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Manufacturing and Characterization of High Water Absorbtion Paving Block by Utilizing Waste of Coffee Skin and Pumice with Polyurethane Resin

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Abstract. Paving block has a high water absorption with coffee shell and pumice and polyurethane resin has been successfully made and characterized. In this study, the composition of coffee shells are 0 gram, 2 grams, 4 grams, 6 grams, 8 grams and 10 grams with variation of polyurethane resins are 15 grams, 20 grams and 25 grams. The characterization of high water absorption paving block includes physical properties (density, porosity and water absorption), mechanical properties (compressive strength, tensile strength and flexural strength) and microstructure analysis using SEM-EDX. The results of the characterization of physical properties shows that the paving block has a high water absorption with the best composition of sand, pumice, coffee shell and polyurethane resin (60:14:6:20) grams, the density is 1.6195 g/cm^3, porosity is 20% and water absorption is 12.3495%. On the other hand, the mechanical properties of compressive strength is 11.61 MPa, tensile strength is 6.41 MPa and flexural strength is 8.68 MPa. High water absorption paving block that are made and characterized in this study will be used as water absorbing material on the highway in order to reduce flooding. This is reinforced by the results of SEM-EDX microstructure testing with a hollow structure in the composition (60:14:6:20) grams and it is compared to the composition (60:20:0:20) grams.

INTRODUCTION

Indonesia is one of the largest coffee producing countries in the world. In 2016, according to the Indonesian Central Statistics Agency, it produces around 667.655 tons of coffee per year. Coffee plants that produce sizable by processing product waste. The product is in the form of coffee shells, the amount ranges from 50-60 percent of the harvest. If the yield is 1000 kg of fresh-skinned coffee, then the coffee beans will be around 400-500 kg. If it is not utilized, it will cause a serious pollution.

Progress in the field of science and technology requires scientists to create and develop something that already exists and create a new, useful and economically valuable. In addition, there have been many innovations that have taken place especially in the field of material technology and have not dampened the fighting spirit of scientists. At this time scientists from among students need to be able to create something new and more valuable in the eyes of the wider community. So that it is classified as a new research, but it does not eliminate the existence of the product.

Indonesia as a developing country needs a special material in building road construction and has high water absorption. Based on SNI 03-0691-1996 paving blocks are one of the materials in the manufacture of highways made from a mixture of cement or similar hydraulic adhesives, water and aggregates (sand) with or without other materials which do not reduce the quality of these materials. In general, paving blocks are used as cover material and hardening of the ground surface. Paving blocks are very widely used for various purposes, ranging from simple

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needs to some special specifications, for example: hardening roads, car parking areas, pedestrian areas and city parks in order to reduce standing water when it rains.

Paving block is a composition of building materials from a mixture of Portland cement or other hydraulic adhesives, water and aggregates with or without other additives which do not reduce the quality of these materials (SNI 03-0691-1996). The advantages of using paving blocks are an easy implementation, because it does not need to have special expertise and does not require heavy equipment in the installation. Can be mass produced, to get high quality pressure is needed when printing. Maintenance is easy and inexpensive, because it can be installed again after dismantling if there is damage in one of the damaged paving blocks. Resistant to vertical and horizontal loads caused by brakes or heavy vehicle speeds. The existence of pores in the paving block can minimize surface runoff and increase infiltration in the soil [1].

Coffee is one of the plants that produce side waste in the processing process, namely coffee skin. Coffee, including plants that produce sizable by product waste from processing. The byproduct is in the form of coffee skins, the amount of which ranges from 50-60 percent of the harvest. If the yield of 1000 kg of fresh-skinned coffee, the coffee beans are around 400-500 kg and the rest is in the form of coffee skin. If it is not utilized, it will cause serious pollution [2].

