MARBLE WASTE AND FLY ASH UTILIZATIONS FOR FINE CERAMIC RAW MATERIALS

SUBARI and SURIPTO
Centre for Ceramics
Jalan Jenderal Ahmad Yani 392 Bandung

ABSTRACT

The possibility of using marble waste and fly ash taken from a textile industry as raw materials for producing fine ceramics was studied. Besides those two materials, clay was also used as the formed agent for ceramic body. There were four compositions noted as T1, T2, T3 and T4 that consist of marble waste 10 %, fly ash 10 – 25 % and clay 65 – 80 %. They were formed by the method of slip casting.The tests pieces of these fine ceramic bodies were then fired at temperature of 600 °C. The glaze were applied to the bodies and further fired at temperature of 1150 °C in a gas kiln. Characterization results of those four composition tests show that the composition of T2 (70 % of clay, 10 % of marble waste and 20 % of fly ash) gives the best result.

Keywords : Ceramic, marble waste, fly ash

INTRODUCTION

The role of mineral resources in Indonesian economics gives significant contribution. These materials are grouped into metallic and non-metalic minerals or known as industrial minerals. The metallic minerals have been exploited, especially for heavy industries, while the industrial minerals are still limited to be exploited. In contrast, the request of the product made from industrial minerals increases in the last decade. In order to solved this problem, it needs to be thought some various alternatives to fulfill the demand.

Marble wastes in the form of marble ash are obtained from processing factory of marble using block cutter or from the result of comminution process using jaw crusher and ball mill until the particle size around 800 µm. Processing marble means changing form and dimension from natural marble by means of cutting and refining and glossing the surface color. Gloss color generally starts from light until dark.

Processing step activity of marble stone consists of loading processes of marble block to block cutter, sawmill, smear, formatting and finishing. The color of marble may vary depend on minerals in it, for example the pure calcite marble having white color, but with existence of graphite mineral and pyrite will give grey color, while hematite mineral will cause pink color.

Marble waste sampling was conducted in Citatah area, Bandung. The location can be reached from Bandung around 30 minutes by car. The distance between Citatah - Cianjur is 30 km.

Fly ash is an inorganic material that usually is rejected in coal utilizing because of some internal issues in preparation, handling and. Besides low characteristics in calorific value, the ash can be formed clinker that reduces industrial efficiency of exploiting of coal especially in using of direct combustion process. Air and water pollutions can be resulted from ash. The problem occured due to planning and way in coal exploiting industry as well as depend on the fly ash characteristics it self.

Fly ash was sampled in a textile company namely PT. AYOUTECH, that locates in Bandung.The fly ash from textile industry comes from a grille. Ash residue will fall from tip grille and directly be accumulated in ash basin. The fly ash from that company still become waste materials, and only small part of used by surrounding people as a brick component.

Received : 22 October 2009, first revision : 26 February 2010, second revision : 10 May 2010, accepted : June 2010

Main raw material for ceramic making is clay. It can be obtained in West Java, such as Ciamis, Tasikmalaya, etc. According to Singer et al (1992), the clay is a fragment of alluvial rock and mineral either smaller than 200 mesh or < 1/256 mm and has plasticity character and toughness in wet condition. It is also hard and fragible in dry condition.

Research purpose is to utilize marble waste from cutting industry and fly ash from textile industry resides in District of Bandung as components to produce fine ceramics (in this case decorative/art ceramics) in terms of goal obtaining accurate information about the elegibility both materials as fine ceramic component.

METHODOLOGY

Method applied in this research covers some steps like sampling and sample preparation, comminution process, screening, specimen making, chemical analysis, examination of water absorption and examination of density.

Sample Preparation

Samples used in this research were marble wastes, fly ashes and clays. The material must be passed through 100 mesh sieve and then was added with water as a solvent. Total materials of the samples were about 4 kg. Chemical material that usually used was water glass or sodium silicate (Na_4SiO_4 - $Na_2ONa_2SiO_3$). Using this material, the mixture can easily be thinned and dissolved so that the material will perfectly mix.

Ceramic Specimens Composition

Specimen composition are designed for 4(four) various mixtures each composition weight is around 4 kg. Table 1 shows 4 composition of this prospects. Sarkar et al (2003) states that fly ash for ceramics should be around 20-25 %. However, the fly ash in this experiment is about 10 – 25 %.

