Khulna University
Life Science School
Forestry and Wood Technology Discipline

Author(s): Fatema Khatun

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Supervisor(s): Md. Obaidullah Hannan, Professor, Forestry and Wood Technology Discipline, Khulna University

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MANUFACTURE AND PROPERTIES OF BAMBOO MAT BOARD AND BAMBOO PARTICLEBOARD

Fatema Khatun
STUDENT ID: 120515

FORESTRY AND WOOD TECHNOLOGY DISCIPLINE
LIFE SCIENCE SCHOOL, KHULNA UNIVERSITY
KHULNA-9208, BANGLADESH.

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Supervisor

07.06.2017.

Md. Obaidullah Hannan
Professor
Forestry and Wood Technology Discipline
Khulna University
Khulna-9208
Bangladesh

Submitted By

Fatema Khatun
7.06.17

Fatema Khatun
Student ID:120515
Forestry and Wood Technology Discipline
Khulna University
Khulna-9208
Bangladesh

DECLARATION

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Dedicated
To
My Beloved Parents and brother

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ABSTRACT

Particleboard and bamboo mat board is popular now a day in the world. Bamboo mat board is the latest one in the industry. These two types of board mainly produce from the same species Kali bamboo (*Gigantochola andamanica)* and bamboo mat using adhesives. Same temperature and pressure are applied on bamboo mat board and bamboo particle board. The physical properties i.e. density, moisture content, thickness swelling, linear expansion water absorption etc. are measured for all types of board and the mechanical properties i.e. MOR and MOE are also tested. Bamboo Particle boards and bamboo mat boards produced using kali bamboo (*Gigantochola andamanica)* particles and bamboo mat. The density of bamboo particle board (BPB) 0.77g/cm^3, single layer Bamboo mat board (SLBMB) 0.79g/cm^3, and double layer bamboo mat board (DLBMB) 0.80g/cm^3. The MOR of bamboo particle board (BPB) 15.32N/mm^2, single layer bamboo mat board(SLBMB)32.01N/mm^2, and double layer bamboo mat board(DLBMB) 41.10N/mm^2 and MOE of bamboo particle board(BPB) 1430.19N/mm^2, single layer bamboo mat board(SLBMB) 2833.32N/mm^2 and double layer bamboo mat board(DLBMB) 3992.71N/mm^2. From all types of board's double layer bamboo mat board (DLBMB) showed highest performance than single layer bamboo mat board (SLBMB) and bamboo particle board (BPB). In most cases physical and mechanical properties shows excellent for bamboo mat board. This product can be used for more widely than the particle board. Hence, it can be concluded that adhesive bonded board from bamboo mat can be alternative material for manufacturing board.

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Chapter one

Introduction

1.1 Background of the study

Forest resources are decreasing day by day due to increase the demand of forest products. There are some problems of solid timber i.e.costly.it cant not used according to our desire such as length. But this problem can be solved easily by composites wood. Composites wood is a general term for built up, bonded products, constructing either or wholly of natural wood, e.g., particleboard, plywood or core board, or of wood in combination with metals, plastics etc (Anon, 1970)

The demand for wood composites from waste wood has been increasing as timber resources in natural forests decline. The use of renewable biomass as a raw material in composites production was one approach and the use of renewable biomass may result in several benefits such as environmental and socioeconomic. Today renewable biomass are mostly accepted as waste materials and are mostly ploughed into the soil or burnt in the field.

According to the end uses of wood-wastes and their possible reuse products, particleboard has found typical applications as flooring, wall and ceiling panels, office dividers, bulletin boards, furniture, cabinets, counter tops, and desk tops, and it seems that the manufacture of Particleboard from recycled wood-based wastes is the most common way to reuse such waste materials

The particleboard is a panel product manufactured under pressure from particles of wood or other lignocelluloses materials and an adhesive.(Nemli and Aydin, 2007). Particleboard has been widely used throughout the world for furniture manufacture and house construction, including flooring systems, etc. Recently, the demand for the particleboard has continued to increase for housing construction and furniture manufacturing

The increasing demands for raw materials in wood composite industries have led researchers to investigate non-wood ligno cellulosic biomass utilization in composite manufacturing including particleboard (Guntekin and Karakus, 2008). Therefore, it seems that the number of plants using Renewable biomass in the production will be more in the future. According to Nemli et al.

(2009), alternative raw materials such as agricultural residues and wood residues will play an important role in the particleboard industry in the future.

Particle board is not so good looking panels for furniture making or other interior purposes where decoration is the main factor. For good looking a new product is introduced in the market and that is bamboo mat board. Bamboo mat board is that of board in which bamboo mat sheet is set in or attached with particle board. Different types and different thickness of bamboo mat is used for bamboo mat board and particle board. This mat board is using more in the furniture making industry now.

Bamboo plants are botanically considered as a special group in grass family which can be planted easily into any kind of land. Bamboo is very fast growing plant with very high strength so it can be used as a structural material. It has higher tensile strength than other wood. A new product made from bamboo woven mat, known as bamboo mat board.

Bamboo mat board is better than common wood board for its good strength, longer durabiy and better dimensional stability. The board has perfect waterproof function for its shrinking rate and expanding rate. Water absorbing rate is better than wood texture and the board is never rusted. It is humidity resistant and smooth in texture.

Bamboo mat boards (BMB) are produced from woven mats of bamboo that are produced in bamboo particle and 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 the Indian Plywood Industries Research Institute (IPIRTI), Bangalore, who have developed a technically feasible and commercially viable technology for its manufacture. Now a day's BFRI (Bangladesh forest research institute) has been developed bamboo mat board. BMB is gaining in popularity and there are currently a handful of BMB factories in operation in India and 16 in China. (International Network for Bamboo and Rattan, 1999)

1.2 Objectives of the study

- To assess the feasibility of bamboo and bamboo mat as a raw material for manufacturing particleboard and bamboo mat board.
- To find out the variation of physical and mechanical properties between particle board and bamboo mat board.

Chapter Two

Literature review

2.1 General Information about particle board

2.1.1 General information

Particle Boards are a relatively new type of engineered wood product that are made from gluing together small chips and saw-dust and firmly pressing them together to make boards or sheets Abhijit Phadke 2012).

Particle board, also known as particleboard and chipboard, is an engineered wood product manufactured from wood chips, sawmill shavings, or even sawdust, and a synthetic resin or other suitable binder, which is pressed and extruded.

