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Abstract	Geopolymer is a new alternative material for construction that does not contain cement and produces very little CO_2. Geopolymer was caused by the reaction of geopolymerization of high concentrations of alkali substances and oxides of silicon and aluminum that can transformed into a strong structural material. Therefore, it is an alternative material that can be used to replace cement. When mixed with charcoal powder of banana peel which is waste in agricultural products form banana plants. This study is mixing with geopolymer with charcoal powder banana peel at 0, 5, 10, and 15% by weight for testing a mechanical property. We used a ratio for fly ash 50% and the mixed with solution 1 part sodium silicate and 1 part of 12 molar sodium hydroxide into 50% by total weight. Last process, we mixed geopolymer part with river sand that passing through sieve no.16 in ratio of geopolymer 1 part per river sand 2 part by weight. Also, we were tested the mechanical properties and testing both powder with scanning electron microscope (SEM) and Energy Dispersive X-Ray Analysis (EDS). We found that charcoal powder banana peel mixed with geopolymer can improved the efficiency of compression and flexural strength and water absorption in an appropriate ratio.

Keywords (separated by '-')	Geopolymer - Cement - Banana peel - Fly ash - Construction

The Mechanical Properties for Using Banana's Peel Ash as Aggregate in Geopolymer Mortar

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Abstract. Geopolymer is a new alternative material for construction that does not contain cement and produces very little CO_2. Geopolymer was caused by the reaction of geopolymerization of high concentrations of alkali substances and oxides of silicon and aluminum that can transformed into a strong structural material. Therefore, it is an alternative material that can be used to replace cement. When mixed with charcoal powder of banana peel which is waste in agricultural products form banana plants. This study is mixing with geopolymer with charcoal powder banana peel at 0, 5, 10, and 15% by weight for testing a mechanical property. We used a ratio for fly ash 50% and the mixed with solution 1 part sodium silicate and 1 part of 12 molar sodium hydroxide into 50% by total weight. Last process, we mixed geopolymer part with river sand that passing through sieve no.16 in ratio of geopolymer 1 part per river sand 2 part by weight. Also, we were tested the mechanical properties and testing both powder with scanning electron microscope (SEM) and Energy Dispersive X-Ray Analysis (EDS). We found that charcoal powder banana peel mixed with geopolymer can improved the efficiency of compression and flexural strength and water absorption in an appropriate ratio.

Keywords: Geopolymer · Cement · Banana peel · Fly ash · Construction

1 Introduction

Banana are the popular fruit in international trade and one of the most common crops grown in the world, especially in Thailand. Today, banana production is an important source of income an employment for the major banana export countries. In Thailand, the great availability of bananas flesh in producing regions throughout the year makes their transformation into banana chip and banana Fig. 1, besides being an important alternative to avoid possible waste of the production. As industrial byproducts, peels represent about 30–40 g/100 g of fruit weight. This resulted in 200 tons of waste from banana peels in Thailand generated each day and this amount tend to increase annually (Pangnakorn, 2006) [1]. The banana peels waste is generally displace in municipal landfills, which contribute to the existing environmental problems.

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Fly ash is one of the by-products produced from the process of coal burning. In Thailand, fly ash is one of the most popular pozzolans [2]. Among the various types of construction waste that can employ highlights are the pozzolanic materials, fly ash concrete has become practically common [3]. The possibility of developing a new material with raw materials reused were studied and add improvements in the technical aspects for the mortar and concrete. In this context the need for the use of banana peel ash as aggregates in the production of mortar in term of Geopolymer is seen that the Geopolymer is the innovative material in the world. In this study, banana peel was mixed in Geopolymer as aggregate to investigate the mechanical properties.

Geopolymer is the term used to represent the binders produced by polymeric reaction of alkaline liquid with silicon and aluminum as source materials [4]. The mixing with Geopolymer with waste from banana peel in term of powder for testing mechanical strength of mortar and water absorption properties. The experimental program involves casting of geopolymer mortar cubes testing them at 28 days for compressive strength, Flexural strength and water absorption. Different parameter for percentage of peel banana 0, 5, 10, and 15% by weight are investigated at the ratio of sodium hydroxide 12 Molarity and the ratio of sodium hydroxide to sodium silicate as constant (1:1). The results were showed that Banana peel ash have affected to the properties of geopolymer mortar.

2 Materials and Methods

Materials:

Fly Ash from the Mae Moh Power Plant in Northern Thailand, Banana's peel powder, Fine aggregate (graded river sand passing sieve No. 16 and retaining on sieve No. 100), Standard Specification for Sampling and Testing Fly Ash or Natural Pozzolans use in Portland-Cement Concrete according to ASTM C 311/C 311M-13 [5].

The physical and chemical properties of materials were shown in Table 1.

