

# Chapter 5

## Energy-Efficient Foundations and Floors

Recommendations	First Cost	% Estimated Savings		Radon Prevention Measure
		Cooling	Heating	
1. Choose slab-on-grade foundation, not crawl space foundation.	R	0-10	0-10	—
2. Follow standard recommended slab construction practices, including: wire mesh layer or control joints, gravel/polyethylene/sand layers, isolation joint at footing, ground sloped away from slab, cured slab.	N	—	—	Yes
3. Seal all penetrations.	S	—	—	Yes
4. Use foundation plantings to shade slab perimeter.	S	0-2	—	—
5. Consider using perimeter insulation.	M	0-2	0-10	—
6. Select tile or stamped concrete finish.	H	0-10	0-10	—
7. Seal and insulate crawl space ceiling.	S/M	—	—	Yes
8. Vent crawl space.	N	—	—	Yes
9. Insulate floors over garages or other nonconditioned spaces to R-11.	S/M	0-5	0-10	—
10. Leave space for ductwork in floor of second story.	R/N	0-10	0-10	—
11. Seal sill plate.	S	5	5	Yes
<b>Maximum Combined Total</b>	<b>H</b>	<b>25</b>	<b>25</b>	

Cost Codes: R = reduced  
 N = negligible  
 S = small (<\$0.25/ft<sup>2</sup> of floor area)  
 M = medium (>\$0.25 and <\$1.00/ft<sup>2</sup> of floor area)  
 H = high (>\$1.00/ft<sup>2</sup> of floor area)

# Marketing Energy-Efficient Foundations and Floors

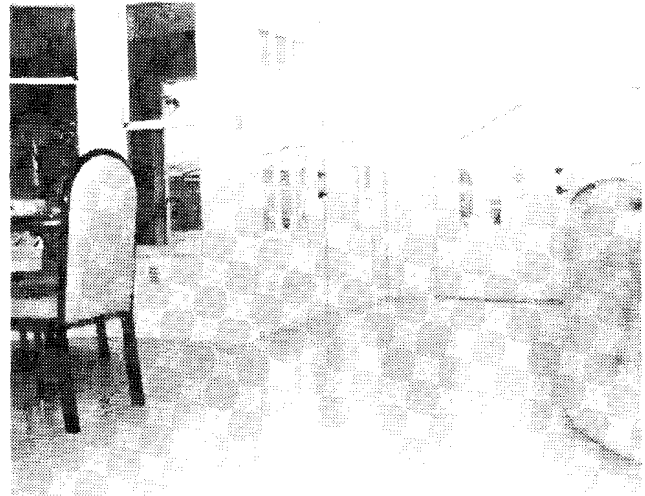
The foundation of a house appears to be an unlikely source of energy savings. However, this chapter offers construction recommendations that are cost-effective for both saving energy and preventing migration of radon or other gases from the soil. Most of these measures already are established practices. Unfortunately, too many builders and subcontractors overlook them. They should be used throughout Florida but are most important where higher radon levels exist.

This chapter also contains information on floor finishes and second-floor construction that can contribute to an energy-efficient home — together with the following tips on how to educate home buyers on the desirability of these features.

Explain to your clients the steps you have taken to minimize the chance of water, heat and cold infiltrating through cracks in and around the foundation. Show photos of other job sites where slabs have cracked or sill plates are not properly caulked, and then show photos of the foundations you built that incorporate the recommendations in this chapter. Clients will grasp the differences and view you as both an energy-conscious home builder and a quality builder.

