The analysis of lightweight brick strength pressure with mixture of glass powder and silica fume

Nursyamsi 1, William Liang 2.

1 Department of Civil Engineering, Engineering Faculty, Universitas Sumatera Utara, 2 Perpustakaan Road, Universitas Sumatera Utara, Medan 20155, Indonesia
2 Department of Civil Engineering, Engineering Faculty, Universitas Sumatera Utara, 2 Perpustakaan Road, Universitas Sumatera Utara, Medan 20155, Indonesia

E-mail: nursyamsi@usu.ac.id and williamliang96@gmail.com

Abstract. Little by little the engineers research how the development of concrete that can utilize waste. In the utilization of the waste, it can be functioned as mixing material which the chemical or the physical traits of the used goods contain similarity to the mixture of concrete in general, one of them is glass powder as the substitute of cement. The glass powder that utilizes is the one that is sifted through sieve No. 200 as much as 10% of the weight of the cement. The testing specimen of the concrete brick is make of the mixture with the ratio of 1:7, then is added with the foaming agent (1:30) and silica fume (10% of the weight of the cement). Furthermore, visual examination, absorption, net weight and testing specimen compressive strength. The data analysis uses the reference of SNI 03 – 0349 – 1989 regarding Concrete Brick for the Match for the Wall. Foaming Agent is make by using modified hand drill and brace. The testing specimen uses the brick mold with the size of 40 cm x 20 cm x 10 cm. Based on this research, it shows that the quality that results from brick is still qualified based on SNI 03 – 0349 – 1989.

1. Introduction
In this era, the material development focuses on waste – the waste that is unused – to produce something that can be used by the human. One type of the waste is glass. Glass is used to replace the cement as the material for brick with the addition of silica fume. To lighten the weight of the structure, especially on tall edifices, addictive material that is the foaming agent is added to reduce the weight of the bricks.

The increasing demand of the market for brick results in the increment of the need of brick material such as concrete. The increase of requirement of cement results in the increment of the price of the cement. One of the innovations that are currently develops is by making the glass powder as the alternative material to lessen the usage of cement. Glass powder has very similar compositions to cement, which are (SiO\textsubscript{2}), Na\textsubscript{2}O and CaO as much as more than 60%. [5]

The following table is the compositions of Portland [3] cement and the compositions of glass powder [2]:

| Composition | Portland Cement | Glass Powder |
|-------------|-----------------|--------------|
| SiO\textsubscript{2} | 20% - 25% | 97,0080% |
| Al\textsubscript{2}O\textsubscript{3} | 7% - 12% | 0,1273% |
| Fe\textsubscript{2}O\textsubscript{3} | 7% - 12% | 0,0026% |
| CaO | 60% - 65% | 0,1084% |

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2. Literature Review

The concrete brick is the material in the form of molded brick as an alternative to the bricks that consist of the composition of sand, Portland cement, and water with the ratio of 1 cement: 7 sand. Brick is focuses as the constructions of non-structural wall building. [2]

To obtain bricks with excellent quality, the factors are the water of the cement, the age of the bricks, the density of the concrete bricks, the textural shape of the stones, aggregate size, aggregate strength, and etcetera. [6]

The brick has to fulfill the physical requirements by table 2. [7]

| Physical Requirement | Unit | Quality Level of Solid Concrete Bricks | Quality Level of Perforated Concrete Bricks |
|----------------------|------|----------------------------------------|--------------------------------------------|
| 1. Min. average gross compressive strength Kg/cm² | I | 100 | 70 | 40 | 25 | 70 | 50 | 35 | 20 |
| 2. The compressive strength of each min. testing Kg/cm² | II | 90 | 65 | 35 | 21 | 65 | 45 | 30 | 17 |
| 3. Average water absorption rate, max. % | III | 25 | 35 | - | - | 25 | 35 | - | - |

