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Influence of grinding of rice husk ash to the workability and strength of concrete

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ABSTRACT : *Producing cement emits a lot of carbon dioxide which would link to bad environmental effects. Partial substitution of cement with natural waste product reduces cement consumption in concrete production. As a result, discharge of carbon dioxide is reduced. This paper presents an investigation on the effects of different grinding time of rice husks ash (RHA) on the physical properties of the concrete which is workability and strength. However, the burnt RHA need to be ground for optimum grinding time before mixing it with other materials. This study is based on experimental program. For laboratory tests, concrete mix proportion samples were introduced with RHA and superplasticiser (Sp) as additives. There were three type of RHA grinding time used; 30, 60 and 90 minutes. Concrete was evaluated for compressive strength and workability. It is found that the increasing of grinding time decreases the workability but increases the compressive strength of the concrete. This research shows that RHA has the potential to be utilized as an alternative material to cement in concrete production. It is also found that RHA grinding time does affect the workability and compressive strength of the RHA concrete.*

Keywords : *Rice husk ash, Ordinary portland cement, Superplasticiser, Workability, Compressive strength*

I. Introduction

High production cost of cement causes high cost in concrete construction industry. By applying supplementary cementitious material (SCM) concept, cement usage can be minimized or reduced while the strength and durability of the concrete can be improvised compared to the conventional concrete [1-3]. In addition it reduces the concrete production cost as well as the negative impact on the environmental [5-7]. So far, RHA has not been utilized yet in the construction industry. The reason for not utilizing this material may probably be due to lack of understanding on the effect of RHA on concrete characteristic. Many researchers have already published the characteristic of RHA concrete on strength and durability. However, only few researchers have been found to write on the effects of RHA grinding time on these characteristics [8].

Global production of rice is approximately 580 million tonnes a year and this is rising as the world population and the consumption of rice increases [9]. Most of the rice husk is burned or dumped as waste. Hence, it is the time to look into the use of this local, sustainable and inexpensive waste material in replacing cement [6]. This paper highlights outcomes from a study which.

II. Materials and treatment

The materials and treatment to the materials used in this study are described in the following subsection.

2.1 Materials used

There are 3 types of RHA used according to the duration of grinding time; RHA1, RHA2 and RHA3. RHA1, RHA2 and RHA3 were ground for 30, 60 and 90 minutes respectively. There were 4 concrete mixtures used. In all the mixtures, Ordinary Portland cement (OPC) was used as the main binder. No cement replacement in mixture no 1. In mixture no 2, 3 and 4, 5% of the OPC was replaced with RHA1, RHA2 and RHA3 respectively. For the sake of understanding, these mixtures will be later known as RHA1, RHA2 and RHA3 concrete respectively in this paper. For coarse aggregate, granite with maximum size of 10 mm with specific gravity of 2.4 was used. For fine aggregates, mining sand with maximum size of 5 mm and 25% passing of 600 µm was used. Chemical composition of OPC and RHA extracted from previous studies by Sumrerng et al. [4,5], Kartini et al. [6], Habeeb et al.[8], Tuan et al.[11], Rukzon et al.[12], and Abu Bakar et al.[13] is shown in Table 1 for reference.

Table 1. Chemical composition of OPC and RHA

Chemical Composition (%)	OPC	RHA
SiO_2	15.05-20.09	92.00-96.70
Al_2O_3	2.56-4.76	0.21-1.01
Fe_2O_3	3.42-4.00	0.05-0.21
MgO	1.25-1.27	0.37-1.59
CaO	65.41-72.17	0.41.1.28
Na_2O	0.08-0.74	0.05-0.26
K_2O	0.35-0.41	0.91-2.31
SO_3	2.71-2.96	0.94-2.90
LOI	0.96-1.33	2.36-4.81

2.2 Treatment of RHA

Rice husk was collected and transported from Bernas factory at Kampung Bukit Tengah, Seberang Perai Tengah, Penang, Malaysia. Abu Bakar et al. [13] suggested that essentially amorphous silica can be produce by maintaining or control the combustion temperature below 500°C. Study done by Habeeb et al. [8], the RHA was burned in the muffle furnace with incinerating temperature not exceeding 700°C. In the current study, incineration was self-sustained with the total duration of 7 hrs at 250°C. The burnt RHA was later left inside the furnace to cool for 24 hrs. After that, burnt RHA was divided into 3 parts for grinding. RHA was ground using Los Angeles mill machine for 30, 60 and 90 minutes. Steel balls were used as grinding tool mixed between two sizes; 25 and 12 mm in diameter. For each part, 1 kg of 25 mm and 0.5 kg of 12 mm steel balls were used for every grinding time. In order to ensure the uniformity and consistency of the RHA, necessary measures were taken to control treatment include mass of RHA fed into the ball mill, milling speed, thickness of rice husk layer in the furnace during incinerating and the duration as well as the temperature of incinerating.

