Technical Manual on Utilization of Sympodial Bamboos

Fu Maoyi Yang Xiaosheng Jiang Shenxue

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China Forestry Publishing House

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PREFACE

There are rich bamboo resources in the world, especially in subtropical and tropical regions in developing countries. There are 1,200 species and 70 genera of bamboo in the world, widely distributed in Asia, Africa, Australia and South and North America. The increase in the production of bamboos in many countries has often not been accompanied by better use and by appropriate modernization of the processing techniques to improve the living conditions of the rural populations.

Over the past few years, the International Tropical Timber Organization (ITTO) has concentrated its efforts on the development and transfer of technology for the processing of bamboos, for the purpose of fostering the creation of bamboo industrial enterprises.

With financial support generously provided by ITTO, RISF-CAF has embarked upon a collaborative project which focuses on management and utilization of sympodial bamboos. This Technical Manual on "Technical Manual on Utilization of Sympodial Bamboos" addresses the selected technologies of sympodial bamboos utilization in Southern China where available improved technologies can be transferred readily to other bamboo growing regions to increase bamboo production and improve incomes of the families now living in poverty through the development of bamboo utilization. It presents the direct experience acquired by the authors from RISF-CAF and Bamboo Engineering Research Centre of Nanjing Forestry University (BERC-NFU) who has implemented such activities for the purposes of training courses.

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PART 1

PROCESSING AND UTILIZATION OF SYMPODIAL BAMBOOS

CHAPTER 1

The Fundamental Properties of Bamboo Timber

1.1 Distribution of Bamboo Resources

There are more than over 1,200 bamboo species and 70 genera in the world, which are mainly distributed in tropics and subtropics, with still a few distributed in temperate zone and frigid zone. Asia-Pacific region is the biggest bamboo-growing region in the world, extending from New Zealand of the south side (42°S) to the central part of Karafuto of the north side (51°N) in latitude, and from the southwest part of the India Ocean of the west side to the Islands in the Pacific of the east side in longitude. More than over 900 bamboo species and 50 genera are distributed in this region, among which sympodial bamboo species account for about 60%, and Monopodial bamboo species about 40% of the total. China can be taken as the bamboo distributing center in the world, having near 500 bamboo species and more than 39 genera. The total bamboo area covers more than 4.21 million ha, of which include 2.80 million ha of moso bamboo (Monopodial bamboo) which has comparatively high utility value. India is second largest bamboo distribution country in the world with 136 bamboo species and 19 genera and around 2.10 million ha of bamboo area that mainly are sympodial bamboos. Besides, there are quite rich sympodial bamboo resources distributed in Viet Nam, Burma, Bangladesh, Philippines and so on. Figure 1 shows *Dendrocalamus sinicus*, sympodial bamboos species growing in Yunnan Province, China.

There are more than 270 bamboo species and 18 genera in America, distributed from the southern part of Argentina (47°S) to the eastern part of the United States (40°N). Among all the 18 genera, 17 are sympodial bamboo species. Bamboos in this continent are mainly distributed in Latin American countries between the tropic of Cancer and the tropic of Capricorn, where there is a variety of bamboo species and some of these have comparatively high utility value, such as *Bambusa*

Guadus which are originally distributed in Costa Rica and Columbiahas high utility value because of characteristic of tall and straight culms, and has extended to all countries of Latin American.

African has a relative smaller distribution area with several native bamboo species. There are only more than 10 species that include the introduced bamboo species. There are no naturally distributed bamboo species in Europe, but it has begun introducing bamboo species in recent years. See Figure 1.1.

Figure 1.1 Biggest Sympodial Bamboos in the World: *Dendrocalamus sinicus*

1.2 Macro-structure of Bamboo Timber

The structure of bamboo material is observed under microscopes of different magnifying power, which is based on the view of physics.

The macrostructure of bamboo timber refers to the composition of bamboo culms with people's naked eyes and under amplifiers. On a bamboo culm's transverse section, there are many dark diamond-shaped spots; while on its longitudinal section, they are strand-looking tissues. They are vascular bundles, which can be picked out with a knife.

Bamboo stem wall is composed of three parts: bamboo skin, bamboo timber and pith. Bamboo skin is the outermost part of cross section of stem wall, where no vascular bundles are seen. Pith is the part of stem wall next to bamboo cavity, it does not contain vascular bundles tool. Bamboo timber is the part between skin and pith. Vascular bundles are observed on its cross section, among vascular bundles are fundamental tissues. The density of vascular bundles decreases from outer side of stem wall to inner side. The outer part where vascular bundles are dense is called bamboo skin, while the inner part where vascular bundles are rare is called bamboo yellow.

The distribution of vascular bundles of cross section of stem wall is showed in Figure 1.2.

