The International Journal of Engineering and Science (IJES)
|| Volume || 11 || Issue || 11 || November || Pages || PP 35-46 || 2022 ||
ISSN (e): 2319-1813 ISSN (p): 20-24-1805

The Effect of Fly Ash and Bottom Ash on the Physical and Mechanical Properties of *Paving Blocks*

G. Setya Budi[1], Faisal[1], Erwin Sutandar[1*]

[1]*FacultyofCivilEngineering,UniversityofTanjungpura,Prof.Dr.HadariNawawiPontianakstreet,WestKalimantan, Indonesia,*

Corespondent: Erwin_sutandar@yahoo.com

In order to preserve the quality and quality produced in line with SNI requirements, the selling price of Paving Block products on the market must be modified to reflect the composition of the materials used due to the significant rise in Paving Block manufacturing material costs. Whereas, with the growth in cement and sand, a permanent solution must be found so that the price, quality, and quality of the paving blocks stay unchanged. Therefore, there is a plan to solve this issue by reducing the usage of cement, sand, and stone by using FABA (Fly Ash and Bottom Ash) from the Batu Barang PLTU, which has been operating in West Kalimantan. 0.5/0.5. Due to the decreased usage of sand and cement, does the quality of Paving Blocks still meet current standards? The variation 1:3:0.5 has the maximum compressive strength at day 28 = 28.202 Mpa and is classified as B. The greatest absorption = 7.637 % places the material in class B, while the wear value of 0.230 mm/minute places it in class D. Variation 1:4:0.5 has the maximum compressive strength on day 28 = 13,743 Mpa and is classified as B. The greatest absorption = 7.178 % classifies this material as B, as does its wear value of 0.113 mm/min. In the 1:6 variant, 0.5 has the maximum compressive strength on day 28 = 12,442 MPa and is classified as D. The greatest absorption = 6,665 % places it in class B, while a wear value of 0.442 mm/minute places it in class D. Thus, FABA may be used into the production of paver blocks in proportion to the desired level of quality.

Keywords: *Paving Block, Bottom Ash, Fly Ash, Cement, Sand, Stone, Absorption, and Compressive Strength*

Date of Submission: 12-11-2022 Date of Acceptance: 26-11-2022

I. INTRODUCTION

Paving Block is a widespread construction material used as a covering for road pavement. Typically used for paving parks, parking lots, walkways, and narrow alleyways. As a result, Paving Blocks must be of sufficient quality to be utilized as a covering for road pavement. Compressive strength is one of the required qualities of Paving Blocks. Generally, paving blocks are formed from a combination of portland cement, aggregate, and water, with or without other additives that do not diminish the quality of the paving block. The utilized aggregate is a fine aggregate (sand). Nonetheless, coarse aggregate (gravel) with a tiny size/diameter is also used on occasion.

Due to the scarcity and expensive cost of this fuel, several businesses have substituted oil (IDO or MFO) with coal as the power source in steam generators/boilers. The use of coal as an energy source in boiler units in the industrial sector has lately been the most popular alternative among business owners since coal is plentiful in Indonesia and may reduce operating expenses. Fly Ash was selected as the focus of this study due to its greater quantity (80 % of the total remaining coal combustion ash) and its smaller grain size (200 mesh), which has a greater potential to cause air pollution. Bottom Ash, on the other hand, still has calorific value, so it can still be used as fuel.

Given that Paving Block has been selected as the construction material, its load-bearing capacity must be examined. Consequently, it is required to evaluate the compressive strength of Paving Blocks manufactured with different Fly Ash combinations as aggregates. By adjusting the composition, it is possible to determine if the varied composition of the added material (Fly Ash) affects the compressive strength of the manufactured Paving Block. Determining if employing coal ash (Fly Ash) as a combination for producing Paving Blocks will make them sturdy, economically valuable, and environmentally friendly requires more investigation.

II. LITERATURE REVIEW

2.1 Paving Blocks

Concrete brick (Paving Block) is a kind of structural concrete that may be used to pave sidewalks, yards, and parks, among other places. Generally, Paving Blocks are colored with natural or added coloring agents and are used for flooring both inside and outside of buildings.

