

# Experimental Analysis of Mechanical and Thermal Properties of Sugar Palm Fiber-Plastic Composite Roofs

Agus Wijianto <sup>a\*</sup>, Mustaza Ma'a <sup>a</sup>, Jupri Yanda Zaira <sup>a</sup>, Rizkyana <sup>b</sup>, Bherry Arif Sitingjak <sup>a</sup>

<sup>a</sup>Mechanical Engineering, Caltex Riau Polytechnic, Pekanbaru, Riau, Indonesia

<sup>b</sup>Computer Science, Persada Bunda Indonesia University, Pekanbaru, Riau, Indonesia

\*Corresponding author: aguswijji@pcr.ac.id

## Paper History

Received: 22-August-2025

Received in revised form: 21-November-2025

Accepted: 30-November-2025

## ABSTRACT

This research aims to enhance the performance of Palm Sugar Fiber (PSF) or *Ijuk* roofing by combining it with recycled High Density Polyethylene (HDPE) plastic as a binder and outer protective layer. The method was used an experimental study with several variations in fiber form and mass, followed by performance testing on temperature, noise, and mechanical properties (tensile, compressive, and impact strength). The results showed that the 40-gram long fiber variation provided the most optimal performance. The indoor temperature beneath the PSF roof was recorded at 38.2°C. The absolute thermal conductivity value was calculated at 0.23 W/m·K. In noise reduction tests, the PSF roof recorded 39.6 dB compared to 74.2 dB for zinc roofing. In terms of strength, the palm fiber roof achieved a tensile strength of 13.24 MPa and the impact strength of 3.16 Joules. Thus, the fiber (fiber) composite roof with HDPE binder demonstrates superior thermal and sound insulation capabilities, as well as sufficient mechanical strength, making it a promising environmentally friendly alternative for modern roofing materials.

**KEYWORDS:** *Palm fiber (ijuk), HDPE, Mechanical testing, Sound insulation, Thermal insulation.*

## 1. INTRODUCTION

Indonesia has a tropical climate with an average temperature of 26.7 °C in the period 1991–2020 and increasing to 27.2 °C in 2023 according to the Meteorology, Climatology, and Geophysics Agency (BMKG) [1]. This affects the thermal comfort value of Indonesians, in general the thermal comfort temperature value of Indonesians themselves is 22.8 °C - 25.8

°C with 70% humidity[2]. One of the influences on thermal comfort in Indonesia is the use of roofing materials and the choice of building shape [3]. The use of zinc roofs greatly affects the temperature value in the room because zinc is a material that is not good at insulating heat, causing the room temperature to increase [4]. *Ijuk* is also often used as a roof for traditional houses with the advantage of being resistant to tropical weather and having thermal insulation, however, *ijuk* roofs have the disadvantage of being susceptible to pests, not fire resistant, and easily rotting [5],[6].

Plastic waste is a serious problem in Indonesia. High Density Polyethylene (HDPE) and Low Density Polyethylene (LDPE) plastic types are widely used because they are heat and chemical resistant [7]. According to data from the National Waste Management Information System (SIPSN), Riau Province produces 188,403.73 tons of plastic waste or 19.29% of the total waste [8]. The weaknesses of natural materials as raw materials for biodegradable plastics are overcome by blending them with synthetic materials such as LLDPE, HDPE, PP, and others. This blending is expected to produce a product with physical and mechanical properties similar to conventional plastics, but with the advantage that the resulting waste is environmentally degradable [9].

The research material of roof showed average home room temperature using a leaf roof type of 29.6°C, 32°C asbestos roof and 32.1°C iron sheeting roof. The average humidity of the house that uses the leaf roof is 72.28%, asbestos 55.7% and iron sheeting 57.3% [10]. Thermal conductivity research on variations of HDPE plastic shows that Average effective thermal conductivities of the HDPE-nano type and spiral fin type were 3.9% and 13.2% higher than the HDPE type, respectively. On the other hand, average effective thermal conductivity of the coaxial type was lower than that of the HDPE type by 4.1% [11].

The literature study related to the chemical treatment of Sugar Palm Fiber (SPF or *Ijuk*) and the mechanical properties of SPF-reinforced polymer composites discovered that Sugar palm fiber has notable mechanical performance, such as flexural, tensile, and impact strength. This property inhibits the wettability of lignocellulosic fiber with the polymer matrix to form good compatibility fiber/matrix for high-strength composites [12]. A study of thatched roofs in traditional

Japanese houses found that the high thermal insulation, high thermal capacity, and shading effect of thatched roofs, which are characteristic of traditional Japanese houses, moderated the increase in indoor air temperature in summer. For relative humidity, the annual average value was lower and the annual range was narrower indoors than outdoors [13]. Roof noise levels during rain are a key factor in a home's comfort level. Research on metal roofs shows that uncoated metal roofs are not recommended for use due to their proximity to the noise threshold. However, coated metal roofs, such as those with a sand coating, are still recommended in this study because the noise level remains below the specified threshold [4],[14]

This research aims to enhance the performance of Palm Sugar Fiber (PSF/*Ijuk*) roofing by developing a composite that utilizes recycled High Density Polyethylene (HDPE) plastic as both a binder and an external protective layer. This opens up opportunities to utilize recycled HDPE as a binder for palm fibers to produce composite roofing materials that have better heat, sound, and mechanical strength insulation performance.

