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Development of Coconut Fiber Composite Concrete Walls: A Study on Compressive Strength and Weight for Rural Housing

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ABSTRACT

Economical, non-toxic, durable, and environmentally friendly building materials are highly needed in rural areas, which are typically distant from ready-to-use construction materials and have low purchasing ability community. This study develops composite concrete walls made from coconut husk fibers (coir) as an alternative construction material for houses in rural areas which commonl found in Indonesia. By developing composite wall materials from readily available coconut husk fibers, the results of this research are expected to reduce production costs, making them economical and accessible to low-income rural communities. Additionally, the relatively simple and quick construction process compared to brick wall construction results in time efficiency for house building in rural areas, which can accelerate housing programs for the community. The aim of this study is to demonstrate the strength of coconut husk fiber-based composite concrete by testing its compressive strength and density. Experiments were conducted using a CTM machine with 15x15x10 cm cube test samples, with eight variations of composite concrete, three samples per variation, resulting in a total of 24 test samples. The test samples were designed in three layers with variations in the alignment of coconut fibers (parallel and cross arrangement), fiber content (50% and 25%), and mortar mixture ratios (1:5 and 1:4) at 28 days of curing, then compared with the characteristics of bricks and concrete blocks. The results showed that the lowest compressive strength of the composite concrete was 13.29 Kg/cm² and the highest was 29.75 Kg/cm², with optimal performance achieved by the cross-fiber design at 50% fiber

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content with a mortar mix ratio of 1:5. The weight of the produced composite wall was approximately 4 kg. These findings prove that the development of composite concrete walls made from coconut husk fibers is a highly promising solution for rural housing applications.

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1. INTRODUCTION

Rural house construction often faces challenges such as limited availability of building materials, high material costs, and a lack of non-toxic, environmentally friendly options. These issues contrast with the potential of rural areas, which often have abundant raw material resources. Therefore, utilizing local raw materials to produce durable, cost-effective, and eco-friendly building materials is essential. The use of environmentally friendly local materials plays a crucial role in supporting sustainable development, particularly in the construction sector. Employing local materials in rural house construction can reduce transportation costs, enhance economic efficiency, and lower the embodied energy of building materials.

The use of local materials is very appropriate for the conditions of Indonesia, which is one of the largest archipelagic countries in the world. As an archipelagic country, the challenges of transportation and accessibility, especially the distribution of goods and services, are often difficult and expensive, especially in remote areas. The high cost of goods when they arrive in several rural areas also affects the price of building materials. This condition causes several obstacles to development in rural areas, such as the provision of quality building materials to produce sturdy, functional, and aesthetic houses. The use of building materials often does not pay attention to the sustainability aspect by selecting environmentally friendly materials.

Coconut fiber is a relatively cheap local raw material (Harish et al. 2009) and is commonly found in almost all corners of Indonesia. Indonesia is recorded to have produced 2,828,818 tons of coconuts in 2022 and is estimated to increase to 2,861,856 tons in 2024 (Direktorat Jendral Perkebunan 2023). Coconut fiber makes up 35% of all coconuts, or the equivalent of 1.8 million tons per year (Astuti et al. 2023; Indahyani 2011). Unfortunately, most people do not know the uses of coconut fiber (Muzaki et al., 2020)—mainly its potential to be processed into building materials—leaving behind the problem of production waste, which can have a negative impact on the environment. The use of coconut fiber as a building material is believed to help reduce the environmental impact of coconut fiber waste (Darsana et al. 2016).

The use of coconut fiber as a natural fiber has attracted the attention of researchers because of its mechanical properties, coupled with its light mass, making it worthy of being developed into a component of building materials. In addition, coconut fiber has environmentally friendly characteristics, with low energy consumption, renewability, and the ability to decompose naturally. Research on the application of composite concrete as a building material has been widely conducted. Several studies have examined the porosity of coconut fiber, which has been shown to have a high porosity of up to 22–30%. Although coconut fiber is not strong and stiff enough (234 MPa and 4.6 GPa), it has a tensile strength of 20–40%, which can increase the strength of the composite material when used as reinforcement (Andiç-Çakir et al. 2014; Apriyatno 2013; Surianti and Arham 2017; Tran et al. 2015) and it has also been applied in retaining walls (Advincula et al. 2018). In addition, the application of coconut fiber demonstrates thermal performance (Brose, Kongoletos, and Glicksman 2019a; Mydin et al. 2016) and acoustic performance (Kochova et al. 2020; Zalukhu, Irwan, and Hutauruk 2017). However, most of these studies focus on the use of fibers that are mixed evenly with concrete, so the percentage of coconut fiber usage tends to be very small. In this study, coconut fiber is not used as a concrete mixture but is constructed as a wall layer in the middle with a sandwich construction (concrete–fiber–concrete). This study aims to test coconut fiber composite concrete walls by measuring the effect of coconut fiber volume (25% and 50%) on compressive strength and weight, with the goal of applying it as a building material for rural house walls.

