PDHonline Course C792 (2 PDH)

TERMITES, Wood Enemy #1

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TERMITES, WOOD'S ENEMY #1

Ruben A. Gomez, P.E.

PREFACE

Wood frame construction has many formidable enemies, such as: bending and bearing stresses, long term deflection, hurricanes, tornadoes, splintering, fire and decay fungi. However, in terms of economic loss, none of those is as destructive and devastating as a termite infestation. In fact, the loss potential is so enormous that it defies logic the persistence of engineers in using a structural material that is the favorite food of such voracious little insects.

Among the different known types of termites, none is more feared than the *subterranean termites*. While the occurrence of subterranean termites is much greater in the American Southern states than in the Northern states where the lower temperatures do not favor the colony development. However, once the colonies are successfully established, the resulting damage to individual homes and buildings may be as equally large in both cases.

In the Unites States there are over 60 million dwelling units subject to termite attack, while only one percent of that number is receiving routine treatment for termite control. The total annual cost of the termite control effort in residential structures is about 2.5 billion dollars, of which one-third of that cost goes to cover damage repairs and the other two-thirds into actual preventive chemical treatments.

Termites are also responsible for damage to institutional, commercial, and industrial buildings, as well as auxiliary buildings, utility poles and fence posts. Considering all those factors, the total annual cost resulting from termite damage and their control probably exceeds five billion dollars.

Although termite attacks cannot be totally eliminated, adequate building planning and design can substantially reduce termite damage through the *design period* of a building or an entire housing development. Preventive measures in all new construction and effective code guidelines can help decrease termite infestations and the resulting damage.

Unfortunately, after a building has become infested, it is always difficult and costly to fully eradicate the termite presence. While some infested buildings may only require simple repair work and chemical treatments performed by a regular exterminator, others may require the involvement of specialized *entomologists,* who may recommend major changes and complicated treatments which could be very costly.

In this course we will cover five fundamental study objectives which should be on the mind and checklist of every building designer or constructor, those objectives are:

#1- Termite habits and their biological characteristics.

#2- Where and how to look for termite infestation in existing buildings.

#3- How to readily recognize the evidence of termite presence in existing buildings.

#4- How to prevent termite attack in existing buildings by using adequate structural features and chemical means.

#5- The description of those available methods which have proven effective to prevent termite access in new residential buildings and homes.

1.0 TERMITE HABITS AND BIOLOGICAL CHARACTERISTICS

Although the dealing with insects is better left to the entomologists and exterminators, however, an engineer dedicated to wood structural design should be thoroughly familiar with all the aspects of the material, including familiarity with the wood enemy #1: the subterranean termite.

Termites are highly social insects of the order designated as *Blattodea.* Although somewhat resembling the ants, they are not related to them. They are rather related to the cockroach family.

The first thing one need to know is how to recognize a termite -particularly the dreaded subterranean termite- and how to distinguish it from other similar insects, such as the *flying ant* with which it has strikingly similar resemblance and characteristics.

Figure 1.1 depicts a sampler (magnified twelve times) of the subterranean termite side-to-side with a flying ant, also known as the *winged ant*. By closely observing those two drawings, one can say that the winged ant has a slightly longer body, longer legs and a triangular marker (D) on the frontal wings. However, those insects are so small, as the *winged termite* is only 0.192 inch long by 0.032 inch in diameter, that anything related to dimensions is hard to be appreciated by the naked eye. Fortunately, there are other more visible fundamental differences that can be used to identify one from the other.

If would be a good idea for you to look at the above referred figure while we describe those differences. First, please notice that the ant has a narrow waistline (A) while the termite has a broad one. Second, the ant has wings of noticeably unequal lengths as compared to the termites. Third, the ant has angled antennas, and on the other hand, the termite has almost straight ones.

The termite depicted on Figure 1.1 is a young reproductive adult that has already gone through the two prior stages from egg to nymph. It also has already reached sexual maturity and is ready to fly away from the nest with its female counterpart, thus becoming a royal pair, and finding a suitable location to establish their own colony.

Once the royal pair is set up in their newly chosen location near a source of wood and moisture, the female termite or *queen* will begin to lay eggs and as time passes its abdomen will become distended and enlarged giving it the capacity to produce up to 20,000 eggs per day. A queen that is well fed and protected by the workers may live up to 40 years. The hatching young termites will be taken care of by their parents until they grow up and develop into either *soldiers* or *workers* as they are shown in Figure 1.2. The soldier termite is larger and has menacing horns on its head; its job is to protect the colony from predators, such as their fierce and relentless archenemies: the *fire ants*. The workers, on the other hand, have the duties of procuring food for the colony, feeding the soldiers and the royal pair, do the necessary tunneling and take care of the infants.

Another noticeable characteristic of the termites is their coloration, as they change (also called *metamorphosis*) with their age progression. The young reproductive termite has a black body while the workers are whitish and the soldiers have a glassy tanned body and darker heads.

Two to three years after the colony is well established, another form of non-migrating reproductive termite without wings develops and lay more eggs to supplement those of the queen, therefore the colony will consist of the founding royal pair, the secondary reproductive group, the soldiers and thousands of workers, or peons, which do all the work.

Subterranean termites will thrive in a warm, moist soil with an abundant supply of wood, paper, fiberboard, cotton fibers, discarded human food and other sources of cellulose material. They are attracted to homes and buildings because that environment normally provides the best and optimum conditions for their development and survival.

They will gather around any source of cellulose material left behind during construction. After settled around a source of food, they will find their way up through cracks in slabs or foundation walls until they reach the upper wood structure. The termite workers will build a tunneling system with moist soil which they will use to commute from the upper structure and down to their underground nests. Those tunnels will protect them from the drying out breeze and against predators as well. Since they need moisture for their basic survival, there is a cycle that must be maintained. This is a very deciding aspect of their lives that is important for the design engineer or architect to be aware of: *unless the termites maintain an often contact with the ground, or other similar source of moisture, they will dry off and perish.*

There are some other characteristics which may be relevant to the curious reader to know. Please refer to the Appendix in the back of this book where we have described them for the common knowledge.

Figure 1.3 depicts a typical set of conditions leading to a termite infestation. Such figure shows how the termites could have found their way into a pocket of construction debris left behind, and down there they developed their colony. After consuming all the wood in the pocket, then they sent some of the workers in an exploratory trek by tunneling over or through the nearby masonry pier; their next step was to climb all the way to the upper wood frame to their most appreciated delicacy. If left alone, in a few years time they would have inflicted so much damage to the structure that it could be left in need for substantial repairs or even total demolition and replacement.

