Prevention and Control of Termites in Buildings

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Elie Tawil, P.E., LEED AP

Continuing Education and Development, Inc.

P: (877) 322-5800
info@cedengineering.ca

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Abstract

Subterranean termites are the most important insect pest of wood in the United States. Living in large underground colonies, termites may attack any wood in contact with the soil and may even construct protective shelter tubes over nonwood materials to attack wood above ground. Most damage in the United States is caused by termites in the genus *Reticulitermes*, but an invasive termite, the Formosan subterranean termite (*Coptotermes*), causes extensive damage in some areas. Termites occur in all 50 States except Alaska but are most common in the Southern States. Termites prefer warm, moist environments, and home builders and homeowners often unwittingly increase the likelihood of termite infestations in homes and other structures by creating such environments. Termite prevention begins with good building practices, which vary depending on the type of structure and how the structure is to be landscaped and decorated. The use of soil-applied insecticides during construction is the most widely employed method of preventing termites and has a long history of success. Use of pressure-treated lumber is another successful practice, but termites may tunnel over treated wood to reach untreated wood elsewhere. Control of termites in existing structures involves periodic inspections for termite activity, remedial insecticide treatments, or use of insecticidal bait technology.

KEY WORDS: insecticidal bait, insecticide, pest control, *Reticulitermes*, structural protection, subterranean termite, wood product protection

Contents

Introduction

Subterranean termites are the most destructive and economically important pests of wood and other cellulose products. They attack wood throughout most of the United States, with the exception of Alaska. They are most common, and hence most destructive, in the warmer regions (fig. 1).

The economic cost of termite damage to wood used in and around buildings is great. It is difficult to establish the exact amount of damage caused by termites, but estimates of yearly damage of $1 billion are common, and some are as high as $7 billion. These numbers may or may not include the cost of treatments (both preventive and curative), repairs to damaged buildings, loss of property value, and damage not immediately attributed to termites (such as wind damage to weakened structures). In any case, much damage certainly goes unreported. Termites also do considerable damage to wood used as utility poles, fence posts, and similar products.

The rising costs of termite control are attributed to several factors. Slab-on-ground construction and concrete or masonry terraces adjacent to foundation walls favor termite attack and result in increased damage to buildings. Slab-on-ground construction is also the most costly to treat after construction. Repairs, remodeling, and landscape changes (if

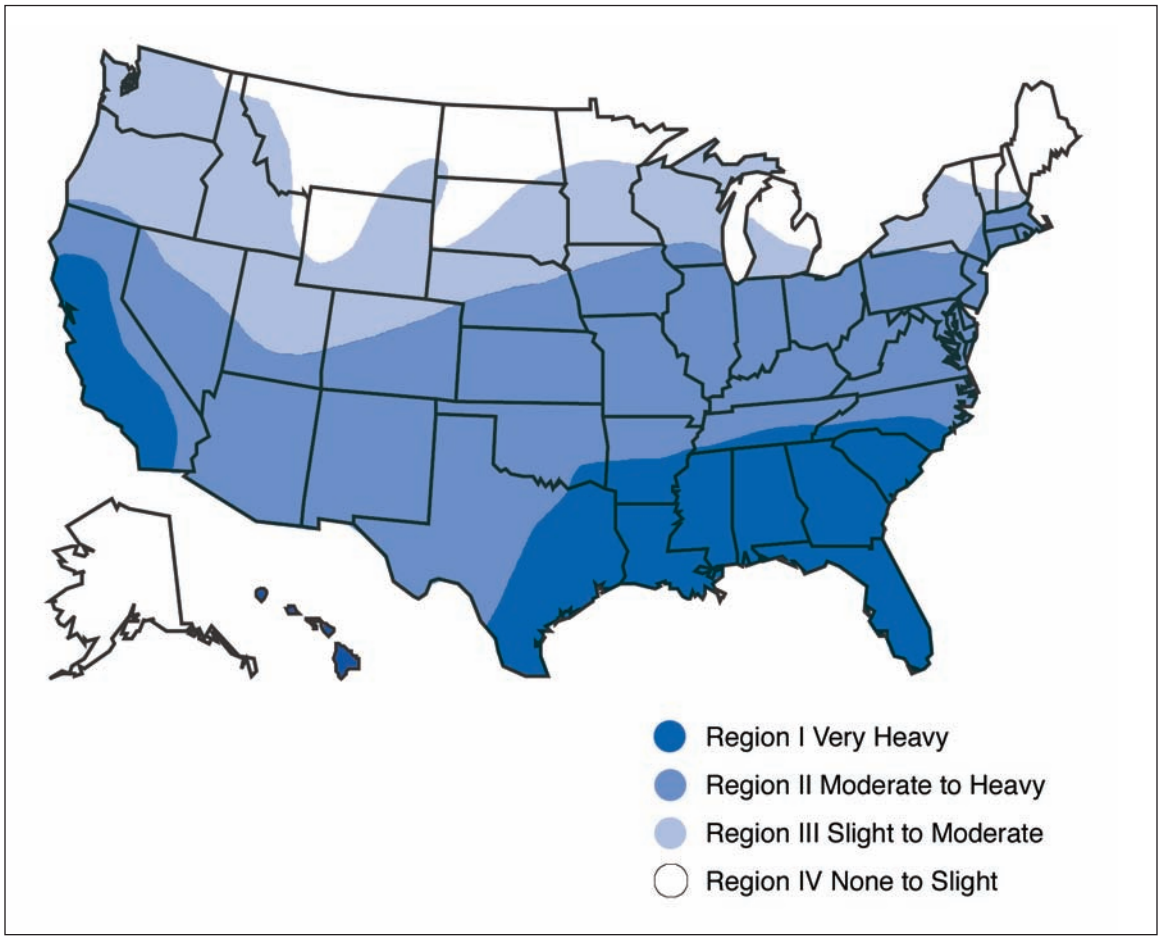

Figure 1. — Relative hazard of subterranean termite infestations in the United States.

made without regard to termite prevention and control) often lead to termite problems and impair the effectiveness of any prior chemical treatment.

The best time to prevent future termite problems is during construction (see the discussion starting on page 9 for more details). Preventive efforts in the planning stage may save the homeowner much anxiety and expense. Buildings should be designed and built to minimize moisture uptake and retention by wood. Additions or repairs to buildings or changes in landscape also should be designed to minimize the chances of termite infestation. Proper protection from termites requires a cooperative effort by architects, builders, pest management professionals, and property owners.

A combination of nonchemical and chemical techniques is recommended for termite prevention and control. Sanitation measures and chemical treatments are the most effective. Proper sanitation involves removing all stumps and wooden debris from the building site before and after construction (including form boards and scraps). Burning of such materials is not sufficient, because burning does not destroy the underground portions of stumps or buried materials. Chemical protection involves treating the soil with an approved chemical before, during, or after construction. Chemical prevention provides a barrier against termite movement into wooden housing parts. Termite baits have become available in recent years for use in place of or in conjunction with chemical soil treatments.

Only a small percentage of the more than 105 million single-family homes in the United States have been treated to control termites. This number does not include rental, commercial, or institutional structures. Some States require termite treatments, but nationwide few structures are treated during construction, although this is the most effective and economical time to prevent future termite infestations. It is more difficult and costly to apply effective control measures after a building has become infested with termites, but a control program usually can be implemented successfully. An infested building should be examined to determine which type of termite is causing the damage, the extent of the infestation, and the measures needed to prevent further damage. Some structures require simple physical changes (such as minimizing wood in contact with the ground), repairs, or chemical treatments that can be made by the owner. Others need major changes or complicated chemical treatments that require the services of a professional who has knowledge of termite habits and is experienced in pest control.

This bulletin provides basic information to the homeowner and pest management professional. It suggests methods for preventing subterranean termite attack in new and existing construction. You may want to check these termite prevention measures with a professional before building or buying a new home or before remodeling. For the professional, this publication may be consulted to better understand the use of termite control products. If using chemical control measures, always read and follow label directions. This publication also tells where to look for termites in existing buildings, how to recognize their damage, and how to control them by both structural and chemical means.

Termites—Biological Considerations

Proper termite identification and knowledge of the species' biology are essential elements in termite control. This information provides the groundwork for control methods based on the habits and behavior of termites.

Termite Ecology

In their natural habitats, termites are considered beneficial insects because they break down dead or dying plant materials and thus are an important part of the nutrient cycle. When termites feed on wooden structures, however, they become pests.

In general terms, three types of termites occur in the United States: (1) drywood, (2) dampwood, and (3) subterranean termites. Drywood termites build their nests in sound, dry wood above ground. Dampwood species locate their nests in moist, decaying wood but can extend tunnels into drier parts of the wood. Subterranean termites typically dwell in the soil and work through it to reach wood above ground. In the United States, the vast majority of loss is caused by subterranean species.

The soil provides several advantages that make it suitable as the dwelling for subterranean termites. It serves as a source of moisture that protects termites against drying out, shields termites from predators, and is used as a building material for shelter tubes above ground. Termites can excavate passageways through the soil to reach food sources. If moisture is available from another source, subterranean termites may not require connection to the soil. Isolated aboveground infestations can occur in homes where subterranean termites have access to water from condensation, leaking roofs, pipes, or other sources.

Distribution of Subterranean Termites

In all areas of the United States, subterranean termites are the most widespread and the most damaging of the three types. They are found in every State except Alaska (fig. 1). Drywood termites cause significant damage in localized areas, but are limited in distribution to the Atlantic coastal States south of Virginia, the entire State of Florida, the Gulf Coast, along the Mexican border, and along the Pacific Coast to just north of San Francisco. Dampwood termites are of only minor importance as structural pests and are limited to the Pacific Coast, the desert Southwest, and southern Florida. Hawaii experiences problems with all three types of termite. This publication will deal exclusively with subterranean termites.

Most of the termite damage in the United States is caused by native termite species. Infestations in buildings, especially in the Northern States, have become more common with the general adoption of central heating units; heated basements also increase termite activity around structures. The construction of suburban homes in forested areas also has increased the termite problem. Changes in building practices and the use of certain construction materials increase the likelihood of termite infestations. Because of this, termites have become a problem in areas where they were formerly of little economic importance.

The Formosan subterranean termite, an introduced species, was detected in Hawaii around 1850 and has since become a pest of considerable importance on the major islands. This termite was first reported in the continental United States in several port cities along the Gulf Coast in the 1960s, but it is not yet

generally distributed. It was found in Florida in 1980, and since then it has been found in isolated parts of Alabama, Mississippi, Texas, Tennessee, Georgia, North Carolina, and South Carolina. It is of great importance in localized areas, such as New Orleans. These termites are larger, feed more quickly, and are more aggressive than native species, and they also occur in larger colonies. In addition, they are less dependent upon ground contact than the native subterranean termites and often can nest in walls. Currently there are no data suggesting long-range movement of this species on its own on the mainland. Its movement has resulted largely from human transportation of wood products (especially railroad ties for landscaping). This is an important fact to consider when transporting wood materials from areas where the Formosan subterranean termite is known to occur.

Biological and Physical Characteristics of the Subterranean Termite Colony

Termites are social insects that live in highly organized colonies. Each colony is composed of "castes" of individuals that have different physical features (fig. 2) or behavioral roles, or both. Three

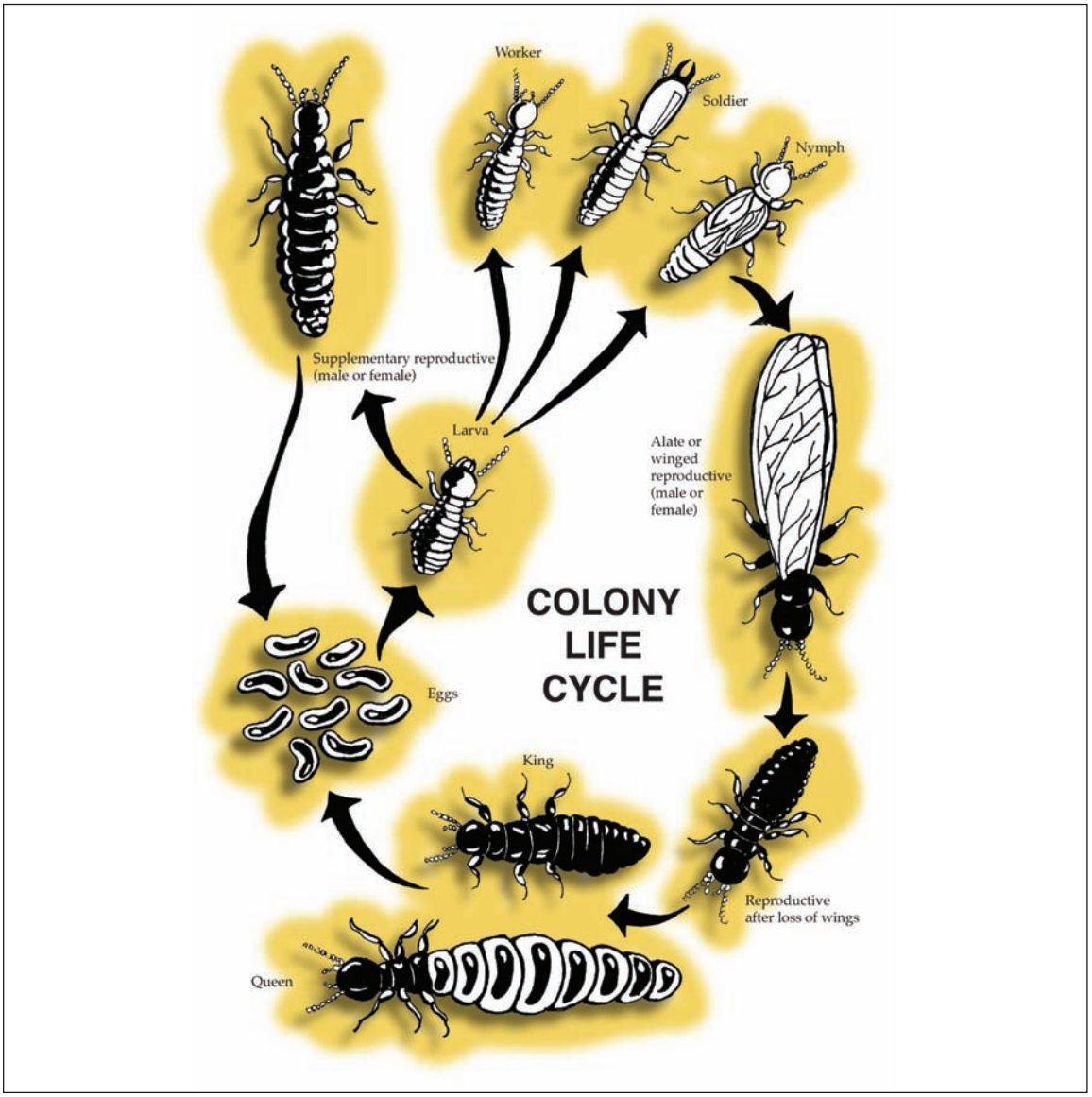

Figure 2. — Typical subterranean termite life cycle.

types of individuals make up the termite caste system: workers, soldiers, and reproductives (which may or may not be winged). Other intermediate forms are also present, but are rarely observed by the homeowner or pest management professional. One can identify termite species by noting physical characteristics of the soldiers and reproductives.