## 2. METHODS

This research was conducted experimentally at the Caltex Riau Polytechnic campus, where testing was conducted in two locations, namely the Mechanical Engineering Laboratory and the Caltex Riau Polytechnic multipurpose building. The main objective of this research was to obtain good roof variations and to compare zinc roofs with roofs made from palm fiber with the best plastic binder. The series of tests carried out were tensile tests, impact tests, heat insulation tests, and sound insulation tests. The PSF-plastic composite roofs manufacturing process shows in Figure1. The steps for data collection can be seen in Figure 2.

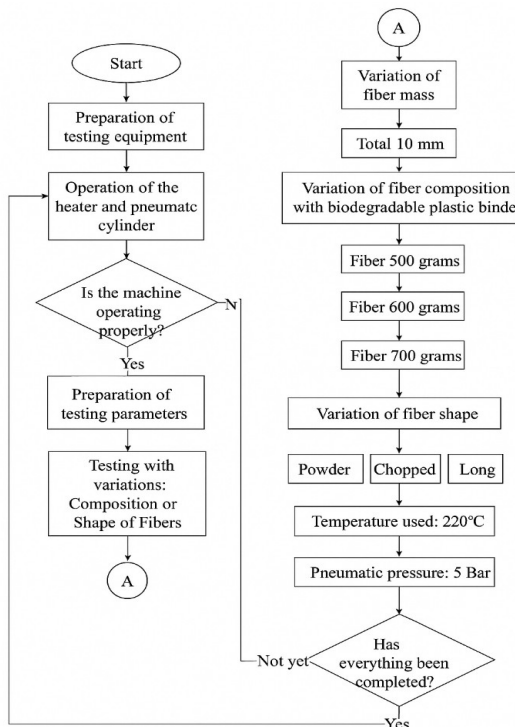


Figure 1: Palm Sugar Fiber (PSF)-plastic composite roofs manufacturing process

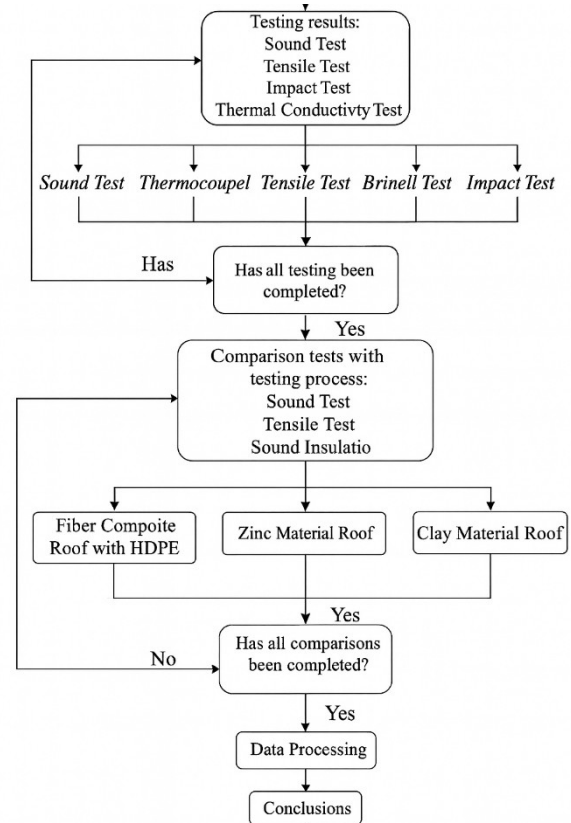


Figure 2: PSF-plastic composite data collection

Data collection in this study was conducted through an experimental approach in the laboratory with the aim of determining the performance of composite roofing materials made from palm fiber and HDPE plastic as a binder. There are three main aspects that are the focus of testing, namely heat insulation capacity, sound insulation, and mechanical strength, both against tensile and impact forces. Tests were conducted on several variations of palm fiber forms, namely in long and chopped form, as well as variations in material mass of 40 grams, 50 grams, and 60 grams. Each variation was tested with standard procedures and measuring instruments, and compared with zinc roofing as a comparison material.

Thermal insulation testing was conducted to assess the composite roof's ability to reduce heat from the outside. In the process, the roof material was placed on the same test stand with a size of 20 cm x 30 cm, then heated using a solar heat source. The temperature at the top of the roof was measured using a thermo gun, which was shot at the roof to obtain heat input data from the top, which was placed in the same position on each sample to obtain consistent data. Measurements were made after the temperature reached a stable condition (steady-state), then compared with the temperature under the roof as a comparison of the difference in roof heat dissipation.