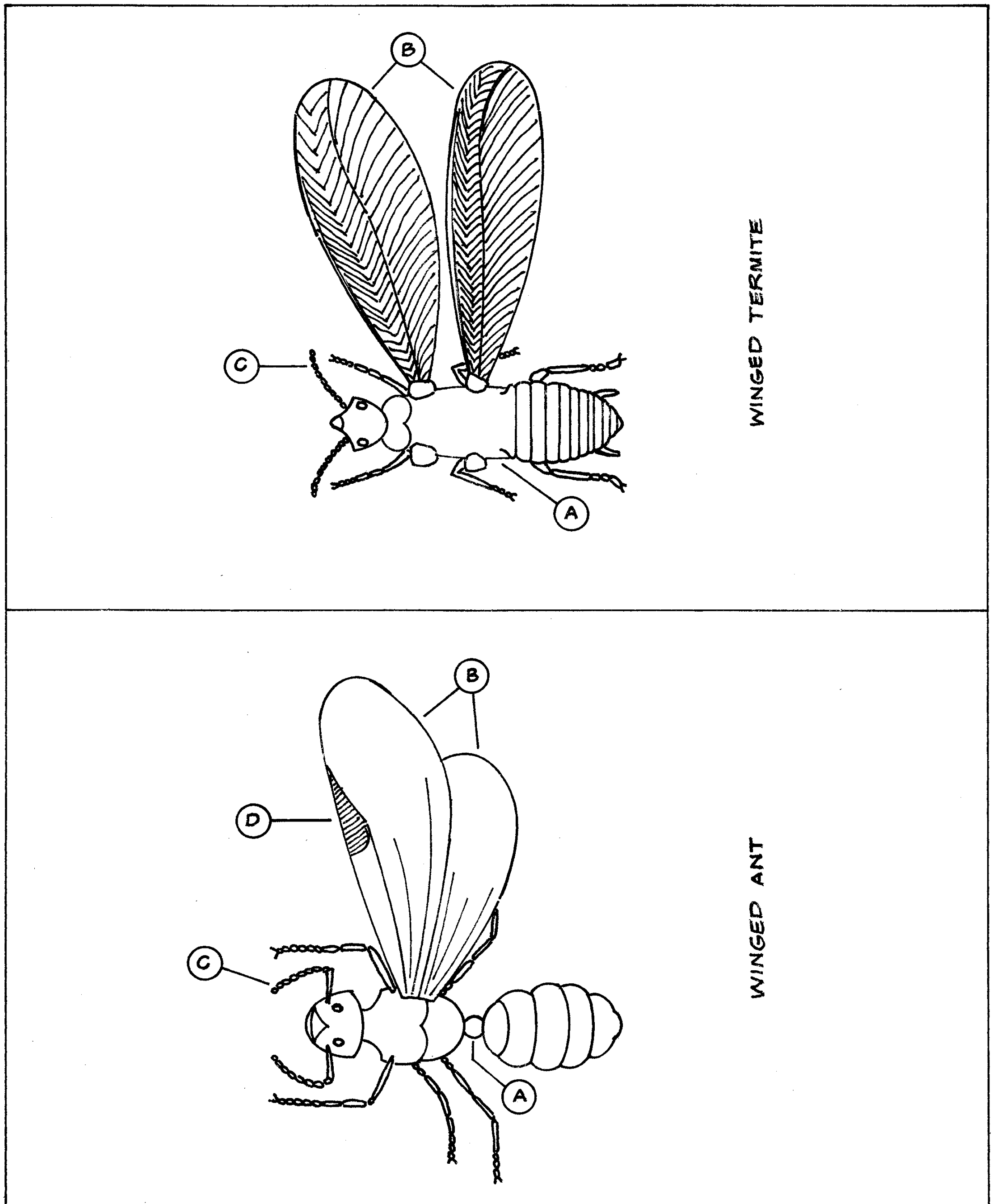
As indicated above, termites need water (or moisture) for three very particular reasons:

a. to help digest all the mostly dry cellulose they eat,

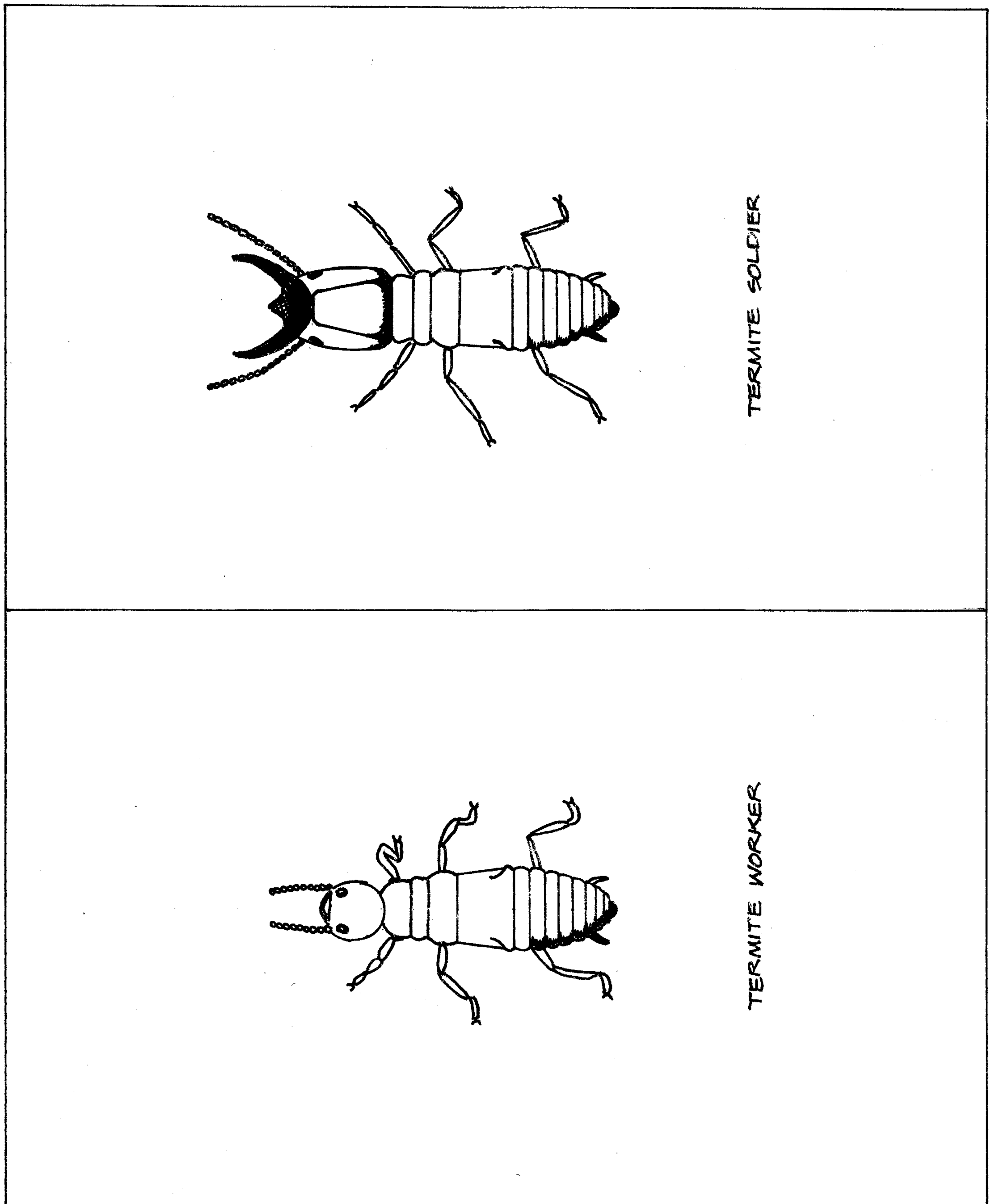
b. to build all the mud tunneling they need to make for their protected commuting, and

c. to maintain their bodies moist and thus avoid an inevitable death from dryness.

