POLITEKNIK SULTAN SALAHUDDIN ABDUL AZIZ SHAH

OSB BANANA STEM

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CIVIL ENGINEERING DEPARTMENT

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This report is submitted to the Department of Civil Engineering as part of the requirements for the award of the Diploma in Wood-Based Technology.

CIVIL ENGINEERING DEPARTMENT

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AKUAN KEASLIAN DAN HAK MILIK

KAJIAN OSB BANANA STEM

1. Kami, MUHAMMAD NAZIRUL BIN ZULKIFLE (040619010701), MUHAMMAD AMALUDDI BIN JOHARI (040819040227) DAN ADAM NAUFAL BIN JAFRI (O4O507060309) adalah pelajar Diploma Teknologi Berasakan Kayu,Politeknik Sultan Salahuddin Abdul Aziz Shah, yang beralamat Persiaran Usahawan, Politeknik Sultan Salahuddin Abdul Aziz Shah, 40150 Shah Alam, Selangor.

2. Kami mengakui bahawa OSB Banana Stem dan harta intelek yang ada di dalamnya adalah hasil karya/reka cipta asli kami tanpa mengambil atau meniru mana-mana harta intelek daripada pihak-pihak lain.

3. Kami bersetuju melepaskan pemilikan harta intelek OSB Banana Stem kepada Politeknik Sultan Salahuddin Abdul Aziz Shah bagi memenuhi keperluan untuk penganugerahan Diploma Teknologi Berasakan Kayu kepada kami.

Diperbuat dan dengan sebenar-benarnya diakui)

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Thank you.

ABSTRACT

OSB BANANA STEM

Oriented Particle Board (OSB) is an engineered wood panel with strength and durability characteristics similar to plywood. The combination of wood and adhesive in OSB creates a strong, dimensionally stable panel that resists bending, peeling, and deformation. Despite its strength, OSB panels are lightweight, easy to handle, and easy to install. Currently, there is a significant amount of unused agricultural waste, which is often discarded or burned, contributing to air pollution. This project utilizes banana stems as a base material to produce OSB, aiming to reduce agricultural waste that is typically burned, thus lowering air pollution. This study involves physical tests such as water absorption, thickness swelling, and density testing on the produced OSB. The process of producing OSB from banana stems includes particle drying, material cutting, moisture content calculation, and the addition of 3% Urea Formaldehyde (UF) resin in accordance with BS EN 319 standards. It is hoped that the results of this study will provide an eco-friendly alternative for using agricultural waste in construction materials, with further testing to be conducted in the field of Wood Composite Technology.

ABSTRAK

OSB BANANA STEM

Papan Partikel Berlapis (OSB) adalah panel kayu buatan yang mempunyai ciri kekuatan dan ketahanan yang hampir serupa dengan papan lapis. Gabungan kayu dan pelekat pada OSB menghasilkan panel yang kuat, stabil secara dimensi, dan tahan daripada lenturan, pengelupasan, serta perubahan bentuk. Berbanding dengan kekuatannya, panel OSB ringan, mudah dipegang, dan mudah dipasang. Pada masa kini, terdapat banyak sisa pertanian yang tidak digunakan dan dibuang tanpa penyelesaian, sebahagiannya dibakar yang boleh meningkatkan pencemaran udara. Projek ini menggunakan batang pisang sebagai bahan asas untuk menghasilkan OSB, dengan tujuan mengurangkan sisa pertanian yang biasanya dibakar dan menyumbang kepada pencemaran udara. Kajian ini melibatkan ujian fizikal seperti ujian penyerapan air, pengembangan ketebalan, dan ujian ketumpatan pada OSB yang dihasilkan. Proses penghasilan OSB daripada batang pisang merangkumi pengeringan partikel, pemotongan bahan, mengira kandungan lembapan serta penambahan resin Urea Formaldehyde (UF) sebanyak 3% mengikut standard BS EN 319. Diharapkan hasil kajian ini dapat menyediakan alternatif penggunaan sisa pertanian sebagai bahan pembinaan yang mesra alam dan akan diuji lebih lanjut dalam bidang Teknologi Komposit Kayu.

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LIST OF SYMBOLS

Symbol	
°C	Degrees Celsius
%	Percent
cm	Centi meters
mm	Milli meters
kg	Kilograms
µm	Micro meter
MPa	Megapascal
Kg/m^3	Kilograms per cubic meter

LIST OF ABBREVIATIONS

OSB	Oriented Strand Board
UF	Urea Formaldehyde
MC	Moisture Content
SD	Standard Deviation
NO	Number
mf wt.	Moisture-free weight
MOE	Modulus of Elasticity
MOR	Modulus of Rupture
ft	Feet

CHAPTER 1

INTRODUCTION

1.1 Background of study

Oriented Strand Board (OSB) is a type of engineered wood similar to particle board, formed by adding adhesives and then compressing layers of wood strands (flakes) in specific orientations. OSB is commonly used as a structural panel in construction due to its strength, durability, and cost-effectiveness compared to traditional plywood.

