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Utilization of Microfiber Waste as Added Material for Paving Blocks Based on Compressive Strength and Water Absorption Testing

Feny Ratna Fadlila[1] Fiki Rika Amalia[2] Riza Susanti[3] Puji widodo[4]
Civil Infrastructure Engineering and Architectural Design Study Program, Diponegoro University, Semarang City, Central Java Province, Indonesia[1,2,3,4]
Email: fenyratnafadlila08@gmail.com[1] fikirikaamalia@gmail.com[2]
rizasusanti@live.undip.ac.id[3] pujiwidodoundip@gmail.com[4]

Abstract
Along with the implementation of infrastructure development, the need for building materials in Indonesia will continue to increase. Building materials themselves are generally sourced from Indonesia's natural resources (SDA). But lately people have an interest in the use of environmentally friendly products. Seeing these two things gave rise to new thoughts to replace some of the aggregates in paving blocks using microfiber waste where microfiber waste is synthesis waste that is difficult to recycle. Experimental studies were chosen as a method in this study which was carried out directly and objectively. This study used a percentage of 0%; 0,25%; 0,5%; 0.75%, and 1% which results in a compressive strength value of 34.03 Mpa; 25.72 Mpa; 34.12 Mpa; 29.29 Mpa; and 23.66 Mpa. The optimum value of the compressive strength of the paving block was obtained at a percentage of 0.5% i.e. 34.11 Mpa. As well as producing a water absorption value each producing a value of 4.42%; 4,34%: 5,09%; 4.78% which is included in the B quality category while the 1% percentage of 6.7% is included in the C quality category.
Keywords: Paving Block, Microfiber Waste, Compressive Strength, Water Absorption

INTRODUCTION

The validity of infrastructure as one of the other supporting variables in advancing development in Indonesia. In this regard, the Indonesian government is aggressively carrying out infrastructure development in Indonesia which is intended to improve people's welfare or life on an equal and equal footing with other developed countries. On the other hand, with the increasing welfare of the community, it can have a big impact on the development of the building materials industry in Indonesia. In addition, along with the implementation of infrastructure development, the need for building materials in Indonesia will continue to increase. Building materials or raw materials are the primary component for physical development in the form of infrastructure facilities and infrastructure. Building materials themselves are generally sourced from Indonesia's natural resources (SDA). But lately people have an interest in the use of environmentally friendly products. Seeing the increasing need for building materials and the existence of public interest in environmentally friendly products gave rise to new thoughts to replace some components of building materials by utilizing community waste in Indonesia (Sugiarto, Eddy Cahyono, 2019).

Community waste was chosen as a component to replace some building materials because there are still many community wastes that are difficult to recycle such as microfiber waste (Togatorop, David, 2017). The content of microfiber waste includes 20% nylon (polyamide) and 80% polyester which can be categorized as a type of plastic synthesis fiber (Synthetic Fiber Reinforced Concrete, SFRC) (Wiranto, Audrey Aulivia, 2021). Examples of microfiber waste are kitchen washcloths, mop wipes, towels, doormats, and so on. With the handling of microfiber waste that has not been maximized, then microfiber waste can be used as a substitute for part

of the aggregate in non-structural construction products such as paving blocks (W., Franz, 2021).

Paving block or under another name conblock is a road pavement construction product that is generally used ranging from private houses to public infrastructure. Paving blocks have a variety of textures, shapes, colors, and sizes which can attract the attention of consumers/ the public. In addition, paving blocks are in great demand by the public because of their easy installation and maintenance. So that paving blocks are suitable to be chosen as research that can later give rise to new innovations among the community (Ruhulessin, Masya Famely, 2021).