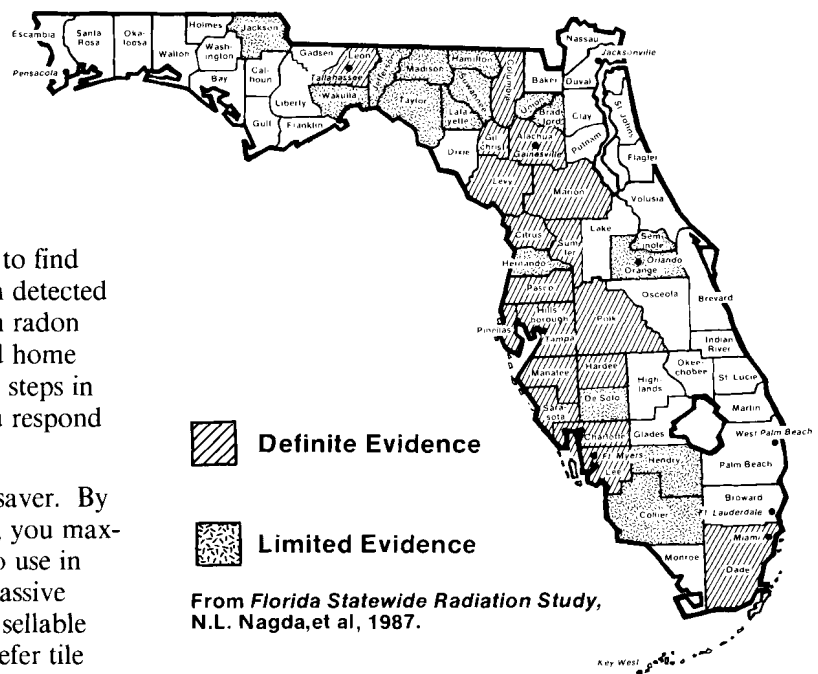
In certain parts of the state, the concentration of radon in the ground is high enough that harmful gases can migrate through cracks in the foundation into the house. The adjacent map shows areas where soil tests indicate potentially harmful levels. However, you should contact local and state health departments to find out if high radon concentrations have been detected near your building site. News coverage on radon has raised the concern of home buyers and home owners. By following the radon-reduction steps in this chapter, you can show clients that you respond to their concern.

You can market a slab floor as an energy saver. By choosing stamped concrete or ceramic tile, you maximize the use of the slab for heat storage to use in conjunction with natural ventilation and passive solar heating. Moreover, you have a very sellable floor: A survey showed that Floridians prefer tile floors to wood ones.



**A ceramic tile floor can help sell houses.**

One of this chapter's recommended strategies is to plan the construction of the second floor in two-story homes with space for ductwork. Depending on the home layout, the quantity of ducting may be reduced, with an overall cost savings that can give you an edge on a competitor. Moreover, you can inform potential home buyers that you may have saved them 10% on their heating and cooling bills!



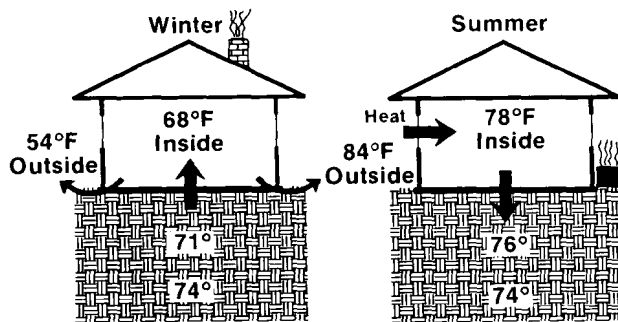
**Florida counties with evidence of elevated radon potential.**

# Constructing Energy-Efficient Foundations and Floors

## 1. Choose slab-on-grade foundations

Slab-on-grade foundations are usually more energy-efficient than raised (crawl space) foundation systems. Heat flow between the ground and slab varies — depending on the type of soil, amount of rain or shade at site, etc. — but a slab-on-grade foundation may reduce home space conditioning costs by as much as 10%.

In South Florida, slabs can reduce heating requirements by 10% and cooling requirements by 0-3%. Conversely, in North Florida, slabs can reduce cooling requirements by about 10% and heating requirements by 0-3%. This cost savings derives from the fact that year-round deep earth temperature stays constant. In Florida it ranges from 70°F (north end of Florida) to 78°F (south end of Florida).

