Fabrication of brick without burning process

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Abstract. Brick is a material with many applications on building materials. The purpose of this research is to study the effect of fly ash addition and hardening time on mechanical properties of brick produced. Brick was formed by mixing cement, clay, water and fly ash with addition point was 0;0,3;0,6;0,9;1,2 kg weight. Brick was dried at room temperature for 7, 14 and 21 days. The result showed that compressive strength with addition 0,6 kg fly ash for 21 days was the strongest where that’s value was 9,375 N/mm². The highest porosity was get in on 21,34 % with 1,2 fly ash addition. The result of TCLP showed that for Pb, Cu, Cr content was still below the quality standards based on PP No.85 TH 1999 and still considered harmless. Leachate value for Pb of 3,10 mg/L, 1,213 mg/L for Cr and 4,374 mg/L for Cu.

1. Introduction
The using of bricks in the construction world as structural and non-structural elements cannot be replaced. The production of bricks was required a burning process. The useful of bricks in the community, not in line with environmental issues regarding air pollution and global warming due to increased production of carbon dioxide gas in conventional combustion bricks process. On the other hand, more industries are using coal that can contaminate the air. One of the waste generated from coal combustion is fly ash as 2-10%. Coal fly ash is generally disposed of in lagoon ash or stacked away in an industrial area. This fly ash buildup created problems for the environment, such as air pollution, waters and declining ecosystem quality [1]. The waste of fly ash can be utilized for mixed materials in the brick production process because it contains pozzolan chemical compounds such as alumina and silica, so it is suitable to be used as construction raw material [2].

Stabilization / solidification is one of the methods used in the handling of solid waste before disposal to a land. This method involves mixing waste with a binder to immobilize the heavy metals contained so that the hazardous and toxic waste (B3) can be converted and acceptable to the environment. Besides being disposed to landfills, the results of solidification can be utilized as construction materials [3]. The solidification study of alumina waste from petroleum processing is capable of providing compressive strength of 10.8 N / mm², 12.8 N / mm² and 16.2 N / mm² [4]. While in addition of cement in brick making yield compressive strength equal to 1,312 N / mm², 2,124 N / mm², 2,905 N / mm², 4,475 N / mm² and 4,595 N / mm² [2]. The mechanical properties, in particular the compressive strength will increase significantly with the addition of coal waste, where as in the chemical properties, in particular leachet it is known that coal waste mixture can immobilize heavy metals well [5].

This paper reported about the effect of drying time on the manufacture of bricks made from fly ash without burning process. Brick making without combustion process is intended to reduce CO2 emissions (carbon dioxide) and the use of wood with clay for 5 minutes and water when stirring.
occurs. Then the mixture is inserted into the brick molding and pressed with a load of 25 kg. The result dried at atmospheric temperature for 7, 14 and 21 days. The resulting product was analyzed by compressive the

2. Material and method
The materials used in this study are coal fly ash, cement and clay. The process of making bricks using solidification techniques [4]. Fly Ash and cement was stirred perfectly. Then, the mixture was stirring the strength analysis, TCLP (Toxicity Caracteristic Leached Procedure) and porosity test.

3. Result and discussion
3.1 Compressive strength analysis
The compressive strength is the ability of a brick product to accept a broad united press force, so the compressive strength identifies the quality of the brick product. The compressive strength of this study was tested on a variety of drying times of 7 days (A sample), 14 days (B sample) and 21 days (C sample). The results of the compressive strength test for 7-day drying time on each of the mixed compositions are shown in Table 1.

| Samples Code | Fly Ash (kg) | Max load (kN) | Compressive Strength (N/mm²) | Compressive Strength Standart (N/mm²) |
|--------------|--------------|---------------|-------------------------------|--------------------------------------|
| A0           | 0            | 7             | 4,375                         | 2.5                                  |
| A1           | 0.3          | 8             | 5.0                           | 2.5                                  |
| A2           | 0.6          | 12            | 7.5                           | 2.5                                  |
| A3           | 0.9          | 5             | 3,125                         | 2.5                                  |
| A4           | 1.2          | 3             | 1,875                         | 2.5                                  |

