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Experimental Study on the Properties of Rice Husk Ash with A.A.A Portland Cement

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ABSTRACT
In the last decades, the use of residue in civil construction, especially in addition to concrete, has been subject of many researches due to reduce the environmental pollution factors, it may lead several improvements of the concrete properties. Myanmar is one of the largest rice producing countries and per capita rice consumption is higher than that in any other countries. Considering that 20% of the grain is husk, and 20% of the husk after combustion is converted into ash. In this study, the chemical composition and physical properties of A.A.A Portland cement are tested. The rice husk ash (RHA) is obtained from Shwebo. And then, the ingredients of mortar and concrete such as sand and aggregate are tested. In this study, Ayeyarwaddy river's sand is used. According to the silica content, the replacement percentage of RHA is considered as 0%, 5%, 10%, 15% and 20% by weight of cement. Finally, the compressive and tensile strength of mortar, and compressive strength of concrete are tested with various percentages of RHA. The results were compared to control sample and the viability of adding RHA to concrete is verified.

KEYWORDS: *Environmental pollution factors, RHA, A.A.A Portland cement*

I. Introduction

Cement is the most essential requirement in concrete mix for the construction structure all over the world. So, every construction in all countries have severe shortages of cement, although their needs are vast.

As most developing countries are agricultural countries, agricultural residues such as rice husk, rice straw and bagasse (the waste from sugar cane) are plenty. Among them, rice husk is suitable for cement replacement as it is available in large quantities and contains a relatively large amount of silica. Moreover, increasing demand for producing cement is the outcome of the fast polluting environment. Supplementary cementitious materials prove to be effective to meet most of the requirements of durable concrete. Rice husk ash is found to be superior to other supplementary materials. Due to its high pozzolanic activity, both strength and durability of concrete are enriched. Hence, rice husk is used as an agricultural residue with the greatest potential as a cement replacement material.

II. Testing of Materials

In this study, the chemical composition and physical properties of A.A.A Portland cement is tested. And then, the ingredients of mortar and concrete such as fine and coarse aggregates are tested.

A. Laboratory Tests for Portland Cement

The quality of cement is verified by conducting various exhaustive tests. Followings are the standard tests for cement.

1. Chemical composition test
2. Fineness test
3. Compressive strength test
4. Tensile strength test
5. Consistency test
6. Setting time test and
7. Soundness test

For this study, detailed chemical analysis of cement is conducted. Table 1 shows the chemical composition of AAA Portland Cement. Table 2 shows the test results for strength of AAA Portland cement.

Table1. Chemical Composition of AAA Portland Cement

Chemical Constituents	Composition in percent (%)
Silica (SiO_2)	19.42
Alumina (Al_2O_3)	4.4
Ferric Oxide (Fe_2O_3)	3.47
Calcium Oxide (CaO)	62.34
Manganese Oxide(MgO)	3.17
Sulphur Trioxide (SO_3)	2.12
Loss	2.92
Total	97.84

Table 2 Test Results for Strength of AAA Portland Cement

Sample name		AAA Portland Cement
Specific gravity		3.14
Fineness(cm^2/g)		4496
Consistency (%)		27
Setting time	Initial Set	2:14
	Final Set	3:05
Compressive Strength (psi)	7 days	4282
	14 days	4999
Tensile Strength (psi)	7 days	413
	14 days	466

B. Testing of Sand

Tests of sand are fineness test, absorption test, specific gravity test and organic impurities test.
The test result of sand are described the following tables.

Table 3 Test Results of Fineness Modulus of Sand

Test name	Sieve analysis for sand				
Description of sample	Ayeyarwaddy River Sand				
Sieve no.	Sieve opening (mm)	Wt. retained (g)	Percent retained (%)	Accumulated percent retained	Percent finer (%)
4	4.76	2.9	0.58	0.58	99.42
8	2.38	53.6	10.72	11.3	88.7
16	1.19	98.5	19.7	31	69
30	0.595	97.1	19.42	50.42	49.58
50	0.297	132.1	26.42	76.84	23.16
100	0.149	92.3	18.46	95.3	4.7
200	0.074	15.6	3.12	98.42	1.58
Pan		7.9	1.58	100	
Total		500		FM = 3.64	

