UTILIZATION OF SOLID WASTE (FLY-ASH) AND RUBBER LATEX MIXED WITH CLAY AND ACID SOLVENT TO PRODUCE CONCRETE BRICK USING SOLIDIFICATION PROCESS

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ABSTRACT

The use of coal as a fuel for steam power plants (PLTU) in the mine is increasing along with the increasing demand of electricity from manufacturing and household industries. The optimization of coal combustion in steam power plants has a negative impact on the environment due to increased of solid coal ash containing hazardous and toxic materials). The use of coal as a raw material for steam power plants leaves approximately 30% ash which is discarded and unprocessed as waste. This encourages researchers to use coal ash to make concrete bricks in more economical and efficient way. In order to make concrete bricks more solid and lightweight, sap rubber mixer which is widely produced in the area of southern Sumatra, was used as a mixture. Rubber prices are not aligned to rubber farmers where the price of rubber is regulated by the rubber market trader so the price is very low. Thus, it is also one of the solutions to diversify the potential of rubber products other than rubber for the tire and automotive industries. The objective of this research is to know the compressive strength of concrete brick with modulus of rupture parameters, cold crushing test of bricks and absorption of bricks according to Indonesian National Standard (SNI); and the amount of acid solvent of ants as rubber clotting. Composition of rubber latex and coal fly ash as follows: 300: 700; 400: 600; 500: 500; 400: 600; 700: 300 with an acid solvent such as: 15ml; 20 ml and 30 ml. The highest MOR and Cold Crushing test values were obtained on the ratio of abubara and 500: 500 rubber glues and the lowest MOR and Cold crushing test values were 15.117kgf / cm2 and 50 kgf / cm^2 while the lowest absorbency in the 500: 500 composition.

Keywords: latex, fly ash, formic acid, brick, B-3 waste

INTRODUCTION

Steam Power Plant using coal as an energy source. The result of coal combustion at the power plant in addition to producing energy, it will also produce combustion byproducts such as fly ash. In the industry, fly ash is discarded I and unprocessed. This can have a negative effect on the environment if left in large quantities because it contain heavy metals. Thus, the coal waste is in need of further processing to avoid pollution to the environment, namely the solidification method (compaction).

Coal fly ash is a material which has a grain size that has grayish color and is obtained from the combustion of coal [1] [20]. Coal burning power plant generates solid waste fly ash (fly ash) and bottom ash (bottom ash). Particles of ash carried by the exhaust gas is fly ash, while the remaining ash and removed from the bottom of the furnace is bottom ash. In Indonesia, the amount of bottom ash and fly ash from year to year increases with consumption use of coal as a raw material for power plant [7].

Fly ash has the inorganic material contained in the coal that have undergone fusion during firing. This material solidified while in the exhaust gases and is collected by means of an electrostatic precipitator. Because these particles will condense during suspended in the exhaust gas, the particles of fly ash will generally spherical. Fly ash particles collected on an electrostatic precipitator usually has a size of 0074-0005 mm. This material is composed of silicon dioxide (SiO_2), aluminum oxide (Al_2O_3) and iron oxide (Fe_2O_3). Commonly, coal fly ash is used in cement plants as an ingredient mix to make concrete. In addition, coal fly ash has a very diverse range of some benefits, those are drafting concrete for dams and roads; as a former mining land hoarders; raw materials

of ceramic, glass, bricks, and refractory; the abrasive material (polisher); filler asphalt, paper and plastics; replacement of cement raw materials; conversion to the adsorbent and zeolite.

Table 1. Composition and Classification of Fly Ash

Component	Bituminus	Subbituminus	Lignit
SiO_2	20-60	40-60	15-45
Al_2O_3	5-35	20-30	20-25
Fe_2O_3	10-40	4-10	4-15
CaO	1-12	5-30	15-40
MgO	0-5	1-6	3-10
SO_3	0-4	0-2	0-10
Na_2O	0-4	0-2	0-6
K_2O	0-3	0-4	0-4

(Source :[200]

Furthermore, Indonesia is one of the largest rubber producer in the world. Rubber is one of the important agricultural commodity in Indonesia. The land area of rubber in Indonesia reaches 2.7 to 3 million hectares, which is the largest rubber plantation in the world, beating other rubber producer countries. This led Indonesia rubber export more abroad. The rubber-producing areas are in Indonesia South Sumatra. However, there are still many obstacles encountered in the processing of rubber in South Sumatra, such as rubber production is not so good, the quality of rubber not meet the standards, and the rubber marketing. In addition, the price of rubber exported was considered too cheap compared to the price of rubber sold by other countries. The price of rubber is too low not to raise the quality of life of rubber farmers. Rubber prices are lower also due to the mixing of good quality rubber and rubber low quality because of the good quality rubber is not available in large quantities. Within this research, it is expected to increase the resale value of rubber that has been processed further as another product.

