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Effect of Fly Ash Use on Compressive Strength and Water Absorption of Paving Block

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ABSTRACT

Paving block is a product of a mixture of mortar which is generally used as a building material and ground surface pavement that can function as a sidewalk or public road that is often passed by pedestrians and vehicles. Mortar mixtures have a composition of cement, fine aggregate, water, and can use other additives. In this study, the additional material used is fly ash. With the right composition and procedures, the addition of fly ash as a cement substitution in the mixture can have a good effect on the compressive strength and water absorption of the paving block. The research was conducted using a mixture of fly ash as much as 10%, 20%, 25%, 30%, 35%, and 40% in laboratory research and 10% and 20% fly ash in research conducted in the field. The mixture used in the manufacture of paving blocks has a cement:sand composition ratio of 1:5. In the implementation of the results of testing the quality requirements of concrete bricks, the highest quality value was found in the range of fly ash use of 10-20%, both research conducted in the laboratory and field research. The highest compressive strength test results in the laboratory had a value of 20.1 MPa in the 10% and 20% variable tests, while for field tests, the highest value was obtained in the variable of using fly ash of 10% with a compressive strength value of 15.74 MPa.

Introduction

Paving block is a composition of mortar mixture that is often used as a building material that has a mixture of composition such as portland cement or materials that have hydraulic adhesive properties, water, and fine aggregate in this case may or may not use other additives according to SNI 03-0691-1996 (Lumingkewas, Hadiwardoyo, & Hadiwardoyo, 2023). Paving blocks are commonly used as non-structural elements such as covers or ground hardeners which are generally used as sidewalks, garden roads, parking lots, and residential roads. However, in this use, the paving block needs to have a compressive strength in accordance with the standards that have been determined as in SNI 03-0691-1996. In the paving block production process, generally using a ratio of cement and sand with a total of 1:3, 1:4, 1:5, 1:6, this can change if there are other compositions that are additives/substitutions for cement (Klarens, Indranata, & Hardjito, 2016). However, the composition used in the manufacturing process has standards that need to be considered and tested in its use. As well as the standard for the use of fine aggregate which can be referred to as fine aggregate if it has a maximum grain size of 4.76 mm, it can come from nature or processed stone (Weno et al., 2014). Similar to the use of water that is not recommended has excessive levels or chemicals so that the water used does not affect the mortar mixture.

Paving blocks (concrete bricks) also have quality classification standards that need to be considered in their use, which is regulated in SNI 03-0691-1996 (Lahoti, Wong, Yang, & Tan, 2018). The highest quality concrete brick, namely quality A, can be used as a road facility, quality B concrete brick can be used as a means of parking equipment, quality C concrete brick is a concrete brick that functions as a pedestrian facility, while quality D concrete brick can be used as a garden road pavement and other uses (Adibroto & Fauna, 2014). The classification has physical properties that need to be met in achieving a certain quality with a maximum limit of water absorption in each category of concrete brick quality. It can be seen that the higher the quality of concrete bricks, the more waterproof the paving block must be or it can be said that the lower the water absorption capacity will be, this can be seen in Table 1.

Table 1
Physical properties of paving blocks

Quality	Physical properties				
	Compressive Strength (Mpa)		Wear resistance (mm/min)		Max average water absorption
	Average	Min.	Average	Min.	(%)
A	40	35	0,090	0,103	3
B	20	17,0	0,130	0,149	6
C	15	12,5	0,160	0,184	8
D	10	8,5	0,219	0,251	10

In addition to the use of materials such as fine aggregates, cement and water as mentioned in mortar mixtures often use other additives. One of the additional materials that is often used in the composition of making paving blocks is fly ash. Fly ash is often used as an additional mortar material because it is considered to have properties that are generally possessed by Portland cement, namely pozzolanic properties. Fly ash is a non-B3 waste in the form of fine residues produced from burning or crushing coal and transported by hot air streams (SNI 2460, 2014). Fly ash waste can be categorized as B3 waste if the coal burning process occurs at coal-fired power plant facilities or from other activities that use technology other than stocker boilers and/or industrial furnaces (Government Regulation Number 22 of 2021 attachment XIV N106). One of the producers of fly ash from coal burning in Indonesia is PT Sumber Alam Sekurau which is located in Tanjung Selor District, Bulungan Regency, North Kalimantan Province. PT

Pesona Khatulistiwa Nusantara utilizes coal as a steam power plant managed by PT Sumber Alam Sekurau. In its use, coal combustion occurs to produce steam which is used as a turbine drive which is used to drive turbines and rotate electric generators. The burning produces 2-3% fly ash and bottom ash (FABA) from burning as much as 9 tons/hour every day. The large number of fly ash produced has led to an innovation in the use of fly ash as a mortar mixture for making paving block products.

