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Effect of Using Roof Clay and Charcoal Ash as a Substitution of Coarse Aggregate and Cement in a Concrete Compressive Strength

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Abstact

Infrastructure and technology development in the construction sector are rapidly evolving, particularly in Indonesia. Because practically every construction building is built of concrete, this supports the increased use of natural materials as raw materials for creating concrete to keep up with the world's rapid development. As a result, new technologies are required to limit the use of substitute elements in concrete mixtures while also minimizing environmental damage. The researchers used clay tile waste and charcoal ash as a substitute for coarse aggregate and cement in the concrete mix in this final project. This study uses an experimental approach with a total of 36 samples of cylindrical samples with a size of 10cm x 20cm, a substitution variation of 20%, 25% of total coarse aggregate, and charcoal ash 5% of total cement weight. On days 3, 7, 14, and 28, the test object will be slumped to see how workable it is and how strong it is. According to the findings, the higher the percentage in the concrete mixture, the lower the slump value, and the compressive strength test results. The highest is the 25% GTL substitution variation. At the age of 28, 5% AA equals 27.3 MPa. The results of testing the compressive strength of concrete with the substitution of tile waste reached the quality of K-225.

Keywords :
Alternative, Charcoal Ash, Compressive Strength, Tile Waste,

1. Introduction

Concrete is defined as a mixture of portland cement or other hydraulic cement, fine aggregate, coarse aggregate, and water, with or without additives, combined together with a paste formed of cement and water to form a mass comparable to rock, according to SNI 2847:2013. Because practically every construction building is built of concrete, this supports the greater use of natural materials as raw materials for creating concrete to keep up with the world's rapid development. According to Metha (1997), global concrete consumption is roughly 8.8 million tons per year, and the need for this material will continue to rise year after year as the world's population grows and the demand for basic human services and infrastructure grows. (Manuahe, Sumajouw and Windah, 2014)

It is also related to construction materials as the period of technology and knowledge progresses. The realization of the environmental damage caused by ongoing mining, as well as the fact that cement manufacture contributes to global warming due to massive CO2 emissions, follows. As the usage of cement in the construction of concrete grows, so does the amount of CO2 gas released into the atmosphere, contributing to global warming.

As a result, new technologies are required to limit the use of substitute elements in concrete mixtures while also minimizing environmental damage. When materials derived from natural resources are used indefinitely, such as coarse aggregate (gravel) and cement, the availability of materials may run out, and the impact of using materials derived from natural resources includes many mining industries that cause environmental damage, air pollution, and water pollution, among other things.

This prompts further study into alternative materials for coarse aggregate and cement, such as clay tile waste and charcoal ash. This research employs an experimental method to increase the waste's economic worth while also determining the test object's workability and compressive strength.

1.1 Formulation Of The Problem

The problem formulation in this study is as follows, based on the background description:

1. What impact does a mixture of charcoal ash as a cement substitute and tile waste as a coarse aggregate substitute have on the slump value of concrete?

2. What impact does varying the proportions of charcoal ash and roof tiles as a cement and coarse aggregate substitute have on the density of concrete?
3. What impact does varying the proportions of charcoal ash and roof tiles as a cement and coarse aggregate substitute have on water absorption in concrete?
4. What effect does varying the proportions of charcoal ash and roof tiles as a cement and coarse aggregate substitute have on the compressive strength of concrete?

1.2 Research Objective

The aims and objectives of this research are

1. Understanding the effect of variations in the effect of a mixture of charcoal ash as a cement substitute and tile waste as a coarse aggregate substitute on the slump value in concrete are the goals and objectives of this study.
2. Understanding the impact of modifications in the blend of charcoal ash and critical waste used as a cement and coarse aggregate substitute on concrete density.
3. Understanding the impact of differences in the blend of charcoal ash and roof tiles used as a cement and coarse aggregate substitute on water absorption in concrete.Mengetahui pengaruh variasi campuran abu arang dan limbah genting sebagai subtitusi semen dan agregat kasar terhadap *density* pada beton.
4. The effect of modifications in the mixture of charcoal ash and roof tiles as a substitute for.
5. cement and coarse aggregate on concrete compressive strength.