OSB is a material with favorable mechanical properties that make it particularly suitable for loadbearing applications in construction. It is now more popular than plywood, commanding 66% of the North American structural panel market. The most common uses are as sheathing in walls, flooring, and roof decking. For exterior wall applications, panels are available with a radiant-barrier layer laminated to one side; this eases installation and increases energy performance of the building envelope. OSB is also used in furniture production. (From Jeremy Yao)

In this study is designed innovation from banana stem to make Oriented Strand Board (OSB). The way to limit the impact on the environment is by reducing the amount of waste that is generated, or the waste must be recycled, composted or reused. When these options are unsuitable, then the waste needs to incinerated or landfilled. The rest of the agricultural produce is made of banana stems.

This research is about OSB. It includes of method how to produce OSB. OSB is manufactured from waterproof heat-cured and rectangular shaped wood strands that are arranged in cross-oriented layers, similar to plywood. There are three layer of wood strand.

1.2 Statement of the problem

Banana stem is commonly assumed as an agriculture waste. Hence, banana stem is usually disposed by open burning that will contribute to air pollution such as haze and greenhouse effect. The disposal of banana stems also causes the presence of poisonous animals because these animals like moist places such as snakes, scorpions and centipedes. So this will harm the gardeners.

The independent variable for this study is to produce composite from banana stem. The control variable to testing the physical properties which is water absorption, thickness swelling and density test.

1.3 Significance of the study

Banana Stems OSB using a material of board which is banana stem. Finding from the study may useful to various factions, including educators and researchers. Researchers and others will acknowledge the importance of information from this research. It also will enhance the knowledge for researchers in board. Therefore, this board to study their physical properties which is water absorption, thickness swelling and density test.

AIM

This research is focusing on the suitability of banana stem OSB. The research will also filling the information gap on banana stem especially on the fundamental characteristic, properties and new research development. Therefore, this board to study their physical properties which is water absorption, thickness swelling and density test.

1.4 Objective

- Producing Oriented Strand Board (OSB) from banana stem.
- Make a testing of physical properties such as, water absorption, thickness swelling test and density testing with banana stem OSB.

1.5 Scope of study

This study is only limited to the investigation of banana stem (Musa Paradisiaca) used as an alternative source for construction frameworks and furniture manufacturing. This project is producing banana stem by liquid resin and proceed at Wood Composite Laboratory Politeknik Sultan Salahuddin Abdul Aziz Shah. Researcher chose this study for further investigation if the banana stem can be an effective ingredient resources to make Oriented Strand Board (OSB).

CHAPTER 2
LITERATURE RIVIEW

2.1 Characters of banana stems

Banana stem fiber, a natural fiber, has good potential as a variable and alternative reinforcement in the production of lower density polyethylene composites. Weak fiber-matrix interaction of fiber-reinforced composites can readily be overcome through fiber modification and pretreatment. Both successfully used to reinforce the polyethylene matrix. Composite reinforced with the treated fiber showed improved physical
and mechanical properties over that reinforced with untreated fibers. The tensile properties of the composites increased with increasing fiber content.
Properties of banana fiber Bilba et al. determined the chemical composition of banana stem by elemental analysis. The results were as follows, cellulose-31-35%, hemicellulose-14-17% and lignin-15- 16%. Reddy and Yang analyses the production processes, structure, properties and suitability of bio-fibers for various industrial applications. They studied the properties of banana fiber, pineapple leaf fiber, coir,
wheat straw, barley straw and rice straw and resulted that pineapple and banana fibers have higher cellulose content 70-82% and 60-65%, respectively. The banana fiber showed the diameter of 80-250 µm with the elongation percentage of 1.0-3.5.
Kiruthika and Veluraja studied the physical properties of banana stem fiber. The varieties selected by them were Red Banana, Nendra, Rasthaly, Morris and Poovan. They found that the tensile strength of Red Banana fibres was high (525 MPa) followed by Nendra (456 MPa), Rasthaly (346 MPa). Banana stalk fiber (BSF) was subjected to chemical pulping and used as reinforcement in low density polyethylene composite. The effects of fiber loading and pretreatment o the physical and mechanical properties of the composites were determined and reported. The analysis of banana stem showed a chemical composition and thermal behaviour similar to other types of lignocellulosic biomass. Banana fibres exhibited high moisture content, volatile matter, and ash content. Banana fibres had high nitrogen and oxygen, but low carbon and hydrogen. The sulphur content in banana wastes was similar to other types of lignocellulosic biomass. The characterization of banana stem and had a high amount of lignocellulose of more than 85 mf wt.% of their dry weight with higher holocellulose, hemicellulose, lignin, and extractive contents, but lower cellulose contents than the reported values elsewhere. Thermal stability of banana stem was around 150°C.