The research was carried out to obtain the right mixture composition in the manufacture of paving block products using additional materials in the form of fly ash from PLTU PT Sumber Alam Sekurau. In addition, this study also aims to see and analyze the effect of the use of fly ash on the quality of concrete bricks (paving blocks) by using compressive strength testing and knowing the water absorption produced from each variable made. With the right composition and good utilization, it is hoped that it can help reduce the fly ash waste produced every day.

Method

The method carried out in this study is an experimental method which is basically a method of testing and controlling the variables owned in the process. The experimental research method aims to find out and find the influence of a treatment on a variable (NOVIANTI, Nevrita, & Fernando, 2023). This method is considered appropriate in the research conducted considering that the purpose of this research requires the creation of several mixed variables that are considered perfect for use in making paving blocks with fly ash additives. The research was carried out in two different places, namely the laboratory and the field, this gave rise to differences in results, treatments, and preparations that occurred in the research process (Kusdarini, Ulviandri, & Sari, 2022).

In research conducted in the laboratory, variations in the addition of fly ash were used by 10%, 20%, 25%, 30%, 35%, and 40%. The addition of fly ash is an additional treatment that replaces the amount of cement, therefore as the fly ash increases, the amount of cement used will be less. The addition of fly ash reaching 40% is considered to have aggressive waterproof properties that are moderate or can be said to be resistant to water (Al-Husseinawi, Atherton, Al-Khafaji, Sadique, & Yaseen, 2022). Research conducted in the field using the addition of fly ash as a substitute for cement has a range of 10% and 20% fly ash use, this refers to the results of the best compressive strength test that was carried out in the laboratory first. However, the use of fly ash used in field research is fly ash that has a different moisture content, namely fly ash with a fairly high moisture content of 28.10% (wet/wet) and fly ash which has a moisture content of 3.50% (dry/dry). Both studies used a cement:sand ratio of 1:5.

The preparation of mortar mixtures for paving block test specimens carried out in the laboratory uses materials in the form of fine aggregate (stone sand), Portland cement, wet/wet fly ash, and water. The four materials used have been taken into account for their use to be a mortar mixture with a test specimen size of length x width x height (5 cm x 5 cm x 5 cm). The mixing process is carried out using a small mixer and compaction is carried out manually/human-powered, using a tamper and an iron plate measuring 2.5 cm x 2.5 cm. 25 collisions were carried out per layer (3 layers/1 test piece). Details of the use of materials in the manufacture of laboratory test pieces are detailed by Table 2.

Table 2
Composition of laboratory paving block mixture

Variable	**Fly Ash**	**Sand**	**Cement**	**Fly Ash**	**Water**	**Total**	**Test Specimen**
	(%)	(gr)	(gr)	(gr)	(ml)	(gr)	(fruit)
P-15-0	0	1875	375	0	181,5	2250	6
P-15-10	10	1875	337,5	37,5	181,5	2250	6
P-15-20	20	1875	300	75	181,5	2250	6
P-15-25	25	1875	281,25	93,75	181,5	2250	6
P-15-30	30	1875	262,5	112,5	181,5	2250	6
P-15-35	35	1875	243,75	131,25	181,5	2250	6
P-15-40	40	1875	225	150	181,5	2250	6

Preparation was carried out from the materials used, one of which was a sieve analysis on the fine aggregate (stone sand) used and the results were obtained that the stone sand used was in the category of medium sand with a fineness modulus of 3.08%. Testing of fine aggregate sludge content was carried out and obtained a result of stone sand mud content of 1.54% with a moisture content of 2.18% (Sengkey, Kandiyoh, Slat, & Hombokau, 2023).