To obtain a rubber, rubber particles contained in the latex is separated from the liquid by way of caking either intentionally or naturally. In principle, clotting occurs due to disruption of the factors supporting the stability of the colloidal system latex, for example, a decrease in pH. Degradation usually occurs due pre-coagulation process. Pre-coagulation will be a problem in the processing of smoke or sit rep dank wind, while the processing is not a problem of the crumb rubber. Pre-coagulation the latex is influenced by several factors, including the activity of microorganisms, enzyme activity, climate, cultivating plants and clones, transportation, and the presence of fecal contamination from the outside. Latex in the coagulation process, changes the sol to gel with the aid of coagulant. In the rubber soles dispersed in the serum, but the gel rubber in latex. Clots can occur with the addition of acid (to lower pH), so the rubber colloid reaches the isoelectric point and pass clots. The role of pH to determine the quality of rubber. Clots at very low pH resulting color gets dark rubber and rubber modulus values lower.

Table 2. Ingredients of fresh latex

No	Ingredients	Composition (%)
1	Rubber	35,62
2	Resin	1,65
3	Protein	2,03
4	Ash	0,70
5	Sugar	0,34
6	Air	59,62

(Source: [16])

In present research, the fly ash and rubber latex mixture was added with clay and acid solvent (formic acid) to produce concrete brick. According to [11], clay can be defined as a mixture of particles of sand, silt and clay parts. One characteristic of the particles of clay are having a positive ionic charge which can be exchanged. This material has absorption with changing levels of humidity. While [19] defines the characteristics of textured clay soils dry very hard in the circumstances, and not easily peeled off only with fingers. The properties owned by [5], among others: the fine grain size, approximately 0.002 mm; low permeability; increased capillary water heights; highly cohesive; levels of fireworks high shrinkage; and the consolidation process is slow.

[13] analyzed the chemical composition of clay by using Scanning Electron Microscopy (SEM) as shown in Table 3

Table 3. Composition of Clay

Element's Symbol	Element	Composition (%)
C	Carbon	0,33
O	Oxygen	46,91
Al	Aluminium	22,05
Si	Silica	13,42
S	Sulphur	0,23
Ca	Calsium	0,21
Fe	Steel	14,78

(Source : [13])

In general, the bricks were used as construction material of a building made from basic materials clay formed in the mold compacted and then burned in a certain period. According to [4] Brick has some advantages and disadvantages when compared to other building materials, particularly brick and stone. The advantages of bricks are: able to hold the fire hazard, especially at the time of the fire; special skills are not required in arrange or laying bricks; it is a relatively inexpensive building materials and is easy enough to find. While the lack of brick when compared to other building materials, namely: not suitable for underwater structures because it easily absorbs water and can easily be damaged when the water absorbing salt; it is difficult to get a stable room temperature when using a brick wall because it easily absorbs heat during the dry season and easy to absorb so cold in the rainy season; there will be cracking in the plaster in case of extreme temperature changes.

Formic acid is a carboxylic acid simplest. Formic acid is naturally among others present in the bee sting and ants, so it is also known as formic acid. The chemical formula of formic acid can be written as HCOOH or CH_2O_2. Formic acid is also a significant combustion product of alternative fuels, the burning of methanol (and ethanol mixed with water), when mixed with gasoline. Formic acid included in weak organic acids group, but has properties that are highly corrosive, colorless, has a pungent odor, and can cause irritation to the eyes, nose, throat and can blister the skin. Formic acid can dissolve perfectly in water, acetone, ether, ethyl acetate, methanol, ethanol, and glycerin. Formic acid and water mixture has frozen eutectic point at a temperature below zero 48,5°C with composition of 70% by weight formic acid. This acid can form azeotrope with water at a formic acid content of 67% by weight (0.1 bar), 78% by weight (1 bar), and 84% by weight (3 bars).