III. Mix proportion and samples preparation

The range of mixes was limited to emphasize on the grinding time parameters. The control OPC concrete was designed to achieve 30 N/mm² using DOE method [14]. Based on this method, cement content of 380 kg/m³ was adopted to all mixes. Coarse aggregates and fine aggregates of 560 kg/m³ and 955 kg/m³ respectively were used in all the mixes. Cement replacement was only 5% for each mix but differs between each mix due to RHA grinding time. The water binder ratio (w/b) used for control mix was 0.61 with a desired slump ranged 60-180 mm. Since rice husk being cellular in nature [6], the used of RHA tend to increase water requirement. Therefore Sp is used in all the mixes except for control specimens. Table 2 summarizes the mix proportions of all the mixes.

Table 2. Concrete mix proportion

Materials	Concrete Mix			
	OPC	RHA1 (5) Sp	RHA2 (5) Sp	RHA3 (5) Sp
OPC (kg/m³)	380	361	361	361
RHA (kg/m³)	0	19 (30 min.)	19 (60 min.)	19 (90 min.)
Fine aggregate (kg/m³)	955	955	955	955
Coarse aggregate (kg/m³)	560	560	560	560
Water (litre)	235	235	235	235
Sp (%)	0	0.5	0.5	0.5

The concrete specimens' size prepared was 100 mm cubes. Mixing of concrete was done using a drum type mixer and casting done in three layers; each layer was compacted using vibrating table to achieve maximum compaction. The samples were demoulded 24 hrs after casting and cured in water maintained at room temperature until the day of testing.

IV. Testing

4.1. Workability

Workability test in term of slump on the fresh mixes in accordance to BS EN 12350-2[15] in achieving desired workability was carried out.

4.2. Compressive strength

The compressive strength of the concrete cubes was determined using 3000 kN concrete compression machine in accordance to BS EN 12390-3[16]. Compressive strength on 100 mm cubes specimens was obtained at the age of 7, 14, 28 and 60 days.

V. Results and discussion

5.1. Workability

Appropriate duration of grinding time of RHA is important for achieving the desired strength of concrete. The longer RHA is ground, the finer RHA size obtained and results in increment of the pozzolanic reactivity due to the higher surface area of rice husk [8]. The slump obtained was 50 - 150 mm. For the same percentage of RHA replacement, increment of RHA grinding time decreases the concrete workability. There are two reasons for this; its absorptive characteristic [17] and fineness of its size as referred by Habeeb and Fayyadh [8] in (Zhang et al., 1996; Ganesan et al., 2008). Both of these features results in high water demand to wet the surface area of RHA.

According to Habeeb et al. [8], due to increment of the specific surface area of RHA, more amount of water is required to wet the surface area of RHA. Since, the water/binder ratio was maintained, Sp was added up as aid to enhance the fluidity. It is found that Sp increased the slump of the first mix (RHA ground 30 minutes) by 10 mm in comparison with the control mix. However, the slump decreases when the grinding time increases as shown in Table 3. Sp is absorbed onto the cement particles and imparts a very strong negative charge which helps to lower the surface tension of the surrounding water considerably and thus greatly enhances the fluidity of the mix [18]. As evident in Table 3, it is seen that for the same amount of water and Sp, and increase in the grinding time, decreases the slump reading.

Change of slump with respect to grinding time is shown in Fig.1 and Table 3. Hence, it can be concluded that the longer RHA is ground the finer the particle would be; thus directly increase the specific surface area of the particles which would increase the water demand [5,8,11]. Therefore maintaining the same amount of water reduces the slump.

