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Please note

Wooden objects have been recovered from the tombs of ancient kings in a perfect state of preservation, and wooden roof structures have often lasted for centuries without deterioration. Many old wooden implements and pieces of furniture in homes and museums are as strong and serviceable today as they were when made sometimes hundreds of years ago. Pile foundations, too, in water and in soil, demonstrate the durability of wood.

On the other hand, there are Biblical references to fungal decay which indicate that it has been a problem since man first learned to build with wood. At the present time cases come to the attention of the Division of Building Research where extensive rotting has taken place of wood floors and roofs in as little as two or three years. Sometimes, when incipient decay has gone unnoticed, almost complete destruction has occurred in only a few years. It is usually difficult or even impossible to repair such damage, and the only solution may be the complete replacement of the building element involved.

Wood does not decay simply because it is wet, but because it has been attacked by fungi under rather special conditions of moisture and temperature. The disintegration and ultimate dissolution of wood substance, known as rotting, is the result of the growth of fungi in the wood tissue. In order to prevent decay it is necessary to know the nature of the fungi that attack wood and the conditions necessary for their growth. It may then be possible to modify its service conditions or treat the wood to prevent the start of fungal growth.

Nature of Fungi

Fungi are generally regarded as a highly specialized class of plants that exhibit great diversity of form, are exceedingly numerous in both numbers and species, and have the means for incredibly rapid multiplication. They do not possess chlorophyll, and unlike green plants are unable to build up sugar and starch from the carbon dioxide in the atmosphere. They feed on and thus decompose a wide variety of organic food materials. They are reproduced by bodies known as spores, which roughly correspond to the seeds of higher plants except that they are very much smaller and usually produced in much larger numbers.

When the spores of fungi fall on a suitable medium under moist conditions they germinate somewhat in the manner of seeds. The spore wall bursts and a minute tube, called a hypha,

grows forth. The hypha branches and the tiny tubes begin to permeate the soil, compost or wood medium on which the hyphae are growing. With wood-rotting fungi the hyphae spread through the wood, disintegrating the cell walls and reducing their strength. The web or mat of tissue formed by the branching hyphae is known as the mycelium or spawn. It may take the form of root-like strands by the aggregation of hyphae, or thick sheets by the matting of the hyphae.

When fungus has been growing for some time and has built up a sufficient mass of mycelium, it usually proceeds to form fruit-bodies, sometimes called sporophores, on the surface of the medium in the form of toadstools, fleshy or woody shelves, or encrusting sheets. Their appearance usually indicates a fairly advanced stage of wood decay. It is the fruit-body on which fresh spores are formed, and their location on the external surface allows for discharge into the air to complete the growth cycle.

The reproductive power of fungi is fantastic when it is considered that a square-foot-area of dry-rot fungus fruit-body can produce five million spores per minute over a period of many days. These microscopic dust-like particles are shed in clouds from the mature fruit-body, and being very light can remain suspended in the air and drift for long distances. There is therefore every likelihood that spores of wood-rotting fungi will be present wherever wood is used.

Conditions for Fungal Growth

Whether or not wood decays will depend on the conditions to which it is exposed and whether these conditions are favourable for fungal growth. There are five essential conditions for germination and growth, and it will normally be possible to prevent wood decay if any one of them is removed. These conditions are listed below:

1. source of infection,
2. suitable substrate (food),
3. moisture,
4. oxygen,
5. suitable temperature.

Source of Infection.

If infected wood is in contact with sound wood, the disease will spread to the sound wood by normal growth of the fungal hyphae from the decayed wood, even without the production of spores. Infection may also spread directly from soil to wood in contact with it, because most soils contain quantities of organic matter in which fungal organisms are growing. Even when there is no contact between sound wood and infected materials, the space between can be bridged by airborne spores, as has already been indicated. Although some locations may be worse than others, it is almost certain that in any area some airborne fungus spores will be present.

Substrate.

Wood provides a suitable substrate for fungus growth, and the cellulose, lignin, and other components of the cell walls and wood tissues provide suitable food. Some species of wood are more naturally durable because they contain substances toxic to fungi, and the heartwood of these will only be attacked by certain fungi. It can be generally assumed, however, that no wood is entirely immune to attack if placed in conditions favourable to fungal growth, allowing for some variation in the susceptibility to decay of different kinds of wood. It is possible to eliminate the food supply by treating it with certain substances toxic to fungi but harmless to men and animals. This is the basis of wood preservative treatment.