2.1 Glass Powder

The glass is the result of decomposition of organic compounds which have undergone refrigeration without crystallization. The element of glass is silica. Glass has specific characteristics compared to the other categories of ceramics. The characteristics are influence by the uniqueness of silica (SiO2) and the formation process. [6]

Glass powder has advantages compared with the other pore fillers. First, it has the properties that do not absorb water. Second, the solidity of the glass causes the concrete to be resistant to abrasion that can only achieve by slightly natural aggregate. Third, glass powder repairs the substance of fresh concrete so that high level of strength can obtain without the utilization of superplasticizer. Fourth, glass powder has the characteristics of pozzolans so that it can function as the substitute of cement. [2]
The utilization of fine glass aggregate that is made of the lime – soda fused glass type began to be developed to produce high-performance concrete. The fine glass aggregate is made in powder form with size and the distribution that is similar to fine aggregate/natural sand. The usage is expected to be able to take advantage of the waste of industry side product for construction industry component and to overcome deficiencies of the available natural sand.

In this research, the material of glass that is used for bricks is the glass powder from various types of used water bottles which is included in the category of the glass of lime soda.

2.2 Silica Fume
Silica fume can be used as the substitute of some parts of cement, for reducing the content of the cement, although it is uneconomical. Secondly, as the addition to repairing the characteristics of concrete, both fresh and hard concrete. For normal concrete with the content of cement above 250 kg/m³, the need for water increase accordingly to the addition of silica fume. The mixture is more cohesive than usual. At the same slump, more energy is to produce streams. It indicates better stability than liquid concrete. Bleeding is much lessen so that early treatment for cracked plastic shrinkage prevention is required, particularly in hot and windy weather. Silica fume is commonly used along with plasticizer. Experiments of silica fume composition by Faseyemi showed that from the mixture of silica fume as much as 0%, 5%, 10%, 15%, 20%, 25%, the one which has the largest compressive strength is the one at 10%. [1]

2.3 Foaming Agent
One of the concepts of light bricks is to reduce the solidity that is find in a sample within the same volume, which means the weight of the object becomes reduced as the result of the decreased solidity, but the object remains the same. This research use foaming agent with trade mark MEYCO FIX SLF 20 that is produce by PT BASF The Chemical Company. The main compiler component of the addictive substance is Alcohol and Sulfuric Ester. The addictive substance is highly to use in the production of light concrete or light bricks. The ratio of the water using is 1:20 to 1:39. [6]

3. Research Methodology
The method that is use in this research is experimental research methodology. The focus of the research is to increase the quality of the previous research with the reshuffle of mixture and addition of silica fume. The glass granules used is sieve-passed no. 200 as much as 10% of the cement weight, the addition of silica fume as much as 10% of cement weight, bricks mixture of 1:7, and foaming agent mixture of 1:30.

First, gather all the materials such as glass, sand, silica fume, the foaming agent, Portland cement. Glass in this research is coming from the waste of bottle around Medan, Indonesia. Then, clean the bottle and dry it. Put the bottle to Los Angeles machine, operate it around 10 – 15 minutes. Remove the glass from the machine. Put it into the rubber and begin to destroy it until become smaller than before with hammer. Remove the glass and mill it with mill-blender. Glass that use in this research is a powder glass pass sieve no. 200.

Check the property value of the material of cement, sand, and glass. Calculate the composition mixture for the testing sample. Make the foaming agent with hand-drill and modified head-drill. Mix all the materials and make the testing sample. Wait for 24 hours, then remove the mold and start curing the sample by pouring water two times a day (in the morning and evening).