Decomposition of banana stem occurred between 300°C and 350°C, while the degradation of the materials took place above 430°C for banana stem. The results obtained in the physical, chemical and thermal behaviour of the samples was similar to the other biomass already used for generation of renewable energy. It also implies their potential for obtaining value added products through combustion and pyrolysis processes. These thermochemical conversion processes can significantly reduce the volume of wastes. Consequently, it helps reducing environmental impact generally caused by its disposal. It is therefore, the used of banana plantation wastes as a feedstock in thermochemical process should be further studied.

2.2 Characters of Oriented Strand Board (OSB)

Oriented Strand Board is a widely used, versatile structural wood panel. Manufactured from waterproof heat-cured adhesives and rectangularly shaped wood strands that are arranged in cross-oriented OSB Grades Strength and stiffness properties MOE for 3- ply MOE for 5- ply MOR for 3- ply MOR for 5- ply O-1 1300 MPa 4500 MPa 9.6 MPa 23.4 MPa O-2 1500 MPa 5500 MPa 12.4 MPa 29.0 MPa layers, OSB is an engineered wood panel that shares many of the strength and performance characteristics of plywood. OSB's combination of wood and adhesives creates a strong, dimensionally stable panel that resists deflection, delamination, and warping; likewise, panels resist racking and shape distortion when subjected to demanding wind and seismic conditions. Relative to their strength, OSB panels are light in weight and easy to handle and install. OSB is produced in huge, continuous mats to form a solid panel product of consistent quality with no laps, gaps, or voids. Finished panels are available in large dimensions, minimizing the number of joints that can "leak" heat and admit airborne noise. Oriented Strand Board does have a low, but existing toxicity, due to the resin in it. The resin puts out a low level of formaldehyde gas, which is not more than 10 percent of national standards. This makes the chance of toxicity low, but it does exist, if a person is more susceptible to it, such as if they have an impaired immune system, are elderly or a baby. These chemicals come from it being made by pieces of wood being glued together. It is also sometimes coated with a boric acid product that is toxic to termites, but this is not dangerous to people.

OSB has its advantages. Some panels have a textured surface, which makes them less slippery when used for roof sheathing. OSB panels often have lines at 16- and 24-in. intervals so you know where underlying studs, rafters and joists are for nailing. In our area, 1/2-in. OSB sheathing costs a few dollars less per sheet than 1/2-in. plywood. And OSB is available in 4 x

9-ft. sheets, which means you can sheathe an 8-ft. tall wall and the joists below with a single sheet. While, OSB does not have a continuous grain like a natural wood, it does have an axis along which its strength is greatest. This can be seen by observing the alignment of the surface wood chips.

2.3 2 Characters of Urea Formaldehyde (UF)

Urea-formaldehyde, also known as urea-methanal, so named for its common synthesis pathway and overall structure [1] is a non-transparent thermosetting resin or polymer. It is produced from urea and formaldehyde. These resins are used in adhesives, finishes, particle board, medium density fiberboard (MDF), and molded objects. UF and related amino resins are a class of thermosetting resins of which ureaformaldehyde resins make up 80% produced globally. Examples of amino resins use include in automobile tires to improve the bonding of rubber to tire cord, in paper for improving tear strength, in molding electrical devices, jar caps, etc. Urea–formaldehyde (UF) resins are the most important type of adhesive resins for the production of wood-based panels. They convince by their high reactivity and good performance in the production and by their low price, however they lack in water resistance of the hardened resin owing to the reversibility of the amino-methylene link and hence the susceptibility to hydrolysis. This need can be overcome by introducing other components like melamine to the UF resin molecules. The former problem of subsequent formaldehyde emission can be considered as solved owing to the decrease of the content of formaldehyde in the resins during the last two decades. Modern laboratory test methods enable a deep insight into the chemical structure and the gelling and hardening behavior of the resins.
Urea-formaldehyde resin's attributes include high tensile strength, flexural modulus, and a high heat distortion temperature, low water absorption, mould shrinkage, high surface hardness, elongation at break, and volume resistance. It has a refractive index of 1.55. The characteristics of plywood panels produced with urea formaldehyde resin (UF) containing borax, were studied. Shear strength, formaldehyde emission, and bending characteristic.

