Study of integrated treatment of used bleaching earth cake from lubricant oil recycling process

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Abstract. “Used Bleaching Earth Cake (UBEC)” is the bleaching earth which has been used and filter pressed from the lubricant oil recycling industry. Comprehensive treatment required to treat UBEC as hazardous waste. This research tested the physical and chemical characteristics of UBEC to acknowledge its potential as engine fuel, and then UBEC was combusted in rotary kiln as refuse derived fuel (RDF). The bottom ash from the combustion process was used as fine aggregate replacement in concrete K350 production, compressive strength and Toxicity Characteristic Leaching Procedure (TCLP) was analyzed. UBEC consists of bleaching earth material (Monmorillonite 53.3% and Klinoptilolith 40%), oil residue, and impurities (heavy metals, carbon residue, etc.). Its calorific value ranges from 3000 to 5000 calories and meet the standards for being used as RDF. The average compressive strength result by replacing fine aggregate with 0%, 5%, 10%, 15% and 20% of its ashes were 31.88 MPa, 34.15 MPa, 38.45 MPa, 37.66 MPa, and 36.69 MPa, respectively. The highest compressive strength was at 10% of replacement. TCLP results still meet the standard. Overall, UBEC can be use as RDF and its bottom ash can be safely use as replacement for fine aggregates in concrete K350 production.

1. Introduction
Activated bleaching earth extraction process has been used as “Green” alternative method for lubricant oil recycling to produce base oil in Indonesia. As for the definition activated bleaching earth referred to material derived from earth that is natural resources from mountain range in Indonesia. Local people called it clay rock as its physical resembles the ground, yellowish brown color, and can be found in mountains and hills at an altitude of 200-600 MASL (meters above sea level). This material was mined and activated by heating the material chips at temperature of 260-300°C, during 45 to 60 minutes. After that, material was mashed with crusher to be 200 mesh particles size. [1] Activated bleaching earth functioned to purify and absorb carbon and metal material in used lubricant oil. This material differs from bentonite material that commonly used to purify crude palm oil.

By extraction method with activated bleaching earth, used bleaching earth cake (UBEC) was produced as solid waste from the filter press final section. Comprehensive treatment required to treat UBEC as hazardous waste. UBEC production has significant amount, around 10-30% of production weight capacity per-day [1], for this amount to be disposed to landfill is surely expensive and inefficient considering that UBEC still has a lot of potential to be utilize.

Refer to UBEC’s characteristic, there are view alternative treatments that can be used to handle and maximize the utilities of UBEC. Therefore, the studied the potential alternative treatment of UBEC by using it as engine fuel (processing as refused derived fuel) and treat its ashes from the combustion
process to be utilized as a substitute material in concrete production in attempt to reduce amount of waste disposal.

2. Methodology

2.1 Characterization

UBEC is solid waste product from this production scheme shows in Figure 1. To determine the suitable treatments therefore characteristic of UBEC should be known in advance. For this study, value, proximate, sulfur, chlor and heavy metals content were analyzed.

![Figure 1. Oil recycling production scheme](image)

2.2 Proposed treatment scenario

After determining and analyzing UBEC characteristic, the propose to use the treatment for UBEC as an alternative fuel for rotary kiln and its bottom ash will be use as replacement for fine aggregate in concrete. By processing UBEC as a Refused Derived Fuel (RDF), we expect that the lubricant oil that still included may be omitted and its calorific value can be utilized as an alternative source of energy. Bottom ash that was produced per-day has sufficient amount to be collected and used again. The selection of the use of bottom ash as a substitute for fine aggregate on the concrete was based on the characteristics of activated bleaching earth and the related literatures.

2.3 Bottom ash residue characterization

Bottom ash that has been mashed was tested to find the characteristic of its composition with X-ray Diffraction (XRD) analysis. The specific gravity and water absorption were also being tested.
2.4  **Compressive strength test**

Dependent variables of this study are the value of compressive strength in variation of time of 7, 14, 21 and 28 days. Controlled variable of this study are dimensional sample of concrete cylinder with 15 cm of diameter and 30 cm of height, and also the conditioning of compressive strength test according to the SNI 1974: 2011.[2] Independent variable of this study is the composition variation in concrete mixture.

The composition of the concrete-making of “control” sample follows the composition of cement, fine aggregate and coarse aggregates to produce the quality of K350 concrete according to SNI-7832-2012 which has target of compressive strength of 31.2 MPa and slump value of 12 ± 2. [3] For variation of fine aggregate replacement percentage in concrete mixture was determine with 5, 10, 15 and 20%.

2.5  **TCLP**

The Toxicity Characteristic Leaching Procedure (TCLP) is the most widely used leaching test method based on the United States Environmental Agency (EPA) Regulatory 1311 to determine the mobility of both organic and inorganic analyzes present in liquid, soil and municipal wastes. Leaching solution of acetic acid is use to simulate co-disposal of industrial and non-industrial waste in a municipal solid waste landfill and the solid wastes samples can be deemed hazardous or non-hazardous based on the concentrations of the TCLP constituents and guidelines [4]. In this paper we only analyze 7 of inorganic parameters.

