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EFFECT OF NANO BLACK RICE HUSK ASH ON THE CHEMICAL AND PHYSICAL PROPERTIES OF POROUS CONCRETE PAVEMENT

Mohd Fadzil Arshad[a], Haryati Awang[b], Ramadhansyah Putra Jaya[b,*], Mohamad Idris Ali[b], Mohd Ibrahim Mohd Yusak[c], Mohd Rosli Hainin[c], Mohd Haziman Wan Ibrahim[d]

[a]Institute for Infrastructure Engineering and Sustainable Management, Faculty of Civil Engineering, Universiti of Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia
[b]Faculty of Civil Engineering and Earth Resources, Universiti Malaysia Pahang, 26300 Gambang, Pahang, Malaysia
[c]School of Civil Engineering, Faculty of Engineering, Universiti Teknologi Malaysia, 81310 Johor Bahru, Malaysia
[d]Faculty of Civil and Environmental Engineering, Department of Material and Structure Engineering, Universiti Tun Hussein Onn Malaysia, 86400 Batu Pahat, Johor Bahru, Malaysia

Abstract
Black rice husk is a waste from this agriculture industry. It has been found that majority inorganic element in rice husk is silica. In this study, the effect of Nano from black rice husk ash (BRHA) on the chemical and physical properties of concrete pavement was investigated. The BRHA produced from uncontrolled burning at rice factory was taken. It was then been ground using laboratory mill with steel balls and steel rods. Four different grinding grades of BRHA were examined. A rice husk ash dosage of 10% by weight of binder was used throughout the experiments. The chemical and physical properties of the Nano BRHA mixtures were evaluated using fineness test, X-ray Fluorescence spectrometer (XRF) and X-ray diffraction (XRD). In addition, the compressive strength test was used to evaluate the performance of porous concrete pavement. Generally, the results show that the optimum grinding time was 63 hours. The result also indicated that the use of Nano black rice husk ash ground for 63hours produced concrete with good strength.

Keywords: Nano; BRHA; Concrete; Pavement; Chemical; Physical.

摘要

黑米殼是這個農業的廢物。已經發現它是二氧化矽。這是對黑米皮灰（BRHA）的研究。採取了由米廠不受控制的燃燒產生的 BRHA。然後用實驗室棒研磨。檢查了四種不同研磨等級的 BRHA。在整個實驗中使用 10kg 粘合劑。使用細度測試，X 射線熒光光譜儀（XRF）和 X 射線衍射（XRD）評估 BRHA 混合物。另外，使用抗壓強度試驗。一般來說，這是 63 個小時。還表明它是在黑米下生產的。

关键词:

納米; 黑米殻灰;混凝土;路面;化工;物理

I. INTRODUCTION

Recently, environmental issues have become a matter of global concern. Because of the environmental benefits, porous concrete has become increasingly used in a variety of infrastructures, pavements and overlays subjected to heavy traffic load. Due to these extended applications, superior strength and durability constitute the main concerns associated with porous concrete [1]. Over the years, developed countries have started to use porous concrete pavement as a solution for storm-water runoff on the road pavement. In addition to its characteristic of allowing water through its structure, porous concrete pavement has the capacity to absorb noise generated from vehicles and other sources.

Porous concrete pavement is well known as concrete with limited or no fine aggregates that have a high percentage of porosity in their structure. The concept of the concrete is indicative of the fact that the void in the concrete structure tends to decrease the strength of the concrete. According to the Specifier's Guide for Pervious Concrete Pavement Design, the recommended structure's void of the porous concrete is 15% minimum and 25% maximum. This high percentage of voids tends to lower the strength of the concrete.

At present, many waste materials have been processed and used in concrete mixtures in order to improve their performance, such as rice husk ash [2], palm oil fuel ash [3], fly ash [4], bottom ash [5], slag and many more [6,7]. Each of these materials contained silica or alumina capable of improving the performance in concrete [8]. However, very limited information is available on concrete pavement containing black rice husk ash (BRHA), specifically in relation to porous concrete pavement. In addition, no research has been conducted in order to evaluate the effects of porous concrete pavement incorporating Nano from the BRHA. Hence, the black rice husk ash (BRHA) was selected as a replacement material in the porous concrete pavement mixture. This material contained high silica that was needed in the concrete reaction in order to improve the performance. In line with the research concept to reuse the waste material, the use of the BRHA in the porous concrete pavement mixture tends to decrease the production of waste material globally and provides benefits to the pavement industries.