CHAPTER 3

METHODOLOGY

3.1 EXPERIMENTAL DESIGN

a) Target density: 580 kg/m3

Thickness: 12mm

Length x Width: 340mm x 340mm

No	Materials	Amount
1	Liquid resin (Urea Formaldehyde)	62g
2	Banana stem	680g

Table 1. 1 The quantity of materials and resin A

b) Target density: 540 kg/m3

Thickness: 12mm

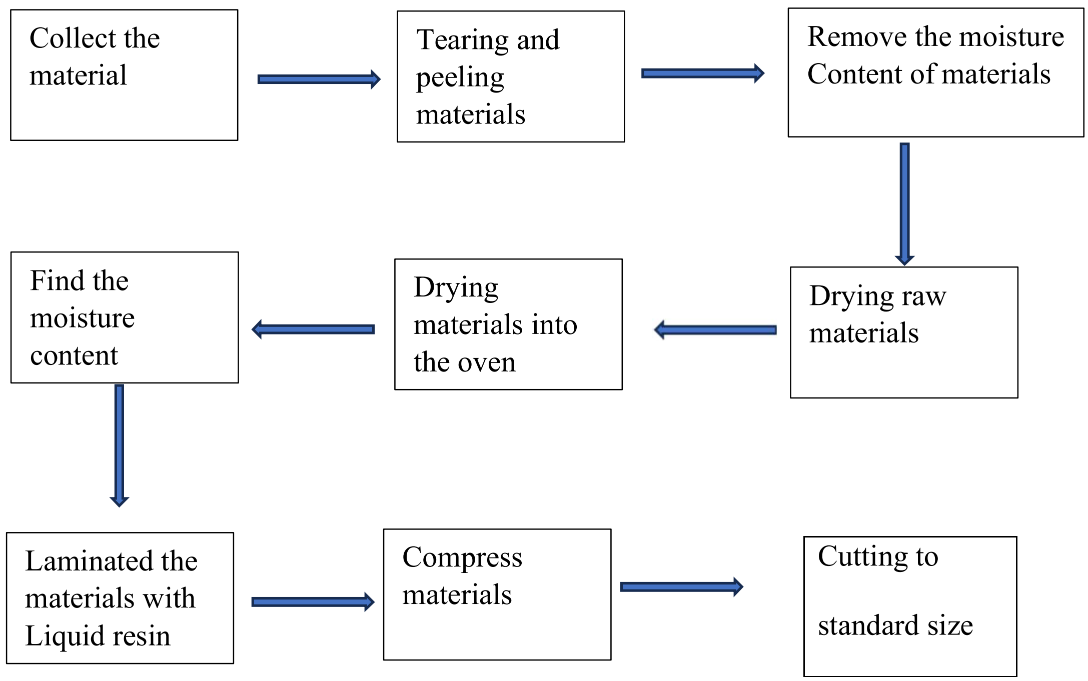
Length x Width: 340mm x 340mm

No	Materials	Amount
1	Liquid resin (Urea Formaldehyde)	62g
2	Banana stem	640g

Table 1. 2 The quantity of materials and resin B

The study is to find the best quality composite wood between agricultural wastes. Then, it becomes a useful composite wood and replaces the raw wood. In this research method, all activities during experimental work are based on standard procedures and scales. It describes each research activity based on standard tests and the requirements that have been used in this experiment are based on the Malaysia Standard.

3.2 FLOW CHART PROCESS



Banana stem

- The water absorption characteristics of the composites was determined manually based on the difference between the weights of specimen test thickness swelling.
- Moisture content in the sample to determine the weight of water in the particle based on air dried minus oven dried.
- Density test is calculating the oven-dry weight of wood fiber contained in a known wood volume of various wood species.

3.2.1 Raw Material

First at all, the banana stems are searchable and collected.


Figure 1: The raw material

3.2.2 Cutting to small size

The banana stems will be cut into the smaller size.

Figure 2: Material preparation

3.2.3 Particle drying

For drying process, the temperature for the oven dry is 105ºC for 24 hours. The target of moisture content is >10%. This process very important to reach the moisture content target for make sure the board not blows also to get the good strength properties of board.

Figure 3: Particle drying process

3.2.4 Calculated of moisture content (MC)

After 24 hours, the moisture content will be taken. The moisture content for 680 g and 640 g banana stem are about 8%.

Figure 4: Determining the moisture content

3.2.5 Mix material with resin

The drying of banana stems will mixing with resin Urea Formaldehyde (UF) blended. Resin Urea Formaldehyde (UF) which are about 62 g.

Figure 5: Mixed material with resin

3.2.6 Arranged with three layers

After doing a mixing, the sample banana stems will arrange by layers.

Figure 6: Layered material arranged perpendicular to the grain

3.2.7 Hot press

The temperature of hot press for upper plate and lower plate temperature is 160ºC. Hot press is using the hot press machine.

Figure 7: Hot pressing stage

3.2.8 Conditioning

After the resin was cured at the time, the board picks it out for conditioning at the normal temperature for 24 hours.

Figure 8: Conditioning stage

3.2.9 Cutting to standard size

After sanding line, the banana stem board will do process cutting with follow the Malaysia standard (MS1787) 50mm x 50mm.

