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PHYSICAL AND MECHANICAL PROPERTIES OF FOAMED CONCRETE WITH CURING TEMPERATURE VARIATION AND RICE HUSK ASH

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ABSTRACT

The development of technological innovation has an impact on the progress in construction, for example the more varied forms architecture of buildings and bridges. Therefore, researchers compete to find the latest innovations from construction materials to simplify the process and to achieve a certain quality.

Foamed concrete is a material component that has a total weight that is lighter than conventional concrete, so it can make a construction becomes lighter, simplify the process of making and also easy to be formed.

In addition, to produce environmentally friendly material components, rice husk ash waste used as Portland cement substitution. This study used a variety of treatment temperatures to obtain a high initial strength. The purpose of this study was to obtain optimum curing temperature for foamed concrete with rice husk ash as substitution. Percentage of rice husk which used in this research are 0% and 10%. Curing temperature variations used 60^oC, 90^oC and 120^oC. This paper reports results of the impact of curing temperature towards physical and mechanical characteristic of foam concrete which cured by ambient and high temperature.

Key words: Foamed Concrete, variation of temperature, rice husk ash, physical and mechanical properties.

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1. INTRODUCTION

Lightweight concrete has lighter density than the concrete in general. According to Amran (2015), the benefits of lightweight concrete construction is a quick and relatively simple, economical in terms of transportation and manpower reduction, weight reduction significantly resulting in savings overall structural framework. According to Neville (2011), lightweight concrete can be divided into three categories, which are the no-fines aggregate concrete, lightweight aggregate concrete and foamed concrete.

According to Amran (2015) and Mydin (2010), a specific gravity of foamed concrete ranges from 400-1,890 kg/m^3. Foamed concrete is generated when the foaming agent is added to the pasta mixture. Lightweight building material that can contribute significantly to the development of infrastructure (Visagie, 2000). Rice husk is a residual waste from agriculture which can then be used as a cement substitute material in the manufacture of concrete mix. Rice husk ash, including the type of fly ash results from the combustion of rice husk in rice mills contain elements of silica dioxide (SiO_2) is higher than the silica dioxide present in the cement, so that the rice husk ash has potential as a substitute for cement in the concrete mix, and can increasing the compressive strength of concrete.

In the cement composition using rice husk ash could provide some advantages in its use as increase endurance and strength, saving on the cost of material requirements, reduces environmental waste, and reduces the production of carbon dioxide. According to Fairbairn (2010) and Hanafiah (2017), there are several advantages of using RHA as improving the durability, strength, and provide benefits to the environment.

Foam concrete is created by uniform distribution of air bubbles throughout the mass of concrete. The foam must be stable, they are not easily broken so they can withstand physical and chemical strength during the process of mixing, laying and hardening of foamed concrete (Sarkawt, 2013). Percentage of foam usage may affect the specific gravity and strength, when using high dose foam makes the density to be lighter. Using high dose foam can also make its strength smaller. This is because the foam can increase the porosity of the concrete so that the concrete has many pores and can reduce the quality of the concrete itself.

To maintain perfect concrete hydration, it is necessary curing to keep the moisture. Concrete treatment is a process to maintain ideal humidity and temperature levels to prevent excessive hydration and keep hydration ongoing. Treatment concrete is completed and reaching the final setting or when the concrete has hard. To get the concrete with high initial strength then needed a treatment, including treatment by using temperature variation. The advantages of temperature variations can accelerate the strength of concrete at an early age, but using too high a temperature can result in a serious effect on the development of concrete strength (Richard, 2013). Therefore, controls and realistic specifications are required to determine the temperature used in the treatment.

2. METHODOLOGY

In this study apply the experimental method. The experimental method performed in this study to analyze the effect of temperature variations in the mix foamed concrete of the density and compressive strength of concrete. Variations in the temperature used are room temperature, 60°C, 90°C and 120°C. The percentage of use of rice husk ash by 10% of the weight of the cement. Testing fresh concrete is done is the slump test using flow table and setting time test using penetrometer. Properties of foamed concrete the analyzed is the density, compressive strength and porosity of foamed concrete against the effects of temperature variations in care. Testing density, compressive strength of concrete is done at the age of 7, 14 and 28 days with prints of cylindrical test specimens measuring 10 x 20 cm.

