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Effect of addition waste bottle and fly ash variation to compressive strength environmentally friendly paving block

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ABSTRACT. The population of Indonesia has increased significantly every year. Increased population growth is directly proportional to infrastructure development. This causes the price of building material goes up, so alternative building materials are needed as a substitute or filler in making mixtures. Paving block is one of the alternative road pavement which is widely use in Sumenep district. Information from civil engineering Wiraraja laboratory in 2018, shows the number of paving block tests reached 211 from 45 companies. Alternative substitute material is fly ash and alternative filler material is the utilization of plastic waste. This research use comparison 1Pc : 4 Ps, fly ash variation 10%, 20%, 30%, 40%, 50% from cement weight and 0,5% of waste plastic from total mixture.
This research presents the result of experiments in the laboratory, there is simultaneous influence on the compressive strength that is influenced by variations of fly ash. The sequentially compressive strength of fly ash variation is 15.90 Mpa, 17.49 Mpa, 15.64 Mpa, 12.24 Mpa, 11.54 Mpa, 9.43 Mpa. The regression equation model obtained Y = 17,538 + (-0,154) X. Therefore, The quality of paving blocks based on SNI namely experiments I and III are included in the C quality category, experiments II is included in the B quality category, experiments IV, V, VI are included in the D quality category.

1. Introduction

Population growth in 2017, according to the Badan Pusat Statistik-BPS (Central Statistics Agency) reached 261 million. Based on Badan Perencana Pembangunan Nasional-BAPPENAS (National Development Planning Agency) in 2013, the National Development Planning Agency (Bappenas) estimates, Indonesia's population in 2018 will reach 265 million. Based on the inter-census population survey in 2015, Indonesia's population in 2019 is projected to reach 266.91 million. The high rate of population growth is directly proportional to the increase in infrastructure growth. Meeting the needs of infrastructure is inversely proportional to the availability of building materials, therefore we need a way to utilize certain natural resources in large quantities to minimize the use of building materials that are diminishing. Paving blocks are one element of building materials that are often used in the construction world. The use of paving blocks as road cover or hardener is widely used for housing projects or residential areas, beautifying parks, yards or yard, surface covering of parking areas (offices, factories, schools, restaurants, apartments, hotels and so on). Paving block mixture material consists of Portland cement, fine aggregate, water, and other added ingredients without reducing the quality of the paving block.

Plastic bottles are non-decomposable materials and fall into the category of inorganic materials. The existence of plastic bottle waste can cause obstruction of water infiltration into the soil, problems that are more complex than the presence of plastic waste arising among others can reduce, air pollution, soil fertility, flooding, and cause toxicity to food chain patterns to the marine ecosystem due to the process of photodegradation (exposure to light the sun against plastic at sea, thus breaking up plastic waste into small beads). According to World Atlas (2018), Indonesia is the country with the No. 4 largest use of plastic bottles in the World, around 4.28 billion. Some mass media have discussed a lot about plastic bottle waste. Sumenep Regency was taken as a research object, with several considerations based on available data, namely: 1) The Sumenep Regency Environmental Office (DLH) noted that there were as many as 20 tons of rubbish daily produced by Sumenep residents. The majority of waste comes from household waste consisting of plastic waste, farmer waste, and non-organic waste (see,e.g., [7]); 2) DLH Sumenep Regency has a limited fleet for the process of transportation from the Temporary Disposal Site to the Final Waste Disposal Site. There are only 17 tracks that serve and the conditions are not feasible (see,e.g.,[8]); 3) Very low level of community awareness in Sumenep Regency regarding Waste management. This is evidenced by the custom of the Kalianget community to throw trash on the beach (see,e.g.,[5]); 4) The lack of handling and management of plastic waste in Sumenep Regency (see,e.g.,[6]). Based on the problems above, a solution is needed as a form of reducing plastic bottle waste. Several studies on paving blocks have utilized plastic bottle waste as material composition including (see,e.g.,[1],[11],[12],[4]). Utilization of waste in the construction world as a composition of paving blocks not only comes from plastic. Coal waste (fly ash) is also often used in the construction world. The reason for using coal waste as a substitute for cement is that it is relatively affordable (cheaper) and more environmentally friendly. Several studies have used coal waste as a material composition therein, namely (see,e.g.,[15],[16],[3],[14]). Based on the background above, it is deemed necessary to conduct this research.

