The Partial Substitution Influence of Fine Aggregate with Egg Tray Waste in the Green Concrete Production

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Abstract: Study on the compressive strength of concrete is carried out by adding egg tray waste as a building material for green concrete. Egg tray waste made into pulp is used as a partial substitute for fine aggregate with a substitution percentage of 1%, 3% and 5%. These three variations were tested for the compressive strength of concrete at the age of 7 days and 28 days which resulted in comparison with normal concrete. The results showed that the compressive strength of concrete at a variation of 1% egg tray as a substitute for fine aggregate gave a concrete compressive strength value of 23.95 MPa at the age of 7 days and 31.29 MPa at the age of 28 days, which is close to the value of normal concrete compressive strength. For samples with variations of 3% and 5% egg tray, the compressive strength for 7 days of age was 9.75 MPa and 8.64 MPa, while for 28 days it was 14.46 MPa and 9.79 MPa. Partial substitution of fine aggregate with 1% egg tray waste can be used as structural concrete, while the egg tray percentage of 3% and 5% is not recommended for use as structural concrete.

1 INTRODUCTION

The increasing quantifier of urban population is not only caused by the high birth rate but also the urbanization of society. With a high population, it will result in an increase in the volume of waste generated from homes (Hasibuan, 2016). Egg tray (egg packaging) is one of the easy-to-find household waste which is generally made from recycled paper waste in Indonesia (Pradana et al, 2019). This condition is due to the highest percentage of the highest amount of waste being in the category of paper waste and paper-based waste so that processing into functional products with selling value is one solution in reducing the amount of uncontrolled waste (Kurniasih and Handoko et al, 2013 and 2018). Based on data from the Central Statistics Agency (BPS, 2020), the production of laying hens in Indonesia in 2020 reached a total of 5,044,394.99 tons. This figure does not include the production of native chicken eggs and duck eggs which also always increase every year. This condition has shown that the use of egg trays will increase based on the demand for egg production which in turn increases the volume of egg tray waste.

The utilization of waste materials as construction materials has become a special concern, one of which is as a building material for green concrete. The term of green concrete is given to concrete made from the use of waste materials so that it becomes environmentally friendly concrete (Agarwal et al and Al-Azzawl et all, 2016 and 2020). Used waste materials to make green concrete can be utilized through the replacement of cement, aggregates, fillers, or fiber reinforcement. Cement as a construction material is considered an environmental pollutant die to the production cycle, while waste materials can have environmental benefits when used instead of coarse aggregate or fine aggregate or to replace cement (Sagban et al and Mohammad et al, 2019).

Study on the use of egg trays as a material in concrete was carried out in the form of egg tray ash combined with rice husk ash. The results of testing the compressive strength of concrete using additional materials of rice husk ash and egg tray ash less than 25% addition variations can be used as lightweight concrete materials for lightweight structures, but for addition above 55% can be used for non-structural lightweight concrete (Tarru et al, 2019). For study on paper waste in the form of waste paper sludge (WPS)

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as a partial substitute for cement, it shows that the addition of WPS at a certain percentage can increase the compressive strength of concrete but the increasing percentage of WPS makes the strength of the concrete decrease (Bhargavi et al, 2016). The addition of paper waste to the concrete mixture with the percentage of paper waste added by weight shows a significant decrease in the compressive strength of concrete along with the increase in the percentage of paper waste addition (Mamta et al and Choudary et al, 2017 and 2018).

The contribution of this study is very supportive in overcoming the problem of household waste. In this case, egg tray waste can be used as an alternative material for making concrete that is more economical and environmentally friendly and can be applied by the society.

2 REVIEW OF LITERATURES

2.1 General

The minimum of research on the use of egg trays in concrete mixtures, to support this study also refers to other research on the use of paper waste in concrete mixtures, which as previously mentioned that egg trays are the result of processing from paper waste.

