

**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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TABLE OF CONTENTS

	page
ACKNOWLEDGEMENT	ii
TABLE OF CONTENTS	iii
LIST OF TABLES	x
LIST OF FIGURES	xiii
LIST OF ABBREVIATIONS	xxii
LIST OF SYMBOLS	xxiv
ABSTRAK	xxii
ABSTRACT	xxiv
CHAPTER ONE: INTRODUCTION	
1.1 Background and Rationale	1
1.2 Problem statement	5
1.3 Aim and Objectives	7
1.4 Scope of research	8
1.5 Structure of thesis	9
CHAPTER TWO: LITERATURE REVIEW	
2.1 Introduction	11
2.2 Ultra-High Performance Fibre Reinforced Concrete (UHPFRC) (definition, components, properties, applications)	11
2.2.1 UHPFRC definition	11
2.2.2 UHPFRC components	12
2.2.2 (a) Cement	14
2.2.2 (b) Silica Fume	16

2.2.2 (c) Sand	19
2.2.2 (d) Superplasticiser (SP)	20
2.2.2 (e) Water	20
2.2.2 (f) Fibres	21
2.2.2 (f) (i) Steel fibre	22
2.2.2 (f) (ii) Polyethylene terephthalate (PET) fibre	22
2.2.3 Effect of PET fibres on concrete workability	25
2.2.4 Effect of PET fibres in mechanical properties of concrete	27
2.2.4 (a) Compressive Strength	27
2.2.4 (b) Flexural behaviour of reinforced PET fibre concrete	29
2.2.4 (b) (i) Flexural strength	29
2.2.4 (b) (ii) Flexural Toughness and Ductility	31
2.2.4 (c) Splitting tensile strength	34
2.2.4 (d) Modulus of elasticity	36
2.2.5 Effect of PET fibres on concrete transport properties	39
2.2.5.1 Water absorption and porosity	39
2.2.5.2 Permeability behavior	40
2.2.6 Application of plastic PET fibre in FRC concrete	43
2.2.7 UHPC and UHPFRC composition principles	44
2.2.8 Applications of UHPFRC in civil engineering constructions	47
2.2.8 (a) UHPFRC in structural applications	50
2.2.8 (b) UHPFRC Architectural applications	55
2.3 Palm Oil Fuel Ash (POFA) and its application in concrete production	58
2.3.1 Effect of POFA chemical compositions in concrete	62
2.3.2 Effect of POFA physical properties in concrete	63

2.3.3	Effect of POFA on fresh concrete properties	64
2.3.4	Effect of POFA on mechanical properties of concrete	67
2.3.4 (a)	Compressive strength	65
2.3.4 (b)	Other mechanical properties: direct tensile, splitting tensile flexural strength and modulus of elasticity	68
2.3.5	Effect of POFA on transport properties of concrete	70
2.3.5 (a)	Permeability, porosity and water absorption	70
2.3.5 (b)	Rapid Chloride Penetration of concrete	73
2.4	Effect of Silica Fume on concrete properties	74
2.4.1	Effect of silica fume on concrete workability and slump flow time	74
2.4.2	Effect of silica fume on mechanical properties of concrete	76
2.4.3	Effect of silica fume on compressive and transport properties of concrete	77
2.5	Curing method of UHPC	78
2.6	Summary	81

CHAPTER THREE: RESEARCH METHODOLOGY

3.1	Introduction	84
3.2	Materials	87
3.2.1	Ordinary Portland cement (OPC)	87
3.2.2	Silica Fume (SF)	87
3.2.3	Palm oil fuel ash (POFA)	88
3.2.3 (a)	Ultra-fine Palm oil fuel ash (UPOFA)	89
3.2.4	Aggregate	95
3.2.5	Water	95