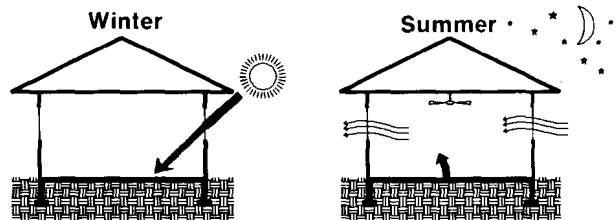


**In winter, heat flows in from the earth and out through the slab perimeter. In spring and summer, the ground helps remove heat.**

In summer, if occupants keep their house at 78°-82°F, the cooler ground can take heat away from the house. In winter, if occupants keep their house at 65°-70°F, the warmer ground can be a benefit (see drawing above). However, the perimeter of the slab (outside edges) loses heat to the cold outdoors. Unless the perimeter is insulated the slab may not help much in heating the home. But crawl spaces lose heat to the cold outdoors in winter and provide no summer benefit.

Concrete slab floors also can be used to store heat. During the summer, daytime heat can be stored for removal at night by ventilation. During the winter, passive solar heat (see Chapter 4) can be stored dur-

ing the day to keep the occupants comfortable through the evening and night.



**Slab floors can store the sun's heat in winter and the coolness from night-vented air in spring, fall and summer.**

## 2. Follow recommended slab construction procedures

For durability of the slab foundation, a number of standard measures should be followed. (See drawings on next page.) They will reduce moisture migration from the ground to the house and keep the air conditioner from working as hard. More important, they may deter the leakage of dangerous gases such as radon or pesticides from the soil into the house.

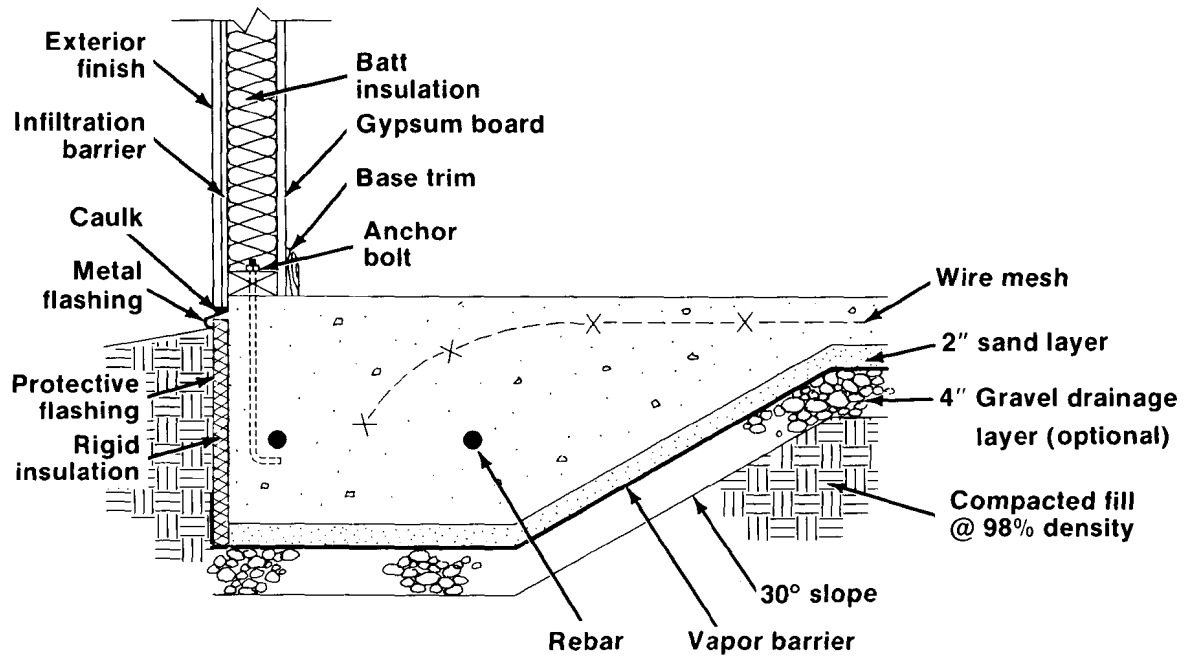
**Radon.** Despite uncertainties about the causes and effects of radon concentration in houses, there is general agreement that:

- Dangerous levels of naturally occurring radon can be found in some homes.
- Radon usually gets into the home from cracks in or around the foundation.