The benefits of Paving Blocks are:

a. Paving Blocks may be utilized immediately, unlike concrete, which must be allowed to cure.
b. The cost is less than that of other forms of pavement.
c. High water absorption in order to prevent flooding.
d. The variety of Paving Blocks' forms allows the beautiful form of the pavement to be shown.
e. It is simple to execute and requires no heavy machinery, so it may be mass-produced.

The Paving Block has the following deficiencies:

a. Pairs of Paving Blocks can be readily wavy if the base is not solid enough.
b. Paving Block is unsuitable for terrain traveled by high-speed vehicles and congested metropolitan environments.
c. It is often the case that the installation is inadequate, resulting in joints that are readily separated and roadways that are not level.

The quality criteria of SNI 03-0691-1998 for Paving Blocks in Indonesia are as follows:

1. Aesthetics of Paving Stones

The surface must be level, and free of cracks and flaws, and the edges and ribs must be difficult to break with finger strength.

2. Size

- The most often used thickness for Paving Blocks is as follows: the thickness of 6 cm For limited frequency, light traffic loads, such as walkers and motorcycles.
- 8 cm in thickness For large traffic loads with dense regularity, including automobiles, pickups, buses, and trucks.
- Thickness of 10 cm or more. Loaders are used for very large loads, such as cranes.

3. Classification

- Paving Block quality A:is used for roads and motorbikes;
- Paving Block quality B: is used for parking lots;
- Paving Block quality C: is used for pedestrians, and
- Paving Block quality D: is used for parks and other users.

Table 1: Quality Standards for Paving Blocks (SNI 03-0691-1998)

Quality	Press Hard (Mpa)		Wear Resistance (Mm/Minute)		Average Water Absorption Max
	Average	Min	Average	Min	(%)
A	40	35	0,09	0,103	3
B	20	17	0,130	0,149	6
C	15	12,5	0,160	0,184	8
D	10	8,5	0,219	0,251	10

2.2 Components of Paving Blocks

2.2.1 Cement

This research will use portland cement as its cement material. In general, cement is an adhesive substance in which cement is utilized as a binding medium (bonding material) together with aggregate and water.

Based on the nature of the chemical reaction, cement may be separated into two distinct categories:

1. Cement from Clinker (calcium silicate and gypsum)

- Portland cement
- Light gray portland cement
- Portland cement with iron content
- Blast furnace portland cement (hoogovencement)
- Portland trans/pozzolan cement
- White portland cement
- Sulfated cement with aluminum cement

According to ASTM, cement may be categorized based on its intended purpose.

1. Type I, is for general construction when no specific criteria are necessary, in contrast to other kinds.
2. Type II, for general construction, particularly where sulfate and moderate hydration heat resistance is necessary.
3. Type III, for projects that need a high starting strength.
4. Type IV, for applications requiring low hydration.
5. Type V, for applications requiring a high sulfate resistance.

2.2.2 Coarse Aggregate

Coarse aggregate may be gravel arising from the natural disintegration of rocks or crushed stone created by crushing stones with a grain size of more than 5 mm. The following requirements must be met while using gravel:

1. Hard grains are impermeable and immortal, meaning they are impervious to the influences of weather like as sunshine and precipitation.
2. It cannot contain more than 1% mud; if it does, it must be cleansed before to use.
3. Must not include compounds that are destructive to rocks, such as alkali-reactive substances.
4. A maximum of twenty % of the total weight may be comprised of flat-grained coarse aggregate. (Aslam Dani, 2019).

2.2.3 Fine Aggregate

Fine aggregate may be natural sand resulting from the natural disintegration of rocks or manufactured sand created by stone-crushing equipment. The following are the specifications for fine aggregate used in accordance with SNI.S-04-1989.F:

1. The grain is crisp, sturdy, and tough.
2. It is everlasting and cannot be damaged or destroyed by the weather.
3. Fine aggregate cannot exceed 5% silt (the part that can pass through a 0.060 mm sieve). If more than five %, the sand must be cleaned.
4. Must be devoid of biological materials, since it would compromise the quality of the concrete.
5. There should be a wide range of grain sizes (gradation) so that there are minimal voids. Between 1.5 and 3 in its fineness modulus. 8. If sieved with the stated sieve configuration, the grain must enter one of the grain arrangement zones 1, 2, 3, or 4. (Mukhlis et al., 2016).

