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RESEARCH ARTICLE

Experimental Study of Asphalt Tile Waste as a Substitute for Coarse Aggregate and Fly Ash as a Partial Substitution of Cement in Concrete Mixtures on Compressive Strength

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Abstract: The increasing growth of residential construction, as well as construction waste is also increasing, including tile roof waste. So this study will process the tile fragments or waste to mix concrete as a substitute for coarse aggregate and fly ash as a partial substitution of cement for compressive strength. The purpose of this study was to determine the effect on slump, water absorption, density, and compressive strength of concrete. The method used in this research is experimental by conducting a trial mix which is carried out at the Concrete Laboratory of DSP - PT. Duta Sarana Prakarsa. From the research results of asphalt tile waste and fly ash substitution, there is a slump level of 6 cm - 8 cm, normal concrete has a slump value of 7 cm. The highest slump value is found on 20% asphalt tile, which is 8 cm from normal concrete. The biggest slump decrease occurred in 10% asphalt tile and 10% fly ash from normal concrete. At the age of 28 days, it can be seen that normal concrete has a water absorption value of 3.78%. Meanwhile, the water absorption with the highest value is found in 20% asphalt tile, which is 4.93%. The lowest water absorption value occurs in 10% asphalt tile, which is 3.40%. At the percentage of the mixture of 20% asphalt tile waste and 10% fly ash, the density decreased the most by 7.93% from normal concrete. The compressive strength value of normal concrete at the age of 28 days was 389.91 Kg/Cm². The greatest decrease in compressive strength occurred in a mixture of 20% asphalt tile waste and 10% fly ash, which was 156.51 Kg/Cm².

Keywords: Asphalt Tile Waste, Fly Ash, Slump, Water Absorption, Compressive Strength.

1. Introduction

Technological advances are currently very developed, besides the use of concrete materials for infrastructure is increasing. And the available materials are easy to get, the use of technology is also easy to implement, it is still considered cheaper than other materials, so it is of great interest at this time. Concrete is one of the combined materials of a material including Portland cement, aggregate (coarse and fine aggregate), water and sometimes



added by using various additives ranging from chemical added materials, as well as non-chemical waste materials in comparison certain (Tjokodimuljo, 1992).

The advantages of concrete according to Kardiyono (2007) are that the price is relatively cheap because the materials are freely available except cement, low maintenance costs because concrete is a durable, wear-resistant and fire-resistant element, the compressive strength of concrete is very high and fresh concrete is very easy to process transferred, printed and shaped.

The growth of residential construction is increasing, and construction waste is also increasing, including the waste of tile roof fragments (Simão, et.al., 2021). So that there is a lot of tile roof waste that has not been utilized, to utilize the remaining unused tile waste materials, this research will process the tile fragments or waste to mix concrete as a substitute for coarse aggregate.

From many previous studies that asphalt tile waste can be used as a substitute for coarse aggregate in concrete mixtures in the manufacture of concrete (Poon & Chan, 2007; Silvestre, et.al., 2013). Therefore, this study aims to prove whether asphalt tile waste can be an alternative material in the manufacture of concrete and how much influence it has on compressive strength.

Using asphalt tile waste materials as a substitute for coarse aggregate in concrete mixtures in Indonesia is still not widely practiced, but has begun to be used, among others, for road patching, speed bumps, parking lots and sidewalks. This is because the raw material for coarse aggregate is easy to obtain. But sooner or later the material will run out, causing the material from year to year to be more expensive.

2. Research Method and Materials

The method used in this research is an experimental method. According to Sugiyono (2009), the research method is defined as a scientific way to obtain data with certain purposes and uses. The research was conducted by conducting an experiment to obtain data that connects the investigated variables.

This study aims to determine how much influence the asphalt tile waste as a substitute for coarse aggregate and fly ash as a partial substitution of cement in the concrete mixture on the compressive strength with research processes and procedures that refer to SNI (Indonesian National Standard) and previous journals by related research.

In the initial process, material preparation is carried out, then aggregate testing is carried out to determine the quality of the aggregate to be used. Aggregate testing includes colloid content test, sieve analysis test, specific gravity, absorption, clay lump test, organic impurities for fine aggregates), density (density), coarse aggregate abrasion test (abration test) then mix design is carried out, after the mixture composition is obtained, a trial mix of concrete is carried out with an initial slump flow test. If the test results are in accordance with the specifications, the concrete mixture is poured into the sample molds. The specimens were molded using a cylindrical mold with dimensions of 10 cm and a height of 20 cm.

In making concrete samples using type I portland cement, fine aggregate, coarse aggregate, clean water, and asphalt tile waste and fly ash.