The selection of paving blocks as a construction product to be used as research by replacing some components of building materials is not the first time it has happened in Indonesia. In previous years, several studies have been carried out, For example, mixing paving blocks with organic waste (water hyacinth fiber, sugarcane fiber, husk ash) and inorganic waste (plastic fiber). Some of these studies have been successfully carried out as evidenced by the addition of compressive strength values in paving block products, some of whose components are replaced with waste (Fatturozak, 2020). Seeing some of the studies that have been successfully carried out gives rise to a new sense of curiosity to try to do research using other waste. Based on the reviews above, microfiber waste is chosen which contains nylon (polyamide) and polyester as a substitute for some components of building materials, namely in the aggregate component. This research is expected to be parallel or able to increase the compressive strength and water absorption power of paving blocks.

The purpose of this study is: to analyze the percentage of composition between conventional paving blocks and paving blocks of microfiber waste innovation; analyzing the value of compressive strength against paving blocks using microfiber waste additives; and analyzing water absorption of paving blocks using microfiber waste additives.

RESEARCH METHODS

Variable Identification

The variables in this study include paving blocks and microfiber waste. For the free variable, namely microfiber waste which will affect the compressive strength and absorption of water will be paving blocks, while the bound variables are paving blocks because they are variables that are influenced and will be measured later.

Data Retrieval Procedure

The procedure in this study is a direct and objective experimental study in the D4 laboratory of Civil Infrastructure Engineering and Architectural Planning of Diponegoro University Vocational School and the location of the paving block manufacturing site, namely the Dipo Company located on Jl. Durian No. 55, Pedalangan, Banyumanik District, Semarang City, Central Java, 50263. The data collection method aims to group data according to the type of research carried out through samples, data sources, and literature.

Paving Block Constituent Materials

The materials used in this study consisted of Cement, Portland Cement Type I brand Three Wheels; Aggregate, Muntilan Sand Ngori area; Water, Well water located around the location of the paving block test object manufacture; and Microfiber waste, obtained from household waste in the form of washcloths and towels. The first step is to wash the washcloth and towel so that it is free from dirt, lpestle dry to dry. After that, cut the fabric into small pieces with a size of 0.5 cm.

Figure 1. Cut Microfiber Waste

Preparation (Processing) of Test Objects

1. Testing of Paving Block Constituent Materials
   a. Testing of moisture content on fine aggregates in accordance with SNI 03-1971-1990
   b. Fine aggregate analysis testing with sieve method in accordance with SNI ASTM C136-2012
   c. Test the aggregate organic content by the whisk method using sand and water 3% NaOH solution based on SNI S-04-1998-F
   d. Test the sludge content of fine aggregate by whisk method using sand and ordinary water based on SNI S-04-1998-F
   e. Test the sludge content of fine aggregate by laundry method based on SNI S-04-1998-FJob Mix Design.
2. In this study, the composition of the mixture used a weight ratio according to the specified plan. Mixing of constituent materials with the determination of the weight ratio of cement and sand 1: 3, fas value 0.4% of the weight of the cement, and microfiber fiber with a varying percentage of 0%; 0,25%; 0,5%; 0.75%, and 1% of aggregate substitutes used.

Table 1. Job Mix Design

Variations Percentage	Constituent Materials of Test Objects	
	Cement : Sand : Microfiber	Water
0% Microfiber	1 : 3 : 0	0,4
0,25% Microfiber	1 : 2,9925 : 0,075	0,4
0,5%Microfiber	1 : 2,985 : 0,015	0,4
0,75%Microfiber	1 : 2,9775 : 0,0225	0,4
1% Microfiber	1 : 2,97 : 0,03	0,4

3. Manufacture of Test Objects. This study used a holland-type paving block test object measuring 21.5 x 10.5 x 6 cm as a sample for testing compressive strength with B quality and water absorption.

Table 2. Number of Test Objects

Variations Percentage	Number of Test Objects		Total
	Compressive Strength	Water Absorption	
0% Microfiber (SNI)	4	1	5
0,25% Microfiber	4	1	5
0,5%Microfiber	4	1	5
0,75%Microfiber	4	1	5
1% Microfiber	4	1	5
Total			25

4. Paving Block Treatment. Care of the test object after printing let stand in a day. Furthermore, curing by covering the surface of the test object using burlap sacks and watering 2x a day, namely morning and evening so that the moisture is maintained until it is 5 days old, drying and hardening the paving block will run well where to avoid cracking / breaking.