2.2.4 *Fly Ash*

The use of Fly Ash as a replacement for fine aggregate in a paver-making mixture was investigated as part of experimental research. Fly Ash (fly ash) is the byproduct of coal combustion in the form of amorphous fine particles, which are inorganic materials created by the combustion-induced transformation of mineral elements. Two forms of ash will result from the combustion of coal in the steam generation unit (boiler): Fly Ash and Bottom Ash. Ten to twenty % of the resultant coal ash consists of Bottom Ash, while the remaining eighty to ninety % consists of Fly Ash. ACI (American Concrete Institute) Committee 226 explains that fly ash has a relatively small grain, passing sieve No. 325 (45m) 5 - 27 % of the time, and a bluish-gray hue.
According to SNI S-15-1990-F criteria, Fly Ash is divided into three categories:
Class F: Fly ash resulting from the combustion of anthracite and bituminous coal.
Class C: Fly ash resulting from the combustion of lignite and sub-bituminous coals.
Class N consists of natural pozzolans such as diatomaceous earth, shale, tuff, volcanic ash, and pumice.

2.2.5 *Bottom Ash*

The use of Fly Ash as a replacement for fine aggregate in a paver-making mixture was investigated as part of experimental research. Fly Ash (fly ash) is the byproduct of coal combustion in the form of amorphous fine particles, which are inorganic materials created by the combustion-induced transformation of mineral elements. Bottom Ash was examined as a replacement for aggregate in asphalt mixtures, the foundation material for roads, embankments, and marine applications (such as coastal erosion), and in the production of concrete mixes as part of an experimental study (Kuo et al., 2013). According to Dou (2017), Bottom Ash offers a wide range of construction applications, including asphalt paving, concrete, Portland cement, landfill cover, and others.

Bottom Ash has the potential to be utilized as an unbound or bound aggregate in road construction, concrete, and asphalt mixes (Astrup et al., 2016). In a number of nations, including Denmark, Belgium, and the Netherlands, Bottom Ash has been utilized as loose aggregate in road-building foundation layers (Sahlin, 2013).

2.2.6 Water

The water-cement factor (FAS) is a crucial indicator in the design of paving blocks. A low FAS will result in less water between the cement particles and close spacing between the cement grains.

A high water-cement factor may result in concrete with low compressive strength, while a lower water-cement factor will result in concrete with greater compressive strength.

However, the lower water-cement factor number does not necessarily equate to increased concrete strength. A low water-cement factor value may lead to challenges in craftsmanship, such as difficulty in compaction, which will ultimately result in a decline in the quality of the concrete. Consequently, there exists an optimal cement water factor value that yields the greatest compressive strength. Normal concrete has a minimum water-cement ratio of around 0.4 and a maximum of 0.65. (Muhammad Ikhwan et al., 2017).

Water is required in the production of Paving Blocks to initiate the cement chemical reaction, moisten the aggregate in the form of sand, and facilitate the production process. In most cases, drinkable water may be utilized in paving block mixtures. Water contains the components necessary for the chemical interaction between cement and water to make cement paste. Additionally, water acts as a lubricant between aggregate grains, making it simple to manipulate and compress. (Imron et al., 2017).

The quality of the water to be utilized is significantly affected by the condition of the concrete. The concrete's strength will diminish if the water includes dangerous chemicals, salt, oil, etc. After the hydration process is complete, an abundance of water bubbles might result from excessive water. And, if there is insufficient water, the hydration process will not be entirely completed, which would reduce the concrete's strength and make it harder to work with. (Praktikto et al., 2019).

The following conditions (SNI Standard S-04-1989-F) must be met by water as a construction material:

1. The water must be pure.
2. Does not contain any visible muck, oil, or floating items. The suspended matter concentration should not exceed 2 grams per liter.
3. Does not include more than 15 grams/liter of salts that might dissolve and harm concrete (acids, organic debris, etc.).
4. Does not include more than 0.5 grams per liter of chloride (Cl).
5. Does not include more than 1 gram per liter of sulfate compounds (as SO_3).

2.3 Method of Paving Block Production

Methods for producing Paving Blocks that are often utilized in society may be divided into two categories:

1. Traditional Procedure

Making Paving Blocks using typical equipment and a compaction load that impacts the worker's energy. The community uses this technology extensively in the home business since the required instruments are inexpensive and the production procedure is straightforward. The more powerful the individual's energy, the denser and stronger the Paving Block generated. The compaction procedure is accomplished by hitting the compactor on the mortar in the mold, which will cause employees to get exhausted rapidly.