II. MATERIALS AND METHODS

A. Materials

Type I ordinary Portland cement (OPC) was used as the major binder material in this study. The cement used was supplied by Tasek Corporation Sdn. Bhd in one batch for the entire experimental works. Furthermore, water is an important material for hydration process in cement paste. To produce good quality of hardened cement paste, the water must not contain any substance that might affect the chemical reaction between cement and water.

B. BRHA and grinding procedure

Nano material was produced from the black rice husk ash (BRHA). The black rice husk ash was ground using laboratory ball mill with porcelain balls. The BRHA was ground into four lots. The original BRHA was generally designated as BRHA0; further explanation exhibited in Table 1.

Table 1.Grinding designation of nano BRHA

Types of Nano BRHA	Grinding Time (hours)
NS1	33
NS2	48
NS3	63
NS4	81

C. Physical and chemical characteristic

In this study, the fineness of OPC and Nano BRHA, expressed as specific surface area, was determined by the nitrogen absorption test (BET). Where the mean particle size distribution of OPC and BRHA were carried out using HELOS particle size analyses, HELOS (H1938) and RODOS, R5: 0.5/4.5…875 µm. In addition, the chemical analysis of the OPC and Nano BRHA used in this study was conducted using the X-ray Fluorescence spectrometer (XRF), X-ray diffraction (XRD), respectively.

D. Mix proportions and curing

A control mix was prepared using OPC. Nano BRHA replacement level of 10%by weight of cement was applied. The mixes were designed to achieve concrete pavement grade of 20 N/mm^2 at 28 days. Amass water-to-binder ratio of 0.34 was used. At laboratory, materials were first mixed for 30 seconds under dry condition. The water was then added into bowl and the mixing was performed for another 1.5 minutes. Then the specimen was casted in the mould. Immediately after casting process, the specimens were kept and cover by wet cloth to avoid moisture loss. After 24 hours, the specimens were transferred for curing in the water until testing time.

E. Compressive strength test

Compressive strength testing was carried out on concrete cubes of size 100 3 100 3 100 mm. During moulding, the cubes were mechanically vibrated. After 24 h, the specimens were removed from the mould and subjected to water curing for 7 and 28 days. After a specified period of curing, the specimens were tested for compressive strength using an AIMIL compression testing machine of2000 kN capacity at a rate of loading of 140 kN/min. The test was conducted according to the British standard test method BS EN 12390-3 [9].

III. Results and Discussion

A. Fineness

The fineness or the surface area of the Nano BRHA and cement was measured using nitrogen gas by BET. Figure 1 shows the specific surface area for cement and Nano BRHA with different grinding times. From the figure, it can be seen that the cement has the smallest specific surface area. The specific surface areas for all samples are 1.63 m^2/g, 6.15 m^2/g, 6.85 m^2/g, 7.74 m^2/g and 8.58 m^2/g for OPC, 33hrs, 48hrs, 63hrs and 81hrs, respectively. The graph shows that the largest specific surface area is Nano BRHA with 81 hours grinding time. While the smallest specific surface area for Nano BRHA is the specimen with 33 hours grinding time. Compared to OPC, the specific surface area for the Nano BRHA samples increases with 277.3%, 320.2%, 374.8% and 442.9% for 33hrs, 48hrs, 63hrs and 81hrs grinding time, respectively. The specific surface area of Nano BRHA increases with the increase in grinding time.

