CHAPTER 4

Foundations and Moisture Management

One of the most significant components of a building is its foundation. Providing a quality foundation is often the most expensive consideration in constructing a new home.

Foundations are integral to overall home performance. They help control water penetration and dampness, reduce heat loss, and minimize unwanted air flow. Paying attention to details when constructing the foundation will help prevent moisture buildup, mold, and mildew.

Please take a look at the Shades of Green Tool Bench resources:

- Basements and Foundations: Guidelines for Moisture Control
- Unconditioned Basements: Venting and Insulation
- Conditioned Basements and Foundations: Insulation and Air Sealing

Techniques for Moisture Management and Environmental Performance

The following construction practices can help minimize water problems as well as improve energy performance and minimize resource use:

- Use insulated shallow foundations in northern climates; consider pier and beam foundations instead of slab on grade.
- Insulate the foundation before backfilling.
- Install enhanced foundation waterproofing such as sub-slab drainage systems or sump pumps.
- Use non-asphalt-based damp proofing.
- Reuse form boards and metal forms.
- Use aluminum forms.
- Install non-vented crawlspaces and insulate crawlspace areas.
- Install proper vapor retardant under slab or in crawl space floor.
- Avoid using expansive soils around the foundation. Instead, replace soil with a backfill material that does not expand when wet (for example, recycled aggregate in concrete.)

Perimeter Footing Drain

- Install perimeter or footing drain system of perforated pipe below the level of the basement slab on the inside and outside of foundation. This type of drain system is also known as a French drain.
- Wrap pipe with filter fabric and surround with clean gravel or crushed stone.

Direct Surface Water Away From House

To keep surface water from soaking in around the foundation, all roof runoff must be directed away from the house. This means putting effective gutters all around the building and sloping the final grade away from the foundation at least 5 inches in the first 10 feet. (That's ½" of slope per linear foot.) To protect the footing from subterranean water, it must bear on at least 4 inches of a non frost-susceptible material such as washed gravel or rock. Check with local code offices to determine the requirements in your area.

French Drains

A French drain is a drainage system that consists of a trench dug into the ground through and out of an area with poor drainage. The trench is filled with a porous material—usually gravel, crushed stone, or slag—along with a perforated PVC plastic pipe to collect and channel unwanted ground water. It is better to install the drain during construction, rather than later, to avoid problems digging around utilities, porches, and other obstacles. French drains will clog over time, so they need to be cleaned periodically.

Types of Foundation Materials

We will discuss the following four different types of foundation materials, how to implement them, as well as the benefits and challenges.

1. Poured Concrete
2. Preserved Wood Foundation (PWF)
3. Insulated Concrete Forms (ICFs)
4. Frost Protected Shallow Foundations (FPSF)

Poured Concrete

A foundation needs to last the lifetime of a home. It is important to pay attention to the details that ensure the poured concrete will remain dry and crack free. A sturdy footing and a vapor-proofed, reinforced-concrete pad sitting on a bed of compacted crushed stone is fundamental for a durable foundation. Adding insulation is crucial for frost impacted areas. Poured concrete foundations are effective and can be completed in a few days. Poured concrete can also be purchased with fly ash premixed in, or you can add your own fly ash on site.

Implementation of Poured Concrete

- Selecting a poured concrete basement requires diverting surface water away from the house and limiting water seepage by installing a perimeter drain. This is especially important for all basement footings sloped to allow for daylighting, drywells, or sump pits.
- Carefully estimate the amount of concrete required to avoid waste.

- Fly ash cement is generally available in two standard colors; coloring agents can also be added at the job site. Fly ash can be used sparingly as an admixture or in large amounts to replace Portland cement. Casa Verde Builders in Austin, Texas, uses 40 percent content fly ash in all its concrete.
- Manufacturers are developing specialty cements, which should be widely available soon, that can be formulated to produce various set times, cold weather resistances, strengths and strength gains, depending on the job.

