The Effect of Coloring and Compacting Pressure Paving Block by Adding 5 Wt.% Fly Ash in The Compressive Strength

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Abstract: This research aims based on SNI 03-0691-1996 to investigate the effect of coloring and compacting pressure with the addition of 5 wt.% fly ash (Fa) on compressive strength. Fa derived from waste material coal-fired Sijantang Sawahlunto thermal power plant. The growing production of Fa caused negative environmental impact. So, one of the solutions to overcome that effects is to use the Fa as a raw material for paving block mixture that can reduce the cost of raw material and increase its strength. Paving blocks are gray and red with 0 wt.%, 5 wt.% Fa + Pb composition. Compaction pressure variations 55, 65, 75, 85 and 95 Kg/cm². The drying time for 35 days. Specimens were produced in the form of rectangular bar (length, L = 20 cm, width, B = 10 cm, thickness, W = 6 cm). The test results showed that the addition of 5 wt% FA has a compressive strength value higher than 0 wt%. The red color has a compressive strength lower than the gray color paving block caused the red color (Iron Oxide) is less binding at the time of mixing the material. Gray and red Paving blocks both increase in each additional compaction pressure, because the higher the compaction pressure will increase the bond between the particles so porosity is reduced increased compressive strength. The overall data, the gray paving block with the composition of 5 wt% FA at compaction pressure 95 kg/cm² with the optimal compressive strength value of 36.1 MPa and the lowest value is found in the red color paving block at 0 wt% FA at a pressure of 55 kg/cm² with a value of 6.5 MPa. Gray and red Color paving blocks has a compressive strength quality based on SNI 03-0691-1996.

Keywords: fly ash, paving block, SNI, colouring and compressive strength.

1. Introduction
Fly ash is residual coal combustion is widely used in the combustion process in a steam power plant. The increasing demand of coal in power plants for the combustion process leading to an increase of production new utilization of fly ash were little, which is approximately 20 to 30%, thus causing environmental pollution such as air pollution and groundwater. Therefore, it is necessary to find a solution to overcome the problem by the use of fly ash as a raw material for mixtures paving blocks that can reduce the cost of raw material and increase its strength. In developing the technical field of fly ash has superior properties, such as: hardness, high strength and capable of good work, so that it can be applied in the fields of construction, mechanical and chemical industry [4]. The utilization of fly ash as an additive can also improve the quality of paving blocks. On the composition of the fly ash 10% - 40%, paving block is watertight aggressive medium, which is resistant to industrial waste water, brackish water and sea water [3].

This study is a continuation of previous research. On the research found 5 wt% the composition of the fly ash is the best composition for the absorption of water by the value of quality A & B Quality Compressive Strength [10]. Binder best is mineral water [11,12] while the drying time is best obtained during 35 days [11]. The research aimed to determine the effect of coloring and compacting pressure with the addition of 5 wt.% fly ash (Fa) on compressive strength and determine the classification of the quality of paving blocks with SNI 03-0691-1996.

2. Paving Block
Paving block is the building material products of cement are used as an alternative ground cover or surface hardening. Paving blocks also known as concrete bricks (concrete block or cone block). Paving block is a building material composition made from a mixture of Portland cement or hydraulic
adhesive material like water and aggregates with or without other material that does not reduce the quality of concrete bricks. Among the various alternatives of land surface covers, paving blocks over have a lot of variety in terms of shape, size, color, pattern and texture of the surface as well as strength.

2.1 Advantages of Paving Block

Absorption of water through Block Paving can preserve the balance of groundwater to support concrete/ houses on it. Weight Block Paving relatively lighter than concrete/ asphalt and support the foundation of a stable house. The house has good water absorption, save soil water availability to be drilled and used for daily purposes. Easy implementation and does not require heavy equipment. Easy Maintenance and can be replaced after being demolished.

2.2 Weaknesses of Paving Block

Easy wavy when the foundation is not strong and less comfortable for the vehicle at high speed, thus paving block pavement is suitable for controlling the speed of the vehicle environment in residential and the crowded urban. Application of paving blocks can be classified based SNI 03-0691-1996 [4]

Table 1.

| Class | Compressive Strength (MPa) | Max average water absorption (%) | Application |
|-------|----------------------------|---------------------------------|--------------|
|       | Average | Min | Average | |
| A     | 40      | 35  | 3       | Road |
| B     | 20      | 17  | 6       | Parking area |
| C     | 15      | 12,3| 8       | Pedestrian |
| D     | 10      | 8,5 | 10      | Parks and other users |

Paving blocks manually produced concrete quality is usually included in class D or C is for the purpose of non-structural use, such as for parks and other uses that are not required to hold the load weight on it. Quality paving block the process by using a press machine can be categorized into concrete quality class C to A with a compressive strength above 125 kg/cm² depends on the mixing ratio of the materials used. Sightings of paving blocks are manufactured by hand and pressed paving block machine in plain view are relatively similar, but the surface of paving blocks are manufactured with a pressing machine looks denser than manually created [6].

2.3 Shapes and Sizes

Based on the shape of paving block can be divided into two rectangles and polygons. The thickness of 6 cm, 8 cm, and 10 cm. The color is generally gray or according to customer orders. Tolerance size is ± 2 mm for the size of the width and ± 3 mm of thickness and weight loss when tested sodium sulfate maximum 1 %.

