WOOD PRESERVATION

by Perry Peralta

This contains a detailed discussion of the causes of wood deterioration and methods of preservation.

Wood statues, like this Buddha image, get attacked by termites if not properly treated.

Wood has always been a pre-eminent engineering material of man. Its advantages over other structural materials have made it invaluable in construction work. Today, despite the competition by other structural materials – steel, concrete, and plastics – the highway departments, railroad, telephone, telegraph, electric light and power companies, and the agricultural, building, mining and navigation industries still depend greatly on wood for their construction requirements.

However, wood, has a major drawback as a structural material. Being of organic origin, it is subject to attacks of bio-deteriorating agents. Where conditions permit the development of organisms, wood could last only for a very limited number of years. Although there are wood species that are naturally durable and could resist decay to a very large extent, their supply have become considerably low such that, during the past several years, wood users have resorted to less durable species. At a time of growing shortage of resources, economical handling and use of the wood are therefore required. Wood protection is absolutely necessary since wood with less natural durability has a growing market.

Outstanding among the practices developed to increase the life span and serviceability of wood is the treatment of wood with chemical substances (preservatives) which reduces its susceptibility to deterioration by destructive agencies. The different aspects of this treatment are covered in this paper.

Some of the benefits derived from the application of preservatives to wood are: increase in the service life of the material, decrease in the ultimate cost of the product, and elimination of the need for frequent replacements in permanent and semi-permanent construction. It also results in the increase in the number of available materials because naturally non-durable species could now be made durable and expected to provide long service and, consequently, in the reduction of prices of wood construction materials and in the conservation of forest resources.

P. Peralta is a faculty member of the University of the Philippines, Los Banos. He prepared this paper for the SPAFA Seminar on Researches on Conservation of Organic Materials held in the Philippines in March 1982.

Biological Agencies of Wood Deterioration

Biological agencies of deterioration are the major causes of wood deterioration. The volume of wood destroyed by these organisms has not been calculated; but miscellaneous estimates and a variety of observations indicate that such biological damage is very large in the aggregate. Although a large percentage of the destruction is unavoidable, much of it could be prevented or at least retarded through proper understanding of the behaviour or misbehaviour of these organisms. They are divided into two general classifications: the wood—inhabiting fungi and the wood—boring insects.

Wood — Inhabiting Fungi

Wood is usually attacked by low forms of plants known as fungi. These microorganisms lack chlorophyll and are, therefore, unable to manufacture their own food. Like animals, they must obtain the complex high-energy nutrients they need in an already synthesized form. Wood-inhabiting fungi obtain their nutrients from substances that are stored in cell lumens or the cell walls of the wood. They may be divided into the decay fungi, stain fungi, and mold fungi. These three groups differ in the nature of their development in and on the wood and the type of deterioration they cause.

Decay Fungi. This group of fungi is the most economically important since it causes most of the damage in wood. It embraces those fungi capable of disintegrating the cell walls and thereby of changing the physical and chemical characteristics of the wood. Decay fungi may, under conditions that favor their growth, attack either heartwood or sapwood giving rise to the condition known as decay or rot.

Decay fungi require a suitable source of food (wood), favorable temperature, and adequate moisture and oxygen for their growth. A deficiency in any of these requirements will inhibit the growth of a fungus, even though it is already well-established in the wood. For instance, treating wood with preservatives, exposing infested lumber to high temperatures in a dry kiln, drying wood below 20% moisture content (mc), or storing logs under water will minimize, if not prevent, the growth of decay fungi.

A decayed wood may be distinguished from a sound wood by the following features:

a) presence of fruiting bodies and hyphae in/on the wood;
b) water-soaked appearance, dark or reddish brown and sometimes whitish or streaky colors;
c) presence of narrow, black or dark-colored zone lines; and
d) light weight, brittle quality, spongy texture and an odor resembling that of mushrooms.

Stain Fungi. Another group of fungi that attack wood is the stain fungi. They discolor wood from blue to dark brown, and even green. Unlike the decay fungi, the stain fungi obtain their nourishment from stored materials in the cell cavities, hence, do not appreciably affect the strength properties of the wood. Stain fungi attack as soon as the tree is cut and have the capability to infest during various stages of wood processing so long as conditions for such attack exist. Most critical of these is the moisture content of the wood. Wood may be protected by immediately drying it to about 20% mc. For better protection, lumber should be treated with preservatives.

