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Sustainable Particle board

Anjana S babu[1], Binshad Basheer[2], Muhemmed Basim[3] and Santhanu G Nath[4], Haleema M5

[1,2,3,4] *UG Students Department of Civil Engineering Musaliar College of Engineering and Technology Pathanamthitta, India*

[5]*Assistant Professor Department of Civil Engineering Musaliar College of Engineering and Technology Pathanamthitta, India*

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ABSTRACT

This study was embarked upon the development of particle board from water hyacinth, an invasive water weed blended with urea formaldehyde resin. Usually, wood is used as the raw material for particle board due to rich in cellulose content. The chemical composition of water hyacinth states that water hyacinth is also rich in cellulose, thereby increasing the scope for the particle board with water hyacinth. The water hyacinth creates lots of environmental issues to the surroundings but no benefits, hence if this water hyacinth is effectively used to develop any product, the environmental hazards can be reduced and there by developing an innovative product from unwanted weed. In this study we made two particle board with two mix ratios as 60:40 and 70:30 of water hyacinth to urea formaldehyde. Tests for physical properties like density and moisture content of water hyacinth were conducted. Mechanical and physical properties of the particle board were reviewed in this report.

IS code used for this project are: Methods of Test for Wood Particle Boards and Boards from Other Lignocellulosic Materials: IS 2380 (Part I-XXI), (1977) & Specification for High Density Wood Particle Boards: IS 3478 (1966).

Keywords: Water hyacinth, Urea formaldehyde, Physical properties, Mechanical properties, Particle board.

I. INTRODUCTION

Wooden particle board is an engineered wood product made from wood chips, saw dust and wood shavings using suitable binders, 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. The increasing demand for wood based products will impact on increasing the amount of logging, both industrial plantations and forests in general. Intensive use of wood can cause environmental problems such as deforestation, floods and also global warming. This over use of wood as main cellulose source can be decreased by substituting other cellulose source material such as water hyacinth.

Water hyacinth (Eichhornia crassipes) is a free-floating perennial aquatic plant. It is one of the fastest growing plants known, which reproduces primarily by way of runners or stolons. Each plant additionally can produce thousands of seeds each year, and these seeds can remain viable for more than 28 years. The common water hyacinth are vigorous growers and mats can double in size in one to two weeks. And in terms of plant count rather than size, they are said to multiply by more than a hundredfold in number, in a matter of 23 days. When not controlled, water hyacinth will cover lakes and ponds entirely; this dramatically affects water flow and blocks sunlight from reaching native aquatic plants which often die. The decay process depletes dissolved oxygen in the water, often killing aquatic animals, resulting in water pollution.

Since water hyacinth is comprised up to 95% water, evapotranspiration rate is high. As such, small lakes that have been covered with the species can dry out and communities without adequate water of food supply. In some areas, dense mats of water hyacinth prevents the use of waterway, leading to the loss of transportation as well as the loss of fishing possibilities. When water hyacinth is allowed to decompose which releases CO_2, CH_4, and nitrous oxides which would all negatively impact to the air quality.

1.1Scope of the Project

Preparation of particle board using stem of Eichhornia crassipes. Commercially cheaper board can be made from water hyacinth. To make the product more sustainable.

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1.2 Objectives of the project

Development of sustainable particle board using water hyacinth. To determine the physical properties of water hyacinth. To study the physical and mechanical properties of particle board. Effective usage of this water pollutant as a raw material

II. MATERIALS AND METHODS

2.1 Raw Material Preparation

Collected water hyacinth were cleaned and stem were separated from the plant. As stem contain large amount of cellulose, it is selected as the raw material for the particle board. The separated stems are then kept under sunshine for drying for 2 weeks.

2.2 Refining

The dried water hyacinth is then refined using a refining machine to the desired size of the particle. Refined water hyacinth is then sieved using IS sieve to sort them as fibers and fillers as shown in figure 3.3. Particles passing through 10mm sieve and retaining on 1.16mm are considered as fibers and that passing through 1.16mm is considered as filler materials.

