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ANALYSIS OF COMPRESSIVE STRENGTH PAVING BLOCKS WITH THE ADDITION OF COCONUT FIBER AND SUPERPLASTICIZER LIQUID

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ABSTRACT

This research was carried out to determine how strong the compressive strength of the Paving Block is to withstand the load above it, by adding coconut fiber and superplasticizer liquid to reduce the impact of environmental pollution. But for Paving Blocks, the effects of adding coconut fiber and superplasticizer liquid are not yet widely known. Further research needs to be done on adding coconut fiber and superplasticizer liquid in making Paving Blocks. The purpose of this research is as a form of knowledge for developing construction materials technology. This research can be used to utilize the potential of existing waste. This research aims to reduce environmental pollution caused by coconut fiber waste, and to use this waste as additional construction material technology and to find out how much compressive strength the Paving Block has so that it can be used as a construction tool. The addition of coconut fiber and superplasticizer liquid can improve the performance of Paving Blocks according to SNI 03-0691-1996 (compressive strength). The results from adding coconut fiber and superplasticizer liquid are higher than Normal Paving (without mixed ingredients). Paving Block 1:5 with the addition of coconut fiber and superplasticizer liquid from 5 samples produces an Average Stress fcr' of 305.42 Kg/cm^2 and Paving Block 1:6 with the addition of coconut fiber and superplasticizer liquid from 5 samples produces an Average Stress -Average fcr' is 237.45 Kg/cm^2. Normal 1:5 Paving Block from 2 samples produces an Average Stress fcr' of 203.47 Kg/cm^2 and normal 1:6 Paving Block from 2 samples produces an Average Stress fcr' of 184.59 Kg/cm^2.

Keywords: *Compressive Strength; Paving Block; Coconut Coir Fiber; Superplasticizer Liquid.*

1. Introduction

Paving blocks are usually used in yards, sidewalks, parking lots and village roads. Paving blocks are made with a certain composition, a mixture of cement, water and aggregate with or without added ingredients that do not reduce the quality of the paving blocks. The mixed paving block materials are then molded by pressing either conventionally or hydraulically and treated by wetting them with water.

Coconut coir fiber can be used as a mixture with cement. Coconut fiber has good compressive strength, so the use of a mixture of coconut fiber is expected to provide the advantages of each material, thereby producing fiber of good quality. Coconut fiber has tenacious properties, can absorb water, and has a good level of durability if it is not in direct contact with the weather, so this material is very good for use as a mixture for making fiber cement. The basic idea in using household materials such as coconut fiber waste is to utilize unused materials that cannot be recycled. Therefore, in this research we try to use coconut fiber inspired by household materials as an additional material in making concrete.

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Coconut coir has a length of 15-30 cm and a thickness of ± 0.2 mm, and has properties such as being resistant to attack by microorganisms, weathering and mechanical work (rubbing and hitting), and is lighter than other fibers, making it possible to be used as an additional material for paving. Block.

The superplasticizer is physically able to make the paste move more freely to fill the paving pores. This results in the porosity of the paving being smaller and the density of the paving increasing so that the strength of the paving block will also increase. The addition of superplasticizer has the effect of maintaining the planned cement water factor but must be adjusted to the recommended dosage. If the dose used is excessive, it will cause the paving to set for a long time and can even reduce the strength of the paving itself. Even at the age of 28 days, paving has not yet reached its maximum strength. Based on the background above, it is concluded that by adding superplasticizer it is necessary to know whether this addition will increase the compressive strength from 7 days, 14 days, 28 days to 56 days, as well as obtaining the optimum composition of the Paving Block mixture.

2. Material and Methods

At this stage, the manufacture and maintenance of test specimens is carried out at the Paving Block factory. The materials to be used in making paving blocks are measured according to the paving block mix plan. The cement, sand, superplasticizer liquid, and coco fiber to be measured are added to the mix. After mixing evenly, add water little by little. Next, the paving block mixture is molded using a hexagonal paving block mold with a side size of 12 cm, and a thickness of 6 cm and then compacted mechanically (compaction is done by machine). The finished paving blocks will be arranged to dry naturally. Carrying out research on concrete that will be designed with a certain material composition, if the implementation is not carried out well, the planned strength of the concrete will be difficult to achieve. The materials used in this study were sand, gravel, cement, water, coco fiber, and superplasticizer liquid. All these materials except water must be obtained from outside because they are not available in the laboratory.