2.1. Material

Preparation before doing research aims to determine what material is used along with the stock in the laboratory in order to supply adequate material used. Materials used during the study is Portland cement, water, foaming agent, fine aggregate and rice husk ash.

Cement

Type of cement used in the concrete mix in this study using a cement type I kind of Ordinary Portland Cement (OPC) in accordance with the provisions of the standard ASTM C 150.

Fine aggregate

Fine aggregate used came from the area of Tanjung Raja and sieve No.16 or 1,18 mm.

Water

The water used is distilled water or water that can be drunk because it does not contain that can damage the reaction time of the making of pasta.

Foaming agent

Foaming agent used for the research came from PT. Mount Degrees is a type of synthetic surfactant liquid consist.

Rice husk ash

Rice husk ash is derived from Beliti Muara District, Musi Rawas which has been filtered by the filter 200.

Table 2.1. The chemical composition of rice husk ash

Ingredients	Weight (%)
SiO_2	71.20
Al_2O_3	0.48
Fe_2O_3	0.56
CaO	2.78
MgO	0.80

2.2. Composition Mix

Table 2.2. Mix design of foamed concrete

Mix design	OPC (kg)	RHA (kg)	Water (liter)	Sand (kg)	Foam	
					FA (gr)	Water (kg)
SK-1	592.4	0	228	592.4	907.6	27.2
SK-2	533.2	59.2	228	592.4	907.6	27.2
60-1	592.4	0	228	592.4	907.6	27.2
60-2	533.2	59.2	228	592.4	907.6	27.2
90-1	592.4	0	228	592.4	907.6	27.2
90-2	533.2	59.2	228	592.4	907.6	27.2
120-1	592.4	0	228	592.4	907.6	27.2
120-2	533.2	59.2	228	592.4	907.6	27.2

Composition of foamed concrete used in this study can be seen on Table 2.2. The step of determining the composition of the mixture (mix design) foamed concrete and do a trial mix. The composition of mixtures foamed concrete designed based on the ACI 523.3R and previous research. The material used is composed of Type I OPC cement, water, fine aggregate, rice husk ash and foaming agent. Percentage of foam used is 30% of a mixture of foamed concrete. Foaming agent has a ratio of 1: 30. Percentage of rice husk ash used was 10% by weight of cement. Plans mixed composition foamed concrete with w/c of 0.45.

3. RESULT AND DISCUSSION

3.1. Slump Flow

Slump flow obtained from the average length of the diameter distribution measurement of concrete in the four sides of the steel plate. Results of testing slump flow conducted on each sample mix design which is a mixture with rice husk ash substitution 10% and rice husk ash 0%. Results of testing the slump flow can be seen in Figure 3.1.

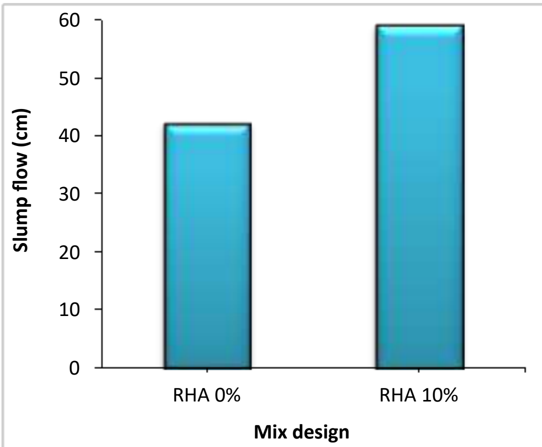

Figure 3.1. Comparison of was used RHA 0% and 10% toward test result of slump flow

Slump flow ranges between 42 - 59 cm. Slump flow the contained in the non RHA mixture of 59 cm, while the value of slump flow the smallest contained in the mixture using RHA by 42 cm. Use RHA substitution led to a slump flow becomes smaller than non RHA concrete, causing the concrete to the substitution RHA has workability. A low reduced value slump of the concrete containing RHA this occurs because RHA has porous particles, so that the water contained in the concrete mixture is absorbed by the RHA. This causes the concrete mixture becomes drier and automatically lowers the workability of concrete, increases the surface area so that the aggregate symptoms segregation and bleeding can be minimized.