The method used in this research includes several main activities, namely: a) Examination of the character of the concrete constituent materials; b) Making concrete mix designs; c) Slump Testing; d) Water absorption; e) Density testing of concrete at the age of 14 and 28 days; f) Testing the compressive strength of concrete at the age of 14 and 28 days; and g) Data analysis and discussion of research results.

Table 1. Concrete Mix Design

Asphalt Tile Waste (%)	Fly Ash (%)	Concrete Mixture Material (Kg/M3)					
		Asphalt Tile Waste	Fly Ash	Cement	Gravel	Sand	Water
0	0	0	0	512	904	654	205
10	0	90,4	0	512	813,6	654	205
20	0	180,8	0	512	723,2	654	205
0	10	0	51,2	460,8	904	654	205
10	10	90,4	51,2	460,8	813,6	654	205
20	10	180,8	51,2	460,8	723,2	654	205

3. Results and Discussion

For Results, provide sufficient detail to allow the results to be meaningful and informative. For Discussion, this should explore the significance of the results of the work, not repeat them. A combined Results and Discussion section is often appropriate. Avoid extensive citations and discussion of published literature.

The results and discussion contain the following descriptions:

3.1. Slump Test

- 1) Normal Concrete.
- 2) GA 10%, namely concrete test object using 10% asphalt tile waste.
- 3) GA 20%, which is a concrete test object using 20% asphalt tile waste.
- 4) FA 10%, namely concrete test object with 10% fly ash substitution.
- 5) GA 10% + FA 10%, namely concrete specimens using 10% asphalt tile waste and 10% fly ash.
- 6) GA 20% + FA 10%, namely concrete specimens using 20% asphalt tile waste and 10% fly ash.

Table 2. Slump Test Results

No.	Mix Design	Slump Value (Cm)	Slump Value (Cm)	Description
1	Normal Concrete	8 ± 2	7	Normal
2	GA 10%	8 ± 2	6	Normal
3	GA 20%	8 ± 2	7	Normal
4	FA 10%	8 ± 2	7	Normal
5	GA 10% + FA 10%	8 ± 2	6	Normal
6	GA 20% + FA 10%	8 ± 2	8	Normal

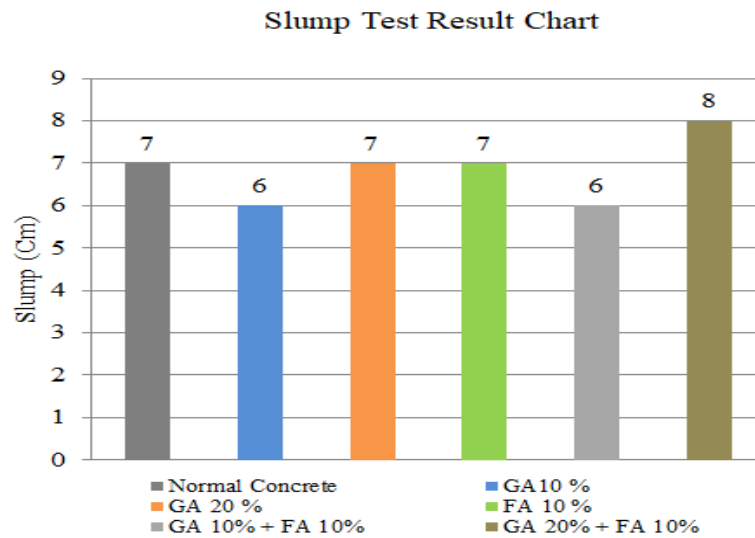


Figure 1. Graph of Slump Test Results
 (Source: Research Data, 2021)

Based on Table 2 and Figure 1, there are slump levels of 6 cm – 8 cm, the highest slump value is found in GA 20% + FA 10%, which is 8 cm. The biggest slump decrease occurred at GA 10% and GA 10% + FA 10%, namely the mix design with a mixture substitution of GA 10% and GA 10% + FA 10%, the height and weight are influenced by physical properties and the amount of aggregate proportion.

