UNIVERSITI PUTRA MALAYSIA

EFFECTS OF NANO TiO2 ON PROPERTIES OF RICE HUSK ASH MORTARS

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By

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

July 2013

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DEDICATIONS

I would like to dedicate this project to all those who have helped me to complete it.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

EFFECTS OF NANO TiO_2 ON PROPERTIES OF RICE HUSK ASH MORTARS

By

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July 2013

Chairman: Professor Dato' Abang Abdullah Abang Ali, IR

Faculty: Engineering

Abstract: The effect of nano TiO_2 on untreated rice husk ash (RHA) mortars was investigated. The enhancement effect of treated RHA as a cement replacement on properties of cement composites has been extensively studied whereas the use of field burnt and untreated RHA has shown undesirable effect on the characteristics of cement-based materials due to the weak pozzolanic nature of untreated RHA. In this study, field burnt black rice husk ash denoted as BRHA was used as cement replacement in fractions of 10%, 20% and 30% of the mortar volume. To compensate the adverse effect of BRHA, 0.5%, 1% and 1.5% nano TiO_2 were added into BRHA cement mortars. The mechanical properties were studied using the compression test and the results compared to a non-destructive method using ultrasonic pulse velocity at the age of 7, 28 and 90 days of curing. Water absorption and SEM tests were performed to study microstructural changes of hardened cement mortars at 7, 28 and 90 days. XRD, TGA and DSC tests were carried out to investigate the chemical composition of BRHA mortars with and without nano

TiO_2. The results indicated that incorporating nano TiO_2 in blended cement with BRHA improved the mechanical properties and microstructure of BRHA mortars. Among the three different fractions of nano TiO_2, addition of 1.5% nano TiO_2 produced the highest value of compressive strength at all ages in comparison with 0.5% and 1% of nano TiO_2-BRHA mixtures. For example, compressive strength of 10% BRHA mix with 1.5% nano TiO_2 was 13% higher than that of control sample at 28 days. This was attributed to better particle packing of BRHA mortars with the presence of 1.5% nano TiO_2. SEM images indeed showed improvement in the interfacial transition zone (ITZ) and density microstructure of BRHA mortars containing 1.5% nano TiO_2. Moreover, a higher rate of pozzolanic activity of BRHA mortars was observed when 1.5% nano TiO_2 was added. XRD results showed higher degree of CH consumption for BRHA mortars containing 1.5% nano TiO_2 in comparison with BRHA mortars at 28 days. TGA results further confirmed the better pozzolanic behaviour for 1.5% nano TiO_2-BRHA mixes compared to BRHA mixes with and without 0.5% and 1% nano TiO_2. The results from DSC indicated that the well-crystalline structure of CH compound of BRHA mixes was transformed to the ill-crystalline phase when nano 1.5% TiO_2 was added, which accounts for the superior pozzolanic activity of BRHA mortars with presence of 1.5% nano TiO_2.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

KESAN NANO TiO_2 DALAM SIFAT-SIFAT MORTAR ABU SEKAM PADI

Oleh

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Abstrak: Kesan nano TiO_2 terhadap mortar abu sekam padi (RHA) telah dikaji. Penambahan kesan RHA yang diproses sebagai pengganti simen di dalam sifat-sifat komposit simen telah dikaji secara meluas di mana penggunaan RHA yang dibakar dan tidak diproses telah menunjukkan kesan yang tidak diingini terhadap ciri-ciri bahan berasaskan simen disebabkan sifat pozzolanik yang lemah RHA yang tidak diproses. Di dalam kajian ini, abu sekam padi hitam yang dikenali sebagai BHRA telah digunakan sebagai pengganti simen dalam pecahan-pecahan 10, 20 dan 30% daripada isipadu mortar. Untuk mengimbangi kesan buruk BRHA, 0.5, 1 dan 1.5% nano TiO_2 telah dicampur ke dalam campuran BRHA simen mortar. Sifat-sifat mekanikal telah dikaji dengan menggunakan ujian mampatan dan keputusan yang diperolehi telah dibandingkan dengan kaedah tanpa musnah dengan menggunakan halaju denyut ultrasonik pada umur 7, 28 dan 90 hari pengawetan. Penyerapan air dan SEM telah diukur untuk mengkaji perubahan mikrostruktur mortar simen keras pada 7, 28 dan 90 hari. Ujian-ujian XRD, TGA dan DSC dijalankan untuk menyiasat komposisi kimia mortar BRHA dengan dan tanpa kehadiran nano