Physical characteristics distinguish the different termite castes. Worker termites (fig. 3) are wingless, soft bodied, and white or yellow-white. They are found in the greatest numbers in a subterranean termite colony and are the ones most frequently seen when infested wood is examined. The duties of these reproductively undeveloped individuals are to care for the eggs and young, feed and clean other termites, forage for food, and construct and repair shelter tubes and other workings. This is the caste that actually eats the wood. Soldiers (fig. 3) have larger, brownish heads and longer mouthparts than workers. They guard the colony and defend against predators. Reproductives (fig. 4), or sexual adults, have black or yellow-brown bodies. They have two pairs of long, whitish, translucent wings of equal size at the time when they disperse from the colony, but they shed their wings soon after flight. With increased age, the body of a functioning female reproductive may become greatly expanded with developing eggs and will attain a size several times that of workers.

Ants are often mistaken for termites, but readily visible characteristics differentiate the two very different insects. Ants, when winged, have two pairs of transparent wings of unequal size; termites have two pairs of equal-sized wings. Also, the region of the body behind the wings is "pinched" in ants but broader in termites. The antennae of ants are elbowed, while those of termites are straight and beadlike. These and other distinguishing features are pictured in figure 5. Additionally, ants generally have harder bodies than termites. Termite workers are almost always soft bodied and white to yellow (sometimes caramel colored), but rarely red, dark brown or black like ants. Finally, subterranean termites are almost never seen foraging out in the open.

A subterranean termite colony is self-perpetuating. When the colony is composed of a large number of individuals, a small percentage of workers develop into winged reproductives that then fly in swarms to establish new colonies. Most winged reproductives perish during the flight because of predators such as birds, bats, lizards, or other insects. The time of day and year when flights occur varies with the species of termite and its geographic location. Flights often occur during the first warm days of spring after a rain (therefore earlier in the year in the South than in the North), but they can occur at any time of the year. In buildings with heated basements, termites occasionally fly during winter.

Figure 3. — Soldier (top, with enlarged head and mandibles) and worker termites.

Figure 4. — Winged adult termite.

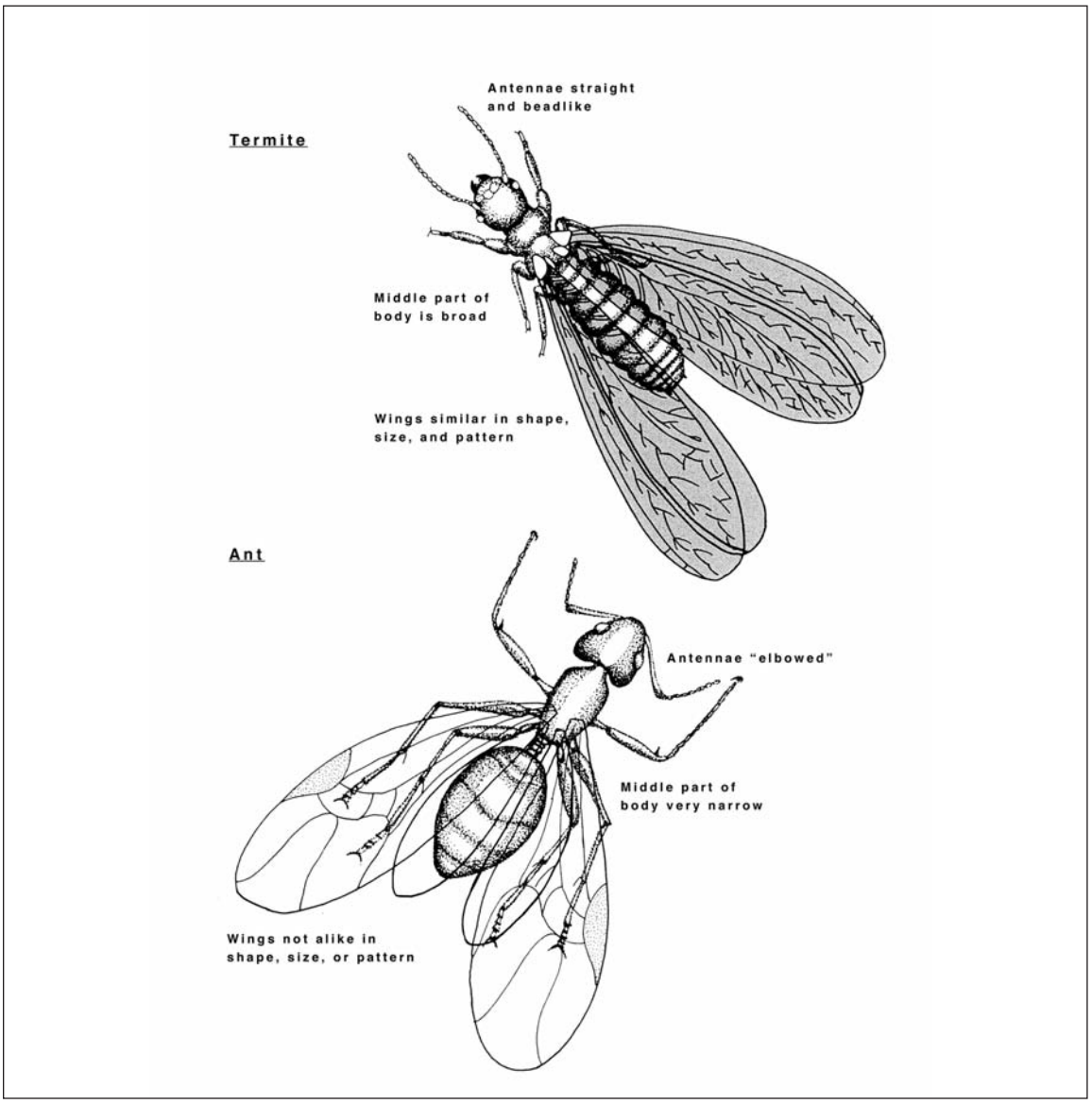

Figure 5. — Physical characteristics distinguish termites from ants.

Males and females in the flights are referred to as kings and queens, respectively. They shed their wings after the flight, and each pair excavates a cell in or near wood in the ground and mate. Most subterranean species in the United States lay fewer than 100 eggs during the first year, but egg laying increases with time.

Depending on species, a colony more than 5 or 6 years old may contain from several thousand to over a million termites and produce winged reproductives each year. In some situations, a few workers may develop into reproductives and supplement the egg laying of the original queen.

Materials Damaged by Subterranean Termites

The principal food of subterranean termites is cellulose obtained from wood and other plant tissues. Termites feed on the wooden portions of buildings, utility poles, fence posts, or other wood products. They can also damage paper, fiberboard,

and various types of fabrics derived from cotton and other plants. They occasionally are found in living plants and sometimes in puffball mushrooms. As termites search for food, they can damage many noncellulose materials, including plastics, rubber, and even thin metal, although these do not serve as food sources.

Conditions Favoring Subterranean Termite Infestation

Understanding the biological requirements and conditions that favor termite activities better prepares one to inspect buildings and identify potential problem areas. An important consideration is the termite's dependency on moisture. Their high moisture requirements increase the likelihood that they will maintain contact with the soil or locate near areas where water collects (such as air conditioning condensers, drains, condensation from pipes, etc.), or both.

Subterranean termites become more abundant in moist, warm soil containing a large supply of food. Such conditions often are found beneath buildings where there is inadequate water drainage, or poor ventilation, or where scraps of lumber, form boards, grade stakes, stumps, or roots are left in the soil. Once termites locate such an area, they can move into buildings in a variety of ways. Termites invade most buildings through wood close to or in contact with the soil, particularly at porches, steps, terraces, fences, or planters. Termites can easily enter small cracks or voids in foundations (including the center of cinder blocks) and concrete floors to reach wood that does not touch the soil. As with all insects, termite activity and development depend on temperature. When soil is kept warm throughout the year, as it is when basements are heated, termite activity is increased and prolonged. Such a "thermal shadow" exists in most structure types and may be increased by heating units, steam pipes, or electrical conduits near the soil.

Termites may eliminate their contact with the soil when an aboveground moisture source is available. Damp wood near sinks, toilets, and leaking pipes or wood kept moist by runoff water, as from the roof or gutters, is a prime location for termites.

Detection of Damage Caused by Subterranean Termites

Early detection of termite infestations and subsequent control measures should enable homeowners to protect their dwellings. A relatively simple, but careful, inspection of one's home may reveal previously undetected signs of termite activity.

Termite damage to wood often is not noticeable on the surface. This is because workers avoid exposure to air by constructing galleries within the materials they attack. Severely damaged wood may have a hollow sound when tapped. Prodding with a screwdriver is a simple way to determine the soundness of a suspected piece of wood. The exterior surface must be stripped away in order to see the extent of damage. Extensive tunnels that run along the grain are signs that subterranean termites have attacked the wood (fig. 6). These galleries are often covered with yellow-brown or gray specks of excrement and soil. Occasionally, termites completely honeycomb wooden timbers, leaving little more than a wooden shell. Subterranean termites do not reduce the wood to a powdery mass

Figure 6. — Wood damaged by subterranean termites.

or push wood particles to the outside, as do many other woodboring insects (such as beetles and carpenter ants).

In exposed areas, termites must protect themselves from the drying effects of air. Thus, earthen shelter tubes constructed over the surface of foundation walls are typical signs of termite infestation (fig. 7). These tubes are usually about 1/4 to 1/2 inch wide, and termites use them as passageways between the wood and the soil. To determine if an infestation is active, break a section of the tube and watch for termites. If you do not see any termites, then check back in several days to see if the termites repair the damaged tubes or build new ones.

Figure 7. — Termite shelter tubes.

Most subterranean termite species found in the United States do not construct a clearly defined nest. The Formosan subterranean termite, however, often builds "carton" nests within walls. The carton nest is a honeycombed mass composed of chewed wood, saliva, and feces that retains water and protects the termites from predators. Although occupied carton nests are relatively moist and pliable, abandoned nests dry and harden to a concrete-like consistency.

Large numbers of winged termites swarming from the soil or wood are often the most obvious sign of a nearby termite colony. Although flights may not be observed, discarded wings on the floor beneath doors or at windowsills suggest that winged termites have either emerged within a building and have been unable to escape, or have emerged nearby. Winged reproductives are produced by well-established colonies, often containing at least several thousand members, and colonies of hundreds of thousands are common.

Planning and Construction To Prevent Attack by Subterranean Termites

The best and least expensive time to protect a building against subterranean termites is during planning and construction.

Improper design and construction of buildings, resulting from either lack of knowledge or indifference to the termite problem, are favorable to infestation. It is therefore important to use good building practices and chemical soil treatments during construction.

Good Building Practices

The building site—All roots, stumps, and other wood debris should be removed from the building site before construction starts. Burying such material will only increase the probability of infestation, and burning will not destroy underground portions. Wooden spreader sticks and grade stakes should be removed before the concrete hardens. Form boards and scraps of lumber should be removed before filling or backfilling around the completed foundation. Wood should not be buried beneath porches and steps (fig. 8). No scraps of lumber should be left on the soil surface beneath or around the building after construction.