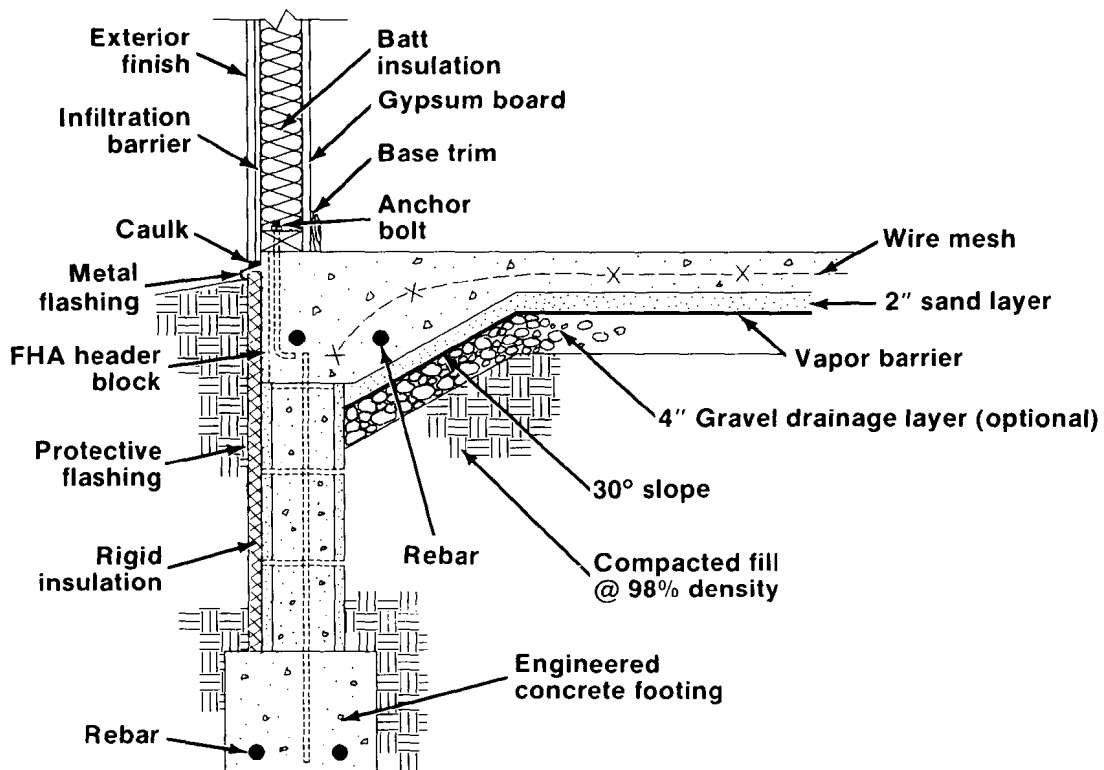
The following radon-reducing steps are suggested measures at this time. The State of Florida may come out with standards in the near future that would supercede any recommendations given here.

- Place wire-mesh reinforcement in the concrete floor slab to minimize cracking. Support the mesh while the concrete is being poured so that it is embedded at the mid-height of the slab.
- Pour the floor slab on 2 inches of sand over a 6-mil polyethylene sheet. The 2-inch sand layer helps cure the concrete to minimize shrinkage cracking, and it also reduces the risk of damage to the gas barrier during the pouring of the concrete. The 6-mil polyethylene sheet is a barrier for

## Constructing Energy-Efficient Foundations and Floors



Recommended monolithic slab-on-grade construction.



Recommended stem wall construction.

vapor and radon gas. Lap and seal the barrier at all seams and penetrations. Some authorities recommend a 4-inch gravel drainage layer underneath the gas barrier, but it is questionable whether there is any benefit from the gravel in Florida.