Compositions design of the mixture are made in a special manner in order to obtain the best material of fine ceramics that will give a good shape at the time of casting or press by hydraulic pressing machine. Before obtaining the marble waste, the block of marble is crushed and then is milled to a finest particle. Subsequently, the fine grain are sieved using 100 mesh size sieve. Equipments used in crushing and milling are jaw crusher and ball mill.

Table 1. Design composition of the fine ceramic specimens

No	Materials	The composition of fine ceramics (%)			
		T_1	T_2	T_3	T_4
1	Clay	65	70	75	80
2	Marble waste	10	10	10	10
3	Fly ash	25	20	15	10

Specimen Preparation

Specimen to examine the shrinkage, water absorption and specific gravity of the ceramic had been made in order to get the proper composition and standard for fine ceramic making. The specimen was made by casting and also pressing method using pressing machine.

a. Casting method

Materials which has been prepared for each composition (clay, marble waste, fly ash and water glass) were added water sufficiently and then mixed by milling equipment, for approximately 30 minutes until homogen. The mixture is poured into the mould fot ± 1 hour to avoid sticky character until it is solids enough to be take from the mould. Let the material in ambient temperature during one day until dry. Dry specimens then fired at 600 °C (biscuit firing). The glaze is the applied to the specimen of fine ceramic and fired at 1150 °C (Norton,1970). Same procedure is conducted to each composition of mixtures.

b. Pressing method

The materials were packed into the press bed. Let the material in a few seconds then take it slowly and dried by sunlight for one day. The specimen is burned to biscuit firing at 600 °C and the glaze is applied according to the color wanted. The specimen then fired at 1150 °C.

Specimens Characterization

- Chemical analysis
  Conducted to get information regarding oxide composition of the material.

Analyzed the parameters of the specimen consist of:

- Water absorption
  The formula for calculating of water absorption is :

  WA = (B – A)/A x 100 %,

  whereas :
  A = specimen weight in a state of dried;
  B = specimen weight in a state of wet, gram.

- Density
  The formula for calculating of density is :

  Ds = SW/SV

  whereas :
  SW = specimen weight, gram
  SV = specimen volume, cm^3.

- Shrinkage
  Shrinkage is conducted to know the level of length differences from a dry specimen before and after firing. Length of dry specimen before firing is measured (Tb cm) and then is packed into the kiln, fired at 1150 ^{0}C for about 6 hours. After cooling periode specimen length is measured (Ta cm). The percentage of shrinkage is :

  (Tb – Ta)/Ta x 100 %.

RESULTS AND DISCUSION

Comminution Process and Screening

Comminution process gets the size of 4 - 200 mesh (2.36 – 0.075 mm). However, for this purpose the desired size should be passed 100 mesh sieve.

Analysis

Result of chemical analyses can be seen in Table 2.

Table 2. Chemical analysis result of raw material for ceramics

Oxides, %	Marble waste	Fly ash	Sukabumi Clay
SiO_2	21.37	65.36	66.48
Al_2O_3	3.92	19.89	18.32
Fe_2O_3	1.23	6.02	1.48
TiO_2	1.36	1.90	0.87
CaO	40.65	3.59	1.49
MgO	6.98	0.68	0.79
Na_2O	1.34	0.63	0.48
K_2O	1.61	0.72	1.45
LOI	21.43	1.13	8.59

Table 2 shows that the ash contains less than 10 % of CaO. This meaning that material can be utilized for fine ceramics such as pottery and decorative ceramic (Subari et al,1997). Marble waste is dominated by silica (SiO_2), calcium oxide (CaO) and loss of ignition (LOI) while dominant compounds with fly ash are silica (SiO_2) and alumina (Al_2O_3). The dominant element with clay are silica and alumina. Silica, alumina and a small portion of calcium oxides seems dominating own material composition for fine ceramic. When such dominant compounds are fired at high temperature (around 1150 °C) they will form mullit and cristobalyte mineral, results in firm ceramics (Vicira et al, 2005).

These compositions can be made for ceramic tile bodies and hollow clay bricks. Batch composition of hollow clay bricks are 30 – 40 % fly ash and 60 – 70 % clay, while the batch composition for ceramic tile bodies are 15 – 30 % $CaCO_3$ sludge which is taken from marble waste, and 70 – 85 % clay. Both products are fired at 1100 – 1150 ^{0}C (Xuanye Zhan et al, 2005).

Water absorption

Result of water absorption analyses is shown at Table 3.