To prevent moisture buildup in the soil beneath a building, the soil surface around the building should be sloped so that water will drain away from it. Gutters and downspouts attached to eaves can help remove water quickly. Where there is poor surface drainage, as on flat surfaces or around buildings

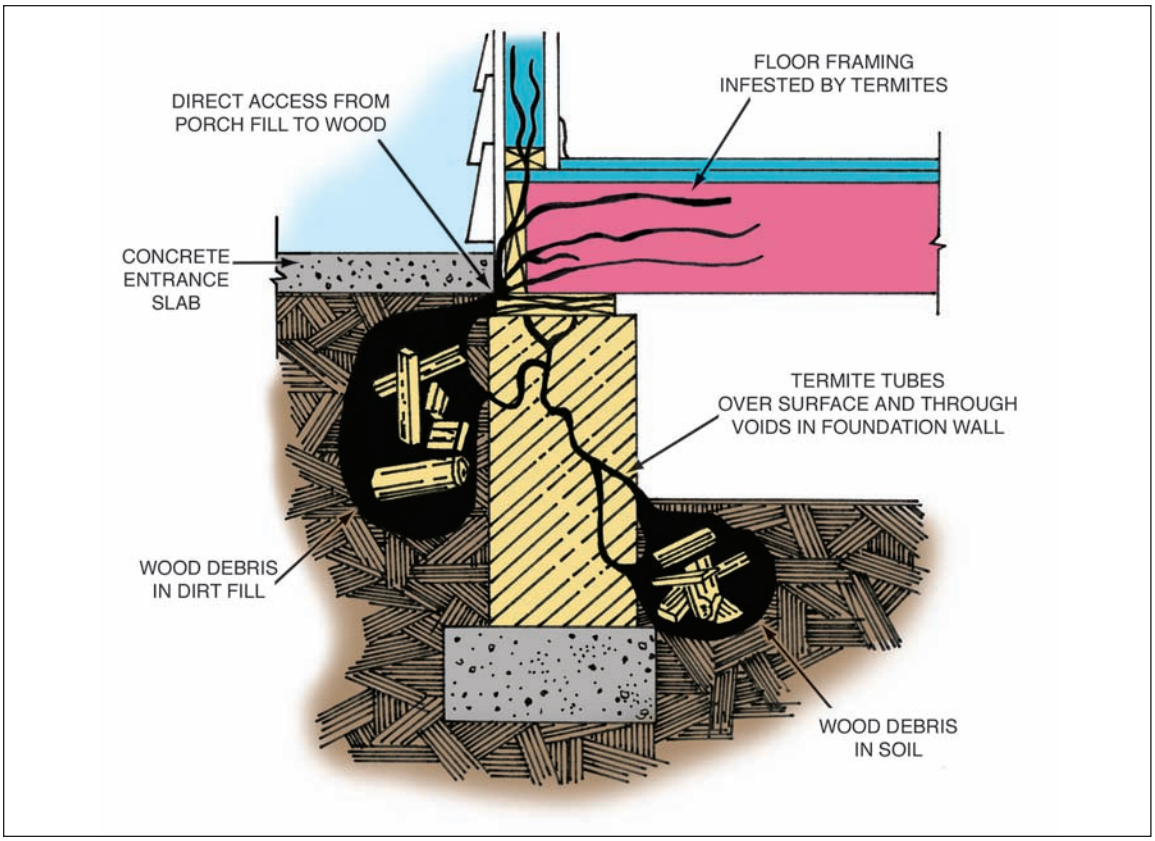

Figure 8. — Termite colonies can develop in woody debris and gain access to the structure.

with basements, the use of drainage tile around the outside of the building foundation may prove helpful.

Crawlspace (wall and pier or "conventional") foundations—The proper construction of foundations is one of the most important measures that can be taken to protect against termites and should be considered very carefully. All foundations should be made as impervious to termites as possible. Crawlspace foundations may be rated from most to least resistant as follows:

1. **Poured concrete** wall and pier foundations (fig. 9) that are properly reinforced to prevent large shrinkage or settlement cracks are the most resistant. Termites can use cracks as small as 0.03 inch (0.8 mm).

2. **Hollow block or brick** wall foundations are less resistant, depending on how they are capped:
   a. The most resistant of this type are capped with **reinforced poured concrete** at least 4 inches (10 cm) thick (fig. 10).
   b. If foundation walls are capped with **solid concrete blocks**, all joints should be completely filled with cement mortar.
   c. If the top course is **hollow blocks**, all joints should be completely filled with concrete. Where hollow blocks remain open no protection is provided unless all voids are chemically treated, or the soil beneath the footing is treated before the footing is poured. Do not apply a termiticide to voids filled with rigid foam insulation.

3. **Wooden piers** or posts used for foundations are the least resistant and should be pressure treated with an approved preservative by a standard process. Some States require this in the building code. However, even pressure-treated piers are susceptible to termite attack because the treatment may not extend to the center of the

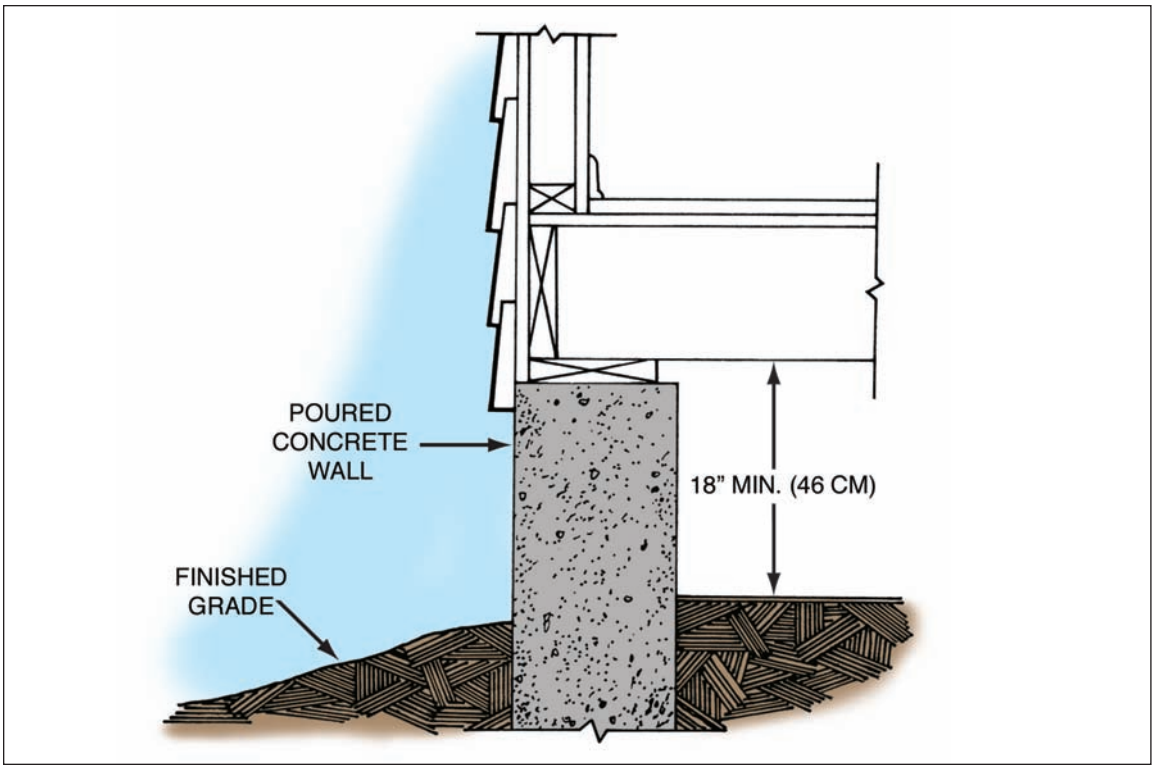

Figure 9. — Poured concrete walls and piers are easily inspected for hidden termite infestations.

pier. Cut ends of pressure-treated piers should not be placed in direct contact with the soil.

Ventilation beneath buildings—Ventilation openings in conventional foundation walls should be large enough and distributed to prevent dead air pockets from forming. Such pockets give rise to humid conditions conducive to termite activity and wood decay. Openings placed within 10 feet (3 m) of the corners of buildings usually give the best cross ventilation. The openings need not be placed on the front side of a building if unventilated areas can be avoided. The size and number of openings depend on soil moisture, atmospheric humidity, and air movement. In general, the total area of ventilation should be 1/150 of the ground area beneath the building. Shrubbery should be kept far enough away from the openings to permit free air circulation and should be far enough from the foundation to allow inspection of wall surfaces for the presence of termite tubes.

Skirting between foundation piers—Where pier foundations are used, it is sometimes desirable to close the spaces between the piers with lattice or wooden skirting. If this is done, the woodwork should be separated from the piers and soil by at least 2 inches (5 cm).

Water pipes and conduits—Keep all plumbing and electrical conduits clear of the ground in crawlspaces. Suspend them from girders and joists where possible. Do not support them with wooden blocks or stakes connected to the ground because termites will tunnel through these wood supports or construct tubes over them to sills, floors, and joists above. Chemically treat the soil around plumbing extending from the ground to the wood above.

Where pipes or steel columns penetrate concrete slabs or foundation walls, fill the spaces around them with either dense cement mortar or roofing-grade coal-tar pitch after the soil around the pipe or column has been chemically treated.

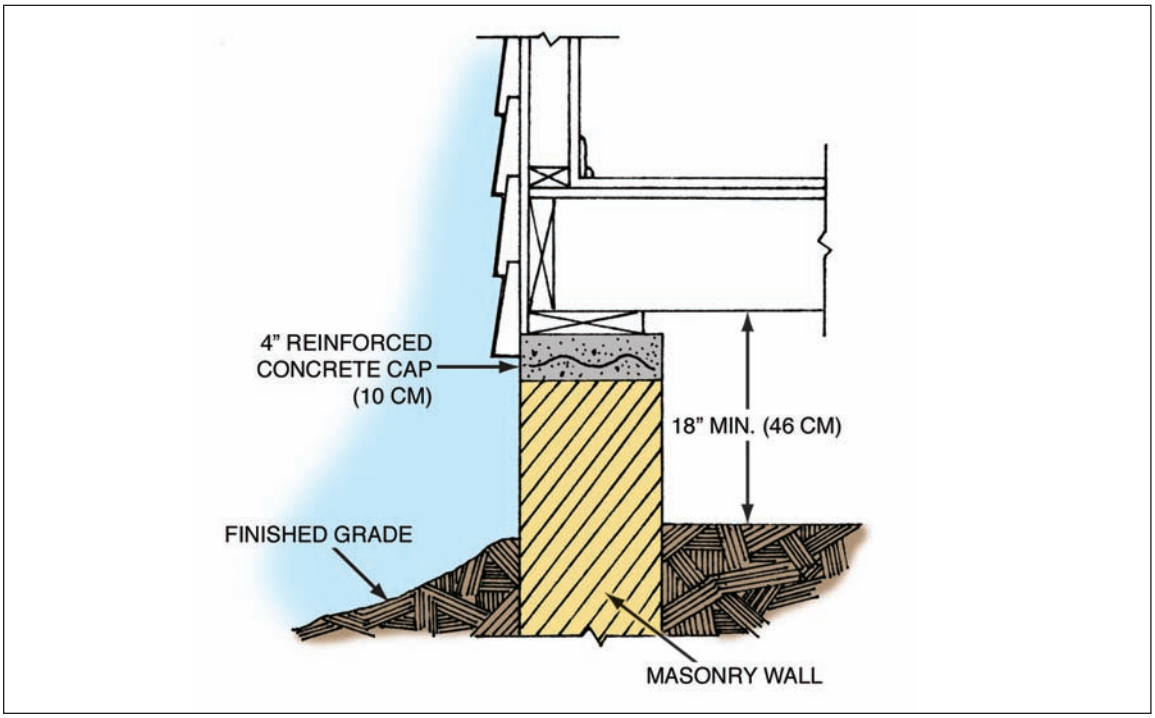

Figure 10. — Reinforced poured concrete cap on masonry walls prevents hidden attack by termites. Clearance between the floor and soil should be at least 18 inches (46 cm).

Closed crawlspace foundations—Closed crawlspace foundations consist of conventional crawlspace foundations that use a mechanical heating and cooling system to control temperature and moisture. No ventilation to the outside is provided, and the walls and floor above are insulated to retard heat loss and moisture condensation. The ground, and frequently the walls, must be covered with a plastic vapor barrier or insulated. When installing insulation in a closed crawlspace, a strip at least 3 inches (7.5 cm) wide must be left exposed along the top perimeter of the foundation wall to allow for detection of termite tunnels during inspection. Special attention must be given to the inspection and treatment of these structures as accessibility of closed crawlspace areas and soil is severely restricted.

Concrete slab-on-ground foundations—One of the most susceptible types of construction, and one that often gives a false sense of security, is the concrete slab-on-ground foundation. Termites can gain access to the building over the edge of the slab, through expansion joints, through openings around plumbing, and through cracks in the slab. Infestations in buildings with this type of construction are very difficult to control.

Because the slab-on-ground construction is extremely susceptible to termite attack and infestations are difficult to control, **treat the soil with chemicals before pouring the concrete.** Such soil treatments, properly applied, are effective and much less expensive and invasive than remedial treatments at a later date.

Do not leave any untreated wood such as forms, scraps, grade stakes, or wood plugs in or beneath the slab. Reinforce the slab at all points where it is likely to crack.

