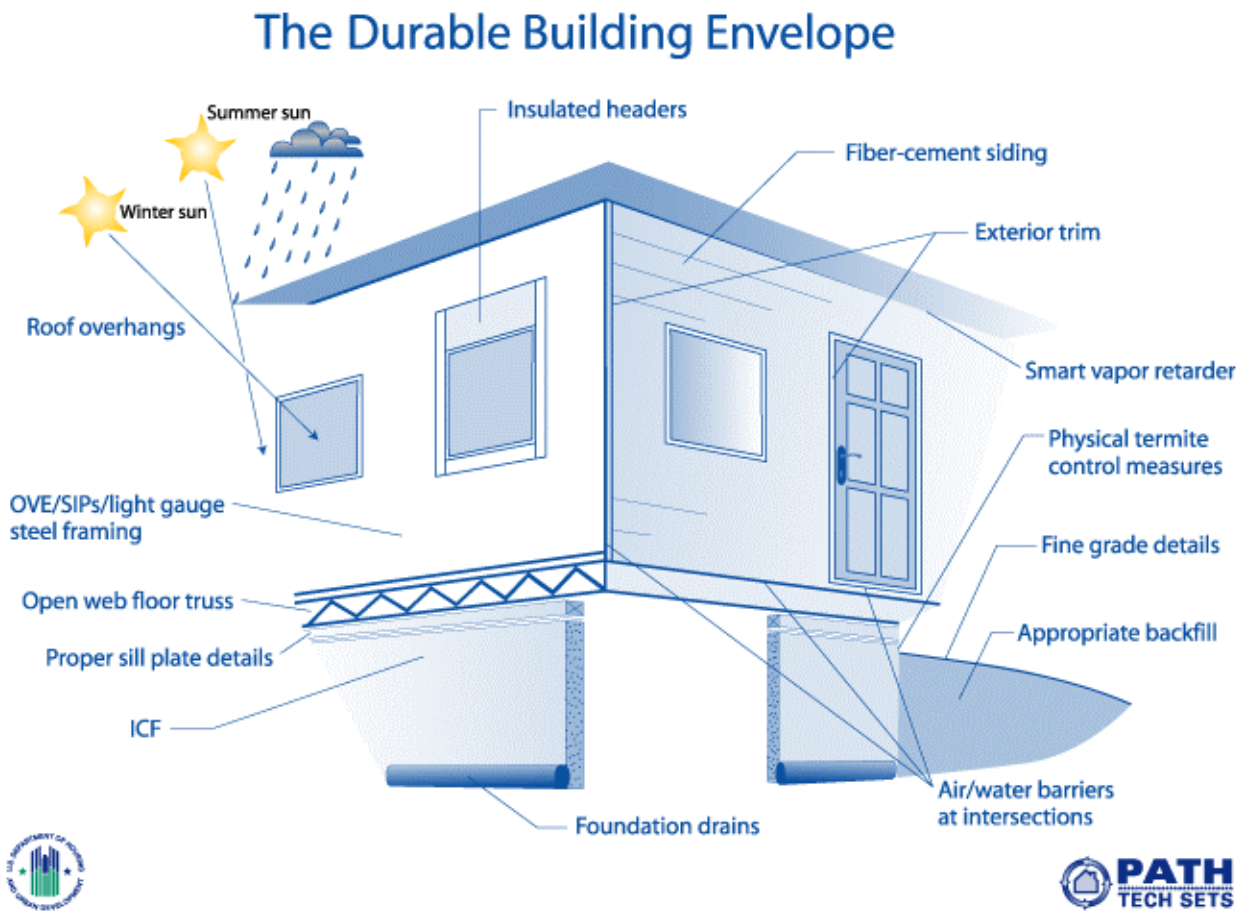
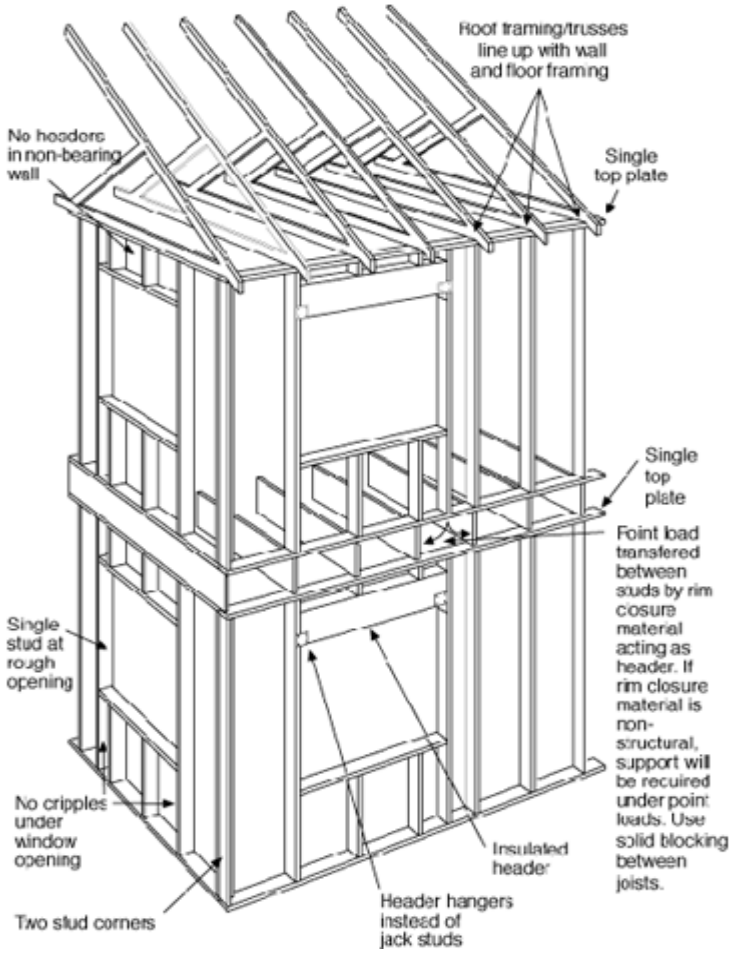
Tech Set 2: Durable Building Envelope