2.1. Study Step

The equipment used in this study are:

1. Container
2. Concrete mixer (drill)
3. Test object molds and other aids for printing and compacting test objects
4. Compressive testing machine
5. Scales
6. Sieve
7. Ovens
8. Tray for fresh concrete containers

The steps taken in making paving blocks in this study are as follows:

1. The materials and tools needed for making paving blocks are prepared in advance
2. The ingredients needed are put into the mixing bowl, successively, sand, cement, superplasticizer liquid and coconut fiber.
3. Then do the stirring of the ingredients so that the mixture is evenly distributed.
4. After mixing thoroughly, add water according to the planned amount. The addition of water is done gradually, namely little by little, then the mixing is repeated and the remaining water and additional ingredients are added which were previously diluted with water. It must be remembered that the amount of water and added ingredients is in the amount that has been planned.
5. After the mixture is evenly filled into the mold, previously the mold is smeared with oh first (so it can be easily removed again) and the mold must be tightly bound.
6. After all the molds are filled, the surface is flattened and stored in a humid place with a temperature of around 18° - 22°C and left for 24 hours.
7. After that it is dried for 7 days, 14 days and 28 days.

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To obtain test results that are as expected, the paving blocks are immediately treated by immersing the paving blocks in water. The day before the test was carried out, the paving blocks were removed from the water and drained.

In carrying out this test, attention must be paid to the readiness of the tools to be used and also the readiness of the operators who will operate the tools so that the test implementation can go according to plan. The minimum number of personnel involved is 2 people, each of whom has their duties. One person controls the work of the machine and also reads the needle indicating the maximum load and one person records the reading results. Before the test is carried out, each test object is first weighed and its cross-sectional area is measured and recorded.

The steps taken for this pressure test are as follows:

1. The test object is placed in a position perpendicular to the flat surface of the pressing machine. Previously, the surface of the test object had to be flat, because this could result in a lack of accuracy during testing.
2. The pressure speed is 160 kg/cm2/second. When failure is reached the pressure speed is increased by ± 2 to 4 kg/cm2/second.

2.2. Data Processing

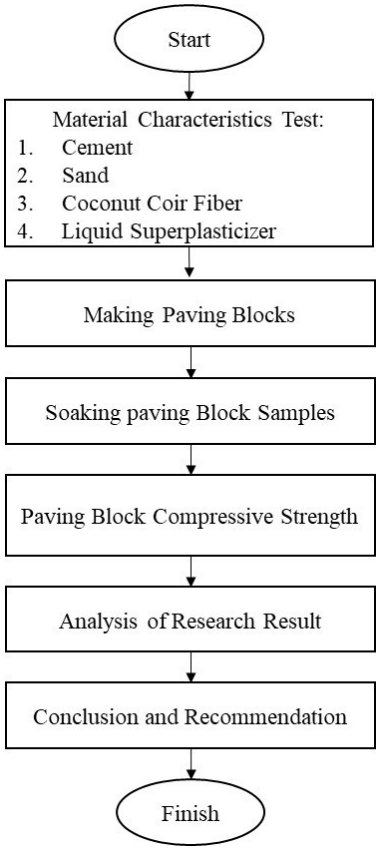

Figure 1. Research Flowchart

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3. Result and Discussion

3.1 Paving Blocks

Paving block is a building material composition made from a mixture of Portland cement or other hydraulic adhesives, water, and aggregate with or without other additives which do not reduce the quality of the concrete, by SNI 03-0691-1996 [16].

Paving blocks have good aesthetic value because in addition to having a rectangular or polygonal shape, they can also be colored like the original or added coloring agents in the manufacturing composition [1].

From the classification of paving blocks based on SNI-03-0691-1996, they are [16]:

a. Quality Concrete bricks are used for roads.
b. B-quality concrete brick is used for parking equipment.
c. Quality C concrete bricks are used for pedestrians.
d. D-quality concrete bricks are used for gardens and other uses.