The process of making test pieces in the field has wet/wet fly ash and dry/dry fly ash materials with other materials in the form of stone sand as fine aggregate, gresik cement, and water. Formwork used in the manufacture of test pieces in the field has dimensions of length x width x height (20 cm x 10 cm x 8.5 cm). Table 3 shows the variables and material details in the process of making test pieces in the field. In the manufacturing process, a large mixer is used with an automatic press machine and compaction is carried out as many as 2 times of pressure/4 test pieces. The preparation was carried out in the form of testing the moisture content of the two types of fly ash used with a wet/wet fly ash moisture content of 28.10% and dry/dry fly ash of 3.50%. A standard test was carried out on stone sand as a fine aggregate used and the results of the filter analysis were obtained with a fineness modulus of 3.46% and included in the medium sand category. The moisture content and mud content of the stone sand aggregate were 3.71% and 1.73% respectively.

Table 3
Composition of the field paving block mixture

Variable	**Fly Ash Conditions**	**% Fly Ash**	**Test Specimen**	**Sand**	**Cement**	**Fly Ash**	**Total**	**Water**
-	-	(%)	-	(kg)	(kg)	(kg)	(kg)	(ml)
P-W-0	Wet	0%	24	82,43	16,49	0,00	98,91	3200
P-W-10	Wet	10%	24	82,43	14,84	1,65	98,91	3200

P-D-10	Dry	10%	24	82,43	14,84	1,65	98,91	3200
P-W-20	Wet	20%	24	82,43	13,19	3,30	98,91	3200

The preparation was carried out in the form of testing the moisture content of the two types of fly ash used with a wet/*wet fly ash* moisture content of 28.10% and *dry/dry fly ash* of 3.50%. A standard test was carried out on stone sand as a fine aggregate used and the results of the filter analysis were obtained with a fineness modulus of 3.46% and included in the medium sand category. The moisture content and mud content of the stone sand aggregate were 3.71% and 1.73% respectively.

Results and Discussion

The test carried out to determine the quality requirements of concrete bricks (*paving blocks*) is a test of compressive strength and water absorption. This is also done to find out the comparison between existing variables and get the variable with the best results to use and one of the factors that affect the compressive strength of the mortar is the age of the mortar (Siahaan, Tanjung, & Siregar, 2024). The calculation of the compressive strength of a mortar can be calculated using the formula of equation 1 as follows:

$$F'c = \frac{P}{A} \quad (1)$$

where F'c = Compressive strength of the test piece (MPa), P = maximum compressive load (N), A = surface area (mm2).

Water absorption testing is carried out on the test piece to show the percentage of water weight that can be absorbed by the aggregate when immersed in the test piece, this is also influenced by the size and number of pores contained in the test piece [8]. The result is obtained through the equation formula 2:

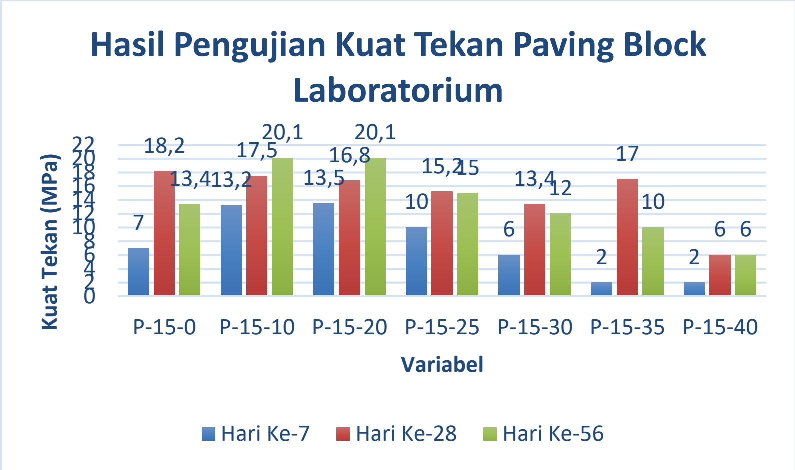
$$Daya\ Serap\ Air = \frac{B-A}{A}\ x\ 100\% \quad (2)$$

with A= Dry weight, B= wet weight.