3.2.5 Superplasticizer (SP)	95
3.2.7 West plastic PET fibre	96
3.3 Designing and proportioning concrete mixtures	97
3.4 Mixing procedures of UHPC and UHPGC with and without PET fibres	99
3.5 Laboratory Tests	101
3.5.1 Fresh concrete tests	101
3.5.1 (a) Flowability of concrete mixtures	101
3.5.1 (b) T500 slump flow time test	103
3.5.2 Casting and curing of fiberised and non-fiberised UHPC and UHPGC	104
3.5.3 Hardened fiberised and non-fiberised UHPC and UHPGC test	108
3.5.3 (a) Morphology with chemical composition	
3.5.3 (b) Mechanical properties of PET fiberised and non-fiberised UHPC and UHPGC	108
3.5.3 (b) (i) Compressive Strength test	109
3.5.3 (b) (ii) Splitting cylinder tensile test	110
3.5.3 (b) (iii) Cylinder compression test	111
3.5.3 (b) (iv) Four point bending test	112
3.5.3 (b) (v) Flexural slab test	115
3.5.3 (c) Non-destructive tests	118
3.5.3 (d) Durability and transport properties tests	120
3.5.3 (d) (i) Initial surface absorption test (ISAT)	120
3.5.3 (d) (ii) Porosity and water absorption test	122
3.5.3 (d) (iii) Gas and water permeability test	125
3.5.3 (d) (iv) Rapid chloride permeability test (RCPT)	128

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1	Introduction	132
4.2	Optimum Silica Fume percentages	133
4.3	Morphology of UHPC and UHPGC with and without PET fibres	134
4.4	Fresh properties test results of UHPC and UHPGC with and without PET fibres	141
4.4.1	Flow table and T500 slump flow time test	141
4.5	Mechanical properties	144
4.5.1	Compressive strength	144
4.5.2	Stress–strain curves	152
4.5.3	Modulus of elasticity (MoE)	157
4.5.4	Splitting tensile strength	160
4.5.5	Flexural behaviour of beam	165
4.5.5 (a)	Flexural load–deflection curves	172
4.5.5 (b)	Flexural strength	169
4.5.5 (c)	Flexural strength failure mode	171
4.5.5 (d)	Flexural toughness	176
4.5.5 (e)	Strain capacity	179
4.5.5 (f)	Flexural stiffness	181
4.5.6	Flexural behaviour of concrete slabs	183
4.5.6 (a)	Flexural toughness of slab	188
4.5.7	Non-destructive concrete test Ultrasonic pulse velocity	189
4.6	Transport property test results for UHPC and UHPGC with and without PET fibres	195
4.6.1	Porosity and water absorption test results	195

4.6.2	Initial surface absorption (ISAT) test results	204
4.6.3	Gas permeability test results of UHPC and UHPGC with and without PET fibres	208
4.6.4	Water permeability test results of UHPC and UHPGC with and without PET fibres	209
4.6.5	Rapid chloride permeability test (RCPT) for fiberised and non-fiberised UHPC and UHPGC	212
4.6.6	Relationship between compressive strength, porosity and water absorption of UHPGC under the effects of PET fibres and ternary binders (OPC-UPOFA-SF)	216
4.7	Summary	218
CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS		
5.1	General	221
5.2	Conclusions	221
5.3	Recommendations for future research	223
REFERENCES		224
LIST OF PUBLICATIONS		

LIST OF TABLES

		Page
Table 2.1	Range of UHPFC mix components (Voort, 2008)	13
Table 2.2	Typical UHPFC mix components(Cheyrezy and Behloul, 2001)	13
Table 2.3	Effect of SF in concrete properties (Chung, 2002)	17
Table 2.4	Classification of w/b and w/c ratios for HPFC(Vande et al .,2008)	20
Table 2.5	Effect of PET fibre inclusion in compressive strength and mechanical properties of concrete	38
Table 2.6	Example applications of the PET fibres reinforced concrete in Japan (Yin et al., 2015)	44
Table 2.7	POFA Chemical compositions from different resources	63
Table 2.8	Physical properties of POFA (Megat Johari et al., 2012; Zeyad et al., 2017)	64
Table 2.9	Influence of UPOF on setting time , workability and viscosity of UHSC (Mohammed et al., 2014)	65
Table 2.10	Positively effects of SF in concrete transport properties of concrete based on previous studies	78
Table 2.11	Influence of curing method on chloride penetration of UHPFRC (Graybeal and Tanesi, 2007)	81
Table 3.1	Physical properties of binders OPC, UPOFA and SF (%)	88
Table 3.2	Chemical composition of binders OPC, UPOFA and SF (%)	89
Table 3.3	UHPC and UHPGC trail mix proportions based on ACI 211-99 absolute volume method	98
Table 3.4	Fiberised UHPC and UHPGC mix proportions based on ACI 211-99 absolute volume method	99
Table 3.5	Flow classifications of freshly mixed UHPPC (Graybeal, 2006; Tayeh et al., 2013)	102

