UTILIZATION OF PALM OIL FUEL ASH IN INTERLOCKING COMPRESSED EARTH BRICK

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FACULTY OF ENGINEERING
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DECLARATION

I hereby declare that the material in this thesis is my own except for quotations, equations, summaries and references, which have been duly acknowledged.

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ABSTRACT

Interlocking compressed earth brick (ICEB) consists of clay soil, sand, ordinary Portland cement (OPC) and water. The usage of OPC in construction industry have been shown to increase the environmental problem and greenhouse effect. Palm oil fuel ash (POFA) has been reported as a potential pozzolanic material that can be used as OPC replacement. This study investigated the pozzolanic reaction of Ultrafine POFA (UfPOFA), finding the control mix proportion of ICEB and studied the effect of using UfPOFA as partial OPC replacement on ICEB performance. The characterization of UfPOFA was in accordance with ASTM C618. The mixture proportion of control ICEB were investigated based on ten (10) different ratios of clay soil and sand. Then, 5 batches of ICEB incorporating 10% to 40% of ultrafine POFA (UfPOFA) as OPC replacement were prepared and cured for 7 and 28 days to investigate mechanical and durability properties. The characterization results found that grinding POFA into ultrafine size has better physical and chemical properties and it conformed Class C pozzolan. Mixture C65S35 (65% clay soil + 35% sand) proved to be the optimum mix proportion of soils for ICEB production. As for the ICEB containing UfPOFA, the bulk density and compressive strength results revealed that it reduced with utilization of UfPOFA. The IRA, water absorption and total volume porosity also showed increment with UfPOFA utilization. All the findings showed that utilization of UfPOFA as OPC replacement did not improve the performance of ICEB. However, mixture CP10 obtained the highest bulk density and compressive strength. The compressive strength obtained was 6.50 MPa, which satisfies the minimum strength requirement of brick (5.20 Mpa) according to MS 76:1972. Mixture CP10 also proved to have the lowest IRA, water absorption and total volume porosity. SEM analysis observed that CP10 had denser microstructure. In conclusion, this study revealed that a 10% UfPOFA (series CP10) have the potential to be utilized as partial OPC replacement in the production of sustainable ICEB.

ABSTRAK

PENGGUNAAN ABU BAHAN BAKAR KELAPA SAWIT ULTRAFINE DALAM BATA MAMPAT SALING MENGUNCI

Bata mampat saling mengunci (ICEB) terdiri daripada tanah liat, pasir, simen Portland biasa (OPC) dan air. Penggunaan OPC dalam industri pembinaan telah terbukti meningkatkan masalah alam sekitar dan kesan rumah hijau. Abu bahan bakar kelapa sawit (POFA) telah dilaporkan sebagai bahan pozzolanik yang berpotensi yang boleh digunakan sebagai pengganti OPC. Kajian ini menyiasat tindak balas pozzolanik POFA Ultrafine (UfPOFA), mencari kadar campuran kawalan ICEB dan mengkaji kesan penggunaan UfPOFA sebagai penggantian OPC separa terhadap prestasi ICEB. Pencirian UfPOFA adalah mengikut ASTM C618. Perkadaran campuran ICEB kawalan telah disiasat berdasarkan sepuluh (10) nisbah berbeza tanah liat dan pasir. Kemudian, 5 kumpulan ICEB yang menggabungkan 10% hingga 40% POFA ultrafine (UfPOFA) sebagai pengganti OPC telah disediakan dan dirawat selama 7 dan 28 hari untuk menyiasat sifat mekanikal dan ketahanan. Keputusan pencirian mendapati bahawa dengan mengisar POFA kepada saiz ultrahalus mempunyai sifat fizikal dan kimia yang lebih baik dan ia menepati pozzolan Kelas C mengikut ASTM C618. Campuran C65S35 (65% tanah liat + 35% pasir) terbukti sebagai bahagian campuran tanah yang optimum untuk pengeluaran ICEB. Bagi ICEB yang mengandungi UfPOFA, ketumpatan pukal dan keputusan kekuatan mampatan mendedahkan bahawa ia berkurangan dengan penggunaan UfPOFA. IRA, penyerapan air dan jumlah keliangan volum juga menunjukkan peningkatan dengan penggunaan UfPOFA. Kesemua penemuan menunjukkan bahawa penggunaan UfPOFA sebagai pengganti OPC tidak meningkatkan prestasi ICEB. Walau bagaimanapun, campuran CP10 memperoleh ketumpatan pukal dan kekuatan mampatan tertinggi. Kekuatan mampatan yang diperolehi ialah 6.50 MPa, yang memenuhi keperluan kekuatan minimum bata (5.20 MPa) mengikut MS 76:1972. Campuran CP10 juga terbukti mempunyai IRA, penyerapan air dan jumlah keliangan volum terendah. Analisis SEM mendapati bahawa CP10 mempunyai struktur mikro yang lebih padat. Kesimpulannya, kajian ini mendedahkan bahawa 10% UfPOFA (siri CP10) berpotensi untuk digunakan sebagai penggantian separa OPC dalam pengeluaran ICEB yang mampan.