3.  **Result and discussion**

3.1  **UBEC characteristic**

Based on the characteristics listed in Table 1 and compared with the criteria of the various standards, it can be determined that UBEC can be used as RDF. However, the ash content on RDF is still high enough that it is still necessary to determine the further processing to process and manage the ash. High ash content in fuel will reduce the thermal efficiency of the coal. As high ash content in fuel may reduce the combustion efficiency and increasing the burning time [7].

| Parameters      | Units   | UBEC  | Eugeniusz M et al (2003)[5] | EURITS[6] | Italy[6] |
|-----------------|---------|-------|-----------------------------|-----------|----------|
| Moisture Content| % wt/wt | 1,08  | ≤ 20                        | -         | ≤ 25     |
| Heat Content    | Kal/g   | 4141  | ≥ 3750                      | 3585      | 3585     |
| Sulfur          | % wt    | <0,005| ≤ 1                         | -         | 0,6      |
| Chlor           | % wt    | <0,005| ≤ 0.75                      | -         | 0,9      |
| Ash Content     | %       | 56,02 | 5                           | 20        |
| Arsen           | mg/kg   | 6,25  | 10                          | 9         |
| Lead            | mg/kg   | 16,5  | 200                         | 200       |
| Chrom           | mg/kg   | 7,23  | 200                         | 100       |
| Cadmium         | mg/kg   | <0,08 | 10                          | 7         |
3.2 Bottom ash residue characteristic

![UBEC XRD result](image)

Based on XRD results in Figure 2, it is known that the Bottom Ash compilers of UBEC combustion consist of Cristobalite beta high 48.56%, Trydimite 31.90% and Berlinite 13.55%. However, that also seen from the constituent oxide chemicals known to consist of SiO$_2$ 73%, AlPO$_4$ 15% and Ca(OH)$_2$ 11%. Trydimite and Cristobalite formed from SiO$_2$ material combustion, where Trydimite is formed at $>870^\circ$C and it converts to Cristobalite at temperatures $1470^\circ$C [8]. UBEC's bottoms ash have a high SiO$_2$ content when compared to sand as fine aggregate. This bottom ash also has a specific gravity of 2.4 gm/cc and water absorption of 2.4%. It has been reported that natural aggregates have specific gravity between 2.6 and 2.8 gm/cc [9]. The specific gravity of bottom ash is less than the specific gravity of sand but higher than trydimite’s and cristobalite’s specific gravity (i.e. 2.3 gm/cc) [8]. It may caused by the mixture of berlinite in the composition which has specific gravity of 2.66 gm/cc [10]. Based on this criteria although bottom ash specific gravity and water absorption is not simmilar with sand is still scan be used as a substitute for fine aggregate as light weight concrete.

3.3 Compressive strength test

Compressive strength of the specimen was calculated by dividing the maximum compressive load taken by the specimen by its cross-sectional area. Values of compressive strength at different percentage of replacement at different times are as given in Table 2 and Figures 3.
Table 2. Compressive strength test result

| Days   | Control | 5% Rep | 10% Rep | 15% Rep | 20% Rep |
|--------|---------|--------|---------|---------|---------|
| 0 day  | 0,00    | 0,00   | 0,00    | 0,00    | 0,00    |
| 7 days | 26,78   | 26,29  | 29,06   | 28,55   | 27,93   |
| 14 days| 29,24   | 30,34  | 33,40   | 30,47   | 31,16   |
| 21 days| 31,16   | 32,32  | 35,49   | 34,33   | 33,15   |
| 28 days| 31,88   | 34,15  | 38,45   | 37,66   | 36,69   |

Figure 3. Compressive strength test result

From the tables 2 we can see that the average compressive strength result by replacing fine aggregate with 0%, 5%, 10%, 15% and 20% of its ashes in 28 days curing period were 31.88, 34.15, 38.45, 37.66, and 36.69 MPa, respectively. The highest compressive strength was at 10% of replacement. Replacing sand composition with bottom ash residue from UBEC combustion up to 20% replacement may increase the compressive strength. It is also indicates that concrete in K350 quality is obtained with 5-20% of fine aggregate replacement.

From Figures 3, the strength gain of the paving blocks increases with the age, for all the replacement levels. For the age of 28 day, the rate of change of compressive strength with respect to control block, for 5%, 10%, 15% and 20% replacement level is about 7%, 20%, 18% and 15% respectively.

Table 3. TCLP result

| No  | Parameters             | Units | 10% Replacement | UBEC |
|-----|------------------------|-------|-----------------|------|
| 1   | Lead, Pb               | mg/L  | < 0,1           | < 0,01 |
| 2   | Cadmium, Cd            | mg/L  | 0,03            | < 0,03 |
| 3   | Copper, Cu             | mg/L  | < 0,03          | < 0,03 |
| 4   | Crom Heksavlen, Cr6+   | mg/L  | < 0,03          | < 0,03 |
| 5   | Zinc, Zn               | mg/L  | 0,40            | 0,76  |
| 6   | Floride, F-            | mg/L  | 0,40            | 0,13  |
| 7   | Chloride, Cl           | mg/L  | 11              | 3,1   |
3.4 TCLP
TCLP test was conducted on the sample of UBEC and 10% bottom ash of UBEC combustion as fine aggregate replacement which has highest value of compressive strength. From TCLP result in Table 3 we can see that all parameters that were tested met the regulatory standard from PP 101:2014 [11]. Chloride and fluoride may get higher from UBEC because of its mixture with cement.

4. Conclusion and recommendation
In conclusion, UBEC can be used as alternative fuel for Rotary Kiln. Bottom Ash residue from its combustion needs further treatment to be used as replacement of fine aggregate in concrete mixture. From concrete compressive strength test, the highest compressive strength value occurred in 10% of replacement of fine aggregate. From concrete sample, TCLP result was below the threshold of regulatory limit value, considering its safety to be use for the environment.

We recommend conducting combustion emission test of rotary kiln to ensure its emission quality to meet regulatory standard. Further study for concrete strength in more curing days needed to ensure that there is no decline of its strength. Other parameters for concrete standard of quality should be conducted.

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