DEVELOPMENT OF PARTICLE BOARD FROM COCONUT SHELL USING GUM ARABIC AS RESIN BINDER

BY

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DECLARATION

I hereby declare that this project is a record of a research work that was undertaken and written by me. It has not been presented before for any degree, diploma or certificate at any University or Institution. Information derived from personal communication, published and unpublished works of others were duly referenced in the text.

Shehu, Alhaji Sayyedi

8/11/2006

Date

CERTIFICATION

This Project entitled "Development of Particle Board from Coconut Shell using Gum Arabic as Resin Binder" by Shehu, Alhaji Sayyedi meets the regulations governing the award of Bachelor of Engineering (B.ENG) of the Federal University of Technology, Minna, and it is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This research work is dedicated to my beloved parents for their supreme support. May Allah be please with them (Amin).

Acknowledgement

All praise and thank are due to |Almighty Allah. I thank Him for manifesting His favor on me by making this piece of writing a reality and seeing me through the course of my studies.

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ABSTRACT

This project work was aimed at producing particle board from coconut shell using Gum Arabic in place of synthetic resin as the resin binder. The essential result obtained during the course of the work shows that, the properties of the particle board depend on the particle size of coconut shell, quality of the resin binder, pressure and method of forming. It was found out that coconut shell gives quality and durable board using Gum Arabic as resin binder. The density of particle board is 585.88 x 10^3kg/m^3. Pressure on the particle board is 33333.3N/m^2. It was found out that particle size of the sample produced quality and durable board due to its size.

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CHAPTER ONE

INTRODUCTION

Particle board, also called chipboard, is an engineered wood product manufactured from wood particles, such as wood chips, sawmill shavings, or sawdust which are the product of wood source from forest.

Forest if the chief source of timber, and deforestation results in poor rainfall in surrounding vicinity; knowing the importance of trees, it becomes essential to check the deforestation and cutting down of trees and it is absolutely necessary to find the substitute of timber.

An important problem in modern society is to make the maximum use of all available material, including the reuse of scrap material back in to useful products. One component of the modern emphasis on recycling materials is the use of scrap material in the production of particle board. Particle board made from agricultural scrap material may be one of the best and effective ways of conserving environment. Every year with production of food, and equal or more amount of biomass as a by-product in form of sack, leaves, husk and shell is produced. A portion of it, is used as animal fed and for some miscellaneous jobs. The remaining portion can be use for manufacturing of particle board.

Particle board as is also known as chip, flake, shavings or waste fibrous material board, has in recent year become increasingly important as a furniture and building sheet materials. Particle board is one of the major panel board materials used in the manufacture

of value-added wood products. Its popularity is mainly due to its much lower cost compare to other panel boards such as medium density fiberboard.

The project discussed the importance of using an Agricultural by-product (coconut shell) instead of the conventional wood products; as source of the raw materials by which particle board can be produced.

Particle board was formed as a flat rigid panel to withstand screw nail impact and abrasion. It consist of coconut shell, broken into smaller chips, sieved, dried to uniform moisture content and mixed with resins. Mat-formed into a panel of model sizes. The above method can be used in place of extrusion method, because, the mat-formed method has limited production and usage. Additions to increase fire-resistance and resistance to fungi and insects attack are not added to the mixture, due to limitation of the project to laboratory method.

The particle board produced from wood mould and the raw materials are source from coconut and Acacia tree. The strength of the boards is based on the application of the pressure during forming process, the static binding, the internal binding of the resins used, abrasion resistance and modules of rapture. All these define the class within which the board falls into.

Generally, the particles board is used in the construction company both on large and small scale. It is used in furniture making, cabinets, motile home decking and sheathing.

1.1 Objectives

The objectives of this project work are:.

1) To substitute the use of imported synthetic resin adhesive known as urea formaldehyde with liquid sugar molasses and Gum Arabic as an effective stabilizer in the production of particleboards.

(2) To ensure effective utilization of Agricultural scrap materials such as coconut shell.

(3) To reduce the production cost in the building and furniture industries that produces particleboards, ceiling board and chip boards etc.

(4) To encourage drastic measures for a better way of utilizing agricultural by-product such as coconut shell, groundnut shell, rice husk and soybean husk.

1.2 Limitation

The research work is not to produce to industrial scale, but restricted to laboratory research method only. Although the two methods are similar in processes and steps, depending on the method of production adopted and the usage of the finished product; such as drying, milling and pressing to be obtained; extraction method and cold/hot mat-formed method etc. Due to available technology, only the cold mat pressing method of production was used. The method virtually eliminates high pressure and temperature coupled with modern equipments that are limited in this project works.

Both the binder and the chips particle used in this research work are from agricultural by-product not from the wood product or synthetic resin types; the sugar molasses and Gum Arabic have higher holding strength properties but prone to fungi attack. When additives are added, will give a perfect protection against fungi attack and

thus make coconut shell as the alternative raw materials in the manufacturing of particle board.

CHAPTER TWO

LITERATURE REVIEW

Manufacturing of particle boards started in the year 1940s after the development of synthetic resins. Particle board is made from natural fibrous materials such as wood particles e.g chips, splinters, sawdust of flakes etc. Many of these materials were once considered scrap material at the saw mill, and now there are combined with synthetic resins adhesive (Urea Formaldehyde) under density board used for inferior purposes e.g kitchen cabinets, partitioning and shelving. The properties of particle board depend on the king and shape of chips and amount of adhesive (Resins), pressure and method of forming. The corresponding values of a particleboard also depend on amount, nature and softness of the cellulose pressure in the cull-wall of the fibrous materials.

Particle board is classified into 5 different groups of density grades in relation to weight of the product, per cubic foot (or cubic cm). These density grades are usually obtained by different pressure applications, during manufacturing processes. Basically, particle board are classified into low density (i.e. Insulating type with density of 350kg/m^3-1400kg/m^3), medium density (i.e. decorating type with density of 15000kg/m^3-1700kg/m^3) and the higher density (i.e. hard board types for heavy construction 18-2100kg/m^3). A standard particleboard in market size of 1.2mx2.4mx0.025m should fall within these regions or its density grade would be rejected. The board are available as unfurnished sheets or in various stages of finishing, with the surfaces and edges filled, and sealed. They are also available in thickness that is different from the common panel size available in the market ranges from 12.5mm to 25mm in thickness.