Formic acid has many benefits and is used in various industries and reaction. One of the industries that use formic acid is the rubber industry. In the rubber industry, formic acid is used as a coagulant for coagulation or agglomerate the rubber latex. The quality of rubber produced by formic acid are of better quality compared to other types of coagulants. In the textile industry, formic acid can be used to adjust the pH of the bleaching process, dyeing / coloring. Formic acid is a stronger acid than acetic acid so that it will produce a better product. In the leather industry, formic acid is used in leather tanning process is as a cleaning agent calcium and pH regulator when dyeing. Formic acid is used to neutralize the lime so the skin becomes large and dense.

MATERIALS AND METHODS

Research was conducted at the Laboratory of Mechanical Reliability and Quality Assurance PT. Pupuk Sriwijaya Palembang in December 2016 - January 2017. The observation variables: the first is fixed variables, consist of mass of clays, burning time, water volume; and the second is independent variables, consist of mass of fly ash and mass of latex, volume of formic acid.

Materials and Tools

Some materials and tools used as follow: Liquid latex, Coal ash (fly ash), Clay of brick-making factory, HCOOH 5%, Clean water coming from taps, Ammonia (NH_3) 25%, Brick mold, weigher, testing Machine, 60 mesh sieve, wire cutters, Measuring cup, jerry can, and Bucket.

Methods

Preparation of Raw Materials

Ammonia (NH3) 25% is added to the latex 2% by weight in order to prevent coagulation.

Making Concrete Brick

Some steps to make concrete bricks are: First, doing separation of each ingredient in accordance with a predetermined variables. Second, mixing clay and fly ash in accordance with a predetermined amount. Add a little water. Once is enough dough, then add gum, did the stirring again. Finally add the appropriate dose of formic acid to the mixture, stirring until the mixture completely blended. Third, a mixture of all the ingredients that have been stirred inserted into the mold the bricks by way slammed from a certain distance with excess dough until dough is printed there that exceed the height of the brick mold. Excess soil above the mold is cut using wire cutters. Fourth, dried in the sun for one week. Afterwards, put bricks in the kiln. Fifth, completed the preparation of all the bricks on the furnace, do fumigation for one day. It is intended that the brick is not broken or destroyed when directly burnt by high temperatures. Sixth, then the bricks began to burn in the furnace at a temperature of 800^{o}C ± for two days (48 hours). After burning is complete, the stem wood used as fuel is pulled out furnaces and incinerators were closed so that heat evenly to all the bricks hingg inside. This process is called the maturation process of bricks. And the last, he ripening process is carried out until the heat discharged by itself, followed by the opening of the cover so-called process of burning or skin opening. If it is not warm anymore, brick can already moved.

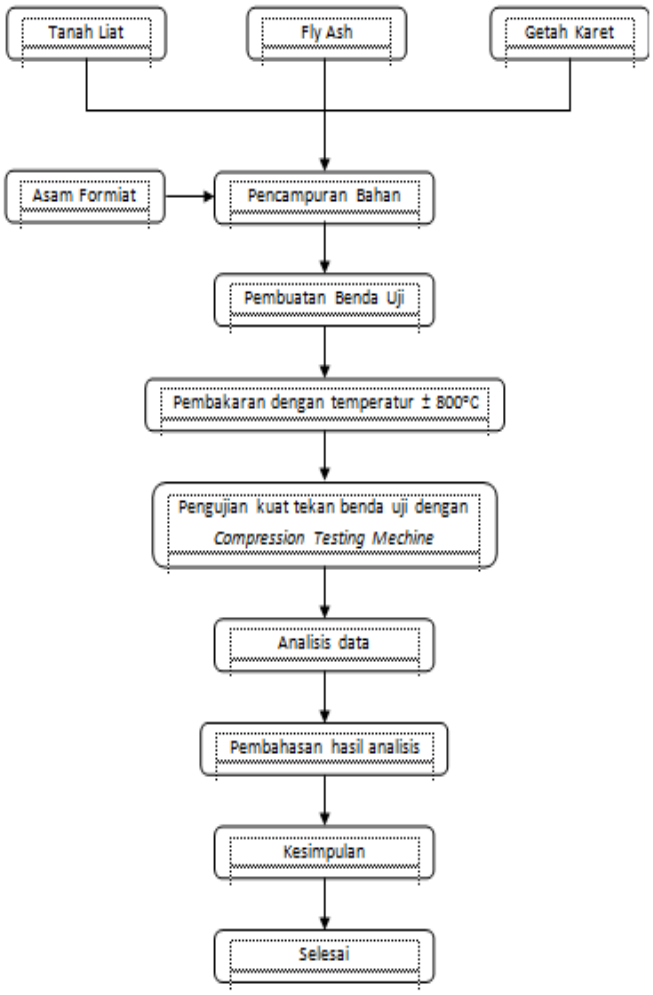

Figure 1. Research flow diagram

Product Analysis

Modulus of Rupture (MOR)