Particle board is cheaper, denser and more uniform than conventional wood and plywood and is substituted for them when cost is more important than strength and appearance. However, particleboard can be made more attractive by painting or the use of wood veneers onto surfaces that will be visible. Though it is denser than conventional wood, it is the lightest and weakest type of fiberboard, except for insulation board. Medium-density fiberboard and hardboard, also called high-density fiberboard, are stronger and denser than particleboard. Different grades of particleboard have different densities, with higher density connoting greater strength and greater resistance to failure of screw fasteners. (Max himmelheber, 1962)

2.1.2 History of particle board

1941 - The first recorded particleboard plant was opened in Bremen, Germany (Hunt, M. O. 1962).

1943 - A French patent was granted for a three-layered board developed by Fahrni. This board had coarse particles in the core and thin flat particles on the outer surfaces.

1945 - Particleboard production was introduced to the United States (Hunt, M. O. 1962).

1949 - The Bartrev horizontal continuous compression type process that produced board in continuous sheet was developed in London, England (Hunt, M. O. 1962).

1951 - Boards produced by the Kreibaum vertical extrusion system became available. This

system was developed in West Germany (Hunt, M. O. 1962).

2.1.3 Types of particle board

The major types of particles used for particleboard are the following:

- **Shaving:** A small wood particle of indefinite dimensions produced when planing or jointing wood. It is variable in thickness and often curled (Anon, 1970).
- **Flake:** A small particle of predetermined dimension produced by specialized equipment. It is uniform in thickness, with fiber orientation parallel to the faces (Anon, 1970).
- **Chip:** A piece of wood chopped from a block by a knife or hammer, as in hammer mill (Anon, 1970).
- **Sawdust:** Produced by sawing, in a wide range of sizes. It is usually further refined (Anon, 1970)
- **Sliver:** Nearly square cross section, with length at least four times the thickness (Anon, 1970)
- **Excelsior:** Long, curly, slender slivers (Anon, 1970).

Density of the particle board

The ANSI (American National Standards Institute standard for particleboard (1999) includes three board-density classifications:

- **High density:** 800 kg/m3 (50 lb/ft3) or greater
- **Intermediate density:** 640 to 800 kg/m3 (40 to 50 lb/ft3)
- **Low density:** less than 640 kg/m3 (40 lb/ft3)

2.1.4 Parameters affecting board properties

- A number of parameters or factors affect the final board properties, whether the product is fiberboard or particleboard.
- The most important characteristic of a species for particle-board manufacture is specific gravity (SG).
- According to general rule (1) The lower-density species are preferred (2) The medium-density woods are used if readily available at a good price (3) The highest-density woods are avoided.
- It might seem that high-density woods should produce the strongest particleboard.
- In fact, the lower the wood density, the higher the board strength at any given density.

This is because lighter-weight species have more particles per kg furnish, require higher pressures for proper densification, and thereby achieve better glue line contact.

- It might seem that high-density woods should produce the strongest particleboard. In fact, the lower the wood density, the higher the board strength at any given density. This also indicates that the strength of particleboard is largely determined by glue bond quality, not by wood strength.

2.1.5 Variables affecting the quality of particleboard

- **Particle geometry and slenderness ratio (s):** The main aspect of particle geometry is the slenderness ratio range of 120 to 200 seems best (Salehuddin, 1992).
- **Raw materials and compression ratio:** Particleboard must be compressed during hot pressing from 5 percent to 50 percent. Lower-density raw materials have greater compression ratio. So higher modulus of rupture, modulus of elasticity, internal bond and tensile strength properties are achieved (Salehuddin, 1992).
- **Binder mixing proportion and mixing:** Generally adhesives mixing proportion for particleboard is different for different types of adhesives. Based on ratio of wood flour and binder WPC board property will vary (Anon, 2006).
- Pressing time, temperature, pressure etc. are also affecting the quality of particleboard.

2.1.6 Uses of particleboard

Particleboards are used as:

- Shelves
- table tops
- cabinets
- wall cases
- benches
- book cases
- kitchen cabinets
- piano and organ parts
- flush-door cores
- mobile homes
- Floor underlayment, etc.

2.1.7 Advantages of particleboard

- The main advantage of particle board over solid wood or plywood is that its cost is very low. Compared to plywood furniture of similar dimensions, particle board furniture costs less than half. This low cost of course comes at a price, because particle boards are not as durable as plywood or solid wood.
- Particle boards are very light in weight, and hence furniture made from these boards is relatively easy to transport and move around.
- The characteristic defects of wood such as knots, spiral grain, etc., may either be eliminated or scattered throughout the particleboard during manufacturing. Thus ensure not occurring defects during service condition.
- During the manufacture of particleboard, various treatments, such as heating, incorporation of chemical additives, etc. may be carried out to improve many physical and mechanical properties including the dimensional stability.
- Particle boards are machine manufactured to desired dimensions, and thus standard pieces of furniture can be mass-produced using these boards. This further brings down the costs since there is no carpenter work involved. This also means ready-to-buy products for customers with zero waiting time.
- By using different species and adhesives, or particles of different size and geometry, particleboard may be manufactured suitable for exposure to weather, for interior use, for interior paneling, for exterior sideboards, for load bearing flooring purposes and so on.

2.2 Detail information about bamboo mat board

2.2.1. General information

Bamboo mat board is better than common wood board for its good strength, longer durable and better dimensional stability and looks attractive. The board has perfect waterproof function for its shrinking rate and expanding rate. Water absorbing rate is better than wood texture and the board is never rusted. It is humidity resistant and smooth in texture. (International Network for Bamboo and Rattan, 1999).

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. The bamboo mat board technology is a commercially and socially effective means of processing bamboo into quality end products for the construction, packaging and transport sectors. (INBAR – IPIRTI 2001)

2.2.2 History of bamboo mat board

Since research on bamboo is of relatively recent occurrence, the potential of this versatile material has remained largely unexploited. Although wide-ranging research has been carried out on the structure, properties and preservation of bamboo, the results have hardly been applied by engineers and architects. (International Network for Bamboo and Rattan, 1999)

In the 1980s on account of dwindling wood supplies in the tropics, interest in bamboo as a material intensified. It emerged as the most potentially important non-timber forest product to replace wood in construction and other uses. The realization that bamboo produces woody biomass faster than most fast-growing trees, and that some of its properties rival those of juvenile wood obtained from such species, has evoked keen interest in theoretical and practical research on bamboo as a wood substitute in housing, furniture, packing, transport and other fields. Bamboo in panel form is well suited to substitute wood and therefore, development/refinement

of cost-effective technologies to produce bamboo-based panels is an important area of research. (S.S. Zoolagud ,1993)