Termites can penetrate some types of slabs more easily than others. The **monolithic** slab (fig. 11) provides the best protection against termites. In this

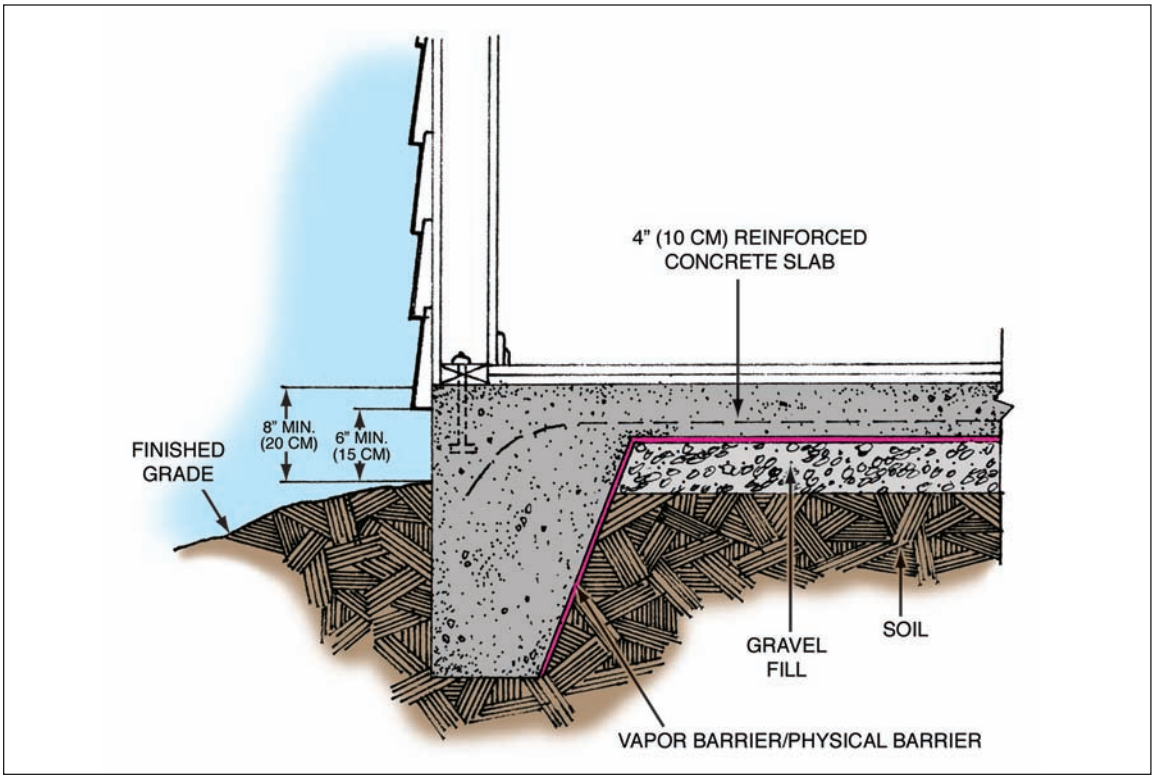

Figure 11. — Monolithic concrete slab-on-ground construction.

type of construction the floor and the footing are poured in one continuous operation, eliminating joints or other structural features that permit termite entry.

A second type is the **suspended** or **supported** slab (fig. 12) that extends completely across the top of the foundation. Here the slab and the foundation are constructed as independent units. This prevents hidden termite attack because even though a vertical crack may develop in the wall, termites still must tunnel over an exposed part of the slab. The lower edge of the suspended slab should be open to view. With the monolithic and suspended slabs, the slab should be at least 6 inches (15 cm) above grade.

A third type is the **floating** slab (fig. 13). It may either rest on a ledge of the foundation or be independent of it. In both instances the slab is in contact with the ground. This is the most hazardous of the three types of slabs because the slab edges come in contact with the foundation walls, and termites may gain hidden access to the wood through expansion joints.

Basement foundations—In many ways, a house with a basement can be seen as a conventional foundation house built over a concrete slab on ground, with continuous walls of poured concrete, cinder block, or brick (sometimes stone). Many of the termite considerations for basement-style houses will be a combination of those for conventional and slab-on-ground construction, and the reader should consult those parts of this booklet. "Dirt basements," where the structure is built over an excavated area, are regarded as crawlspace foundations. Basements do provide some unique situations, however, which are described below.

Basement rooms—Termite infestations in basement rooms are very difficult to detect and control. Such situations exist commonly in finished basements where untreated wood floors and furring strips are used. The best way to prevent such infestations is

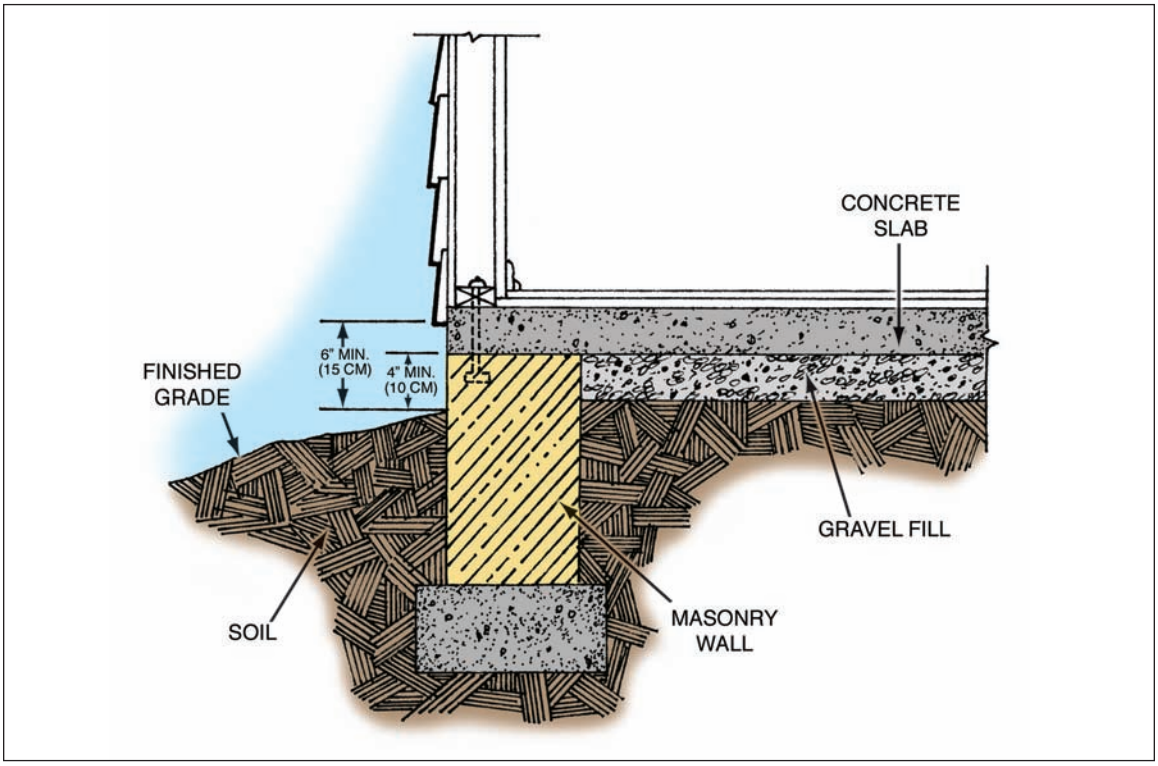

Figure 12. — Suspended concrete slab-on-ground construction.

to treat the soil below the basement floor and along the outside of the foundation, preferably before the foundation and basement floor are constructed. Pressure-treated lumber should be used for wood screeds, subflooring, and furring strips because of the danger of decay.

Partitions and posts—Install wooden basement partitions, posts, and stair carriages **after the concrete floor is poured**. They should never extend into or through the concrete. Wood posts, partitions, stair carriages, heating units, and other loadbearing points should rest on concrete floorings that extend at least 3 inches (8 cm) above the floor level. Use reinforced concrete because the concrete may crack, providing entrance points for termites (fig. 14).

Windows below grade—Where window frames or other openings near or below outside grade are made of wood, the foundation wall surrounding the wood should be made impervious to termites. The bottom of the window well should be at least 6 inches (15 cm) below the nearest wood.

Girders, sills, and joists—Wooden girders, sills, and joists that are in or on foundation walls in basements should not be placed below the outside grade level. Termites may find hidden access to this

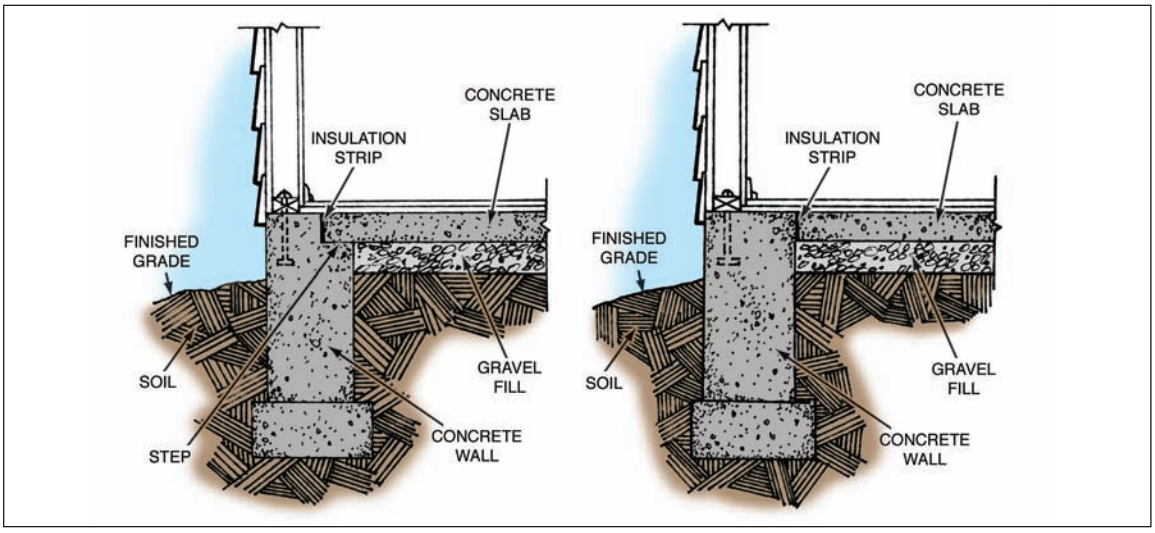

Figure 13. — Slab-on-ground construction (floating slab): (above, left) slab suspended on foundation wall; (above, right) slab rests entirely on ground.

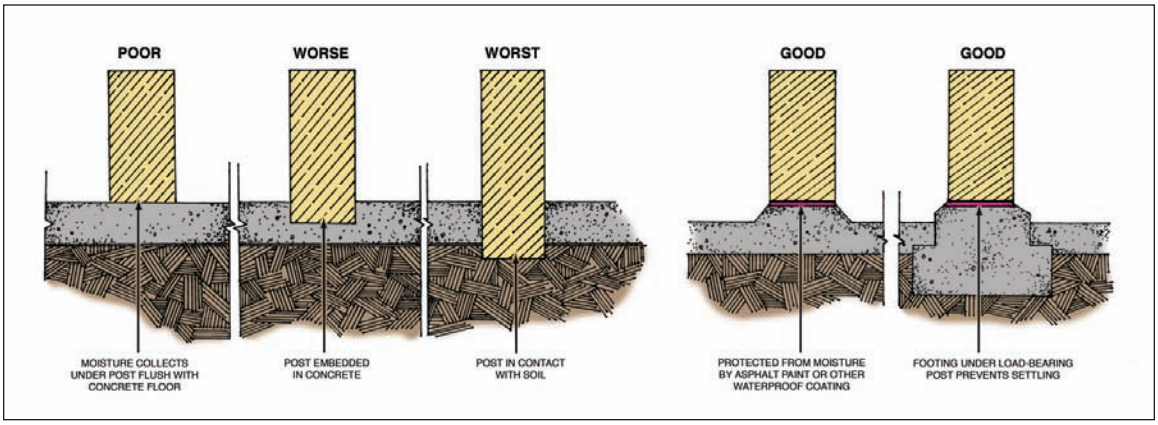

Figure 14. — Posts in concrete: Certain situations increase vulnerability to termite attack.

wood and it may be subject to decay. Because of the difficulty of replacing girders, sills, and joists, it is a good practice to use preservative-treated lumber for these structural members. Termites generally will not eat wood treated with preservatives, but they will tunnel over treated wood to reach untreated wood.

Physical barriers—For conventional foundations, metal or plastic termite shields (fig. 15) have been used as a replacement for the concrete cap or other methods of sealing masonry foundations. If properly designed, constructed, installed, and maintained, shields will force termites out into the open, revealing any tunnels constructed around the edge and over the upper surface of the shield. Experience has shown, however, that very few shields are properly constructed and installed and that homeowners usually fail to inspect shields frequently enough to detect termite infestations. The shields make infestations easier to detect, but do not provide effective protection and should not be solely relied upon to control termites.

In recent years stainless steel mesh and plastic physical barriers have been introduced. Such materials are placed underneath the slab before the concrete is poured (fig. 16). If the material is impermeable plastic, it may be used in lieu of the vapor barrier, if that is in accordance with the manufacturer's instructions. Areas around pipes, conduits, and other service penetrations of the slab receive an additional protective flange of the material to prevent termite entry (fig. 17). When wooden posts are in direct contact with the ground, such as for a deck support, the posts are wrapped with a sleeve of material (fig. 15). Some physical barriers are impregnated with insecticide to provide even more protection.

