Production of bamboo mat board, India

SUMMARY:
Bamboo and rattan are ideal resources for development that integrates poverty reduction and environmental sustainability, and the International Network for Bamboo and Rattan- INBAR priority is giving people at all levels the knowledge and skills they need for long-term development involving bamboo and rattan. Therefore, bamboo mat board, a plywood-like wooden board made from layers of woven bamboo mats that have been pressed together, has enormous income generating potential for the rural poor and particularly for women, who make up the vast majority of weavers. The following technology describes how to produce bamboo mat board.

KEYWORDS:
Bamboos [1]
Forest resources [2]
Forest management [3]
Reforestation [4]
Plywood [5]
Resins [6]
Cottage industry [7]
India [8]
Asia [9]

CATEGORY:
Forestry [10]
Natural Resources Management [11]

COUNTRIES:
India

DESCRIPTION:

INTRODUCTION

DEVELOPMENT ATTRIBUTES, TARGET GROUPS and BENEFITS

1. Bamboo mat board

Bamboo mat boards (BMB) are produced from woven mats of bamboo that are soaked in adhesive resin and then pressed firmly together in a hot press. They were the first of the wide range of different panel boards presently available that use bamboo as a raw material, but they are the simplest to produce, involve only bamboo raw materials and have great income generating potential for the rural poor, who are able to weave the mats from which they are formed. The technology for the manufacture of BMB in India has been developed by the Indian Plywood Industries Research Institute (IPIRTI), Bangalore, who have developed a technically feasible and commercially viable technology for its manufacture. BMB is gaining in popularity and there are currently a handful of BMB factories in operation in India and 16 in China.

Bamboo mat board is very versatile and can be produced up to 6 mm thick by varying the number of mat layers used; boards are usually formed of 2, 3, 5 or 7 mats. For thicker laminated boards, wood veneers are interleaved with the bamboo boards to produce bamboo mat-veneer composite boards (the production of these is not covered in this TOTEM). BMB is at least as durable and stable as wood-based plywood and is very resistant to pest attack, extreme climatic conditions and fire. It can be used for many of the uses to which plywood is now put such as paneling, ceilings, prefabricated shelters, packing cases and storage bins, roofs, doors and door panels, furniture, and household utensils such as trays and plates. BMB is much more flexible than wood-based-plywood and can be used in structural applications such as stressed skin panels, wall bracings and web beams for which plywood is not suitable.

2. History of development of bamboo mat board technology

2.1 International development efforts

The first recorded production of bamboo based panels was in China during the mid 1940s where bamboo mat board bonded with casein (enamel) glues was used in the interior of aeroplanes as an alternative to aircraft-grade plywood. At about the same time research was initiated in India to develop synthetic resin-bonded bamboo mat board, for which the technology became available a decade and a half later. Since then, research has been carried out in several countries and over 30 types of panel products have been developed - some made of bamboo only and others of bamboo in combination with wood, lignocellulosic materials and inorganic materials. Research and development efforts have been mostly confined to countries of the Asia-Pacific region i.e. China, India, Indonesia, Japan, Laos, Malaysia, Philippines, Taiwan, Thailand and Vietnam. Canada (in collaboration with Costa Rica) is the only country outside Asia where research on bamboo panels is being carried out.

Although there was some pioneering work in Taiwan and innovative products such as plybamboo (bamboo glue-lam) were developed, the bamboo board industry is reported to be facing extinction there due to the sharp increase in wages and shortages of raw materials. In Thailand, the only product manufactured is bamboo mat board glued with Urea Formaldehyde (UF) resin and this is mainly produced for export. In countries such as Laos, the Philippines and Vietnam, interest in bamboo matboard production is relatively new, and the industries there are presently in the phase of exploratory studies and experimental or pilot scale production.

2.2 Diversification of manufacturing technologies of bamboo based panels

Bamboo is gaining importance as a replacement for wood in flooring and roofing panels and other housing components (such as windows, doors and partition panels), in furniture and in packing cases. Some of these products are made of bamboo mat board, some have a core of bamboo mats with thin veneer facings and others are made of laminated bamboo slabs/strips of different sizes and shapes (bamboo parquet and floorboards). In some products, wood veneer or shavings are used to give a wood-like appearance to the surface.

At present, China has developed the largest number of bamboo based panel products and produces annually approximately 250,000 cubic metres in about 250 manufacturing units. The most popular panel product is bamboo mat plywood (about 100,000 cubic metres) followed by bamboo curtain board, bamboo strip board, bamboo lath board, bamboo based particle board, bamboo flooring panels and bamboo moulded products.

