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# FRESH CONCRETE AND COMPRESSIVE STRENGTH USING ALTERNATIVE CEMENT MADE FROM RECYCLED WASTE MATERIAL

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## ABSTRACT

*The waste problem is a problem faced all over the world. Gradually, the high volume of waste has a negative impact on the environment. In the research, the researchers have produced an organic cement that is the latest alternative cement aside from portland cement which is made through organic waste recycling system, fly ash, bottom ash, and substitution of mediteran soil and clay. The research is oriented to compressive strength, tensile strength, setting time and slump test of concrete by using organic cement and portland cement. Age of concrete in the research are 3, 7, 14, 21, and 28 days. Result for compressive test of cylinder concrete with organic cement, it obtained 14,52 MPa while the cylinder concrete with portland cement, it obtained 22,37 MPa. Result for tensile splitting strength of concrete with portland cement is 2,03 Mpa and cylinder concrete witch organic cement is 1,22 MPa. Slump test for fresh concrete using portland cement is 12,55 cm and fresh concrete using organic cement is 10,35 cm. Normal consistence formed in organic cement is 37% and in portland cement is 25%.*

**Key words:** Mediteran soil, organic cement, organic waste, portland cement, setting time.

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## 1. INTRODUCTION

This paper is a continuation of the results of the author's research. In the initial phase research that has been done is the utilization of waste recycle on materials that do not contribute much in the community life so far This study aims as the development of previous experimental research that researchers have done titled Chacarteristic Of Compressive and Tensile Strength Using The Organic Cement Compare With Portland Cement [1]. But to make improvements and increase the results obtained, then the researchers conducted research development by utilizing Mediteran soil, clay, fly ash and bottom ash [2].

Increased demand for housing and infrastructure automatically demands the need for ever-increasing building materials. Increased need of building materials must be addressed with the use and discovery of building materials that is capable of being an alternative. The experimental research that has been conducted related to this matter is make use of mediteran and clay soils with waste through organic waste recycling system that is household waste, coal waste (fly ash and bottom ash) to become organic cement which is an alternative cement besides portland cement.

Mediteran soil is often regarded as rocky soil that does not contribute to human life. This is because its lime content is high enough to make it difficult for plants to grow. Mediteran soil is a soil formed from weathering of sedimentary and limestone rocks. This type of soil contains a considerable amount of carbonate and other compounds of iron, water, aluminum, and some other organic matter [3].

Clays are among the most widespread sedimentary rocks, which are mainly composed of clay minerals like kaolinite, illite, montmorillonite and other aluminum silicates as well as other various ingredients. Due specific properties, clays are widely used in various industries [4]. Clay that through the combustion process with temperatures exceeding 600ºC will change into a solid, hard and permanent mineral [5].

Waste is goods or objects that have been depleted the value of the benefits and create a negative impression that makes the waste viewed as objects that must be removed from the home page any way [6]. Handling of organic waste is done through the combustion process with furnace at a temperature of $700^{o}$ C to ashes will contain elements of $CaCO_3$ 69.7%, KCl 12.1%, $SiO_2$ 3%, Fe 8.1% and $Al_2$ 3% [7].

Although fly ash and bottom ash as waste that is not utilized, but in cement production, it is deemed necessary to pay attention to the amount of content usage. This is in line with the results of research which states that the use of fly ash that is large enough as a partial replacement for cement will lead to reduced heat of hydration thereby it slows down the chemical reaction and slows down the cement bonding time [8]. The use of saturated fly ash is one of the ways to reduce high exposure in the hydration process against the density of cement in the concrete [9]. With a high enough silica content, it allows fly ash meets the criteria as a material that has the properties of cement / pozzolan [10]. The use of fly ash creates a reduction in air pollution emissions that negatively impact the economy. It has been observed that 0.9 tons of $CO_2$ is produced per ton of cement production. In addition, the cement composition is 10% by weight in cubic units of concrete. Thus the use of fly ash makes it possible to reduce atmospheric $CO_2$ emissions as a form of eco-friendly engineering

[11]. The effect of adding a certain amount of fly ash will increase the strength of the concrete [12]

