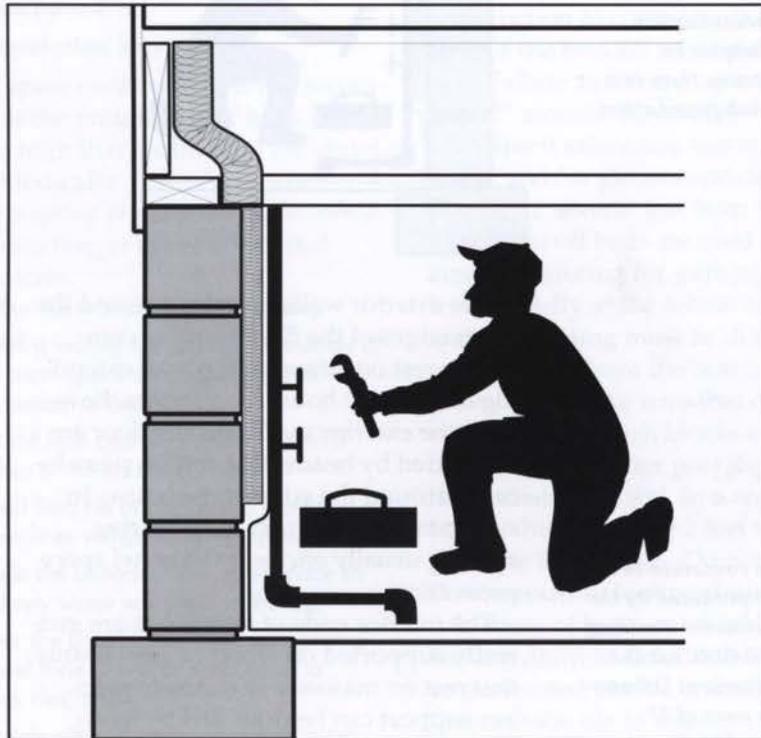


Crawl Spaces in the Home



Crawl space houses should and can be constructed so that they are free from the problems of moisture.

Repair and modernization problems are simpler in crawl-space houses than in a house with a slab foundation.

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CRAWL SPACE CONSTRUCTION

Many houses without basements are built over crawl spaces. That is, the floor of a house is built over an excavation deep enough for someone to gain access to the underfloor space by crawling. The minimum depth of the crawl space should be 24 inches under the floor joists, or 18 inches under any beams or supports. An 18-inch clearance beneath duct work is also desirable.



The exterior walls of the house and the outer edges of the floor framing commonly rest on a foundation wall extending around the house. Sometimes, however, the exterior walls and the floor are supported by beams that rest on piers located around the edge of the house. In such construction, non-load-bearing skirting usually encloses the crawl space excavation.

The interior ends of floor joists are generally supported on wood or steel beams that rest on masonry or concrete piers, but support can be provided by load-bearing walls.

Floors overhead are usually of wood with conventional joist construction. However, concrete, masonry, metal, or a combination of these materials can be used. Normally, the crawl space contains only plumbing pipes, heating and cooling ducts or pipes, and electrical wiring. Easy access should be provided for in-

spection purposes and to service equipment, such as a sump pump or furnace.

MOISTURE SYMPTOMS AND SOURCES

Obvious symptoms of excessive moisture passing up through the floors and walls include:

- ▲ a musty odor; mold on the walls near the floor, in corners, and in closets;
- ▲ moisture condensation on windows which are equipped with insulating glass or storm windows;
- ▲ moisture or frost on the underside of roof sheathing; and
- ▲ peeling paint on walls with moisture condensation.

In the crawl space itself, moisture problems may be indicated by:

- ▲ toadstools or furry mats on lumber;
- ▲ damp earth;
- ▲ mold on the ground;
- ▲ condensation on masonry foundation walls; and
- ▲ mildew or condensation on band joists and subfloor. These are more likely to appear along the north side of the house.

Sometimes there are no visible symptoms of moisture problems within the crawl space itself.

The only satisfactory way to avoid moisture problems is to prevent moisture from entering the crawl space. Moisture problems that show up within a house as condensation or frost on the underside of roof sheathing, or as condensation or frost on windows in the living area may be the result of dampness in the crawl space. An uncorrected moisture problem can cause decay of the wood-floor framing and ultimately structural failure of the house.

Moisture problems in crawl spaces may be due to:

- ▲ the construction of a crawl space in an area of high water tables;
- ▲ improper grading of the lot for drainage; or
- ▲ the absence of moisture control devices such as a ground cover or ventilation openings.

