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Effect of Curing Method on Mechanical Properties of Precast Reinforced Green Concrete Beams

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Abstract:
Background*: Green concrete, as an innovation in the concrete industry, is an option in manufacturing precast reinforced concrete beams (PRCB). The choice of material aims to reduce waste in nature and reduce the use of cement. This study aims to determine the feasibility of using Rice Husk Ash (RHA) to manufacture precast beams.*
Materials and Methods*: Experimental methods with three variations of RHA presentation and three curing methods were applied to cylindrical and reinforced concrete beam samples. Testing the compressive strength and flexural strength of concrete are two parameters that are indicators of mechanical properties.*
Results*: The compressive strength of concrete at 7 and 28 days showed the best value at the RHA5% composition. In contrast, the RHA composition of 2.5% and 7.5% by weight of cement produces low performance. The results of the concrete flexural strength test on PRCB showed that the proportion of 5% RHA was the best choice. Concrete treatment with Wet Hessian produces better mechanical properties than curing air. Comparison of the flexural strength of PRCB in the Wet Hessian treatment equivalent to PRCB immersed curing.*
Conclusion: *The results showed that green concrete could be applied as a base material for precast reinforced concrete beams. Using a percentage of 5% produces concrete properties that are relatively the same as normal concrete. Wet hessian is the best method for producing the precast reinforced green concrete beams*
Key Word*: Rice Husk Ash (RHA). Compressive strength, flexural strength*

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I. Introduction

The construction industry is growing rapidly due to the increasing number of choices of materials. The development of building materials as supporting construction materials is characterized by selecting precast concrete types [1]. Substantial material is an attractive choice because the forming material is easy to obtain and manufacture. Furthermore, the development of precast concrete materials has also developed in response to the ease of work in the field and the effectiveness of using a professional workforce. On the other hand, using precast concrete in the construction industry is also a choice for work effectiveness[2].

Various advantages of precast concrete are revealed in many papers. The developer can reduce the material budget because they do not have to provide formwork material as in situ concrete work. In addition, the developer chooses precast concrete for reasons of quality accuracy. The precision in size and quality is more guaranteed in concrete printed at the printing location and not in the construction work area[3]–[5].

The reason for choosing precast concrete is also to shorten the processing time. For concrete that is worked on construction sites, it takes a minimum of 28 days for the developer to reach the concrete with the planned strength. Meanwhile, precast concrete work allows developers to work on construction elements with the precast concrete material in a shorter time. Tayabji et al. (2013) outline four attributes that precast elements must meet: constructability, durability, load transfer at the joint, and the condition of the panel supports [6]. The ease of installation of a construction element depends on the technology and availability of equipment, as well as the ease of installation.

Furthermore, the durability of concrete is designed based on the fabrication process, namely its strength and durability. Transferring the load on the connection is achieved by an appropriate and economical working mechanism [7]. Furthermore, the condition of the panel support needs adequate supporting element strength. It has stability under the load received by the construction elements.

Reinforced concrete is widely used as a construction material for slab elements, walls, beams, columns, foundations, and others. Beams as construction elements that carry vertical loads experience a risk of collapse due to lower flexural abilities than external loads. Precast concrete beams are designed with proper characteristics to accept all external loads in the construction. Therefore, the accuracy of material quality is the best guarantee in using precast beams. On the other hand, the choice of concrete materials has also developed into the use of waste materials as part of implementing an environmentally friendly spirit in the construction industry. The development of Green concrete is characterized by the use of fly ash, construction waste, or agricultural waste [8]. In this article, researchers present green concrete using agricultural waste. Rice husk ash is a green concrete material because of its pozzolanic properties with silica and CaOH content. It produces strength similar to ordinary concrete [9], [10]. Rice husk ash has properties similar to fly ash because it contributes to the power of concrete due to the pozzolanic reaction at the start of mixing. This pozzolanic material can reduce the risk of cracking in concrete due to the response of the alkali – silica which forms a gel and absorbs the mixing water. In another study, rice husk ash also affected the shrinkage properties of concrete [11] . The fineness level of rice husk ash has an effect on drying shrinkage. If the fineness of rice husk ash is higher than portland cement, then the shrinkage that occurs is also greater than that of concrete without RHA. Therefore, there needs to be an effort to smooth the rice husk ash particles to the equivalent of cement.

