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ECO PROCESSED POZZOLAN, MATERIAL FOR THERMAL INSULATION

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Abstract

The rapid growth of the palm oil industry, particularly in Indonesia and Malaysia, has led to a substantial increase in the generation of spent bleaching earth (SBE), a silica-rich waste material produced during crude palm oil refining. Eco-Processed Pozzolan (EPP), derived from thermally treated SBE, has emerged as a promising supplementary cementitious material due to its reactive silica and alumina content. This study investigates the thermal insulation performance of concrete incorporating EPP as a partial cement replacement. Two concrete types—100% OPC and a blended mix containing 70% OPC and 30% EPP—were tested using a controlled furnace exposure at 340 °C. Temperature readings were obtained using dual-channel K-type thermocouples positioned at the inner and outer walls of the specimens. Results show that the EPP-based concrete (Type Z) required a longer duration (234 minutes) to reach temperature intersection and exhibited a lower final equilibrium temperature (281.9 °C) compared to the OPC control sample (293.1 °C at 196 minutes). These findings indicate that incorporating 30% EPP enhances the thermal resistance of concrete by slowing heat transmission and lowering internal temperature rise. Overall, the study demonstrates that EPP is a viable sustainable material for improving thermal insulation performance while also supporting waste valorization in the palm oil industry.

Keywords; Eco-Processed Pozzolan, Thermal Insulation, Spent Bleaching Earth, Heat Resistance, Cement Replacement

INTRODUCTION

Palm oil Industry in some countries like Indonesia and Malaysia have given contribution for Its economics and income for people, opportunity working for people in palm oil sector, economic movement, tax and foreign exchange for the country. The area of palm oil plantation in Indonesia increase from 10.75 million hectares in 2014 to 12.76 million hectares in 2018 and crude palm oil (CPO) production on 2014 amount 29.28 million tons and increase amount 36.59 million tons on 2018.

Table 1. CPO Production and Palm Oil Plantation from 2014- 2018

(Biro Pusat Statistik 2019, catalogue 4504003)

Year	CPO (Crude Palm Oil) Production (MillionTons)	Palm Oil Plantation (Million Ha’s)
2014	29.28	10.75
2015	31.07	11.26
2016	31.49	11.20

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2017	34.94	12.38
2018	36.59	12.76

One of material used in palm oil is bleaching earth. Bleaching earth is agent that functions as an absorbent to absorb the color carrying elements in CPO. Before process bleaching, the color CPO is reddish orange after bleaching process the color of CPO becomes white-yellow. The amount bleaching earth that needed linearly with the volume and production quality.

METHODOLOGY (Material and Method)

1. Type of Pozzolan

Pozzolan is a material containing silica or silica alumina and alumina oxide, which does not have binding properties like cement, but in the form of fine granular and in the presence of water, these compounds will react with calcium hydroxide at atmsophere temperature to form calcium hydrates that are hydraulic and have a relatively low solubility rate properties like cement but not dissolved in water.

The types of pozzolan in the process of formation in ASTM 593-82 is classified into two types, one is natural pozzolan and other artificial pozzolan. Source of natural pozzolan from volcano that produces active silica. As for artificial pozzolan, there are many kinds, product combustion from furnace, and the utilization of waste that processed into ash that containing silica reactive with through the combustion process, such as fly ash, rice husk ash, silica fume and others.

2. The Classification of Pozzolan

Pozzolan quality standards according to ASTM C618- 92a are classified into three classes, each class is determined chemical composition and physical properties. Pozzolan has a good quality if the number of levels of SiO2 + Al2O3 + Fe2O3 is high and have a high reactivity with lime. Pozzolan class are:

N: natural pozzolan or the product of combustion, natural pozzolan that classified in this type such as diatomoic soil, opaline cherts and shales, tuff and volcanic ash or pumicite, which can be processed through a combustion or not. Various material properties of combustion products that have a good pozzolan characteristic.

C: fly ash that produced from lignite burning or subbituminous coal. This fly ash has a pozzolan properties beside has the properties of cement with lime levels greater than 10%.

F: fly ash that produced from anthracite burning or coal. It has the properties of pozzolan fly ash.