1.3 Scope and Limitations of Problem

To avoid research that is too broad, it is necessary to limit the problem as below :

1. Use of charcoal ash as a cement substitute in concrete mixtures.
2. The use of tile waste as a coarse aggregate alternative in concrete compositions.
3. The sand used in this project is bangka sand.
4. The cement used is type I Portland cement.
5. The cylindrical test object has a diameter of 100 mm and a height of 200 mm.
6. The test item is 3 days, 7 days, 14 days, and 28 days old, with 3 samples each.
7. The percentage of charcoal ash substitution is 5%, clay tile content is 20%, and the percentage of clay tile content is 25%.
8. Using a press machine to test the compressive strength of concrete.

2. Literature Review

2.1. Meaning of Concrete

Concrete is defined as a mixture of Portland cement or other hydraulic cement, fine aggregate, coarse aggregate, and water, with or without admixtures, according to SNI 2847:2013. The concrete will harden as it ages, and by the age of 28 days, it will have reached the design strength (f'c). Concrete is made by hardening a mixture of cement, water, fine aggregate (sand), and coarse aggregate (gravel) into a solid mass (gravel crushed stone). To increase the quality of the concrete, a mixture of other ingredients (admixture) is sometimes added (Efendi, Kurniawan and Wulandari, 2019).

2.2. Concrete Materials

2.2.1. Cement Portland

Cement is a mixture of lime (CaCo3) and clay in a certain proportion that is fired and hardens into a stone-like mass over time. Because cement works as a binder for the aggregates to create a solid unit through a chemical process, namely hardening owing to the reaction of the cement-forming ingredients with water or water vapor, cement is the most significant ingredient in concrete.

2.2.2. Air

In order to moisten the chemical reaction with cement, wet the aggregate, and lubricate the mixture so that it is easier to work with, water is required in the production of concrete. The water used to manufacture concrete must be clean and free of oil, acid, alkali, salts, organic compounds, and other contaminants that might harm concrete and reinforcing steel.

2.2.3. Agregat

a. Sand

Fine aggregate, often known as sand, is a mineral that comes in the form of fine particles, such as crystals with a particle size of less than 0.075-5.0 mm or that has passed through a filter no. 40. Natural sources of fine aggregate or sand can be found. Crushed concrete, crushed slag ash, and river and manufactured sand from stone crushers. Bangka sand was used in this experiment.

b. Gravel

According to SNI (1969), coarse aggregate is gravel that has a grain size of 4.75 mm (No. 4) to 40 mm (No. 12 inches) and is produced by natural disintegration of rock or crushed stone obtained from the stone crusher business.

2.3. Clay Tile

In addition to asbestos, which serves as a heat and rain barrier, tile is a common roof covering in Indonesia. Tile manufacturers produce tile shard trash as a byproduct of the clay-to-tile manufacturing process. Wasted fractional trash can harm the environment if it is not properly managed.

2.4. Charcoal Ash

Wood charcoal ash contains silica, which is an excellent aggregate binder, as well as aluminum and iron, which meet the requirements for pozzolan according to SNI and ASTM, and serves the same purpose as cement in a concrete mix. The use of charcoal ash waste should result in less pollution of natural ecosystems.

2.5. Compressive Strength

Concrete's compressive strength reflects the structure's quality. The larger the yield of the final concrete compressive strength, the stronger the intended structure. When the test object is loaded with a given compressive force produced by the press machine, the compressive strength of concrete is the amount of load per unit area that causes it to collapse.