Crawl space houses should and can be constructed so that they are free from the problems of moisture, they resist termite

infestation, and the floor and rooms above the crawl space can be kept at comfortable temperatures with a minimum of heat loss from the structure.

Ground Water

Sometimes the level of the water in the ground (water table) is raised above the bottom surface of the crawl space.

Water may penetrate the foundation walls or rise through the ground surface in the crawl space, allowing water to stand in the crawl space.

This is commonly due to:

- ▲ heavy or prolonged rains;
- ▲ a spring which appears during wet seasons only and was not discovered when the house was built;
- ▲ water flowing along an impervious layer within the soil; or
- ▲ an overlooked farm drain tile.

Crawl space construction is not recommended if the ground-water level in the area is so high that it can flood the crawl space periodically.

Where a spring or drain tile is discovered after construction, or where unexpected flooding occurs:

- ▲ detour the drain around the house;
- ▲ install a footing tile around the outside of the crawl space at foundation level with the bottom of the footing;
- ▲ backfill with coarse gravel to within 8 inches of the finished grade;
- ▲ install field tile or perforated plastic drain lines within the crawl space;
- ▲ grade the bottom of the crawl space so that any water will drain to the tile;
- ▲ cover the crawl space area with coarse gravel (fine gravel or sand tends to block tile); and
- ▲ provide either a gravity drain or sump pump to remove the water collected by the drainage lines.

Costs and installation problems inhibit the use of other effective methods of groundwater control, such as a membrane waterproofing system.

Surface Water

Surface drainage problems usually occur because the floor of the crawl space is two to three feet below the finish grade outside the house. Heavy soils may retain surface drainage and create water

pressure against the crawl-space walls. Rainwater falling on the ground or from the roof can pass through or under the foundation walls. To avoid such problems, grade the lot so that drainage runs away from the house and no water is allowed to stand on the site.

Minimum grading specifications will suffice for most conditions:

- ▲ the slope of the grade should be at least 6 inches in 10 feet;
- ▲ the ground should fall at least 6 inches on all sides of the house; and
- ▲ the slope should extend at least 10 feet out from the foundation, except where side yards are narrower.

In new construction, it will usually be necessary to provide additional fill next to the house the first year or two after construction to compensate for the settling of the backfill around the foundation. Failure to do so may result in a "moat" around the house.

To divert rainwater, use wide overhangs and/or gutters and downspouts extending several feet from the house. Where gravel beds are used as a drip area substituting for gutters, the ground level is really at the *bottom* of the gravel and the grading must be done so that water drains from the bottom of the gravel bed. Make sure that downspout extenders or splash blocks are used to discharge rainwater past the backfill onto the undisturbed soil. In a crawl space house, this is usually 2 feet to 3 feet away from the foundation. Do not connect downspouts to footing drains.

In areas of high water tables, install a footing drain or field tile with open joints or perforated plastic drainage tubing. Connect the tile to a sump pump, or to "daylight." Waterproof the outside walls with a bituminous coating.

Capillary Rise of Ground Moisture

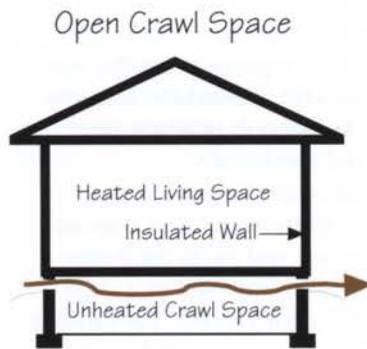
Moisture travels upward from lower layers of certain soils by capillary action and evaporates within the crawl space (as much as 13 gallons per day have been noted to rise under a 1,000 square foot house). Capillary rise occurs in nearly all crawl spaces built in areas where the soil is composed of clay or silt. The moisture is present even though the ground in the



Dampness within a crawl space can usually be avoided if the lot is graded correctly and a moisture-control device, such as a plastic ground cover, is used.

crawl space may seem dry, dusty, and even cracked.

Moisture from capillary rise can be kept out of the crawl space by using a vapor-retarding ground cover that is not susceptible to damage by fungi. Polyethylene film, 6 mils thick is effective. To install this, grade and smooth the ground, and remove any trash or debris. Turn up the ground cover four to six inches on the wall of the crawl space. Hold the polyethylene in place against the walls with sand or bricks to help achieve a neat installation. Where more than one piece of polyethylene is needed, lap the edges four to six inches. Sealing the edges is not necessary. Use wide rolls of polyethylene to reduce the number of edge joints.