- Seal the joint between the concrete floor slab and foundation wall or grade beam. If expansion joint material is placed along the slab edge, pour a liquid sealant into the joint over a foam backing rod.
- Remove all grade and plumbing support stakes as soon as possible during the slab pour, so that they will not create a passageway for radon.
- Completely seal around all pipes, drains and ducts that penetrate the concrete floor. Use a product designed to seal weather-exposed concrete joints.

**Cracks.** To reduce or eliminate cracks in the foundation, consider these construction practices for any slab:

- For stem wall construction, the floor slab should not rest directly on the footing. Instead, provide an isolation joint to permit vertical movement without cracking. Seal the joint to prevent radon gas entry.
- After the slab has been poured, use proper wet curing practices for reduced cracking and improved strength (a slab allowed to air dry will have only 55% of its rated strength). Other methods to reduce cracking include the use of: air-entrained concrete; the maximum practical aggregate size (the largest dimension should not exceed one-third of the slab thickness); a low water-to-cement ratio; post-tensioning of the slab.
- Make sure the concrete brought to the job site already has the right mix of water. Do not add water on site.
- In radon-prone areas, a wire mesh layer placed 2 inches below the top surface of a 4-inch concrete slab is strongly recommended. In other areas, the use of control joints (saw cuts, etc.) direct any cracks to predictable locations and, unlike random cracks, can be sealed. The control joint is formed by reducing the slab thickness by 25% at the joint location. Control joints should be used at intervals not exceeding 10 to 15 feet in each direction according to the Portland Cement Association.

Non-rectangular slabs should have contraction joints across the slab perpendicular to and at points of offset that exceed 10 feet.

**Drainage.** Proper drainage is important to prevent moisture migration into the house. In addition to

the gravel/polyethylene/sand layer described under radon control, the following practices should be followed:

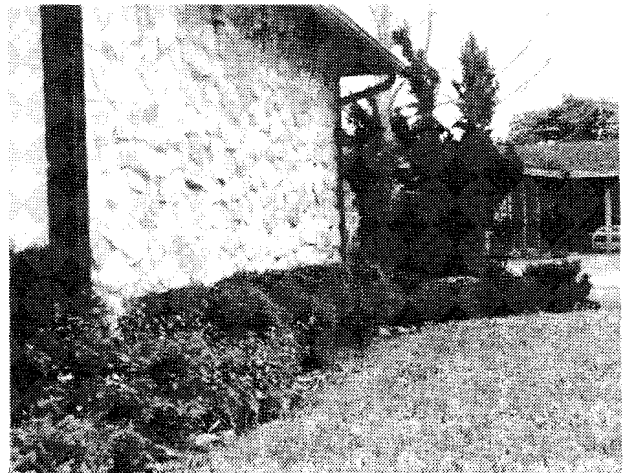
- Slope the ground surface downward at least 6 inches over the first 10 feet surrounding the foundation, to direct surface water run-off away from the house.
- Use long (3-foot) overhangs, or downspouts and gutters, to direct roof water run-off away from the foundation.
- Place the top of the slab and sill plate at least 8 inches above grade, or higher if local officials specify it.

### 3. Seal all penetrations

The area around all pipe, drain, or other slab penetrations should be well sealed. To prevent tears in the vapor barrier, instruct concrete laborers not to puncture holes in it as they pull up on the wire mesh. Repair any punctures in the vapor barrier prior to pouring concrete. Seal the vapor barrier around conduit and piping penetrations with asphaltic-based sealant. All grade and plumbing support stakes should be removed prior to setting, and the holes should be plugged with wet cement.

### 4. Shade the slab perimeter

Use foundation plantings to shade the perimeter of the slab and the soil near the house. This can prevent most of the sun's heat from being conducted into the house through the slab. Consult the Florida Native Plant Society (see the "For further information" section of Chapter 3) for plants which are well adapted to your climate and soil so they will survive with little or no maintenance.



