

A REVIEW OF THE CAUSES OF WOOD DETERIORATION AND SOME PREVENTIVE MEASURES

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Abstract

This paper examines the problems and prospects associated with the structural use of wood. The paper reveals that wood deterioration is caused by microbiological and entomological agents and weathering among others. Deterioration due to microbiological and entomological agents is as a result of the actions of bacteria, fungi and insects while weathering is as a result of the actions of water, light and heat. The paper also suggests that the deterioration due to these two main causes can be prevented through the use of naturally durable woods, wood preservatives and site and soil treatments. The paper concluded by observing that wood is the most widely used of all building materials because of its abundance and good workability.

1. Introduction

Wood is a fibrous and complex chemical material. It is made up of large chemical identities such as cellulose, lignin, ash and cellular extracts. Variations in different wood varieties are due to different proportions of these four components and variation in individual cellular structures. The type and amount of these extracts may have pronounced effects on the properties (such as durability, colour and odour) of such wood (Mohammed, 1991).

Biodeteriogens belong to many groups of flora and fauna (DeGroot and Esenther, 1978). This review addresses the impact of bacteria, fungi and insects upon wood used or exposed to various conditions, and identifies criteria for the design of micro-organism and insect resistant wood structures.

Destruction of wood by insects is by successive mechanical removal of small bits of tissues from the larger wood substrate, whereas bacteria and fungi induce a biochemical attack within individual cells of wood tissue. This difference in mode of action partly accounts for the types of attack that occur within different wood moisture contents. Wood moisture content is considered the key environmental factor that must be either controlled or reckoned with in the design of durable wood structures (DeGroot and Esenther, 1978).

Wood is an extremely durable material even under adverse conditions, but the durability depends upon the environment. Buried under the ground, fully exposed to the weather, submerged in water or hidden in an ancient tomb, it can last for tens of centuries (Feist, 1978). There are many examples of structures, ships, and other wooden objects that have survived centuries of use (Browne, 1960; Borgin, 1969).

The advantages of wood as a structural material include:

- i. Wood is an abundant resource. It is easily worked, structurally sound, and a reasonably good insulator (Phillips, 1981).
- ii. Wood is a renewable material. It renews itself unaided although its renewal could be greatly accelerated by modern techniques.

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- iii. Wood is a beautiful material and has high aesthetic value.
- iv. Wood as a structural material is quite easily prefabricated, and therefore the work at the site of construction could be greatly reduced.
- vi. Maintenance and repair of wooden structure are quite easy. Only simple tools like saw and hammer are needed.
- vii. Versatility in use. Wood can be used for the construction of many structures like houses, silos, bridges and dams.
- viii. Wood is not corrosive.

2. Causes of wood deterioration

2.1 Microbiological and entomological causes

Wood is a biological material and is subject to attack by microbiological and entomological agents which include bacteria, fungi and insects. The actions of these agents reduce the life span of wood. Service life can be greatly improved by taking care of these agents of deterioration.

Bacteria

Bacteria and fungi are important microbiological agents for natural decomposition of organic materials. Bacteria are mostly single-celled organisms, passively dispersed within the environment. They grow within or upon a food substrate. Bacteria require free water to grow and are common in saturated, water-soaked, or moist wood. Some cause serious disease to plants and animals. The initial consequence of bacterial infestation of wood is a marked increase in permeability, a slight decrease in toughness, but no loss in specific gravity. Increased permeability is associated with decomposition of materials stored in the rays, possibly destruction of ray parenchyma cells, and attack on pit membranes (DeGroot and Esenther, 1978).

Wood-decay fungi

Wood-decay fungi are usually grouped into three categories: white rots, which tend to bleach the affected wood; brown rots, which produce a brown, crumbling type of decay; and soft rots, a term originally coined to describe a progressive softening of the surfaces of wood products (DeGroot and Esenther, 1978).

Stain fungi

The fungi in this group do not significantly affect the strength or stiffness of the wood but its appearance. Stain fungi produce bluish black to brownish discolourations in sapwood of recently cut trees, in rewetted trees, and in forest products. All woods are susceptible to these fungi, which are common world-wide. The most important species are blue stains which attack both hardwood and soft wood. The stain fungi obtain their food from the carbohydrate stored within the cell of sapwood. Stain fungi may continue to grow in softwood until the moisture content drops below 24% and in hardwood until the moisture content drops below 55% (DeGroot and Esenther, 1978).