The second PATH Tech Set, "Durable Building Envelope Details for New Construction and Additions" shows builders the components of an affordable and durable building envelope--the foundation, walls and roof that separate conditioned and unconditioned spaces.





Alternative Framing Techniques

Optimum Value Engineering, **Engineered Wood Wall Framing**, **Structural Insulated Panels**, and **Light Gauge Steel Framing** are advanced approaches to building exterior walls. Each technique has significant benefits over traditional framing measures.

Optimum Value Engineering/Advanced Framing

Optimum value engineering (OVE) or advanced framing refers to framing techniques that reduce the amount of lumber used to build a home while maintaining the structural integrity of the building.
Using OVE techniques results in lower material and labor costs and improved energy performance for the building. While the various techniques can be applied as a whole package, many components can be used independently, depending on the specific needs of the project.

These techniques can benefit all builders who build stick-frame homes, even if only the interiors are stick-built.

Specific techniques include:

- 19.2" and 24" on center framing
- Modular layout
- Single top plate - Exterior and bearing walls
- Single top plate - Interior non-bearing partitions
- Right-sized headers
- No headers in non-bearing partitions
- Ladders at T-intersections
- Open corner framing
- Doubling the rim joist in lieu of header

Some of these techniques are shown in the diagram to the right.

Engineered Wood Wall Framing

The decreasing supply of large-diameter, old-growth trees has resulted in an increased popularity of engineered wood materials that use young, small-diameter trees. The materials are processed into strands, then reassembled into panels, boards, and framing.

Engineered wood wall framing can be used as a one-to-one replacement for traditional 2 x 4 and 2 x 6 dimensional lumber, headers, and beams. Engineered framing can be installed with the same processes, tools, and fasteners as conventional wood framing, but is stronger and has fewer defects.

Structural Insulated Panels

Structural insulated panels (SIPS) are made from a thick layer of foam (polystyrene or polyurathane) sandwiched between two layers of oriented strand board (OSB), plywood, or fiber-cement. The result is an engineered panel that provides structural framing, insulation, and exterior sheathing in a solid,

one-piece component. Some SIP manufacturers precut the panels based on a digital blueprint of the house, which allows workers to assemble the panels rapidly with minimal training. SIPs construction allows builders to quickly construct an exterior building envelope that is strong, airtight, and very energy efficient.