3. Pozzolan Side Product from Crude Palm Oil.

Crude palm oil (CPO) with color yellow-white need additive to absorb impurities in CPO to

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be light colour. During a refining process involves degumming-bleaching and deodorization, generates plentiful of spent bleaching earth (SBE). Bleaching earth is a very fine powder and its main component is silicon dioxide (±57% and more depending on the type). It is prepared by treating montmorillonite clay (represented by $Al2O3 \cdot 4SiO2 \cdot nH2O$) with mineral acids and by eluting basic components such as aluminium, iron and magnesium.

In excess of 2 million tons per year (2014) of SBE is generated world-wide with major quantities available in the middle-east where significant volumes of edible oils are produced. Bleaching earth using in the pretreatment process which is used in the degumming and bleaching of crude palm oil stage, bleaching earth is added to produce refined palm oil, SBE is a solid waste that one of side products of crude palm oil refining process.

Bleaching earth has been used to absorb dark color matters and odor-causing substances in crude oil and vegetable oil. It is estimated that about 600,000 metric tons or more of bleaching earth was utilized worldwide in the refining process based on the worldwide production of more than 60 million tons of oils. The sustainable products extracted from SBE are shown in Figure 1.

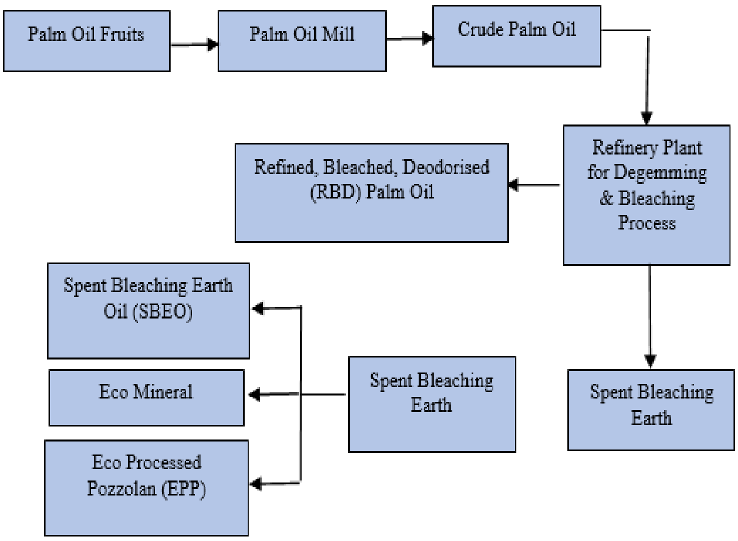

Figure 1. Production Eco Processed Pozzolan

RESULT AND DISCUSSION

1. Innovation from The Waste

Spent bleaching earth as disposal from refinery mill must be managed improved it to be useful thing. Innovation process must be applied to it. Consists of some material like silica, alumina and ferro can use as fertilize, adsorbent in water treatment, partial cement replacement and partial material in paving block.

2. Mechanic Thermal Analysis

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Concrete was used to make a variety of structures which you use every day. It was used to make pavements, building structures, foundations, high-ways/roads, overpasses, parking structures, brick/block walls and footings for gates, fences and poles. The composition of concrete was traditionally relatively simple. Cement was the main ingredient in concrete. Ordinary Portland cement was the most common cement in circulation, which was just a basic mix of mortar and plaster. Water was another ingredient in the manufacture of concrete. The water/cement ratio (mass ratio of water to cement) was the key factor that determines the strength of Concrete, this water and cement paste hardens over time, and both fine and coarse aggregates are added to provide bulk Widely used aggregates include sand, gravel and crushed stone

Some literature has studied about Eco Process Pozzolan Foamed Concrete (EPPFC) is the mixing of cement paste with preformed foam which EPP is used as replacement for cement. Previous study on foamed concrete utilize fly ash aggregates (Jones & McCarthy, 2005) stated that, with density of 1600 kg/m3 , the compressive strength for 30% foamed concrete utilize fly ash fine aggregates (FA fine) as cement replacement at the age of 28 days is 28 MPa. This indicates that foamed concrete in structural applications is a realistic proposition although it is unlikely that a direct substitution for normal weight concrete should be attempted.

Beside the strength of the Concrete has been studied, other property of concrete as flame retardant should be known. Concrete was naturally fire-resistant. Concrete buildings typically qualify for reduced fire insurance rates up to 60 percent less on fire and extended coverage for warehouses and storage buildings. Many accidents from fire in building or house, so concrete should expect to slow down propagation fire to other place. If fire does occur, concrete walls and partitions effectively divide the building into compartments, separating areas and limiting the amount of property damage.