Benefits of Fly Ash Concrete

- Some manufacturer's proprietary fly ash cement is considered a non-shrink material with advantages in workability, water retention, and strength.
- Because fly ash mixes with less water, it is less likely to crack.
- Fly ash has low embodied energy and is an industrial by-product.
- Fly ash concrete is currently cost-competitive with Portland cement concrete.
- Because fly ash is made of spherical tiny glass beads it is lighter than Portland cement.
- Because fly ash cement requires less water than Portland cement, it is easier to use in cold weather and withstands chemical absorption.
- Fly ash can be substituted for traditional raw aggregate materials such as shale, clay, or sand.

Challenges of Fly Ash Concrete

- Fly ash comes from various operations in different regions, so its mineral makeup may vary among manufacturers.
- Fly ash may not be available in your area.
- There are some concerns about freeze-thaw performance and a tendency of mixes made with fly ash to leave a powdery substance on the surface. This "efflorescence" happens especially when fly ash is used as a complete replacement for Portland cement.
- If concrete contains too much fly ash, it become impervious and will not form a bond with tile and stone adhesive mortars

FAST FACT

Fly ash is a fine, glass-like powder recovered from gases created by coal-fired electric power generation. U.S. power plants produce millions of tons of fly ash annually; this fly ash is sent to landfills.

Fly ash is an inexpensive replacement for cement used in concrete. It improves the strength, segregation, and ease of pumping of the concrete. Fly ash is also used as an ingredient in brick, block, paving, and structural fills.

Preserved Wood Foundation (PWF)

Preserved wood with batt insulation can be used to construct foundation walls. The preserved wood is soaked in a salt solution and pressure-treated, making it less vulnerable to water and more adaptable to outdoor usage. A vapor and water barrier must be installed at the interface between the soil and the wood because the wood will absorb water, which can cause mold and insect invasion. The R-value for a 4 ft. preserved-wood wall is around R-19 if 2x4 construction is used with a full-depth fiberglass batt. Permanent wood foundations must be preservative-treated in accordance with American Wood-Preservers' Association (AWPA) Standard C22, "Lumber and Plywood for Permanent Wood Foundations - Preservative Treatment by Pressure Processes."

Implementation of Preserved Wood Foundation

A PWF is not simply an exchange of treated wood for concrete. It requires a building system that keeps water away from the foundation through a bed of gravel and free draining soil. A treated wood floor system will eliminate the need for concrete foundation work, allowing construction to proceed regardless of weather and utilizing the same wood framing construction crew. PWF enclosing habitable space must be protected by a 6 millimeter polyethylene moisture barrier. It must be applied to the plywood by embedment into vertical beads of sealant or into uniformly applied damp proofing. Use of appropriate vapor barriers, including a sump pump or drain piping is recommended, depending on soil or weather conditions.

Benefits of Preserved Wood Foundations

- PWFs are dry, comfortable, easy to finish, and more economical to convert to fully livable space than masonry foundations.
- PWFs are easily insulated and finished, which reduces foundation heat loss by up to 50 percent without the added expense of extra studding or furring.
- Unlike concrete or block, a PWF does not allow moisture or dampness to pass through the foundation walls, virtually eliminating the cold, damp, and musty basement feeling and maximizing comfortable living space.
- A PWF can easily be plumbed and wired just like the rest of a house.
- The PWF is approved by the 2000 International Residential Code (IRC) which specifies fasteners, wood treatment, and gravel or crushed stone footings and often refers to American Wood Preservers Association (AWPA) standards. Check with local code offices to determine the requirements in your area.
- When building a PWF, you can reduce building costs by as much as $10 per square foot.
- A preserved wood system would be a good choice for a house in a rural area because wood is lightweight and easier to transport, store, and use than ready-mix concrete.

Challenges of Preserved Wood Foundation

- In the event of a hurricane, a tornado, or flooding, a wood basement is unlikely to perform as well as concrete blocks or other foundations.
- The walls have little thermal mass, and since the exterior soil is often moist, the relative humidity near the wall will often be 100 percent, even if water is not present.
- Structural problems resulting from soil pressure on the foundation walls can occur. Any evidence of movement or failure of the structure requires a specialist in PWFs.