Residential Light-Gauge Steel Framing

The use of light gauge steel framing is common in commercial building and gaining acceptance in home construction due to its rot and termite resistance, uniformity, and lower cost when compared with wood. Steel studs can be used for both non-load-bearing and load-bearing applications. Steel studs, joists, and rafters fit into a top and bottom track. Steel framing members can be cut with a chop saw, aviation snips, or electric shears.

Concrete Foundation Walls

There are numerous varieties of insulated concrete foundation walls, including **Insulated Concrete Forms**, and **Precast Foundation Walls**. Each offers unique advantages. When using concrete, it is often beneficial to use **Concrete Admixtures**, which can impact the concrete's workability, curing temperature range, set time, or color.

Insulated Concrete Forms

Insulated concrete forms (ICFs) are rigid plastic foam forms that hold concrete in place during curing and remain in place to serve as thermal insulation for concrete walls. The foam blocks or planks are lightweight and result in durable, energy-efficient construction. Because of their benefits¾including sound attenuation, impact resistance, and high R-value¾ICFs are desirable in above-grade applications as well as foundations.

Insulated concrete forms allow poured concrete foundation and above-grade walls to be installed without costly, reusable forms.

Photo Courtesy of Building America's Building and Science Corporation.

ICFs allow trade contractors to construct concrete walls without a significant investment in reusable wood and metal forms. Because ICFs fit together easily and remain in place after concrete is poured, they can simplify and speed construction. ICFs increase the temperature range for pouring concrete to below freezing (freezing inhibits proper curing) by insulating the concrete until it is fully cured. ICFs can also result in stronger walls than standard cast-in-place concrete due to more constant, predictable cure during all seasons.

The three basic types of ICFs are hollow foam blocks, foam planks held together with plastic ties, and 4 x 8 panels with integral foam or plastic ties.

Precast Concrete Foundation Panels

Precast concrete foundation panels are cast and cured in a controlled factory environment. Built in the factory and installed on site in a fraction of the time of poured foundations, precast concrete panels help avoid weather delays. A typical panelized foundation can be erected in four to five hours, usually by bolting the panels together on site, without need of a concrete pour. The precast panels often come with rigid insulation already installed and furring strips pre-attached to the stud face to further simplify site construction.

Manufacturers are able to produce mixes that harden to 5,000 psi, which is stronger than concrete block or concrete walls formed and cast in the field. Panels range in size from 2-12 feet in width and 8-12 feet in height. They are typically installed by a crane, which lifts the panels into place on top of 4-6 inches of compacted stone.

Precast panels are installed using a crane.

Photo Courtesy of Building America's Building and Science Corporation.

Concrete Admixtures

Admixtures are materials that can be added to concrete either before or during its mixing to alter its properties, such as workability, curing temperature range, set time, or color.
Admixtures do not include cement, aggregate, or water. Some admixtures have been in use for a very long time, such as calcium chloride, which assists with cold-weather setting. Other admixtures are more recent and represent an area of expanding possibilities for increased performance. Not all admixtures are economical to employ on every project. Also, some characteristics of concrete, such as low moisture absorption, can be achieved simply by consistently adhering to high-quality concreting practices.

Based on their functions, admixtures can be classified into the following five major categories:

- Retarding admixtures
- Accelerating admixtures
- Super plasticizers
- Water reducing admixtures
- Air-entraining admixtures

Other important admixtures that do not fit into these categories assist with bonding, shrinkage reduction, damp proofing, and coloring.

Cement substitutes, like fly ash and slag, can improve the quality of the concrete make it more environmentally friendly by substituting waste products for cement. Fly ash, slag cement, and silica fume are waste byproducts from power plants, steel mills, and other manufacturing facilities. Concrete substitutes also make good environmental sense because producing Portland cement generates significant greenhouse gasses.