2.3 Moulding process

For moulding process, a wooden mould of 30cm x 30cm x 5cm was taken. Plastic sheet was placed on the mould to avoid sticking of particle board with the mould. Proper estimation was carried out to calculate the amount of raw materials needed for both the ratios taken for the study. Required amount of raw materials were weighed. Addition of accelerator in to the resin was done for faster setting of the board. Then raw materials are added layer by layer. After partial drying, load was applied. The mould was demoulded after 24hr and dried under sunshine.

Fig 1. Moulding

2.4 Loading and Demoulding

The specimen was pre-loaded before the application of the load. Then a uniform load of 4.35 kN/m2 was applied to the specimen such that the thickness of the board reaches to the desired 1cm. The board is kept undisturbed for 24hrs and then demoulded by removing the locks of the wooden mould. Then it is dried under sunlight for 2 days for proper bonding.

III. PHYSICAL PROPERTIES OF WATER HYACINTH

3.1 Density

The actual density of the water hyacinth were measured by using the Archimedes principle. According to this principle, when an object is immersed in a liquid, the apparent loss in its weight is equal to the weight of the liquid it displaces. This method is covered in ASTM standard D792. Archimedes principle is very useful for calculating the volume of an object that does not have a regular shape. The oddly shaped object can be submerged, and the volume of the fluid displaced is equal to the volume of the object.

Density = Mass (g) / Volume (cm^3)

3.2 Moisture Content

Moisture plays an important role in processing agricultural products. It has a significant effect on the level of mechanical damage especially during processing operations, ability of the plant to flow on surface during conveyance, air separation during cleaning and sorting operations. It is therefore, necessary to determine the moisture content of water hyacinth for this study.

MC = (Weight of water / Weight of solid) x 100

Table 1. Properties of Water hyacinth

Physical Properties	Values
Density	0.628 g/ cm^3
Moisture Content	87.3 %

3.3 Properties of Urea formaldehyde

Urea formaldehyde has a very high tensile strength. It has the property of flexural modulus, heat distortion temperature, mould shrinkage and high surface hardness. Has the capacity of low water absorption. It can be elongated at break. It is volume resistance in nature. It have a density of 1.282 g/cm^3.

IV. ESTIMATION OF PARTICLE BOARD

Raw materials used for this particle board are water hyacinth and urea formaldehyde. Two ratios of water hyacinth to urea formaldehyde were chosen as 60:40 and 70:30. Water hyacinth taken is a mixture of fiber and filler. Small specimens were made to check the ratio of fiber and filler as shown in figure 2. It was found that specimen with more filler material was brittle and breaks quickly. Hence we took a ratio as 60% fiber material and 40% filler material of water hyacinth.

Fig 2. Specimen made

Table 2. Determination of Volume of Raw materials

Ratio between WH and UF	Volume of WH (cm^3)	Volume of UF (cm^3)
60:40	216	144
70:30	252	108
Total	468	252

4.1 Estimation of Particle board of ratio 60:40

Particle board from water hyacinth of 60:40 ratio between water hyacinth to urea formaldehyde was successfully made. The use of water hyacinth particles was proved as promising for the production of particleboard for the ratio 60:40. The proper hydrogen bonding of cellulose in water hyacinth was able to utilize to form a particle board.

Fig 3. Particle board from Water hyacinth, 60:40 ratio

4.2 Estimation of Particle board of ratio 70:30

The specimen of 70:30 ratio between water hyacinth to urea formaldehyde failed due to lower concentration of urea formaldehyde resin. 70:30 presented restrictions for utilization in particleboard manufacturing.

Fig 4. Particle board from Water hyacinth, 70:30 ratio

V. PHYSICAL AND MECHANICAL PROPERTIES OF PARTICLE BOARD

Durability is the measure of the ability of briquette to withstand mechanical handling. This test is done to minimize losses and preserve quality of the product during handling and storage. It is a function of moisture content and density. High moisture content reduces durability whereas high density enhances it.