The two basic method of producing particle board are the extrusion and mat-forming method, with the later being more obsolete. The mat-formed method of produce particle board consists of binding together plant chips or particle with synthetic resin through heating and application of pressure, to achieve the desired density (strength).

Before the forming process, the particles are grinded in homogeneous pattern and dried to uniform moisture content. The pressed boards will cure for one week, can then cut and trimmed to standard sizes with multiple saws and precision sanded on both sides to accurate thickness. Then parked for dispatch.

The characteristic that defines the particle board is dictated by the quality of the resins that glues the particles readily, enabling a simplified car case or box joints to be used.

Other factors are the nails and screw holding capacity which varies between types of boards produced. Higher holding capacities in boards are obtained when nails and screw are inserted in to the faces than the edges. Manufactures recommend boring for screws especially in edges grains where relatively long screw should be used such as shacks proof and twin fast screws (John,1982).

2.1 Molecular Structure of Cellulose materials

Cellulose is a polymer of D-glucose linked in he Beta-1,4 Glucosidal bondages. The bonding is theoretically valuable to hydrolysis cellulose containing materials such as fibers are difficult to hydrolysis because of the following:

1. The secondary and tertiary arrangement of the cellulose materials that confers a high crystalline on them with composition of $C_6H_{12}O_5$.
2. The presence of lignin in the fibrous materials. When cellulose is hydrolyzed with acid, a portion known as amorphous zone that makes up to 15% is easily hydrolyzed

leaving a highly crystalline part occurs as a small rod-like particle which can be hydrolyzed only with strong acid (Peter, 1985).

2.2 Types of Binder

The choice of a particular type of binder to use can be dictated by the presence of cellulose and lignin in fibers of the raw material to be used. Binders are chemical substances which aid in holding together the flaking (chips) particles known as adhesive or resins. Adhesive are available in different types such as urea formaldehyde, phonetic resins, gum resin and timing adhesive etc. These bonding agents are useful in preventing the flakes of particles from loosing out of shape and to increase the strength and shape and to moisture, heat, insect attack and decay.

Adhesive resins are obtained chiefly from plants or made synthetically by the addition of other chemicals. In these resins Oozes out from wounds in the back of the trees (gum Arabic) and other are obtained by distilling wood, other are extracted from plants body by solvent, such as sugar molasses in sugar cane.

In the manufacturing process of particle boards, some adhesive are recommended such as Animal glues, casein Starch, Plant Resins polyvinyl alcohol (PVA) and acrylic based emulsion.

This research work will consider using resin in Gum Arabic as the binder of an holding the material (i.e coconut shell particles) because it often high gloss, odorless and good ink retention, but has the disadvantages of sweetness effect on end product, that will make it prone to insect attack, but introduction of added preservative, wax emulsion and dehydration chemicals may be added into the mixture to preserve it from insect attack, which is beyond the scope of the project (Ency. 1982).

2.3 Main Considerations of Coconut

As with many palms, coconut palms are multi purpose plants, their leaves are woven melted, twisted or plaited to make clothing, mats, baskets and roofing; their fruits provide food, drink, oil, medicine, containers, fibers for ropes and mats; and their wood helps build houses and boats. Coconut shells are used to make gas masks. The most important use of coconut shell is for carbonization into charcoal which is mainly used in the manufacturing of high quality activated carbon. Other uses of shell and which is the main consideration of the research or project work is the manufacturing of shell flour.

Coconut shell charcoal produces the most valuable activated carbons used in the military and industrial gas masks, gold dust recovery, solvent recovery plant etc.

Native of the pacific, coconut spread to much of the tropic on Ocean currents before human intervention. It has been used through out history in south Asia for a wide range of purposes and also feature in mythology.

2.3.1 Origin of coconut

The coconut is the most familiar palm of the tropic, yet until recently, its origin was mostly disputed. It is now thought to come from the western pacific and spread via human activity and ocean currents to more of the tropics. Today it is a domesticated plant and has become an essential resource for food, shelter, fuel and tools.

South Asia is no exception and coconuts features in everyday life, particularly in South India. Today, India is the third largest producer of coconut in the world, with the state of Kerala leading the production following by the other Southern states of Tamil Nadu, Andhra Pradesh and Karnataka coconut play an important role in India ritual and features in India mythology, for it resembles, a human head with three marks on its shell like eyes and a mouth, and fibers like hair. It was known as sriphala or the fruit of gods

and cutting the tree was abhorred. The coconut palm is also known as the tree which grants all wishes. The nuts are an essential part of Hindu religious ceremonies such as weddings. They symbolize complete usefulness, selfish service, prosperity and generosity. (F.O.A,2000).

2.3.2 Commercial Utilization of Coconut Shell in the Development of Particleboard

The development of particleboard is facilitated by the availability of the natural fibrous raw materials e.g flakes of plant wood and the resins chosen. The quality and suitability of these raw materials depends on the nature of the fibrous materials, the cellulose present in the cell-wall which may be single, or combined with pectin or lignin in the cell-wall of the materials (Britt, 1970).

For the purpose of this project work, the choice of coconut shell as raw materials in place of wood product is based on the availability in large commercial quantities of the coconut in eastern and southern part of the country (Nigeria), predominantly considered as waste.

2.4 Gum and Resins

Vegetable Gum and resins are exudations from plants. They either harden by exposure to the air or remain moist or even in a liquid state, and in that case are called oleo-resins. They are all compound of carbon, hydrogen and oxygen, and have the character of acids or anhydrides, which are capable of combination with alkalis. Resins are simply dissolved in a hydrocarbon, that is soluble in alcohol, ether, benzol e.t.c, but insoluble in water; conversely gums are soluble in water (or at all events are readily acted on by water) but insoluble in alcohol. The degree of solubility in water is, in fact, an all important feature in estimating the merit of the true gums. Resins may, however, be

found mixed naturally with gums, the substance being then spoken of as a gum—resin; when mixed with benzoic acid, or any of its congeners