3.2. Water Absorption Test Results

The results of the water absorption test on each test object are as follows:

Table 3. Water Absorption Test Results

No.	Mix Design	Days	Water Absorption (%)
1	Normal Concrete	28	3,78
2	GA 10%	28	3,40
3	GA 20%	28	4,93
4	FA 10%	28	3,90
5	GA 10% + FA 10%	28	4,63
6	GA 20% + FA 10%	28	4,37

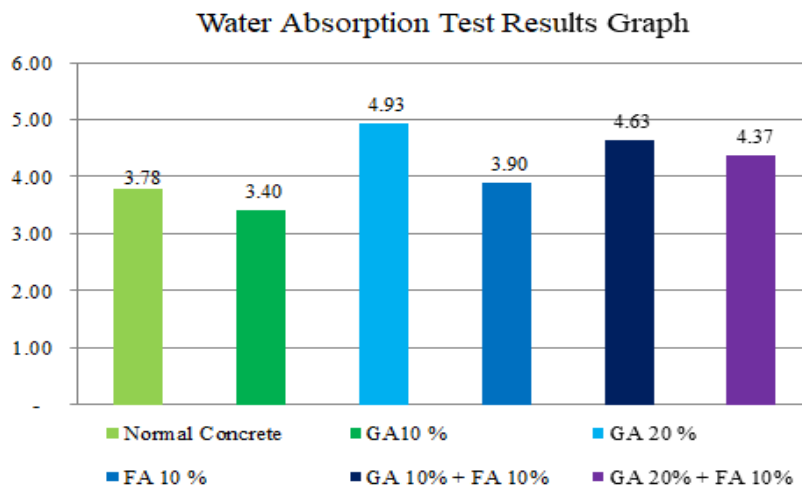


Figure 2. Graph of Water Absorption Test Results
 (Source: Research Data, 2021)

Based on Table 3 and Figure 2, at the age of 28 days it can be seen that normal concrete has a water absorption value of 3.78%. While the water absorption with the highest value is found in GA 20%, which is 4.93%. The lowest water absorption value occurred at GA 10%, which was 3.40%. This means that the more mixture of asphalt tile waste, the higher the water absorption value obtained. While concrete using fly ash substitution produces a high water absorption value than normal concrete because the properties of fly ash are only similar to cement but are not exactly the same, besides that fly ash is very dry and coarser than cement, it is very possible for fly ash absorb more water.

3.3. Concrete Density Test Results

The results of the density test on each test object after immersion in water are as follows:

Table 4. Results of Average Density of Concrete

No.	Mix Design	Days	Density (kg/m ³)	Description
1	Normal Concrete	14	2,234	Fulfil
2	GA 10%	14	2,256	Fulfil
3	GA 20%	14	2,203	Fulfil
4	FA 10%	14	2,186	Does not meet
5	GA 10% + FA 10%	14	2,125	Does not meet
6	GA 20% + FA 10%	14	2,169	Does not meet
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1	Normal Concrete	28	2,365	Fulfil
2	GA 10%	28	2,299	Fulfil
3	GA 20%	28	2,226	Fulfil
4	FA 10%	28	2,257	Fulfil
5	GA 10% + FA 10%	28	2,226	Fulfil
6	GA 20% + FA 10%	28	2,192	Does not meet

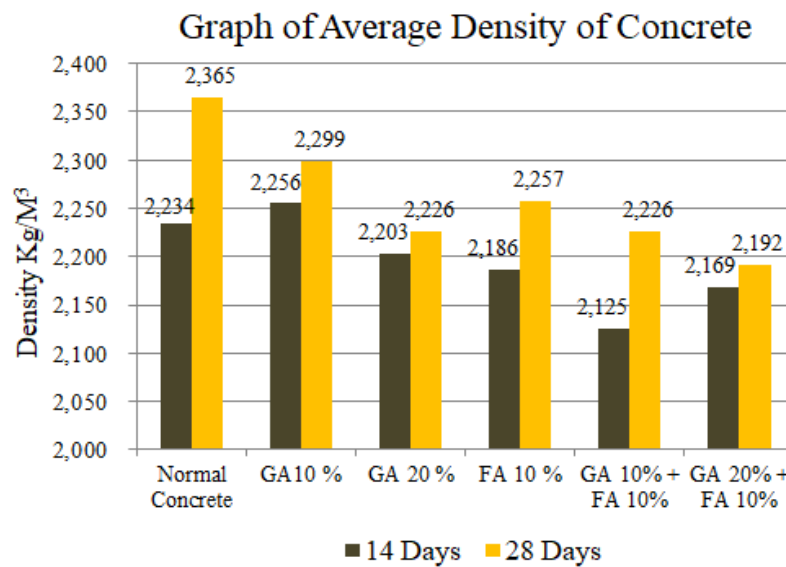


Figure 3. Graph of Average Density of Concrete
 (Source: Research Data, 2021)

Based on Table 4 and Figure 3, it is known that the 10% GA waste percentage has an increase in density at the age of 28 days by 1.91% from the age of 14 days. At the percentage of 20% GA waste, the density increased at the age of 28 days by 1.04% from the age of 14 days. At 10% FA percentage increased density at 28 days of age by 3.25% from 14 days of age. At the percentage of GA 10% and FA 10%, the density increased at the age of 28 days by 4.78% from the age of 14 days. However, the percentage of waste GA 20% and FA 10% decreased in density at the age of 14 days and 28 days. It is also known that the more waste asphalt tile, the more the density of concrete decreases. This proves that when the gravel is replaced with asphalt tile waste or the mass of gravel is heavier than the asphalt tile waste component, the density will tend to decrease or the concrete tends to be lighter. More precisely, the use of too much asphalt tile waste can be used for lightweight concrete types.