## 2. RESEARCH METHODOLOGY

Organic cement concentrate is formed by utilizing natural materials substitution in the form of mediteran soil and recycling of organic waste that are household waste, fly ash, bottom ash and clay. To form an organic cement concentrate, all the main ingredients are burned to a temperature of $1400^0$ C. The discussion in the results of current research is examination of physical properties, measurements of compressive strength and tensile strength of concrete cylinder using organic cement. The used sample is cylinder concrete with a height of 20 cm and a diameter of 10 cm. The concrete compressive examination was performed after the test specimen was 3, 7, 14, 21,and 28 days, while for tensile strength test was done on specimen of 28-days. Testing is done by using Universal Testing Machine (UTM). The compressive strength test is based on ASTM C 39/C39M-05 [13]. The value of tensile strength is calculated using the formula based on the normative reference ASTM C-496 / C966M-17 [14].Testing of concrete slump test using ASTM C-143 reference [15]. For setting time test value, it is calculated by reference standard according to ASTM C-191-04 [16]. Figure 1 below shows the organic cement raw material before the management process becomes organic cement concentrate.

A B C D E

**Figure 1** Mediteran soil (A) ,Household waste (B), Clay (C), Fly ash (D) Bottom Ash (E)

## 2. RESULTS AND DISCUSSION

To see the feasibility of organic cement concentrate as an alternative cement, the research development that is conducted by the researcher is to study organic cement concentrate on examination of physical properties in the form of compressive strength, slump test and seting time test.

### 2.1. Setting Time

Setting time is the time needed for cement to harden starting from mixing with water until the cement turns into paste later become hard enough to resist a strenght as seen in figure 2. In the study, the setting time of cement being studied is the initial setting time and final setting time. Initial setting time of portland cement was tested with vicat needle with a diameter of 1 mm piercing through cement paste as long as 24 mm at 90 minutes after the needle has been released. The initial setting time of organic cement is also tested with similar method piercing the cement 25 mm long at 105 minutes after the needle is released. The final setting time of portland cement is at 180 minutes, while for organic cement is at 225 minutes. The standard used for setting time is ASTM C-191-04.

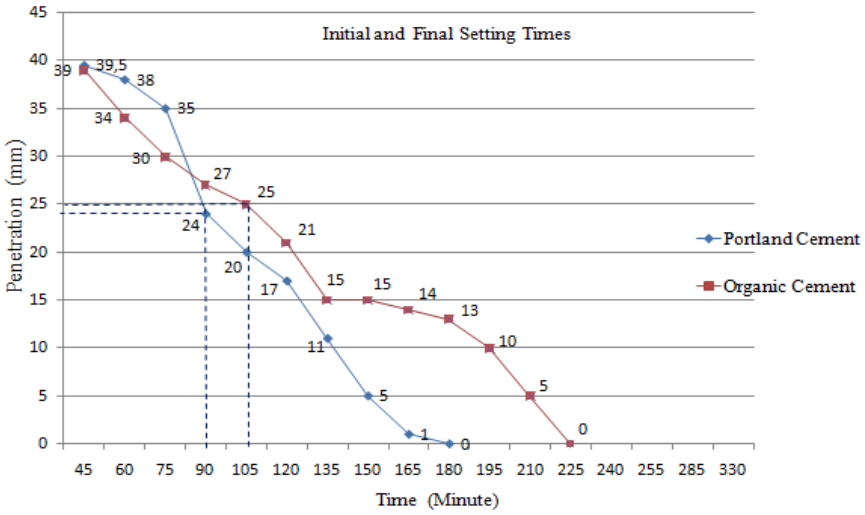


**Figure 2** Initial and final setting time Graph

# 3. CONCRETE USING ORGANIC CEMENT

## 3.1. Workability

Water has an influence on the workability of concrete paste, its strength, shrinkage, and durability. Normal consistence formed in organic cement is 37% and in portland cement is 25%. The following table 1 shows the result of normal consistency test. The test of normal consistency is referred to ASTM C 187-04 [17]. To obtain good and fresh concrete, it is to be in a room temperature of about $20^0$C, $30^0$C, and $35^0$C. The cement temperature is conditioned to $20^0$C, $40^0$C, and $60^0$C [18].

