# The Effect of Basalt Material Composition and Rice Husk Ash on The Characterization of Paving Block

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**Abstract**

*Paving block (concrete brick) is a composition of building materials made from a mixture of Portland cement or other hydraulic adhesive. The making of paving blocks is done by a process of molding, soaking, physical testing including compressive strength, density, porosity, and absorption, and characterization including XRF and XRD. The paving blocks are made without the addition of basalt stone and rice husk ash and with the addition of 5%, 10%, 15%, 20% and 25% with a test life of 7 days, 14 days and 28 days. The materials used are cement, sand, basalt stone, rice husk ash and water. Paving blocks without the addition of basalt stone and rice husk ash have the highest compressive strength at the test age of 28 days of 9.9 MPa and absorption of 15.06%, whereas with the addition of basalt stone and rice husk ash the highest compressive strength is at a concentration of 5% at age 28day test of 12.25 MPa and the absorption value of 7.12%. The results of XRF characterization showed that the more concentrations of basalt stone and rice husk ash, the CaO contained in the paving blocks increased while the SiO2 decreased. The results of XRD characterization showed that the phases formed were ternesite, microline maximum and yeelimite.*

**Keywords:** *paving blocks, ash, rice husk, basalt, characterization.*

## I. Introduction

Paving blocks (concrete bricks) are an alternative choice for ground surface pavement layers, easy installation, relatively inexpensive maintenance and fulfill the beauty aspect. Paving block (concrete brick) is a composition of building materials made from a mixture of Portland cement or other hydraulic adhesives [1]. The use of paving blocks really supports going green which has been proclaimed nationally or internationally, because water absorption through the installation of paving blocks can maintain ground water balance [2]. Its quality depends on the composition of the basecoat and undercoat which must be formulated appropriately [3]. A good understanding in terms of the quality and selling price of paving blocks in the community will give interest in being able to use paving blocks as materials for pavements for roads and yards [4].

Rice husk is a by-product or waste from the rice milling industry. The rice milling industry can produce 65% rice, 20% rice husk and the rest is lost. Currently, rice husk has been developed as a raw material for producing rice husk ash known as rice husk ash (RHA). Rice husk ash produced from burning rice husk at 400-500° C will become amorphous silica and at temperatures greater than 1000° C will become crystalline silica. Amorphous silica produced from rice husk ash is thought to be an important source for producing pure silicon, silicon carbide and silicon nitrite flour [5]. The main components of RHA are cellulose (50%), lignin (30%) and organic compounds (20%) [6]. Rice husk ash (RHA) is a major environmental threat that causes damage to the soil and environment around landfills [7].

Basalt stone are classified as igneous rock groups. Basalt is chemically rich in oxides of magnesium, calcium, sodium, potassium, silicon and iron. Basalt stone can be used as an alternative raw material for portland cement [8]. Basalt comes from volcanic magma and flood volcanoes, a very hot liquid or semifluid material beneath the Earth's crust, condensing in the open air [9]. Basalt stone is generally only used as a foundation for roads, bridges, buildings, or as an aggregate. Basalt rock contains a chemical composition of 56.15% $SiO_2$, 17.37% $Al_2O_3$, 4.62% $Fe_2O_3$, 8.25% CaO, 6.90% MgO, 3.28% $K_2O$, 99% TiO and MnO of 0.46% [10]. Based on [11] that $SiO_2$ + $Fe_2O_3$ + $Al_2O_3$ is at least 70%.

In this study, paving blocks were made using basalt stone and rice husk ash with variations of 0%, 5%, 10%, 15%, 20% and 25%. Soaking paving blocks in water is carried out for 7, 14 and 28 days. Paving block samples will be tested for compressive strength, specific gravity, porosity, absorption and characterized by X-Ray Diffraction (XRD) to determine the crystal phase and X-Ray Fluerescence (XRF) to determine chemical composition.

## II. Materials and Methods

### A. Tools and Materials

The tools used are a ball mill, mixer, beaker glass, 5×5×5 cm mortar molds, analog scales, digital scales, ovens, measuring cups, mesh sieves, compressive strength testing machines, XRF testing machines, XRD testing machines, buckets, cup, plastic zipper, spatula, agate mortar and pastel. The materials used are basalt stone from East Lampung, cement type PCC, sand from Labuhan Maringgai East Lampung, water from Tanjung Bintang and rice husk ash.