2.4.1 Gum Arabic or Gum Acacia

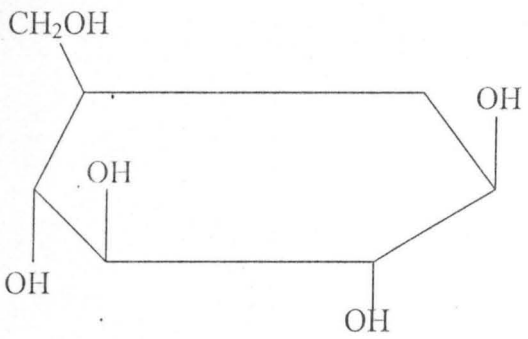
Gum Arabic would imply that it come from Arabia. It seems likely that it may, in ancient times, have reached Europe through that country, or simply have been procured from Arab traders. The chief supply to—day neither come from Arabia nor is obtained from Acacia Arabica. It is procured from Kordafan on the east and Senegal on the west side of Africa. The Gum appears on the stems and branches during the prevalence of dry desert winds, which blow in winter after the close of the raining season, and the flow is aided by certain methods of treatment. To a large extent the superiority of Gum Arabic from Kordafan is a consequence of the environment allowing the growth, but one species of gum yielding tree over a considerable track of country. In other localities the merit of certain gums is greatly lowered through the inferiors grade of other equally abundant gums with which they are regularly and almost unavoidably mixed.

Gum Arabic is odorless and tasteless, but quite soluble in water, the best qualities taking one and half times their weight of water to form a thick, viscid mucilage(Wright 1976)

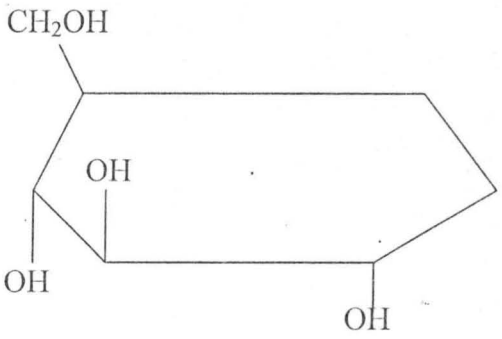
2.4.2 Chemical Composition and Structure of Gum Arabic

This resin gum Arabic just like any other resin has chemical compositions which are highly branched polymer of gelatos, rhammose, arabinose and glucoronic acid. It is well known that gum Arabic is a mixture of calcium, magnesium and potassium.

The term gum Arabic denote a group of industrially useful polysaccharides or their derivatives that hydrate in hot or cold water to from vicious solutions or dispersions. Gum Arabic is classified as natural gums. Natural gums are produced principally in Arabic or Asia and are obtained from seeds, seaweed or exudates from free. All hydrocolloids from plant or microbes are polysaccharides. The stereo-chemistry ring as shown in the following structures:



β- D-GLUCOSE



α-D-GLUCOSE

2.4.3 Botanical Consideration of Gum Arabic

This small (Acacia), one of the chief source of Gum Arabic, is readily recognized by the triple spines at the base of the bran chalets. This character is shared with the very similar acacia dudgeon, and occasionally a third spine is met within acacia latex. It came from Senegal to North-Easter Africa and South to Mozambique.

Gum Arabic also called acacia gum is exudation of the small tree acacia Arabic, and various species of acacia trees. Sennear-gum is gum Arabic, exported from Arabic

port on the red dry regions of North West Africa and some parts of Nigeria e.g Maiduguri, Zamfara, Bida etc.

2.5 Manufacturing Steps of Particle Board

In Nigeria building industries, a simplify steps, in the manufacturing of particleboard practiced, includes material handling machine (logging defibering, refining,forming the mat, hydraulic press, humidifying and transportation.

The manufacturing of particleboard begins by sourcing the raw materials to be used and subjecting it to size reduction into flakes, splits and sawdust etc. using manual operation or milling equipments. The broken particles are then classified, dried to uniform moisture content mixed with a binder (adhesive), compressed to proper density and curing under heat and pressure. The mixture is consolidated and the resulting particle board is formed by two most important methods:

(a) Extrusion method

(b) Cold/hot mat formed method

Extrusion boards are homogeneous (single layer) in structure and are made by forcing a mixture of manufactured particle and synthetics resin adhesive through an orifice (opening) formed by heated metal plates corresponding in size to the thickness and width of the boards. The heated plates cure the glue as the board is formed in a continuous sheet on a moving belt.

An alternative process for manufacturing of particleboard is to use an extrusion process. In the manufacture of extruded particleboard, the starting material is likewise wood, wood-related or other lignocelluloses products blended together with a binder or other substance which impact desirable properties to the final product. For extruded particleboard, however, it is not necessary to include in the blend of starting materials a

defined wood or lignocelluloses fiber. Instead, it is common in the production of extruded particleboard to include plastic (typically scrap plastic) in the blend of starting materials.

The production of extruded particleboard typically does not involve the addition of binders to the starting blend (the plastic acting as the binding agent in this sense).

However, "coupling agents" for binding the wooden materials to the plastic are required to be included in the blend for extrusion. Coupling agents are essentially materials for the binding in the blend for extrusion. Coupling agents are essential materials for the binding the wood and wood fiber to the plastic as the typical woos tends not to bind directly to the plastic without the assistance of special materials for facilitating the binding.

The common goal in the production of extruded particleboard is to reduce the amount of plastic which is included in the particleboard as much as possible. The use of less plastic filer along with an increased proportion of wood material tends to produce a more economical product with more desirable physical properties, more nearly resembling those of particleboard. The problem has been in reducing the amount of plastic material included in the blend while maintaining the extrudability of the material.

A reduction of the amount of plastic tends to reduce the extrudability of the product, especially in the surface finish. It has proven to be a serious challenge to reduce the proportion of plastic materials used in the blend while still extruding a product with a good surface finish. The typical problem has been that the extrusion with less plastic results in a rough surface textures in the product.

In mat-formed particle board, the mixture are consolidated and formed as flat panel consisting of binding particle of wood together with synthetic resin. The particles are treated to remove lignin by digestion method. It also has the advantage of exposing

the lignocelluloses attack. In this method a single layer structure and three layers or sandwich structure can be formed. The single layer board has the advantage of forming a solid structure when great pressure is applied while the three layer structure increase the binding strength and stiffens of the board.

There are two broad methods of processing fibers to produce particleboards such as mechanical and chemical method. The mechanical method involves blending and applying pressure (about 6.9Mpa) at high temperature of about 200^0C, the blended finished mats becomes very loose particle as its thickness are gradually reduced by application of pressure on the mixture until final thickness is achieved and a solid particles is formed while lignin was removed.

