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A new strategy to improve quality of ready mixed concrete using rice husk ash

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Abstract

Quality improvement of ready mixed concrete would be achieved by control of surface properties of its constituents, which are cement and additives. Rice husk ash (RHA) which is solid waste received from rice husk fire combustion process would help improve such cement properties and reduce environmental burden due to land-filling. A new strategy to improve quality of ready mixed cement has been experimentally explored using ground RHA as an additive to mix with cement. Because of amorphous silica within ground RHA which could involve with the pozzolanic reaction, control of particle size distribution of RHA and weight ratio of RHA to cement would lead to quality improvement of ready mixed concrete. In this work, particle size distribution of RHA is represented by the fineness of RHA which is set from 3,200 to 5,100 cm^2/g. Meanwhile, the mixing ratio of RHA to cement is set from 5 percent to 20 percent by weight. It was found that the RHA fineness and the mixing ratio of RHA to cement could affect the 3, 7 and 28-day compressive strength of the ready-mixed concrete. RHA with a fineness of 5,100 cm^2/g could provide the highest compressive strength with the 10-15 percent of RHA is mixed with cement.

Keywords: Rice husk ash, Cement, Pozzolanic reaction, Amorphous silica

1. Introduction

Nowadays, the environment is significantly affected by the growth of the industry. To raise awareness of environmental issues, leading companies in Thailand provide a policy that focuses on improving manufacturing processes, efficiently using natural resources, and reducing waste in the production process that regarded as a social responsibility. Thailand is an agricultural country which could produce many agricultural products, especially rice. Therefore, Thailand has been the world's largest rice exporter for a long period. Consequently, there is a lot of waste material left behind after rice harvest such as rice husks. In addition, the rice milling process provides rice husks around 5 million tons in each year. Each ton of milled rice contains the rice husks around 200 kilograms. Currently, the method used to get rid of rice husk is to apply it as fuel in the large and medium scale manufacturing industries that use heat to produce steam. If the rice husk is burned, its ash will be about 20 percent of the weight of rice husk or about 40 kilograms [1]. Some researchers have proposed a variety of usage of RHA remaining from the manufacturing process. Meanwhile it is well recognized that Rice husk ash or RHA received from rice husk fire combustion process would help improve such cement properties and reduce environmental burden due to land-filling. A new possible strategy to use RHA as an additive to mix with cement would provide an impact on the environment by reducing its amount instead of burning. The rice husk ash has high silica content and is suitable for agricultural development of pozzolanic material. It is used as an ingredient in concrete to help improve properties and quality of the concrete surface, reduce production costs and add value to functional cement. This approach provides leadership in the manufacturing industry and protects the environment, both within the industry and sustainable communities.

2. Materials and methods

2.1 Material

The cement used in the experiment was Portland cement type 1 with specific areas (fineness) of 3410 cm^2/g obtained from the Siam Cement (Thung Song Plant) Co., Ltd. This cement is produced under TIS. 15, Volume 1-2555 [2]. Rice husk ash (RHA) the fineness of 3,200 cm^2/g was obtained from the Siam Fibre-Cement Co., Ltd. (Thungsong Plant). Limestone with assorted sizes was used for concrete testing with regard to the qualifying standard of ASTM C33-97 [3]. Also, sand with assorted sizes was collected from the Tapi river for the concrete testing with regard to the same standard. As commercial confidential a

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concrete additive type D was supplied from the W.R. Grace (Thailand) Co., Ltd.

2.2 Preparation method

The RHA with a fineness of 3,200 cm^2/g was ground in a ball mill to improve its texture for 2 hours until the fineness of 5,100 cm^2/g was achieved. Pristine RHA and ground RHA were mixed with a weight ratio of 50:50. Then, the pristine RHA, ground RHA, and mixed RHA were further mixed again with the weight fraction in a range of 5, 10, 15 and 20 percent in order to prepare standard samples with designated composition as summarized in Table 1. To physicochemical analyses, mineralogical analysis was subjected to X-Ray Fluorescense (XRF) and X-Ray Diffactometer (XRD). Specific surface area of each sample was analyzed by Blaine's air permeability apparatus [4]. The compressive strength of each ready-mixed concrete sample prepared in 3, 7 and 28 days was conducted based on (ASTM C192 standard [5].