2.2 Review of Various Research

- The study conducted by Tarru et al (2018) used a combination of rice husk ash and egg tray ash as an additive in concrete. The results showed that the compressive strength of concrete using rice husk ash and egg tray with the addition of 10% reached 16.27 MPa at the age of 28 days. Meanwhile, normal concrete at the age of 28 days reaches a compressive strength of 15.33 MPa. In addition variations of 25%, 55%, 80% and 95% had compressive strength at the age of 28 days respectively 8.93 MPa, 4.33 MPa, 2.80 MPa and 3.27 MPa. From these results, the variations of 10% and 25% can be used as lightweight materials for lightweight structures, while the additions of 55%, 80% and 95% can be used to make non-structural lightweight concrete.
- Bhargavi et al (2016) conducted a study using waste paper sludge (WPS) as a partial substitute for cement. The replacement of cement with an additional 4% WPS resulted in a concrete compressive strength of 32.41 MPa at the age of 28 days, while at the same age for normal concrete it was 30.50 MPa. For the additional conditions of 8%, 12% and 16% WPS, the compressive strength of concrete at the age of 28 days was 25.42 MPa, 22.19 MPa and 20.56 MPa. This shows that the addition of WPS at a certain percentage can increase the compressive strength of concrete but the increasing percentage of WPS makes the strength of the concrete decrease.
- The investigation of various proportions of waste paper in the concrete mixture was carried out by Mamta et al (2017) with the addition of waste paper 0%, 5%, 10% and 15% by weight. The compressive strength of concrete for 0% condition at the age of 28 days reached 26.27 MPa. With the addition of 5%, 10% and 15% additional paper waste, the compressive strength values were obtained which decreased to 19 MPa, 16 MPa and 15.67 MPa.
- Similar results were also obtained by Choudhary et al (2018) with the use of waste paper pulp as a partial substitute for sand through variations in the addition of waste paper pulp by 5%, 10% and 15% for several conventional concrete qualities. With the increase in the percentage of waste paper pulp in the concrete mixture, the compressive strength of the concrete will decrease.

3 METHODOLOGY

Research and sample testing was carried out at the Materials Testing Laboratory, Department of Civil Engineering, State Polythecnic of Kupang using local materials for fine aggregate and coarse aggregates, and for cement using PPC type 1. Egg tray waste used is obtained from household waste as well as from traditional markets (see Figure 1). Testing for the characteristic of the material is carried out first to determine whether the quality of the material used has met the required specifications standards.

Mixed design was carried out to obtain a compressive strength of normal concrete with target f'c=30 MPa. The specimens were made in 4 (four) sample variations for the percentage of egg tray waste with variations of 0% for normal concrete, 1%, 3% and 5% for variations in substitution of fine aggregate with egg tray. The egg tray waste used is cleaned of dirt so that it remains in a clean state which is then made into pulp to be mixed into the concrete. The percentage of egg tray addition is based on the ratio to the weight of the fine aggregate. Each sample variation was made as many as 8 samples of cylindrical specimens with a diameter of 15 cm and a height of 30 cm. The specimens was given treatment in water after 24 hours produced and the compressive strength test was carried out at the age of 7 days and 28 days.

Figure 1: Egg tray from household waste and traditional markets.

For specimens with variations in the addition of egg trays, corrections are made to the water requirement based on the moisture content of the fine aggregate and egg tray due to the egg tray must be made into pulp before being mixed with concrete so that the egg tray can mix well and become homogeneous with the concrete

4 RESULT AND DISCUSSION

The mixed design obtained to make the concrete mixture in the variation of the sample for 1 specimen is shown in Table 1 and detailed of specimen is shown in Table 2. The water requirement for the concrete mixture with variations in partial replacement of the egg tray needs to be corrected due to the egg tray that is mixted is in the form of pulp so that it can be homogeneous with other materials.

Table 1: Composition of concrete mixture for 1 specimen.

Egg Tray Content	PCC (kg)	Fine Aggregate (kg)	Coarse Aggregate (kg)	Water (liter)	Egg Tray (kg)
0%	2.47	4.22	4.73	1.07	0.00
1%	2.47	4.18	4.73	1.25	0.04
3%	2.47	4.09	4.73	1.61	0.13
5%	2.47	4.01	4.73	1.98	0.21

Table 2: Number of specimens.

Age of sample	Percentage of Egg Tray			
	0%	1%	3%	5%
7 days	4	4	4	4
28 days	4	4	4	4
Total of sample	8	8	8	8

The specimens produced from each variation of the egg tray percentage as a substitute for sand in the concrete mixture showed different volumes of test specimens within 24 hours after being poured into the mold as shown in Figure 2. In normal concrete specimen and 1% egg tray percentage variations, there is no change in the specimen height, which is still according to the existing mold of 300 mm. However, for variations in the egg tray percentage of 3% and 5%, there was a decrease in the volume of the specimen which was seen from the decrease in the sample height from the height of the mold. The 3% egg tray variation has an average specimen height of 298 mm, while the 5% egg tray percentage variation has an average specimen height of 296 mm. This shows that in the sample variation of the egg tray percentage variation of 3% there is a shrinkage of 0.67% and it is increasing in the sample variation of the egg tray percentage of 5% with shrinkage of 1.25%.