Several things need to be considered in determining the quality of paving blocks which must meet the requirements of SNI 03-0691-1996, including the following [16]:

a. Appearance: Paving blocks must have a flat surface, no cracks and defects, and corners and ribs are not easily chipped with finger strength.
b. Size: Paving Block must have a nominal thickness of 60 mm with a tolerance of + 8%.
c. Physical Properties: Paving blocks for floors must have physical strength
d. Resistance to sodium sulfate: Concrete bricks when tested must not be deformed, and the maximum permissible weight loss is 1%.

The use of paving blocks has several advantages, including [15]:

a. Can be mass-produced.
b. Can be applied to road construction without requiring special skills.
c. Under normal loading conditions (according to the quality of the road and vehicles passing through), paving blocks can be used safely, are durable and are not easily damaged.
d. Paving blocks are easier to spread and can be used immediately without having to wait for them to harden like concrete.
e. Does not cause noise and dust disturbance when working on it.

Figure 2. Paving Blocks

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3.2. The compressive strength of paving blocks

The compressive strength of paving blocks is basically the same as the compressive strength of concrete, namely the amount of load per unit area [3]. The compressive strength test process is a test of paving blocks whether they meet the required quality or not. The higher the quality of the paving block, the greater the compressive strength value [9]. This test is carried out by subjecting the test object to a certain compressive force using a block tool with a compaction load that affects the energy of the person doing the work [8]. Testing the compressive strength of paving blocks according to ASTM C-192 is to obtain the maximum compressive load that can be accepted by paving blocks.

The test equipment used is the UTM (Universal Testing Machine). This test can be carried out by applying a compressive force to the object as much as possible until the object cracks or is destroyed. By placing the test object on the center support of the UTM tool, turning on the machine and setting the maximum compression given, then the test progress is complete, and the results will appear on the monitor screen in the form of graphics [5].

Testing the compressive strength and water absorption capacity of paving blocks with a mixed composition of plastic waste with different percentage mixture ratios to obtain an optimum mixture of compressive strength values for paving blocks. Compressive strength checks are carried out to find out how strong the paving blocks are when used [12].

3.3. Fine Aggregate

Fine aggregate is natural sand as a result of the natural splitting of crushed stone obtained from the stone crushing industry and has a fine-grained fineness of 2 mm – 5 mm. In general, fine aggregate has a maximum grain size requirement of 4.75 mm according to SNI 03-6821-2002 [13]. Namely:

1. Fine aggregate consists of sharp and hard grains.
2. Fine grains are eternal, that is, they are not damaged or destroyed by the weather. Saturated salt solutions can be applied to determine the permanent characteristics of fine aggregates. When sodium sulfate is applied, the crushed component should not exceed 10% by weight.
3. Fine aggregate contains a minimum of 5% mud (based on dry weight), sand must be cleaned if it exceeds 5%.

3.4. Portland Cement

Portland cement is an adhesive material that is produced by grinding Portland cement slag which consists of calcium silicate which is hydraulic and ground together with additional materials in the form of one or more crystalline forms of calcium sulfate compounds and other additional materials may be added. Cement is the material most often used in construction in construction. All types of construction of public facilities in the form of schools, houses, bridges, dams, airports, train stations, and others all use a cement mixture to support construction [4].

Cement is an adhesive as well as cohesive material, that is, it binds minerals together into a solid unit. In cement production, the main component in cement is silicate which can act as a binder if water is added and becomes hard if the water content in the cement mixture is reduced or lost. Components contained in cement include Dicalcium Silicate (2CaO.SiO2 or C2S), Tricalcium Silicate (3CaO.SiO2 or C3S), Tricalcium Alumina (3CaO.Al2O3 or C3A), and Tetra Calcium Aluminate Ferrite (4CaO.Al2O3 or C3AF) [14].

3.5. Water

Water is needed to react with cement, as well as to act as a binding agent between the aggregate grains so that it is easy to use. It must always be present in paving, not only to hydrate the cement but also to turn it into a paste so that the paving becomes smooth and functions as a lubricant for the aggregate and cement to provide a hardening reaction. on paving. The amount of water used to make paving mortar can be determined by the size of the contents or the size of the weight and must be done correctly [11].