The formula 2.1 below can be used to calculate the compressive strength of concrete:

$$f'c = \frac{P}{A}$$

$f'c$ = Maximum force (Mpa)
A = larea under pressure (mm^2)
P = Maximum Load (N)

3. Research Methodology

The data and results from the research were obtained utilizing an experimental approach that will be carried out in the Mercu Buana University laboratory by combining or substituting coarse aggregate with tile fragments waste material and cement substitution with charcoal ash in the concrete mixture. Charcoal ash was employed as a partial replacement for cement in this study, accounting for 5% of the weight of cement, 20% of clay tiles, and 25% of the weight of coarse aggregate, respectively. A cylindrical mold with a height of 20 cm and a diameter of 10 cm will be used to mold the concrete test object. After that do the curing by immersing the concrete test object into plain water for 3, 7, 14, 28 days.

3.1. A Flowchart

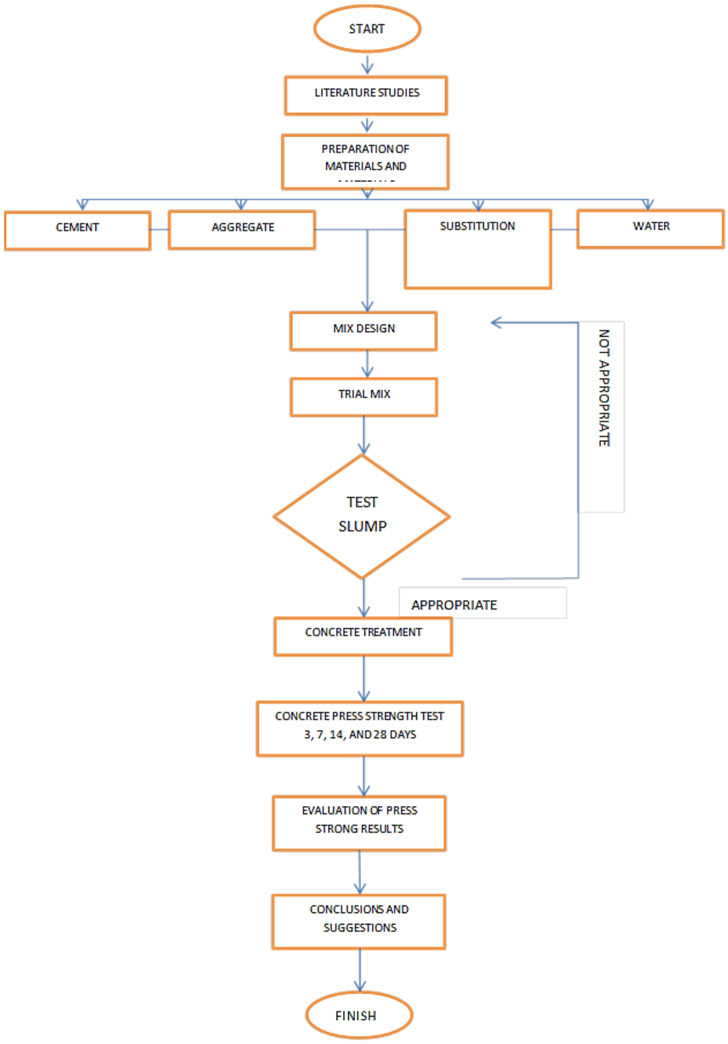

Figure 1 Flowchart

4. Result and Analysis

4.1. Slump Analysis

The slump test is used to determine the concrete mix's workability or viscosity. The following are the outcomes of the slump test that was performed:

Table 1. Slump Score in cm

Sample	Curing (Days)	Slump Plan (cm)	Slump Test (cm)
BN	7 3 28 28	8-12.	11
SU1	7 3 28 28	8-12.	10.5
SU2	7 3 28 28	8-12.	12

The results of the normal and substituted concrete workability tests are provided in the histogram form below, as reported in table 1:

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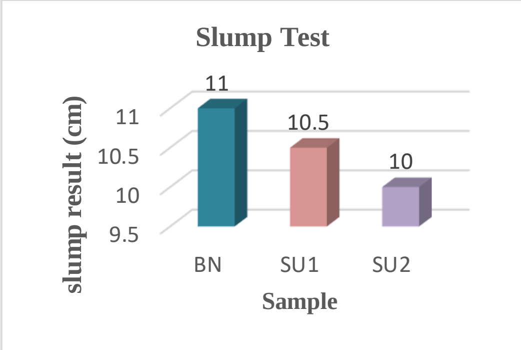

