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Compared and Properties of Oil Palm Empty Fruit Bunching Fibers to Be Used as a Roofing Material

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ABSTRACT
The objective of this research is to study the Compared and Properties of Oil Palm Empty Fruit Bunching fibers used as a Roofing Material. The roofing sheet material is produced like a corrugated. Regarding the process of producing, they use synthetic adhesive Polymeric Diphenylmethane Di-isocyanate resin (pMDI) , Urea formaldehyde resin (UF) and synthetic adhesive Phenol formaldehyde resin (PF), 5% and 10 wt%. The roofing sheet material has a density at 700 kg m-3 and 15 mm. thickness. After that, it is tested for physical, mechanical and Thermal properties, according to the Industrial Standards of TIS.876-2547,TIS 535-2556, JIS A 5908-2003 (8 type), ASTM D 256-2006a. The thermal properties are also tested, according to ASTM C 177-2010.The study reveals that oil palm empty fruit bunching fibers used as a roofing material can be pressed into an corrugated roofing material. They have required physical the properties, and mechanical the properties meet the Industry Standard TIS 876-2547and TIS 535-2556. The properties taken into consideration are; a density, moisture, water absorption, water leakage and thickness swelling, modulus of rupture and modulus of elasticity resistance and impact strength. According to the study using three types of adhesives, it is found that synthetic Polymeric Diphenylmethane Di-isocyanate resin provides the best mechanical properties. For the thermal the properties, it is found that the thermal conductivity and resistance of the roofing sheet material use urea formaldehyde resin (UF) is better than the properties.

Keywords
Empty Fruit Bunching fibers, Physical properties, Mechanical properties, Thermal properties

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1. Introduction

Thailand is one of the countries that has a lot of agricultural waste materials. However, such materials are rarely re-used and are neglected on cultivation areas which ends up being burnt. At present, agricultural waste materials are scattering all over the country, depending on agricultural product quantity of each particular area. The most agricultural wastes contain 3 main types of organic chemical components is cellulose, hemi-cellulose, and lignin In the ratio of 4: 3: 2 Kuhad, R.C. [1] In the past, it was found out that there were a lot of waste materials more than 43 million tons/year. S.Tengkaew. et.al. [2] Such agricultural waste materials with huge quantity are sugarcane and oil palm empty fruit bunching fibers. It composes of gathering fiber which can divide into single one. Some are used to get benefit and become approach to develop new products of industrial sectors. P.Wangwan.et.al.[3]Oil palm empty fruit bunching fibers is a kind of agricultural waste material with high nutritional value, compared with fresh grass. However of materials have high quantity and very low value, these waste materials are suitable to use as low materials to produce roofing Material.

The researchers are interested in taking agricultural waste materials i.e. Empty Fruit Bunching fibers to mix with adhesives. Then, the materials are formed into corrugated roofing sheet. Using local materials can generate great benefits. It is also considered as adding value to natural waste materials. The researchers study how to produce corrugated roofing sheet materials made from oil palm empty fruit bunching fibers. Regarding the adhesives, they use synthetic adhesive Di-isocyanate resin (pMDI), Urea Formaldehyde (UF) and synthetic adhesive Phenol-Formaldehyde (PF) 5%and 10%. Then the three types of adhesives are compared with same quantity. After that the material is formed with 15 mm. thickness. Total hot compress duration is set for 15 minutes with 120 $^{\circ}$C. The pressure of hot compression is 150 kg sq-1 centimeters. The outcome product of corrugated roofing sheet is set

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in 15 minutes with a pressure of 150 kg sq-1 centimeters, at temperature of 120 $^{\circ}$C. If the standard is higher than this, the board will deteriorate. Finally, it is tested for physical, mechanical, and thermal properties, according to the industry standard.

2. REVIEW OF LITERATURE

From past research studies of compared and properties of oil palm empty fruit bunching fibers used as a roofing material

A.Pasilo.et.al.[4]studied the investigation of the properties of roofing tiles manufactured from agricultural residues. The agricultural residues in this work are corncob fibre,plam fruit bunch fibre and water hyacinth fibre. Synthetic urea formaldehyde resin adhesive was selected as the binder. Main properties of roofing tiles investigated in this work were physical, mechanical and thermal properties. Consequently Finally, it was found that the properties of roofing tiles constructed in this work are similar to commercial roofing tiles.

