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Coal Powder Effect on Concrete Compressive Strength

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***Abstract*—Environmentally-sounded construction is a new issue which has to be developed in terms of both the operation and management. Concrete-construction development using additional material, organic waste taken from coal powder, can espouse the need for construction material, and it decreases the use of refined aggregate material which is in the form of sand and solves environmental issues in which the concrete can be categorized as ecologic material for construction, and it has high-pressure strength with additive material. By adding additive material (Sikament NN) which aims to strengthen the pressure on the concrete by 40% so that it can produce concrete made of organic-added material (coal powder) with high-pressure strength. The method used is in this research as the same as the production of concrete by loading all of the materials in which the mass has been calculated based on desired level to be evenly mixed, and it is put into the cylinder mold (15 cm x 30 cm). Testing of concrete pressure was doing at 28 days turned with 3 samples for each variation by using Universal Testing Machine (UTM). From the results can be known that the weight of the biggest volumetric weight is a normal concrete in amount of 2396,792 kg/m^3 and the smallest volumetric weight is 20 % proportion in amount of 2340,175 kg/m^3. from the five variants of testing materials added by coal powder with proportion of 5%, 10%, 15%, and 20%, the pressure strength of coal-added concrete is still unequal to the normal one whose strength is 569.86 kg/cm^2 and , the highest coal-added concrete strength is 436.33 kg/cm^2 in the proportion of 5%.**

I. INTRODUCTION

The pace of construction development in Indonesia is followed by the increasing construction materials needed, especially the use of concrete as one of the structure materials. Concrete is widely used due to its advantages. For instance, it is bendable and has high-pressure of strength. Concrete basically contains two main parts which are cement and aggregate. Cement pasta consists of Portland cement, water, and admixture. On the other hand, aggregate is made of coarse aggregate (gravel) and smooth aggregate (sand). Those materials have to be provided in a large number in either natural or artificial form.

The fact that the number of concrete is highly needed in a building structure leads a research to develop both the materials and the way of producing concrete. For instance, the admixtures are added to the concrete mixture. Mostly, the material used as additional one in making concrete mixture is coal powder, steel charcoal, and silicafume. However, those are limited and relatively expensive. Thus, it needs to invent an affordable alternative to replace filler material as the concrete mixture by employing available resources and local potency around us.

This research tries to take advantages from both the geographical condition of Indonesia and the use of local materials which are possible to make a new alternative of concrete-production technology with good quality. One of the ways is employing organic waste which is coal powder taken from wood to replace some of the cement, so the use of coal powder is expected to obtained a maximum concrete compressive strength.

II. REVIEW OF RELATED LITERATURE

A. Concrete

Concrete is a composite of several materials in which the main substances consist of cement, smooth aggregate, coarse aggregate, water, and or without other additional material in a set proportion. As concrete is a composite, the quality of concrete really depends on the quality of each material. (Kardiyono Tjokrodimulyo, 2007)

In order to produce a high-pressure strength of concrete according to the plan, it needs a mixed design to decide the number of each material needed. Furthermore, concrete mixtures need to be homogenous with a set mud in order to dissolve segregation. The compressive strength of concrete depends not only on the density of the mixtures but also on the ratio of each material. The smaller cavity produced in the concrete mixture will result a higher concrete compressive strength..

B. Additional Materials for Concrete

Additional materials refer to the ones other than the main materials such as water, cement, and aggregate which are added to the mixture. The aim is to change some concrete characteristics on which it is still fresh, or after it becomes coarse. The additional materials are supposed to be useful once there is a careful evaluation of its effects on the concrete, especially a condition in which the concrete is expected to be used. These additional materials is usually added in a relatively-small amount, and a tight supervision need to be given in order to control the mixture. As once the mixture is overloaded, it will worsen the concrete quality.