2. Method Mechanical

This mechanical process is often referred to as the press method. Due to the relatively high cost of the machine tools (compression equipment) required for the production of paving blocks, this mechanical approach is often used by companies with a medium or large industrial scale.

2.4 Evaluation of Test Articles

Paving Blocks provides the following information based on SNI 03-0691-1996:

Dimensional Analysis

Bricks made of concrete must have a level surface, be free of cracks and flaws, and have corners and ribs that are resistant to finger pressure. Bricks made of concrete must have a level surface, be free of flaws and fissures, and have corners and ribs that are not readily crushed by finger pressure. The agreement between the user and the producer may determine the form and size of concrete floor bricks. Each producer must provide a written description of the form, size, and composition of the concrete floor bricks in the brochure. 3 mm of variance is permitted in the thickness of concrete bricks for flooring.

Volume Weight Testing

The purpose of volume weight testing is to determine the mass of every unit of an object's volume. The greater the mass of an item, the greater the mass of its individual volume. The porosity of an item decreases as its volumetric mass increases.

Water Absorbency

Water absorption is the proportion of water by weight that an aggregate can absorb when submerged in water. Variations in pore diameters are fairly pronounced among the aggregate grains. These holes are distributed throughout the grain; some are encased in the substance, while others are accessible to the grain surface. Several kinds of commonly used aggregates have a closed pore capacity ranging from 0 to 20% of the grain volume. (Revelatory Wibowo, 2018).

According to SNI 03-0691-1996, water absorption is a crucial metric for forecasting the strength and quality of the paving stones that are produced. Paving blocks of quality class A must have a water absorption capacity of no more than 3 %, those of quality class B no more than 6 %, those of quality class C no more than 8 %, and those of quality class D no more than 10 %. Paving Blocks are anticipated to be more robust and long-lasting because of their low water absorption rate. (Satya Adi et al., 2018).

Specimens that have undergone the combustion process for each combination are tested for water absorption. The pores or cavities on the test item have a significant effect on the amount of water absorbed. If the test item has larger pores, it will absorb more water, resulting in a reduction in resistance.

Compression Strength

In addition, to wear resistance and water absorption, the compressive strength of paver blocks is a quality characteristic that must be addressed. The ratio of component materials has a significant impact on Paving Blocks' compressive strength. According to SNI 03-1974-1990, the compressive strength of concrete is the load per unit area that causes the specimen to be crushed when pressed with a certain compressive force produced by a press machine.

Tests for Wear

Flexural strength is the capacity of a concrete beam set on two bearings to sustain a force applied perpendicular to the axis of the specimen until it breaks, expressed in Mega Pascals (MPa).

III. METHODOLOGY

This study employs experimental research techniques because, via experimentation, it is possible to establish objective truth based on data and facts. This study was undertaken in order to evaluate the physical and mechanical qualities of Paving Blocks that conform to the Indonesian National Standard.

