STRENGTH PROPERTIES AND ACID RESISTANCE PERFORMANCE OF MORTAR AND CONCRETE USING BLENDED COCKLE SHELL ASH AND COAL BOTTOM ASH

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Peningkatan pelepasan gas rumah hijau hasil daripada aktiviti industri simen yang berkembang untuk memenuhi permintaan pengeluaran konkrit menimbulkan kesan negatif kepada alam sekitar. Perlombongan batu kapur untuk dijadikan simen menyebabkan kehabisan bahan mentah, kemusnahan alam sekitar, dan gangguan pada ekologi. Selain itu, pembuangan kulit kerrang dari kawasan industri perikanan dan abu dasar arang batu dari loji jana kuasa arang batu terbukti mencemarkan alam sekitar. Kejayaan mengubah bahan buangan untuk digunakan dalam pembuatan produk konkrit akan menyumbang ke arah penggurangkan pelupusan sisa dan persekitaran yang mampan. Penyelidikan ini mengkaji tentang potensi penggunaan penggantian simen separa abu kulit kerang (CSA) dan abu dasar arang batu (CBA) dalam mortar dan konkrit. Eksperimen dijalankan dalam tiga peringkat untuk mencapai setiap objektif kajian. Pada peringkat pertama, eksperimen melibatkan pelbagai peratusan CSA antara 0 hingga 60% dengan selang 10% digunakan sebagai penggantian separa simen untuk menentukan kesannya terhadap masa penetapan adunan simen, keteraliran dan kekuatan mampatan mortar. Kandungan CSA optimum iaitu 10% yang menyumbang kepada peningkatan kekuatan mortar telah digunakan pada peringkat kedua dan ketiga. Pada peringkat kedua, pengaruh peratusan berbeza CBA daripada 0 hingga 60% terhadap masa penetapan adunan simen, keteraliran dan kekuatan mampatan 10% mortar simen campuran CSA telah dikaji. Pada peringkat akhir, kesan CBA sebagai penggantian separa simen terhadap kebolehkerjaan, prestasi mekanikal jangka panjang, penyerapan air dan rintangan asid konkrit simen campuran abu kulit kerang telah disiasat. Antara ujian yang telah dijalankan ialah ujian runtuhan, ujian kekuatan mampatan, ujian kekuatan tegangan belah, ujian kekuatan lentur, ujian modulus keanjalan, penyerapan air, dan rintangan asid. Dapatan kajian menunjukkan bahawa adunan simen dengan 10% CSA menyumbang ke arah masa penetapan yang lebih lama dan meningkatkan kekuatan mampatan mortar. Penggabungan 10% CBA sebagai penggantian separa simen dalam 10% adunan simen campuran CSA membentuk keteraliran yang lebih rendah dengan peningkatan kekuatan mortar. Penggunaan 10% CBA menyumbang kepada pemadatan mikrostruktur konkrit berasaskan simen abu kulit kerang melalui tindak balas pozzolanik yang menghasilkan peningkatan sifat ketahanan konkirt. Apabila terdedah kepada serangan asid, konkrit yang mengandungi 10% CBA menunjukkan kehilangan jisim dan kemerosotan kekuatan yang paling rendah. Analisis morfologi menggunakan analisis Imej Pancaran Medan Mikroskopi Elektron Pengimbasan (FESEM) menunjukkan bahawa konkrit simen campuran CSA yang mengandungi 10% CBA juga menunjukkan kemerosotan paling sedikit semasa serangan asid. Kesimpulannya, pengeluaran simen secara lestari dengan menggunakan sisa tempatan daripada kedua-dua akuakultur dan loji jana kuasa arang batu mampu meningkatkan sifat mortar dan konkrit dengan menggunakan 10% CSA dan 10% CBA sebagai simen campuran. Selain itu, penggunaan CSA dan CBA sebagai simen campuran juga boleh mengekalkan persekitaran yang hijau dan bersih kerana pencemaran yang lebih rendah yang terhasil daripada industri simen.

ABSTRACT

The increasing release of greenhouse gas resulting from activities of the expanding cement industry to cater for the demand of concrete production poses a negative impact to the environment. Harvesting of limestone for cement production causes raw material depletion, environmental destruction, and ecological disruption. Moreover, the disposal of cockle shells from fisheries trade and coal bottom ash from coal power plant significantly pollutes the environment. Successful transformation of the waste materials for concrete product manufacturing would contribute towards reduction in waste disposal and sustainable environment. The present research investigated the potential use of cockle shell ash (CSA) and coal bottom ash (CBA) as partial cement replacement in mortar and concrete. The experimental work was conducted in three stages to achieve each of the three research objectives. During the first stage of the experimental work, various percentages of CSA ranging from 0 to 60% with intervals of 10 were used as partial cement replacement to determine its effect on the setting time of cement paste, flowability and compressive strength of mortar. The optimum CSA content, namely, 10% contributing to strength enhancement of mortar, was used during the second and the third stages. During the second stage, the influence of the different percentages of CBA from 0 to 60% towards setting time of cement paste, flowability and compressive strength was used in 10% CSA blended cement mortar. During the third and thus final stage, the effect of CBA as partial cement replacement on the workability, long-term mechanical performance, water absorption, and acid resistance of cockle shell ash blended cement concrete was investigated. Among the tests conducted were the slump test, compressive strength test, splitting tensile strength test, flexural strength test, modulus of elasticity test, water absorption, and acid resistance. The findings showed that the integration of 10% CSA contributed towards longer setting time and enhanced the compressive strength of mortar. The incorporation of 10% CBA as partial cement replacement in 10% CSA blended cement paste formed lower flowability with increased mortar strength. The use of 10% CBA contributed towards the densification of CSA cement-based concrete through pozzolanic reaction resulting in strength properties enhancement. Upon exposure to acid attack, concrete containing 10% CBA exhibited the lowest mass loss and strength deterioration. The Field emission scanning electron microscopy (FESEM) morphology analysis shows that CSA blended cement concrete containing 10% CBA upon acid attack also exhibits the least degradation. Conclusively, the development of sustainable cement by utilizing local waste from both aquaculture and coal-fired power plants could improve the end product which is mortar and concrete properties by implementing 10% of CSA and 10% of CBA as blended cement. Moreover, the use of CSA and CBA as blended cement also could preserve a green and cleaner environment due to the lesser pollution caused by the cement industry.

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