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WORD COUNT 4339
TIME SUBMITTED 31-OCT-2020 09:24PM
PAPER ID 64610846

Ukarst : Universitas Kadiri Riset Teknik Sipil.
Volume 4 Number 2, (2020).

ISSN (*Online*) 2581-0855
ISSN (*Print*) 2579-4620

Available online at
http://ojs.unik-kediri.ac.id/index.php/ukarst/index

U KaRsT

http://dx.doi.org/10.30737/ukarst.v3i2

The Effect Of Using Ceramic Waste Powder As A Substitute For Cement On The Compressive Strength Of K250 Concrete

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A R T I C L E I N F O

Article history :
Article entry : 20-10-2020
Article revised : 22-10-2020
Article received : 24-10-2020

Keywords:
Concrete, Compressive Strength, Ceramic Waste, K250

IEEE style in citing this article:
[20] P. Tamayo, J. Pacheco, C. Thomas, J. de Brito, and J. Rico, "Mechanical and durability properties of concrete with coarse recycled aggregate produced with electric arc furnace slag concrete," Appl. Sci., 2020, DOI: 10.3390/app10010216

A B S T R A C T

In every construction work, you will find the remains of building materials no longer used and disposed of as waste, one of which is a ceramic waste. Ceramic waste is waste that has no selling value. Therefore the authors in this study will utilize ceramic waste as a substitute for cement with concrete quality K250. Several studies have also explained that ceramic waste contains silica, which has high adhesion, making it suitable as a substitute for cement. The process of mixing ceramic waste as a K250 quality concrete mixture is carried out according to the Indonesian SNI Standard and ASTM standards by laboratory testing using a variation of 3%, 4%, and 5% as a substitute for cement. From these results, the composition of the addition of 3% ceramic waste has an average compressive strength of 330.99 kg/cm2, a composition of 4% has an average compressive strength value of 243.88 kg/cm2, and a percentage of 5% has an average compressive strength value 258.41 kg/cm2. The more the ceramic waste mixture as a substitute for cement, the lower the compressive strength of the concrete..

1. Introduction

Concrete is a material obtained by mixing water, coarse aggregate, fine aggregate, and Portland cement as a binder, with or without additives that form a solid mass [1]. Currently, the manufacture of concrete has undergone many modifications, such as using other materials such as fly ash, silica fume, sandblasting, etc. as a substitute for cement or aggregate [2].

In every construction work, you will find the remains of building materials no longer used and disposed of as waste, one of which is a ceramic waste. Ceramic waste is waste that has no selling value. Therefore the authors in this study will utilize ceramic waste as a substitute for cement with concrete quality K250. Several studies have also explained that ceramic waste

contains silica, which has high adhesion, making it suitable as a substitute for cement. This study aims to determine the effect of adding ceramic waste powder, provided that it passes 200 filters so that it can become fly ash [3][4], on the compressive strength of K250 quality concrete.

2. Literature Review

Research Previously conducted by Candra & Agata in 2019 with the title "Utilization of Filter Cigarette Butt Waste as a Lightweight Porous Concrete Mixture" obtained the highest compressive strength value at 28 days of concrete reached K-115.56, which means it has reached the target. For concrete paving of K-100. Meanwhile, the absorption value is quite high. From the tests for ¼ hour, 1 hour, 4 hours, and 24 hours, the average value is 0.116 liter, 0.269 liters, 0.374 liters, 0.699 liters. The study of the density of concrete with a coarse aggregate of cigarette butts waste reached an average of 1831.11 Kg / m^3. For the pore number study, the average value was 0.2854 and Then obtained the porosity value was an average of 0.222016 [5]. Likewise, previous research conducted by Bobby & Zulkifli in 2018 with the title "The Effect of Addition of Hazardous Waste to the Quality of K-175 Concrete Strength" obtained the results of the research, the more the dregs mixture of carbide (hazardous waste) on concrete, the lower the compressive strength in the concrete. The best composition for making carbide dregs concrete is at 5% carbide dregs composition with an average compressive strength of 20.33 Mpa with an increase of 1.78% compared to normal concrete, which reaches average crushing stress of 19.976 MPa. In comparison, the composition of carbide dregs 10% and 15% experienced a decrease in compressive strength [2].

