RUBBER TREE - A POTENTIAL SOURCE OF TIMBER

Dr.C.P.Reghu

Rubber Research Institute of India

With the rapid industrialisation during the twentieth century, the fragile earth is put to tremendous enviornmental pressure. In this context, protection of the natural forests has become a necessity. However, with the increase in population, the demand for timber has increased many fold in recent years. In the name of conserving forests we cannot substitute timber from natural forests with any other materials. The best and suitable eco-friendly alternative source of timber in place of the depleting natural timber resources is rubber plantations as these plantations are maintained in a sustained yield rotation of 25-30 years without any enviornamental hazards. Rubber wood has become an industrial raw material only about a decade ago mainly as a substitate for valuable tropical timber species. The total production of rubber wood in India as in 1996 is 1.27 million m^3 per annum.

Rubber tree (*Hevea brasiliensis*) is a perennial dicotyledonous species belonging to the family Euphorbiaceae. The tree has an unbranched straight trunk attaining 79-110 cm diameter at breast height with a profusely branched dense canopy. The tree grows to a height of about 30m. The girth of the trunk may vary from tree to tree depending on clonal and agro-climatic factors. Nevertheless, the plantations raised from seedling populations normally showed a higher girth when compared to those raised from budgrafted planting materials. Over time the budgragted polybag plants are being popularised across the major natural rubber producing countries as the primary objective is to obtain higher levels of rubber yield rather than timber. This development had serious implication on the yield of timber per tree compared to the availability during the early times as the volume of wood is directly proportional to the girth of the tree. It has been estimated that a seedling tree gives 35 cft. wood and a budded tree gives 20cft wood at the time of clear felling of which 60% is trunk wood and 40% branch wood. The shortage of good quality timber and its ever increasing demand underline the need to explore the characteristics and structural features of rubber wood for the utilisation in the field of various industrial aplications.

Gross structure of rubber wood

Rubber wood shows a general gross structure of dicotyledenous (hardwood) timber with certain characteristics specific to the species. Based on the density classification, rubber wood comes under the category of light hardwood. (Bosshard, 1996) with an air dry specific gravity 0.557 and average weight of about 515 kg/m^3 at 12%m.c (Sekhar, 1989). The wood is diffuse porous, straight to slightly interlocked grained and medium coarse textured with a characteristic odour of rubber latex when freshly cut. The timber is whitish yellow in colour when freshly sawn (green wood) and turns pale cream after seasoning. Usually growth rings are absent or ill-defined in rubber wood and the growth ring like structure displayed in the cross sectional view of the timber are merely false rings which are formed by the distribution pattern of reaction wood (tension wood) fibres which is a characteristic fearture of rubber wood (Fig 1). The sapwood (outer wood) is not differentiated from heartwood (inner wood) due to the lack of deposition of pigmented extraneous materials that usually occur during the heartwood formation of other hardwood timber species.

Heartwood formation is a long term ageing process in wood were the reserve metabolites get converted into pigmented substances during the course of necrobiosis of storage cells. Though reserve metabolites in the form of soluble sugar and starch etc. are abundant in rubber wood, the conversion of these materials into heart wood substances does not take place during the course of its economic life span mainly due to the fast growing tendency of the tree. Hence heartwood formation is virtually absent in rubber tree and the storage tissue is filled with soluble sugar and starch which in turn is easily attacked by biological agents. Early wood and late wood differentiation is not possible in rubber wood even though significant seasonal variation has been reported during the growth phase of the tree. The long and continuous period of cambial activity associated with the fast growing nature of the tree also restricts the formation of early/late wood.