5. Paving Block Testing
   a. Compressive strength testing according to SNI 03-0691-1996. The test was carried out when the paving block age turned 14 days with a total number of 20 pieces. The first step taken is to measure the test object in detail (length, width, and height) with a calipers and weigh the test object. Next, place the test object symmetrically on the press, equipped with a wedge. Then run the machine, recording its maximum load during the test (until the paving block is destroyed).
   b. Water absorption test according to SNI 03-0691-1996. The test is carried out when the paving block age turns 5 days with a total number of 5 pieces. The first step taken is to soak the test object for 24 hours in water, followed by wet weight weighing using a digital balance sheet. Then dry the test object in an oven with a temperature of approximately 105oC for ±24 hours until the weight reaches twice the weight of the difference of < 0.2%. After that weigh the dry weight.

RESULTS OF RESEARCH AND DISCUSSION

Material Test Results

Before making paving blocks, researchers test fine aggregates (sand) because the material that makes up this paving block is obtained without any specifications, so that it is possible to affect the strength of the paving block when mixed with certain materials. Here is a recap of the fine aggregate material test results:Kadar air agregat halus sebesar 5,82%, yang pengujiannya berdasarkan SNI 03-1971-1990

1. Analysis of fine aggregate sieve according to the result of fineness modulus of 2.37 qualifies according to SNI 03-2843-2000 and is classified as coarse sand type. Here is a graph of the smooth aggregate test results.

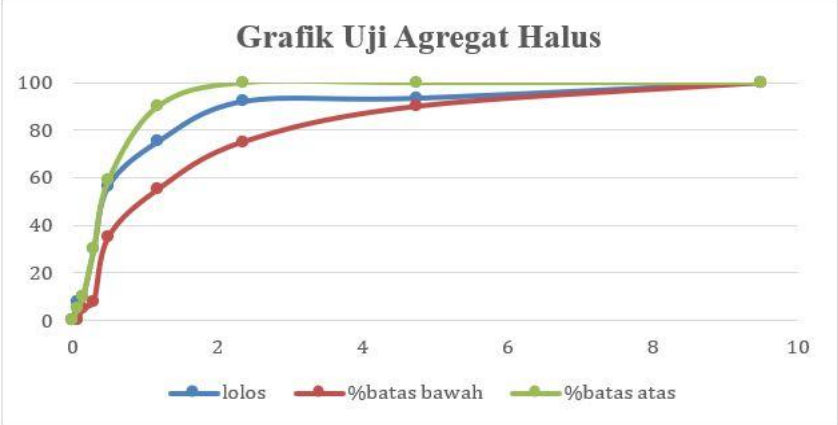

Figure 2. Fine Aggregate Test Graph (SNI 03-2843-2000)

2. The color of the mixture resulting from testing organic substance levels is a light yellow color. Based on the test results above, it shows that there are very few organic substances contained in sand which meet the SNI S-04-1998-F standard. Therefore, sand is declared suitable for use as a constituent material for paving blocks.
3. The value of fine aggregate sludge content by the whisk method using ordinary sand and water is 98.54%. So that sand can be used as a constituent material for paving blocks because the sludge content value > 70% according to the analysis in SNI S-04-1998-F.
4. The value of the fine aggregate sludge content with the laundry method is 3.2%. So that sand can be used as a constituent material for paving blocks because the sludge content value < 5% according to the requirements stated in SNI S-04-1998-F, 1989.

Paving Block Compressive Strength Test Results

Based on SNI 03 - 0691 - 1996, the average min. The compressive strength value on the paving block is 40 Mpa for quality A, 20 Mpa for quality B, 15 Mpa for quality C, and 10 Mpa for quality D. There is a mixture type on the paving block to see the compressive strength, namely normal paving blocks and paving blocks with a mixture of microfiber waste. Testing was carried out paving blocks aged 14 days. Furthermore, the conversion is within 28 days of age and is presented on graphs and tables.