Moulds

The moulds are another category of fungi which decay wood. They are similar to those found in bread and cheese. They produce a softening growth on the wood surface and usually appear on seasoned wood in a warm humid place where little or no drying can take place. They can be controlled easily by crushing from the surface since they do not penetrate wood

deeply as those mentioned above. Under favourable conditions, common moulds can cause substantial losses in weight and strength of wood fibreboards.

Insects

(i) Termites: Termites are by far the most economically important wood-destroying insects (DeGroot and Esenther, 1978). They attack all kinds of wood. Depending on their type, termites vary in moisture requirement from very high to very low. Termites are found in warm areas and can be classified as subterranean termites, dry-wood termites and damp-wood termites. Damp-wood termites require damp wood for successful colonization. Subterranean termites require high moisture content. They can also attack very dry wood as long as there is access to a source of water. The range of moisture tolerance by dry-wood termites varies greatly depending on the species. They are able to meet much of their moisture requirements with metabolic water. Subterranean termites cause more damage than the other two categories. Termites nest in the ground and their principal food is cellulose, which is digested by protozoa in the digestive tract of the insect. The cellulose is removed from the wood by the worker termite (by excavating tunnels and creating chambers which are later used as shelters). The reduction in strength they cause is as a result of the galleries they leave behind. The galleries tend to weaken the wood structural member. Termites enter the building through very small cracks in the foundation and then to the wood. They can also move in through the column (e.g. wooden columns embedded in concrete slabs).

(ii) Powderpost beetles: The term 'powderpost' was originally applied to these beetles because they attack wood and leave residue in a finely pulverised condition. Powderpost beetles begin attacks on drying trees, green logs, or wet wood. Normally, they require the presence of bark to begin an attack. The attack by powderpost beetles is confined to the sapwood of the hardwoods. The main food they go for is the cellulose.

(iii) Carpenter ants: Carpenter ants nest in wood and cause a considerable amount of damage to poles and buildings. They invade trees after accessing them through the wounds. They also live in colonies consisting of a variety of individuals and they damage wood to create galleries so as to provide more accommodation. They do not actually utilize wood for food; therefore, they are not deterred by natural unpalatability factors. They derive food from secretions of other insects like millibugs and grasshoppers. They invade wood primarily for accommodation. The ant nest may be detected by the activity of the workers - accumulation of piles of sawdust and fragments at the base of the structure.

2.2 Deterioration due to weathering

In this part of the world, weathering results from the wetting and drying of wood. In temperate climates it results from freezing and thawing. Wood exposed outdoors without protection undergoes:

- i. photodegradation by ultraviolet light,
- ii. leaching, hydrolysis, and shrinking and swelling by water,
- iii. discoloration and degeneration by decay micro-organisms,

Wood surfaces exposed to weather without any protection erode, change colour and get roughened by photodegradation and surface checking. In the absence of decay, wood exposed to the weather can last for centuries. Although physical and chemical changes occur due to weathering, the changes affect only the surface of the exposed wood. Some few millimetres under the surface of the wood is essentially unchanged and unaffected.

In weathering of smooth wood, original surfaces become rough as grain raises and the wood checks, and the checks grow into large cracks. Grain may loosen and pull away from fasteners. The roughened surface changes colour, gathers dirt and may become unsightly. The wood loses its surface coherence and becomes friable; splinters and fragments can come off.

Weathering factors

(i) Water: The principal cause of wood weathering is frequent exposure of the surface to rapid changes in moisture content (Brown, 1925; Borgin, 1968). Rain or dew falling upon unprotected wood is quickly absorbed by capillary action in the surface layer of the wood, and then absorbed within cell walls. Water vapour is taken up directly by absorption under increased relative humidity. Absorbed water has been shown to virtually add its volume to that of cell walls, resulting in swelling (Feist, 1978). Stresses are set up in the wood as it swells and shrinks as a result of moisture gradients between the surface and the interior. These stresses may result in warping, cupping and face checking.

(ii) Light: Ultraviolet (*UV*) light degrades the organic materials in wood. Photodegradation by *UV* light induces change in chemical composition, particularly in the lignin (Webb and Sullivan, 1964).