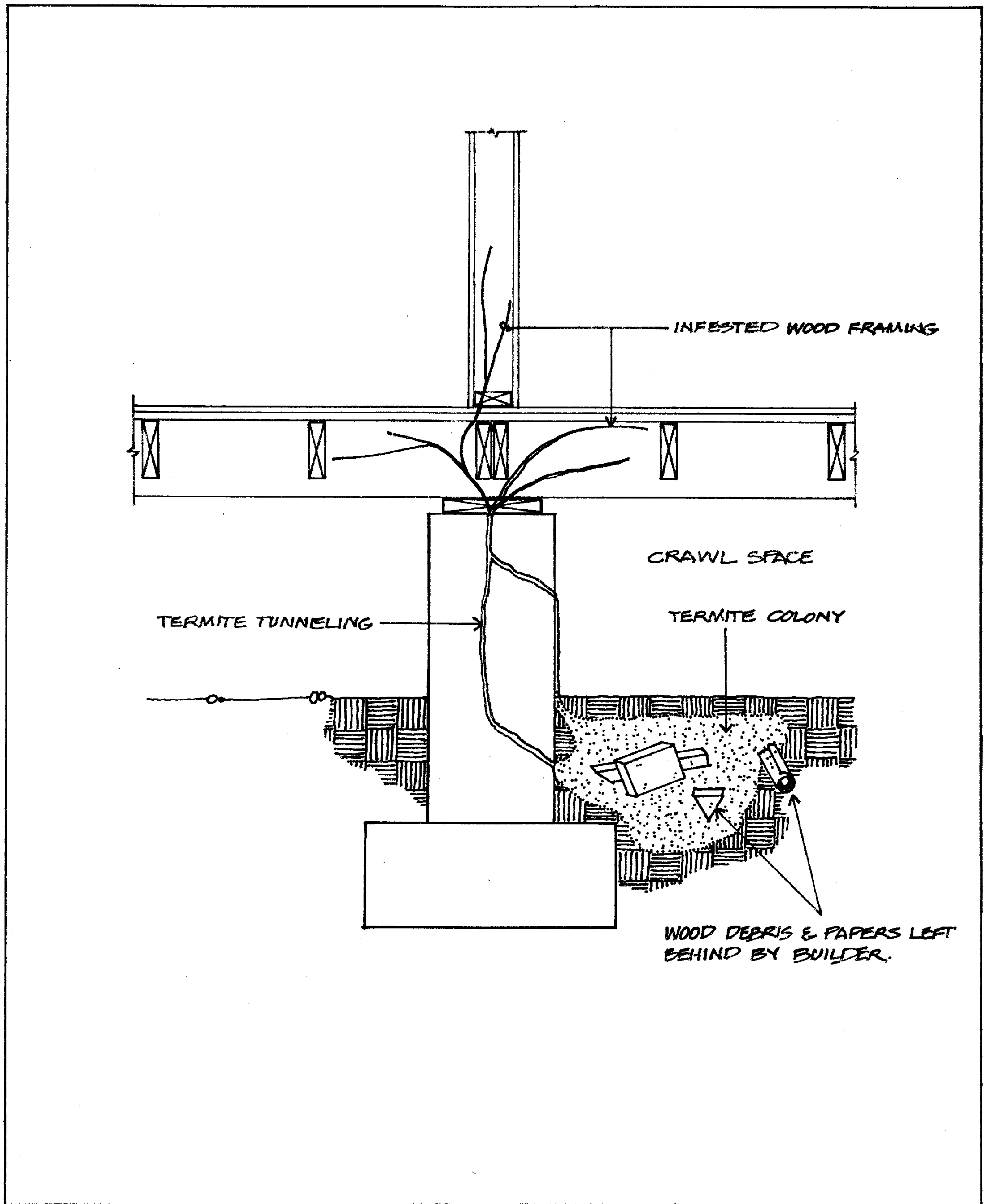
Therefore, the best wood frame design is one that precludes contact with the soil, impedes passage and blocks free circulation of the insects. We will cover this matter in more detail in the coming chapter 3.0.



TERMITE VS ANT COMPARISON
FIGURE 1.1



ADULT WORKER & SOLDIER
FIGURE 1.2



TYPICAL PROGRESSION OF TERMITE INFESTATION
FIGURE 1.3

2.0 HOW TO RECOGNIZE A TERMITE INFESTATION

Although termites would go a long way to remain hidden and out of sight, there are some signs indicating their presence to the keen observer:

1. Discarded wings could be found in an infested building or house near doors and windows. Those wings are not only an indication of their presence, but it also means that the colony is somewhere nearby.

2. Since the termite workers avoid exposure to air and wind by building galleries within the material they attack or by making mud tunnels on exposed surfaces such as the inside faces of foundation walls. Anytime those tunnels are detected, not only they indicate a commuting path for the workers, but they would lead to their nests.

3. By tapping or pricking the sides of the interior baseboards, moldings, as well as door and window trims, the hollowed out galleries will be uncovered thus giving away the likely presence of a termite infestation.

4. A growing number of dogs have been trained to sniff the presence of termites in a very effective way.

3.0 PREVENTIVE MEASURES BY THE DESIGN ENGINEER

The best time to provide effective measures against termites is during the planning and design of a house or building. Naturally that in order to do so, the design engineer or architect must be well versed on the habits and behavior of termites, so to be able to provide an effective design product where termite control and avoidance could be extended to the maximum.

Conversely, inadequate design and poor construction practices resulting from the lack of knowledge or indifference to the termite reality could well be favorable conditions conducive to undesirable infestations. Therefore, it is also important that every effort is made to emphasize the value of adequate building practices as well as the use of chemical soil treatments *before* and *during* construction.

BUILDING SITE

All wood debris such as, roots, limbs, stumps, used stakes, paper wraps, discarded clothing, form-boards and scraps of lumber should be removed before filling or backfilling the low areas as specified by the site grading plan requirements.

To prevent undesirable water accumulation, ponding or moisture buildup beneath or around the new building, the finished ground surface should be sloped so that the rain or spilled water will effectively drain away from the building and its appurtenances.

CHEMICAL SOIL TREATMENT

The best time to treat the soil underneath a building is before the structure is erected in place. The spraying of a water emulsion to saturate the soil by using any of these four chemicals is very effective for subterranean termite control: *Aldrin, Chlordane, Dieldrin or Heptachlor*. Tests have shown that those chemical formulations would provide adequate protection for periods from 18 to 20 years.

Those above mentioned chemicals are in most cases government controlled substances and are toxic to humans and pets, therefore, they should be handled with particular care or let them to the license exterminators to deal with.

SLAB ON GROUND

This type of construction, particularly the monolithic slab foundation, which often times gives a false sense of security, is the most susceptible to termite infestation. The insects can gain access over the edge of the slab, through expansion joints, pipe penetrations and cracks in the slab. Furthermore, infestations in this type of construction are the most difficult to permanently eradicate.

The indicated protocol to avoid infestations in slab-on-ground construction in general, should include thorough chemical soil saturation before pouring the concrete in place. After the slab is cast and before the erection of walls is started, the second part of the procedure should consist of an adequate treatment along expansion joints, early developed shrinkage cracks, anchor bolts, straps and around plumbing pipes.