In the chemical method, lignin (a three dimensional polymer formed from cyclic alcohol to protect cellulose from hydrolysis) are removed from fiber mixture by adding pulping chemicals. These chemicals will greatly reduce lignin and hemicelluloses in the fiber. It was advantage of lesser application of pressure on the mixture and disadvantage of cost in production than the chemical method.

2.5.1 Properties 0f Particle board

Structural application of particleboard shows their unique durability and resistant to impact and abrasion. The properties of particleboard are characterized by the kind of shape of chips, kind and amount of adhesive, pressure and methods of forming. Materials to be used for the production of particleboard should have the ability to absorb huge amount of moisture and yet retaining its properties. The board should be able to attain high holding properties e.g when nails/screw and joints is driven into it.

The primary influence of binder selected and particle size of the coconut shell described the performance of a particleboard. The smaller the particles size, the more the

effectiveness of the binder as it's penetrates into the intricate of the bulk of the particles. A suitable binder creates a rapport which combines the discrete flakes and the sawdust together under heat and pressure by creating internal bonding (Shukar, 1977).

1. **Tensile Strength**:

This is the measure of resistance that a material offers to tensile stress. The specimens of particle board were cut for the test and the test and the tensile load at which the specimen failed was recorded. Tensile stress was calculated by using the formula

$$r_t = \frac{Wt}{b \times t}$$

Where w_t - is the failure tensile load in kg

b - is the breadth of specimen in cm

t - is the thickness of specimen in cm

r_t - is the tensile stress in kg/cm^2

2. **Hardness**

Hardness denotes the inherent power, which a material has to resist fracture by bending. In test, it is measured by the capacity for bending through a definite angle one or more times without sustaining a fracture. Hardness and strength are not identical since a material may be strong, i.e. rigid without being hard. A material of this nature may be able to sustain great tensile force up to a certain point and then given way suddenly without previous warning (Tuve, 1977).

3. **Abreaction Test**

This is a measure of scratch that a material can withstand. Wearing or scratch on the smooth surface of the material to be tested. By comparing the results of different materials by reference to hardness scale, the relative hardness is found; or a better test is by means of a lever attached to a vertical pillar and by taking the pillar by hand it makes a scratch. The weight in grams required to produce a scratch of standard depth gives a measure of hardness (Gladius, 1977).

4. **Static bending**

The ability of material to withstand a load the static bending of a material results either from a purely dead load from a variable load. It is a very importance test enabling one to ascertain the maximum allowable load on materials. The bending can be achieved if density of the materials satisfied (Gladius, 1977).

5. **Nailing Test**

Nailing on particle board is the ability of the material to withstand nailing or screwing without splitting or disintegration of the binder used. Nailing test is done in order to ascertain the bending strength of the material. Particle board should have a minimum holding force of not less that 178N (40IB).

Nailing and screwing effect-Both, metallic nails and wooden screw of 2mm, 4mm and 6mm diameter were used to find their effect on particle boards under test. Mainly, the test included the visual observations on the development of cracks on their insertion. Skill experienced carpenter was employed for this purpose.

6. Compressive strength

The specimen of particle board in cubical shape of 6mm - 7mm thickness were cut and the compressive load at which the specimen dialed was recorded the compressive stress was calculated by using the formula:

$$r_c = \frac{Wc}{b \times t}$$

where w_c is the failure compressive load in kg and r_c is the compressive stress in kg/cm^2

7. Bending strength

The specimen of particle board was cut and the load at failure was recorded. The bending stress was calculated using the formula:

$$I = \frac{bt^3}{12} \qquad M = \frac{W}{4} \quad \text{and} \quad r_b = \frac{M}{I} \times y$$

Where I is the moment of inertia in cm^4

I is the span of specimen in cm

W is the load applied in kg

y is the distance of extreme fiber from neutral axis in cm (y=t/2);

r_b is the bending strength in kg/cm^2

m is the bending moment in kg/cm.

8. Density

Density is a measure of strength of material, depending on the pressure applied per unit volume express as kg/m^3, g/cm^2 respectively. The values obtained can be affected by pressure, temperature and purity. The recommended density of particle board should fall between lower density of $350kg/m^3$ - $1400kg/m^3$ and higher density of respectively $1600kg/m^3$ - $2100kg/m^3$ respectively.

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} (\text{kg/m}^3)$$

9. Water absorption characteristics

The samples of particle board of known initial weigh were dipped in water at room temperature, kept them there and taken out at a regular interval of 30min. the final weights of particle board samples found after free surface water was removed by the board on blotting paper. Water absorption percent was calculated by using the formula:

$$\text{Water Absorption} = \frac{W_t - W}{W} \times 100$$

Where w is the weight of specimen before dipping in water in kg and w_t is the weight of specimen after t min of dipping in kg.

10. Curing

This is the process of controlling the rate of water (moisture) loses from fresh particle board. The setting and hardening of stuck (mix) depend on the presence of water. Drying out (or rapid dehydration) if allowed to take place rapidly would result in low

strength and brittle board. Method of curing to be adopted depends on the atmospheric conditions of the stacking condition. The lower the temperature, the slower is the rate at which boards harden if efficient curing method is adopted, the strength of the product is adopted, the strength of the product in creases resistance to abrasion. Effective curing method is thus most necessary and may last for several days.