Floor Trusses and Headers

New technologies, including **Trim-able Open Web Floor Trusses**, **Insulated Headers**, and **Steel L-Headers** can allow for the more rapid installation of premium building products.

Trim-able Open Web Floor Truss

Open web, or parallel flat chord trusses, represent the predominate type of floor truss used in homes.

Trim-able floor trusses can be shortened by as much as 12 inches on each end.

Photo Courtesy of Building America's Building and Science Corporation.

They typically consist of a wood top and bottom chord, usually 2x4 material, and wood web materials connected at joints with metal plates. A few manufacturers use steel webs.

One advantage of open web over dimension lumber or I-joists is that the open space between web members allows for easier routing of utilities and ductwork. Open web floor trusses eliminate the need for field cuts for utility installations, reducing the risk of structural damage in the field.

However, truss dimensions must be known in advance to be within fairly close tolerances. Manufacturers and codes generally do not permit trusses to be trimmed or altered in the field.

Fortunately, new trim-able floor trusses now exist. These trusses, which can be trimmed onsite, add the flexibility of allowing the member to be shortened by as much as 12 inches on each end.

Insulated Headers

Insulated headers are similar to Structural Insulated Panels (SIPs), in which two OSB webs enclose a layer of EPS foam insulation. The result is a lightweight header with a thermal break that does not sacrifice structural performance. The headers are straighter and more dimensionally stable than the usual un-engineered header, and less subject to shrinkage and warping that often causes drywall to crack in conventionally framed header areas.

Steel L-Headers

The steel L-header is a new header design that cuts labor time over the C-channel design by significantly reducing the amount of cutting and fastening. Steel L-headers consists of two "L" shaped, light gauge steel angles. The shorter leg of the angle is about 1-1/2 inches wide, and the longer leg ranges from 6 to 10 inches long. The short leg rests on the wall's top track and the longer leg extends down toward the window or door opening. Steel thickness typically ranges from 16 to 20 gauge.

Fiber Cement Siding & Exterior Trims

Alternatives to wood siding and exterior trim are becoming popular because of their improved durability and competitive costs. **Fiber-Cement Siding**, **Fiber-Cement trim**, **Cellular PVC trim**, and **Recycled Wood/Composite trim** are all more durable than wood, and require little maintenance.

Fiber-Cement Siding

Fiber-cement siding is composed of cement, sand, and cellulose fiber that has been autoclaved (cured with pressurized steam) to increase its strength and dimensional stability. It is a durable alternative to wood, termite resistant, non-combustible, and warranted to last 50 years. The installed costs of fiber-cement are less than traditional masonry or synthetic stucco, equal to or less than hardboard siding, and more than vinyl siding.

Photo courtesy of James Hardie & Coy Pty Limited.

Like wood siding, fiber-cement siding is installed over studs or exterior wall sheathing with an appropriate water-resistant barrier, using galvanized nails or screws that penetrate into wall studs. The fiber cement planks should be cut with a blade designed specifically for fiber-cement dust reduction, such as Hitachi's Hardiblade or Dewalt's PCD Fiber Cement Blade. Alternatively, snapper shears or a guillotine-type cutter can also be used. For finishing, fiber-cement products come either primed or unprimed.

Cellular PVC Trim

Cellular PVC is a solid, extruded plastic that has the working characteristics of wood and is used for interior trim, exterior trim, and paneling as well as windows and doors, blinds, and furniture. Cellular PVC keeps its shape and never needs painting.

Recycled Wood/Composite Trim

Recycled wood/plastic composite lumber is one of the prime uses for recycled plastic trash bags and waste wood fibers. Manufacturers claim that products produced with recycled wood/plastic lumber are more durable than conventional preservative-treated lumber, and more rigid than 100-percent plastic recycled lumber. These products contain no toxic chemicals such as those used in conventional treated lumber.

Fiber-Cement Trim

Like fiber-cement siding, fiber-cement trim is more durable than wood. Fiber-cement is composed of cement, sand, and cellulose fiber. The fiber is added to reinforce the concrete and to prevent cracking. Fiber-cement trim comes in a variety of colors, thicknesses, and grain patterns for corners, columns, windows, rakes, and friezes.