Bamboo based panels developed in some countries, particularly China, have been covered under patents and details are usually not available.

2.3 Development of bamboo mat board: the Indian experience

In India, research efforts to make panels from bamboo were initiated in the mid 1950s at the Forest Research Institute, Dehra Dun. In the 1960s this institute developed the first manufacturing process. However, high production costs inhibited commercialization of the process. Research and development efforts were revived at IPIRTI in 1979 and a second and cost-efficient manufacturing process was developed for the production of bamboo matboard. In 1985, a factory was established in Angamally where the Kerala State Bamboo Corporation produces boards based on this new process. However, due to some inherent deficiencies, which will be noted in section 10, this technology was still not very suitable and did not become popular for enterprise development.

For this reason, in 1990 IPIRTI undertook new studies to develop improved BMB under a project sponsored by the International Development Research Centre (IDRC), Canada. Under this project, a third, innovative and appropriate technology was developed for the production of high quality, economical BMB up to 6-mm thickness. This time IPIRTI was successful in solving the deficiencies and developing a suitable manufacturing process. According to a feasibility analysis conducted by the Agricultural Finance Corporation Ltd. (AFC), Mumbai, the current process is technically feasible and financially viable. In this way the potential of the BMB as a wood substitute has been demonstrated, as well as the techno-economic feasibility of its manufacture.

An updated annotated bibliography on bamboo-based panels was compiled based on these experiences and a manual was produced for the production of BMB. Some units in Meghalaya and Orissa States in India have successfully implemented the new technology.

As a sign of its appropriateness, the International Selection Commission of the World Expo 2000 earmarked the BMB technology developed at IPIRTI as an exemplary demonstration of the practical implementation of AGENDA 21. Consequently, the technology was registered as a World Project for Expo 2000.

3. General development attributes and advantages

As explained previously, the BMB technology is suitable for the production of eco-friendly alternative panel products to substitute for wood and help conserve forest resources. Moreover, the technology can serve as a basis for economic development in rural areas.

The main development attributes of the technology are as follows:

- Reduced dependence on timber resources and natural forests due to an increased use of wood substitutes, leading to environmental protection.
- Rehabilitation of degraded forests and other waste lands through increased areas of bamboo plantation.
- Creation of employment opportunities in mat weaving, particularly for rural and tribal women, and in bamboo growing.
- Improvement of peoples skills, and enhancement of their earning capacities, leading to improved welfare of the economically weaker sections of society.
- The production of mats is flexible in time and place, favoring part-time and homebound weavers (such as young and old people and housewives) who can continue working close to their own houses whenever they are free from other engagements.

Apart from the above development attributes, BMB has several advantages above other panel materials. The advantages of the BMB developed at IPIRTI are:

- BMB is a very versatile panel material, is highly popular and environmentally friendly.
- The boards posses physical and mechanical properties on a par with waterproof plywood and have an excellent internal bond strengths, a high plane rigidity and hence high racking strength.
- They are as durable and resistant to boiling water, weather and biological agencies (decay, insects and termite attack) as phenolic-bonded plywood.
- They have better scratch and stain resistance properties than plywood.
- They are as fire resistant as fire-retardant treated plywood.
- They have a rich natural appearance.

4. Suitable agro-ecological regions

The BMB technology is suitable for bamboo-growing regions with sufficient raw material that are inhabited by traditionally skilled crafts people, or other (potential) bamboo mat weavers. Apart from regions with natural bamboo forests, BMB could be produced in regions where bamboo is grown on plantations or in homesteads. The technology is particularly suitable in regions where bamboo plantations are desirable for the restoration of degraded forests or wastelands such as abandoned shifting cultivation areas. The production of mats requires the use of large culmed species and the unit is therefore particularly suitable for tropical, subtropical and warm temperate regions where larger bamboos grow.

5. Target groups

The direct beneficiaries of the BMB technology will be the many traditionally-skilled rural and tribal people who make their living of weaving a variety of products from bamboo. In India, the beneficiaries are especially housewives and young and very old people, who have time to spare, but who are unable to leave the house or are unfit to perform hard work. In areas where the depletion of natural forests results in the expenditure of foreign exchange for the import of wood, this money will be saved and the government and the nation will also benefit. The unit will also create employment opportunities for unskilled, semi-skilled and technically trained personnel who can be recruited locally.

