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Performance Evaluation of Water Hyacinth Fiber Reinforced Self-Compacting Concrete using varied Rice Husk Ash as Admixture

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Abstract: **Self-compacting concrete (SCC) was first developed in Japan in 1988. The use of this mixture in general concrete construction practice was introduced to achieve durable structures independent of the quality construction work. Since this kind of mixture uses different kind of admixtures, it is not cheap. Low-cost materials are therefore used to make this mixture economical. Water Hyacinth, a problematic plant, can be utilized and have good promises for a growing economy. Its fiber (WHF) has been used in concrete to improve the concrete‟s physical and bending load properties. Rice hull ash (RHA) has been used to replace cement in concrete mixtures. The performance of compressive and flexural strength and Durability revealed that the addition of RHA has significant influences over the concrete's strength. The objective of this research is to evaluate the performance of SCC using varied RHA as admixture of 0.4% WHF.
This paper presents a study on the performance evaluation of slump flow, passing ability, and the compressive and flexural strength and Durabity up to 56 days of SCC and standard concretes with 0.4% volume fraction WHF and RHA. Three different replacement percentages of cement with varied volume fractions were used for both SCC and normal specimen. Results were compared to standard mixtures, concluded that WHF-RHA provides positive result on the mechanical properties at 28 days. Based on the result, mixture with 0.4% WHF and 10% RHA have higher value than standard concrete in flexural test, while mixture with 0.4% WHF and 10% RHA has close range in compressive test.**

Key words: **Self-compacting concrete (SCC), Water Hyacinth, Rice hull ash (RHA), compressive, flexural strength and Durability**

1. INTRODUCTION

In the construction industry, concrete is the most commonly used material. The components of a concrete are cement, fine aggregates such as sand, coarse aggregates such as stone, and water. It is usually the cheapest and most readily available material on the job (Mehta & Monteiro, 2014). Hajime Okamura, a professor in Tokyo, Japan, proposed the concept of self-compacting concrete (SCC). The SCC fills formworks perfectly by flowing under the effect of its own weight, and wraps around all the reinforcing bars without causing blockage. Reduction in manpower and placing delay are some of the advantages of SCC. Health effects of concrete construction such as sound disappear because vibration is not used when setting the SCC. This is why SCC tends to increase on a large scale (Loukili, 2011).

By using modern acrylic-based superplasticizers, mineral admixtures, and advanced viscosity-modifying agents (VMA), Fiber-Reinforced Self-Compacting According to Mehta & Monteiro (2014), Concrete has been developed. SCC is very efficient in accommodating the addition of fibers, because of its high workability. Fiber- reinforced self-compacting concrete performs better under shear loading than any conventional fiber-reinforced concrete. Admixtures are industrial waste. It is added in small quantities during concrete mixing. According to Goncalves & Margarido (2015) admixtures are not cheap products, but it can lead to some savings by increasing the toughness of concrete, less cement is used, and workforce needed is also reduced. Agriculture is a well-known cause of water, land and air pollution. The agricultural wastes cause problems to the country and its people. Rice hull, rice straw coconut husk, coconut shell and bagasse are the most common waste. These wastes can be converted to provide renewable energy and productive uses (Villanueva, R., *Philstar*, 19 February 2015).

1.1. Scope of the projects

The study mainly focused on conducting tests to evaluate the mechanical properties of water hyacinth fiber-reinforced concrete with volume fractions of 10%, 20%, and 30% as replacement for cement. The Analysis of Variance (ANOVA) was used in this study to compare the relationship of the concrete mixture having 0.4% water hyacinth fibers and 0% rice hull ash to the concrete mixtures with 0.4% water hyacinth fibers and varying percentages of rice hull ash. Cost analysis was neglected in the study since this was experimentation purpose only.

2. METHODOLOGY AND PROPERTIES MATERIALS

Data gathering and several experiments were conducted to evaluate the performance of 0.4% Water Hyacinth Fiber reinforced self-compacting concrete using 10%, 20% and 30% Rice Hull Ash as admixture to assess the flowability of Self-Compacting Concrete using Slump Test, to determine the passing ability and filling ability using L-box and V-funnel Test. Tests conducted to determine the compressive and flexural strength. A statistical method called Analysis of Variance (ANOVA) was used to determine the significant change in each strength test. All of which were compared to the controlled sampled.