2.1 Concrete Technology

A. Fresh Concrete

Fresh concrete is a combination of aggregate cement and water, which binds to each other and has not yet hardened is soft and can form easily [3][4]. Good fresh concrete can be stirred, transported, poured, compacted. There is no tendency for segregation (separation of gravel from mortar) or bleeding (separation of water and cement from the mix). This is because segregation and bleeding result in poor concrete obtained [4][6].

Three things need to be known from the characteristics of fresh concrete, namely: ease of work, separation of gravel (segregation), separation of water (bleeding) [6][7].

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2.2 Concrete Stacking Materials

A. Cement

Based on Indonesian National Standard (SNI) number 15-2049-2004, Portland cement is hydrolyzed cement produced by grinding portland slag, especially of calcium silicate. Hydrolytic and ground, with additional materials in the form of one or more crystalline form calcium sulfate compound (CaSO4.xH2O), may be added with other additives [8]. Hydraulic means very happy to react with water. Hydraulic compounds will react with water quickly. Portland cement is hydraulic because it contains calcium silicate and calcium sulfate (CaSO4.xH2O), hydraulic, and reacting very quickly with water. The reaction of cement with water is irreversible, meaning that it can only happen once and cannot return to its original state [6] [8].

B. Aggregates

Aggregates are mineral grains resulting from the natural disintegration of rocks or stone crushing machines breaking natural stones. Aggregate is a filler in concrete. However, the role of aggregate in concrete is very important. The aggregate content in concrete reaches approximately 70% - 75% of concrete volume [7].

C. Water

Water for the manufacture of concrete qualifies as a minimum of drinking water that is fresh, odorless. It does not contain materials that can damage concrete, such as oil, acids, alkalis, salts, or other organic materials that can damage concrete or reinforce [9][10].

2.3 Ceramic Waste

Waste Ceramic waste is a waste of fragments or remaining pieces of waste during the installation of ceramics. So far, ceramic waste has caused many problems in handling, which have allowed to pile up and sold at low prices even though with large-scale sales, which all have a negative impact [11][12] on the environment so that the prevention needs to be considered [13]. One way that can be taken is to become a value-added product with applicable and popular technology to easily disseminate the results to the public [14][11].

http://dx.doi.org/10.30737/ukarst.v3i2

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ISSN (*Online*) 2581-0855
ISSN (*Print*) 2579-4620

Source : research documentation

Figure 1. Ceramic waste powder

2.4 Compressive Strength Test

Examining the concrete's compressive strength was carried out to determine the concrete's compressive strength at the age of 28 days, which resulted in following what was required [15]. In the compressive test machine, the object is placed and given a load until the object collapses, that is, when the maximum load works [16]

can calculate compressive strength of concrete with the formula :

$$P = \alpha = \frac{A}{p} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.1)$$

Dengan :

σ = test object (kg/cm^2)

P = maximum load (kg)

A = cross-sectional area (cm^2)

compressive strength on the compression testing machine, the object is placed and given the load until the object collapses. That is when the maximum load works [16].

3. Methodology

Methods This research method is carried out using testing in the laboratory following the Indonesian National Standard (SNI) for concrete. The sample made was fresh concrete with cylindrical specimens. The ratio of the percentage composition of the mixture using ceramic waste as a concrete mixture was 3%, 4% and 5% [17]. With each percentage sample, 3 specimens were made using a 15 cm x 30 cm cylindrical specimen, which would be reviewed on compressive strength and implemented according to SNI and ASTM [18]. At the Concrete Laboratory, Faculty of Engineering, Civil Engineering Study Program, Islamic University of Lamongan.