This study contributes by enriching the test data on the performance of coconut fiber composite cement walls with a sandwich configuration, particularly regarding the mechanical properties of compressive strength and weight. Therefore, this study is believed to have several positive impacts: supporting the community's economy, promoting innovation in local building materials and natural fibers, contributing to the reduction of embodied energy in wall materials, lowering carbon footprints, and minimizing coconut fiber waste, thereby reducing negative environmental impacts.

The use of coconut fiber composite walls is also believed to help address the problem of building walls that are too heavy due to the use of bricks. Heavy materials have disadvantages during earthquakes. Therefore, coconut fiber composite walls have great potential as an alternative solution for rural house wall construction, as they have been proven to possess good mechanical properties, such as high tensile strength (Elhusna dan Suwandi 2012), are lighter in weight, and have good thermal and acoustic properties (Mahmud et al. 2023). Other benefits include contributing to the reduction of agricultural waste (Nurlia et al. 2022; Shahidan et al. 2016) and supporting the concept of a circular economy (Astuti et al. 2023) for sustainable development.

2. LITERATURE REVIEW

Coconut fiber is a material extracted from the mesocarp tissue of coconut trees (Kurinjimalar et al. 2021), composed of cellulose, hemicellulose, and lignin (Kadam et al. 2014). Coconut fiber is a hygroscopic natural fiber, has a high mechanical tensile strength of 131-220 MPa, an elastic modulus of between 4 and 6 Gpa, and a low density ranging from 1.15 and 1.46 g/cm³. In addition, coconut fiber has a high natural resistance (not affected by rodents or insects and is not affected by mold when dried) (Restrepo and Echavarría 2023).

Coconut fiber is a promising material for sustainable building construction applications (Asim et al. 2020). Research shows that coconut fiber can be effectively utilized in mortar and concrete, offering advantages such as low density and better thermal performance. Coconut fiber composites have good thermal conductivity and resistivity, supporting energy-efficient building designs (Robert et al. 2019). The water absorption characteristics of coconut fiber contribute to structural integrity under various environmental conditions (Shahidan et al. 2016). However, despite its great potential, the long-term durability and performance of coconut fiber under extreme conditions require further research to ensure its reliability in diverse applications.

2.1 Mechanical Properties of Coconut Fiber

Mechanical properties are physical characteristics of materials that describe their reactions to compressive, shearing, and tensile forces. These properties define how a material behaves when subjected to forces that compress, stretch, bend, erode, scratch, or break (Kurinjimalar et al. 2021). Coconut fiber has a tensile strength ranging from 131 to 220 Mpa (Restrepo dan Echavarría 2023). Previous studies indicate that the tensile strength of coconut fiber reaches an optimal values in the longitudinal direction, which is beneficial for load-bearing applications, where green coconut fiber is more resilient than brown fiber with maximum resistance in the longitudinal tensile direction and transverse compressive direction (Kadam et al. 2014). Coir fiber has a hydrophilic surface morphology and is therefore water resistant; thus, its application in concrete mixes requires a purification process (Rumbayan, Sudarno, dan Ticoalu 2019).