Mold Fungi. Mold fungi usually produce cottony growths which range in color from white and other light shades to black. Most of the mold fungi grow only on the surface of woods with high moisture contents and, therefore, are very prevalent on freshly cut woods that have been piled in a manner where drying could hardly take place. Molds do not cause any appreciable damage on wood because of the superficiality of attack and therefore could be easily brushed or planed off the surface.

The surface molds have the same growth requirements as that of stain fungi, thus, the presence of surface molds in wood may also result in the presence of stain fungi.

Powder-post beetle also causes deterioration of wood.

Wood-Boring Insects

Insects are second only to decay fungi in the economic loss they cause to converted lumber and wood in service. Wood-boring insects of economic importance are the termites and some beetles. For example, survey of termite infestation in the Forestry Campus, College, Laguna in 1958 showed that 63% of 79 residential and office buildings inspected had termites damage. A similar inspection of a government housing area in Manila and Quezon City showed that 45% of the 673 housing units, 2 to 12 years old, were infested with termites and/or powder post beetles.

Another example of how termites destroy wood

Termites. Termites are often called "white ants" though they are neither ants, nor white. From the standpoint of their methods of attack on wood, termites can be grouped into two main classes: (1) the ground-inhabiting or subterranean termites, and (2) the wood-inhabiting or non-subterranean termites.

The subterranean termites are by nature soil-inhabiting, entering wood only from the ground, and require a constant supply of moisture for their existence. Subterranean termites develop their colonies and maintain their headquarters in the ground. But in their search for food, they usually form runways which are constructed of tiny fragments of earth and partly digested wood cemented together by insect excretions. Thus, a telltale sign of the presence of the subterranean termites is the appearance of earthen tubes. If these earthen tubes are cut off and the termites cannot find another source of moisture, they will eventually die.

The non-subterranean termites are distinct from the subterranean termites in that the former is entirely wood-inhabiting and never enters the ground. Non-subterranean termites are further subdivided into the drywood and dampwood termites.

Drywood termites require no moisture other than that which they can derive from the wood itself. They are able to work in wood with a moisture content as low as 10 to 12 per cent (possibly lower).

One indication of the presence of dry-wood termites is the accumulation of fecal pellets which are minute, brown powder under the structure that they attack. This type of termite causes less damage than the subterranean species.

Dampwood termites differ from the drywood termites in their dependence on an abundant supply of moisture for their existence. Accordingly they confine their activities largely to damp or decaying wood. Dampwood termites are seldom encountered in buildings.

In the Philippines, there are, to date, 54 known species of termites. Luckily, however, only 6 of these cause destruction of wood and other cellulosic materials in service. Four of these belong to the subterranean group and are known locally as "anay"; while the other two belong to the drywood termite group and are known locally as "unos"

The four subterranean termite species are:

a) **Coptotermes vastator,** Light or milk termite
b) **Macrotermes gilvus,** Hagen or mound-building termite
c) **Nasutitermes luzonicus,** Oshima or Luzon pointheaded termites
d) **Microcerotermes losbanosensis,** Oshima or Los Banos termite.

while the 2 drywood termites species are:

a) **Cryptotermes cyanocephalus,** Light
b) **Cryptotermes dudleyi,** Banks

Beetles

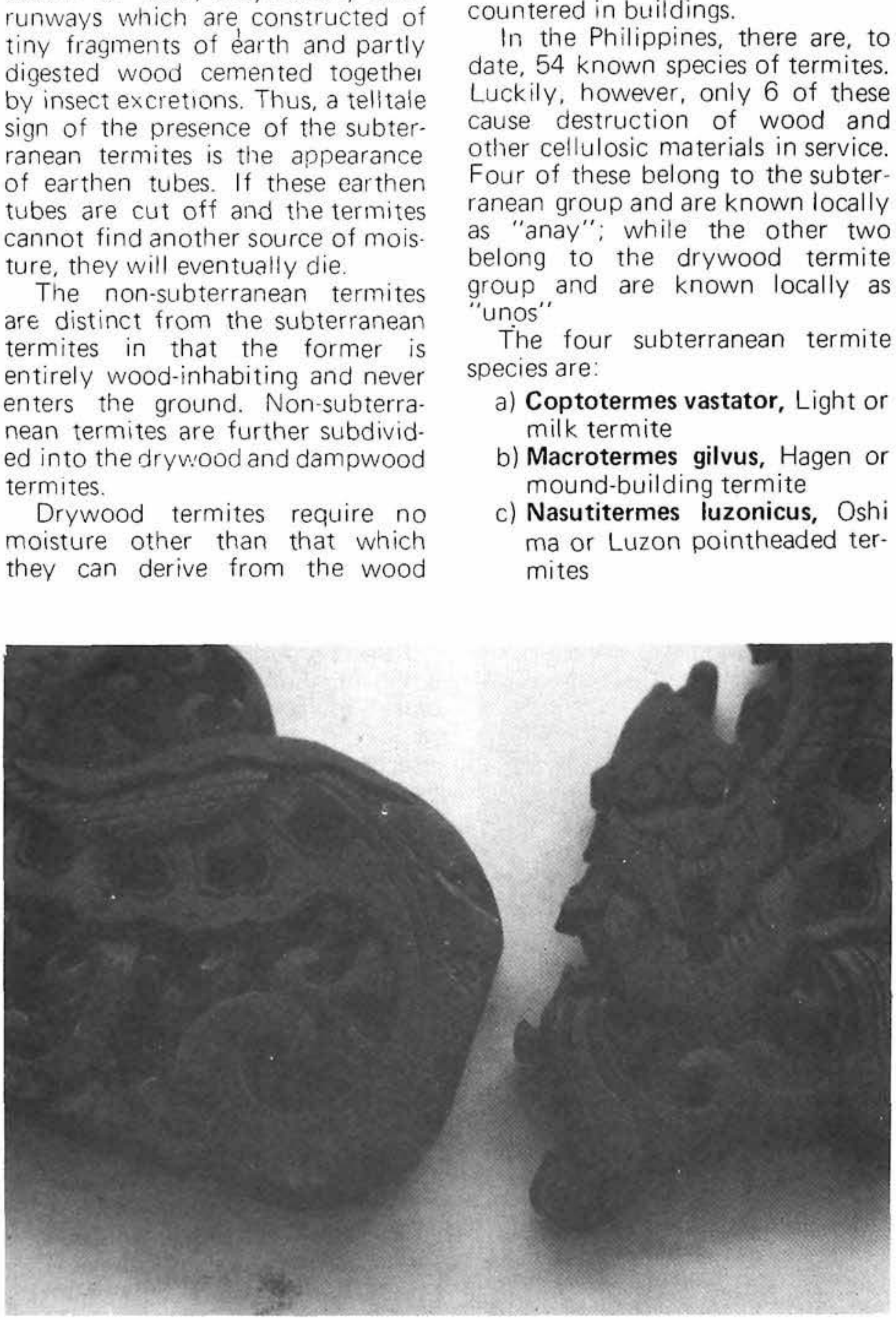
Ambrosia beetles. Insects comprising this group are more commonly known to lumbermen as "pinhole" beetles. They are pests of green logs and freshly sawn lumber and the damages they cause are characterized by small, round holes ranging from 0.5 to 3.0 mm in diameter. The holes are usually stained dark by "ambrosia" fungi introduced and cultivated by the beetles in the tunnels. These fungi furnish the entire food for the insects; the galleries cut into the wood serve only as a shelter and place for the fungi to grow.

Logs become infested by these insects immediately after felling and the pinhole injuries are manifested in sawn lumber. Freshly cut lumber may be further attacked until such time when the moisture content drops to about 40 per cent.

Infestation by these beetles in logs may be minimized, if not completely avoided, by prompt removal from the forest and immediate conversion and seasoning of lumber. Where hazards of infestation are high, lumber should be dip-treated with a preservative.

Powder-post beetles. This group of insects is, generally, a serious pest of well-seasoned sapwood lumber either in storage or in service. These insects are so-called because of the condition to which they render the infested wood. Underneath wooden structures attacked by this group of insects are heaps of fine dust or powder. These and the small holes on the woodwork are the indications of a powder—post beetle infestation.