2. Method

This research is an experimental research that is research in solving problems using trials in the laboratory. The variables used are variable x (independent variable) and variable y (dependent variable). The independent variable used is the variation of fly ash and the dependent variable is the compressive strength of paving blocks. The samples used were 3 pieces for each variation of fly ash.
This research will measure the effect of adding plastic bottle waste with the addition of fly ash to the compressive strength of environmentally friendly Paving blocks. The compressive strength testing procedure to be carried out is guided by the Indonesian National Standard (SNI) 03-0691-1996 (see,e.g.,[13]) concerning concrete bricks (paving blocks). The testing steps are:

A. Measure the specimen using a ruler of 0.1 mm accuracy. Thickness measurements were made in three different places and the average value was taken.
B. Test specimens that are ready to be pressed to shatter with a pressure machine after 28 days old. The speed of pressure from the start of loading until the test object is destroyed takes about 1 to 2 minutes. The direction of the pressure of the test specimen, adjusted for the direction of the load pressure in its use.
C. Calculate the compressive strength using the following formula:

$$\text{Compressive strength} = \frac{P}{L} \quad (1)$$

Information :
P = Press load (N)
L = Area of Press (mm^2)

D. Calculate the average compressive strength of paving block by adding up the results of all the compressive tests by the number of specimens

E. The results of experiments conducted at the Laboratory are presented in tabular form which is then analyzed with simple linear regression. The regression equation that will be obtained from the results of the analysis are (see,e.g.,[10]) :

Y = a + bx .... (2)

Where :

Y is the dependent variable / dependent variable

X is an independent variable / independent variable

a is a constant

b is the regression coefficient (increase or decrease value)

F. The results of the regression obtained next hypothesis testing, whether there is a significant effect of the addition of waste plastic bottles with variations in the addition of fly ash to the compressive strength of environmentally friendly paving blocks. Hypothesis testing is used using a linearity test and a significant test. The linearity test rule is if F arithmetic ≤ F table then Ho is accepted, otherwise if F arithmetic ≥ F table then Ho is rejected. The test rule is significant if -t tablet ≤ t table ≤ + t table then Ho is accepted, otherwise if t arithmetic > t table then Ho is rejected (see,e.g.,[2],[10]).

G. Testing simple linear regression analysis using SPSS software. Paving block data from the laboratory test results are also analyzed on the classification of paving blocks which refers to SNI 03-0691-1996 about concrete bricks (paving blocks).

3. Main Results

A. Composition of Paving Block Mixture

The comparison of cement and aggregate in paving blocks is a weight ratio. The weight of paving blocks with dimensions of 20 cm x 10 cm x 6 cm, it is assumed that the weight of 1 test piece is around 2.5 kg. Comparison of the weight of cement and aggregate, with an aggregate cement ratio of 1Pc: 4Ps with a ratio of 1Pc: 4 Ps mixed volume with the addition of fly ash with variations of 10%, 20%, 30%, 40%, 50% of the weight of the cement and additional material in the form of 0.50% plastic bottle waste to the paving block mixture in the test specimen.