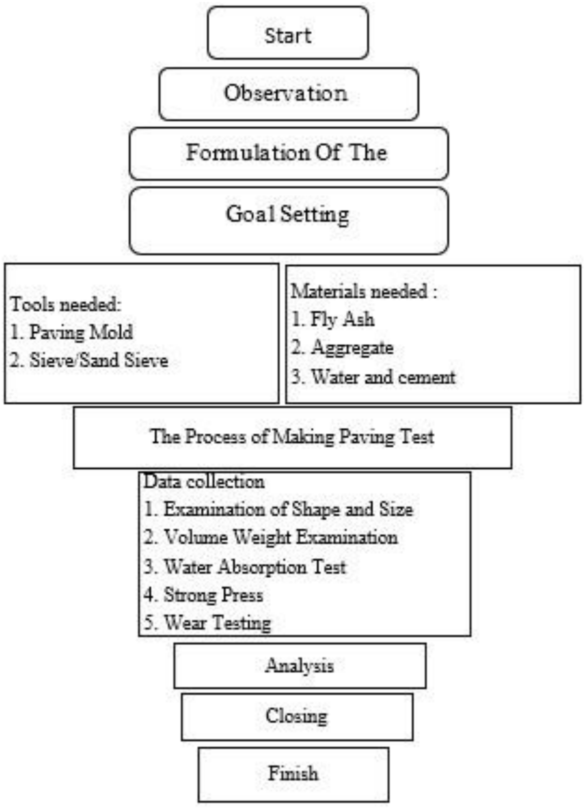

Fig. 1.Analysis

Composition 1:3:0,5						
Code	Compressive Test Day to				Water Absorption Test	Wear Resistance Test
	7	14	21	28		
FABA 0%	5	5	5	5	5	5
FA 5%	5	5	5	5	5	5
FA 10%	5	5	5	5	5	5
FA 15%	5	5	5	5	5	5
FA 30%	5	5	5	5	5	5
BA 5%	5	5	5	5	5	5
BA 10%	5	5	5	5	5	5
BA 15%	5	5	5	5	5	5
BA 30%	5	5	5	5	5	5
Total	180				45	45

Table 2. Number of Samples in Composition 1:3:0,5

Composition 1:4:0,5						
Code	Compressive Test Day to				Water Absorption Test	Wear Resistance Test
	7	14	21	28		
FABA 0%	5	5	5	5	5	5
FA 5%	5	5	5	5	5	5
FA 10%	5	5	5	5	5	5
FA 15%	5	5	5	5	5	5
FA 30%	5	5	5	5	5	5
BA 5%	5	5	5	5	5	5
BA 10%	5	5	5	5	5	5
BA 15%	5	5	5	5	5	5
BA 30%	5	5	5	5	5	5
Total	180				45	45

Table 3. Number of Samples in Composition 1:4:0,5

Composition 1:6:0,5						
Code	Compressive Test Day to				Water Absorption Test	Wear Resistance Test
	7	14	21	28		
FABA 0%	5	5	5	5	5	5
FA 5%	5	5	5	5	5	5
FA 10%	5	5	5	5	5	5
FA 15%	5	5	5	5	5	5
FA 30%	5	5	5	5	5	5
BA 5%	5	5	5	5	5	5
BA 10%	5	5	5	5	5	5
BA 15%	5	5	5	5	5	5
BA 30%	5	5	5	5	5	5
Total	180				45	45

Table 4. Number of Samples in Composition 1:6:0.5

IV. RESULTS AND CONCLUSION

4.1 Visual Testing of Paving Blocks

Description	Explanation	Sample State Average	According to SNI 03-0691-1996
Variation0%	Field a. harmony b. Rift c. Fine	 Flat Not Cracked Rough	 Flat Not Cracked Fine
	Ribs		

	a. Eldest b. Sharpness c. Strength	Elbow Not Sharp Strong	Elbow Sharp Strong
Variation5%	Fields a. evenness b. Rift c. Fine	Flat Not Cracked Rough	Flat Not Cracked Fine
	Ribs a. Eldest b. Sharpness c. Strength	Elbow Not Sharp Strong	Elbow Sharp Strong
Variation10%	Fields a. evenness b. Rift c. Fine	Flat Not Cracked Rough	Flat Not Cracked Fine
	Ribs a. Eldest b. Sharpness c. Strength	Elbow Not Sharp Strong	Elbow Sharp Strong
Variation15%	Fields a. evenness b. Rift c. Fine	Flat Not Cracked Rough	Flat Not Cracked Fine
	Ribs a. Eldest b. Sharpness c. Strength	Elbow Not Sharp Strong	Elbow Sharp Strong

Table 5. Results of the Visual Paving Block Test Variation 1:3:0.5

Description	Explanation	Sample State Average	According to SNI 03-0691-1996
Variation0%	Field a. harmony b. Rift c. Fine	Flat Not Cracked Rough	Flat Not Cracked Fine
	Ribs a. Eldest b. Sharpness c. Strength	Elbow Not Sharp Strong	Elbow Sharp Strong
Variation5%	Fields a. evenness b. Rift c. Fine	Flat Not Cracked Rough	Flat Not Cracked Fine
	Ribs a. Eldest	Elbow	Elbow

	b. Sharpness c. Strength	Not Sharp Strong	Sharp Strong
Variation10%	Fields a. evenness b. Rift c. Fine	 Flat Not Cracked Rough	 Flat Not Cracked Fine
	Ribs a. Eldest b. Sharpness c. Strength	 Elbow Not Sharp Strong	 Elbow Sharp Strong
Variation15%	Fields a. evenness b. Rift c. Fine	 Flat Not Cracked Rough	 Flat Not Cracked Fine
	Ribs a. Eldest b. Sharpness c. Strength	 Elbow Not Sharp Strong	 Elbow Sharp Strong