2.2 Use of Coconut Fiber in Composite Materials

Coconut fiber has long been studied for its combination as a composite material that can be used in construction, particularly as a reinforcement for concrete elements, in lightweight concrete, mortar, and fillers, as well as in fiber cement boards and cement floor beams. These studies show a decrease in the thermal conductivity of these elements (Restrepo dan Echavarría 2023). In addition, previous research also shows the mechanical properties of coconut fiber mortar composites, some of which demonstrate potential, such as higher compressive strength, tensile strength and flexural strength compared to traditional mixtures (Kumarasamy, Kandasamy, dan Ramasamy 2023). The use of coconut fiber is very suitable for strengthening mortar mixtures (Bui et al. 2020). The flexural and compressive strength of coconut fiber composite materials can be further increased by combining them with other materials (Bakri, 2010). The mechanical strength of coconut fiber can be used effectively in construction applications, including building walls, if properly controlled (Bui et al. 2020). Sharma and Kumar's research shows that replacing polyurethane foam with 20% coconut fiber in sandwich panels improve the compression and flexural properties, making it suitable for construction materials (Sharma dan Prasath Kumar 2023). Additionally, coconut fiber composite material is also suitable for wall applications in ferrocement structures due to its lightweight and sustainable properties (Kumarasamy et al. 2023)

Research by Brose et al. shows that coconut fiber cement panels with a fiber volume of 30% of the total panel produce an average compressive strength of 33.7 N/mm² and a flexural strength of 4.55 N/mm²—74% higher than samples without coconut fiber, which had a flexural strength of 2.62 N/mm² (Brose, Kongoletos, and Glicksman 2019b). Munoz et al. found that adding 0.5% coconut fiber to a 1:3 mortar mixture increased compressive strength by 3.9%, flexural strength by 65.9%, and diagonal compression strength by 3.3% compared to standard samples (Muñoz et al. 2023). The addition of coconut fiber also improves the flexural strength and stiffness of concrete, as proven in Hardjasaputra et al.'s research using small blocks (6 cm x 6 cm x 30 cm), where the optimal percentage of coconut fiber content was 0.175%, resulting in a modulus of rupture of 0.73 MPa—higher than that of blocks without coconut fiber (Hardjasaputra et al. 2017). Coconut fiber composite concrete has also shown increased tensile strength values of 2.68, 2.90, 3.11, 3.25, and 2.33 MPa with the addition of 1% to 5% coconut fiber, indicating its potential as a sustainable building material (Parbhane and Shinde 2014). However, excessive fiber addition can reduce tensile strength due to bonding issues between the fiber and the concrete matrix (Hardjasaputra et al. 2017; Rumbayan et al. 2019).

The numerical values of the compressive, tensile, and flexural strength of coconut fiber in wall applications vary based on the specific mixture and percentage of fiber used. Research shows that coconut fiber significantly improves the mechanical properties of concrete and mortar, making it a good choice for wall applications. Although coconut fiber shows promising improvements in mechanical properties, it is important to balance its use with the workability and other performance factors of the construction material.

2.3 Coconut Fiber Application Methods on Composite Concrete Construction Materials

Previous studies on the application of coconut fiber composite materials tend to involve several treatments such as alkaline treatment, acid treatment, and silane treatment. Alkaline treatment generally uses sodium hydroxide (NaOH) to remove surface impurities, increase fiber roughness, thereby enhancing adhesion to composite materials (Nazi Mwambegu and Gnanamoorthy 2023; Zamboni Schiavon and de Oliveira Andrade 2023). Acid treatment aims to reduce extractives and increase tensile strength (Andrade, 2023) [36]. Meanwhile, silane treatment aims to reduce hydroxyl groups, improve the physical properties of the fiber-

polypropylene composite to produce superior mechanical performance. (Dugvekar dan Dixit 2022; Gisip 2023).

2.4 GAP Research on Coconut Fiber in Composite Concrete Construction Materials

Although many studies have been conducted on coconut fiber composite concrete, several areas remain underexplored, such as:

- The application method of coconut fiber is generally applied by mixing it directly with the mortar cement mixture, which requires strong adhesion. As a result, chemical pre-treatment is often needed. However, research exploring coconut fiber as a core layer in a sandwich wall configuration (mortar–fiber–mortar) is still very limited.
- Tests involving variations in the arrangement of coconut fibers, involving diagonal and cross-parallel arrangements are rarely raised in previous studies. Consequently, data on the effect of fiber arrangement affects wall strength is difficult to find.
- The use of chemical processing to enhance coconut fiber properties remains a point of debate due to its environmental impacts. Therefore, more sustainable alternatives for fiber processing are needed.
- Research conducted on a real-life building scale is limited. Previous studies are limited to small-scale models, thus requiring exploration of coconut fiber applications at the scale of actual residential buildings.
- The initial treatment of coconut fiber using chemicals may be impractical for community-level construction, where local residents act as laborers. Thus, further research on the application of coconut fiber without chemical treatment in practical construction settings is needed.