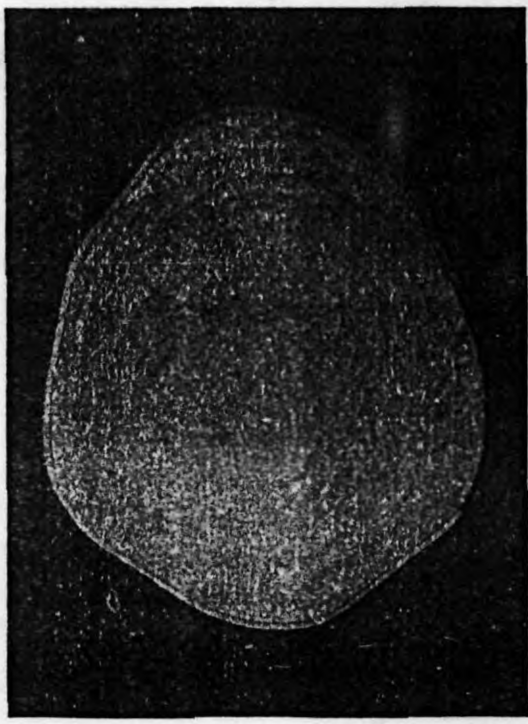

Fig. 1. Rubber Wood Disc showing natural colour and tension wood zones (white 'wooly' lustrus arcs) Clone - RRII 105.

Anatomy of rubber wood

The properties of timber vary according to the structure and composition of wood elements at different plains even within a tree. Hence, proper and accurate selection of timber for each purpose necessitates a detailed and thorough knowledge about its anatomical characters and alignment of tissue at different plains. Macroscopic and microscopic examination of wood sections at different plains display the three dimensional structure of wood and orientation of wood elements (Fig. 2 - A,B,C)

Rubber wood is composed of fibres (58%), vessel elements or pores (8.5%), axial parenchyma (11.5%), and rays (22%) and are distributed in different patterns and proportions as in typical hard wood species. Bhat *et al* (1984) quantified the proportion of wood elements in rubber and concluded that the proportion of wood fibres is moderate in comparison to other fast growing timber species.

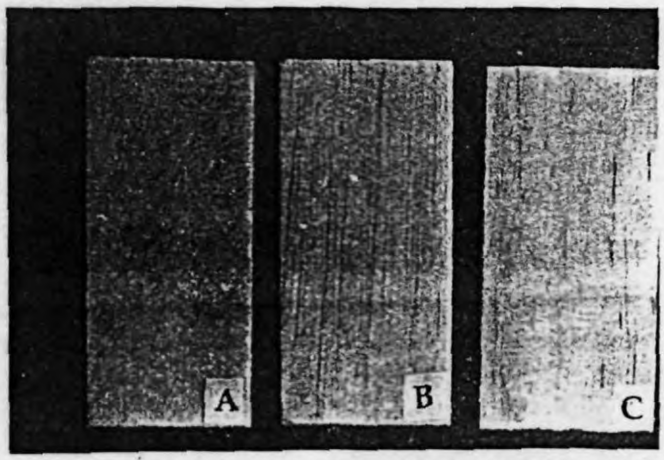

Fig. 2. Structure of Rubber wood at different plains showing the orientation of wood elements.

A- Cross sectional view showing the distribution of pores.

B- Tangential Longitudinal section (T. L. S) showing the longitudinal vessel lines, fibers etc.

C- Radial Longitudinal Section (R. L. S) showing vessel lines, fibers etc.

FIBERS : Fibers are nonseptate and belong to the medium group with an average length of 1.1- 1.4 mm (Anonymous, 1956; Bhat *et al*, 1984; Reghu *et al*, 1989). They are square to rectangular in shape and are aligned radially in transverse sections, with an average wall thickness of 3.5µm. The width of fibers ranges from 19-27 µm with an average value of 22 µm (Silva, 1970; Anonymous, 1956; Reghu *et al*, 1989). The fibers are lignified or partially lignified, depending on their location in the normal and tension wood zone respectively. Studies conducted so far on the dimensional aspects of fibers revealed the superiority of rubber wood as a raw material for pulp industry.

Vessel Elements: The diffuse-porous nature of rubber wood is caused by the distribution pattern of vessel elements or pores (Fig. 3). The structure, alignment and properties of pores also determine the chemical impregnation capacity of rubber wood during preservative treatments. The vessels are evenly distributed as solitary or radial multiples of 2-3 or rarely more,

