EFFECT OF ECO-PROCESSED POZZOLAN AS A PARTIAL CEMENT REPLACEMENT ON PROPERTIES OF INTERLOCKING COMPRESSED EARTH BRICK

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ABSTRACT

Housing price in Malaysia is unaffordable for most middle to lower income citizens. This is due to, Malaysia has been using massive amount of conventional construction materials such as concrete, fired earth bricks and cement-based bricks, which are expensive and hazardous to the environment. The Interlocking Compressed Earth Brick (ICEB) has been proved to have numerous advantages over the conventional method, including the ability to reduce overall building construction costs. The ICEB is the mixture of soil, sand, water and stabilizer such as cement. Agricultural by-products such as Eco-Processed Pozzolan (EPP) can be used to partially replace cement percentages in ICEB. However, the optimum design and the effect of EPP on ICEB's strength and durability are unknown. Therefore, this study was conducted to establish the optimum mix design of ICEB units using 10%, 20%, 30%, 40% and 50% EPP as partial cement replacement based on compressive strength. In addition, determination of water absorption, porosity, crystallographic as well as the morphology of ICEB units has been carried out to study the effect of EPP towards the durability properties of the ICEB units in terms of water absorption and porosity. Based on the laboratory test results, 20% of EPP as partial cement replacement with 16% water absorption and 31% porosity is chosen as an optimal replacement level because it uses high amount of EPP in design mixture without affecting the compressive strength and durability of the ICEB. Therefore, EPP may be recommended as an admixture in the construction of green buildings and structures in the future.

ABSTRAK

KESAN ECO PROCESSED POZZOLAN SEBAGAI GANTIAN SEPARA SIMEN PADA SIFAT BATA MAMPAT SALING MENGUNCI

Harga rumah di Malaysia tidak mampu dimiliki bagi sesetengah rakyat yang berpendapatan rendah dan sederhana. Ini kerana, Malaysia menggunakan sejumlah besar bahan binaan konvensional seperti konkrit, bata tanah yang di bakar dan batu bata berasaskan simen, yang mahal dan merbahaya kepada alam sekitar. Bata mampat saling mengunci telah terbukti mempunyai banyak kelebihan berbanding kaedah konvensional, termasuk kemampuan untuk mengurangkan kos keseluruhan pembinaan bangunan. Bata mampat saling mengunci terdiri daripada campuran tanah, pasir, air dan penstabil seperti simen. Sisa agrikultur seperti Eco-Processed Pozzolan (EPP) dapat digunakan untuk mengganti sebahagian peratusan simen di dalam bata mampat saling mengunci. Walau bagaimanapun, reka bentuk optimum dan kesan EPP terhadap kekuatan dan ketahanan bata mampat saling mengunci tidak diketahui. Oleh itu, kajian ini dilakukan untuk menetapkan reka bentuk campuran optimum bagi unit bata mampat saling mengunci dengan menggunakan 10%, 20%, 30%, 40% dan 50% EPP sebagai gantian separa simen berdasarkan kekuatan mampatan. Disamping itu, penentuan penyerapan air, keliangan, kristalografi dan juga morfologi bagi unit bata mampat saling mengunci telah dilakukan untuk mengkaji pengaruh EPP terhadap ketahanan unit bata mampat saling mengunci. Berdasarkan hasil ujian makmal, 20% EPP sebagai gantian separa simen dengan 16% penyerapan air dan 31% keliangan dipilih sebagai tahap penggantian yang optimum kerana ia menggunakan jumlah EPP yang tinggi di dalam reka bentuk campuran tanpa menjejaskan kekuatan mampatan dan ketahanan ICEB. Oleh itu, EPP boleh disarankan sebagai campuran dalam pembinaan bangunan dan struktur hijau di masa depan.

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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-H-S	-	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
FESEM	-	Field emission scanning electron microscopy
IBS	-	Industrialized Building System
ICEB	-	Interlocking Compressed Earth Brick
LCH	-	Low Cost House
LL	-	Liquid Limit
LOI	-	Loss of Ignition
OMC	-	Optimum Moisture Content
OPC	-	Ordinary Portland Cement
P	-	Portlandite
PC	-	Portland Cement
PI	-	Plasticity Index
PL	-	Plastic Limit
POFA	-	Palm Oil Fuel Ash
PSBE	-	Processed Spent Bleaching Earth
Q	-	Quartz
RM	-	Ringgit Malaysia
RSBE	-	Regenerated Spent Bleaching Earth
RBE	-	Regenerated Bleaching Earth
S	-	Sulphur
SAI	-	Strength Activity Index
SBE	-	Spent Bleaching Earth
SEM	-	Scanning electron microscope
Si	-	Silicon
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

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	-	Dry Density
µm	-	Micrometer
^0C	-	Degree Celsius
C_c	-	Coefficient of Curvature
C_u	-	Uniformity Coefficient
ml	-	Mililiter
SG	-	Specific Gravity
cm^3	-	Cubic Centimeter
ɵ	-	Theta
nm	-	Nano meter
kV	-	Kilovolt
k	-	Kilo
s	-	Second
h	-	Hour
MPa	-	Megapascal

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Global housing demand increase rapidly over the past decade resulting an escalation in housing affordability crisis particularly in the cities where economy has grown at a healthy pace and prevailing (O'Dea, 2019). Although housing is the most basic needs of the population worldwide, several country are facing same major challenges where most of their citizen who earn stable income are still unable to buy or rent affordable house (Menon *et al.*, 2019). This is due to house affordability not only revolved around the cost of construction and development, it also includes the operation and maintenance costs as well as accessibility of work and social infrastructure. Therefore, as the housing price continuous to increase in conjunction with the rapid economic growth, and the fact that middle-income households struggling to own their affordable house around the world including Malaysia itself, the first attempted by public sector to develop rural public Low Cost Housing (LCH) programmes in Malaysia was launched in 1950 by the Housing Trust that represented the Federal Government (Sulaiman *et al.*, 2005).

Malaysia's government then announced the initiative towards the LCH which was introduced during the First Malaysian Plan (1966-1970), whereas the Second Malaysia Plan (1971-1975) witnesses the private sectors actively involved in various housing programmes in Malaysia to promote the welfare for lower income groups (Zainon *et al.*, 2017) due to the inability of the government to provide adequate LCH for the citizens (Mohd Arshad & Ku Hassan, 2015). The Fourth Malaysia Plan (1981-1985) introduced a formal guideline for LCH and the government has ensured that every five (5) years, a development plan must continuously emphasise the development of LCH for lower income groups (Sulaiman *et al.*, 2005). While