This article presents an experimental study of the potential use of green concrete made from rice husk ash to manufacture reinforced concrete beams. The beam of choice is sloof beam as a material for making simple houses. The sloof element functions as a binder for columns and foundations so that subsidence in the soil will not cause a decrease in the columns and floors.The development of the precast model for reinforced concrete beams also adopts a work pattern that enables optimal compressive strength to be achieved. Several studies describe that the curing method greatly influences reinforced concrete's compressive and flexural strength. The curing process greatly affects the quality of the concrete. Treatment of concrete materials with certain temperature and humidity conditions results in an optimal cement hydration process [12]. Concrete quality can be predicted based on temperature and curing time. The treatment method is the determining factor for the optimum hydration level of the cement. The concrete material's maturity level is achieved following the cement material's increase in strength and hardening[6]. Wetting treatment of concrete attempts to prevent cracking due to drying and shrinkage [13]. The method used is wet burlap, spraying, and soaking in water. Another treatment is to use compounds that prevent water loss without applying an external moisture source.The concrete curing method generally uses the wet jute method or covers it with plastic sheeting [14]. But in practice, applying the immersion method to reinforced concrete beams is very difficult because it requires a work area equipped with a soaking tub. Therefore, this study describes the effect of immersion on precast reinforced concrete beam (PRCB) made from green concrete.

II. Material And Methods

The experimental method on PRCB was carried out by making a cylindrical sample with a height of 30 cm and a diameter of 15 cm to find the compressive strength of concrete. The flexural strength parameter of concrete uses reinforced concrete beam specimens with a size of 15 x 15 x 60 cm. Samples of reinforced beams using plain steel with a diameter of 8 mm and brackets with a diameter of 6 mm and a distance of 15 cm.

Study Location: Sampling was carried out at the location of the Griya Antang Harapan housing complex, Jalan Tamangapa, Gowa Regency. Sample testing was carried out at the Material Testing Laboratory of the Ujungpandang State Polytechnic.sampel dilaksanakan di lokasi perumahan Griya Antang Harapan, Jalan Tamangapa, Kabupaten Gowa. Pengujian sampel dilaksanakan di Laboratorium Pengujian Bahan Politeknik Negeri Ujungpandang.

Study Duration: Juli 2022 to November 2022.

Sample size and Treatment :

Preparation of samples for test specimens refers to SNI 03-2834-2000 concerning procedures for making normal concrete with a design concrete quality of 250 $kgcm^2$. Table 1 describes the characteristics of the concrete constituents.

Table 1. Characteristics of Concrete Composition Materials

Material	Characteristic
Sand	0.075 mm – 4.75 mm
Gravel	Maximum 20 mm
Portland Cement	Type I
Water	pH = 7
Rice Husk Ash (RHA)	Max 0.9 mm

The composition of normal concrete constituents with weight and volume composition for 1 m3 of normal concrete is presented in table 2. Furthermore, the composition of rice husk ash for the four types of treatmentis shown in table 3.

Table 2. Material Composition, Weight,and Volume for 1 $M^3$of Normal Concrete

Material	Composition by weight (Kg)	Composition by volume
Sand	973.55	2.212
Gravel	839.81	2.470
Portland Cement	379.63	1
Water	205	0.540

Table 3. Composition of Rice Husk Ash (RHA) by Cement Portland

RHA (%)	0	2.5	5	7.5
RHA Weight	0	9.491	18.982	28.472

The curing treatment of concrete within 28 days is divided into three forms: water immersion, wet hessian, and air curing. Water immersion is a method of immersing concrete samples on the condition that all sample bodies are submerged in water. The requirement for immersion water is a temperature between 20oC – 25oC and pH = 7. Wet hessian is done by wrapping the sample body with a wet sack. Guaranteed wetting is spraying water every four hours during the day at an air temperature of 28oC – 30oC. Meanwhile, air curing is placing concrete samples in an open space.Concrete compressive strength and flexural strength tests were carried out at 7 and 28 days of concrete with the number of samples presented in table 4.