Base on Table 1, the addition of coal fly fly ash in the manufacture of bricks will initially increase the compressive strength of the brick products, but more fly ash will decrease the compressive strength of the bricks obtained. In this study the addition of 0.6 kg fly ash increased the compressive strength of the brick products, but the addition of 0.9 kg to 1.2 kg fly ash decreased the compressive strength of the brick products. The addition of fly ash to brick making can improve the mechanical characteristics of the resulting bricks [2]. The addition of fly ash above 50% in brick making can decrease the compressive strength of the resulting product [3]. Influence The comparable strength strength results were also obtained in samples with a drying time of 14 and 21 days as shown in the following table.
Table 2. Strong analysis results press bricks at drying time 14 days and 21 days

| Samples Code | Fly Ash (kg) | Max load (kN) | Compressive Strength (N/mm²) | Compressive Strength Standard (N/mm²) |
|--------------|-------------|---------------|------------------------------|-------------------------------------|
| B0           | 0           | 9             | 5,625                        | 2,5                                 |
| B1           | 0,3         | 10            | 6,25                         | 2,5                                 |
| B2           | 0,6         | 14            | 8,75                         | 2,5                                 |
| B3           | 0,9         | 6             | 3,75                         | 2,5                                 |

| Samples Code | Fly Ash (kg) | Max load (kN) | Compressive Strength (N/mm²) | Compressive Strength Standard (N/mm²) |
|--------------|-------------|---------------|------------------------------|-------------------------------------|
| B4           | 1,2         | 4             | 2,5                          | 2,5                                 |
| C0           | 0           | 10            | 6,25                         | 2,5                                 |
| C1           | 0,3         | 11            | 6,875                        | 2,5                                 |
| C2           | 0,6         | 15            | 9,375                        | 2,5                                 |
| C3           | 0,9         | 7             | 4,375                        | 2,5                                 |
| C4           | 1,2         | 5             | 3,125                        | 2,5                                 |

Table 2 shown that the highest compressive strength was obtained in the addition of 0.6 kg fly ash and decreased in addition to 1.2 kg. The effect of coal fly ash adds to the free lime-binding reaction produced in the cement hydration process by the silica contained in fly ash coal. In addition, the much smaller coal fly ash grains make the bricks more dense because the cavities between the aggregate granules are filled by coal fly ash so as to minimize the existing pores and utilize the existing pozzolan properties of fly ash to improve rock quality brick. Fly ash coal is an active ingredient when mixed with cement, and bricks made with fly ash coal mixture have higher compressive strength than normal bricks [1]. The same can be seen from the results of the compressive strength test in Table 2. From Table 2 showns that the addition of 0.3 kg fly ash increased the compressive strength from 5,625 N / mm² to 6.25 N / mm² or increased by 0.625 N / mm² for the drying time is seven days, while for the drying time of 14 days the addition of 0.3 kg fly ash increases the compressive strength from 6.25 N / mm² to 6.875 N / mm² or up 0.625 N / mm². The increasing continues until the addition of fly ash as much as 0.6 kg. While the addition above that number causes a decrease in compressive strength for various drying variations. The decrease in the strength of the bricks is due to the reduction in the value of the masonry of large brick-making materials due to the large amount of fly ash use of the brick material, resulting in a lack of binding strength between clay and fly ash. Between 10% -40% the use of fly ash can be utilized depending on the value of the keplastisan of the material used [4].

3.2 TCLP (Toxicity characteristic leached procedure) analysis

The aim of TCLP testing is to determine the level of protection of the nature of B3 in coal fly ash material after undergoing a solidification process with a brick product. The TCLP test was performed after 7 days, 14 days and 21 days old brick by Atomic Absorption Spectrofotomete (AAS) method. Further testing of the heavy metal content on bricks that have been tested the compressive strength. By
doing this test we will know the ability of the bricks to immobilize the heavy metals contained in the sample. In the TCLP method the solidified material is crushed into grain particles which are further destructed until the process is obtained filtrate of filtrate which is then tested with AAS. The TCLP test on bricks was performed on samples with the highest compressive strength. TCLP test results of heavy metal content in the sample are as follows.