(iii) Heat: Variation of temperature affects wood through expansion and contraction, which result in warping, cupping and face checking. Also, microbial activities are enhanced by conducive levels of temperature.

3. Prevention of deterioration

3.1 Naturally durable woods

Use of naturally durable woods was perhaps one of the earliest measures taken to prevent wood deterioration. Subsequent approaches include: treatment of wood products, structures, and/or the immediate environment. In the 'durable' species, it is the central core of heartwood that possesses resistance. Toxic extractable substances deposited during the formation of heartwood are the principal source of decay resistance (DeGroot and Esenther, 1978). Wood hardness may retard the rate of insect damage, but it is not considered to be a major resistance factor.

3.2 Wood preservatives

Treatment of wood with preservative chemicals contributes to resistance against bacteria, fungi and insects. The degree of protection rendered is dependant on the treating process, level of treatment and the chemical employed. Treatment processes provide either a superficial or an in-depth protection of wood. Chemical effectiveness depends on method of application if the preservative has proven ability as a toxicant against wood destroyers, and if the wood allows an acceptable degree of penetration of the preservative liquid. Superficial protection of wood with water-repellent preservatives is achieved with short dips of green lumber in treating solutions, spraying, and brush-on application at the construction site. Such treatments do not provide protection for wood used in contact with the ground or in other uses with equally severe decay hazard.

Pressure treatment of wood with preservatives does not provide protection for all woods against all organisms. Certain woods are difficult to treat, and chemicals vary in their effectiveness against biodeteriogens (DeGroot and Esenther, 1978). Nevertheless, adequate pressure treatments with preservatives do significantly extend the service lives of otherwise

nondurable woods. There are two types of pressure methods, namely, full cell and empty cell. The methods refer to the amount of preservative left in the treated wood. For example, as the name implies, full cell method will tend to leave behind the greatest amount of chemical while the empty cell method will leave the wood cells untreated. However, both methods give good distribution with a limited amount of preservative. The amount of chemicals applied can be measured in terms of chemical retention {kg (chemical/m³ (wood))}.

Preservative chemicals are classified into three groups, namely, preservative oils (e.g. creosote), water-borne (e.g. aqueous solution of CuSO₄) and organic solvent type (e.g. a kerosene solution).

3.3 Site sanitation and soil treatment

Site sanitation and soil treatments provide protection for structures against subterranean termites. Wood debris and other similar materials buried at the building site provide foodstuffs which termites require for the establishment of new colonies. Removal of such materials from around the structure is a recognized first step in the control of subterranean termites (DeGroot and Esenther, 1978). The treatment of soil at the time of construction is required when termites are already present at the construction site or are likely to infest the site soon thereafter.

3.4 Protection through designs

Designs that protect wood above ground from decay either prevent wood from exposure to water or employ decay-resistant woods where high moisture contents are prevalent. Drainage patterns for surface water should be away from buildings. Bases of unprotected columns should be elevated above hard surfaces upon which water may collect, be treated with a water-repellant preservative, or be constructed from decay-resistant wood. Adequate roof extensions, or drainage gutters should be used to prevent water draining from rooftops from coming into contact with exterior wood below.

3.5 Protection against weather

Wood exposed to weather can be protected by paints, and varnishes. Paints provide the most protection to exposed wood surfaces, since they are generally opaque to the degradative effects of ultraviolet light and protect wood to some degree against wetting. Varnishes are similar to paints but do not perform satisfactorily and hence require frequent refinishing.

3.6 Protection against fire

Wood combustibility can be prevented by treating the wood with fire retardants. Examples of fire retardants include zinc chloride and boric acid. Most of these fire retardants are applied as aqueous solutions by pressure impregnation. However, some formulations of these chemicals can equally be applied as coatings.

Fire hazards can be reduced by design through sacrificial design, elimination of rough surfaces, rounding up sharp edges and compartmentalisation (areas where wood can be subjected to fire should be identified and non-combustible materials used in those areas).

4. Conclusion

Wood is the most widely used of all building materials. There are many reasons for this popularity. Wood is abundant, workable and structurally sound. In the absence of deterioration caused by weathering and microbiological and entomological agents, wood can

last for centuries. Finally, in spite of all the limitations, chances are high that the use of wood will continue in the future.

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