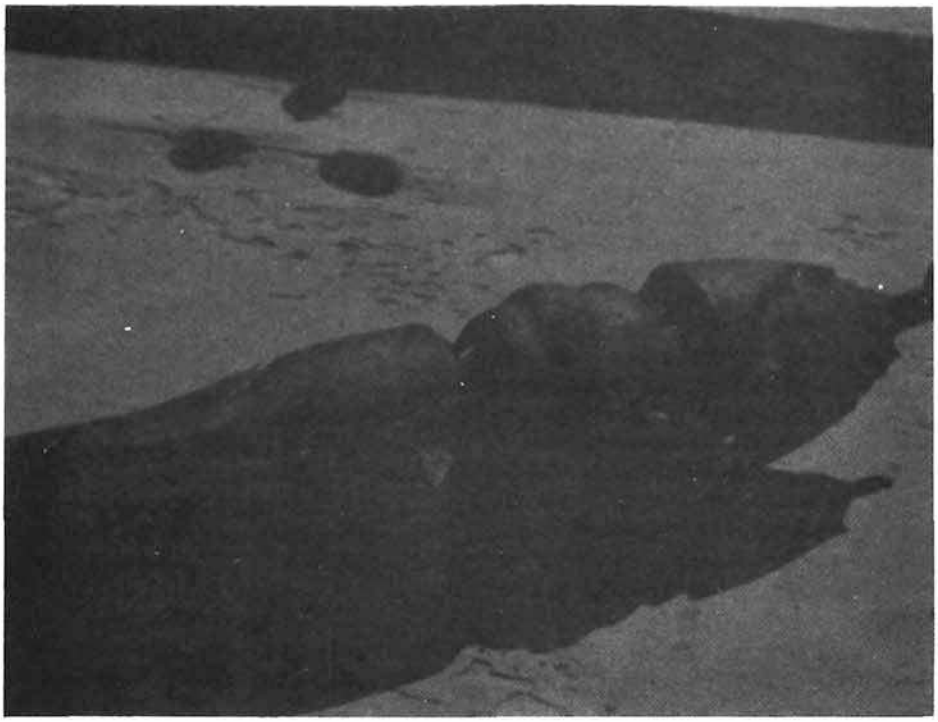
It is also difficult to estimate the value and extent of damage caused by these insects. While ambrosia beetle is more prevalent on unsawn



Insects also cause damage to organic materials.

logs with usually high moisture content, powder-post beetles generally confine their attack to dried lumber, structural timbers and wood in service.

Since starch is a principal substance of the larvae of the powder post beetles, the susceptibility of wood to their attack is indicated by its starch content. Thus injury to the wood is confined only to the sapwood of susceptible species. Logs immersed in water after felling are not susceptible to their attack. When wood is soaked in water, the parenchyma cells in the wood continue to function and the starch present in the sapwood may be entirely transformed to other materials. On the other hand, when wood is seasoned rapidly or exposed to high temperature, the parenchyma cells die before the supply of starch is used up and consequently the sapwood is susceptible to attack.



An insect-damaged wood collection

Marine Wood Borers

Two groups of organism attack wood in marine waters: the Molluscan borers which are related to the oysters and clams and the Crustacean borers which are kin to the lobsters and crabs. The marine borers reported to be active in Philippine waters are the shipworms, the Martesia of the Molluscan group and Limnoria of the Crustacean group. The shipworms and Limnoria attack wood as a source of food and for shelter while Martesia, feeding on plankton and sessile micro-organisms in their burrows, excavate wood for dwelling only.

Preservative treatment of lumber intended for ships, deepsea fishing boats, piles and other marine construction will provide protection against marine borers.

Natural Durability of Wood

Natural durability is the property of wood to resist deterioration by the various wood destroyers without the aid of applied chemicals. Different wood species possess different degrees of resistance to biological agents of deterioration. Experience has shown that some species provide long service even in hazardous conditions while others last only for a few years in less severe conditions of use. For example molave, a naturally durable species, may last for 25 to 30 years when used for railroad ties while an untreated apitong may last for only a few years or even months.

Investigations on durability indicate that the durable woods owe their resistance to deterioration to the chemical components they contain which are collectively known as extractives. These chemical components can be removed from wood by extraction with water, alcohol, benzene, or other organic solvents. These extractives may be toxic or repellent to the wood-destroying microorganisms. The extractives are found in the heartwood. It has been suggested that as the sapwood changes into heartwood when the parenchymatous cells die, the extractives are formed or deposited in the cellwalls and cavities. These extractives include tannins, essential oils, complex phenolic substances and other sugars and ethers. The effect of toxic extractives on prolonging the life of wood in service has been demonstrated unequivocally. The removal of extractives from wood and its subsequent rapid decay as compared with a natural, unextracted sample is a convincing evidence of this.

In woods with comparatively durable heartwood, the relative amount of sapwood present in untreated timbers will naturally have a decided influence upon their serviceability when exposed to conditions that favor decay. Thus, in a pole or post, complete decay of a thin ring of sapwood may not seriously impair the usefulness of the piece. On the other hand, if the band of sapwood is wide, its destruction will probably result in failure of the timber, even though the small center of the heartwood is not attacked. In the latter instance, the decay resistance of the heartwood is of little or no consequence in determining the service life of the timber.