An open crawl space is used where the foundation vents must be kept open the year around due to moisture problems or to provide combustion air to a furnace located in the crawl space.

Moisture From Mechanical Systems

Often moisture is introduced into the crawl space from the mechanical systems within the home. To prevent this, be sure to vent the clothes dryer to the outside. Be sure that all dryer-vent pipe connections are tight, and the pipe is supported. To prevent condensation within the vent pipe, keep the pipe as short as possible.

Also be sure to discharge condensate water from central cooling systems into storm or sanitary drains. Often, the condensate from mechanical cooling systems is drained through a tube into the crawl space and allowed to either drip on top of the ground cover or run into a drywell beneath the ground cover. Drainage should always be made to sewer lines if the soil is silt or clay. Condensate drainage on top of the ground cover is never acceptable.

A common source of water is a humidifier. Humidifiers should not be used if they lead to condensation running down windows.

VENTILATION

Before the effectiveness of polyethylene ground covers was proven, large ventilation openings were required in the foundation wall to allow moisture to escape from the crawl space. With the use of a polyethylene ground cover to prevent moisture from the ground rising into the crawl space, a minimum level of ventilation may still be recommended.

Provide at least four corrosion-resistant foundation vents that can be closed during the heating season and during humid summers. The bottom of the vent opening should be at least 2 inches above the soil grade to prevent rainwater from entering the crawl space through the vent.

Insulated covers should be cut from panels of rigid foam insulation. The vent openings should be screened with eight-by-eight corrosion-resistant mesh (64 openings per square inch) to keep out insects. If the crawl space is dry, opening the vents may not be necessary, even in the summer; but it is much easier to block and insulate vents that were not needed than to install vents that were not originally provided.

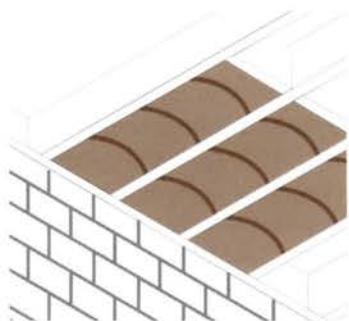
Open Crawl Spaces

Open crawl spaces are those that are ventilated to such an extent that the temperature within the crawl space approaches that of the outside air. This accommodates situations where the furnace resides in the crawl space, which in that case must be left open to meet the requirements for combustion air for the heating system. Of course, furnaces should be connected to a flue or chimney so that combustion products are not discharged into the crawl space, where they could taint the air via seepage into the house.

In cold areas, water pipes in open crawl spaces must be insulated to protect against freezing. It is also important to insulate heating and cooling pipes and ducts to prevent excessive energy loss. The standard for insulated ducts is only one inch of insulation or less, which is not adequate in the northern half of the United States.

Where air ducts also handle cool air in summer, the insulation must have a vapor retarder on its outside. Any joints in that vapor retarder should be sealed with a vapor-retarder tape to prevent condensation inside the insulation during the cooling season.

In cold climates, insulating the floors of the house is critical to comfort. To maintain a desirable surface temperature and reduce energy loss, the floor should be insulated to limit the heat loss through the floor to five British Thermal Units per



Batt-type insulation is often held in place under the floor with lengths of wire sprung into place between joists.

hour (Btu/h) per square foot. If the outdoor temperature is -30 F, the resistance of the insulation (R-value) should be at least 19; for 0 F, R-13; and 30 F, R-7.

These resistances serve as a guide in selecting the insulation material. If flexible insulation is installed in the space between the joists underneath the floor, it should be supported by hardware cloth, wire netting, or sheet material fastened to the bottom edge of the joists, or arched wires sprung into place to hold the insulation against the bottom of the subfloor. Batt insulation is available with nominal R-values of 7, 13, and 19. Closed-cell foam insulation board such as polystyrene, polyurethane, or polyisocyanurate has an R-value of approximately 4-per-inch of thickness.

Closed-cell foam insulation panels are vapor retarders, so no additional vapor retarder is needed.

In open crawl space construction, the undersides of the joists should be covered when this material is used, and not left exposed to the cold air and ground of the crawl space. Leaving the bottoms of the joists uncovered can lead to rotting of exposed surfaces.

The undersides of the joists can be covered with closed-cell insulation panels, as described above, or by the kraft or foil flanges of faced insulation, or polyethylene sheet, or roofing felts. Because such a covering could constitute a "cold-side vapor retarder", there should be holes or joints to allow any condensed water to drain out. Floor insulation should fit snugly around insulated pipes and ducts that penetrate it.