Exterior woodwork—Finishing work on the outside of buildings should be constructed with the prevention of termite infestations in mind.

***Clearance between wood and soil*—**Except when a basement is present, the outside finished grade should always be equal to or below the level of the soil underneath the structure (figs. 9, 10, and 18)

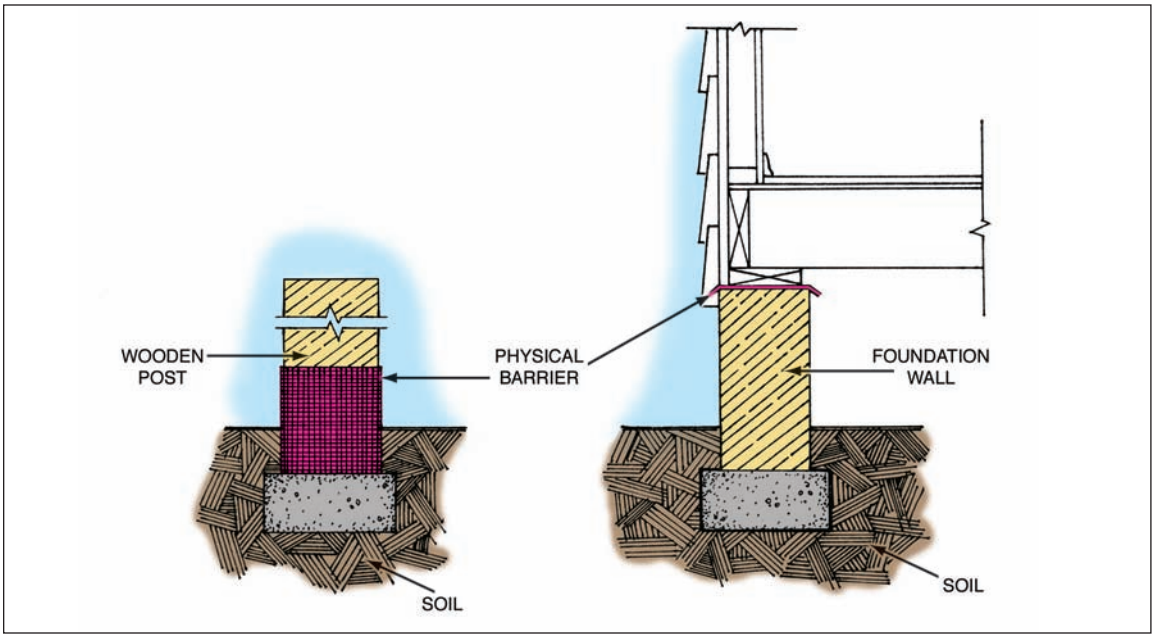

Figure 15. — Physical barriers: (above, left) around a post; (above, right) as a wall cap (termite shield).

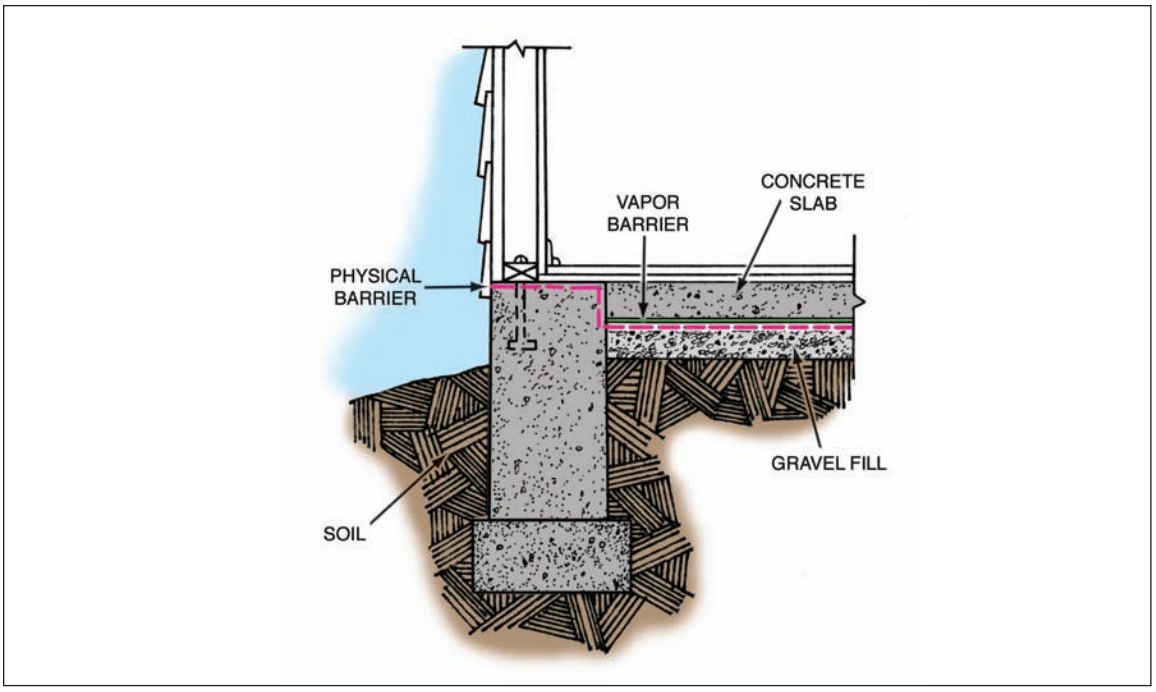

Figure 16. — Physical barrier placed beneath the slab over gravel fill.

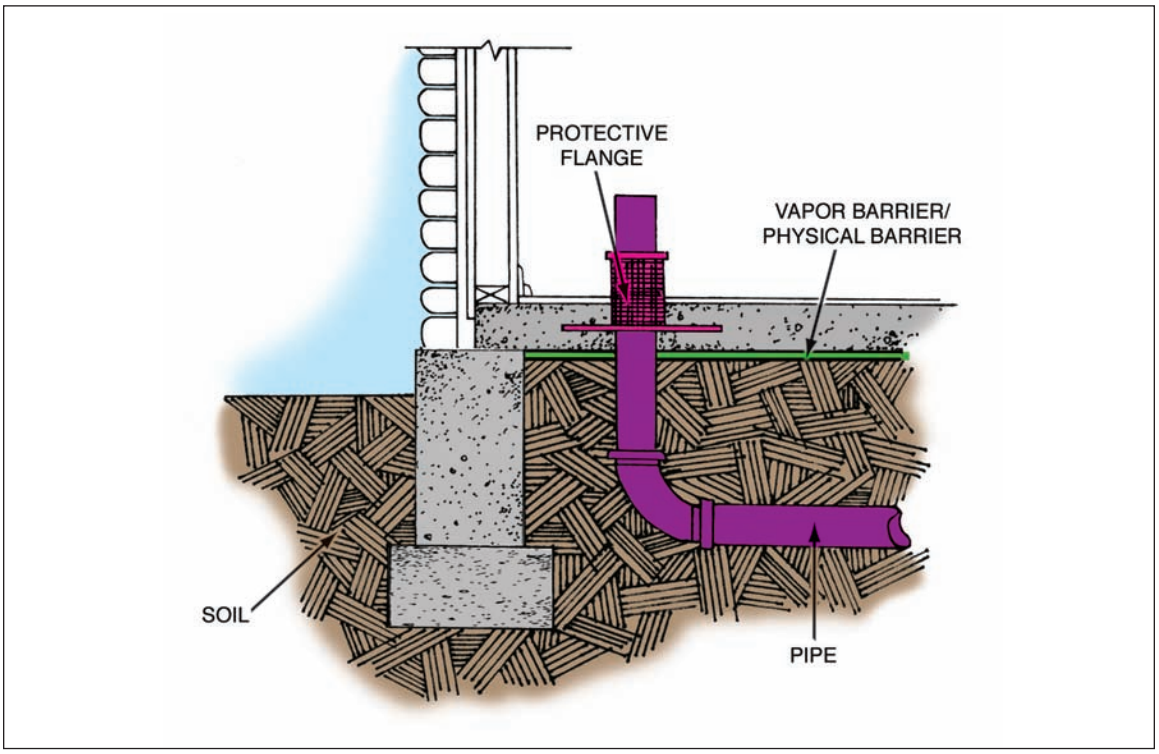

Figure 17. — Protective physical barrier embedded in concrete around service penetrations.

so that the foundation wall is exposed and can be inspected. This will help prevent the collection of water underneath the house. Siding should not extend more than 2 inches (5 cm) below the top of the foundation walls, piers and concrete caps, and should be at least 6 inches (15 cm) above the outside grade. This will force termites out into the open where their tunnels can be seen before they reach the wood. In crawlspaces the minimum clearance between the ground and the bottom of the floor joists should be 18 inches (46 cm); such clearances for beams and girders should be 12 inches (30 cm) (fig. 18).

Wooden porches and steps—Porch supports (such as piers) adjacent to a building should be separated from the building proper by 2 inches (5 cm) to prevent hidden access by termites. Wooden steps should rest upon a concrete base or apron that extends at least 6 inches (15 cm) above the grade (fig. 19).

Door frames—Door frames and jambs should never extend into or through a concrete floor.

Raised porches and terraces of concrete or masonry—Dirt-filled porches and terraces contribute to a large proportion of all termite infestations in buildings. Therefore, spaces beneath concrete porches, entrance platforms, and similar raised units should not be filled with soil. Such spaces should be left open with access doors for inspection. If this cannot be done, or if the spaces beneath such raised units must be filled, leave 6 inches (15 cm) of clearance between soil and wood and thoroughly treat the soil with a registered soil termiticide.

Direct Control Methods

Chemical treatment of the soil around and under the foundation is one of the prime methods of preventing termite attack. This should not be used as a substitute for good building practices.

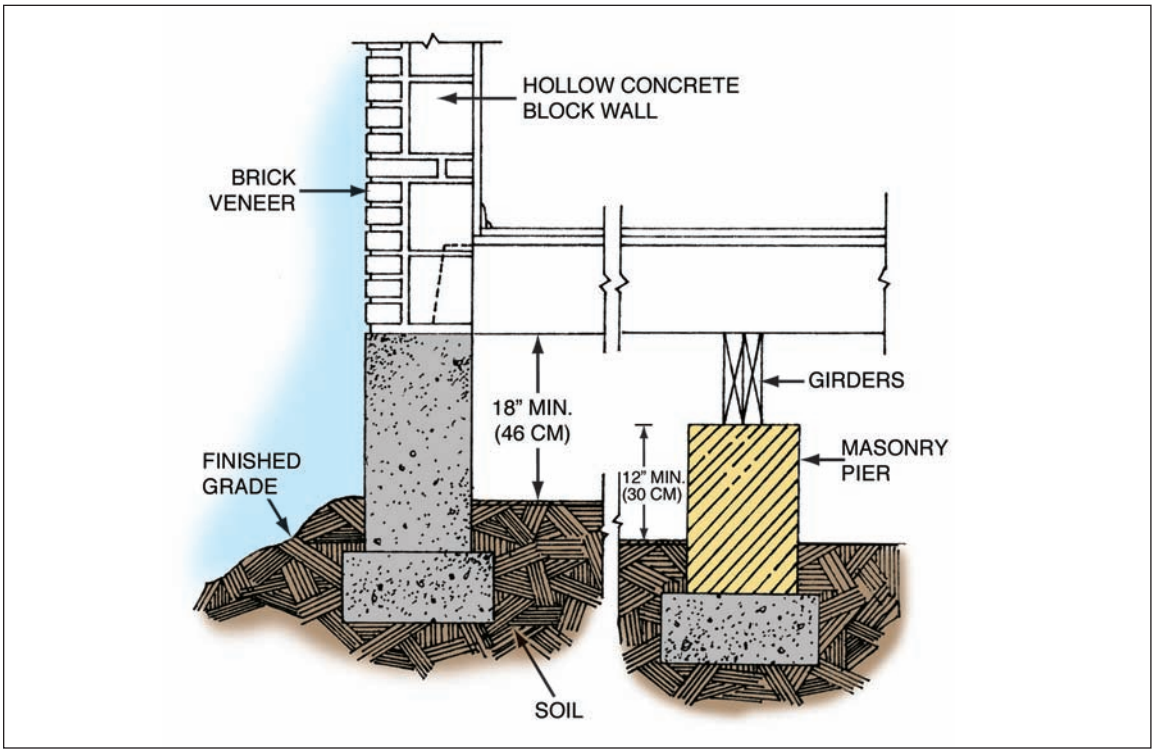

Figure 18. — For masonry superstructures, provide adequate clearance between wood and soil both outside and inside the building.