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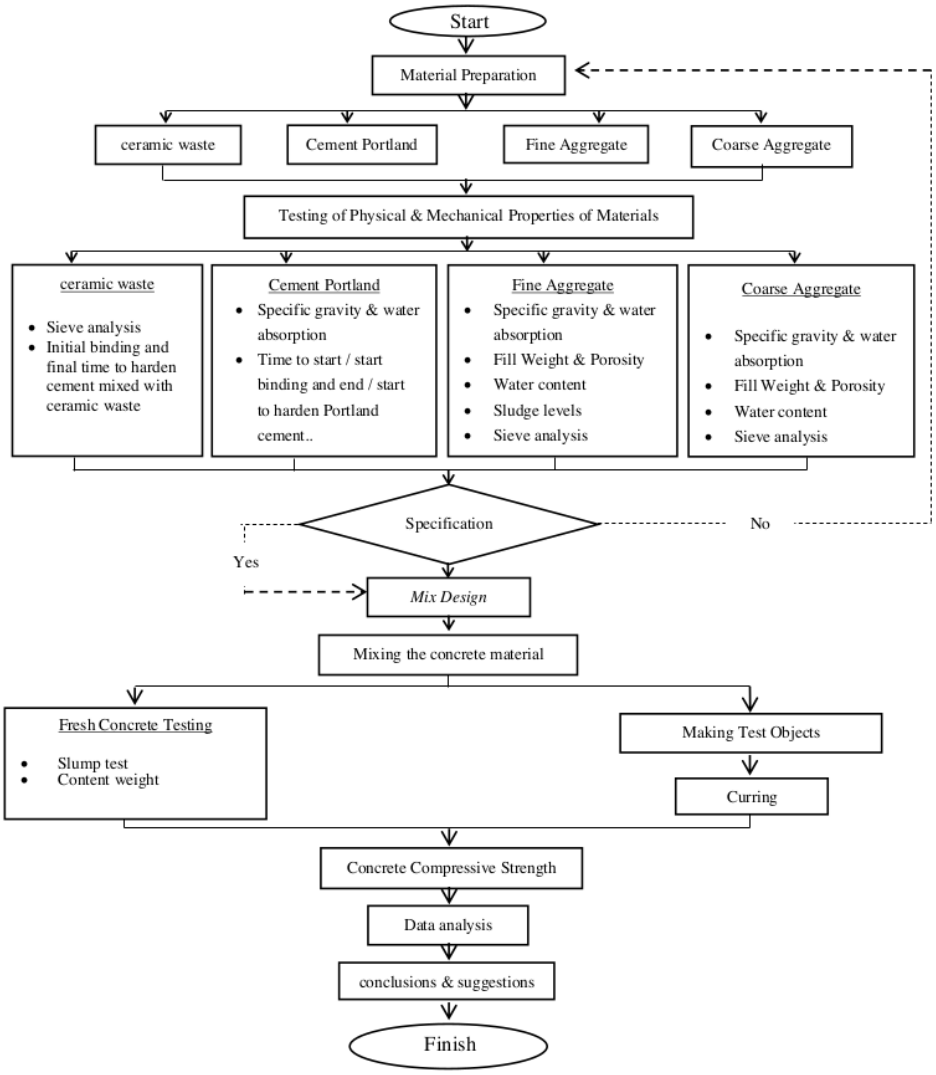
Volume 4 Number 2, (2020). ISSN (*Print*) 2579-4620

The following is a flow chart in this study.



Source : Research Results, 2020

Figure 2. Research Flow

The research begins with preparing tools and materials, such as ceramic powder, cement, fine aggregate, and coarse aggregate[19]. The next step is to analyze the material test to find out whether the material specifications have met or not. If it is fulfilled, the process of mixing concrete with added ingredients of ceramic powder is 3%, 4%, and 5%. After seven days [13], the compressive strength test was carried out and data analysis.