Table 4 Test Results of Absorption of Sand

Container no.	1	2
Wt. of container + wet sand (g)	143.5	138.5
Wt. of container + dry sand (g)	142.9	137.8
Wt. of container (g)	56.4	53.9
Wt. of water (W_w) (g)	0.6	0.7
Wt. of dry sand (W_d) (g)	86.5	83.9
Absorption = $\frac{W_w}{W_d} \times 100$	0.69	0.83
Average (%)	0.76	

Table 5 Test Results of Specific Gravity of Sand

Bottle no.	1	2
Wt. of bottle (W_1) (g)	149.9	154.1
Wt. of bottle + sand (W_2) (g)	610.4	644.5
Wt. of bottle + sand + water (W_3) (g)	957.1	982.1
Wt. of bottle + water (W_4) (g)	673.5	682.1
Wt. of sand ($W_2 - W_1$) (g)	460.5	490.4
Wt. of water ($W_3 - W_2$) (g)	346.7	337.6
Wt. of sand ($W_4 - W_1$) – ($W_3 - W_2$) (g)	176.9	190.4
Specific gravity of sand, $GS = \frac{W_2 - W_1}{(W_4 - W_1) - (W_3 - W_2)}$	2.6	2.58
Avg specific gravity of sand, GS	2.59	2.59

When the organic content can be judged by the colour of the solution, the greater the organic content the darker the colour. The test result of organic matter of sand is good and is not darker than the standard yellow colour. Testing of organic impurities of sand is shown in Figure 1.

Figure 1 Testing of Organic Impurities of Sand

C. Testing of Aggregates

Tests of the aggregate are grading test, absorption test, moisture test, specific gravity test and fineness test.
The fineness modulus is an index number which is roughly proportional to the average size of particles in a given aggregate; the coarser the aggregate is the higher the fineness modulus.

Coarse aggregate can be tested for absorption in accordance with ASTM standard. In this study, the absorption of coarse aggregate is 0.57.

The specific gravity of most aggregates is approximately 2.65 although lime stone may have a specific gravity of 2.5 or less. In this study, the specific gravity of coarse aggregate is 2.72. Fineness modulus of coarse aggregate is shown in Table 6.

Table 6 Fineness Modulus of Coarse Aggregate

Sieve no.	Sieve Opening (mm)	Wt. retained (g)	Percent retained (%)	Accumulated percent retained	Percent Finer
11/2	38	-	-	-	100
1	25.4	-	-	-	100
3/4	19	-	-	-	100
1/2	12.7	12.72	29.76	29.76	70.24
3/8	9.51	17.00	39.78	68.54	30.46
No.4	4.76	11.42	26.72	95.26	3.74
No.8	2.36	1.60	3.74	100	-
No.16	1.18	0	-	100	-
No.30	0.60	0	-	100	-
No.50	0.30	0	-	100	-
No.100	0.15	0	-	100	-
Pan	-	-	-	-	-
Total	-	42.74	-	FM=6.94	-

D. Chemical Composition of Rice Husk Ash

Table 7 shows the chemical composition of rice husk ash.

Table 7 Chemical Composition of Rice Husk Ash

Constituent	Percentage by weight (%)
Silica - SiO_2	92.43
Alumina - Al_2O_3	1.49
Ferric Oxide - Fe_2O_3	0.41
Calcium Oxide - CaO	0.02
Magnesium - MgO	0.02
Loss on Ignition- L.O.I	2.56

Table 8 shows test results for physical properties of RHA.

Table 8 Test Results for Physical Properties of RHA

Sample name		RHA
Specific gravity		1.85
Fineness(cm²/g)		4496
Consistency (%)		33
Setting time	Initial Set	4:35
	Final Set	8:00

III. Testing OF MORTAR

Compressive strength and test tensile strength test of mortar with 0%, 5%, 10%, 15% and 20% RHA are performed. The test results are described the following tables and figures.