6. Applicability

A major reason to use bamboo as an alternative in wood applications such as panels is the authenticity of the material and the cultural history of its use in bamboo-rich countries. In many parts of India, for example, bamboo is an important cultural feature. Since the beginning of civilization, bamboo has played an important role in the daily lives of Indian people. Bamboo craftwork is one of the oldest cottage industries primarily due to the versatility, strength and lightness of bamboo and to the ease with which it can be worked with simple hand tools. Bamboo has been put to use in various applications ranging from construction to household utensils. There are more than 1000 documented uses including an important industrial use in paper and pulp manufacturing. For this reason it is easy to involve local people in the making of bamboo mats and in the manufacturing of bamboo boards.

7. Scope for small enterprise development

Given the benefits for the many people involved, including governments and consumers, the market conditions for the production of bamboo matboards and for the development of related industries and businesses are favorable. As will be shown in the final sections of this report, the establishment of a small BMB-producing enterprise/factory/plant requires a considerable investment, while the BMB can be manufactured in an existing plywood factory with very few additional facilities and investment. All that is required in this case is a resin applicator and, eventually, a drying chamber.

For the establishment of a new bamboo mat board-manufacturing unit, the estimated capital investment (including land and building) is Rs.153.36 lakhs (approx. USD$ 333, 000). In India, the establishment of such a unit would take place in the Small Scale Sector, and it would thereby become eligible for all incentives provided by the Government for this sector.

8. Limitations of the technology

As mentioned in the section on the history of the BMB technology, the earlier manufacturing processes developed in India, suffered from several drawbacks and resulted in low quality bamboo panels. These deficiencies were:

- High quantities of resin required
- Non-uniform bonding due to inadequacy, or even absence, of resin on slivers in the overlapped areas of mats
- Unseemly appearance caused by resin pushed to the surface through the intersliver spaces during hot pressing
- Frequent application of releasing agent required to prevent panels from sticking to metal caul plates

- Limited durability.

With the new process of BMB production, presented in part two of this report, most of these deficiencies can be overcome. Nevertheless, while initiating the production of such boards in a new factory, one should be aware of the potential shortcomings listed above.

9. Requirements for success

The essential requirements for successful implementation of BMB technology are:

- Sustained availability of bamboos suitable for making BMB mats.
- Traditionally skilled bamboo craftspeople with formal training to produce BMB mats.
- Appropriate technologies, machinery and technically trained personnel to manage a BMB production unit.
- Mechanisms to identify suitable markets and promote the sale of BMB in domestic and export markets.
- Continued research and development support during commercialization to solve problems arising during the transfer of technology from laboratory to production unit.
- The availability of inexpensive labor is essential to the viability of a bamboo matboard based on the manual weaving of mats. As has been shown in Taiwan, the financial sensitivity of the labour input is high.

10. Potential improvements and research needs

- Concerted efforts are required to explore the possibilities of value addition through appropriate end use applications.
- Further research and development efforts are required to commercialize the technologies already developed in laboratory-scale experiments, and to explore the potential of this versatile material to the fullest extent.
- Additional research and development efforts should be employed to analyse and improve the activities, skills and benefits of the different people involved in the BMB production chain.
- Extension and training activities could enlarge the efficiency and sustainability of the production of bamboos, matweaving and commercialization, and improve the income effect and distribution of benefits for the people involved.

Concluding remarks

The bamboo mat board technology is a commercially and socially effective means of processing bamboo into quality endproducts for the construction, packaging and transport sectors. Its development attributes imply considerable scope for income and welfare improvement for rural poor people. In addition, it enables governments and wood-based industries to cope with the problem of wood shortages and to reduce environmental degradation due to overharvesting of timber trees. If properly organised and guided by private enterprises, state agencies and/or NGOs, the technology as well as its backward and forward linkages can increase the income and welfare of many people in a sustainable manner.

MANUFACTURING PROCESS FOR BAMBOO MAT BOARD

1. Introduction

Bamboo mat board is produced by a simple technical process comprising the following main steps:

1) Mat making (raw material preparation).
2) Application of adhesive/binder to mats.
3) Assembling of mats in preparation for pressing.
4) Formation of boards by hot- or room temperature-pressing under pressure (curing).
5) Cutting to size (dimensioning).
6) Finishing (such as coatings or lamination).

2. Production of Bamboo mats

2.1 Harvesting bamboo

Matured bamboo culms are extracted following the locally prescribed silvicultural methods and crosscut into convenient lengths varying from 50 to 250 cms. The nodal portions are retained in species with short internodes, such as *Dendrocalamus strictus* (30 cms), whereas in species with long internodes such as *Ochlandra travancorica* and *Melocanna baccifera* (50 to 100 cms), the nodal portions are removed. The splits of long-internoded species, such as *Ochlandra travancorica* are of a more even thickness than those of short-internoded species such as *Dendrocalamus strictus*. Although both species are suitable for mat making, about 40% more resin is required for bonding mats made of *D. strictus* and other similar short-internoded species.

