Optimization of Flyash Composition and Drying Time in Water Absorption and Compressive Strength Concrete Brick

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Abstract. One of the most crucial components of construction materials is concrete bricks that can be applied to the walls of houses, office buildings and fences. Concrete brick is a ceramic material that has brittle properties and to increase its strength and reduce the weight of concrete brick, fly ash is used as a mixture in concrete brick material. Fly ash which is the residual combustion or coal waste from the Sigantang Sawahlunto Power plants with a variety of composition fly ash and concrete bricks drying time which aims to determine the optimal conditions in water absorption and compressive strength test which refers to SNI 03-0349-1989 standard and light or normal concrete brick. The material used is sand plus aggregate, cement and water as a binder, with fly ash as added material. The composition variations are 0, 5, 10 and 15 wt.% fly ash. Then it is compacted manually with size (34 x 12 x 9) cm³ based on SNI 03-0349-1989 standard. After that it is dried for 7, 14, 21, 28, and 35 days. The results showed that the optimal composition was on the addition of 5 wt.% fly ash with a drying time of 28 days resulting in Water Absorption 7.84 % quality and compressive strength 51.98 kg/cm² quality III of SNI 03-0349-1989 which can be applied to constructions that do not carry loads, for insulating walls (under the roof).

1. Introduction

Development for housing and buildings is increasing every year. These needs are increasing along with population growth and the economy, therefore it is necessary to find ways to use and discover new building materials that are able to provide ease of work and savings in terms of cost [13]. Concrete brick is the right choice as one of the alternative substitutes for bricks which are considered more practical in terms of installation and construction and many are produced at lower prices for components of wall building materials [6].

Fly ash is produced from coal combustion residues in steam power plants that cause pollution of the air, soil and water, because its utilization is only 20-30%. Therefore it is necessary to find a solution by using fly ash as a mixture or material added to the manufacture of concrete brick, because fly ash in the engineering field has the best properties, including: hardness, high strength and good work, so that it can be applied in the construction field, mechanical and chemical industry [3]. Fly ash is one of the waste materials that can be used in manufacturing high quality concrete bricks [8].

The addition of fly ash to the concrete block 0, 5, 10, 15 wt.% produces compressive strength 17, 21, 25, 19 MPa, and for normal brick concrete 13 MPa. This study research the effect of adding flyash on the compressive strength of the concrete brick[5]. This research aims to determine the optimization of the fly ash composition and drying time in water absorption and compressive strength on the manufacture of SNI-standard concrete bricks.
The fly ash addition with a certain composition of the cement weight can increase the compressive strength [2]. Concrete brick with a drying time of 28 days produces a mass of 12.128 kg, the density value of 2.118 gr/cm\(^3\), the water absorption capacity of 12.876\% and a compressive strength of 1.97 MPa [4]. The addition of fly ash to the concrete block as much as: 0\%, 5\%, 10\%, 15\% produces compressive strengths of 17, 21, 25, 19 MPa, and for normal brick concrete 13MPa. This study shows the effect of adding fly ash against the compressive strength of the brick [5].

The compressive strength of concrete brick increases with the increasing age of concrete blocks. Therefore, as a standard of strength, concrete blocks are used for strength at 28 days of brick making. To find out the strength of the brick at 28 days, it can be done by testing the compressive strength of the brick at the age of 3 or 7 days and the results are multiplied by certain factors to get the estimated compressive strength of the brick at 28 days. the drying time of 28 days of cement will have a hardness reaching the maximum value, it can also be known from the bright color of cement from before [14].

**Concrete Brick**

brick or commonly known in the general public with concrete brick is a material formed from a mixture of sand with gravel (aggregate), portland cement and water. Based on the shape, concrete blocks consist of two types, solid and hollow concrete brick.

**Figure 1.** The concrete brick shape (a). solid concrete brick, and (b) Hollow concrete brick

Factors affecting the quality of brick depend on: water factor, cement, concrete brick density, brick age, rock shape and structure or aggregate size etc[9].