In 1990, the International Development Research Centre of Canada commissioned an evaluation on past research and research needs for bamboo and rattan. The report issued in 1991 indicated the need for further attention on bamboo panels. Although the environmental and socio-economic implications of bamboo-based panel industries favor their promotion, neither detailed environmental neither impact neither assessment nor socio-economic impact assessment of these industries has been carried out. Nonetheless, it is tentatively reckoned that if bamboo mat boards replace plywood to an extent of one-fourth the present production in India, 400 000 m3 of round wood from natural forests will be saved, thereby preventing disturbance to 30 000 ha of forests per year (D. Turcke 1993)

It is commercially produced in China (under the name bamboo mat plywood), India, Thailand and Vietnam, while laboratory-scale production is reported in the Philippines. BMB is the first bamboo-based panel to be produced commercially. Its versatility has been widely recognized and further research is in progress to improve its efficiency, enlarge its application potential and optimize production costs .Bamboo mat board is very versatile and can be produced up to 6 mm thick by varying the number of mat layers used. For thicker laminated boards, wood veneers are interleaved with the bamboo boards to produce bamboo mat-veneer composite boards (Zhu Huan-Ming, 1993)

The first recorded production of bamboo-based panels was in China. During World War II, a simple technology was developed in China to manufacture bamboo mat board bonded with Casein glue, for use as alternate to plywood in the interiors of aircrafts. At about the same time, research was initiated in India to develop resin-bonded bamboo mat board; technology became available about a decade later. Since then, research has been carried out in several countries and as many as 28 panel products some of bamboo and others of bamboo in combination with wood and/or inorganic materials have been developed. While R&D efforts have been mostly confined to Asia (China, India, Indonesia, Laos, Malaysia, the Philippines, Taiwan-China, Thailand and

Vietnam), Canada, in collaboration with Costa Rica, has also carried out research on bamboo boards. (International Network for Bamboo and Rattan, 1999)

China has developed the maximum number of panel products, although many of these are based on commercially uncertain technologies. The growth of bamboo panel board industries in China is related to two factors. First, there were inadequate supplies of raw material. The growth rates and harvesting cycles of temperate bamboo are longer than that of tropical species. Hence, despite the large area under bamboo, availability of culms is low. Moreover, traditional and established uses such as handicrafts, basketry, chopsticks and poles compete with use for boards. Second, costs associated with bamboo are steadily increasing, throwing the economics of panel manufacture out of gear.

In India, although several products have been developed, bamboo mat board is the only one that has attracted entrepreneurs and gained user acceptance. In Thailand, bamboo mat board glued with urea-formaldehyde (UF) resin is being manufactured, mainly for export. In countries such as Laos, the Philippines and Vietnam, interest on bamboo board is recent and still experimental or at the level of pilot production.

2.2.3. Characteristics of bamboo mat board

- Bamboo mat board has similar properties to plywood, and is sufficiently rigid and flexible to substitute for it in a wide range of applications.
- It is more flexible than plywood can be used for stressed used for stressed skin panels and wall bracing for which plywood is not suitable.
- Bamboo mat board looks attractive, very durable highly resistant to fungal and insect attack and as fire resistant as fire retardants

2.2.4. General development attributes and advantages

As explained previously, the BMB technology is suitable for the production of "ecofriendly" 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. (International Network for Bamboo and Rattan 2001).

2.2.4.1The 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

2.2.4.2 Advantage of bamboo mat board

- ➢ 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.

2.2.5. Uses of bamboo mat board

Bamboo mat board can be used for

- paneling,
- ceilings,
- prefabricated shelters,
- packing cases,
- storage bins,
- roofs, doors and door panels,
- Furniture and household utensils such as trays and plates.
- BMB is also used in concrete formwork

2.3 Detail information of about Kali bamboo (*Gigantochola andamanica)*

2.3.1. General description

Local name: Kali bash

Scientific name: *Gigantochola andamanica*

Synonyms

Oxytenanthera nigrociliata sense munro

Classification of bamboo

Taxonomic position according to coronquist

Name	Kali bamboo
Kingdom	Plantae
Division	Magnoliophyta
Class	Liliopsida
Order	Poales
Family	Poaceae
Genus	*Gigantochola*
Species	*andamanica*

Fig1:2.3 Kali bamboo (*Gigantochola andamanica)*

2.3.2. Characteristics of Kali bamboo *(Gigantochola andamanica)*

Shurubby, moderate, close local species fail to survive. The species has the ecological protective role on the scrubby hilly dry forest ground clump the species has the capability to tolerate the repeated cutting, occasional ground fire while most of the other

2.3.3 Natural Distribution and habitat

Gigantochola andamanica grows mainly in Tripura, assam, bihar, chattisghar, Pradesh, maharastra and kantaka of india and in the forest of sylhet and Chittagong. This is an ever green and semi-deciduous medium sized tufted bamboo with comparatively smaller diameter having prominent nodes. The species is found to grow gregariously on the flat ground and low elevations along the streams in the moist semi-deciduous forest of Chittagong hill tracts (CHT) as observed in kassalong valley and sitapahar of kaptai and the evergreen forest of mayanmar characteristically the species is plentiful and found as a congested clump in the fringes and the both sides of Chittagong cox's bazaar road near the fringes of chunati and harbang forest (Banik 1994a). The species has the capability to tolerate the repeated cutting, while most of the other bamboo species fail to survive. This species also found to grow in isolated clumps on the distributed scrubby and drier hills of Chittagong and keochia,bandarbans ,hyanko ,ramgharkaptai and rangamati of Chittagong hill tracts(CHT) .Cultivated in greater sylhet and Chittagong hill tracts of districts.

2.3.4 Climatic condition

The species grows well in moist and moderately high rainfall (4000-5500mm) area with temperature range from 9 to 40 degrees centigrade and seen up to 300m altitude.

2.3.5. Vegetative

2.3.5.1 Plan habit

Gigantochola andamanica is an ever green and semi-deciduous medium sized tufted bamboo. The clump is upright and straight with persistent culm sheath tufted with pachymorph rhizome system. Young shoots are green and sheaths are covered with glossy black pubescence with a medium galabrous patch; blades are erect imbricating with nacked auricle (Banik 2004b).

Culm height

6-15tall and erect

Culm diameter

2.5-5.3cm

Culm thickness

At the basal internode, culm thickness is 0.85-1.49cm at mid culm zone 0.44-0.67 cm and at the top 0.18-0.23 cm

Culm colour

Glossy green to dark green sometimes marked with longitudinal yellow stripes

2.3.6. Branching

Branch bud is oval, about 1.5 x 1.5 cm. The tip is rounded and slightly keeled, keels are nacked branches are from lower mid –culms to upwards.

2.3.7Leaves

Leaves are 15-30 cm long, lanceolate, rounded or tapering at base into a short petiole, ending in a subulate twisted point, somewhat scabrous above and little hirsute at first but afterwards glabrous; margin are scabrous; main vein is prominent and secondary veins are 8-12 and inconspicuous; sheaths is stiff and hairy at first but afterwards smooth, terminating in two thick glossy auricles; ligule is narrow and inconspicuous.

