# TERMITE ATTACK IN BUILDINGS

**CONTENT**

## (1) Introduction

Termites or white ants, as they are commonly called, are found most abundantly in tropical countries and are widely distributed in temperate regions. Termites are unique among insects in their ability to derive nutritional benefit from cellulose, which is the component of wood and plants that gives structural rigidity to cells. They contain bacteria in their digestive systems that break down the complex carbohydrate cellulose into simpler carbohydrates that the termites can use for energy. Since cellulose is the major constituent of most plant tissues, it follows that the majority of plants and plant products are likely to be susceptible to termite damage.

In nature, termites play an important part in the ecosystem in that they feed on dead trees and plants, thus returning the nutrients to the soil so new growth can occur. They feed on wood and serve an important function in nature by converting dead trees into organic matter. Their greatest contribution is the role they play in recycling wood and plant material. Their tunneling efforts also help to ensure that soils are porous, contain nutrients, and are healthy enough to support plant growth.

They only become pests when they feed on man-made wooden structures. Under natural conditions, termites of one sort or another feed upon the roots or stems of grasses, living trees, dry wood or decaying vegetable matter. Unfortunately, the wood in buildings is equally appetizing to termites and they cause serious damage to residential and commercial buildings. Thus, when given the opportunity, they may damage or destroy paper, linoleums, leather and bone and may also attack stored food, books, and household furniture. Even buried telephone cables, plastic waterpipes and the lagging around steam pipes can be attacked by termites. Thus, whenever they occur, some termite species are likely to damage or destroy articles useful to humans and precautions must be taken to minimize the losses they might cause. The old adage that prevention is better than cure applies to termite attack as much as to anything else. New buildings can be given protection against termite attack by the inclusion of suitable barriers into the structure during construction and timbers of low natural resistance can be given immunity from attack by means of preservative treatments. The cost of such precautions generally represents only a small fraction of the total cost of the structures which they protect. To take precautions is good insurance; to ignore them in areas of unknown or high termite hazard is unwise.

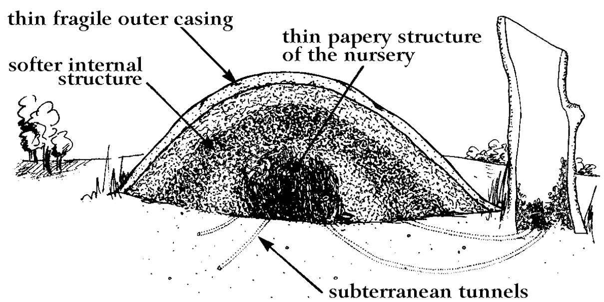
### (2) Termite Ecology

Termites feed on dead plant cell wall material, such as wood, leaf litter, roots, dead herbs and grasses, dung, and humus. Chemically, their food can be characterized as lignocellulosic matter, which is the most abundant organic material in the biosphere. Termites are able to digest cellulose, and some species can also digest lignin, with the assistance of symbiotic intestinal protozoa and bacteria. Many termites also have symbiotic relations with nitrogen fixing bacteria. In converting lignocellulosic biomass to insect biomass, termite production supports a large proportion of tropical vertebrate biodiversity, including many species of amphibians, reptiles, birds, and ground foraging insectivorous mammals.

### (3) Termite Nest (Termitarium)

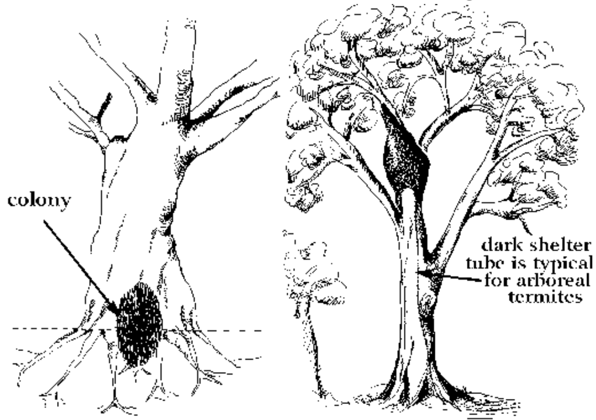
The queen, the brood and most of the colony's individuals live in a so-called **termitarium** (plural: **termitaria**). It is composed of mud that is sometimes as hard as concrete and a paper-like substance made from chewed wood. The conditions inside the nest are dark, moist and cool and suit the requirements of the mostly blind unpigmented termites with their soft cuticles. Runways or **galleries** are built by the workers radially from the nest in all directions and connect the termitarium with sites where the colony gathers food.

**Figure 1: Mound nest**



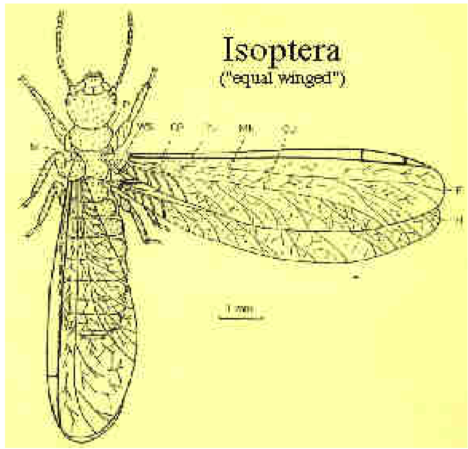

These galleries are either **subterranean** about 20 to 50 cm deep or are built from mud (**mud packs** or **mud galleries**), attached to a stem or other substrates. The termites' road system can be enormous and reach a radius of 50 to 100 metres around the nest. Each termite species builds its particular type of nest, either a **mound nest** (shown above) made above the ground, or a **subterranean nest** in a buried log, a decaying stump or the crown root of a tree, or an **arboreal nest** attached to a branch or to the stem of a tree. Mound nests can reach a height of up to six metres. The mound nest of the Australian species *Amitermes meridionalis* is flattened and the tapered sides always orientate towards the north and south. Constructing the nest this way ensures that the inside of the nest is not heated up by the sun since only the narrow sides are exposed to direct sun light. Subterranean nests buried at a depth of 50 cm or even reaching depths of several metres, are invisible and therefore difficult to discover.

**Figure 2: Subterranean** (left) **and arboreal** (right) **termite nest**



**(4) Order: Isoptera**

**Figure 3: Isoptera**




**Isoptera** is the insect order to which the termites belong. The name Isoptera (iso = equal; ptera = wing) refers to the adult primary reproductives which possess two pairs of equal length wings. The body plan or morphology of termites is rather simple indicating that they diverged very early in insect evolution from a generalized insect ancestor with gradual metamorphosis and the ability to fold the wings flat over the back. Although simple in morphology they are advanced in social behaviour.

Termites are most closely related to cockroaches (Blattaria). The primitive termite genus, *Mastotermes*, like cockroaches, lays its eggs in an ootheca-like mass and has a lobe in the hind wing.

Recent tabulations indicate that as of 1995 there were approximately 2,753 validly named termite species in 285 genera in the world. The vast majority of termite species occur in the tropics.

Like ants, wasps and bees, termites are social insects. They exhibit brood care within their social community or "colony". A colony is really just a very large family of insects. Within this family there is an overlap of parent and offspring generations. Some of the offspring diverge from the normal course of development to become various castes. Unlike most insects, which have only one linear developmental pathway, termites have branching developmental pathways. Therefore, we say that they are polymorphic.

### (5) The family

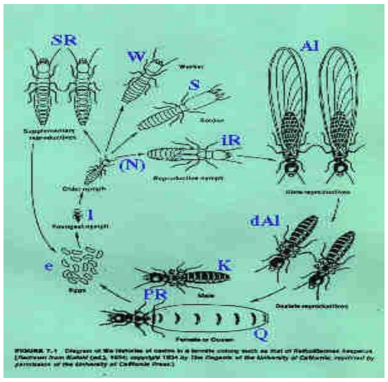



**Figure 4:** Termite Family

Termites are said to live in "colonies" but this is misleading. A colony is really just a family of insects. One of the most profound and defining attributes of the termite family is that it is built on monogamy. Termites are faithful. They are probably the most monogamous group of animals on earth. The evolutionary outcome of this commitment to monogamy is a large and integrated family. As far as biologists know, termite colonies are the most sophisticated families ever to evolve in the universe. Human families are not nearly as advanced. Humans, in contrast to termites, have the most advanced, non-family based type of social system known in the universe. Termite colonies are comprised of three basic castes: workers, soldiers, and reproductives. Reproductives come in several forms, most common being the winged, primary reproductives, which are commonly called swarmers.

Winged termites (swarmers) are often confused with flying ants. Swarmers have a thick waist, straight antennae and a pair of long equal-length wings that break off easily. Ants have pinched waists, elbowed antennae and forewings are larger than rear wings, and not easily detached.

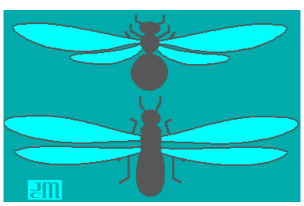


**Figure 5:** Ant at top, termite on bottom. Termites have thick waists, straight antennae and wings of equal size.

The swarmers (reproductives) are called "alates" and are commonly seen when they swarm on a hot humid summer evening around dusk; they have eyes; are poor fliers but are swept along by the wind; they land, drop their wings, find a mate to become king and queen of a new termite colony. The swarmers are emitted in their thousands when a mature termite nest is large and well established. They land, shed their wings and attract a mate by pheromone chemical signal.

**(a) Reproductives**

They possess compound eyes and are more or less brown due to their sclerotized cuticle. Developing reproductives have wing buds, wings or wing stumps. Reproductives can be further divided into:-

- **Alates**, the young winged reproductives of both sexes. From time to time about 100 to 1000 alates leave the colony for a mating and colonising flight. After mating a pair settles down at a suitable site like a rotting scar on a tree in order to establish a new colony.

**(5) <u>The family (Cont'd)</u>**

(a) Reproductives (Cont'd)

- **De-alates**, alates that cast their wings after the colonising flight and successively turn into queens and kings. Initially only a few eggs are laid and brought up by a female de-alate. As the number of individuals in the colony grows, the more workers are available to help the young queen to care for the brood. After three to five years the number of individuals is already so large, that the colony of a pest species can turn into the damaging stage.

**Reproductives** develop either from alates or neotenics. Alates are winged termites. Each species produces a cohort of alates at a particular season. The alates of each species fly at a unique time of day and under specific conditions. The alates develop from nymphs by growing wings and compound eyes. After flying, the alates break off their wings along a basal suture and are then called dealates. Dealates form tandem courtship pairs, and after a brief courtship run, dig into the soil adjacent to wood, mate, and start a family. The offspring constitute the colony. The founding reproductive pair is now the queen and king of the new colony.

**Primary reproductive** females, vary in size depending on the species. They are generally darker in colour than the other members of the nest and gave two pairs of wings, which are voluntarily shed after they have come to ground from the nuptial flight before they mate. After mating they are called the King and Queen. The Queens abdomen becomes enlarged with time, extremely so in the more advanced families such as the "Termitidae" when she is referred to as being "physogastric".

Tropical queens may measure 10 centimetres in length and produce thousands of eggs a day. At her peak she will lay an egg every 3 seconds or 30,000 a day in some species and she will lay 10's of millions of eggs during her life. The enlarged abdomen makes her relatively immobile and dependent on the workers. She is licked and fed constantly and closely attended by her relatively small mate, the king. There is usually just one pair of primary reproductives per colony but some species have a low incidence of colonies with multiple reproductives (polygamy).

The "Primary Sexuals" have a more developed brain and they suppress the sexual development of the rest of the nest through hormones they secrete which are passed from one individual of the nest to another by anal liquid exchange or "oral anal tropholaxis". Once the nest is well established, the Queen no longer eats wood but is fed on the saliva of the workers and/or on the fungi in the Macrotermitinae.

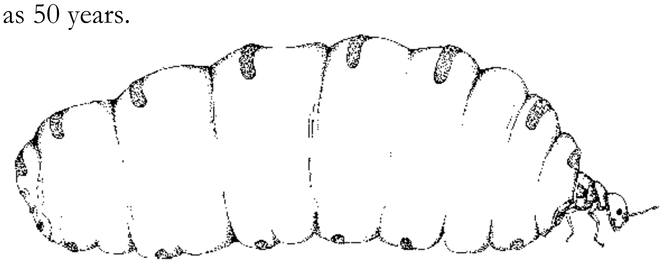
**(5) <u>The family (Cont'd)</u>**

(a) Reproductives (Cont'd)

**Secondary reproductives** may develop from either unflown alates (=adultoids), nymphs (=nymphoids) or workers (=ergatoids). If a primary reproductives dies it is usually quickly replaced by a secondary reproductive of the same sex. In the more primitive, wood-inhabiting termites large numbers of pseudergates quickly moult to neotenics when removed from the pheromonal inhibition of a primary reproductive. These newly moulted neotenics then engage in lethal fights with same sex siblings, eventually resulting in the survival of only one secondary replacement reproductive of each sex. It seems surprising that these termites which are so co-operative with their siblings as immatures are so viscously competitive and siblicidal upon maturation. Unlike primary reproductives that usually outbreed, secondary reproductive always mate incestuously resulting in inbreeding. They tend to be much more common in the lower termites than in the highly evolved forms.

(b) Queen & King

**Queen and king**, which are the main reproductive individuals in a colony. Once there are many workers to help the queen, her only job is to produce a tremendous number of offspring. A large queen may lay more than 1000 eggs per day. The life span of a queen can be as much as 50 years.



Neotenics assist the queen in laying eggs, once her productivity decreases. When the queen has died or deteriorated, one of the neotenics takes her place. That is the reason why the removal of a queen from her colony does not necessarily mean the end of the colony.

(c) Workers

The worker comprises the bulk of the population. They are by far the largest cast in the termite colony and the one that does the damage; they are a creamy translucent colour, soft bodied and carry out all work in the nest, including gathering food (timber and other cellulose); constructing tunnels; repairing and enlarging the colony nest; grooming each other and feeding the soldiers, the king, queen and also caring for the young nymphs until mature.

**(5) <u>The family (Cont'd)</u>**

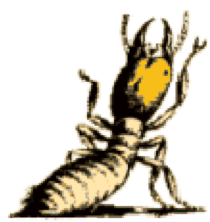
(c) Workers (Cont'd)

Worker termites are 3 mm to 4 mm long, wingless, are sterile and blind males and females. Their cuticle is unpigmented and not hardened, therefore the animals are confined to a dark and moist environment. Workers build the nest and galleries, they fetch food, care for the brood and feed reproductives and soldiers. They work 24 hours a day for several years life span in some species. In lower termites there is a false worker caste called pseudergates who retain the potential to become alates.

Workers feed all the dependent castes: larvae, nymphs, soldiers and reproductives. They also dig tunnels, locate food and water, maintain colony atmospheric homeostasis, and build and repair the nest. In some species their job description also includes mushroom gardening.

Only the worker termite caste can digest timber by the use of symbiotic protozoa in their gut. Worker termites feed their partly digested semi-liquid food, regurgitated from their mouth or passing from their anus, to the other termites, a process known as trophallaxis. The worker's life span is one to two years.

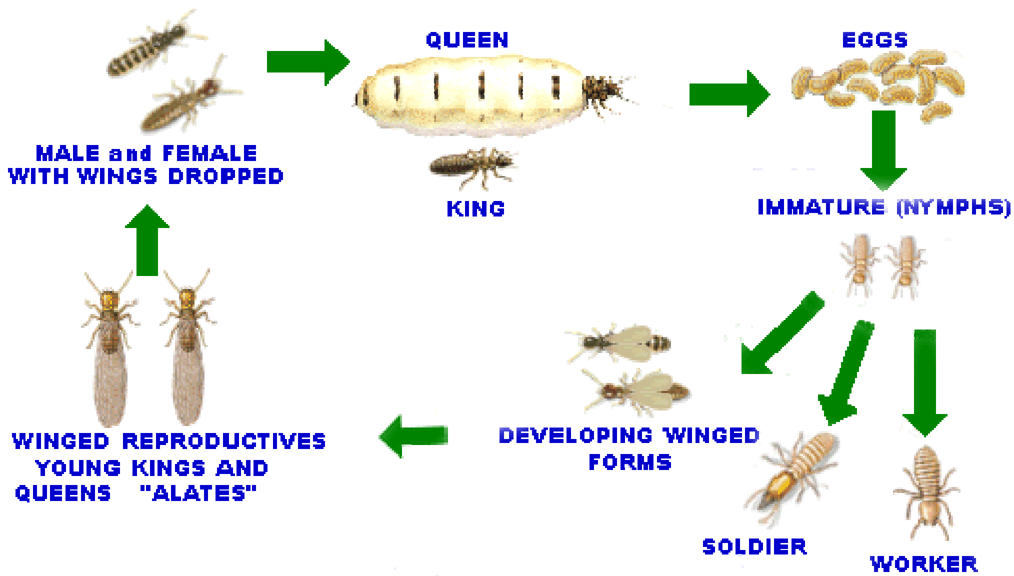
(d) Soldiers



Soldiers develop from nymphs, pseudergates, or workers. The soldiers commonly have an orange coloured armoured head with mandibulate pinchers which they use to crush an attacker, such as ants; some have hard pointed snout which eject a white sticky latex to ensnare their enemies.

Soldiers are, like workers sterile, wingless and blind males and females with an unpigmented, unsclerotized cuticle. The soldier termite is usually the first to be seen in large numbers when any active termite workings (shelter tubes or damaged timber) are opened. Soldier termites will rush out to guard the opening whilst worker termites repair the breach. They defend their colony from intruders by the use of powerful jaws and/or by ejecting a white sticky repellent from an opening on their head. Soldiers can't feed themselves, they have to be fed by workers. Usually the number of soldiers is much smaller than the number of workers. Soldiers can be mandibulate or nasute, depending on the species. Therefore soldiers can be used for the identification of termite species. The life span of the soldiers is one to two years.

**(6) Termite Life Cycle**




Termites are social insects that live in highly organized colonies. Like many insects, termites have an egg, an immature and an adult stage. There are three main types of adult colony members, or castes: reproductives, workers and soldiers. The reproductives include the king and queen, and in large colonies, supplementary reproductives that produce eggs. Workers are usually the most numerous individuals in the colony. They are small, wingless and whitish and may be found in damaged wood. Workers care for all of the other termites and forage for food (wood). The soldiers protect the colony from attackers such as ants.