3.2. Setting Time

Test results setting time can be seen on Figure 3.2. Setting time conducted to determine the time of binding of cement with water when the mixture is still fresh to start experiencing stiffness until completely stiff. Testing setting time is divided into two, namely the initial fastening time (initial time), and when tied end.

Test results initial time for the of use rice husk ash 10% is 300 minutes and a mixture of non-rice husk ash is 290 minutes and the test results in the final time to a mixture of non-rice husk ash was 610 and 630 minutes to a mixture of 10% rice husk ash. The maximum time of the test results setting time contained in the mixture with the use of rice husk ash 10%.

The compound found in semen is C_3S, C_2S, C_3A and C_4AF, where the compound that forms the initial strength of the cement is a compound C_3S assisted by the heat of hydration of compound C_3A. The reaction product will react with the main elements contained in rice husk ash are silica and alumina thus hydration reaction chains are lengthening, which in turn increase the time of hardening concrete.

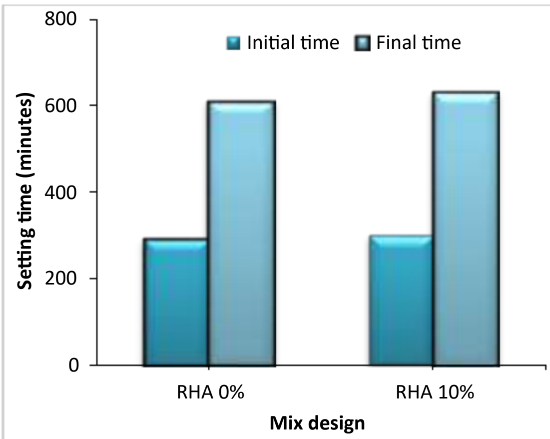

Figure 3.2.Comparison of was used RHA 0% and 10% toward test result of setting time

3.3. Concrete Testing Results

In concrete testing there are three tests, namely the specific gravity (density), compressive strength, and the porosity of the concrete. Testing the compressive strength and density performed on the concrete 7, 14 and 28 days, while the porosity of the concrete is done on the concrete 28 days on concrete treated at room temperature, 60°C, 90°C, 120°C, and concrete mixed-use RHA 10% and RHA 0%. Tests carried out at the Laboratory of Materials and Concrete Civil Engineering Faculty of Engineering, University of Sriwijaya, PT. Nindya Karya and PT. Semen Balfour. Results of testing the density, compressive strength and porosity of the concrete can be seen in the following explanation.

3.3.1. Density

The test results density concrete ages 7, 14 and 28 days can be seen in Figure 3.3 and Figure 3.4. Concrete specific gravity value obtained from the average density of five specimen cylinders. This test aims to determine the specific gravity of foamed concrete using rice husk ash 10% and compared with the density non rice husk ash. Density testing is done by weighing the concrete samples.

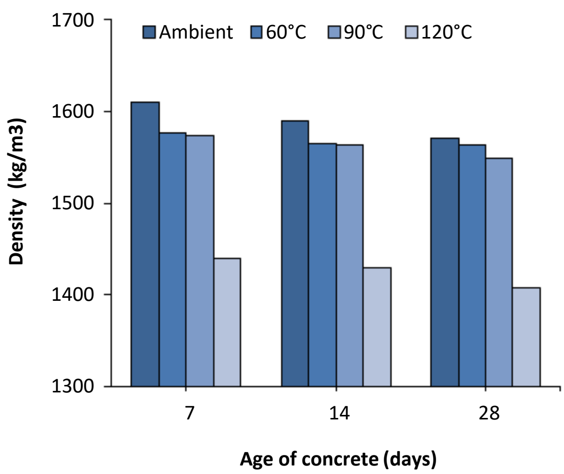

Figure 3.4. The comparison variation temperature of curing toward density in 7, 14 and 28 days with mix design RHA 10%

Concrete density at the age of 28 days using rice husk ash 10% ranging from 1,407 - 1,610 kg/m^3. Density highest in the concrete with the use of rice husk ash 10%, is in the concrete life of 7 days with treatment at room temperature of 1,610 kg/m^3 and the lowest at the age of concrete 28 days treated with a temperature of 120°C is equal to 1,407 kg/m^3, Concrete generally reaches maximum density and hardens perfectly at 28 days. Density produced at the concrete age 7, 14, and 28 on mix design non-RHA ranges from 1,424 - 1,680 kg/m$^{3.}$ The maximum density contained in the concrete at the age of 7 days were treated at room temperature is 1,680 kg/m^3. The weight ratio of the lifetime of concrete types can be seen in Figure 3.3 and 3.4.