The compressive strength test carried out in the laboratory has a number of tests of 3 times with details of the 7th day of testing, the 28th day of testing, and the 56th day of testing. The test was carried out using a hydraulic compressive strength test tool using two test pieces on each variable and each test. Meanwhile, the test method in water absorption refers to SNI 03-0691-1996 and the results obtained can be seen through the category results according to table 1. Physical properties of *paving blocks.* So the results of the compressive strength test of the test object in the laboratory are shown in Table 4 with a comparison graph of each test variable shown in Figure 1.

Table 4
Laboratory compressive strength test results

No.	Variable	Kuat Tekan (Mpa)								
		Hari Ke-7			Hari Ke-28			Hari Ke-56		
		Benda Uji 1	**Benda Uji 2**	**Rata-rata**	**Benda Uji 1**	**Benda Uji 2**	**Rata-rata**	**Benda Uji 1**	**Benda Uji 2**	**Rata-rata**
1	P-15-0	4	10	7	20	16,4	18,2	12,4	14,4	13,4
2	P-15-10	14,4	12	13,2	20	15	17,5	19,9	20,3	20,1
3	P-15-20	12,5	14,5	13,5	17,2	16,4	16,8	20,2	20	20,1
4	P-15-25	8	12	10	15,6	14,8	15,2	16	14	15
5	P-15-30	6	6	6	14,8	12	13,4	14,8	9,2	12
6	P-15-35	2	2	2	14	20	17	10	10	10
7	P-15-40	2	2	2	6	6	6	6	6	6



Picture 1
Laboratory Compressive Strength Testing Chart

The results of the laboratory compressive strength test showed that the test on the variables P-15-10 and P-15 20 had the highest compressive strength test results at the age of 56 days with an average compressive strength result of 20.1 MPa, both variables contained 10% fly ash and 20% fly ash. The results of the compressive strength are in accordance with table 1. The physical properties of the paving block test piece are included in the category of concrete brick quality B or can be used optimally as parking equipment. The variable P-15-25 and containing 25% fly ash at the age of 56 days is classified in category C or as a means of walking. The variable with the highest compressive strength result has compressive strength results that increase with each test while some other variables have results that fluctuate. Table 5 shows the results of water absorption testing conducted in the laboratory with tests carried out 3 times.

Table 5
Laboratory Water Absorption Test Results

	Pengujian penyerapan air (Hari ke-7)					Pengujian penyerapan air (Hari ke-28)					Pengujian penyerapan air (Ha			
Variable	No.	Berat Awal (gr)	Berat Akhir (gr)	% Penyerapan	Rata-rata	No.	Berat Awal (gr)	Berat Akhir (gr)	% Penyerapan	Rata-rata	No.	Berat Awal (gr)	Berat Akhir (gr)	% Penyerap
P-15-0	1	242	251	3,72	3,32	3	264	273	3,41	3,64	5	258	272	5,43
	2	273	281	2,93		4	259	269	3,86		6	258	271	5,04
P-15-10	1	271	280	3,32	3,33	3	264	273	3,41	3,55	5	252	263	4,37
	2	270	279	3,33		4	271	281	3,69		6	272	282	3,68
P-15-20	1	264	275	4,17	4,12	3	254	265	4,33	4,21	5	273	286	4,76
	2	270	281	4,07		4	269	280	4,09		6	266	278	4,51
P-15-25	1	245	261	6,53	6,60	3	259	278	7,34	7,36	5	264	283	7,20
	2	255	272	6,67		4	257	276	7,39		6	260	278	6,92
P-15-30	1	253	260	2,77	2,71	3	269	277	2,97	3,37	5	270	279	3,33
	2	263	270	2,66		4	266	276	3,76		6	275	284	3,27
P-15-35	1	268	279	4,10	3,95	3	269	280	4,09	4,36	5	253	264	4,35
	2	263	273	3,80		4	259	271	4,63		6	268	280	4,48
P-15-40	1	268	281	4,85	4,42	3	275	288	4,73	4,60	5	278	291	4,68
	2	276	287	3,99		4	268	280	4,48		6	274	290	5,84

Water absorption testing is carried out on each test piece and each variable can be seen that each variable has water absorption in accordance with the category of concrete brick quality requirements in table 1. Properties of physics. In the variable with the highest compressive strength, namely the variables P-15-10 and P-15-20 have water absorption of 4.02% and 4.64% respectively, which in category B the maximum water absorption owned by the test specimen is 6%. The highest water absorption occurs in the P-15-25 variable which has a fly ash content of 25% of 7.06%. However, this figure is in accordance with the category owned by the test piece, namely category C with a maximum absorption of 8%.