Insulated Concrete Forms (ICF)

Insulated Concrete Forms (ICF) are constructed from expanded polystyrene (like white foam coolers) and stacked like building blocks to form the exterior walls of a home; the forms are reinforced with steel and filled with concrete to complete the foundation or build walls. The forms interlock and fasten to each other to provide seamless “foundation to rafter” insulated, reinforced concrete walls. Window and door openings of any size are possible. ICFs provide a lasting building envelope, designed to withstand high wind, fire, the elements, and the test of time.

Implementation of Insulated Concreted Forms

Basement waterproofing materials for windows and doors for an ICF basement need to be ordered with wider jamb extensions to accommodate the increased wall thickness. The level of manufacturer support, including training, on-site and technical support, and marketing materials will vary between manufacturers. In practice, it’s not difficult to stack ICFs into walls, although bracing and leveling before the pour are critical. Cuts in the forms can make the concrete pour more shaky; avoid cutting corner blocks, use plenty of bracing, and secure large joints with scraps of plywood.

Benefits of Insulated Concrete Forms

- ICF construction is compatible with all home designs.
- ICF walls benefit from concrete’s inherent structural qualities, particularly important in regions affected by severe weather.
- The combination of a continuous concrete wall and the integral interior and exterior insulation provides superb energy efficiency and lower utility bills.
- ICFs energy efficiency translates into even, consistent temperatures throughout the home. Outdoor pollutants can be kept to a minimum.
- With several inches of concrete sandwiched by foam insulation, ICF homes are typically quieter than conventionally built homes.
- ICFs save money, conserve resources, and use recycled materials.
- ICFs are not subject to rot and result in a better insulated foundation.

Challenges of Insulated Concrete Forms

ICF homes may cost up to 10 percent more to build, depending on the manufacturer, shipping costs, and other factors impacting local building costs. Lower heating and cooling loads will offset the increased up-front construction costs with lowered requirements for HVAC equipment and long-term utility savings.

Frost-Protected Shallow Foundations (FPSF)

A Frost-Protected Shallow Foundation protects against frost damage without the need for excavating below the frost line. An FSPF has insulation placed strategically around the outside of a foundation to direct heat loss from the building toward the foundation, and to use the earth's natural geothermal energy.

Implementation of Frost-Protected Shallow Foundation

To install frost-protection properly, the builder must apply one layer of insulation to the outside face of the foundation, while a second layer of insulation extends horizontally away from it. The rigid foam traps any heat that the ground absorbs from the building, keeping soil temperatures around the footing above freezing. The building's heating system can be safely turned off for up to three weeks in the winter because thermal lag in the concrete will maintain the soil temperature above freezing.

Benefits of Frost-Protected Shallow Foundation

- Homeowners experience effective energy savings because FPSFs use geo-thermal heat to maintain sub-slab soil temperatures above freezing.
- FPSFs reduce construction, labor, and material costs and are an affordable method in building a comfortable and insulated foundation will less excavation required.
- FPSFs can be constructed using conventional materials, such as rigid expanded or extruded polystyrene foam, which is readily available.
- FPSFs have insulated footings that can keep the soil above freezing even in the coldest weather.

Challenges of Frost-Protected Shallow Foundation

- In some areas it may be difficult to acquire permit approval.
- An FPSF is only cost-effective if the frost line is 30 inches deep or deeper.
- If you have a walkout basement and the grade comes down the sides of the house, you must plan for and install dampproofing where required.
- You will need to train subcontractors about the importance of frost- protected insulation.

CASE STUDY

Green and Red Construction in Guadalupe, Arizona

In this small town with a population of just over 5,000 people, YouthBuild Guadalupe has constructed more than 100 new, Energy Star rated affordable homes in partnership with the City of Guadalupe and Habitat for Humanity. This new construction has greatly improved the housing stock, while respecting designs that celebrate the local culture – all while delivering energy efficiency.

