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To cite this article: Danai Jongphimai *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **600** 012015

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# Effect of $\text{Na}_2\text{SiO}_3/\text{NaOH}$ ratio on compressive strength of lateritic soil mixed with bagasse ash geopolymer

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**Abstract.** This paper investigated the effect of  $\text{Na}_2\text{SiO}_3/\text{NaOH}$  ratio on compressive strength of lateritic soil-bagasse ash geopolymer. Lateritic soil was obtained from Sikhio District, Nakhon Ratchasima. Bagasse ash is a waste from the burning of sugarcane for electricity. The lateritic soil to binder ratio was fixed at 85/15. The alkaline activator was composed of sodium silicate solution ( $\text{Na}_2\text{SiO}_3$ ) and sodium hydroxide solution ( $\text{NaOH}$ ) at concentration of 5 M. The  $\text{Na}_2\text{SiO}_3/\text{NaOH}$  ratios were 80/20, 70/30 and 50/50. The compressive strength of lateritic soil-bagasse ash geopolymer samples was evaluated at curing time of 7, 14, 28 and 60 days. It can be seen that the compressive strength of lateritic soil mixed with bagasse ash geopolymer increases as the  $\text{Na}_2\text{SiO}_3/\text{NaOH}$  ratio and curing time increase. The maximum compressive strength of lateritic soil-bagasse ash geopolymer was found at the  $\text{Na}_2\text{SiO}_3/\text{NaOH}$  ratio of 80/20 and curing time of 60 days, which gave maximum compressive strength of 9.84 MPa.

## 1. Introduction

Interlocking brick has been widely used construction material. The raw material used in the production of interlocking blocks consists of soil, cement and water. Generally, interlocking brick was produced by compression machine. However, interlocking brick used Portland cement. The process of cement releases large amount of carbon dioxide into the atmosphere and causes the greenhouse gases [1,2]

Geopolymerization is a process that creates cementitious compounds by the dissolution of aluminosilicate compounds by highly alkaline liquids. The geopolymerization of aluminosilicate-rich materials results in strong cementitious compounds [3-7]. Bagasse ash is a waste from the burning of sugarcane for electricity. Particles of bagasse ash are large and high porosity. Bagasse ash has main aluminosilicate-rich material which can be classified as Class N pozzolanic materials according to ASTM C 618 [8].

This research aimed to investigate the compressive strength of lateritic soil mixed with cement and bagasse ash. Alkaline activator, L consists of sodium silicate solution (Sodium silicate solution,  $\text{Na}_2\text{SiO}_3$ ) and sodium hydroxide solution (Sodium hydroxide solution,  $\text{NaOH}$ ). The strength of sample was evaluated using the unconfined compressive strength (UCS) at curing time of 7, 14, 28 and 60 days.



## 2. Materials and testing methods

### 2.1. Materials

Lateritic soil (LS) was obtained from Sikhio District, Nakhon Ratchasima. The specific gravity of LS is 2.72. the liquid limit and the plastic limit of LS are 32 and 21, respectively. This soil can be classified as clayey sand (SC) according to the Unified Soil Classification System (USCS).

Bagasse ash (BA) is a waste from the burning of sugarcane for electricity, the Khonburi sugar factory. The chemical composition of bagasse ash was shown in Table 1. It can be seen that the BA has  $\text{SiO}_2$  of 70.91 and  $\text{Al}_2\text{O}_3$  of 4.28, respectively. BA can classified as type N according to ASTM C 618.

The alkaline solution consists of sodium hydroxide solution (NaOH) with a concentration of 5 molar and sodium silicate solution ( $\text{Na}_2\text{SiO}_3$ ).



(a) Lateritic soil



(b) Bagasse ash

**Figure 1.** Characteristic of lateritic soil and bagasse ash

### 2.2. Sample preparation

The lateritic soil-bagasse ash geopolymer is a mixture of laterite, bagasse ash, and liquid alkaline activator (L) (sodium hydroxide solution, NaOH and sodium silicate solution,  $\text{Na}_2\text{SiO}_3$ ). Lateritic soil and bagasse ash ratio was fixed at 85/15. The  $\text{Na}_2\text{SiO}_3$ /NaOH ratios were 80 / 20, 70/30 and 50/50. NaOH concentration was fixed at 5 molar. Modified Proctor compaction effort in accordance with

ASTM D1557-12 [9] was used to compact the lateritic soil-bagasse ash geopolymer. Next the lateritic soil-bagasse ash geopolymer was prepared by static compression with a 50 mm in diameter and a 100 mm in height using a cylindrical split mold. Then, the specimens were wrapped in clear vinyl to prevent moisture loss throughout curing. These specimens were subjected to Unconfined compressive strength (UCS) tests with reference to ASTM D2166 [10] at curing time of 7, 14, 28, and 60 days.