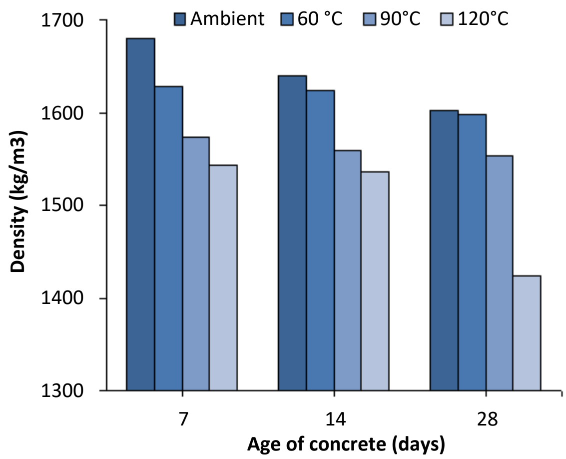

Figure 3.5. The comparison variation temperature of curing toward density in 7, 14 and 28 days with mix design RHA 0%

3.3.2. Compressive Strength

Testing the compressive strength of concrete is done at the age of 7 days, 14 days and 28 days. Compressive strength value obtained from the average of five specimen cylinders. The test is performed to compare the use of rice husk ash 10% and 0% rice husk ash with a temperature variation in the treatment of the concrete mix. This test produces a different compressive strength of concrete mix every substitution uses. Comparison of compressive strength containing RHA 10% and 0% with treatment temperature variation can be seen in Figure 3.7 and Figure 3.8.

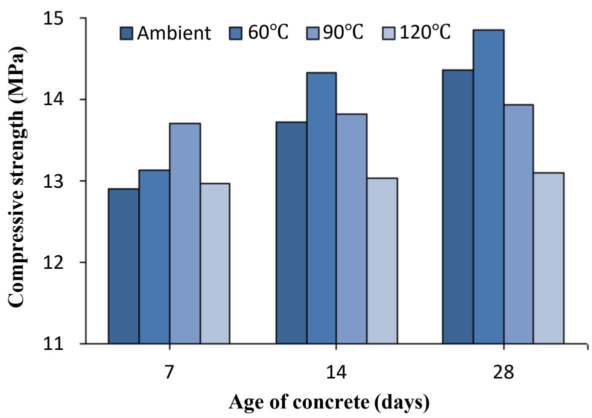

Figure 3.7. The comparison variation temperature of curing toward compressive strength in 7, 14 and 28 days with used RHA 10%

The high temperature treatment at the time of placement makes the greater initial rate of increase in concrete, but lower long-term strength of the concrete was treated at room temperature. Treatment with this method aims to determine the appropriate temperature in order to rapidly increase the strength of concrete can be related to the rate of chemical reactions that lead to process improvement and hardening of concrete while the availability of sufficient moisture or preventing excessive water loss can be maintained in the presence of water vapor.

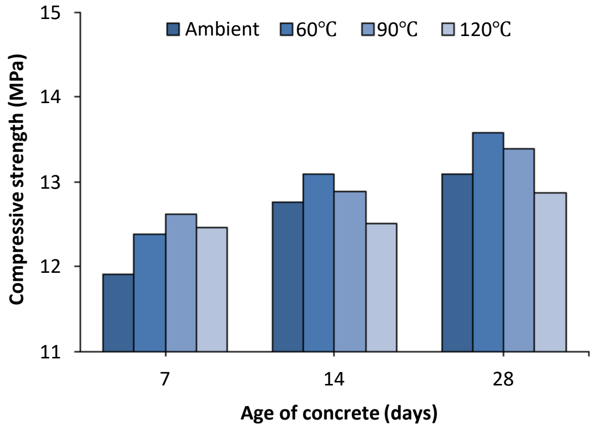

Figure 3.8. The comparison variation temperature of curing toward compressive strength in 7, 14 and 28 days with used RHA 0%

Curing with temperatures can increase the strength of concrete because the cement with aggregate holding capacity and increased strength at high temperatures. Decrease heat of hydration in concrete with a mix of RHA resulting in the development of the concrete strength longer than normal concrete. One of the ways to accelerate the hydration process is to treat the concrete using a high temperature. Treatment with temperature making the rate of hydration in concrete will increase. Use of the curing temperature produces a high compressive strength of concrete at early age.

