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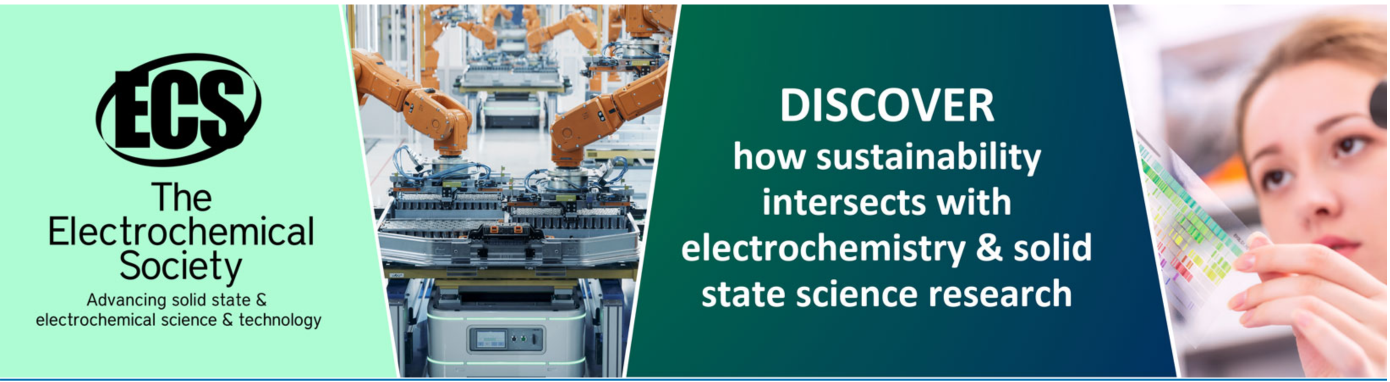

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Parametric study on the compressive strength geopolymer paving block

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Abstract. This paper reported about the investigated of sodium hidroxida concentration, effect of ratio liquid to solid (L/S), temperature and time on the compressive strength of geopolymer paving block using fly ash and fine aggregate as base material and combination of sodium hidroxida and sodium silicate as alkaline activator and the ratio of Na_2SiO_3/NaOH was 2 and fly ash to aggregate of 1: 3. The experiments were conducted with variation of the sodium hidroxida concentration of (10-16 M) liquid to solid (L/S) 0.1- 0.7 ratio, curing temperature 30-100 ºC and curing time (7-28 day). The main evaluation techniques in this experimental were Compressive strength, X-ray diffraction (XRD),and Scaning Electron Microscope (SEM). The result showed that the compressive strength of Geopolymer Paving block has increased with an increasing of concentration, liquid to solid ratio, curing temperature and curing time.

1. Introduction
Fly ash is composed a mixture of metal oxides and non-metal oxides. In addition, the fly ash also contain toxic substances such as chromium, arsenic, fluorine, boron and selenium [1]. Toxic substances are deposited in the soil (landfill) can be spread through the medium of water and air that can pollute the environment. One method for the management of fly ash waste is environmentally friendly with solidification way. In this research, the solidification method is the geopolymer process. Geopolymer produced by reacting solid aluminosilicate material contained in the coal fly ash with a strong base activator produce the binder/adhesive such as cement [2], binders have the same properties as

Factors that affected to the properties of the concrete/paving blocks geopolymer, the type and concentration of activators, activators modulus, temperature and duration of treatment, as well as the levels of alkaline solution in solids. The previous studies reported that each of these factors in the right amount into parameters to produce concrete/paving blocks geopolymer with a high compressive strength [4]. In this research the aims of this study is to check the parameters that influence the compressive strength of geopolymer paving blocks including the concentration difference, the ratio of liquid to solid, temperature and duration of treatment.

2. Materials and methods
In this study, fly ash is came from Paiton Probolinggo East Java as the source material geopolymer paving blocks. The chemical composition of fly ash are listed in Table 1.

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Table 1. Chemical composition of fly ash

Oxida	(%) by mass
SiO2	53.616
Al_2O_3	28.47
Fe_2O_3	5.525
CaO	4.974
P_2O_5	0.569
SO_3	0.584
K_2O	0.857
TiO_2	0.724
LOI	4,681

Next, is by varying one variable to another variable fixed at the same time. There are 16 parameters shown in Table 2 below.