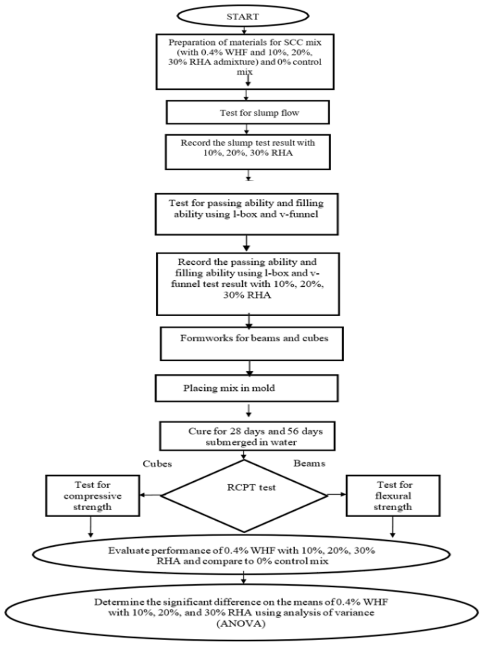

Fig 1. Methodology

2.1 Materials and equipment

Water hyacinth fibers and rice hull ash are the main materials that were used in this experiment which were purchased from Taguig City, Metro Manila, Philippines and from Los Baños, Laguna, Philippines, respectively. Sodium hydroxide (NaOH) was also used for the treatment of the water hyacinth fiber

Portland cement (Type I), gravel, and sand were purchased at a local hardware. These materials were then mixed with water along with the water hyacinth fibers and the rice hull ash to form the concrete mixture.

The equipment used in the experiment for the preparation of the concrete specimens were mixing pans, weighing scale for determining the weight of materials, shovel for collection and mixing of large quantities of sand, gravel and concrete mix, slump cone, ruler, tampering rod for slump test, and molds used for the concrete samples.

Materials for the molds such as plywood, nails, PVC pipes, and metal wires were all purchased from a local hardware. A Universal Testing Machine (UTM) was used to determine the maximum load and breaking load for the computation of compressive and flexural strength, respectively.

2.2 Concrete mix design

The concrete mix used in this experiment is patterned according to specifications. An IS standard mold for concrete cylinders and rectangular concrete were used in pouring the concrete mix. In preparing the concrete mix, a shovel was used to facilitate the mixing of sand, gravel, cement and water. The quantity of cement, sand, gravel, WHF and RHA that has been used can be seen in Table 1.

Table 1: Quantity of cement, sand, gravel, water, WHF and RHA

Mix	Cement (kg)	Sand (L)	Gravel (L)	Water (L)	WHF (kg)	RHA (kg)
SCC w/ 0% RHA	27	25	20	8	0.44	0
SCC w/ 10% RHA	24.3	25	20	8	0.44	2.7
SCC w/ 20% RHA	21.6	25	20	8	0.44	5.4
SCC w/ 30% RHA	18.9	25	20	8	0.44	8.1

3. RESULTS AND DISCUSSIONS

3.1 Preliminary tests results

Tests methods such as L-Box test, V-Funnel test and Slump-flow by Abrams cone were performed to four different concrete mixtures having 0%, 10%, 20%, and 30% volume fraction of RHA with 0.4% WHF each to characterize the mixture as a Self- Compacting concrete. According to the results shown in Table 2, the researchers discovered that all of the mixtures are not to be classified as Self-Compacting concrete due to the fact that it did not satisfy all of the requirements stated by EFNARC.

Table 2: Preliminary test results of mixtures with varying RHA and 0.4% WHF

Mix	L-Box Test	V-Funnel Test (sec)	Slump Flow Test/Abrams Cone (mm)
SCC w/ 0% RHA	0.134	7	810
SCC w/ 10% RHA	0.107	7	565
SCC w/ 20% RHA	0.091	60+	550
SCC w/ 30% RHA	0.055	60+	495

3.2 Compressive strength

A total of 12 samples were brought to the testing site after 28 days and another 10 samples after 56 days of curing. These samples were tested using the UTM. The compressive strengths of the concrete samples containing water hyacinth fibers and varied rice hull ashes are shown in Tables 3 and 4.