Closed Crawl Spaces

The moisture control provided by a polyethylene ground cover is so effective that crawl-space ventilators can usually be kept closed during both the heating and cooling seasons. It provides the maximum comfort on the floor above with a minimum expenditure for insulation. This "closed" crawl space construction is recommended *except* under severe moisture conditions.

Insulation around water pipes and heat ducts is usually not needed in the closed crawl space. However, insulating cooling ducts to prevent condensation on the

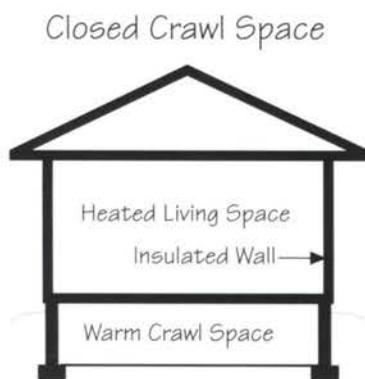
duct work during the summer may still be necessary with a vapor retarder on the outside of the insulation. Ventilation of the crawl space in the summer may increase the problem of condensation on ducts carrying cooling air. The use of a dehumidifier in a closed crawl space may be appropriate during the summer months.

If the temperature in the crawl space can be maintained within 5 degrees Fahrenheit of the thermostat temperature setting in the house, the surface temperature of the floors in the rooms will also be comfortable. The heat loss into the ground through the earthen floor of the crawl space is negligible. Vagrant heat from non-insulated warm-air ducts or hot-water heating pipes will usually keep an insulated, closed crawl space near that desired temperature range.

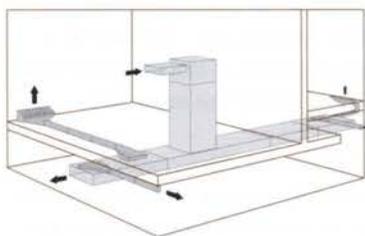
Insulate the walls enclosing a crawl space to reduce heat loss and help maintain the crawl space temperature. To properly insulate a closed crawl space, the box-sill headers and the end joists of the floor must be insulated, preferably with close-fitting panels cut from rigid foam insulation such as extruded polystyrene, polyurethane or polyisocyanurate. Alternately, use a flexible-type insulation (batt or blanket) that provides vapor protection on one side. The vapor retarder should face the interior of the crawl space.

For exterior walls, insulation in sheet or block form is most easily applied. Tempered nails or an adhesive mastic is suggested. Insulation should be of a type not affected by termites or dampness. Expanded polystyrene foam is the most common type of insulation used for crawl space walls. **Note: Exposed plastic foam boards of all types do present some fire hazard, which may be significant if the furnace is in the crawl space or if the entire crawl space is used as a heating plenum.**

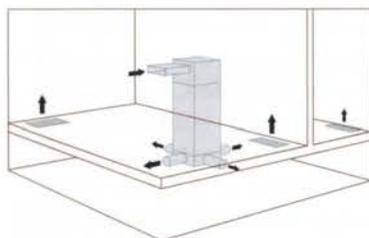
Cover the ground surface of the crawl space with polyethylene film. Do not extend the film over the insulation, or the moisture vapor below the ground cover could flow upward into the insulation. If batt-type insulation is used, either suspended from a nailing strip on the plate



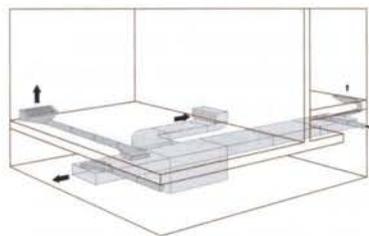
A closed crawl space is one that can be heated. The use of a ground cover is essential for this type of crawl space.



The most common heating system in crawl-space houses uses a down-flow warm air furnace with the plenum and complete duct system located in the crawl space.



Sometimes the entire crawl space is used as a plenum for a down-flow warm air furnace. Stub ducts point toward heat outlets, which are holes cut in the floor and covered with register grilles.



A heating system using a horizontal warm air furnace located in the crawl space is difficult to service and requires an open crawl space.

or supported by furring strips, a continuous vapor retarder should supplement any vapor retarder incorporated in the batt or blanket to reduce the number of joints in the vapor retarder.

Conditions may be ripe for mold growth on the underside of the plastic ground cover. This might seem to be a cause for concern; however, there is no indication to date that this poses a problem in the house. The benefits of a ground cover as the principal means of moisture control on the crawl space floor have been firmly established.