Figure 9: Sample cutting to standard size for mechanical and physical testing

3.3 BOARD EVALUATION

Testing that we have done is divided into 3 testing. First testing is density test and the second testing is water absorption test. The other testing is thickness swelling.

3.3.1 Water Absorption

Water absorption ASTM D570 is used to determine the amount of water absorbed under specified conditions. Factors affecting water absorption include: type of plastic, additives used, temperature and length of exposure. The data sheds light on the performance of the materials in water or humid environments. For water absorption test, the specimens are dried in an oven for a specified time and temperature and then placed in desiccators to cool. Immediately upon cooling the specimens are weighed. The material is then emerged in water at agreed upon conditions, often 230C for 24 hours or until equilibrium. Specimens are removed, patted dry with a lint free cloth, and weighed. Water absorption is expressed as increase in weight percent.

Percent water absorption = [(wet weight – dry weight) / dry weight] x 100

3.3.2 Density

The density, or the volumetric mass density, of a substance is its mass per unit volume. The density has the same numerical value as its mass concentration. Different materials usually have different densities, and density may be relevant to buoyancy, purity and packaging. To simplify comparisons of density across different systems of units, it is sometimes replaced by the dimensionless quantity 'relative density' or 'specify gravity', the ratio of the density of the material to that of a standard material, usually water. This a relative density less than one means that the substance floats in water. The density of a material varies with temperature and pressure. This variations is typically small for solids and liquids but much greater for gases. Increasing the pressure on an object decreases the volume of the object and thus increases its density. Increasing the temperature of a substance (with a few exceptions) decreases its density by increasing its volume. In most materials, heating the bottom of a fluid results in convection of the heat from the bottom to the top, due to the decrease in the density of the heated fluid. This causes it to rise relative to more dense unheated material. The reciprocal of the density of a substance is occasionally called its specific volume, a term sometimes used in thermodynamics. Density is an intensive property in that increasing the amount of a substance does not increase its density rather it increases its mass.

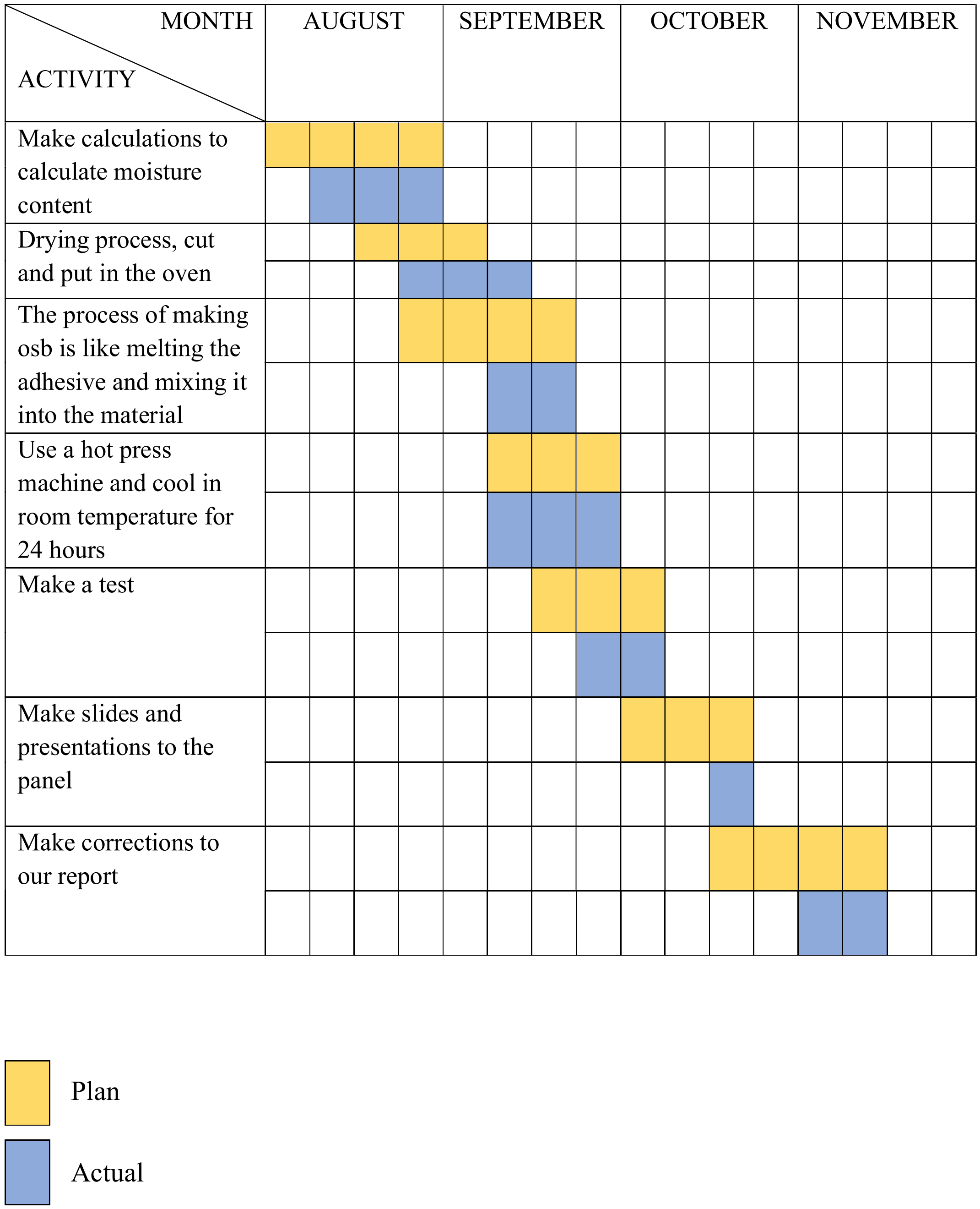
Density = mass / volume (kg/m3)