Table 1. The physical and chemical properties of materials

	Fly ash	Sand
Physical properties		
Specific gravity	2.77	2.56
Absorption (%)		1.21
Moisture content (%)	0.06	0.47
Voids (%)		34.6
Fineness modulus		2.76
Blaine fineness (cm^2/g)	2,580	–
Median particle size (micron)		–

(*continued*)

Table 1. (*continued*)

	Fly ash	Sand
Retained on sieve number 325 (%)		–
Chemical composition (%)		
Silicon dioxide (SiO_2)	26.96	92.86
Aluminum oxide (Al_2O_3)	11.84	3.17
Iron oxide (Fe_2O_3)	10.36	0.27
Calcium oxide (CaO)	39.40	0.55
Magnesium oxide (MgO)	2.88	0.49
Potassium oxide (K_2O)	1.30	0.32
Sodium oxide (Na_2O)	1.30	0.42
Sulfur oxide (SO_3)	4.09	0.55
Loss on Ignition (LOI)	0.86	0.67

Methods:

Microstructure of Banana's peel ashes were studied by using scanning electron microscope (SEM) and EDS. In addition, chemical composition, specific gravity, median particle size and fineness of banana's peel were investigated.

Banana's peel ashes were used to add on fly ash at dosage levels of 0%, 5%, 10% and 15% by mass of binder. A constant water to binder ratio (w/b) of 0.5 was used throughout the investigation. The pastes were mixed in a mechanical mixer and the specimens were cast in 50 × 50 × 50 mm cube moulds for compression samples and 50 × 50 × 150 mm moulds for flexural samples. The fresh samples were dried in the temperature room. After 24 h, the samples were removed from the moulds and cured in room temperature (35–37 °C).

Mixing:

AQ1 All samples were separated testing according to ASTM standard, ASTM C 109 and ASTM C 1609. Each compressive strength and flexural strength values were the average of five samples.

The experimental study was investigated with the mechanical properties of geopolymer mortar mixing with banana peel ash. The ratio of mixing geopolymer mortar were shown in Table 2.

Fig. 1. Show physical of fly ash powder, Mae Moh, Lampang Province and banana peel charcoal powder

Table 2. The proportion of geopolymer mortar mixing with banana peel ash

Sample	Fly ash (g.)	NaOH (g.)	Na_2SiO_3 (g.)	Sand (g.)	Banana peel ash (g.)
0% banana peel ash	1500	375	375	3000	0
5% banana peel ash	1425	375	375	3000	75
10% banana peel ash	1350	375	375	3000	150
15% banana peel ash	1275	375	375	3000	225

3 Results and Discussion

The process to produce banana's peel ash is by burning the banana's peel with 100 °C for 24 h in oven. Then, the material was crush to powder and was sent to laboratory to investigate the physical and chemical properties of banana's peel ash by a Scanning Electron Microscope (SEM) and Energy Dispersive X-Ray Analysis (EDX) testing. Table 2 show the chemical compositions found in banana's peel ash.

In Fig. 2 and Fig. 3 show the fly ash results from Scanning Electron Microscope (SEM) and Energy Dispersive X-Ray Analysis (EDX) testing. Fly ash consists of silt-sized particles which are generally spherical, typically ranging in size between 10 and 100 micron.

In this study, fly ash is produced from the Mae Moh generating plant of the Electricity Generating Authority of Thailand in Lampang province, in the north of Thailand.

In Fig. 4 show the banana's peel ash results from Scanning Electron Microscope (SEM) and Energy Dispersive X-Ray Analysis (EDX) testing. Banana's peel ash consists of silt-sized particles which are generally wavy cube typically ranging in size between 30 and 150 microns.

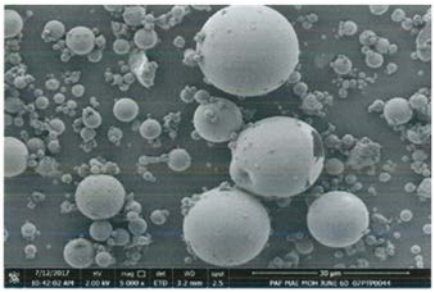


Fig. 2. Show scanning electron microscope (SEM) of fly ash

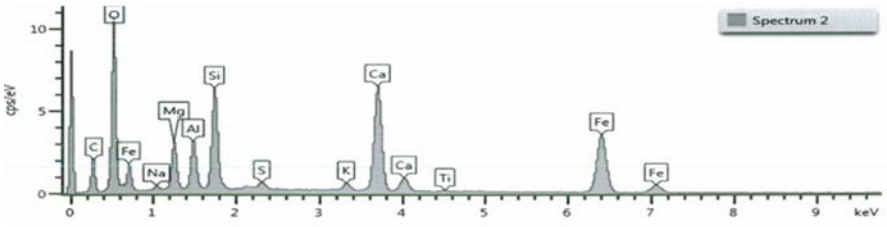
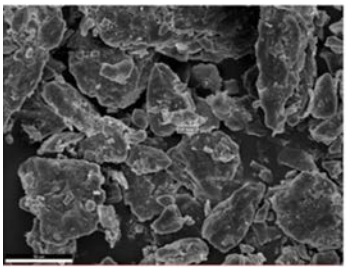