Table 3. Test Results of Compressive Strength of Paving Block Aged 14 Days

Percentage of Microfiber Waste	Size (cm)			Weight (kg)	Compressive Strength			Mean Press Strength (Mpa)	Mean compressive strength (Kg/cm²)
	P	l	T		Kn	Mpa	Kg/cm²		
0%	21,2	10,7	6,6	3,540	727	32,05	386,14	29,95	360,81
	21,2	10,6	6,7	3,400	686	30,53	367,83		
	21,2	10,9	6,4	3,415	659	28,52	343,61		
	21,2	10,8	6,6	3,455	657	28,69	345,66		
0,25%	21,2	10,8	6,8	3,480	536	23,41	282,05	22,66	272,95
	21,2	10,7	6,6	3,440	529	23,32	280,96		
	21,3	10,6	6,8	3,480	519	22,99	276,99		
	21,2	10,7	6,7	3,420	474	20,90	251,81		
0,5%	21,0	10,6	5,8	2,865	715	32,12	386,99	30,02	361,63
	21,2	10,6	5,6	2,790	697	31,06	374,22		
	21,1	10,6	5,7	2,750	645	28,84	347,47		
	21,1	10,8	5,7	2,895	639	28,04	337,83		
0,75%	21,1	10,7	6,0	2,980	675	29,90	360,24	25,78	310,54
	21,1	10,7	5,8	2,930	561	24,85	299,40		
	21,1	10,7	6,0	3,135	551	24,41	294,10		
	21,2	10,7	5,8	2,865	543	23,94	288,43		
1%	21,2	10,5	5,6	2,852	522	23,45	282,53	20,82	250,84
	21,2	10,6	5,9	2,845	463	20,60	248,19		
	21,2	10,7	5,6	2,630	454	20,01	241,08		
	21,2	10,7	5,5	2,570	436	19,22	231,57		

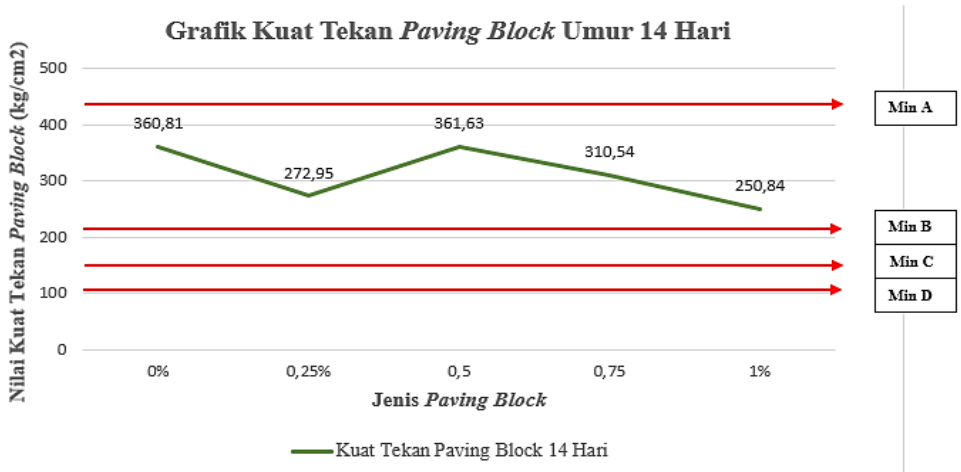

Figure 3. Graph of Examination Results of Compressive Strength of Paving Block Aged 14 Days in (Kg/Cm²)

