

PROPERTIES OF FOAMED CONCRETE
WITH PROCESSED SPENT BLEACHING
EARTH AS PARTIAL CEMENT
REPLACEMENT

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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

Pengeluaran Portland simen membawa kepada sejumlah besar karbon dioksida (CO_2) yang dikeluarkan dari penambatan batu kapur. Berkaitan dengan ini, industri pembinaan berpeluang untuk mengurangkan pelepasan CO_2 dengan menggabungkan bahan buangan atau produk sampingan industri sebagai pengganti simen akan menghasilkan konkrit yang lebih mesra alam. Tanah pelunturan yang digunakan untuk proses penyulingan semasa proses penapisan minyak kelapa sawit membentuk satu enap cemar pepejal yang dipanggil SBE. Sisa buangan ini dibuang di tapak pelupusan tanpa rawatan. SBE dijana dalam kuantiti yang besar dan menjadi semakin sukar untuk mengabaikan pelupusan SBE apabila pengeluaran minyak sawit meningkat. Oleh itu, penyelidikan ini menyelidik kesan SBE yang telah diproses (PSBE) sebagai pengganti separa simen pada sifat-sifat seperti kebolehterjaya, kekuatan mekanikal dan ketahananlasakan untuk konkrit berbuih (FC). Pemprosesan konkrit berbuih PFC adalah campuran simen dengan buih dan PSBE sebagai pengganti separa simen. Penggunaan PSBE akan mengurangkan penggunaan simen, mengurangkan sisa buangan dibuang di tapak pelupusan dan dapat mengurangkan masalah pencemaran alam sekitar. Objektif pertama kajian ini adalah untuk menentukan peratusan optima PSBE sebagai pengganti separa simen. Eksperimen yang melibatkan enam jenis campuran dengan penggantian separa simen sebanyak 0%, 10%, 20%, 30%, 40% dan 50% PSBE telah dijalankan. Campuran yang mengandungi 30% PSBE spesimen mempamerkan kekuatan mampatan 56% lebih tinggi, 40% lebih tinggi kekuatan lenturan dan modulus keanjalan 58% lebih tinggi berbanding dengan spesimen kawalan konkrit berbuih (FC). Objektif kedua kajian ini adalah untuk mengkaji kesan pengawetan yang berbeza seperti pengawetan air, pengawetan udara, pengawetan air permulaan untuk tujuh hari dan seterusnya pengawetan udara, pengawetan cuaca semula jadi dan pengawetan air permulaan untuk tujuh hari dan seterusnya cuaca semula jadi pada sifat-sifat kekuatan konkrit berbuih. Konkrit berbuih yang mengandungi PSBE dan spesimen yang diawet dalam air awal selama tujuh hari dan seterusnya cuaca semula jadi mempamerkan hasil yang sangat baik, sementara spesimen yang diawet dalam pengawetan udara memberikan hasil terendah berbanding yang lain. Objektif ketiga kajian ini adalah untuk mengkaji sifat-sifat ketahanan konkrit berbuih yang mengandungi PSBE. Spesimen 30%PSBE mempamerkan ketahanan yang lebih baik dengan penyerapan air yang 52% lebih rendah, keliangan yang lebih rendah 45% dan kedalaman karbonasi yang lebih rendah 60% berbanding dengan spesimen kawalan konkrit berbuih (FC). PFC menunjukkan 77% lebih rendah daripada FC terhadap penembusan ion klorida dengan kebolehtelapan rendah sederhana. Pada akhir tempoh rendaman dalam asid hidroklorik, spesimen 30% PSBE mempamerkan ketahananlasakan yang lebih tinggi daripada spesimen kawalan FC dengan kehilangan jisim sebanyak 0.25% dan kehilangan kekuatan mekanikal 5.42% dalam larutan 5% asid selepas 1800 jam. Begitu juga selepas rendaman dalam natrium sulfat, spesimen 30% PSBE mempamerkan ketahananlasakan yang lebih baik daripada spesimen kawalan FC dengan perubahan jisim sebanyak 1.32%, perubahan dalam pengembangan sebanyak 0.98% dan kehilangan kekuatan mekanikal sebanyak 7.5% dalam 5% natrium sulfat selepas 52 minggu. Kajian mikrostruktur telah menunjukkan struktur dalaman PFC menjadi lebih padat daripada spesimen kawalan FC dengan imej kapas yang padat yang berbentuk kecil (CSH) dan beberapa plat heksagon (CH) yang membawa kepada peningkatan kekuatan dan ketahananlasakan. Berdasarkan analisis regresi, hasilnya menunjukkan korelasi yang kuat antara pemboleh ubah bebas yang dipilih dan pemboleh ubah bersandar kerana nilai R^2 lebih dekat dengan satu. Kesimpulannya, konkrit berbuih yang mengandungi 30% PSBE sebagai pengganti separa simen memenuhi syarat untuk kekuatan bebas galas struktur yang telah mempamerkan kekuatan dan ketahananlasakan yang lebih baik daripada konkrit berbuih biasa mempunyai potensi untuk digunakan dalam aplikasi pembinaan.