Fig. 3. Show energy dispersive X-Ray analysis (EDX) of fly ash



eZAF Smart Quant Results

Element	Weight %	Atomic %	Net Int.
O K	53.71	80.23	210.13
MgK	1.5	1.47	12.04
SiK	2.09	1.78	22.39
PtM	19.65	2.41	70.54
ClK	1.31	0.88	9.17
K K	17.63	10.78	100.95
CaK	4.11	2.45	19.03

Fig. 4. Show scanning electron microscope (SEM) of banana's peel ash

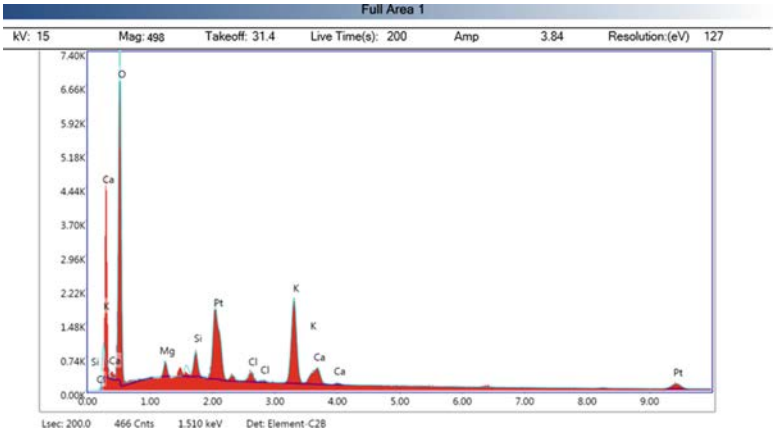


Fig. 5. Show eZAF smart quant results of banana's peel ash

Both of particle shape between fly ash and banana peel ash are different in structure.

Strength Results

The mechanical properties of geopolymer mortar were shown in Table 3.

Table 3. The mechanical properties of geopolymer mortar mixing with banana peel ash

Samples	Compressive strength (MPa)	Flexural strength (MPa)	Absorption (%)
0%	30.48	3.31	7.83
5% with banana peel	40.94	4.17	2.81
10% with banana peel	42.32	2.78	4.46
15% with banana peel	41.80	2.62	5.13

From the test results, it was observed that the compressive strength is the highest at the ratio of 10% of banana peel charcoal powder, the compressive strength is 42.32 MPa. While the flexural strength of the test sample at the powder mixture ratio is 42.32 MPa. Banana peel charcoal at 5% was able to improve the flexural strength of 4.17 MPa. As for the absorption percentage of the test sample, it increases with the addition ratio of banana peel charcoal powder at 5%, 10% and 15%, respectively, with the greatest value being the mixing ratio at 0%. Absorption is 7.83%.

It can be observed that the mixing ratio of banana peel charcoal powder in the geopolymer material increases. It will help to increase the compressive strength and flexural strength at the right mix ratio. which is likely to be caused by the calcium content in the chemical composition of banana peel powder. The water-absorbing properties of the geopolymer material mixed with banana peel charcoal will provide an effective protection against the accumulation of moisture in the geopolymer material. which in the ratio not mixed with banana peel charcoal powder It was found that the percentage of water absorption was higher than that of the samples mixed with charcoal powder. This is probably a result of the structure of the geopolymer material having a crystalline physical structure with a spherical shape. There is a gap in the crystallization. Therefore, when combining banana peel charcoal powder with a geopolymer material with a rather slender, wavy crystal structure as shown in the above Fig. 5, the crystal structure Therefore, there are few gaps in alignment with the geopolymer structure. Thus, reducing the water absorption ratio in an appropriate proportion.

4 Conclusions

The research finding of the mechanical properties for using cement mixed with banana peel charcoal in geopolymer in three different percentages (5%, 10%, and 15%) are presented in this paper. These mechanical properties were used to investigate the effect of banana peel charcoal in the properties of geopolymer mortar at Alkaline Solution/Fly ash ratio 0.5 and ratio $NaOH/Na_2SiO_3$ of 1:1 and ratio sand/Fly ash of 2:1 respectively

at the sodium hydroxide concentration was 12 M. Based on the test results obtained, the following conclusion were drawn.

1. The water absorption rate of the test showed that the mixing of banana peel charcoal powder It can help to reduce the water absorption rate of the geopolymer material at an appropriate ratio of 5%.
2. Testing for compressive strength values showed that the mixing of banana peel charcoal powder The compressive strength can be increased at the 10% mixing ratio of banana peel charcoal powder at 10%
3. Testing the flexural strength values showed that the mixing of banana peel charcoal powder The flexural strength can be increased at the mixing ratio of banana peel charcoal powder at 5%.
4. Crystal structure of banana peel charcoal powder has a crystal structure with a wavy shape. There is a squareness on the surface which is different from the crystal structure of fly ash powder from Mae Moh, Lampang Province, which has a spherical shape, smooth surface and different chemical composition.
5. Banana Peel Powder Can Used in Geopolymer Material for Improving the Properties of Strength.

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AQ2

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Chapter 8

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