Aggregate is a constituent material in the concrete production process. Aggregate is a collection of broken stones, gravel, sand, or other minerals that are the result of disintegration by the ground [3]. Pumice is a type of rock that is brightly colored, containing scum made from glass-walled bubbles, and is usually referred to as silicate volcanic glass rock. The minerals contained in pumice are feldspar, quartz, obsidian, cristobalite, and tridymite [4].

River sand is commonly used and is most suitable because it is less than chemical impurities. Lost sand (sand from broken pieces of large pebbles) may be used as a substitute. To guarantee the quality of the concrete produced, river sand or this amount must meet the aggregation requirements [5]. Polyurethane resins are mainly produced by the reaction of diisocyanates and polyhydroxy compounds are called polyols because they have more than two final OH-groups. This type of resin is strong, both in conditions of abrasion, oil resistance and solvent resistance [6].

RESEARCH METHODOLOGY

At first the coffee shells is separated from the coffee beans. Then the coffee shell is cleaned of dirt that clings. After that the coffee shell is dried in the sun for several days until it looks dry. Then the coffee shell is crushed using a blender and the results are placed in a container. Pumice stone is washed thoroughly. Then dried in the sun. After that it is crushed and filtered using a 100 mesh sieve and the results are placed in a container. Sand is separated from small rocks and the results are placed in a container. Polyurethane resins are provided with variations of 15 grams, 20 grams and 25 grams as adhesives in the manufacturing of sample tests.

Coffee shells, pumice, sand and polyurethane resin are mixed in a container and then they are stirred using a spatula until homogeneous. It is coated under and upper of the iron plates with aluminum foil and then apply with liquid paraffin. Put an iron mold on it. Then put the mixture into an iron mold until it is spread evenly using a spatula. After that the iron mold is closed using an iron plate and put into the hotpress. Then set the temperature at 170oC within 30 minutes. Then the results of the paving block samples are removed and their mechanical and physical properties are tested.