5.1 Water Absorption test

Water absorption is the amount of water absorbed in the composites. It is calculated as the weight difference between the samples exposed to water by wetting and drying cycled samples. The determination of water absorption tests were performed according to IS 2380 (Part: XVI), 1977.

As per IS 2380 (Part: XVI), 1977, specimens with dimension 30cm X 30cm X 1cm should be made for water absorption test. Note the dry weights of particle board specimens as W1. The samples are then immersed in the water bath at 250C for different time durations. The specimens were taken out from water and the surface were dried using a clean dry cloth. Specimens were reweighed to the nearest 0.1mg within 1 min of removing them from the water to take wet weight of the specimen, and noted as W2. The specimens were weighed at 2 hours and 24 hours exposure in water.

Water absorption (%) = (W2 – W1) / W1
Where,
W1 = Dry weight
W2 = Wet weight

5.2 Thickness swelling test

The test specimens shall be prepared and conditioned as specified in 2.2.1 of IS: 2380 (Part XVII) ·1977.

Each test specimen shall be 200mm X 100 mm and shall be of the thickness of the board. The thickness at the edge of each test specimen shall be measured to an accuracy of 0·01 mm at three places along one long edge approximately 50 rnm, 100 rnm and 150 111m from one end. The points at which the thicknesses are measured shall be clearly and indelibly marked. Note the initial thickness specimens as T1. The samples are immersed in the water bath at 250C for different time durations. The specimens were taken out from water and the surface were dried using a clean dry cloth. The specimen thickness were measured again within 1 min of removing them from the water to take final thickness of the specimen, and noted as T2. The specimens were measured at 2 hours, 24 hours exposure in water.

Thickness swelling (%) = (T2 – T1) / T1
Where,
T1 = Initial thickness
T2 = Final thickness

5.3 Density

The width, length and thickness of each board shall be measured in the manner specified in IS: 2380 (Part III)-1977. The mass shall be determined to an accuracy of ±O·2 percent.

Where independent determinations of density are to be made, test specimens of size specified under 2.1 of IS: 2380 (Part III)-1977 shall be used. i.e., the specimens shall be of the full thickness of the material and shall be 7·5 cm wide and 15 cm long. Where density of the specimen used for the static bending test is to be determined, the specimen used for the static bending test may be used for the determination of density [3.4 of IS: 2380 (Part IV)-1977]. After the density determination, the test specimens may be kept for use in other tests.

Density = Mass / Volume

5.4 Moisture Content test

According to IS: 2380 (Part III)-1977, the specimens shall be of the full thickness of the material and shall be 7·5 cm wide and 15 cm long. Smaller specimens may be used when deemed necessary. When the moisture content of test specimens of any other test is required, the same shall be determined from a coupon cut as near the failure of the specimen, as possible, and shall be of the maximum possible size available from the same. When for any reason additional determinations of moisture content arc required, separate samples shall be prepared from the same material as is used in preparing the test specimens. The test shall be carried out immediately after cutting the specimen.
Each specimen shall be weighed to an accuracy of not less than ± 0.2 %. The specimens shall then be dried in a ventilated oven at a temperature of 103 ± 2°C until the mass is constant to ±0.2 % between two successive weighing made at an interval of not less than 1 hour.

Moisture Content (%) = (Mi – Mo) / Mo
Where,
Mi = Initial mass
Mo = Oven dry mass

Table 3. Physical Properties

Physical Properties	Obtained results
Water absorption	13.87 %
Thickness swelling	1.25 %
Moisture content	6.14 %

5.5 Static Bending Strength

IS 2380 (Part IV), 1977 covers method of determination of static bending strength of particle board. Each test specimen shall be 75 mm in width if the nominal thickness is greater than 6mm, and 50 mm in width if the nominal thickness is 6 mm or less. The thickness shall be the thickness of the material. The length of each specimen shall be,
L= 50 + 24t mm
Where t is the nominal thickness of the board in millimetres.