2.5.2 Uses Of Particle Board

Particle board is used not only in wood products like furniture, cabinets, and homes but also in many basically metal products such as automobiles, refrigerators, and trailers. About 50 percent of all particle board is used in building construction for siding, interior panel, under laying, kitchen cabinets, and similar purpose. Furniture manufactures use 20 to 25 percent for such items as exteriors television cases drawer bottoms, and the backs of cases and cabinets. Some furniture manufacturers use particle board in making their own lumber core plywood, strips of solid wood.

i. Working with particle board

For ordinary interiors installations individual sheets of particle and should stand on edge 24 hours or more, allowing adjusting to the surrounding air. Particle board that will be subjected to high humidity (for bathrooms, utility rooms or exterior use), should be "pre expanded" by long exposure to damp air or by scrubbing water into the back of the panel with a broom. Scrubbed panels should then be stacked back-to back under a tarpaulin for 24 hours if standard board, 48hours if tempered.

ii. Sawing

Particle board may be sawed as many other wood product with hand or power tools for best results sharp high-speed power saws should be used for high-production work, saws must be carbide-tipped, of a design recommended by the saw manufacturers.

iii. Machining

Particle board may be machined the same way as other wood products could be machined such operation as shaping, routine and planning give best results if tools are kept sharp. Absence of grain in particle board allows uniformly fine machining without splintering.

iv. Sanding

The quality of particle board is such that surface sanding is not normally required. However, sawed edges, machined surfaces, and surface scratches can be dressed up by normal wood sanding procedures. Also, precision sanding to close tolerance can be done.

v. Beading

Wide dry bends may be made by fastening particle board solidly to curved forms for smaller-radius bends wet the particle boards, and then bend it over heated forms until dry.

Tighter bends without rupturing may be made by slow, deliberate bending. The thinner the board, the sharper the curve that can be bent. Also, tempered particle board will bend tighter than the same thickness of no tempered varieties.

Vi Drilling

Particle board may be drilled the same way other wood product could also be drilled for best results, the piece should be placed up ward and a solid backing used to attained clean edges.

vii. Fastening

Particle board may be fastened with any of the common wood fasteners, such as nails staple, automatic nail, screws bolts, adhesives or rivets etc.

Nailing Particle Board

Start at the edge adjoining the previous panel and work across the board to word the free edge. Use 3d finishing nails (galvanized against preference) for interiors. As insurance against fiber putting around nail heads and nail loosening, it is recommended that annular-thread or ring groove hardboard nail be selected. These nails are designed to be set flush with the work. Allow some freedom of movement between the boards, taking

cave no to force them tightly together, space nails 6" on center, make joints only where solid support is available. For exteriors, at least a 5.5d galvanized nail (casing or box), a shake nail, or a hardened siding nail should be chosen.

Staples of Particles Board

For best result stapler with narrow screw and divergent points (branding out in different directions) should be used, along with a hummer-types stapler or air gum spacing of 3.5" or " is recommended, length of staplers should be at least 1" plans the thickness of the board. The power required varies with the thickness and laid of board.

Screws and Bolts of Particles Board

Any thickness of hardboard may be screwed or bolted to a frame or base after drilling holes large enough to accommodate the size of screws or bolts. Also this size particle board and its thickness should have excellent screw-holding capacity for attaching hinges or other hardwire.

Drilling holes smaller than the screw diameter, metal sheet should be use first to make the hole in line with the screw.

Painting of Particle Board

Particle board will take almost any type of finish, brush, spray. Roller may be used according to the finish require. Interior-wall panels require no special sealer. However, it sealer is to be applied , rubber or vinyl-base white are good choices oil base paint require no special sealer water paint should be mix with sealer clear finishes require a recommended non-pigmented sealer. Clear varnish or resin sealers should not be used as a first cost. Best result are obtained with transparent filler-sealer, natural paste wood filer, or clear-drying white vinyl-glue. Stain finishes may be obtained with pigmented resin sealers, oil wool stains colored pasted-wood fillers of stain waxes. These are wipe

on finishes because they are not good to be paint along with the board. Texture paints or wall paper may only be applied when joint are properly taped and filled.

2.6 Types of Adhesive

i. Vegetable - starch adhesive:- Obtained from Cassava when peeled and grinded. The grinded Cassava is sieved and allowed to settle, it is latter decanted and dried to prevent it from bacterial attack. Other adhesives like Casein adhesive made from Curd of soured mill (Othmer and FOA,1968).

TABLE 2 REMARKS ON WOKING CHARACTERISTICS OF MANUFACTURED PARTICLES BOARD

OPERATION	REMARK
Bending	Fair
Drilling	Good
Hardness	Medium
Laminating	Good
Nailing	Good
Painting	Unfilled - fair
Punching	Filled - good
Routing	Fair
Sanding	Good
Sawing	Good
Screw holding	Good

ii. Formaldehyde-based binders or adhesive are one category of adhesive commonly in use although this materials is under increasing scrutiny due to the toxicity of the under lying formaldehyde compounds.

iii. Polyurethane-type of adhesive, including under this general term specific compounds such as polymeric dispheny limethane di-isocyanate and related compaounds generally referred to as "MDI".

iv. Phenolic-based binders or adhesive. The phenolic based binders tend to be more costly but offer quality advantages in particle boards of higher value.

v. Synthetic resin adhesive:- the product is a combination of Urea and Phenol furnished board when powder formaldehyde are used.

The resins are by chemical means suit able in paint and plastic industry.

vi. Gum Resins:- Contained gum, which differs from resins in that it is soluble in water. They include frankincense and myrrh used in perfume and asafetida as medicinal. (New standard Encyclopedia, 1986).

The customary process of manufacturing particles board involves the blending of the binder with the wood or wood related particles in to a substantially dry blend in which typical about 8% by weight would be binder.

2.7 Function of Adhesive

Adhesive can be said to be ideal for a particular operation if it has the following characteristics:

1- Fast grab attack

2- Dehydration of binding area.

3- To be easy to apply and require no special or flexing equipment

4- To be resistance to creep at high temperature.

5- Have low moisture content.

6- Resin should be flexible on application.

The selection of an adhesive will depend on the following:-

i. Its design life

ii. Loading factors

iii. Effects on near by materials

iv. Economic factor

v. Heat and safety factors

There are also other things to be considered in the selection of an adhesive. The adhesive must not be toxic to material chosen. It must no be flammable or toxic and must be available in commercial quantities, such as sugar molasses and vegetable starch (Galdius, 1977).

CHAPTER THREE

MATERIAL AND METHODS

3.1 Material / Equipment

To develop particle board the following parameters were selected for study;

Independent parameters

Residue or raw material	coconut shell
Sample size (g)	100
Particle size (micron)	230
Moisture content (%)	5

Dependent parameters

Tensile strength

Compressive strength

Bending strength

Effect of Nailing and screwing

Water absorption characteristics

The materials and equipment used for the production and characterization of particle board from agricultural by products are given in the table below (table 3.0 and 3.1).

