CURRENT PROBLEMS IN THE CONSERVATION OF WOOD IN THAILAND

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In Thailand, wooden artefacts are composed principally of hardwood. Preferable hardwoods often contain natural wood preservatives. These toxic substances prevent or retard decay. Moreover, these artefacts have normally been treated with traditional wood finishes to reduce the rate of swelling and shrinking. The major causes of deterioration of wooden artefacts are tropical rainy climate, solar radiation, insects and micro-organisms. A series of experiments to solve these problems is under way.

INTRODUCTION

Wood is a versatile material that is easily worked from a natural state into many objects that are necessary in everyday living. In Thailand man has utilized wood from the earliest times as a renewable resource for tools, weapons, shelters, utensils, containers, and artistic creations. Wood is probably the oldest structural material since it is in some respects ideal for building purposes. It is light but very strong for its weight. It is easily accessible and worked.

A great number of wooden artefacts and buildings survive. Wood was an integral part of houses, temples, palaces, offices, and almost every kind of architectural structure. Wood is also ideal for the construction of vessels, furniture, musical instruments, sculptures, tools and containers.

Carved decorations are always popular for Thai style buildings. Wood carved into decorative patterns adorn windows, doors and gables. Thai furniture is often carved out of wood, such as cupboards, tables, chairs, beds and mirror frames. They are generally painted, guilded and lacquered. A number of them are decorated with mother of pearl, coloured glass, mirror and ivory.

TYPES AND PROPERTIES OF WOOD

Wood is made up of bundles of fibres which run lengthwise down the trunk. These fibres are more or less well-defined according to species, and form the grain. The fibres can be close and compact or loosely bound together forming hard and soft woods respectively.

Thailand lies entirely within the region of tropical and monsoonal climate. Therefore, the forest is composed principally of hardwood trees. Hardwood is the wood of deciduous or broadleaved trees. The conducting tissue in hardwoods consists of vessels or pores. The vessels can be seen in transverse section as holes in characteristic patterns, and in longitudinal section as long thin furrows. The cells of these woods are large and quite noticeable. Under a microscope, the cell structure of a hardwood is open-ended. The open cell spaces are larger and more numerous in the rainy phase of the annular ring than in the dry phase of the wood. The size and shape of the cell structure varies in the various woods.

Hardwoods are not always hard. The strengthening tissues of hardwood consists of fibres. The important strength characteristics of hardwoods are usually dependent on the wood fibre construction.

These woods can be cut along the grain or across the grain, each kind of cut producing a well-marked figure on the surface which is often used decoratively.

Physical properties of some common hardwoods in Thailand:

	Bending strength kg/cm²	Natural durability years
Afzelia xylocarpa Craib	1229	11.1
Balonocarpus heimii King	1753	14.0
Chukrasia velutina Wight & Arn.	1111	> 6
Cotylelobium melanoseylon Pierre	1489	> 9
Diospyros mollis Gr i f f.	1789	> 15
Dalbergis oliveri Gamble	1781	> 15
Dalbergia cochinchinensis Pierre	1751	> 15
Dipterocarpus obtusifolius Teijsm.	1200	7.1
Dipterocarpus tuberculatus Roxb.	1297	7.1
Hopea adorata Roxb.	1172	7.7
Hopea ferrea Pierre	1609	10.5
Pt erocarpus sp.	1334	> 10
Pentacme simensis	1352	> 10
Shorea obtusa Wall.	1732	> 10
Sindora sp.	1221	> 10
Tectona grandis	1023	16
Terminalia mucronata Craib & Hutch.	1800	8.4
Xylia kerrii Craib & Hutch.	1305	> 10

Among the many kinds of wood available in Thailand, teak has long been widely used. The teak tree is native to the tropics of Asia. This wood is similar in coloration to the black walnut, being mainly yellowish-

golden brown. The colour and durability of the teak is dependent largely upon the locale of the tree. The weight per cubic foot is 36–40 lbs. Its specific gravity is 0.642.