Any wood components or wood plates in contact with the concrete should be isolated by using tar paper and/or specifying *pressure treated* wood members. Needless to say, the design engineer should require adequate steel reinforcement in those areas of the slab where experience indicates the propensity to cracking.

METAL SHIELDS

As we have mentioned above, foundation walls and piers give termites the opportunity to climb up to reach into the upper wood structure (if any). Therefore, those members should be designed in such a manner to avoid cracks which would give the termites an opportunity to further advance their infestation on their way up.

In addition of all above prescribed preventive measures, there is one more provision which will add one more layer of security, and that is the *metal shield,* which should be installed by capping foundation walls and piers as indicated in Figure 3.1.

Properly designed and installed termite shields can add many years of protection and peace of mind; very unfortunately, in practice they are rarely well installed. Termites still could build their mud tunnels right against the shield, and at that point it is up to the shield to "save the day". The following are the particular details and considerations we recommend to derive a maximum benefit from those shields:

a. do not use plastics because termites could possibly cut through them, particularly a variety of those insects now found in the vicinity of the Gulf of Mexico and the Atlantic towns and urban communities, the *Formosan* termite, which is a species by far more aggressive than the traditional native species of the United States,

b. instead of plastics of any kind, use 24 gauge double-dipped galvanized steel or as an alternative, 24 gauge zinc plates, as they should be specified,

c. all shield plates above piers must be made out of a single metal piece, no splicings,

d. foundation walls must be capped in their entirety, splices should be double folded and the joints fully soldered,

e. the installation must be continuous and follow the configuration of the top of the foundation wall, regardless of changes in level or direction,

f. holes cut or drilled through to allow passage of inserts, straps and anchor bolts must be carefully filled with elastomeric or bituminous sealers. Avoid using any asphalt compounds for they are not effective in the long run,

g. since metal shields are ineffective when used in the proximity of the ground, they must be at least 12 inches above grade,

h. their projection beyond the foundation wall or pier surface must be as shown in Figure 3.1.

Since termite shields are commonly installed in crawls spaces where they are of easy view and access, they should be inspected every 6 months. To allow comfortable access and adequate ventilation flow, crawl spaces should provide a minimum clearance of 18 inches. Please refer to dimension “h” as shown in Figure 3.1.

SUSPENDED PIPES & PIPE PENETRATIONS

When installed in the crawl spaces, it is much better to keep all plumbing, electrical and mechanical pipes off the ground and have them suspended from joists, beams and girders whenever possible. The engineer should discourage the builder from supporting them by using wooden blocks, shims or stakes driven into the ground, since termites could easily tunnel through the wood supports and follow the pipes’ path into the indoors.

Where pipes penetrate foundation walls or go through the floor framing, fill in the annular spaces with expansive cement, bituminous sealers or polyurethane foam, all in according to the case.

There are some instances where the plumber finds that he must drill through a spandrel beam or girder and he asks you, as the *engineer-of-record* that you could be, permission to do so. In such case you must evaluate the consequences and possibilities of his request, and if found appropriate and properly documented, allow passage through the *middle-third* of the member’s depth.

CLEARANCES & GEOMETRIC FACTORS

The very minimum clearance between the outside finished grade and the bottom edge of the wall siding slats should be not less than a clear six (6) inches. In crawl spaces, the very minimum clearance between the ground and the bottom surface of the floor faming members should be at least eighteen (18) inches.

OTHER CONSIDERATIONS

Crawl spaces beneath buildings or houses should be adequate to prevent stagnant air pockets from forming, otherwise, those pockets of stale air will sponsor rising humidity which would be favorable to termite activity.

The size of those ventilation openings should depend on soil moisture, prevailing air humidity and air movement. Generally, the net free area of ventilation openings should equal to at least 0.00625 multiplied by the covered crawl space area.

Shrubbery should be kept away from ventilation openings to allow air movement. They should also be kept clear off foundation wall surfaces, so to allow visual detection of termite tunneling activity.

WOOD PRESSURE TREATMENT

Pressure treatment is always an option that the design engineer and/or architect have at their disposal. Structural wood can be treated against almost every known condition and eventuality: fungi growth, conflagration (fire) retarding, water repellency, insect attack and others. In the same manner, there are a slew of preservatives for virtually any given situation to be encountered; some of those chemicals are common and others not so common. Here is a list of some of them:

Chrome Arsenate
Copper Chromate
Copper Arsenite
Creosote
Pentachlorophenol
Zinc Arsenate
Zinc Chloride

For proper use, those chemical agents are generally dissolved in water or ammonia. The liquid will evaporate by the completion of treatment, thus leaving a deposit of the active chemical in the treated wood.

The effectiveness and adequacy of treatments are measured by two factors: *retention* and *penetration.* Testing standards are determined by the American Standard for Testing and Materials (ASTM), while the treatment methods are generally established by the AWPA (American Wood Preservers Association), the VWPI (Vacuum Wood Preservers Institute), and the NWMA (National Woodwork Manufacturers Association).

Although the benefits of pressure treatment are enormous for the preservation of the structural wood against decay, fire and insect attack, there are also some drawbacks as well, for treatment may affect: workability, paintability*, gluing and design stress allowances. However, in most cases the benefits will outweigh the side effects. This is for the design engineer to consider and evaluate on a case-by-case basis.

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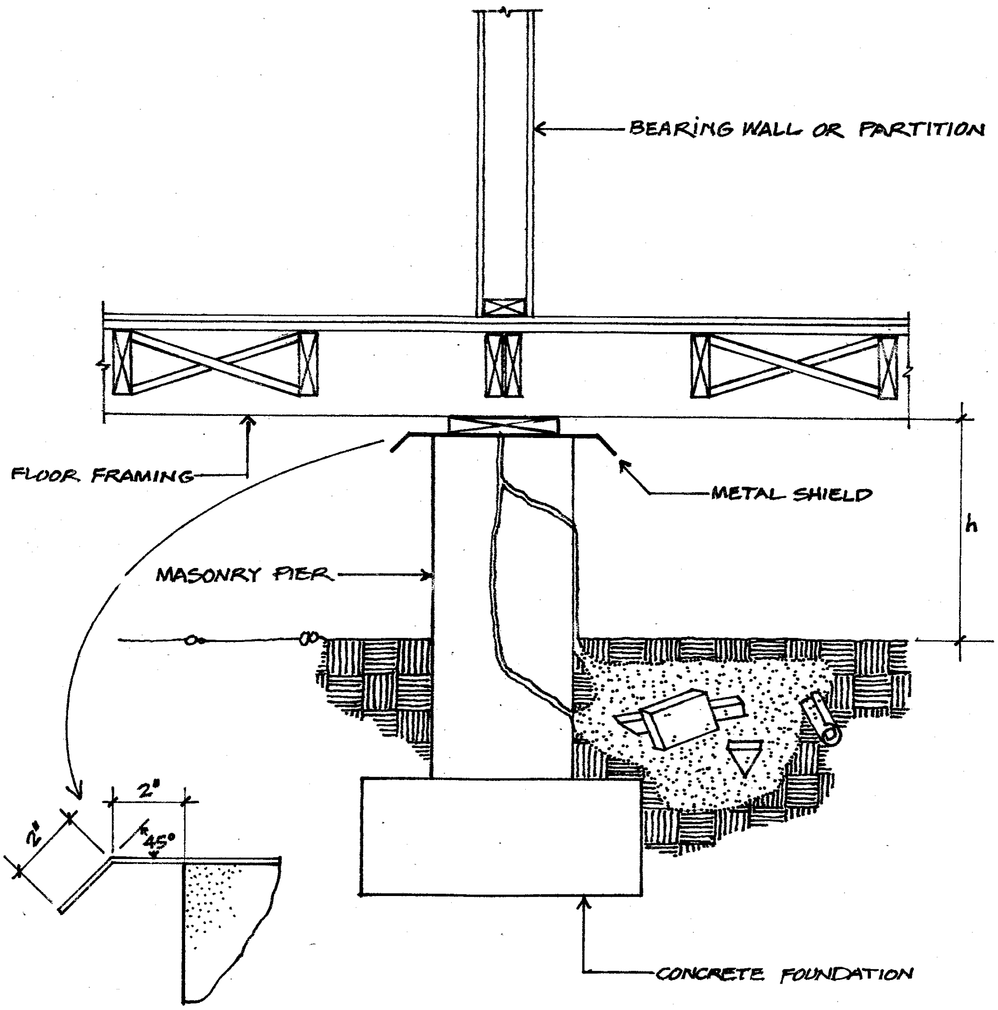
*Paint application on wood treated surfaces may become a problem in most cases, as the treating chemicals will tend to leach through the finished paint showing undesirable darker spots, thus necessitating the application of a thick primer, several coats of the