2.3.8 Vegetative growth

Only 10% culms emerge in the month of May, and a maximum number emerge during the month of July to September and least in October and November; no emergence from December to April

2.3.9. Seeds

Caryopsis is linear to oblong, 14-17mm long, 2.5 mm broad and glabrous; a 10g contains on an average 26.5 glumed seeds.

2.3.10. Seeds germination

Fresh seeds germinate within 5-7dayes of sowing, with 80-85% germination in the germination bed

2.3.11. Uses

Kali bamboo is used for many purposes these are as follows:

- The poles are used for any sort of construction and
- Excellent for decorative purposes and furniture making.
- It is used for basket making and used in housing construction
- It is a very desirable bamboo for making traditional musical instruments
- Handicrafts and fencing panels.
- Fuel ,hedges
- Walking sticks, baskets sticks
- Fencing and tool handles
- Agricultural implements and fodder

CHAPTER THREE

MATERIALS AND METHODS

3.1Materials and method

- Main raw material for manufacture and properties of bamboo particle board and bamboo mat board is bamboo inner part and bamboo mat.
- The important raw material is binder or adhesives (urea formaldehyde).

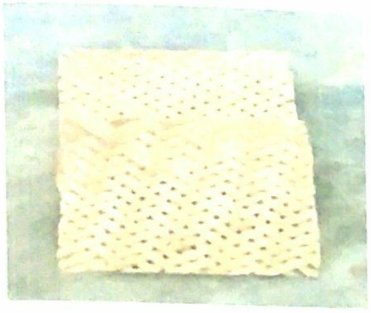

Fig: 3.1 Bamboo mat

Fig: 3.2 Kali Bamboo and Inner part of kali Bamboo

3.2 Methods and procedures

3.2.1 Collection of raw material

Kali Bamboo and different types of bamboo mat was collected from Gollamari Bazaar and Rupsha Bazar of Khulna city.

3.2.2 Preparation of raw material

After collection of raw material it was air dried for 21days. Then the inner part of bamboo was cut into 1-4 cm size by using conventional hand tool manually.

3.2.3 Screening of particles

Grinding: 1-4cm sized chips was inserted into the laboratory grinding machine manually. Then the grinded particles were collected from the grinded machine manually. After grinding the particles were screened manually by two types of sieve.

3.2.4 Drying of particle

After screening the particles were kept oven dried at 103±3°C for 24 hr 4% to moister content. For use with binder, the particles must be dried and moisture content reduced about 2% to 7% moisture content (Anon, 2006).Then the raw material was ready to make bamboo particle board and bamboo mat board.

3.2.5 Mixing of raw materials

The adhesives urea formaldehyde resin was used. A digital balance was used to measure the weight of the ingredients. After preparation the particles were mixed with 8% adhesives. This process was accomplished manually by hand shaking.

Fig: 3.3 mixing of particles and adhesives

3.2.6 Mat formation

After blending, each mixture was hand formed into a rectangular of iron mould on a stainless steel plate. Hand formed mat measuring 180×140×37mm before hot pressing. For bamboo mat board, bamboo mat was used as back layered and mixing particles were used as core then bamboo mat used as face layer. In, mat formation mats and mixing particles were press at the same time.

Fig: 3.4 Mat formation processes of bamboo mat board and particleboard

3.2.7 Hot pressing

After formation the mat was inserted manually into the hot press for pressing. The pressure was 5MPa and there total pressing time 12 min for each type of board was provided. Temperature was 170^0 C.

Fig:3.5 hot pressing

3.2.8 Curing

Then after releasing the temperature the board was kept in pressure for 15 min for curing. Then the pressure was released. The same procedure was followed for each type of board

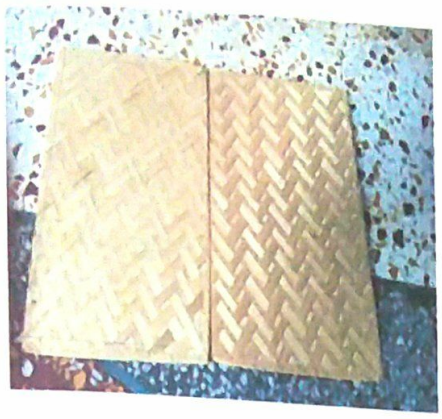

Fig: 3.6 curing of Bamboo mat board

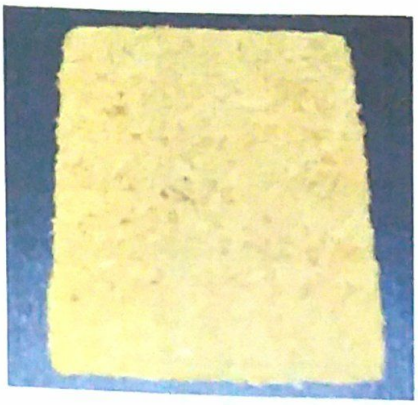

Fig: 3.7 curing of bamboo particleboard

3.2.9Trimming

After the boards of each type were produced separately, these were trimmed at edges with the fixed type of circular saw. The dimensions of each type of board were170× 130mm. The board is trimmed to obtain the desired length and width and to square the edges.

Fig: 3.8 Trimmed Bamboo mat board

3.3 Specifications of manufactured bamboo particleboards and bamboo mat board

Table 3.1: Specifications of manufactured bamboo particleboards and bamboo mat board

Dimensions (mm)	180× 140
Density (gm/cm^3)	0.7-0.8
Adhesives	Urea formaldehyde resin(8%)
Total no. of board manufactured	9
Types of board	3 (Bamboo particle board, single layer bamboo mat board and Double layer bamboo mat board)
Thickness(mm)	8

3.4 Manufacturing process of Bamboo mat board

Fig: Manufacturing process of Bamboo mat Board

3.5 Laboratory Test

The laboratory tests for characterization of physical properties and mechanical properties for each type of particleboards were carried out respectively in the Wood Technology Laboratory of Forestry and Wood Technology Discipline of Khulna University and in the Laboratory of Civil Engineering Department of Khulna University of Engineering and Technology, Khulna. The properties were tested according to the procedures defined in the American standard for particleboards (ANSI A208.1–1993) (NPA, 1993) as well as the Indian standard for particleboards (IS: 3087-1985) (Anon, 1985).