TABLE 3.0 MATERIALS USED FOR THE PROJECT

MATERIAL	SOURCES	COMMENT
Coconut shell	Bida Godobe market	Dried and crushed
Gum Arabic	Bida Etsu musa market	Shredded, wash crush and sieved.

TABLE 3.1 EQUIPMENT USED FOR THE PROJECT

MATERIAL	SOURCES	RESEARCH CODE
Manual press square shaped wood mould with steel plate cover	Source material outside and make use of school central workshop	
Measuring cylinder	Elt - England	B.S 410/1986
Cylindrical steel container size $0.18m^3$	Made in Minna	Metal
Mortal and pestle	Made in Bida	Wooden frame
Local sieve	Made in Bida	Wooden frame
B.S sieve	Elt-England	BS 410/1986
Milk can	Chemical lab	C1, C2 and C3
Nails and screws	Made in Nigeria	

3.2 Preparation of Coconut Shell Particle Board with Gum Arabic and curing.

The coconut shell used undergoes some form of preparation to obtain reasonable particle size: (small chips) and thus useful for the purpose of making particle board. In this instances, the ordinary coconut shell which was obtained from Mall. Selling coconut fruit seller in Bida godobe market was sun dried by daily spreading it in the sun, until suitably dried coconut shells were pounded in to particle form using pestle and mortar. The coconut shells were pounded with mortar and pestle to loosen and break into particles (splinter, flakes, and saw dusts).

These particles were again sum dried for several days to reduce the moisture contents to about 5% M.C the particles were sieved using the regulated standard of

keeping the particles dried to about 5% m.c the particles were sieved using. An experiment to determine the moisture content of the sample was taken.

The summary of the final preparation of these raw materials are itemized below:-

i. The coconut shells were sun dried for several days to facilitate easy pounded and sieving.

ii. The manual pounded was used that is mortar and pestle to reduce it sizes into flakes, chips, splinters and saw dust, known as particle of coconut shell.

iii. The particle was sieved using British standard sieve to determine particle size to be used to form a homogeneous or the same consistency. The finer the particle size the better in quality of the particle board produced.

iv. The retained particles sizes were sum dry further for some time to reduce the moisture content.

v. After sundry the moisture content test was conducted in the laboratory to keep the particle below or within 5% m.c

vi. The solidified acacia and other foreign bodies were stocked to the extract.

vii. About 50g of the treated acacia extract was mixed with about 60% of hot water at temperature of 100% for some hours, after that the dissolved moisture was sieved and weighed in a weighing balance.

The mixture was collected in a beaker, it was heated in a hot metal plate to the certain temperature for 30 minutes to achieve homogeneity, and the mixture was agitated until a targeted viscosity was obtained. The content was then cooled in a water bath until the temperature reduces.

viii. The steel mould was greased with oil on sides, bottom, surface and cover to reduce frictional resistance created during forming operation.

Note:

Coloring and anti-fungi agents were not added to the solutions (Gum Arabic and Sugar molasses) due to scope of the laboratory work.

3.3 Manufacturing Process of Particle Board

A given sample weighing 0.96kg of coconut shell particles was poured freely into open steel container in damped condition. A liquid Gum Arabic was added to the coconut shell particles and mixed thoroughly for sometimes, to form thick starry called "Stuck". Pieces loose but damped mattresses of particles were forced to achieved reasonable workability for easy compaction. The stuck (mixture) was forced into wood mould with steel top plate cover. The board was shaped to require size as the stuck was compacted several time on the top steel plate cover to achieve a manufacturing pressure. Standard (BS) 2604 part 2 code of manufacturing particle board and plywood. The formed sample was then left to dry atmospheric condition for several days. The mound was removed, after placing and compacted..

3.3.1 Conditioning (curing)

The particles board was produced after mixing and compacting to desired pressure. The wood mould was removed leaving behind the formed board to dry open air and at room temperature for several days.

The purpose of the conditioning is to equalize the moisture content through content through out the board and to minimize.

3.3.2 Characterization of the Board.

The board produced had attained the recommended pressure of 3333.3N/m^2 and lower density range of 350kg/m^2 - 1400kg/m^3 as compared to the recent origin of the loc-density particle boards. The standard used in this work is that plywood and other

wood-based panels by the FOA (1963). The standard is base mainly on experience in the flax shivers for the production of these types of board to determine the efficiency of the board made from the coconut shell and Gum Arabic and Sugar molasses. It is also necessary to establish the minimum standard of bending and tensile strength and other properties in general.

3.3.3 Observation of formed Boards

In this project, a sample of developed particle board is produce using binder (Gum Arabic), using standard particles size of coconut shell (2.86mm

CHAPTER FOUR

LABORATORY EXPERIMENT/TESTS AND RESULTS

This research work is based on scientific methodology as such; several laboratory experiments and test were conducted using the experimental variables to obtain the results which are analyzed here.

The experiment were conducted mostly on the coconut shell particles sample in order to determine the moisture content by reducing it to as lower as possible. To analyze the particles size distribution and achieve homogenous mix, and also to verify the suitability of the binder and come out with the most suitable one among the two binders.

The experimental tests procedures, observations and results must be recorded as follows.

Federal University of Technology, Minna

Department of Agric Engineering

Material Testing Laboratory

WORK: Project Research

TITLE: Sieve analysis of coconut shell particles

AIM: To determine the particle size distribution of coconut shell particle sample with intention of choosing less medium, medium and finest particles for the production of particle boards, with British Standard Sieve (BS 410).

APPARATUS:

Electronic squinter weighing balance (accurate to 0.0.1 degree) and a mechanical shaker.

PROCEDURES:

Each of the seven sieves was weighing empty using the electronic saunter balance 200g of the grinded coconut shell particles were poured in to the top sieve and the set was placed and secured to the mechanical shaker where they were shaken for 10 minutes. The sieves were arranged in decreasing order of size such as 2.80mm, 1.40mm, 1.00mm, 859Nm, 710Nm, 500Nm, 250Nm and the bottom pan were each weighed with their contents and the results were show in the table below:

TABLE 4.0

BS/SIEVE MESH SIZE	WT OF SIEVE (9)	WT OF SIEVE + SAMPLE (9)	WT OF RE-TAINED SAMPLE (9)	% RETAINED	CUMULATIVE % RETAINED
2.80MM	403.2	958.4	441.2	51.04	51.04
1.40MM	366.6	687.2	264.3	24.62	75.66
1.00MM	349.4	545.0	152.6	7.87	83.53
850MM	312.4	494.3	58.6	1.38	84.91
710MM	335.7	487.4	9.4	3.39	88.30
500MM	310.8	453.8	23.8	3.68	91.98
250	290.0	432.1	31.2	5.64	97.62
BOTTOM PAN	267.3	383.3	21.9	2.38	100.00
TOTAL			668.5		673.04

PRECAUTION

1- The sample was dried sufficiently in order to reduce the moisture content.