Table 4. Number of Samples for Various Curing Methods

Sample	Compressive Strength		Flexural Strength	
	7 days	28 days	7 days	28 days
Cylinder (0% RHA)	10	10	3	3
Beam (0% RHA)	10	10	3	3
Cylinder (2.5% RHA)	10	10	3	3
Beam (2.5% RHA)	10	10	3	3
Cylinder (5% RHA)	10	10	3	3
Beam (5% RHA)	10	10	3	3
Cylinder (5% RHA)	10	10	3	3
Beam (5% RHA)	10	10	3	3

Analysis Method: Analysis of the compressive strength and flexural using equations 1 and 2.

$$f'c = P/A \text{…………………eq.1}$$

The fc' value is the sample's compressive strength in kg/cm2 units. The P value is the maximum load the Compressive Strength tool indicates when the test object is crushed. Furthermore, the value of A is the cross-sectional area in cm^2. The analysis of the flexural strength of the beam is calculated based on the maximum load, length, and cross-sectional dimensions of the beam. The formula calculates the calculation of the flexural strength of concrete:

$$Tb = \frac{3PL}{2bh^2} \text{………………………………..Eq.2}$$

III. Result

The compressive strength test results for seven-day concrete age with various curing methods are presented in figure 1. Furthermore, the same analysis for samples 28 days is shown in figure 2.

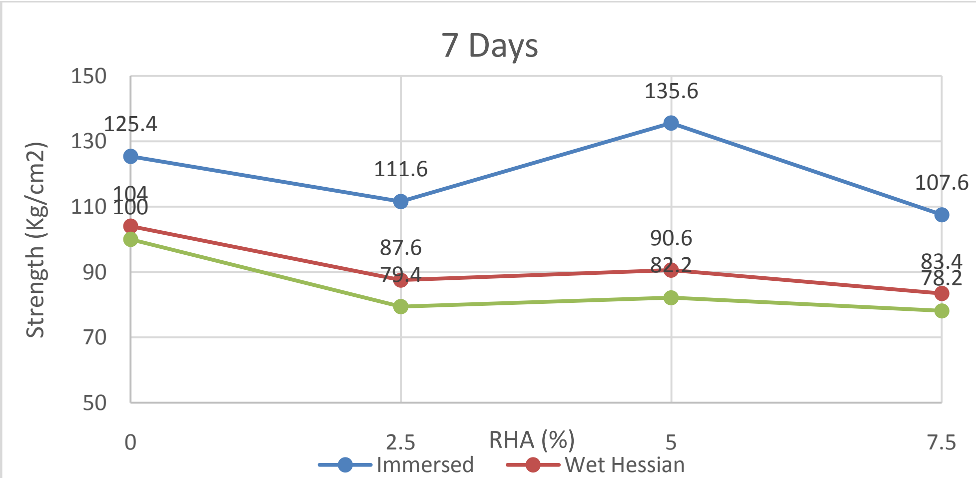

Figure 1. The Concrete Compressive Strength Test at age 7

Based on Figure 1, it can be seen that the results of the concrete compressive strength test at 7 days old using 3 treatment methods. The immersed method shows the highest results, while the lowest marks use the air curing method. Figure 2.

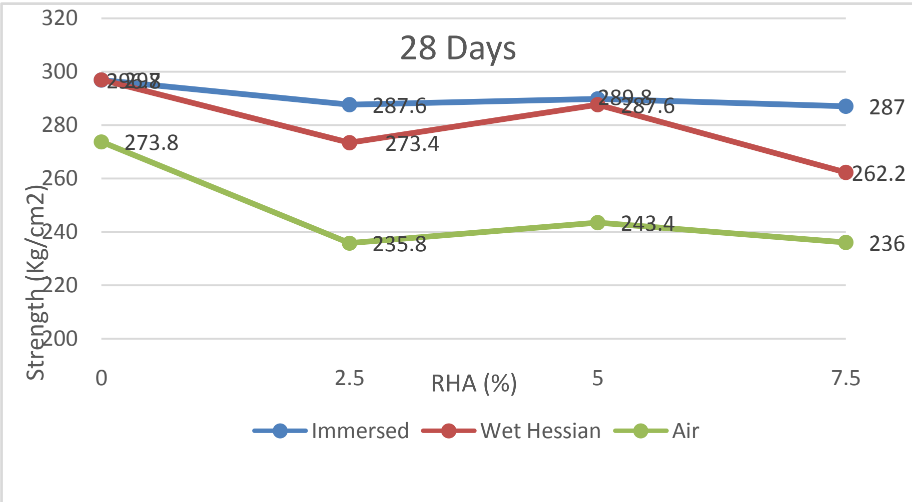

Figure 2. Results of Concrete Compressive Strength Test at 28 days of age

Based on figure 2, it can be seen that the results of the concrete compressive strength test at 28 days old using 3 treatment methods. The results of this compressive strength show the same results as the compressive strength at the age of 7 days. The immersed method offers the highest results, while the lowest results use the air curing method.

