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WATER PERMEABILITY OF CONCRETE MIXING ASH AND CRUSHED DUST

Phongphoom Sornchomkaew[a*], Kritsada Anantakarn [b], and Thongchai Phothong [c]

[a] *Department of Civil Engineering, Faculty of Engineering, Rajamangala University of Technology Rattanakosin, THAILAND.*
[b] *Department of Civil Engineering, Faculty of Engineering, Rajamangala University of Technology Tawan-ok, THAILAND*
[c] *Department of Civil Engineering, Faculty of Engineering, King Mongkut's University of Technology Thonburi, THAILAND*

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ABSTRACT

The objectives of the research studied the use of pozzolan and crushed dust as admixtures in general concrete for permeability. The replacement of Portland cement with palm oil waste ash by 0, 10, 20, and 30 percent by weight respectively, and replacement sand with crushed dust at levels of 100, 90, 80, and 70 percent by weight were determined. After 28 days of curing, the results showed suitable quantities of replacing cement with pozzolan waste ash is 30 percent by weight, and 100 percent replacement sand with crushed dust can improve the physical and mechanical properties of concrete. Ash and crushed dust can decrease the permeability of concrete by 1.50–3.30 time. Concrete replacement sand with crushed dust 100, 90, 80, and 70 percent by weight can decrease the permeability of concrete by 20 percent. The rate of the permeability in concrete is reduced in proportion to the increase of pozzolan ash and crushed dust.

1. INTRODUCTION

The use of natural rocks in the construction industry must be processed to be suitable to use. The limestone mountain must be blown, and then the rocks come into the milling process to obtain the required sizes. This process produces crushed dust which is very small and cannot pass through the sieve, the crushed dust will be blown out to pile aside as waste dust causing waste and cost keeping it in the place and carry away. Effects of replacement were studied e.g. by Sornchomkaew et al. (2018). by replacing natural sand in concrete mixture with rice hull ash, dark husk ash, and crushed dust.

The residue of palm fruit from agriculture which considered as waste can be used as fuel for steaming of water to generate electricity. This process leaves over the ash which has to carry away as this ash is dusty and disperse around. The ash may cause air pollution in surrounded environment area which cost money to solve this problem. Many recent pieces of the research reported that this dust could be used as a pozzolan in concrete work to replace cement. So this research was purposed to study the permeability in concrete mixed with bio-ash and crushed dust which encourage the compressive strength well. The concrete texture which had a mixture of dust, as observed, was rougher and had more porosity than the normal concrete. Hence, it was possible that this concrete might resist the water permeability less which is not a good concrete property. This research had tested by steady flow water passed through the concrete as the water could not pass through the concrete or could pass through slowly, meant the water had less damage to concrete. Since the fluid can pass through the concrete less, steel inside the concrete will cause less rusty as well.

Figure 1: Palm-oil ash obtained from the production process

2. MATERIALS

2.1 PALM-OIL ASH

The palm-oil ash used in this research study was derived from the burning process for the fuel production in the palm-oil mill in Chon Buri Province. The result from physical properties analysis found that the specific gravity of palm-oil ash was 2.25 and the moisture content was 45.31%. Considering the physical characteristic of the palm-oil ash using high magnification by Scanning Electron Microscope: SEM of palm-oil shell ash from X-Ray Fluorescence Analysis (XRF) from the laboratory of the Department of Science Service which magnified of 100 times. It was found that the particles from palm-oil ash were in uncertain shape, lumpy, non-layered round, and porous. When the palm-oil shell as was magnified at 1,000 times, it was found the ash appeared as round grains, rugged surface, and porous.

Table 1: Chemical property of palm-oil ash.

Oxide	Percent by weight (%)
	Palm-oil ash
SiO_2	54.05
Al_2O_3	13.06
Fe_2O_3	1.02
CaO	7.85
MgO	5.24
SO_3	2.32
Other oxides	-
LOI.	10.80

From the chemical properties analysis of palm-oil ash in Table 1, whereas the sum of silicon dioxide SiO_2, aluminum oxide AI_2O_2 and iodide oxide Fe_2O_3 in palm-oil ash; the amount was 68.1%, the sulfur trioxide SO_3 was 2.32% and the loss on ignition was 10.80%. Considering the chemical composition of the palm-oil ash according to ASTM C628 standard, it can be classified as Class N pozzolan which is natural pozzolan material.

