

PROPERTIES OF MORTAR WITH NATURAL  
COCKLE SHELL WASTE AS PARTIAL SAND  
REPLACEMENT

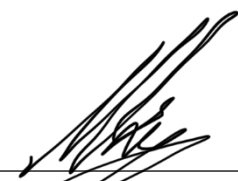
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## SUPERVISOR'S DECLARATION

We hereby declare that We have checked this thesis and in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Master of Science.



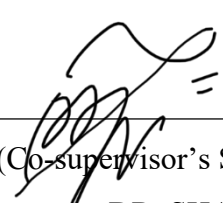
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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti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

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HANIS NADIAH BINTI RUSLAN

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for the award of the degree of  
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## ABSTRAK

Pasir sungai merupakan bahan binaan yang paling banyak digunakan dalam industri pembinaan. Walau bagaimanapun, penggunaan pasir sungai secara meluas akan menimbulkan ancaman yang tidak diingini kepada persekitaran sungai dan juga boleh mengakibatkan kehabisan sumber semula jadi pada masa hadapan. Sementara itu, permintaan bekalan kerang dalam industri makanan yang berkembang pesat menghasilkan sisa kulit kerang yang dibuang di tapak pelupusan. Justeru itu, proses melupuskan sisa kulit kerang yang diamalkan sekarang boleh mengakibatkan pencemaran alam sekitar. Memandangkan pembinaan mampan dan persekitaran yang lebih sihat, pendekatan menggunakan kulit kerang yang dihancurkan sebagai pengganti pasir dalam mortar akan dapat meminimumkan penggunaan pasir sungai dalam industri pembinaan dan mengurangkan pelupusan sisa kulit kerang. Penyelidikan tentang penggunaan sisa kulit kerang sebagai bahan campuran dalam mortar adalah terhad. Kesan penyepaduan cengkerang kerang sebagai penggantian separa pasir terhadap sifat mekanikal jangka panjang dan ketahanan mortar tidak diketahui. Penyelidikan ini menguji kesan kulit kerang yang dihancurkan sebagai pengganti pasir ke atas prestasi mortar. Objektif kajian ini adalah untuk menentukan kesan kulit kerang yang dihancurkan sebagai pengganti pasir ke atas sifat ketumpatan, sifat mekanikal, sifat ketahananlaksakan, dan sifat-sifat mortar yang lain. Sebanyak lima campuran mortar telah digunakan. Campuran mortar yang mengandungi pelbagai tahap peratusan kulit kerang hancur pada 0%, 10%, 20%, 30%, dan 40% daripada berat pasir sungai telah disediakan. Dua jenis keadaan pengawetan digunakan iaitu awetan air dan awetan udara. Ujian kebolehaliran, ujian ketumpatan pukal, ujian kekuatan mampatan, ujian kekuatan lentur, dan ujian keanjalan modulus dinamik telah dijalankan. Kemudian, Kaedah Rangsangan Permukaan (RSM) digunakan untuk memodelkan dan mengoptimumkan sifat mekanikal mortar. Selain itu, ujian penyerapan air, isipadu lompong telap, ujian pengkarbonatan, rintangan asid, dan rintangan sulfat telah dijalankan untuk menentukan ketahananlaksakan mortar. Untuk sifat-sifat yang lain, rintangan api juga telah diperiksa. Penemuan telah menunjukkan bahawa penggunaan 10% kulit kerang hancur sebagai pengganti pasir meningkatkan kebolehaliran dan sifat mekanikal mortar berbanding dengan 0% mortar. Integrasi kulit kerang yang dihancurkan membentuk struktur dalaman mortar yang lebih padat menyebabkan nilai serapan air dan isipadu lompong telap yang paling rendah di antara semua campuran. Spesimen yang diawet menggunakan air menghasilkan keputusan yang lebih baik berbanding dengan spesimen yang diawet menggunakan udara. Penggabungan kulit kerang yang dihancurkan mempengaruhi prestasi mortar apabila terdedah kepada ujian pengkarbonatan dan direndam dalam asid. Telah terbukti bahawa mortar yang mengandungi 10% kulit kerang yang dihancurkan mengalami kedalaman pengkarbonatan yang lebih tinggi berbanding dengan 0% mortar. Dari segi rintangan asid, spesimen mortar yang mengandungi 10% cengkerang kerang yang dihancurkan mengalami lebih kemerosotan berbanding dengan mortar 0% selepas direndam dalam larutan asid hidroklorik. Adalah menarik untuk diperhatikan bahawa, 10% mortar cengkerang kerang yang dihancurkan menunjukkan ketahanan yang lebih baik apabila terdedah kepada larutan sulfat. Perubahan jisim dan kehilangan kekuatan spesimen adalah lebih rendah dengan -0.11% dan 7.09% daripada -0.2% dan 16.47% untuk 0% mortar. Mortar yang mengandungi 10% kandungan kulit kerang yang dihancurkan mencatatkan lebih banyak kehilangan jisim dan pengurangan kekuatan berbanding dengan campuran tanpa kulit kerang apabila terdedah kepada suhu tinggi. Secara keseluruhan, penggabungan 10% cengkerang kerang yang dihancurkan sebagai pengganti pasir dalam mortar meningkatkan sifat mekanikalnya. Kejayaan dalam menghasilkan mortar lestari menggunakan sisa kulit kerang akan menyumbang ke arah persekitaran yang lebih bersih dan pembinaan mampan untuk kehidupan negara yang lebih sihat..

