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Pulverized Water Hyacinth as an Admixture for Concrete

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Abstract: This study sought to evaluate the setting time and strength property of concrete when pulverized water hyacinth serves as an admixture by weight. The materials used in this study included water hyacinth plants, cement, coarse and fine aggregates. Dried water hyacinth was pulverized and added to the concrete with two different percentages in each mixture. A standard mixture without water hyacinth was also created for comparison with the concrete cylinders with mixture that has pulverized water hyacinth. The first concrete cylinder contains 0.5% of pulverized water hyacinth by weight and the second concrete cylinder contains 1% of pulverized water hyacinth by weight. The curing was done for 28 days, and the properties of the concrete cylinders, namely setting time and strength, were recorded. It was revealed in the setting time test that the concrete with 0.5% pulverized water hyacinth may serve as accelerator for concrete while the concrete cylinder with 1% pulverized water hyacinth by weight can be a retarder. Moreover, the concrete cylinders with 0.5% pulverized water hyacinth and 1% pulverized water hyacinth have a 2.39% and 3.83% increase in compressive strength, respectively compared to the concrete cylinder without pulverized water hyacinth.

Keywords: Concrete, accelerator, retarder, compressive strength, water hyacinth

1. Introduction

Today, concrete mixes contain supplementary materials called admixtures that help in the pouring process and improve concrete quality. Concrete admixtures are added ingredients of concrete that are immediately added before or during mixing. It is used to improve concrete properties that include acceleration or retardation of setting time, compressive strength, and many others [1]. Generally, there are two types of admixtures; chemical admixtures and mineral admixtures [2]. Chemical admixtures are added to change or control the reactivity of concretes. It could serve as a retarder that is used in hot weather to reduce the setting time of the concrete, or it could serve as an accelerator that is used in cold weather to increase the setting time of concrete [3]-[5]. Superplasticizer is also a kind of chemical admixture used to reduce the water requirement in fresh concrete. Mineral admixtures, on the other hand, are added to the concrete to act as an additional binder to increase its strength. The mineral admixtures act as partial replacement of cement, which is pozzolanic like silica fume, fly-ash, and rice husk ash [6]. Admixtures that are made of inorganic products are available in the market, but researchers today are testing the used of abundant organic products to reduce cost and reduce pollution.

The water hyacinth is abundant in tropical and subtropical countries. It is an invasive plant [7] that is known to be the most troublesome in the world because it causes ecological and socioeconomic problems that affect people's

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ecosystem and livelihood [8]. While the world continues to witness its negative environmental impact, researchers continue to explore its economic values. For example, it has been used as livestock feed [9] and as material in making furniture, paper, bags, and ropes [10]. Some researchers also used it as an admixture in concrete, and it shows promising results in improving the quality of concrete.

Previous studies used water hyacinth extract [11] as a superplasticizer to reduce the water requirement in fresh concrete, while other studies used water hyacinth ash [12]-[14] as a pozzolanic material to increase the strength of the concrete. However, the use of water hyacinth in these studies is focused only on affecting one property, and its preparation is costly, which involves the use of machines.

This study will investigate the effectiveness of water hyacinth in affecting more than one property of concrete, particularly the acceleration or retardation of setting time and compressive strength. The water hyacinth will be prepared using natural ways that include drying and pulverizing. Experiments were done to compare the setting time and compressive strength of concrete cylinders wherein two of the cylinders have an additional pulverized water hyacinth. The other cylinder is a standard concrete, which will serve as the control cylinder.

2. Materials and Methods

2.1 Water Hyacinth

The researchers harvested the water hyacinth in the Pinacanauan River in Tuguegarao City, Philippines. It was cleaned up to get rid of the mud and other impurities. The water hyacinth was then dried and cut into pieces of about 10 mm. It was pulverized manually using pestle and mortar. A sample of pulverized water hyacinth is shown in Fig. 1.

Fig. 1 - Pulverized Water Hyacinth

2.2 Concrete Cylinder Mixtures

The materials used in the production of the concrete are shown in Table 1 with their specific amount. The mixing ratio for the concrete cylinder mixture is 1:2:4. This is an M15 grade of concrete that typically has a maximum compressive strength of 14 MPa for 28 days of curing [15]. The amount of pulverized water hyacinth was based on weight and computed for the appropriate percentage used. A slump test was conducted to assess the fresh concrete's consistency and check if the correct amount of water has been added to the mix.

2.3 Constructing of Concrete Cylinders

After mixing the materials, the concrete cylinder mixtures are constructed. The cylinder moulds used have a dimension of 12 inches in length by 6 inches in diameter and are made up of steel for it does not react with concrete containing Portland cement or other hydraulic cement. The concrete mixtures were placed in separate cylinder moulds. In each mould, there are three layers of approximately equal volume, which are compacted with 25 strokes as specified by ASTM standards [16]. Uniform distribution on the strokes was done over the cross-section of the mould for each upper layer. By doing this, air will be removed from the fresh concrete.

After 24 hours of casting, the concrete cylinders were removed from the moulds. They were placed immediately in water to prevent moisture loss. The curing period for the concrete cylinders is 28 days to reach its maximum compressive strength. The concrete cylinders are shown in Fig. 2.

Table 1 - Mixtures of the concrete cylinders

Mixture	Cement (kg)	Fine Aggregates (kg)	Coarse Aggregates (kg)	Water Hyacinth (kg)
Standard Concrete	6.6	10.6	15.8	0
Concrete with 0.5% Pulverized Water Hyacinth	6.6	10.6	15.8	0.04
Concrete with 1% Pulverized Water Hyacinth	6.6	10.6	15.8	0.07

Fig. 2 - Concrete cylinders of the different mixtures

2.4 Testing of Concrete Cylinders

After 28 days of curing, the three concrete cylinders were tested using Universal Testing Machine to determine their compressive strength and pulverized water hyacinth effectiveness as an admixture. For the setting time test, the three mixtures of cement paste (0%, 0.5%, and 1%) were cured with a temperature of 20^0 C, and each was tested using the Vicat Apparatus.