Eva lubloy et al. experimented about fire resistance by using Portland-Pozzolona or Portland-fly ash cement. All type of specimen (cement paste and concrete specimen) were kept in water 7 days, then in laboratory condition for 21. In their experiments binary blended and ordinary Portland cements were involved: two Portland cement with different clinker compositions and three binary blended Portland cements containing trass or fly ash additives as replacement of clinkers. The test cubes of 28 days heated (heating rate was about 40°C min^{-1}, the cooling rate was 10°C/min) to the given temperature (50, 150, 300, 500 or 800°C) in electric furnace, then they were kept there 2 hours, after the 2 hour long thermal load, the specimen were removed from the furnace and cooled down in laboratory conditions to room temperature. As result thermal load, the relative residual compressive strength of concrete prepared from pozzolans and fly ash containing Portland-

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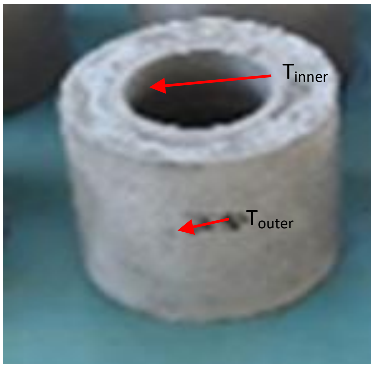
composite cement is higher or at least equal to those of concrete specimens prepared from Portland cement.

Umasabor and Okovido reported on fire resistance evaluation of rice husk ash concrete. The by-product of rice milling industry is called rice husk ash (RHA). When the rice husk is burnt, it produces relatively large proportions of ash which contains around 90% (Swamy, 1986). Its excellent pozzolanic properties are due to is high silica content. An experimental method was adopted as the research design about this work, concrete specimens with the addition of rice husk as in weighted percentages of 5%, 10%, and 15%. They were cured and tested at 7 days, 28 days, 30 days, 60 days, 90 days, 120 days, 150 days and 200 days. After the targeted curing days, the specimens were exposed to temperatures of 100ºC, 200ºC, 300ºC, 400ºC, 500ºC, 600ºC, 700ºC for 2 hours in muffle electric furnace. As conclusion from this study state that Original Portland Cement can be replaced with RHA pozzolans up to 15% by weight in the binary blended cement of grade 20 when cued up to 200 days without reducing it compressive strength. The 5% weighed RHA blended concrete still had advantage in compressive strength, over the OPC concrete when subjected to temperature up to 700ºC for 2 hours. Rice husk ash (RHA) can find its usefulness in industries where productions of fire insulating materials are of a great concern.

3 Result

This study involves data analysis covering the duration required to reach the set-point temperature and the temperature values observed for each sample. The OPC used is Portland-limestone cement produced by Cement Industries (SABAH) SDN BHD and EPP was collected from Ecooils, Lahad Datu, Sabah, Malaysia. The sample type has 2 types, and each type have 3 specimens. The furnace oven with setting 340˚C, was used to conduct the heating sample experiment. the temperature recorded was by using K-type dual channel thermocouple with thickness 1 inchi, where Tout at the outer wall and Tin is inner wall of the concrete. The data was taken using data logger software Artisan. Measurement will finish when T outer intersect with T inner.



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(a) (b)

Figure 2. (a) Specimen and (b) furnace oven

Each specimen, defined by its material composition and corresponding treatment, is designated as a distinct set as Table 2 below.

Table 2. Mixture and curing proportions of concrete

Type	Material		Sample			Curing
	OPC	FPP				
0 (Control)	100%	0%	01	02	03	28 days at atmosphere conditions
Z	70%	30%	Z1	Z2	Z3	28 days at atmosphere conditions

The results of the experiment on the samples, which underwent heating in a furnace oven, and the collection of parameters during the process, yielded the following data.

1. Analysis sample type O: O1, O2 and O3

Sample O1 intersected Tin with Tout at Temperature 297.2ºC and required time for 150 minutes.