**Table 1** Normal consistency of organic cement

| Experiment | Portland Cement | | | Organic Cement | | |
|---|---|---|---|---|---|---|
| | I | II | III | I | II | III |
| Cement (gr) | | 500 | | | 500 | |
| Water (ml) | 128 | 125 | 122 | 175 | 180 | 200 |
| Consistency (%) | 25,6 | 25 | 24,4 | 35 | 36 | 40 |

To obtain good and homogenous material mix (workability), suitability is needed between water and the coarse, smooth aggregate, as well as the cement used. Slump value test is to prove the workability of fresh concrete before being applied to cast a test material of cylindrical concrete. Figure 3 shows slump test process of fresh concrete. The slump measurement in this case is closely related to planed concrete mix design. This test uses cement water (fas) 0,52%. Concrete cylinder slump test refers to ASTM C-1611. The slump planned height is 12 cm and the reached height is:

Fresh concrete using portland cement $\frac{10.7 + 14.4}{2}$ = 12.55 cm

Fresh concrete using organic cement is $\frac{9.8 + 10.9}{2}$ = 10.35 cm

High ratio of water against cement in a concrete mix is one of the factors degrading the strength of the concrete. In the concrete mixture, the ratio of water against the cement is defined as water weight and cement weight shortened w/c. the ratio of w/c has a strong influence on the strength of a concrete. For certain mixture to increase the ratio of the w/c will decrease the strength of all ages and to decrease the w/c ratio will increase the strength of the concrete strength [19].

**Figure 3** Slump test of fresh concrete organic cement

To obtain mix proportion as required by the plan, a mix design should be made as shown in Table 2.

**Table 2** Mix design

| Sampel | WC (%) | Temperature ($^0$C) | Curing Condition and Method | Water (kgm$^3$) | Cement (kgm$^3$) | Maximum size (mm) Aggregates | | Materials (kg/m$^3$) | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Fine | Coarse | Fine | Coarse |
| Organic Cement | 52 | 30 | Water<br>Dry,30$^0$C-60$^0$C | 195 | 375 | 2,5 | 20 | 538 | 1232 |
| Portland Cement | 52 | 30 | Water<br>Dry,30$^0$C-60$^0$C | 195 | 375 | 2,5 | 20 | 538 | 1232 |

## 3.2. Compressive Strength Test

The compressive strength test of the cylinder concrete made from portland cement using water curing method results in 22,37 MPa. and using dry curing method 19,71 MPa.The compressive strength test for the cylinder concrete made from organic cement using maintaining method of water curing, results in 8.52 MPa and using dry curing method 14,52 MPa. The figure 4, shows test process of compressive strength. The graphs of the test results of compressive strength of cylinder concretes of organic cement and of portland cement using dry curing and water curing methods can be seen in figure 5. The compressive strength values produced was calculated with normative standard reference using formula according to ASTM C-39/39M-05.

**Figure 4** Test process of compressive strength cylinder concrete organic cement

The compressive strength test of cylinder concrete was calculated with the following formula:

$$\sigma = \frac{P}{A} \ (kg/cm^2) \qquad (2)$$

which:

σ = Concrete Compressive Strength Characteristics (kg/cm²)

P = Compressive Force (kg)

A = Cylinder Concretesectional stress field (cm²).

