International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies

http://TuEngr.com

CHLORIDE INFILTRATION EFFECTS BY REPLACING NATURAL SAND IN CONCRETE MIXTURE WITH RICE HULL ASH, DARK HUSK ASH, AND CRUSHED DUST

Phongphoom Sornchomkaew [a*], Boonsap Witchayangkoon [b], and Sayan Sirimontree [b]

[a] *Department of Civil Engineering, Rajamangala University of Technology Rattanakosin Wang Klai Kang Won Campus, Prachaup Kiri Kan 77110, THAILAND*
[b] *Department of Civil Engineering, Thammasat University, Rangsit Campus, Pathumtani 12120, THAILAND*

ARTICLEINFO

Article history:
Received 12 January 2018
Received in revised form 04 March 2018
Accepted 16 March 2018
Available online
20 March 2018

Keywords:
Pozzolanic reaction ;
Colorimetric technique;
Scanning Electron Microscope (SEM);
chloride infiltration depth.

ABSTRACT

This research studied the infiltration effects of chloride in concrete mixed with rice hull ash, dark husk ash and crushed dust to replace sand. The experiment carried out by making cylindrical concrete specimens with mixture of rice hull and dark husk ash instead of cement at the consequent percentages of 0, 10, 20, and 30 by weight and also the use of crushed dust instead of sand at the consequent percentages of 0, 10, 20, and 30 by weight. These concrete specimens have been soaked in marine environment at Cha-Am Beach, Petchburi province of Thailand for 90 days, tested for chloride infiltration in the concrete specimens by Colorimetric technique. The finding stated that chloride infiltration in all concrete samples was at 50% compared with the standard concrete. The best resistance of chloride infiltration was the one sand 10% replacement of crushed dust. According to the study, it showed that concrete specimen with rice hull ash and dark husk ash mixture caused Pozzolanic reaction effecting for more density, durability and thus decreasing of chloride infiltration in long term.

1. Introduction

Rice hull ash and dark husk ash remained from burning of rice hulls biomass at temperatures 800–900 degrees Celsius for electricity production which made good quality ash, but the real use of this ash was still less because of sizes and Pozzolanic quality. This ash was applied in this study by using it as mixture in concrete, together with cement, fine aggregate or sand, coarse aggregate or gravel, water and other mixture. One main mixture in concrete was sand which has similar physical quality to crushed dust. Many research studies in the past showed good results in using crushed dust to replace sand in mixing concrete that made porous in finished concrete. It was assumed that

*Corresponding author (P. Sornchomkaew) Mobile: +66-86-330-3806. E-mail: phongphoom.sor@rmutr.ac.th.

the concrete with mixture of crushed dust might cause grater chloride infiltration than concrete mixture with sand even crushed dust could resist better in compression. So this study tested this quality by mixing crushed dust into concrete as well as rice hull ash and dark husk ash then evaluated according to ASTM standard test.

2. Materials and Methods

2.1 Materials

Rice hull ash and dark husk ash from burning of rice hulls biomass from electricity production plant in Phanom Sarakham district, Chachoengsao province, and crashed dust from crushing plant in Saraburi province.

2.2 Materials testing

The conclusion of materials testing was as following

1) Testing of materials' specifications; appearances of rice hull ash and dark husk ash by Scanning Electron Microscope (SEM) and chemical compositions.

2) Testing for grain size distribution of the ash by sieve analysis (Sieve Analysis) to compare sizes of crushed dust which used instead of sand, then classify for consistency coefficient and curvature coefficient. [1]

3) Testing of cement specification; test of specific gravity of Portland cement type 1 and test of specific gravity of rice hull ash and dark husk ash according to ASTM C188 standard. [2]

4) Testing of standard slump test and test of concrete mixed with rice hull ash, dark hull ash and crushed dust instead of sand according to Department of Public Works and Town & Country Planning's standard.

5) Testing of unit weight and voids in the aggregate by ASTM C29 Standard. [3]

2.3 Concrete mix design

The design for proportion of rice hull ash and dark hull ash mixture to replace cement in concrete mixture in the ratio percentage of 0, 10, 20, and 30 were coded in R00, R10, R20, and R30 alternatively. The mixture of crushed dust to replace sand in the ratio percentage of 0, 10, 20, and 30 were coded in D00, D01, D02 and D03 consequently comparing to standard concrete coded PC.

Figure 1: Concrete specimens in marine environment.

2.4 Specimens soaked under marine environment

The area used for testing of samples in marine environment was at fishing pier in Cha Am

District, Petchburi Province which caused natural sea tide as in Figure 1. The specimens were left in this environment for 90 days then tested for Chloride infiltration in samples by cut the concrete specimen in half, in order to identify the depth of Chloride infiltration.

2.5 Testing for the depth of Chloride Infiltration by Colorimetric Technique

The concrete specimens were cut in half vertically and sprayed by Silver Nitrate with the intensity of 0.1 N. thorough the inside surface which changed into purple color. Then the Chloride infiltration was observed and measured for depth, length and conditions of infiltration [4] as in Figure 2.