Table 3.6	Chloride ions penetrability based on total charge passed ASTM C1202 (ASTM, 1997b)	131
Table 4.1	Main parts of the analysis and interpretation results	132
Table 4.2	Mixtures with binders and PET fibres details	134
Table 4.3	Influence of PET fibres on the workability and viscosity of UHPC and UHPGC	142
Table 4.4	Compressive strength results of UHPC and UHPGC with and without PET fibres at different ages	145
Table 4.5	Load capacity, flexural strength, and flexural stiffness of non fiberised and fiberised UHPC and UHPG at 28 days	167
Table 4.6	Load capacity, flexural strength, and flexural stiffness of non fiberised and fiberised UHPC and UHPG at 90 days	168
Table 4.7	The ultimate load deflection and toughness calculated from the flexural test of concrete slabs	185
Table 4.8	UPV values of concrete mixes (Km/sec) at 7, 28 and 90 days	190
Table 4.9	Classification of concrete quality based on UPV (Solis- Carcaño and Moreno, 2008)	191
Table 4.10	Porosity% results of UHPC and UHPGC with and without PET fibres at different ages	195
Table 4.11	Influence of PET fibres in UHPC and UHPGC water absorption at different ages	200
Table 4.12	Water permeability coefficient results for fibreised and non-fiberised UHPC and UHPGC at different age	209

LIST OF FIGURES

page

Figure 1.1	Palm oil industry stacks (a) Palm oil fruit stack, (b) Process of palm oil squeeze, (c) Waste of palm oil content empty fruit bunches fibres and kernels, and (d) Palm fuel ash (POFA)	2
Figure 1.2	Global plastic production growing (1950–2015)	4
Figure 1.3	Waste plastic environment pollution	5
Figure 2.1	Example of different waste plastic PET used in concrete mix PET bottle fibre,(b) Synthetic embossed PET fibres,(c) and (d) Plastic PET flakes	25
Figure 2.2	Effect of waste PET fibres on slump flow (mm) of concrete (Al-Hadithi <i>et al.</i> , 2016)	27
Figure 2.3	Effect of waste PET fibres on concrete viscosity (Al-Hadithi <i>et al.</i> , 2016)	28
Figure 2.4	Effect of PET fibre in concrete strength (Rahmani et al., 2013)	29
Figure 2.5	Effect of PET content in bending load capacity (Fraternali et al., 2011)	31
Figure 2.6	Stress–strain diagram of fibre-reinforced concrete with different volumes (Foti, 2011)	33
Figure 2.7	Effect of PET fibre in concrete ductility (Kim et al., 2010)	35
Figure 2.8	Effect of PET fibres in splitting tensile concrete with different PET lengths at age 28 days(Ghernouti et al., 2015)	36
Figure 2.9(a)	Elasticity modulus of concrete specimens at different PET percentage (Rahmani et al., 2013)	38
Figure 2.9(b)	Effect of PET fibre inclusion in elastic modulus of concrete (Kim <i>et al.</i> , 2010)	38
Figure 2.10	Effect of PET inclusion on concrete water absorption (Choi et al., 2009)	41
Figure 2.11	Effect of PET inclusion on chloride permeability (coulombs) of concrete(Won et al., 2010)	43

