

Foundations—Moisture Resistant Construction

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Joseph Lstiburek

Abstract:

Builders for many years have put mechanical equipment and ducts in non-living spaces such as crawls and attics primarily to save valuable floor space. Be that as it may (there are lots of good reasons for having this equipment in conditioned spaces, GIVEN proper attention to ventilation and pressurization issues), it makes perfect sense to condition these areas, for a variety of energy, moisture and durability reasons.

Foundations -- Moisture Resistant Construction

Introduction

Foundations are the unglamorous part of a building that frequently are taken for granted. Too often, little thought goes into the design of residential foundations especially with respect to moisture management. To make matters worse, foundation materials are selected largely on the basis of lowest cost and then some of the work is delegated to inexperienced workers. While foundations in the United States rarely collapse (they are frequently overbuilt), they often transfer enough moisture into the building to cause decay and poor indoor air quality.

Foundations can be built in many different ways although crawl spaces, slab-on-grades and basements are the three most commonly used in residential construction. Regardless of the type, all foundations must:

- hold the building up
- keep the groundwater out
- keep the soil gas out
- keep the wind out
- keep the water vapor out
- allow the water and water vapor out if it gets inside
- keep the heat in during the winter
- keep the heat out during the summer

Let's look at the general principles involved in how we accomplish each of these goals before we look at how we design a specific foundation.

Holding the Building Up

This is rarely an issue in residential construction because most foundations systems are over built for the load they support. This over design means that our foundations usually work even when soil conditions are not ideal. The most important factor to consider is how that load is transferred to the ground. For this reason foundations are placed on undisturbed soil that will not deform significantly when the load of the building is placed upon it. For unstable soils such as recent landfill an engineering analysis of the soil is necessary.

Keeping the Ground Water Out

This is a big deal and it the biggest reason that foundations are often wet. The simplest solution to this problem is to build on the top of a hill and keep the house off the ground, up on piers Don't laugh, it works! However, for those of us who live in central Ohio, there are no hills on which to build although we could still build off the ground. Next we could build a slab-on-grade and keep the slab above ground level. Yes this means going up a step or two to get into the house. But it does make it easier to keep the slab dry. You have a choice here: slab above grade that is dry or slab at grade that is more likely to be damp.

Regardless of what type of foundation we use or whether we build above, at or below grade, we can slope the ground away from the foundation. Because of the force of gravity water runs down hill or more precisely toward the center of the earth. Gravity is free and as far as we know unailing, so we ought to take advantage of it wherever we can. We can also install gutters and downspouts that drain the runoff from the roof away from the foundation. Next we could do something radical and install a system that actually drains groundwater away from the foundation. This requires a material next to the foundation that does not hold water but rather allows water to freely run through it. This free draining material can be gravel, sand, drainage boards or exterior foundation insulations with drainage properties. Any of these systems prevent water from building up against the foundation and exerting hydrostatic pressure on the foundation. At the bottom of this free draining material is some type of conduit to collect and drain the water safely away from the foundation, either to a sump or to daylight at a lower elevation.

Concrete, cement block and wood all are hygroscopic; that is they readily absorb water and allow the water to move through them. This is mostly through capillary action by which water can move into very small spaces even against the force of gravity. Remember that we use hygroscopic materials to build our foundations. We can use coatings to fill the capillary pores in materials and prevent most of the water from moving through the foundation. Or we could use a high strength concrete that absorbs little water.

Why not use a waterproof coating? This is a great idea in theory, but not so great in practice. Yes, these coatings or membranes are very waterproof and flexible. But what happens when they are attached to a solid wall that cracks as all concrete and block walls do? What happens to that waterproof coating over the life of the building? Even boats and submarines leak; they have bilge pumps to handle the water that leaks in even with

expensive waterproof coatings on the hull. Waterproof coatings are not bad; they are not, however, a substitute for an adequate drainage system.

Since we know that concrete cracks, we can plan for it and try to control where the cracks occur. By adding control joints (actually a fancy name for “the place where I want my concrete to crack”) we can cover the control joint (crack) with a flexible sealant. This is not an absolute guarantee against a crack expanding enough to allow water to enter the wall. However, if we have an effective drainage system on the outside water pressure will not be able to drive water through the crack.

Keeping the Soil Gas Out

If we could build on perfect sites we might not have to worry about soil gas. Unfortunately we are building our houses on more sites that were previously treated (intentionally or unintentionally) with chemicals of all sorts, from pesticides to petroleum to PCBs. Radon is only one of many soil gases that we need to keep out of the foundation.

Fortunately there is a simple solution to keeping soil gases out of a foundation and out of the house. Install a granular drainage pad under the concrete slab that becomes a sub-slab ventilation system when you add a vent pipe that extends above the roofline of the house. Passive stack effect may be adequate to depressurize the sub slab space, but an exhaust fan can easily be added later if necessary.

Keeping the Wind Out

Doesn't the concrete or block keep the wind out? Yes, but the gaps between the foundation wall and the sill plate let air in if we don't seal them. But we let even more air in and we do it intentionally; we call it crawl space ventilation. Who came up with that crazy idea? When do we usually open crawl space vents? In the summer, when the air is very humid. Is this a problem? Well yes, in two ways. First the floor between the crawl space and the conditioned space is never airtight so moisture migrates into the house. Second if there are air conditioning ducts in the crawl space the warm moist air is likely to condense on the cold ducts. Now we have water dripping onto our crawl space floor that we otherwise designed and built to keep dry.