In the advanced technology, it has been conducted some researches about those additional materials. According to Moosberg, et al. (2004), additional materials which are in the form of filler are the ones based on the size and form in which those materials are able to interact with cement in some ways: to improve particle bound and

even to reduce concreted cement without losing the strength. There are some fillers that have been employed in researches such as dust, husk dust, etc. Based on the research conducted by Pedro et al. (2015), it was explained that the use of dust and lime as fillers can reduce the cement and strengthen the concrete. It affirms that it needs some fillers to reduce the other materials in order to cut the outcome in producing the concrete.

By adding some husk in the concrete, it can boost the use of water in the concrete mixture and significantly raise the strength by 10%. It happens because there is an increase by 30.8% if it is compared to the mixed-design change, and it is only 20% of the cement which can be replaced by husk without causing any reduction (Ghassan Abood Habeeb et al., 2010). It can be concluded that adding some fillers in the concrete causes different effects to the concrete mixture. Hence, the process of adding additional materials needs to be examined what is going to happen.

C. Coal Powder

Coal powder is black residue containing impure carbon which is produced by taking out the water and volatile components of plants and animals. Coal powder is generally derived by heating some woods, sugar, bones, and the other things. The black coal which is light and brittle contains of 85% to 98% carbon, and the rest is either dust or chemical substances. Wood coal is the one made from wood. It is widely used in cooking. Moreover, the other usages of wood coal are cleaning water, health purposes, and so on. The woods used to produce wood coal are the good ones in which the woods are not decayed.

Figure 1. Coal powder in use

D. Sikament NN

Sikament NN is a super-plasticizer liquid which is very effective with double actions as a material producing flowing concrete or reducing water in concrete to produce a high initial and last strength. It is free of chlorine based on ASTM C 94-92 type F, as well.

Sikament NN is used as super-plasticizer in producing flowing concrete so that it enables casting process in the slight structure with a close ossification. The use of Sikament NN also reduces water to 20% which means that it will improve the pressure strength to 40% in 28 days. Therefore, the use of materials will be more efficient. Concrete with a low FAS is the characteristics of concrete with a high-pressure strength, so in 12 hours, concrete derived from Sikament NN has a high-pressure strength.

III. Research Methodologies

A. Research Location

This research is conducted in the laboratory of material mechanics and structures of engineering faculty, Universitas Negeri Semarang.

B. Materials

The materials used are:

1. Cement, Portland cement of type 1, Tiga Roda
2. Coarse aggregate in the forms of gravel with a maximum diameter of 20 mm
3. Smooth aggregate, which is taken from Muntilan sand
4. Clean water taken from water mains of structure laboratory of engineering faculty, Universitas Negeri Semarang
5. Coal powder taken from the coal production in Gunung Pati, Semarang
6. Sikament-NN

C. Equipment

The equipment consists of:

1. A pair of scales to measure the weight of the materials and testing stuff
2. A sieve, used to test the aggregate gradation
3. Graduated glass to measure the water
4. Picknometer, used to test the specific weight of sand
5. Abrams cone, used to test the slum value
6. Oven, used to obtain a dried testing material
7. Cylinder mould
8. Bekisting, used to make the material of beam test
9. Cement mixer, used to mix concrete slurry
10. Ruler and slide-gauge, used to measure the slump value and the dimension
11. Water container, used to soak the testing materials during the maintenance
12. Pounding stick, used to condense the testing material
13. Compression testing machine (ELE), used to test the pressure strength

D. The Plan of Testing Material

In this research, the testing materials will be created in a cylindrical form to be tested in case of the pressure strength. The cylindrical testing materials are divided into two kinds, which are concrete which does not contain any additional materials and the one added by some coal powder. Each of those consists of 5 testing materials, so there are 10 (5 x 2) testing materials.

The shape of sample that for testing to get the result of compressing test can be seen on Picture 2 and samples for testing pressure strength is displayed in Table 1.