RESULTS AND DISCUSSION

Characterization of Physical Properties

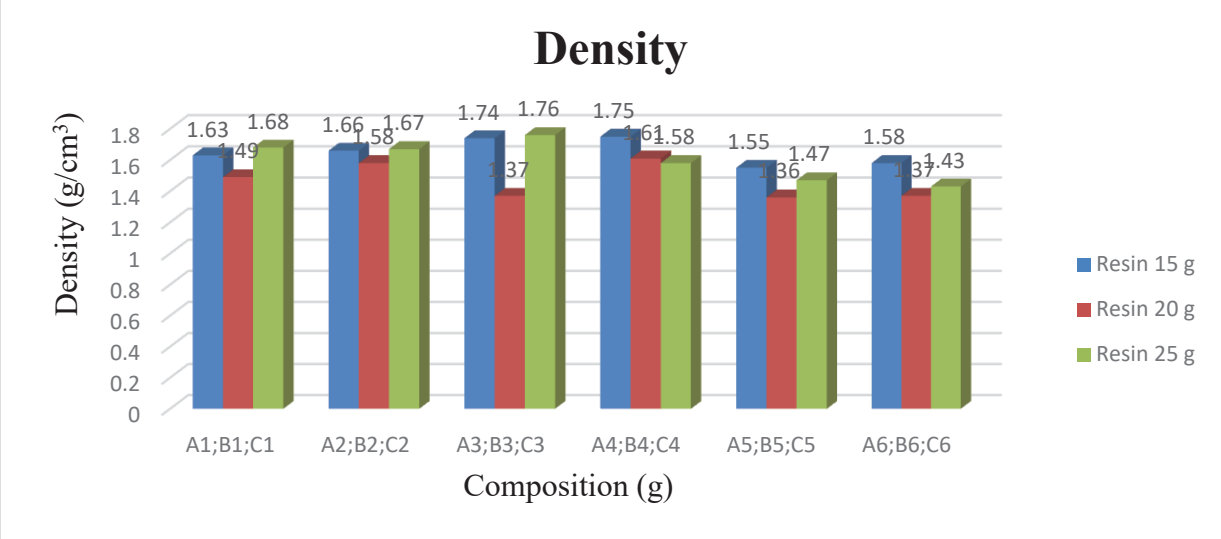


FIGURE 1. Graph of Relationship between Density and Composition

It can be seen that the density value from paving block A are (1.5510-1.7525) g/cm^3, paving block B are (1.3660-1.6195) g/cm^3 and paving block C are (1,4385-1,7640) g/cm^3. The best density is found in sample B4 that is 1.6195 g/cm^3 because it has reached the peak limit and the lowest density is found in sample B5 that is 1.3660 g/cm^3.These results indicate that the density increases with the increasing composition of the coffee shell and polyurethane resin.

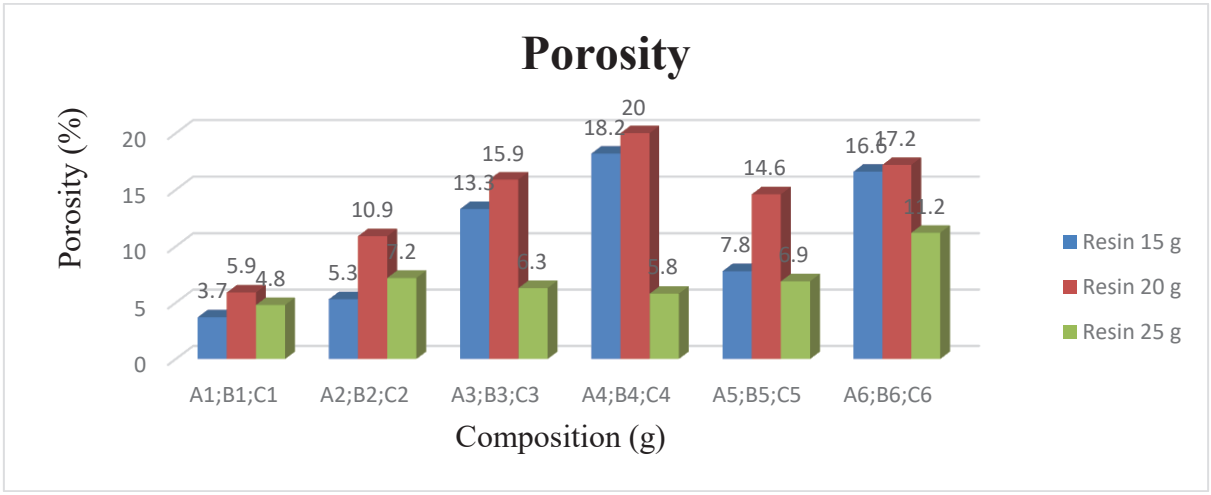


FIGURE 2. Graph of Relationship between Porosity and Composition

It can be seen that the porosity value obtained from paving block A are (3.7-18.15)%, paving block B are (5.9-20)% and paving block C are (4.75-11, 15)%. The best porosity is found in sample B4 that is 20% and lowest porosity is found in sample A1 that is 3.7%. These results indicate that porosity increases with the increasing

composition of the coffee shell and polyurethane resin which binds the composition of sand, pumice and coffee shell.