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3.1 Technical Data Analysis

Analysis technique carried out in this study has several stages, namely :

A. Cement Testing

1. Testing the normal consistency of cement Portland
2. Testing the density of cement.
3. Test the time of bonding and cement hardening.

B. Fine Aggregate Testing

1. aggregate moisture testing.
2. Sand density testing on SSD conditions.
3. I was testing the moisture content of fine aggregate infiltration.
4. Fine aggregate weight test.
5. Fine aggregate sieve analysis test.

C. Coarse Aggregate Testing

1. Aggregate moisture test.
2. Test coarse aggregate density on SSD conditions.
3. Test the moisture content of coarse aggregate infiltration.
4. Coarse aggregate volume weight testing.
5. Coarse aggregate sieve analysis test.

D. Ceramic Waste Testing

1. Test Moisture testing of ceramic waste.
2. Density test of ceramic waste.
3. Test the water content of ceramic waste infiltration.
4. Ceramic waste volume weight test.
5. Test of ceramic waste filter analysis.

E. Fresh Concrete Testing

1. Slump test
2. Content Weight.

F. Testing of Hard Concrete

1. Compressive strength test
2. Testing the weight of the hard concrete

http://dx.doi.org/10.30737/ukarst.v3i2

Ukarst : Universitas Kadiri Riset Teknik Sipil. ISSN (*Online*) 2581-0855
Volume 4 Number 2, (2020). ISSN (*Print*) 2579-4620

4. Results and Discussion

Based on the applicable standard reference testing method, testing was carried out at the Laboratory of the Islamic University of Lamongan (UNISLA). Testing the characteristics of the fine and coarse aggregate material is a preliminary test carried out to determine the fine and coarse aggregate characteristics before carrying out the concrete mix design, which refers to the SNI.

From the data obtained during the test, a mixed design (Mix Design SNI 03-2834-2000) was carried out on concrete using ceramic powder waste as a substitute for cement. In this test, concrete refers to medium quality concrete by setting the compressive strength f'c 21.7 MPa (K250).

4.1 Material Test Analysis

Table 1. Material Test Analysis Results

Description	Test Results
Cement	
Testing the time of binder and cement hardening	225 minutes
The specific gravity of cement	3.10 t/m3
Fine Aggregate	
Sand moisture	2.56%
The density of fine aggregate	2.7 gr/dm3
Water content test for fine aggregate infiltration	2.78%
Sand volume weight testing	1.42 gr/lt
Fine aggregate sieve analysis	FM = 3.19%
Coarse Aggregate	
Gravel moisture	1.25%
The specific gravity of coarse aggregate	2.41 gr/dm3
Coarse aggregate infiltration water testing	1.2%
Coarse aggregate volume weight testing	1.45 kg
Ceramic Waste	
Sieve analysis	Sieve passes 200
Initial binding and final time to handen cement mixed with ceramic waste	230 minutes

Source : Laboratory Test Results

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4.2 Concrete Mix Planning Form

Table 2. Concrete Mix Planning Form

No	Description	Table	Value
1.	Required compressive strength	Set	21,7 Mpa on 7 days error 5%, k=1.64
2.	Standard Deviation	Set	7 Mpa
3.	Added value (margin)	Set	1,64*7 = 11.48
4.	The compressive strength of the average target	Set	33.18
5.	Types of cement	Set	PC Semen Gresik Type I
6.	Fine aggregate type Coarse aggregate type	--	Natural sand Stone-broke
7.	Water factor free cement	Set	0.35
8.	Cement water factor max	Undefined	0.4
9.	Slump	Undefined	60-180 mm
10.	Max aggregate size	Curved graphics mixed aggregate	20 mm
11.	Free water content	Set	205
12.	The amount of cement	11.07	586
13.	The amount of cement max	Undefined	-
14.	The amount of cement min	Undefined	325 kg/m^3
15.	Adjustable cement water factor	-	-
16.	The composition of the grain size of fine aggregate	Sand analysis	Zone 2 grading area
17.	Percentage of fine aggregate	Curved graphics mixed aggregate	43%
18.	Aggregate real density (SSD)	Calculate	2400 kg/m^3
19.	Concrete density	Grafik 16	2210
20.	Combined aggregate content	19-12-11	1419
21.	Content of fine aggregates	17x20	610.2928571
22.	Content, of course aggregates	20-21	809