Figure 2: Concrete specimens soaked for 90 days under marine environment.

3. Results and Discussion

3.1 Scanning electron microscope

From Figure 3, the study of rice hull ash and dark hull ash appearance were showed by Scanning Electron Microscope (SEM) from Electron Microscope and Analysis Microscope laboratory conducted at the National Metal and Materials Technology Center (MTEC). The enlarged photos of 500, 1,000, 5,000, and 10,000 expansions demonstrated rice hull ash and dark hull ash appearance as tough edged angle particles with different sizes and uncertain forms.

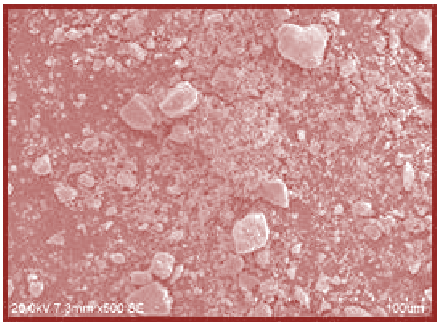

Figure 3: Rice hull ash and dark hull ash appearances at 10,000 expanded enlarged photos;

3.2 Chemical compositions

The chemical compositions of rice hull ash and dark hull ash shown in table 2 demonstrated the total SiO_2, Al_2O_3, and Fe_2O_3 with highest at 75.75% had the SO_3 less than 4% with the quantity of LOI (Loss on ignition) at 10.90%. It was assumed that the higher LOI quantity caused by the lower temperature in burning which might cause incomplete combustion and this affected to water

*Corresponding author (P. Sornchomkaew) Mobile: +66-86-330-3806. E-mail: phongphoom.sor@rmutr.ac.th.

molecule in rice hull ash and dark hull ash volatile at 550 degree Celsius and affected to higher LOI [5] as in Equation (1):

$$Ca(OH)_2 \xrightarrow{Burning\ at\ 550^{\circ}C} CaO + H_2O(\text{Gas}) \qquad (1)$$

According to the chemical compositions of rice hull ash and dark hull ash toward ASTM C618 Standard, it could be classified as Pozzolan Class N.

Table 2: Chemical compositions of rice hull ash and dark hull ash.

Oxide	% by Weight	Oxide	% by Weight
Na_2O	0.19	MnO	0.35
MgO	0.81	Fe_2O_3	4.48
Al_2O_3	2.19	Cuo	0.02
SiO_2	69.08	ZnO	0.04
P_2O_5	0.89	Br	< 0.01
SO_3	0.66	Rb_2O	0.01
Cl	0.69	SrO	0.03
K_2O	2.97	ZrO_2	0.03
CaO	6.40	PbO	0.01
TiO_2	0.19	LOI. At 1025°C	10.90
Cr_2O_3	0.02		

3.3 Testing for grain size distribution of fine aggregate

Comparing grain sizes of crushed dust used to replace sand in this study in the percentage proportion of 0, 10, 20, and 30 consequently were coded in S100D00, S90D10, S80D20, and S70D30 respectively. It was found similar sizes of these two materials in the beginning. During the sieving process, the crushed dust showed bigger size than sand which left on the sieve as more as the quantity of crushed dust. Finally, the two materials had similar left mass on the sieve in all proportions as showed in Figure 4.

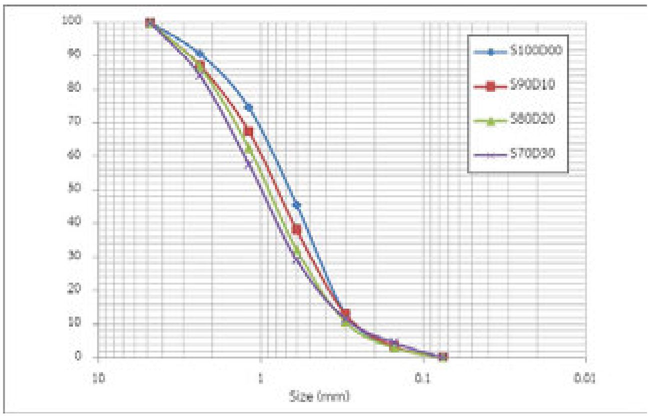

Figure 4: Grain size distribution of fine aggregate of crushed dust to replace sand;

3.4 Results of compared depth in chloride infiltration

This research was designed to mix rice hull ash and dark hull ash to replace cement in concrete mixture in the percentage proportion of 0, 10, 20, and 30 by weight which coded ranges for P100R00, P90R10, P80R20 and P70R30 and also the use of crushed dust to replace sand in concrete mixture in the percentage proportion of 0, 10, 20, and 30 by weight which coded ranges for

D00, D10, D20, and D30. The designed mixture in this study was compared to the standard concrete mixture in order to investigate the chloride infiltration in concrete by the implication of Colorimetric Technique.