Plant shrubs to shade slab perimeter.

### 5. Consider using perimeter insulation

To make the slab more energy-efficient, insulation can be placed around the perimeter. This will reduce winter heating requirements, and it may reduce summer cooling requirements if the perimeter is exposed to significant sunlight. Note, however, that perimeter insulation is not highly cost-effective, particularly where heating requirements are small (South and South Central Florida) and where the slab perimeter is at least partially shaded. Covering perimeter insulation with siding or stucco to make it blend with your wall treatment adds significantly to the cost of installing the insulation.

Perimeter insulation may be cost-effective for a North or North Central Florida home when:

- the perimeter will be exposed to sun, or
- the finish treatment will not be an additional cost (in brick veneer homes, for example).

If you decide to insulate, use extruded polystyrene because of its low water-absorbing characteristics. Attach the insulation both with adhesives and mechanical fasteners. Tape all seams with a long-lasting tape which adheres to plastic. The detail drawings on page 5-4 show the preferred location for installing insulation.

### 6. Select conductive slab floor finish

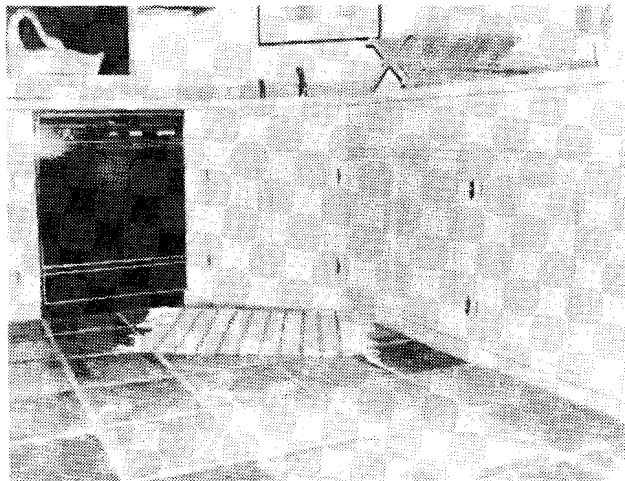
A highly conductive floor finish such as tile or concrete is desired for slabs for these reasons:

- to make use of the slab's thermal mass (see Chapter 4) for passive heating or cooling
- to permit the greatest flow of heat from the house to the ground in early summer
- to enhance summer comfort by reducing the average "radiant" temperature of the room and by cooling through direct physical contact.

A highly conductive floor will feel cool to the feet because it is cooler than skin temperature (around 90°F). In Florida, that is a benefit for the bare-footed home occupant during most of the year. Although cold floors can be a discomfort in winter, their overall comfort and energy benefits outweigh that disadvantage.

There are two finishes that provide a highly conductive slab surface. The most common is ceramic tile, which has one drawback: It is expensive. Some builders are using stamped and dyed concrete as a less costly alternative to tile. It is better than tile for

conducting heat, and provides the option of a larger pattern size. Use either of these finishes throughout the house.



**Tile and stamped concrete are attractive finishes for providing thermal mass.**

Carpeting is undesirable as a slab finish since it restricts the interaction of the slab and the living space. Vinyl and wood floor treatments rank between ceramic tile and carpeting in terms of effectively using the slab for its thermal mass.