Based on the data from the roof heat test, the radiation value and convection value were calculated as the basis for calculating the thermal conductivity value, which this data will be used as comparative data with the K value of zinc. To determine the soundproofing capability, acoustic insulation testing was conducted using a sound level meter. In this test, the roof was placed on a test frame and simulated conditions of falling objects from above, such as stones or using an artificial sound hammer from the roof.

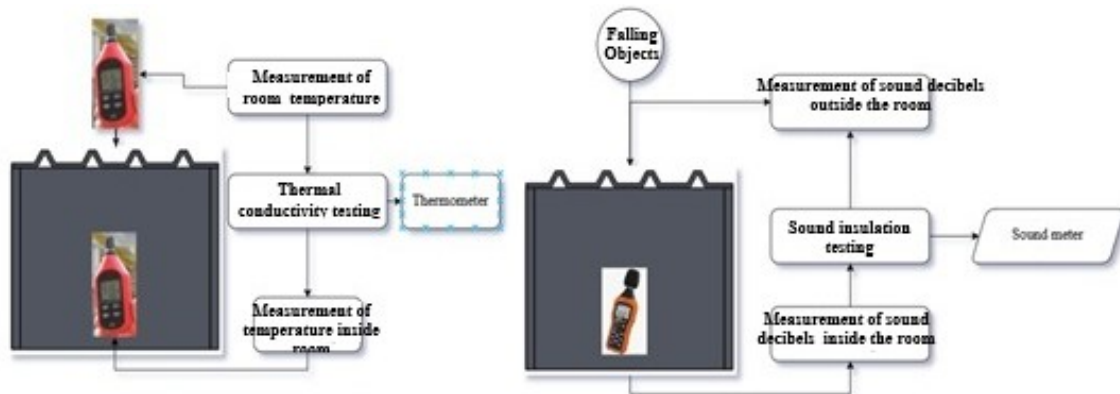


Figure 3: PSF-plastic composite roof acoustic insulation testing

The sound level meter then measured the level of noise transmitted by the material downward, and the results were recorded in decibels (dB). Lower decibel values indicated better sound insulation capabilities for the heat and sound test images shown in Figure 3.

Furthermore, mechanical strength testing is carried out through two types of tests: tensile testing and impact testing. Tensile testing is carried out based on the ASTM D638 standard using a universal tensile testing machine. Composite roof specimens are cut to standard shapes and pulled to break to obtain the maximum tensile strength (MPa) value. Meanwhile, impact testing is carried out using the Charpy method based on ASTM D256, where data from the specimens is subjected to two tests, namely testing based on calculations or theory and testing using an impact test tool. This data will later be compared, for theoretical testing the specimen is hit using a pendulum to measure the absorbed energy when an impact occurs. The results of this test are expressed in Joules (J) and reflect the material's toughness against impact loads. This approach, researchers obtained a comprehensive picture of the thermal, acoustic, and mechanical performance of palm fiber-HDPE composite roofs on various material variations, so that the best combination that is suitable for use as an environmentally friendly roofing material can be determined.

### 3. RESULT AND DISCUSSION

To determine the performance of a composite roofing material made from palm fiber and HDPE plastic binder, a series of mechanical, thermal, and acoustic tests were conducted. These tests aimed to evaluate the material's resistance to tensile forces, its ability to absorb impact energy, the difference in mass due to the injection process, its effectiveness in reducing heat, its absolute thermal conductivity, and its soundproofing performance. All test results were then compared across variations, as well as with zinc roofing material as the primary comparator.

#### 3.1 Tensile Test

Based on the tensile test results, data was obtained showing the values of the stress strain and elastic modulus. The data is shown in Table 1. The test results show that I 40g long is the best variation. This variation has the highest stress value of 13.24 MPa, which indicates the material's resistance to high tensile forces. The strain value of 1.53% is also in the ideal range, meaning this material is quite flexible but not too elastic.

Table 1: Stress-strain and elastic modulus of PSF-plastic composite roof

Variation	Stress (MPa)	Strain (%)	Modulus of Elasticity (GPa)
I 40 g powder	13.24138	1.518974	0.871732
I 40 g chopped	13.21724	0.619538	2.133401
I 50 g long	9.951724	0.426718	2.332155
I 50 g chopped	7.962069	0.080513	9.9889194
I 60 g long	13.24138	0.367179	3.606242
I 60 g chopped	8.9434483	0.393538	2.270295

In addition, its elastic modulus of 0.871 GPa indicates balanced stiffness, making this material stiff enough to be used as a roof but not too brittle. The combination of these values shows that I 40g of long was able to withstand tensile forces and maintain its shape when used as a roof covering.