Moisture.

The development of fungi on wood is largely controlled by the moisture content; all wood-decaying fungi require moderate amounts of water for growth. If there should be insufficient moisture, after growth has started, the fungi do not necessarily die, but will probably become

merely dormant. Active growth can start again, sometimes years later, when sufficient moisture returns.

It is necessary for the substratum to be moist and the humidity of the surrounding atmosphere to be high for the germination of fungal spores. Wood always contains a certain amount of moisture; air-dried wood may contain as much as 18 per cent, although it is generally considered that wood in this condition is immune to fungal attack. About 35 to 50 per cent moisture is required for wood rotting fungi to flourish, the actual moisture content depending on the species of fungi and the kind of wood. Fungal spores do not germinate readily on wood that has a moisture content below the fibre saturation point, commonly reached at around 25 to 30 per cent. Wood cannot be considered immune, however, until the moisture content is below about 20 per cent, as is the case in most buildings in Canada (**CBD 85**, **CBD 86**). When wood is put into service at such low moisture contents, subsequent conditions can cause high local moisture contents, which may be conducive to fungi growth. Once started fungi can produce a certain amount of moisture by the chemical decomposition of the wood, and can thus increase the moisture content of the wood if evaporation loss is low.

Oxygen.

All wood-rotting fungi require some air for growth, and many species die quickly if they are deprived of it. The air-moisture balance in the cells within the wood, therefore, is a most important factor controlling the susceptibility of wood to decay. Fungi need oxygen for the oxidation of sugars, which they use for growth and the supply of energy. The breakdown of carbohydrates in the respiration process produces water and carbon dioxide.

If there is no interchange of air, the fungus will die from suffocation by carbon dioxide. For example, when cell spaces are completely filled with water, as they are when wood is submerged in water, the air supply is cut off and growth is stopped. Burial in the ground below the water table will similarly cut off the air supply.

Temperature.

The growth of wood-rotting fungi is affected by temperature in much the same way as the growth of ordinary green plants. It is faster in warm weather than in cold. There are variations in the response to temperature, and for each species there is an optimum at which growth is most rapid. Tests by the Forest Products Laboratories and others on a number of species of fungi common in Canada indicate that temperature conditions for optimum growth range from 65 to 95°F. All fungi show little or no growth at freezing temperatures or slightly above, but most wood rotting fungi are not killed by temperatures well below the freezing point. They can withstand the cold of winter in a dormant state and can recommence active growth when temperatures increase again if other conditions are right.

Growth becomes less rapid as temperatures are increased above 95°F and ceases for most fungi at temperatures slightly in excess of 100°F. Prolonged exposure to temperatures slightly above the maximum for growth, or even short exposure to temperatures much above the maximum, can kill fungus completely. The actual death point is influenced by temperature, length of time and moisture content.

The practical conclusion, therefore, is that in most locations where wood is used in building elements it is more susceptible to decay in summer than in winter.

Other Factors.

In addition to the essentials for growth of wood-rotting fungi. there are other factors that may have an effect. Light usually has a retarding influence, and exposure to intense light such as bright sunlight can kill the mycelium of some species. Most species grow more vigorously in subdued light, but some do not grow normally in total darkness.

The acidity and alkalinity of the wood can also have an effect. Most wood-rotting fungi flourish on materials that are slightly acid, and very few can tolerate alkaline conditions. Organic acids

are produced by fungal growth, thereby increasing wood acidity. This may be a factor in the corrosion of metal fittings in contact with the wood.

Treatment of wood with nitrogenous materials stimulates growth of wood-rotting fungi, and contamination of wood by urine or manure can increase susceptibility to decay.

Effects of Decay

The decomposition of wood by fungi is of two main types, often referred to as brown rot and white rot. In brown rot the cellulose and its related pentosans are attacked while the lignin is more or less unchanged. This causes wood to darken in colour, and to shrink and cross-crack into cubical or oblong pieces that can be readily broken and crumbled between the fingers into a brown powder.

In white rot all the components of the wood, including the lignin, may be decomposed and used by the growing fungus. White rot does not produce cross-cracking, but the wood becomes paler in colour, sometimes in pockets or streaks of various sizes with firm wood in between, and may eventually become a fibrous whitish mass. In some white rots, however, the cellulose may remain intact.

