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INVESTIGATIONS ON THE NATURAL DURABILITY OF INDIGENOUS TIMBERS FOR USE IN MARINE CONSTRUCTION

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Summary

Investigations have been carried out on the underwater natural durability of commercially available Indian timbers, at five ports of India, viz. Bombay, Cochin, Marmagoa (Goa), Port Blair (Andamans), and Visakhapatnam. The destruction of timbers at these ports by various groups of woodborers have been observed and their natural durability at each port has been determined.

Substitution of Teak wood, most commonly used for various purposes with other durable and strong timbers has been suggested. Recommendations on use of timbers for marine construction at specific ports have been made along with a small note on the characteristics of the timbers recommended for use.

Introduction

In India as well as in most other countries abundant in forest resources, timber has always been a pre-eminent constructional material. In the present era of highly durable and strong structural materials made of iron, glass, re-inforced plastics and cement concrete, timber still finds wide use in many important industrial applications including structures of marine importance.

Different types of structural timbers are employed for specific purposes. The important timbers used for various purposes are Teak (*Tectona grandis*), White cedar (*Dysoxylum malabaricum*), Dhaman (*Grewia* sp.), Chaplash (*Artocarpus chaplasha*), Himalayan fir (*Abies pindrow*), and Chir (*Pinus longifolia*). However, Teak can be said to be the single important timber widely employed for a variety of purposes requiring strength and durability. In addition to the above, Lignum vitae (*Gniacum* sp.) and Green heart (*Ocotea radioae*), which have special properties and are used for specific purposes, are still being imported.

Marine Bio-Deterioration of Timbers

The deterioration of timber when exposed to sea water is faster and more severe compared to that when exposed to atmospheric conditions. The damage to the timber is caused by diverse groups of organisms present in the sea ranging from micro-organisms like bacteria and fungi to crustacean and molluscan wood borers. The damage to timbers by this wide variety of marine flora and fauna is very high. According to Becker (1958) in India the cost of periodical replacements of fishing craft alone would amount to 2.5 million rupees. Since similar expenditure by way of repair and replacements of harbour constructions and other items are

not known, the total annual expenditure due to marine borer damage is not even computed. This problem is experienced by all the maritime nations and as per available statistics, the damage to boats, barges, and bulk heads and other marine structures by the wood borers in United States alone exceeds 50 million dollars every year (Nair and Saraswathi, 1971).

Though the damage and destruction of timbers by marine borers is experienced universally, the borer damage is very extensive in the tropics due to the high rate of breeding in these waters. The organisms responsible for the damage to timbers under marine conditions belong to two main groups viz. the molluscan wood borers comprising of teredinid and pholadid borers and crustacean borers represented by limnorids and sphaeromids. The distribution of all these four groups varies in different ports and in some cases even in different localities of the same port.

Terenid borers:

The total number of teredinid species distributed throughout the world has been found to be not more than sixty six(Turner, 1966) out of which 23 species have been recorded in India, signifying the intensity of borer population. Two genera of teredinid worms viz., *Teredo* and *Bankia* are of economic significance in connection with timber destruction. These animals are highly specialized bivalve molluscs having an elongated worm like body. The bivalve shell of the animal has lost its conventional structure and function of protection as in mussels and clams and instead has been modified into an efficient drilling equipment. The soft regions of the body and mantle lie posterior to the shell unlike in mussels. The animals enter the surface of timber in the young larval stages and burrow inside the timber by mechanical action (Miller, 1924). The animal once inside the timber grows into adult by forming its burrow. The teredinid worms have been found to possess a timber digesting enzyme cellulase with the help of which the animal utilises the cellulose from the timber as its food (Miller, 1926).

The burrow thus formed by the animal subsequently becomes its habitat as the animal loses its motility exhibited during the early phases of development prior to the attack on timber. These animals are bisexual, the same animal acting as male and female during different periods of its lifetime. Though both *Teredo* and *Bankia* have similar sexual development, in *Bankia* fertilization of the gametes takes place outside the body of the animal i.e. external fertilization. In many species of *Teredo* as in the case of *Teredo furcifera* on the other hand, the fertilization is not only internal, but even the development of eggs to the early veliger stage of the larva occurs in the body of the female. The veliger larvae ready for attacking fresh substrates are liberated in the sea water.