#### 3.2 Impact Test

This test data displays the toughness value of each variation of roofing material that was tested using theoretical calculations and impact test equipment using a small pendulum following existing standards. The table below shows the impact test results on seven variations of composite materials made from palm fiber and HDPE formed into impact test specimens with fixed dimensions, namely 10 mm thick, 29 mm wide, and a 2 mm deep notch. This impact test aims to determine the toughness or resistance of the material to sudden impacts, which is quantitatively measured in the form of impact strength with units of Joules/mm<sup>2</sup>.

Table 2: The toughness of PSF-plastic composite roof

Variation	E Theory (J)	E Testing (J)
I 40 g long	10.54	10
I 40 g chopped	1.7	2
I 50 g long	8.41	8
I 50 g chopped	3.49	3
I 60 g Long	8.41	8
I 60 g Chopped	3.49	3

Based on the comparison of the data in Table 2, it was found that the value of the comparison of the theoretical test using calculations and testing using an impact tool had different

value, such as in the 40g long palm fiber test, the theoretical test value was 10.54 J, while in the test using the impact tool, the theoretical test value was 10.54 J. Using the tool, a value of 10 J was obtained. This can be influenced by the reading on the test tool which has a value per line of 1 J. The Fracture and ductility of PSF-plastic composite roof testing result can be seen in Table 3.

Table 3: The Fracture and ductility of PSF-plastic composite roof

Variation	E Testing (J)	Impact Price (J/mm)
I 40 g long	10	0.043
I 40 g chopped	2	0.008
I 50 g long	8	0.034
I 50 g chopped	3	0.012
I 60 g long	8	0.034
I 60 g chopped	3	0.012

The data was obtained by calculation using the fracture value obtained from the test. The highest ductility value was achieved by *Ijuk* 40g long, which is 0.0431 J/mm<sup>2</sup>, with a fracture energy value of 10 Joules. This means that the material in this variation is able to absorb the most energy before experiencing damage. This was followed by *Ijuk* 50g long and *Ijuk* 60g long, which have identical ductility values, namely

0.03448 J/mm<sup>2</sup>, with fracture energy of 8 Joules each. On the other hand, *Ijuk* 40g chopping shows the lowest ductility value, only 0.00862J/mm<sup>2</sup>, with fracture energy of 2 Joules, which means this variation were easiest to crack or break when hit.

### 3.3 Variation Data

Variation data is obtained from comparing the coconut fiber and HDPE plastic used. The purpose of this variation is to obtain the variation with the highest value. This data also serves to show the difference between the injection results and the remaining injection that did not fully enter the mold. This data is typically measured in grams.

Based on the data obtained in Table 4, there is a significant difference because basically when it carry out the injection process, the plastic that is pressed is not fully entered into the mold. There is plastic that comes out through the exhaust hole in the mold, which indicates that the mold is fully filled. There is also plastic that comes out of the press, which is caused by trapped air in the molding pipe. Based on the data in Table 4, it can be seen that in variation 3 with 50 grams of palm fiber in the form of shreds, the plastic weight is higher. The injection process of variation three is the first variation did the injection. Therefore, the amount of 147 grams of plastic value is trapped in the molding pipe. Then, the further data used a plastic weight of 1000 grams.

Table 4: Compositions of PSF-plastic composite roof

Variation	Fiber Form	Volume (Cm <sup>3</sup> )	Mass of coconut fiber (g)	Plastic Mass (g)	Remaining Inject (g)	Total Mass (g)	Difference (Gram)	Density (G/Cm <sup>3</sup> )
Variation 1	chopped	1002	40	1000	107	793	100	0.7194
Variation 2	Long	1002	40	1000	262	624	114	0.628
Variation 3	chopped	1002	50	1100	231	722	147	0.7206
Variation 4	Long	1002	50	1000	280	669	51	0.6677
Variation 5	chopped	1002	60	1000	277	638	85	0.6367
Variation 6	Long	1002	60	1000	250	743	7	0.7415
Variation 7	-	1002	-	1000	125	834	41	0.8323

### 3.4 Heat Insulation Testing

The data contained in this test differs from the thermal conductivity data due to the absence of a heat flux meter, which makes this data the difference in heat attenuation between each roof variation. This test was conducted to obtain data on the heat received from the roof. Each roof variation was exposed to the sun for the same amount of time and in an open location without any obstructions. This data collection was carried out at the Caltex Riau Polytechnic. This data was the average value of 25 tests with a time span of 15 minutes per test, as shown in the Table 5.