When a termite colony matures, which requires from 2 to 4 years and relatively large, it may produce another form of adult termite called a "swarmer." Swarmers have four wings, are often brown or black and range in size from approximately 3/8 to ¼ inch. Swarmers are the termite's way of sending out new kings and queens to start colonies. After a termite colony matures, which requires from 2 to 4 years, swarmers are produced. Swarming usually occurs from January through April, during the daylight hours, usually after a rain. Environmental factors such as heat, light and moisture trigger the emergence of swarmers. Each species has a definite set of conditions under which it swarms. The number of swarmers produced is proportionate to the age and size of the colony.

Most termite species swarm in late summer or fall, although subterranean termites may also swarm in spring. Both male and female swarmers can fly from a single colony and travel varying distances. They are extremely weak fliers; wind currents usually carry those that travel any distance. Only a small percentage of swarmers survive to develop colonies; the majority fall prey to birds, toads, insects and other predators. Many also die from dehydration or injury.

**(6) Termite Life Cycle (Cont'd)**

A pair that survives lands and immediately seeks suitable nesting site near or in wood and constructs a small chamber, which they enter and seal. Soon afterward, the female begins egg laying. **Eggs** hatch into tiny immatures incapable of feeding called larvae. Larvae are totipotent which means that they are genetically capable of developing into any caste. The male, or king, will remains with the female because periodic mating is required for continued egg development.

Time of year, diet, and pheromones all play a role in determining which developmental pathway any given termite follows. Eggs are not deposited continuously; in fact, only a few hundred are deposited during the first year. In subsequent years, the young queen grows larger and lays more eggs. Larvae hatch from the eggs within several weeks and are cared for by the new king and queen. Both the king and queen feed the young on predigested food until they are able to feed themselves.

The larvae molt into pseudergate workers, and then into presoldiers or brachypterous nymphs. Once workers and nymphs are produced, the king and queen are fed by the workers and cease feeding on wood. The workers take over care of the young from the queen and king. Once enough workers are established, soldiers and other castes will develop from eggs produced by the queen. Termites go through incomplete metamorphosis with egg, nymph, and adult stages. Nymphs resemble adults but are smaller. Adult termites may be soldiers, workers or reproductives; only the reproductives have wings. Soldiers have greatly enlarged heads and mandibles which they use to defend their colonies. Workers, the most numerous caste in colonies of many termite species, are responsible for constructing living chambers and tunnels and foraging for food. They also groom and feed one another and other colony members. More primative termite species such as the drywood termites, which do not have a worker caste, have these functions carried out by immature soldiers. Workers of the more advanced species probably evolved from this soldier caste. Reproductives are long-lived queens and kings that are winged during their early adult life but lose their wings after dispersing from their original colony.

Two or three years after the establishment of the colony, secondary reproductives are produced. These greatly increase the egg-laying activity and population of the colony. Normally at least three to four years or more will pass before any swarming of winged termites from the colony occurs. The colony stabilizes when the queen reaches maximum egg production. If the queen dies, secondary reproductives take over the queen's duties.

**(7) Termite Life Cycle (Cont'd)**

The maximum size of a colony depends on such factors as location, food availability and environmental conditions, especially temperature and moisture. Some colonies remain small; others contain up to several thousand individuals.

New colonies form when the old colony produces swarmers or when groups of termites become isolated from the main colony and establish subcolonies. This is called colony splitting. These subcolonies may exist independently or unite with the main colony.

Termites are very attracted to odors of wood-decaying fungi that, through the decay process, make the wood easier to penetrate. In some instances, the fungi provide a source of nitrogen in the termite diet.

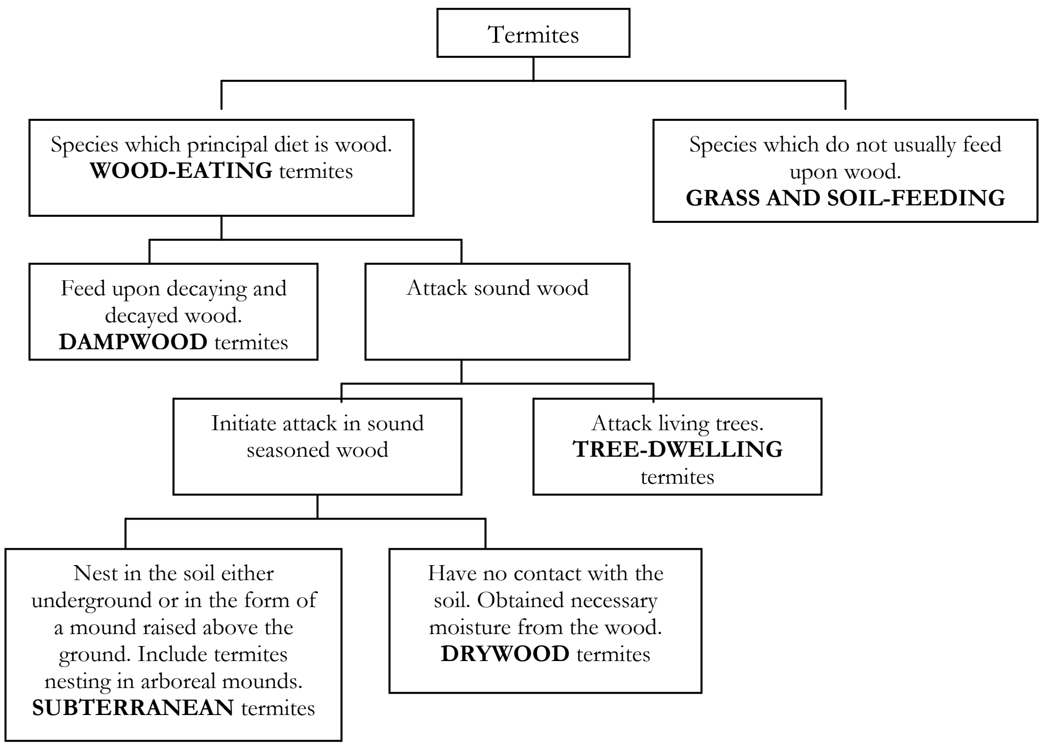
**(8) Termite Caste System**

The simplified model of a termite life cycle indicates the three castes, the reproductives, the soldiers and the workers (see the illustration on termite family above for details). Due to the fact that termites are hemimetabolous insects, even the nymphs take part in the social life and have their specific tasks to fulfill. The so far poorly understood concept of caste determination does not seem to be definitive or too rigid. Once the caste of an individual is determined, development into other castes is still possible. Soldier, also referred to as intercastes, might turn into workers or even into reproductive if there is a shortage of individuals of other castes. This process is controlled by pheromones. In the case of the queen, there is a specific 'queen' pheromone, preventing other individuals from turning into queens. Only if the queen is removed or dies, does the lack of the specific pheromone promote the development of a new queen.

## (9) Termites Classification

Correct identification of the different species of termites requires considerable skill and experience. Fortunately, such a detailed identification is seldom necessary when dealing with species of economic importance to wood-using industries. With broad limits and with the clear understanding that some species might by correctly placed in more than one class, Figure 1 is a simple classification serves to segregate the different classes or groups of species which are of economic importance and defines the characteristics of the few species which are of direct concern to the timber user.

**Figure 6:** Classification used to differentiate between groups of important species of termites




There are more than 2,500 different types of termites in the world, however, there are two basic types of termites, those that live entirely in wood, and those that can tunnel into the ground. There two groups can be classified as: dampwood & drywood (wood-inhabiting termites), subterranean (tunnel into soil) and mound builders (either both). Dampwood termites are very limited in their distribution their name is derived from the fact that they live and feed in very moist wood, especially in stumps and fallen trees on the forest floor. Drywood termites are common on most continents and can survive in very dry conditions, even in dead wood in deserts. They do not require contact with moisture or soil. Subterranean termites are very numerous in many parts of the world and live and breed in soil, sometimes many feet deep. Lastly, the mound builders are capable of building earthen towers 25 feet or more in height and may be located either in the soil or in trees. They are very noticeable and remarkable.

## (9) Termites Classification

**Figure 7:** Diagram showing different type of termites

**Subterranean Termite Swarmer** (note black body / white wings)

**Drywood Termite Swarmer** (note red body / black wings)

(a) Wood-inhabiting termites

The wood-inhabiting termites are the more primitive type. Their colonies consist of excavated galleries inside dead branches or logs. Once the dead wood is consumed the colony dies. Since single pieces of dead wood can not sustain a very large family, their colonies rarely ever number more than a few thousand termites. These wood inhabiting termites have a primitive type of caste system. Instead of having true workers they have false workers which are older nymphs who have undergone a regressive molt and that temporarily stay in the nest galleries and help their parents to raise more brothers and sisters. The soldiers have enlarged orange heads and long toothed jaws. The soldier's main purpose is to defend the colony from termite's mortal enemies, the ants. Most nymphs gradually grow wing pads and then transform into winged termites called alates. The alates fly from the colony at a certain time of the year to start new colonies.

Among the wood inhabiting termites, there are various specialists such as rotten wood termites, damp wood termites and dry wood termites. Dry wood termites can be very serious pests of houses and furniture. All wood inhabiting termites produced fecal pellets. If you have dry wood termites in your house you are likely to see the coarse sand-like pellets long before you discover the termites themselves.

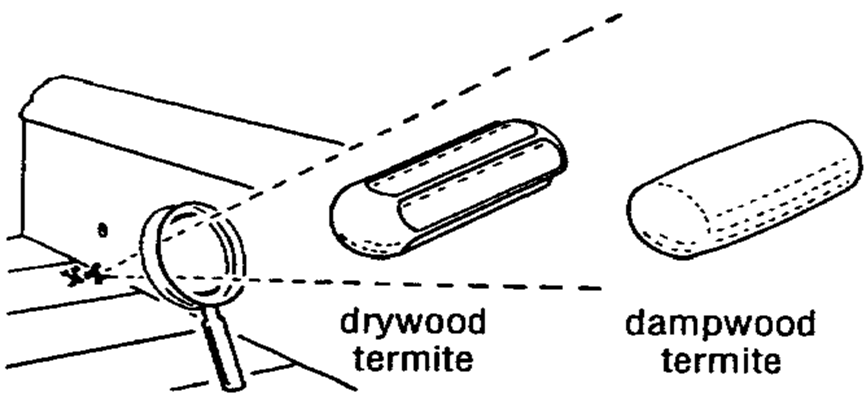



**Figure 8:** Pellet of dampwood & drywood termite

**(8) Termites Classification (Cont'd)**

(a) Wood-inhabiting termites (Cont'd)

(i) Dampwood Termites
They nest in wood buried in the ground, although contact with the ground is not necessary when infested wood is high in moisture. Because of their high moisture requirements, dampwood termites most often are found in cool, humid areas along the coast and are typical pests of beach houses. Winged reproductives typically swarm between July and October, but it is not unusual to see them at other times of the year. Dampwood termite winged reproductives (sometimes called swarmers) are attracted to lights.

**Figure 9:** Dampwod Termite

Dampwood termites produce distinctive fecal pellets that are rounded at both ends, elongate, and lack the clear longitudinal ridges common to drywood termite pellets.

Winged reproductives are dark brown with brown wings. Soldiers have a flattened brown or yellowish brown head with elongated black or dark brown mandibles. Nymphs are cream colored with a characteristic spotted abdominal pattern caused by food in their intestines. Nevada dampwood termites are slightly smaller and darker than the Pacific species; reproductives are about 3/4 inch long.

**(9) <u>Termites Classification (Cont'd)</u>**

(a) Wood-inhabiting termites (Cont'd)

(ii) Drywood Termites

Drywood termites are social insects that live in colonies in sound, dry wood. Each colony consists of offspring from an original pair (male and female). There are three growth stages – eggs, immatures and adults.

In comparison to other termites drywood colonies are rather small (a few thousand individuals), and the colony develops relatively slowly. They neither live in the ground nor maintain contact with the soil, and they do not build mud tubes.

Subterranean termites produce liquid feces, whereas drywood termites produce characteristic pellets. These pellets are eliminated from the galleries through "kick holes". Pellets tend to accumulate on surfaces located below the kick holes and are usually the first evidence of a drywood termite infestation.

Drywood termites tend to cut across wood grain destroying both the soft spring wood and the harder summer growth. Subterranean termites typically follow the grain of the wood, feeding primarily on the soft spring wood.

The reproductives are winged (alates or swarmers) or wingless males and females that produce offspring. The primary reproductives, also called swarmers or alates, vary in body color from dark brown to light yellowish tan. Their wings may be almost clear to smoke gray, and have few distinct veins in them. Swarmer drywood termites are about 7/16 inch long, including the wings. If the primary reproductives die, they are replaced by immatures that can become capable of reproductive activity. They are known as replacement or secondary reproductives.

In most drywood species there is no true worker caste (subterranean termites do have a true worker cast); this function is taken over by immatures. These immatures are wingless, white to beige in color, 1/4 to 3/8 inch long and make up the largest number of individuals within a colony. They gather food, enlarge the nest and feed and care for the queen, younger immature forms and others in the colony.

Soldiers resemble immatures in color and general appearance. However, they have large, brownish to yellowish-brown heads with enlarged, heavily sclerotized mandibles (jaws). Soldiers defend the colony against invaders, primarily ants. Soldiers are about 5/16 inch long.

**(9) Termites Classification (Cont'd)**

(a) Wood-inhabiting termites (Cont'd)

(ii) Drywood Termites (Cont'd)

After a drywood termite colony has matured (several years), winged alates (swarmers) are produced that leave the colony to establish new colonies. Swarming activity (nuptial flights) generally occurs at dusk or during the night and they tend to fly towards areas of greatest light intensity, gathering around lights or illuminated windows. However, the dark western drywood termite (Incisitermes minor) is a daytime swarmer. Swarming of Arizona species occurs in early to late summer with certain species swarming during the winter months of January and February also.

Some termite species are very regular down to the time and day of year that nuptial flights are made. Other species vary widely on the day and time. Certain environmental conditions, such as heat, light (time of day), rainfall and moisture conditions, wind, atmospheric pressure (especially rapid changes in pressure) and the electrical properties of the atmosphere (associated with thunderstorms) trigger the emergence of alates, and each species has a definite set of conditions under which swarming will occur. The number of alates produced will be proportionate to the age and size of the colony, while environmental conditions regulate the number of swarms emerging from the colony. The bulk of a colonies alates will be released in one or two synchronized swarms, then a few at a time are released throughout the rest of the season. Swarming constitutes a dispersal stage, rather than a true mating flight.

Male and female alates fly from the colony and travel varying distances. They are extremely weak flyers, but individuals can travel great distances carried by air currents during the summer monsoon season. Any alates that try to return from the outside are usually killed. Often, the soldier castes congregate around colony openings to defend the release of the alates.

Only a small number of the swarmers survive to develop colonies. The majority fall prey to birds, toads, reptiles, insects (primarily ants) and other predators. Many others die from dehydration or injury. When a pair alights, they shed or pull off their wings and immediately attempt to enter wood. Swarmers usually enter wood through cracks, natural checks, overlapping or adjoining pieces, or exposed end grain. A very small nest is developed after the pair has mated. Initially the queen lays relatively few eggs. The male, or king, remains with the female, since periodic mating is required for continued egg development.

**(9) Termites Classification (Cont'd)**

(a) Wood-inhabiting termites (Cont'd)

(ii) Drywood Termites (Cont'd)

Immatures hatch within several weeks and are cared for by the king and queen. After two molts, immatures assume the role of workers and begin to feed and care for the original pair. Eggs are not deposited continuously, and in fact, very few are deposited the first year. In subsequent years, the young queen matures and will lay more eggs. Eventually, the colony stabilizes when the queen reaches maximum egg production. At that point the colony will contain eggs, immatures, soldiers and reproductives. If the queen dies, one or more secondary reproductives take over her duties. The maximum size of a colony depends on factors such as location, food availability and environmental conditions. Most colonies remain small, but multiple colonies in the same piece of wood may contain up to 10,000 individuals. A colony grows through the queen's increased egg production and the accumulation of long-lived individuals.

Drywood termites derive their nutrition from cellulose in wood. Within the termite's gut are large numbers of bacteria and single-celled animals called protozoa. The protozoa produce enzymes that digest cellulose causing the break down of wood particles to simpler compounds that termites can absorb as food. The immatures consume wood and share their nourishment with the developing young, soldiers and reproductives.

Moisture is not as important to drywood termites as it is to subterranean termites. Drywood termites require no contact with the soil or with any other source of moisture. They extract water from the wood on which they feed, and also produce water internally during the digestive process. They require as little as 2.5 to 3 percent moisture, but prefer wood with 10 percent moisture content. Drywood termites often establish nests in roof materials and wooden wall supports accessed under eaves. However, despite being capable of surviving on low wood moisture they are also found in wood associated with a water source such as a leaky pipe or water heater. Dead wood accumulating around buildings and homes often serves as a source of infestation.

Winged adults of western drywood termites *(Incisitermes minor)* are dark brown with smoky black wings and have a reddish brown head and thorax; wing veins are black. These insects are noticeably larger than subterranean termites.

**(9) Termites Classification (Cont'd)**

(a) Wood-inhabiting termites (Cont'd)

(ii) Drywood Termites (Cont'd)

**Figure 10:** Drywood termite larvae

**Figure 11:** Drywood termite Alates

**Figure 12:** Drywood termite Soldiers

**Figure 13:** Drywood termite Immatures

(b) Subterranean termites

As their name implies, subterranean termites live in the soil and feed upon wood. Subterranean termites require moist environments. Generally speaking, subterranean termites must stay in close reach of the soil at all times, lest they die from dehydration. To satisfy this need, they usually nest in or near the soil and maintain some connection with the soil through tunnels in wood or through shelter tubes they construct. These shelter tubes are made of soil with bits of wood or even plasterboard (drywall).

Subterranean termites are ground-inhabiting. Most termites are the subterranean type and are able to tunnel in the soil. The ability to tunnel allows them to find many separate pieces of wood, on which to feed. Since they are not limited to one piece of wood, their colonies can be much bigger than those of wood-inhabiting species. Usually their colonies number from hundreds of thousands to several million.

**(9) <u>Termites Classification (Cont'd)</u>**

(b) Subterranean termites (Cont'd)

A colony or nest of subterranean termites may be up to 18-20 feet below the soil surface to protect it from extreme weather conditions. These termites travel through mud tubes to reach food sources above the soil surface. The mature termite colony has three castes: a) reproductives (king and queen), b) soldiers, and c) workers. The colony reaches its maximum size in approximately 4 to 5 years and may include 60,000 to 200,000 workers. New colonies are formed when winged males and females from a parent colony emerge in flight or swarm.