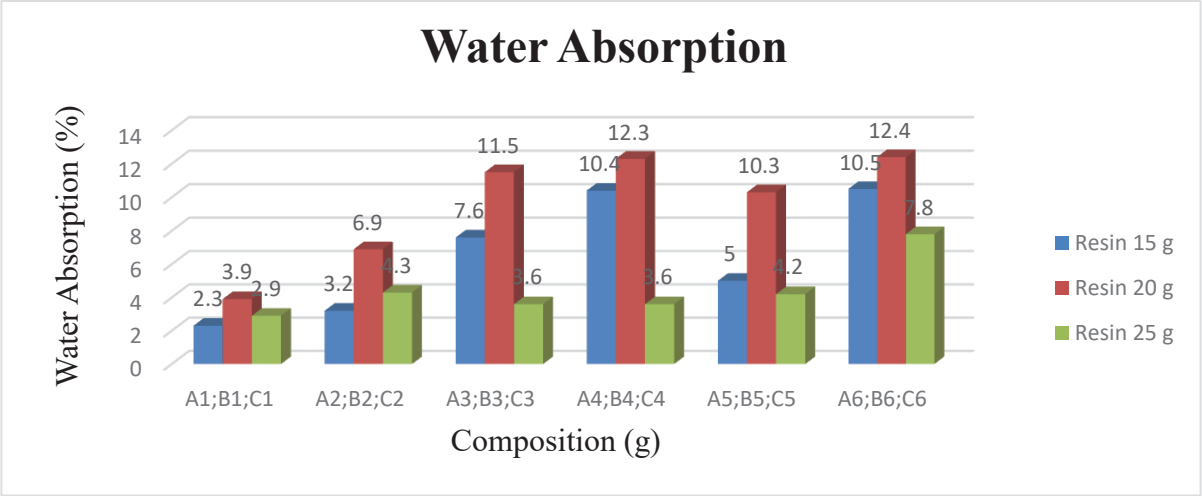


FIGURE 3. Graph of Relationship between Water Absorption and Composition

It can be seen that the value of water absorption obtained from paving block A are (2.2616-10.4647)%, paving block B are (3.9491-12.4365)% and paving block C are (2.8190 -7,7511)%. The best water absorption in sample B4 is 12.3495% and the lowest water absorption in sample A1 is 2.2616%. These results indicate that water absorption is increased because the pores in the paving block is a high water absorbent which binds the composition of the sand, pumice and coffee shell.

Characterization of Mechanical Properties

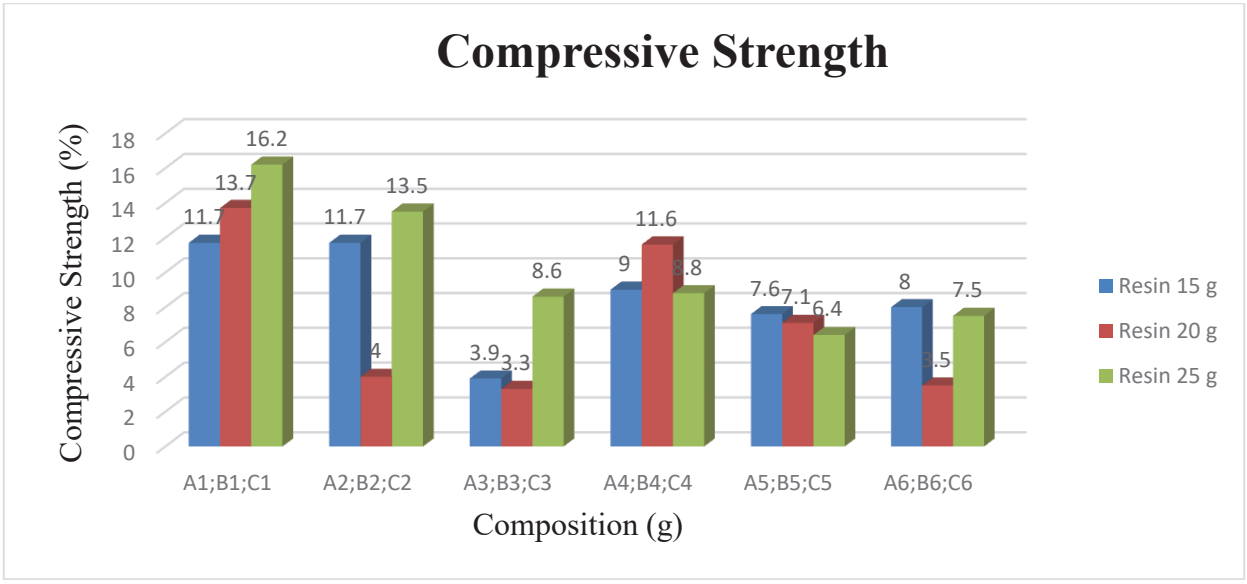


FIGURE 4. Graph of Relationship between Compressive Strength and Composition

From Fig. 4 it can be seen that the compressive strength values obtained from paving block A are (3.88-11.67) MPa, paving block B are (3.25-13.70) MPa and paving block C are (6.44 -16,15) MPa. The best compressive