A number of studies have been made to determine the natural durability of Philippine woods. Notable of the earlier studies are those of Nano (1924) and Aguilar (1941). A more recent report is that of Siriban (1970) who is currently studying the durability of some Philippine species. Table 1 integrates the three reports. Except for a few species, their classifications are in general agreement.

Wood Preservatives

One of the best protections that can be provided to wood against the degradations of the various organic agencies of deterioration is the application of chemicals known collectively as wood preservatives. Since the first successful impregnation of wood with chemicals about 150 years ago, a large number of chemicals either as single compounds or mixtures of compounds have been introduced, most, rather dubiously, as wood preservatives.

Not all preservatives provide the same degree of protection to the wood. Some are effective than others for a particular use while others may not be adaptable to certain use requirements. All, however, must penetrate the wood to some distance to provide more lasting protection and should not be easily carried away from the wood by moisture. For general construction purposes, a good wood preservative must possess the following properties:

a) High toxicity to wood destroyers,
b) Permanence in the treated wood,
c) Capable of deep penetration into the wood,
d) Not health hazards to the wood preserver and user
e) Non-corrosive to metals and also not deleterious to the wood itself,
f) Readily available and economical.

For specialized uses, there are other characteristic requirements. The preservative should not be poisonous to men or higher animals if the treated wood is to come in contact with foodstuffs or animal feeds. Furthermore, it should not increase the flammability of the materials treated; it should be non-swelling, moisture repelling, clean and paintable; and it should not give off fumes that may be injurious to plants and animals nearby.

No one preservative possesses all the properties mentioned nor is there one that suits all purposes and occasions. In most instances, the choice is limited and the user must decide which properties are most important for his purpose.

Wood preservatives are subdivided into two groups, the oil or oil-borne type and the water-borne type.

Oil and oil-borne preservatives

Oil preservatives include by-product oils obtained in coal distillation, coal-tar refining, petroleum refining, wood distillation, and the manufacture of gas. Important examples under this type are the following:

The tunnels in the wood are built by termites.

Coal-tar creosote. Coal-tar creosote is a distillate of coal-tar produced by high temperature carbonization of bituminous coal. It is still regarded as the most effective substance for general use in protecting wood against all forms of wood-destroying organisms. It also penetrates well especially when heated and used in well-dried materials; is chemically stable, not volatile and does not leach out; presents no health hazard except probably to a few who may develop some allergy to it; and although not produced locally, is easily obtainable at reasonable price.

Although creosote is in general use for various purposes, it is far from being a universal preservative. It could not be applied to materials that come in contact with food due to its color. Also, workers especially of telephone and power companies show objection to creosote as it is dirty to handle and soils clothes.

Creosote-petroleum solution. To lower preservative costs, certain additives are often mixed with coal-tar creosote in various proportions. Petroleum of the heavy, fuel-oil type is often used as the diluent. The usual mixture is 70 per cent creosote and 30 per cent petroleum, by weight.

The addition of petroleum reduces the toxicity of the resulting solution. Hence, the mixture is not recommended for use in marine or salt water. Moreover, since the resulting mixtures becomes more viscous, it does not give as good a penetration as the straight creosote.

Oil-borne preservatives are prepared by dissolving toxic chemicals in solvent oils. One example under this type is pentachlorophenol. Pentachlorophenol is a compound formed by the reaction of chlorine on phenol. It is very soluble in heavy petroleum oils, but has lower solubility in lighter petroleum solvents such as kerosene and mineral spirits like turpentine, and similar oils. When pentachlorophenol is mixed with petroleum oils, its concentration should not be less than 5% by weight. It has been found that pentachlorophenol is toxic against fungi and insects but not effective against marine wood borers. It is irritating to the skin and mucous membrane, thus, long contact with the skin should be avoided.

Water-borne preservatives

Water-borne preservatives are prepared by dissolving the chemicals in water. Well-known examples under this group are the following:

Chromated Copper Arsenate (CCA). Most of the present-day water-borne preservatives are of the CCA-type. CCA type preservatives are toxic to fungi and insects. However, it is not recommended for use on marine or salt water. Some proprietary CCA-type preservatives available in the Philippines are Boliden K-33, Wolman CCA, and Tanalith CCA.

