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Review

Natural durability of timbers under Indian environmental conditions – An overview

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ABSTRACT

Over the millennia, mankind has recognized the inherent resistance of certain wood species against attack by fungi, insects and marine borers. Despite our advances in wood protection technology, people still rely on naturally durable timbers for construction of various structures. Of late, this property of several wood species, known for their high durability, has become unreliable due to changes in silvicultural and pre-harvesting practices, which reportedly interfere with their durability performance. This warrants a periodic assessment and rating of natural durability properties to select the right species for various end uses. Moreover, the drastic decline in the availability of naturally durable timber species towards the end of 20th century has resulted in the import/export of timber world-wide. The inherent durability of these species under different climatic conditions is unknown but must be determined to utilize them effectively. Studies on natural resistance of wood to biological damage are therefore of prime importance. Before initiating durability studies, background information on different factors that impart durability to a timber is vital. This paper aims to compile secondary data on such aspects and to provide a necessary check-list of durability ratings of Indian and exotic timbers that have been tested under Indian environmental conditions. Probable factors responsible for imparting a built-in resistance to wood against bio-deterioration have also been discussed.

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Introduction

Timber, being an organic material, is susceptible to bio-deterioration by a variety of organisms. Among the various bio-deteriorating organisms, microbes such as fungi (McCarthy et al.,

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2009) and bacteria (Edlund and Nilsson, 1998) and insects such as termites, (Scheffrahn, 1991), beetles and marine borers (Tsunoda, 1990; Highley, 1999) are major threats to the service life of wood. Some timbers have a comparatively high inherent capacity to resist this kind of attack, showing remarkably greater resistance when exposed to biodegrading agents (Harris, 1961). This built in property of a wood species to withstand bio-deterioration is known as natural durability. Durability is one of the key performance factors used to assess the suitability of a timber species for specific construction. The sapwood of all timber species has very poor resistance; natural durability ratings apply only to the heartwood of a timber species (Wong et al., 2005).

Methods of determining the natural durability

The natural durability rating of a timber species is its ability to prevent attack by wood-destroying agents in the absence of any physical or chemical modifications. Durability ratings of wood can be assigned by testing small stakes and poles, prepared from the heartwood, by embedding them in the ground or in laboratory testing units, and exposing them to degrading and deteriorating organisms. Both laboratory and field testing are useful. In laboratory tests, resistance to an individual bio-deteriogen can be investigated under controlled conditions (Eaton and Hale, 1993). Results from field testing are generally preferred for assigning durability classifications because wood is exposed to a wider range of biodeteriogens in the field that colonize wood sequentially and may act synergistically with other abiotic climatic factors (Sen-sarma and Chatterjee, 1968; Eaton and Hale, 1993). Though field testing is time consuming because wood is observed for longer periods of time, it is more reliable. In general, there are two main factors that influence the performance of timber in service: the natural durability of a particular species (Harris, 1961) and the type and degree of hazard to which the timber is exposed (Rao et al., 1982). Durability ratings are not intended to predict precise life expectancies for a wood species because of variability within the species and due to the differences in conditions between sites and applications where the timber species is used.

Knowledge of the durability class of wood is of great economic importance for the rational and judicious utilization of timber (Sen-sarma et al., 1975). As per the Indian Standards (BIS – 4833: 1993; BIS – 401:1982), field evaluation of natural durability of timber must be conducted with wooden stakes measuring 60 cm × 5 cm × 5 or 30.5 cm × 3.8 cm × 3.8 cm implanted in the ground to half of their lengths. The condition of the specimens must be examined at frequent intervals; average useful life is calculated from these observations. The ability of the wood species to resist bio-deterioration is classified into 3 durability classes; class-I (life span of over 120 months), class- II (life span between 60 and 120 months) and class-III (life span up to 60 months). Those species that fail before 60 months are considered perishable or nondurable, possessing no natural resistance at all.

Durability of timber under laboratory conditions against fungi must be tested by exposing the test blocks of timber in a favorable atmosphere to colonization by decay fungi as per BIS 4873 (2008) and Bakshi et al. (1967). They are then classified, based on their percent weight loss, into 4 groups: highly resistant/durable (<10%), resistant (11–24%), moderately resistant (25–44%) and non-resistant (45% above). These rating are equvalent to durability class I (highly resistant/durable), durability class II (resistant), durability class III (moderately resistant) and perishable or not at all durable (nonresistant class).

This paper deals with an analysis of secondary data on timber durability, ratings and the causes of wood durability, with special reference to work done in India. For this purpose, records on durability studies published by various investigators under Indian conditions from 1965 to 2013 on different wood species were collected from diverse sources, including journals, books and dissertations. Data were compiled so as to prepare a check-list of timbers of India based on their durability. Additional relevant information is also included. Results are compared and discussed in the light of similar work done in other countries on the probable factors responsible for the inherent resistance of woods. The compilation is expected to highlight the existing knowledge of the durability of various timber species available in India, which may help users select wood species for proper end use.

Durability of timbers under Indian conditions

Approximately 370 different timber species have been tested under Indian environmental conditions to determine natural durability classes (Table 1). Out of 370 species, 351 were evaluated under field conditions (mostly against termites); 86 species were tested in the laboratory (against fungi); only 86 species data were tested under both laboratory and field conditions. In most of the cases, there is a correlation between durability ratings obtained from laboratory and field tests. Only 21% of the timbers showed differences in durability ratings based on field versus laboratory testing. This may be attributed to differences in their resistance to termites and fungi. Vagaries of climatic and weather parameters of the test site and experimental error might also contribute to such inconsistencies.

Within the 351 species that were tested in the field, 53% belonged to durability class III, 21% fell under durability class II, and 26% to durability class I. In few cases (0.6%), studies were conducted for less than 60 months and therefore the results cannot be properly assigned to any durability class as per the Indian Standards. As mentioned earlier, only 86 species have been tested against decay fungi; of these 50% were assigned to durability class III, 12% to class II, and the remaining 38% to class I. For 48 timber species, both outer- and inner-heartwood was tested for resistance. Using these criteria, 60% were assigned to durability class III, 19% to durability class II and 21% to class I.

Discussion

Pioneering work on wood durability was started at the Forest Research Institute, Dehra Dun, as early as 1926, and the results of these series of investigations were published in 1952 by Purushotham and Mascarenhas (1952). The field exposure trials were continued, and a second set of results was published by Das et al. (1965). Purushotham et al. (1968) published details of natural durability of commercially important timber species and the efficacy of preservative treatment under terrestrial conditions. This was followed by a second study published in 1973. Similar studies were further continued by Sen-sarma, Chatterjee and their co-workers (1963–1975), who presented their results in a series of articles comprising six parts. The first publication (Sen-sarma, 1963a) described the methodology for laboratory culture of colonies of *Heterotermes indicola* using artificial feed of sawdust obtained from forty common Indian timbers, standardized to ascertain the longevity of the test organisms. The second part (Sen-sarma, 1963b) was a major study in which 37 common Indian timbers were tested against *H. indicola*. In subsequent publications, 9 species of timbers were tested against *Kalotermes flavicollis* (Sen-sarma, 1963c); qualitative and quantitative resistance of sixteen species of Indian timbers were determined against *Neotermes bosei* under laboratory conditions (Sen-sarma and Chatterjee, 1965); the natural resistance of three Indian wood species, namely 'axle-wood' (*Anogeissus latifolia*), 'mahua'(*Madhuca longifolia*) and 'teak'