Table 9 Compressive Strength of Mortar with A.A.A Portland Cement Alone

Sample no.	Compressive Strength, psi		
	7 days	14 days	28 days
1	4325	4950	5672
2	4320	4946	5690
3	4330	4960	5700
4	4328	4952	5682
5	4325	4963	5693
Mean	4326	4954	5687

Table 10 Compressive Strength of Mortar with A.A.A Portland Cement (95%) and Rice Husk Ash (5%)

Sample no.	Compressive Strength, psi		
	7 days	14 days	28 days
1	4350	5100	6010
2	4349	5090	5980
3	4345	5102	6020
4	4356	5005	6030
5	4352	5101	5990
Mean	4350	5080	6006

Table 11 Compressive Strength of Mortar with A.A.A Portland Cement (90%) and Rice Husk Ash (10%)

Sample no.	Compressive Strength, psi		
	7 days	14 days	28 days
1	3700	3800	4100
2	3710	3806	4102
3	3697	3798	4080
4	3720	3810	4050
5	3760	3804	4102
Mean	3717	3804	4086

Table 12 Compressive Strength of Mortar with A.A.A Portland Cement (85%) and Rice Husk Ash (15%)

Sample no.	Compressive Strength, psi		
	7 days	14 days	28 days
1	2902	3200	3910
2	2930	3212	3892
3	2890	3205	3920
4	2950	3210	3900
5	2966	3211	3880
Mean	2928	3208	3900

Table 13 Compressive Strength of Mortar with A.A.A Portland Cement (80%) and Rice Husk Ash (20%)

Sample no.	Compressive Strength, psi		
	7 days	14 days	28 days
1	2629	2890	3425
2	2730	2900	3430
3	2743	2898	3450
4	2751	2903	3435
5	2690	2900	3470
Mean	2708	2898	3442

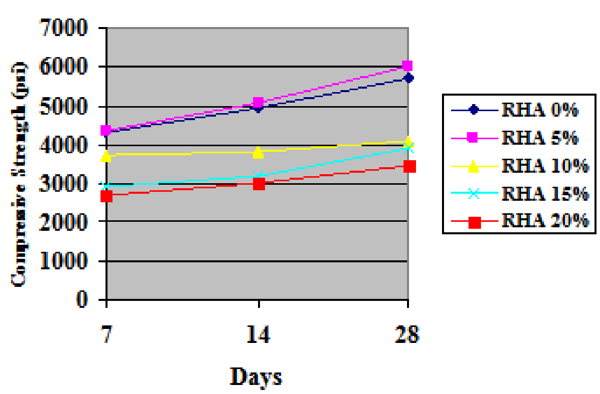

Figure 2 Comparisons for Compressive Strength of Mortar with Various Percentages of RHA

Table 14 Tensile Strength of Mortar with A.A.A Portland Cement Alone

Sample no.	Tensile Strength, psi		
	7 days	14 days	28 days
1	388	450	486
2	394	452	480
3	420	448	489
4	431	451	490
5	412	456	482
Mean	409	451	485

Table 15 Tensile Strength of Mortar with A.A.A Portland Cement (95%) and Rice Husk Ash (5%)

Sample no.	Tensile Strength, psi		
	7 days	14 days	28 days
1	440	470	498
2	456	480	503
3	462	485	495
4	454	483	502
5	443	481	499
Mean	451	480	499

Table 16 Tensile Strength of Mortar with A.A.A Portland Cement (90%) and Rice Husk Ash (10%)

Sample no.	Tensile Strength, psi		
	7 days	14 days	28 days
1	356	430	450
2	344	434	458
3	366	440	460
4	352	438	462
5	359	436	452
Mean	355	436	456

Table 17 Tensile Strength of Mortar using with A.A.A Portland Cement (85%) and Rice Husk Ash (15%)

Sample no.	Tensile Strength, psi		
	7 days	14 days	28 days
1	338	388	420
2	329	378	412
3	326	380	415
4	327	379	422
5	334	383	424
Mean	330	382	418

Table 18 Tensile Strength of Mortar with A.A.A Portland Cement (80%) and Rice Husk Ash (20%)

Sample no.	Tensile Strength, psi		
	7 days	14 days	28 days
1	283	310	340
2	290	300	334
3	294	323	335
4	289	315	336
5	293	318	342
Mean	290	313	337

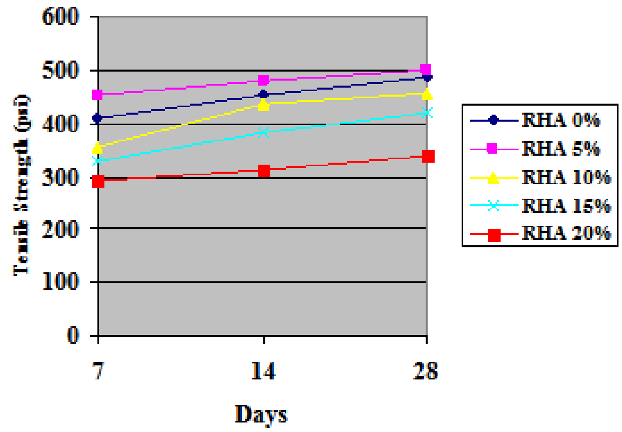

Figure 3 Comparisons for Tensile Strength of Mortar with Various Percentages of RHA

Compressive strength test of concrete with 0%, 5%, 10%, 15% and 20% RHA is performed. The test results are described the following tables and figure.