Moisture Management

Moisture can effect both a home's durability and indoor air quality. 'Wet walls' can lead to mold and even rotting studs. The extensive use of **vapor barriers** and **air sealing** can help prevent moisture problems.

Air Sealing

Proper air sealing will lower a home's energy use and increase comfort levels by reducing the amount of air infiltration into a home. Air sealing will also improve a home's durability by minimizing the amount of moisture penetration into the walls and living spaces.

Southface's Air Sealing Checklist

- Seal the bottom plate of exterior walls with caulk or gasket. Seal inside edges with caulk after walls are up.

- Seal band joists with caulk, spray foam, or gasketing between the top plate and band joist, and between the band joist and subfloor.
- For bathtubs on outside walls, insulate the exterior wall and air seal behind the tub with sheet goods or plastic before the tub is installed. After the drain is installed, seal the tub drain penetration with sheet goods and caulk or spray foam. Is sheet goods correct?
- For dropped ceilings or soffits, duct and flue chases, and open partition walls, use sheet goods and sealant to stop air leakage from the attic into the soffit and then insulate. Another alternative is to install framing and drywall for the soffits after the taped ceiling drywall is installed.
- Caulk the backsides of window flanges to the sheathing during installation.
- Seal between door thresholds and subflooring with caulk.
- Seal window and exterior door rough openings with backer rod and caulk, or use non-expanding latex-based spray foams that will not pinch jambs or void window warranties.
- Seal all electrical wire, plumbing, and HVAC penetrations between any conditioned and unconditioned spaces with caulk or spray foam.
- Seal wiring and knockouts in electrical boxes with caulk. Also seal outdoor mounted boxes to the exterior sheathing.
- Repair any damaged sheathing pieces.
- Seal all exterior penetrations, such as porch light fixtures and phone, security, cable and electric service holes with caulk or spray foam.
- Seal the weather-resistive barrier paper. Be sure to properly overlap sheets.
- If you are not using housewrap or another weather-resistive barrier paper, seal all sheathing seams with housewrap tape or caulk.

Be sure to seal the platform intersections, such as the joists to sill plate and deck to wall plate, since these are frequently overlooked.

Water Sealing

A vapor retarder, or a vapor barrier, is a layer in the building envelope that restricts the diffusion of water vapor. Water vapor will go from an area of high vapor pressure (i.e., high humidity) to low vapor pressure (i.e., low humidity). Typically, indoor air in cold climates is at a higher vapor pressure than outdoor air, which is dryer and colder. The opposite is true in hot/humid climates, where the lower vapor pressure is indoors (and accentuated by the use of air conditioners and dehumidifiers).

A smart vapor retarder exhibits low permeance under dry conditions and much higher permeance under damp conditions. In cold weather, the product is designed to function much like a conventional vapor retarder, blocking vapor flow from inside the house into the wall cavity. However, during hot weather, a smart vapor retarder will permit a damp wall cavity to dry towards the indoors. It can also be used in mixed-humid climates where conventional vapor retarder placement is problematic. Smart vapor retarders are not recommended for hot-humid climates.

When installing vapor retarders, remember to also install them next to the attic insulation. Most homes are now built with vapor retarders in the exterior walls, but the attic is often neglected. Attics are critical because they often experience high levels of humidity.

For additional information on vapor retarders, visit PATH's Durability by Design.

Durability Details

To ensure that your home will last for generations, you need to look at many areas, both large and small. Two areas--both important for durability--that are sometimes glossed over are the proper **anchoring of the sill plate**, and the use of **physical barriers** to control termites.