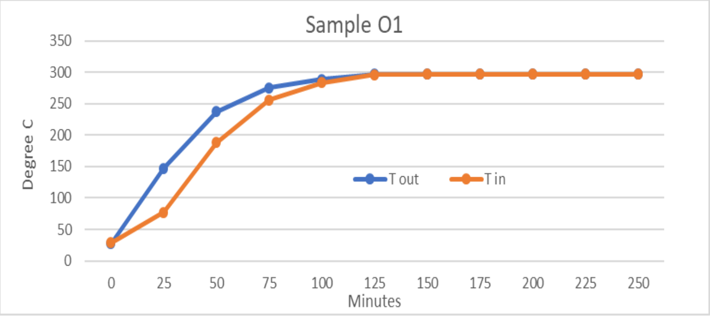

Figure 3. Temperature intersection and time required for sample O1

Sample O2 intersected Tin with Tout at Temperature 289.9ºC and required time for 215 minutes and 18 Seconds.

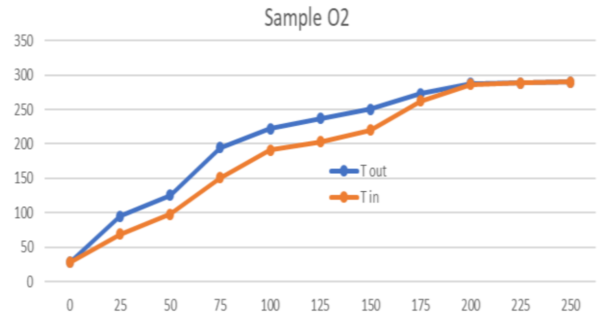

Figure 4. Temperature intersection and time required for sample O2

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Sample O3 intersected Tin with Tout at Temperature 292^{0}C and required time for 223 minutes and 58 Seconds.

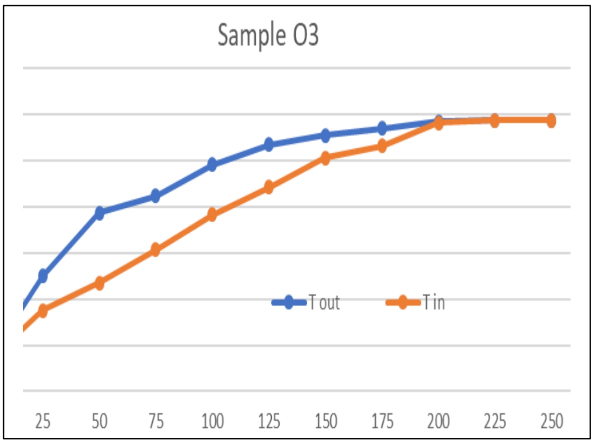

Figure 5. Temperature intersection and time required for sample O3

Average time required to reach the intersection of the inner and outer temperature both temperatures are same) for type O (specimen sample O1,O2 and O3) is 196 minutes at 293.1°C .

2. Analysis sample type Z: Z1, Z2 and Z3

Sample Z1 intersected Tin with Tout at Temperature 295°C and required time for 13757 seconds or 229 mins 17 sec.

Figure 6. Temperature intersection and time required for sample Z1

Sample Z2 intersected Tin with Tout at Temperature 253.1oC and required time for 14277 seconds or 237 minutes and 57 seconds.

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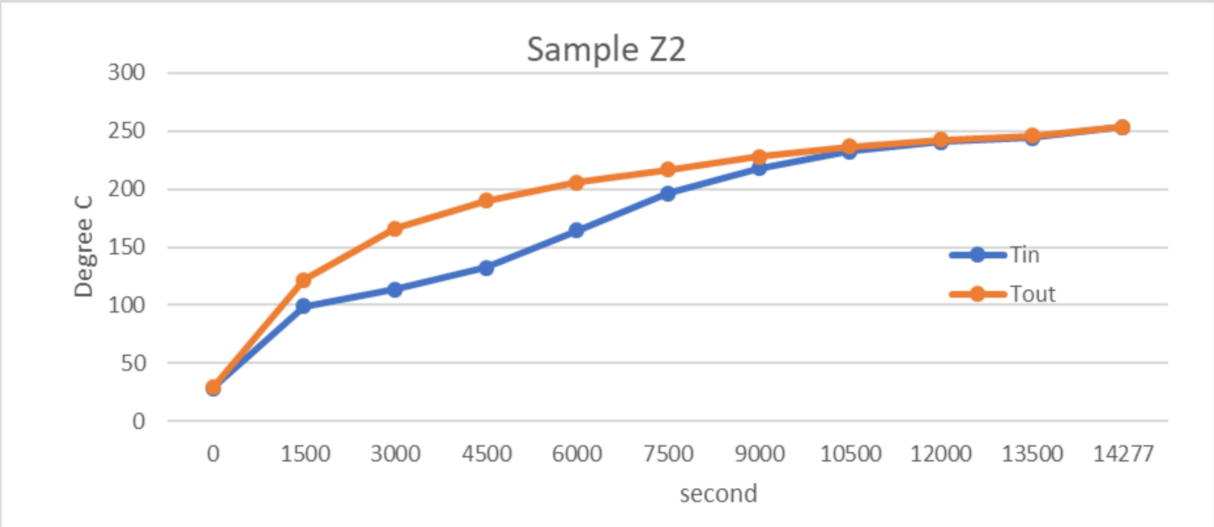