Flour-Chrome Arsenate Phenol (FCAP). This type of preservative is highly effective against fungi and insects. It is recommended for interior use. A proprietory preservative of this type available locally is Tanalith U.

Acid Copper Chromate (ACC). Tests on stakes and posts exposed to decay and termite attack indicate wood well-impregnated with ACC gives good service. It also has some resistance to marine wood borers. However, the protection against marine borers is much less than that provided by a standard treatment with creosote. A proprietary preservative of this type available is Celcure A.

Wood Preserving Processes

The wood treating processes may be classified into two groups: (a) the non-pressure and (b) the pressure processes. The former is carried without the use of artifical pressure while the later is carried out inside a treating retort or cylinder with the preservative forced into the wood under considerable pressure.

The non-pressure processes

The processes in this group are simple, cheap and easy to apply. However, the penetration and absorption obtained are superficial, inadequate and generally low in effectiveness except when applied to extremely permeable materials. The low cost associated with their application does not necessarily mean true economy since they seldom provide adequate protection. The more common methods under this group are:

Brushing and Spraying. The application of wood preservatives by brushing or spraying is the simplest treatment available. It requires a minimum investment in equipment.

Penetration of preservative is slight and superficial and therefore this method can not be recommended except as a temporary measure. If any physical damage should rupture the thin protective shell, the piece is subject to attack through the open area.

Dipping. This treatment consists in merely immersing wood in a bath of preservatives for a few seconds or minutes. It provides a little more effectiveness than brushing or spraying. Complete immersion probably provides greater uniformity of coverage than brushing and spraying and gives more assurance that all checks are filled.

Steeping and Cold Soaking. Steeping and cold soaking are merely prolonged immersions of wood in preservative solutions. The term cold soaking refers to the soaking of wood in an unheated oil or oil-borne preservative while steeping is simply submerging wood in a tank of waterborne preservative. If the wood is submerged in the preservative for quite a long period, absorption and penetration would equal, if not exceed, those obtained in pressure treatments.

Hot and Cold Bath Treatments. This method of treatment is undoubtedly the most effective of the so-called non-pressure treatments. In this process, the materials are first heated in a preservative solution and then transferred to a cold preservative solution.

Diffusion Processes. The processes included in this group allow gradual diffusion of preservative from a concentrated source. Some of the more popular processes in this group are:

a) the dip diffusion process involves dipping the green materials into the solution of water-borne preservative. Later they are solid-piled and covered tightly with waterproof paper or other suitable material to prevent loss of moisture. The treated wood is left covered for 3 to 4 weeks during which time the pure salts which cling on the surface of the wood diffuse into the water of the green material and thereby penetrate it.

b) the double diffusion process consists of soaking the green materials in a solution of copper sulfate and, then, in a second solution containing sodium chromate and sodium arsenate. The chemicals diffuse into the wood and react to precipitate a toxic preservative with high resistance to leaching. Other pairs of solutions can be used in the same manner.

Pressure Processes

Pressure processes constitute the more commonly used commercial methods in the country today. Under these processes, the wood is flooded with preservative in an air tight cylinder, then, pressure is applied to force the chemicals into the wood. These methods provide deeper and more uniform penetration than those obtained in the non-pressure processes. Furthermore, the absorption of the chemicals can be controlled to obtain the proper amount needed for effective protection. However, these methods are more complicated and require expensive equipment.

Table 1. Relative durability of some Philippine woods from stake tests of heartwood specimens.

SPECIES Common Name	SCIENTIFIC NAME	CLASSIFICATION1/ Nano	Aguilar	Siriban
Acacia	*Samanea saman*	25	21 (MD)	(SD)
Akle	*Serialbizzia acle*		90(VD)	
Almaciga	*Agathis philippinensis*	5	13 (P)	(ND)
Almon	*Shorea almon*	20	15 (P)	(SD)
Amugis	*Koordersiodendron pinnatum*		25 (MD)	(D)
Anabiong	*Trema orientalis*		5 (VD)	(P)
Antipolo	*Artocarpus blancoi*		60 (D)	
Anubing	*Artocarpus ovata*	100	100 (VD)	
Api-api	*Avicennia officinalis*		5 (VD)	(ND)
Apitong	*Dipterocarpus grandiflorus*	30	16 (P)	(ND)
Apitong, broad winged	*Dipterocarpus speciosus*			(ND)
Apitong, round leaf	*Dipterocarpus orbicularis*			ND)

Continued on page 46