Based on brick making materials can be grouped [12]
- white brick (trass): made from a mixture of trass, limestone, and water. Trass is a brownish-white soil type that originates from weathering of volcanic rocks, the color is white and brownish white. The general size is 2.5 to 3 cm with a thickness of 8-10 cm, and a height of 14-13.
- Cement Brick / Press: made of a mixture of cement and sand or stone ash. Some are made manually (using hands) or using machines. The difference can be seen from the density of the brick surface. Generally it has a length of 36-40 cm and 18-20 cm.
- Light brick: made from quartz sandstone, lime, cement and other materials which are categorized as material for lightweight concrete. Maximum specific gravity is 1850 kg / m\(^3\). Its dimensions are larger than conventional brick which is 60 × 20 cm with a thickness of 7-10 cm making the wall work faster than conventional brick.

Advantages of using brick:
- Making brick making is easy without requiring a burning process. If the brick making is neat, it doesn't need to be plastered.
- The size of the brick is bigger than red brick, so the installation time is faster without the need to be soaked in water and the installation costs are cheaper.
- Hollow brick can be used as an air vent.

Disadvantages:
- Easily experience hair cracks on the wall.
- Easy to hole or break because there is a hole in the inner side.
- Poor for heat and sound insulation
### Table 1. Standard brick size and tolerance SNI 03-0349-1980

| No | Type          | Size (mm) | Wall thickness min. (mm) | Length | Width | Height | Outside | Inside |
|----|---------------|-----------|--------------------------|--------|-------|--------|---------|--------|
| 1  | Solid         | 390 ± 5   | 90 ± 2                   | 100 ± 2 | -     | -      | -       | -      |
| 2  | Hollow: Small | 390 ± 5   | 190 ± 5                  | 100 ± 2 | 20    | 15     |         |        |
|    | Large         | 390 ± 5   | 190 ± 5                  | 200 ± 3 | 25    | 20     |         |        |

### Table 2. Quality requirements for concrete brick SNI 03-0349-1980

| NO | Requirements for quality brick concrete | Unit   | QualityConcrete Brick (Solid) |
|----|----------------------------------------|--------|-------------------------------|
|    |                                        | Kg/cm²| I    | II   | III  | IV   |
| 1  | Gross compressive strength and average min. |        | 100 | 70  | 40   | 25   |
| 2  | Gross compressive strength of each specimen min. |        | 90  | 65  | 35   | 21   |
| 3  | Average water absorption max.            | %      | 25  | 35  | -    | -    |

### 2. Methodology

The composition for Concrete Brick manufacturing is as follows:

### Table 3. Brick composition for 7 specimens

| Fly ash (wt.%) | Cement (kg) | Sand (fine sand + aggregate) (kg) | Mass of fly ash (kg) | Water (Liter) |
|----------------|-------------|-----------------------------------|----------------------|---------------|
| 0              | 3           | 46.30                             | 0                    | 3.0           |
| 5              | 3           | 43.98                             | 2.35                 | 4.5           |
| 10             | 3           | 41.67                             | 4.47                 | 5.4           |

Figure 2: Material: (a) cement, (b) sand, (c) fly ash, and (d) water

Specimens were produced in the form of rectangular bar [10]
The composition of each test specimen can be seen in table 3, then the material is mixed into one until homogeneouswhile being given water to form a pasteafter that it is inserted into concrete brick molds and pressed manually. The concrete brick is then removed from the mold and placed on a board and the brick is allowed to stand for 1 night without being exposed to direct sunlight to prevent cracking. The brick is ready to be tested after drying for 7, 14, 21, 28, and 35 days.

The water absorption test is a measure of the ability of a porous concrete (reservoir) to absorb fluid[10],using the formula:

$$\text{Absorption} = \frac{(A - B)}{B} \times 100\%$$

Where: Wet Weight (A), brick soaked in clean condition for ± 24 hours, then removed from the water and wiped the surface with a cloth to remove excess water that is still left behind after it is weighed. Dry Weight (B), the brick is dried in furnice (± 105 ° C) until it weighs no more than 0.2% of the previous weighing. The weighing difference (A) and (B) is the amount of water absorption and is calculated based on weight percent.