finishing paint or the use of a paint specially formulated for such application.

Generally speaking, one may conclude that the ideal wood structure is one which is built entirely of pressure treated material. However, in addition to those indicated in the above paragraph, there are also some limitations regarding the size of the components. Lumber sizes are limited by the pressure treating cylinders used in the process, while sizes up to 12 inches are competitive enough in price; larger sizes usually come up with an added premium that may make them too impractical to use.

It must also be said here that there are some species of wood which are defined as *termite resistant,* although not termite proof, for no wood species is totally immune to insect attack. Those known resistant species are: the *turpentine tree* (Syncarpia glomulifera), *teak* (Tectona grandis), *white cypress* (Callitris glaucophylla) and most of the *sequoias.*



MEASURES TO PREVENT TERMITE PROPAGATION
FIGURE 3.1

4.0 PREVENTIVE MEASURES BY THE HOMEOWNWER

Just because a building or house has been designed by an expert engineer or built by a conscientious builder, it does not mean that the owner should not be attentive to the needs of adequate maintenance and observant to the signs of termite presence. In general, buildings and houses become infested because little or not enough attention was given to preventive measures that would have otherwise made them resistant to termite attack.

To prevent infestations in existing buildings, the best solution is to eliminate conditions which would favor the development of termite colonies in the surrounding soil, and from there, allow them to pass to the woodwork in the building.

The first line of defense is to make periodic inspections for evidence of termite presence. The frequency of such inspections should depend on the geographic area and the type of construction. In areas of moderate termite hazard, inspections should be made annually, while in areas of extreme hazard they should be made semi-annually.

There are certain minimum sanitation practices that should be implemented to keep your building or house free from termite infestation and they are:

a. remove all wood debris from the adjacent areas or underneath in the crawl space,

b. remove all wooden structures, such as posts and trellises, which are embedded or driven into the ground and in contact with the outside of your building or house,

c. replace promptly any damaged or decayed sills, joists, sidings or spandrels by using new, sound and adequate material,

d. maintain a minimum of 18 inches of air space in all crawl spaces,

e. maintain adequate drainage by sloping grade away from your property,

f. fill in any voids, cracks or open joints with either cement grout or bituminous sealers, according to the case in question.

If termites are detected in your backyard, you may reduce the probability of members of the colony creeping into your building or house by using the method described in Figure 4.1. This methodology would particularly apply in the case of monolithic slab foundations and it has the purpose of providing a barrier through which termites cannot cross to reach the building in question. It would help if you follow our narrative while looking at the figure:

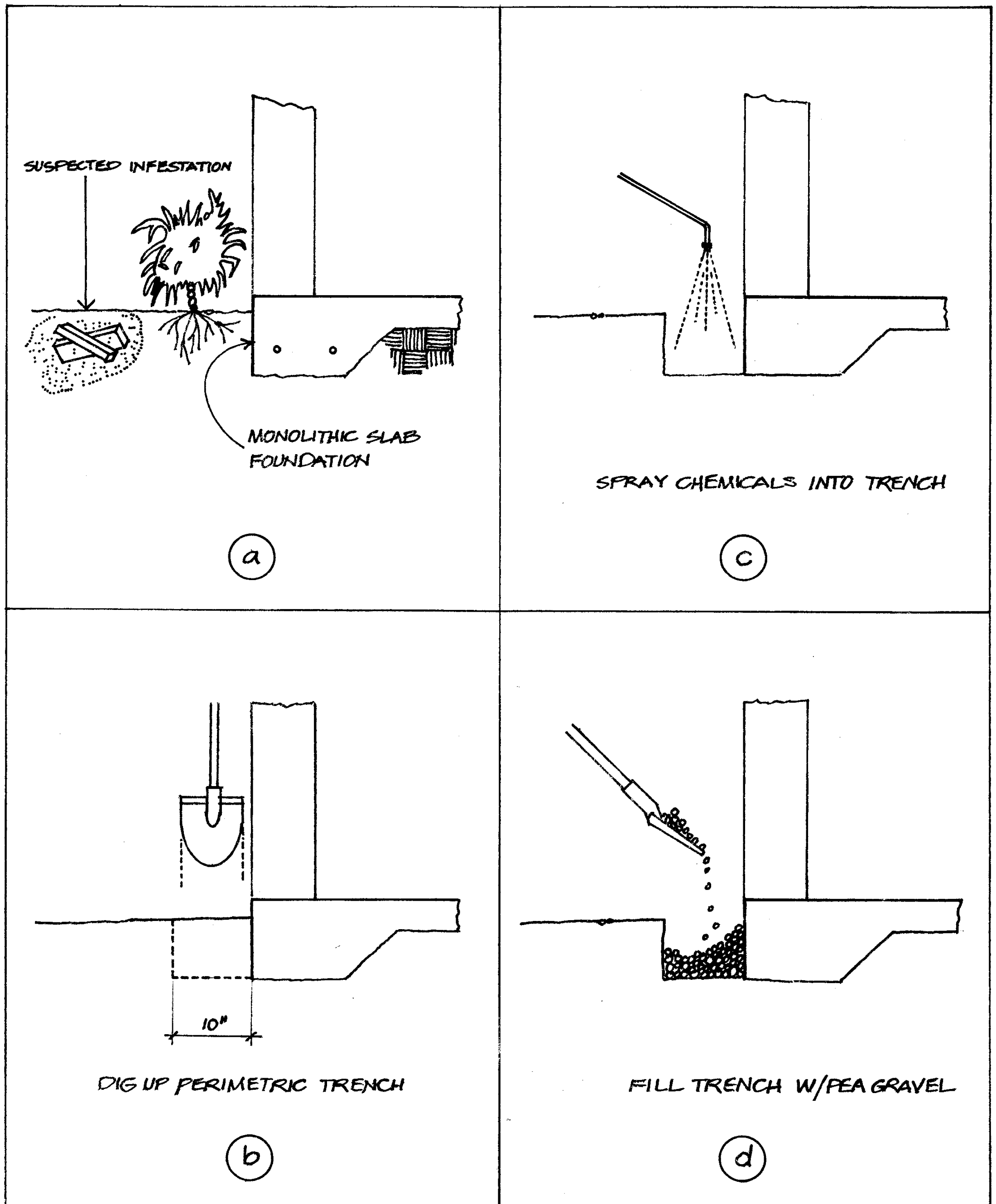
4.1(a) Clear all vegetation and wood debris from around the perimeter of your house.