Table 6. Results of the Visual Paving Block Test Variation 1:4:0.5

Description	Explanation	Sample State Average	According to SNI 03-0691-1996
Variation0%	Field a. harmony b. Rift c. Fine	 Flat Not Cracked Rough	 Flat Not Cracked Fine
	Ribs a. Eldest b. Sharpness c. Strength	 Elbow Not Sharp Strong	 Elbow Sharp Strong
Variation5%	Fields a. evenness b. Rift c. Fine	 Flat Not Cracked Rough	 Flat Not Cracked Fine
	Ribs a. Eldest b. Sharpness c. Strength	 Elbow Not Sharp Strong	 Elbow Sharp Strong
Variation10%	Fields a. evenness b. Rift c. Fine	 Flat Not Cracked Rough	 Flat Not Cracked Fine
	Ribs a. Eldest b. Sharpness	 Elbow Not Sharp	 Elbow Sharp

	c. Strength	Strong	Strong
Variation15%	Fields a. evenness b. Rift c. Fine	 Flat Not Cracked Rough	 Flat Not Cracked Fine
	Ribs a. Eldest b. Sharpness c. Strength	 Elbow Not Sharp Strong	 Elbow Sharp Strong

Table 7. Results of the Visual Paving Block Test Variation 1:6:0.5

On the basis of the preceding table and visual inspections of paving blocks, it can be inferred that the average variation has the same flatness, lack of cracks, roughness, angularity, and sharpness.

1:3:0,5					**Based On SNI 03-0691-1996**
Variation	**t (mm)**		**p (mm)**	**l (mm)**	
	Rata-rata	**Deviation SNI 03-0691-1996**			
Without FABA	91,626	± 3mm	200	100	Fulfill
FA 5%	79,112	± 3mm	200	100	Not Fulfill
FA 10%	82,962	± 3mm	200	100	Not Fulfill
FA 15%	78,394	± 3mm	200	100	Not Fulfill
BA 5%	83,922	± 3mm	200	100	Not Fulfill
BA 10%	78,788	± 3mm	200	100	Not Fulfill
BA 15%	80,963	± 3mm	200	100	Not Fulfill

Table 8. Results of Visual Inspection of Paving Block Variation 1:3:0.5

1:4:0,5					**Based On SNI 03-0691-1996**
Variation	**t (mm)**		**p (mm)**	**l (mm)**	
	Rata-rata	**Deviation SNI 03-0691-1996**			
Without FABA	91,788	± 3mm	200	100	Fulfill
FA 5%	78,184	± 3mm	200	100	Not Fulfill
FA 10%	76,682	± 3mm	200	100	Not Fulfill
FA 15%	76,458	± 3mm	200	100	Not Fulfill
BA 5%	79,404	± 3mm	200	100	Not Fulfill
BA 10%	78,706	± 3mm	200	100	Not Fulfill
BA 15%	78,605	± 3mm	200	100	Not Fulfill

Table 9. Results of Visual Inspection of Paving Block Variation 1:4:0.5

1:6:0,5					**Based On SNI 03-0691-1996**
Variation	**t (mm)**		**p (mm)**	**l (mm)**	
	Rata-rata	**Deviation SNI 03-0691-1996**			
Without FABA	89,118	± 3mm	200	100	Fulfill

FA 5%	82,812	± 3mm	200	100	Not Fulfill
FA 10%	84,442	± 3mm	200	100	Not Fulfill
FA 15%	84,166	± 3mm	200	100	Not Fulfill
BA 5%	85,972	± 3mm	200	100	Not Fulfill
BA 10%	84,026	± 3mm	200	100	Not Fulfill
BA 15%	83,493	± 3mm	200	100	Not Fulfill

Table 10. Results of Visual Inspection of Paving Block Variation 1:6:0.5

On the basis of visual inspections of paving blocks based on the table above, it may be inferred that the average height of the FABA sample does not match the specifications.