The results of the flexural strength test for seven days of concrete with various curing methods are presented in Figure 3.

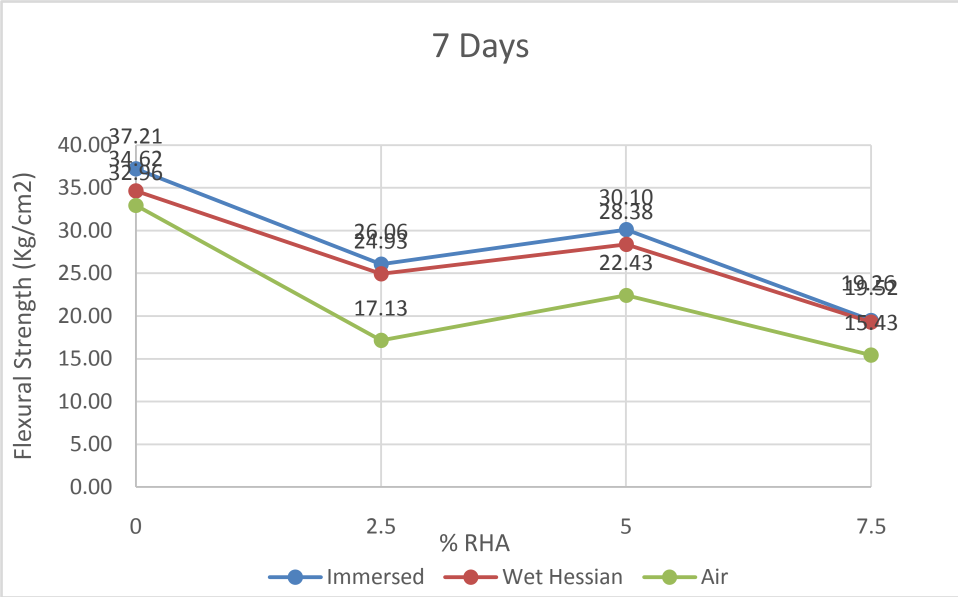

Figure 3. Flexural Strength Test Results of Concrete at the age of 7 days

Based on Figure 3, it can be seen that the results of the concrete flexural strength test at 7 days using 3 treatment methods. The immersed method shows the highest results, while the lowest results use the air method.The results of the flexural strength test for concrete aged 28 days with various curing methods are presented in figure 4

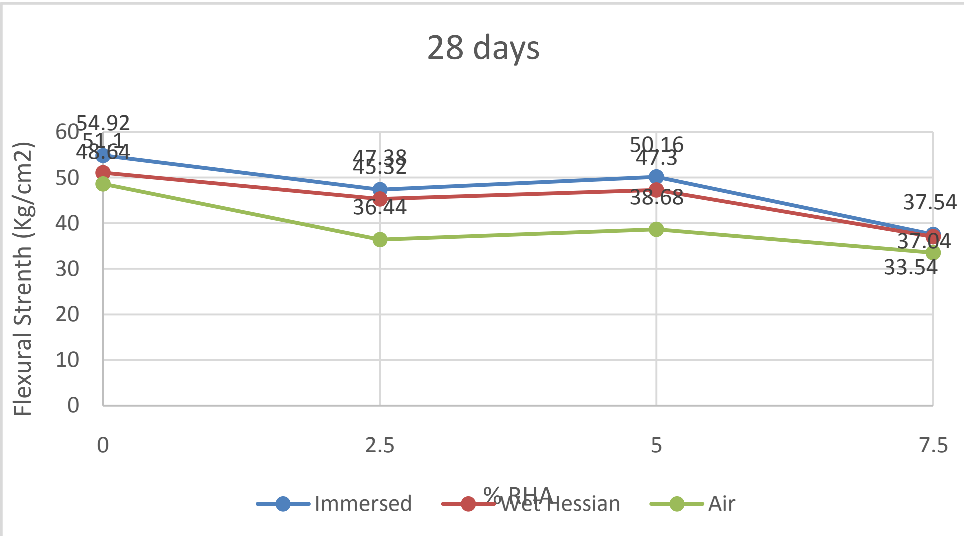

Figure 4. Flexural Strength Test Results of Concrete at 28 days of age

Figure 4 shows the results of the flexural strength test of concrete at 28 days old using 3 treatment methods. The flexural strength results show the same results as the flexural strength at 7 days old the immersed method leads the highest results while the lowest results are using the air curing method.