This study aims to address these research gaps by testing a coconut fiber composite concrete sandwich system, exploring variations in fiber composition, fiber orientation, and mortar ratios. The goal is to develop a method that is practically applicable for rural housing.

3. RESEARCH METHODS AND MATERIALS

This research was conducted using an experimental method by testing a composite concrete wall with a coconut husk/coir core and a mortar layer. The study aimed to evaluate the physical and mechanical characteristics of the resulting wall, such as compressive strength, density, and material weight. The tests were conducted at the Civil Engineering Concrete Laboratory of Tadulako University using the CTM test tool.

3.1 Materials and Tools

The materials used in this study were: pure coconut fiber (cocofiber) without purification supplied from local materials from Pulu Village as core filler material, plastering sand, portland cement, clean water for mortar mixture and cocofiber core retaining wire. The tools used were: mortar mixer, container, tarpaulin, cube mold (dimensions 15 × 15 × 10/11 cm), compression test equipment, analytical scales for mass measurement, fiber cutting tool, and digital camera.

3.2 Research Design

The composite walls tested used several variations, namely: a mortar mixture with a cement and sand ratio of 1:4 and 1:5, coconut fiber arrangement with parallel and cross patterns, and wall thicknesses of 10 cm and 11 cm. Specimens were also tested with variations in the volume ratio of mortar - fiber - mortar of 1:1:1 and 1:2:1 (Table 1). The manufacture of test specimens was carried out in several steps, starting with cutting coconut fiber according to the specified length and then arranging it based on the parallel or cross direction.

Furthermore, wire was used to clamp and compact the fibers. The mortar was mixed until homogeneous, according to the specified ratio. After that, the mortar and fiber were molded using the provided mold in a sandwich arrangement, where the fibers were placed in the core of the wall and sandwiched with wire and mortar on both sides of the coconut fiber, forming five layers (Figures 1 and 2). The specimens were cured using the wet curing method for 7, 14, and 28 days to ensure maximum strength. Before testing, all specimens were grouped based on their sample types, and images were recorded along with the sample variation settings (Figure 3).



Figure 1 Configuration layout of the composite wall with layer system (Source: Author, 2024)



Figure 2 Concrete-Making Process and Testing with Composite Concrete Cubes (Source: Author, 2024)

Table 1 Variations of Concrete Test Specimens

No.	Sample	Volume Comparison	Mortar Comparison	Fiber direction	Number of specimens
1	Sample A	1:1:1	1:4	parallel	3
2	Sample B	1:1:1	1:4	they	3
3	Sample C	1:2:1	1:4	parallel	3
4	Sample D	1:2:1	1:4	they	3
5	Sample E	1:1:1	1:5	parallel	3
6	Sample F	1:1:1	1:5	they	3
7	Sample G	1:2:1	1:5	parallel	3
8	Sample H	1:2:1	1:5	they	3

(Source: Author, 2024)



Figure 3. Flowchart Study
(Source: Author, 2024)

3.3 Material Testing

The specimens were tested for compressive strength, weight, and density. Compressive Strength testing was carried out using a standard compression tester to determine the mechanical strength of the material, specifically the ability of coconut fiber composite concrete to withstand a compressive force per unit area. The compressive strength was calculated by dividing the maximum load at failure by the cross-sectional area of the specimen, referring to SNI 03-6825-2002: Compressive Strength Testing Method of Portland Cement Mortar for Civil Works (Badan Standardisasi Nasional 2002). In the compressive strength testing machine, the specimen was placed and loaded until it collapses, defined as the point at which the maximum load is reached. Each specimen tested was weighed beforehand to determine its mass, while the density of the specimen was calculated based on the specimen's weight and volume.

3.4 Research Location

The test was carried out at the Civil Engineering Concrete Laboratory of Tadulako University using the CTM tool. Meanwhile, the application of coconut fiber composite concrete walls was conducted in Pulu Village, Sigi Regency, Central Sulawesi, Indonesia, over a period of four months (May - November 2024).