In the compressive strength test carried out in the field, there were 4 tests at the age of the test specimen 7 days, 18 days, 29 days, and 56 days. Each test was taken 3 test pieces per variable with two curing methods , namely the water immersion method and the no-treatment method. The results of the compressive strength testing of test objects in the field with the water immersion curing method are shown in Table 6 with a comparison chart of each test variable shown in Figure 2.

Table 6
Field compressive strength test results (water immersion)

Variable	Hari ke-8			Hari ke-18			Hari ke-29			Hari ke-56		
	Rendam Air			Rendam Air			Rendam Air			Rendam Air		
	Kn	Mpa	Rata-rata (Mpa)	Kn	Mpa	Rata-rata (Mpa)	Kn	Mpa	Rata-rata (Mpa)	Kn	Mpa	Rata-rata (Mpa)
P-W-0	126	8,51	10,14	247	16,26	9,94	208	14,44	10,60	163	11,13	8,70
	214	14,46		95	6,25		173	12,01		155	10,59	
	110	7,43		111	7,31		77	5,35		64	4,37	
P-W-10	167	11,28	10,25	141	9,28	8,93	188	13,06	12,45	238	16,26	14,39
	154	10,41		148	9,74		156	10,83		209	14,28	
	134	9,05		118	7,77		194	13,47		185	12,64	
P-D-10	124	8,38	7,45	70	4,61	7,33	131	9,10	7,82	98	6,69	7,49
	125	8,45		127	8,36		146	10,14		123	8,40	
	82	5,54		137	9,02		61	4,24		108	7,38	
P-W-20	193	13,04	10,63	234	15,41	10,80	218	15,14	12,31	164	11,20	11,98
	121	8,18		149	9,81		173	12,01		136	9,29	
	158	10,68		109	7,18		141	9,79		226	15,44	

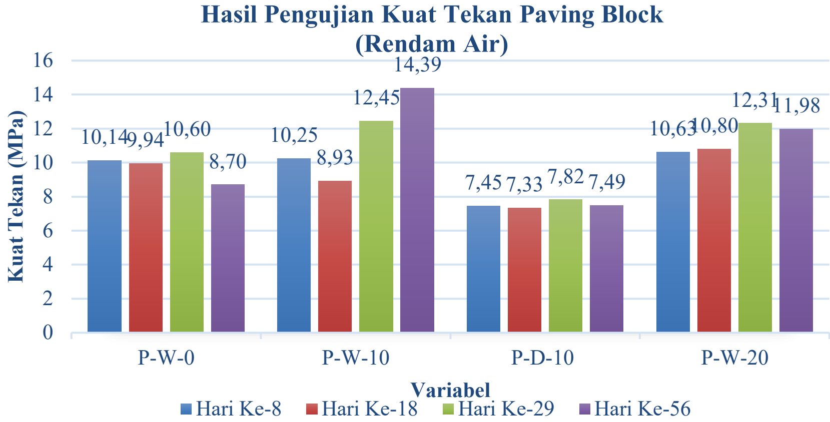


Figure 2
Field compressive strength test graph (water immersion)

The compressive strength test carried out on *the paving block* test piece had the result with the highest average compressive strength of 14.39 MPa which occurred in the P-W-10 variable with a test specimen life of 56 days. This variable has *a fly ash content* of 10% and the P-W-10 variable enters the category of concrete brick quality requirements C with the category of pedestrian facility use. In addition to the P-W-10 variable, the P-W-20 variable is also included in the *paving block* which can enter the quality requirements of concrete bricks in accordance with SNI 03-0691-1996 in category D for use as pavement, roads, gardens and other uses. The P-W-0 variable in the 28-day age test had a compressive strength result that could enter the D quality requirement category, but on the 56th day of the test, there was a decrease in the compressive strength result so that it could not enter the compressive strength quality requirement of concrete bricks along with the P-D-10 variable. The results of the compressive strength testing of test objects in the field with the water-soaked curing method are shown in Table 7 with a comparison chart of each test variable shown in Figure 3.