3.3.3 The thickness swelling

The thickness swelling test in water absorption testing is an important evaluation for board materials, particularly for products like particleboard, fiberboard (MDF), plywood, and other engineered wood products. This test assesses how much a board's thickness increases when exposed to water, simulating real-world conditions where boards may face moisture. Thickness swelling can impact dimensional stability and strength, making it crucial for quality control in applications like furniture, cabinetry, and construction. This test is typically conducted per standards such as ASTM D1037 (for wood-based fiber and particle panel materials) or ISO 16983.

Thickness Swelling = Final Thickness – Initial Thickness / Initial Thickness x 100 (%)

3.4 GANTT CHART



3.5 PARAMETER

The parameter of this study is the difference in material size to produce OSB boards.

1. OSB Banana Stems A (size 30cm)

Figure 10: Size material

2. OSB Banana Stem B (size 12cm)

Figure 11: Size material

CHAPTER 4

RESULT AND DISCUSSION

4.1 Density test

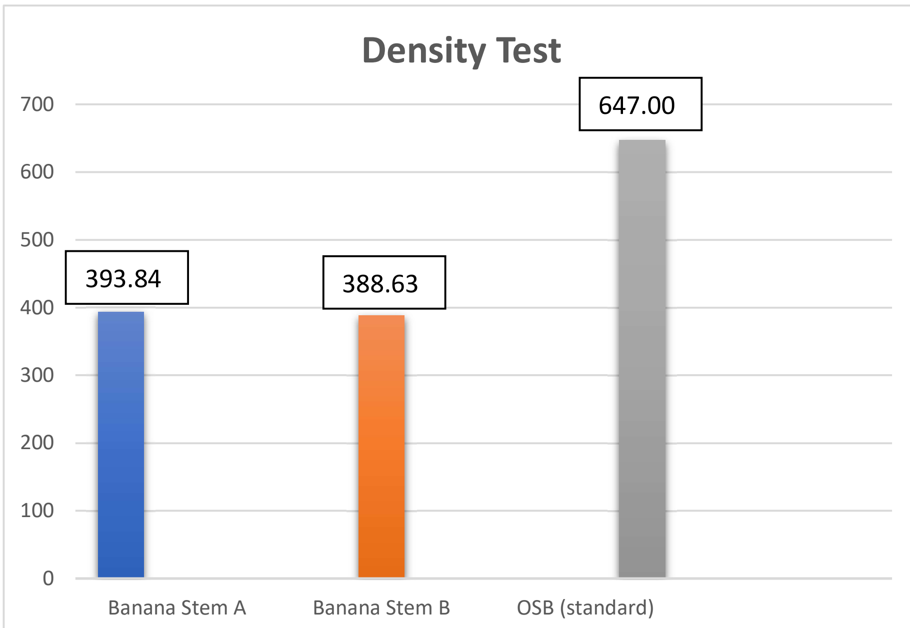


Figure 12: The density testing of osb banana stem

From the result, the density for OSB Banana Stem A and OSB Banana Stem B have not achieved the value of standard but achieved on target density between 480kg/m until 580kg/m. The density of OSB Banana Stem B is lower than the OSB Banana Stem A because the size of material OSB Banana Stem B is short, compared with OSB Banana Stem B that have long size of material.

