Proceedings

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Multidisciplinary International Student Conference

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Using Silica Sand Waste for Making Concrete with Taguchi Method Approach to Determine Optimum Compressive Strength

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Abstract

PT Swadaya Graha is one of the companies that use silica sand for sandblasting process. The sandblasting process produces silica sand waste which is very harmful to the body because of its very small size and can be inhaled also dissolved in the blood. Until now there is no party or certain agencies that utilize silica sand waste to reduce the amount of waste so that the number continues to grow from year to year. One of the utilization of silica sand waste is to use it as a concrete additive. This research uses Taguchi method to determine the optimal combination so as to produce a high compressive strength, to know what factors will affect the compressive strength of the concrete, and perform cost analysis because the utilization of this waste has a great chance to produce concrete with a more affordable price. The result is concrete with a mixture of silica sand suitable for use in non-loaded areas (non-structural concrete) with type K 175. although it does not have a high type but this is still an excellent opportunity to reduce the amount of silica sand waste.

Key Words: Silica Sand Waste, Concrete, Taguchi Method, Compressive Strength

1. Introduction

The domain characteristic of Indonesian has changed, in the past Indonesian income comes from agriculture then change to industrial sector (Thomanetz, 2012). The impact of it felt on several factors, one of those are the environmental factor. The by-products of the production process are solid, liquid, gas, and hazardous waste. PT Swadaya Graha is one companies that produces hazardous waste from sandblasting prose, each year it produces more than 2 tons of silica sand waste. Sandblasting is the process of fired silica sand to remove polluters on the workpiece (Hughes, 2001). The silica sand that has been used, then discarded because silica sand already contains lot of polluters and it can not be reused as sandblasting material. Silica sand is classified as hazardous waste because silica sand waste has a size less than 10 microns. Meanwhile, according to Occupational Safety and Health Administration (OSHA) in the 29 CFR regulation (1926) said that the level can be inhaled by workers is at Permissible Exposure Level (PEL) 50 µg / m3.

Down to date there is no industry that utilizes silica sand waste to produce a new product. In this study, utilizing existing silica sand waste to be used as an additional material in producing concrete. This research used Taguchi method to determine optimal composition to produce concrete with optimum compressive strength. Concrete is material composed of three component: water, aggregate (stone, sand, gravel) and cement. Cement will react with water and bind other components. Concrete can also be altered to a variable scale so that its quality can be tailored to the needs of the user (Hill, Mc Graw, 2003).

2. Methodes

The method used in this research is Taguchi method. The Taguchi method is a tool that fixes work efficiency in organizations (Chomamutrdan Jongprasithporn, 2012). Taguchi as off line quality control using orthogonal array (OA) as an experimental layout. OA is arranged in a table that determines the contribution of factors that affect the quality, so the OA table can also know the level of factors that provide optimal results to be achieved. The OA table can be adjusted so as to shorten time, costs, and experiment material (Wuryandari, 2009). The Taguchi method is widely used in several cases such as food coloring maximization (Krishnaiah and Shahabudeen, 2012), Failure Mode and Effect (FMEA) analysis (Iswanto, 2015), quality control (Telaumbanua, 2013) and so forth.

3.1. Factorial design

Before the OA is prepared the thing done is to determine how many tests will be implemented. The factorial design can also elicit the main effects and interaction effects. The factorial design has 2 or more levels, so if the factor consists of 2 levels denoted as 2^k and if the fator consists of 3 levels it is denoted as 3^k. This research use 3 factor design factor and 3 level so that the factorial design is $3^3 = 27$, with Minitab 17 it decided to use 9 runs with 4 replication for each specimens.

3.2. Orthogonal Array (OA)

The use of OA may reduce the number of trials (Montgomery, 1991) and it has relationship with the factorial design. Some things that must be determined to construct OA are parameters that affect the process and level used in the test. If the difference between the minimum and maximum values has a far range then more value will be tested. However, if the range of test scores gets closer then the fewer number tested (Karna and Sahai, 2012). The OA table used in this study is shown in Table 1. In Table 1 it is explained that the number 1 shows the lowest level, the number 2 is for the medium level, and the number 3 indicates the highest level of the factor.

Table 1 OA table L_9 (Source: Wuryandari,2009)

	Factor		
Run	A	B	C
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

As for the numbers of the high, middle, and moderate levels described in Table 2 with the notation S is Sand, SS is Silica Sand, C as Cement, and FAS as the cement and water ratio.

Table 2 Research level factor

		Factor				
		A			B	C
		S (kg)	SS (kg)	C (kg)	FAS	Gravel (mm)
Level	1	0,45	0,3	0,25	0,5	5-10
	2	0,31	0,27	0,42	0,7	10-20
	3	0,15	0,5	0,35	0,9	20-30

3.3. Signal to Noise Ratio (SNR)

SNR is the logarithm of a function to evaluate the quality of a product (Wahjudi and Pramono, 2001). In terms of characteristics of quality, Taguchi method divide SNR type into 3 categories, these are: nominal is the best, lower is better, and higher is better. Based on the research objective to find the composition of concrete with the optimum compressive strength, it use SNR higher is better, which formulation is

$$SNR = -10 \log\_10 [1/n \sum\_(i = 1)^n 1/(y\_i^2)] \quad (1)$$

3. Result and Discussions

After testing the specimens that have been made based on OA, it obtained the result of compressive strength (Mpa) as in table 4 below:

Table 3 Test results of compressive strength of concrete specimens

Run	Compressive Strength (Mpa)				Average
	1	2	3	4	
1	17,50	8,00	16,00	16,00	14,38
2	14,00	13,00	11,00	11,00	12,25
3	9,50	7,50	8,00	9,50	8,63
4	11,00	11,00	13,00	15,00	12,50
5	16,00	12,00	16,00	12,00	15,00
6	17,00	17,00	17,50	19,00	17,63
7	12,50	14,00	16,50	16,50	14,88
8	11,00	9,00	12,00	11,00	10,75
9	12,00	14,00	14,00	15,00	13,75

3.1. *Normality test*

The obtained data then processed using Minitab 17 for the normality test which is shown in figure 1. In Figure 1 it is known that the result of P-Value is greater than the alpha (α) 0.05 and the plot distribution in the image has a close proximity to the line, It can be said that the data is normal.

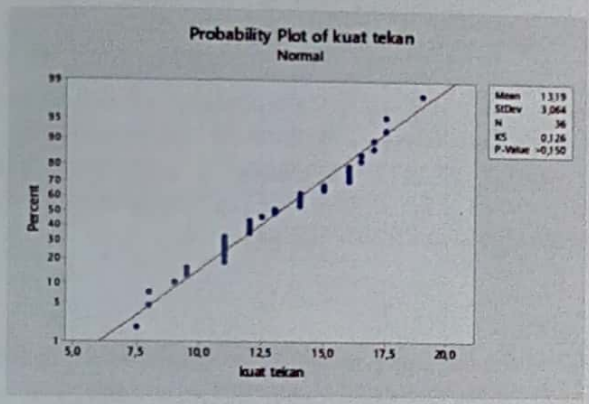
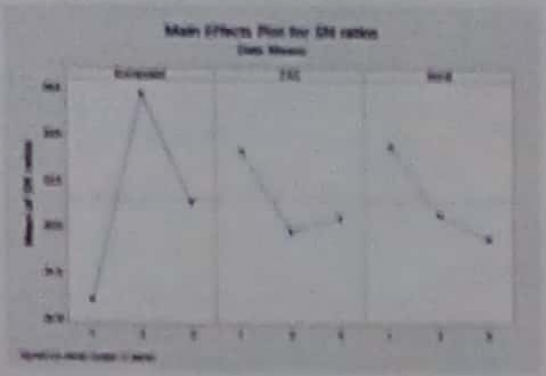


Figure 1 Normality test results with Minitab 17

3.2. *Effect and combination of optimum composition*

The combination of optimum composition is obtained from the SNR value calculated by Minitab 17. Based on the output of Minitab 17, a graph in figure 2.a shows that the composition at 2nd level, FAS at 1st level and gravel at 1st level is the combination of composition that will Produce optimum concrete compressive strength. While influence of the factor shown in figure 2.b which explains that the factor that has a significant influence on compressive strength is composition because the value of the composition significance is 0.007 smaller than the α 0.05. While for FAS and gravel factor have no significant effect to compressive strength of concrete, because the value of FAS and gravel significance is greater than α 0,05.

a



b

Source	Type I Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	213.130[a]	8	26.641	5.746	.000
Intercept	8287.381	1	8287.381	1787.521	.000
Komposisi	92.597	2	46.299	9.986	.001
FAS	15.398	2	7.699	1.661	.197
Kawur	35.733	2	17.867	3.853	.035
Komposisi * FAS	121.837	2	60.919	13.137	.000
Komposisi * Kawur	.000	0	.	.	.
FAS * Kawur	.000	0	.	.	.
Komposisi * FAS * Kawur	.000	0	.	.	.
Error	116.000	25	4.640		
Total	8416.000	36			
Corrected Total	329.130	35			

a. R Squared = .647 (Adjusted R Squared = .535)

Figure 2 a) combination of optimum composition b) result of effect test using Anova

3.3. Confirm the experiment results

After the combined otimal is obtained, further experimentation is performed and the specimens is given the same treatment as the treat on the previous specimens. After 28 days of concrete, then the specimens are given a compressive strength test and the results are listed in table 4 below

Table 4 Hasil kuat tekan kombinasi optimal

Run	Compressive strength (Mpa)				Average (Mpa)	SNR
	1	2	3	4		
BEST	16,50	16,50	18,50	18,50	17,50	24,86

The results of the compressive strength test in Table 4 show that with the optimum composition combination it has om[ressive strength average of 17.50 MPa. It is greater than the average value of the previous compressive strength. So that for producing concrete with compressive strength 17,50 using sand blasting waste, it used 0,31 Kg of sand, 0,27 Kg of silica sand waste, 0,42 Kg of cement, 0,7 of ratio cement and water, then gravel sized 5-10 mm.

4. Conclusions

The conclusion of this research is that the composition gives significant influence to the compressive strength of concrete. With a strong 17.50 Mpa concrete is classified as non-structural concrete which means the concrete can not receive a large load so that the designation of concrete with a compressive strength of 17.50 Mpa is for parts such as floors and walls that do not get a large load.

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