Figure 2.12	Effect of coarse aggregate size on the force transfer in concrete mixture (Voort, 2008)	46
Figure 2.13	Silica fume acting as “micro-filler” between cement granular (Spasojević, 2008)	47
Figure 2.14	Durability properties of UHPC and HPC with respect to normal concrete (Voort, 2008)	49
Figure 2.15	Pedestrian Bridge, Sherbrooke, Quebec, Canada (Adline et al., 1998)	50
Figure 2.16	Footbridge Sakata-Mirai, Japan (Rebentrost and Wight, 2008)	51
Figure 2.17	Haneda International Airport, Japan (Resplendino, 2012)	52
Figure 2.18	Footbridge of peace in Seoul, South Korea	53
Figure 2.19	Details of UHPC-U- Girder Kampung Linsum Bridge, Negeri Sembilan, Malaysia (Lei. et al., 2012)	54
Figure 2.20	Kampung Linsum Bridge, Negeri Sembilan, Malaysia (Lei et al., 2012)	55
Figure 2.21	Martel Tree Sculpture made of UHPC (Deem, 2001)	55
Figure 2.22	Shawnessy LRT using UHPFRC canopies, Canada (Batoz, 2009)	56
Figure 2.23	Wilson Hall, Perak, Malaysia during construction	57
Figure 2.24	Development of UHPFRC applications in the world (Lei et al., 2012)	58
Figure 2.25	Difference in sectional dimensions of an L-shaped wall, made of conventional concrete and UHPFRC (Voo et al., 2012)	59
Figure 2.26	Worldwide Palm Oil production, 2016/2017(GPD, 2011)	61
Figure 2.27	UPOFA treatment procedures (Megat Johari et al., 2012; Zeyad et al., 2017)	66
Figure 2.28	Development of compressive strength HSGC with different levels of UPOFA (Zeyad <i>et al.</i> , 2013)	68
Figure 2.29	Relationship between compressive strength and UPOFA replacing level with cement of UHSC (Mohammed et al., 2014)	69

Figure 2.30	Influence of POFA inclusion on ultimate flexural strength of Green cementitious composites mixtures (Altwair et al. 2014)	70
Figure 2.31	Effect of POFA on HSGC permeability (Zeyad et al., 2017)	73
Figure 2.32	Effect of POFA on HSGC gas permeability (Megat Johari et al., 2012)	73
Figure 2.33	Influence of POFA on UHSGC porosity (Mohammed et al., 2014)	74
Figure 2.34	Influence of POFA on UHSGC water permeability (Mohammed et al., 2014)	74
Figure 2.35	Conditions of standard heat curing (Mohammed et al, 2014)	81
Figure 3.1	Flowchart of the research methodology	92
Figure 3.2	Silica Fume	94
Figure 3.3	Original POFA (W-POFA)	95
Figure 3.4	Electrical oven used for drying POFA	97
Figure 3.5a	Ball mill vessel	97
Figure 3.5b	Ball mill machine	97
Figure 3.6	Ground palm oil fuel ash G-POFA	98
Figure 3.7	Burning treatment of GPOFA: (a) before treatment and (b) after treatment	98
Figure 3.8	Ultrafine Palm Oil Fuel Ash UPOFA	99
Figure 3.9	UPOFA preparation processes	99
Figure 3.10	Superplasticser (SP)	102
Figure 3.11	(a): Waste plastic bottle (b): Shredded plastic PET fibre	103
Figure 3.12	Concrete mixing procedures (a) Pan mixture (b) Add PET fibres to dry ingredients (c) PET fibres and dry ingredients after mixing (d) Thick paste concrete in final step	107
Figure 3.13	Flow table test (a) Device (b) Mini steel cone after filling by concrete (c) Average flow measurement	109
Figure 3.14	Sketch of T500 test apparatus	110

Figure 3.15	T500 slump flow time test procedures	111
Figure 3.16	Concrete specimens on vibrating table	112
Figure 3.17	Concrete after casting (a) cubes specimens, (b) cylinders and beams specimens, and (c) slabs specimens	113
Figure 3.18	Steam curing process (Tayeh et al., 2012b)	114
Figure 3.19	Steam curing of fiberised and non-fiberised UHPC and UHPGC	114
Figure 3.20	Water curing of concrete samples	115
Figure 3.21	Automatic compression concrete machine	116
Figure 3.22	Splitting cylinder tensile test according to ASTM: C496 (1996)	117
Figure 3.23	(a) Cylinder compression test machine according to ASTM: C469(2014) and (b) Smoothing and flattening sample surface before test	118
Figure 3.24	Four-point bending test ASTM: C78 (2010)	120
Figure 3.25	AG-X Shimadzu Universal Testing Machine for flexural determination	120
Figure 3.26	Flexural stiffness and toughness calculation ASTM C 1018(1997) (Najim and Hall, 2012; Atutis, Valivonis and Atutis, 2018)	122
Figure 3.27	Concrete slab specimens	124
Figure 3.28	Flexural test of slabs: (a) experimental test set-up (b) schematic of slab and supports	125
Figure 3.29	UPV instrument	127
Figure 3.30	ISAT apparatus details	129
Figure 3.31	concrete cylindrical core sample	131
Figure 3.32	The vacuum saturation apparatus	132
Figure 3.33	Water and gas permeability apparatus	136
Figure 3.34	RCPT cell	138
Figure 3.35	RCPT apparatus	139
Figure 4.1	Main parts of the analysis and interpretation results	140