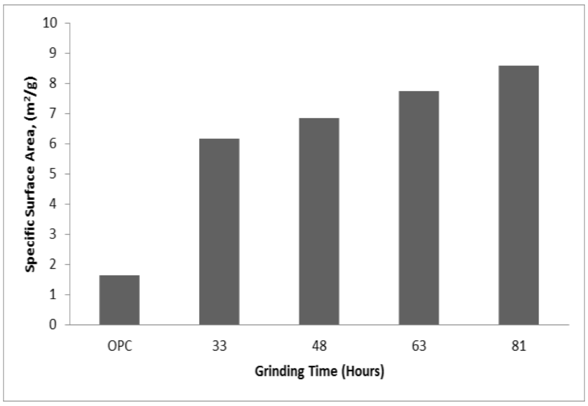

Figure 1. Specific surface area for cement and Nano BRHA

B. Particle size

Figure 2 shows the effect of the grinding time to the mean particle size of nano-silica. Compared to NS1, the other nano BRHA sizes decrease to 10.6%, 22.4% and 24.7% for NS2, NS3 and NS4, respectively. It clearly shows that an increase in the grinding time will decrease the mean particle size of nano-silica. It is because the increase in grinding time will increase the grinding effort to the BRHA.

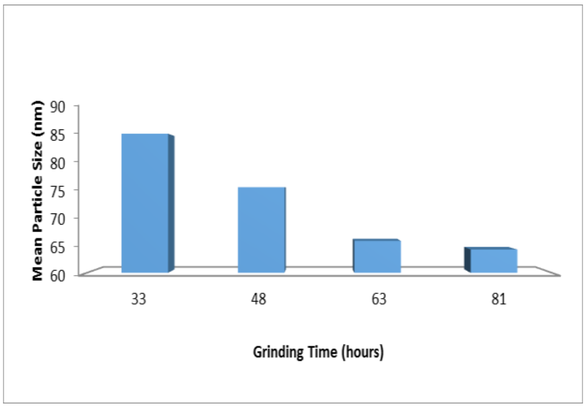

Figure 2. Effect of grinding time on the mean particle size of Nano BRHA

C. Chemical composition

Table 1 shows the chemical composition of OPC and BRHA. It was found that the calcium oxide had the highest percentage of composition in OPC, namely 62.27 % followed by silica at 22.68 %.The other elements had a small percentage of 4.72 %, 3.5 %, 1.89 %, 0.31 % and 4.29 % for alumina, iron oxide, magnesium oxide, potassium oxide and sulphur trioxide, respectively. From the result obtained, the chemical composition for OPC fulfilled the standard composition requirements as stated in the Standard Specification for Portland cement [10]. While for the BRHA, it contained high percentage of silica of 91.33 %. The other elements in BRHA are alumina, iron oxide, magnesium oxide, sodium oxide, potassium oxide and sulphur trioxide, which contained 0.07%, 0.07%, 0.45%, 0.28%, 0.01%, 2.64% and 0.05%, respectively. According to ASTM C618 [11], the BRHA used in this study satisfied the Class N requirement for natural pozzolan used in concrete, which indicates that the total amount of silicon dioxide, aluminum oxide and iron oxide must be equal or greater than 70%.

Table 1. Chemical composition of OPC and BRHA

Oxides	OPC	BRHA
SiO_2	22.68	91.33
Al_2O_3	4.72	0.07
Fe_2O_3	3.5	0.07
CaO	62.27	0.45
MgO	1.89	0.28
Na_2O	-	0.01
K_2O	0.31	2.64
SO_3	4.29	0.05

D. Mineralogical and phase identification

The result for x-ray diffraction (XRD) of ordinary Portland cement (OPC) is shown in

Figure 3. It can be observed that the main components in OPC are Alite and Belite. This result has confirmed the XRF result for OPC, indicating that the major constituents are calcium and silica. According to Poulsen et al. [12], the hydraulic properties of Portland cement are mainly related to alite and belite, which are impure forms of the calcium silicates Ca_3SiO_5 (C_3S) and Ca_2SiO_4 (C_2S), respectively. Both of these silicates will react in the cement hydration process to strengthen its structure. Figure 4shows the X-ray diffraction analysis result of the black rice husk ash. From the figure, it may be inferred that the highest intensity peak located at 21.84° 2θ is silicon oxide (SiO_2). It indicates that the major composition in the black rice husk ash material is silica. This result confirmed the XRF result for black rice husk ash in Table 4.4, where silica is the major element in the black rice husk ash.