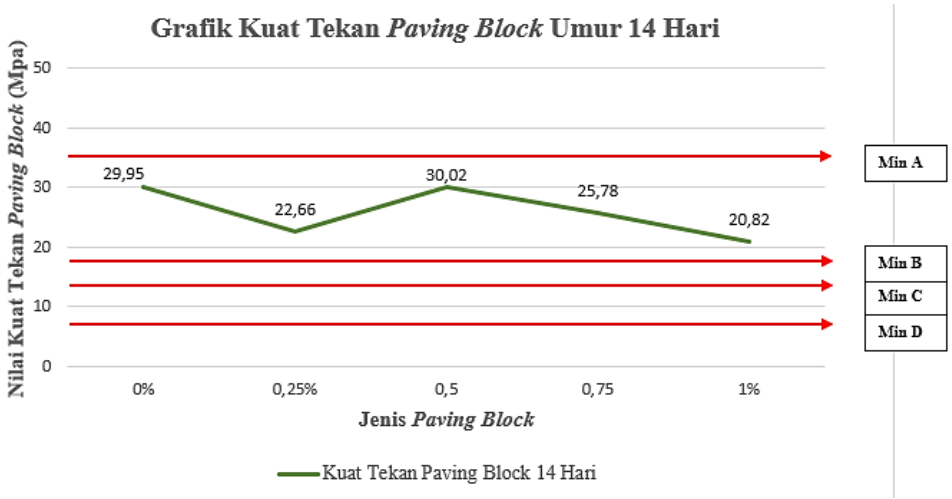

Figure 4. Graph of Examination Results of Strong Press Paving Block Age 14 Days in (Mpa)

Based on the graphic figure 4 compressive strength of the paving block mixture of microfiber waste 0.25% there is a decrease in the compressive strength value when compared to the normal paving block, which is 7.29 MPa and the average compressive strength value is 22.66 MPa. The compressive strength value of the microfiber waste mixture paving block percentage of 0.5% there was an increase in the compressive strength value when compared to the microfiber waste paving block percentage of 0.25% which was 7.36 MPa and the average compressive strength value was 30.02 MPa. The compressive strength value of the microfiber waste mixture paving block of 0.75% decreased the compressive strength value when compared to the microfiber waste paving block percentage of 0.5% which was 4.24 MPa and the average compressive strength value was 25.78 MPa. The compressive strength value of the paving block of the microfiber waste mixture of 1% decreased the compressive strength value when compared to the microfiber waste paving block percentage of 0.75% which was 4.96 MPa and the average compressive strength value was 20.82 MPa.

Based on the elaboration The graph above can be said that with the addition of microfiber waste of 0.5% of the weight of the sand, the compressive strength value of the paving block is higher than the normal paving block compressive strength value of 0.07 MPa. Then the paving block percentage of 0.5% achieves optimum results where the compressive strength value is greater than other percentages, namely 30.02 MPa. While the addition of microfiber waste is a percentage of 0.25%; 0,75%; and 1% of the weight of the sand gets a lower compressive strength value of the paving block than the value of the compressive strength of the normal paving block each value of 7.29 MPa; 4.17 MPa; and 9.13 MPa.

Table 4. Conversion of Compressive Strength Value of Paving Block Age 28 Days

Percentage of Microfiber Waste	Size (cm)			Weight (kg)	Compressive Strength		Mean Press Strength (Mpa)	Mean compressive strength (Kg/cm²)
	P	l	T		Mpa	Kg/cm²		
0%	21,2 21,2 21,2 21,2	10,7 10,6 10,9 10,8	6,6 6,7 6,4 6,6	3,540 3,400 3,415 3,455	36,42 34,69 32,41 32,60	438,80 417,95 390,48 392,77	34,03	410,00
0,25%	21,2 21,2 21,3 21,2	10,8 10,7 10,6 10,7	6,8 6,6 6,8 6,7	3,480 3,440 3,480 3,420	26,60 26,50 26,02 23,75	320,48 319,28 313,49 286,14	25,72	309,85
0,5%	21,0	10,6	5,8	2,865	36,50	439,76	34,12	410,90