**Table1.** Chemical compositions of BA.

| Chemical compositions          | BA (%) |
|--------------------------------|--------|
| SiO <sub>2</sub>               | 70.91  |
| Al <sub>2</sub> O <sub>3</sub> | 4.28   |
| Fe <sub>2</sub> O <sub>3</sub> | 6.61   |
| CaO                            | 8.91   |
| MgO                            | 0.75   |
| SO <sub>3</sub>                | 0.56   |
| Na <sub>2</sub> O              | 0.11   |
| K <sub>2</sub> O               | 3.48   |
| MoO <sub>3</sub>               | N.D.   |
| LOI                            | 3.28   |

### 3. Research results and discussion results

**Figure 1** shows the relationship between relationship between dry weight unit and liquid alkaline content at different Na<sub>2</sub>SiO<sub>3</sub>/NaOH ratios. It was found that The Na<sub>2</sub>SiO<sub>3</sub>/NaOH ratios have an effect on the dry weight unit of lateritic soil-bagasse ash geopolymer. The dry weight unit of lateritic soil-bagasse ash geopolymer increased with increasing Na<sub>2</sub>SiO<sub>3</sub>/NaOH ratios. The optimum liquid alkaline content of lateritic soil-bagasse ash geopolymer was 13, 14 and 15 % for Na<sub>2</sub>SiO<sub>3</sub>/NaOH ratios of 80/20, 70/30 and 50/50, respectively. The maximum dry weight unit of lateritic soil-bagasse ash geopolymer was 18.5 kN/m<sup>3</sup> at Na<sub>2</sub>SiO<sub>3</sub>/NaOH ratios.

**Figure 2** shows the compressive strength of lateritic soil-bagasse ash geopolymer at different Na<sub>2</sub>SiO<sub>3</sub>/NaOH ratios. The compressive strength of lateritic soil-bagasse ash geopolymer increases with increasing Na<sub>2</sub>SiO<sub>3</sub>/NaOH ratios. The maximum compressive strength of the lateritic soil-bagasse ash geopolymer sample was found at Na<sub>2</sub>SiO<sub>3</sub>/NaOH ratio of 80/20 and curing time of 60 days, which gave maximum compressive strength of 9.84 MPa. The compressive strength of lateritic soil-bagasse ash geopolymer increases as curing time increases until the curing time of 28. Then the compressive strength of lateritic soil-bagasse ash geopolymer is constant as curing time increases. It is because the alkaline solution can leach more silica and alumina from bagasse ash and result in the formation of geopolymerization products.