Jessada W.O.et.al.[5] stated that mechanical and physical properties of roof Tile prepared from sugar cane fiber. sugar cane, renewable fiber resources, were used for roof tile production. Urea formaldehyde, phenol formaldehyde and isocyanate resin were used as binders in this study. Roof tile specimens with 400 mm wide, 400 mm long and 5 mm thick were prepared by compression molding.

Jacob O.A.et.al.[6] have development of roofing sheet material using groundnut shell particles and epoxy resin as composite material. Sample A and B have the best possible proportion to be taken into consideration for the production of commercial roofing sheets. Sample "A" was adopted in this work because of its excellence performance properties. The results revealed that groundnut shell particles can be used as reinforcement for polymer matrix for the production of roofing sheets.

Darsana P.R.A,et.al.[7] have development of coir-fiber cement composite roofing tiles. In order to optimize the cost of construction, engineers have always been on the lookout for efficient and light roofing which requires minimum maintenance and labor to install. Coir is a green building material and has potential as a raw material for the production of roofing materials like corrugated sheets and tiles.

Santhosh B.S.et.al.[8] studied the strength of corrugated roofing elements reinforced with coir. Roofing sheets were casted with flyash- based coir fibers and are experimentally evaluated for the strength of the corrugated sheetsin terms of flexural and impact load. Flyash based coir fibre has witnessed improved result in the strength of the corrugated roofing sheets due to flexural and impact loads as compared to the corrugated sheets without coir fibers. The Result of study revealed that the fly ash with coir fiber can be used to replace asbestos in production of corrugated roofing sheets

3. METHODOLOGY

3.1 Preparing the Fibers Material

In preparing the roofing sheet fiber, oil palm empty fruit bunching fibers received from Oil Palm industry in Surat Thani Province, Thailand. The oil palm empty fruit bunching fibers were washed in water then treated by alkalization using sodium hydroxide (NaOH, provided by company in Thailand) for 24 h. The treated fibers were cleaned by water, dried, cut and ground to fine fibers. The ground fibers were sieved to an average particle size of 5 mm. shown in Fig 3.1

Fig 3.1 Hammer mill machine to crush oil palm empty fruit bunching fibers

3.2 Chemicals used in the experiment

Reaction Catalyst: This type of chemical is the accelerator of the reaction rate of adhesive solidity. It can reduce the time period of hot compressing. There are three types i.e. Common catalyst and Latent catalyst. The three types of catalyst are mixed with adhesives to accelerate the materials as soon as the materials get heat. Such catalysts mixing in general glue are; ammonium sulfate, ammonium chloride, and sizing agent which helps reducing water absorption. In addition, paraffin emulsion is used in the study. The researchers also use adhesive Di-isocyanate (pMDI), Urea formaldehyde resin and synthetic adhesive Phenol formaldehyde resin for the experiment.

3.3 Materials and Research Equipment

The research equipment used are as follows; steel mold size of 300×320 mm shown Fig.3.2,wood frame of 300×320mm,digital Vernier caliper which can measure in details of 3digits. Also, the equipment include micrometer which can measure in details of 1.01 mm, and weight scale which can measure in details of 0.001 g.

3.4 Specimen preparation

For the test specimen's preparation, the corrugated roofing sheet material were cut into the exact dimensions described in related standards. The specimen for physical, testing samples density, moisture content (MC), water absorption (WA), thickness swelling (TS) was 50x50 mm and water leakage 300x320 mm samples. The specimen for mechanical properties testing was 50x50x15 mm. The specimen with the dimensions of 12.70±0.20 mm wide by 63.50±2.0 mm long and 6 mm thick was prepared for impact strength test. For modulus of rupture (MOR) and modulus of elasticity (MOE) test, the specimen was 50x200 mm. Sample of 300x300 mm were used to test the thermal and resistivity conductivity.