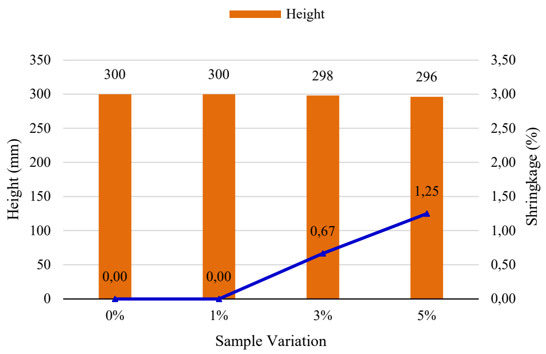

Figure 2: Shringkage for height of sample.

The partial substitution fine aggregate with an egg tray can reduce the density of the concrete shown in Figure 3. Based on the sample specimens, normal concrete has an average density of 2403.47 kg/m3. The replacement of sand with a percentage variation of 1%, 3% and 5% egg tray resulted in a concrete density of 2313.05 kg/m3, 2199.16 kg/m3 and 2105.72 kg/m3. This shows that there is a significant decrease in the specific gravity of the concrete with the addition of an egg tray to the concrete mixture. For the percentage variation of 1% egg tray, the specific gravity decreased by 4.36%, and with an increase in the percentage variation of 3% and 5% egg tray, the specific gravity of the concrete decreased of 9.07% and 12.93%.

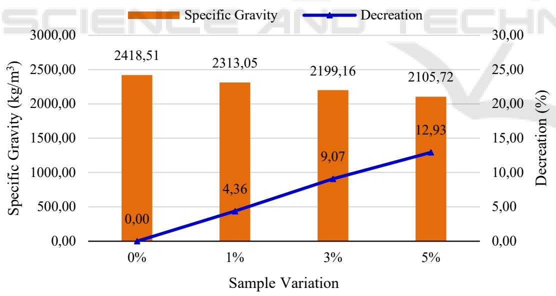

Figure 3: Influence of egg tray content on specific gravity of concrete.

Based on the results of testing the compressive strength of concrete for each sample variation shown in Figure 4, it was obtained that at the age of 7 days the average compressive strength for normal concrete specimens was 28.86 MPa. The specimens with variations in the percentage of egg tray as a partial substitute for fine aggregate of 1%, 3% and 5% respectively were 23.95 MPa, 9.75 MPa and 8.64 MPa. At the age of 28 days of concrete for normal test specimens, the average compressive strength of concrete is 36.14 MPa, while for variations of 1%, 3% and 5% egg tray, the average compressive strength of concrete is 31.29 MPa, 14.46 MPa and 9.79 MPa.

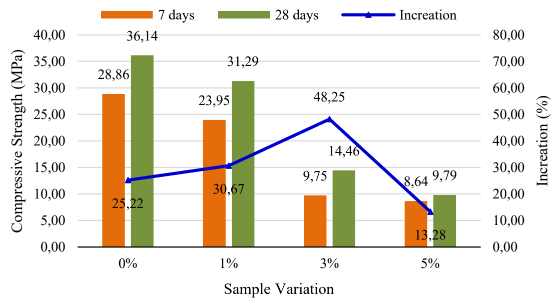

Figure 4: The results of the compressive strength of concrete at the age of 7 and 28 days.

Generally, there is an increase in the compressive strength of concrete from the age of 7 days to the age of 28 days. For the normal concrete, the increase in the compressive strength of concrete is 25.22%, while the increase in the compressive strength of concrete is more significant at 3% egg tray percentage variation, which is 48.25%. In the variations of 1% and 5% egg tray, the compressive strength of concrete increased by 30.67% and 13.28%.

These investigation can be concluded that the partial substitution of fine aggregate with 1% egg tray can be used as structural concrete due to the compressive strength of concrete of up to 30 MPa. The partial substitution of fine aggregate with 3% and 5% egg tray, it is not recommended to use it as structural concrete. By replacing fine aggregate with egg tray, it will further reduce the weight of the concrete as the percentage of egg trays increases, but it will also reduce the compressive strength of the concrete.

5 CONCLUSION

Based on the result of this study, it can be concluded that egg tray waste can be used as a substitute for fine aggregate in making green concrete for structural concrete functions with a percentage of replacement of fine aggregate by 1% due has a compressive strength value is close to normal concrete, while for egg tray 3% and 5% as a substitute for sand in concrete is not recommended for use as structural concrete. As the percentage of egg tray increases in the concrete mixture, the density of the concrete and the compressive strength of the concrete will decrease.

Further research development needs to be carried out to determine the characteristics of flexural strength, splitting tensile strength and modulus of elasticity produced with egg tray percentage variations below 1%.

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