4.2 Water absorption

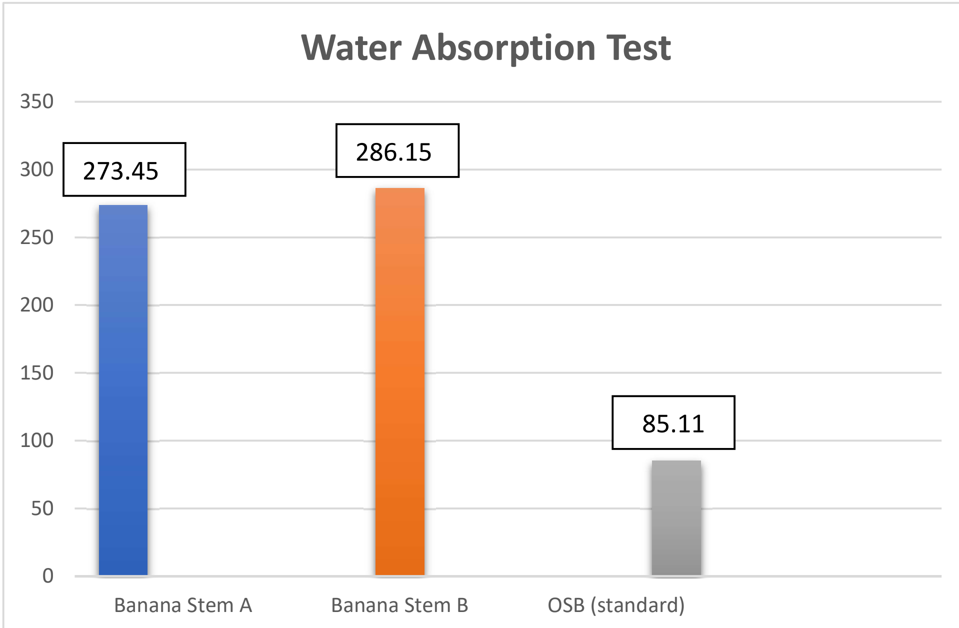


Figure 13: The water absorption testing of osb banana stem

From the result, the water absorption for OSB Banana Stem B is higher than the OSB Banana Stem A because OSB Banana Stem B have hollows that can absorb more water, compared with OSB Banana Stem A that can absorb a little water.

4.3 Thickness swelling

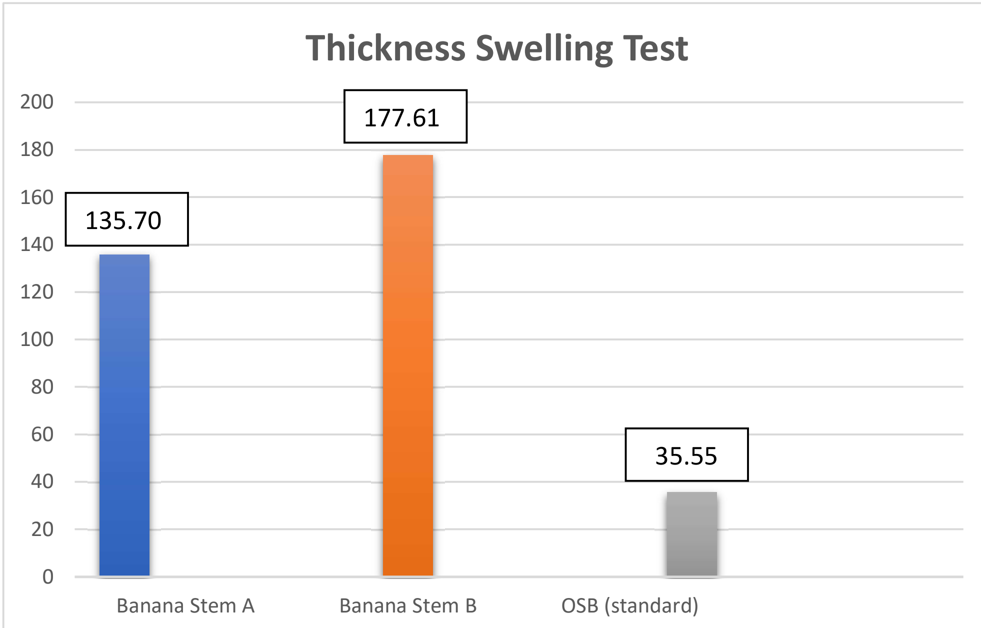


Figure 14: The thickness swelling testing for osb banana stem

From the result, the thickness swelling for OSB Banana Stem B is higher than OSB Banana Stem A because shorter particle size may have more surface area exposed to moisture, leading to increased water absorption. This increases swelling as more water is absorbed into the material.

CHAPTER 5

5.1 CONCLUSION

As conclusion, the study on OSB from Banana Stem A and Banana Stem B with a resin content of 62g at an average density of 480kg/m^3 to 580kg/m^3 showed varying results in terms of strength and other physical properties. Although there was improvement in certain properties, the findings do not fully meet the required standards. This suggests that other factors, such as particle size, resin absorption rate, and actual density, may influence the strength and durability of the OSB. Therefore, further research is needed to improve the material formulation and ensure more consistent results that meet the desired standards.