3.5.1 Preparation of samples for testing

Three replications of each type of boards were manufactured as stated earlier. For testing physical properties, three samples were collected from each board of each type. So the total number of sample was nine (9) for each type of particleboard for testing of physical properties. The Density and Moisture Content were determined on the same nine (9) samples and the Water Absorption, Thickness Swelling and Linear Expansion were determined on the other nine (9) samples. For testing mechanical properties, three samples were collected from each board of each type. So the total number of sample was nine (9) for each type of particleboard for testing of mechanical properties. The MOR and MOE were determined on the separate samples.

The dimension of samples for testing the physical properties was approximately (50 mm x 45 mm) and for testing the mechanical properties was approximately (170 mm x 45 mm).

Fig: 3.9 Sample for mechanical test

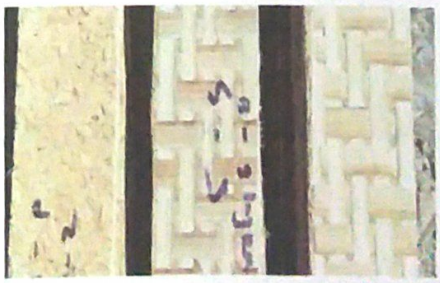

Fig: 3.10 sample for physical test

m = Mass of the sample

v = Volume of the sample

3.6.2 Moisture content

The moisture content was measured from the difference in weight after the sample had been drying in the oven at 103±3°C until constant weight was reached. Initial and final weight of the sample was measured by electric balance.

It was calculated by following formula,

$$mc\ (\%) = \frac{m_{in} - m_{od}}{m_{od}} \times 100$$ .....Equation 2 (Desh and Dinwoodie, 1996)

Where,

mc = Moisture content (%)

m_{int} = Initial mass of the sample (g)

m_{od} = Oven- dry mass of the sample (g)

3.6.3 Water absorption

The water absorption was measured from difference in weight of sample before and after 2 hours, 24 hours immersion in water and weight measured by electric balance. The water absorption calculated by following formula,

$$A_w(\%) = \frac{m_2 - m_1}{m_1} \times 100$$ ..... Equation 3 (Young quist et al, 1997)

Where,

A_w = Water absorption (%)

m_2 = the weight of the sample after immersion in water

m_1 = the weight of the sample before immersion in water

3.6.4 Linear expansion

Linear expansion was measured by digital calipers from difference in length of sample before and after 2 hours, 24 hours immersion in water.

It was calculated by following formula,

Linear expansion (%)= $\frac{l_2-l_1}{l_1}\times 100$.....Equation 4 (Young quist et al, 1997)

Where,

L2 = length of the sample after immersion in water

L1 = length of the sample before immersion in water

3.6.5 Thickness swelling

Thickness swelling was measured by digital calipers from difference in thickness of sample before and after 2 hours, 24 hours immersion in water.

It was calculated by following formula,

$G_t = \frac{t_2-t_1}{t_1}$.....Equation 5 (Young quist et al, 1997)

Where

Gt = Swelling (%)

T2 = Thickness of the sample after immersion in water

T1 = thickness of the sample before immersion in water

3.7 Determination of Mechanical properties

3.7.1 Modulus of rupture

Modulus of rupture (MOR) was measured by universal testing machine (UTM), (Model no: UTM-100, serial no: 11/98-2443). It was calculated by following formula-

$$MOR = \frac{3PL}{2bd^2} \quad \text{.....Equation 6 (Desch and Dinwoodie, 1996)}$$

Where.

MOR = Modulus of rupture in N/mm^2

P = load in N

L = Span length in mm

b = width in mm

d = thickness in mm

3.7.2 Modulus of elasticity

Modulus of rupture (MOR) was measured by universal testing machine (UTM), (Model no: UTM-100, serial no: 11/98-2443). It was calculated by following formula-

$$MOE = \frac{P'L^3}{4\Delta bd^3} \quad \text{.....Equation 6 (Desch and Dinwoodie, 1996)}$$

Where,

MOR = Modulus of elasticity in N/mm^2

P' = Load in N at the limit of proportionality

L = Span length in mm

b = width in mm

d = thickness in mm

Δ = deformation of the board in mm at the limit of proportionality

3.8 Statistical analysis

All the data, produced during the laboratory tests for characterization of physical and mechanical properties of each type of board, were analyzed by Microsoft office excels, 2010.

Chapter four

Result and Discussions

4.1 Physical properties

4.1.1. Density

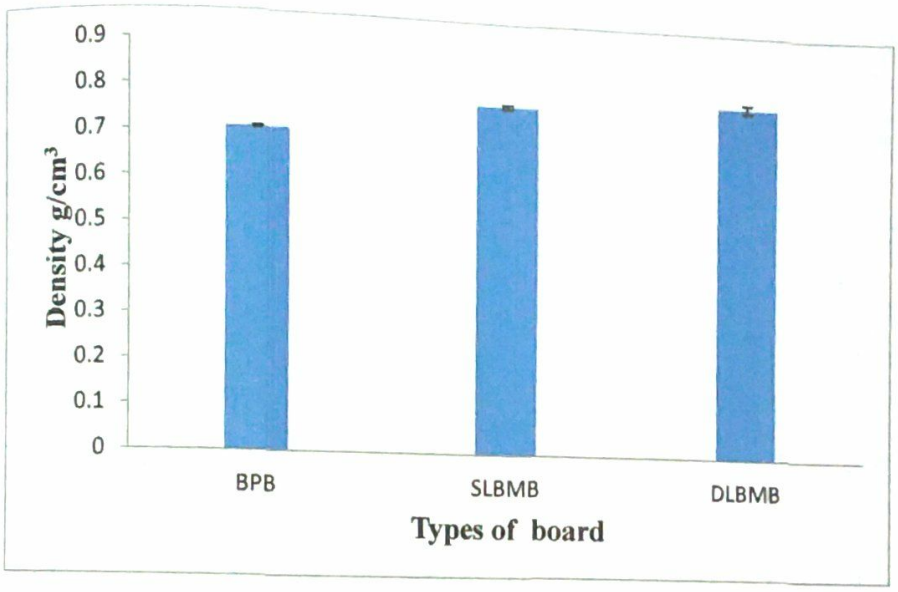

Fig.4.1 Density of three types of board

It was found that, the density of bamboo particle board (BPB), single layer bamboo mat board (SLBMB) and double layer bamboo mat board (DLBMB) were 0.71g/cm^3, 0.78g/cm^3 and 0.80 g/cm^3 respectively.

Board manufactured from double Layer bamboo mat board (DLBMB) and single layer bamboo mat board (SLBMB) shows greater density than the bamboo particle board (BMB).Because of bamboo mat was used as face and back layer of board .It also observed that the density of three types of boards compared with particle board made from *bambusa vulgaris* (Najmul, 2012) with density of 0.83g/cm^3 and it was found that only bamboo particle board is lower but single Layer and double Layer bamboo mat board value were about near.