Figure 2 Histogram Slump Test

4.2. Concrete Compressive Strength Result
4.2.1. Normal Concrete Strength Analysis

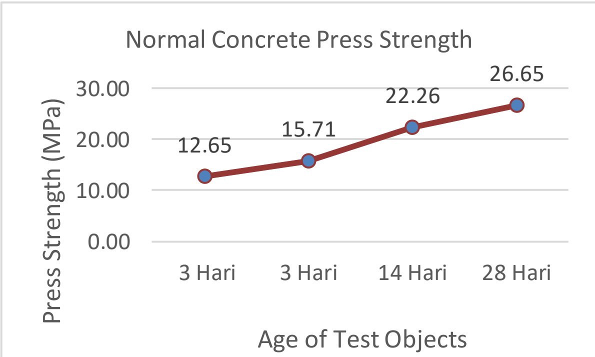

Figure 3 Graph of Normal Concrete

The average compressive strength of concrete on day 3 is 12.64 MPa, 15,709 MPa on day 7, 22,260 MPa on day 14, and 26.65 MPa on day 28. This can also be seen in the graph, which shows that the increase continues up to 28 days old.

4.2.2. Variation of AA5% and GTL 20% Concrete Mix

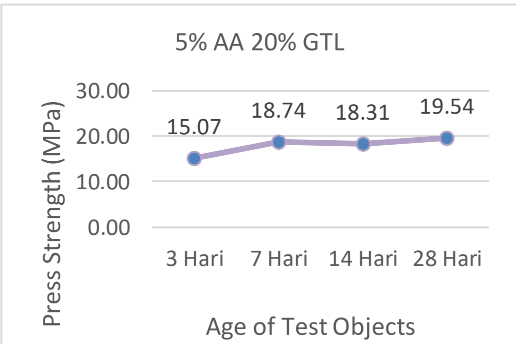

Figure 4 Graph of AA 5% and 20% GTL

The compressive strength of concrete with 5% AA substitution and 20% GTL on the 3rd day is 15.06 MPa, the 7th day is 18.74 MPa, and the 14th day is 18.30 MPa on the 28th day, according to the graph above. 19.54 MPa, to be precise. The graph also shows that the growth continues till the age of 28. With the substitution of AA 5% and GTL 20%, the concrete quality at 28 days reaches K-225, indicating that the concrete has entered the class II concrete quality, i.e. the quality of concrete for construction. structure.

4.2.3. Variation of AA5% and GTL 25% Concrete Mix

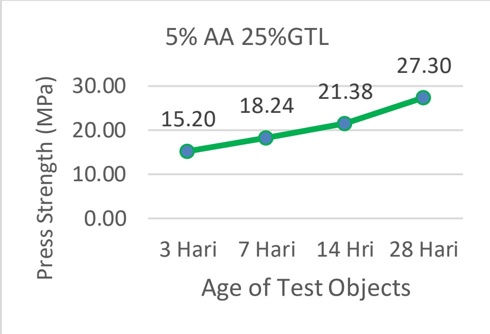

Figure 5 Graph of AA 5% and 25% GTL

The compressive strength of concrete with 5% AA substitution and 25% GTL on the 3rd day is 15.20 MPa, the 7th day is 18.24 MPa, the 14th day is 21.38 MPa, and the 28th day is 21.38 MPa, according to the graph above. e.g. 27.30 MPa The graph also shows that the growth continues till the age of 28. With the substitution of AA 5% and GTL 25%, the concrete quality at 28 days reaches the K-225 quality, indicating that the concrete has entered the class II concrete quality, namely the structural concrete quality.