3.3.3. Porosity

Tests conducted on the concrete porosity of 28 days to determine the level of water absorbtion of foamed concrete. Porosity comparison to treatment with the room temperature and a temperature of 60°C, 90°C, and 120°C can be seen in Figure 3.9.

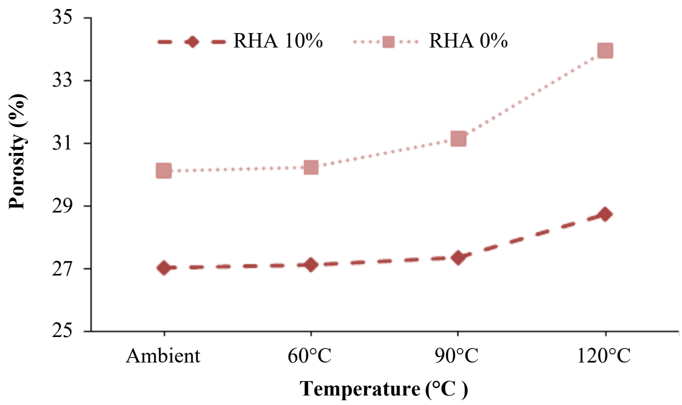

Figure 3.9. Comparison of temperature toward porosity foamed concrete in 28 days

On Figure 3.9 the temperature greatly affects the porosity of foamed concrete. The highest porosity of the concrete non RHA treated at a temperature of 120°C is equal to 33.65%, while the lowest porosity of the concrete containing RHA 10% with treatment at room temperature that is equal to 19.02%. This shows that with increasing temperature the higher the porosity produced. Use of the RHA 10% were able to reduce the porosity of foamed concrete.

3.4. Relations Density and Compressive Strength

At RHA 10% mix concrete that has been taken care of by variation temperature can affect the density and compressive strength. The relationship between density and compressive strength foamed concrete of concrete at the age of 28 days with 10% substitution RHA can be seen in Figure 3.10.

Figure 3.10 based on regression relationship compressive strength and density foamed concrete with substitution RHA 10% at 28 days after being treated with variations in temperature. The relationship between the data is $y = 5.1377e^{0.0007x}$

where

y = compressive strength (MPa)

x = density (kg/m^3)

Residual value rate nearing one showed that foamed concrete with substitution RHA 10% had been treated with temperature variation can affect the density and compressive strength. Treatment with temperature variations that are too high will reduce the density and compressive strength. While the relationship between density and compressive strength foamed concrete of concrete at the age of 28 days with substitution RHA 0% can be seen on Figure 3.11.

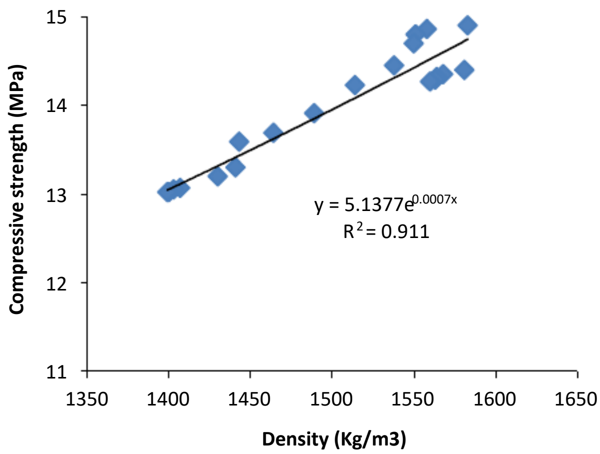

Figure 3.10. Relations compressive strength and density with the RHA 10%

On Figure 3.11 regression relationship compressive strength and density foamed concrete with substitution RHA 0% at 28 days after treatment with temperature *variation*. The relationship between the data is $y = 7.2465e^{0.0004x}$. Residual value nearing one indicate that foamed concrete with substitution RHA 0% had been treated with temperature variation can affect the density and compressive strength.