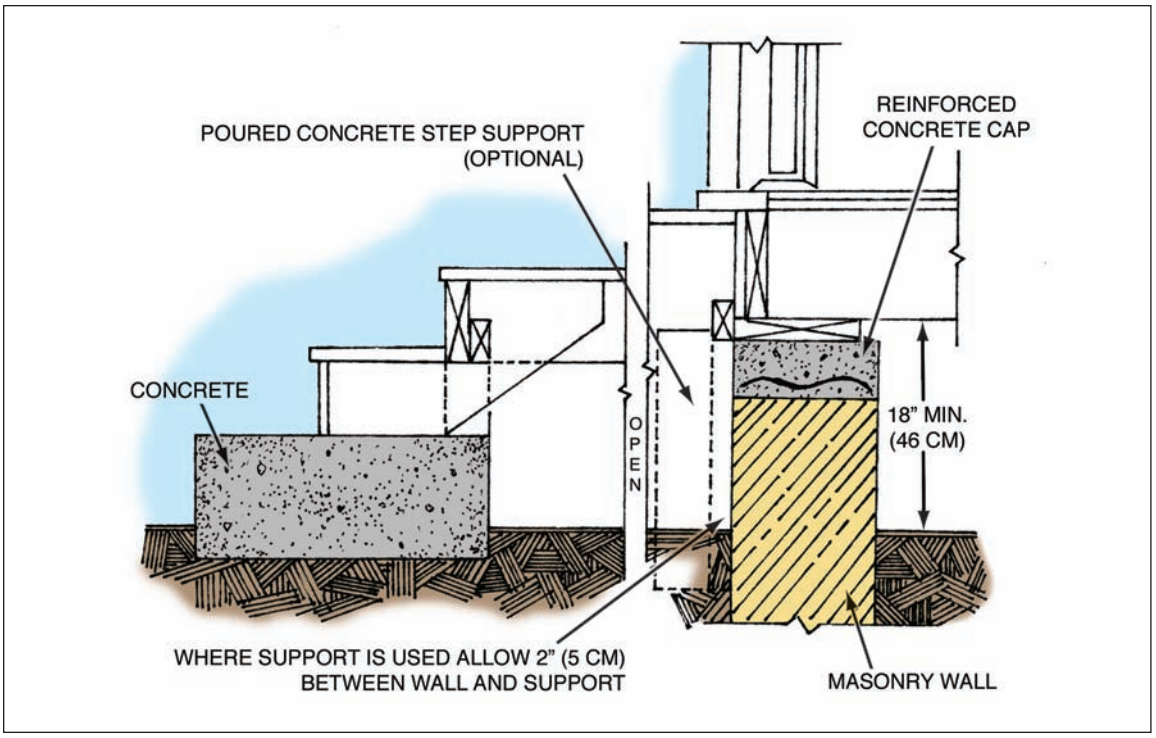

Figure 19. — Construction of wooden steps to prevent hidden termite attack.

Chemically treated and naturally resistant woods can reduce the susceptibility of wooden structures to termite attack. Baits are not currently used during construction for termite control, but some States do allow them to be used in lieu of chemical treatment even though installed after construction is completed.

Chemical soil treatment before construction— Insecticide-treated soil serves as one of the most important means of isolating a building from termites. Soil treatment is most effective when done before and during construction of the foundation. It is particularly important when using concrete slab-on-ground construction.

The Environmental Protection Agency (EPA) regulates pesticide use in the United States. Several chemical formulations are registered with the EPA for the treatment of soil to prevent termite attack. The chemicals available for use vary over time. Such factors as economics, human safety, environmental hazards, and Federal regulation determine which pesticides may be used, and by whom. Some pesticides may be purchased and used by the homeowner, but most require certification by the State and a license to purchase and use. Additionally, individual States may impose further regulations or recommendations specific to their area. Be sure to check with your State authorities before attempting to use a pesticide product.

Note: The following sections are provided for information purposes only. They are intended to give a better understanding of how soil treatments for termite control are used. They are not meant as a substitute for the label of any product. Be aware that many termite control pesticides are limited to use by only State-licensed termite control applicators. **ALWAYS READ AND FOLLOW LABEL DIRECTIONS.** It is unsafe, ineffective, and a violation of Federal law to use a pesticide in a manner other than prescribed on the label.

***Preparation of chemical solutions*—**A soil chemical is often purchased as a **liquid concentrate**. The concentrate is formulated according to the percentage, or weight in pounds per gallon, of the insecticide it contains. Each concentrate contains inert ingredients that improve application and performance, and it must be diluted before use. Some compounds are purchased as a **wettable powder** that dissolves or becomes suspended when mixed with water. Wettable powders contain several inert ingredients also. Neither powders nor concentrates provide better termite control. The form the pesticide comes in is determined by manufacturing considerations. Directions are given on the container for diluting the concentrated solution to the desired strength. The label directions must be followed exactly.

***Rates and methods of application*—**The objective of treating soil with chemicals is to provide a continuous chemical barrier in soil surrounding the building foundation. The chemical must be applied thoroughly and uniformly to block all routes of termite entry. This requires that the treatment be applied at all potential termite entry points. The rates and methods of application vary with the type of construction.

1. ***Crawlspace houses (conventional foundation)***—The soil under and around crawl space houses should be treated as follows:
   a. Four gallons (15 liters) of diluted chemical are applied per 10 linear feet (3 m) of trench along the inside of all foundation walls and along all sides of interior supports and plumbing (figs. 20 and 21).
   b. A trench 6 to 8 inches (15 to 20 cm) wide is dug along the outside of the foundation (including the soil beneath porches and patios before the concrete is poured). Where the top of the footing is more than 12 inches (30 cm) deep, holes will be made in the soil at intervals no greater than 12 inches (30 cm) to the top of the footing. The holes may need to be closer together in hard-packed clay soils than in light sandy soils. Four gallons (15 liters) of diluted chemical are applied to 10 linear feet (3 m) of trench for each foot (30 cm) of depth from grade to footing. The soil is saturated with the chemical as the trench is being refilled.
   c. If an attached porch, carport, or other structure contains wood, the soil beneath the slab should be treated with 1 gallon (4 liters) for 10 square feet (1 m^2) before the concrete is poured. This is to prevent termites from gaining access to the main structure through wood in the attached structure.

2. ***Slab-on-ground construction*—**This type of construction should be treated with a registered termiticide after any backfilling, leveling, and tamping of the soil and before the concrete is poured. The chemical is applied with a power sprayer using low pressure to avoid misting and off-target drift.

   a. Where the fill is soil or unwashed gravel, 1 gallon (4 liters) of diluted chemical per 10 square feet (1 m^2) of area is applied as an overall treatment under the slab and any attached slab porch, carport, garage, and terrace (fig. 22).
   b. If the fill is washed gravel or other coarse absorbent material, such as cinder, 1.5 gallons (6 liters) are applied per 10 square feet (1 m^2) to ensure penetration of the termiticide to the soil beneath.
   c. In critical areas under the slab, such as along the inside of foundation walls, along both sides of interior partition walls, and around plumbing, 4 gallons (15 liters) of diluted chemical are applied to the soil per 10 linear feet (3 m).

Figure 20. — Application of a chemical to soil around a foundation.

d. Voids in masonry blocks or foundations may be treated as well. If the voids are inaccessible, it may be necessary to drill holes near the footing and inject a chemical to form a continuous barrier. Two gallons (8 liters) of diluted chemical are applied to 10 linear feet (3 m) of wall or foundation (fig. 23). Do not apply a termiticide to wall voids filled with rigid foam insulation.

e. After the slab is poured, a trench 6 to 8 inches (15 to 20 cm) wide is dug along the outside of the foundation (fig. 20). Where the top of the footing is more than 12 inches (30 cm) deep and where large volumes of chemical must be applied, holes are made about 12 inches (30 cm) apart in the bottom of the trench to the top of the footing using a soil auger, crowbar, metal rod, or grouting rod. These holes permit better distribution of the chemical by providing access to the soil at depths below the trench. The holes may need to be closer together in hard-packed clay soils than in light sandy soils. Four

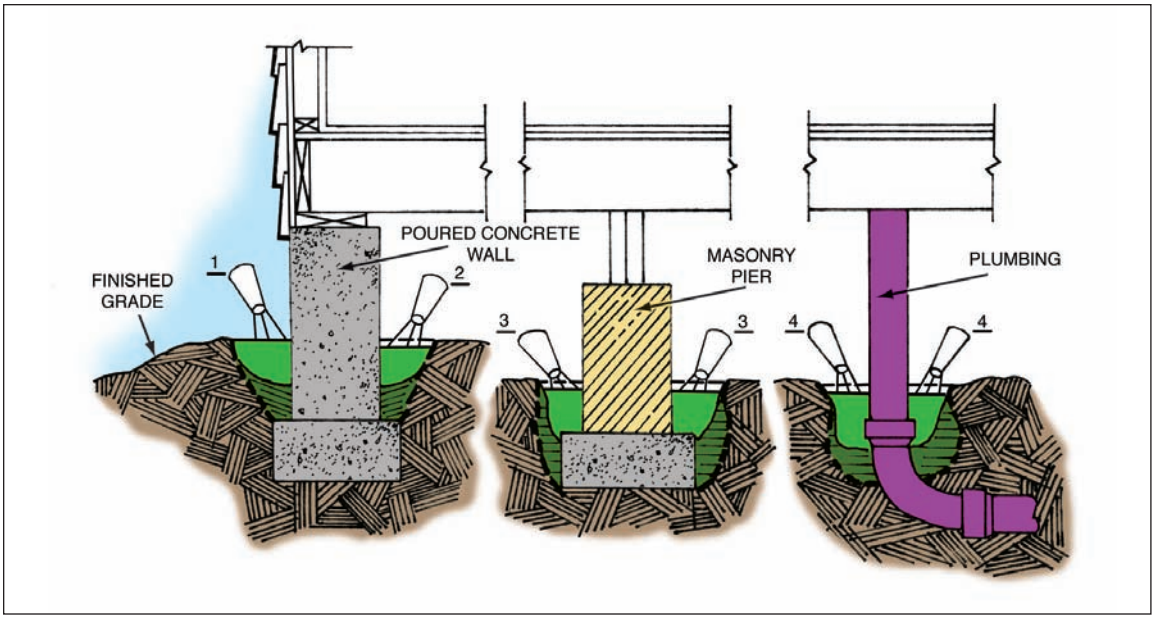

Figure 21. — Application of a chemical to crawlspace construction. Soil treatment is applied (1) alongside outside wall, (2) inside wall, (3) around pier, and (4) around plumbing.

Figure 22. — Chemical treatment of fill material before slab is poured.

gallons (15 liters) of diluted chemical are applied to 10 linear feet (3 m) of trench for each foot (30 cm) of depth from grade to footing. The soil is saturated with the chemical as the trench is filled.

3. ***Basement houses***—The soil under and around houses with basements should be treated as follows:
   a. The soil under and around basement houses is treated in the same manner as recommended for slab-on-ground construction (figs. 22 and 24).
   b. Voids in masonry foundations may be treated at or near the footing with 2 gallons (8 liters) of chemical per 10 linear feet (3 m) of wall. Do not apply a termiticide if the voids have been filled with rigid foam insulation.

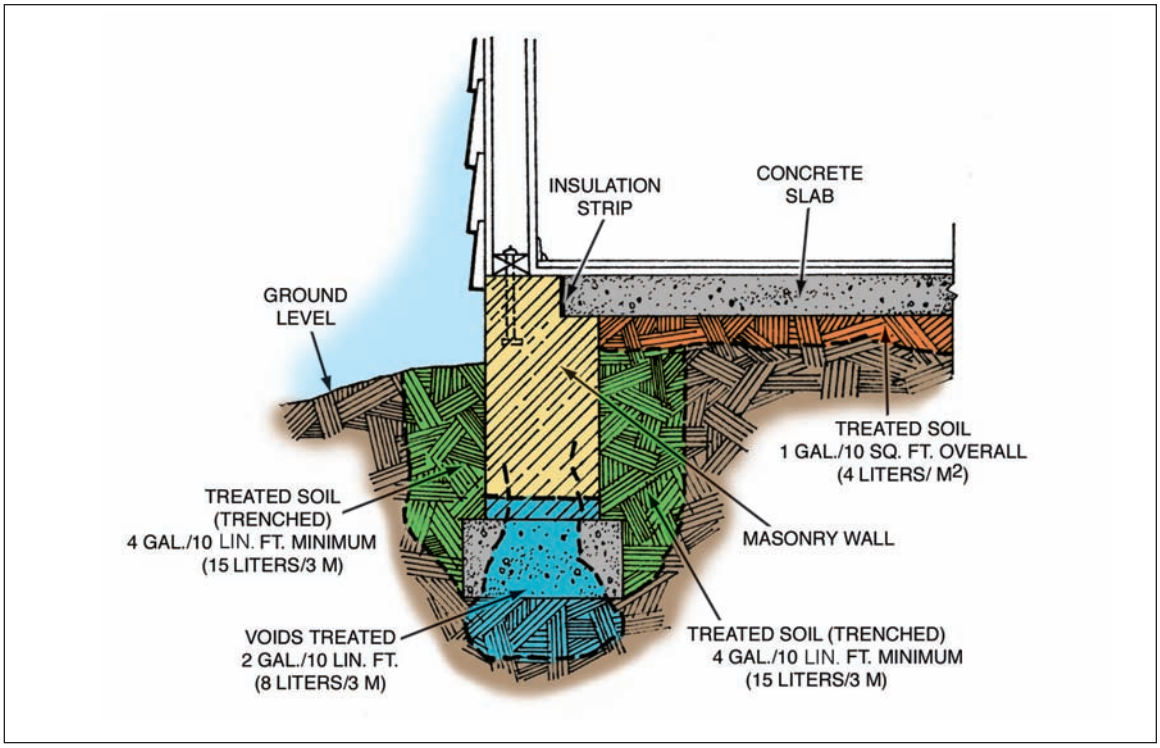

Figure 23. — Application of chemical to slab construction.