Table 7
Field compressive strength test results (no maintenance)

Variable	Hari ke-8 Tanpa Perawatan			Hari ke-18 Tanpa Perawatan			Hari ke-29 Tanpa Perawatan			Hari ke-56 Tanpa Perawatan		
	Kn	Mpa	Rata-rata (Mpa)	Kn	Mpa	Rata-rata (Mpa)	Kn	Mpa	Rata-rata (Mpa)	Kn	Mpa	Rata-rata (Mpa)
P-W-0	160	10,81	11,51	177	11,65	13,63	231	16,04	13,31	222	15,16	15,28
	200	13,51		248	16,33		185	12,85		286	19,54	
	151	10,20		196	12,90		159	11,04		163	11,13	
P-W-10	182	12,30	12,23	202	13,30	15,19	237	16,46	15,74	159	10,86	11,63
	172	11,62		233	15,34		218	15,14		187	12,77	
	189	12,77		257	16,92		225	15,63		165	11,27	
P-D-10	155	10,47	10,29	66	4,35	7,75	73	5,07	9,31	87	5,94	9,49
	159	10,74		89	5,86		127	8,82		132	9,02	
	143	9,66		198	13,04		202	14,03		198	13,52	
P-W-20	139	9,39	11,19	270	17,78	14,24	166	11,53	12,11	164	11,20	13,48
	143	9,66		233	15,34		158	10,97		237	16,19	
	215	14,53		146	9,61		199	13,82		191	13,05	

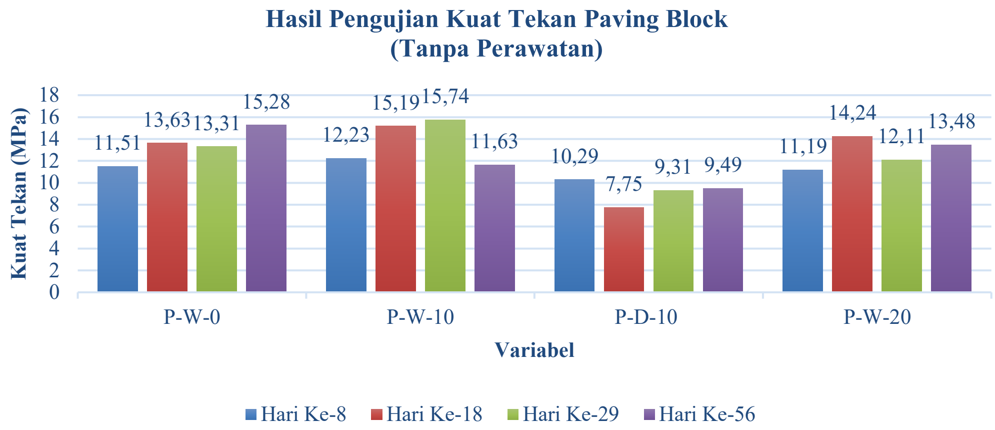


Figure 3
Field compressive strength test graph (without maintenance)

On the test specimen with the curing method without maintenance, it can be seen that the variable P-W-0 is the variable with the highest average compressive strength test result of 15.28 MPa at a test age of 56 days. Refer to table 1. The physical properties of the variable P-W-0 are a category of quality requirements for concrete brick C with its use as a pedestrian facility. This variable is a variable with a test piece without the use of *fly ash* as the main material. However, on the 28th day of testing, the P-W-10 variable is the variable that has the highest average compressive strength test result with a value of 15.74 MPa and is included in the quality condition category C. This variable experienced a decrease in the average compressive strength test result on the 56th test day and only entered the quality requirement D category or use as a pavement for garden roads and other uses. Variable P-W-20 according to table 1. The physical properties can be categorized as D quality concrete bricks from the 7th day of testing to the 56th day of testing. While the P-D-10 variable at the test age of 7 days is included in category D, but after that this variable cannot meet the quality requirements of any concrete brick. While the results of water absorption testing carried out in the field are shown in Table 8, this can also be used as a correction factor whether the water absorption power possessed by certain variables is proportional to the compressive strength test value obtained. The water absorption test was carried out 4 times and the results were obtained that the test pieces made in the field until the 4th test did not have good water absorption results and showed very high results were also too waterproof and did not enter the water absorption standard *of the paving block* which had a range of 3%-10%. The P-W-20 variable is the only variable with sufficient absorption according to SNI 03-0691-1996 in table 1. Properties of physics. This can be caused by several factors that cause the test piece to absorb too much water, resulting in too high absorption such as cavities in the test piece that may be too much and too open.