Vicat Apparatus shown in Fig. 3 is a device for determining the cement paste's normal consistency and time setting [17], [18]. It consists of a rod weighing 300 grams, having a plunger for normal consistency, and a needle in its end for time setting. It is supported by a frame with a graduated scale to measure the distance to which the plunger or needle penetrates the cement.

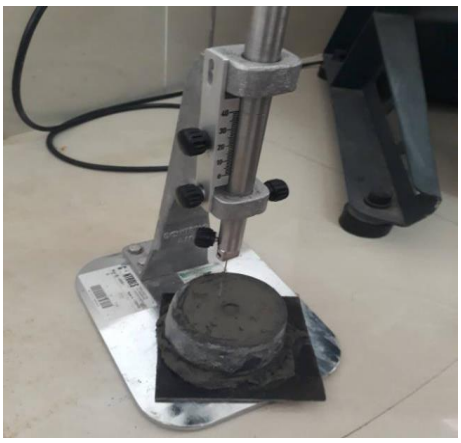

Fig. 3 - Setting time test

A consistency test was done before starting the test procedure to find out the necessary water that will make the paste normal in terms of consistency, and it took 650g of cement for the first mixture, 646.75g of cement, and 3.25g of pulverized water hyacinth for the second mixture, 643.5g of cement and 6.5g of pulverized water hyacinth for the third

mixture. After the consistency test, neat cement paste was then prepared. Gauge time was kept for three to five minutes. The Vicat Apparatus mould was filled with a block of cement when sitting on a glass plate with a gauged cement paste. This cement block was leveled with the top of the Vicat Apparatus mould. The cement block prepared is called the test block.

Universal Testing Machine is an instrument designed to exert a tensile, compressive, or transverse stress on a concrete cylinder under test [19][20]. After 28 days of curing, the three concrete cylinders with and without pulverized water hyacinth admixture were tested using Universal Testing Machine to determine their compressive strength. The testing of the concrete cylinders using the Universal Testing Machine is shown in Fig. 4.

Fig. 4 - Compressive strength test

3. Results and Discussion

The first property of concrete that was tested was its setting time. Table 2 shows the setting time of each of the concrete cylinders wherein 10 millimeters penetration was used. The concrete cylinder with 0.5% of pulverized water hyacinth increased the setting time of the concrete compared with the standard concrete cylinder. This means that it can be used as an accelerator. It follows the same finding with the concrete cylinders with water hyacinth ash [21], wherein it was observed that water hyacinth reduces the water absorption characteristic of concrete, resulting in an increase in setting time.

On the other hand, the mixture with 1% of pulverized water hyacinth decreased concrete setting time. This means that it can be used as a retarder. This result ties nicely with a previous study that uses water hyacinth extract [11] wherein the admixture's inclusion retards the hydration rate and hardening process of the concrete, making it flow longer; thus, high flowability and filling ability was achieved.

The study results imply that the addition of pulverized water hyacinth in a concrete mixture can either serve as a retarder or an accelerator dependent on the amount of water hyacinth to be added. It should be noted that only two samples of concrete mixtures with pulverized water hyacinth were tested. Therefore, it is yet to be known if more than 1% of pulverized water hyacinth can all be used as a retarder or less than 0.5% can all be used as an accelerator.

Table 2 - Setting time of the concrete mixtures

Mixture	Required Time (minutes)	
	Initial Setting	Final Setting
Standard Concrete	187.2	255.0
Concrete with 0.5% Pulverized Water Hyacinth	172.2	270.0
Concrete with 1% Pulverized Water Hyacinth	72.0	165.0

The second property of concrete that was tested was its compressive strength. Table 3 presents the impact of the pulverized water hyacinth percentage on the compressive strength of the concrete made with the same ratio of gravel

and sand. The increase in compressive strength was observed at the concrete cylinder with 0.5% and 1% of water hyacinth by weight. The concrete cylinder with 0.5% of water hyacinth by weight has a 2.39% increase in compressive strength compared to the standard concrete cylinder. However, an even better result was achieved with the concrete cylinder with 1% of water hyacinth by weight which has a 3.83% increase of compressive strength compared to the standard concrete cylinder. These results show that the pulverized water hyacinth performs well in terms of compressive strength when added to concrete. The increase of compressive strength compared with the standard mixture was also evident in the previous studies using water hyacinth ash [12]-[14] and water hyacinth fibers [22].

Table 3 - Compressive strength of the concrete cylinders

Mixture	Mixture Destroy Load (N)	Compressive Strength (MPa)
Standard Concrete	382.113	20.9
Concrete with 0.5% Pulverized Water Hyacinth	389.878	21.4
Concrete with 1% Pulverized Water Hyacinth	395.372	21.7

4. Conclusion

The study concludes that pulverized water hyacinth as an admixture can serve two functions. It can affect the setting time property of the concrete based on the amount that will be added. It can also affect the strength property of the concrete, and regardless of the amount that is added, the compressive strength increases. The possible usage of pulverized water hyacinth as an admixture to provide better cement quality is highly recommended. However, future studies should explore other percentages of pulverized water hyacinth as it reaches the yielding point to identify the optimal amount to be added in a concrete mixture. Moreover, at least three cylinders per mixture should be tested to get the average result.

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