4. ***Other types of construction***—It is not possible to list in detail all the various types of construction available. However, treatments should be made according to the individual component parts, using the specifications that apply to each.

Considerations when treating new construction—The type of soil encountered at the building site and the amount of moisture present in the soil just prior to treatment will have an effect on the acceptance of liquids at the recommended rates. A soil fill will best accept a treatment when it is damp but not excessively wet or dry. Most product labels prohibit application to saturated or frozen soil. If the soil is excessively wet, there is a chance of runoff, and the chemical will not penetrate the soil. In frozen or excessively dry soil the chemical solution is repelled and puddling occurs, resulting in poor distribution of the termiticide.

Mechanical disturbance of treated soil breaks the continuity of the insecticide barrier and increases the probability of termite penetration. The treatment of fill under slabs is less than 2 inches (5 cm) deep and the majority of the material is in the top 3/4 inch (2 cm); therefore very little disturbance to the treated soil can be tolerated. The final treatment on the outside of the foundation walls should be done **after all grading and other soil disturbance has been completed.** A freshly treated slab foundation site should be protected with a polyethylene sheet or other waterproof material. This will prevent rain from washing away the insecticide or treated soil.

Any disturbance of treated soil, even years after treatment, can disrupt the integrity of the termiticide barrier. Laying of pipes, cables, phone lines, etc., into a house through the treated barrier can disrupt the barrier, and disturbed soil should be retreated

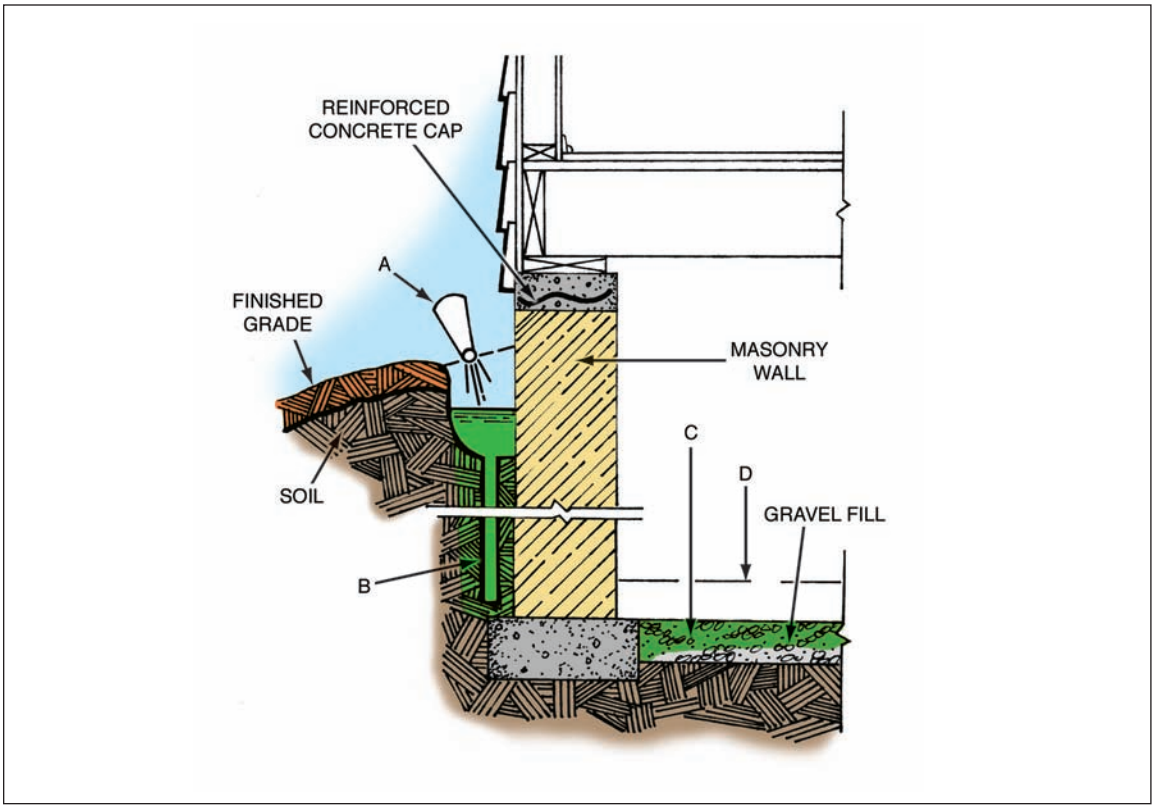

Figure 24. — Application of chemical in basement construction: (A) treatment along foundation, (B) rodding to top of footing, (C) treatment of fill below slab, and (D) slab poured after fill has been treated.

once the work is finished. Landscaping practices near the foundation wall may disrupt the barrier and make inspections more difficult. Care should be taken when planting shrubs or other plants that the treated area is not disturbed. Landscape timbers placed over a treated zone may provide a bridge for termites to bypass the barrier and gain entrance into the house. Use treated lumber for such purposes, and make sure the wood does not come in direct contact with the house.

The termiticide is stable once it dries on the soil. Because most commonly used termiticides are insoluble in water, leaching is not a problem. There is a slight risk, however, of contaminating a well or other water supply if insecticides are applied to nearby soil that either contains layers of gravel or tends to crack severely in periods of dry weather. In these situations, the soil should not be treated with chemicals and other control methods should be used.

Many termiticides are extremely toxic to fish and other aquatic organisms. Therefore, special care must be used to avoid insecticide drift when treating buildings near bodies of water. Care should also be used if there is a chance of treated soil washing into a pond or stream if it rains before the slab is poured. Do not apply a termiticide if precipitation is likely.

Naturally resistant woods—Untreated sapwood is highly susceptible to termites and has a short service life when termites are allowed access to it. However, the heartwood of some tree species has varying degrees of termite resistance. This resistance is attributed to chemical components produced naturally by the living tree that are toxic and/or repellent to the termites. The practice of using resistant woods has been almost completely replaced in the United States by using chemicals to protect wood. Even the most resistant wood is not completely immune to attack, because termites will still eat resistant wood if a preferred wood is not available.

Different woods vary in their relative resistance to termites. Some species typically considered resistant are bald cypress, eastern red cedar, chestnut, Arizona cypress, black locust, redwood, Osage orange, black walnut, and Pacific yew. It should be noted that **even the most resistant woods cannot be considered termite barriers.** Termites can tube over resistant wood and attack susceptible wood. Generally, the use of resistant wood throughout a structure can be economically justified only when drywood termites or decay are considered serious problems and protection from them is necessary.

Chemically treated woods—Chemically treated wood safeguards against both termites and decay. The degree of protection obtained depends on the kind of preservative, the penetration achieved, and the retention of the chemical in the wood. Woods of various species and types differ in their ability to be treated, and the heartwood resists treatment more than the sapwood.

The life of wood structures can often be increased by applying wood preservatives at standard retention rates and ensuring that the wood is satisfactorily penetrated. For maximum protection, the wood should be pressure treated with an approved chemical by a standard process. In less severe conditions, a vacuum treatment usually gives adequate protection. Brush, spray, or short-period soak treatments only give limited protection of wood above ground and should not be relied upon to give long-term protection from termite attack.

As with the naturally resistant woods, termites are able to tube over treated wood and attack untreated wood. Again, because of cost, only where drywood termites and decay are a problem should chemically treated wood be used throughout a structure.

Control of Subterranean Termites in Existing Buildings

Ridding existing structures of termites and making them resistant to future infestations are major problems in termite control. Generally, buildings become infested because little or no attention was given during construction to the preventive measures that would have made the structures resistant to termites. It is in such buildings that termites cause heavy losses each year.

Observe the same principles that are recommended for the prevention of infestations in new buildings when controlling termites in existing buildings. That is, eliminate conditions favoring the development of termite colonies in the soil and permitting passage of termites to wood within the structure. Subterranean termites in the wooden parts of a building will die if they are unable to maintain contact with the soil or other sources of moisture.

Inspection

Regardless of previous preventive measures, wooden structures should be inspected periodically for evidence of active infestation. If no preconstruction measures were employed, the structure should be inspected more frequently. Under certain circumstances, termites may breach even the best physical barriers, and even insecticides may be ineffective in stopping termites. The continuity of the termite barrier may be broken, and maintenance or repair personnel may leave a condition that favors termite infestation after working underneath or around the structure. A homeowner can inadvertently disturb the treated soil or place wood on the soil against or under the building. If not cautious, the homeowner may overlook vegetation that has grown over or through the chemical barriers, providing access for termites. Settlement cracks may occur in the foundation walls or concrete slabs and allow termite entrance.

With proper inspection, very little termite damage should result before discovery. Termites typically work slowly and can be detected and controlled before causing structural weakness to the timbers. Although extreme haste is not required, **once an infestation is discovered, treatment should be applied within a few months.**

Sanitation

Sanitation and structural control measures should be given consideration in the control of existing infestations. In addition to chemical treatments, the following control measures should be used:

1. Remove all wood, including form boards and other debris containing cellulose, from underneath and adjacent to buildings.
2. Remove exterior wooden structures, such as trellises, that connect the ground with the woodwork of the house. Any wood remaining in contact with the soil should be treated with preservative.
3. Replace heavily damaged (structurally weakened) sills, joists, flooring, etc., with sound wood. Where possible, remove all soil within 18 inches (46 cm) of floor joists and 12 inches (30 cm) of girders (fig. 10).
4. Fill voids, cracks, or expansion joints in concrete or masonry with cement or roofing-grade coal-tar pitch.
5. Provide adequate drainage (see pages 9 through 10).
6. Provide access for inspection of vulnerable areas.

7. Provide adequate foundation ventilation in crawlspace construction. A barrier of polyethylene or similar material should be placed on the soil to retard moisture.

Chemical Control

Chemicals used to prevent termite infestations are sometimes also used to control existing infestations in buildings. The rates of application, method of preparation, and necessary precautions are discussed on pages 17 through 23.

The many variations in construction prevent a detailed discussion of exact procedures for chemical treatment in all situations. In applying treatments, however, remember that **the purpose is to establish a chemical barrier between termites in the soil and wood in the structure** or to reestablish the barrier if it has been broken. It is best to have this work done by a professional. Some procedures for treatment of existing buildings are as follows:

1. ***Crawlspace construction***—Buildings with crawlspaces usually can be treated easily and effectively. The procedures recommended for pretreatment can also be used for termite control in existing buildings (see pages 19 through 20).

2. ***Slab-on-ground construction***—Termite infestations in buildings with this type of foundation present serious control problems. It is difficult to form an effective chemical barrier in the soil beneath such floors. One way to treat under a slab is to drill a series of vertical holes about 0.5 inch (1.2 cm) in diameter through the slab and into the soil beneath, particularly at the base of partition walls and other points where the termites may be entering (fig. 25). In most cases, holes should be no more than 12 inches (30 cm) apart. Because a complete barrier is necessary for the treatment to be effective, the chemical injected into each hole must meet with that injected in adjacent holes. The advantage of vertical drilling is that the chemical will flood and cover the surface of the soil.

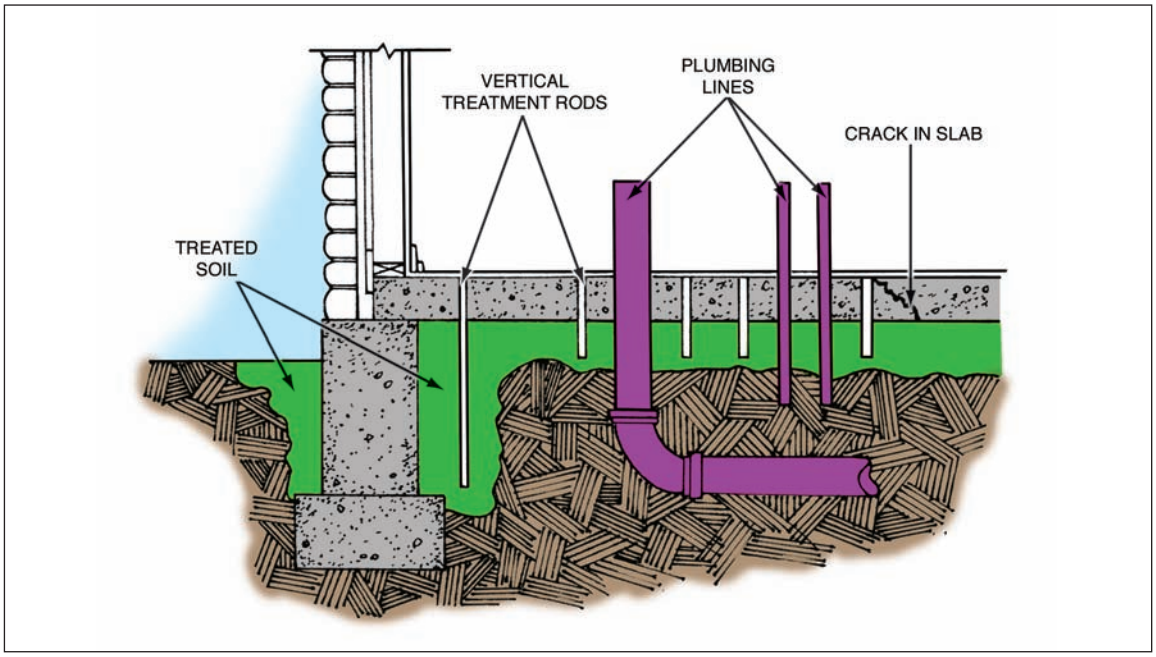

Figure 25. — Treatment under a concrete slab with vertical rodding to reestablish the chemical barrier.