B. Paving Block Compressive Strength Test

Paving blocks are tested for absorption at 28 days. Tests are carried out based on SNI 03-0691-1996 (see, e.g., [13]). The samples used for testing the absorption of water are 3 test pieces. The following are the results of absorption testing of paving blocks presented in the form of graphic images,

Figure 1. Paving Block Compressive Strength Chart
(Source: Data Analysis, 2019)

Based on Figure 1 above it can be informed that the average compressive strength in sequence for each treatment variation of fly ash 0%, 10%, 20%, 30%, 40%, and 50% is 15.9 MPa, 17.49 MPa, 15.64 MPa, 12.24 MPa, 11.45 MPa, 9.43 MPa

C. Normality and Heteroscedasticity Test of Paving Block Compressive Strength with Fly Ash Variation

A normality test is used to determine whether the research data that has been obtained has a normal distribution or not. Normality testing uses SPSS 20 for windows. The normality in this study using Kolmogorov-Smirnov. Standardized data decision-making methods are normally distributed if the sig value > 0.05

Table 1
Normality Test Data of Paving Block Compressive strength with Fly Ash mixture variation

One-Sample Kolmogorov-Smirnov Test

		Unstandardized Residual
N		30
Normal Parameters[a,b]	Mean	0E-7
	Std. Deviation	1.78901060
Most Extreme Differences	Absolute	.119
	Positive	.119
	Negative	-.103
Kolmogorov-Smirnov Z		.651
Asymp. Sig. (2-tailed)		.790

a. Test distribution is Normal.
b. Calculated from data.
Sumber : Analisis Data SPSS (2019)

Standardized residual values are stated to spread normally, because a significant value of 0.790 > 0.05.

Heteroscedasticity test is used to find out whether or not there is a deviation from the classical assumption of heteroscedasticity. Heteroscedasticity means that there are various variants in the regression model that are not the same while what is expected in the regression model is constant. Heteroscedasticity testing uses SPSS 20 for windows. Testing heteroscedasticity in this study using the Glejser method. Symptoms of heteroscedasticity are shown by the regression coefficient of the independent variable to the absolute value of the residual. Decision making that there is no symptom of heteroscedasticity if the value of the probability is greater than the alpha value (0.05).

Table 2
Heteroscedasticity Test Data of Paving Block Compressive Strength with Fly Ash mixture variations

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-1.251E-015	.589		.000	1.000
	fly ash	.000	.019	.000	.000	1.000

a. Dependent Variable: ABS_RES
Source: SPSS Data Analysis (2019)

The regression model occurs heteroscedasticity because of the value of sig. variable fly ash to absolute residuals is 0.001 < 0.05.

D. Regression Analysis and Hypothesis Testing of Paving Block Compressive Strength

The compressive strength data obtained were analyzed using simple linear regression, which had previously been tested using the normality test and heteroscedasticity test. Based on the test that has been done shows that the regression model has met the requirements. The next step is a regression analysis to determine the effect of variations of the fly ash mixture on the compressive strength of the paving block. The results of data analysis can be seen in the following table.

Table 3
Summary of Compressive Strength Analysis Results

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.831[a]	.691	.680	1.82045	.691	62.496	1	28	.000

a. Predictors: (Constant), fly ash
b. Dependent Variable: kuat tekan
Source: SPSS Data Analysis (2019)

Based on table 3 it can be analyzed that the relationship between variations of the mixture of fly ash with compressive strength is 0.831. Contributions contributed by variations of fly ash on compressive strength of 0.691 or 69.1% this means that the variable variation of fly ash affects the compressive strength of 69.1%. Value of std. Error of the estimate is 1.82. This shows the deviation between the regression equation and the dependent real value of 1.81. The smaller the value of std. Error of the estimate, the better the equation is as a prediction.

Table 4
Results of Compressive Regression ANOVA Analysis

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	207.115	1	207.115	62.496	.000[b]
	Residual	92.793	28	3.314		
	Total	299.908	29			

a. Dependent Variable: kuat tekan

b. Predictors: (Constant), fly ash

Source: SPSS Data Analysis (2019)

The probability value (sig) is 0,000 and the significant value is 0.05. Then the next step is to compare F arithmetic and F tables as well as sig and α. From table 4 it is known that the calculated F value is 62.496 while the F table value is 4.20. Then F value = 62.496 > F table 4.20 (Ho is rejected) and sig = 0.000 < 0.05 (Ho is rejected). Thus the decision can be taken that there is a simultaneous influence on compressive strength with the addition of variations of fly ash.