The winged reproductives are dark brown to brownish black and have two pairs of equal size wings that extend well beyond the body. Swarms are common in spring and fall, especially after a rain. After a flight, the winged males and females return to the ground and shed their wings. The wingless males and females pair off and search for sources of wood and moisture in soil. The royal couple digs a chamber in the soil near wood, enters the chamber and seals the opening. After mating, the mother of the colony starts laying eggs. The mother is usually quite grossly pregnant. These mothers are the mothers of all mothers, so to speak. Hence, they are called queens. The queen may live up to 25 years and lay more than 60,000 eggs in her lifetime. The eggs are yellowish white and hatch after an incubation of 50 to 60 days.

Full-grown workers are soft-bodied, wingless, blind and creamy white. Workers are slightly smaller than reproductives, wingless, and have a shorter head than soldiers; their color is similar to that of soldiers. In early stages, they are fed predigested food by the king and queen. Once workers are able to digest wood, they provide food for the entire colony. The workers perform all the labor in the colony such as obtaining food, feeding other caste members and immatures, excavating wood, and constructing tunnels. Workers mature within a year and live from three to five years.

## (9) Termites Classification (Cont'd)

### (b) Subterranean termites (Cont'd)

Soldiers are wingless with white bodies and pale yellow heads. Their long, narrow heads have no eyes. Soldiers of subterranean termites have a gland on the head that secretes defensive chemicals. The soldier jaws are modified in many weird and wonderful ways; they may be sword-like, serrated, toothed, hooked, rod-like, etc. Soldiers must be fed by workers because they cannot feed themselves. They are less numerous in the colony than workers and their only function is to defend the colony against invaders. Soldiers mature within a year and live up to five years. Reproductive winged forms of subterranean termites are dark brown to brownish black, with brownish gray wings. On warm, sunny days following fall or sometimes spring rains, swarms of reproductives may be seen.

Many subterranean termites have specialized diets and may eat plant litter, grass, dung or humus, instead of wood. In tropical areas many subterranean termites build nests or mounds which are among the most impressive examples of animal architecture.

**Figure 14:**
Subterranean termites - build *shelter tubing* to travel between the soil and wood that is nearby, but is not actually touching the soil. The shelter tubing provides a dark, moist environment that protects the termites from sunlight, predators, or dehydration. Termites may also build shelter tubes through the soil to avoid certain highly repellant termiticides. The presence of shelter tubing in a building is a sure sign that the structure has (or has had) a problem with termites.

**Figure 15:**
You May Find Subterranean Termite Swarmers, Soldiers and Workers. Normally, you will not find, Queens or Kings because they are hidden deep inside their colony.


In rare cases, however, subterranean termites may establish colonies in wooden structures themselves. This only happens when a damaged piece of wood is continually moist enough to satisfy the termites' water requirements.

Subterranean termites can be very serious structural pests of houses. Much of the damage they cause occurs in foundation and structural support wood. Because of the moisture requirements of subterranean termites, they are often found in wood that has wood rot.

They do not produce fecal pellets like the drywood termites. Instead, the entry of subterranean termites into a house is usually revealed by the presence of mud shelter tubes on walls.

**(9) <u>Termites Classification (Cont'd)</u>**

(b) <u>Subterranean termites</u>

**<u>Figure 16:</u>** Subterranean Termite Swarmers

Subterranean Termite Mud Shelter Tubes Emerging From Sheetrock In Walls and Ceiling.

**Figure 17:** Subterranean Termites In Ceiling

**Figure 18:** Subterranean Termites In Ceiling

Termites Entering Structure Through Plumbing Entrances

**Figure 19:** Plumbing Line In Wall

**Figure 20:** Plumbing Line In Wall

And Around Toilets, Showers, Tubs, Etc.

**Figure 21:** Plumbing Vent Stack

**Figure 22:** Shower Stall Removed

**(9) Termites Classification**

| | DRYWOOD TERMITES | SUBTERRANEAN TERMITES |
|---|---|---|
| FOOD | CELLULOSE (derived from wood and wood based products.) | CELLULOSE (derived from wood and wood based products.) |
| MOISTURE | No outside moisture needed. Can survive on a small amount of moisture within wood. | Require an outside moisture source. This may be from the soil, leaky plumbing, roof tops, etc... |
| ENVIRONMENT | Colonies live within the wood and do not require contact with the soil. | Normally live and forage in the soil. Can establish a nest above the soil if an acceptable moisture source is found. Build protective mud tubes that lead from the soil to the home. Can move colony within soil when environmental conditions require. |
| COLONY SIZE | SMALL (few hundred to a thousand termite members.) | LARGE (A well established colony may contain over 7 million termites. Some species have numerous smaller colonies of several thousand termite members.) |
| EVIDENCE OF ACTIVITY | "Sand-Like" pellets or "droppings". Kick-out holes on the walls, ceilings or wood. Infestation may take two years before evidence of droppings is present. | 1) Mud Tubes ascending from the ground to the structure or protruding from walls and/or trim.<br>2) Heavy termite swarming within the structure<br>3) Slits in the wood (flight slits)<br>4) Uncharacteristic waviness in the wood. |
| PREVENTIVE MEASURES | 1) Use treated lumber during construction.<br>2) Coat any untreated wood or exposed wood end cuts with an appropriate termiticide.<br>3) Seal all cracks and crevices with caulking. | 1) Install a termite monitoring or detection system at the home or structure.<br>2) Perform treatment to the soil before construction with an appropriate termiticide.<br>3) Eliminate conditions conducive to infestation. |
| CONTROL MEASURES | Light Activity:<br>1) locate kick-out holes<br>2) lightly puncture kick-out hole<br>3) inject appropriate insecticide in kick-out hole.<br>4) Seal kick-out hole with caulk.<br><br>Heavy Activity:<br>Tent fumigation | **Prevention through education, detection and elimination of conducive conditions are the most effective and cost efficient control measures. When activity is already present, treat the structure with a liquid termiticide. |
| DAMAGE LEVEL | Minimal*<br>* When compared to subterranean (ground) termites. Takes up to two years for evidence of activity to be present. | Some species of subterranean termites can consume 15 pounds of wood per week. |

**(10) <u>Diet</u>**

(a) <u>Drywood Termite</u>

Drywood termites infest dry, undecayed wood, including structural lumber as well as dead limbs of native trees and shade and orchard trees, utility poles, posts, and lumber in storage. They eat wood in houses, utility poles, furniture and dying trees. They can not digest the cellulose directly. They have other microorganisms (protozoans and bacteria) in their stomachs that help break down the cellulose which then can be digested by their own metabolism.

(b) <u>Subterranean termites</u>

Subterranean termites feed exclusively on wood and wood products containing cellulose. Termites have protozoa (microorganisms) in their intestines that provide enzymes to digest cellulose. Although termites are soft-bodied insects, their hard, saw-toothed jaws work like shears and are able to bite off extremely small fragments of wood, a piece at a time. Termites often infest buildings and damage lumber, wood panels, flooring, sheetrock, wallpaper, plastics, paper products and fabric made of plant fibers. The most serious damage is the loss of structural strength. Other costly losses include attacks on flooring, carpeting, art work, books, clothing, furniture and valuable papers. Subterranean termites do not attack live trees.

**(11) <u>Habitat</u>**

(a) <u>Drywood Termite</u>

Drywood termites have a low moisture requirement and can tolerate dry conditions for prolonged periods. They remain entirely above ground and do not connect their nests to the soil. They live in small social colonies in dry wood. They mate and fly to new dry wood areas; enter a small hole in the wood and start to form a colony. In the first year, colony size may be only around 50. After 4 years, there may be as many as 700 individuals in one colony. At this time, the colony may swarm to start the cycle over again. After 15 years, the colony will have grown to approximately 3,000 individuals. *They do not need a source of water and live off of the water that is produced from the digestion of the cellulose.*

They infest dry, undecayed wood, including structural lumber as well as dead limbs of native trees and shade and orchard trees, utility poles, posts, and lumber in storage.

**(11) Habitat (Cont'd)**

(b) Subterranean Termite

Subterranean termites communicate primarily by secreting chemicals called pheromones. Each colony develops its own characteristic odor. An intruder is instantly recognized and an alarm pheromone is secreted that triggers the soldiers to attack. If a worker finds a new source of food, it lays a chemical trail for others to follow. The proportion of termites in each caste within the colony is also regulated chemically. Nymphs or immatures can develop into workers, soldiers or reproductive adults depending on colony needs.

Sound is another means of communication. Soldiers and workers may bang their heads against the tunnels creating vibrations perceived by others in the colony and serving to mobilize the colony to defend itself. Mutual exchange of foods enhances recognition of colony members.

**(12) Signs of Infestation**

(a) Drywood Termites

Generally, the first indirect sign of infestation is the discovery of fecal pellets or the presence of alates on windowsills or near lights. Alates found inside the house (if windows and doors have been closed), are an indication of infestation within the structure. Another indication of infestation is the presence of discarded wings near emergence sites, on windowsills or caught up in cobwebs. The presence of alates outdoors is a natural phenomenon and is not an implication of home infestation.

Drywood termites spend their entire lives inside wood. They construct round "kick holes" in infested wood, through which the fecal pellets are eliminated from the galleries or tunnels. These pellets accumulate in small piles below the kick holes, or will be scattered if the distance between the kick hole and the surface below is very great. Fecal pellets also may be found caught in spider webs.

**Figure 23:** Drywood Termite pellets

Fecal pellets are distinctive and used for identification of drywood termite infestation. Drywood fecal pellets are hard, elongated and less than 1/25 inch long. They have rounded ends and six flattened or concavely depressed sides with ridges at angles between the six surfaces. The characteristic shape results when the termite exerts pressure on the fecal material to extract and conserve moisture in its hindgut. Typically the pellets are a light tan in color with some black ones mixed in.

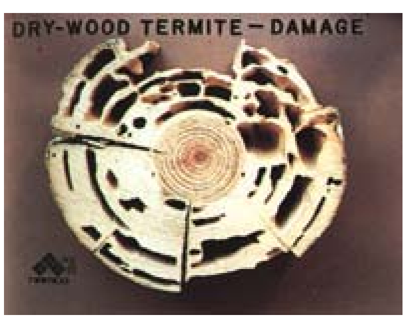



**Figure 24:** Typical drywood termite damage.
Note that the galleries are extensive and that they cut across several annual rings.

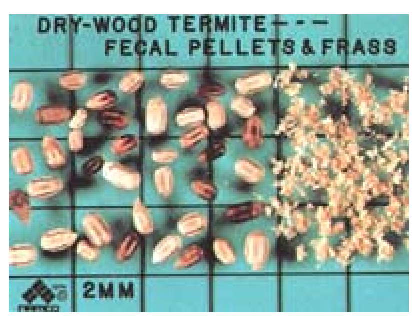



**Figure 25:** Drywood termite fecal pellets "frass".
Often these materials are pushed out of the galleries through "kickout" holes.

**(12) <u>Signs of Infestation (Cont'd)</u>**

(b) <u>Subterranean Termite</u>

Subterranean termite damage almost always is confined to the soft, springwood growth of the wood. Tunnels tend to follow the wood grain. They either are lined with the same material used to build shelter tubes, or have a pale, spotted appearance resulting from soft fecal material plastered on tunnel surfaces.

The presence of flying winged males, females or their shed wings inside the building, the presence of mud or shelter tubes extending from the ground to woodwork or on foundation walls also may indicate infestation. Workers travel periodically via shelter tubes to their nest to regain moisture and perform feeding duties. Each mud tube is approximately the diameter of a lead pencil.

Based on normal feeding activity, it takes three to eight years to cause appreciable damage. There have been some predictions that, under ideal conditions, a termite colony of 60,000 workers may consume a one-foot length of 2" x 4" pine in 118 to 157 days. In Nebraska, the extent of damage may be different because of reduced feeding activity during the cold season.

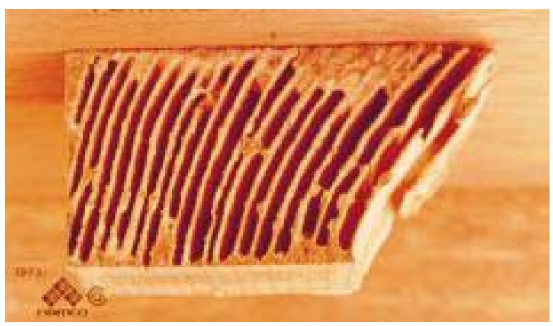


**Figure 26:** Typical wood damage by subterranean termites.

**(13) The Nature Of Termite Damage**

The general picture of termite damage to buildings is straightforward; the worker termites remove all palatable wood except the outer layers are left to provide the shelter and freedom from disturbance that are necessary for termites. There are, however, considerable differences in detail among the different groups of termites as already outlined.

(a) <u>Drywood Termite</u>

Drywood termites eat out galleries in the timber and these provide accommodation for the kind and queen, the soldiers and the various young stages of the community. The community is found in the vicinity of maximum feeding activity at any time. In course of time their galleries coalesce to form large cavities. At intervals the working nymphs make small holes to the exterior, the size of woodworm holes, through which they eject the accumulated faecal pellets. Small heaps of this ejected frass accumulated beneath infested woodwork and provide the first indications of drywood termite infestation. If these indications are ignored, the presence of the termites may continue to be to be unsuspected until such time as the structure is subject to some unusual strain such as during an earthquake, a hurricane or perhaps just a party. Since colonies of drywood termites consist of only a few hundred individuals and as they usually start from a single pair of flying adults, the rate at which the infestation builds up is slow; but given time the number of colonies will increase to the limit of the food supply.

**(13) The Nature Of Termite Damage (Cont'd)**

(b) Subterranean Termite

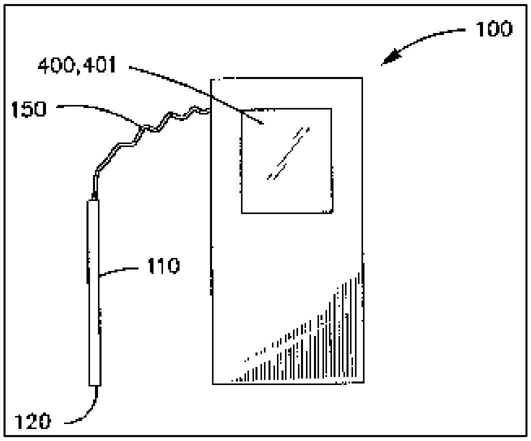
Subterranean Termites, on the other hand, have fixed nests from which the workers move out in search of food and to which they return with their spoil. Distances of thirty metres may be traveled by the small workers with their loads of wood. Communities of subterranean termites number many thousands of individuals and those which make the distinctive large mounds in the tropics are estimated to run into millions. For this reason, the rapidity and scale of their attack on new buildings is much more spectacular than that of drywood termites. Typical of subterranean termite infestation is the presence of soil or a mixture of sand and chewed wood in the excavated timber, while earthen tubes or covered ways are constructed over impenetrable foundations and walls to provide lines of communication between nest and food. When timber is in direct contact with the ground, the termites prefer to approach it from below through tunnels in the soil and so enter without any outward signs. A wall of mud bricks or of masonry with mud mortar or built with a continuous cavity, will provide a direct and unsuspected route to timber roof members. When there is some impenetrable obstacle to negotiate, the termites resort to covered ways on the outside until the timber is reached. The size and manner of construction of these covered ways is a clue to the sort if termite involved.

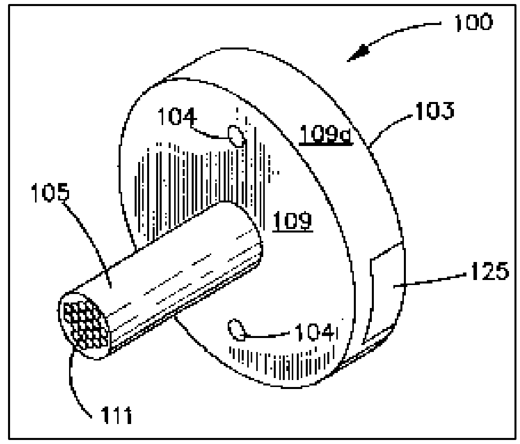
Subterranean termites belonging to the family Rhinotermitdae nest in old trees stumps, buried timber and similar situations and their work is characterized by the thin laminae of wood left behind to divide up the excavations into a series of floor and by the presence of sponge-like masses of pale coloured wood pulp in the larger galleries. The gallery walls and the inner lining of the covered ways have a pale spotted appearance, like dried oatmeal porridge. The covered ways are constructed with chewed wood and perhaps a little sand. *Coptotermes* damage in the tropics and *Reiculitermes* damage in the temperate zone is frequently diagnosed as "dry rot".

The remaining subterranean termites of the family Termitidae, including all the mound-building species and the fungus-growing termites of Africa and Asia, tend to remove wood *en masses*, filling the spaces within the remaining thin outer layer with packed earth to maintain to some degree the rigidity of the structure. Woodwork below ground or encased in masonry tends to disappear entirely. The ability of these small blind worker termites to leave only the thinnest of outer layers to hide them from observation is quite inexplicable. So is their ability to appreciate the need for some internal support, either in the form of ribs of wood left uneaten or of soil mixed with saliva to set like mortar.

**(14) Termite Detection**

(1) Electronic Termite Detection




Termites have evolved in such a way that stealth is largely on their side as a means of survival. They are commonly difficult to detect, especially in their early stages of infestation, even by a trained professional under some circumstances. And detection is absolutely paramount both for the safety of the structure, and for proper accurate delivery of control pesticides.

Technology has made inroads into new detection devices, and they have ranged from sophisticated devices such as listening apparatus to moisture meters, and even as far as trained dogs. But until now an efficient, effective, reliable and economical detection means was not available.

Inventors David Martin of Metairie, La., and Eric Tober of Alexandria, Va., have developed a new "Termite Detection Apparatus" that actually relies on the gasses termites emit for their detection.

The system comprises a sensor and associated microprocessor that detect the presence of gases emitted by termites. The processor relays a signal to an appropriate output device to alert a user that the system has detected the presence of termites. Now assigned to Relative Solutions Corporation in Metairie, La., the invention received U.S. Patent no. 6,150,944 on November 21, 2000.

Entomologists have discovered that termites, simply in the course of carrying out their biological life cycle, emit a number of specific gasses not typically found in the open atmosphere. These include naphthalene, delta-3-carene, 2,3,7-trimethyloctane, 2,6,10-trimethyldodecane, elemene, alpha-longipene, aristolene, calarene, beta-guaiene, N-(1-methylhexylidene)-methylamine, 2,6,10,14-tetramethylpentadecane, alpha-muurolene, and fenchone. The inventors have developed their detector with a sensor specifically sensitive to only this group of gasses or combinations of them.