5.2 RECOMMENDATION

OSB made from banana stem can be used as a soundproof wall by adding a layer of acoustic foam or gypsum board to help reduce noise. Between the OSB and the main wall, add sound-absorbing materials like mineral wool or acoustic fiber to reduce sound transmission.

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APPENDICS STANDARD

ORIENTED STRAND BOARD STANDARD

DENSITY TEST					
Samples No.	Length	Width	Thickness	Weight	Density
	mm	mm	mm	g	Kg/m^3
1	51.25	50.81	12.14	20.34	634.41
2	50.95	50.92	12.26	20.62	648.28
3	50.74	50.72	12.12	20.45	655.63
4	50.83	50.75	12.00	20.63	666.44
5	50.71	50.86	12.15	19.75	630.26
Average	50.90	50.81	12.13	20.35	647.00
SD	0.22	0.08	0.09	0.34	14.94

Table 1. 3: Density Test of OSB Standard

WATER ABSORPTION			
Samples No.	Weight(mm)		(%)
	Before	After	
1	20.34	37.90	86.33
2	20.62	38.42	86.32
3	20.45	37.15	81.66
4	20.63	36.12	75.08
5	19.75	37.57	96.18
Average	20.35	37.43	85.11
SD	0.36	0.87	7.71

Table 1. 4: Water absorption of OSB Standard

THICKNESS SWELLING			
Samples No.	Thickness(mm)		(%)
	Before	After	
1	12.14	16.83	38.63
2	12.26	16.00	30.50
3	12.12	16.36	34.98
4	12.00	16.25	35.41
5	12.15	16.80	38.27
Average	12.13	16.44	35.55
SD	0.09	0.36	3.27

Table 1. 5: Thickness swelling test of OSB Standard

APPENDICS A

ORIENTED STRAND BOARD BANANA STEM A

DENSITY TEST					
Samples No.	Length	Width	Thickness	Weight	Density
	mm	mm	mm	g	Kg/m^3
1	50.10	50.62	13.60	15.28	443.02
2	50.35	50.82	13.62	11.82	339.20
3	50.43	50.48	13.84	12.80	363.30
4	50.20	50.01	13.51	17.38	512.42
5	50.22	50.74	13.64	10.82	311.30
Average	50.26	50.53	13.64	13.62	393.84
SD	0.12	0.30	0.12	2.31	73.78

Table 1. 6: Density Test of OSB Banana Stem A

WATER ABSORPTION			
Samples No.	Weight(mm)		(%)
	Before	After	
1	15.28	51.20	235.10
2	11.82	47.92	305.41
3	12.80	44.51	247.73
4	17.38	59.50	242.35
5	10.82	47.25	336.70
Average	13.62	50.10	273.45
SD	2.68	5.78	45.06

Table 1. 7: Water absorption of OSB Banana Stem A

THICKNESS SWELLING			
Samples No.	Thickness(mm)		(%)
	Before	After	
1	13.60	29.26	115.15
2	13.62	29.45	116.22
3	13.84	32.20	132.66
4	13.51	37.53	177.80
5	13.64	32.28	136.66
Average	13.64	32.14	135.70
SD	0.12	3.34	25.42

Table 1. 8: Thickness swelling test of OSB Banana Stem A

APPENDICS B

ORIENTED STRAND BOARD BANANA STEM B

DENSITY TESTING					
Samples No.	Length	Width	Thickness	Weight	Density
	mm	mm	mm	g	Kg/m^3
1	51.00	50.74	13.72	13.99	386.43
2	50.93	50.00	13.50	12.79	372.04
3	50.84	50.00	13.20	11.82	352.26
4	50.46	50.14	13.71	15.18	437.62
5	50.23	50.00	13.00	12.89	394.80
Average	50.70	50.17	13.42	13.33	388.63
SD	0.30	0.30	0.28	1.15	28.42

Table 1. 9: Density Test of OSB Banana Stem B

WATER ABSORPTION			
Samples No.	Weight(mm)		(%)
	Before	After	
1	13.99	59.00	321.72
2	12.79	42.85	235.02
3	11.82	50.00	323.01
4	15.18	65.46	331.22
5	12.89	41.22	219.80
Average	13.33	51.70	286.15
SD	1.29	10.41	54.02

Table 1. 10: Water Absorption Test of OSB Banana Stem B

THICKNESS SWELLING			
Samples No.	Thickness(mm)		(%)
	Before	After	
1	13.72	36.40	165.30
2	13.50	27.18	101.33
3	13.20	43.85	232.20
4	13.71	47.44	246.02
5	13.00	31.62	143.23
Average	13.42	37.30	177.61
SD	0.32	8.38	60.85

Table 1. 11: Thickness swelling test of OSB Banana Stem B