4.3. Compressive Strenght Compare

4.3.1. 3 Day Compressive Strength

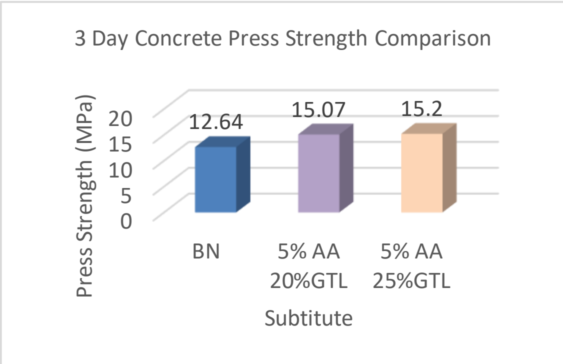

Figure 6 Histogram of 3 Day

The greatest compressive strength of concrete with the substitution of concrete tile waste at the age of 3 days is 25 percent substitution, which is 15.2 MPa, while the lowest compressive strength is in regular concrete, which is 12.65 MPa, as shown in the histogram above.

4.3.2. 7 Day Compressive Strength

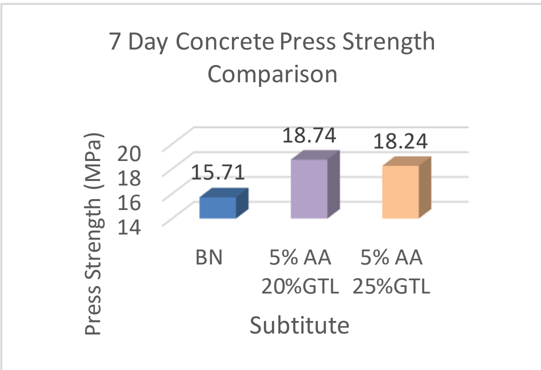

Figure 7 Histogram Of 7 Day

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The greatest compressive strength of concrete with the substitution of concrete tile waste at the age of 3 days is 25 percent substitution, which is 15.2 MPa, while the lowest compressive strength is in regular concrete, which is 12.65 MPa, as shown in the histogram above.

4.3.3. 14 Day Compressive Strength

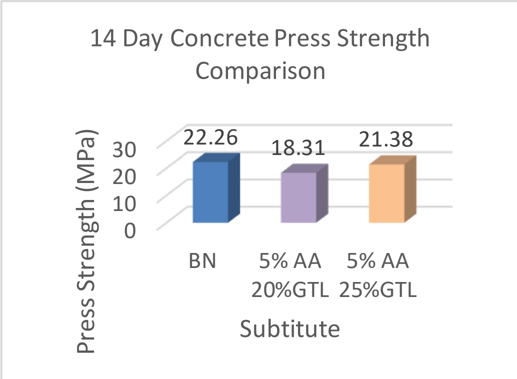

Figure 8 Histogram Of 14 Day

The substitution of 25 percent GTL, which is 21.38 MPa, has the maximum compressive strength of concrete with the substitution of concrete tile waste at the age of 14 days, while the substituted concrete of 5 percent AA and 20 percent GTL, which is 18.31 MPa, has the lowest compressive strength.

4.3.4. 28 Day Compressive Strength

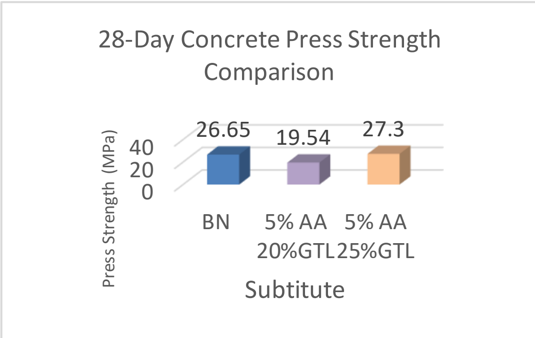

Figure 9 Histogram Of 28 Day

The highest compressive strength of concrete with the substitution of waste concrete tile at the age of 28 days is 27.3 MPa, while the lowest compressive strength is 19, 54 MPa in replaced concrete with 5 percent AA and 20 percent GTL tile. Several reasons can contribute to this, including the influence of the test concrete (formwork) and the quality of the substitute material that does not match the specifications.