**(14) Termite Detection (Cont'd)**

(1) Electronic Termite Detection (Cont'd)

The inventors have arranged their device in two different forms. The first style (shown above) appears to be a permanent or semi-permanent detector that is installed in a structure and fastened in place. The "wand" is inserted into the wall, and the sensor/detector is mounted on the face of the wall. This is tantamount to the pest control equivalent of a smoke detector. The second style, shown here, is a mobile unit specifically designed and intended for pest control inspectors. In this style of device the gas sensors are installed in the end of a long wand at the end of a cable. The instrument body contains the processor and the output device, which is preferably a LCD display. This allows the inspector to insert the wand and make an analysis on areas that would otherwise be inaccessible with substantial invasive surgery to the structure.

How the processor utilizes the signals from the sensor and makes a determination about the specific gasses present is actually a fairly sophisticated process within the device. The patent outlines a number of different methods that can be used. On the simplest end of the software spectrum is perhaps use of a commercial software package called Data Acquisition and Analysis ($DA_2$) Software, available from Pondscum, Inc. of North Aurora, Ill. As the patent goes on however, it starts to list other candidates incorporated into the brain of the device such as a "neural net module" incorporating "Additional methodology, available under license from Argonne National Laboratories in connection with a license of suitable sensors…" The neural net module can be trained to recognize particular gasses.

All of this high-end technology is ostensibly already incorporated into the termite detector by the manufacturer so the pest inspector doesn't have to be a computer scientist to use the equipment. Under the auspices of the patent at least, the detector can incorporate either the LCD display mentioned earlier, a computer read-out screen, simple indicators lights and/or audible signals. Standard dry-cell batteries, just like those used in any small radio, power the entire device. Admittedly there is no reason to believe that it couldn't just as well utilize a more complex rechargeable battery like the type typically used on a mobile telephone without deviating from the intent of the patent.

## (15) <u>Controlling Drywood Termites</u>

Drywood termite colonies are usually small, making it possible at times to control them by removing and replacing damaged wood. However, more than one colony may exist in a structure. Destroy damaged and infested wood promptly, preferably by burning if this is allowed. Otherwise, transport the material to a sanitary disposal site. Other control methods that may be used by pest control professionals include freezing with liquid nitrogen, electrical treatment, fumigation, or spot treatment of galleries by injecting them with insecticides. The use of heat is another means of controlling drywood termites that shows promise and may reduce or eliminate the need for insecticides. A comprehensive study on the advantages and disadvantages of each method has been completed and results will be forthcoming.

**Summary of Drywood Termite Control Options**

| Treatment | Efficacy | Considerations | Damage to Home |
|---|---|---|---|
| Fumigants* | >99% | Must vacate, expensive, extinguish pilot lights | Minor |
| Heat* | >95% | Must vacate, expensive, extinguish pilot lights, no chemicals used | Can be a problem for electronic equipment, toilets sealed using wax rings |
| Chemical treatment of wood post construction | Varies depending on chemical and application | Residual protection good but only in the specific areas treated | Some drilling may be required |
| Liquid nitrogen* | >90% | Benign material | Some drilling may be required |
| Biological control | Data required | No chemicals used | Unknown |
| Electrocution* | 10-99% | No chemicals used | More effective when more holes are drilled |
| Microwaves* | 90% | No chemicals used | Possible heat damage |
| Physical barriers | Data required | No chemicals used | Pre-construction incorporation |
| Pressure-treated wood | Data required | Long term protection | Pre-construction incorporation or can be used to replace damaged materials |

**(15) Controlling Drywood Termites (Cont'd)**

There are several alternatives for dealing with drywood termite infestations or damage, depending on the extent of the problem. This places great importance on an extremely accurate inspection of the structure.

**No Control.** Where the infestation is slight or damage is cosmetic and limited to one or two small areas, you may choose not to use any control measures. Drywood termite colonies often develop slowly; therefore, the costs incurred with some control measures may not be warranted. But if you choose not to control, be sure to maintain a monitoring program so you'll know when and if control becomes necessary.

(a) Wood Replacement
Where the infestation is limited, remove and replace damaged wood, preferably with pressure-treated wood that will protect against both termites and wood decay. Or it may be more practical to have a pest control operator apply special formulations of wood preservatives. They penetrate fairly deeply into unpainted wood surfaces, particularly cut ends and structural joints. Certain precautions are necessary to protect ceilings and painted surfaces from staining.

(b) Fumigation
If infestations are widespread or suspected in areas that cannot be inspected or replaced (such as in wood shingles, between walls or in eaves or attics), fumigation is a control alternative. First, a structure is completely enveloped in gas-proof tarpaulins or heavy plastic sheeting. Masonry construction with flat, composition shingle roofs may be sealed around the doors, windows and vents. Then a fumigant gas is released into the structure. The gas penetrates into cracks, crevices, void areas and directly into wood to kill termite colonies. Lethal concentrations are contained by the tarpaulins long enough to permit uniform penetration deep into all infested areas.

Despite its effectiveness, there are disadvantages to fumigation. It does not leave any chemical residue to deter future infestation. Fumigation is extremely hazardous and the occupants of the home may have to vacate for several days. Also, fumigation is labor intensive and requires the specialized knowledge of a licensed, professional pest control firm and can be expensive. Fumigation requires special certification because of the extreme hazard. It is imperative to remove all household pets, plants and food products from the home prior to treatment.

**(15) <u>Controlling Drywood Termites (Cont'd)</u>**

(c) Whole-Structure Treatment

Fumigants (methyl bromide and sulfuryl fluoride) treat all infestations simultaneously, and have high levels of control, usually reaching 100% if correctly applied. Major issues to be considered by pest control companies include the difficulty of installing tarpaulins, the difficulty in determining the correct dosage, the need to protectively seal food items, and the lack of residual control. People, animals and plants must vacate structures for 1 to 2 days to allow for treatment and ventilation.

Heat is a nonchemical option for whole-structure treatment. The treatment process involves heating all wood in the structure to a minimum of 124°F and holding this temperature for at least 30 minutes. The benefit of heat treatment is the ability to treat the entire structure without the use of chemicals and the relatively short period of time the structure must be vacated (several hours). An additional advantage is that portions of large structures can be treated separately, which is very useful in apartments and condominiums. The major drawback to using heat is that certain areas within a structure may be difficult to heat, such as wood on concrete (called a heat sink). Other issues to consider include the possible damage to sensitive items in homes.

(d) Localiezed or Spot Treatments

There are many localized/spot treatment methods available that include both chemical and nonchemical options. The chemical options include liquid organophosphates and pyrethroids, borate and silica gel dusts, and liquid nitrogen. For the liquid and dust insecticides to be effective, they must be touched or ingested by termites. Best results are obtained by drilling into the termite galleries and injecting products directly. Liquid nitrogen is different from the other spot treatment methods in that its mode-of-action is thermal; it causes a sudden drop in temperature, which kills the termites. Laboratory studies have shown that 5 minutes at -5°F kills drywood termites.

Microwave devices are also available for drywood termite control. Microwaves kill termites by causing fluids inside their cells to increase in temperature, which destroys the cell membranes. Advantages of microwaves include relative portability; and a nonchemical nature. When using microwaves, however, detection accuracy is critical to success. Both microwaves or heat treatments may damage the surface or interior of wood boards, depending on the power of the device. As with heat treatments, it may be difficult to heat areas with heat sinks to high enough temperatures with microwaves for effective control. Microwave devises are limited to certain areas because it may be impossible to use the device in small spaces, behind cabinets, etc.

High voltage electricity, is another nonchemical option for controlling drywood termites. The device currently marketed uses high voltage (90,000 volts), but low current (< 0.5 amps). The advantage of electrocution is that the equipment is portable. The limitations include detection accuracy and access to the entire collony. If drill holes and copper wire are used to enhance the flow of current into wood, minor damage occurs to wall coverings, walls, and structural wood members.

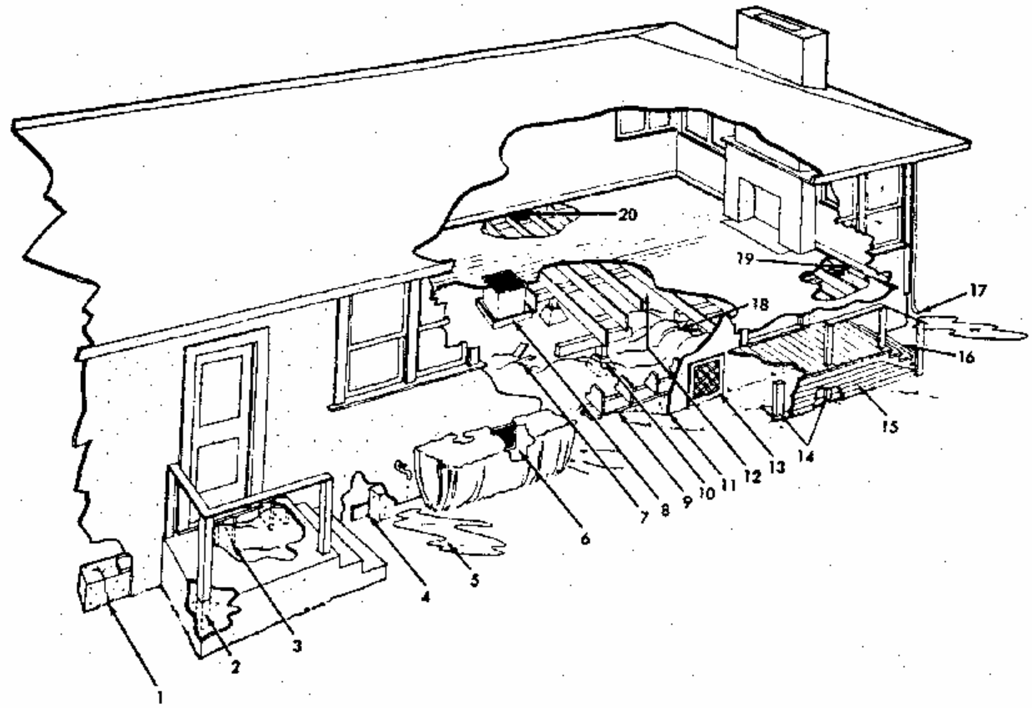
Minor damage to the structure occurs from the holes drilled for spot treatments of chemicals and for liquid nitrogen insertion. For all spot treatments, it is critical that all infestations in a structure are detected so that they all receive treatment.

**(15) Controlling Drywood Termites (Cont'd)**

(d) Localiezed or Spot Treatments (Cont'd)
Wood replacement is another remedial treatment option. However, similar to the other spot treatments, its effectiveness is highly dependent on detection accuracy and extent and location of the infestation, and it may be expensive to accomplish. Painting also affords protection. Double coats of paint increases protection and epoxy enamel paint appears to be the most effective protection against drywood termites.

## (16) Controlling Subterranean Termites

Subterranean termites cannot be properly controlled by fumigation, heat treatment, freezing, or termite electrocutor devices because the reproductives and nymphs are concentrated in nests near or below ground level in structures, out of reach of these control methods.




1. Cracks in foundation permit hidden points of entry from soil to sill.
2. Posts through concrete in contact with substructural soil. Watch door frames and intermediate supporting posts.
3. Wood-framing members in contact with earthfill under concrete slab.
4. Form boards left in place contribute to termite food supply.
5. Leaking pipes and dripping faucets sustain soil moisture. Excess irrigation has same effect.
6. Shrubbery blocking air flow through vents.
7. Debris supports termite colony until large population attacks superstructure.
8. Heating unit accelerates termite development by maintaining warmth of colony on a year-round basis.
9. Foundation wall too low permits wood to contact soil. Adding top soil often builds exterior grade up to sill level.
10. Footing too low or soil thrown against it causes wood-soil contact. There should be 8 inches of clean concrete between soil and pier block.
11. Stucco carried down over concrete foundation permits hidden entrance between stucco and foundation if bond fails.
12. Insufficient clearance for inspection also permits easy construction of termite shelter tubes from soil to wood.
13. Wood framing of crawl hole forming wood-soil contact.
14. Mud sill and/or posts in contact with soil.
15. Wood siding and skirting form soil contact. Should be a minimum of 3 inches clearance between skirting and soil.
16. Porch steps in contact with soil. Also watch for ladders and other wooden appurtenances.
17. Downspouts should carry water away from building.
18. Improper maintenance of soil piled against pier footing. Also makes careful inspection impossible.
19. Wall girder entering recess and foundation wall. Should have a 1 inch free air space on both sides and end and be protected with a moisture-impervious seal.
20. Vents placed between joists tunnel air through space without providing good substructural aeration. Vents placed in foundation wall give better air circulation.

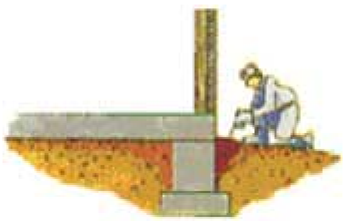
**Figure 9-4**. Typical Points of Attack by Subterranean Termites.

**(16) Controlling Subterranean Termites (Cont'd)**

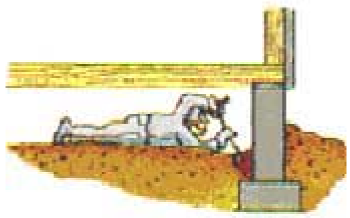
(a) Chemical barriers

The most common and considered the most effective method of treatment is the barrier system. This treatment involves placing a material barrier between the subterranean termite colony and the structure. This involves spraying and injecting pesticide into the soil around the foundation thus creating a persistent toxic barrier. Because of variations in soil texture and moisture, and restricted access it can be very difficult to achieve a uniform chemical barrier--even with extensive drilling of foundations and injection with long rods. Therefore re-treatments are often required. The pesticides use can be (i) Liquid termiticides; (ii) Repellent termiticides; and (iii) Non-Repellent Termiticides

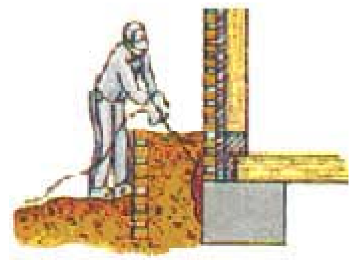
**The installation of a chemical soil barrier requires expert knowledge and specialized equipment to form a complete and continuous barrier to protect the building from a termite entry and infestation - as illustrated below:**



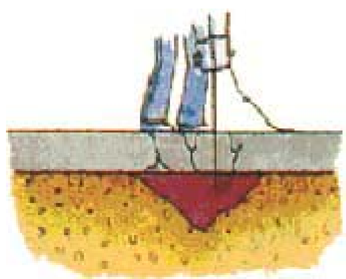
**Trench and treat soil around external concrete slab edge - a common termite entry point**



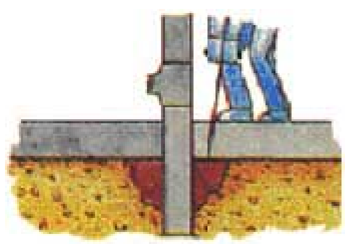
**Trench and treat soil around walls and piers in the sub-floor area**



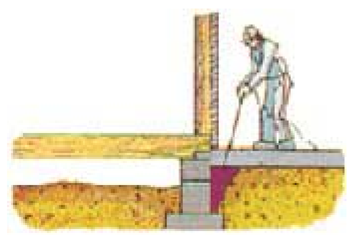
**Use rod injection to treat soil along and around the external perimeter area of the building**



**Drill concrete floor along all expansion joints and cracks, and treat soil there under**



**Drill concrete floor around pipes and treat soil there under**



**Drill concrete patio areas and treat soil area therein - a high risk termite nest location**

**(16) Controlling Subterranean Termites (Cont'd)**

(a) Chemical barrier (Cont'd)

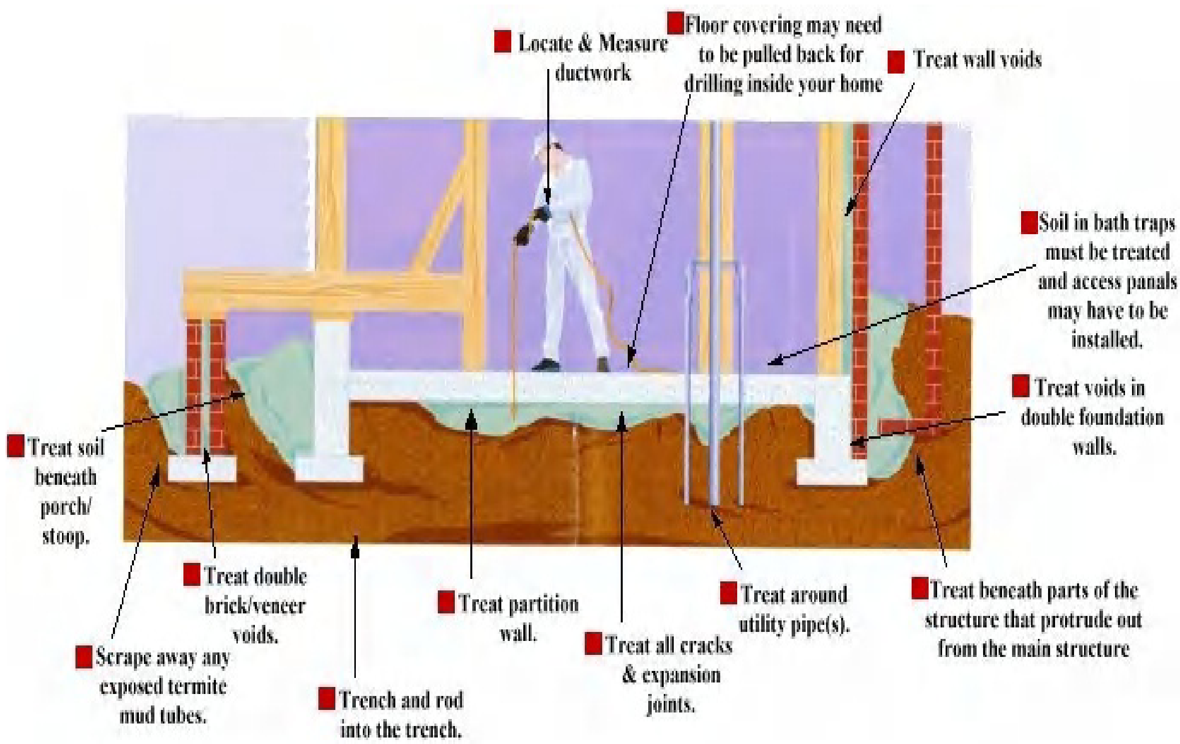



**Figure 27:** Typical Subterranean Termite Treatment

**(16) Controlling Subterranean Termites (Cont'd)**

(a) Chemical barriers (Cont'd)

(i) Liquid termiticides

Liquid termiticides are usually applied completely around and underneath a structure covering all areas where termites might gain access. For new construction, this is accomplished by treating the graded soil before the slab is poured. For an existing building, the perimeter of the foundation is trenched and drilled then treated with termiticide. The goal of the treatment is to put a chemical barrier between the termites in the soil and the structure above. The chemical barrier can also affect those termites inside a building by preventing their return to the soil. In many cases these termites will die of dehydration.