### B. Methods

The first step is to prepare the basalt stone by grinding it using a ball mill for ± 6 hours, then sieving it using 5 and 10 mesh passes and then characterizing it using XRF and XRD.

The second step was to prepare rice husk ash by burning the rice husk to become ash, then pounding the rice husk ash using mortar and pastel and then characterized using XRF and XRD.

**Table 1**. Material composition

| No | Material | Variation (%) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 0 | 5 | 10 | 15 | 20 | 25 |
| 1 | Cement (gr) | 150 | 150 | 150 | 150 | 150 | 150 |
| 2 | Sand (gr) | 850 | 807,5 | 765 | 722,5 | 680 | 637,5 |
| 3 | Basalt Stone (gr) | 0 | 21,25 | 42,5 | 63,75 | 85 | 106,25 |
| 4 | Rice Husk Ash (gr) | 0 | 21,25 | 42,5 | 63,75 | 85 | 106,25 |
| 5 | Water (ml) | 100 | 100 | 100 | 100 | 100 | 100 |

The next stage is making paving blocks by preparing all the ingredients to be mixed such as cement, sand, baslt stone, rice husk ash and water. Then the cement and sand are weighed according to the composition with a ratio of cement: sand = 1: 6, then basalt stone and rice husk ash are weighed according to the variation in the concentration of addition to sand, namely 0%, 5%, 10%, 15%, 20% and 25%. Next, mix all these ingredients into a container by adding 100 ml of water which is then stirred using a mixer until homogeneous for 20 minutes with the same repetition for each variation in the concentration of adding basalt stone and rice husk ash to the sand. Then it was printed using a 5 × 5 × 5 cm mortar mold and then left for 24 hours at room temperature then released from the mold as a test object (sample). The samples were then immersed in clean water for 7 days, 14 days and 28 days. Then the compressive strength, specific gravity, porosity and absorption tests were carried out on the sample. Next characterization using XRF and XRD on the sample.

## III. Results and Discussions

### A. Basalt Testing Results

**Table 2**. Results of XRF characterization of basalt stone

| No | Compound | Persentage (%) |
|---|---|---|
| 1 | $SiO_2$ | 43,023 |
| 2 | $Fe_2O_3$ | 21,614 |
| 3 | $Al_2O_3$ | 14,795 |
| 4 | MgO | 2,362 |
| 5 | $TiO_2$ | 1,723 |
| 6 | $P_2O_5$ | 0,753 |
| 7 | $K_2O$ | 0,704 |
| 8 | MnO | 0,64 |
| 9 | $Cr_2O_3$ | 0,112 |

The XRF characterization results of basalt rock are shown in **Table 2**. Based on **Table 2**. shows the XRF results of the basalt rock samples that have the highest oxide compound content respectively, namely $SiO_2$ of 43.023%, $Fe_2O_3$ of 21.614%, $Al_2O_3$ of 14.795%, MgO of 2.362%, $TiO_2$ of 1.723%, $P_2O_5$ of 0.753%, $K_2O$ of 0.704%, MnO of 0.641% and $Cr_2O_3$ of 0.112%. Basalt stone has pozzolanic properties according to ASTM C168 where $SiO_2$ + $Al_2O_3$ + $Fe_2O_3$ is at least 70% while the value of basalt stone in this study is 79% so it can be used as a pozzolanic material that meets ASTM requirements.

The results of XRD characterization on basalt rock can be seen in **Figure 1**.