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3.6. Coconut Fiber

Coconut fiber is a fibrous material with a thickness of about 5 cm. It is the outermost part of the coconut fruit. The coconut fruit itself consists of 35% fiber, 12% shell, 28% fruit flesh and 25% fruit juice. Coconut fiber consists of 78% cell walls and 22.2% cavities. One way to get fiber from coconut fiber is by extracting it using a machine. The fiber that can be extracted is 40% hair fiber and 60% mattress fiber. From 100 grams of abstracted coir, 70 parts of husk are obtained, 18 parts of mattress fiber and 12 parts of hairy fiber. From a technical perspective, coconut fiber has beneficial properties, including being 15-30 cm long, being resistant to attack by microorganisms, weathering and mechanical work (rubbing and hitting) and being lighter than other fibers [6].

Coconut fiber is a fibrous material with a thickness of around 2 - 5 cm and is the outermost part of the coconut fruit. Coconut fiber consists of epidermis, fiber and husk (dust). However, the most optimal use is only the fiber part. This is also the background for trying to research the extent of the contribution of adding coconut fiber in influencing the strength of paving blocks.

Coconut fiber contains fat which can make the bond between cement, sand and water and the coconut fiber less strong so that it can form pores in the paving. For this reason, NaOH or alcohol is needed to release the fat in the coconut fiber [2].

Figure 3. Coconut Fiber

3.7. Superplasticizer Liquid

The addition of additives that function to facilitate concrete work but still maintain the specified cement water factor value is using Sika Viscocrete 1003 as a superplasticizer (Sika Viscocrete-1003 product catalog). Superplasticizer is physically able to make the paste move more freely to fill the pores of the concrete. This results in the porosity of the concrete being smaller and the density of the concrete increasing so that the strength of the concrete will also increase [7].

The addition of superplasticizer has the effect of maintaining the planned cement water factor but must be adjusted to the recommended dosage. If the dose used is excessive, it will cause the concrete to set for a long time and can even reduce the strength of the concrete itself. Even at 28 days, concrete has not yet reached its maximum strength [10].

3.8. Paving Compressive Strength Test Results

In this research, the focus is actually on Paving Blocks with a mixture of coconut fiber and superplasticizer liquid. Normal paving here is only for comparison, to find out the compressive strength results of normal paving so only 2 samples of 1:5 and 2 samples of 1:6 were made. Meanwhile, for mixed Paving Blocks, 5 samples each are made in either a ratio of 1:5 or 1:6.

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Compressive Strength Test Results on Paving 1: 5 with a mixture of Coconut Coir Fiber and Superplasticizer Liquid

Sample 1
Manufacture Date = 21 August 2023
Test Date = 28 August 2023
Sample Age = 7 Days
Sample Weight = 4000 Grams

Area of Test Object = $(\frac{2}{3} \times \sqrt{3}) \times S^2$ (1)
$= (\frac{2}{3} \times \sqrt{3}) \times 12^2$
$= 374\ cm^2$

Dial reading = 690 KN

Compressive Strength = (Dial Reading x 101.987) / Area of Test Object (2)
= (690 x 101,987) / 374
= 188,16 Kg/cm^2

Time Conversion = 0,65

7 Day Compressive Strength fb' = Compressive Strength / Time Conversion (3)
= 188,16 / 0,65
= 289,47 Kg/cm^2

Average Voltage fcr' = Total Compressive Strength 7 Days fb'/ Number of Samples (4)
= (289, 47 + 293, 67 + 302, 06 + 314, 65 + 327, 23) / 5
= 1527,08 / 5
= 305,42 Kg/cm^2

Compressive Strength Test Results on Paving 1: 6 with a mixture of Coconut Coir Fiber and Superplasticizer Liquid

Sample 6
Manufacture Date = 21 August 2023
Test Date = 28 August 2023
Sample Age = 7 Days
Sample Weight = 4100 Grams

Area of Test Object = $(\frac{2}{3} \times \sqrt{3}) \times S^2$ (5)
$= (\frac{2}{3} \times \sqrt{3}) \times 12^2$
$= 374\ cm^2$

Dial reading = 580 KN

Compressive Strength = (Dial Reading x 101.987) / Area of Test Object (6)
= (580 x 101,987) / 374
= 158,16 Kg/cm^2

Time Conversion = 0,65

7 Day Compressive Strength fb' = Compressive Strength / Time Conversion (7)
= 158,16 / 0,65
= 243,33 Kg/cm^2

Average Voltage fcr' = Total Compressive Strength 7 Days fb'/ Number of Samples (8)
= (243,33 + 230,74 + 230,74 + 247,52 + 234,94) / 5
= 1187,27 / 5
= 237,45 Kg/cm^2