Source : SNI 03-2834-2000 Procedure for Making Mixed Concrete Plan

http://dx.doi.org/10.30737/ukarst.v3i2

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Ukarst : Universitas Kadiri Riset Teknik Sipil. ISSN (*Online*) 2581-0855
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Table 3. The Amount of Materials Needed in K250 Concrete

Lots of ingredients	Cement (kg)	Fine aggregate (kg)	Coarse aggregate (kg)	Water (kg)
Each m^3	586	610	809	205

Source : Calculations

Table 3. as a concrete mix plan, can determine the total volume of material needed for the manufacture of research specimens and material requirements for making concrete with cylindrical specimens. The following is the volume of material required for each variation of the concrete mixture:

Table 4. Needs of cylindrical concrete specimens

Test objects k 250	Prosentase	Cylinder volume	Noes	Total Volume	Unit	Cement	Sand	Gravel	Water
Cylinder test	Normal	0.0053	4	0.021195	m^3	12.41	12.935	17.146	4.344
							Mixed Total Weight		93,68

Source : Author's calculations

Source : Lab Research Results, 2020

Figure 3. Ceramic waste powder sieve process

http://dx.doi.org/10.30737/ukarst.v3i2

Source : Lab Research Results, 2020

Figure 4. Mix concrete with ceramic waste powder added material.

4.3 Slump Test

After the implementation of mixing all materials is carried out in the Slump test, the Slump test is an empirical test/method [20] [9], which is used to determine the fresh concrete mixture's consistency/stiffness to determine its workability.

Table 5. Slump Test Results

No	Comparison of mixture	Slump (cm)
1	Ceramic Waste 3%	12
2	Ceramic Waste 4%	9
3	Ceramic Waste 5%	10

Source : Lab Research Results, 2020

Source : Lab Research Results, 2020

Figure 5. Slump Test

http://dx.doi.org/10.30737/ukarst.v3i2

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4.4 Concrete Compressive Strength

This concrete compressive strength test refers to SNI 03 -1947-1990. This compressive strength test is intended as a guide in testing for determining the compressive strength of concrete with cylindrical specimens made and ripened (curring) in the laboratory [16]. The purpose of the concrete compressive strength test is to determine the composition of the concrete stacking material, especially carbide dregs to meet the planned quality, namely K250 quality concrete.

Source : Lab Research Results, 2020

Figure 6. Weighing the test object

Source : Lab Research Results, 2020

Figure 7. Concrete compressive strength test

http://dx.doi.org/10.30737/ukarst.v3i2

ISSN (*Online*) 2581-0855
ISSN (*Print*) 2579-4620

Table 6. Result of Compressive Strength of Concrete mixture of ceramic waste 3%

No.	Age	Weight (kg)	Crushed pressure (tonnes)	Crushing stress (kg / cm2)	Crushing stress (MPa)	FK	Conversion 28 days (kg / cm2)
1	7 days	12,6	37	209,48	17,38	0,65	322,28
2	7 days	12,4	42	237,79	19,74	0,65	365,83
3	7 days	12,5	35	198,16	16,45	0,65	304,86

Source : Results of Lab Research, 2020

Table 7. Result of Compressive Strength of Concrete mixture of ceramic waste 4%

No.	Age	Weight (kg)	Crushed pressure (tonnes)	Crushing stress (kg / cm2)	Crushing stress (MPa)	FK	Conversion 28 days (kg / cm2)
1	7 days	12,3	25	141,54	11,75	0,65	217,76
2	7 days	12,4	32	181,17	15,04	0,65	278,73
3	7 days	12,5	27	152,87	12,69	0,65	235,18