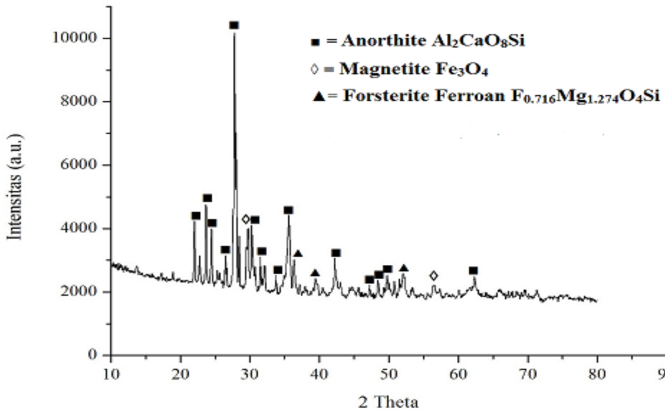


**Figure 1**. XRD spectrum of basalt stone sample.

The XRD characterization results of basalt rock are shown in **Figure 1**. Based on **Figure 1**. It shows that the characteristics of the basalt samples which are dominated by the peaks of the phases include *anorthite, ordered* ($Al_2CaO_3Si_2$) phase with ref. code ICDD 00-041-1486 at the peak the highest which is 2θ = 27.78 ° and the *magnetite* ($Fe_3O_4$) phase with ref. code ICDD 01-089-0951 at the highest peak is 2θ = 29,738 °. Another phase formed is ferroan forsterite (Ca-dopped) ($Fe_{0.716}Mg_{1.274}O_4Si$) with ref. ICDD code 01-071-0794 at the highest peak is 2θ = 36,325 °.

The results indicate that the basalt rock used in this study contains major minerals such as *anorthite, ordered* or *calcium aluminum silicate* ($Al_2CaO_3Si_2$), *magnetite* or *iron oxide* ($Fe_3O_4$), and *ferroan forsterite* or *magnesium iron silicate* ($Fe_{0.716}Mg_{1.274}O_4Si$).

### *B. Rice Husk Ash Testing Results*

**Table 3**. Results of XRF characterization of rice husk ash

| No | Compound | Persentage (%) |
|---|---|---|
| 1 | $SiO_2$ | 84,557 |
| 2 | $K_2O$ | 7,465 |
| 3 | CaO | 3,530 |
| 4 | $P_2O_5$ | 2,134 |
| 5 | $SO_3$ | 1,075 |
| 6 | $Fe_2O_3$ | 0,437 |
| 7 | MgO | 0,367 |
| 8 | MnO | 0,306 |

The results of XRF characterization of rice husk ash are shown in **Table 3**. Based on **Table 3** shows the XRF results of the husk ash sample which has the highest oxide compound content respectively, namely $SiO_2$ of 84.557%, $K_2O$ of 7.465%, CaO of 3.530%, $P_2O_5$ of 2.134 %, $SO_3$ of 1.075%, $Fe_2O_3$ of 0.437%, MgO of 0.367% and MnO of 0.306%. The highest compound content is $SiO_2$, this is consistent with research [12] that rice husk ash contains a lot of $SiO_2$ compounds which can be used as filer material in making *paving blocks*.

The results of XRD characterization on rice husk ash can be seen in **Figure 2**.

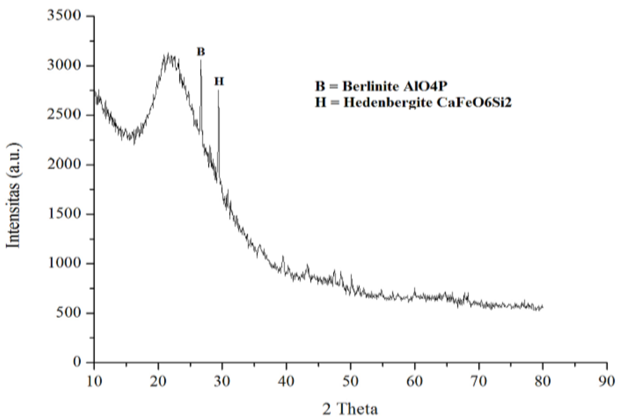


**Figure 2**. XRD spectrum of rice husk ash sample

The results of the XRD characterization of rice husk ash are shown in **Figure 2**. Based on **Figure 2**. shows that the characteristics of the rice husk ash sample which are dominated by the peaks of the phases include *hedenbergite, syn* ($CaFeO_6Si_2$) with ref code ICDD 01-071-1502 at the highest peak which is 2θ = 29.387 ° and phases *berlinite, syn* ($AlO_4P$) with ref code ICDD 01-076-0228 at the highest peak is 2θ = 26.666 °.