The width, length and thickness of each specimen shall be measured to an accuracy of not less than ±0.3 percent. One half of the test specimens shall be prepared with the long dimension parallel and the other half with the long dimension perpendicular to the long dimension of the board in order to evaluate directional properties. The specimen shall be weighed correct to ±0.2 percent.

5.6 Tensile testing

The test of tensile strength parallel to surface shall be made on specimens both conditioned according to 2.2 or 2.2.1 of IS: 2380 (Part VI)-1977. That is the required test specimens shall be cut to the specified size subject to a tolerance of ±2 m on the length and width, except where otherwise specified. Each test piece shall be rectangular, with all edges cut square to the surface. This test may be applied to material 25 mm or less in thickness. When the material exceeds 25 mm in thickness, crushing at the grips during test is likely to affect adversely the test values obtained. It is recommended that for material greater than 25 mm in thickness, the material be sawn to not less than 12 mm thickness and tested. Test values obtained from specimens so sawn may be only approximate, because strengths of material near the surface may vary from the remainder. It is also recommended that both the portions obtained by sawing be tested and the average obtained. With boards varying in strength across their thickness such laterally sawn specimens would not be of much value. Moisture content is same as for perpendicular loading.

5.7 Hammer Impact test

Test specimen shall be 35cm x 35 cm and shall be of thickness of the board. Each specimen shall be conditioned as specified in 2.2 of IS 2380 (Part IX)-1977 and the thickness shall be measured to the second decimal place of centimetre.

The test specimen shall be clamped firmly between 2 frames made of 2 cm thick and 5cm wide hardwood strips by 8 bolts of 1 cm diameter placed at equal distances from the corner. This frame containing the specimen shall be held rigidly on 4 pillars at its corners. It may be noted that the internal area of the test specimen shall be 25cm x 25cm. A block having a mild steel hemispherical end with a radius of 25 mm shall be arranged to fall freely on the centre of the specimen by suitable means.

5.8 Hardness testing

Each specimen shall be nominally 7.5cm in width and 15 cm in length and at least 25mm thick. If necessary, the specimen for test shall be made by bonding together several layers of the particle board to make the required thickness. A rubber cement or other suitable flexible adhesive shall be used. The initial specimen shall be trimmed after bonding so that edges are smooth. The dimensions of the specimen shall be measured to an accuracy of not less than ±0.3percent.

A steel indentor with a hemispherical end 11.3 ± 0.05 mm in diameter (1 cm projected area) shall be used for determining hardness. The indenting ball shall be advanced till it has penetrated to one-half of its diameter into the specimen. The load required shall be recorded.

Two penetrations shall be made on each of the two flat faces of the particle board. The locations of the points of penetration shall be at least 25 mm from the edges and the ends of the specimen and far apart from each other so that one penetration will not affect another.

The load shall be applied continuously throughout the test at a uniform rate of motion of the movable cross head of the testing machine of 6 mm per minute.

VI. CONCLUSION

In this report we made an attempt to develop particle board using water hyacinth blended with urea formaldehyde resin. We have realised that water hyacinth with urea formaldehyde resin adhesive possess better binding properties. As strength of this particle board is not determined, this particle board is applicable in non-load bearing structures due to deficiency of raw materials.

The particle board with 60:40 of water hyacinth to urea formaldehyde was successfully made while particle board with70:30 of water hyacinth to urea formaldehyde failed due to lower amount of resin to the water hyacinth added.

60% of water hyacinth used was fibre of particle size 1.16mm to 10mm and rest 40% was fillers, those passing through 1.16mm sieve.

3kg of water hyacinth was utilised for this project. Hence large quantity of pollution causing water hyacinth can be effectively utilised for the large scale production of water hyacinth particle board.

Studied about the tests for determination of physical and mechanical properties of water hyacinth particle board.

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