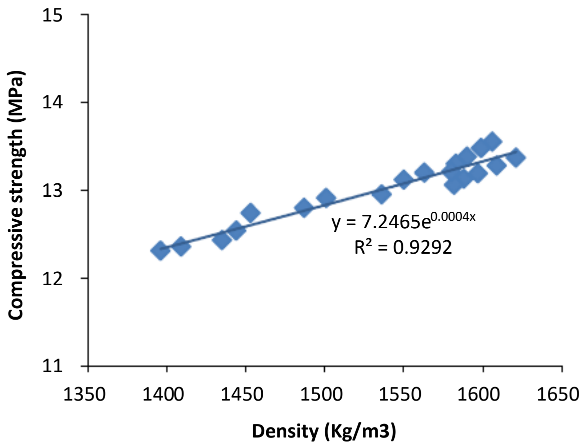

Figure 3.11. Relations compressive strength and density with the RHA 0%

3.5. Density and Porosity Relationship

Foamed concrete that uses a mixture of RHA 10% and RHA 0% has different porosity in each sample. Substitution of rice husk ash used has a smaller specific gravity of cement can affect the density of concrete produced. Density and porosity relationship with substitution RHA 10% in foamed concrete can be seen in Figure 3.12

On Figure 3.12 shows that the regression relationship of porosity and density foamed concrete at 28 days exponential equations obtained as follows $y = 8318.7e^{-0.062x}$

where:

y = density (kg/m^3)

x= porosity (%)

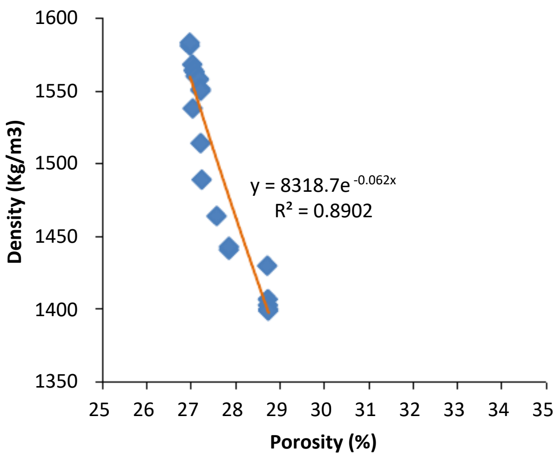

Figure 3.12. Relations porosity and density with the RHA 10%

On Figure 3.12 explain that concrete with substitution RHA 10% yield porosity caused this small rice husk ash particles which can be refined filler. So that the concrete denser Relationships density and porosity of foamed concrete with substitution RHA 0% can be seen on Figure 3.13.

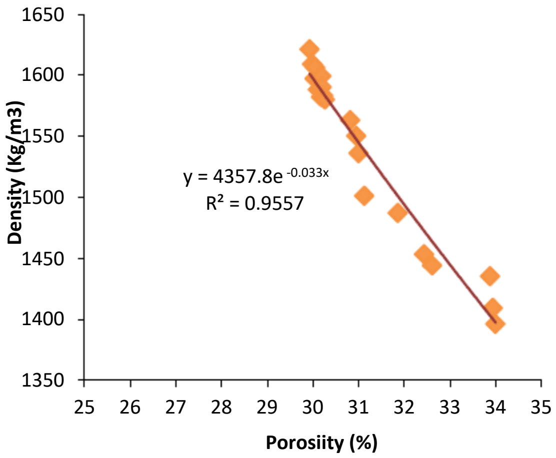

Figure 3.13. Relations porosity and density with the RHA 0%

On Figure 3.13 shows that the regression relationship of porosity and density foamed concrete at 28 days exponential equations obtained as follows $y = 4357,8e^{-0,033x}$. In Figure 3.13 explains that the higher the density of concrete then becomes increasingly lower porosity. However porosity foamed concrete with substitution RHA 0% was still higher when compared with the value of the substitution RHA porosity of 10%, this is caused because the absence of a material that serves as a filler for covering pores. Temperature treatment can lower the density and increase the porosity of the concrete due to rapid evaporation.

3.6. Relations Compressive Strength and Porosity

The temperature variation of care and the use of rice husk ash can produce different hydration heat with foamed concrete non rice husk ash. Heat of hydration can affect the compressive strength and porosity of concrete, can be seen on Figure 3.14.