4.1(b) Dig an 8 x 10” trench all around the perimeter.

4.1(c) Saturate the trench soil by using a water emulsion of Aldrin, Chlordane, Dieldrin or Heptachlor. Dilution should be prepared in strict accordance with the manufacturers' recommendations. It usually takes 4 to 5 gallons of emulsion for every 10 linear feet of trench.

4.1(d) Backfill trench with pea-gravel and grade accordingly making sure that positive drainage is kept by sloping the ground away from the building or house in question.

After completion of the above described barrier system, inspection should be made every six months to make sure that the conditions are safe and the method is working effectively. If a second line of defense is desired, a row of bait stations could be erected as described in the case history covered in Section 6.0.



BARRIER TO TERMITE PATH
FIGURE 4.1

5.0 OTHER TERMITES AND RELATED INSECTS

Although we have dedicated most of this course to cover the subject of the subterranean termites, the reader must also be aware of the fact that there are other insect species which should not be neglected, because they could inflict their own share of damage if left ignored and unattended for a particular period of time.

Therefore, in addition to the subterranean termites, the design engineer or architect should also be familiar with *dry-wood termites, powder-post beetles,* and the *carpenter ants.* It is important to notice that while subterranean termites cut *along* the grain of the wood they invade, they also eat the wood and leave behind their excrement. The other three mentioned above, cut *across* the grain and leave behind partially digested wood residues.

Dry-wood termites are non-subterranean and prefer old dry wood to eat. They usually leave behind compressed pellets consisting of partially digested wood. These termites are usually found in the American southern states and all the way down to the Florida Keys. However, some sporadic infestations have also been detected in California and Washington states.

Powder-post beetles are smaller in size than their cousins; their presence is recognized by the tiny small holes they bore through old and even new wood out of the lumber yard, brand new buildings and other wood products, such as furniture and cabinets.

Carpenter ants, although not termites, they are mentioned here because they can inflict their own share of damage to existing construction. They also cut across the grain of partially decayed wood and leave behind wood residues which are the result of the boring efforts to construct their nesting places. Usually they have a particular preference for columns in open porches, pillars in decorative entrances, doors as well as window sills, overhead spandrels and trimmings.

6.0 CASE HISTORY

Termite activity in the extremely humid areas of Central, Northeast Florida and Southeast Georgia is very high and detrimental to building durability and life expectancy. It is estimated that one in every 24 homes in that area has an ongoing termite infestation at all times.

As a matter of descriptive example, we have included a history case that took place in the town of Kingsland, Georgia, which is quite typical of such an area of the United States. The case consisted of a single story 1,800 square feet house circa 1975 and built on a monolithic slab with a wood framing and brick facing all around its perimeter. As part of the property, there also was a wood framed garden tool storage building and a large wood log edged planting area near the rear of the house.

In 2010 a severe termite infestation was discovered in the rear storage building, immediately after its discovery, under controlled conditions the facility was burned down to the foundation slab and the problem was deemed resolved at that time. However, in 2013, a termite infestation was discovered at the modesty panel below a bay window and the rest of the rear wall of the dining room of the house. At that point, the owner realized it was time for radical measures to bring the problem under control.

An exterminating service company was hired to survey the backyard of the property. They detected two active colonies near the rear of the house. Figure 6.1 provides a fairly complete scenario of the situation. The site and partial floor plan shows the original colony (A) at the storage shed. Seemingly, the original termite colony propagated to the planting area (B), and from there, a new queen relocated to the underneath of the bay window (C). The lapsed time seemed to have allowed the infestation to propagate from the floor, upwards the wall framing and unto the roof supporting framing as indicated on the cross section as part of the same figure.

TREATMENT & REPAIR METHODOLOGY

Having removed all wall finishing, it became evident the size and extent to the damage. After preliminary chemical treatment and having installed adequate shoring for the roof trusses, the builder removed the roof beam and all damaged studs, blockings and other wall framing components as indicated in Figure 6.2.

After all damaged members and components had been adequately replaced and the temporary shoring removed, then, the final step of the chemical treatment took place in accordance to a predetermined sequence which has been herein depicted in Figure 6.3.

The first step is shown in Figure 6.3(a) and consisted of drilling at intervals of six (6) inches, both indoors and outdoors. The interior drilling was performed by using a standard 6 in. long ¼” drill bit and for the exterior; a sixteen (16) inch ½” drill bit was used making sure to have the ground under the slab disturbed to facilitate saturation.

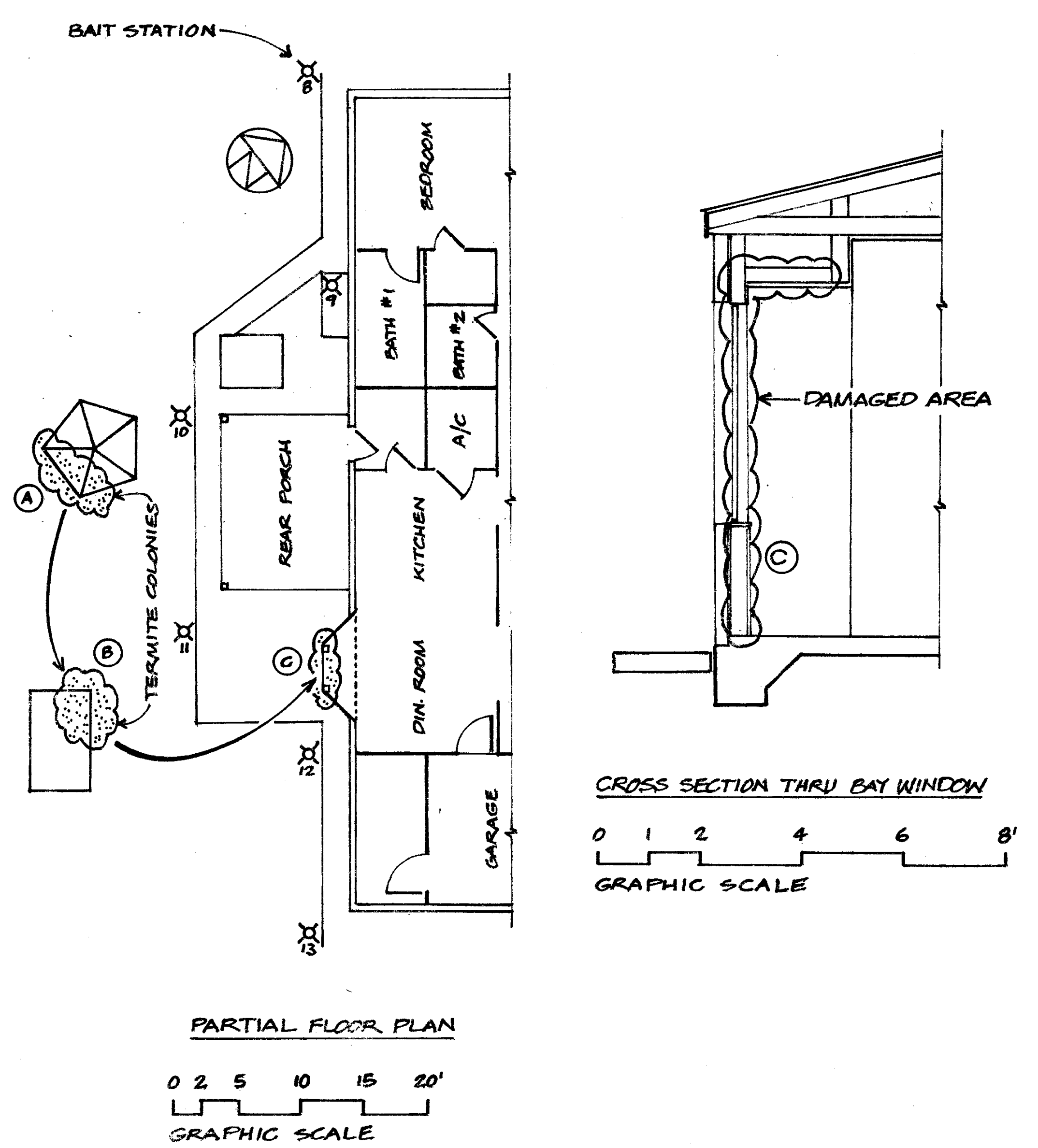
The chemicals injected in both places had different formulations. Please peruse the illustrations in Figure 6.3(b). The mix injected in the wall cavity had a urethane foam base (F) to promote expansion into the wall void spaces. On the other hand, the outside under the slab compound (G) was as gel which, as injected, would get mixed and integrated with the soil and hardened into a solid bulb. Both formulations had as ingredients, active poisons which would kill termites immediately on contact.