It has been reported that 7,000 such larvae were present in the first brood of *T. furcifera* and that as the breeding potential increases subsequently as many as 30,000 or more veliger larvae would be liberated from a single animal (Karande, 1968). This extremely high capacity of reproduction coupled with the fact that the animals eat and digest the timber and timber products, results in the extensive

deterioration of timber structures by these marine wood borers.

Pholadid borers

The pholadid borers like the teredinid counterparts are also universal in their distribution. Although species belonging to six genera viz., *Jouannetia, Pholas, Penitella, Pholadidea, Martesia* and *Xylophaga* have been found to inhabit Indian waters, only *Martesia* spp. are of economic importance (Purushotham and Satyanarayana Rao, 1971). Only two species of *Martesia* viz. *M. striata* and *M. fragilis* have been encountered, of which the former is primarily responsible for large scale destruction of timber, throughout the country. *M. fragilis* is restricted mainly to Madras and Cochin waters where it was recorded from pelagic timbers. *M. striata*, on the other hand, is indiscriminate in its destruction attacking not only timber structures but also granite rocks and mooring ropes. Unlike teredinid worms, the pholadids retain their bivalve shells throughout their life cycle. The pholads lack the ability to digest timber and the main purpose of these animals in attacking timbers appears to be for shelter. The reproduction of these borers is by external fertilization. The eggs metamorphose into motile veliger larvae which attack the substratum and develop into adult shelled forms after entry.

Limnoriid borers

These are crustacean wood borers represented by the genus *Limnoria*. 9 species of *Limnoria* have been recorded in Indian waters by various workers from different parts (Palekar and Bal, 1957; Becker and Kampf, 1959; Pillai, 1961; Ganapati and Lakshmana Rao, 1969). These animals are very small in size measuring hardly 5 mm in length, but cause extensive damage to the surface of timbers making it loose and spongy. The small tunnels constructed by these borers normally house *Limnoria* in pairs, the female of which after fertilization carries a brood of 14-15 eggs in its pouch. The young ones after liberation fall out from the parent tunnel to new surfaces and make their own tunnels. It is a continuous process involving heavy destruction to timbers. As in the case of teredinid borers, limnoriid borers also possess the ability to digest the timber by cellulolytic enzymes. The animals, are mainly temperate water species but in the recent years have migrated to tropical waters getting adapted to the new environment. The destruction to timber by this group of borers should be viewed with great concern in view of the fact that even timbers treated with creosote are not immune to their attack. The *Limnoria* sp. as a matter of fact have also been known as 'Creosotphile' (Purushotham and Satyanarayana Rao, 1971).

Sphaeromid borers

These are yet another group of crustacean borers represented in the country by six species belonging to the genus *Sphaeroma*. In principle these animals are surface scrappers and do not appear to cause any serious damage to the structural properties of the timbers examined in the present study. Several workers have earlier recorded extensive deterioration of timbers by *Sphaeroma* particularly at Cochin and has been reviewed in detail by Purushotham

and Satyanarayana Rao (1971). The less predominant role played by these borers at Cochin may probably be due to changes in predominance occurring at that harbour.

Natural Durability of Timbers

When the timber is exposed to sea-water it is subjected to this varied fauna of borer species, which attack and destroy timber either singly or collectively. Most timbers are subjected to heavy deterioration as a result of borer activity, although quite a few are known to possess the ability to withstand their attack. This resistance or durability of timbers is not necessarily uniform against all types of wood borers and in many a case, timbers proven to be resistant against terrestrial animals failed to survive against marine animals. The maritime nations, of late, have been concentrating on the evaluation of the natural resistance of timbers locally available, against marine borers in an effort to make best use of the available resources.

