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PRELIMINARY STUDY OF THE UTILIZATION OF ASH WASTE FROM POWERPLANTS TO PRODUCE ARTIFICIAL LIGHT WEIGHT AGGREGATES

(Studi Awal Penggunaan Abu Limbah dari Pembangkit Tenaga Listrik untuk Memproduksi Agregat Berbobot Ringan)

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Abstract

A large amount of disposed ash can cause severe environmental pollutions especially in large coal fired electric powerplants. One of many methods for reducing its negative impacts is to utilize the waste to produce ALWA (artificial leight weight aggregates) which is required to make light concrete for building constructions. However thorough researches have to be conducted first to find out the proper process conditions for ALWA production from fly ash and bottom ash of Indonesian coals. The investigated process conditions are the mixture composition of required raw materials and the sintering conditions (e.g. temperature, duration, etc.). Moreover, an equipment to mix raw materials homogeneously and to produce other shapes of ALWA, which may be better than the existing shapes, must be built during the research. The last objective of the research is characterizing the physical and mechanical properties of the ALWA and some prototypes of light concrete made from the ALWA. It is expected that both the ALWA and the light concrete can satisfy the quality and specifications determined by existing standards.

Key words: ALWA, aggregates, ash

Abstrak

Abu yang terbuang dalam jumlah besar dapat menyebabkan polusi lingkungan, terutama abu yang berasal dari batubara yang terbakar untuk keperluan pembangkit tenaga listrik. Salah satu dari berbagai metode untuk meredusir/mengurangi dampak negatif adalah dengan menggunakan limbah untuk memproduksi ALWA (artificial light weight aggregates) yang diperlukan untuk membuat beton ringan untuk konstruksi bangunan. Tetapi, riset secara menyeluruh harus dilakukan untuk menemukan kondisi proses yang benar untuk produksi ALWA yang berasal dari abu yang berterbangan dan abu yang ada di dasar yang berasal dari batubara Indonesia. Kondisi penelitian proses adalah campuran dari komposisi material mentah yang diperlukan serta kondisi sintering (suhu, durasi dsb.). Tambahan lagi, suatu peralatan untuk mencampur material mentah secara homogin dan untuk memproduksi berbagai bentuk ALWA, yang mungkin lebih baik dari bentuk yang sekarang ini ada, harus dibuat selama penelitian. Tujuan terakhir

bentuk ALWA, yang mungkin lebih baik dari bentuk yang sekarang ini ada, harus dibuat selama penelitian. Tujuan terakhir penelitian ini adalah mengidentifikasi karakter dari fisik dan mekanik ALWA dan prototype beton ringan yang dibuat dari ALWA. Diharapkan bahwa ALWA dan beton ringan dapat memenuhi kualitas dan spesifikasi dari standard yang ada.

Kata kunci: ALWA, agregate, abu

INTRODUCTION

In order to respond to the rapid growth of electrical energy demand, some large scale electric powerplants have been erected. Although there are several kinds of fuel available for energy conversion process in these powerplants, economic considerations have dictated to utilize coals. However, a large amount of disposed coal ash can cause severe environmental pollutions and negative health effects especially in the vicinity of the powerplants. The larger the power output, the more amount of coal consumed and consequently the more serious the hazard. The idea of establishing some mine mouth powerplants is certainly a proper solution of the problem. However in Indonesia it will apply mostly for powerplants of the future, since existing large powerplants are situated away from coal mines and relatively close to settled areas. One of many other methods for reducing its negative impacts is processing the waste to produce ALWA (artificial light weight aggregates) which is required to make light concretes for building constructions. In this way coal ash is no longer waste, but a kind of inexpensive raw material which can reduce the production cost in concrete making industries. Therefore, powerplant management do not have to spend money to „hide" the coal ash, but earn a little bit money from sale of the material. One example of strong efforts to cope with coal ash waste has been shown by an electric powerplant management which ordered and supported several surveys on the characteristic identification and prospective utilization of coal' ash waste, on the production and feasibility study of light building materials (e.g.: light concrete tiles), instant dry mortar, and PPC (Pozzolan Portland Cement). All of those are partly composed of coal ash (Suhanan et al., 1999).

Actually some nearly similar researches on ALWA production have been conducted, for example by Kashi et al. (2001) and Nishiwaki (2002), but probably the results were not appropriate for ash of specific coals. Therefore the planned research aims to find out the proper process conditions for ALWA production from disposed fly ash and bottom ash. The investigated process conditions are mainly mixture compositions of required raw materials, shape and dimension of pre-sintered materials, and sintering conditions (e.g. temperature, duration, etc.). An extruder to mix raw materials homogeneously and to produce various shapes of ALWA, which may be better than the existing shapes, and also a heating rotary kiln must be built for the research. The final activities of the research are characterizing the physical and mechanical properties of the ALWA and some prototypes of light concrete made from it. It is expected that both the ALWA and the light concrete can satisfy the quality and specifications determined by existing standards, so that people are going to utilize ALWA and light concrete without any doubt because they are not only technically and economically better, but also environmentally friendly (UKQAA, 2002).

RESEARCH METHODOLOGY

Materials

The main material is coal ash (both fly ash and bottom ash) disposed from a coal-fired electric powerplant. The auxiliary materials are clay, coal powder and ordinary water which serves as binder

Moreover an additive may be required.

Equipments

Some important equipments that will be required to carry out the research are :

- A laboratory scale rotary kiln designed up to 1100 ^{0}C for sintering green ALWAs (pre-sintered ALWAs). The required thermal energy is supplied from the combustion of LPG-gas.
- A specifically modified extruder which consists of two stages of screw extruder. The first stage is equipped by rollers to ensure good mixing and the second stage is equipped by a specific die to produce a specific form of ALWA.
- An electronic scale (balance)
- A compression strength testing apparatus

Procedures

The following are the procedures conducted in this research.