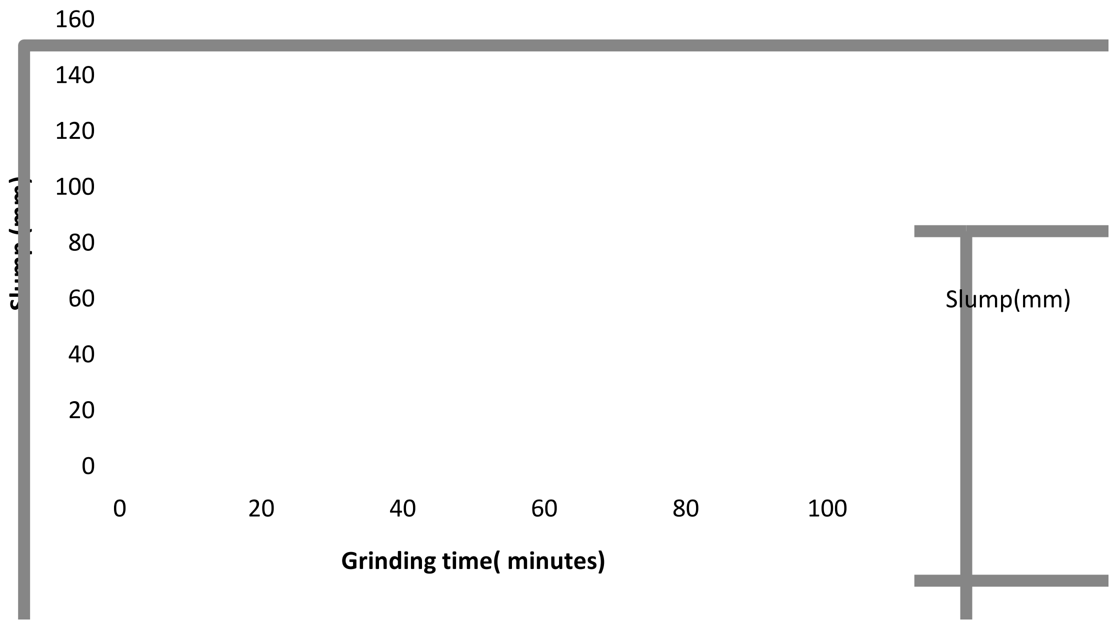

Fig.1. Effect of grinding times to the slump of concrete

5.2. Compressive strength

Compressive strength of all the mixes is presented in Table 3 and the strength development is shown in Fig.2. All RHA concrete achieved the target strength of 30 N/mm² at 28 days. At all ages, the RHA concrete shows higher strength than the OPC concrete. Strength of RHA1 dropped a little bit from 14 to 28 days which makes it just slightly higher than the OPC concrete when it reached 28 days. Strength of RHA3 developed tremendously from 14 to 28 days. After that, all the mixes continued to rise at about the same rate between each other. No data was taken after 60 days of age. In all cases, highest compressive strength is shown by RHA3 except for 1 case; at the age of 14 days, RHA3 shows the same strength with RHA2 and the value is slightly lower than the value obtained from the OPC concrete.

In general, compressive strength increases as the grinding time of RHA rises [8]. Finer RHA particles (due to longer grinding time) demands more amount of water and therefore reduces the slump [6,10]. Since, RHA is a type of pozzolanic materials; it contributes additional formation of calcium silicate gel that contributes to the strength development of the concrete because the C-S-H gel was produced twice [19]. This gel filled the void between cement matrix and causes the densification effect [19]. As shown by Habeeb et al. [8], the increase of grinding time will increase the RHA fineness and specific surface area. As a result, bigger quantity of C-S-H gel produced which increased the strength of the concrete. Development of concrete strength against grinding time is given in Figure 3.

Table 3. Slump and compressive strength of all the concrete mixes

Mixes	Slump (mm)	Density (kg/m³)	Compressive Strength (N/mm²)			
			7d	14d	28d	60d
OPC	140	2317.8	18.3	20.1	29.5	32.2
RHA1 (5) Sp	150	2345.9	23.9	30.1	29.9	40.1
RHA2 (5) Sp	90	2384.9	24.9	29.2	34.1	44.3
RHA3 (5) Sp	50	2428.3	26.1	29.2	40.6	47.1