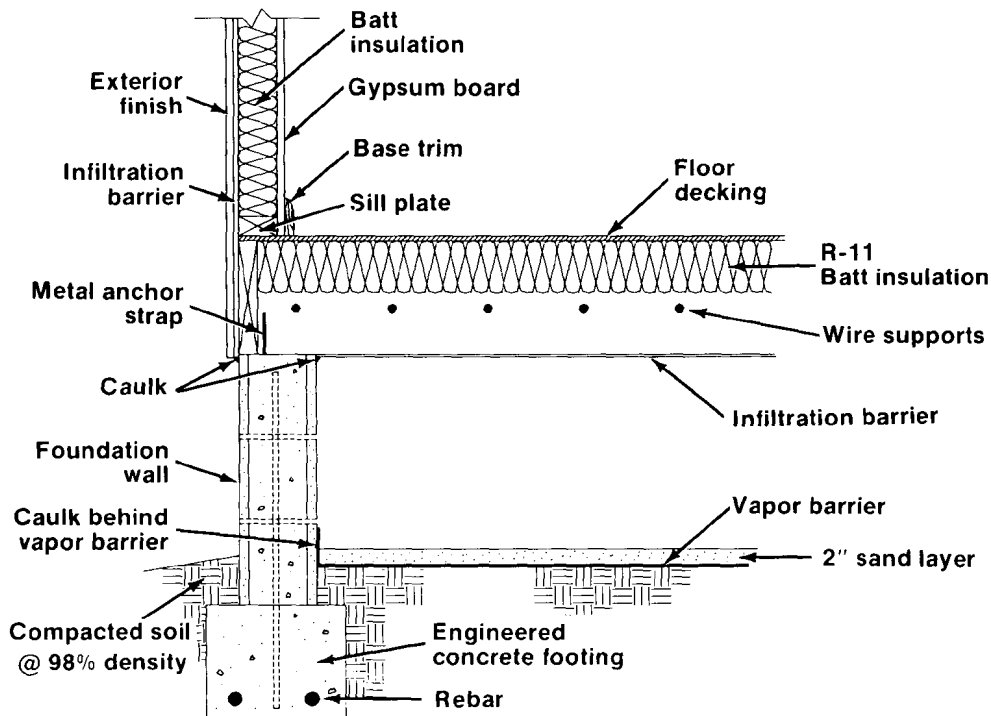
### 7. Seal and insulate crawl space ceiling

If you are using an off-grade (crawl space or pier type) foundation, it is important that seams, joints and penetrations through the crawl space ceiling (house floor) are all sealed. It is also important that the house be insulated from the air beneath it.

**Sealing.** Use sealant adhesives to prevent air leakage at the seams and joints of the off-grade floor. Use foam caulking to seal all plumbing, wiring and other penetrations through the floor.

Seal off-grade floors in the following manner: Using tongue-and-groove plywood for the subflooring, fill each groove completely with a 1/4-inch bead of sealant and mate and nail the panels immediately; where two panels abut at a joist, place a separate bead of adhesive under each panel.

**Insulation.** Insulate spaces between the floor joists to reduce heat loss in winter and heat gain in summer. Place insulation up against the subfloor, making sure it is snug but not compressed. An insulation level of R-11 is recommended for off-grade floors in Florida.



**Recommended crawl space construction.**

**Moisture and Radon.** To prevent unwanted moisture migration, and to reduce potential radon gas seepage from the ground, place a 6-mil polyethylene vapor barrier over the entire crawl space floor and extend it up over the foundation wall on the interior. Overlap polyethylene sheets 4 to 6 inches. Place a 2-inch layer of sand over the polyethylene to protect and hold it in place. (See diagram above.) Important: Make sure the crawl space is well vented, as discussed in the following section.

### 8. Vent the crawl space

Vented crawl space construction is recommended in Florida to reduce problems of moisture and, where applicable, radon gas. Place vents on all four sides of the crawl space, no farther than 3 feet from the corners, and as high on the walls as possible.

For crawl spaces with vapor barriers, there should be one square foot of total free-vent area for each 1000 to 1500 square feet of floor area. For example, a crawl space that covers 3000 square feet in area should have at least 2 to 3 square feet of total free-vent area. The free-vent area is the unrestricted opening; the total opening is much larger, as shown in the following table for two different vent openings. Note that if a ground cover (6 mil polyethelene) is not used under the crawl space, the required vent area increases tenfold.

#### Crawl Space Vent Area Requirements

Divide gross floor area by 1500 (for more vent area, divide by 1000), then multiply by appropriate number below to determine total openings required.		
	Multiplication Factor	
Obstruction in Vent	Without polyethylene soil cover	With soil cover*
1/4-inch mesh hardware screen	10	1.0
Louvers + 1/4-inch hardware cloth	20	2.0
* Use at least four vents.		

