement is wet, make the basement dry. Don’t try to disconnect the basement from the home, it only creates problems. Especially if you put mechanical equipment in the basement. The mechanical equipment connects the basement to the house.