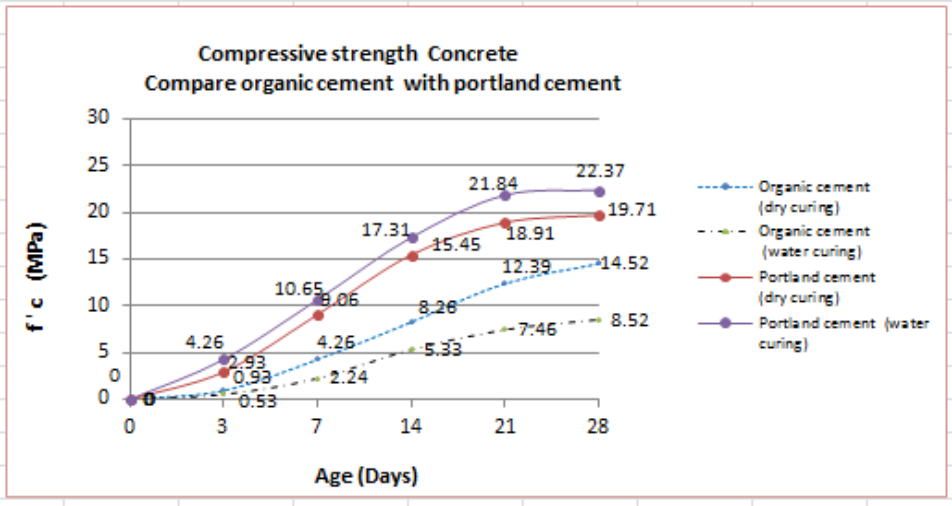


**Figure 5** The comparison graphs of compressive strength of cylinder concrete between organic cement and portland cement

## 3.3. The Splitting Test

Results of spliting test indicate the measurement of the material endurance against mechanical strenght, and thermal strenght. The tensile strength of cylinder test shows tensile strength of concrete normally is around 0.05 to 0.1 compare with compressive strength value [20]. The tensile strength value of the tested materials can be calculated using the formula:

$$fct = \frac{2 \times P}{LD}$$

Which fct = Tensile Splitting Strength

P = Maximum Test Load (N)

L = Length of Test Item (mm)

D = Test Item Diameter

Tensile splitting strength of concrete with portland cement at water curing treatment method has more strength than the concrete treated with dry curing method. Water curing method result 2,03 Mpa, while dry curing result in 1,59 Mpa. Tensile splitting strength of concrete with organic cement at water curing treatment has an ability lower than the one using dry curing method. The water curing method result 0,96 Mpa and while dry curing method result in 1,22 Mpa.

The graph of the splitting test results is revealed in figure 6 which is the results of tensile splitting strength test of cylinder concrete based on the concrete age plan i.e. 28 days.

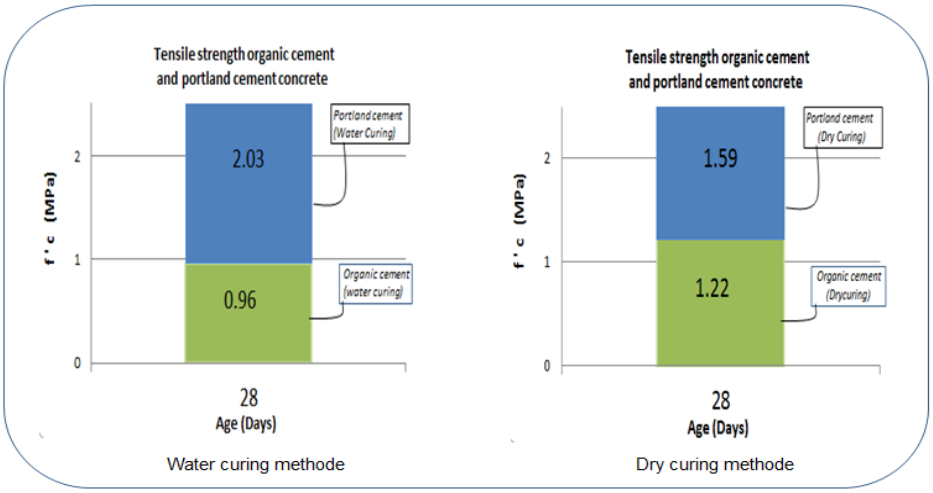


**Figure 6** The comparison graphs of tensile splitting strength of cylinder concrete between organic cement and portland cement

Figure 7A is a form of concrete cylinder using organic cement concentrate, while in 7B is a form of concrete cylinder using portland cement.

A B

**Figure 7** Cylinder concrete of organic cement (A). Cylinder concrete of portland cement (B)

## 4. CONCLUSIONS

From the examination results Based on the results of the organic cement feasibility test, it can be assumed that organic cement can be used for non-structural work. However, to obtain a more optimal approach to organic cement as an alternative cement, it is deemed necessary to undertake advanced experimental studies to ensure that the quality of organic cement can be as expected based on the reference of American Standard Testing And Material (ASTM)..

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