The density of these three boards are compared with the density of bamboo mat board (Bureau et al,1994) 0.77-0.83 g/cm^3 only bamboo particle board is lower and single Layer bamboo mat

board and double layer bamboo mat board is on range of these standards. According to IS specification 3087 (Anon, 1985) the density of standard particleboard is 500-900 kg/m^3 and according to German standard Din 68761 (Verkor 1975), particleboard standard is 590-750 kg/m^3. From this standard it can say that bamboo particle board, single layer bamboo mat board and double layer bamboo mat board is on the range of medium density particleboard.

4.1.2 Water absorption

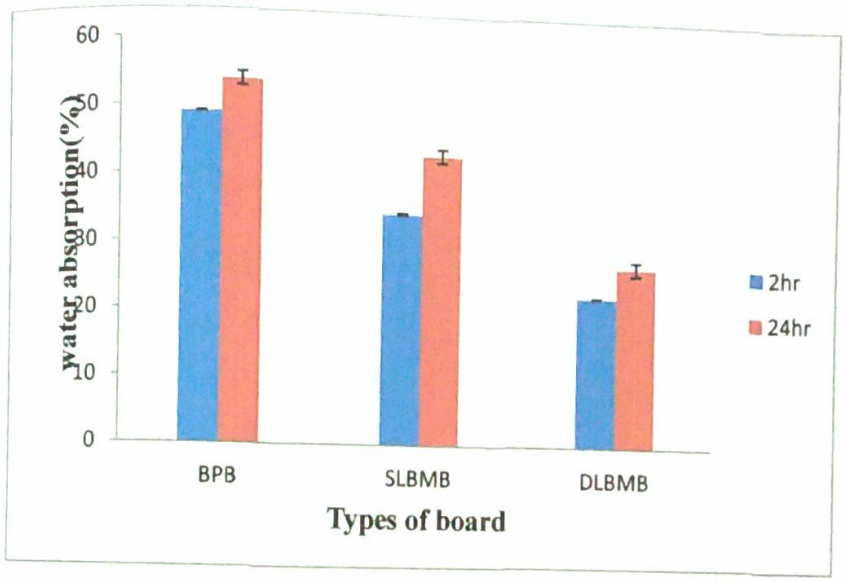

Fig: 4.2 water absorption of three type of board

It was found that, after two hour the percentage of water absorption capacity of bamboo particle board (BPB), single layer bamboo mat board (SLBMB) and double layer bamboo mat board (DLBMB) were 49.15%, 34.56%and 22.69% respectively. After 24hours the percentage of water absorption capacity of bamboo particle board (BPB), single layer bamboo mat board (SLBMB) and double layer bamboo mat (DLBMB) were 53.96%, 43.41% and 27.28%respectively. Water absorption of double layer bamboo mat board (DLBMB) was lower than single layer bamboo mat board (SLBMB), and Bamboo particle board (BMB).It may be due to the density of this boards. The density of the double layer bamboo mat board (DLBMB) and single layer bamboo mat board (SLBMB) is greater than bamboo particle board (BMB). These three types of board are compared with bamboo wastes particleboard having water absorption 64.25 %(Alam, 2012) And it was found that all three types of board shows less water absorption than bamboo wastes

particle board (Alam, 2012).These three types of board also compared with bamboo mat board (Bureau et,al 1994) having water absorption 41.01% it was found that bamboo particle board (BPB) and single layer bamboo mat board(SLBMB) shows higher water absorption and double layer bamboo mat board (DLBMB) absorb less water than bamboo mat board (Bureau et,al 1994). According to IS specification 3087 (Anon, 1985) the absorption of water by standard particleboard is 50% after 24 hours soaking. The water absorption in the 24 hour water soak test was highly correlated with the board density (Vital et al, 1994). For all species combination, the higher compaction ratio always absorbed a lower amount of water than the lower compaction ratio. Water entry into the higher density board occurred at a slower rate due to the decreased porosity and the increased wood material. Thus the higher density of double layer bamboo mat board (DLBMB) shows less water absorption then other two types of board.

4.1.3 Moisture content

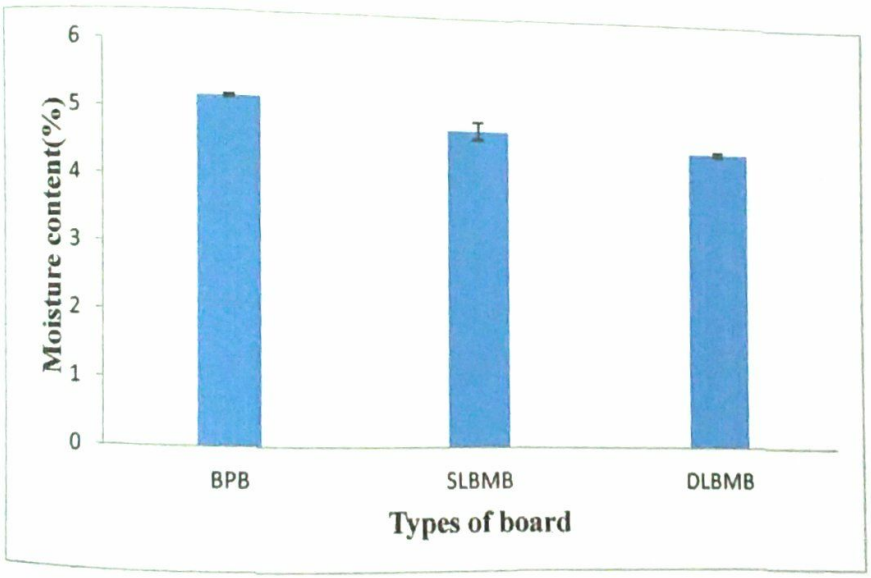

Fig: 4.3 Moisture content of three type of board

It was found that, the moisture content of bamboo particle board (BPB), single layer bamboo mat board (SLBMB) and double layer bamboo mat board (DLBMB) were 5.17%, 4.74% and 4.48% respectively. Compare to bamboo particle board (BPB), and single layer bamboo mat board (SLBMB) of moisture content percentage was lower in double layer bamboo mat board (DLBMB).According to china and Thailand standard (CH/THS; 1884) the moisture content of

standard bamboo mat board 4.1-5.7% And it was found that all three types of board is on the range of this standard. According to Australian and Newzeland Standard (AS/NZS 1859.1: 2001.Int), The moisture content of standard particleboard is 5-8% (for 18 mm thick board) .From this standard it was found that only double layer bamboo mat board (DLBMB) and single layer bamboo mat board (SLBMB) shows lower moisture content and bamboo particle board (BPB) is near.