The solution is simple: Don't ventilate crawl spaces! This is important enough to repeat: Don't ventilate crawl spaces! But, but the code requires it. So, change the code. Or in the mean time be more creative and subtle. Does the code require ventilation of basements? No, of course

not, that would be stupid. What if you call your crawl space a mini-basement? Most codes willingly accept this with the stipulation that it be conditioned. That's actually a good idea since we've already said that the air in a crawl space communicates with the house. To make the crawl space conditioned means that it is livable at least for crawling. To make it conditioned it should be insulated, have air distribution (heating and cooling) and a ground cover sealed to the perimeter wall and piers. This polyethylene ground cover should be at least 6 mil in thickness, pieces overlapped 12 inches and the overlaps sealed with tape or mastic. On perimeter walls and piers or columns, the poly should also be sealed to the foundation with adhesive or mastic. Better yet, pour a thin concrete floor. Now the ductwork can be installed in the crawl space without compromising indoor air quality.

Keeping the Water Vapor Out

We have actually accomplished most of this by keeping water away from the foundation and keeping warm moist air out of the crawl space or basement. In some areas, however, ground water can still be a source of moisture. The subslab drainage pad provides a capillary break so that ground moisture cannot enter the slab by capillary action and then evaporate into the house. Polyethylene sheeting is then placed on top of the drainage pad and the concrete is poured directly on top of the poly. The polyethylene sheeting is a vapor barrier blocking the migration of water vapor from the ground into the concrete slab. A few small holes in the poly don't matter as long as the poly is in direct contact with the underside of the concrete. The concrete slab is an air barrier that prevents moisture laden air from moving through the holes in the poly. In a crawl space without a concrete slab the drainage pad is still a good idea. Of course you still have to put the polyethylene vapor barrier on top of the drainage pad. But now holes in the poly matter because there is no concrete air barrier on top of the poly

Allowing the Water Vapor to Get Out if it Gets In

Unfortunately no matter how hard we try to keep foundations dry there are times when they will get wet. This is not a problem unless they stay wet and transport this moisture to sensitive materials. The key to this dilemma is understanding the direction in which drying occurs. In heating climates the drying is mostly to the exterior, while in cooling climates the drying is mostly to the interior. What complicates this is that we usually apply damp-proofing to the exterior of the foundation. Consequently our

drying potential to the exterior is severely compromised. The solution is to use insulating materials that are permeable or semi-permeable such as extruded polystyrene (EPS) or extruded polystyrene (XPS); these materials are also not sensitive to moisture. Or better yet, insulate on the exterior as suggested below.

Keeping the Heat in During Winter and the Heat out During Summer

We have accomplished some of this by controlling the movement of air into our foundation system. We still need to block the conductive heat transfer by insulating the foundation. The amount of insulation needed and the location for installation vary depending upon climate and type of foundation. In hot climates foundation insulation is typically not installed because of concerns with termites and because the energy losses from foundations are relatively small.

Slab on grade foundations should have insulation along the exterior of the grade beam or stem wall and (depending on the climate) extending out from the bottom of the foundation horizontally the distance equivalent to the frost depth.

Basements can be insulated along the interior or the exterior of the foundation wall. Exterior insulation has the advantage of warming the wall so that condensation cannot occur on the wall and the wall can dry to both the interior and the exterior. Installation of exterior insulation has some technical difficulties because it must be protected from damage during back filling around the foundation. It can be done successfully, but it takes more planning and effort. Interior insulation should be permeable or semi-permeable yet it must be “air tight” to prevent warm, moist interior air from condensing on the cold concrete or block wall. Some foam insulations such as EPS and XPS can satisfy both conditions if installed properly.

Do we need to insulate under a basement concrete slab? The answer depends on how the basement will be used. The heat loss through an uninsulated concrete slab may be minimal depending on deep ground temperature. However, most of the year that slab will be colder than the interior air and therefore a potential surface on which condensation can occur. Carpet should not be installed directly over an uninsulated concrete basement slab. Any moisture that condenses on the cold slab becomes a nice habitat for mold and other biologicals. Impermeable paints should also not be applied to an uninsulated basement slab. Moisture that condenses on the cold, coated surface cannot be absorbed by the concrete. The thin film

of water that forms on the surface of this floor is very slippery. Insulating under the slab during construction is the best way to make the basement conducive to many subsequent uses.

What about crawl space insulation? That's easy. Remember, a crawl space is actually a conditioned mini-basement so most of what applies to basements applies to crawl spaces. The one difference is that we live in our basements and we won't live in our crawl spaces. Therefore even if you pour a thin concrete "rat" slab in your crawl space you would not have to insulate under it. That is unless you have a burning desire to install carpet in your crawl space.

About the Author

Joseph Lstiburek, Ph.D., P.Eng., is a principal of Building Science Corporation in Westford, Massachusetts. He has twenty-five years of experience in design, construction, investigation, and building science research. Joe is an ASHRAE Fellow and an internationally recognized authority on indoor air quality, moisture, and condensation in buildings. More information about Joseph Lstiburek can be found at www.buildingscienceconsulting.com

Direct all correspondence to:
Building Science Corporation, 30 Forest Street, Somerville, MA 02143

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