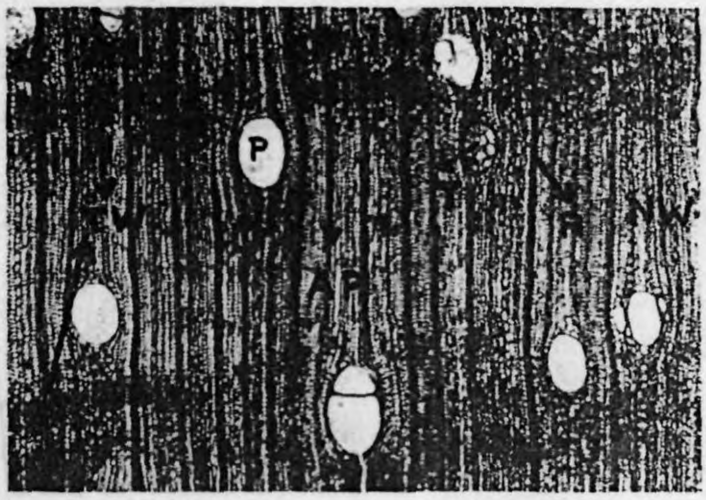

Fig. 3. Microscopic Structure of Rubber wood.

P - Pores (vessels). AP - Axial Parenchyma bands., R - Medullary rays.,

TW - Tension wood zones, NW - Normal wood zones, T - Tylosis with 1-4 pores per mm. They are moderately large to small, and vessel members are 154-789 µm in length (mean-500µm) with a diameter ranging from 70 - 224 µm (mean-155 µm). The lumen of the vessels is usually filled with balloon-like parenchymatous structures calls **tylosis.**

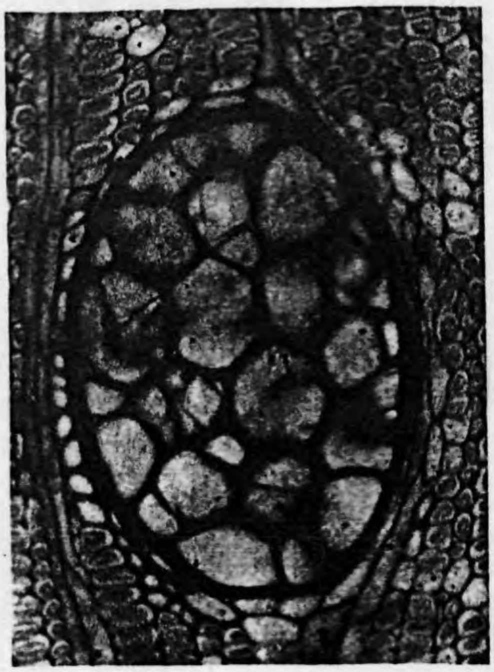

Fig. 4. Rubber wood section showing the vessel lumen filled with Tyloses.

Occurrence of tylosis is a characteristic feature of rubber wood. They are formed by the ingrowth of parenchymatous cells towards the vessel lumen through the pit cavities of the vessel walls (**Fig. 4**)

The presence of numerous tyloses in wood has certain practical significance: they are helpful in checking fungal growth inside the wood during storage and also affects the permeability of wood to liquids. In rubber wood, the presence of tyloses may have certain adverse effects during preservative impregnation, as it blocks the free entry of wood preservatives during processing. However, an extensive study on the nature and extent of tyloses formation in rubber wood and its impact on preservative penetration has not been ascertained so far. It has long been proved that artificial wounding accelerates tyloses formation in wood. In this context it is reasonable to believe that tyloses formation is unavoidable in rubber tree as tapping for rubber latex is a continuous wounding process which in turn stimulates the formation of tyloses. Tapping of the tree without wounding the cambium and wood tissue can minimise the intensity of tyloses formation in rubber.

PARENCHYMA TISSUE : Axial and ray parenchyma (rays) cells are the parenchymatous tissue in wood. They are considered as the soft tissue with the main function of storing the reserve metabolites. The axial parenchyma is apotracheal and banded with undulating lines. Scanty paratracheal parenchyma are also found in association with vessel elements. The rays are heterogeneous, uni to penta seriate. Both axial and ray cells occasionally have crystal deposits.

An increase in the proportion of soft tissue in wood will reduce its density as a whole. In rubber wood, the higher percentage of soft tissue (33.5%) reflects its light hardwood nature. Moreover, unike in other durable hardwood species the soft tissues in rubber wood are filled with reserve metabolites, especially in the form of soluble sugar and starch without any conversion into heartwood substances; hence, it is very susceptible to the attack of biological agents in natural conditions. This demerit of rubber wood is the major bottleneck for its wide utilization for various industrial applications without preservation treatment.