4.1.4 Thickness swelling (%)

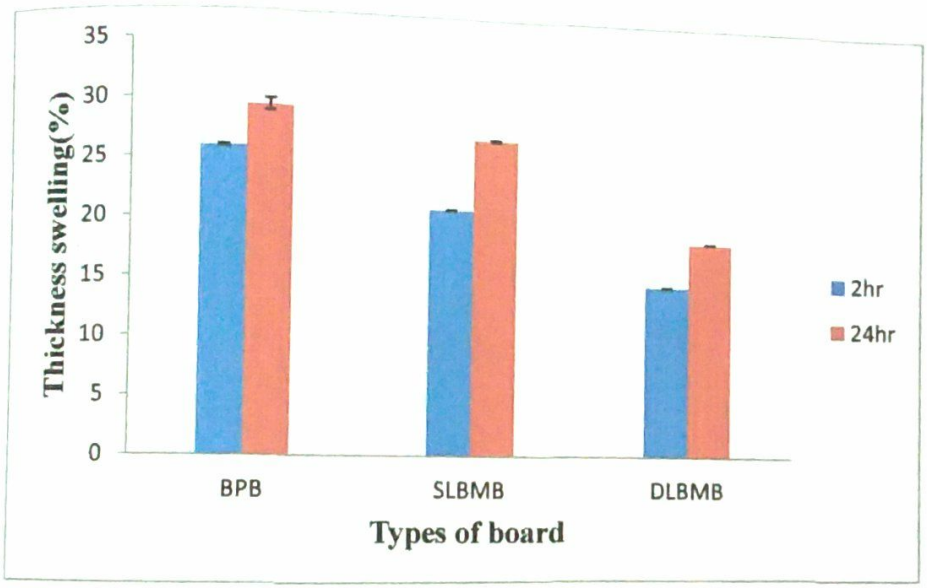

Fig: 4.4Thickness swelling of three type of board

It was found that, after 2 hour the percentage of thickness swelling of bamboo particle board (BPB), single layer bamboo mat board (SLBMB) and double layer bamboo mat board (DLBMB) were 26%, 21% and 14.79% respectively. After 24 hour the percentage of thickness swelling of bamboo particle board (BPB), single layer bamboo mat board (SLBMB) and double layer bamboo mat board (DLBMB) were 29%, 27% and 18.67% respectively.

Board manufactured from double Layer bamboo mat board (DLBMB) shows lowest thickness swelling than single layer bamboo mat board (SLBMB) and bamboo particle board (BPB). It may be due to the density. Higher the density lower the water absorption, lower the water absorption lower the thickness swelling. The density and water absorption capacity have more effect on thickness swelling of particle board. It also observed that the thickness swelling of three

types board are compared with particle board made from *bambusa vulgaris* (Hasnin et al, 1997) with thickness swelling of 28% it was found that only bamboo particle board (BPB) shows higher thickness swelling and double Layer bamboo mat board (DLBMB) and single Layer bamboo mat board (SLBMB) shows lower thickness swelling than *bambusa vulgaris* particle board. But according to Australian and Newzeland Standard (AS/NZS 1859.1: 2001.Int), the thickness swelling of standard particleboard is 15 % .From this standard it can say that all three types of board shows higher result than the standard

4.1.5 Linear expansion

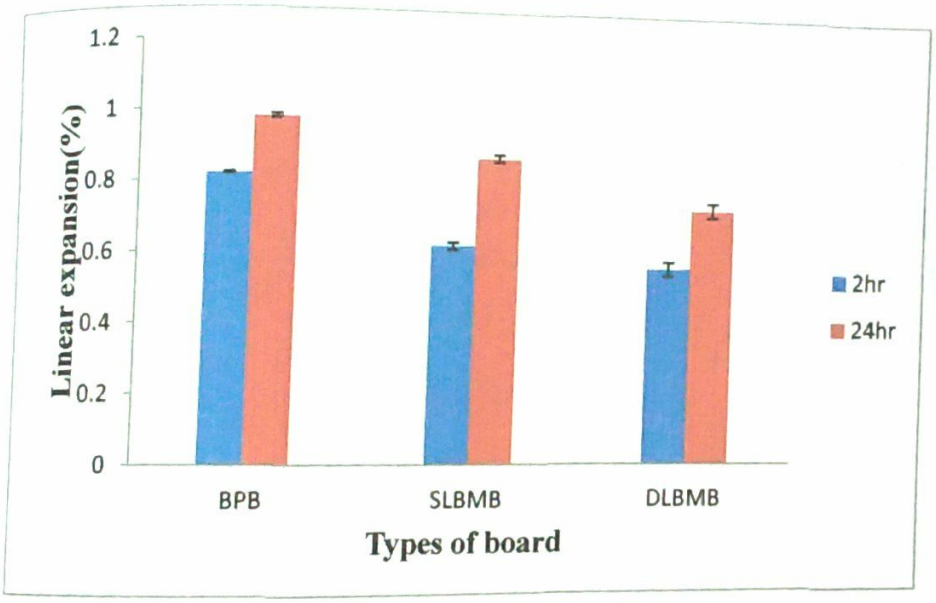

Fig: 4.5 linear expansion of three type of board

It was found that, after 2 hour the percentage of linear expansion of bamboo particle board (BPB), single layer bamboo mat board (SLBMB) and double layer bamboo mat board (DLBMB) were 0.82%, 0.62% and 0.56% respectively. After 24 hour the percentage of linear expansion of bamboo particle board (BPB), single layer bamboo mat board (SLBMB) and double layer bamboo mat board (DLBMB) were 0.98%, 0.87% and 0.73% respectively. Linear expansion of double layer bamboo mat board (DLBMB) was lower than single layer bamboo mat board (SLBMB), and bamboo particle board (BPB). It may also be due to the density. Higher the density lower the water absorption, lower the water absorption lowers the linear expansion.

It also observed that the thickness swelling of three types board are compared with bagasse particle board (Wu, 2001) having thickness swelling 0.92% .It was found that only bamboo particle board (BPB) shows higher linear expansion and double Layer bamboo mat board (DLBMB) and single Layer bamboo mat board (SLBMB) shows lower linear expansion than bagasse particle board. According to ANSI A208.1–1993 (NPA, 1993), the maximum average linear expansion of standard particleboard is 0.35 %, the linear expansion values for all three types of board is higher than the standard range.