Heating Systems

Heating systems that supply heat near the floor or along the exterior walls of the house are very effective for a crawl space house, because they eliminate or reduce uncomfortable drafts along the floor. Therefore, baseboard heating or perimeter heating is recommended with the heat distributed through ducts in the crawl space for the perimeter system.

All furnaces have filters that require frequent changing or maintenance. A horizontal furnace in the crawl space is difficult to service and requires that the crawl space be left open to provide combustion air. A furnace in the garage at the end of the house requires longer duct work, resulting in reduced air flow and lower temperatures reaching the far end. Also, lost heat from the furnace jacket warms the garage instead of the house. A down-flow furnace installed in a closet or utility room in the house is the preferred heat source.

TERMITE CONTROL

Periodic inspection for subterranean termites is a good practice in areas where infestations occur. Termites may enter a structure at any of several points, most often through untreated wood in contact with the soil. Common entries are wooden steps and supports, dirt fills under porches, and around wood-framed access openings with wood sills at or below grade.

When the wood is some distance above the ground, termites may construct a shelter tube to enable moving between the nest and untreated wood.

Composed mainly of earth, wood particles, and excreta, these small tubes have been found on the surface of concrete slabs, on concrete piers in crawl spaces, on one or both surfaces of foundation walls, and in the cavities of hollow masonry.

Termites can also enter through or bypass improperly installed termite shields. Cracks, expansion and construction joints in concrete slabs and other concrete work also provide excellent passageways. Untreated wood embedded or left in the concrete may permit direct access to the interior partitions of the structure. If a colony is present below the excavated area, easy entry to the structure can occur.

Several common construction practices raise the probability of termite attack.

These include:

- ▲ leaving scrap pieces of wood, fiber board, paper, or other wood items under or near the foundation or in the backfill around the foundation walls;
- ▲ construction details that make future inspection difficult;
- ▲ leaving untreated form boards and grade stakes embedded in the concrete;
- ▲ failing to treat the soil where wood is close to the soil and termites can travel from the soil to wood unseen. The latter is especially critical in masonry-veneer construction when the masonry extends below grade;
- ▲ chemical treatment has been inadequate.

Termite Shields

Termite shields provide a metal barrier between the termite nest and food supply. A shield should be made of a durable metal, such as zinc, copper alloy, copper, terneplate, or galvanized iron or steel. Copper-plated paper products are not acceptable.

A termite shield does not prevent infestation. A termite shield forces termites to build shelter tubes so that the infestation can be seen and further treatment applied.

The key to termite shield effectiveness is proper installation and continuous inspection. This is feasible only where both edges of the shield are open to inspection, which means a crawl space must be

deep enough to permit easy access for such inspection.

The termite shield is a strip of metal placed between concrete or brickwork and wood to force the termites to build shelter tubes where they can be seen.

The main weakness of termite shields is improper installation. Termites can move through a hole as small as 1/32 of an inch. Thus, the shield should be soldered completely at all seams, at overlapped corners, and at other breaks or holes in the metal. Openings around anchor bolts, plumbing and heating ducts, and other breaks should be soldered or filled with coal-tar pitch. For best results, the shield should be at least 8 inches above the ground with a 2-inch lip extending horizontally on each side of the foundation or pier and an additional 2 inches bent downward at a 45-degree angle. For appearance and safety reasons, the extension on the outside of the foundation is often bent down or omitted. However, these practices impair the effectiveness of the shield.

Soil Treatment

Although soil treatment was developed primarily to control infestations in existing structures, the most control-effective time to apply the chemicals is during the construction of the foundation. After construction has been completed, treatment is more expensive, time

consuming, and sometimes practically impossible.

