MECHANICAL AND TRANSPORT PROPERTIES OF ULTRA HIGH PERFORMANCE GREEN CONCRETE CONTAINING ULTRA FINE PALM OIL FUEL ASH (UPOFA) AND POLYETHYLENE TERAPHTHALATE (PET) FIBRE

by

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LIST OF ABBREVIATIONS

ACI	American Concrete Institute
ASTM	American Society for Testing and Materials
BS	British Standards
C	Cement
$Ca(OH)_2$	Calcium hydroxide
C-S-H	Calcium Silicate Hydroxide
EDX	Energy Dispersive X-ray microanalysis
FRC	Fibre reinforced concrete
ITZ	Interfacial transition zone
OPC	Ordinary Portland cement
POFA	Palm Oil Fuel Ash
PET	Polyethylene Terephthalate
RILEM	Reunion International des Laboratories et Experts des Materiaux, Systems de Construction et Outrages
RS	River Sand
SEM	Scanning electron microscope
SF	Silica Fume
SP	Superplasticiser
Ternary binder	OPC-UPOFA-SF
UPV	Ultrasonic-pulse velocity
UHPFRC	Ultra High Performance fibre Reinforced Concrete
UHPC	Ultra High Performance Concrete
UHPPRC	Ultra-High Performance PET-Reinforced Concrete
UHPGC	Ultra-High Performance Green Concrete
UHPPRGC	Ultra-High-Performance PET-Reinforced Green Concrete
w/b	Water to binder ratio
w/c	Water to cement ratio

LIST OF SYMBOLS

A	Cross-section area of concrete sample
b	Span of beam
D	Cylinder diameter
d	Depth of beam
E	Modulus of elasticity of concrete
ε	Strain of concrete
ε_o	Strain at effective end of the tensile softening
ε_c	Strain of concrete at ultimate compressive strength
f_{cu}	Uniaxial compressive strength
f_{tu}	Maximum tensile strength
K	Flexural stiffness
Kw	Coefficient of water permeability
L	Sample length
m	Mass
P	Flexural load
P_t	Load rate applied to the cylinder
P_{in}	Pressure at inlet
P_{out}	Outlet pressure
Q	Volume flow rate
R	Flexural strength
S	Span length
T	Time of penetration
t	Average time
v	Total porosity
W_2	Weight of specimen in saturated and surface dry condition in air
W_3	Weight of saturated specimen in water
W_4	Weight of oven dried specimen in air

μ	Viscosity of the gas
σ_t	Splitting cylinder tensile strength
σ	Stress

MEKANIKAL DAN PENGANGKUTAN KONKRIT HIJAU BERPRESTASI TINGGI YANG MENGANDUNGI ABU SISA BAHAN BAKAR KELAPA SAWIT TERAWAT HALUS (UPOFA) DAN GENTIAN POLYETHYLENE TERAPHTHALATE (PET)

ABSTRAK

Penggunaan semula bahan buangan kitar semula dalam campuran konkrit sebagai bahan binaan yang mesra alam telah menjadi perhatian penyelidik sejak beberapa tahun kebelakangan ini. Penyelidikkan ini mengkaji kesan mengintegrasikan abu sisa bahan bakar kelapa sawit terawat halus (UPOFA) dan abu silika (SF) dengan sisa botol plastik kitar semula dalam bentuk Polyethylene Terephthalate (PET) terhadap sifat-sifat konkrit berprestasi tinggi (UHPGC). Kajian berkaitan kesan gentian PET dalam UHPC dan UHPGC adalah terhad. Oleh itu, kajian ini bertujuan untuk menyelidik kesan penambahan gentian PET sebanyak 1% pada sifat konkrit baru, sifat mekanikal dan sifat pengangkutan UHPC dan UHPGC yang mengandungi sehingga 50% UPOFA dan 20% SF sebagai pengganti pengikat dengan simen biasa (OPC). UPOFA yang bersaiz zarah 2 μm selepas proses pengisaran dan pembakaran digunakan dalam pengeluaran UHSGC. Botol plastik minuman yang dikitar semula dalam bentuk gentian PET telah digunakan sebagai bahan bertetulang gentian dalam pengeluaran konkrit berprestasi tinggi PET bertetulang (UHPPRC) dan konkrit hijau berprestasi tinggi PET bertetulang (UHPPRGC). Keputusan kajian menunjukkan bahawa kehadiran gentian PET dapat mengurangkan aliran dan kelikatan UHPRC dan UHPPRGC berbanding dengan campuran kawalan UHPC. Selain itu, kandungan gentian PET meningkat dengan ketara dalam sifat mekanik UHPC dan UHPGC. Berbanding dengan campuran kawalan UHSC, kekuatan mampatan, rintangan tegangan dan lenturan terbesar diperolehi dalam UHPPRGC sebanyak 148.7, 8.28 dan 19.096 MPa pada 28 hari dan 154.2, 13.61 dan 21.731 MPa pada 90 hari. Begitu

juga, dalam UHPPRGC yang mengandungi merekodkan nilai gentian PET beban lenturan terbesar bagi spesimen papak pada 28 hari berbanding dengan campuran kawalan UHSC. Dalam trend yang sama, sifat-sifat pengangkutan yang dinilai oleh keliangan, penyerapan permukaan awal, penyerapan air dan ujian kebolehtelapan klorida, gas dan air menunjukkan peningkatan yang lebih baik UHPPRGC yang mengandungi UPOFA-SF dan gentian PET untuk masa yang singkat (28 hari) dan panjang (90 hari). Oleh itu, penggunaan gentian PET dengan bahan pozolana UPOFA dan SF boleh membantu dalam menghasilkan UHPC dan UHPGC dengan sifat mekanikal yang mencukupi dan sifat ketahanlasakkan yang tinggi.

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ABSTRACT

Reusing recycled waste materials in concrete mixtures as environment-friendly construction materials has been a concern of researchers in recent years. This research investigated the effects of integrating Ultrafine Palm Oil Fuel Ash (UPOFA) and Silica Fume (SF) with shredded recycled waste bottles in the form of Polyethylene Terephthalate (PET) on the properties of Ultra-High Performance Concrete (UHPC) and Ultra-High Performance Green Concrete (UHPGC). Studies on the effect of PET fibre inclusion in UHPC and UHPGC are limited. Therefore, this research aims to explore the effect of adding 1% PET fibre on the fresh, mechanical and transport properties of UHPC and UHPGC containing up to 50% of UPOFA and 20% of SF as a replacement binder with cement. UPOFA, with a particle size of 2 µm after the grinding and burning process was utilised in UHPGC production. Recycled waste beverage plastic bottles in the form of PET were shredded and utilised as fibre- reinforced materials in the production of Ultra-High-Performance PET- Reinforced Concrete (UHPPRC) and Ultra-High-Performance PET- Reinforced Green Concrete (UHPPRGC). Results showed that the presence of PET fibre reduced flowability and viscosity of UHPPRC and UHPPRGC compared with UHPC control mix. Moreover, the PET fibre content substantially improved the mechanical properties of UHPC and UHPGC. Compared with UHPC control mix, the largest compressive, splitting tensile and flexural strengths of beam were realised in UHPPRGC by 148.7, 8.28 and 19.096 MPa at 28 days and 154.2, 13.61 and 21.731 MPa at 90 days, respectively. Similarly, the PET fibre inclusion in