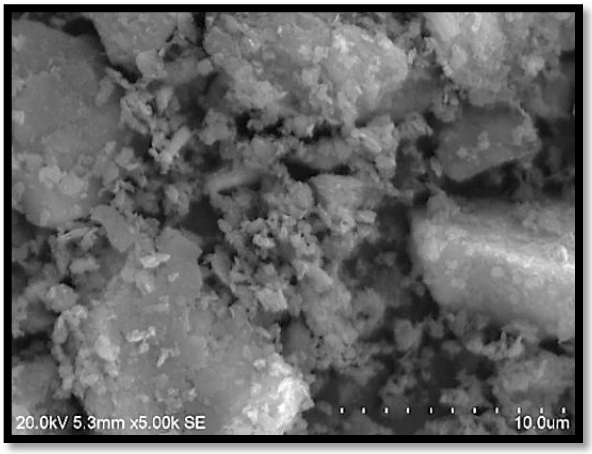

Figure 2: Physical appearance of palm-oil ash.

2.2 CRUSHED DUST AND SAND

Crushed dust which was used in this research study had tested properties according to ASTM C628 standard by testing the grain size analysis of fine aggregate with the sieve analysis which resulted in values of Cu = 24 and Cc = 3.58. The test of organic impurities in fine aggregate for organic matter determination by using indicator papers comparing with bottle liquid, from comparing the color of indicator papers of 3 % concentrated sodium hydroxide over the crushed dust samples with the standard color, resulting in a lighter color than the standard color. Hence, this crushed dust was appropriate to use.

Figure 3: Crushed dust.

The sand used in this research had the following chemical properties; SiO_2 = 98.8%, AI_2O_3 = 0.2%, Fe_2O_3 = 0.07%, Cao = 0.4% and MgO = 0.08%. From the grain size analysis of fine aggregate by sieve analysis to compare the standard size of fine aggregate and crushed dust was showed the beginning of the line and the end of the line showed the similar value of the standard and crushed dust.

But the value in the middle hold more space which meant that in the beginning the crushed dust remained the same as standard value in the sieve and then hold more space in the middle when the crushed dust had bigger grain sizes, after that it came close to standard value again at the end since that it had similar percentage value of size as both crushed dust and sand shared the similar quantities.

3. EXPERIMENTAL DETAILS

3.1 CONCRETE MIX DESIGN

To test the concrete permeability, the sample concrete was mixed and cast as the trial-and-error design of water proportion toward palm-oil ash and crushed dust. The designed compressive strength was 250 Kilogram per square centimeter (ksc) and the concrete slump was from 5cm to 10cm according to ACI211 standard as shown in Table 2

Table 2: Proportion of Concrete Mixtures

Code	Mixture Material (kg/m^3)					
	Cement	Palm-oil ash	Sand	Crushed Dust	Stone	Water
C-PC	347	-	842	-	881	215
C-100-0	347	-	-	842	881	204
C-100-10	312	35	-	842	881	205
C-100-20	278	69	-	842	881	206.5
C-100-30	243	104	-	842	881	208
C-90-0	347	-	84	758	881	204.5
C-90-10	312	35	84	758	881	205
C-90-20	278	69	84	758	881	206
C-90-30	243	104	84	758	881	208
C-80-0	347	-	168	674	881	205
C-80-10	312	35	168	674	881	206.5
C-80-20	278	69	168	674	881	208
C-80-30	243	104	168	674	881	210
C-70-0	347	-	253	589	881	205.5
C-70-10	312	35	253	589	881	207
C-70-20	278	69	253	589	881	208
C-70-30	243	104	253	589	881	210

3.2 WATER PERMEABILITY OF CONCRETE

The testing of concrete permeability in the concrete sample aged 28 days, the cylindrical concrete sample was cut at a longitudinal center with a thickness of 4 centimeters. The casted epoxy of 2.5 cm thickness around the side surface of the cut concrete sample and left for 24 hours. After that, the block shell was assembled underwater with the pressure of 5 bars, then brought to set at the testing machine as shown in Figures 4, 5, 6.

Figure 4: Assembled Epoxy.