Sample A



Sample B



Sample C



Sample D



Figure 4 Photo of Composite Concrete Cube Specimen with Coconut Fiber
(Source: Author, 2024)

4. RESULTS OF COMPRESSIVE STRENGTH AND WEIGHT TESTING OF COMPOSITE CONCRETE WALLS MATERIALS

The results of the analysis show that coconut fiber can be processed into composite concrete material with adequate physical and mechanical characteristics for use in constructing rural house walls. Tests indicate that this material has sufficient strength, good compressive resistance, and is lightweight. This shows that coconut fiber has the potential as an environmentally friendly alternative material in construction. This study analyzes the use of coconut fiber as an alternative material for building environmentally friendly rural house walls. In testing the physical and mechanical characteristics of the resulting material, several parameters were analyzed, including compressive strength, material density, and weight. The test results show that coconut fiber performs well in composite concrete wall applications and is suitable for rural house construction, offering significant environmental benefits.

First, the use of this waste can reduce the volume of waste disposed of into the environment, helping to reduce the negative impact on the ecosystem. In addition, the use of this alternative material can also reduce the consumption of new materials that rely on non-renewable natural resources. Although it has great potential, there are several challenges that need to be addressed in the use of coconut fiber as an alternative material. One of these is ensuring that the manufacturing process meet quality standards and construction requirements. Additionally, it is important to ensure that this alternative material offers adequate durability and safety in its application.

4.1 Results of Composite Concrete Cube Specimen Test

The results of the three cube compression tests and the weight measurements of the material for each composition variation show an average weight of 4.72 kg, or a volume weight of 2,098 kg/m² (see the composite concrete sample test table and coconut fiber). According to the SNI 15-2094-2000, the standard for bricks used in 1/2 brick thick walls (± 11 cm), the volume weight ranges from 180 - 220 kg/m². Meanwhile, the volume weight of bricks based on their density is approximately 1,800 - 2,000 kg/m³, while composite concrete is generally lighter, with a volume weight of around 1,675 kg/m³. Composite concrete walls offer greater advantages in building structural safety, as they reduce both self-weight and earthquake loads. The average compressive strength of each composite concrete variation tested in this study ranged from a minimum of 13.29 kg/cm² to a maximum of 29.75 kg/cm² (2.975 MPa); see Tables 1–8 for sample test data. According to SNI 03-0349-1989, the specification for concrete bricks for wall masonry (Badan Standarisasi Nasional, 1989), the

average compressive strength of concrete blocks is 2.5 MPa. Meanwhile, for solid red bricks used in wall masonry, based on SNI 15-2094-2000 (Badan Standarisasi Nasional, 2000), the minimum compressive strength is $\geq 25 \text{ kg/cm}^2$ (2.5 MPa) for non-structural walls and $\geq 50 \text{ kg/cm}^2$ (5 MPa) for red bricks used in structural wall masonry.

The walls of the rural houses developed in this study are non-structural walls, and the results of the composite concrete conversion show a lowest compressive strength value of 0.275 MPa and a highest of 3.852 MPa. Therefore, it is proven from the test cubes that this coconut fiber composite concrete has a compressive strength value that falls within the standard.

Table 2 Sample A Test Results

Test Specimen	Composition	Age	Weight (grm)	Dimensions	Maximum load (KN)	Compressive strength (Kg/cm ²)	Compressive strength 28 hr konv . 0.91 (Kg/cm ²)	Average (Kg/cm ²)
A1	Mortar 1:4 Parallel	29	3880	15x15x15	10	4.53	4.53	3.56
A2	cocofiber arrangement	17	4080	15x15x15	5	2.27	2.40	
A3	Composite 3.5:3:3.5	17	4350	10x15x15	5	3.40	3.74	

Table 3 Sample B Test Results

Test pecimen	Composition	Age	Weight (grm)	Dimensions	Maximu m load (KN)	Compressive strength (Kg/cm ²)	Compressive strength 28 hr konv . 0.91 (Kg/cm ²)	Average (Kg/cm ²)
B1	Mortar 1:4	15	4710	10x15x15	9	3.40	3.82	13.65
B2	Cross cocofiber arrangement	13	3600	15x15x15	15	6.80	8	
B3	Composite 3.5:3:3.5	13	4580	15x15x15	55	24.93	29.12	

Table 4 Sample C Test Results

Test Specimen	Composition	Age	Weight (grm)	Dimensions	Maximum load (KN)	Compressiv e strength (Kg/cm ²)	Compressive strength 28 hr konv . 0.91 (Kg/cm ²)	Average (Kg/cm ²)
C1	Mortar 1:4 Parallel	26	4450	15x15x15	85	38.52	38.91	17.66
C2	cocofiber arrangement	26	4180	10x15x15	5	3.40	3.43	
C3	Composite 2.5:5:2.5	13	4700	15x15x10	20	9.06	10.66	