A second line of defense was created by placing an alignment of bait stations spaced at about sixteen feet apart from each other; please go back to the plan shown in Figure 6.1 for location. Those stations consisted of a *proprietary* ventilated bait cartridge containing a cellulose attractant and an active chemical poison. The cartridge had a removable lid to facilitate inspection and bait replacement. For easy identification and recording, the bait stations were numbered in sequential order and in a counterclockwise pattern.

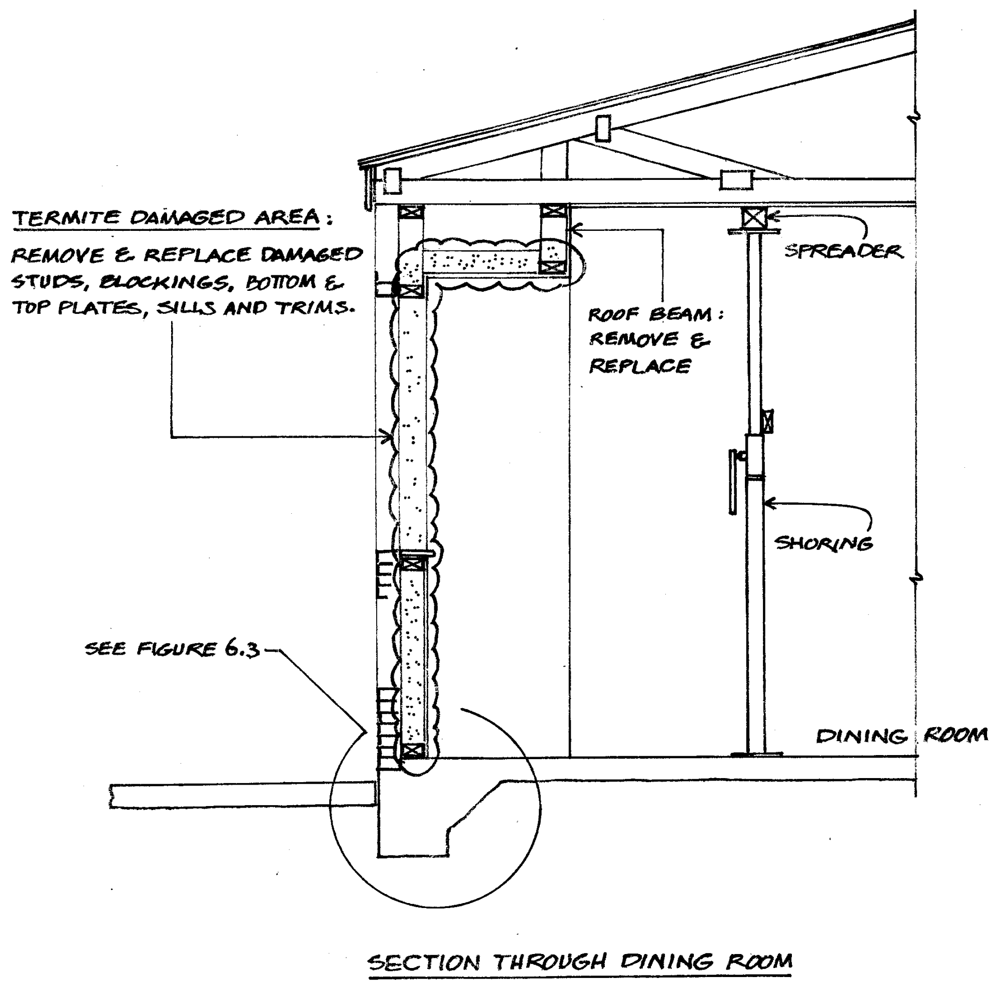
The theory giving support to such a strategy was based on the criteria that any termites which could have survived in the house and went seeking moisture and variety in their food diet, would venture outside and find one of the bait stations. They would eat the tainted cellulose, get some of the dust on their bodies and go back to the colony nest where they would contaminate the other members while in the process of grooming each other up, in a similar fashion as the cockroaches usually do.

That same second line of defense also had another purpose, and that was to attract any of those termites trying to bridge over from the "colony B" location, as shown in Figure 6.1, to the house.