3.5 Experimental Procedure

First, the researchers use hammer mill machine to crush oil palm empty fruit bunching fibers. The materials are crushed and then become smaller. Then, they are sifted in order to split size by screening machine with grills. The fiber bunches that have been crushed. To analyze the size of oil palm empty fruit bunching fibers used in the extrusion of roofing sheet materials. It was found that the pieces of oil palm bunches that remained on the 40 strains were the highest by 71.18%, with the average width of 0.72 mm., The average length was 4.77 mm. Average thickness is 0.17 mm and the proportion is slim at 27.93 of slender as much. The humidity of both oil palm empty fruit bunching fibers before mixing adhesive is 3.5%, and 10–12% after mixing. After that 1% of paraffin emulsion and 2% of catalyst are infused in the materials. Then, the researchers prepare to form the board by cold pressing method. They sprinkle the fiber with adhesives and other mixture into wooden box of 300×320 mm then, they put the sheet on hot compressors. It is the process of hot pressing by hydraulic compressor set. After hot pressing, the sheet is adjusted moisture condition at the room temperature for 24 h. After adjusting the sheet's temperature, 4 edges are cut. To get standard size, each edge is cut off 1.5 cm by sawing machine. Finally, the sheet or board is tested for physical, mechanical, and thermal properties, according to the industry standard. shown in Fig 3.2

Fig 3.2 Roofing sheet material from oil palm empty fruit bunching fibers

4. RESULTS AND DISCUSSIONS

According to the process, the researchers form a sample of roofing sheet material from oil palm empty fruit bunching fibers. The size is 15 mm thick. The duration of hot compressing is 15 minutes with 120 °C temperature. The pressure of hot compressing is 150 kg cm^{-3}.Then, sample is tested according to the industry standards of TIS. 876-2547[9], TIS. 535-2556,[10] JIS A 5908-2003(8 types) [11], ASTM D 256-2006a [12], and ASTM C 177-2010[13]

4.1 Results of Physical Properties

It is found that the physical properties of the roofing sheet material from oil palm empty fruit bunching fibers compose of density, moisture content, water absorption for 2 and 24 h, water leakage for 2 h and thickness swelling for 2 and 24 h, according to the industry standard.

Table 4.1 Details of Testing an roofing sheet material from oil palm empty fruit bunching fibers

Type and Quantity of Adhesives (%)	Average Density (kg m^{-3})	Symbols
Di-isocyanate resin (pMDI 5%)	763.45	a
Di-isocyanate resin (pMDI 10%)	786.61	b
Urea formaldehyde resin (UF 5%)	761.49	c
Urea formaldehyde resin (UF 10%)	775.95	d
Phenol formaldehyde resin (PF 5%)	756.73	e
Phenol formaldehyde resin (PF 10%)	767.84	f
TIS 876-2547 JIS A5908-2003 (8 Type)	400-900 400-900	g (standard)

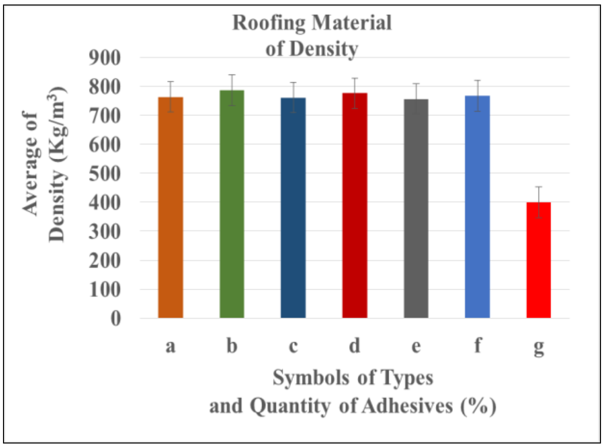

Fig 4.1 Average of density

The study shows that the roofing sheet material from oil palm empty fruit bunching fibers with synthetic adhesive at 5% and 10% phenol formaldehyde resin has average density at 756.73 and 767.84 kg m-3. Synthetic adhesive isocyanate resin has average density at 763.45 and 786.61 kg m-3 respectively. Regarding the corrugated roofing sheet material with synthetic adhesive urea-formaldehyde resin, the average density is found at 761.49 and 775.95 kg m-3. Similarly, the roofing sheet material from oil palm empty fruit bunching fibers respectively. The roofing sheet material from oil palm empty fruit bunching fibers can pass the standard level of TIS 876-2547 which defines the density value at 400-900 kg m-3 show Fig 4.1.