4.2 Mechanical properties

4.2.1 Modulus of rupture

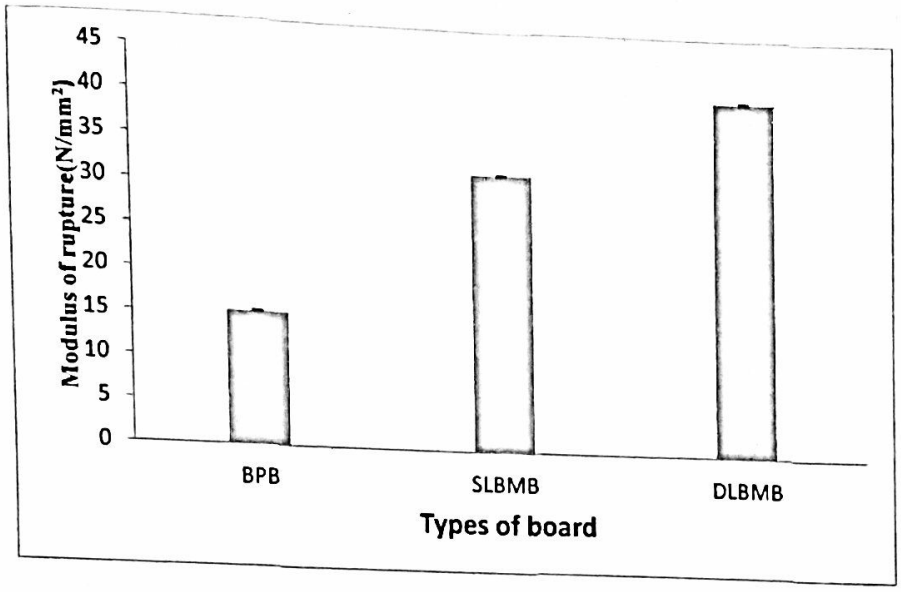

Fig: 4.6 Modulus of rupture of three types of board

It was found that, the MOR of bamboo particle board (BPB), single layer bamboo mat board (SLBMB) and double layer bamboo mat board (DLBMB) were 15.33N/mm^2, 32.01N/mm^2 and 41.10N/mm^2 respectively.

It also observed that the modulus of rupture of three types of board compared with particle board made from *bambusa vulgaris* (Papadopoulos et al, 2004) with MOR of 18.3N/mm^2. It was found that only bamboo particle board (BPB) is lower but single Layer bamboo mat board (SLBMB) and double Layer bamboo mat board (DLBMB) is greater than *bambusa vulgaris* particle board because of bamboo mat was used as face and back layer of the board.

Double layer bamboo mat board (DLBMB) and Single layer bamboo mat board (SLBMB) showed the higher MOR than the bamboo particle board (BPB). It may due to the bamboo mat was used as faced and back layer of board. It was also found that there is a positive relationship between density and MOR (Ayayiand badejo, 2005).Due to the higher density of double Layer bamboo mat board (DLBMB) and the single layer bamboo mat board (SLBMB) of MOR is higher than the bamboo particle board (BPB).

According to IS:13658-1984 the MOR of bamboo mat board range from 35-50.06N/mm^2 From this range it can be say that two types of bamboo mat board are on these range i.e., they follow the range but bamboo particle board (BPB) is lower the range. The MOR of these three boards are compared with the MOR of bamboo mat board (Bureau et al,1994) 35.0N/mm^2 only bamboo particle board (BPB) is lower ,single Layer bamboo mat board (SLBMB) is near and double layer bamboo mat board(DLBMB) is higher. According to ANSI A208.1–1993 (NPA, 1993), the MOR of standard particleboard is 16.5- 23.5 N/mm^2 for high density grade, 11.0- 16.5 N/mm^2 for medium density grade and 3.0- 5.0 N/mm^2 for low density grade. According to IS: 3087-1985 (Anon, 1985), the MOR of standard particleboard is 10.98 N/mm^2. But according to Australian and Newzeland Standard AS/NZS 1859.1: 2001.In British Standard BS: 5669 (Anon, 1979) and German Standard DIN 68 761 (Verkor and Leduge, 1975), the MOR of standard particleboard is 16 N/mm^2 (for 18 mm thick board), 13.80 N/mm^2 and 17.65 N/mm^2, respectively.

4.2.2 Modulus of elasticity

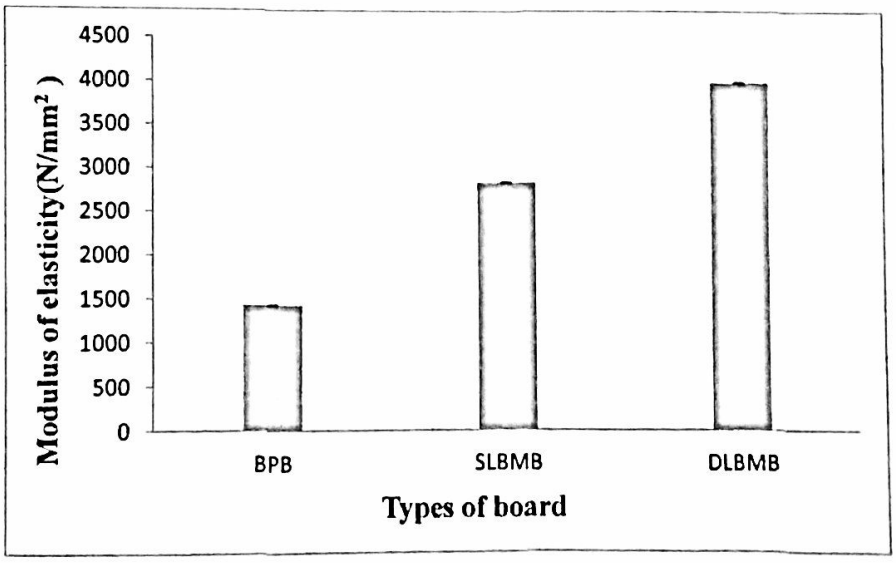

Fig: 4.7 Modulus of elasticity of three types of board

It was found that, the MOE of bamboo particle board (BPB),single layer bamboo mat board (SLBMB) and Double layer bamboo mat board (DLBMB) were 1430.19N/mm^2, 2833.32N/mm^2 and 3992.71N/mm^2 respectively.

Chapter five

Conclusion

5.1 Conclusion

- In considering the physical properties (density, moisture content, water absorption, thickness swelling linear expansion)and mechanical properties viz(modulus of rupture and modulus of elasticity) of Bamboo particle board and Bamboo mat board it is clear that the bamboo mat board showed the better performance than the bamboo particle board.
- The quality of two types of board is different from each other, physical and mechanical properties are good for bamboo mat board. Bamboo mat board looks attractive than the bamboo particle board.
- Now a day's Bamboo mat board is better than common wood board for its good strength, longer durable and better dimensional stability.
- Further study is needed to improve board quality by using different bamboo mat geometry for manufacturing bamboo mat board and bamboo particleboard.

Chapter six

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