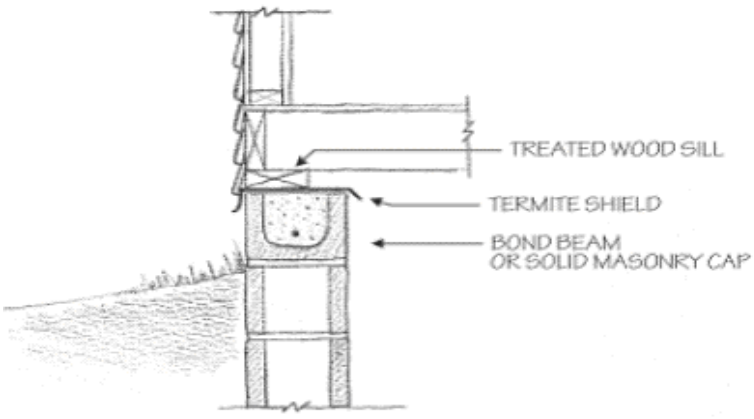
Sill Plate Anchor

It is very important to ensure that the sill plate is properly anchored to the foundation, especially in earthquake and high-wind areas. In particular, pay attention to proper sizing and spacing of the sill plate anchor hardware.

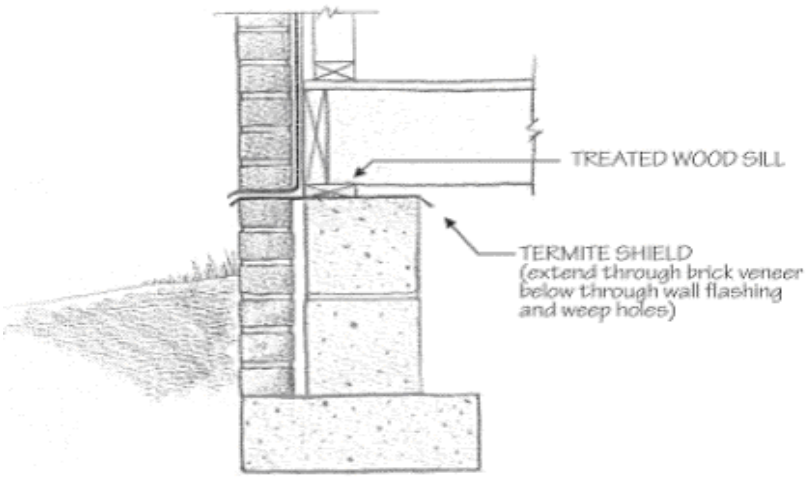
The Uniform Building Code requires sill plates to be bolted to the foundation with 5/8-inch diameter bolts in seismic areas. These bolts should be spaced no more than 6 feet apart. A bolt should be placed within 9 and 12 inches from the ends of all sill plates, and placed near the center of the stud.

Always consult local codes and manufacturers details before installing a product.

Physical Termite Control Measures



a) Masonry foundation construction



b) Brick veneer construction

Termite control traditionally is performed through soil chemical treatments that act as barriers between subterranean termites and the house.

Barrier control methods that do not rely on termiticides as the primary deterrent are called physical barriers. Physical barriers can isolate particularly vulnerable elements of a house such as penetrations through foundations and slabs, or protect the entire perimeter of the foundation.

Although costs are typically higher than using termiticides, proper placement and installation of physical barriers can provide termite protection for houses with little to no risk of pesticide exposure to the occupants.

Once installed properly, reapplications of the physical barriers are unnecessary, unlike chemical control measures.

With physical barriers, a shield is placed between the masonry foundation and wood framing to prevent termites from gaining access to the wood framing components.

Termite shields must be made of termite-resistant materials such as thick metal or concrete since some termites can chew through plastics and thin metals. Also, any seams in a termite shield must be soldered or otherwise sealed.

For more detailed information see Chapter 6 of PATH's Durability by Design.

Foundation Drainage

Many problems can occur in a basement or foundation that was not designed to withstand the elements, especially standing water.

By damp proofing or waterproofing the foundation appropriately, installing appropriate foundation drains, and properly backfilling and grading the soil around a house, moisture problems can be averted.

Foundation Drains

Improper drainage around the foundation is a major cause of leaking foundations. When a drainage system is used in residential construction, it is usually a combination of a gravel drainage layer with a foundation drain, made of either a drain tile or perforated PVC pipe. However, as drainage occurs, small soil particles can plug up the drainage path, compromising the drainage system. Water pressure then builds up and eventually causes leakage through the foundation wall.

The typical foundation drainage system consists of a waterproofing membrane at the foundation with a preformed path (a grid system or a solid, porous board) and a filter to keep the drain path clear of small particle build-up. Filters have traditionally been a course or specially-graded aggregate, ranging from crushed stone or gravel to coarse angular sand.