Compressive Strength Test Results on Paving 1: 5 Normal

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Sample 11
Manufacture Date = 21 August 2023
Test Date = 28 August 2023
Sample Age = 7 Days
Sample Weight = 4000 Grams
Area of Test Object = $(\frac{2}{3} \times \sqrt{3}) \times S^2$ (9)
$= (\frac{2}{3} \times \sqrt{3}) \times 12^2$
$= 374\ cm^2$
Dial reading = 480 KN
Compressive Strength = (Dial Reading x 101.987) / Area of Test Object (10)
= (480 x 101,987) / 374
= 130,89 Kg/cm^2
Time Conversion = 0,65
7 Day Compressive Strength fb' = Compressive Strength / Time Conversion (11)
= 130,89 / 0,65
= 201,37 Kg/cm^2
Average Voltage fcr' = Total Compressive Strength 7 Days fb'/ Number of Samples (12)
= (201,37 + 205,57) / 2
= 406,94 / 2
= 203,47 Kg/cm^2

Compressive Strength Test Results on Paving 1: 6 Normal

Sample 13
Manufacture Date = 21 August 2023
Test Date = 28 August 2023
Sample Age = 7 Days
Sample Weight = 4150 Grams
Area of Test Object = $(\frac{2}{3} \times \sqrt{3}) \times S^2$ (13)
$= (\frac{2}{3} \times \sqrt{3}) \times 12^2$
$= 374\ cm^2$
Dial reading = 450 KN
Compressive Strength = (Dial Reading x 101.987) / Area of Test Object (14)
= (450 x 101,987) / 374
= 122,71 Kg/cm^2
Time Conversion = 0,65
7 Day Compressive Strength fb' = Compressive Strength / Time Conversion (15)
= 122,71 / 0,65
= 188,79 Kg/cm^2
Average Voltage fcr' = Total Compressive Strength 7 Days fb'/ Number of Samples (16)
= (188,79 + 180,40) / 2
= 369,19 / 2
= 184,59 Kg/cm^2

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Table 1. Paving Block Compressive Strength Test Results

No	Test Object Name	Sample Weight (gr)	Test Object Area (cm^2)	Dial Reading (KN)	Compressive Strength (fc) (kg/cm^2)	Compressive Strength 7 Days fb' (kg/cm^2)	Average Stress fcr' (Kg/cm^2)
1	1:5 Mix	4000	374	690	188,16	289,47	305,42
2		4150	374	700	190,88	293,67	
3		4000	374	720	196,34	302,06	
4		4200	374	750	204,52	314,65	
5		4250	374	780	212,70	327,23	
6	1:6 Mix	4100	374	580	158,16	243,33	237,45
7		4450	374	550	149,98	230,74	
8		4250	374	550	149,98	230,74	
9		4200	374	590	160,89	247,52	
10		4300	374	560	152,71	234,94	
11	1:5 Normal	4000	374	480	130,89	201,37	203,47
12		4200	374	490	133,62	205,57	
13	1:6 Normal	4150	374	450	122,71	188,79	184,59
14		4000	374	430	117,26	180,40	

Source: Calculation Results, 2023

Figure 4. Paving Block Compressive Strength Test Process

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Figure 5. Sampling After Testing

Figure 6. Paving Block that has been Tested

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4. Conclusions

Based on the results of research on "Analysis of the Compressive Strength of Paving Blocks with the Addition of Coconut Fiber and Superplasticizer Liquid" several conclusions are: 1) The addition of coconut fiber and superplasticizer liquid can improve the performance of Paving Blocks according to SNI 03-0691-1996 (compressive strength). The results from adding coconut fiber and superplasticizer liquid are higher than Normal Paving (without mixed ingredients). 2) Paving Block 1:5 with the addition of coconut fiber and superplasticizer liquid from 5 samples produces an Average Stress fcr' of 305.42 Kg/cm^2 and Paving Block 1:6 with the addition of coconut fiber and superplasticizer liquid from 5 samples produces the fcr' average stress is 237.45 Kg/cm^2. Normal 1:5 Paving Block from 2 samples produces an Average fcr' Stress of 203.47 Kg/cm^2 and a normal 1:6 Paving Block from 2 samples produces an fcr' Average Stress of 184.59 Kg/cm^2.

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