It is found that the moisture content of the roofing sheet material from oil palm empty fruit bunching fibers with synthetic adhesive at 5% and 10% of phenol-formaldehyde resin consists of average moisture content at 12.15 and 11.14%. And the roofing sheet material from oil palm empty fruit bunching fibers sheet with synthetic adhesive isocyanate resin contains average moisture content at 10.42 and 9.91% respectively. Whereas the sheet with synthetic adhesive urea-formaldehyde resin has average moisture content at 10.57 and 9.94 % respectively. The value can pass the standard level of TIS 876-2547 which defines the moisture content at 4-13%. show Fig 4.2.
In terms of water absorption for 2 and 24 h, the roofing sheet material from oil palm empty fruit bunching fibers with synthetic adhesive at 5% and 10% of phenol-formaldehyde resin has average of water absorption for 2 h at 13.25 and 41.21%, and

for 24 h at 41.21 and 39.12%. Similarly, the roofing sheet material from oil palm empty fruit bunching fibers sheet with synthetic adhesive isocyanate resin contains average of water absorption for 2 h at 12.22 and 33.74%, and for 24 h at 11.71 and 31.92 % respectively. However, the sheet from oil palm empty fruit bunching fibers with synthetic adhesive urea-formaldehyde resin has average of water absorption for 2 h at 12.75and 11.94%, and for 24 h at 38.83 and 35.62%. respectively. The value meets the standard level of TIS 876-2547. The value can pass the standard level of TIS 876-2547 define the value of water absorption for 2 and 24 h. show Fig 4.3.

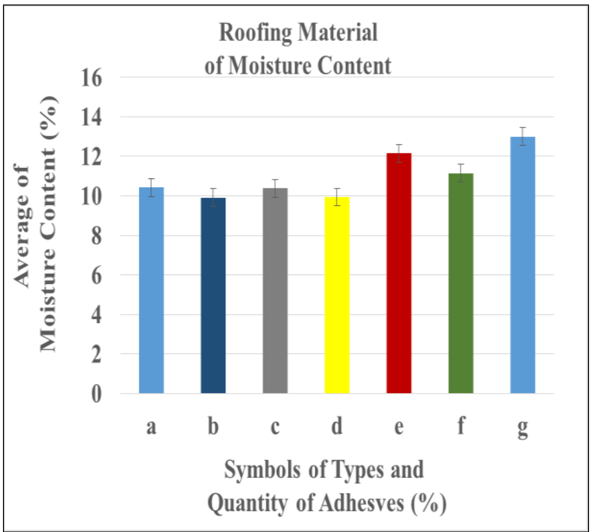

Fig 4.2 Average of moisture content

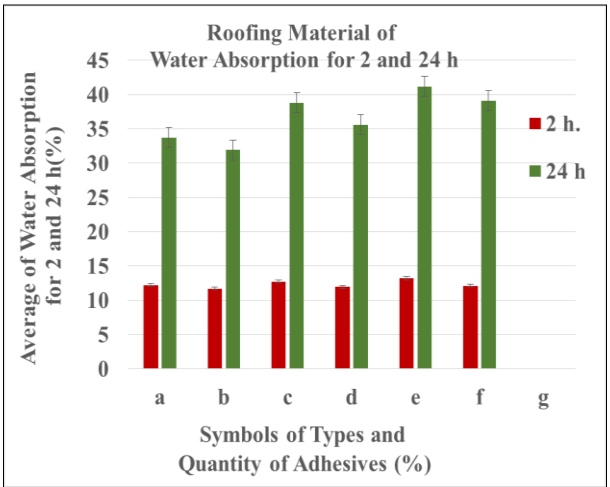

Fig 4.3 Average of water absorption for 2 and 24 h.

At water leakage tested at 2 hours of roofing sheet using PMDI, UF and PF resin as the adhesive were 5% and 10% for the sheet with the density of 700 kg m–3. For the water leakage tested at 2 hours. the results of leak proof test of roof sheet material from roofing sheet material from oil palm empty fruit bunching fibers did not appear to leak under the water the washed side of the sheet.