	21,2 21,1 21,1	10,6 10,6 10,8	5,6 5,7 5,7	2,790 2,750 2,895	35,30 32,77 31,86	425,30 394,82 383,73		
0,75%	21,1 21,1 21,1 21,2	10,7 10,7 10,7 10,7	6,0 5,8 6,0 5,8	2,980 2,930 3,135 2,865	33,98 28,24 27,74 27,20	409,40 340,24 334,22 327,71	29,29	352,89
1%	21,2 21,2 21,2 21,2	10,5 10,6 10,7 10,7	5,6 5,9 5,6 5,5	2,852 2,845 2,630 2,570	26,65 23,41 22,74 21,84	321,08 282,05 273,98 263,13	23,66	285,06

Table 5. Paving Block Quality Classification

Percentage of Microfiber Waste	Kuat Tekan Beton Umur 14 Hari		Kuat Tekan Beton Umur 28 Hari		Kelas Mutu Paving Block
	Mpa	Kg/cm²	Mpa	Kg/cm²	
0%	29,95	360,81	34,03	410,00	Mutu B
0,25%	22,66	272,95	25,72	309,85	Mutu B
0,5%	30,02	361,63	34,12	410,90	Mutu B
0,75%	25,78	310,54	29,29	352,89	Mutu B
1%	20,82	250,84	23,65	285,06	Mutu B

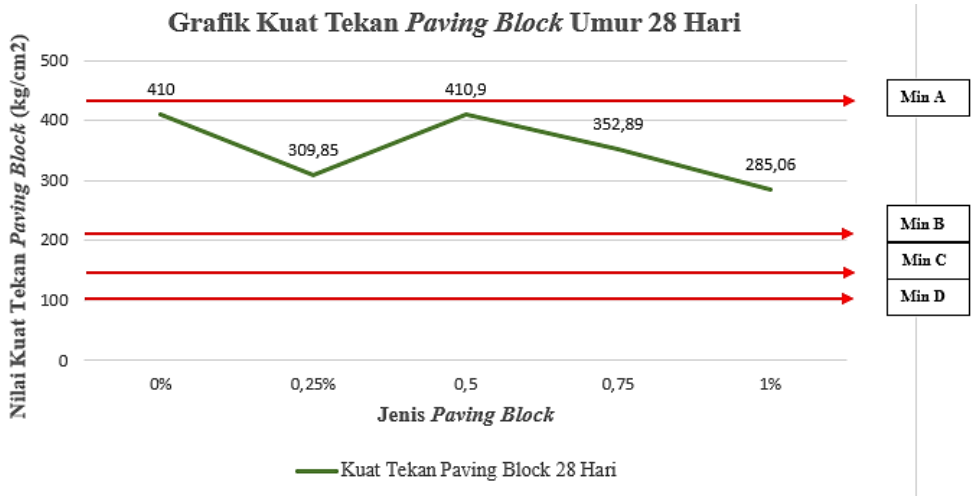

Figure 5. Graph of Examination Results of Strong Press Paving Block Age 28 Days in (Kg/Cm²)

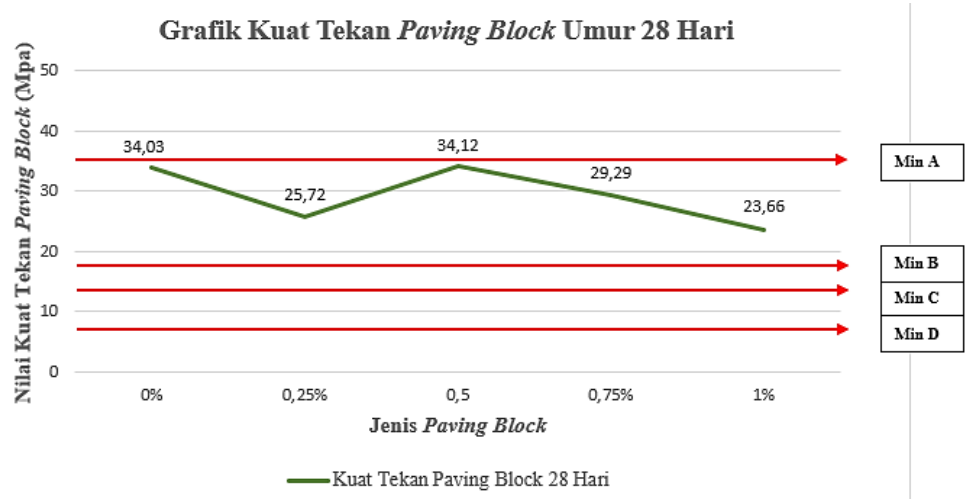

Figure 6. Graph of Examination Results of Strong Press Paving Block Age 28 Days in (Mpa)