### *C. Sand Testing Result*

**Table 4**. Results of sand XRF characterization

| No | Compound | Persentage (%) |
|---|---|---|
| 1 | $SiO_2$ | 61,846 |
| 2 | $Al_2O_3$ | 18,636 |
| 3 | $Fe_2O_3$ | 10,182 |
| 4 | $K_2O$ | 4,237 |
| 5 | $TiO_2$ | 2,036 |
| 6 | CaO | 1,631 |
| 7 | $P_2O_5$ | 0,788 |
| 8 | $ZrO_2$ | 0,259 |

The XRF characterization results of sand are shown in Table 4. Based on Table 4. Shows the XRF results of the sand samples that have the highest oxide compound content respectively, namely $SiO_2$ of 61.846%, $Al_2O_3$ of 18.636%, $Fe_2O_3$ of 10.182%, $K_2O$ of 4.237%, $TiO_2$ of 2,036%, CaO of 1,631%, $P_2O_5$ of 0,788% and $ZrO_2$ of 0,259%. It can be seen here that the sand used still contains a lot of mud, this can be seen from the high $Al_2O_3$ content. The silica content in the sand functions as a filler material, while the lime content plays a role in the binding process [13].

The results of XRD characterization on sand can be seen in **Figure 3**.

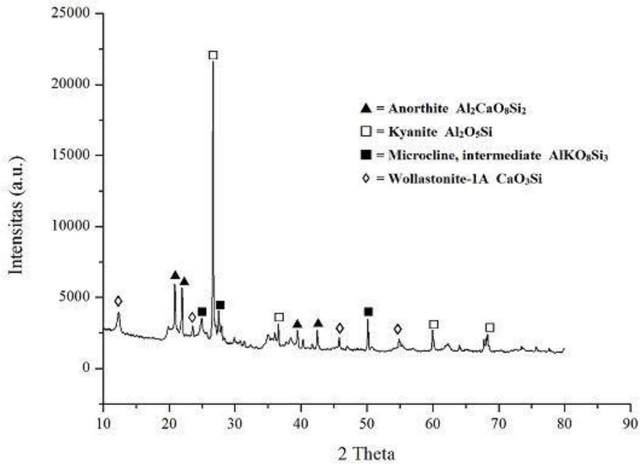


**Figure 3**. XRD spectrum of sand sample.

The results of the XRD characterization of sand are shown in **Figure 3**. Based on **Figure 3**. It shows that the characterization of sand samples which are dominated by the peaks of the phases includes the *kyanite* ($Al_2O_5Si$) phase with ref code ICCD 01-074-1827 at the highest peak located 2θ = 26,627 °, *anorthite* phase ($Al_2CaO_8Si_2$) with ref. ICDD code 01-089-1460 at the highest peak located 2θ = 20,939 °, the phase *microcline, intermediate* ($AlKO_8Si_3$) with ref. ICDD code 00-019-0932 at the highest peak located 2θ = 50.167 ° and the phase wollastonite-*1A* ($CaO_3Si$) with ref. ICDD code 01-073-1110 at the highest peak which is located 2θ = 12,427 °.

### *D. Paving Block Physical Test Results*

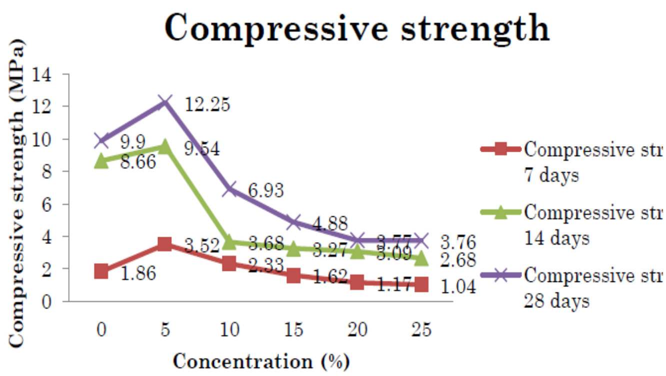


**Figure 4**. Graph of paving block compressive strength test results

The results of the paving block compressive strength test are shown in **Figure 4**. Based on **Figure 4** shows that the weight concentration of basalt stone and rice husk ash can affect the compressive strength of the paving blocks. The maximum weight concentration of basalt rock and rice husk ash is 5%. The greater the compressive strength value, the better the quality and quality of paving blocks [14]. The high compressive strength is due to the bonding of cement and aggregates, so that cement can cover all the aggregates and is also influenced by the reaction of additional materials which are pozzolan originating from basalt rock and rice husk ash [15].