Measuring compressive strength is used by equation:

$$\sigma = \frac{F}{A}$$

Where, $\sigma$ denote the compressive strength (kg/cm$^2$), F is Force press (kg) and A form sectional area (cm$^2$).

3. Result and Discussion

Water absorption Water

Water absorption test is carried out on a brick with composition variations 0, 5, and 10 wt.% Fly ash with drying time 7, 14, 21, 28, and 35 days, can be seen in table and graph 4.

| Fly ash composition (wt.%) | 7 days  | 14 days | 21 days | 28 days | 35 days |
|---------------------------|---------|---------|---------|---------|---------|
| 0                         | 12.75   | 12.44   | 11.53   | 11.02   | 10.65   |
| 5                         | 11.90   | 9.42    | 8.04    | 7.84    | 12.11   |
| 10                        | 10.86   | 8.65    | 7.91    | 8.42    | 11.48   |

Figure 4. Relationshipfly ash composition with water absorption
The composition of 0 wt.% fly ash, the longer drying time is 7, 14, 21, 28, and 35 days causes water absorption to decrease because the density value increases [15 & 5] due to the hydration reaction between cement and water which causes the concrete brick to become hard. The highest percentage of water absorption occurred at 7 days of drying by 12.75% using a composition of 0 wt. % fly ash and get quality 1 according to SNI 03-0349-1989.

The concrete brick with the addition of 5wt.% fly ash has a water absorption of 12.11 to 7.84%, while 10 wt.% fly ash has the absorption of water is 8.42 - 11.48%. The addition of fly ash composition in concrete brick is very influential on the water absorption of concrete brick, because the more the composition of fly ash make the smaller the water absorption, this happens because the size of fly ash is smoother than the size of other materials so that fly ash can fill the cavity between particles and cover porosity on concrete brick. The use of fly ash will reduce water absorption in concrete or mortar [11].

Based on SNI 03-0349-1989, all Batako Test are included in quality I which can be used for protected non-structural walls.

**Compressive Strength**
Compressive strength shows the ability of concrete brick to accept the compressive force of broad unity, so that the compressive strength can identify as concrete brick quality.

| Drying Time | 7 days | 14 days | 21 days | 28 days | 35 days |
|-------------|--------|---------|---------|---------|---------|
| Fly ash composition (wt.%) | Compressive Strength (kgf/cm²) |
| 0 | 42.34 | 34.30 | 32.70 | 34.02 | 31.62 |
| 5 | 44.85 | 39.25 | 35.81 | 51.98 | 39.31 |
| 10 | 26.76 | 26.59 | 25.09 | 23.88 | 26.64 |

**Figure 5. Relationship fly ash composition compressive strength**

Figure 5 illustrates the highest compressive strength results occur at the addition of 5 wt.% Fly ash, 28 days drying time is 51.98 kgf/cm², while the lowest compressive strength on drying time is 28 days, composition of 10 wt.% is 23.88 kgf /cm². The research data shows the addition of 5 wt.% Fly ash has a higher compressive strength compared to the addition of 0 wt.% Fly ash and at the addition of 10 wt.% Fly ash produces the lowest compressive strength when compared with the addition of 0 - 5 wt.% Fly ash every drying time. The use of 10 wt.% Fly ash causes the compressive strength to decrease because fly ash has the properties of absorbing water so that the hydration process between
cement and water does not run perfectly because of the high water content that can block the binding process and the low water content causes the reaction not to finish so that it can decrease compressive strength. This can be seen from the increased absorption of water so that the concrete brick becomes porous.

Based on SNI 03-0349-1989, the research resulted in a quality III concrete brick compressive strength used for unprotected non-structural walls, may be exposed to rain and heat and the quality IV is used for non-structural walls protected from weather.

4. Conclusion

1. The addition of fly ash makes the water absorption capacity decrease because the size of the fly ash is smaller than the size of the brick material so as to reduce porosity.
2. The highest compressive strength occurs at the addition of 5 wt.% Fly ash with 28 days drying time of 51.98 kgf/cm², while the lowest compressive strength on 28 days drying time is 10 wt.% Composition of 23.88 kgf/cm².
3. Concrete bricks made are included in quality III and IV.

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