TABLE I. Samples for Testing Pressure

No	Size of Sample	Coal Percentage	Quantity
1	D15 x 30	0%	2
2	D15 x 30	5%	2
3	D15 x 30	10%	2
4	D15 x 30	15%	2
5	D15 x 30	20%	2

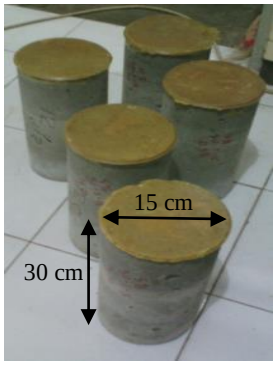

Figure 2. Samples Concrete Cylinder (D15 cm x 30 cm)

E. Testing Stages

1) Examining concrete composers

This inspection aims to examine the material specification which will be used as concrete composers. The inspection varies on controlling water, cement, and aggregate.

2) Designing Concrete Mixture

The design of comparing normal concrete is based on a rule in which SK SNI T-15-1991-03 with the value of cement liquid factor (FAS) is taken 0.3. It can be derived that the proportion of normal-concrete mixture for 1 m^3 is 700 kg cement : 596 kg of sand 894 kg of gravel : 210 liters of water. On the other hand, the coal-added concrete with the same proportion is added some coal powder with intensity of 5%, 10%, 15%, and 20% taken from the cement needed.

3) Producing the Testing Material

To make the testing materials, some steps have to be done as follows:

1. Preparing the cylindrical mould (15 cm x 30 cm)
2. Preparing and weighing the materials used based on the set proportion according to the calculation of mix design
3. Stirring the mixture using the cement mixture and adding the other materials continuously to make the mixture evenly spread
4. In mixing the coal powder, it needs to spread the coal powder evenly to the cement mixture (whipping in a normal speed) in which the basic components of concrete has been added sequentially. The process of adding coal powder is done by hand carefully so that each grain of coal powder can get into the mixture separately. It is expected that there is no coagulation.
5. The mixed materials is added to the set mould.
6. Once the mixture is kept for one day, the mould is opened and soaked for 28 days after the concrete is moulded.

4) Maintaining the Testing Materials

The maintenance of testing materials is based on the rule of SK SNI M-62-1990-03. Maintaining concrete is a mean to keep the surface moist from the process of making concrete mixture to the one in which the concrete is hard enough at the set time.

F. Testing the Materials

1) Testing the Concrete Slump

The concrete mixtures which has been analyzed are formed cylindrically with the diameter of 20 cm on the bottom and 10 cm on the top, and its height is 30 cm. To conduct such test, it requires a mould called Abrams cone.

2) Testing the Pressure Strength

The testing of concrete-pressure strength is based on standard ASTM using compression testing machine. It can be calculated by using formula of fc' = P max/A.

The process of testing concrete can displayed in Picture 3.

Figure 3. Testing concrete pressure by using ELE machine

IV. Results And Discusion

A. Results of Mix Design

The design of comparing normal concrete is based on a rule in which SK SNI T-15-1991-03 with the value of cement liquid factor (FAS) is taken 0.3. It can be derived that the proportion of normal-concrete mixture for 1 m^3 is 700 kg cement : 596 kg of sand 894 kg of gravel : 210 liters of water. On the other hand, the coal-added concrete with the same proportion is added some coal powder with intensity of 5%, 10%, 15%, and 20% taken from the cement needed.

B. Volumetric Weight of Concrete

Volumetric weight of concrete is a comparison between weight of concrete and concrete volume, which depends on the material composition of concrete planned. So when the constituent materials have a big of volumetric weight that will happen too on concrete. Testing of volumetric weight is doing before the testing of concrete pressure. The volumetric weight of concrete can be known by weighting of samples and height measuring and diameter of samples, so that we got the weight and volumetric weight of concrete. The result of testing volumetric weight is displayed in Table 2.