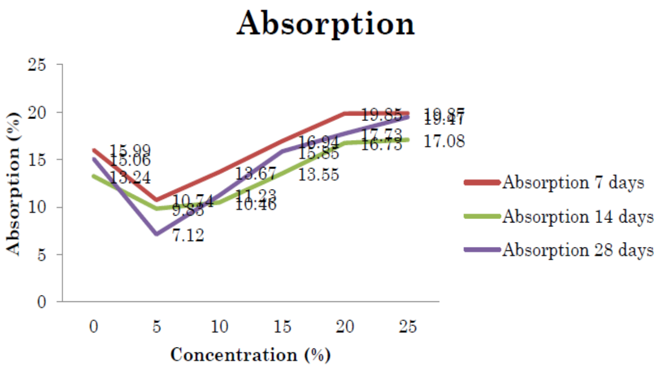


**Figure 5**. Graph of paving block absorption test results

The results of the paving block absorption test are shown in **Figure 5**. Based on **Figure 5**. shows that the weight concentration of basalt stone and rice husk ash can affect the absorption value of paving blocks [16]. The concentration of basalt stone and rice husk ash by 5% has the lowest decrease in absorption value, the lower the absorption value, the higher the compressive strength of the paving block. The lower the absorption value (water absorption) of the paving block, the better the quality of the paving block. Big or small the resulting absorption value depends on the density and number of cavities contained in the paving block [17].

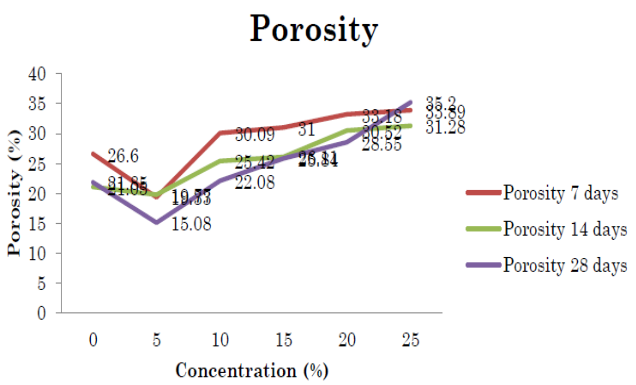


**Figure 6**. Graph of paving block porosity test results

The results of the paving block porosity test are shown in **Figure 6**. Based on **Figure 6**. shows that the weight concentration of basalt stone and rice husk ash can affect the value of paving block porosity. The concentration of basalt stone and rice husk ash by 5% had the lowest decrease in porosity values, for the concentration values of 10%, 15%, 20% and 25% were increasing. This is because along with the increase in the percentage of basalt stone and rice husk ash, the high increase in paving blocks is influenced by the process of making these paving blocks [18].

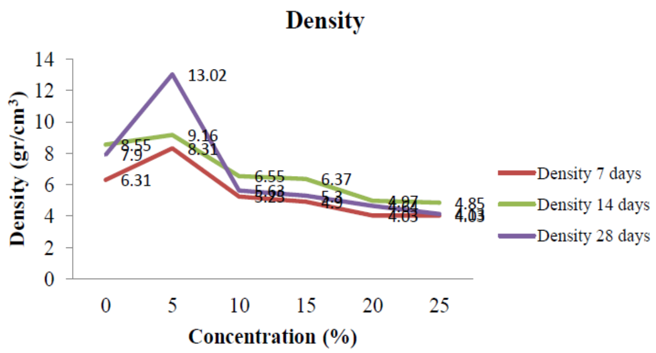


**Figure 7**. Graph of density test results for paving blocks

The results of the paving block density test are shown in **Figure 7**. Based on **Figure 7**. shows that the concentration of basalt stone weight and rice husk ash can affect the density value of paving blocks. The maximum weight concentration of basalt rock and rice husk ash is 5%. The addition of higher concentrations, tends to reduce the density of paving blocks [19]. The greater the density of the paving block, the greater the compressive strength and the better the quality of the paving block.

### *E. Paving Block Characterization Results*

**Table 5**. Results of the XRF characterization of paving blocks

| No | Compound | Persentage 0% | Persentage 5% | Persentage 25% |
|---|---|---|---|---|
| 1 | CaO | 43,013 | 41,296 | 43,118 |
| 2 | $SiO_2$ | 33,123 | 35,304 | 36,708 |
| 3 | $Al_2O_3$ | 9,404 | 9,081 | 7,147 |
| 4 | $Fe_2O_3$ | 9,223 | 8,955 | 8,172 |
| 5 | $K_2O$ | 2,481 | 2,780 | 2,407 |
| 6 | $TiO_2$ | 1,381 | 1,360 | 1,087 |
| 7 | $SO_3$ | 0,585 | 0,610 | 0,546 |
| 8 | MgO | 0,174 | - | 0,213 |
| 9 | SrO | 0,174 | 0,166 | 0,177 |
| 10 | MnO | 0,129 | 0,138 | 0,170 |