IV. Discussion

Results of concrete compressive strength test at the age of 7 days in the various curing method compared with the control group or the normal concrete

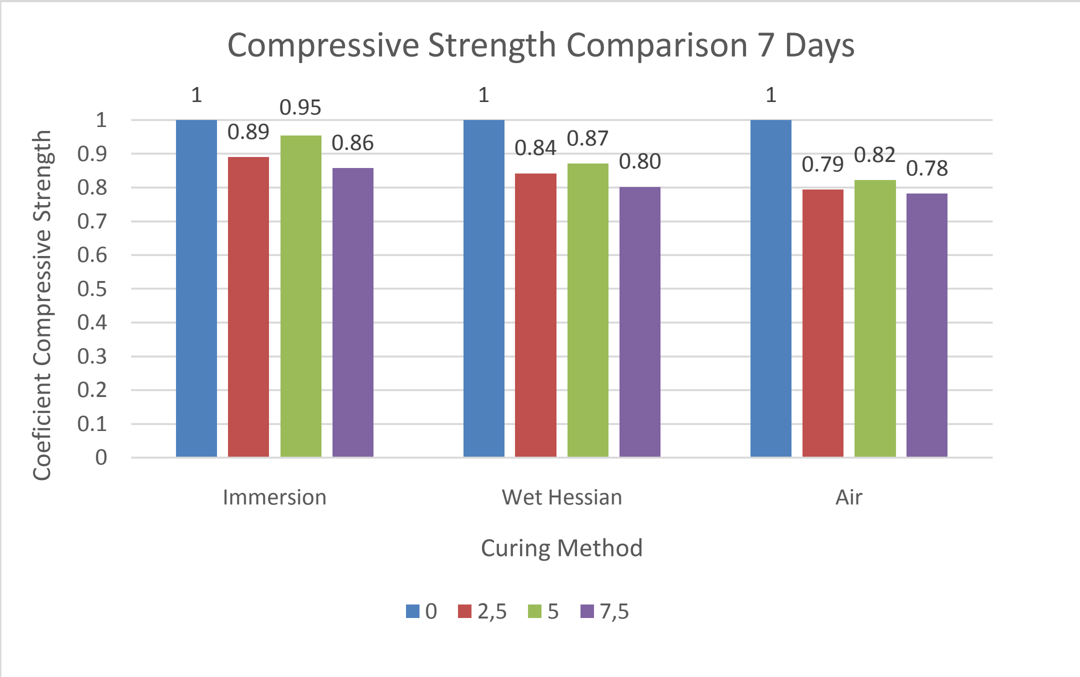

Fig 5 The comparison of the compressive strength of the test object to the control test object at the age of 7 days.

Figure 5 compares the compressive strength of the test specimen to the control specimen at 7 days of age in the three types of treatment. It can be seen that the test object using RHA cannot match the compressive strength of the control test object. The compressive strength of concrete in the wet hessian and water method only ranges from 0.79 to 0.87 times the compressive strength of concrete without RHA. However, the immersion treatment of concrete with 5% RHA can reach 0.95 times the strength of concrete without RHA.

Results of concrete compressive strength test at the age of 28 days in the various curing method compared with the control group or the normal concrete