Based on the results of temperature testing on variations of palm fiber roofs with HDPE binders, quite clear differences in thermal performance were obtained. The highest

temperature difference between the top and bottom of the roof was found in variation I 50 g chopped, which was 4.94°C. The lowest difference was achieved by variation I 60 g chopped with a value of 4.42°C. This shows that the 50 g chopped variation has the best heat reduction ability, while 60 g chopped was relatively less optimal in retaining heat. In terms of the top temperature, the highest value was recorded in variation I 40 g chopped with a temperature of 48.86°C, while the lowest bottom temperature was found in variation I 40 g long, which was 40.49°C. This condition confirms that although 40 g chopped receives the highest heat at the top of the roof, variation I 40 g long was able to maintain a lower bottom temperature, thus potentially providing better thermal comfort in the space below.

Table 5: Heat insulation PSF-plastic composite roof

Variation	Rooftop Temperature °C	Under-Roof Temperature °C	Upper and Lower Temperature Difference °C	Room Temperature °C
I 40 g long	45.32	40.49	4.82	35.5
I 40 g chopped	48.86	41.12	4.74	35.5
I 50 g long	46.60	41.79	4.81	35.5
I 50 g chopped	45.86	40.95	4.94	35.5
I 60 g long	45.62	41.05	4.57	35.5
I 60 g chopped	45.96	41.54	4.42	35.5

### 3.5 Thermal Conductivity

Absolute thermal conductivity calculation is a calculation of thermal conductivity using radiation and convection as the heat transfer rate used as q in the thermal conductivity calculation. This value will later become the absolute thermal conductivity value.

#### 1. Radiation calculation

The first calculation is a radiation calculation to obtain q rad using the Stefan-Bolzman constant formula with the equation:

$$Q_{rad} = \epsilon \cdot \sigma \cdot A \cdot (T_{source}^4 - T_{surroundings}^4)$$

From the equation, radiation value data is obtained using the Stefan-Bolzman formula as in the Table 6. The analysis can be made that the radiation value that occurs on the roof variation 4 or Ijuk 50 grams of chopped fiber form has the highest value in radiation while the zinc value itself has the lowest value. The higher the radiation value, the hotter the roof, but the heat value of this roof is also influenced by thermal conductivity, whether the roof sends heat in well or is a good insulator.

#### 2. Convection calculation

Convection is a heat transfer process that occurs with a combined working system of the heat conduction system, where the heating process uses an intermediary such as water or gas where the heat will move following the movement of the water or air particles caused by differences in density, therefore the equation for heat transfer through the convection system is as follows:

$$Q = h \cdot A(T_s - T_{\infty})$$

Based on the calculation data, the highest convection value is found in 50 grams of chopped coconut fiber, where the value obtained is 4.94 watts, and the lowest value is found in the roof, which has a convection value of 4,420 watts.

#### 3. Convection Calculation

Convection is a heat transfer process that occurs with a combined working system of the heat conduction system, where the heating process uses an intermediary such as water or gas where the heat will move following the movement of the water or air particles caused by

differences in density, therefore the equation for heat transfer through the convection system is as follows:

$$Q = h \cdot A(T_s - T_{\infty})$$

Based on the calculation data, the highest convection value is found in 50 grams of chopped coconut fiber, where the value obtained is 4.94 watts, and the lowest value is found in the roof, which has a convection value of 4,420 watts.

#### 4. Absolute Thermal Conductivity

The calculation of absolute thermal conductivity is carried out by using the calculation data of the q value from radiation and q from convection obtained and added together as the q value or the rate of radiation heat transfer that has been obtained.

$$K_{rad} = \frac{Q_{rad} \cdot L}{A \cdot (\Delta T)}$$

Based on test results, the thermal conductivity of palm fiber material is in the range of 0.234–0.257 W/m·K. Compared to zinc roofing, which typically reaches approximately 50 W/m·K, palm fiber is clearly much better at retaining heat. This means it has great potential as an environmentally friendly roofing material that can reduce indoor temperatures.

The comparison between variations:

- I 60g long has the smallest absolute Q value (11.28 W), it was meaning the least heat enters the room.
- I 50g chopped) has the highest ΔT (4.94 °C), it was meaning the best at maintaining the difference between outside and inside temperatures.
- I 40g long has the lowest K value (0.234 W/m·K), it was meaning that in theory, it was the best as a heat insulator.

However, the samples with a larger mass (60 g) actually show higher K values. This is consistent with the literature, which states that denser fibers, the easier it is for heat to conduct due to reduced air space. Therefore, increasing mass does not always mean better. Furthermore, differences in fiber shape (cut lengthwise / long versus chopped) also play a role. Non-uniform fiber orientation can produce different results even with the same mass.