Another way to treat under slabs is to drill horizontally through exterior foundation walls to the soil just beneath the slab and inject the chemical in the holes. This method is complicated, requires special equipment, and should be performed only by a professional. Extreme caution should be taken to prevent drilling into plumbing, electrical conduits, or heating ducts that may be imbedded in concrete. **Injection of termiticides into these areas must be avoided.** Always treat along the outside of the foundation (see pages 19 through 21).

3. ***Basement construction***—Treat the soil along the outside walls of basements (see page 21).

4. ***Raised porches, terraces, and entrance slabs***—Termite infestations frequently occur at porches, terraces, and entrance slabs. The most satisfactory way to control infestations at these locations is to excavate the soil adjacent to the foundation wall, remove all wood debris, and apply a chemical to the soil as recommended. Place an access panel over the foundation opening to permit inspection. Alternatively, holes may be drilled either through the adjacent foundation wall from within the crawlspace or basement, or through the entrance slab at intervals no larger than 12 inches (30 cm). Chemicals should be injected to form a continuous barrier.

5. ***Buildings with wells, cisterns, sump pumps, French drains, or irrigation systems***—Although most termiticides are not very soluble in water once they have dried to the soil, during application the chemical can be washed or blown into a well, cistern, or drainage system. Where wells are located close to or within foundation walls, care must be taken to avoid contamination of the well or cistern. If the label allows, the **treated backfill** method may be used. The soil around the well or cistern is removed onto a heavy plastic sheet or into a wheelbarrow. The termiticide formulation is applied at a rate equivalent to 4 gallons (15 liters) of diluted chemical to 10 linear feet (3 m) of trench for each foot (30 cm) of depth. The termiticide is thoroughly mixed into the soil and the soil is replaced into the trench.

Some termiticide producers caution against using their product near sump pumps and French drains. A termiticide may usually be applied near a sump pump if the water level in the pit is not rising. The soil around French drains usually may be treated if the soil is dry. For sump pumps and French drains, the treated backfill method may be used if desired. Do not apply a termiticide if precipitation is likely, and do not use irrigation systems until the termiticide has had time to dry.

Termiticidal Baits

Several termite bait applications have become popular in recent years. Baiting technology relies on certain biological principles. Termites, being social insects, are known to feed each other, and termites foraging on a treated substance (paper, cardboard, etc.) can transfer a portion of the active ingredient to nestmates (fig. 26). The idea is that not all termites need to encounter the bait itself to be killed. Some baits may be purchased and used by homeowners, others need to be installed and monitored by licensed professionals. Baits are applied in the same manner regardless of construction type.

Most currently available baits employ the placement of untreated monitor stations around or near a structure (fig. 27). The placement is determined by the manufacturer's instructions. Here, the termite presence may be detected before the termites enter a structure. Most monitoring stations consist of a plastic tube with holes or slits cut to allow termite entry. Within the station is a food source, often

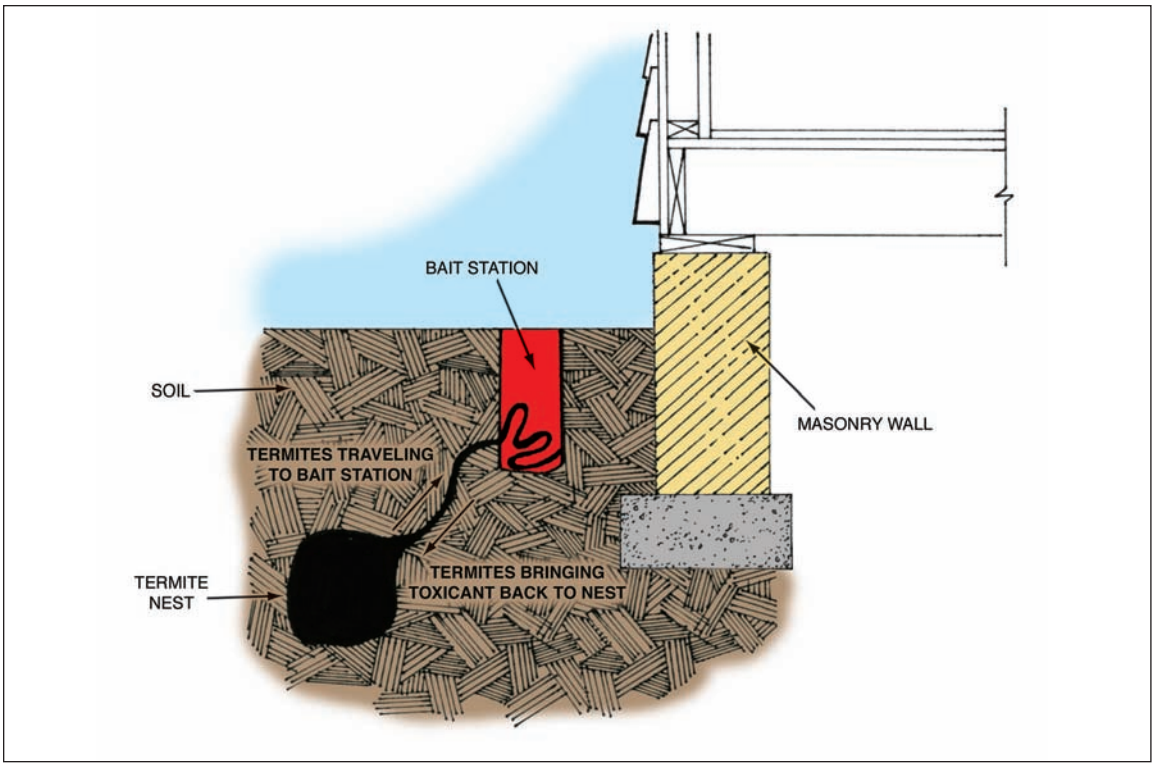

Figure 26. — Termite bait is taken by termites and then shared with others in the colony.

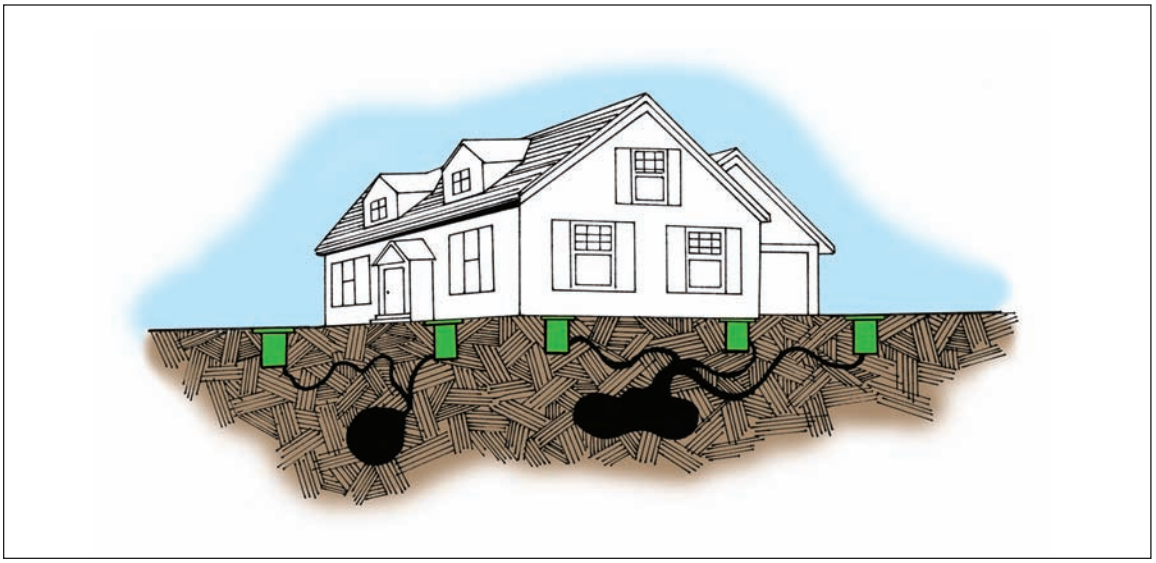

Figure 27. — Bait stations placed along the perimeter of a house (number shown is less than that typically recommended by the manufacturers).

wood, paper, or cellulose powder. The stations are monitored on a schedule and, once termites are detected in the monitoring stations, the toxic bait is added. The bait may or may not be in the same form as the monitoring material. The stations continue to be monitored and new bait added until termite activity stops for a specified amount of time, such as 1 year. Once this happens, the bait station is removed and replaced with a new monitoring station.

The active ingredients of some baits are insect growth regulators that interrupt important processes in the insect's life, such as the shedding of skin. As a result, they are usually specific to insects with few effects on noninsect life. However, because they interfere only with certain stages, it may take weeks, months, or even years to control an infestation. Other baits use metabolic poisons, which affect a specific point in the termites' energy cycle.

Baits may be used alone, or in conjunction with chemical treatments. Care should be taken to ensure that chemicals do not contaminate the monitoring/bait stations. Such contamination may cause the termites to avoid the monitoring station, allowing them to go undetected. Also, care should be taken when using lawn care and landscaping pesticides in areas where bait monitoring stations may be present.

Because most homeowners cannot afford to use both chemical and bait treatments, the question arises as to which technology is preferable. This will depend on the homeowner's preferences. Both chemical treatments and baits are popular. Table 1 describes some important advantages and disadvantages of baits and chemical termiticides.

Table 1. — Comparison of the advantages and disadvantages of baits and soil-applied liquid termiticides.

Baits	Liquid termiticides
Lower amounts of chemical are used—ounces (g) versus gallons (liters).	Large amounts of chemical are used—gallons (liters).
Require ongoing service contract—protection ends the day the contract is cancelled or expires and bait is removed.	Do not require ongoing contract—single treatments are effective for years (periodic inspections are still recommended).
Specific to insects (IGRs)—fewer environmental concerns.	More general poisons—more hazardous to the environment if used incorrectly.
Role in preconstruction applications uncertain.	Effective in preconstruction applications.
Slower acting—require weeks or months to be effective.	Faster acting—insects die in hours or days after encountering toxicant.
Less disruptive to property to install.	More disruptive to property to install.
Sharing of bait spreads toxicant through colony.	Some compounds show spread through colony.

IGR = insect growth regulator.

Other Insects That Damage Wood in Buildings

Other insects attack wood in buildings, and their damage may be mistaken for that caused by subterranean termites. The insects most commonly involved are drywood termites, wood-destroying beetles, carpenter ants, and carpenter bees.
The work of these insects differs from that of subterranean termites in that the wood they attack is converted either to compressed pellets, powder, or shredded fibers. In contrast, subterranean termites leave small, grayish-brown specks of excrement in excavated areas. Subterranean termite galleries follow the grain of the wood, whereas the tunnels of most of the other insects mentioned usually cut across the grain.

Risk Factors for Termite Problems—A Checklist

Any items checked "yes" below should receive special attention at inspections and be checked more frequently. If possible, the problem should be corrected.

Are there…

Yes/No Cracks in concrete foundation?

Yes/No Posts in concrete?

Yes/No Earth-filled porches?

Yes/No Form boards left in place after construction?

Yes/No Leaking pipes or faucets?

Yes/No Shrubs near air vents?

Yes/No Wood debris underneath or around the house?

Yes/No Low foundation walls or footings?

Yes/No Brick veneer covering foundation? If bond fails, termites have hidden access.

Yes/No Flower planters near foundation walls?

Yes/No Wooden forms around drains?

Yes/No Porch steps in contact with the ground?

Yes/No Obstructions around heating unit?

Yes/No Paper collars around pipes?

Yes/No Trellises? Do they touch the soil?

Yes/No Rigid board insulation, stucco, or siding that extends all the way to the soil?

Acknowledgments

Colorized line drawings were prepared or redrawn by Beth Dishongh, Mississippi State University, Office of Agricultural Communications, Mississippi State, MS. Photographs for figures 6 and 7 were taken by Tom Murray, Boxborough, MA. Figure 22 was photographed by Tim Lockley, Mississippi Bureau of Plant Industry, Mississippi State, MS.

Pesticide Precautionary Statement

Pesticides used improperly can be injurious to humans, animals, and plants. Follow the directions and heed all precautions on the labels.

Store pesticides in original containers—out of reach of children and pets—and away from foodstuffs.

Apply pesticides selectively and carefully. Do not apply a pesticide when there is danger of drift to other areas. Avoid prolonged inhalation of a pesticide spray or dust. When applying a pesticide it is advisable that you be fully clothed.

After handling a pesticide, do not eat, drink, or smoke until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first aid treatment given on the label and get prompt medical attention. If the pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

Dispose of empty pesticide containers by wrapping them in several layers of newspaper and placing them in your trash can.

It is difficult to remove all traces of an herbicide (weed killer) from equipment. Therefore, to prevent injury to desirable plants do not use the same equipment for insecticides and fungicides that you use for an herbicide.

Note: Registrations of pesticides are under constant review by the Environmental Protection Agency (EPA). Use only pesticides that bear an EPA registration number and carry directions for home and garden use.

The U.S. Department of Agriculture Forest Service is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the national forests and national grasslands, it strives—as directed by Congress—to provide increasingly greater service to a growing Nation.