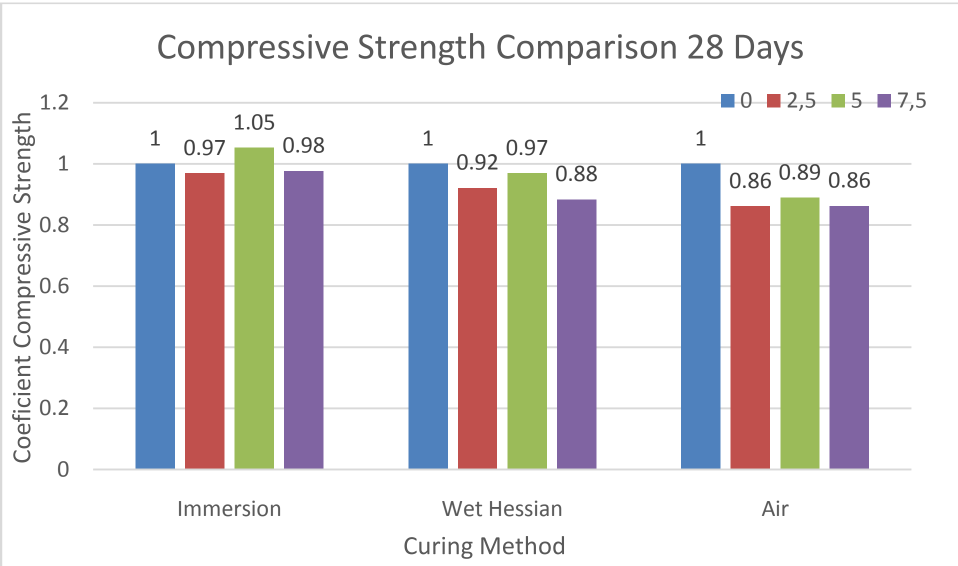

Fig 6 The comparison of the compressive strength of the test object to the control test object at the age of 28 Days

Figure 6 compares the compressive strength of the test specimen against the control specimen at 28 days of age for the three types of treatment. It can be seen that the test object using RHA can match the compressive strength of the control test object for each type of treatment. The compressive strength of the immersion and wet hessian methods ranged from 0.88 to 1.05 times the compressive strength of concrete without RHA. As for air treatment, it shows the lowest coefficient, which is below 0.9. A comparison of the results of the concrete flexural strength test on green concrete with normal concrete for the 7-day age test is presented in figure 7.

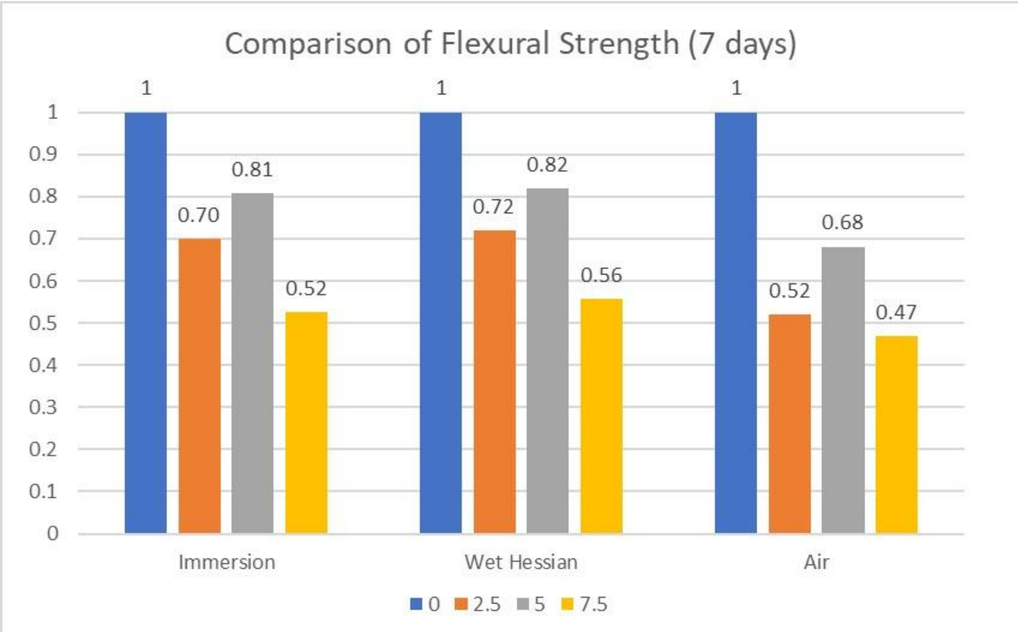

Figure 7. Comparison of the flexural strength of green concrete with normal concrete at the age of seven days

Figure 7 compares the flexural strength of the test specimen against the control specimen at 7 days of age in the three types of treatment. It can be seen that the flexural strength of the test object using RHA cannot match the compressive strength of the control test object. However, the flexural strength of the wet hessian method is almost the same as that of the immersion method. The coefficient values are relatively the same and range from 0.52 to 0.82. Thus, the wet hessian method can be used in the field as a substitute for the immersion method. In comparison, the water method shows the lowest coefficient, below 0.7. The results of the flexural strength test of concrete at the age of 28 days were carried out by comparing the properties of green concrete with normal concrete in various testing techniques