Table 5
Coefficients of Compressive Strength Analysis Results

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	17.538	.589		29.765	.000	16.331	18.745
	fly ash	-.154	.019	-.831	-7.905	.000	-.194	-.114

a. Dependent Variable: kuat tekan
Source: SPSS Data Analysis (2019)

Testing the research hypothesis can be done based on the coefficients table. Table 5 shows the regression equation model to estimate the absorption value that is influenced by variations of fly ash is $Y = 17.538 – (0.154 X)$

Drawing conclusions based on linearity test, the t-test test rules are, if -t table ≤ t arithmetic ≤ t table (Ho is accepted) but if t arithmetic > t table (Ho is rejected). From table 5 it is known that the calculated t value is -7,905 while the t value of table is 1,701. Then t arithmetic = 7.905 > t table = 1.701 (Ho rejected). Thus the decision can be taken that there is a significant effect between the addition of variations of fly ash on the absorption of paving blocks.

Conclusions are drawn based on the significance test, the rules of testing if Sig ≤ α (Ho is rejected) and if the value of Sig > α (Ho is accepted). Based on the table the value of Sig is 0,000 and the value of α is (α / 2) = 0.025 so Sig = 0,000 < α = 0.025 (Ho is rejected). Thus the decision can be taken that there is a significant effect between variations of fly ash on the absorption of paving block water.

E. Paving Block Classification Based on SNI

1. Treatment I with a mixture of fly ash from cement volume is 0% and plastic bottle waste from paving block volume is 0%, has an average compressive strength value 15.90 MPa, so it is categorized as quality C concrete brick with an average compressive strength the required average is 15 MPa and a minimum compressive strength of 12.5 MPa.
2. Treatment II with a mixture of fly ash from cement volume is 10% and plastic bottle waste from paving block volume is 0.50%, has an average compressive strength value 17.49 MPa, so it is categorized as high quality concrete brick B with compressive strength an average requirement of 20 MPa and a minimum compressive strength of 17 MPa.
3. Treatment III with a mixture of fly ash from cement volume is 20% and plastic bottle waste from paving block volume is 0.50%, has an average compressive strength 15.64 MPa, so it is categorized as high quality C concrete brick with compressive strength an average requirement of 15 MPa and a minimum compressive strength of 12.5 MPa.
4. Treatment IV with a mixture of fly ash from cement volume is 30% and plastic bottle waste from paving block volume is 0.50%, has an average compressive strength 12.24 MPa, so it is categorized as D quality concrete brick with compressive strength an average requirement of 15 MPa and a minimum compressive strength of 12.5 MPa.
5. Treatment V with a mixture of fly ash from cement volume is 40% and plastic bottle waste from paving block volume is 0.50%, has an average compressive strength 11.45 MPa, so it is categorized as D quality concrete brick with compressive strength the required average is 10 MPa and the maximum compressive strength is 8.5 MPa.
6. Treatment VI with a mixture of fly ash from cement volume is 50% and plastic bottle waste from paving block volume is 0.50%, has an average compressive strength 9.43 MPa, so it is categorized

as D quality concrete brick with compressive strength the required average is 10 MPa and the maximum compressive strength is 8.5 MPa.

5 Conclusions

Based on the results of the analysis and discussion carried out on the subject of the previous discussion, the following conclusions are obtained:

1. The linear regression equation for the variation of fly ash on the compressive strength of paving blocks is Y = 17.538 - 0.154 X, the analysis shows that there is a significant influence between the variation of fly ash on the compressive strength of paving blocks.
2. The quality of paving blocks based on SNI namely experiments I and III are included in the C quality category, experiments II is included in the B quality category, experiments IV, V, VI are included in the D quality category

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