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LIST OF SYMBOLS

%	-	Percentage
$KgCO_2/m^3$	-	Kilogram of carbon dioxide equivalent per cubic meter
mm	-	Milimeter
kg/m^3	-	Kilogram per cubic meter
N/mm^2	-	Newton per square milimeter
g	-	Gram
kg	-	Kilogram
V	-	Volume
ρ	-	Density
µm	-	Micrometer
^0C	-	Degree Celsius
Cc	-	Coefficient of Curvature
Cu	-	Uniformity Coefficient
ml	-	Mililiter
cm^3	-	Cubic Centimeter
ɵ	-	Theta
nm	-	Nano meter
kV	-	Kilovolt
k	-	Kilo
MPa	-	Megapascal
σ_{dry}	-	Dry compressive strength
σ_{wet}	-	Wet compressive strength
w	-	Water absorption
ρ_{dry}	-	Dry bulk density
n	-	Total volume porosity

LIST OF ABBREVIATION

AASHTO	-	Association of State Highway and Transportation Officials
Al	-	Aluminium
Al_2O_5Si	-	Aluminosilicates
Al_2O_3	-	Aluminium oxide
ASTM	-	American Society for Testing and Materials
BS	-	British standard
C	-	Calcite
Ca	-	Calcium
$Ca(OH)_2$	-	Calcium Hydroxide / CH
CB	-	Control Brick
CEB	-	Compressed Earth Brick
CO_2	-	Carbon Dioxide
CoV	-	Coefficient of Variation
CSEB	-	Compressed Stabilized Earth Blocks/Bricks
C_2S	-	Dicalcium Silicate
C_3A	-	Tricalcium Aluminate
C_3S	-	Tricalcium Silicate
C_4AF	-	Tetracalcium Aluminoferrite
C-S-H	-	Calcium Silicate Hydrate
C-A-H	-	Calcium Aluminate Hydrates
C-A-S-H	-	Calcium Aluminium Silicate Hydrates
E	-	Ettringite
EPP	-	Eco-Processed Pozzolan
Et al.	-	And others
FCB	-	Fired Clay Bricks
Fe_2O_3	-	Iron oxide
IBS	-	Industrialized Building System
ICEB	-	Interlocking Compressed Earth Brick
IRA	-	Initial Rate of Absorption
LL	-	Liquid Limit
LOI	-	Loss of Ignition

OMC	-	Optimum Moisture Content
OPC	-	Ordinary Portland Cement
P	-	Portlandite
PI	-	Plasticity Index
PL	-	Plastic Limit
POFA	-	Palm Oil Fuel Ash
Q	-	Quartz
SAI	-	Strength Activity Index
SEM	-	Scanning electron microscope
SiO_2	-	Silicon dioxide
Sg	-	Specific Gravity
SO_3	-	Sulfur trioxide
UMS	-	Universiti Malaysia Sabah
USCS	-	Unified Soil Classification System
USDA	-	United States Department of Agriculture
UTM	-	Universiti Technologi Malaysia
XRD	-	X-ray diffraction
XRF	-	X-ray Fluorescence

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