The results of the XRF characterization of paving blocks are shown in **Table 5**. Based on **Table 5**, it shows that the content of the paving blocks has the highest oxide compounds, namely CaO compounds and followed by other compounds, namely $SiO_2$, $Fe_2O_3$ and $Al_2O_3$. The decrease in CaO compounds in the addition of basalt rock and rice husk ash by 5% was caused because rice husk ash had the highest compound content of $SiO_2$ and the lowest compound CaO, while cement had the highest compound content of CaO and the lowest compound content of $SiO_2$. The increase in $SiO_2$ at concentrations of 0%, 5% and 25% was due to the rice husk ash and basalt stone containing high $SiO_2$ content.

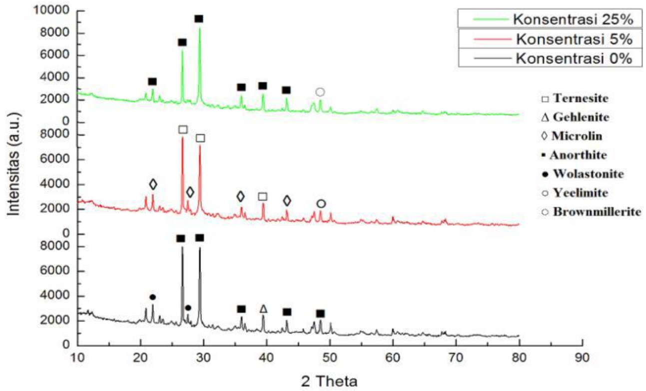


**Figure 8**. XRD spectrum of a paving block sample

The results of the XRD characterization of paving blocks are shown in **Figure 8**. Based on **Figure 8** shows the XRD results of paving blocks for concentrations of 0%, 5% and 25%. At a concentration of 0% the formed phase is *anorthite* ($Ca(Al_2Si_2O_8)$), *wollastonite-1A* ($CaSiO_3$), *gehlenite* ($Ca_2(AlSi)O_7$), the highest phase is *anorthite* ($Ca(Al_2Si_2O_8)$) and has the main peak with the highest intensity located at $2\theta$ = 29.337 °. At a concentration of 5%, the formed phase is *ternesite* ($Ca_5(SiO_4)_2SO_4$), *microcline* ($KAlSi_3O_8$), *yeelimite* ($Ca_4Al_6O_{12}SO_4$), the highest phase is *ternesite* ($Ca_5(SiO_4)_2SO_4$) and has the main peak with the highest intensity located at $2\theta$ = 27.886 °. At a concentration of 25% the phases formed are *anorthite* ($Ca(Al_2Si_2O_8)$) and *brownmillerite* ($Ca_2(Al,Fe{+}3)_2O_5$), the highest phase is *anorthite* ($Ca(Al_2Si_2O_8)$) and has a main peak with The highest intensity lies at $2\theta$ = 29.348 °. The formation of *anorthite* ($Ca(Al_2Si_2)O_8$) phase at a concentration of 0% and 5% comes from the material used that cement contains a lot of CaO compounds of 63.22%, basalt stone contains a lot of $Al_2O_3$ compounds as large as 14.795% and rice husk ash contained a lot of $SiO_2$ of 84.557%.

## IV. Conclusions

Based on the results of this study, it can be concluded that basalt stone and rice husk ash can be used as additional materials for making paving blocks. The maximum addition of basalt stone and rice husk ash is at a concentration of 5% and produces a compressive strength value of 12.25 MPa. The paving blocks are classified into D quality, namely their use for parks and others with an average compressive strength of 8.43 MPa.

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### REFERENCES


[1] Standar Nasional Indonesia (SNI) 03-0691-1996. *Bata Beton (Paving Block)*. Badan Standardisasi Nasional.

[2] Adibroto, F. 2014. Pengaruh Penambahan Berbagai Jenis Serat pada Kuat Tekan *Paving Block*. *Jurnal Rekayasa Sipil*. Vol. 10. No. 1. Pp. 1-11.

[3] Charin, N., Chaiwut, B., Weerachat, T., dan Chai, J. 2018. Development of Concrete Paving Blocks Prepared from Waste Materials without Portland Cement. *Materials Science*. Vol. 24. No. 1. ISSN 1392-1320.