- Chemical and mineralogy identification of coal ash waste by using AAS and XRD equipments.
- Proper design of an extruder to ensure good mixing and good formability in producing green ALWAs.
- Determining the best mixture of raw materials.
- Production of specific shapes of green ALWAs with the help of the extruder.
- Sintering the green ALWAs in the rotary kiln. The investigated variables during the process are mainly : Process temperatures and durations, Shapes and Dimensions of the sintered materials, etc.
- Identification of the produced ALWA properties (e.g.: compression strength, specific gravity, etc.). The results of the identification can be used to determine the best process condition.
- Production of light concrete prototypes composed from the best ALWA and then identification of its quality.

The block diagram for producing ALWA is shown in Fig. 1.

PRELIMINARY RESEARCH ACTIVITIES

Some activities and achieved results during the early period of the research are reported in the paper.

Both fly ash and bottom ash from an electric powerplant in the East Java have been collected and tested. The tests are mineralogy test (with the help of XRD equipment) and chemical test (by using AAS equipment).

The result of the chemical test is shown in the following Table 1.

The extruder and rotary kiln are still in the esign phase, meanwhile during the preparation of the research some results of preliminary ALWA production using existing old type equipments can be observed and discussed. The preliminary ALWA production serves merely as a useful reference to the more seriously conducted research later, for example drawbacks of old equipments can be detected and efforts should be made to design new problem-free equipments.

The preliminary ALWA productions are carried out by varying the compositions of fly ash, clay and pulverized coal, and then heating the green ALWAs with the temperature of 1000 °C for 60 minutes in a stationary oven. Finally the products are examined to find out their compression strengths.

Table 1 : Composition of Coal Ash Waste

Composition	Fly ash Weight %	Bottom ash Weight %
SiO_2	58.91	60.44
Al_2O_3	19.35	18.18
Fe_2O_3	3.97	3.67
CaO	8.65	5.94
MgO	3.79	2.25
Na_2O	0.67	0.51
K_2O	0.62	0.31
MnO	0.28	0.14
TiO_2	1.13	0.98
P_2O_5	0.31	0.32
H_2O	0.47	0.90
LOI	0.98	5.76

The following Table 2 shows the result of the tests.

The graphical results are shown in Figure 2.

RESULTS AND DISCUSSIONS

The experimental results have indicated the following facts :

1. More fly ash content (from 75% to 80%) causes substantial reduction of compression strength. In this case, more fly ash content will increase the porosity of ALWAs, reduce their density and therefore their compression strength.
2. However if more fly ash is still added (from 80% up to 90%) the compressive strength will increase slightly, because the solid bond (which has been developed during the sintering process) among fly ash particles is stronger than those between fly ash and clay particles. It means that more clay will even weaken the ALWA.
3. More pulverized coal content (from 5% to 15%) causes significant reduction of compression strength due to increased void fractions within the ALWA left by burned / gasified coal. The ALWA will be less compact.
4. However if more powdered coal is still added (from 15% up to 20%) the compressive strength will increase again, because more reaction heat can be generated within the ALWA which then supports better sintering process. As a result, stronger solid bond among particles can be obtained.
5. There are two competing factors which influence the strength of ALWA. These are : interparticle solid bond and porosity. The more dominant factors between those two will determine whether the ALWA can be stronger or weaker.

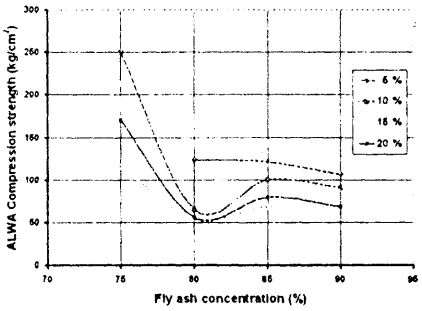

Figure 2. Compression strength vs. Fly Ash concentration

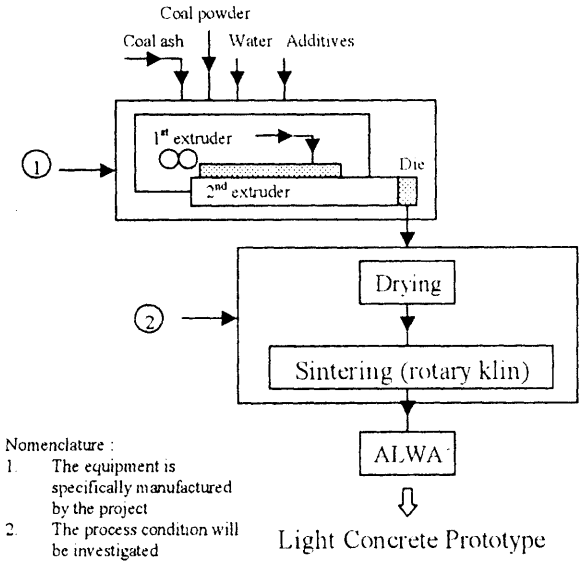

Figure 1. Block diagram for producing ALWA

Table 2 : Compression Strength (kg/cm^2) as A Function of FA (Fly Ash), Clay and Coal Concentration.

FA and Clay (mass-%)	5 % coal	10% coal	15% coal	20% coal
90% + 10%	106.13	90.84	67.93	83.85
85% + 15%	121.36	99.97	68.35	79.53
80% + 20%	123.74	65.29	54.38	55.88
75% + 25%	---	249.77	115.71	170.32

SUMMARY AND CONCLUSIONS

1. It is possible to produce ALWA from ash waste with significant compression strength which is sufficient to be used as construction materials.
2. Thorough mixing and uniformly applied heating are highly required to obtain good results.

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