Regarding thickness swelling for 2 and 24 h, the oil palm empty fruit bunching fibers sheet with synthetic adhesive at 5% and 10% of phenol-formaldehyde resin contains average of thickness swelling for 2 h at 8.15 and 5.24%, and at 11.34, 9.32 % for 24 hours. Similarly, the oil palm empty fruit bunching fibers with synthetic adhesive isocyanate resin contains average for 2 h at 3.15and 2.81%, and at 9.24 and 5.82 % for 24 hours respectively. By comparison, the sheet made from oil palm empty fruit bunching fibers with synthetic adhesive urea-formaldehyde resin has average of thickness swelling for 2 h at 6.25 and 3.12%, and at 10.33 and 8.43% for 24 hours respectively. The value is considered to pass the standard level of TIS 876-2547. That is the thickness swelling value of a flat pressing sheet for 2–24 h must not exceed/or equal 12%.

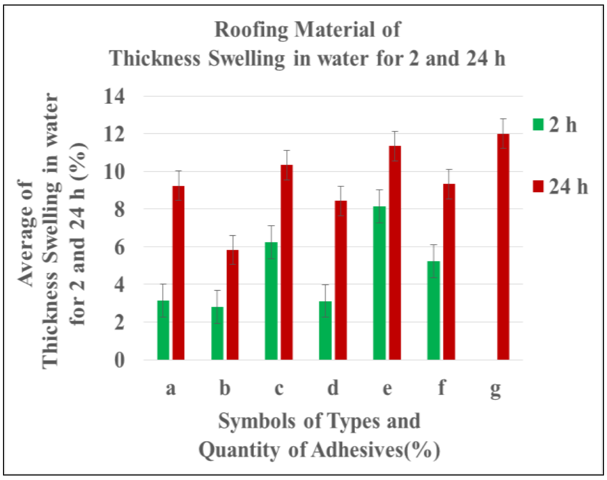

Fig 4.4 Average of thickness swelling in water for 2 and 24 h

4.2 Results of Mechanical Properties

The researchers test the sheet to find mechanical properties. Such properties compose of bending force resistance, modulus of rupture and elasticity, as well as impact strength which are tested by

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Universal Testing Machine. In addition, the tests cover. The tests depend on the standard test of TIS 876-2547, JIS A 5908-2003 (8 types) and ASTM D 256-2006.

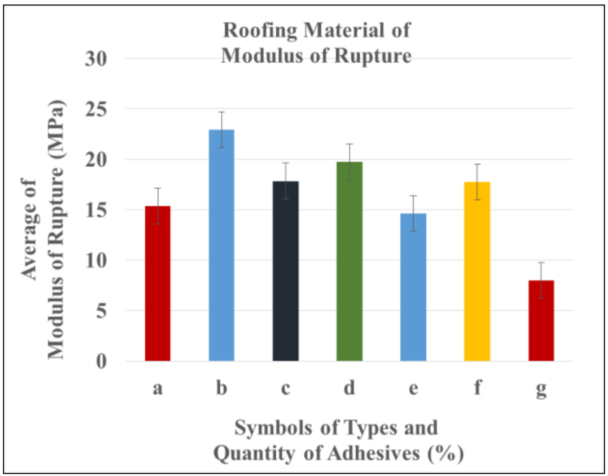

Fig 4.5 Average of modulus of rupture

Regarding bending force resistance and modulus of elasticity, the sheet made from oil palm empty fruit bunching fibers with synthetic adhesive at 5% and 10% of phenol -formaldehyde resin consists of average at 14.64 MPa and 17.74 MPa. Whereas the sheet with synthetic adhesive isocyanate resin consists of average at 15.35 MPa and 22.95 MPa respectively. However, the sheet made oil palm empty fruit bunching fibers and synthetic adhesive urea-formaldehyde resin consists of average at 17.84 MPa and 19.72 MPa. shows the average of modulus of elasticity at 31.51MPa and 2128 MPa.