1. The resulting brick placed on the compressive strength tested using compressive strength testing machine (Testing Mechine).
2. Turn on the testing tools that would impose a burden on the hydraulics.
3. When the broken brick, read the figures for test equipment.
4. Analysis of the results on a machine readable compressive strength test on each sample using the formula below.

$$MOR\ (\frac{kgf}{cm^2}) = \frac{3PL}{2bd^2}$$

Cold Crushing Test

1. Bricks were formed was cut into a size of 4 cm x 4 cm.
2. Pieces are placed under a hydraulic that will suppress it.
3. Turn on the testing tools that would impose a burden on the hydraulics.
4. When these pieces were destroyed, read the figures for test equipment.
5. Analysis of the results obtained in accordance with the existing formula.

$$S\ (\frac{kgf}{cm^2}) = \frac{W}{A}$$

Brick's Absorbency

1. The resulting brick weighed, and record the values read.
2. Bricks soak in water for 24 hours.
3. Remove the bricks from the soaking and then weigh again.
4. Calculate the difference in weight of the bricks before immersion and after immersion.

$$Absorbency\ (\%) = \frac{Mb - Mk}{Mk}$$

RESULTS AND DISCUSSION

The result of Modulus of Rupture and Cold Crushing Test Brick

In the study of making bricks from fly ash, clay, and latex, we performed Test Modulus of Rupture (MOR) on the bricks.

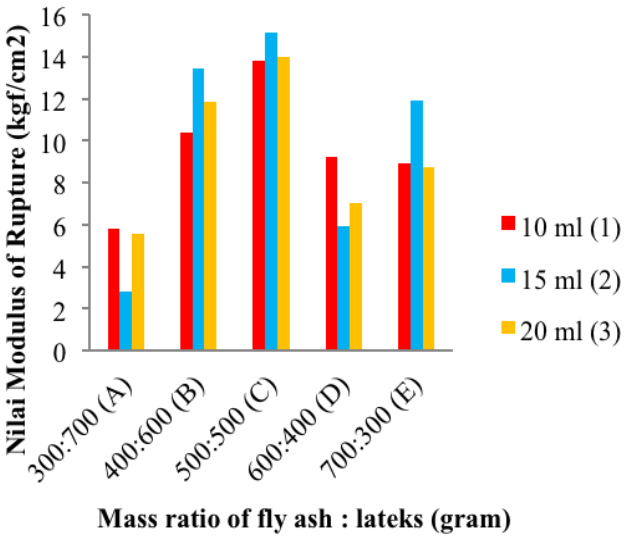

Figure 1. The relationship between the mass of fly ash and latex on each sample against a brick

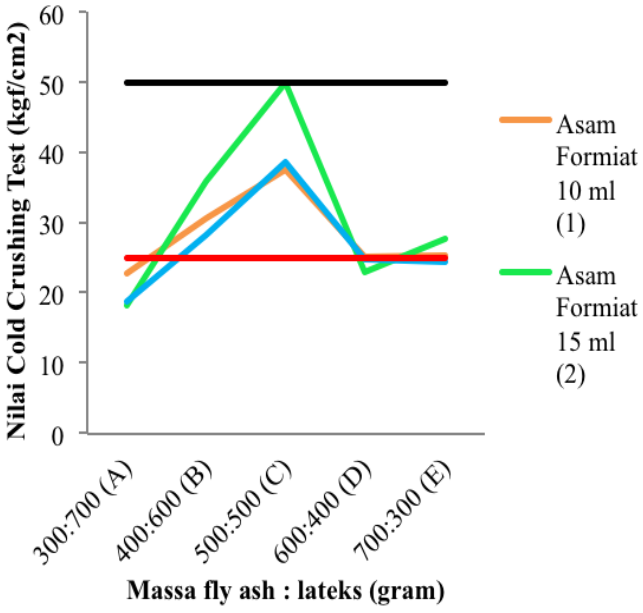

Figure 2. The relationship between volume HCOOH on each sample to the value Cold Crushing Test