3.4. Concrete Compressive Strength Results

The compressive strength test of concrete aims to determine the strength of the concrete in accepting the load. The compressive strength test is carried out at the age of 14 days and 28 days. The compressive strength test was carried out to determine the compressive strength of concrete by adding a mixture of asphalt tile waste and fly ash substitution in the cement mixture using type I cement. The target compressive strength is 30 MPa at 28 days of age (SNI-03-6468-2000).

Table 5. Average Compressive Strength of Concrete

No.	Mix Design	Days	MPa	Description
1	Normal Concrete	14	33,70	Fulfil
2	GA 10%	14	20,29	Does not meet the
3	GA 20%	14	15,13	Does not meet the
4	FA 10%	14	16,32	Does not meet the
5	GA 10% + FA 10%	14	11,12	Does not meet the
6	GA 20% + FA 10%	14	9,24	Does not meet the

No.	Mix Design	Days	MPa	Description
1	Normal Concrete	28	38,26	Fulfil
2	GA 10%	28	23,03	Does not meet the
3	GA 20%	28	15,59	Does not meet the
4	FA 10%	28	18,34	Does not meet the
5	GA 10% + FA 10%	28	14,10	Does not meet the
6	GA 20% + FA 10%	28	15,36	Does not meet the

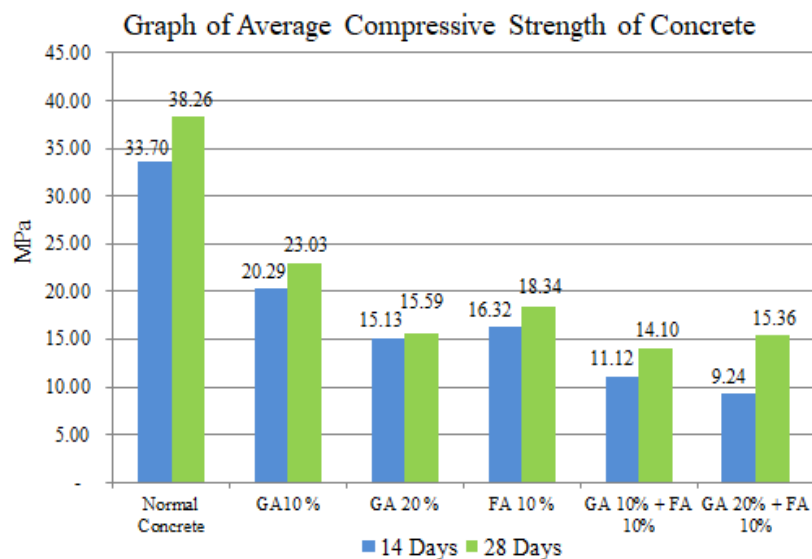


Figure 4. Graph of Average Compressive Strength of Concrete
 (Source: Research Data, 2021)

Based on Table 4.6 and Figure 4.3, it is known that the percentage of 10% GA waste experienced an increase in compressive strength at the age of 28 days by 13.48% from the age of 14 days. The percentage of GA 20% waste experienced an increase in compressive strength at the age of 28 days by 3.04% from the age of 14 days. At 10% FA percentage, there was an increase in compressive strength at the age of 28 days by 12.35% from the age of 14 days. The percentage of waste GA 10% and FA 10% experienced an increase in compressive strength at the age of 28 days by 26.81% from the age of 14 days. The percentage of waste GA 20% and FA 10% experienced an increase in compressive strength at the age of 28 days by 66.24% from the age of 14 days. The value of the compressive strength of concrete decreased gradually from the addition of asphalt tile waste and the addition of fly ash substitution. The decrease in compressive strength with the addition of a mixture of asphalt tile produces a lower compressive strength than normal concrete because the compressive strength of asphalt is lower than that of gravel and asphalt tile has a high water absorption rate. While the effect of adding fly ash on the physical properties of concrete using fly ash substitution, namely, the concrete added with fly ash has a more even and smoother surface than the concrete surface that is not added with fly ash. The more the addition of fly ash, the smoother and flatter the concrete surface. While the effect of adding fly ash on the mechanical properties of concrete using fly ash substitution is the compressive strength value achieved by concrete using 10% fly ash substitution. The compressive strength at the age of 28 days is 18.34 MPa with a decrease of 52.08% from normal concrete. The concrete produces a lower compressive strength than normal

concrete because the properties of fly ash are only similar to cement but not exactly the same, besides that fly ash is very dry and coarser than cement, which allows fly ash to absorb more water.