Foundation drainage panels like the dimpled polyethylene sheet pictured above are becoming increasingly common.

Photo Courtesy of Building America's Building and Science Corporation.

Geotechnical fabrics, commonly called "filter fabrics," and other foundation drainage panels are now quite common. Compared to traditional granular fill, foundation drainage panels offer lighter weight; greater dimensional stability; dependable and increased flow; full flow continuity; and protection against freeze-thaw and backfilling damage.

Foundation drains should drain water by gravity away from the building to a daylight outfall, a sump pump, or drywell, depending on the site's conditions. When draining to an outfall, it is important to ensure that the outfall pipe is designed and located to minimize erosion.

For particularly wet sites, installing a radial drainage pipe system under the slab that directs water to a sump pump could be beneficial. Sump pumps are used to lower the water table to a point below the slab.

Appropriate Backfill and Grading

Poor surface and subsurface drainage can lead to water ponding around the house, leakage of ground water through the basement or crawlspace walls, and structural damage to the foundation from the build-up of hydrostatic water pressure. Successful drainage requires leading surface water away from buildings with appropriate grading and backfill.

The grading immediately adjacent to the building should be sloped a minimum of about 5% (or 3 inches every 5 feet) for at least 10 feet outward from a building foundation or as far as practical. In areas that receive a large amount of water, the ground around the foundation should slope away a minimum of 10 percent for at least 10 feet outward from the building foundation.

Backfilling the soil around the foundation of the house with appropriate materials is important. Avoid silt, heavy clay, or expansive clay backfill, particularly around basement walls. Use granular soils

instead. Backfill should be tamped firmly to prevent excessive settlement and be covered with 2 inches of topsoil.

Keep the soil at least 8 inches below the point where the framing starts. Because foundation plantings-trees, shrubs, and flowers placed near the foundation of a home-may promote mold and fungus growth on siding that is protected from the sun, they should be planted at least one foot away from the foundation.

Roof Overhangs

Appropriately sized roof overhangs have two major benefits: They keep unwanted, hot summer sun from heating a home, and they help protect the home from moisture damage caused by precipitation.

While protecting the walls and foundation from excess moisture, roof overhangs over entries and windows are also convenient for the occupant during foul weather. This architectural feature that can also enhance a home's visual appeal.

Durability

An overhang over an entry, such as a porch or even an eave, protects occupants from precipitation, but also protect the door's finish from moisture around jambs, trim, and thresholds, thereby minimizing the need for maintenance.

Overhangs above windows allow the resident to enjoy the sound of falling rain without worrying about the rain coming inside.

Studies have shown that the larger the size of overhang for windows or doors, the less frequently moisture penetration problems will occur on the exterior and foundation walls.

The local climate will determine the minimum size of overhangs. In moist climates with significant rainfall, liberal use of overhangs is strongly recommended.

Recommended Minimum Roof Overhang Widths for One- and Two-Story Wood Frame Buildings

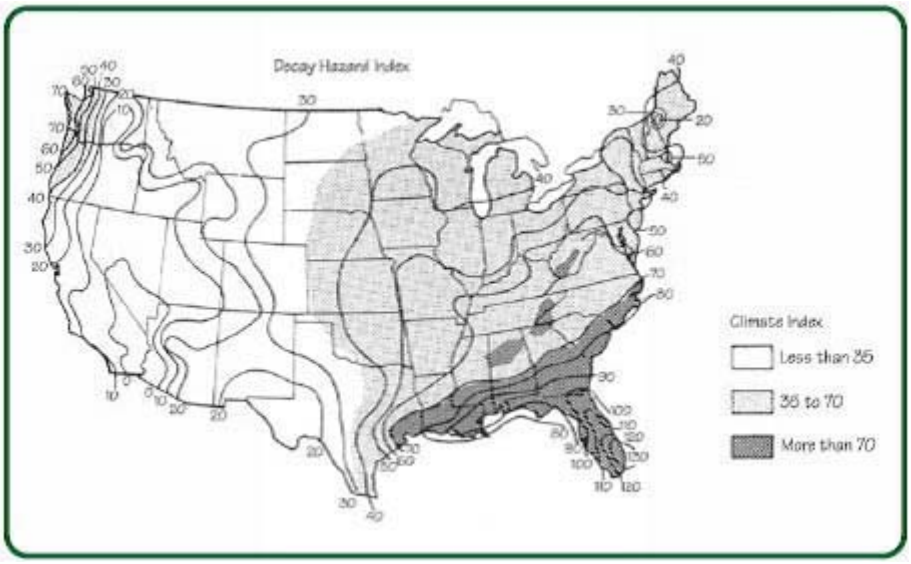
Climate Index (See Figure Below)	Eave Overhang (Inches)	Rake Overhang (Inches)
Less than 20	N/A	N/A
12 to 40	12	12
40 to 70	18	12
71 and above	24 or more	12 or more