Fig. 1. and Fig. 2. showed an analysis result graph modulus of rupture and cold crushing test of bricks using a testing machine. Modulus of rupture is broken flexural strength or mechanical properties associated with the power brick which is a measure's ability to withstand a load or external force acting on it and tends to change the shape and size of the bricks. While the Cold Crushing Test is the modulus of the failure of the brick due to be given the maximum load. Standard modulus of rupture and Cold Crushing Test bricks by ASTM C 67-03. From the figure it can be observed that an enhancement and impairment MOR and the CCT bricks. Raising the value of MOR continues to occur until the composition C and decreased in composition D and E. The highest brick MOR value obtained on the composition C with a mass of fly ash: latex amounted to 500: 500 and MOR value of 15.11707 kgf / cm2, while the value of CCT the highest obtained at brick composition C2 amounted to 50 kgf / cm2. This is due to the presence of grains of fly ash smaller will fill cavities in the dough bricks so that the sample becomes denser, and the nature pozzolan from the fly ash will cause the fly ash reacts with water and forms a compound of calcium aluminate hydrates that have a nature like cement. Actually, fly ash (fly ash) does not have the ability to bind as well as cement, but with the presence of water and the size is fine, silica oxide contained in the coal ash will react chemically and would produce binding properties. This binding properties which will increase the strength of the bricks. Pozzolanik reaction is a reaction that occurs between calcium silicate or aluminate form a cementing agent (CaSiO2H2O and CaAl2O3H2O), as shown in the following reaction [19]:

$$CaO + H_2O \rightarrow Ca(OH)_2$$

$$Ca(OH)_2 \rightarrow Ca^{++} + 2(OH)^-$$

$$Ca^{++} + 2(OH)^- + SiO_2 \rightarrow CaSiO_2H_2O$$

$$Ca^{++} + 2(OH)^- + Al_2O_3 \rightarrow CaAl_2O_3H_2O$$

Cementing agent is hard and rigid nature. In addition to time, perfect whether pozzolanik reaction is determined by the concentration of carbonate produced from the reaction of carbonation. Carbonation reaction is the reaction between the clay (CaO) with carbon dioxide gas CO2, which is shown by the following reaction:

$$CaO + CO_2 \rightarrow CaCO_3 + Calor$$

Calcium carbonate provides a weak effect and inhibit optimal pozzolanik reaction, so the value of MOR and CCT decreased.

CCT and MOR value and highest in composition C containing formic acid for 15 ml. Formic acid in this study serves as a coagulant that is coagulant latex that has been preserved in liquid form using ammonia. Formic acid serves to accelerate the coagulation process latex when mixed clay and fly ash. Value MOR in bricks experience raising and decreasing. This occurs because of human error in the mixing process. Where the process of mixing the clay using a manual process or using human power, so there is a mixture of clay with fly ash and other materials that may not have been mixed with average. In addition, the combustion process is also done is done in a furnace bricks in a large scale so that samples of burnt bricks may experience uneven burning process.

MOR value and CCT on the bricks decline it could be assumed that after the burning, H2O element in the bricks is reduced because evaporates, causing the weakening of ties with other materials and finally broken. This condition can cause an increase in pores in the brick so that absorption of water increases.

There was a decrease in the compressive strength of bricks with compositions D and E are caused due to an increasing number of the number of fly ash is added, the more CaO reacts with CO2 to produce CaCO3 which will reduce the strength of the brick.

Latex also will affect the compressive strength is generated. The content of the latex containing 59.62% water will react with the fly ash resulting in binding properties and increase the value of MOR and CCT on the bricks.