2- Reading were made immediately and recorded

3- During pounding, care was taken to avoid splashing of particle out of the muter

4- The sample was allowed.

USES OF THE TEST

The test is very important in terms of separating the crushing coconut shell into flakes, and chips. Hence the determination of the suitability of the coconut shell was achieved the test also helped in choosing the particle size of 2.80mm, 140mm and 710mm of the crushed sample, to be used as homogenous particles for the production of particle board.

LIMITATION

The limited to sample retained in sieve 2.80mm, 1.40 and 710Nm graphical represent of the % passing on particle size was not necessary.

: Federal University of Technology, Minna

Department of Agric Engineering,

Material Testing Laboratory

Percentage Moisture Contents Determination

WORK: Project Research

TITLE: Moisture Contents Determination

AIM: To determine the percentage moisture content of the crushed sample of the coconut shell.

PROCEDURE

The dry sample of coconut shell particle was scooped and put into the container whose empty weights as (w1) had been. taken the mass in (g) of net sample and the container was put into the oven and left there for some time (30 minutes) to dry at temperature of 85°c. The dry weight of the container and sample was weighed and recorded as (w_3)

Using the obtain data, the percentage moisture content was calculated.

Using the obtain data, the percentage moisture content was calculated.

$$\frac{W_2 - W_1}{W_3 - W_1} \times 100$$

PRECAUTION

1. The container had to be cleaned with neat dry cloth
2. The dried sample must not allowed to come in contact with moisture before or during weighing.
3. The dried sample was allowed to cool before taking the weight.
4. Results were collected carefully and fast as possible as shown in table 4.1

TABLE 4.1: MOSTURE CONTENT

% moisture content	Test 1 (can no 1 (9)	Test 2 (can no 2) (90)
Weight of container (w)	24.55	20.22
weight of wet sample + containing (W_2)	58.80	56.58
Weight of dried sample + container (W_3)	44.07	43.53
Weight of dried moisture ($W_2 - W_3$)	14.73	13.05
Weight of dried sample ($W_3 - W_1$)	19.52	23.31
Moisture content $W = W_2 - W_3/W_3 - W_1$	0.7546	0.5598

USE OF THIS TEST

The amount of water present in the sample was known through the test. During crushing some water was added to avoid splashing of the crushed particles, and was reduced to 5% moisture content. Sine the moisture above this can affects the strength of the particle board to be produce.

4.1 Particle Board Density

Table (4.2) shows the result of mechanical test carried out on the particle board produce using coconut shell of deferent particle size. The mixed composition can be seen in (4.2) with its various densities recommended in BS 2604 part 2 (1970) for lower value, the result also shows different event values of densities for different size of parties used in the sample produced.

4.2 Particle Board Tensile strength

Table (4.2) shows the tensile strength of board produced from coconut shell particles/Gum Arabic. This result indicates a high tensile strength and very inversely with densities.

4.3 Optimum Concentration of the Binder.

The Gum Arabic concentration proved to give a good retention than that of sugar molasses and it's more effective as a resin adhesive.

4.4. Nail / Screw Withdrawal Test

Dry particle board of size 27cm x 32.50cm x 1.60cm, a rooting nail was driven into the board to a depth of 15mm, using hammer.

The nailing test shows that the particle board satisfied the minimum holding force specified by FAO (1963).

4.5 Possible Factors leading to the Loss in Strength of Particle Board.

Several factors may have been responsible for the loss in strength of the particle board developed, such as:

1- Mould used:- Then would used may cause loss in strength if it is not properly design for effective composition

2- Drying effect:- It was discovered that the drier the board, the higher is the strength. However, the very dense Binder which appear Oily, coupled with the oiled surfaces of the board made it extremely difficult for the board to dry fact.

When sample was oven dry there was a significant difference in terms of cracks occurrence, and burning effects on sample surface than that sample air dry for several days at room temperature.

3- Particle sizes:- The choice of different size of crushed particle of coconut shell affects the density and strength of the board developed. Nothing that, the smaller the particle size the more the effectiveness of the binder as it penetrates into the intercedes of the bulk of the particles

TABLE 4.2 SUMMARY OF COMPARATIVE MATERIAL COMPOSITION AND TEST RESULT.

Material composite	Types of resin binder	Volume of corm cob particle	Weight of formed particle (kg)	Density (Kg/m^2)	Grade particle	Pressure (N/m^2)	Comment bonded properties of Gum Arabic	Date of manufacture	Curing condition	General remark or comment
Sample 100% coconut shell particle size (230mm)	Gum Arabic	$5.0625x 10^3$	0.2561	505.88	Low density	33333.3	High	23/11/05	Room tem. Of (27^0c)	Slow dehydration