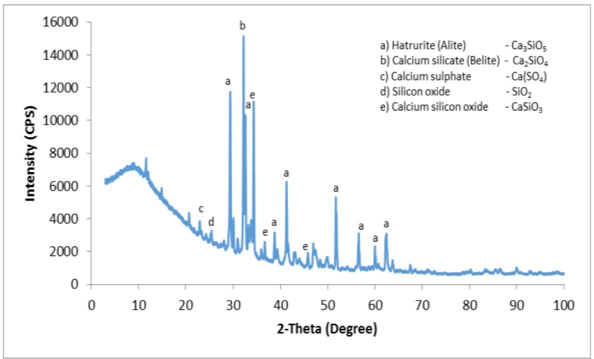

Figure 3. X-ray diffraction of ordinary Portland cement

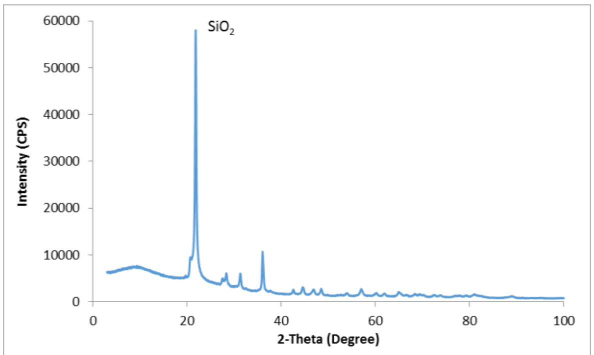

Figure 4. X-ray diffraction of black rice husk ash

E. Compressive strength

Figure 5 shows the compressive strength of the porous concrete specimens containing OPC and Nano BRHA at different grinding times. The test results indicate that the compressive strength of the porous concrete specimen containing NS3 is higher between the other NS's for both 7 and 28 days. However, it is slightly lower than the compressive strength of the OPC. The compressive strength of the porous concrete containing OPC and NS3 at 7 days is 16.12 MPa and 14.36 MPa respectively. While for 28 days, the compressive strength for porous concrete containing OPC and NS3 is 21.18 MPa and 18.99 MPa. The lowest strength for both specimens at 7 and 28 days age are NS1, which is 8.38 MPa and 12.49 MPa, respectively. Furthermore, from the figure, it can be observed that the compressive strength of the porous concrete increased with the increasing grinding time. This finding is supported by Ramadhansyah et al. [13], where they found that the compressive strength of concrete increases with the increasing of the rice husk ash grinding time, and then the compressive strength decline after the peak value is reached.

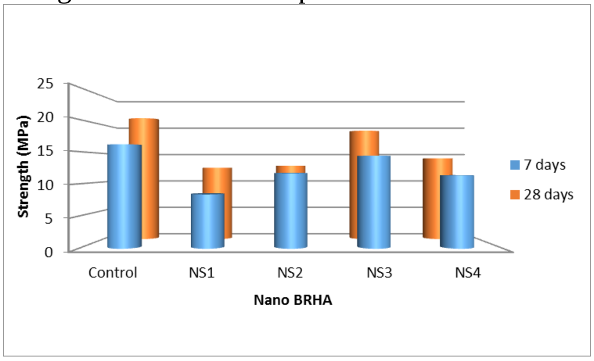

Figure5. Compressive strength of pavement concrete containing Nano BRHA

IV. Conclusion

- The fineness of BRHA increased with increased grinding time. The results also indicate that the cement has the smallest specific surface area compared to Nano BRHA. In addition, increase in the grinding time was decrease the mean particle size of Nano BRHA.
- Generally, it was found that the OPC had the highest percentage of calcium oxide where BRHA contained high percentage of silica.
- The use of NS3 resulted in good strength development in comparison with the other BRHAs ground for different times.
- There appears to be an optimum BRHA grinding time of approximately 63 hours, for which compressive strength increased significantly.

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