



UNIVERSITI PUTRA MALAYSIA

**PHYSICAL AND CHEMICAL PROPERTIES OF
UNGROUND PALM OIL FUEL ASH MORTARS
INCORPORATING NANO-SiO₂**

HOSSEIN NOORVAND

FK 2013 37



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UNIVERSITI PUTRA MALAYSIA
BERILMU BERBAKTI

**PHYSICAL AND CHEMICAL PROPERTIES OF
UNGROUND PALM OIL FUEL ASH MORTARS
INCORPORATING NANO-SiO₂**

By

HOSSEIN NOORVAND

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

**PHYSICAL AND CHEMICAL PROPERTIES OF UNGROUND
PALM OIL FUEL ASH MORTARS INCORPORATING NANO-SiO₂**

By

HOSSEIN NOORVAND

July 2013

Chairman: Professor Dato' Abang Abdullah Abang Ali, IR

Faculty: Engineering

Abstract: Palm oil fuel ash (POFA) is an abundant agro-waste material obtained from palm oil process. The produced POFA in the mills has large particle size and porous structure which adversely affects the microstructure and pozzolanic reactivity of cementitious mixes, thus grinding process is suggested which can be considered as a physical treatment for morphology of original sized POFA. However, the purpose of this study was to overcome the detrimental effect of morphology of unground POFA (UPOFA) on cement mixtures by incorporation of small amount of nanosilica (NS). In particular, this study was aimed to investigate the effect of 0.5-1.5% NS on the physical and chemical properties of hardened cement mortars containing 10-30% UPOFA. Flowability of fresh samples, and mechanical properties (studied by compression and UPV tests) and microstructural changes (investigated by water absorption, permeable void ratio and SEM tests) of hardened mortars at 7, 28 and 90 days were examined to determine the physical properties of mixes. Furthermore, to trace the chemical composition changes of UPOFA

cement mortars with and without NS, X-Ray diffraction analysis (XRD) was carried out at 7 and 28 days, and thermo gravimetric analysis (TGA) was conducted at 90 days. The results revealed incorporation of NS compensated the adverse effect of UPOFA on the flowability, mechanical properties and microstructure of mortars. Admixing only 0.5% NS increased the compressive strength of UPOFA by 11% higher than control sample at 28 days. Besides, incorporation of 0.5% NS augmented the replacement level of UPOFA up to 20% with almost comparable strength to control mortar. Microstructural studies indicated that admixing NS caused remarkable improvement in the porosity and density microstructure of the UPOFA mixes. Significant enrichment within ITZ microstructure of mixes was also observed from SEM images. Moreover, XRD pattern indicated that incorporating NS enhanced pozzolanic reactivity of UPOFA mortars which could further improve the density of matrix. However, no noteworthy enhancement in the compressive strength of UPOFA mortars with NS was observed at 90 days which was also verified by analyzing the CH content using TGA test. It was also observed that lower amount of NS was more effective at enhancing the properties of UPOFA mortars in the course of hydration.

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

**SIFAT-SIFAT FIZIKAL DAN KIMIA MORTAR SIMEN ABU
KILANG KELAPA SAWIT DENGAN NANO-SiO₂**

Oleh

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Julai 2013

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Abstrak: Abu sisa kelapa sawit (POFA) adalah bahan sisa pertanian yang banyak hasil daripada proses minyak kelapa sawit. POFA yang dihasilkan di kilang-kilang mempunyai saiz partikel yang besar dan struktur berliang di mana memberi kesan buruk kepada mikrostruktur dan tindak balas pozzolana terhadap campuran simen. Oleh itu proses pengisaran dicadangkan di mana ia boleh dipertimbangkan sebagai rawatan fizikal terhadap morfologi saiz asal POFA. Walau bagaimanapun, tujuan kajian ini adalah untuk mengatasi kesan mudarat terhadap morfologi POFA yang tak dikisar (UPOFA) pada campuran-campuran simen dengan penggabungan sejumlah kecil nanosilica (NS). Secara terperinci, kajian ini ni bertujuan untuk menyiasat kesan 0.5-1.5% NS terhadap sifat-sifat fizikal dan kimia mortar-mortar simen terkeras yang mengandungi 10-30% UPOFA. Kebolehaliran sampel-sampel baru dan sifat-sifat mekanikal (kajian melalui ujian mampatan dan UPV) dan perubahan mikrostruktur (kajian melalui penyerapan air, nisbah liang resapan dan SEM) terhadap mortar-mortar terkeras pada 7, 28 dan 90 hari telah dikaji untuk menentukan sifat-sifat fizikal campuran. Sebagai tambahan, untuk mengesan pe-