Table 2. Parameters used in this study

MIX DESIGN	[NaOH] M	Alkalin liquid to Fly Ash (L/S)	Curing Temperature(C)	Curing time (days)
M1	10	0,5	80	7
M2	12	0,5	80	7
M3	14	0,5	80	7
M4	16	0,5	80	7
M5	10	0,1	80	7
M6	10	0,3	80	7
M7	10	0,5	80	7
M8	10	0,7	80	7
M9	10	0,5	100	7
M10	10	0,5	80	7
M11	10	0,5	60	7
M12	10	0,5	T.room	7
M13	10	0,5	80	7
M14	10	0,5	80	14
M15	10	0,5	80	21
M16	10	0,5	80	28

The concentration of activator were used in this study with the range between 10-16 M, the ratio of liquid to solid(L/S) between 0.1 to 0.7, temperature between RT/Room temperature (30°C) – 100 °C, and length of treatment between 7-28 days, with Mix 1 as control and variable fixed modulus activator (Ms) = 2 and ratio of fly ash to aggregate (1: 3). Paving blocks geopolymer was started with mixing a solution of NaOH and Na_2SiO_3 activator, it was made for 24 hours before stirring. Aggregates (sand) saturated surface dry condition (SSD); aggregate and fly ash is mixed for 3 minutes. The aggregate, fly ash, and activator were stirred until homogeneous approximately for 5 minutes. Then the mixture is poured into molds or molding machine paving blocks. Paving blocks was formed and then stored in room temperature for 3 days, then put in the oven for treatment with the variation of temperature , i.e. (30), 60, 80, and 100 ° C for 24 hours, after which the compressive strength test for the treatment time 7,14, 21 and 28 days. This was followed by XRD and SEM analysis.

3. Result and discussion

3.1. Variations of the activators concentration

Activator concentration is an important parameter to produce geopolymer material with a high compressive strength, in addition to the type of activator, the temperature and time of treatment [5]. Differences activator concentration will have effect to the difference in the mechanical properties of geopolymer produced particularly strong press.

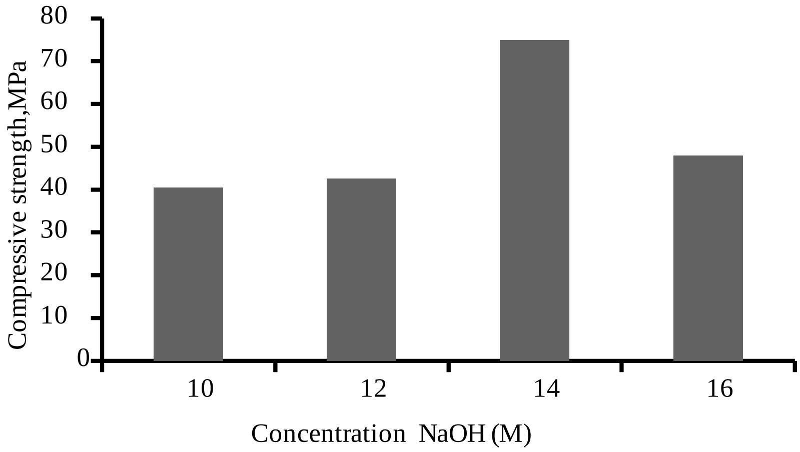

Figure 1. Effect of concentration activators on compressive strength.

The influence of concentration activator of compressive strength NaOH with a concentration of 10 to 16 M can be seen in Figure 1. It shown that there is an increase in the compressive strength of the concentration activator between 10 and 14 M, the higher is the concentration of NaOH. OH^- ion useful in controlling the leaching process Al^{3+} ions and Si^{4+} to accelerate the geopolimerisation reaction. In addition, it also have an effect on the solubility of silica-alumina. The high concentration cut off (breaks) of glassy material origin (fly ash) structure can helps atoms Si and Al become in the geopolimerisation reaction on the formation of the order geopolymer. It made the bond strength between the molecules become more reactive in order to generate monomers form, which affects the obtained compressive strength [6]. However, the compressive strength was decreased when the activator at 16 M due to the addition of alkaline activator concentration on the mixture which led to the increased coagulation of silica. It can reduce the mixture workability so that the mixture was hard to stirred and blend which caused the decreasing of the compressive strength of geopolymer [7].

3.2. Variations liquid to solid (L/S)

In Figure 2 below shows the effect of the ratio of liquid to solid (L/S) of compressive strength, where the compressive strength has increasing for the ratio is 0.1, 0.3 to 0.5. Because the mixture workability increased by the raised of liquid to solid ratio until ratio optimum at 0.5 (L/S). At 0.7 L/S ratio, compressive strength was decreased since the addition of the excess liquid activator which produced OH^- ions. It would leave the system thus weaken the geopolymer's structure. Besides that, the high liquid content caused the interaction among the fly ash particles become lessen and the distance between particles was getting wider [8].