V. Paving Block Volume Weight

Comparison	Variation	Volume Weight **(kg/m3)** Days to -			
		7	**14**	**21**	**28**
1:3:0,5	**Plain**	1987,700	2255,091	2036,813	1963,144
	FA 5%	2058,790	2001,909	2009,809	2009,809
	FA 10%	1979,822	1916,540	2091,319	1913,527
	FA 15%	1966,031	2037,784	1980,381	2045,756
	BA 5%	1812,695	1815,674	1911,001	1863,337
	BA 10%	1907,331	1905,797	1968,709	1974,847
	BA 15%	1938,747	1937,160	1968,891	1967,305

Table 11. Results of Paving Block Volume Weight Variation Examination 1:3:0.5

Comparison	Variation	Volume Weight **(kg/m3)** Days to -			
		7	**14**	**21**	**28**
1:4:0,5	**Plain**	1922,909	1947,422	1910,653	1591,711
	FA 5%	1921,749	1884,976	1883,378	1924,946
	FA 10%	1969,171	1892,556	1956,131	1926,789
	FA 15%	1849,054	1759,136	1826,166	1785,294
	BA 5%	1799,343	1882,777	1802,491	1798,818
	BA 10%	1853,854	1798,207	1801,386	1812,516
	BA 15%	1796,242	1874,063	1883,592	1802,065

Table 12. Results of Paving Block Volume Weight Variation Examination 1:4:0.5

Comparison	Variation	Volume Weight **(kg/m3)** Days to -			
		7	**14**	**21**	**28**
1:6:0,5	**Plain**	2075,899	2026,807	2081,510	1685,145
	FA 5%	1862,653	1782,652	1845,546	1846,049
	FA 10%	1782,288	1696,431	1786,729	1816,335

	FA 15%	1826,747	1704,964	1770,311	1810,410
	BA 5%	1740,392	1736,030	1730,214	1802,913
	BA 10%	1708,307	1696,443	1739,448	1734,010
	BA 15%	1724,169	1710,780	1762,847	1743,508

Table 13. Results of Paving Block Volume Weight Variation Examination 1:6:0.5

Based on the average volume weight derived from different variations, the 1:3:0.5 Fly Ash 10 % variation has the highest average volume weight at 2211.856 kg/m3, while the 1:6:0.5 Bottom Ash 5 % variation has the lowest average volume weight at 1680.780 kg/m3.

4.3 Test of Paving Block Quality

No	Variation	Compression Strength (MPa)	Quality
		Average	
1	NO FABA	28,202	A
2	FA 5%	12,833	C
3	FA 10%	10,936	C
4	FA 15%	10,905	C
5	BA 5%	13,397	C
6	BA 10%	13,471	C
7	FA 15%	13,695	C

Table 14. Results of Paving Block Quality Inspection Variation 1:3:0.5

No	Variation	Compression Strength (MPa)	Quality
		Average	
1	NO FABA	13,743	C
2	FA 5%	7,340	-
3	FA 10%	9,137	D
4	FA 15%	8,260	-
5	BA 5%	7,041	-
6	BA 10%	7,292	-
7	FA 15%	8,108	-

Table 15. Results of Paving Block Quality Inspection Variation 1:4:0.5

No	Variation	Compression Strength (MPa)	Quality
		Average	
1	NO FABA	12,442	C
2	FA 5%	5,702	-

3	FA 10%	3,436	-
4	FA 15%	4,386	-
5	BA 5%	4,203	-
6	BA 10%	5,099	-
7	FA 15%	6,287	-

Table 16. Results of Paving Block Quality Inspection Variation 1:6:0.5

The 1:3:0.5 0 % variation has the highest average compressive strength at the age of 28 days with a compressive strength of 28.772 MPa, so it is classified as grade A, while the 1:6 variation:0.5 Bottom Ash 5 % has the lowest average compressive strength at the age of 28 days with a compressive strength of 2.924 MPa, so it is classified as grade D.

VI. CONCLUSION

On the basis of the average compressive strength of 28 days derived from several variations, it can be concluded that the quality decreases when Fly Ash is used and improves when Bottom Ash is used at a %age of 15%.

The 1:4:0.5 Bottom Ash 15 % variation has the highest average absorption, at 19.640 %, while the 1:6:0.5 0 % variation has the lowest, at 6.665 %.