Table 6: Heat insulation based on conductivity of PSF-plastic composite roof

Types	Emissivity	σ(W/mk)	a(m <sup>2</sup> )	T outside C	T Outer k <sup>4</sup>	T Environment	T Environment	Sigma t	Radiation 0.1 m <sup>2</sup>
I 40g long	0.93	5.67E-08	0.10	45.32	1.03E+10	35.30	9.03E+09	1.23E+09	6.50
I 40g chopped	0.93	5.67E-08	0.10	45.86	1.03E+10	35.30	9.03E+09	1.30E+09	6.87
I 50g long	0.93	5.67E-08	0.10	46.6	1.04E+10	35.30	9.03E+09	1.40E+09	7.38
I 50g chopped	0.93	5.67E-08	0.10	45.89	1.03E+10	35.30	9.03E+09	1.31E+09	6.89
I 60g long	0.93	5.67E-08	0.10	45.62	1.03E+10	35.30	9.03E+09	1.27E+09	6.71
I 60g chopped	0.93	5.67E-08	0.10	45.96	1.04E+10	35.30	9.03E+09	1.32E+09	6.94

Table 7: Heat convection of PSF-plastic composite roof

Type	T Outside C	T In C	A( m <sup>2</sup> )	H	q Convection
I 40g long	45.32	40.49	0.1	10	4,830
I 40g chopped	45.86	41.12	0.1	10	4,740
I 50g long	46.60	41.79	0.1	10	4,810
I 50g chopped	45.89	40.95	0.1	10	4,940
I 60g long	45.62	41.05	0.1	10	4,570
I 60g chopped	45.96	41.54	0.1	10	4,420

Table 8: Absolute thermal conductivity of PSF-plastic composite roof

Type	T Outside C	T In C	A (m <sup>2</sup> )	Radiation (Watts)	L(m <sup>2</sup> )	Q convection	Q radiation	Absolute Q	K ( W/mk)
I 40g long	45.32	40.49	0.1	6.50	0.01	4.83	6.50171	11.33171	0.2346110
I 40g chopped	45.86	41.12	0.1	6.87	0.01	4.74	6.87002	11.61002	0.2449372
I 50g long	46.60	41.79	0.1	7.38	0.01	4.81	7.37779	12.18779	0.2533845
I 50g chopped	45.89	40.95	0.1	6.89	0.01	4.94	6.89054	11.83054	0.2394846
I 60g long	45.62	41.05	0.1	6.71	0.01	4.57	6.70610	11.27610	0.2467417
I 60g chopped	45.96	41.54	0.1	6.94	0.01	4.42	6.93843	11.35843	0.2569781

### 3.6 Sound Test

This test was conducted to determine which roof variations were most effective at reducing sound when objects were dropped from the roof at the same distance, approximately 1 m from the roof. This comparison will be presented in three tests, with the average sound attenuation from the three tests, as shown in the Table 9.

Based on the data in Table 9, it was found that the best sound proofing value was found on the roof variation 2 with a sound value of 39.83 dB. The highest among all the *ijuk* variations was the roof variation of 50 chopped with a value of 47.77 dB. When compared with the zinc roof, the zinc roof was far inferior with the existing value of 74.60 dB.

Table 9: Sound level meter roof

Sound Comparison Between Roof Types								
No	40		50		60		Plastic	Zinc
	Long	dB	Long	dB	Long	dB		
Test 1	55	39.7	46.8	36.3	44.8	43.6	35.9	79.4
Test 2	45.2	45.2	49.6	51.7	39.5	42.4	42.5	67
Test 3	58.3	34.6	61.7	55.3	41.4	40.4	43	77.4
Average	52.83	39.83	52.70	47.77	41.90	42.13	40.47	74.60

### 3.6 Comparative Analysis of Variations of Palm Fiber Roofs with HDPE Binding

Based on the testing process, an analysis can be carried out on the results obtained by using a point system for each variation of the palm fiber roof with HDPE plastic binders with a roof made of HDPE plastic only. The comparative analysis table all refers to the results of the test data carried out on all variations of the palm fiber from the tensile test process, sound test, heat test, and impact test. The data will be displayed in the form of a ranking from the sum of the least rankings that show the best value.

Based on the Table 10, it is found that I 40 long is ranked 1, which shows that the roof made from 40 gram capacity palm fiber with HDPE plastic binder bottle cap with code 02 has the best value of the 6 other types of variations. This ranking is taken based on several main determining factors such as in the tensile test. The main thing that is the basis for consideration is the variation that has the highest stress value and the one that has the largest modulus of elasticity value.

Basically, a good material for a roof is a material that has strong resistance and stiff material.

In the impact test data, rankings were taken from the level of resistance of variations to receive shock loads from an object before breaking because if the roof is not strong enough to receive shock loads it will cause fatal things when used. In the sound insulation test, it showed that out of 3 times the process of dropping objects onto the roof variations, the roof variations had a fairly high level of damping and this damping value also greatly influences someone in choosing a roof.

In the absolute thermal conductivity test data, the ranking is taken from the smallest value of absolute thermal conductivity that occurs on the roof which will affect the heat release from the roof material. Roof variation two is included in level 4, however, from the test value of the k thermal value of I 40 long of roof, it is included in rank 1 and in other tests, variation 2 has the highest value, so it is concluded that I 40 Long is the variation that is mixed with the zinc roof.