Table 1 Weight fraction of cement and RHA in each typical sample

Sample	Cement: RHA Ratio	Type of RHA
B (blank)	100:0	None
P5	95:5	Pristine RHA
P10	90:10	Pristine RHA
P15	85:15	Pristine RHA
P20	80:20	Pristine RHA
M5	95:5	Mixed RHA
M10	90:10	Mixed RHA
M15	85:15	Mixed RHA
M20	80:20	Mixed RHA
G5	95:5	Ground RHA
G10	90:10	Ground RHA
G15	85:15	Ground RHA
G20	80:20	Ground RHA

3. Results

Because of amorphous silica within ground RHA which could involve with the pozzolanic reaction, analyses of its microscopic properties would be essential for its strategic usage. First, XRF analytical results of typical samples of cement and pristine RHA were conducted and summarized in Table 2. It could be clearly observed that the main constituent of cement and RHA is silica with a percentage of 19.70 and 85.44, respectively. In addition, XRD analyses of the mixture of RHA to cement within a range of 5 to 20 percent by weight as shown in Table 1 were also conducted. In the RHA contents, amorphous silica RHA structure was reached to 96.96 percent by weight. The percent crystalline was shown in Table 2.

Table 2 XRD analytical results of each sample

Sample	Alite	Belite	Alum	Ferrite	FCaO	Amorphous	Other
B	64.04	9.00	4.22	13.27	0.53	0.00	8.94
P5	59.86	8.24	3.77	12.70	0.55	5.41	9.47
P10	58.20	7.32	3.75	11.16	0.33	9.87	9.37
P15	56.88	5.95	3.46	10.48	0.33	13.51	9.39
P20	53.12	6.76	3.27	9.70	0.22	17.53	9.40
M5	59.99	8.47	3.89	12.42	0.26	4.91	10.06
M10	57.37	8.46	3.65	11.25	0.39	9.08	9.80
M15	56.74	6.95	3.52	10.51	0.24	12.16	9.88
M20	54.33	5.45	3.37	9.99	0.21	17.53	9.12
G5	59.47	9.02	3.80	12.56	0.45	4.45	10.25
G10	57.91	8.72	3.57	11.80	0.29	8.03	9.68
G15	56.02	7.76	3.51	10.53	0.30	12.05	9.83
G20	51.23	6.01	3.28	9.79	0.25	19.86	9.58

Table 3 XRF analytical results of cement and RHA

Percentage	Cement Blank	Pristine RHA
SiO_2	19.70	85.44
Al_2O_3	4.73	0.30
Fe_2O_3	3.05	0.12
CaO	64.74	0.70
MgO	2.06	0.04
K_2O	0.83	1.62
Na_2O	0.00	0.00
Other	4.89	11.78

The XRF analytical results of each sample summarized in Table 3 suggest the composition, contents of cement and pristine RHA. Meanwhile, the results of compressive strength of ready-mixed concrete incubated for 3, 7 and 28 days based on ASTM C192 were shown in Figure 1, respectively.

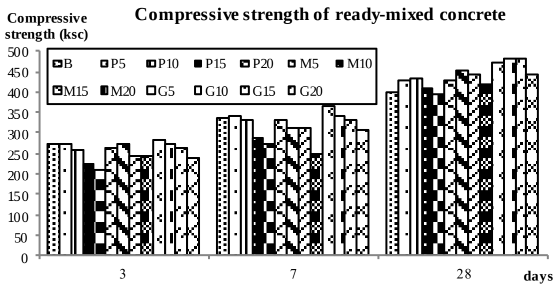

Figure 1 Compressive strength of ready-mixed concrete (3, 7 and 28 days)