Tension wood

Tension wood is considered as a natural defect or an abnormal structure of wood, which plays an active role in the normal architectural development of a tree. The degree of modification of wood structure involved in tension wood formation is extremely variable within the same species and between tree species. The formation of tension wood is a common phenomenon in rubber tree and its distribution is not restricted to a specific zone of the axes unlike in other hardwood species where its formation is usually limited to the upper side of the leaning stem and branches. When the tree is felled and freshly cross-cut, the tension wood zones are clearly visible even to nake eye as white 'woolly' lustrous bands or arcs (Fig 1).

The proportion of tension wood in rubber varies from position to position within a tree as well as between trees (Vijendra Rao, 1983) depending on the influence of the environmental factors where it grows. The proportion of tension wood is gradually increasing from the base to top of the tree trunk with a range of 7% to 36% (Reghu *et al,* 1989), while its range in sawn planks varies between 15% to 65% (Sharma and Kukreti, 1981). Structurally tension wood differs from normal wood in many of its properties and most of these differences are mainly associated with the structure of wood fibers. Tension wood fibers are specialized fibers known as **gelatinous fibers (G-fibers)**. The third layer of the secondary wall of G-fibers is **unlignified** and made up of crystalline cellulosic microfibrils which give its characteristic gelatinous nature. Hence, the wall structure of G-fibers (Fig.5) in rubber wood is **P+S1+S2+S3(G)** where **P - primary wall (lignified); S1,S2 - first and second layers of the secondary walls (lignified); and S3 (G) - third layer of the secondary wall (unlignified and gelatinous).**

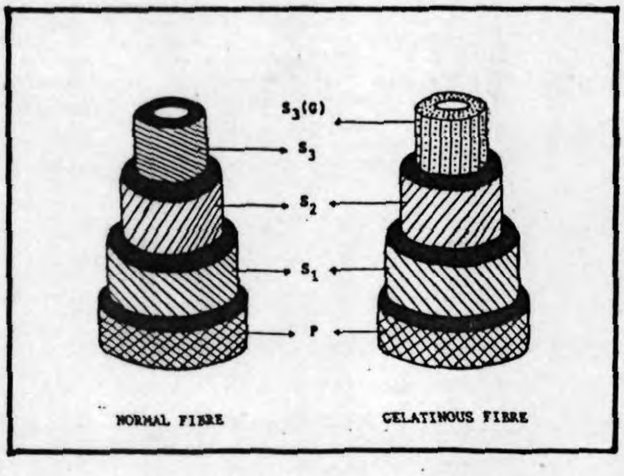

Fig. 5. Diagrammatic representation of the organisation of fibre walls in normal and tension wood fibres in rubber wood.

P - Primary wall S1, S2, S3 - Secondary wall layers (lignified) S3(G) - Third layer of the secondary wall (unlignified gelatinous layer) of tension wood fibre.

Wood working and seasoning problems due to tension wood

The abnormal structure and peculiar properties of gelatinous fibers will make tension wood, a natural defect, causing various wood working and seasoning problems as mentioned below:-

- While cutting and sawing, the G-layer of tension wood fibers tends to detach from the adjacent secondary wall and frequently forms convoluted masses in the fiber lumen, or is ejected out from the lumen especially when the planks are sawn at radial and tangential planes which in turn sticks to the saw blade and disturbs the free movement of the saw.

* As the G-layer is rich in moisture content and lacks lignin, longitudinal shrinkage of tension wood is severe during seasoning and causes uncontrollable distortion.

* Major seasoning defects caused by tension wood are **warping** in the form of twisting, bowing, cupping and collapse etc. which in turn results in dimensional instability of sawn planks.

* Tension wood zone always depicts a rough surface while plaining and finishing and makes the end-products less attractive.

As rubber wood has a high content of tension wood, its wood working and seasoning problems are uncontrollable and unpredictable. To evaluate a tree as a potensital source of timber for various end uses, the nature, proportion and properties of tension wood in rubber wood have to be taken into account. Avoiding tension wood formation in rubber tree is not possible, but to control its deleterious effects is essential. Hence, a versatile utilization of rubber wood for industrial applications need re-investigation, rethinking and co-ordinated research activities, failing which tension wood problem will remain as a serious 'woody' problem in rubber wood industry.