Table 10: Mechanical Properties of PSF-plastic composite roof

Variation	Radiation Test	Tensile Test	Absolute Value	Sound Test	Impact Test	Total Value	Ranking
I 40 long	1	1	1	1	7	11	1
I 40 chopped	4	2	3	7	1	17	2
I 50 long	7	7	6	6	5	31	7
I 50 chopped	5	5	2	5	4	21	5
I 60 long	2	6	5	3	2	18	4
I 60 chopped	6	4	7	4	2	23	6
Plastic	3	3	4	2	5	17	2

### 3.8 Comparative Analysis of the Best Variations with Zinc Roof Materials

This comparative analysis of the palm fiber roof type with HDPE plastic binder variation 2 with the roof made of zinc material was carried out to compare the data, which is in terms of radiation value, thermal radiation conductivity and also in terms of sound dampening. Comparison of radiation data and absolute thermal conductivity is depicted in Table 11.

Table 11: Comparison of radiation data and absolute thermal conductivity

Type	K (W/mk)
I40g chopped	0.2346110
Zinc	40-50

The thermal conductivity value for I 40g long of material is 0.234 W/m·K, while for zinc it is in the range of 40–50 W/m·K. This difference indicates that zinc has a heat conductivity almost 200 times greater than that of 40g long of palm fiber. In principle, the lower the thermal conductivity (K) value, the better the material is at retaining heat so that it is not quickly transferred into the room. With this very large difference in values, it can be concluded that a palm fiber roof (I 40g long) has much better thermal insulation properties than a zinc roof.

The zinc roof used in buildings can cause heat from outside to spread more quickly into the room. So, the inside temperature increases drastically. Conversely, a palm fiber roof with a low K value is able to slow the rate of heat transfer, making the room below it cooler and more comfortable. Therefore, in practice, the use of a palm fiber roof is not only more effective in reducing heat, but also more environmentally friendly, energy efficient because it can reduce the need for air conditioning, and provide better comfort compared to a zinc roof.

Comparison of sound proofing data roof of *ijuk* and zinc can be seen in Table 12. Based on the results of tests on the sound-dampening capabilities of two types of roofing materials, namely palm fiber-HDPE and zinc, there is a significant difference in terms of acoustic performance. Test data shows that the palm fiber-HDPE roof has an average sound intensity of 39.83 dB, while the zinc roof produces an average sound intensity of 74.6 dB. These values indicate that the sound heard under the palm fiber-HDPE roof is much lower than the zinc roof.

Table 12: Comparison of sound proofing data

Roof	Test			Average
	1	2	3	
<i>Ijuk</i>	39.7	45.2	34.6	39.833
Zinc	79.4	67	77.4	74.6

This difference can generally be explained by the characteristics of the materials. Zinc is a metal with high sound conductivity, so it lacks the ability to absorb sound waves. Meanwhile, the palm fiber-HDPE composite has a fibrous structure and is not as dense as metal, making it better able to absorb sound waves and reduce reflections. The sound of rain falling on a zinc roof often creates noise that disturbs

occupants. Therefore, using a palm fiber-HDPE roof can be a better solution for improving the acoustic comfort of buildings, especially for residences or spaces that require quiet. Therefore, based on test results and its relevance, a palm fiber-HDPE composite roof is superior in terms of soundproofing compared to a zinc roof and is recommended as an environmentally friendly and acoustically comfortable alternative.

## 4. CONCLUSION

Based on the results of testing and analysis of roofs made of palm fiber with HDPE plastic binding and comparing them with zinc roofs. The best heat reduction test results were obtained from a roof variation made from 40 gram capacity palm fiber in the form of long fibers with HDPE plastic binders with a heat reduction value reaching 4.82 °C. Based on the calculation of the thermal conductivity value using the q value instead of the q value of convection and radiation, the best thermal conductivity value obtained as insulation or as a roof that reduces the heat value is HDPE palm fiber with a weight of 40 g of palm fiber in the form of long fibers with a value of 0.23W/mk. In the sound insulation test, the best result was found in the roof variations made from 40 gram capacity palm fiber in the form of chopped fiber with HDPE plastic binder with a sound value of 39,83 dB, while the worst sound insulation value was found in zinc with a sound value of 74.6 dB.

Based on the impact test results, it was found that the highest tenacity value was owned by Variation 2, which was 0.037 J/mm<sup>2</sup> with a fracture energy of 10 Joules. This shows that the 40 gram capacity coir variation in the form of long fibers has the highest toughness and is able to absorb the greatest impact energy before being damaged. Meanwhile, the 40 gram capacity coir in the form of chopped fibers was recorded as the weakest, with a tenacity value of 0.008J/mm<sup>2</sup> and a fracture energy of 2 Joules, so it is less recommended for applications that are at risk of sudden impacts. Based on the tensile test results, it was found that the 40 gram capacity coir variation in the form of long fibers was the best variation with the highest tensile strength (13.24 MPa), sufficient strain (1.53%), and balanced stiffness (0.865 GPa), making it suitable for roofing materials. On the other hand, the 50 gram capacity coir in the form of long fibers had the weakest performance due to the lowest stress and strain and was too stiff, so it is not recommended for roofing applications.