Teak is not classified as a hardwood. It yields easily to the will of the carver who may impress in it the nervous cut of the chisel. Teak stands fairly well under the exposure of the atmospheric agents, but in the long run, when exposed outside, although protected by a coat of wood finish, it is degraded by the rain. In addition, teak's texture contains such toxic chemicals as 2–methyl anthraquinone, lapacol, tectol and dehydrotectol, so it has the advantage of not being susceptible to attack by termites, beetles and fungi.

The natural resistance of certain hardwoods result from the accumulation of natural preservatives in the wood. Several woods are reported to contain toxic chemicals, e.g. *Dalbergia floribunda* Craib and *Xylia kerri* Craib & Hutch. (Red wood) contains Pterocarpol ($C_{15}H_{26}O_2$) and Homopterocarpin ($C_7H_{16}O_4$), *Dalbergia cochinchinensis* Pierre contains Latifolin ($C_{17}H_{18}O_4$), and *Anthocarpus lakoocha* contains 2,4,3,5, tetrahydroxy stilbene. The amount and distribution of such chemicals vary considerably from tree to tree of a given species. These substances prevent or retard decay. The ancient craftsmen were wise enough to utilize durable woods. They also used only the heartwood of well-seasoned timbers.

In addition, wood has normally been treated with wood-finishes to protect its surface against mechanical, physical, and chemical influences or to enhance the natural beauty of the wood. Surface coatings usually aim at reducing the rate of swelling and shrinking by minimizing the exchange of moisture into or out of the cell wall structure of the wood.

Common traditional wood finishes are mineral oils, rosin, shellac, paints, varnishes, and lacquer. The cheapest and most common wood finishes are mineral oils mixed with red pigments. This kind of wood finish is not very effective.

The most effective wood finish is lacquer. Important wooden artefacts have usually been coated with several layers of lacquer. Thai lacquer is made from the sap of the lacquer tree (*Melanorrhoea usitata*), which under suitable conditions solidifies, and becomes a hard material of great strength capable of being polished and carved. It has long been used as a protection and watertight covering for wood. Hardened lacquer film is hard and flexible at the same time, and exhibits excellent resistance to weathering.

The natural colour of lacquer is black. But it can be modified by the addition of various pigments e.g. mercuric sulphide, arsenic sulphide, etc. The decoration designs are usually made of coloured lacquer, mother-of-pearl, and glasses. Gold leaf is widely used as a surface decoration in Thailand.

However, lacquer exposed outdoors generally deteriorates due to the ultraviolet radiation and the solar heat. It changes colour and loses luster. Long periods of exposure causes scaling or flaking. When cracks are present the wooden materials start to decay.

CAUSES OF DECAY

As an organic material, wood is susceptible to disintegration and destruction by several agents of deterioration. The locality and conditions of storage and use largely determine the nature of the deterioration.

I. Weathering

Wood is susceptible to changes in humidity and extremes of temperature. The rate of wood degradation is accelerated when artefacts are continuously exposed to the atmosphere. Much wood deterioration is a direct result of high humidities caused by poor maintenance and ventilation. Objects that are frequently wet by rain, develop a checquered surface as a result of different expansion and contraction of the wood. Long periods of exposure result in a finely broken surface that is easily eroded by wind. The surface fibres become friable and actually disintegrate. These situations are complicated by the action of solar radiation, and by the presence of micro-organisms. The heat of direct sunshine accelerates the rate of drying, the wood cannot shrink as a whole

and breaks. East- and west-facing artefacts are destroyed faster than those facing north and south.

During the rainy season some parts of Thailand are overwhelmed by typhoons from the east or southeast. These winds, rains, and high tides sometimes cause heavy floods. Therefore, the east- and southeast-facing surfaces show a much greater degree of deterioration than other surfaces. In addition, sunlight also affects the deterioration of wood. Ultra-violet radiation is absorbed in the surface of the wood substances. The surface of most exposed wood turns to a silvery grey colour due to photochemical changes in the cellulose. At first lignin is decomposed, and this colours the wood brown. When the decomposed lignin is bleached away, light grey delignified cellulose remains.