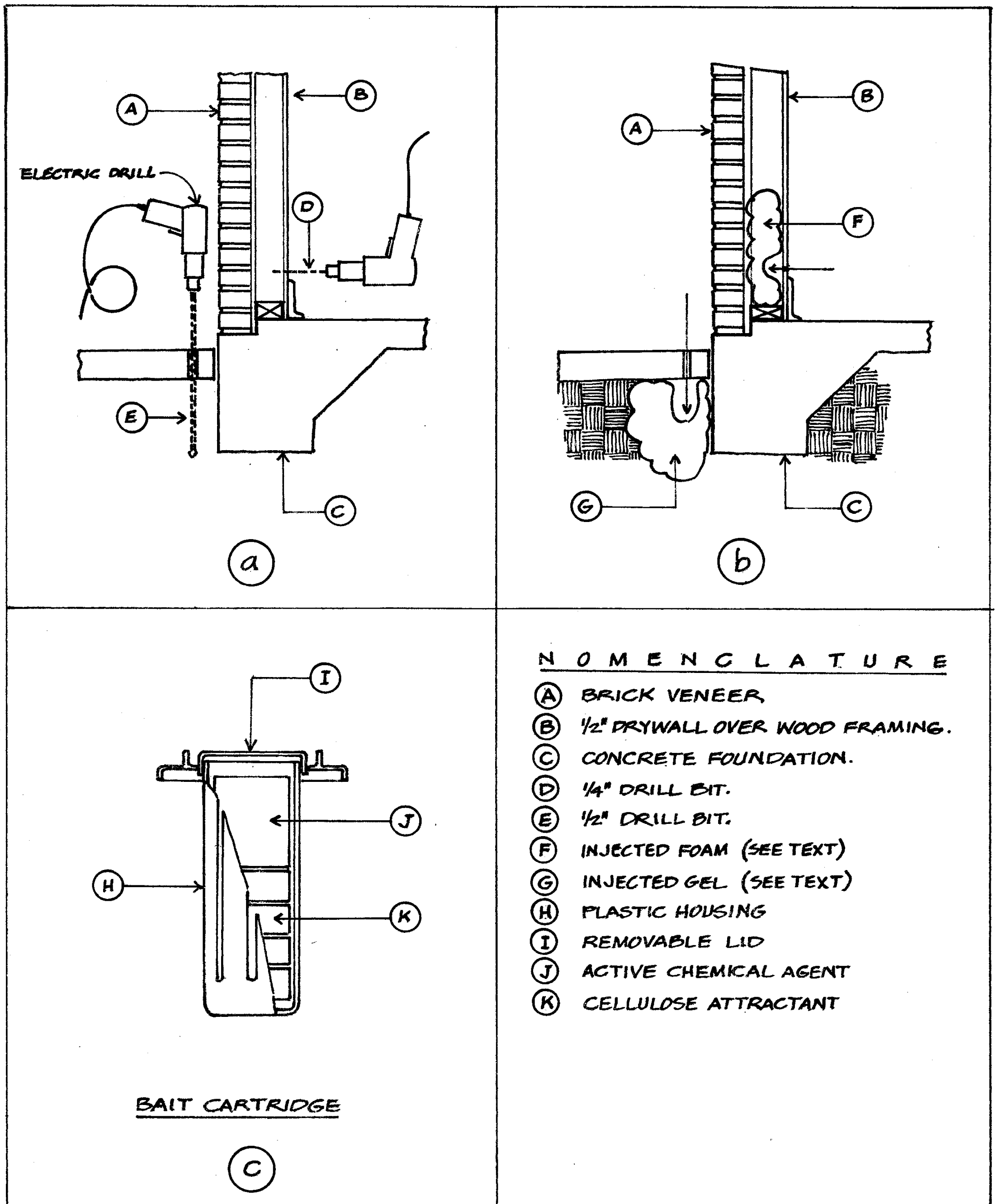
After completion of the treatment, the dislodged winged termites kept on showing up all over the dining room area, however, they died immediately after they emerged from window joints and sills. In order for the exterminator to provide an effective and sustainable warranty, a quarterly inspection program was agreed upon for the first year, which would taper off to yearly inspections afterwards.



SITE OF TERMITE INFESTATION
FIGURE 6.1



TERMITE DAMAGED AREA
FIGURE 6.2



CHEMICAL APPLICATION PROCEDURE
FIGURE 6.3

CONCLUSION

Before anything else is said, it must be stated herein that wood is perhaps the prettiest material for the purposes of furniture making and building finishing and trimming. Such qualities are inherent to the material and those merits cannot be taken away from it. That being said, we must also add that for decades we have been advocating to the fact that because of its formidable enemies, such as wind forces, tornadoes, fire, long term deflection, crushing/bearing stresses and termites, just to mention a few, wood is not exactly the most appropriate material for any serious structural use.

Of course, we must also recognize that because of its wide and abundant availability, wood has been used as a structural material since the beginnings of mankind. Further, design engineers have for long been indoctrinated for its applicability in design and construction use, therefore, our advocacy and peroration feels much as a "faint voice in the wilderness" because regardless of the results and consequences, those engineers will likely continue to use structural wood for as long as it is part of the construction codes. Consequently, we feel compelled to at least indicate its vulnerability and shortcomings to what we consider to be its most relentless enemy: the miniscule and unsanitary subterranean termite.

As we feel tacitly obligated to accept the popular use of structural wood because of its low price and ease of handling and erection, as a minimum expectation, we should be allowed the privilege to receive in exchange a termite resistant design where at least those basic considerations as indicated in this course, are taken into account by the responsible engineer and/or architect, who are unquestionably the trend setters for the contractors and the consumers to follow up.

A man who has committed a mistake and fails to correct it, has just committed a worse second mistake. (Confucius)

APPENDIX

Although not so important to the work of the design engineer or architect, there are some other details and characteristics which may be of interest to entomologists, pest exterminators or insect study enthusiasts. In spite of the fact that most of us perceive termites as a despicable and undesirable nuisance, there are some positive aspects that are worthwhile mentioning:

TERMITES AS A SOURCE OF FOOD

Since termites contain high levels of fat and proteins, and are also regarded by the users as pleasant in taste, they are part of the diet of native populations of some African nations such as, Tanzania, Uganda, Zambia and Zimbabwe.

They are eaten row, roasted or fried and the order of preference is concentrated on the soldiers and the queens, which although hard to get, are considered a supreme delicacy. In addition to eating the insects, they also eat the soil within the termite mounds known as *termitaria.*

TERMITES AS A SOURCE OF CLEAN ENERGY

As a termite consumes the cellulose in wood by utilizing the enzymes in its gut, the microbial community in the same is able to efficiently manufacture large amounts of *hydrogen* which is ultimately used by the termite as a source of energy.

Considering the usefulness of such process, the U.S. Department of Energy (DOE) is in the process of research based on the possibility of using termites as a renewable source of clean energy. Consequently, instead of the general public perception of them being despicable and repugnant insects, their role may be about to change to becoming the helpers of mankind on their search for a panacea, as the DOE's engaged scientists try to mimicking their hydrogen processing.

TERMITES AS TEACHERS OF AIR CIRCULATION

As part of the architecture of termite mounds, it includes vent tunnels and flues from the nests core to the top and upper sides of the mounds, which facilitate the catching of the prevailing breezes and the resulting needed air ventilation. As the wind blows outside, the hot and exhausted air from the lower chambers is drawn by pressure differential out of the mound, thus creating an active and positive air circulation.

The architects have taken note of the termites' design and have incorporated their ideas into the design of domes, vaults, hyperbolic-paraboloids and similar tridimensional membranous structures, so to maintain an efficient air movement throughout.

We must comment on the fact that the termites proceed to create such facilities entirely driven by their built-in instincts, while we humans need to learn such knowledge because we have long lost the acuity in perceiving our natural instinctive encryptions.

TERMITES IN CAPTIVITY

As unlikely as it may seem that termites could be kept in captivity, in September 2008 a Swiss zoo started two colonies and all went well until it was time for the young winged adults to leave the nest. Not enough room and/or adequate relocation setting choices were provided, and that mere fact resulted in the death of thousands of male termites that followed their instinctive and natural urge to fly away to start their own colonies.

Conclusively, there is no other way to keep termites in captivity, but by replicating the same environmental conditions provided by nature: plenty of space, a warm climate, camouflaging vegetation, plenty of dirt, moisture and dead wood to chew on and hide in.

END