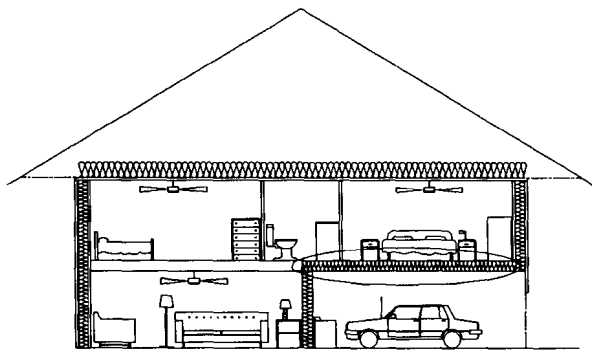
Insulate all ducts and, in North Florida, pipes that are located in the crawl space. (Ductwork located in the crawl space requires a means of access and a minimum of 24 inches of space under the joists.)

An alternative to venting is used in some parts of the country and calls for insulating and air-tightening the perimeter of the crawl space. This method is not recommended in Florida. Its use would require moisture-resistant insulation and would entail greater difficulty in blocking moisture and radon gas.

Further, the Southern Building Code requires venting of crawl spaces.

### 9. Insulate all floors over nonconditioned spaces

Some house designs have a second-floor room over a garage, porch or other nonconditioned first-floor area. It is important to insulate those floors to reduce summer heat gain and winter heat loss. An insulation level of R-11 is recommended.



Insulate floors over garages.

### 10. Leave space for ductwork between floors

The space between floors in a two-story home is ideal for ductwork. Locating ducts inside the conditioned space eliminates the heating and air conditioning losses associated with ducts in attics or crawl spaces (see Chapter 9). Duct runs can typically be shorter when ductwork is located between floors. Air can be distributed to first-floor rooms by putting grilles on the ceiling. The grilles for the second floor can be put in the floor or part way up a wall (but preferably not where a bed or other furniture is likely to block them).

### 11. Seal the sill plate

The sill plate is framing lumber laid horizontally on the foundation (slab or crawl space) upon which the walls are built. The sill plate is also referred to as a sole plate or bottom plate (all are used interchangeably in this book). It is responsible for 10-50% of the air leakage inside a home. Take special care when attaching it. Have a dedicated, quality-conscious worker perform this task routinely. Use an oil-based acoustical sealant between the bottom

plate and the foundation wall, and apply it generously but uniformly from the outside. An alternative for wood frame walls only is sealing the air infiltration barrier or sheathing directly to the foundation wall (see Chapter 6).

### Summary

Energy-efficient foundations and floors can be constructed by observing most standard practices and using long-lasting materials. Steps taken to prevent cracks will reduce moisture and radon problems. A tile or stamped concrete floor can provide the thermal mass needed to maximize savings from natural ventilation and passive solar heating. Insulation should be placed over a well-vented crawl space and between conditioned and unconditioned spaces such as a garage. Sill plates should be inspected before proceeding with wall construction to make sure a good seal was made with a durable sealant.

### For further information

EPA Regional Office #4 , 345 Courtland Street, NE, Atlanta, GA 30365; (404)347-2904.

*Florida Statewide Radiation Study*, Final Report to the Florida Institute of Phosphate Research, N. L. Nagda, M. D. Koontz, R. C. Fortmann, W. A. Schoenborn, L. L. Mehegan, 1987.

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"Radon in Buildings," NCMA-TEK 153, National Concrete Masonry Association, 1985.

"Residential Concrete Reinforcement", *Concrete Construction*, January 1986.

*Building Foundation Design Handbook*, Kenneth Labs, John Carmody, Raymond Sterling, Lester Shen, Yu Joe Huang, Danny Parker, ORNL/Sub/86-72143/1, 1988.

*Design and Control of Concrete Mixtures*, Portland Cement Association, 12th Edition 1979.

"Treatment of Joints and Embedded Items", *Concrete Construction*, June 1986.