Based on the average wear of the different variants, the 1:4:0.5 Fly Ash 10 % variation exhibits the highest average wear at 1.095 mm/minute, while the 1:4:0.5 Fly Ash 5 % variation exhibits the lowest average wear at 0.113 mm/minute.

ACKNOWLEDGEMENTS

Thank you to the Faculty of Engineering, University of Tanjunpura, Pontianak, West Kalimantan, as well as other parties engaged in this study, for their support and funding.

REFERENCE

[1]. Achmad Freddya Eka Prasandha, Triwulan, Januarti Jaya Ekaputri, 2015,Paving Geopolimer Berbahan Dasar *Bottom Ash* dan Sugar Cane Bagasse Ash (SCBA), Jurusan S1 Teknik Sipil, Fakultas Teknik Sipil dan Perencanaan (FTSP), Institut Teknologi Sepuluh Nopember (ITS).

[2]. Agoes Soehardjono, Prastumi, Taufik Hidayat, Gagoek Soenar Prawito, 2013, Pengaruh *Bottom Ash* Sebagai Pengganti Semen Terhadap Nilai Kuat Tekan Dan Kemampuan Resapan Air Struktur Paving, Jurusan Teknik Sipil Fakultas Teknik Universitas Brawijaya Malang.

[3]. Dewi. R, Maulana. I & Andika. T., 2014, Pengaruh Penambahan Bubuk Lumpur Lapindo Sebagai Pengganti Sebagian Semen Dalam Pembuatan *Paving Block*, Laporan Penelitian, Universitas Muhamadiyah Yogyakarta.

[4]. Faridah, A.M, 2012. Karakteristik Abu Dasar PLTU Paiton: Pengaruh Perlakuan Magnet , HCl dan Fusi dengan NaOH. Pusat Studi Energi, ITS. Surabaya.

[5]. Harris, H., Anam, S., & Mahmudsyah, S, 2013. Studi pemanfaatan limbah padat dari perkebunan kelapa sawit pada PLTU 6 MW di Bangka Belitung. Jurnal Teknik ITS, Surabaya

[6]. Kevin Klarens, Michael Indranata, Antoni, Djwantoro Hardjito, 2015, Pemanfaatan *Bottom Ash* Dan *Fly Ash* Tipe C Sebagai Bahan Pengganti Dalam Pembuatan *Paving Block*, Jurusan Teknik Sipil, Fakultas Teknik Sipil, Universitas Kristen Petra Surabaya.

[7]. Lincolen, K. (2017). .Pengaruh Abu Terbang Sebagai Bahan Pengganti Semen Pada Beton Beragregat Halus *Bottom Ash*. Digilib Unila.

[8]. Mulyati., Maliar, S., 2015. Pengaruh Penggunaan *Fly Ash* Sebagai Pengganti Agregat Terhadap Kuat Tekan *Paving Block*. Institut Teknologi Padang,Sumatra Barat.

[9]. Murugan. R. B, Natarajan. C, Chen.S., 2016, Material Development For a Sustainable Precast Concrete Block Pavement, Jurnal Of Traffic and Transportation Engginering, Chang'An University

[10]. Purwanto & Priastiwi. A. Y., 2008, Testing Of Concrete *Paving Block*s, Jurnal, Fakultas Teknik, Universitas Diponegoro, Semarang.

[11]. Sebayang, Surya. 2010. Pengaruh Kadar Abu Terbang sebagai pengganti sejumlah Semen pada Beton Alir Kuat tekan Tinggi. Bandar Lampung :Universitas Lampung

[12]. SNI-03-0691-1996, Persyaratan kuat tekan bata beton (*Paving Block*),. Badan Standarisasi Nasional, Jakarta.

[13]. Syarif Akbar Harriad, Olivia Monita, Saputra Edy, 2016, Kuat Tekan *Paving Block* Geopolimer Abu Sawit (Palm Oil Fuel Ash) Dengan Perawatan Suhu Ruang, Jurusan Teknik Sipil, Fakultas Teknik Universitas Riau.

[14]. Yusuf, Yulizar .2013. Pengaruh Penambahan Abu Terbang (*Fly Ash*) Terhadap Kuat Tekan Mortar Semen Tipe PCC Serta Analisis Air Laut Yang Digunakan Untuk Perendaman. Jurusan Kimia, Fakultas MIPA, Universitas Andalas : Padang