II. Wood-boring insects

Termites

The most important group of insects injurious to wood are termites. The ground dwelling termites or subterranean termites usually attack wood which is in direct contact to the ground or adjacent to crevices in masonry or concrete, through which they travel to reach their food. They have a fixed nest from which the workers move out in search of wood and to which they return with their spoil. They build earth-like runways over brick, stone and concrete foundations to reach wood. They require a constant supply of moisture for their existence. The presence of subterranean termites in wood may not be discovered until the more seriously attacked pieces of wood begin to show definite evidence of decomposition. The common species are *Coptotermes havilandi* and *Coptotermes gestroi.*

The wood-dwelling termites are entirely wood inhabiting, never entering the ground, and require no moisture other than that which they can derive from the wood itself. At the time of swarming, the alates or winged reproductives enter the wood directly from the air. Then they excavate galleries in the materials. Infestation is frequently overlooked especially in the early stages of the attack. The major species are *Coptotermes domesticus, Coptotermes thailandis,* and some *Glyptotermes spp.*

Powder-Post beetles

This group of insects infest wood under a wide range of conditions.They attack softwoods as well as hard-woods, heartwood as well as sapwood, and green logs as well as seasoned wood. The larvae or grubs of these insects bore through wood for food and shelter, leaving the undigested parts of the materials in the form of a fine powder. Since the larvae work in the inner portion of the wood, considerable damage has already occurred before it is discovered.

Amongst the most important families of wood-tunnelling larvae are the Lyctidae and Bostrichidae. The species *Minthia rugicollis* (Walker) of the family Lyctidae causes extensive damage to wood products with high starch content. The adults of this species are only about 1/8 inch long and have brown wings covered with yellowish scales. The damage is accordingly confined to the sapwood of seasoned wood (moisture content 6–30%). The following timbers are known to be susceptible to attack by *Minthia rugicollis* (Walker); Artocarpus, bamboo, Bombax, *Hevea brasilensis* Muell. Arg, for example.

The species *Lyctus brunneus* are also common. The young larvae, when hatched, are about 0.65 mm long and 0.23 mm wide and they are creamy-white in colour. They usualy attack bamboo, Bombax, and pine.

Major Bostrichid beetles are *Heterobostrychus aqualis* or wood-borer and *Dinoderus minutus* Fabricius or bamboo-borer. Another important wood-borer is *Stromatium longicorne* of the Cerambycidae family. These insects are important pests in Southeast Asian countries. Great damage is done by the larvae which bore their galleries into the wood. *Heterobostrychus aqualis* prefer the sapwood of certain woods which have poor natural decay resistance and high moisture content (> 30%). *Dinoderus minutus* have the common habit of reducing wood to powder. The larvae bore their tunnels parallel to the long axis of the wood and usually occur just beneath the inner walls. The tunnels are filled with tightly packed frass. The outer and inner skins of the wood remain intact until they are so fragile that they rupture under a slight stress.

III. Wood-inhabiting micro-organisms

Microbiological growth is one of the most deleterious factors in the deterioration of wood. Architectural structures and wooden artefacts exposed out of doors are most prone to micro-organism attack because they usually become wet. Decay is most prevalent in wood in direct contact with moist soil or in locations where moisture collects and cannot readily evaporate. It is also prominent in wood exposed unpainted to the weather. The decay process usually proceeds when the moisture content rises above the fibre saturation point. Extensive damage sometimes occurs in interior artefacts where the moisture content of the wood becomes abnormally high.

Microbiological action on wood is a cause of numerous undesirable situations, for instance, loss in water repellency, loss in strength and discolouration. Decay fungi disintegrate the cell walls and thereby change the physical and chemical characteristics of the wood. The normal colour of the wood is more or less modified. Microbiological activities often darken and disfigure the exterior surface of wood. The decompositon of the wood by micro-organisms usually causes shrinkage, warping and cracking. The strength and density of the wood is reduced. The wood is friable, light and falls to powder under pressure.

Microbiological deterioration of wood is attributable to fungi, bacteria, algae, and lichens. Frequently occurring fungi on wood are *Trichoderma spp., Aspergillus spp., Aureobasidium spp., Penicillium spp., Cladosporium spp., Fusarium spp., Rhodotorula spp.*, and several unknown species. Many fungi are cellulytic, that is capable of causing the breakdown of cellulose through the action of enzyme systems. Some of them are able to produce organic acids.