TABLE II. RESULT OF TESTING VOLUMETRIC WIGHT

Samples	Proportion of Coal	Size		Volumetric Weight (kg/m3)
		d (cm)	h (cm)	
Normal Conrete	0 %	15	30	2396.792
Coal-Added Concrete	5 %	15	30	2370.937
	10 %	15	30	2368.483
	15 %	15	30	2359.047
	20 %	15	30	2340.175

From the results in Table 2 can be known that the weight of the biggest volumetric weight is a normal concrete in amount of 2396,792 kg/m^3 and the smallest volumetric weight is a concrete that added by coal powder with 20 % proportion in amount of 2340,175 kg/m^3.

From these results it appears that the volumetric weight of concrete is so varied, this is due to weight of coal powder lighter than weight of cement. By increasing of added coal powder on concrete it can make volumetric weight of concrete to be light weight, it also affected of mix design and compacting of fresh concrete during casting.

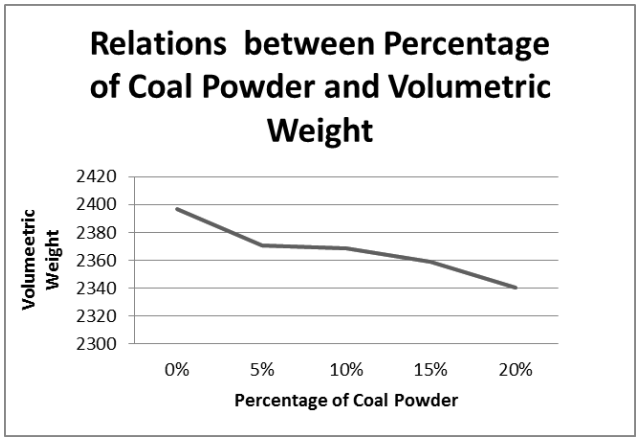

Figure 4. Relations between percentage of coal powder and volumetric

C. The Strength of Concrete Pressure

The strength of concrete pressure depends on the composition of concrete materials, the strength of each material, and the adhesion force of cement pasta and aggregate. Testing of concrete pressure was doing at 28 days turned with 3 samples for each variation by using Universal Testing Machine (UTM). The results of testing pressure strength is displayed in Table 3.

TABLE III. RESULT OF TESTING PRESSURE STRENGTH

Samples	Coal Percentage	Result Concrete Pressure (MPa)
Normal Conrete	0 %	569.86
Coal-Added Concrete	5 %	436.33
	10 %	419.90
	15 %	388.28
	20 %	358.43

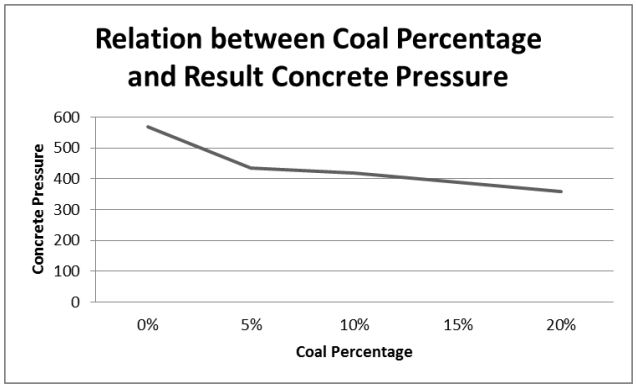

Figure 5. Relations between coal precentage and result concrete pressure

V. CONCLUSIONS

According to the results, it can be concluded that from the five variants of testing materials added by coal powder with proportion of 5%, 10%, 15%, and 20%, the pressure strength of coal-added concrete is still unequal to the normal one whose strength is 569.86 kg/cm^2. On the other hand, the highest coal-added concrete strength is 436.33 kg/cm^2 in the proportion of 5%.

VI. SUGGESTIONS

Based on the previous explanation which refers to the results and discussion of coal-added concrete, it was found many weaknesses. Thus, in order to get the better coal-added concrete, it requires some suggestions such as:

1. A good quality control is needed in producing coal-added concrete.
2. It needs more variants of coal-added concrete in order to get more accurate results.

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