Based on figure 6, the compressive strength of the paving block mixture of microfiber waste 0.25% there was a decrease in the compressive strength value when compared to the normal paving block, which was 8.31 MPa and the average compressive strength value was 25.72 MPa. However, the decrease that occurred in the paving block of microfiber waste percentage of 0.25% remained at quality B. Compressive strength value of paving block mixture of microfiber waste percentage 0.5% there was an increase in the compressive strength value when compared to microfiber waste paving block percentage of 0.25% which was 8.4 MPa and the average compressive strength value was 34.12 MPa. Although the paving block has increased the compressive strength value, the paving block remains at quality B. Compressive strength value of the paving block mixture of microfiber waste 0.75% there is a decrease in the compressive strength value when compared to the microfiber waste paving block percentage of 0.5% which is 4.83 MPa and the average compressive strength value is 29.29 MPa. However, the decrease that occurred in the paving block of microfiber waste percentage of 0.75% remained at quality B. Compressive strength value of paving block mixture of microfiber waste 1% there was a decrease in the value of compressive strength when compared to microfiber waste paving block percentage of 0.75% which was 5.63 MPa and the average compressive strength value was 23.66 MPa. However, the decrease that occurred in the paving block of microfiber waste percentage of 0.75% remained at quality B.

Based on the description of the graph above, it can be said that with the addition of microfiber waste of 0.5% of the weight of the sand, the compressive strength value of the paving block is higher than the normal paving block compressive strength value of 0.09 MPa. Then a percentage paving block of 0.5% achieves optimum results where the compressive strength value is greater than other percentages, namely 34.12 MPa. While the addition of microfiber waste is a percentage of 0.25%; 0,75%; and 1% of the weight of the sand gets a lower paving block compressive strength value than the normal paving block compressive strength value of 8.31 MPa each; 4.74 MPa; and 10.37 MPa.

Paving Block Water Absorption Test Results

In SNI 03 – 0691 – 1996, paving blocks are declared to have passed the water absorption test if the average is max. 3% for quality A, average max. 6% for quality B, average max. 8% for C quality, and max average. 10% for quality D. Paving block absorption is tested when it is 5 days old. Here are the results of water absorption testing.

Table 6. Results of 5 Days Old Water Absorption Test (SNI 03 – 0691 – 1996)

Percentage of Microfiber Waste	Dry Weight (gr)	Wet Weight (gr)	Water Absorption	Paving Block Quality Class
0%	3505	3660	4,42%	B
0,25%	3455	3605	4,34%	B
0,5%	2750	2890	5,09%	B
0,75%	2930	3070	4,78%	B
1%	2685	2865	6,7%	C

Based on the description of the results of water absorption, all variations of paving blocks meet the maximum water absorption requirements according to SNI 03 - 0691 - 1996 where the percentage water absorption value is 0%; 0,25%, 0,5%; 0.75% and 1% respectively were 4.42%; 4,34%; 5,09%; 4,78%; and 6.7%.