1.3 Chemical Composition of Bamboo Timber

The organic composition of bamboo timber is quite similar to that of wood. It consists of cellulose (about 55%), lignin (about 25%) and hemicellulose (pentosan, about 20%).

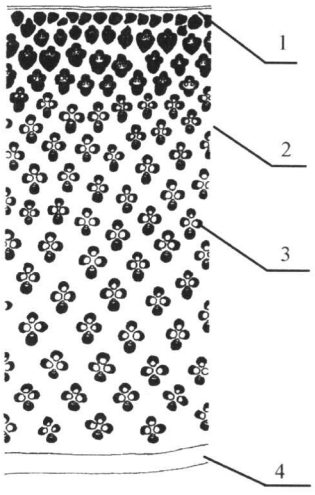
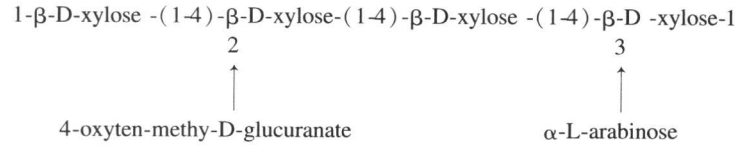


Figure 1.2 Macrostructure of Cross Section of Stem Wall
1. Bamboo skin 2. Fundamental tissue
3. Vascular bundle 4. Pitch

1.3.1 Hemicellulose

It is mostly composed of pentosan, with little hexoan. 90% of hemicellulose in bamboo timber is made up of xylan. Experiments have shown that bamboo xylan is D-glucuranate arabinoxylan, which comprises 4-oxygen-methyl-D-glucuranate, L-arabinose and D-xylose. Their molecule ratio is 1.0:1.0 – 1.3:24 – 25, as follows:



The composition of arabinoxylan of bamboo is different from that of conifers and broad-leaved trees. The polymerized molecules of bamboo xylan are more than that of tree. The content of pentose in bamboo timber is between 19% and 23%, which is close to that of broadleaves and much higher than that of conifers (10% – 15%). This indicates that bamboo timber can not only be used to make pulp or hydrolyze, but also be synthetically used as uronic acid.

1.3.2 Lignin

bamboo timber lignin is a typical herbaceous lignin, which is composed of three phenyl propane units, i.e. paradinum, guaiacyl and mauve in the ratio of 10:68:22. This means the bamboo lignin is similar to broad-leaved lignin qualitatively, not quantitatively.

The specific features of bamboo lignin lie in the existence of dehydrogenated polymerides and 5% – 10% of acrylic ester. The lignin content of one-year old bamboo is in the range of 20% – 25%, approaching to broad-leaved wood and some grass (such as straw of wheat 22%) and is a little lower than that of conifers. Less lignin content means less consumption of chemicals in pulping process and easier

pulping process.

1.4 Physical Properties of Bamboo Timber

1.4.1 Moisture Content

As the rule, the moisture content of growing bamboo is rather high, but it varies as seasons change. It also varies among different bamboo species and different bamboo culms. The moisture content of moso bamboos at cutting age is approximately 80%.

The equilibrium moisture content after air-drying varies as air temperatures and humidity change. According to the statistics, the equilibrium moisture content of moso bamboo in Beijing area is 15.7%.

1.4.2 Density

The basic density of bamboo timber (the mass of the whole culm/ the volume of the raw bamboo timber) is between 0.40 and 0.8 (0.9) g/cm^3. This is mainly depends on the density and the composition of vascular bundles. As a rule, the density of a culm grows gradually from inner to outer part, and from lower to upper part. The thickness of the culm reduces as it grows taller and the density of the culm's inner part increases while its exterior part has little change. The density of bamboo timber node is a little bigger than that of the internode.

1.4.3 Dry Shrinkage

After it is cut, during the process of its drying, the bamboo timber is shrunk because of water evaporation. The shrinkage of the bamboo timber has obvious differences in different directions. From its air-drying to full drying, when its moisture content is reduced by 1%, the average shrinkage of moso bamboo is measured and the results are: longitudinal direction 0.024%, tangential direction 0.1822%, radial direction 0.1890% (on node parts 0.2726%, on inter node parts 0.1521%). Obviously, the shrinkage in longitudinal direction is much less than that in radial direction, while there is not much difference between the shrinkage in tangential direction and that in radial direction.

The shrinkages of the inner part and the exterior part are also different even at the same horizontal height of a bamboo culm. The shrinkage of "bamboo green" part in longitudinal direction is so small that it can be purely ignored while its shrinkage in radial direction is the biggest; the absolute value of the shrinkage of "bamboo yellow" part in longitudinal direction is still small even though it is bigger than that of "bamboo green" while its shrinkage in radial direction is much smaller