Table 3: Compressive strength test results for 28 days curing

Sample No.	% RHA, 0.4% WHF (MPa)	10% RHA, 0.4% WHF (MPa)	20% RHA, 0.4% WHF (MPa)	30% RHA, 0.4% WHF (MPa)
1	35.50	34.40	32.60	33.90
2	35.20	33.80	32.90	33.00
3	34.90	33.70	33.00	34.10
Average	**35.20**	**33.97**	**32.83**	**33.67**

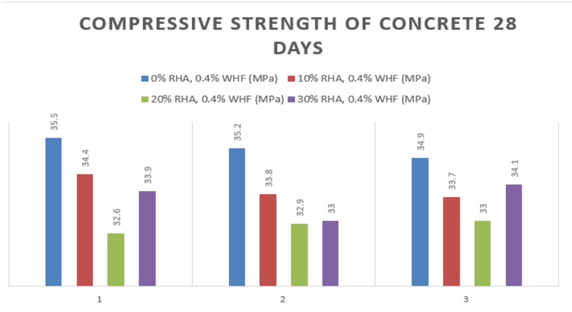

Figure 1: compressive strength of concrete

Table 4: Compressive strength test results for 56 days curing

ample	0% RHA, 0.4% WHF (MPa)	10% RHA, 0.4% WHF (MPa)	20% RHA, 0.4% WHF (MPa)	30% RHA, 0.4% WHF (MPa)
1	38.90	35.90	36.80	37.10
2	37.90	40.50	35.80	35.60
3	38.20	38.00	30.25	30.29
Average	**38.33**	**38.13**	**34.20**	**34.23**

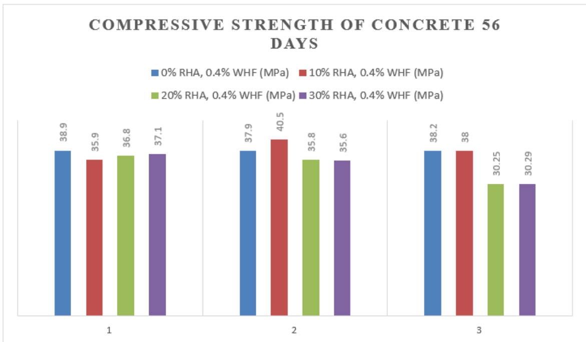

Figure 2: compressive strength of concrete

Using single factor analysis of variance (ANOVA) as a statistical tool for comparing the means of compressive strength of the samples, the researchers found out that the calculated P-value was less than the degree of freedom of 0.05. Also, the value of F is greater compared to the F-critical. Based on these results, has a significant difference for 28 and 56 days of curing.

3.3 Flexural strength

The results of flexural strength of concrete samples with 0.4% water hyacinth fibers and varying rice hull ashes cured for 28 and 56 days are shown in Tables 5. and 6, respectively. Comparing the concrete samples with varying hull ash as replacement for cements and 0.4 % water hyacinth to that of the controlled sample having 0.4% water hyacinth only, the results showed that the concrete samples with 10% rice hull ash and 0.4% water hyacinth fibers had the nearest value for 28 days of curing and even exceeding the results for 56 days of curing.

Table 5: Flexural strength test results for 28 days curing

Sample No.	0% RHA, 0.4% WHF (MPa)	10% RHA, 0.4% WHF (MPa)	20% RHA, 0.4% WHF (MPa)	30% RHA, 0.4% WHF (MPa)
1	7.24	6.57	4.81	3.98
2	5.17	6.46	4.65	6.62
3	5.27	6.54	4.45	4.03
Average	**5.90**	**6.52**	**4.64**	**4.88**

Table 6: Flexural strength test results for 56 days curing

Sample No.	0% RHA, 0.4% WHF (MPa)	10% RHA, 0.4% WHF (MPa)	20% RHA, 0.4% WHF (MPa)	30% RHA, 0.4% WHF (MPa)
1	7.27	7.81	6.93	4.37
2	7.81	9.93	8.04	5.64
3	7.34	9.77	6.67	6.88
Average	**7.47**	**9.17**	**7.21**	**5.63**

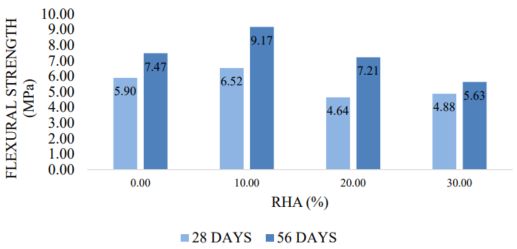

Figure 3: Flexural strength test results of 28 and 56 days of curing

Using single factor analysis of variance (ANOVA) as a statistical tool for comparing the means of compressive strength of the samples, the researchers found out that the calculated P-value was greater than the degree of freedom of 0.05. Also, the value of F is less than compared to the F-critical. Based on these results, has no significant difference for 28 and 56 days of curing.