During the course of the IDRC-sponsored BMB research project at IPIRTI, several bamboo species were studied for BMB manufacture. All were found to be suitable.

2.2 Splitting bamboo

The crosscut bamboo lengths can be split by the following methods:

1) With a machete
2) With hand splitting knives or
3) With a splitting machine

When using a splitting machine, the bamboo pole is fixed longitudinally in front of the set of splitting knives and a mechanical pushing device pushes the bamboo over the knives to produce splits of a uniform size. The number of splits produced depends upon the number of knives present in the splitting knives set. In general the width of the splits varies from 10 mm to 15 mm depending on the species and quality of bamboo. The splits are then allowed to dry in the air or in artificial ventilation to reduce their moisture content to around 30%.

2.3 Knot removal

It is necessary to remove the nodes to maintain an even thickness of sliver and to facilitate further processing. The inner and outer knots are removed from the splits either manually with a sharp knife or mechanically with a knot removal and width-sizing machine. This machine also sizes the width of the splint and planes the surface.

2.4 Sliver making

The green epidermal layer of the splints is removed using a sharp knife and can be set aside and used for making other products. It is not suitable for making into slivers. Slivers 0.6 mm thick (+/-10%) and 12-16mm wide are made manually from splints using a sharp knife or a slivering machine. Keeping the variation in thickness of the slivers to within 10% is very important. Higher variation than this results in increased requirements for resin.

2.5 Drying and Weaving

Slivers are dried to around 15% moisture content. The dried slivers are manually woven into mats of different sizes and patterns depending on the specific requirements set. The two most common weaving patterns are the herring bone pattern (45 degrees) and the rectangular pattern (90 degrees). The most common sizes of the mats are 250cm x 125cm, 180 cm x 125cm, and 180 cm x 150cm.

3. Storage of Mats

Woven mats can be air-dried further and stored without any treatment for 3-4 weeks. Prophylactic treatments must be applied if they are likely to be stored for a longer period. The simplest and most effective treatment for mats, if they are not likely to be exposed to water, is to spray them with a 1% solution of a mixture of boric acid and borax in a 1:1 ratio. Spraying can be done with a hand sprayer or a knapsack sprayer. Alternatively the mats can be soaked in the solution for about 10 minutes.

Treated mats are dried either in the air or in a drier, and stored under cover. Treated mats should not come into contact with the ground and hence it is advisable to store them on wooden pallets of 12 to 18 cm (4 to 6 inches) above ground level. Treated bamboo mats can be stored for 3 to 4 months without deterioration. They must be stored in well-ventilated locations with low relative humidity and negligible changes in humidity. The chances of fungal or insect attack are increased if the relative humidity is very high. Mats should be resprayed once every three months and should be checked regularly (at least once per fortnight) for any signs of fungal growth, mould and/or borer attack.

4. Resin manufacturing

Phenol formaldehyde (PF) resin is generally used for manufacturing BMB. The resin is prepared in a resin kettle or batch resin reactor made of either mild steel or stainless steel. The most suitable resin formulation and method of production is given below:

4.1 Chemical ingredients

Phenol: Pure phenol is a white crystalline solid with a melting point of 43 degrees C. It should conform to IS: 538-1968, Specification for phenol (carbolic acid).

Formaldehyde: Formaldehyde is a gas usually available as formalin which is a solution of 37% concentration (by weight) in water with methyl alcohol as a stabilizer. It should conform to IS: 3321 - 1973, Specification for formaldehyde.

Sodium hydroxide: Sodium hydroxide is available in pellets as well as in flake form. It is white in colour, hygroscopic and highly soluble in water.

4.2 Resin manufacturing process

One hundred parts by weight of phenol is charged into a resin kettle followed by 150 to 200 parts by weight of 37% formalin and stirring is commenced. Between five and fifteen parts by weight of sodium hydroxide dissolved in double the quantity of water is then added. Stirring is continued. The chemical reaction starts after the three components have been mixed and takes about 90 minutes to complete. The temperature of the reaction mixture is maintained between 82 degrees C - 85 degrees C. During the course of the reaction, the flow time of the resin is checked periodically using a B-4 cup as described in IS: 3944. The reaction is stopped when the flow time increases to around 15 seconds when the resin is hot. The resin is then cooled to room temperature by circulating cold water in the jacket of the kettle. The cooled resin is discharged from the kettle and stored in airtight containers.

4.3 Properties of PF resin

The cooled resin should have the following properties for optimum results.

