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Experimental Behaviour of Water Hyacinth Ash as the Partial Replacement of Cement In Concrete

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ABSTRACT

Concrete is probably the most extensively used construction material in the world. The main ingredient in the conventional concrete is Portland cement. The amount of cement production emits approximately equal amount of carbon dioxide into the atmosphere. Cement production is consuming significant amount of natural resources. That has bought pressure to reduce cement consumption by the use of supplementary materials. Water hyacinth (Eichhornia crassipes), an entirely free source of biomass is found unutilized as supplementary cementitious material until now. It grows vigorously and richly to produce a large biomass and doubles the population in two weeks. In this work, studies have been carried out to evaluate this bio-waste for the first time as cementitious material and this will be beneficial for future application of Water hyacinth ash in cement concrete. The study focuses on the workability, compression strength and split tensile strength performance of the blended concrete containing different percentage of water hyacinth ash as a partial replacement of cement. The cement in concrete is replaced accordingly with the percentage of 10% and 20% by weight. Concrete cubes are testing at the age of 7 days of curing. Finally, the workability and strength performance of ash blended concrete is compared with conventional concrete. From the experimental investigation, it has been observed that, the optimum replacement of Water hyacinth ash to cement is 10% for M30 grade concrete.

Keywords : Water Hyacinth, Cement, Concrete, Setting time and Compressive Strength.

I. INTRODUCTION

Concrete is a commonly used construction material made by combining mainly cement, water and aggregates. In this cement is costly. The production of concrete has always lead to massive exploitation of natural resources. Manufacturing 1 tonne of Portland cement requires quarrying 1.5 tonnes of limestone and clay (civil and marine, 2007). Moreover, continuous extraction of natural aggregate; sand and gravel; from river beds, lake and other water bodies over the years have led to erosion which eventually leads to flooding and landslides. Further, there is less filtration of rain water due to reduced amount of natural sand, causing contamination of water needed for human consumption. 1.4 tonnes of Ordinary Portland cement being produced yearly around the globe contributes to 5 percentage of greenhouse gas, carbon dioxide, emission worldwide (civil and marine, 2007). Not only burning fuel to heat the kiln emits carbon dioxide, but also decomposition of limestone emits even more gas. These identified problems clearly, contribute significantly to climate change. The ideal target to partly solve the above phenomenon is to develop a sustainable system loop which can turn resources which are landfilled as waste material into useful products in the construction industry, thus preserving the natural resources. Concrete is a tension-week building material, which is often crack ridden connected to plastic and hardened states, drying shrinkage and the like. The cracks generally develop with time and stress to penetrate the concrete, thereby impairing the water proofing properties and exposing the interior of the concrete to the destructive substances containing moisture, bromine, acid sulphate, etc.

So partial or full replacement of cement in concrete with another suitable material will provide a means of reducing the cost of construction materials. Over the last few decades, replacement is done by locally available raw materials such as industrial, agricultural or domestic waste such as fly ash, blast furnace slag, silica fume, rice husk, oil palm shell, coconut shell, corn cob, tobacco waste, bamboo leaf, sugarcane baggage, groundnut shell, egg shell. The search for a new and viable alternative is important for conservation of natural resources and reduction in the manufacturing cost. Plant extracts contain a wide range of organic components. Extracts of plant based materials have been used as admixtures in altering the various properties of cement and many researches in this focal point have been constantly undertaken. Many research activities are undertaken elsewhere on possible ways of improving the quality of concrete. On one hand, bio-concrete accelerating admixture is developed as an alternative to calcium chloride component in cement. On the other hand, research on bio-based retarding admixture of concrete for tropical environments is underway.

Water hyacinth (Eichhornia crassipes), an entirely free source of biomass is found unutilized as supplementary cementitious material. It grows vigorously and richly to produce a large biomass and doubles the population in two weeks. The plant consists of long and fibrous roots which may be up to three meters in length and has fibrous stem. The average length of the fiber is 1.604 mm and the average diameter 5.5 micron. In this work, studies have been carried out to evaluate this bio-waste for the first time as supplementary cementitious material.