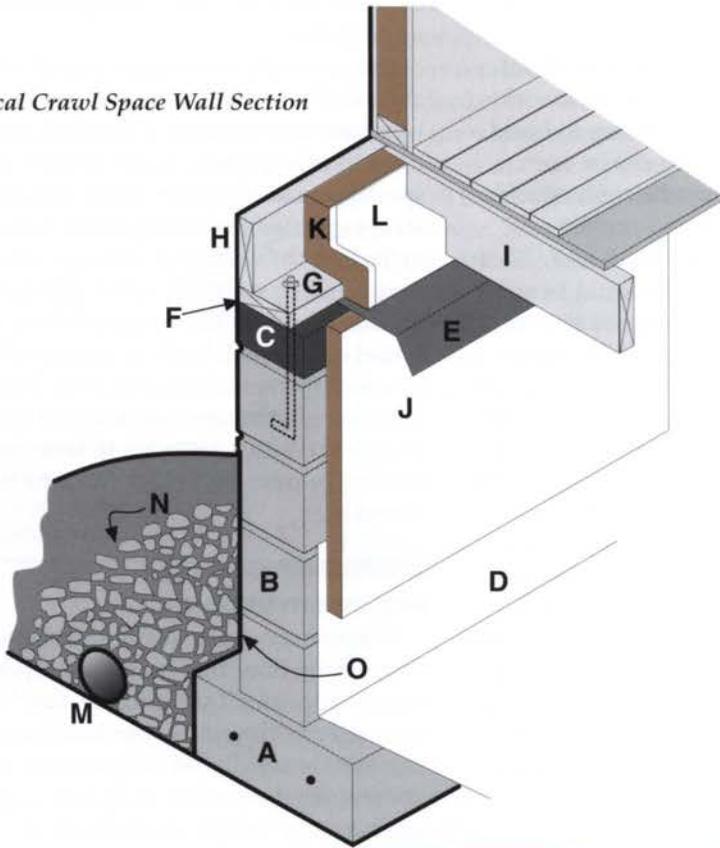
The principle of termite control with chemical barriers is to isolate the structure from the termites. Chemical applications to existing structures require reinspection in subsequent years. For extensively infested buildings, some termites, including the ones that can reproduce, may be trapped in the wood above the chemical barrier. On occasion these have found a new path back to untreated soil, where they reestablish a colony. This is increasingly the case as the trend in chemical control has been to treat only around or near the current termite infested area.

PIER CONSTRUCTION

Where the outside walls and the outer edge of the floor of a house rest upon a beam supported by piers, the crawl space is usually enclosed by non-load-bearing (curtain) walls placed between the piers. Sometimes the curtain wall may support the masonry veneer walls above it. The footing for the curtain wall should be poured integrally with the footings of the piers, unless the bottom section of the curtain wall is reinforced to span between piers. Common size limitations for pier construction are given below:

Table 1. Common Size Limitations for Pier Construction		
	Minimum Dimensions	Limit on Height
Piers		
Concrete	8-inch diameter	10 times the least dimension
Solid Masonry	8 inches × 12 inches	10 times the least dimension
Hollow Masonry	8 inches × 16 inches	4 times the least dimension
Curtain Walls		
Concrete	4 inches	14 times thickness*
Solid Masonry	4 inches	14 times thickness*
Hollow masonry	4 inches	10 times thickness*

Typical Crawl Space Wall Section

**KEY TO ILLUSTRATION**

A - Poured concrete continuous wall footing either 12 inches by 6 inches or 16 inches by 8 inches, preferably with two round, ½-inch steel reinforcing rods.

Size of footing depends on bearing value of soil. Footings specified above are suitable for most conditions.

B - For frame houses, 8-inch masonry wall or 6-inch poured concrete wall. (Check local building code.)

Where the exterior walls to be supported by the foundation are thicker (as in solid masonry or masonry veneer house), the foundation wall must be

correspondingly thicker. The foundation wall should extend at least 8 inches above grade and remain exposed at least 6 inches.

C - Masonry wall cap.

A hollow masonry foundation wall must be capped with a course of solid masonry or a 4-inch poured concrete cap reinforced with #14 wire mesh 2 inches × 2 inches.

D - Ground cover.

6-mil polyethylene film.

E - Metal termite shield.

Use corrosion-resistant metal that is stiff enough to retain the form shown - 26 gauge galvanized iron or 16-ounce copper. Where anchor bolts penetrate the shield, the area should be well-sealed with coal-tar pitch or tight lead washers. Need not be installed if soil poisoning is used.

F - Sealer for the sill plate

Use material similar to expansion joint or a fiberglass sill sealer.

G - Sill plate 2 × 6, anchored with ½-inch bolts, 8 feet on center - minimum of two bolts to each piece of sill.

Lumber that is pressure-treated with preservative is strongly recommended for sill plate 1) to prevent decay in lumber likely to be caused by condensation, and 2) to discourage termites.

H - Band joist.

I - Joists.

J - Foundation-wall insulation, may be rigid foam insulation or mineral fiber insulation with a vapor retarder against the wall.

K - Band joist insulation.

L - Vapor retarder.

M - Footing tile.

N - Coarse gravel backfill.

O - Parging and waterproofing.

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