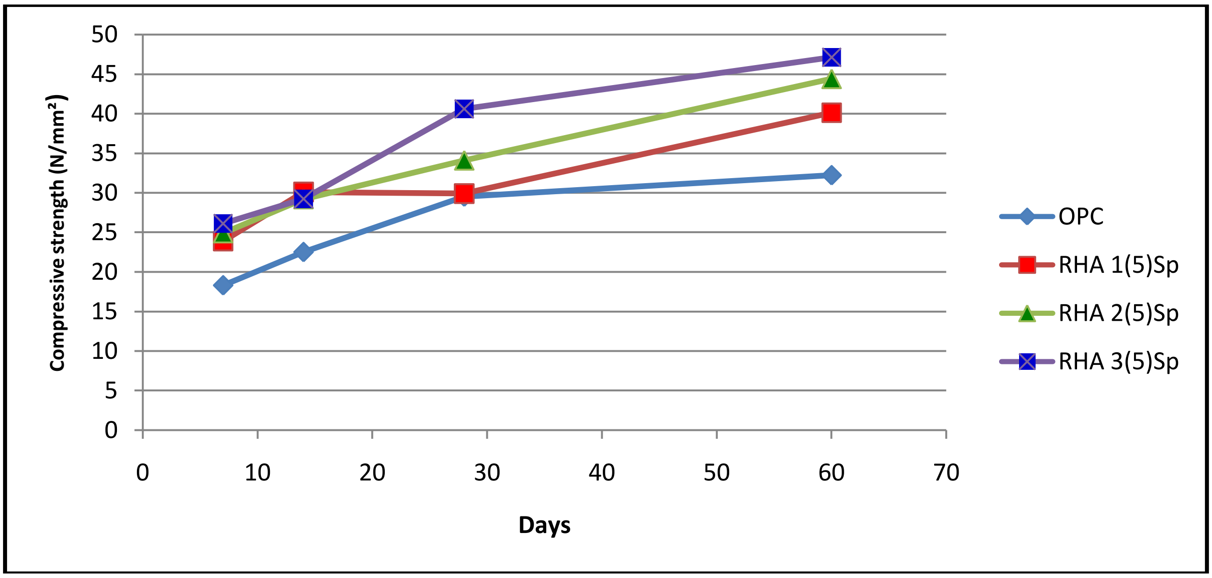

Fig.2. Development of the concrete compressive strength at various ages

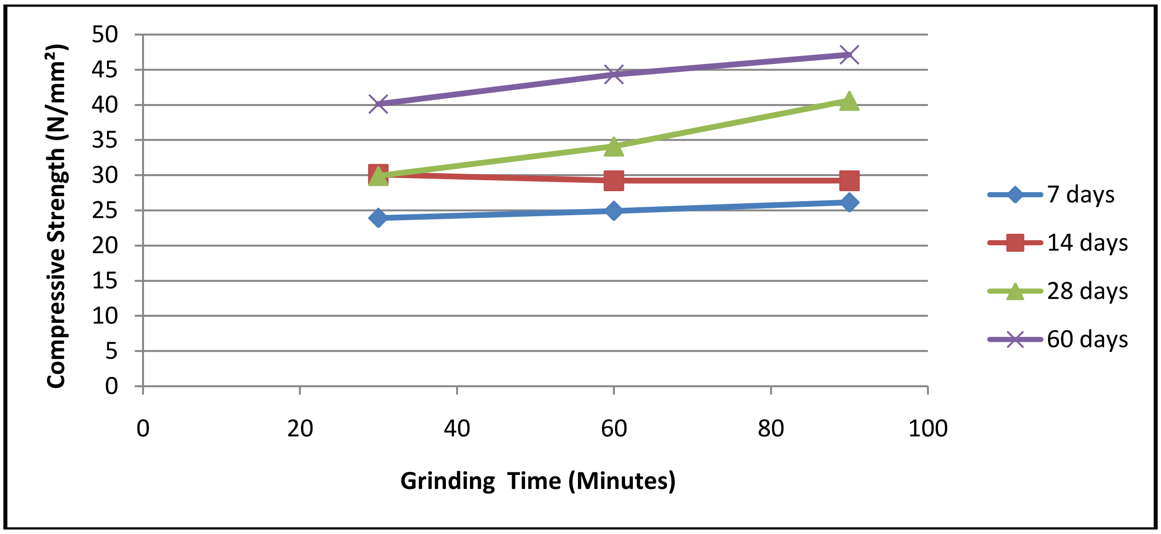

Fig. 3. Effect of grinding time to the concrete compressive strength

VI. Conclusions

From the study carried out, it can be concluded that increase in grinding time of the RHA particles results in reduction of the concrete fluidity but increase the concrete compressive strength. Also it is recommended that dosage of superplasticiser has to be increased in order to maintain the workability.