Historical account

A large volume of work has been done by various workers throughout the world to determine the varieties of resistant timbers available in the forests. The review of work done in various countries on the subject is beyond the scope of present report. However, mention must be made to the exhaustive work carried out by W.F. Clapp of U.S.A. and his associates during the twenties and still being actively pursued at Clapp Laboratories, USA.

In India for the first time, British Oak was substituted with teak in the early stages of ship building (Money, 1811). The credit for early studies on the natural durability of timbers in Indian ports goes to pioneering work by the members of the Institute of Civil Engineering. Messent (1920) observed that piles of Green heart timbers were attacked by *Pholas* in Bombay harbour upto a depth of one to one and half inches. The approach jetties of Kidderpore dock near Calctuta made of world reknowned Green heart timber in 1890 were found to be badly eaten up by marine borers within ten years (Devenish-Meares, 1904). Similar observations were also recorded by Kean (1950) in Calcutta harbour almost five decades later.

The formation of a Marine Organisms Committee by the Forest Research Institute in the fifties was probably the first organized work on the underwater durability of indigenous timbers. Individual research workers in Universities and private organisations have since realized the importance of the marine borer problem and have been examining the natural durability of timbers to a limited extent (Nagabhushanam, 1960; Nair, 1961; 1966; Balasubramanian and Menon, 1964; Kalyanasundaram and Ganti, 1974).

In spite of the voluminous work done on the biology and physiology of the boring organisms, the country even now lacks any guidelines on the proper utilisation of timber for marine use. Only about 200 species have so far been put into active commercial use (Balasubramanian and Menon, 1970) though many more timbers may be available for constructional purposes in the vast forest resources of the

country. As a result only a few known durable timbers have so far been employed for specific purposes requiring strength and durability resulting in their faster depletion. Need for surveying more number of timbers for suitable substitution of the few known timbers is, therefore, of prime importance before it is too late.

In the present investigation, a large number of timbers obtained from three different regions viz., Maharashtra, Andaman Islands and Andhra Pradesh were studied for assessing their underwater durability. The organisms responsible for the damage have been identified wherever possible. The hydrographic conditions prevailing in local waters during the period of the present study were also determined. The investigation was carried out at five ports viz., Bombay, Cochin, Port Blair (Andamans), Marmagoa (Goa), and Visakhapatnam.

Material

Commercially available indigenous timbers possessing good mechanical and structural properties were selected for studying their underwater durability. The various timbers were procured commercially as well as from the forest departments. Experimental panels of the dimensions 20.32 × 10.16 × 2.54 cms. (8″×4″×1″) were cut from the untreated heart wood and these panels were then firmly bolted to frames. The frames with the timbers were then exposed at 1 foot below the lowest low water mark in all the five ports of examination. Himalayan fir (*Abies pindrow*), a timber highly susceptible to borer attack was simultaneously exposed as a control in order to record the incidence and intensity of borer activity in the individual port. Simultaneously, panels of two imported timbers of well known durability, viz., Green heart and lignum vitae were also exposed as controls.

Sites of exposure

Five ports namely, Bombay, Cochin, Port Blair, Goa and Visakhapatnam were selected for investigations. The details of the various sites and stations at each port are described below:

BOMBAY

At Bombay, two stations were selected representing two entirely different environmental locations. The first station was representing more or less inshore waters. The second station represented open sea conditions.

COCHIN

Single station was selected for the present work, in the backwaters of the Cochin harbour.

PORT BLAIR

Initially five jetties were selected for exposures. Subsequently, however, with the expansion of jetties at Port Blair all the five stations could not be maintained throughout the period of investigation. Only one station was continued throughout the period primarily because of the constant supervision by the personnel of Government Saw Mill which prevented pilferage of the exposure material. At other places the frames were lost at one

time or other due to either human agencies or climatic conditions.

GOA

The frames were exposed only at a jetty near Vasco-da-Gama, Marmagoa harbour.

VISAKHAPATNAM

Three stations were selected for the present investigations representing inshore waters. No suitable site was available near open sea and due to the non-availability of raft facility studies in the open sea condition could not be carried out.

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