4. Discussion

The main factors of the compressive strength of ready-mixed concrete incubated for 3, 7 and 28 days would rely on the value of specific surface area (cm^2/g) and content of SiO_2. The best early compressive strength of ready-mixed concrete samples incubated for 3 and 7 days were achieved when the percentages of cement replaced by 5% rice husk ash (RHA) was used. It decreased appreciably as the percentage of RHA increased. The sample of G5 exhibited the highest strength because of its surface area and the amount of clinker content that was larger than others as shown in Table 2. This result would suggest that the pozzolanic reaction contributed by the ground RHA was more enhanced. Furthermore, an increase in the amount of RHA would reduce the amount of Alite in cement, resulting in the reduction of compressive strength because the Alite is a phase contributing to the early compressive strength. In Figure 2, it is found that by-product Ca $(OH)_2$ was likely to occur in the early compressive strength. Similarly, the pozzolanic reaction was also likely to occur as well as the reduction of $Ca(OH)_2$.

According to the late compressive strength of ready-mixed concrete incubated for 28 days, the sample of G10 and G15 exhibited higher strength than other samples. This result would be attributed to the amorphous silica content of the RHA and surface area which were of the most important constituents of Pozzolanic Cement as shown in Table 2. Due to an increase in the late-stage of the by-product $Ca(OH)_2$ as shown in Figure 2, the pozzolanic reaction with the amorphous SiO_2 content existing in RHA would result in calcium silicate hydrate (CSH), which is a phase contributing to the higher compression strength.

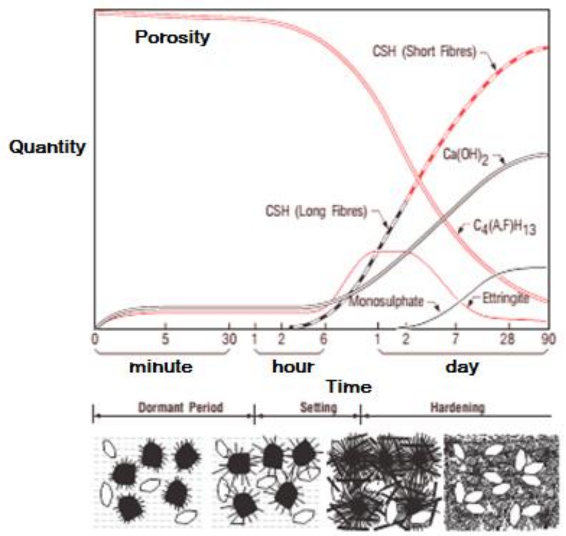

Figure 2 The hydration product development of cement hydration by time [6]

5. Conclusions

The ready mixed concrete quality can be improved by mixing with 10-15 percent by weight of RHA. The use of RHA with the fineness of 5,100 cm^2/g could increase the 28-day compressive strength of concrete approximately to 82 ksc due to the pozzolanic reaction. The mixing of RHA received from the waste of the manufacturing process would help increase the cement strength with higher environmental friendliness and reduce carbon dioxide emissions in the cement burning process.

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7. References

[1] Luh BS. Rice: Production and Utilization. Westport, Connecticut: Avi Publishing Company; 1979.

[2] Thai Industrial standard Institute. TIS 15 Part 1-2555 (2012): Portland cement Part 1 Specification. Bangkok: Ministry of Industry; 2012.

[3] American Society for Testing and Materials. ASTM C33-01: Standard Specification for Concrete Aggregates, Annual Book of ASTM Standards. Philadelphia: ASTM Intenational; 2001.

[4] Thai Industrial standard Institute. TIS 15-2521 (1978): Portland cement Part 6 Fineness of Hydraulic Cement by Air-Permeability Apparatus. Bangkok: Ministry of Industry; 1998.

[5] American Society for Testing and Materials. ASTM C192/C192 M-00: Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory, Annual Book of ASTM Standard. Philadelphia: ASTM Intenational; 2001.

[6] The Siam Cement Group. Cement and Applications. Bangkok: SCG Cement Co. Ltd.; 2005.