ABSTRACT

The production of Portland cement leads to a significant amount of carbon dioxide (CO₂) emitted from the calcination of limestone. Related to this, the construction industry stands to reduce CO₂ emission by incorporating waste or industrial by-products as cement replacements that lead to making the concrete more environmentally green. The bleaching earth that used for decolouring during the palm oils refining process form a solid sludge called spent bleaching earth (SBE). The waste usually dumped in a landfill without any treatment. The SBE is generated in large quantity and it is becoming increasingly difficult to ignore the disposal of SBE when production of palm oil increased. Therefore, this research investigates the effect of Processed Spent Bleaching Earth (PSBE) as a partial cement replacement on the fresh properties, mechanical properties and durability properties of foamed concrete (FC). Processed Spent Bleaching Earth Foamed Concrete (PFC) is a mixture of cement paste with pre-foamed foam by using PSBE as partial cement replacement. The usage of PSBE will decrease the cement consumption, lesser the waste thrown at the landfill and reduce the environmental pollution issue. The first objective of the study is to determine the optimum percentage of PSBE as a partial cement replacement. The experiments involved six different types of mixtures with partial replacement of cement by 0%, 10%, 20%, 30%, 40% and 50% of PSBE were conducted. Mix containing 30% PSBE specimen exhibited 56% higher compressive strength, 40% higher flexural strength and 58% higher modulus of elasticity as compared to control FC. The second objective of the study is to investigate the effect of different curing regimes such as water curing, air curing, initial water for 7 days and follow by air curing, natural weather and initial water for 7 days and follow by natural weather on the mechanical properties of FC containing PSBE. The specimen cured in initial water for 7 days and follow by natural weather exhibited excellent results, while specimen cured in air curing provides lowest results compared to others. The third objective of the study is to investigate the durability properties of FC containing PSBE. It is interesting to note that 30% PSBE specimen exhibited better durability with 52% lower water absorption, 45% lower porosity and 60% lower carbonation depth as compared to control FC. The 77% lower charge passes than FC shown the great resistance to chloride ion penetration with low moderate permeability. At the end of the immersion period in hydrochloric acid, the 30% PSBE specimen exhibit better durability than control specimen FC with 0.25% loss in mass and 5.42% loss in strength in 5% acid solution for 1800 hour. Similarly, after immersion in sodium sulphate, the 30% PSBE specimen exhibit better durability than control specimen FC with 1.32% change in mass, 0.98% change in expansion and 7.5% loss in strength in the 5% sodium sulphate after 52 weeks. The microstructure study has confirmed that inclusion of PSBE in FC is known to improve the internal structure of PFC to be denser than control FC specimen with the visible image of crowded tiny of cotton shaped (CSH) and few hexagonal plates (CH) contributing to enhanced strength and durability. Based on the regression analysis, the results show strong correlation between the selected independent variable and dependent variable due to the R² value closer to one. Conclusively, the foamed concrete containing 30% PSBE as partial cement replacement fulfill the requirement for strength of structural bearing load which exhibits enhanced strength and durability than plain foamed concrete has the potential to be used in construction application.

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LIST OF SYMBOLS

%	Percentage
°C	Degree Celcius
μm	Micrometre
ρ	Density
σ	Stress
θ	Degree
T	Temperature
k	Thermal conductivity
±	Plus minus sign
σ	Compressive strength
P	Maximum Load
A	Cross sectional area
N	newton
f	Flexural strength
F	Maximum Load of prism
ε	Strain
Q	Heat Conduction

LIST OF ABBREVIATIONS

ASTM	American Society for Testing and Materials
Al ₂ O ₃	Aluminium Oxide
BS	British Standard
BS EN	British European Standard
Ca	Calcium
Si	Silicon
Al	Aluminium
Mg	Magnesium
K	Potassium
Fe	Ferum
CaCO ₃	Calcium Carbonate
CH	Calcium Hydroxide
CO ₂	Carbon Dioxide
C ₃ A	Tricalcium Aluminate
C ₃ S	Tricalcium Silicate
CSH	Calcium Silicate Hydrate
FC	Foamed Concrete
GHG	Greenhouse Gases
H ₂ O	Water
kg/m ³	Kilogram per meter cube
L	Litre
m ³	Meter cube
MPa	Mega Pascal
mm	Millimeter
OPC	Ordinary Portland Cement
SiO ₂	Silicon Dioxide
SBE	Spent Bleaching Earth
PFC	Foamed Concrete with PSBE
PSBE	Processed Spent Bleaching Earth
w/c	Water cement ratio
LOI	Loss on Ignition

SEM	Scanning Electron Microscopy
FA	Fly ash
GGBS	Ground granulated furnace slag
SF	Silica fume
RHA	Rice husk ash
POFA	Palm oil ash
XRD	X-ray diffraction
ACI	American Concrete Institute
BET	Brunauer Emmet Teller
EDS	Energy dispersive x-ray spectroscopy
TG	Thermogravimetric
DTA	Differential thermal analysis
FMD	Foamed concrete mix design
DOE	Design of experiment
MIRHA	Microwave incinerated rice husk ash
E	Modulus of elasticity
HCl	Hydrochloric acid
W/mk	Thermal
AC	Air curing
WI	Water immersion
NW	Natural weather
7AC	7 days water immersion and then followed by air curing
7NW	7 days water immersion and then followed by natural weather
	Curing
RCPT	Rapid Chloride Permeability Test

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