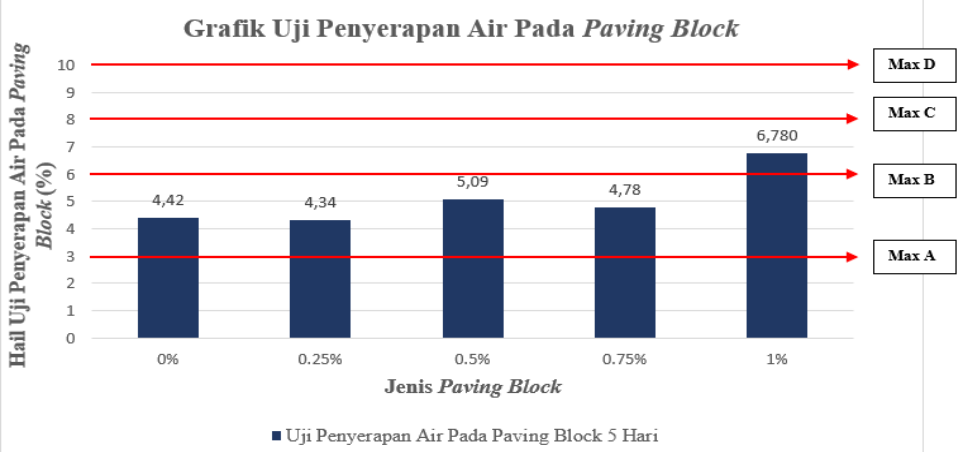

Figure 7. Histogram of Water Absorption Results

Based on the histogram of figure 7, the water absorption above shows that the histogram bars are up and turn at each percentage. The percentage value of water absorption in microfiber waste paving blocks percentage 0% is 4.42% which is used as a reference for other test objects. The water absorption value in the microfiber waste paving block percentage of 0.25% decreased when compared to the percentage of microfiber waste mixture of 0% which was 0.08% where the resulting water absorption value was 4.34%. Basically, the quality of the paving block of microfiber waste percentage of 0.25% has increased, but the quality of the paving blcok is still at the same quality as the paving block of microfiber waste percentage 0%, namely quality B. Water absorption value in the paving block microfiber waste percentage 0.5% there is an increase when compared to the percentage of microfiber waste mixture 0.25% which is 0.75% where the value of water absorption produced is 5.09%. Basically, the quality of microfiber waste paving block quality percentage of 0.5% has decreased, but the quality of paving blcok is still at the same quality, namely quality B.

The water absorption value in the microfiber waste paving block percentage of 0.75% decreased when compared to the percentage of microfiber waste mixture of 1% which was 0.31% where the resulting water absorption value was 4.78%. Basically, the quality of microfiber waste paving block quality percentage 0.75% has increased, but the quality of paving blcok is still at the same quality, namely quality B. Water absorption value in microfiber waste paving block percentage 1% increases when compared to the percentage of microfiber waste mixture 0.75% which is 2% where the absorption value of water produced is 6.78%. Basically, the quality and quality of microfiber waste paving blocks percentage 1% has decreased, which is at quality C. Water absorption test paving block microfiber waste percentage 0%; 0,25%; 0.5% and 0.75% are included in quality B while percentage 1% is included in quality C. The best quality of water absorption in paving blocks is at a percentage of microfiber waste of 0.25%.

CONCLUSION

Based on the results of the research on paving blocks, several conclusions were obtained, including: Microfiber waste in paving blocks which is used as a substitute for part of the aggregate compressive strength value and the water absorption value meets quality B for a percentage of 0.25%; 0,5%; and 0.75%; while the compressive strength value for a percentage of 1% meets quality B but the water absorption value is included in the C quality category according to SNI 03-0691 1996. The compressive strength value of the paving block is 28 days old which makes microfiber waste as a partial replacement of the aggregate with a percentage

of 0%; 0,25%; 0,5%; 0,75%; and 1% each produced a value of 34.03 Mpa; 25.72 Mpa; 34.12 Mpa; 29.29 Mpa; and 23.66 Mpa which can be categorized as B quality according to SNI 03-0691 1996. The optimum value of the compressive strength of the paving block was obtained at a percentage of 0.5% which is 34.11 Mpa. Water absorption test paving block microfiber waste percentage 0%; 0,25%; 0.5% and 0.75% resulted in a value of 4.42%; 4,34%: 5,09%; 4.78% which is included in the B quality category while the 1% percentage is included in quality C. The best quality of water absorption in paving blocks is at a percentage of microfiber waste of 0.25%.

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