The result of Modulus of Rupture and Cold Crushing Test Brick

In Fig.3, an analysis result graph absorption bricks by soaking the bricks in water for 24 hours. Before and after soaking, carried bricks weighing to determine the weight of dried bricks and heavy wet bricks. In accordance with

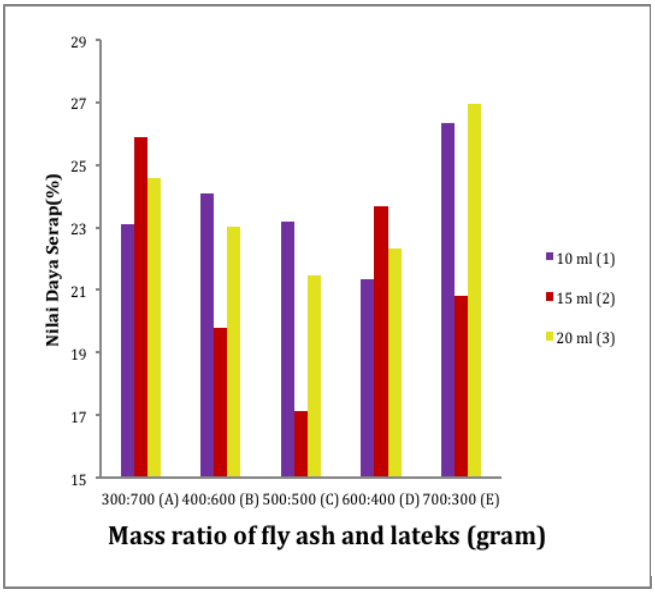

Figure 3. The relationship between volume HCOOH on each sample absorption rate against the bricks

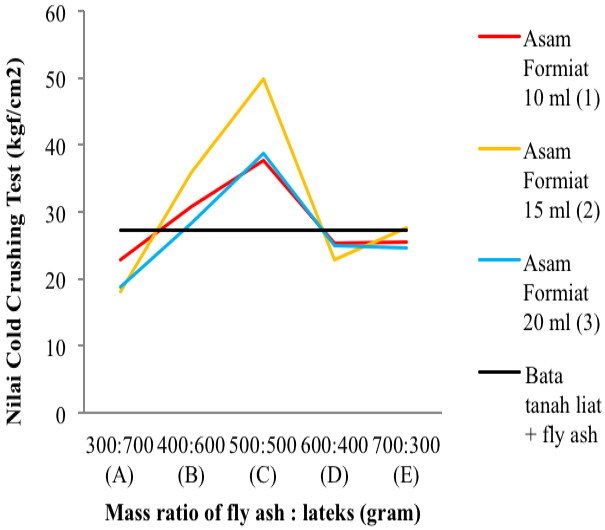

Figure 4. The comparison of compressive strength of bricks between the research result and previous research

the absorption calculation formula described in chapter 3, obtained data is represented in Figure 4.3. This test is intended to determine the extent of water absorption is affected by the pore - pore or air cavity material contained on the bricks after the combustion process. The larger the pore space of the material contained on the bricks, the greater the rate of water absorption, so the durability of bricks will be reduced. This is due to lack of density or density of the material composition of bricks.

Value absorption will be inversely proportional to the value of MOR and CCT. Values produced the lowest absorption on the bricks and the graph MOR C2 and C2 brick CCT has the highest value. This is because the bricks with high absorption values have pores that more so that the water absorption will be even greater. If more pores of the increasingly fragile brick construction. In this study, also conducted on samples of brick stucco. Once the cement is dry, the sample brick stick well together like bricks on the market in general, but previously necessary dyeing sample bricks into the water to cement used can stick better.

Based on the classification by the compressive strength of the bricks, the bricks with raw clay, fly ash, latex included in class 25 and 50. In standard production, the bricks have been included in a standard brick. Fly ash used in this study is the kind of B-3 waste that needs proper handling of the process so as not to pollute the environment. Handling recommended the Government Regulation No. 18 of 1999 and Government Regulation No. 85 of 1999 is the solidification, where the nature of the process B-3 in the coal ash will be stable and can be used as a product that is safe for health and the environment.

Table 4. The average compressive strength of bricks (SII-0021-1978)

Class	Average Compressive Strength of Bricks	
	Kg/cm²	N/mm²
25	25	2,5
50	50	5,0
100	100	10
150	150	15
200	200	20
250	250	25

Process of solidification / stabilization in principle is to change the physical and chemical properties of waste B-3 by adding binding materials form compounds monolith structure is compact so that the movement of waste B-3 inhibited or restricted, solubility is reduced so that the toxicity of the waste B-3 are reduced. Binding materials in question have been clay, limestone, asphalt and portland cement. Solidification is the way in which the fly ash is converted or made into the form of massive, solid and stable. One way is to use a solidification of fly ash as an additive or additional materials in the manufacturing process of brick. Thus, the use of fly ash for brick making is apt to cope with waste B-3 at a plant that uses coal as a fuel source.

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