## ABSTRACT

River sand is the most used building material in the construction industry. However, extensive usage of river sand would pose undesirable threat to the river environment and also can result in the depletion of this natural resource in future. Meanwhile, the prospering cockle trade generates cockle shell wastes which are disposed of at dumping sites. Thus, existing approach in disposing of cockle shell wastes causes environmental pollution. In view of sustainable construction and healthier environment, the approach of utilizing crushed cockle shells as sand replacement in mortar would be able to minimize the amount of river sand consumed in the construction industry and reduce cockle shell waste disposal. Research on the utilization of cockle shell waste as mixing ingredient in mortar is limited. The effect of integrating cockle shells as partial sand replacement towards mechanical properties and durability of mortar is unknown. The present research investigated the effects of crushed cockle shells as sand replacement on performance of mortar. The objective of this study was to determine the effects of crushed cockle shells as sand replacement on fresh properties, mechanical properties, durability properties and other properties of mortar. A total of five mortar mixtures were employed. Mortar mixes containing various levels of percentage of crushed cockle shells at 0%, 10%, 20%, 30% and 40% by weight of river sand were prepared. Two types of curing conditions were applied, namely, water and air, until the testing age. Flowability test, fresh density test, compressive strength test, flexural strength test and dynamic modulus elasticity test were conducted. Then, the Response Surface Methodology (RSM) was used for modelling and optimization the mechanical properties of mortar. Other than that, water absorption, volume permeable void, carbonation test, acid resistance, and sulphate resistance were conducted to determine the durability of mortar. For other properties, fire resistance was also examined. The findings have shown that the use of 10 % crushed cockle shell as sand replacement increased the flowability and mechanical properties of the mortar as compared to those of the 0% mortar. Integration of crushed cockle shell formed denser internal structure of mortar resulting in it exhibiting the lowest water absorption value and volume permeable void amongst all mixes. Water-cured specimens yielded better results compared to air-cured specimens. Incorporation of crushed cockle shell influenced the performance of mortar when exposed to carbonation test and immersed in acid. It was evident that 10% crushed cockle shell mortar resulted the higher carbonation depth compared to 0% mortar. In terms of acid resistance, the mortar specimens containing 10% crushed cockle shell experience more deterioration as compared to 0% mortar after immersed in hydrochloric acid solution. It is interesting to note that, 10% crushed cockle shells mortar exhibited better durability when exposed to sulphate solution. The mass change and strength loss of the specimens were lesser with -0.11% and 7.09% than those of the -0.2% and 16.47% for 0% mortar. Mortar containing 10% content of crushed cockle shell recorded more mass loss and strength reduction in comparison to the mix without cockle shells when exposed to elevated temperature. On overall, incorporation of 10% of crushed cockle shells as sand replacement in mortar increases its mechanical properties. Success in producing sustainable mortar using cockle shell waste would contribute towards cleaner environment and sustainable construction for healthier life of nation.

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