Figure 1. Water Hyacinth plant

II. MATERIALS and Methods

Ordinary Portland cement was adopted in this work. The cement used is 53 grade.

The aggregate used in this project mainly of basalt rock which comes under normal weight category. The aggregate are locally available. The nominal size of coarse aggregate used is 20mm. The coarse aggregate was also tested for various properties like specific gravity, fineness modulus, crushing strength, water absorption to check their suitability for the experiment. Natural sand which is easily available and low in prise was used in the work. It has cubical or rounded shape with smooth surface texture. Being cubical rounded and smooth texture it gives good workability. Particles of this sand have smooth texture. Sieve analysis was done to find out fineness modulus and specific gravity for sand as per IS 383.

Colourless, odourless and tasteless fresh potable water, free from any type of organic matter was used. Water Hyacinth were collected from waste water stagnant pool located at Coimbatore, Tamilnadu. The plant collected were throughly washed in clean running water to get rid of muddy debris and impurities. Then the sample were uniformly cut into 2 inch pieces using table knife and air dried for two weeks. The sample was then kept in oven under 200^0C for 6 hours in order to remove organig matter and for complete oxidation. Then the sample is pulverized using a milling machine. Those passing through a 150 micron sieve were used to prepare test concrete specimens.

Figure 2. Water Hyacinth final product

Some common test like Specific gravity, Fineness and Water absorption test is carried out for cement, Fine aggregate, coarse aggregate and Water Hyacinth ash and the result are presented in Table 1.

Consistency for the cement sample without Water Hyacinth was found out using Vicat apparatus and the value was founded out and also for different replacement. Again, the setting time for various replacement percentage of admixtures viz., 0, 10 and 20% was checked and the results are presented in Fig. 3.

For preparing conctete specimen batching of materials was done by weight. A design mix proportion of 1:1.68:2.85 (Cement:Sand:Coarse aggregate) with water/cement ratio of 0.45 value obtaineed from IS 10262 was used as control. All other mixes were batched with 10% and 20% by weight of water hyacinth to replace cement. For each mix, slump test was performed on fresh concrete. Test specimens of concrete cubes were cast in 150mm x 150mm x 150mm for compression strength and concrete cylinders were cast in 150 mm diameter with 300 mm height for split tensile strength. The specimen were removed from the mould after adequate setting is allowed for 24 hours and they were cured. Compression and Split tensile strength of samples of a mix at different curing age of 7,14 and 28 days were carried out. Compression testing machine is used for testing the specimens. With the help of these result reinforced column is casted for optimum percentage replacement of size 100mm x 100mm x 600mm with 4 numbers of 12 mm dia rods and 8 mm dia ties at 100 mm center to center spacing. Testing is carried out at curing age of 28 days in universal testing machine.

$$\text{Compressive strength} = \frac{\text{Load in N}}{\text{Area in Sq.mm}}$$

$$\text{Split tensile strength (T)} = \frac{2P}{\pi LD}$$

Where P = Load in N

L = Height of cylinder in mm

D = Diameter of cylinder in mm.

III. RESULT AND DISCUSSION

The Specific gravity test is carried out with the help of pycnometer as per IS 2386 and fineness test is carried out with the help of Indian Standard Sieves. Results are given below

TABLE 1 : Test report of materials

	Cement	**Fine Aggregate**	**Coarse Aggregate**	**Water Hyacinth**
Specific gravity	3.15	2.74	2.74	2.12
Fineness	less than 150 microns	Zone II	20 mm	less than 150 microns
Water absorption	-	1%	0.50%	-

The graph of water consistency in Figure 3 indicates that the water required for normal consistency increased with the increase of cement replacement level and it is because of the high hygroscopicity nature of water hyacinth stem ash.