On a raised foundation this involves treating both sides of the foundation wall and at each pier post. Where a slab abuts the structure we drill and inject termiticide into the soil below. Any termites left in the structure will have to go back to the soil.

(ii) Repellent Termiticides

There are several repellent termiticides on the market. These termiticides are all pyrethroids. Pyrethroids are fast acting nerve poisons that are highly toxic to termites but have low toxicity to mammals. Some of the pyrethoid termite products include Dragnet FT, Cynoff, and Talstar (FMC Corporation, Philadelphia, PA) and Demon and Prelude (Syngenta, Inc., Greensboro, NC). The pyrethroids are also highly repellent to termites. In most cases, they are so repellent that termites foraging under the soil will avoid coming into contact with the termiticide and forage elsewhere.

There are advantages and disadvantages to repellent termiticides. One advantage is that a complete barrier will effectively keep termites from coming into the structure. Also, the pyrethroids used for these barriers are relatively inexpensive and last for several years. The disadvantage is that termites are able to detect these termiticide barriers in the soil and avoid lethal contact with them. This is important because applying a perfect barrier under a fully constructed house is very difficult. Construction features, plumbing lines, and landscaping are just a few of the obstacles that hinder liquid termiticide application. Because of these difficulties, there are often gaps in the treatment where the termiticide was not applied completely. Eventually, foraging termites may locate these gaps and gain access into the structure. If these termites find the structural wood, they will tunnel back through the untreated gap and recruit other termites into the building.

(i) Non-Repellent Termiticides

The non-repellent termiticide treatments available on the commercial market are nerve poisons like the pyrethroids, but they attack different sites on the nerve. These chemicals are not repellant and termites cannot detect them in the soil. Therefore, the termites tunnel into the termiticide while foraging, contact the chemical, and die.

Premise (Bayer Corporation, Kansas City, MO.) contains the active ingredient imidocloprid. Imidocloprid is unique because it not only kills termites that contact a lethal dose, but it also kills them at doses too small to cause immediate death.

## (16) <u>Controlling Subterranean Termites (Cont'd)</u>

(a) <u>Chemical barriers (Cont'd)</u>

(i) Non-Repellent Termiticides

If a termite contacts even a very small amount of imidocloprid it will become lethargic and forget to eat and feed other termites. It will also forget to groom itself so it soon becomes infested with soil fungi. The termite eventually dies as a result of these indirect symptoms of imidocloprid exposure. A disadvantage to Premise is that it is somewhat more expensive than the pyrethroid termiticides and in some cases may not last as long in the soil.

**Figure 28:** Illustration of the Premise Transfer Effect

Termidor (See appendix 2.0 on how its works) is the newest termiticide on the market. Termidor became available in February 2000 for use as a non-repellent termiticide. The active ingredient is fipronil. Fipronil is unique in that it can be transferred from one termite to another through contact and trophallaxis (communal feeding). This allows it to affect more termites than those that contact the chemical directly. The advantage of this product is its long-term effectiveness in the soil. Test data indicate that fipronil may be effective longer after the initial application than other liquid termiticide products. A disadvantage is that Termidor is more expensive than other liquid termiticides.

These Termiticides has the following advantages and disadvantages.

Advantages

- Intended to provide immediate protection for the structure
- Relatively inexpensive compared to baiting systems
- Lasts multiple years in the soil
- Non-repellent termiticides eliminate the problem of termites locating "gaps" in the treatment

Disadvantages

- Even the most conscientious pest control operator will have difficulty putting down a chemical barrier that is free of "gaps." Gaps in termiticide applications may later provide access to termites.

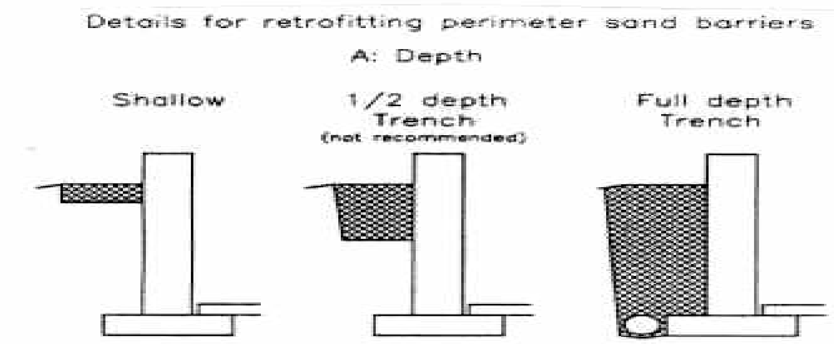
Liquid termiticides applied within 50 feet of a body of water, well or cistern is a water contamination risk. However, it is not illegal to use liquid termiticide near these areas. A treatment method where the soil around a structure is removed, treated, dried and replaced is frequently used where water contamination is a concern. However, this treatment method does not eliminate the risk of the chemical leaching into a water source over time. In areas of potential water contamination, termite baiting is a better option.

**(16) Controlling Subterranean Termites (Cont'd)**

(b) Physical barriers

The four main types of physical barriers are termite shields, termite barrier sands, stainless steel mesh barriers, and waterproof membrane barriers. Termite shields have been in use in some parts of the world for decades but the other physical barrier methods have only recently become a focus of research and commercial development. A termite shield is simply a sheet of non-corroding metal with a projecting 1" lip bent down at a 45 degree angle capping the foundation wall or concrete support piers. Sand barriers consist of sand mixtures in which a majority of the grain sizes are within the range of 1.4 to 2.4 mm with no more than 30 % fines (preferably less than 5% below 1.4 mm) and no more than 50% in the range of 2.4 to 6.3 mm.

(i) Perimeter Sand Barriers

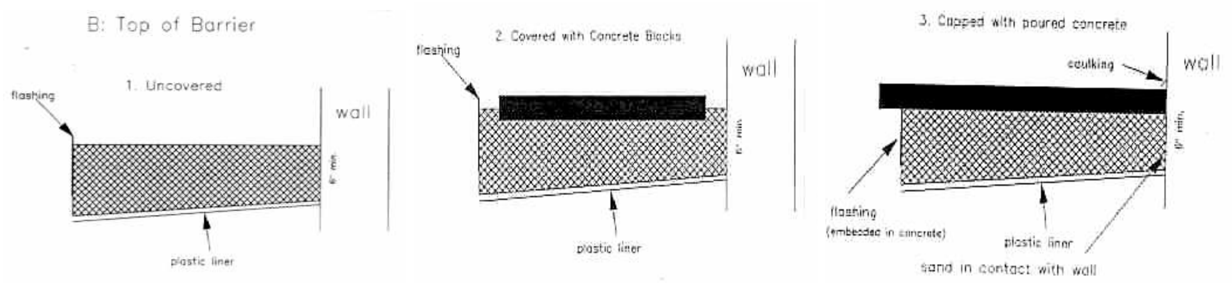



Sand barriers are most easily installed and most effective when put in as a preventive "pretreatment" during construction. In Hawaii and Australia a 6 inch layer of barrier sand is used in place of crushed stone as a bedding material beneath the slab. However, the barrier sand can not be placed beneath the footing since the footing must rest on solid undisturbed ground. The barrier sand could be used as backfill adjacent to the foundation walls provided that adequate consideration is given to surface drainage. The overhang of eaves, drainage from downspouts, the contour of the surrounding grade, and landscape watering practices should all be taken into consideration to ensure minimal drainage of surface water into full depth trenches. During backfill the barrier should be compacted at intervals of every two feet to prevent settlement later. Care must be taken that compaction does not cause cracking of the wall. A further consideration is the effect which the porous sand barrier might have on heat loss from the basement wall.

Unfortunately, termite control efforts are usually not undertaken until after the house is constructed and has become infested. In this case retro-fitting is needed. Retro-fitted barriers can be installed either in a shallow perimeter layer or in a full depth perimeter trench which connects to the weeping tile system. However, sand barriers should not be installed as half-depth trenches because the porous barrier sand will act as a vertical drain which, if not connected to the drainage system, could lead to water perching against the basement wall and leakage problems. The top of the perimeter sand barrier can either be left uncovered or, in places where people are likely to be walking, it can be covered with flat stones, bricks, blocks, or poured concrete to form a walkway (see figure below).

**(16) Controlling Subterranean Termites (Cont'd)**

(b) Physical barriers (Cont'd)




1. Uncovered 2. Covered with concrete blocks 3. Capped with poured concrete

(ii) Mesh Barriers And Waterproofing Membranes
A commercial stainless steel mesh barrier has been developed by an Australian company, Termi-Mesh Ltd. Termi-Mesh is approximately a 35 mesh material (pores sizes about 0.5 mm). Accelerated corrosion experiments and field trials in Australia indicate that it should be effective for over 50 years.

Recent tests in our laboratory indicate that rubberized asphalt membranes and other bituminous membranes commonly used for waterproofing exterior basement foundation walls are also impenetrable to termites and could therefore be effective termite barriers if properly installed or retro-fitted. Two basic types of waterproofing membranes are available, the adhesive peel and stick type (often used for roofing) and the trowel-applied rubberized asphalt type. The adhesive type might be more convenient to apply, especially for limited application to identified cracks. The trowel-applied rubberized asphalt however would probably give a superior seal due to its monolithic nature and firmer bonding to concrete surfaces.

(iii) Blocking Points Of Entry From Interior
There are various ways of repairing cracked foundations. These include filling voids, resurfacing cracked surfaces, grouting or injecting cracks with various materials. When hollow concrete block foundation walls become cracked termites can explore throughout the interconnected hollow void space. Although such walls are normally capped with mortar, it is not uncommon for there to be many small gaps in the capping mortar which the termites may eventually find. To physically block such termite entry points the foundation walls can be drilled and the voids filled with a 3 to 1 sand to cement mixture or with cement grout. With solid poured concrete walls cracks can be repaired by injection of various patching compounds. Epoxy injection involves the mixture of two components which form a quick-drying, strong-bonding seal.

Polyurethane is used in place of epoxy in wet cracks and reacts with water, foaming to fill the crack. The bonding of polyurethane may not be as strong as the epoxy. Injectable rubberized crack patching compounds are also newly available. Various joint sealant, polysulfides, polyurethane, silicon, and self-bonding cement mixes are available that can be used to patch cracks. Cracks should be chiselled out to a 1/2" depth and 3/4" width before patching. Injectable bonding materials have some elasticity to resist re-cracking whereas the cement mixes are likely to re-crack if soil heaving or settlement is causing ongoing foundation movement.

**(16) <u>Controlling Subterranean Termites (Cont'd)</u>**

(c) <u>Subterranean Termite Baits</u>

Termite baiting takes a very different approach to subterranean termite control than liquid termiticide application. Instead of attempting to protect a structure by creating a barrier between it and the termites, baiting targets the termites themselves. Termite baits are designed to suppress or eliminate the termite colony living in the soil.

Commercial termite bait systems are a relatively new technology. The most widely used bait products are applied very similarly. The initial installation of any baiting system involves plastic stations being inserted into the ground around the periphery of the structure approximately every 10 feet. Inside these stations are untreated wood monitors. The stations are usually inspected every month for termite activity. If live termites are found in the station, a toxic bait will be placed inside and the infested monitor may or may not be removed. The idea is to get the termites that have been recruited to the wood monitor to now pick up the bait instead. Certain bait products are intended to be used by themselves, while others can be used in combination with a spot application of liquid termiticide (applied only to areas where termites are active) or a complete liquid treatment.

Because the in-ground bait stations are placed outside the structure, they do not directly affect termites that are already foraging inside. To address these inside infestations certain manufacturers provide above ground stations. Above ground stations are basically plastic boxes that contain a paper matrix (bait) laced with the active ingredient (toxicant). The boxes can be attached over a termite mud tube or directly onto infested wood. The termites forage inside the box and consume the paper bait.

The following is a description of the most widely used baiting systems available on the commercial market.

Sentricon System - The Sentricon system was the first termite baiting system commercially available. It is now the most widely used bait system within the United States and internationally. It was developed in 1990 by Dow AgroSciences (Indianapolis, IN) and the University of Florida. Sentricon is a stand-alone system and is not intended for use in combination with liquid termiticide.

The bait system consists of in-ground stations that contain 2 pieces of untreated wood ("monitors"). The stations are checked on a monthly schedule to see if termites have invaded or "hit" the monitors. If so, the termites are collected from the monitors and placed inside a tube of bait. The bait then replaces the monitors in the station and the termites must then eat their way out of the bait tube.

Sentricon System

**(16) <u>Controlling Subterranean Termites (Cont'd)</u>**

(c) <u>Subterranean Termite Baits (Cont'd)</u>

**Figure 29:** Another method of post treatment control is baits. Baits include Sentricon, FirstLine, and Exterra. Bait stations are spaced anywhere from 12" to 2' apart, depending on the material. Bait stations are environmentally friendly because very little chemical is needed. However, it is sometimes a slow process because termites must find the bait station for this treatment to be effective.

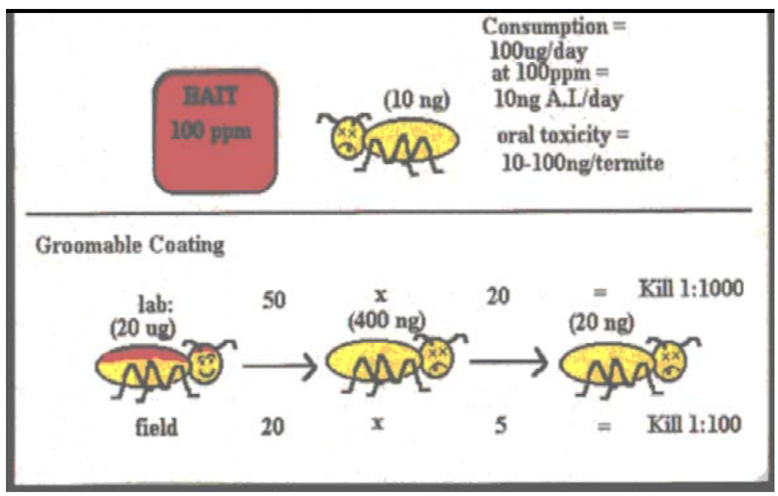



**Figure 30:** Transmission of baits versus grooming coatings

**(16) Controlling Subterranean Termites (Cont'd)**

(c) Subterranean Termite Baits (Cont'd)

The Sentricon system is marketed as a termite colony elimination system. In order for a colony elimination system to work, the bait must affect every termite in the colony. Worker termites do all of the foraging, so how does the bait get from the worker termites to the rest of the colony? Remember that the worker termites are responsible for feeding all of their nestmates. They do this by consuming food themselves then regurgitating part of it into the mouths of the other colony members. This same natural behavior is exploited by the Sentricon system to disperse the bait toxicant throughout the termite nest. It is important to note that the bait cannot work too fast. If the active ingredient killed the termites too rapidly, the worker termites would die before they could pass the bait to other colony members.

The active ingredient in the Sentricon bait is hexaflumuron, a slow acting toxicant. Hexaflumuron is an insect growth regulator (IGR). IGRs interfere with the insect's physical development. This particular IGR interferes with the insect's ability to molt. Insects have their skeleton on the outside of their bodies, an exoskeleton. In order to grow larger they must periodically shed this exoskeleton in a process called molting. Hexaflumuron does not allow the termite to molt properly so it dies in the process. When hexaflumuron is passed from one termite to another the affected termites die during their next molt. In time, there are too few termites left to take care of the colony and feed the queen. When the queen dies the colony is eliminated.

The Sentricon system also supplies above ground stations that the pest control operator (PCO) can place directly on termite mud tubes or infested wood. Hexaflumuron is the active ingredient in the above ground stations as well.

Exterra System - This system was developed by Ensystex (Fayetteville, NC) and can be used either as a stand-alone bait or in combination with a liquid termiticide. The Exterra bait station is lined with strips of untreated wood, called "interceptors". The center of the station is left empty until termites hit the station. When the station is hit, bait is placed in the center of the station but the interceptors are left in place so that termite feeding is not disturbed.

The Exterra stations are larger than other commercial bait products so the inspection interval for the large stations can be as long as 90 days. The longer interval between inspections makes the Exterra system less expensive to maintain than Sentricon. However, it may be possible for termites to completely consume the interceptors and abandon the station before the hit is discovered and baited. Baited stations with termite activity are usually checked at one month intervals.

The active ingredient in the Exterra bait is diflubenzuron (dimilin). Like hexaflumuron, diflubenzuron is a slow acting insect growth regulator that is passed from termite to termite by trophallaxis. Diflubenzuron also interferes with termite development killing them during the molting process. Thus like Sentricon, Exterra is a colony elimination system. As of this writing, Ensystex does not offer above ground bait stations.

FirstLine System - (FMC Corporation, Philadelphia, PA) The FirstLine bait system was developed for use in combination with spot treatments of liquid termiticide. The bait system resembles the Sentricon system in that the stations are inspected monthly and the untreated wood monitors inside the stations are replaced with bait if there is a termite hit.

## (16) Controlling Subterranean Termites (Cont'd)

(c) Subterranean Termite Baits (Cont'd)

The active ingredient in the FirstLine system is sulfluramid. Sulfluramid is a stomach toxicant that interferes with the termite's ability to produce energy. Sulfluramid is faster acting than either hexaflumuron or diflubenzuron. However, in the FirstLine system the concentration of sulfluramid is so low that exposed termites survive for approximately 3 weeks. This allows them enough time to pass the toxicant to other members of the colony. However, the FirstLine system does not eliminate termite colonies but is a colony suppression system only. Therefore, remediation of an active infestation comes from the combined treatment of baiting the termite colony and applying liquid termiticide at the site of infestation. FMC also provides above ground bait stations as part of the FirstLine system.