(a) Viscosity - 65 +/- 20 mPas at 25 degrees C.
(or)
Flow time in a B-4 cup (IS: 3944) - 27 seconds +/-5 seconds at 25 degrees C.
(b) Water tolerance - 1:6 to 1:20 depending on quantity of sodium hydroxide used.

(c) Solids content - 48% +/- 2%.
(d) Pot life - 2-3 weeks at 25 degrees C.

5. Board manufacturing

5.1 Resin application

Application of resin to bamboo mats is one of the most important steps, both from the point of view of quality and economy. Most crucial at this point are a) the amount of resin applied, b) the mode of application, c) the duration. Resin application is done by dipping.

5.2 Resin dilution with water for dipping

Approximately 200 kg of PF resin is poured into the resin applicator, which is sufficient for the production of about 575-600, 3-layered boards. Two kilograms of sodium octaborate tetra hydrate dissolved in 400 kg of water is added to the resin as a preservative. The concentration of sodium octaborate tetra hydrate is one per cent by weight of the liquid PF resin. This boron compound penetrates into the slivers along with the resin, is fixed during hot pressing, and confers resistance to fungus and insect attack on the BMB. About 60 mats are dipped into the resin solution each time and are dipped for five minutes. Resin soaked mats are removed from the resin solution and kept in an inclined position for about 30 minutes to allow excess resin to drain away.

5.3 Quantity of PF resin required

The quantity of PF resin required per unit area of BMB depends upon the number of bamboo mat layers in the board. The average quantity of resin required for BMB is in the range 0.33 to 0.35 kg PF liquid of 50% solids/m2 for a 3-layered board. However it will be necessary to proportionately increase the quantity of resin used if the variation in sliver thickness is beyond the prescribed limits.

5.4 Stabilization and drying of resin coated mats

Resin coated mats are laid one above the other for at least 2 hours after treatment for stabilization. The stabilized mats are dried in either a drying chamber or industrial dryers such as a band dryer, at a temperature of 95 degrees +/- 5 degrees C until the moisture content falls to 10% +/- 2%.

5.5 Assembly

Dried resin-coated mats are assembled on aluminium metal cauls that are thoroughly coated with a releasing agent, such as silicone - 17 compound. The number of mats assembled depends upon the required thickness of the board. The releasing agent used to coat the metal cauls should be reapplied after 15 to 20 hot pressing cycles.

5.6 Hot pressing

Hot pressing melts the resin in the mats and bonds them together tightly. The assembled mats are first loaded on to the hot press and the mats pressed according to the following protocol.

Pressure - 16 kg/cm2
Temperature - 145 degrees C +/- 5 degrees C
Time - 6 minutes for 3 mats (with 1 minute extra
for every additional mat layer)

5.7 Trimming and Checking

The hot pressed boards are trimmed to the required size in a DD saw.

5.8 Testing

Bamboo mat boards are tested for conformity as per IS: 13958, 1994, specification for bamboo mat board for general purposes (Indian standard).

6. Comprehensive inputs

6.1 Plant layout

Bamboo mat board can be manufactured in a plywood factory with very few additional facilities. All that is required is a resin applicator and a drying chamber if a band dryer is not already available.

6.2 Capital investment

A bamboo mat board-manufacturing unit can be established in the Small Scale Sector and thereby become eligible for all incentives provided by the Government for this sector in India. The estimated capital investment (including land and building) is Rs.153.36 lakhs (USD$ 333, 000).

6.3 Recurring costs

Recurring costs involved are for 1) raw material, 2) energy, 3) machinery and equipment maintenance, 4) managerial and labour and 5) postproduction activities.

The recurring costs are estimated on the assumption that:

- The unit works one shift of 8 hrs per day.
- The number of working days in a year is 300.
- The unit works to 50% of installed capacity in year 1, 75% in year 2 and 100% from year 3 onwards.

SOURCE(S):

International Network for Bamboo and Rattan (INBAR) [12]

Country:
China

Source URL: http://teca.fao.org/technology/production-bamboo-mat-board-india

Links:
[1] http://teca.fao.org/keywords/bamboos
[2] http://teca.fao.org/keywords/forest-resources
[3] http://teca.fao.org/keywords/forest-management
[4] http://teca.fao.org/keywords/reforestation
[5] http://teca.fao.org/keywords/plywood
[6] http://teca.fao.org/keywords/resins
[7] http://teca.fao.org/keywords/cottage-industry
[8] http://teca.fao.org/keywords/india-0
[9] http://teca.fao.org/keywords/asia-0
[10] http://teca.fao.org/technology-categories/forestry
[11] http://teca.fao.org/technology-categories/natural-resources-management
[12] http://teca.fao.org/partner/international-network-bamboo-and-rattan-inbar-1