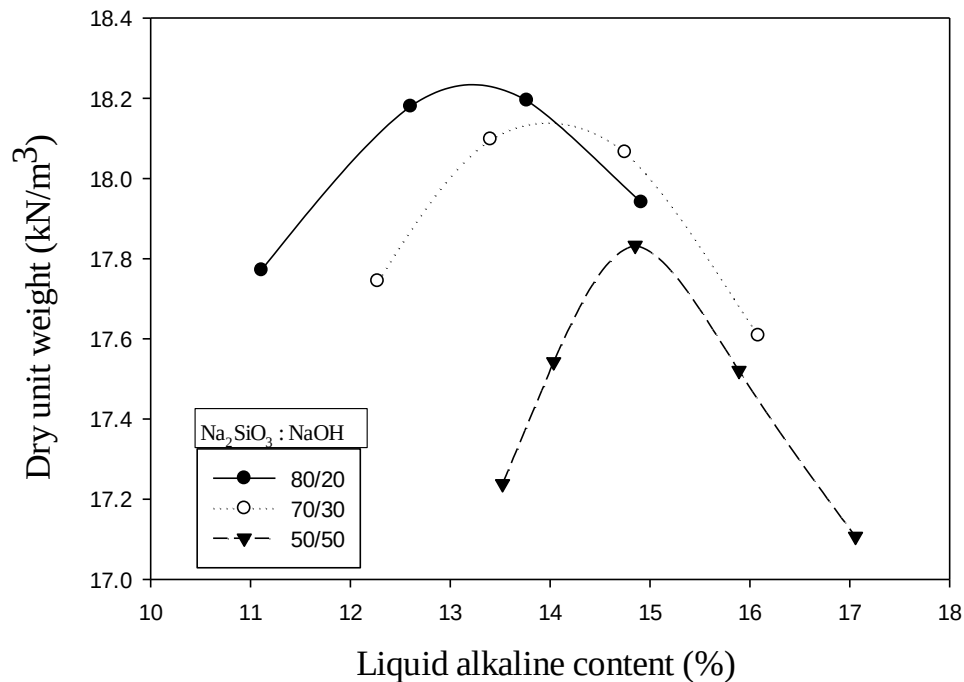


**Figure 2.** Relationship between dry weight unit and liquid alkaline content at different  $\text{Na}_2\text{SiO}_3/\text{NaOH}$  ratios.

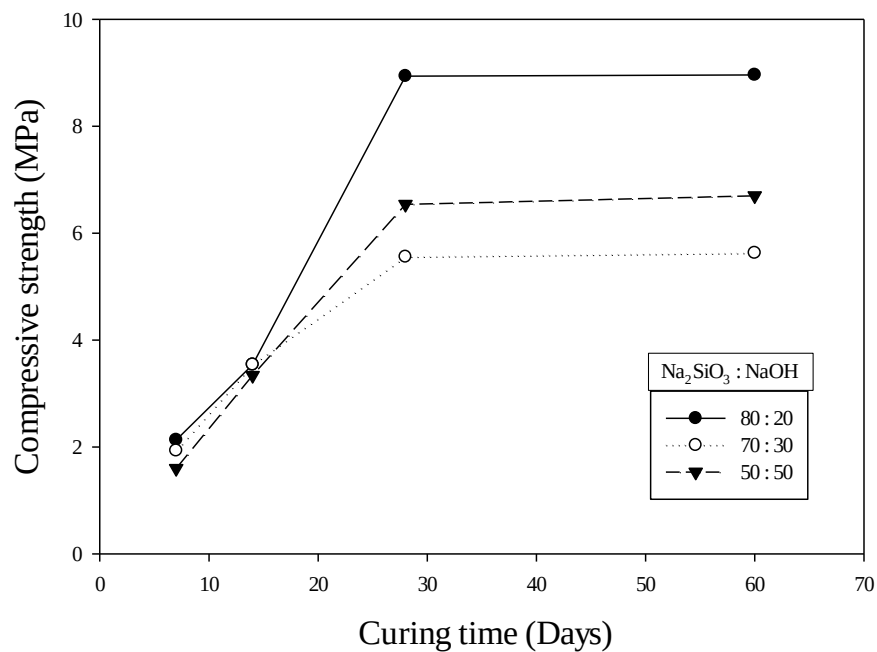


**Figure 3.** The compressive strength of lateritic soil-bagasse ash geopolymer at different  $\text{Na}_2\text{SiO}_3/\text{NaOH}$  ratios

#### 4. Conclusions

The effect of  $\text{Na}_2\text{SiO}_3/\text{NaOH}$  ratio on compressive strength of lateritic soil-bagasse ash geopolymer was evaluated in this study. The conclusions can be drawn as follows. The dry weight unit of lateritic soil-bagasse ash geopolymer increased with increasing  $\text{Na}_2\text{SiO}_3/\text{NaOH}$  ratios. The optimum liquid

alkaline content of lateritic soil-bagasse ash geopolymer was 13, 14 and 15 % for  $\text{Na}_2\text{SiO}_3/\text{NaOH}$  ratios of 80/20, 70/30 and 50/50, respectively. The maximum compressive strength of the lateritic soil-bagasse ash geopolymer sample was found at  $\text{Na}_2\text{SiO}_3/\text{NaOH}$  ratio of 80/20 and curing time of 60 days, which gave maximum compressive strength of 9.84 MPa.

### Acknowledgments

This work was financially supported by the Thailand Research Fund under the Research and Researcher for Industry (RRi) program Grant No. RTA MSD61I0004. The authors acknowledge the financial support from the Pakpanyawat Ltd., Part and the Rajamangala University of Technology Isan.

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