Terminate - Terminate is a consumer termite bait product that is available at hardware and home stores. It is manufactured by United Industries Corp. (St. Louis, MO) and is a stand-alone system. Monitoring is not part of the Terminate baiting process. The active bait is inside of the stations at the time of purchase. The bait instructions direct the homeowner to place the stations in the soil near infested locations within the structure and in areas that retain moisture. Like the FirstLine system, the active ingredient in the Terminate is sulfluramid. Terminate is intended to suppress termite activity in a localized area. Although the Terminate product does kill termites, as of this writing, there is no research documenting that Terminate can prevent or eliminate subterranean termite infestation.

Termite baiting system has the following advantages and disadvantages.

**Advantages**

- Baits are very environmentally friendly because there is considerably less active ingredient put into the environment compared to the hundreds of gallons of diluted insecticide used in liquid treatments.
- Termite baits are ideal for use around structures inhabited by persons with chemical sensitivity.
- In situations where the infested structure is within 50 feet of a well or 100 feet of a body of water, termite baits may be the only treatment option.

**Disadvantages**

- There are no means of coaxing termites into stations that are being monitored so it may take months before baiting can begin.
- Professional baiting systems are generally more expensive than barrier treatments because of the monthly inspections.

Termite baiting systems when used alone do not protect the structure directly. Termites feeding within the structure will continue to do so until the colony is eliminated or they are controlled with an above ground station.

**(16) Controlling Subterranean Termites (Cont'd)**

(d) Dusting – Corrective treatment (Cont'd)

Termites may be aggregated and dusted using a small bulb duster.. Arsenic trioxide is commonly used as a "termite dust". The white arsenic dust is finely ground and is extended with a material such as ferric hydroxide to improve its flow. Treater aims to get relatively large quantity of air to carry a small amount of dust into convenient locations in one or more tubes. Brown paper is frequently used to reseal holes made for treatment. If used correctly, 1-2g of arsenic trioxide is sufficient to eradicate a colony of termites in 10-20 days. Arsenic trioxide is highly toxic to humans, therefore for the method to be effective and safe, operator skill is required in judging both the quantities and placement of dust and in handling the toxin and the termites.

**(17) <u>Subterranean Termite Treatment Cheat Sheet</u>**

| Control Method | Repellent Liquid Termiticide | Non-repellent Liquid Termiticide | Bait Systems |
|---|---|---|---|
| How it is supposed to control Subterranean Termites | The termiticide is injected into the soil around the foundation of the home. The slab is drilled and the soil treated underneath. Trenches are dug around the foundation outside and within crawl spaces and filled with termiticide. The termiticide repels the termites and ideally turns them away from the structure. | The structure is drilled, trenched and injected as with the repellent liquid, but the termiticide is not repellent to the termites. The termites cannot detect the non-repellent termiticide in the soil so they tunnel into it and are killed. | Wood monitoring stakes are inside stations that are placed in the ground around the structure. Monitors are inspected monthly or quarterly. If termites are found inside a station, the bait is put in. Termites consume the bait and are killed. Sentricon and Exterra baits are designed to kill the termite colony. |
| Termiticide Products used by Certified Pest Control Operators | Tribute, Demon TC, Dragnet, Prelude, Prevail, Talstar and Torpedo | Premise<br>Termidor (NEW 2000) | Sentricon<br>Exterra<br>FirstLine (used in combination with liquid treatment) |
| Relative costs | Usually the least expensive of the 3 treatments. Preparing for the injection of the liquid is labor intensive and the greatest source of the cost. Many gallons of termiticide are used in the treatment (~ 4 gallons /10 linear feet). | Can be more expensive than the repellent treatment because the termiticide is more costly. The application is the same as the repellent treatment so labor costs are equivalent. | Sentricon is the most expensive treatment. The station installation and monthly monitoring are responsible for most of the cost. Other bait products vary, but are usually priced between barrier treatments and Sentricon. |
| Treatment longevity | Under optimal conditions repellent termiticides can last ~ 5 years | Premise < 5 years<br>Termidor 5+ years | Continuous process of monitoring with baits applied as necessary. |
| Advantages | Provides immediate protection for the structure. Relatively low cost and long lasting. | Provides immediate protection for the structure. Most effective treatment because it kills foraging termites. | Environmentally friendly, extremely low toxicity to humans and pets. |
| Disadvantages | Termites are not killed, just turned away from the chemical. They often find tiny gaps in the treatment and tunnel through them to the structure. | Premise breaks down in water so it may dissipate more quickly in the soil than some repellent termiticides. | Structure not directly protected. With no means of attracting termites into the monitors, actual baiting may take a long time to begin. This leaves the structure at risk. |

**(18) Case Study**

Telok Kurau Secondary School

This is a 20+ year old school located at Chin Cheng Avenue. In the recent years, the school experiences termite attack at several locations at their science block. Inspection by specialist pest control operator showed that the infestation concentrated mainly at the science block. The other blocks within the school do not experience infestation like the science block. The infestation could probably due to the serious differential settlement at their science block. This settlement could have "breaks" the chemical barrier between the building structure & the soil, resulting in the failure and the attack by subterranean termites.

Experience pest control operators are invited to the school to propose & cost for the possible termite control methods. 4 pest control operators were called in to quote for the works. All 4 operators proposed soil treatment method, with each of them proposing the use of different chemicals. The lowest quote was selected for its competitive price and the chemical used for the soil treatment is **Premise**.

Following are the photos showing the works conducted.



Holes of size of 10mm wide at the distance of 1500mm away from each other are drilled around the perimeter of the school. Depth of holes differs, but all must be drilled through the concrete slab and reach the soil.
External = apron slab; internal = corridor and partition of individual rooms

Diluting of chemical – Colour of chemical is transparent and when mixed when water, turned whitish in colour.

**(18)Case Study (Cont'd)**

Telok Kurau Secondary School (Cont'd)

Pump used for the injection of chemical into pre-drilled holes.

Corridor of the science block

Chemical injection into the apron ground (soil) through the pre-drilled holes.

**(18)Case Study (Cont'd)**

Telok Kurau Secondary School (Cont'd)



Sealing of the pre-drilled holes after injection of the chemical.




Senticon tubes are also installed at the turf area infront of the science la to monitor the success of the chemical barrier treatment & the present of anymore termite.



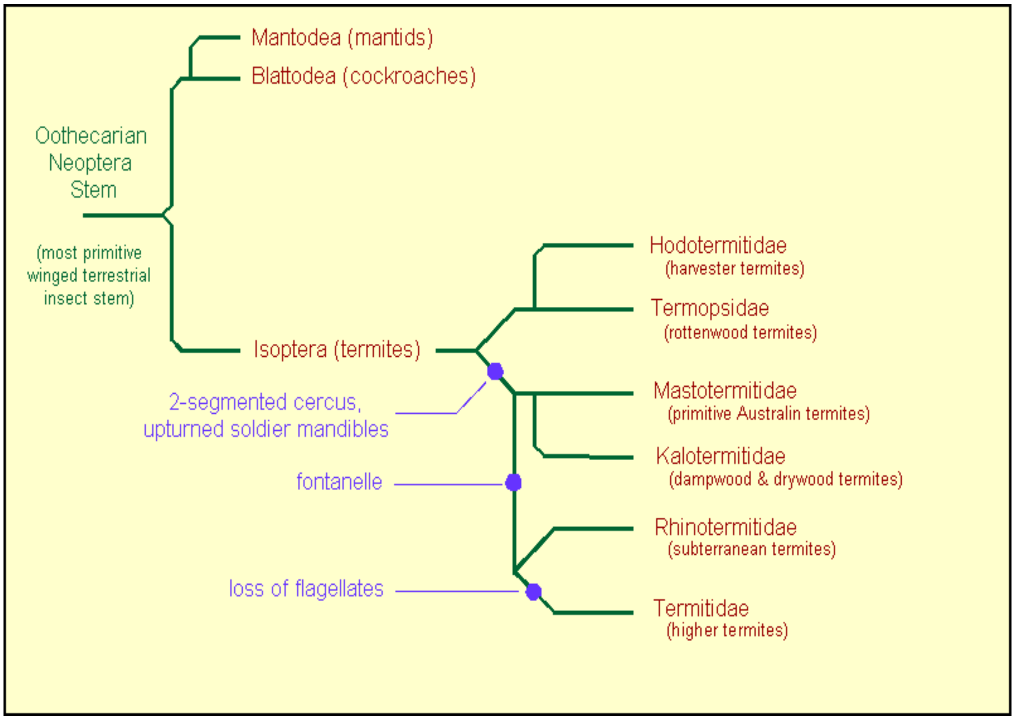
Used of timber food source to lure any termites that still present. Upon detection of termite trace (through the look of the timber food source inserted in the senticon tubes), treated timber will be replaced into the tubes to kill the remaining termites.

**(19) Conclusion**

The principles of termite control have undergone few significant changes in several decades. The time may be ripe, however, for new developments. New techniques such as use of insect diseases, sterilants and attractants as well as new chemicals are being utilized against pests of agricultural and public health importance. These or other methods and materials may be adaptable to termite control. The exploding human population will create a demand for an unprecedented quantity of housing and in many parts of the world the quality of housing will create a demand for improved and expanded termite control.

Regardless of the refinement of present techniques or the sophistication of new principles of termite control, their efficient use requires a sound understanding of the biology of termites.

# Isopteran Phylogenetic Tree




**Termites (Isoptera) of the World**
A list of valid termite species
(updated to Zoological Record, Vol 132 1995/1996)

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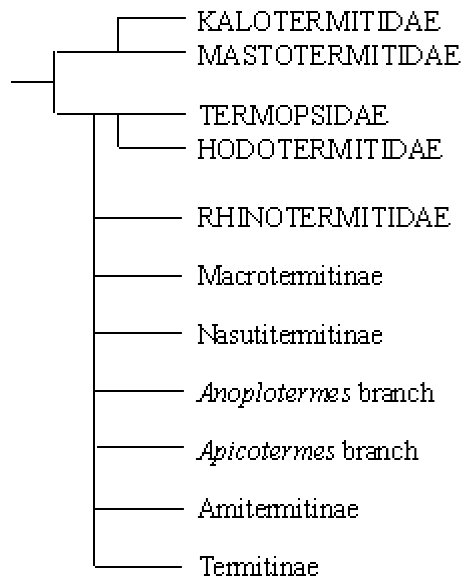
| **Family / Subfamily** | **# Genera** | **# Species** |
|---|---|---|
| Termopsidae | 5 | 20 |
| Hodotermitidae | 3 | 19 |
| Mastotermitidae | 1 | 1 |
| Kalotermitidae | 22 | 419 |
| Rhinotermitidae | 14 | 343 |
| Serritermitidae | 1 | 1 |
| Termitidae | | |
| Macrotermitinae | 14 | 349 |
| Nasutitermitinae | 91 | 663 |
| Amitermitinae | 17 | 295 |
| Apicotermitinae | 43 | 202 |
| Cubitermitinae | 28 | 161 |
| Termitinae | 43 | 288 |
| **Totals** | **282** | **2,761** |