Based on the variation data testing, it was found that the Plastic Variation has the highest density, namely 0.83 g/cm<sup>3</sup> and a total mass of 834 grams, making it the heaviest and densest variation. Conversely, the 40-gram capacity long fiber palm fiber is the lightest variation with a density of 0.63 g/cm<sup>3</sup> and a total mass of 624 grams, making it the most ideal for use as a roofing material because it is light and has the best mechanical performance.

## ACKNOWLEDGEMENTS

First and foremost, the author would like to express gratitude to Allah Subhanahu Wa Ta'ala for His endless blessings, guidance, and sustenance, which have enabled the completion of this research. The author also wishes to convey sincere

appreciation to all parties who have provided assistance and support.

## REFERENCES

- [1] Sudirman, M. (2023). *Anomali suhu udara rata-rata tahun 2023*. BMKG. <https://www.bmkg.go.id/iklim/anomali-suhu-udara/anomali-suhu-udara-rata-rata-tahun-2023>.
- [2] Talarosha, B. (2005). Menciptakan kenyamanan thermal dalam bangunan. *Jurnal Sistem Teknik Industri*, 6(3), 148–158.
- [3] Ginting, S. G., & Novrial. (2024). The effect of material and roof shape on thermal comfort in residential buildings. *International Journal of Architecture and Urbanism*, 8(3), 497–503. <https://doi.org/10.32734/ijau.v8i3.16321>.
- [4] Frumensia, S., Setiadi, I., & Putra, H. A. (2024). Pelapis cat hitam pada penggunaan penutup atap seng sebagai perbandingan suhu dalam ruang. *Jurnal Lingkungan Karya Arsitektur*, 3(2), 112–119. <https://doi.org/10.37477/lkr.v3i2.651>.
- [5] Daffa, M. F. (2023). *Atap ijuk: Apa itu atap ijuk, fungsi, kelebihan dan kekurangannya*. Interior Design. <https://interiordesign.id/apa-itu-atap-ijuk/>.
- [6] Gunawarman, A. A. G. R. (2019). Konsep desain mitigasi bencana kebakaran pada bangunan pura beratap ijuk. *Jurnal Arsitektur Zo.*, 2(1), 25. <https://doi.org/10.17509/jaz.v2i1.15058>.
- [7] Setyowati, V. A., & Widodo, E. W. R. (2017). Studi sifat fisis, kimia, dan morfologi pada kemasan makanan berbahan styrofoam dan LDPE (Low Density Polyethylene): Telaah kepustakaan. *Jurnal Ilmiah Teknik Mesin*, 8(1), 39–45.
- [8] SIPSN. (2024). *Komposisi sampah*. <https://sipsn.kemenvh.go.id/sipsn/public/data/komposisi>.
- [9] Waryat, W., Romli, M., Suryani, A., Yuliasih, I., & Johan, S. (2013). Karakteristik morfologi, termal, fisik-mekanik, dan barrier plastik biodegradabel berbahan baku komposit pati termoplastik-LLDPE/HDPE. *agriTECH*, 33(2), 197–207. <https://doi.org/10.22146/agritech.9800>.
- [10] Fatimah, F., Juanda, J., & Santoso, I. (2019). Jenis atap, suhu dan kelembaban dalam rumah. *Jurnal Kesehatan Lingkungan: Jurnal dan Aplikasi Teknik Kesehatan Lingkungan*, 16(1), 727–732. <https://doi.org/10.31964/jkl.v16i1.108>.
- [11] Bae, S. M., Nam, Y., Choi, J. M., Lee, K. H., & Choi, J. S. (2019). Analysis on thermal performance of ground heat exchanger according to design type based on thermal response test. *Energies*, 12(4). <https://doi.org/10.3390/en12040651>.
- [12] Asyraf, M. R. M., et al. (2022). Sugar palm fibre-reinforced polymer composites: Influence of chemical treatments on its mechanical properties. *Materials*, 15(11). <https://doi.org/10.3390/ma15113852>.
- [13] Kokubo, M., et al. (2021). Relationship between the microbiome and indoor temperature/humidity in a traditional Japanese house with a thatched roof in Kyoto, Japan. *Diversity*, 13(10). <https://doi.org/10.3390/d13100475>.
- [14] Krismani, A. Y., & Pambudi, Y. S. (2021). Pelapis Atap Metal Sebagai Peredam Suara. *Jurnal Ekonomi, Sosial & Humaniora*, 3(04), 108-117.