4. Conclusion

Based on the results of research that has been carried out in the laboratory, it can be concluded as follows:

- 1) The slump value of concrete with the addition of a mixture of asphalt tile and fly ash has a not too significant difference, namely the lowest 6 cm and the highest 8 cm. So that the addition of asphalt tile and fly ash has no effect on the normal slump of concrete.
- 2) The value of water absorption in normal concrete without using a mixture of asphalt tile waste and fly ash substitution was 3.78%. The value of water absorption using 10% asphalt tile waste obtained 3.40% with a decrease of 10.95% from normal concrete. The water absorption value using 20% asphalt tile waste obtained 4.93% with an increase of 23.38% from normal concrete. The value of water absorption using 10% fly ash substitution was 3.90% with an increase of 3.17% from normal concrete. The value of water absorption using 10% asphalt tile waste + 10% fly ash obtained 4.63% with an increase of 18.50% from normal concrete. The value of water absorption using 20% asphalt tile waste + 10% fly ash obtained 4.37% with an increase of 13.54% from normal concrete. Water absorption in normal concrete with a mixture of 20% asphalt tile waste as a substitute for coarse aggregate has a high percentage of water absorption value of 4.93% of normal concrete. So that asphalt tile waste has considerable potential for water absorption.
- 3) The density value achieved by concrete without using a substitute for coarse aggregate or normal concrete at the age of 28 days obtained a density value of 2.365 Kg/M³. The density value achieved by concrete using asphalt tile waste or a substitute for coarse aggregate 10% density at the age of 28 days obtained 2.299 Kg/M³ with a decrease of 2.87% from normal concrete. The density value achieved by concrete using asphalt tile waste or substitute for coarse aggregate 20% density at the age of 28 days obtained 2.226 Kg/M³ with a decrease of 6.26% from normal concrete. The density value achieved by concrete using 10% fly ash substitution at the age of 28 days was 2.257 Kg/M³ with a decrease of 4.81% from normal concrete. The density value achieved by concrete using 10% asphalt tile waste + 10% fly ash density at the age of 28 days was 2.226 Kg/M³ with a decrease of 6.26% from normal concrete. The density value achieved by concrete using 10% asphalt tile waste + 10% fly ash density at the age of 28 days was 2.192 Kg/M³ with a decrease of 7.93% from normal concrete. At the percentage of 20% asphalt tile waste mixture + 10% fly ash, the density decreased the most by 7.93% from normal concrete. This proves that too much use of asphalt tile waste and fly ash will result in a decrease in the value of concrete density to 30 MPa quality concrete.
- 4) The compressive strength value achieved by concrete without using a substitute for coarse aggregate or normal concrete at the age of 28 days obtained a compressive strength of 38.26 MPa. The compressive strength value achieved by concrete using asphalt tile waste or substitute for coarse aggregate 10% compressive strength at the age of 28 days obtained 23.03 MPa with a decrease of 39.81% from normal concrete. The compressive strength value achieved by concrete using asphalt tile waste or substitute for coarse aggregate 20% compressive strength at the age of 28 days obtained 15.59 MPa with a decrease of 59.24% from normal concrete. The compressive strength value achieved by concrete using 10% fly ash substitution. The compressive strength at the age of 28 days was 18.34 MPa with a decrease of 52.08% from normal concrete. The compressive strength value achieved by concrete using 10% asphalt tile waste + 10% fly ash compressive strength at the age of 28 days obtained 14.10 MPa with a decrease of 63.15% from normal concrete. The compressive strength

value achieved by concrete using 20% asphalt tile waste + 10% fly ash compressive strength at the age of 28 days was 15.36 MPa with a decrease of 59.85% from normal concrete. This proves that the use of too much asphalt tile waste and fly ash in normal concrete results in a decrease in the value of the compressive strength of the concrete. So that the greater the percentage of asphalt tile waste and fly ash, the smaller the compressive strength of the concrete that occurs and does not reach the value of the compressive strength of concrete with a quality of 30 MPa.

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