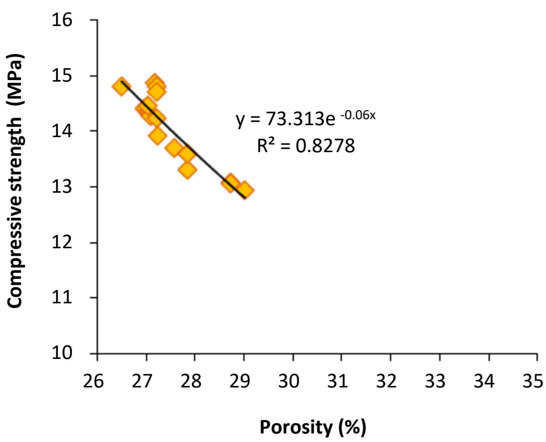

Figure 3.14. Porosity and compressive strength relationship with the RHA 10%

On Figure 3.14 porosity and compressive strength foamed concrete at 28 days exponential equations obtained as follows $y = 73.313e^{-0,06x}$

where:

y = compressive strength (MPa)

x = Porosity (%)

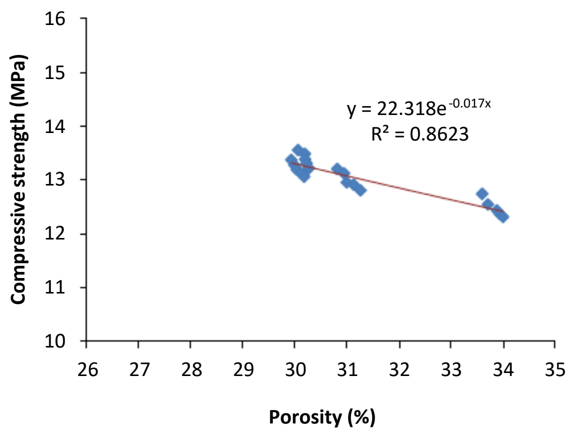

Figure 3.15. Porosity and compressive strength relationship with the RHA 0%

Figure 3.15 based on regression relationship porosity and compressive strength foamed of concrete at 28 days exponential equations obtained as follows:

$y = 22.318e^{-0.017x}$

where:

y = compressive strength (MPa)

X = porosity (%)

In Figure 3.15 explains that the higher the compressive strength of concrete then the lower porosity, therefore porosity greatly affects the quality of concrete. Treatment with temperatures could increase the early compressive strength of concrete because the cement with aggregate holding capacity and increased strength at high temperatures.

4. CONCLUSION AND SUGGESTION

4.1. Conclusion

The conclusion that can be drawn from the research that has been done among other things:

Influence of temperature variation treatments to room temperature, 60°C, 90°C and 120°C, to the physical and mechanical properties, namely:

- Treatment temperature variation of 90°C and 120°C is able to improve early compressive strength of concrete. However, lower long-term strength of concrete was treated at room temperature.
- The optimum treatment temperature is 60°C because it can increase the compressive strength of concrete at the age of 7, 14 and 28 days and to produce the highest compressive strength of 14.85 MPa.
- Treatment with a temperature of 60°C, 90°C, 120°C is able to reduce the density of concrete compared to concrete treated at room temperature. The higher the temperature of treatment used, the lower the density of concrete produced by
- The high temperature treatment causes the formation of pores in the concrete thereby increasing the porosity of foamed concrete.

The effect of using rice husk ash to the physical and mechanical properties of foamed concrete, among others:

- The use of 10% rice husk ash produces a maximum compressive strength of concrete at the age of 28 days is 14.85 MPa.

- The use of 10% rice husk ash affects the density of concrete so that the density of concrete to be lighter than concrete non RHA.
- The use of 10% rice husk ash lowers the value of the slump flow, workability and slows the process of setting time foamed concrete.
- The use of 10% rice husk ash able to reduce porosity in the foamed concrete.

4.2. Suggestion

Some suggestion that can be given after the research has been carried out, among others:

- Tools and materials to be used for research, should be ready and in good condition prior to use in order to be more effective job retention.
- Further studies should be done to a higher temperature.
- SEM testing needs to be done to look at the size of the pores as a result of temperature variations that use

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