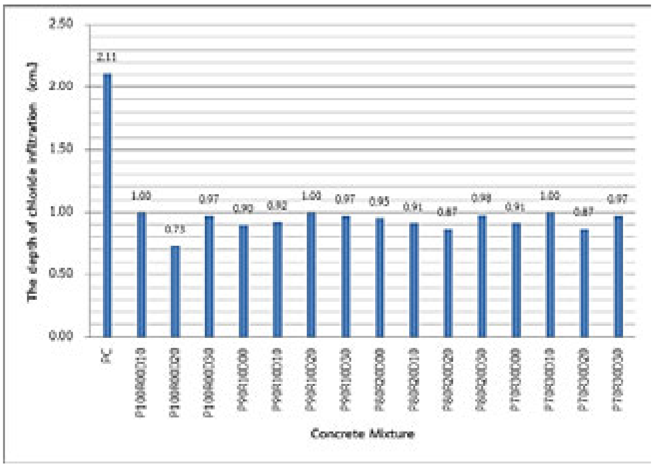

Figure 5: The depth of chloride infiltration into concrete mixed with rice hull ash, dark hull ash and crushed dust to replace sand.

The depth of chloride infiltration into sample concrete specimens which mixed with rice hull ash, dark hull ash and crushed dust to replace sand and placed in the marine environment for 90 days was less than in standard concrete. From Figure 5, the depth of chloride infiltration in standard concrete was 2.11 cm. only 0.73 to 1.00 cm. in the samples. The results significantly identified less of chloride infiltration in sample concrete specimens, than the standard concrete.

4. Conclusion

From the experiment, the following can be concluded

1) Testing of the grain size distribution in mixed materials which used crushed dust to replace sand in all proportion showed fine purified mixture with very less organic substances and the quantity of silt was less than 5% by the regulation of Engineering Institute of Thailand.

2) The study of particles appearance in rice hull ash and dark hull ash by Scanning Electron Microscope (SEM) in Electron Microscope and Analysis Microscope laboratory at National Metal and Materials Technology Center (MTEC) at the enlarge of 10,000 times demonstrated the appearances of rice hull ash which were tough edged angle particles with different sizes and uncertain forms.

3) The Chloride Infiltration in concrete specimens mixed with rice hull ash, dark hull ash and crushed dust to replace sand showed the least infiltration at 0.73 cm. in depth in the sample coded P100R00D20 which was the concrete specimen mixed with 0% of rice hull ash and dark hull ash by weight and mixed with 20% of crushed dust by weight.

4) The percentage of chloride infiltration in concrete specimen mixed with rice hull ash, dark hull ash and crushed dust was slightly decreased more than 50%. The least infiltration was at 0.73 cm. in depth or 65.4% compared to the chloride infiltration in standard concrete.

*Corresponding author (P. Sornchomkaew) Mobile: +66-86-330-3806. E-mail: phongphoom.sor@rmutr.ac.th.

5. Acknowledgements

This research was financially supported in Research Support Project by Rajamangala University of Technology Rattanakosin.

6. References

[1] ASTM, C. (2006). C136, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates, *Philadelphia, PA: American Society for Testing and Materials.*

[2] ASTM, C. (2003). C618, Standard specification for fly ash and raw or calcined natural pozzolan for use as a mineral Admixture in Portland Cement Concrete, *Philadelphia, PA: American Society for Testing and Materials.*

[3] ASTM, C. (1997). C29,Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate. *Philadelphia, PA: American Society for Testing and Materials*.

[4] Ninrat, P., & Chalee, W.) 2015). Evaluation of long term chloride penetration in concrete under marine environment by Bulk diffusion test method. *Burapha Science Journal*, *20*(1), 42-57.

[5] Jaturapitakkul, C., & Cheerarot, R. (2003). Development of bottom ash as pozzolanic material. *Journal of materials in civil engineering*, *15*(1), 48-53.

Phongphoom Sornchomkaew is a lecturer in Department of Civil Engineering, Faculty of Engineering and Architecture, Rajamagala University of Technology Rattanakosin Wang Klai Kang Won Campus, Prachaup Kiri Kan, Thailand. He holds a Master of Engineering degree from Thammasat University. His research focuses on technology applications to facilitate and foster civil engineering study.

Dr. Boonsap Witchayangkoon is an Associate Professor of Department of Civil Engineering at Thammasat University. He received his B.Eng. from King Mongkut's University of Technology Thonburi with Honors. He earned his PhD from University of Maine, USA in Spatial Information Science & Engineering. Dr. Witchayangkoon current interests involve applications of emerging technologies to engineering.

Dr. Sayan Sirimontree earned his bachelor degree from Khonkaen University Thailand, master degree in Structural Engineering from Chulalongkorn University Thailand and PhD in Structural Engineering from Khonkaen University Thailand. He is an Associate Professor at Thammasat University Thailand. He is interested in durability of concrete, repair and strengthening of reinforced and prestressed concrete structures.