At the same time, the oil palm empty fruit bunching fibers sheet with synthetic adhesive at 5% and 10% of phenol-formaldehyde resin consists of average at 2183 MPa and 2214 MPa. Similarly, the roofing sheet material from oil palm empty fruit bunching fibers sheet with synthetic adhesive isocyanate resin shows the average at 2186 MPa and 2221MPa and urea-formaldehyde resin consists of average at 2184 MPa and 2218 MPa. respectively. So, it can be said that the sheet from oil palm empty fruit bunching fibers can pass the standard level of TIS 876-2547.

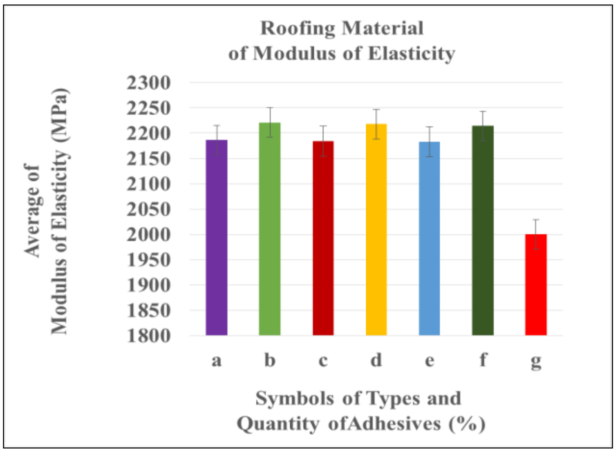

Fig 4.6 Average of modulus of elasticity

The standard clarified that a flat compressing sheet must contain bending force resistance required that is more than 8 MPa. In addition, the modulus of elasticity must be more than/or equal 2000 MPa. Unfortunately, the oil palm empty fruit bunching fibers sheets with synthetic adhesive phenol-formaldehyde resin and synthetic adhesive isocyanate resin and urea-formaldehyde resin can pass the standard level of bending force resistance and modulus of elasticity.

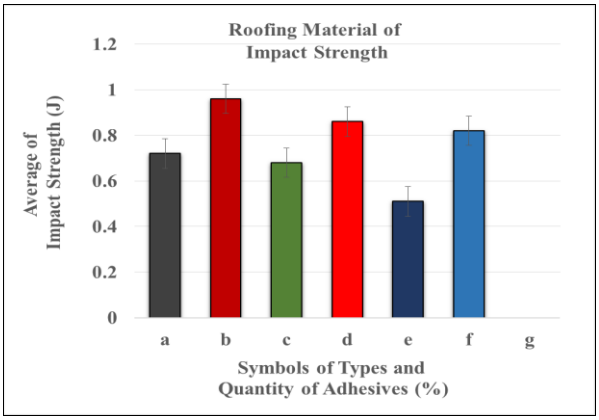

Fig 4.7 Average of impact strength

Considering the value of impact strength the result shows that the sheets of oil palm empty fruit bunching fibers with synthetic adhesive at 5% and 10% of phenol -formaldehyde resin consists of average at 0.51 J and 0.82 J. Similarly, the roofing sheet material from oil palm empty fruit bunching fibers sheet with synthetic adhesive isocyanate resin contains the average of impact strength at 0.72 J and 0.92 J. whereas the one with synthetic adhesive Urea formaldehyde resin contains 0.68 J and 0.86 J. respectively.

4.3 Results of Thermal Properties

Result of Testing Thermal Property, the researchers operate thermal analysis by Thermogravimetric Analysis (TGA) Instrument. It is the process to measure thermal conductivity and thermal resistance. The researchers test the cutting part of corrugated roofing sheet of size 300×300 mm, referring to the standard of ASTM C 177-2010.