Algae and lichens are densely found on exposed and unprotected wood. Their growths are always associated with moisture retention. It was found that the number of micro-organisms is greatest in the rainy season.

CONCLUSION

The major causes of deterioration of wooden artefacts and wooden buildings in Thailand are climate, solar radiations, insects and micro-organisms. The tropical rainforest has proven to be a severe environment for both organic and inorganic materials. Moisture, through its direct action, or otherwise, is the prime agent in tropical deterioration. In addition, the short wavelengths of visible and ultraviolet radiations are powerful enough to disintegrate wood surfaces. The presence of insects and micro-organisms often cause extensive damage.

These problems are serious and require urgent intervention. The application of appropriate water-proof materials and wood preservatives is, therefore, the most efficient method. A series of experiments to solve these problems is under way. The project needs continuous and long-term observations in order to get adequate information

For historic buildings, planning for the restoration processes should be carefully undertaken beforehand. Consultation among conservation scientists, architects and restoration engineers is essential. There should be sufficient preparation in the study of various problems in restoralion so that there will be enough data to establish a work plan.

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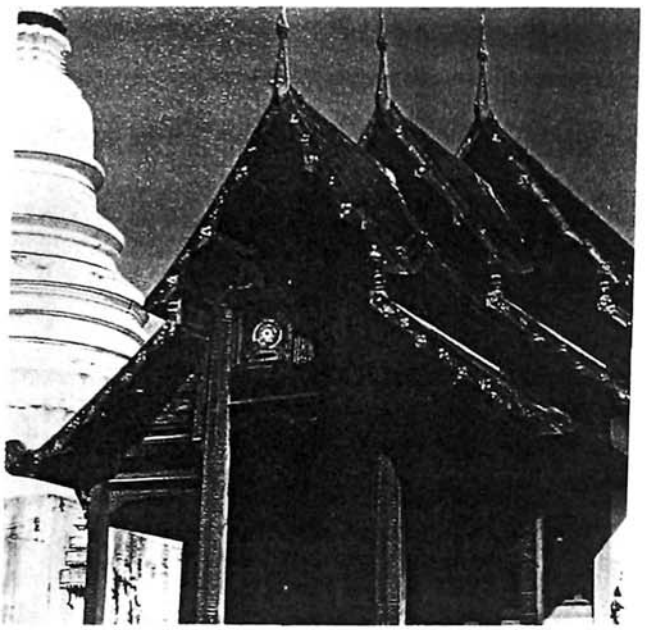
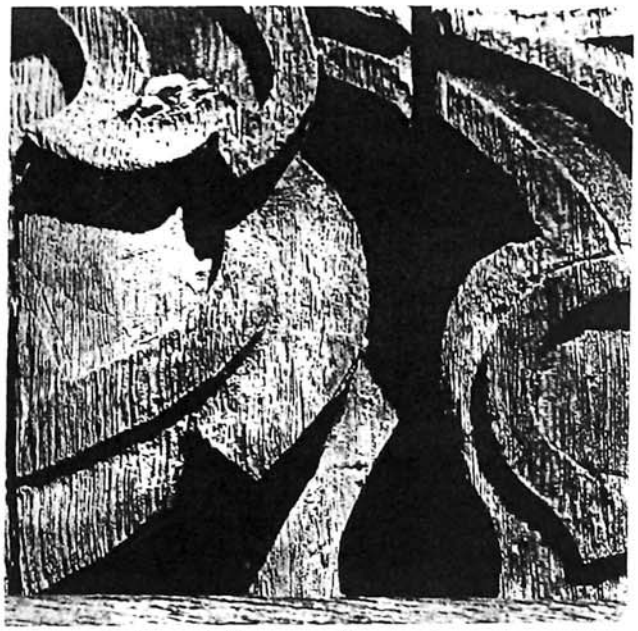
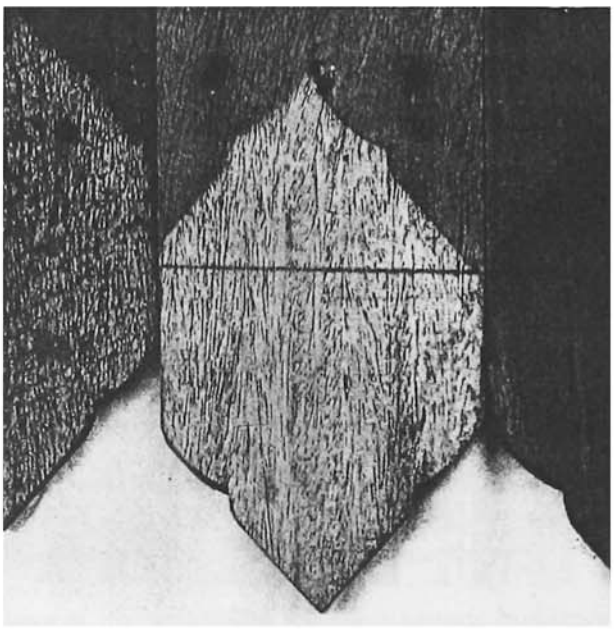