strength is found in sample B4 that is 11.6055 MPa and the lowest compressive strength is found in sample B3 that is 3.25 MPa. These results indicate that the compressive strength decreases with the increasing of coffee shell and polyurethane resin which binds the composition of sand, pumice and coffee skin shell.

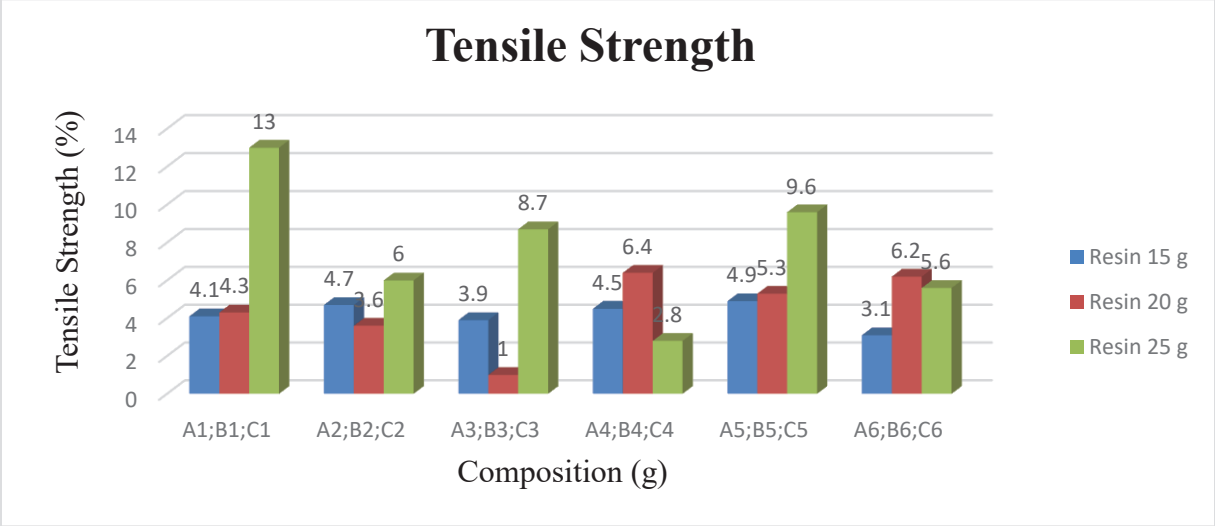


FIGURE 5. Graph of Relationship between Tensile Strength and Composition

From Fig. 5 it can be seen that the tensile strength value obtained from paving block A are (3.11-8.48) MPa, paving block B are (1.01-6.41) MPa and paving block C are (2.75 -13.02) MPa. A good tensile strength is found in sample B4 that is 6.41 MPa and the lowest tensile strength is found in sample B3 that is 1.01 MPa. These results indicate that the tensile strength decreases with the increasing composition of the coffee shell and polyurethane resin which binds all of the compositions.