Table 19 Compressive Strength of Concrete with A.A.A Portland Cement Alone

Sample no.	Compressive Strength, psi		
	7 days	14 days	28 days
1	1863	2100	2560
2	1800	2108	2580
3	1889	2008	2600
4	1870	2111	2580
5	1880	2132	2582
Mean	1860	2092	2580

Table 20 Compressive Strength of Concrete with A.A.A Portland Cement (95%) and Rice Husk Ash (5%)

Sample no.	Compressive Strength, psi		
	7 days	14 days	28 days
1	2200	2639	3100
2	2233	2650	3090
3	2302	2700	3110
4	2260	2680	3120
5	2280	2670	3140
Mean	2255	2668	3112

Table 21 Compressive Strength of Concrete with A.A.A Portland Cement (90%) and Rice Husk Ash (10%)

Sample no.	Compressive Strength, psi		
	7 days	14 days	28 days
1	1638	1800	2100
2	1660	1790	2050
3	1610	1780	2080
4	1690	1798	1998
5	1600	1786	2020
Mean	1640	1791	2050

Table 22 Compressive Strength of Concrete with A.A.A Portland Cement (85%) and Rice Husk Ash (15%)

Sample no.	Compressive Strength, psi		
	7 days	14 days	28 days
1	1400	1575	1890
2	1310	1563	1900
3	1380	1570	1860
4	1368	1580	1850
5	1410	1600	1920
Mean	1374	1578	1884

Table 23 Compressive Strength of Concrete with A.A.A Portland Cement (80%) and Rice Husk Ash (20%)

Sample no.	Compressive Strength, psi		
	7 days	14 days	28 days
1	1076	1200	1670
2	1094	1198	1710
3	1100	1210	1700
4	1112	1220	1720
5	1089	1208	1740
Mean	1094	1207	1708

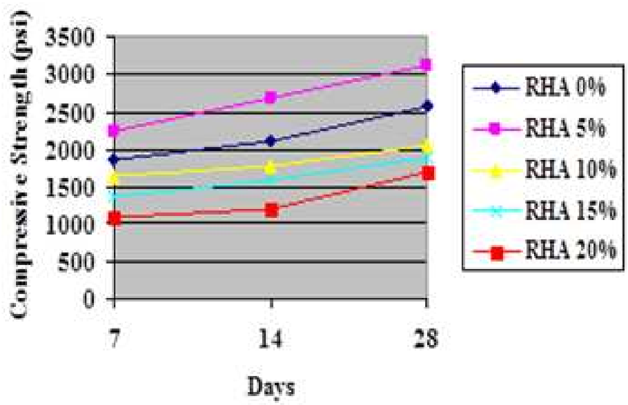

Figure 4 Comparisons for Compressive Strength of Concrete with Various Percentages of RHA

IV. Conclusion

The employment of RHA in cement and concrete has gained considerable importance because of the requirements of environmental safety and more durable construction in the future. The use of RHA as partial replacement of cement in mortar and concrete has been extensively investigated in recent years. The RHA used in this study is efficient as pozzolanic material; it is rich in amorphous silica. The compressive and tensile strength of mortar and concrete are tested with various RHA replacements (5%, 10%, 15%, and 20%).

The compressive strength of concrete for all mix increases with age at curing and decreases as the RHA content increases. The compressive strength of the mortar with 5% RHA is the highest and it is higher than that of cement alone is about 5%. But that of cement alone is higher than other percentage of RHA. The tensile strength of mortar with 5% RHA is greater than that of mortar with RHA other percentage and cement alone and it is nearly equal to 500 psi. The concrete with 5% RHA has the highest compressive strength and it is higher than that of concrete with Portland cement alone about 530 psi. And then concrete with other percentage is less than that of concrete with Portland cement alone. So RHA can be used up to 5% in mortar and concrete to increase compressive strength.

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