Table 8
Field water absorption test results

Variable	Hari ke-7			Hari ke-14			Hari ke-28			Hari ke-56		
	Berat Awal (kg)	Berat Akhir (kg)	Penyerapan (%)	Berat Awal (kg)	Berat Akhir (kg)	Penyerapan (%)	Berat Awal (kg)	Berat Akhir (kg)	Penyerapan (%)	Berat Awal (kg)	Berat Akhir (kg)	Penyera (%)
P-W-0	3	3,55	18,33	2,95	3,5	18,64	2,8	3,1	10,71	2,95	3,03	2,71
P-W-10	3,25	3,65	12,31	3,2	3,8	18,75	3	3,5	16,67	3,2	3,26	1,87
P-D-10	3,1	3,65	17,74	2,95	3,5	18,64	2,85	3,3	15,79	3	3,06	2,00
P-W-20	3,15	3,6	14,29	3,25	3,7	13,85	3,15	3,45	9,52	3,1	3,2	3,23

If you look at each test result, both compressive strength testing and water absorption testing, of course, the results are obtained that the tests carried out in the laboratory have better test results than the tests carried out in the field. This can be caused by differences in the treatment carried out in the process of making test pieces or differences in treatment when preparing for the use of materials. With the difference in treatment that occurs in the manufacturing and preparation process, there are various results that are considered to be able to reduce the quality both in terms of compressive strength and water absorption. One of them is about the difference in preparation for the use of stone sand materials, the use of stone sand as a fine aggregate certainly requires some preparation so that the stone sand used does not pass the standard for the use of the maximum grain size of fine aggregate. Fine aggregate itself is one of the important components that plays a role in determining the strength of concrete bricks in general (Nofrianto & Hutrio, 2023). Fine aggregate in the use of concrete brick making has a maximum grain size of 4.75 mm and this is missed in the use of fine aggregate in the field because it is not filtered with a sieve that is in accordance with the maximum size of fine aggregate, the condition of the aggregate can be seen in Figure 4 and Figure 5 respectively. Filtration is carried out on the use of materials in the laboratory so that the test piece in the laboratory does not have an aggregate that is more than its maximum grain size.

Picture 2
Fine aggregates in laboratory specimens

Picture 3
Fine aggregates in field test specimens

This also affects the presence of many cavities or parts on the test piece that are not fully filled so that the water absorption capacity of the paving block made in the field is very high while the test piece made in the laboratory has enough density so that the water absorption capacity is in accordance with the quality requirements of concrete bricks. Figure 6 and Figure 7 show the collapse condition of the test specimen with each cavity present in the test piece.

Picture 4
Cavity density of laboratory test pieces

Picture 5
Field specimen cavity

In addition to the cavities found in the test piece, the amount of fly ash used also affects the water absorption on the paving block because referring to several studies on the properties of fly ash, fly ash is a material that absorbs more water than cement (Pataras, Arliansyah, Kadarsa, Fatimah, & Diningrum, 2023). So that as the number of fly ash used in the manufacture of paving block test pieces increases, the water absorption properties in the paving block will allegedly be higher.

Conclusion

Based on the research that has been conducted, fly ash can be used as a substitute or substitute for cement with the right amount and procedure. The optimal use of fly ash from coal combustion by PT Sumber Alam Sekurau for additional materials for making paving blocks is in the range of 10%-20%. The results of laboratory tests showed that the highest compressive strength values were obtained in the use of fly ash of 10% and 20% (variables P-15-10 and P-15-20) with a compressive strength value of 20.1 MPa at the age of 56 days, meeting the quality of category B concrete bricks with water absorption of 4.02% and 4.54% respectively. Meanwhile, the results of the test in the field showed the highest compressive strength value of 15.74 MPa in the P-W-10 variable with a percentage of fly ash of 10%, obtained at the age of 28 days, included in the quality category of concrete brick C, although the water absorption of 16.67% still requires correction. Differences in the manufacturing process and material preparation are important factors that affect the difference in test results.

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