Figure 1. Forms of paving block
2.4. Fly Ash

Fly ash is a coal combustion residue in the form of amorphous fine particles; an inorganic material is formed from mineral material changes due to the combustion process. From the coal combustion process in a steam generating unit (boiler) will form two types of ash are: fly ash and bottom ash. The composition of the coal ash produced consists of 10-20% bottom ash, while the remaining approximately 80-90% in the form of fly ash captured by the electric precipitator before being discharged into the air through the chimney.

According to ACI Committee 226, explained that the fly ash has a fairly smooth grain, which passes a sieve No. 325 (45 mile micron) 5-27% by the specific gravity of between 2.15 to 2.6 and blackish-gray color. Coal ash contains silica and alumina about 80% with partial-shaped amorphous silica. The physical properties of coal ash include a density of 2.23/cm³, about 4% water content and mineral composition is predominantly α-quartz and mullite. Besides coal ash containing SiO₂ = 58.75 %, Al₂O₃ = 25.82%, Fe₂O₃ = 5.30% CaO = 4.66 %, alkaline= 1.36 %, MgO = 3.30% dan other material = 0.81%.. Actually, fly ash does not have the ability to bind as well as cement, but with the presence of water and the size is fine, oxides of silica contained in the coal ash will react chemically with the calcium hydroxide formed from the hydration process of cement and will produce a substance that has the ability of binding .

3. Method

A specimen was performed in Industrial paving block Sumber Intan Betung Tebal Padang. Paving block material consisting of cement and sand sized 0.0625 to 2 mm (matrix), while for reinforcing materials used fly ash with a size of 80 meshes. Binder is mineral water.

![Material used: (a) Fly ash, (b) Cement, (c) sand, (d) Red iron oxide coloring and (e) Mineral Water](image)

Table 2. Paving block composition for 10 specimens

| composition (wt.%) | cement (kg) | Sand (kg) | FA (Kg) | Water (liter) | Iron Oxide (gr) |
|-------------------|-------------|-----------|---------|--------------|----------------|
| 100               | 4.7         | 23.3      | 0       | 0.8          | 133.33         |
| 95                | 4           | 22.6      | 1.4     | 0.8          | 133.33         |

Based on SNI 03-0691-1996, Specimens were produced in the form of rectangular bar (length, L = 20 cm, width, B = 10 cm, thickness, W = 6 cm). Paving block color is gray and red (thickness ± 1.3 cm of 6 cm). Based on the Composition of Materials paving block (Table 2). The materials are manually mixing to homogeneous and flush with mineral water until it forms a paste after that into a mold paving blocks. Compaction using a press machine with pressure variations: 55, 65.75, 85 and 95 Kg/cm². After finish compacting, Paving was placed above the board and let it harden for 1 night and not exposed to direct sunlight to avoid cracking, after that paving block is dried in direct sunlight for 35 days.
The Compressive Strength Test:
The process employs measuring compressive strength by equation:

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

Where:
- $\sigma$ = compressive strength (kg / cm$^2$)
- $F$ = Force press (kg)
- $A$ = sectional area (cm$^2$)

4. Results And Discussion

Gray and red paving blocks are both experienced an increase in each additional compaction pressure, because the higher the pressure molding the density is also higher because of the higher compacting pressure will increase the bonding between the particles so that the gaps between the particles/porosity is reduced through the new particle contact and leads to better packing and increased compressive strength. The thickness of the paving blocks are also influential because it is a parameter that must be maintained as thick as 6 cm [4] so that its increases weight.

The compressive strength higher than the overall data is the gray paving block with a composition of 5% by weight of fly ash which is at a pressure of 95 kg/cm$^2$ with a value of 36.1 MPa and the lowest value contained in the paving block of red in the composition of 0 wt % fly ash that is at a pressure of 55 kg/cm$^2$ with a value of 6.5 MPa.

Comparison of the results of the compressive strength test of the gray paving blocks higher than the color red, this is due to dye red iron oxide used in the manufacture of paving blocks to contain 95 % Fe$_2$O$_3$ which is a ceramic material that bonding process be better if aided by the heating process.

| Compaction Pressure (kg/cm$^2$) | Compressive Strength (MPa) |
|---------------------------------|-----------------------------|
|                                 | Grey Quality | Red Quality |
| 5% wt. FA                       |               |             |
| 55                              | 17.8 B       | 11.8 D      |
| 65                              | 26.9 B       | 13.7 C      |
| 75                              | 27.9 B       | 15.6 B      |
| 85                              | 32.2 B       | 18.0 B      |
| 95                              | 36.1 A       | 22.5 B      |
| 0% wt. FA                       |               |             |
| 55                              | 14.8 C       | 6.5 <D      |
| 65                              | 18.3 B       | 7.1 <D      |
| 75                              | 20.1 B       | 10.8 D      |
| 85                              | 24.8 B       | 13.1 C      |
| 95                              | 30.3 B       | 15.1 C      |

All the test results included in the SNI 03-0691-1996: Quality A: for roads, Quality B: the Court parking Quality, C: Pedestrians Application and Quality D: Applications Parks and other.
5. Conclusions

Based on the results, it can be deduced as follows:
The higher Compacting pressure paving block make the increased compressive strength. Compressive Strength is highest in pressure 95 Kg/cm² in both compositions. Compressive strength between the gray higher than the red color paving blocks. The compressive strength between gray and red paving blocks have quality according to the standard SNI 03-0691-1996.

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