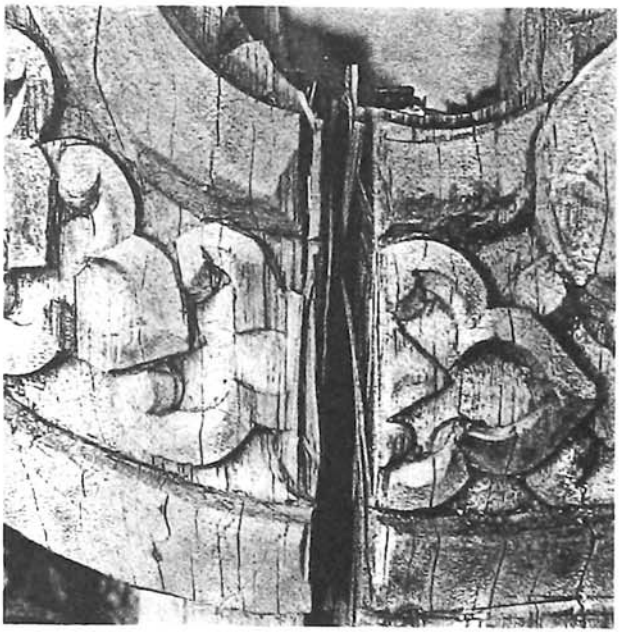
Wooden building



The heat of direct sunshine accelerates the disintegration of exposed surfaces

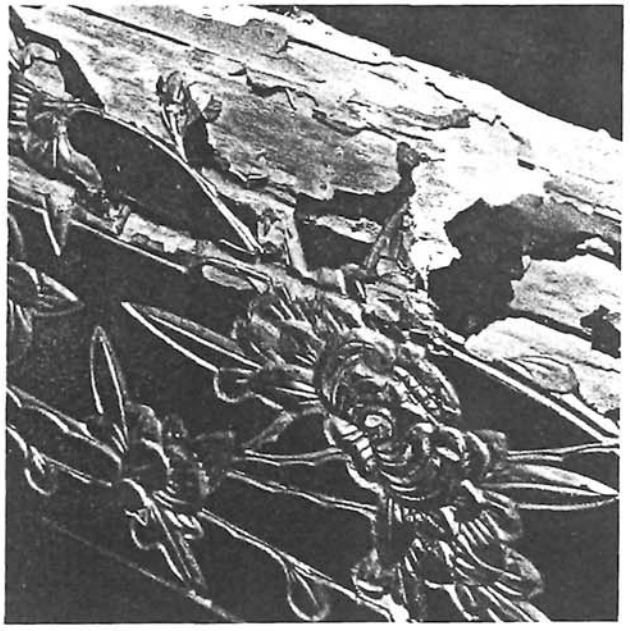


Colour changes on the surfaces of exposed wood



Damage caused by changes in humidity

The decomposition of wood by micro-organisms



Wood-dwelling termites excavate galleries in artefacts