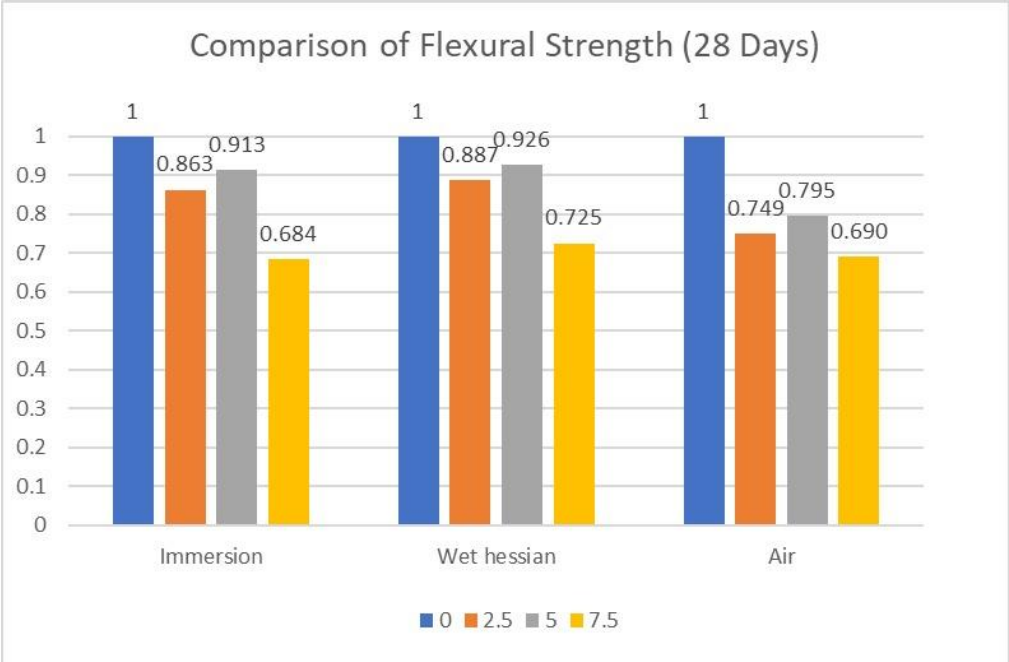

Figure 8. Comparison of the flexural strength of green concrete with normal concrete at the age of 28 days

Figure 8 compares the flexural strength of the test specimen against the control specimen at 28 days of age for the three types of treatment. The resulting coefficient is greater than the 7-day age coefficient. The coefficient of flexural strength on the specimens 2.5 RHA and 5% RHA ranged from 0.863 to 0.926 in the immersion and wet hessian treatments. The data shows that the two curing methods can produce a higher flexural strength than the air curing method.

Rice husk ash as a cement substitute can improve concrete's mechanical properties. The test results found that using 5% RHA is suitable for use as green concrete. The resulting compressive and flexural strength values were almost equivalent to normal concrete. Furthermore, the immersion method gives better concrete characteristics than other curing techniques. However, the immersion method requires an investment of space and other resources and will contribute to an increase in the selling price of the material.

Achieving good strength with the wet hessian method provides an opportunity to be applied due to the relatively good characteristics of the concrete produced. The pozzolanic properties of RHA are capable of absorbing water and causing a good potential for a hydraulic reaction. Some researchers have reported a reduction in bleeding in fresh concrete due to its affinity properties of microporosity of RHA [15], [16].

The production of precast concrete blocks made from green concrete is the right choice for making simple houses. Reducing work costs by applying precast concrete can be reduced by reducing the use of cement. On the other hand, green concrete that utilizes waste is an effort to save the environment. The increasing volume of agricultural waste causes soil pollution.

V. Conclusion

The use of green concrete as an innovation in the precast concrete industry allows it to be developed. Using RHA of 5% portland cement substitution produces good compressive and flexural strength. The precast concrete curing method using wet hessian also has properties equivalent to immersion curing. The development of precast by utilizing agricultural waste materials can be developed in various patterns considering the properties of the concrete produced.

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