Defects of rubber wood

The defects or demerits of rubber wood can be generally grouped into three. (i) **biological defects,** (ii), **Natural defects,** and (iii), **seasoning** or **processing defects.** Biological defects are caused by biological agents such as fungi, insects (borers and beetles), termites and marine organisms which can easily be controlled by adopting perfect preservative treatment schedules. Natural and seasoning defects are mainly due to the occurrence of tension wood for which a perfect control measure is yet to be developed. In addition to the above, certain other minor defects are common in rubber wood which are formed either naturally or artificially as mentioned below :-

KNOTS. The left over portion of the branches present in the main truck after cutting the branches are called knots. In rubber wood knots are not so predominant and hence it is not a serious defect.

TAPPING WOUND. Tapping is a process which involves controlled wounding and excision of bark tissue. The wounding causes by tapping leaves residual bark above the cambium. By unscientific and careless tapping, the tapping knife happens to injure the cambial cells and even the wood tissue creates permanent marks known an **tapping marks or tapping wounds** associated with callus formation. The injured wood portion becomes defective and discoloured. This artificial man-made defect of rubber wood is more common in rubber plantations where unscientific tapping is adopted. In plywood and veneer industry these tapping marks in rubber wood creates serious problems and thereby the recovery loss is very high.

TAPER. The reduction in the diameter of the tree trunk or log from base upwards is termed as taper which is considered as a defect when the conical form is pronounced. The extent of taper varies with the age of the tree, influence of environmental factors and cultural operations. Rubber trees raised from seedling population show a slight tapering of trunk from base to top whereas budgrafted trees always produce cylindrical trunks. Hence the volume estimation of logs from seedling trees is imprecise unless many diameter measurements are made along the length of the log. Though taper creates certain practical problems during stacking, transporting, and sawing of timber in general, it is not reported as a serious problem in rubber wood.

Conclusion

The major limitations of rubber wood for its wide industrial applications are its high susceptibility to insect and fungal attack (biological defects) and incidence of tension wood (natural defect). Substituting rubber wood in place of the depleting quality timber resources necessitates the improvement of its quality and durability. The structural and anatomical characteristics of rubber wood enable the penetration and impregnation capacity of wood preservatives to protect from biological deterioration. But the nature, structure, distribution and the extent of tension wood fibers adversely affect the physical, mechanical and seasoning properties of rubber wood to a greater extent, for which a perfect control measure has not been developed so far. As the impact of tension wood on various applications of rubber wood is unpredictable, a comprehensive scientific approach to quantify, ascertain and solve the problems associated with tension wood formation in rubber tree is essential from a long term perspective.

References.

Anonymous, 1956. Rubber wood as a raw material for paper pulp or building material. ***Planter's Bulletin***. *Rubber Research Institute of Malaysia*. 23 : pp. 58-63.

Bosshard, H.H 1966. Notes on the Biology of Heartwood Formation. ***IAWA News Bulletin***, 1:pp. 11-14.

Bhat, K.M., Bhat, K.V. and Damodaran, T.K. 1984. Some Wood and Bark properties of *Hevea brasiliensis*. ***Journal of Tree Sciences***. 182.pp. 40-46.

Reghu, C.P. Premakumri, D. and Panikkar, A.O.N. 1989. Wood Anatomy of *Hevea brasiliensis* (Willd. Ex. ADR DE. JUSS). Muell Arg. 1. Distribution pattern of Tenion wood and Dimensional variation of wood fibers. ***Indian Journal of Natural Rubber Research***, 2(1), pp. 27-37.

Silva, S.S. 1970. Industrial Utilization of Rubber Wood-based Panel Products. ***Rubber Reserch Institue of Sri Lanka Bulletin***, 384,pp. 40-53.

Sekhar, A.C. 1989. Rubber Wood. Production and Utilization. ***Rubber Research Institute***, Kottayam.

Sharma, S.N. and Kukreti, D.P. 1981. Seasoning behaviour of Rubber Wood. An under utilized non-conventional timber resource. ***Journal of Timber Development Association of India***, 27 (2), pp. 19-29.

Vijendra Rao, R. Dayal R. and Sharma, B. 1983. Studies on the nature and pattern of distribution of Tension wood in *Hevea brasilinsis*. Muell. arg. (Rubber wood). ***Indian Forester***, 109 (5), pp. 286-291.