Table 3. Results of heavy metal content analysis on bricks

| Component | TCLP Analysis of Brick (mg/L) | Standard of PP 85/1999 (mg/L) |
|-----------|-------------------------------|-------------------------------|
|           | 7 days | 14 days | 21 days |                   |
| Pb        | 5.03   | 4.93    | 3.10    | 5                  |
| Cu        | 6.34   | 5.551   | 4.374   | 10                 |
| Cr        | 2.864  | 1.600   | 1.213   | 5                  |

From Table 3 it can be seen that brick as a solid waste asphalt produces maximum result in immobilizing heavy metals contained in the waste. From the picture above can also be seen that the longer the drying process will be more difficult heavy metal released to the environment due to the number of fewer in the sample of bricks. For 21-day drying Pb metals will decrease heavy metal content to 3.10 mg / L from 5.03 in seven-day drying. Likewise, in heavy metals Cu and Cr which decreased after concentration in solidified into bricks, this decrease caused by trapping heavy metals in the matrix of bricks making it difficult to decompose the environment. From the results of TCLP test above also shows that in some brick products produced are still below the quality standard of PP 85 of 1999 so that its use is safe for the environment.

3.3 Porosity of brick analysis

Porosity is the ratio of pores or empty space in the bricks to the volume of bricks. There is the result of porosity analysis

Table 4. Porosity calculation result on brick

| Samples | Fly ash | Drying Times | W1   | W2   | W3   | Porosity |
|---------|---------|--------------|------|------|------|----------|
| A0      | 0       |              | 87.46| 97.26| 30   | 17.06    |
| A1      | 0.3     | 7 days       | 94.43| 102.63| 30   | 12.73    |
| A2      | 0.6     | 7 days       | 98.02| 104.72| 30   | 9.85     |
| A3      | 0.9     |              | 92.8 | 104.87| 30   | 19.22    |
| A4      | 1.2     |              | 88.98| 103.32| 30   | 24.31    |
| B0      | 0       | 7 days       | 81.22| 87.42 | 30   | 12.11    |
| B1      | 0.3     | 14 days      | 87.87| 93.57 | 30   | 9.85     |
| B2      | 0.6     | 14 days      | 91.15| 95.25 | 30   | 6.70     |
| B3      | 0.9     |              | 85.95| 94.35 | 30   | 15.01    |
| B4      | 1.2     |              | 82.07| 92.31 | 30   | 19.67    |
| C0      | 0       |              | 75.2 | 80.5  | 30   | 11.73    |
| C1      | 0.3     |              | 81.83| 86.43 | 30   | 8.88     |
| C2      | 0.6     | 21 days      | 85.03| 86.53 | 30   | 2.75     |
| C3      | 0.9     |              | 79.75| 87.15 | 30   | 14.87    |
| C4      | 1.2     |              | 75.77| 84.67 | 30   | 19.45    |
The result data above will be compared with the compressive strength obtained. The compressive strength is inversely proportional to the porosity of a brick. The higher of the compressive strength of the porosity of the brick is getting smaller. This means that the highest compressive strength will result in low porosity. This is in accordance with the results of porosity test conducted, where from Figure 4. above can be seen that the highest porosity found in the addition of fly ash as much as 1.2 kg (compressive strength 1,875 N / mm²) and drying time of sample for seven days ie 24.31%. The lowest porosity was obtained by adding fly ash 0.6 kg (9.375 N / mm²) and 21 days drying time 2.73%.

4. Conclusion
Ash waste (fly ash) can be used as raw material for brick making without burning and can reduce pollution process. The best compressive strength bricks of 9.372 N / mm² were produced at the addition of 0.6 kg fly ash and drying time of 21 days. The resulting porosity is 1.875 N / mm². The TCLP test of the resulting bricks showed Pb metal content of 3.10 mg / L, Cu of 4.37 mg / L, Cr of 1.21 mg / L after the solidification process.

References
[1] Hughes E Randall 1996 Bricks Manufacture with Fly Ash from Illinoios Coals (USA: ICCI Project)
[2] Garrabrants A C and Kosson D S 2005 Leaching Processes and Evaluation Tests for Inorganic Constituent Release from Cement-Based Matrices, Stabilization and Solidification of Hazardous, Radioactive, and Mixed Wastes (Florida – USA: CRC Press)
[3] Spence R and Shi C 2005 Stabilization and Solidification of Hazardous, Radioactive, and Mixed Wastes (Florida – USA: CRC Press)
[4] Hardjito D and Rangan B V 2005 Development and Properties of Low Calcium Fly Ash Based Geopolymer Concrete Faculty of Engineering Curtin University of Technology Perth - Australia.
[5] Stegemann J A 2005 Interactions between Wastes and Binders Stabilization and Solidification of Hazardous, Radioactive, and Mixed Wastes (Florida – USA: CRC Press)