Source : Results of Lab Research, 2020

Table 8. Result of Compressive Strength of Concrete mixture of ceramic waste 5%

No.	Age	Weight (kg)	Crushed pressure (tonnes)	Crushing stress (kg / cm2)	Crushing stress (MPa)	FK	Conversion 28 days (kg / cm2)
1	7 days	12,5	28	158,53	13,16	0,65	243,89
2	7 days	12,5	32	181,17	15,04	0,65	278,73
3	7 days	12,6	29	164,19	13,63	0,65	252,59

Source : Results of Lab Research, 2020

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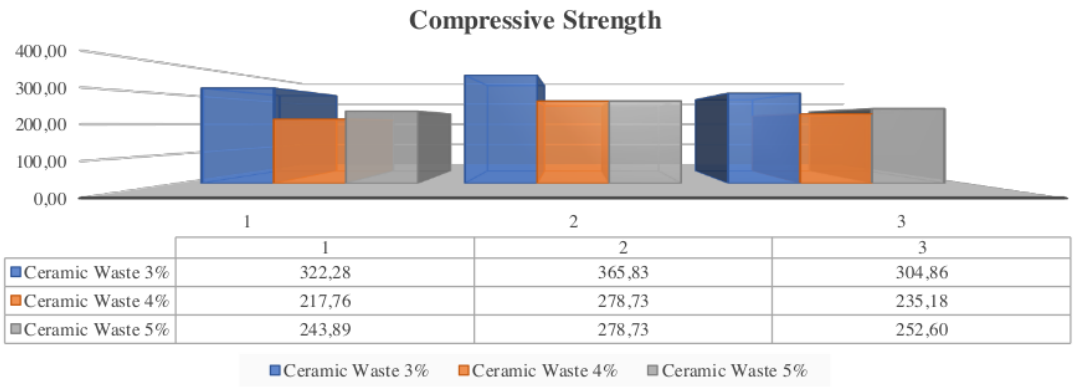

	1	2	3
Ceramic Waste 3%	322,28	365,83	304,86
Ceramic Waste 4%	217,76	278,73	235,18
Ceramic Waste 5%	243,89	278,73	252,60

Ceramic Waste 3% Ceramic Waste 4% Ceramic Waste 5%

Source : Lab Research Results, 2020

Figure 8. Graph press concrete

Based on the results of testing the compressive strength of concrete, the percentage of 3% has an average value 330.99 kg / $cm^{2,}$ equivalent to K300. The addition of a ceramic composition waste 4% has a compressive strength value an average of 243.89 kg / cm2. The last addition of ceramic wastes with a percentage of 5% has a compressive strength value an average of 258.41 kg / cm^2.

5. Conclusions and Suggestions

conclusion of this research is :

1. The more the ceramic waste mixture as a substitute for cement, the lower the compressive strength of the concrete.
2. The percentage of the best composition in this study is 3% with an average compressive strength value of 330.99 kg / cm^2, as well as the 4% percentage has a compressive strength of 243.89 kg / cm^2 and in the percentage of 5% has a value of 258.41 kg / cm^2

5.2 Suggestions

Based on the results of the analysis of the research conducted, it is necessary to conduct further research on the utilization of ceramic waste to obtain the maximum percentage value of concrete's mechanical properties. besides researching with different concrete tests such as the flexural strength of concrete

http://dx.doi.org/10.30737/ukarst.v3i2

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ISSN (*Print*) 2579-4620

6. Acknowledgment

The preparation of this research can not be separated from the support of various parties.

The author specifically thanked Kemenristek Dikti for providing financial support so that the preparation of this research could run smoothly.

http://dx.doi.org/10.30737/ukarst.v3i2

Ukarst : Universitas Kadiri Riset Teknik Sipil. ISSN (*Online*) 2581-0855
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