Appendix 1.0

Termite Phylogeny

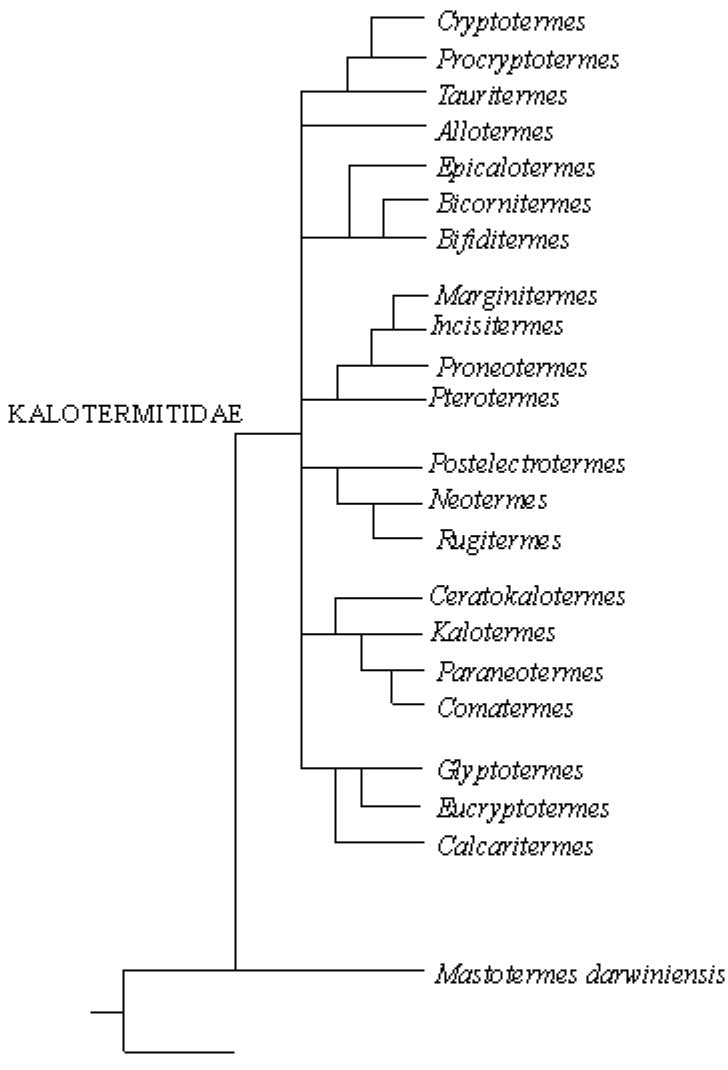
ISOPTERA



Appendix 1.0

Termite Phylogeny

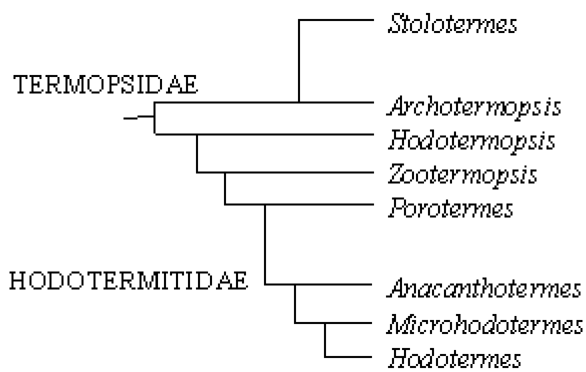
KALOTERMITIDAE & MASTOTERMITIDAE



Appendix 1.0

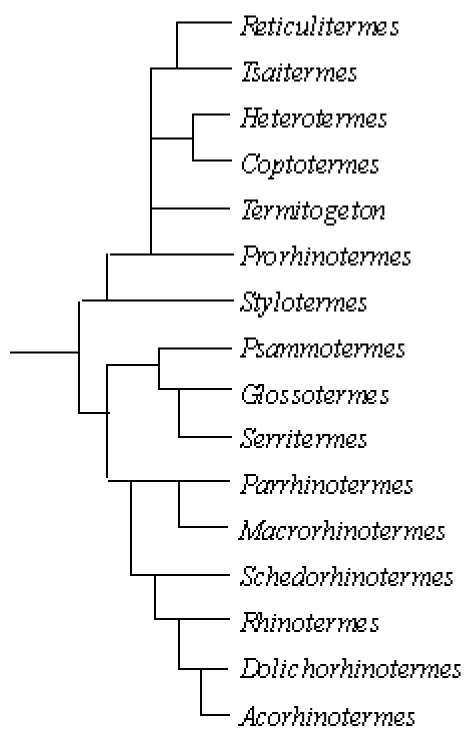
Termite Phylogeny

TERMOPSIDAE & HODOTERMITIDAE




Termite Phylogeny

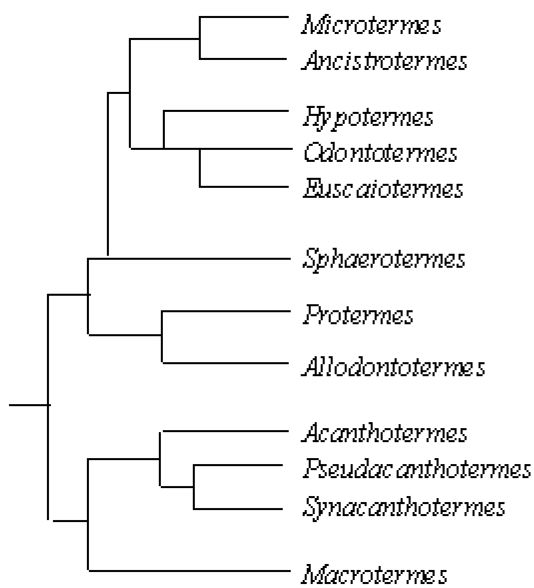
RHINOTERMITIDAE



Appendix 1.0

Termite Phylogeny

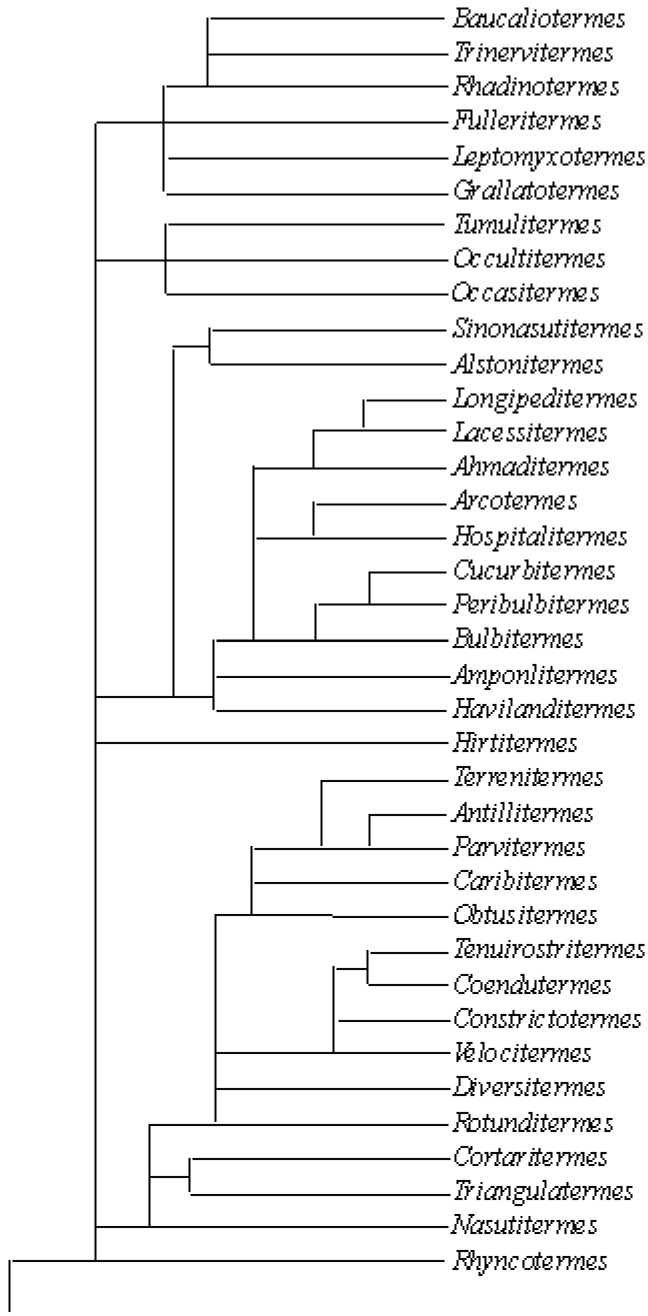
MACROTERMITINAE



Appendix 1.0

Termite Phylogeny

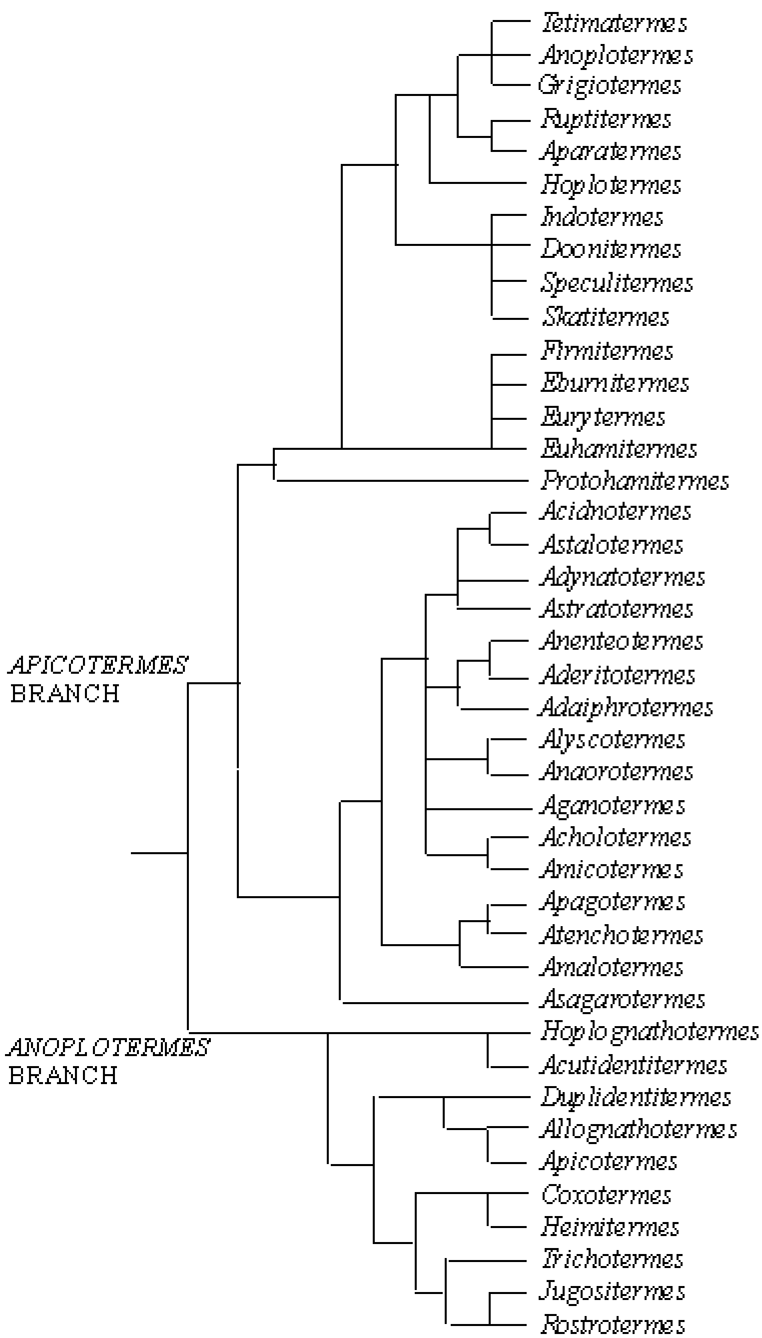
NASUTITERMITINAE



Appendix 1.0

Termite Phylogeny

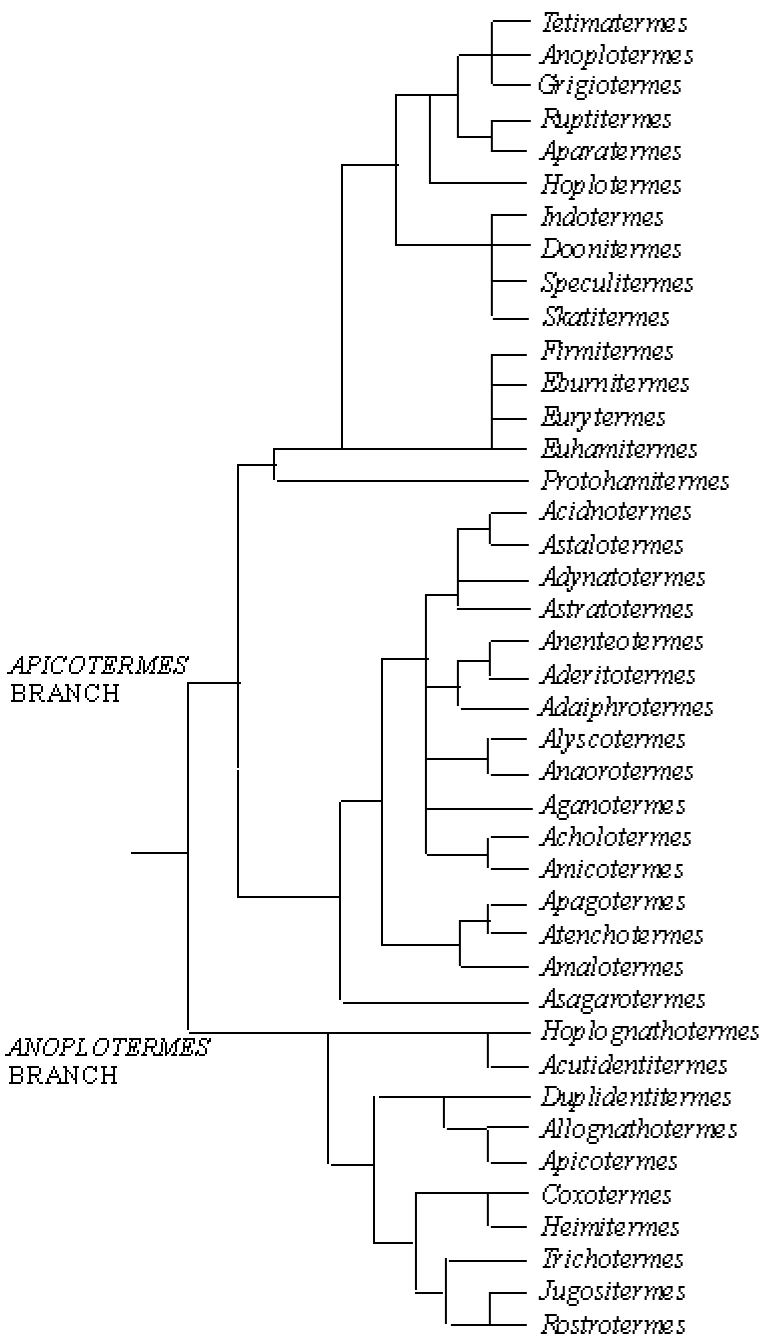
APICOTERMITINAE



Appendix 1.0

Termite Phylogeny

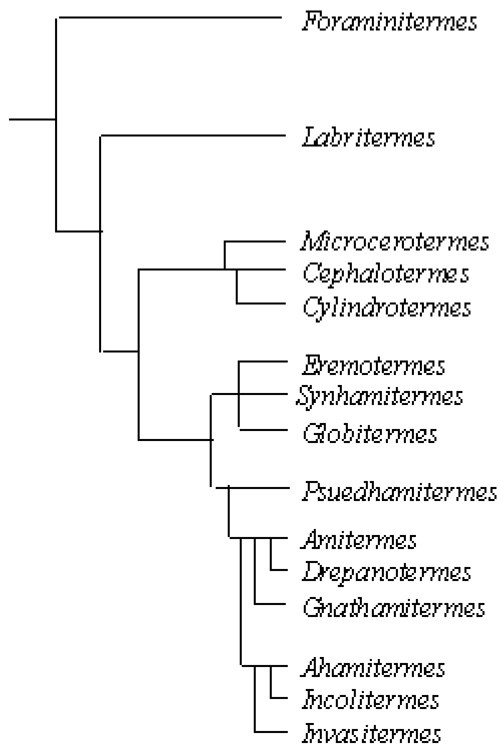
APICOTERMITINAE



Appendix 1.0

Termite Phylogeny

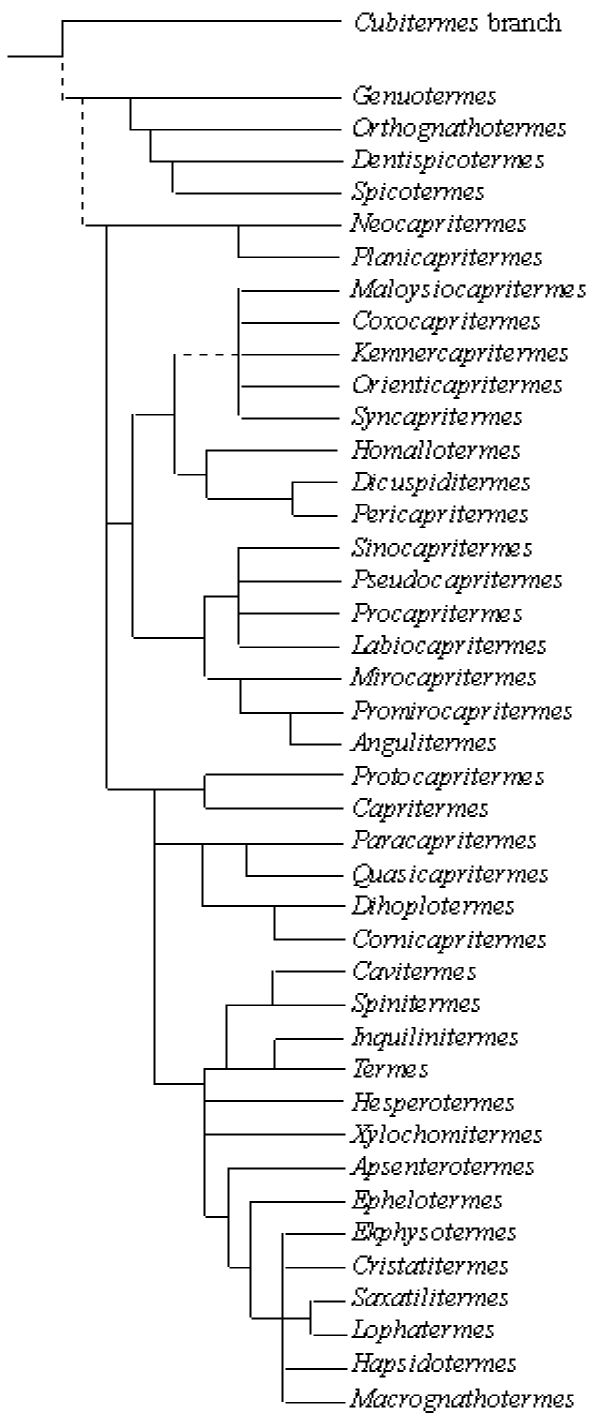
AMITERMITINAE



Appendix 1.0

Termite Phylogeny

## TERMITINAE



Appendix 2.0

**How Termidor's "Transfer Effect" works**


The active ingredient in Termidor is fipronil and it works quite differently from other termiticide active ingredients. Most termiticides are repellents, which mean they keep termites away from a treated area, rather than killing them. These repellent termiticides also kill termites. However, since the termites are repelled when they come in contact or just before actually contacting pyrethroid treated soil, the 'killing power' is less dramatic and if anyone took the time to count dead termites, less efficient. Termidor is non-repellent. Termites can't detect it. Since they don't know it's there, they forage freely in a treated area.

Like other leading liquid termiticides, Termidor is lethal to termites when they ingest it (which they do readily since they don't know it's there). But, unlike all other termiticides, Termidor is lethal by contact as well. Once a termite comes into contact with Termidor, they carry it back to the colony on their bodies. Every other termite it contacts will itself become a carrier, contacting and infecting others. This is known as "The Transfer Effect".

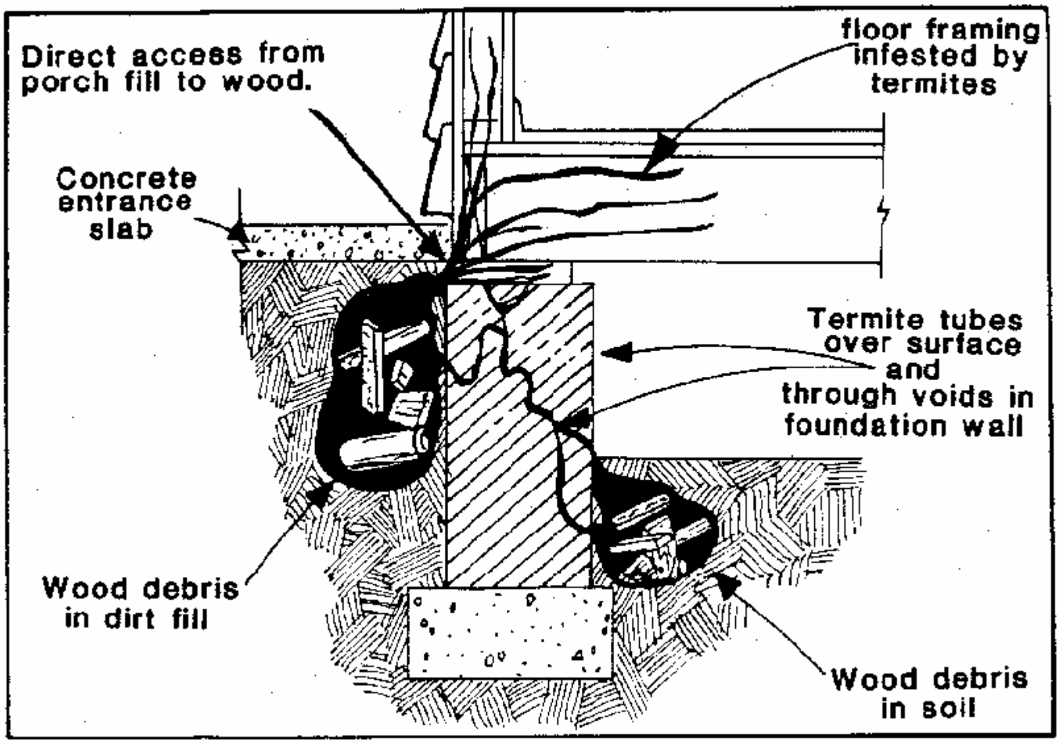



**Figure 9-6.** Faulty Construction Practices Contributing to Subterranean Termite Attack. (Termite Colonies can develop in wood debris or soil and gain entrance into a building, particularly at the concrete entrance slabs of porches.)

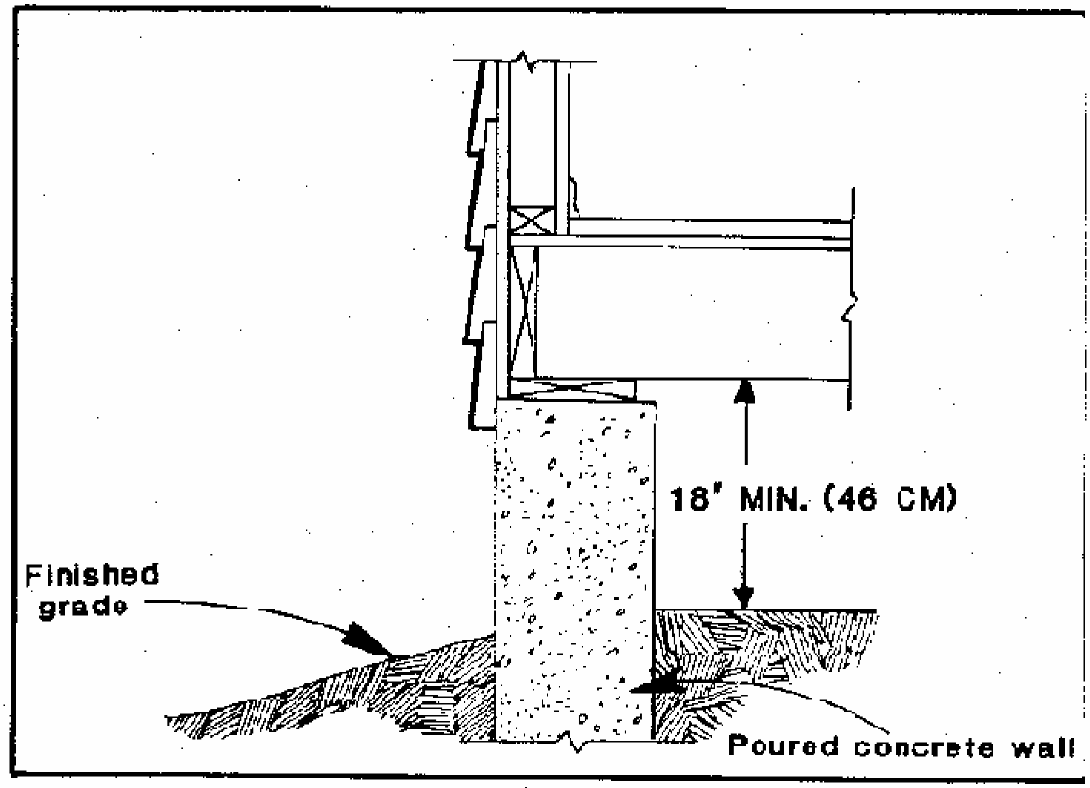



**Figure 9-7** Poured Concrete Foundation Walls or Piers. (Such areas are easily inspected and offer protection against hidden termite infestations.)