3.4 Rapid Chloride Penetration Test

The results on RCPT showed that concrete samples with 0.4% water hyacinth fibers and 30% rice hull ash has the nearest value compared to that of the concrete samples with 0.4% water hyacinth fibers and 0% rice hull ashes during the 56 days of curing.

Table 7: RCPT 56 days

Mix	Specimens (Coulombs)		Mean (Coulombs)
Control Concrete	Specimens- 1	1710	1697
	Specimens- 2	1704	
	Specimens- 3	1679	
0% RHA, 0.4% WHF (MPa)	Specimens- 1	1665	1648
	Specimens- 2	1602	
	Specimens- 3	1679	
10% RHA, 0.4% WHF (MPa)	Specimens- 1	1534	1581
	Specimens- 2	1587	
	Specimens- 3	1622	
20% RHA, 0.4% WHF (MPa)	Specimens- 1	1653	1639
	Specimens- 2	1632	
	Specimens- 3	1630	
40% RHA, 0.4% WHF (MPa)	Specimens- 1	1691	1706
	Specimens- 2	1718	
	Specimens- 3	1709	

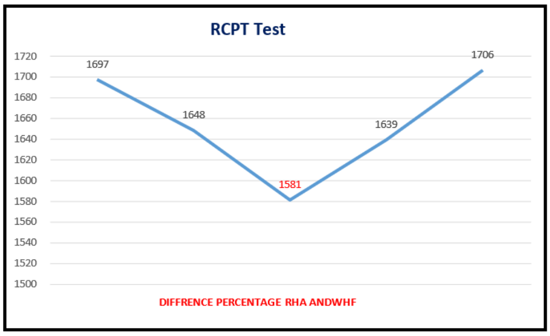

Figure 4: RCPT 56 days coulombs

Using single factor analysis of variance (ANOVA) as a statistical tool for comparing the means of RCPT of the samples, the researchers found out that the calculated P-value was greater than the degree of freedom of 0.05. Also, the value of F is less than compared to the F-critical. Based on these results, has no significant difference for 56 days of curing.

4. CONCLUSIONS

The study evaluated the performance of the self-compacting concrete samples with 0.4% WHF and varied RHA as admixture. methods of proportioning were followed in designing the concrete mix. The SCC mix underwent slump flow tests following Indian standards to measure its flowability, L-box tests to measure its passing ability, and V-funnel tests to measure its filling ability. The cured samples were subjected to IS tests to determine the samples‟ compressive, flexural strength and RCPT. The results obtained from the tests were compared to the control mix with 0.4% WHF and 0% RHA.

- Based on the result of the slump flow test, the control mix with 0% RHA gave the largest spread of 810mm while the mix with 30% RHA gave the smallest spread of 495mm. There is a 245mm difference between the result of the control mix and of the 10% RHA mix. The values of the slump flow results of the mixes with 10%, 20%, and 30% RHA were close being 565mm, 550mm, and 495mm respectively. None of the samples achieved the desired SCC slump flow which is between 650mm and 800mm. A clear pattern can be discerned from the obtained data: The amount of RHA replacing the cement in the mixture is inversely proportional to the slump flow.
- The results of the L-box test show that the mix with higher RHA percentage has lower passing ratio. The results of the samples with 10%, 20%, and 30% RHA as admixture are 0.107, 0.91, and 0.55 respectively. The control mix gave a higher result of 0.134. The desired passing ratio ranging from 0.8 to 1.0 was not obtained by any of the samples. The conducted V-funnel test, used to measure the flowing ability of the SCC mix, show that the control mix and the mix with 10% RHA admixture passed the criteria to be classified as SCC. Both mixes were emptied in 7 seconds, which is between the minimum 6 seconds and the maximum 12 seconds. The concrete mix with 20% and 30% RHA both failed the test finishing at a time of over 1 minute.
- The results in the average compressive strength of the 0%, 10%, 20%, and 30% RHA showed that the control mix with 0% RHA obtained the highest results. The compressive strength of the 10% RHA samples lagged the control samples in the 28-day test but narrowed the gap in the 56-day test with a difference of only 0.20MPa from the control mix.
- The obtained average flexural strength of both the 28 days and 56 days samples show that the 10% RHA mix obtained the optimum flexural strength. The flexural strength of the 10% RHA was higher than the control mix by 0.62MPa and 1.70MPa in the 28 days and 56 days samples, respectively. RCPT test are RHA 30% replace the 0.4 % WHF are high coulombs are passed. The 20% and 30% mixes registered lower results than the control mix.

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