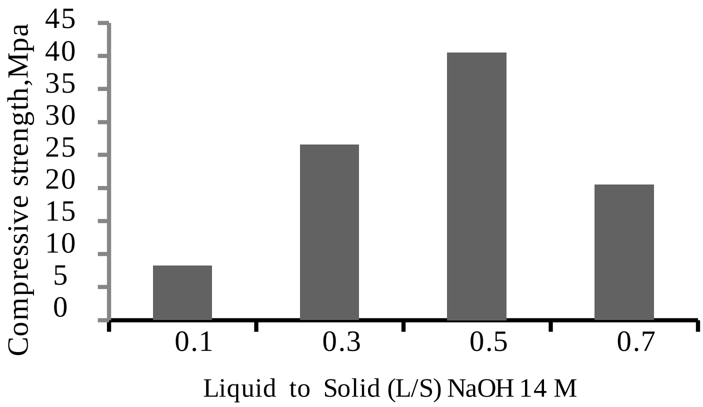

Figure 2. Effect of liquid to solid ratio (L/S) on compressive strength.

3.3. Variation of curing temperature

In figure 3 shown the effect of the temperature treatment of the compressive geopolymer strength, it seen that the paving block of room temperature to 80 °C compressive strength will be increasing with the increase of the temperature (> 80 °C).

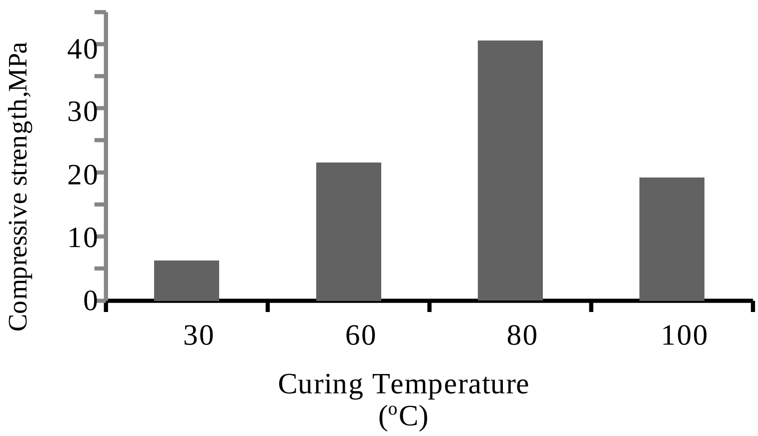

Figure 3. Effect of curing temperature (°C) on compressive strength.

A decrease in compressive strength, which is in line with previous researchers that the increase in temperature affects the mechanical strength of the concrete / paving blocks geopolymer but rise higher temperature and curing time longer can decrease the compressive strength due to lack of moisture in the structure caused easily occur cracking and also shrinkage of paving blocks / geopolymer concrete so that it can decrease the compressive strength [9, 10].

3.4. Varian duration of treatment

Figure 4 shows the compressive strength is influenced by the length of the treatment time at 7, 14, 21 and 28 day, it also will increased the compressive strength.

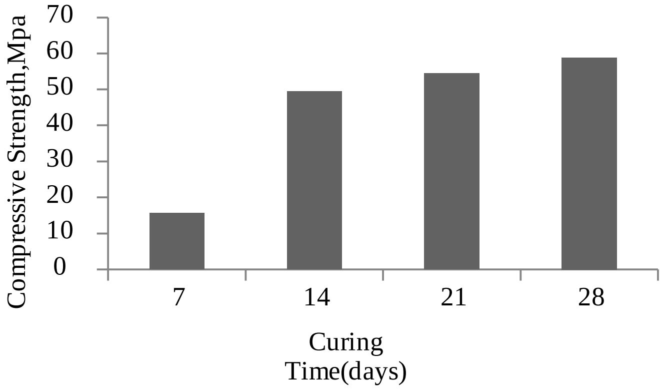

Figure 4. Effect of curing time (days) on compressive strength.

This is because the rate of chemical processes (solidification) takes on the mechanical strength of the paving blocks geopolymer, and according to the previous researchers also reported that the treatment the compressive strength increases [11-12].

3.5. X-Ray diffraction (XRD) analysis

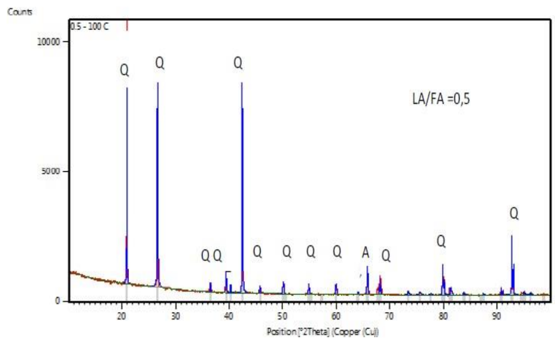

Figure 5. X-Ray Diffraction Analysis (XRD) on Paving Block geopolymer ratio L / S 0.5 NaOH 14 M (Q= quartz , A = Albite).