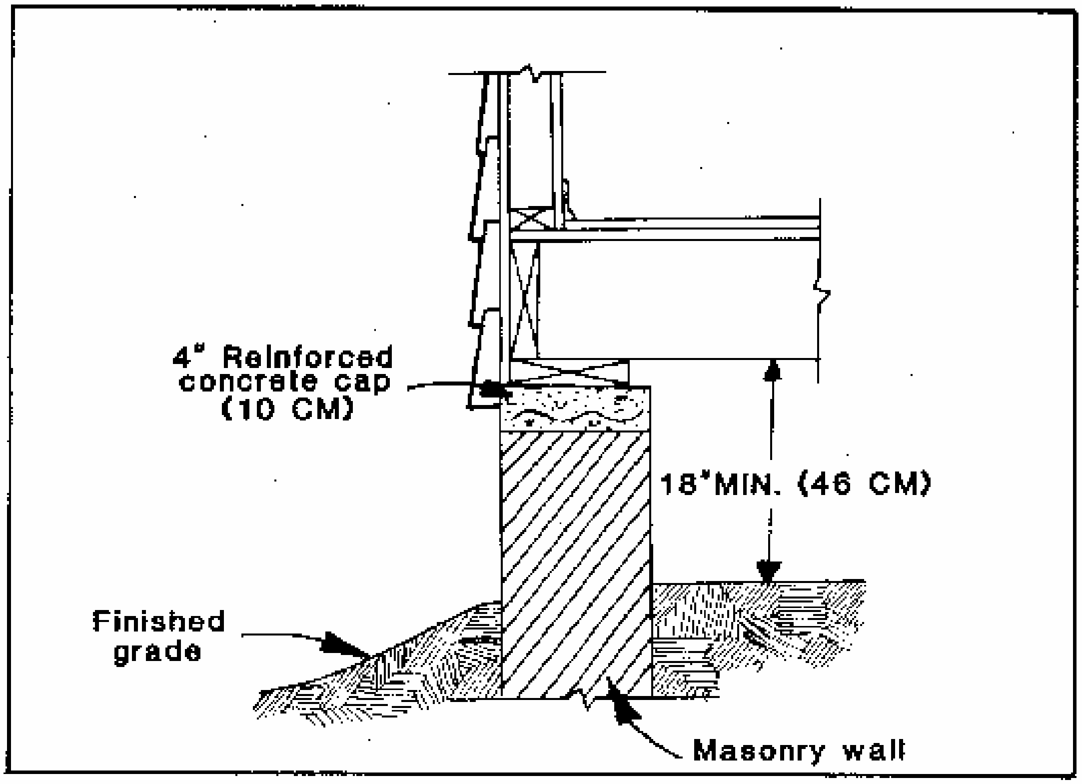



**Figure 9-8.** Reinforced Poured Concrete on Masonry Walls or Piers. (This technique prevents hidden termite attack. A minimum clearance of 18 inches under floor joists allows inspection for termite tubes or possible cracks in the cap.)

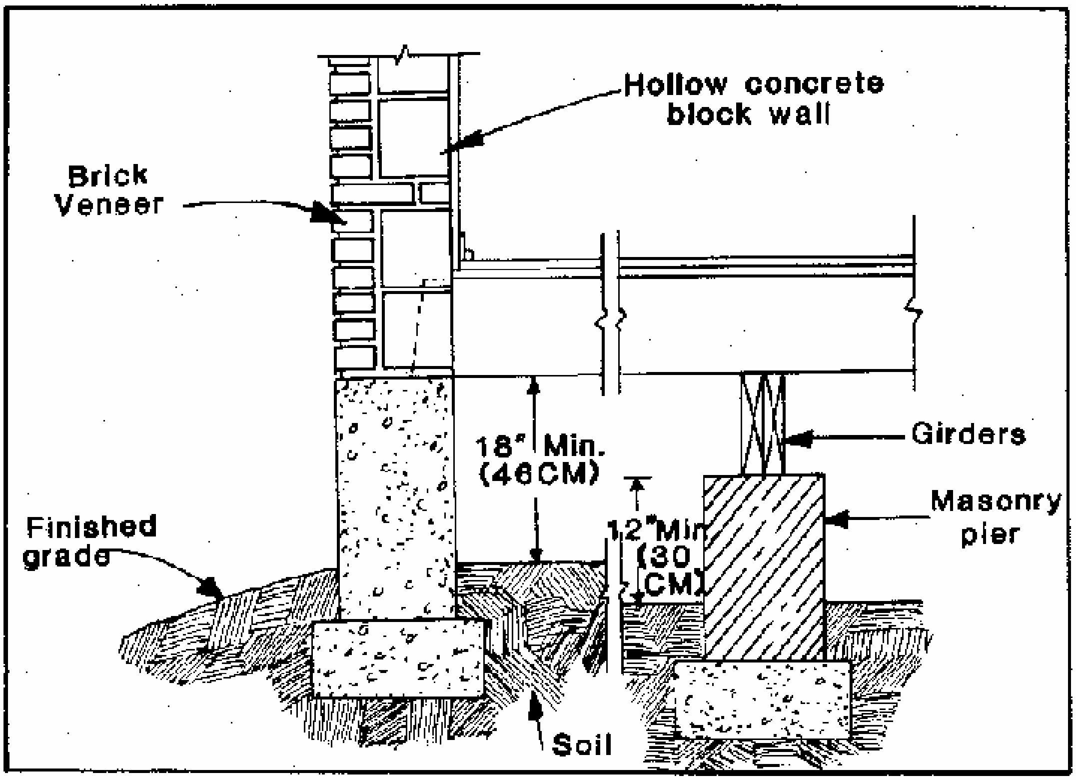



**Figure 9-9**. Proper Construction Where the Building Superstructure is Masonry. (Adequate clearance should be provided between wood and soil both inside and outside the building).

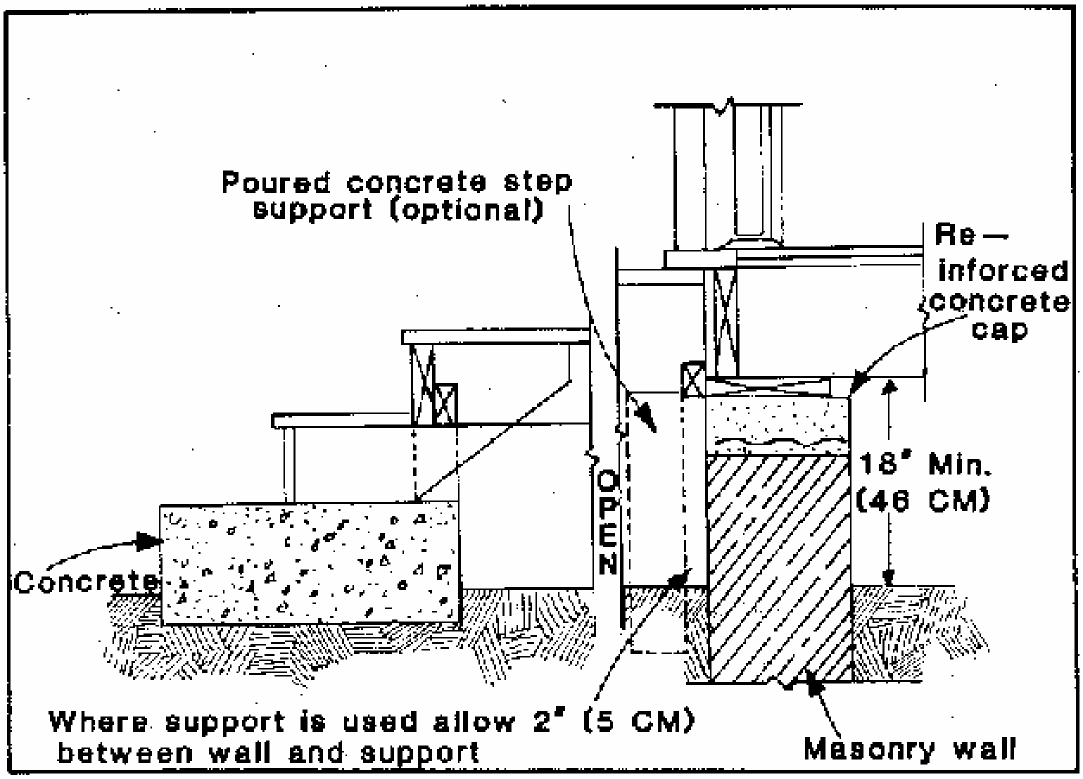



**Figure 9-10.** Construction of Wooden Steps to Prevent Hidden Termite Attack.

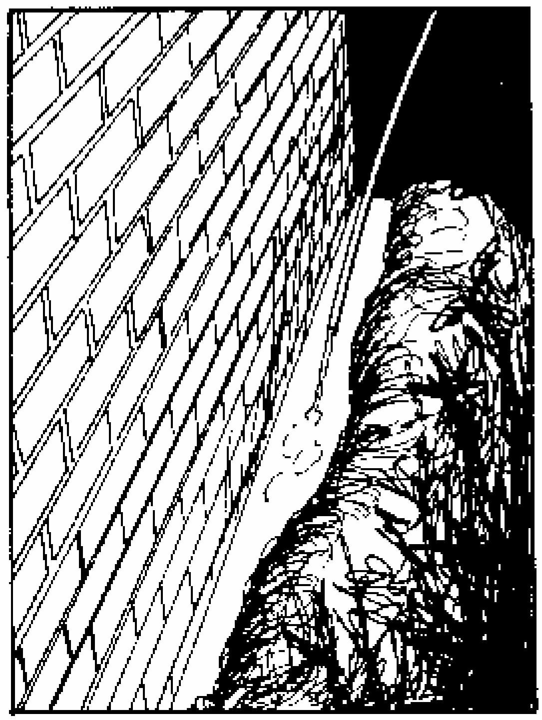


Figure 9-11. Chemical Application Around Foundation Soil.

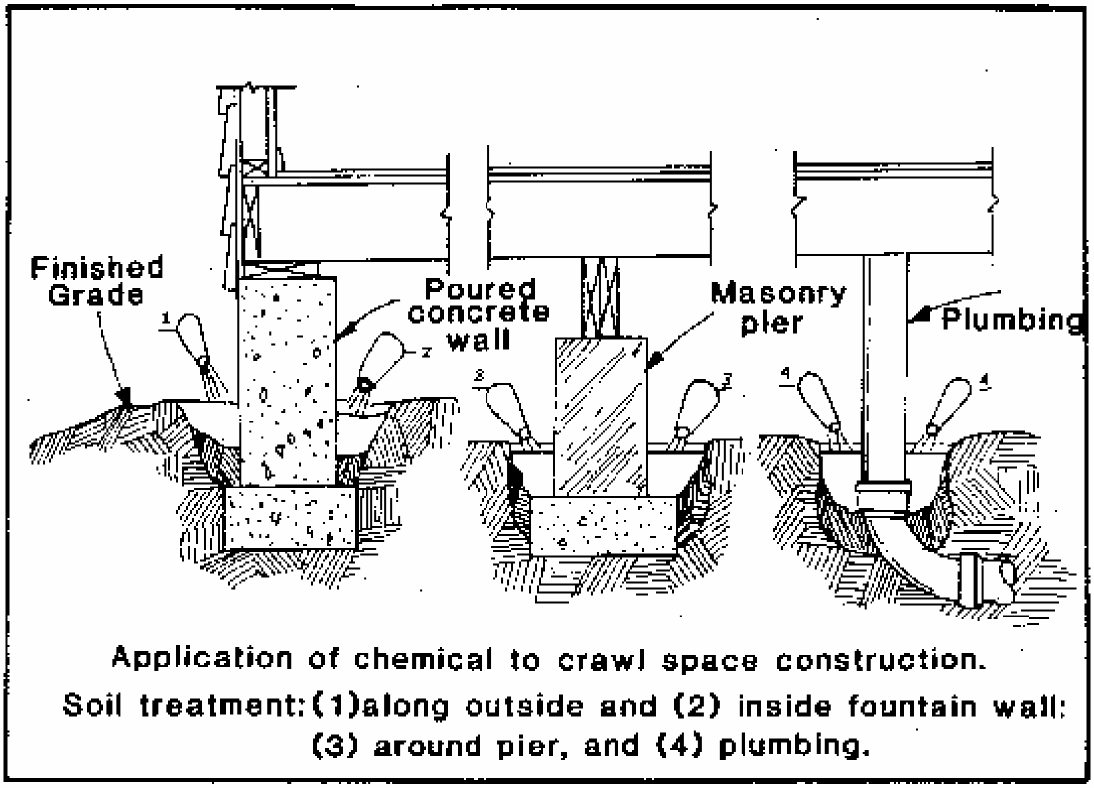



**Figure 9-12**. Chemical Application to Crawl-Space Construction. (Soil treatment 1)along the outside, (2) inside the foundation wall, (3) around a pier, and (4) around plumbing.)

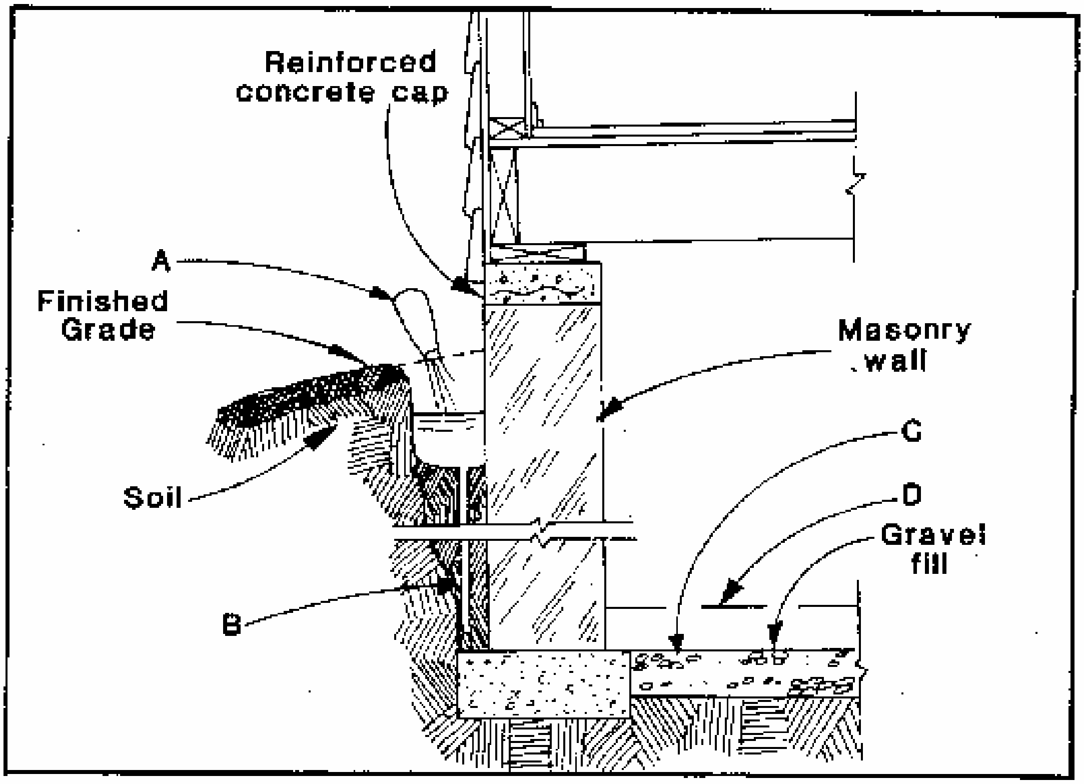



**Figure 9-13.** Chemical Application to Soil In and Around a House with a Full Basement. (A. treatment along outside of foundation; B, rodding from bottom oftrench to top of footing; C, treatment of fill or soil beneath a concrete floor in the basement; D, concrete slab poured after chemical is applied.)

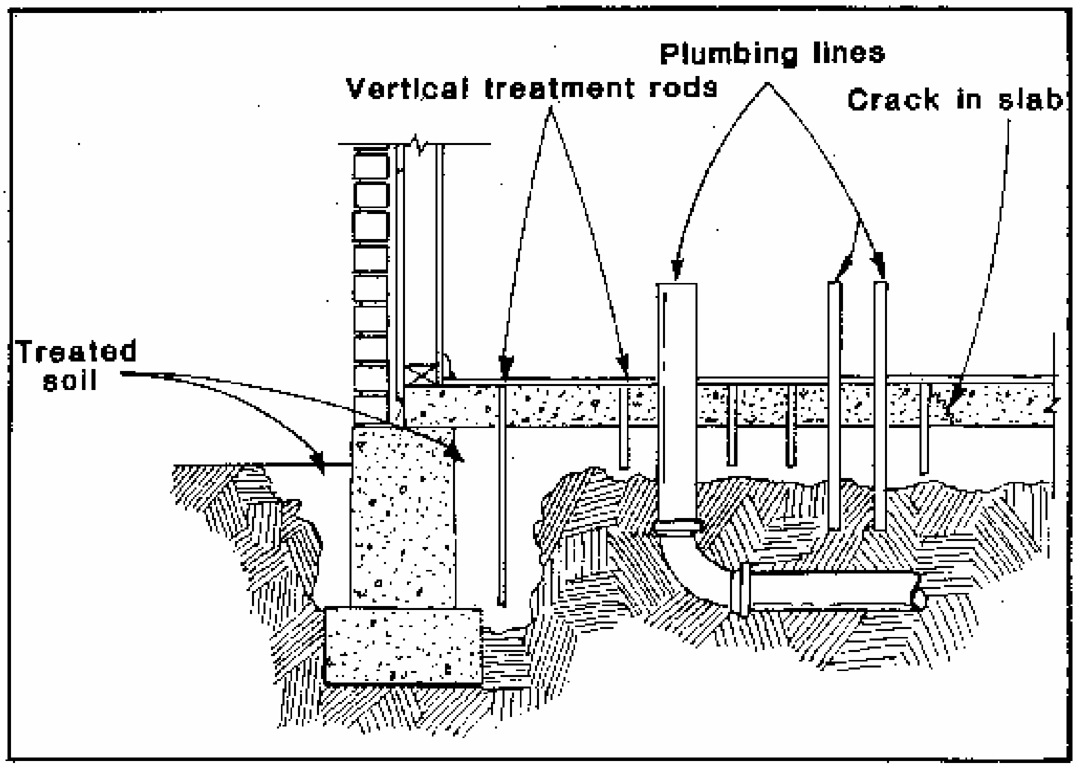



Figure 9-14. Treatment under Concrete Slab with Vertical Rodding at Joints, Cracks, and Openings Around Plumbing.