Table 3. Result of water absorption analyses

Code	Dry weight (A gram)	Wet weight (B gram)	Water absorption (%)
T.1	96.31	107.65	11.77
T.2	194.20	213.16	9.76
T.3	65.74	72.53	10.32
T.4	206.24	230.70	11.85

As shown in Table 3, water absorption with specimen ranges from 10 - 15 %, so that the specimen can be categorized in fine earthenware. Ceramic

products in this group include kitchen wares, art ceramics and table wares. Ceramic bodies are commonly classified by their water absorption as shown in Table 4 (Mishulovich et al, 2003).

Table 4. Classification of ceramic bodies

Type of body	Water absorption, %
Non vitreous	> 7.0
Semi vitreous	3.0 – 7.0
Vitreous	0.5 – 3.0
Impervious	< 0.5

Based on Table 4, ceramic bodies can be classified as non vitreous body because its water absorption is more than 7.0 % but it is still can be used for fine ceramics like art ceramic or decorative ceramic.

Density

Result of density analysis from is described in Table 5.

Table 5. Result of density analysis

Code	Dry weight (g)	Volume (cm^3)	Density (g/cm^3)
T.1	194.20	100	1.942
T.2	96.31	110	0.875
T.3	65.74	50	1.314
T.4	206.24	120	1.718

From Table 5, average density of the specimens is less than 2 g/cm^3. This indicates that the specimen is categorized into light material type.

Shrinkage

Examination of shrinkage is conducted to shrinkage specimens before and after firing. The results is described at Table 6.

There is significant difference results between T1, T2 and T3, T4 (Table 6) due to existence of the differences in bending strength, the owned by the object as a consequences of specimen mixture composition. In addition, the clay content in T1 and T2 is less than T3 and T4, but the fly ash content on composition T1 and T2 more than from composition T3 and T4.

Table 6. Result of shrinkage

Code	Length before firing (Tb), cm	Length after firing (Ta), cm	shrinkage, %
T.1	14.10	13.60	3.546
T.2	10.20	9.80	3.921
T.3	6.20	5.70	8.064
T.4	5.30	4.80	9.433

CONCLUSIONS AND SUGGESTION

Conclusions

Clay, marble waste and fly ash are dominated CaO, SiO_2 and Al_2O_3. If this materials are fired at high temperature around 1150 °C, it will be formed mullite and cristobalyte, causing ceramics product has dense character.

Based on water absorption analysis, all tested materials are classified into fine ceramics (earthenwares). The value of water absorption is between 10 - 12 %. Density analyses shows that the average material has density below 2 g/cm^3, the product is grouped into the light weight ceramics.

Of the four compositions mixtures, T2 that contains 70 % of clay, 10 % marble waste and 20 % fly ash is the best ceramics product.

Suggestion

It is suggested that:

– The material for ceramics must perfectly be well mixed and homogen in order to obtain the best product;

– To mix materials less than 10 kgs, it is better be conducted mechanically using a laboratory scale mixer instead of ball mill.

REFERENCES

Kostic-Pulek A., Marinkovic S., Simonovic B., Popov S., Trifunovic P., 2007. Investigation of the Possibility of Reutilizing Wastes from Thermal Power

Plants, *Interceram, Vol.56 No.4*.

Mishulovich A., Evanko J.L., 2003. Ceramic Tiles from high carbon fly ash. *International Ash Utilization Symposium*, Center for Applied Energy Research – University of Kentucky

Norton, F.H., 1970. *Fine Ceramics Technology And Applications*, Mc Graw Hill Book Company, New York.

Sarkar R. and Das S.K., 2003. Porous Ceramic Tiles From Industrial Solid Waste, *Tile & Brick International, Vol 19 No. 1*.

Singer F and FS Sonya, 1992. *Industrial Ceramics*. Chapman and Hall, London.

Slamet, Retno, 1998. *Hasil Pengujian Sifat-Sifat Abu Batubara Muara Tiga Bukit Asam*. Direktorat Jenderal Pertambangan Umum, Pusat Pengembangan Teknologi Mineral, Bandung.

Subari, Sagala, M. dan Edwin, F., 1997. *Pembuatan Keramik Basalt Stoneware Dari Bahan Baku Utama Pasir Galunggung*. Balai Besar Litbang Industri Keramik, Bandung

Vicira C.M.F., Sanchez R. and Monteiro S.N., 2005. Microstructure Evolution in Kaolinitic Clay as a Function of Firing Temperature, *Interceram, Vol. 54, 4 July*.

Xuangnye Zhan and Guansheng Lu, 2005. Investigation of application Possibilities for High Calcium Industrial Wastes in Bricks, *ZL Magazine, November 2005*.