Red Construction—A Culturally Conscious Design

The new home designs incorporated the input of citizens from three community forums. To reflect Southwestern culture, YouthBuild members skinned log trees (referred to as “Vegas”) for the supportive roof structure. A courtyard area was designed to perform as an outdoor family gathering space. The community requested buildings that serve multiple generations, and the design group responded by creating a “casita” for rental income or a mother-in-law apartment—a small house with its own bathroom and kitchenette. The larger, main home was also constructed to structurally support a second story for an additional two bedrooms, to accommodate a growing family. The design also includes cut-outs, or enclaves in the wall system, to place statues or other items.

Green Construction—An Environmentally Conscious Design

The house is designed as a passive solar building, using orientation and layout to maximize the benefits and reduce problems of its desert climate. The courtyard, in addition to making sense culturally, was designed to help cool the rest of the house. The home wraps around the courtyard on three sides forming a C-shape. A fountain cools the space, which in turn, along with the shading from indigenous plants, cools the house. The courtyard also features an outdoor cooking area because traditional Native and Hispanic cooking is done outdoors to help keep the house cooler.

The roof is enclosed with a mirror seal—a nontoxic white, reflective, elastomeric flat roofing system that replaces the usual rubber or petroleum based products.. Most roofs are made of toxic materials and require special handling and training, but the non-toxic white reflective roof can be installed safely by Guadalupe youth. The roof reflects the sun light, so that it keeps the house cooler, another solar energy-efficient design.

Because the weather is hot and dry, Guadalupe YouthBuild can use evaporative coolers instead of traditional refrigerant air conditioning. The central AC is a water cooled air chiller that uses no Freon, so it helps prevent prevents ozone layer depletion. The exhaust air from the evaporative cooler is only 80° (Freon air conditioning exhaust is well over 100°) and as a result, the construction crews funnel the exhaust into the courtyard to keep it even cooler.

For a watering system, three cistern water tanks will collect 4,000 gallons a year of rainwater from the roof for landscaping.

Another green element is a Flex-Crete block locally produced on the Navajo reservation in Page, Arizona. The Flex-Crete product is a fiber-reinforced aerated concrete product that uses large volumes of fly ash. Fly ash is abundant where coal is burned for electricity production. The ash is combined with concrete, fiber, and aluminum chloride. This particular block gives a high "R" value, which measures insulation quality. Traditional building insulation quality is measured at R-19, and the Flex-Crete product provides up to an R-40 value. It is soundproof, fireproof, and termite-resistant. For more information, visit www.flex-crete.com.

Even the deconstruction material taken from the original home was reused. For example, the original concrete foundation was broken up and the larger pieces used as pavers throughout the courtyard. They also used the old plywood from the old carport for the new carport.

Contact Jennifer Drury for advice on green and culturally-conscious building designs: mailto:jdrury@guadalupeaz.org.

Link and Learn

Shades of Green Tool Bench: Basements and Foundations:
http://www.ybshadesofgreen.org/files/helper-pdf/Basements-MoistureControl-050210-v8.pdf

Shades of Green Tool Bench: Conditioned Basements and Foundations:
http://www.ybshadesofgreen.org/files/helper-pdf/ConditionedBasements-050310-v7.pdf

Shades of Green Tool Bench: Unconditioned Basements: Venting and Insulation:
http://www.ybshadesofgreen.org/files/helper-pdf/UnconditionedBasements-050310-v7.pdf

RSMeans, *Green Building: Project Planning & Cost Estimating*, (Contributing Authors, 2002)

Raised Floor Living; Rediscover the Raised Floor Home:
http://www.raisedfloorliving.com/homepage.asp

Toolbase Tech Spec on Frost-Protected Shallow Foundations from the Partnership for Advanced Technology in Housing (PATH):
http://www.toolbase.org/pdf/techinv/fpsf_techspec.pdf

Overview of Insulated Concrete Forms from Green Building Advisor:
http://www.greenbuildingadvisor.com/green-basics/insulated-concrete-forms

Inspectapedia's types of building foundation damage:
http://www.inspectapedia.com/structure/FoundationOccur.htm

Home Energy Magazine's comparison of foundations and basement walls:
http://www.homeenergy.org/archive/hem.dis.anl.gov/eehem/99/990311.html