Table 5 Sample D Test Results

Test Specimen	Composition	Age	Weight (grm)	Dimensions	Maximum load (KN)	Compressiv e strength (Kg/cm ²)	Compressive strength 28 hr konv . 0.91 (Kg/cm ²)	Average (Kg/cm ²)
D1	Mortar 1:4	17	4180	15x15x15	35	15.86	17.43	23.59
D2	Cross cocofiber arrangement	13	4570	15x15x10	75	37.35	37.35	
D3	Composite 2.5:5:2.5	13	4720	10x15x15	20	16.60	16.00	

Table 6 Sample E Test Results

Test Specimen	Composition	Age	Weight (grm)	Dimensions	Maximum load (KN)	Compressiv e strength (Kg/cm ²)	Compressive strength 28 hr konv . 0.91 (Kg/cm ²)	Average (Kg/cm ²)
E1	Mortar 1:5 Parallel	23	4460	15x15x15	75	33.99	35.41	20.08
E2	cocofiber arrangement	16	4460	10x15x15	10	6.80	6.80	
E3	Composite 3.5:3:3.5	14	4410	15x15x15	35	15.86	18.03	

Table 7 Results of F Sample Test

Test Specimen	Composition	Age	Weight (grm)	Dimensions	Maximu m load (KN)	Compressiv e strength (Kg/cm ²)	Compressive strength 28 hr konv . 0.91 (Kg/cm ²)	Average (Kg/cm ²)
F1	Mortar 1:5	23	4000	15x15x15	55	24.93	25.96	16.85
F2	Cross cocofiber arrangement	16	4480	10x15x15	5	3.40	3.78	
F3		9	4375	15x15x15	40	18.13	20.80	

Test Specimen	Composition	Age	Weight (gm)	Dimensions	Maximum load (KN)	Compressive strength (Kg/cm ²)	Compressive strength 28 hr konv . 0.91 (Kg/cm ²)	Average (Kg/cm ²)
	Composite 3.5:3:3.5							

Table 8 Sample G Test Results

Test Specimen	Composition	Age	Weight (gm)	Dimensions	Maximum load (KN)	Compressive strength (Kg/cm ²)	Compressive strength 28 hr konv . 0.91 (Kg/cm ²)	Average (Kg/cm ²)
G1	Mortar 1:5	23	4290	15x15x10	55	24.93	25.96	
G2	Parallel cocofiber arrangement	15	4520	10x15x15	5	3.40	3.82	13.26
G3	Composite 2.5:5:2.5	14	4550	15x15x10	20	9.06	10	

Table 9 Sample G Test Results

Test Specimen	Composition	Age	Weight (gm)	Dimensions	Maximum load (KN)	Compressive strength (Kg/cm ²)	Compressive strength 28 hr konv . 0.91 (Kg/cm ²)	Average (Kg/cm ²)
H1	Mortar 1:5	18	4520	15x15x10	70	31.72	35.25	
H2	Cross cocofiber arrangement	11	4380	15x15x10	55	24.93	31.96	29.75
H3	Composite 2.5:5:2.5	9	4280	15x15x10	35	15.93	22.03	

Figure 5 shows the variation in the compressive strength test results of the concrete samples, where each variation shows almost the same test results. However, some samples showed significantly different test results, because some of the concrete specimen was made on different days and manually produced without compaction during manufacture.

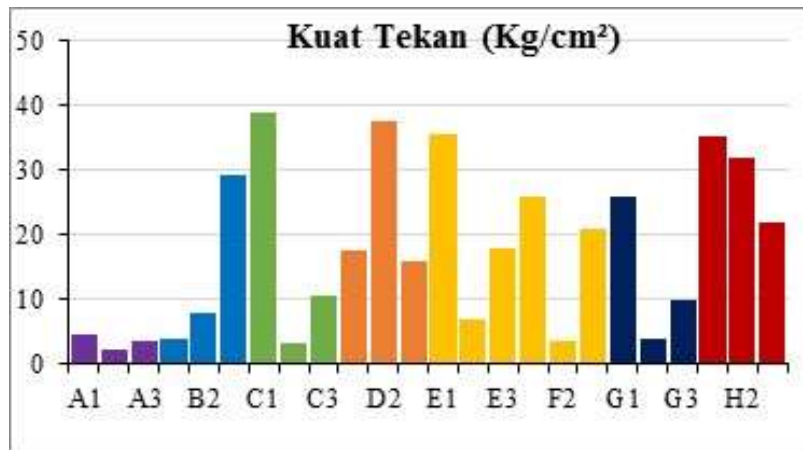


Figure 5 Compressive Strength Graph of All Concrete Samples (Source: Author, 2024)