Figure 5: Underwater assembled block shell. **Figure 6**: Settled block shell at a testing machine

4. DISCUSSION

The result of concrete permeability which was the main objective of this research was concluded in Table 3. It was found that the controlled concrete C-PC code 28 days of curing, the coefficient of permeability was 1.202 × 10-2 m/s. Whereas, the concrete which mixed with 0% palm-oil ash and 100, 90, 80, 70 % of crushed dust replacement of sand showed the coefficient of permeability of concrete 28 days of curing at C-100-0, C-90-0, C-80-0, and C-70-0 code. At 28 days of curing concrete, the coefficient of permeability was 9.708×10^{-13}, 9.810×10^{-13}, 9.903×10^{-13} and 1.001×10^{-12} m/s respectively. To explain this result, the permeability was decreased because crushed dust had more fine particles than the fine aggregate which helped to fill the void in the concrete and resulting in higher density in concrete mixed by crushed dust as shown in Table 3.

Table 3: Results of permeability testing in concrete with all cement mixture and with crushed dust mixture instead of sand

Code	Water Permeability of Concrete at 28 days (m/s)
C-PC	1.202×10^{-12}
C-100-0	9.708×10^{-13}
C-90-0	9.810×10^{-13}
C-80-0	9.903×10^{-13}
C-70-0	1.001×10^{-12}

In addition, it was found that the concrete using palm-oil ash instead of cement at 0, 10, 20, and 30 mixed with all crushed dust instead of sand could decrease the coefficient permeability at the code of C-100-0, C-100-10, C-100-20 and C-100-30 was 9.708×10^{-13}, 6.104×10^{-13}, 4.583×10^{-13}, and 3.645×10^{-13} m/s respectively. Because of the finer particles of palm-oil ash and calcium silicate hydrate which reacted with pozzolan helped fill the void and resulted in concrete mixed with palm-oil ash and crushed dust to obtained more density and higher impermeability as shown in Table 4.

Table 4: Result of permeability testing of concrete mixed with 100 % crushed dust instead of sand

Code	Water Permeability of Concrete at 28days (m/s)
C-PC	1.202×10^{-12}
C-100-0	9.708×10^{-13}
C-100-10	6.104×10^{-13}
C-100-20	4.583×10^{-13}
C-100-30	3.645×10^{-13}

5. CONCLUSION

The research studies the permeability in concrete that mixed with pozzolan as palm-oil ash instead of cement and crushed dust instead of sand. The study finds that the replacement of crushed dust instead of fine aggregate at 100%, 90%, 80%, and 70% by weight in concrete with 28 days of curing could make less coefficient of permeability than in controlled concrete at 1.20 to 1.24 times. Also, the replacement of palm-oil ash and crushed dust instead of cement and fine aggregate in concrete with 28 days of curing could make less coefficient of permeability than in controlled concrete at 1.50 to 3.30 times. From the laboratory experiment, the best proportion of using palm-oil ash instead of cement and crushed dust instead of fine aggregate to obtain well impermeability was 30% of palm-oil ash and 100% of crushed dust by weight.

6. DATA AVAILABILITY STATEMENT

The used or generated data and the result of this study are available upon request to the corresponding author.

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Phongphoom Sornchomkaew is a Lecturer at 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. Kritsada Anantakarn is a Lecturer at the Department of Civil Engineering Technology, Faculty of Engineering and Architectures, Rajamongala University of Technology Tawan-ok, Uthenthawai Campus, Thailand. He earned his Bachelor of Engineering (Civil Engineering) from Faculty of Engineering Rajamangala Institute of Engineering, and a Master's degree in of Urban and Environmental Planning from King Mongkut's Institute of Technology Ladkrabang, and a PhD from Thammasat University. He is interested in GPS/GNSS and spatial technology.

Dr. Thongchai Phothong is a Lecturer at Department of Civil Engineering Department, Faculty of Engineering, King Mongkut's University of Technology Thonburi (KMUTT). He is at KMUTT. He earned his Bachelor Degree (Civil Engineering) from King Mongkut's University of Technology Thonburi (KMUTT), Thailand, and Master Degree in Geotechnical Engineering also from KMUTT. He earned his PhD from Thammasat University. He is interested in spatial technology and applications.