Compressive strength examination conducts at Material and Concrete Engineering Laboratory of the University of North Sumatra. The test holds on the seventh day calculated since the testing material made with two variations that amounted to 10 testing materials. By SNI 03 – 0349 – 1989, for minimal press test 5 testing materials of each are used.
4. Results and Discussion
For the test of the visual research, it can be seen from the table 3, 4 and figure 2, 3 below:

| Table 3. Visual Testing Result |
|-------------------------------|
| No | Variation | Bricks Size (mm) | Length | Width | Height |
|    |           | SNI 03 – 0349 – 1989 |  | SNI 03 – 0349 – 1989 |  | SNI 03 – 0349 – 1989 |
| 1  | Bricks + Foaming Agent | 400 | 5 | 201 | 2 | 101 | 2 |
| 2  | Bricks + Glass + Foaming Agent | 400 | 5 | 200 | 2 | 100 | 2 |
| 3  | Glass + Foaming Agent | 400 | 5 | 201 | 2 | 101 | 2 |
| 4  | Agent | 400 | 5 | 200 | 2 | 100 | 2 |
| 5  | Average | 400 | 5 | 200 | 2 | 100 | 2 |

| Table 4. Comparison Result of Visual Testing |
|---------------------------------------------|
| Bricks Size | Reby | Fathur | Researcher |
| B + 0% G (mm) | 401 x200,8 x101,4 | 400 x200,056 x100,056 | 400 x200,6 x100,2 |
| B + 10% G (mm) | 400,8 x 200,7 x 101,2 | - | 400 x 200,4 x 100,6 |
| B + 20% G (mm) | 400,9 x 200,7 x 100,2 | 400,085 x 200,031 x 100,062 | - |

From the result of table 3 and 4, the visual research of lightweight bricks are still accepted in Indonesia Standard for bricks and almost the same with the previous research.

For absorption testing, the result is as follows:
Table 5. Comparison Result of Absorption Test

| Variation  | Reby Absorption (%) | Quality | Fathur Absorption (%) | Quality | Researcher Absorption (%) | Quality |
|------------|---------------------|---------|-----------------------|---------|--------------------------|---------|
| B + 0% G (%) | 3,133               | I       | 16,918                | I       | 18,416                   | I       |
| B + 10% G (%) | 3,282               | I       | -                     | -       | 16,264                   | I       |
| B + 20% G (%) | 4,62                | I       | 14,070                | I       | -                        | -       |
| Brick Type | Solid               |         | Light                 |         | Light                    |         |

From the result of figure 4 and table 5, the absorptions are still the same quality as the previous research.

For net weight testing, the result is as follows:

Table 6. Comparison Result of Net Weight Testing

| Net Weight (kg/m³) | Reby Result | Fathur Result | Researcher Result |
|--------------------|-------------|---------------|-------------------|
| B + 0% G           | 2373,525    | 1202,618      | 1198              |
| B + 10% G          | 2384,363    | -             | 1325,5            |
| B + 20% G          | 2263,9      | 1329,875      | -                 |
| Brick Type         | Solid       | Light         | Light             |

From the result of figure 5 and table 6, the net weight of this research is the lightest. For compressive strength testing, the result is as follows:
From the testing of material, the result from figure 6 and table 7 discovered is exceed the previous research regarding light bricks. The quality obtained on previous research was by SNI 03 – 0349 – 1989 included in IV. Therefore, researchers excelled in improving the quality to be quality III. However, the result still cannot exceed the quality of solid bricks as pores exist in light. The larger the pores in the bricks, the higher the absorption value, nevertheless the quality generated from the bricks are getting lower.

5. Conclusions
By SNI 03 – 0349 – 1989, the absorption quality of bricks + foaming agent include in I which is 18.416%, meanwhile brick quality + foaming agent include in quality I is 16.264%. Brick net weight + foaming agent is 1198 Kg/m$^3$. Meanwhile net brick weight + foaming agent is 1325.5 Kg/m$^3$.

By SNI 03 – 0349 – 1989, brick quality + foaming agent include in quality II which is 84.286 Kg/cm$^2$. Meanwhile brick quality + foaming agent include in III is 43.429 Kg/cm$^2$.

The quality obtained in this research exceeds the quality of light brick from Fathur’s research. However, it is lower than the solid bricks from Reby’s research.

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