rubahan komposisi kimia simen mortar UPOFA dengan dan tanpa NS, Analisis Pembelauan X-Ray (XRD) dijalankan pada 7 dan 28 hari dan Analisis Thermo gravimetric (TGA) telah dijalankan pada 90 hari. Keputusan-keputusan menunjukkan penggabungan NS mengurangkan kesan buruk pada UPOFA dalam kebolehaliran, sifat-sifat mekanikal dan mikrostruktur mortar-mortar. Hanya 0.5% percampuran NS telah meningkatkan kekuatan mampatan UPOFA sebanyak 11% lebih tinggi daripada sampel kawalan pada 28 hari. Di samping itu, penggabungan sebanyak 0.5% NS telah menambah aras penggantian UPOFA kepada 20% hampir dengan kekuatan mortar kawalan. Kajian mikrostruktur telah menunjukkan penambahan NS telah menyebabkan penambahbaikan yang ketara dalam keliangan dan ketumpatan mikrostruktur campuran UPOFA. Pengkayaan yang ketara di dalam zon transisi antara muka (ITZ) campuran telah diperhatikan daripada imej SEM. Tambahan lagi, pola XRD menunjukkan bahawa penggabungan NS menggalakkan tindak balas pozzolana mortar-mortar UPOFA di mana ia boleh mempertingkatkan ketumpatan matriks. Walau bagaimanapun, tiada peningkatan ketara dalam kekuatan mampatan mortar-mortar UPOFA dengan NS diperhatikan pada 90 hari di mana ia juga dibuktikan dengan menganalisis kandungan CH menggunakan ujian TGA. Didapati juga bahawa jumlah NS yang rendah lebih berkesan dalam penambahbaikan sifat-sifat mortar UPOFA semasa penghidratan.

ACKNOWLEDGEMENTS

My first and foremost appreciation is dedicated to God for giving me the strength to complete this study. I also would like to extend the token of gratitude to those with whom this thesis might not have come to final.

I would like to express my sincere appreciation to Professor Dato Abang Abdullah Abang Ali, my supervisor and the respectable supervisory committee members; Prof. Dr. Ramazan Demirboga and Dr. Farah Nora Aznieta Binti Abd Aziz. Their guidance and encouragement have been a source of inspiration to me throughout completion of my study. I am truly thankful to my supervisor Professor Dato Abang Abdullah Abang Ali for his continuous support and constructive suggestions. I am indebted to Dr. Nima Farzadnia for his generous contributions and direct involvement in my study. I wish to thank the technicians and all the staff from Housing research centre (HRC) for their kind cooperation.

I wish to express my deep gratitude to my friends, especially Neda Javadi for unfailing support and encouragement. A heart-felt gratitude goes to my beloved brother, Hassan Noorvand for always being there. A very special gratitude goes to my parents for their countless blessing and everlasting love.

I certify that a Thesis Examination Committee has met on 15 July 2013 to conduct the final examination of Hossein Noorvand on his thesis entitled “Physical and Chemical Properties of Unground Palm Oil Fuel Ash Mortars Incorporating Nano-SiO₂” 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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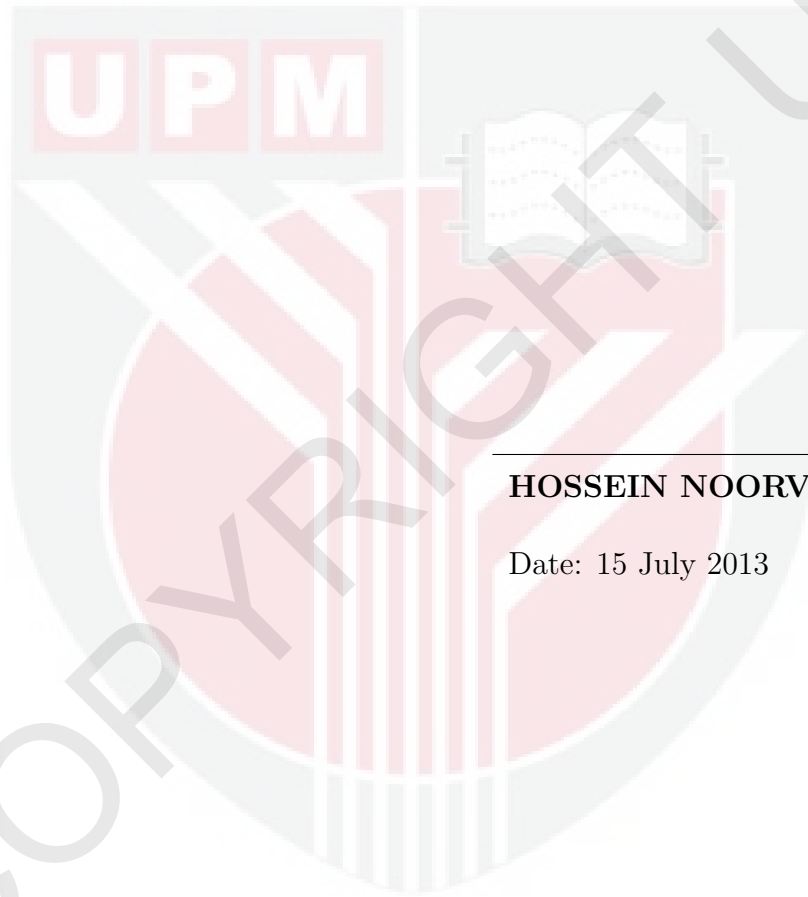
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DECLARATION

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: 15 July 2013

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