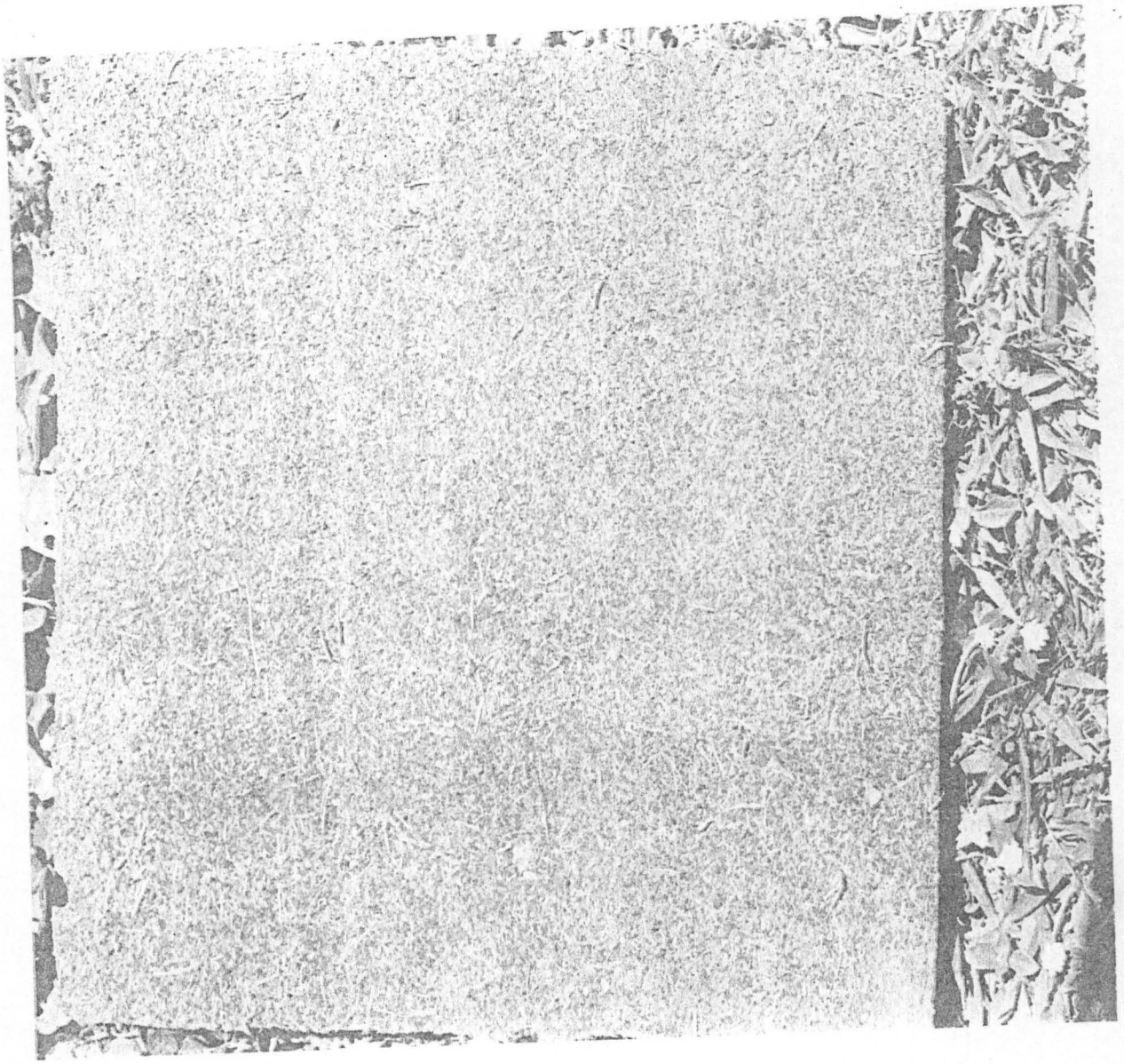


Plate 1 : Developed Particle Board.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Agricultural by- product has been successfully utilized in the production or development of particle board. Coconut shell particle board is a newer area of agricultural waste utilization. It is anticipated that interest and commercial development will continue in this area. More than enough agricultural by-products are available to support particle board manufacturing needs although the agro-based materials may not have a suitable geographical distribution to provide an economically feasible endeavor.

Coconut shell are altercative materials source for particles board because they are light weight after crushing, economical and required little amounts of energy for processing. In addition their growth, use and disposal are considered environmentally friendly.

Gum Arabic is used here in place off synthetic resin as a binder to formulate particle boards.

Most of the strengths properties increased linearly with board densities. This information is important when considering process design for selecting the type of agricultural by-products for particle boards development.

The board formed can be used in the following areas:

1. Flow underlay: - Panels specially engineered for floor underlay, to serve as underlay for carpets or resilient floors covering.
2. Acoustic paneling: - Low density boards could be used in the construction and building of sound proof houses, auditorium etc (Madoux, 1963).

3. Insulator: - Due to the nature of their structural formulation and low-density, these kinds of boards could be used lagging in heating materials and in electronic casing regulate the heat maintained within the surrounding of the electronics (Chittenden,1971)

4. General furniture density boards are widely used in place of woods to reduce costs, weight of material used, described as light furniture, like TV, cabinet, wardrobe, shelves etc.

5.2 Recommendation

Based on the result of this project, the following recommendations can be made for future works. The design and fabrication of a local recycling particle board plant is highly recommended, since all the raw materials required (agricultural by-product and Gum Arabic) can be obtained locally and cheaply. There is the need to increase the tonnage and plant augment the production of particle board in large commercial quantities in Nigeria building industries.

The establishment of building industries in the country that would utilize the waste generated from agricultural by-products to reduce cost of production presently experienced in some of their basic raw materials.

Further studies on other environmental waste in agricultural by-product such as palm kernel, rice husk, and groundnut shell.

The Gum Arabic should be improved upon; to effectively replace the use of synthesis resin adhesive (urea formaldehyde) presently imported into our country for the manufacturing of particle board, chip board, fiber board and ceiling boards.

Curing of particle board by oven drying should be encouraged at 100^0c.

APPENDICES

Calculations

To calculate the density of dried particle board based on the weight of the cure board per unit volume.

Density = Mass

Volume

Weight of particle board "A" = 256.1g

Volume of particle board = 0.15x0.15x0.025

$= 5.0625 \times 10^{-4}$

Density of particle board = $2561/5.0625 \times 10^{-04} = 585.88 \times 10^{3}$kg

Compaction

Using 75kg standard rammer, falling at a distance of 0.4m on iron mould pallet to compact particle board mixture, the force of application can be computed as: force of application = Mass(kg) x Acceleration due to gravity

75 x 10 750N

Pressure

Pressure = Force (N/m^2)

area

$= \frac{750}{0.15 \times 0.15} = 33333.3 N/m^2$

MIX PROPOSITION (BATCHING BY VOLUME)

The mix ratios of coconut shell particles and gum Arabic using the proportion below to avoid unnecessary wastages are:

Resin gum Arabic in volume denoted as R = 400mL = 0.4 liter

Volume of coconut shell particles (C) = $5.0625 \times 10^{-04} m^2$

Note 1 liter = 1000mL

Ratio of R/C = $\frac{0.4}{5.0625 \times 10^{-04}}$

R/C = 711.1

To find R = 711.1C.

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