[4] Syukur, S., Wayan, D., dan Alexander, P. 2011. Perbandingan Mutu *Paving Block* Produksi Manual Dengan Produksi Masinal. *Jurnal Rekayasa*. Vol. 15. No. 2.

[5] Desniati, Emmi. 2013. *Studi Kekuatan Paving Block Pasca Pembakaran Menggunakan Material Tanah Lempung dan Semen serta Abu Sekam Padi untuk jalan lingkungan*. Bandar Lampung: Universitas Lampung.

[6] Fernandes, I.J., Calheiro, D., Kieling, A.G., Moraes, C.A.M., Rocha, T.L.A.C., Brehm, F.A., and Modolo, R.C.E. 2016. Characterization of rice husk ash produced using different biomass combustion techniques for energy. *Fuel*. 165. 351–359.

[7] Ankit, G., Rahul, B., dan Nishant, S. 2019. A Study On Use Of Rice Husk Ash In Concrete. *Engineering Heritage Journal (GWK)*. Vol. 3. No. 1. Pp. 01-04.

[8] Vishal, P, K. 2014. Basalt Rock Fibres New Construction Material. *Acta Engineering International*. Vol. 2. No. 1. Pp 11-18.

[9] Karyanto. 2004. Cross Diagonal Survey Geolistrik Tahanan Jenis 3D untuk Menentukan Pola Penyebaran Batuan Basal di Daerah Pakuan Aji Lampung Timur. *Jurnal Sains Teknologi*. Vol. 10. No. 3. Pp 195-200.

[10] Amin, M., dan Suharto. 2017. Pembuatan Semen Geopolimer Ramah Lingkungan Berbahan Baku Mineral Basal Guna Menuju Lampung Sejahtera. *Jurnal Kelitbangan*. Vol. 5. No. 1.

[11] ASTM C168. 2003. Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete. Annual Books of ASTM standards. USA.

[12] Bakri. 2008. Komponen Kimia dan Fisik Abu Sekam Padi Sebagai SCM untuk Pembuatan Komposit Semen. *Jurnal Perennial*. Vol. 5. No. 1. Pp. 9-14.

[13] Alfiyan, U., Ir. Utari, K, MT., dan Ir. Soerjandani, PM, MT. 2018. Pasir Kuarsa Tuban Sebagai Bahan Substitusi Semen Dan Batu Pecah Substitusi Pasir Untuk Campuran Paving. *Jurnal Rekayasa dan Manajemen Kontruksi*. Vol. 6. No. 1. Pp. 47-52.

[14] Agustina, D, S., Zakki, R, M., Achmad, C, S., dan Erika, R. 2017. Pembuatan Batako dengan Campuran *Fly Ash* dan Styrofoam. *Jurnal Ilmiah Teknik Kimia*. Vol. 1. No. 1. Pp 1-7.

[15] Didik, H., Endang, K., Boedi, W., dan Sulchan, A. 2014. Penambahan Abu Ampas Tebu (AAT) dan Limbah Boma Bisma Indra (BBI) untuk Pembuatan *Paving Block*. *Jurnal Aplikasi*. Vol. 12. No. 1. Pp 17-26

[16] Diah, L., Iswan., dan Setynto. 2016. Uji Kuat Tekan Paving Block Menggunakan Campuran Tanah dan Kapur dengan Alat Pemadat Modifikasi. *JRSDD*. Vol. 4. No. 1. Pp. 11-22.

[17] Artiyani, A. 2010. Pemanfaatan Abu Pembakaran Sampah Sebagai Bahan Alternatif Pembuatan Paving Block. Spectra. Vol. 8. No. 16. Pp 1-11.

[18] Kanti, E, P. 2014. Pengaruh Penambahan Limbah Pembakaran Ampas Tebu Pada Paving Block Terhadap Jenis Semen PPC dan PCC. *Jurnal Teknik Sipil dan Perencanaan*. Vol. 16. No. 2. Pp 125-134.

[19] Euniza, J., Hasanan, N., Zaitun, H., Norhidayah, A, H., and Ramadhansyah, J. 2019. Porosity and Density Characteristic of Double-layer Concrete Paving Blocks Incorporating Rubber Granules. National Colloquium on Wind and Earthqquake Engineering. Vol. 244.