4.3.5. Combined Compressive Strength

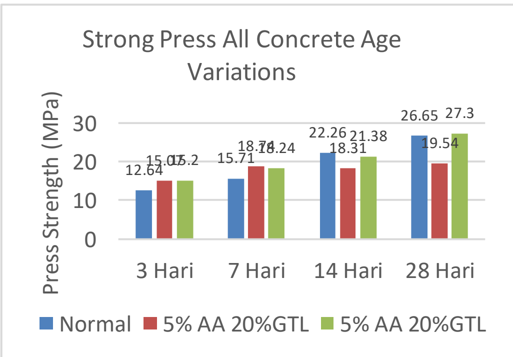

Figure 10 Histogram Of Compressive Strength

On day 14, the compressive strength of regular concrete increased by 0.1 percent, while the compressive strength of concrete with a substitution of 5% AA and 20% GTL fell by 0.1 percent, as shown in the combined histogram above. The compressive strength of the test object's concrete increased after 5 percent AA and 25 percent GTL were substituted.

4.4. Density

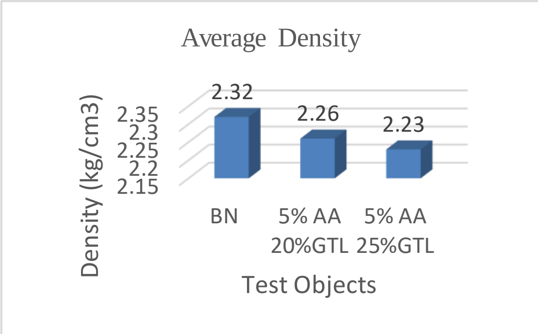

Figure 11 Combined Concrete Density Histogram

According to the histogram above, the average density value of each normal concrete and the substitution mixture of AA 5% and GTL 20%, 25% is 2.32 kg/cm3, 2.26 kg/cm3, 2.23 kg/cm3 respectively.

4.5. Water Absorption

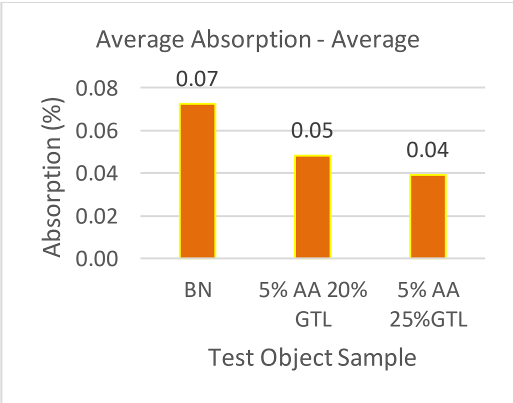

Figure 12 Histogram of Absorption

From the graph above, it can be concluded that the average absorption values of normal concrete and a mixture of 5% charcoal ash substitution and 20%, 25% tile waste are 0.07%, 0.05%, and 0.04%.

5. Conclusion

1. The lower the slump value, the greater the clay tile mixture in the concrete mixture. The more harder anything is to do, the less the value. This is owing to the tile's ability to absorb water from the concrete mix, causing the concrete mix to thicken. As a result, the waste of concrete roof tiles has an impact on the concrete's workability.
2. The highest density concrete, with a mixture of 5% AA and 25% GTL, has a density of 2.32 kg/m3, while the lowest density concrete, with a mixture of 5% AA and 25% GTL, has an average density of 2.23 kg/m3. The lesser weight of the mixture of charcoal ash and clay tile compared to the mass of cement and coarse aggregate produced the decrease in density value.
3. The absorption reduces as the percentage of concrete tile waste in the concrete mixture increases. This is owing to the tile's ability to absorb water from the concrete mix, causing the concrete mix to thicken. As a result, charcoal ash and concrete tile waste have an impact on concrete's water absorption (absorption).
4. The more the percentage of waste concrete tile in the concrete mixture, the absorption decreases. This is due to the nature of the tile that easily absorbs water in the concrete mix so that the concrete mix

becomes thicker. Thus charcoal ash and concrete tile waste affect the water absorption (absorption) of concrete.

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