VII. Acknowledgements

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References

[1] Bhaskar Sangoju, Ravindra Gettu, B. H. Bharatkumar and M. Neelamegam, Chloride-induced corrosion of steel in cracked OPC and PPC concretes: Experimental study, *Journal of Materials in Civil Engineering*, July 2011, 1057-1066.

[2] Gangné, R., Ollivier, J. ,And Latreiile, Y., Effect of superplasticiser, retarding agent and silica fume on the air permeability of high performance concrete, *American Society For Testing And Materials(ASTM)*, 1998, P.248.

[3] Gjorv, O. E., Tan, K., and Monteiro, P. J. M., Effect of elevated curing temperature on the chloride permeability of high-strength lightweight concrete, *Cement, Concrete, and Aggregates,* CCAGPD, Vol. 16, No. 1, June 1994, P.57-62.

[4] Sumrerng Rukzon And Prinya Chindaprasirt, Strength and carbonation model of rice husk ash cement mortar with different fineness, *Journal Of Materials In Civil Engineering*, March 2010, 253-259.

[5] Chindaprasirt,P., Jaturapitakkul,C., Rattanasak,U., Influence of fineness of rice husk ash and additives on the properties of light weight aggregates, *Construction And Building Material 88*,2009,P. 158-162.

[6] Kartini, K., Mahmud,H.B., Hamidah, M.S., Absorption and permeability performance of Selangor rice husk ash blended Grade 30 concrete. *Journal of Engineering Science and Technology*, Vol. 5, No.1,2010, P.1-16.

[7] A.A.Ramezanianpour, M.Mahdi Khani, Gh.Ahmadibeni, The effect of rice husk ash on mechanical properties and durability of sustainable concretes, *International Journal Of Civil Engineering*, Vol.7, No.2, June 2009, P.83-91.

[8] G.A. Habeeb, M.M. Fayyadh, Rice Husk Ash Concrete ,The effect of RHA average particle size on the mechanical properties and drying shrinkage, *Australian Journal Of Basic And Applied Science*, 3(3),2009,1616-1622.

[9] Reddy, D.V. And Alvarez,M., Marine Durability Characteristics Of Rice Husk Ash Modified Reinforced Concrete, *Fourth LACCEI International Latin American And Caribbean Conference For Engineering And Technology (LACCET'2006) "Breaking Frontiers And Barriers In Engineering: Education, Research And Practice"*, 21-23 June 2006, Mayagüez, Puerto Rico.

[10] Kartini, K., Rice husk ash-pozzolanic material for sustainability, *International Journal of Applied Science And Technology*, Vol.1, No.6, Nov 2011, P.169.

[11] Tuan,N.V., Ye,G., Breugel,K.V, Fraaij,A.L.A, Dai,B.D., The study of using rice husk ash to produce ultra high performance concrete, *Construction And Building Material* 25, 2011, P. 2030-2035.

[12] Rukzon, S., And Chinaprasirt, P., Strength and carbonation model of rice husk ash cement mortar with different fineness, *Journal of Material in Civil Engineering(ASCE)*, March 2010,P.253.

[13] Badorul Hisham Abu Bakar, Ramadhansyah PutrajayaC and Hamidi Abdul Aziz, Malaysian rice husk ash – improving the durability and corrosion resistance of concrete: Pre-review, *Concrete Research Letters,*Vol. 1 (1) ,March 2010, P.6-13.

[14] Department Of Environment (DOE) (1992). *Design of Normal Concrete Mixes*. BRE Publication, United Kingdom.

[15] British Standard Institution, BS EN 12350-2:2009. *Testing fresh concrete. Slump test.*

[16] British Standard Institution, BS EN 12390-3:2009. *Testing Hardened Concrete. Compressive strength of test specimen.*

[17] Kartini, K., Mahmud,H.B., Hamidah, M.S., Strength properties of Grade 30 rice husk ash concrete, *31st Conference On Our World In Concrete & Structure*, 16-17 August 2006, Singapore.

[18] Superplasticiser in concrete, *The Aberdeen Group Laboratory*, 1978.

[19] A.M.Neville, *Properties of Concrete* (England, 4 th Ed.: Pearson Prentice Hall, 2010).

[20] P.Kumar Mehta and Paulo J.M.Monteiro,*Concrete-Microstructure,properties and materials* (New York, 3 th Ed.:McGraw Hill, 2006)

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