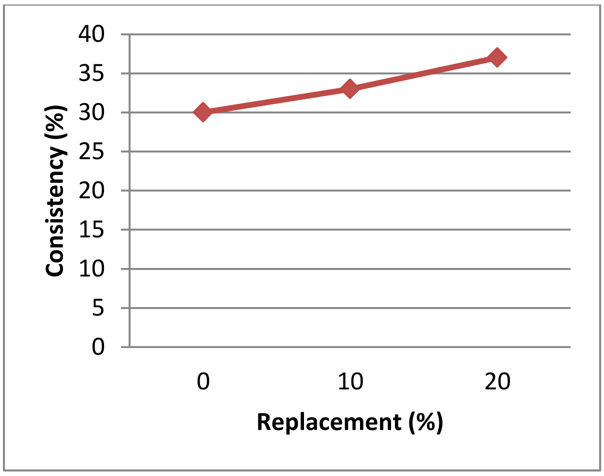

Figure 3. Consistency for different replacement of water hyacinth

From the chart of setting time in Figure 4, it is observed that with the addition of Water Hyacinth, the setting time is retarded and this is due to the absorption of water at the surface of Water Hyacinth. With the increase in the proportion of Water Hyacinth, the absorption of water is also increased and hence the higher amount of water has delayed the setting time. However, the setting time values are found to be well within the permissible limits as per IS: 8112-1989 [13].

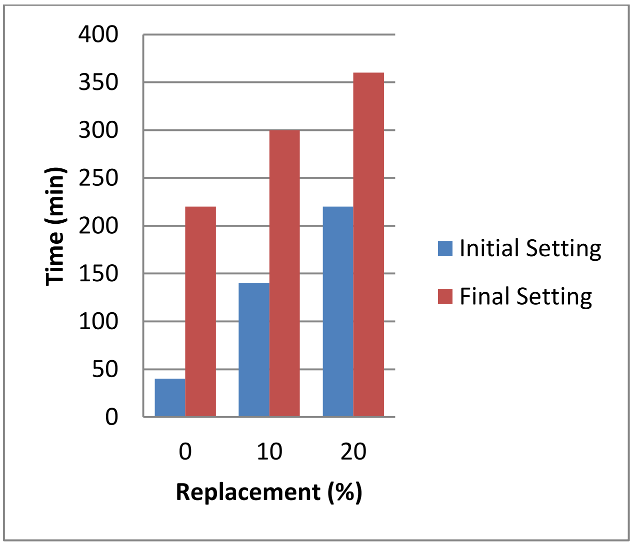

Figure 4. Setting time for different replacement of water hyacinth

The slump test result is shown in Table 2. The 0% Water Hyacinth ash concrete was found to have a slump of 45 mm, 10% Water Hyacinth ash concrete gave 95 mm slump 20% Water Hyacinth ash concrete gave 130 mm slump. The results show that all slumps were within the medium and high degree of workability and it tends to improve with a higher percentage of water Hyacinth ash in concrete.

TABLE 2 : Slump Characteristics of Water Hyacinth Ash

Percentage of Water Hyacinth ash	Slump (mm)
0	45
10	95
20	130

Figure 5 shows variation in compression strengths for control and Water Hyacinth blended concrete cubes with different ages. It can be seen that strength increased with the curing age for all the samples. Control concrete gained 76% at day 7 and 88% after 14 days, 99% after 28 days of curing. The Water hyacinth blended concrete gained 50-66% at day7, 65-70% after 14 days, and 72-82% after 28 days of curing. It is clear from the observation that strength enhancement is lower than the cement concrete between 7 and 28 days. However the 10% replacement of WHA to OPC can be considered as optimal limit.