Figure 7. Temperature intersection and time required for sample Z2

Sample Z3 intersected Tin with Tout at Temperature 297.6oC and required time for 14310 or 238 minutes and 30 sec.

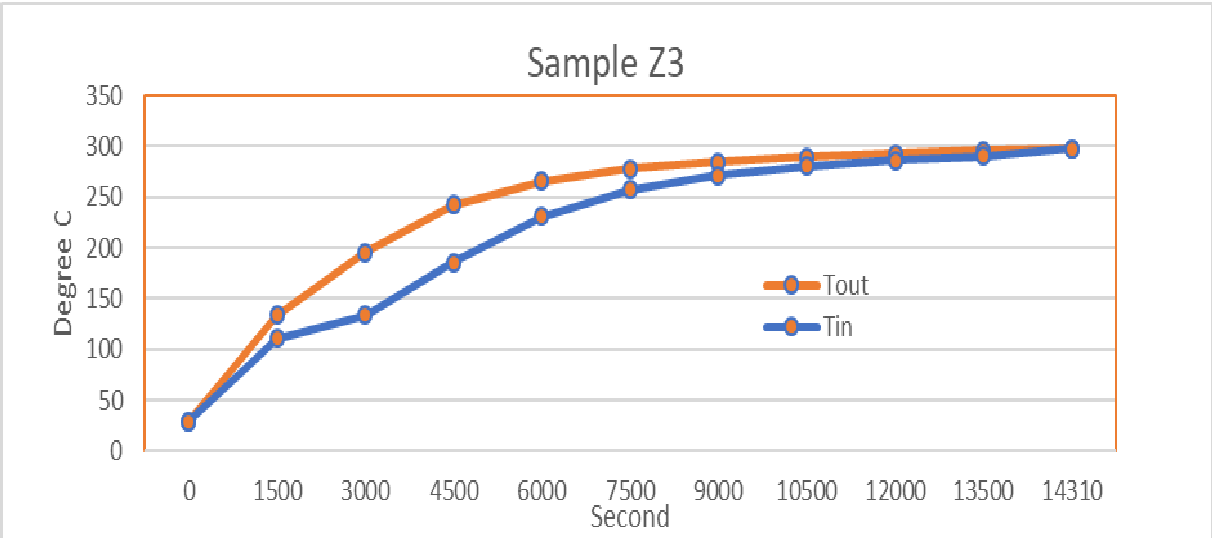

Figure 8. Temperature intersection and time required for sample Z3

Average time required to reach the intersection of the inner and outer temperature (both temperatures are same) for type Z (specimen sample Z1,Z2 and Z3) is 234 minutes at 281.9ºC. Average temperature intersection and time required for sample type A and B are presented in the following Table 3.

Table 3 Average temperature intersection and time required

Type	**Material**		**Average Temperature Intersection (Degree Celsius)**	**Average Time Required (Minutes)**
	OPC	FPP		
0 (Control)	100%	0%	293.1	196
Z	70%	30%	281.9	234

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Sample O (100%OPC) reaches a higher average temperature intersection (293.1°C) in a shorter time (196 minutes), suggesting it allows heat to pass through more quickly. Sample Z (70%OPC + 30 % EPP), on the other hand, reaches a lower temperature (281.9°C) and takes a longer time (234 minutes), indicating that it resists heat flow more effectively. Therefore, sample Z demonstrates better insulating properties because it delays temperature increase for a longer duration and reaches a lower final temperature, which are typical characteristics of a good thermal insulator.

CONCLUSION AND SUGGESTION

The conclusions that may be drawn from the present paper are set out below: Pozzolan can use as substitution OPC in blended concrete, its compressive strength and fire resistant are suitable as substituent OPC. Every pozzolan has characteristic its self. For optimum concrete performance, the percentage of cement substitution depends on the type of pozzolan and curing period and composition of aggregates.

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