TiO_2. Analisis XRD dan SEM telah dilakukan pada umur 7 dan 28 hari dan analisis terma (TGA-DSC) telah dijalankan untuk mengkaji kesan umur lanjut pada hari ke-90. Keputusan menunjukkan nano TiO_2 yang telah dicampur ke dalam campuran BRHA-simen telah menambahbaik sifat-sifat mekanikal dan mikrostruktur mortar BRHA. Nano TiO_2 telah mempercepatkan proses penghidratan oleh fungsi penukleusan nano TiO_2 dan menambahbaik mikrostruktur ITZ berdasarkan kesan pengisian nano TiO_2. Di antara tiga pecahan nano TiO_2 tersebut, penambahan sebanyak 1.5% nano TiO_2 menghasilkan nilai kekuatan mampatan paling tinggi pada semua peringkat umur berbanding dengan 0.5% dan 1% daripada campuran nano TiO_2 BRHA. Sebagai contoh, kekuatan mampatan untk campuran 10% BRHA dengan 1.5% nano TiO_2 adalah 13% lebih tinggi daripada sampel kawalan pada 28 hari. Ini telah disebabkan oleh pengisian partikel mortar BRHA lebih baik dengan kehadiran 1.5% nano TiO_2. Imej SEM sememangnya menunjukkan peningkatan zon transisi antara muka dan ketumpatan mikrostruktur mortar BRHA yang mengandungi 1.5% nano TiO_2. Tambahan lagi, kadar aktiviti pozzolanik mortar BRHA yang tinggi diperhatikan apabila 1.5% nano TiO_2 ditambah. Keputusan XRD menunjukkan darjah penggunaan CH yang tinggi unutuk mortar BRHA yang mengandungi 1.5% nano TiO_2 dibandingkan dengan mortar BRHA pada 28 hari. Keputusan TGS mengesahkan bahawa kelakuan pozzolanik lebih baik untuk 1.5% campuran nano TiO_2-BRHA berbanding dengan campuran BRHA dengan dan tanpa 0.5% dan 1% nano TiO_2. Keputusan daripada DSC menunjukkan bahawa struktur kristal elok sebatian CH daripada campuran BRHA telah bertukar kepada fasa kristal yang tidak elok apabila 1.5% nano TiO_2 telah dicampurkan menunjukkan aktiviti pozzolanik mortar BRHA yang unggul dengan kehadiran 1.5% nano TiO_2.

ACKNOWLEDGEMENTS

My utmost gratitude goes to God. I would like to express a special thanks to my academic advisor Professor Dato' Abang Abdullah Abang Ali. It was a well rewarding experience to have been under his supervision. I deeply appreciate his patient instructions and continuous support he has given me during my study and research. I am also graceful to my supervisory committee member, Prof. Dr. Ramazan Demirboga and Dr. Farah Nora Aznieta Binti Abd Aziz. I warmly thank Dr. Nima Farzadnia for his generous contributions and invaluable advices to my research. I would like to thank HRC staff and technicians for their collaborations. I would especially like to thank all my friends for their supports during the difficult moments of my research.

On a personal note, a special thanks goes to my beloved brother Hossein Noorvand for his kind support and encouragement to complete this research. I owe my loving thanks to my beloved parents for having faith in me.

I certify that a Thesis Examination Committee has met on 12 July 2013 to conduct the final examination of Hassan Noorvand on his thesis entitled "Effects of Nano TiO_2 on Properties of Rice Husk Ash Mortars" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Degree of Master of Science.

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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

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Date: 12 July 2013

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