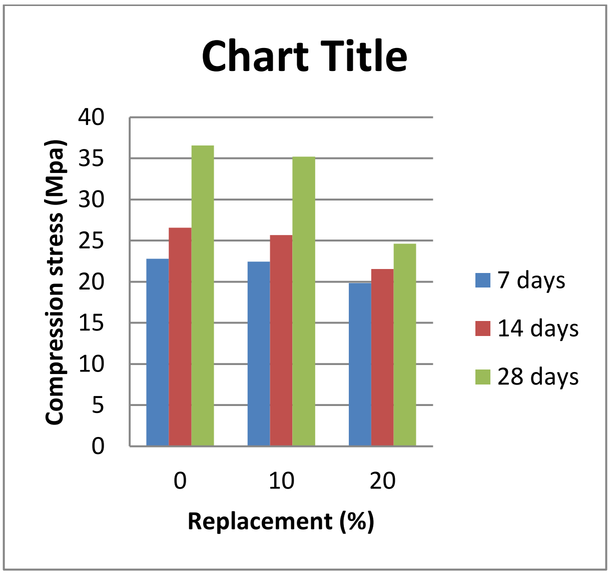

Figure 5. Compression Stress for different replacement of water hyacinth

Figure 6 shows variation in Split tensile strengths for control and Water Hyacinth blended concrete cubes with different ages. It can be seen that strength increased with the curing age for all the samples.

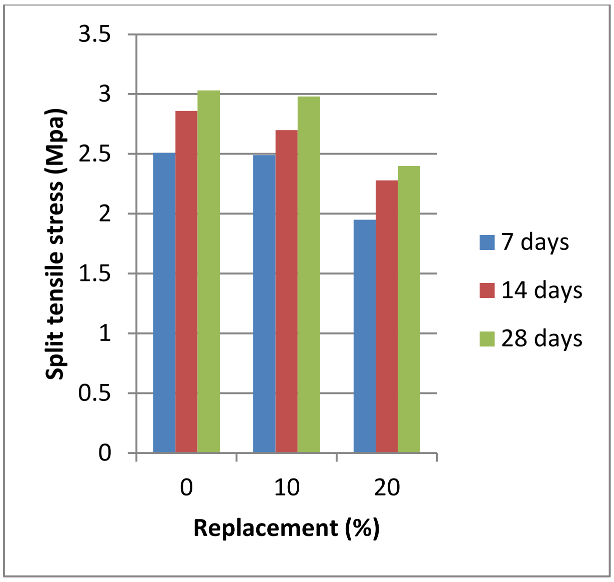

Figure 6. Split tensile Stress for different replacement of water hyacinth

Figure 7 and Table 3 shows variation in load and buckling for control and Water Hyacinth blended reinforced column at curing age of 28 days. It can be seen that load capacity increases with decrease in buckling.

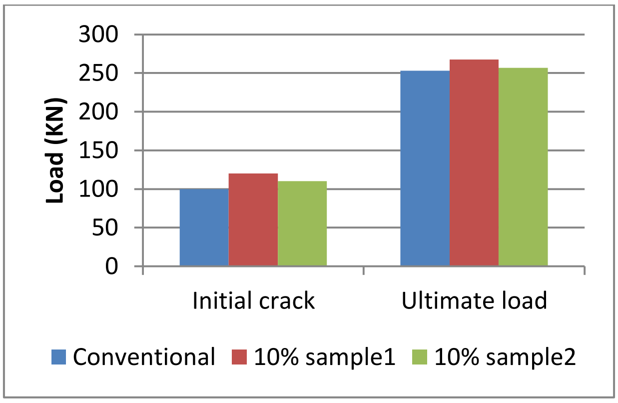

Figure 7. Loads at initial crack and failure

TABLE 3 : Load and Buckling result

Sl.no	Description	Load (KN)	Deflection (mm)	Remarks
1	Conventional	100	4.09	Initial crack
		253	6.58	Ultimate load
2	10% replacement sample 1	120	3.14	Initial crack
		267.6	5.45	Ultimate load
3	10% replacement sample 2	110	2.79	Initial crack
		256.68	5.21	Ultimate load

IV. CONCLUSION

This study was carried to obtain the results, tests conducted on the water hyacinth ash modified cement concrete mix, in order to ascertain the influences of water hyacinth ash on the characteristic strength of concrete.

- The optimum dosage for partial replacement of cement by water hyacinth ash is 10%.
- The compressive strength and tensile strength of concrete decreases at the dosage of 20% replacement of cement by water hyacinth ash.
- The initial and final setting time of water hyacinth ash added cement paste is increasing by addition of water hyacinth ash.
- The workability of concrete increasing with respect to the Water Hyacinth ash replacement.
- Replacement of water Hyacinth ash in the concrete mix significantly influenced the cracking behavior and ultimate strength of column.

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