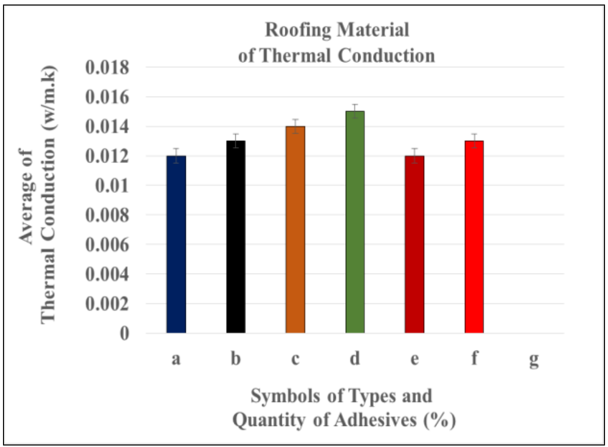

Fig 4.8 Average of thermal conduction

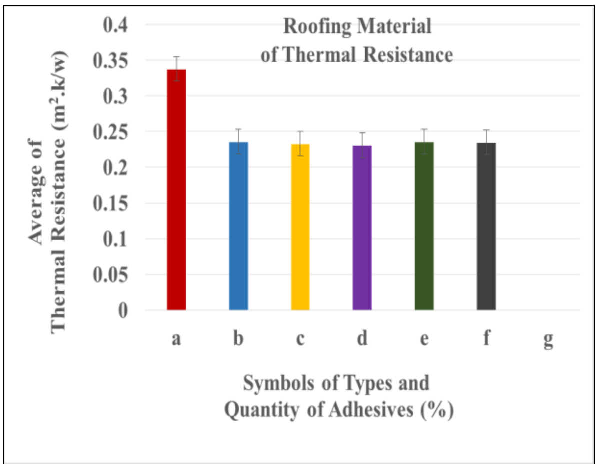

Fig 4.9 Average of thermal resistance

As a result, the average of thermal conduction and thermal resistance for the sheets of oil palm empty fruit bunching fibers mixed with synthetic adhesive at 5% and 10% of isocyanate resin indicates at 0.012 W.m k-1, 0.338 m^2.k W-1, and 0.013 W.m k-1, 0.236 m^2.k W-1. And the oil palm empty fruit bunching fibers sheets with synthetic adhesive Urea formaldehyde resin consists the average at 0.014 W. m k-1, 0.233 m2 k W-1 and at 0.015 W.m k-1, 0.231 m2.k W-1respectively. By comparison, the oil palm empty fruit bunching fibers sheets with synthetic adhesive Phenol-formaldehyde resin shows the average at 0.012 W m k-1 and 0.236 m2 k W-1and 0.013 W m k-1 and 0.235 m2 k W-1 respectively.

The study of producing roofing sheet material from oil palm empty fruit bunching fibers aims at studying the quantity of adhesives. That is synthetic adhesive Phenol-formaldehyde and urea-formaldehyde at 5%,10% and synthetic adhesive isocyanate resin .The study deals with testing physical, mechanical, and thermal properties, according to TIS 876-2547 and JIS A 5980-2003 and ASTM C 177-2010 and ASTM D 256-2006a. Also, According to the test, it is found that the roofing sheet from oil palm empty fruit bunching fibers with synthetic adhesive isocyanate resin 5% and 10% contains higher properties than the one with synthetic adhesive Phenol-formaldehyde 5%and 10%. That is synthetic adhesive isocyanate resin provides higher mechanical properties. The sheet is durable for serious situations. It is dense and hard. The surface is strong enough to anchor impact strength and modulus of rupture. Regarding thermal properties, it is found that thermal conductivity is at nearly level as insulation of commercial production 0.1212-0.1585. (Value of thermal resistance of other types of commercial production materials 0.023-0.280 W/m.k-1

5. CONCLUSIONS

The following conclusions are made based on the laboratory experiments carried out in this investigation.

In this study, the physical, mechanical and Thermal properties of corrugated roofing sheet material produced from oil palm empty fruit bunch fibers were investigated. The roofing sheet material from oil palm empty fruit bunching fibers has smooth external surface. The material in fibers and inside the sheet touch each other closely. The board passes the standard level of TIS 876-2547 dealing with Flat pressed particleboards. It is obvious that natural fiber has specific property. Which means, it is helpful for heat insulation, light, resistant to bending force. It is a way to increase alternative material which is inexpensive and has good quality for building material. Hence, it is another alternative material that will reduce capital cost. People can select agricultural waste material which are easy to find in locality. Appropriate material and production technology can be operated. Besides, the most important thing, the product will make people more understand and realize the value of using natural resources. The achieved roofing sheet material were suitable for material asbestos roofing tiles making. The product is also regarded as another choice to add value for farmers.

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