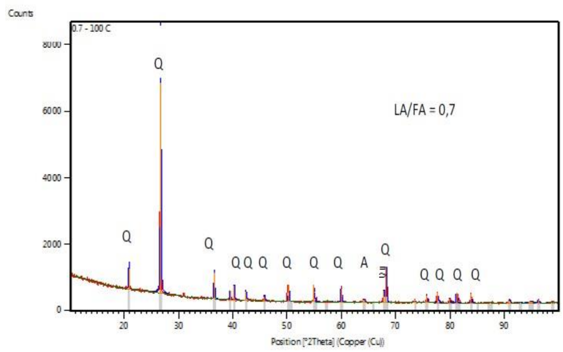

Figure 6. X-Ray Diffraction Analysis (XRD) on Paving Block geopolymer ratio L/S= 0.7 ,NaOH 14 M (Q=quartz,= Albite).

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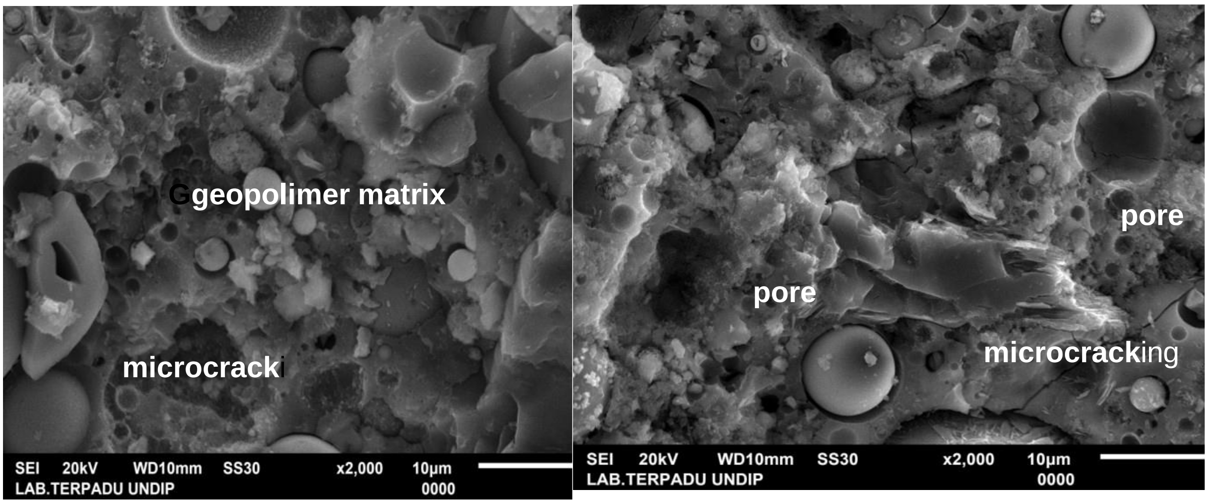
Figure 5 and 6 show the X ray diffraction (XRD) analysis for the L / S ratio of 0.5 and 0.7, respectively with the maximum compressive strength. the highest peak for all designs of the mixture is shown with quartz (Q) quartz. its shown that the level of violence. At the L / S ratio of 0.5, there are three highest Q peak (quartz), and there is a detected A (albite) peak indicating the strength of the geopolymer paste from the crystalline formation of the aluminasilicate gel [13]' while in the L / S ratio of 0,7 is not detected peak A (albite) and there is only one highest Q quartz peak so it can be concluded that L / S 0,5 has an optimum compressive strength because it has peak Q with highest intensity [14].

3.6. Scanning electron microscope (SEM) analysis



(a) L/S 0.5 (b) L/S 0.7

Figure 7. Geopolymer with difference ratio liquid to solid (L/S).

Figure 7a illustrates a geopolymer sample with ratio L/S 0.5 it shows complete geopolymerisation and fly ash reacts homogeneously with alkaline activator thus leading to maximum compressive strength. Geopolymer sample with ratio L/S 0.7 as in Figure 7b showed incomplete geopolymerisation the quantity of alkaline acktivator affects the saturation rate of the geopolymerasation process and the strength of geopolymer. In this sample, pores and microcrack was detected and probably due to the sample preparation for the SEM analysis.

4. Conclusion

Some of the parameter has been carried out for fly ash geopolymer paving block using various concentrasion activator, liquid to solid ratio, temperatur and time. It shown that the compressive strength of geopolymer paving block increased with an increasing of the concentration activator, liquid to solid ratio, curing temperatur and curing time. The presence of albite during XRD analysis was also detected in the geopolymer sample and the morphology of geopolymer samples will changes in the matrix with the increasing of the temperature.

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