Decayed wood is less dense than sound wood, may suffer a loss of strength. even with incipient decay, shrinks excessively on drying, shows changes of colour and often a change of smell. In the advanced stage of decay it may become punky, soft and spongy, stringy, ring-shaked, pitted or crumbly. The loss of weight for brown rot is about 70 per cent, since the lignin still remains, but for white rot total destruction is possible. Even slight decay can reduce the toughness or shock resistance of wood and allow it to break easily under impact although it may still appear hard and firm to the touch. Fungi that cause brown rot usually bring about a more rapid drop in most strength properties than do those that cause white rots, but both types soon reduce the toughness of any wood they attack. The fresh and resinous smell of sound wood is usually replaced by a distinctive mushroom odour as wood decays, and some wood-rotting fungi produce characteristic aromatic or sweet smells.

Types of Fungi

By examination of rot and any fruit-bodies that may have developed, wood pathologists can usually identify a species with moderate certainty, but it may sometimes be difficult even for specialists to make such an identification and determine whether the species are active or inactive. Extensive laboratory work may be necessary. Expert advice is essential for detailed determination, but the building practitioner should be generally aware of the fungi that may be involved.

The Forest Products Laboratory of the Canadian Department of Forestry and Rural Development lists five types of building-rot fungi that are of importance. These are *Lenzites saepiaria, Lenzites trabea, Fomes roseus, Lentinus lepideus,* and *Merulius lachrymans*. All can be active agents in the destruction of wood in damp locations, but two of the five are perhaps the most common. *Lenzites saepiaria* is probably the most active destroyer of softwoods and has been identified in many of the rotted wood roofs in Canada. *Merulius lachrymans*, sometimes referred to as the true "dry-rot" fungus, does extensive damage to buildings in Europe and also occurs fairly frequently in Canada. It has great virulence when once established.

Lenzites saepiaria is a brown rot, which in its early stages yellows and softens wood, and may give it a laminated appearance because decay begins and proceeds most rapidly in the spring or sap-wood. Rot may occur in pockets, which merge as decay proceeds. Shrinkage and checking take place both radially and tangentially, gradually reducing the wood to a yellowish-brown friable mass. Fruit-bodies are comparatively small, yellowish or orange yellow at first, later changing to a rusty or dark brown.

Merulius lachrymans grows very profusely when once established on damp wood, producing snowy white mycelial mats from which glistening yellow or lilac coloured moisture drops usually exude. It requires rather constant conditions of temperature and humidity for its growth and

thrives best in unventilated places where the air is quite still. Wood decayed by the fungus is pale brown in colour, and becomes broken up into large brick shaped pieces as it dries and shrinks. The decayed wood is easily crumbled to powder between the fingers. Fruit-bodies are formed in shapes somewhat resembling pancakes on horizontal surfaces, but may form shelves on vertical surfaces. The surface of the fruit-bodies is tough and wrinkled, and on it millions of rusty red spores are formed.

From the centres of profuse growth of *Merulius lachrymans* fungus can send out mycelial strands which may pass over or through brickwork, plaster or other building materials. These strands can transport water from the damp place in which the fungus first established itself to wood of low moisture content at some distance, thus wetting the wood and starting new fungus growth.

Conclusion

Dampness is one of the five essential conditions for fungal growth and should be the easiest to control. If dry materials are used in building and moisture can be prevented from reaching or accumulating in wood portions of the finished structure, rotting will be eliminated. Dampness in a building or in some element of a building can be attributed to a lack of consideration during design, poor workmanship during construction, neglected maintenance, or some combination of these. To prevent it the designer needs to pay particular attention to rain penetration, ventilation and condensation, as described in previous Digests. The contractor should protect materials against moisture and take care with construction details to avoid air leakage paths. If the building is reasonably well designed and constructed, little maintenance may be required, but undetected leakage in roofs or drainage systems can provide the damp conditions necessary for rotting. It is therefore essential to have regular inspection and maintenance procedures.

When moisture cannot be controlled or wood has to be placed in wet locations, adequate treatment with wood preservatives will effectively control decay.

Bibliography

1. Canadian Woods: their Properties and Uses, Canada, Forest Products Laboratories, Ottawa, 1951.
2. Findlay, W. P. K. Dry Rot and Other Timber Troubles, London, Hutchinson, 1953.