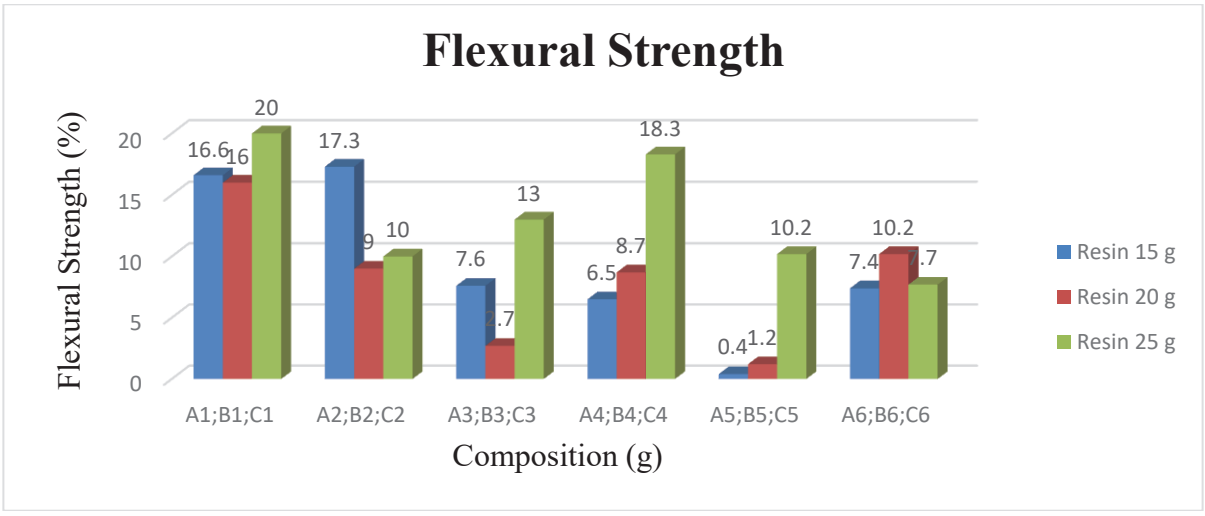
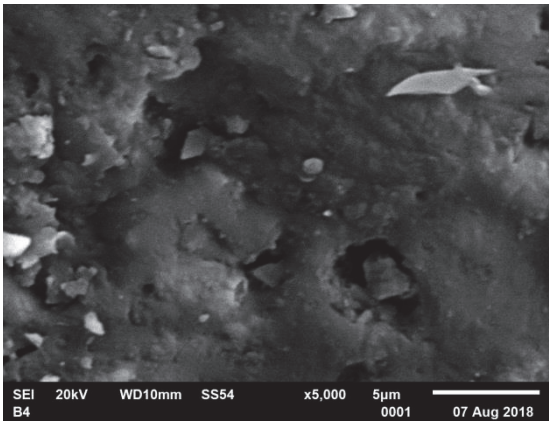


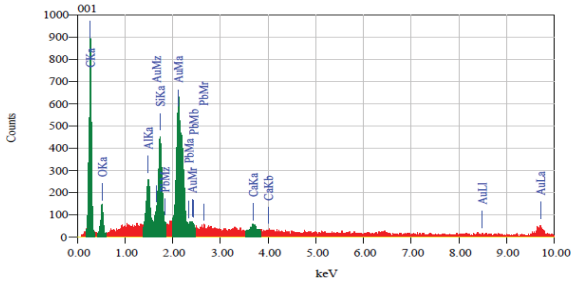
FIGURE 6. Graph of Relationship between Flexural Strength and Composition

From Fig. 6 it can be seen that the flexural strength values obtained from paving block A are (0.41-16.56) MPa, paving block B are (1.24-16.04) MPa and paving block C are (7.70 -20.04) MPa. The best flexural strength is found in sample B4 that is 8.68 MPa and the lowest flexural strength is found in sample A5 that is 0.41 MPa. These results

indicate that the flexural strength decreases with the increasing composition of the coffee shell and polyurethane resin which binds the composition of sand, pumice and coffee shell.