Figure 6 Average Compressive Strength Graph by Test Concrete Variation Group (Source: Author, 2024)

In graphic image 5-6, the compressive strength of the test concrete is shown, which proves that the composite concrete and coconut fiber has great potential to be developed into wall materials for houses in rural areas with coconut plantations and villages that process coconut copra.

4.2. Rural House Wall Application System

The application of composite concrete walls in rural houses uses simple technology, namely by creating a modular system in the span between structural columns that are 3 meters apart. In the sample house at the research location, the distance between the structural columns on the walls is 3 meters. This modular system is intended to make the walls rigid and stable. The modules made in the sample house are 1 meter x 2.8 meter in size, so each wall consists of 6 modules if there are no window or door openings. The modules are connected to the building's structural columns using 6 cm fisher bolts. The material composition of this composite concrete wall is arranged in layers: plastering, wire mesh, plastering. The construction stages begin with making modules from light steel material, followed by inserting the cocofiber arrangement tightly into the middle of the wall. Wire mesh is then installed on both sides, and plastering is carried out in two stages. On both outer sides of the wall, the first plastering layer is 1.5 cm thick using rough plaster to ensure adhesion to the cocofiber. After the first layer is semi-dry, the second plastering layer is applied on the same side with another 1.5 cm of smooth plaster, preparing the surface for finishing and painting. The following is a picture of the cocofiber composite concrete wall construction system using the modular method.

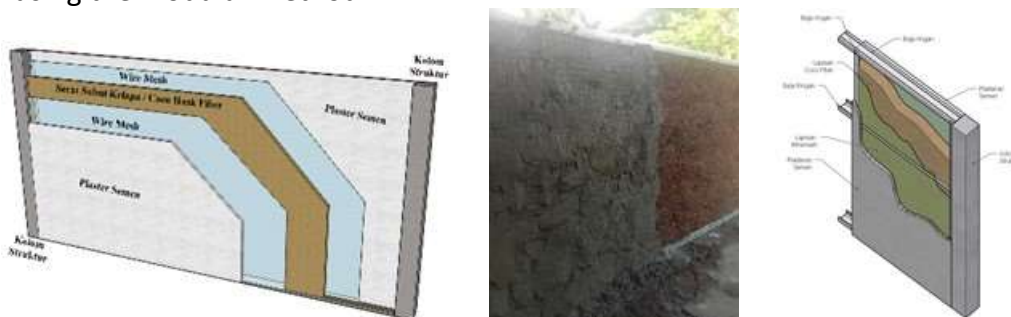


Figure 7 Application of Composite Concrete in Sandwich Configuration on the Wall of a Rural Housing
(Source: Author, 2024)

5. CONCLUSION

Based on the SNI compressive strength for bricks and for concrete blocks, it is proven that coconut fiber composite concrete can meet and even exceed the compressive strength standards making it highly promising as a new material for rural house wall construction. The average weight of coconut fiber composite concrete is 4.72 kg, or a volume weight of 2,098. kg / m² making it much lighter than conventional concrete blocks and bricks. This offers structural safety advantages by reducing both self-weight and earthquake loads. Additionally, this composite concrete material is environmentally friendly as it utilizes agricultural waste and is cost-effective. Wall applications at the research location use a simple and practical appropriate technology approach suitable for rural housing. A modular system is applied to walls measuring 3 meters in length and 2.8 meters in height, divided into 1x1.4 meter modules. Each wall area contains six modules made from light steel channel C75. The inner layer of the wall is filled with compacted cocofiber with a thickness of 4cm, then covered with wire mesh on both outer sides, followed by cement plastering on both sides, also with a thickness of 4cm. Finally, the wall is smoothed and painted. As a suggestion, similar research

should be continued for all types of agricultural waste that can be used as new materials with better quality and environmentally friendly.

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