Source: Modification of Prevention and Control of Decay in Homes by Arthur F. Verrall and Terry L. Amburgey, prepared for the U.S. Department of Agriculture and U.S. Department of Housing and Urban Development, Washington, DC, 1978.

Use the overhang widths in the table above if all walls have a properly constructed weather barrier, roofs are adequately guttered, and normal maintenance of the exterior will occur. For overhangs protecting more than two stories of walls with exposed windows and doors, consider using larger overhangs.

Rake (gable end) overhangs deserve special consideration because more costly "outrigger" framing methods will be required for overhangs exceeding about 12 inches in width, and the appearance may not be acceptable to some home buyers. For sites subject to frequent wind-driven rain, larger overhangs and drainage plane techniques that include an air space behind the siding should be considered. For non-decay-resistant wood sidings and trim (e.g., windows and door casings), larger overhangs and porch roofs are recommended.

Climate Index Map Based on Wood Decay Potential



Source: Theodore C. Scheffer, "A climate index for estimating potential for decay in wood structures above ground," Forest Products Journal, Vol. 21, No. 13, October 1971.

The climate index map does not directly account for wind-driven rain, a condition that varies with local climate or site exposure.

Solar Shading

As with rain on the building envelope, properly sized roof overhangs can minimize the exposure to solar radiation and radiation-related problems such as fading of furniture and carpeting.

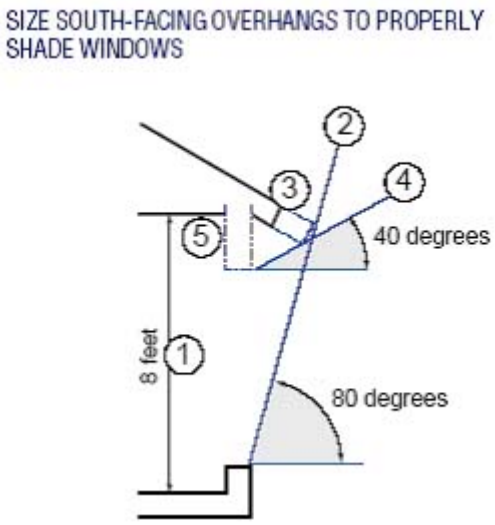
It is possible to block unwanted direct summer sunlight from entering windows while allowing the heat gain through windows from winter sunlight. The width of a roof overhang that allows this seasonal solar shading depends on where the building is located with respect to the equator. Buildings situated farther south receive greater protection from the summer sun by roof overhangs because at higher latitudes, the sun is lower in the sky than at lower latitudes.

To determine the exact size a south-facing overhang that allows winter sun into a home but protects the interior from direct summer sun, visit Durability by Design or see the instructions below.

Overhang Sizing Rules

1. Draw the wall to be shaded to scale.
2. Draw the summer sun angle upward from the bottom of the glazing.
3. Draw the overhang until it intersects the summer sun angle line.
4. Draw the line at the winter sun angle from the bottom edge of the overhang to the wall.
5. Use a solid wall above the line where the winter sun hits. The portion of the wall below that line should be glazed.

Source: US DOE EERE, Passive Solar Design Technology Fact Sheet, December 2000



For information on the technologies in the image above, visit the PATH Technology Inventory at www.pathnet.org.