Scanning Electron Microscope - Energy Dispersive X-Ray (SEM-EDX) Characterization



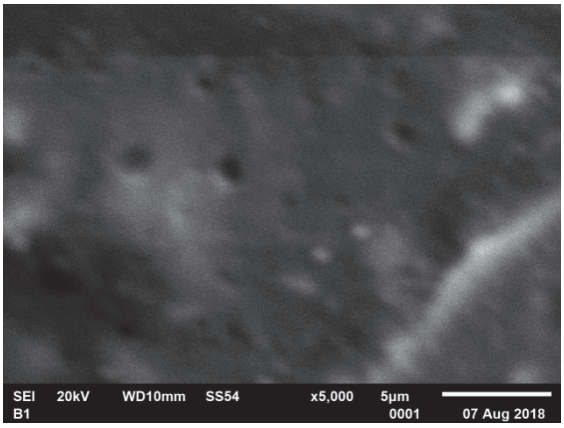


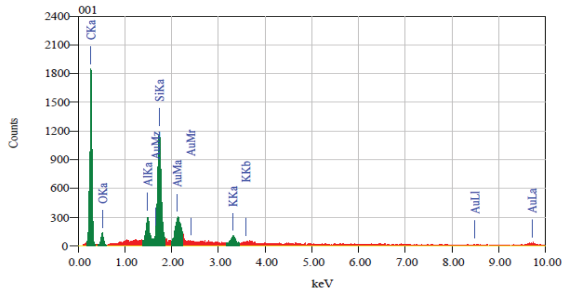
ZAF Method Standardless Quantitative Analysis
Fitting Coefficient : 0.2861

Element	(keV)	Mass%	Error%	Atom%	Compound	Mass%	Cation	K
C K	0.277	55.32	0.06	79.30				34.9448
O K	0.525	13.29	0.29	14.31				9.9997
Al K	1.486	2.34	0.07	1.49				3.7510
Si K	1.739	4.14	0.06	2.54				7.6543
Ca K	3.690	0.55	0.10	0.24				1.1860
Au M	2.121	22.58	0.24	1.97				39.7241
Pb M	2.342	1.78	0.32	0.15				2.7401
Total		100.00		100.00				

FIGURE 7. Testing of EDX SEM with 5000x magnification on a paving block using a coffee shell

From Fig. 7 it can be seen that the sand, pumice, coffee shell and polyurethane resin are mixed quite well because the white part of the paving block is invisible. Coffee shells are scattered in the paving block that has the function to absorb water and the cavities is formed in the paving block so that it can produce a good porosity value whish is 20%.





ZAF Method Standardless Quantitative Analysis
Fitting Coefficient : 0.2567

Element	(keV)	Mass%	Error%	Atom%	Compound	Mass%	Cation	K
C K	0.277	71.85	0.07	85.21				55.9415
O K	0.525	9.84	0.45	8.76				6.8700
Al K	1.486	1.80	0.08	0.95				3.4273
Si K	1.739	8.38	0.08	4.25				18.0181
K K	3.312	0.84	0.11	0.31				2.0189
Au M	2.121	7.29	0.33	0.53				13.7243
Total		100.00		100.00				

FIGURE 8. Testing of EDX SEM with 5000x magnification on a paving block without using coffee shells

From Fig. 8 it can be seen that the white part is a polyurethne resin that binds sand and pumice quite well, so that it produces a good density in the composition of 1.4940 g/cm^3. The elements contained in this high water absorption paving block of coffee shells namely, Carbon, Oxygen, Aluminum, Silicon, Calcium and Plumbum.

CONCLUSION

From the results of the research, it can be concluded that the best mixture of sand, pumice, coffee shell and polyurethane resins in the manufacture of high water absorption paving block is in the composition of B4 which

results in water absorption is 12.33495%, porosity is 20% and density is 1.6195 g/cm^3. On the other hand, the mechanical properties of compressive strength is 11.61 MPa, tensile strength is 6.41 MPa and flexural strength is 8.68 MPa. From the results it can be concluded that the effect of the coffee shell on the manufacturing high water absorption paving block on physical properties are density increased from (1.490-1.6195) g/cm^3, porosity increased from (5.9-20)% and water absorption also increased from (3.949-12.2495) and mechanical properties are compressive strength decreased from (13.70 to 11.61) MPa, tensile strength decreased from (6.41-5.33) MPa and flexural strength decreased from (16.04-8.68) MPa.

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