Figure 4.2	UHPGC trail mixes at age of 3, 7, 14, 28 and 90 days	141
Figure 4.3(a)	SEM and EDX micrograph for UHPC control mix	145
Figure 4.3(b)	SEM and EDX micrograph for green concrete of U50–UHPGC mix	146
Figure 4.3(c)	SEM and EDX micrograph for green concrete of U50-SF20-UHPGC	147
Figure 4.3(d)	SEM and EDX micrograph for PET fibre-reinforced U50-SF20-UHPPRGC	148
Figure 4.4	Flow slump test. (a) Device, (b) UHPC control mix and (c) U50-SF20-UHPPRGC	151
Figure 4.5	Effect of PET fibre inclusion on the compressive strength of UHPC and UHPGC at ages of 3, 7, 14, 28 and 90 days	153
Figure 4.6	Relative strength of the binary and ternary binders and PET fibres of UHPC and UHPGC mixes at ages of 3, 7, 14, 28 and 90 days (UHPC as reference)	153
Figure 4.7	Effect of PET fibre inclusion on compressive strength developments for UHPC and UHPGC at different ages of 3, 7, 14, 28 and 90 days	158
Figure 4.8	Failure mode of compressive strength for: (1) UHPC, (2) U50- UHPGC, (3)U50-SF20-UHPGC, (4) UHPPRC,(5) U50-UHPPRGC, and (6)U50-SF20-UHPPRGC	159
Figure 4.9	Stress–strain curves of UHPC and UHPGC beam specimens with and without PET fibres at 28 days	160
Figure 4.10(a)	Compression failure mode for UHPC	161
Figure 4.10(b)	Compression failure mode for U50-SF20-UHPGC	162
Figure 4.10(c)	Compression failure mode for PET fibred HPPRGC	163
Figure 4.10(d)	Compression failure mode for PET fibred U50-SF20-UHPPRGC	164
Figure 4.11	Effect of PET fibre content in the MoE of UHPC and UHPGC at 28 days	165
Figure 4.12	Effect of PET fibre inclusion on the splitting tensile strength of UHPC and UHPGC	166
Figure 4.13(a)	Failure mode of splitting tensile strength specimens for UHPC	170

Figure 4.13(b)	Failure mode of splitting tensile strength specimens for U50-SF20-UHPGC	171
Figure 4.13(c)	Failure mode of splitting tensile strength specimens for UHPPRC	171
Figure 4.13(d)	Failure mode of splitting tensile strength specimens for U50-SF20-UHPPRC	172
Figure 4.14	Relationship between compressive and splitting tensile strengths of fiberised and non-fiberised UHPC and UHPGC at 28 and 90 days	173
Figure 4.15	Load–deflection curve of fiberised and non-fiberised USHC and UHPGC at 28 days	174
Figure 4.16	Load–deflection curve of fiberised and non-fiberised USHC and UHPGC at 90 days	175
Figure 4.17	Correlation between compressive and flexural strength of fiberised and non-fiberised UHPC and UHPGC at 28 and 90 days	179
Figure 4.18	UHPC failure mode before and after flexural load	180
Figure 4.19	U50-SF20-UHPGC failure mode before and after flexural load	181
Figure 4.20	UHPPRC failure mode before and after flexural load	182
Figure 4.21	U50-SF20-UHPPRC failure mode before and after flexural load	183
Figure 4.22	Methodology for calculating flexural toughness ASTM C 1018 (1997)	185
Figure 4.23	Effect of PET fibres on the flexural toughness of UHPPRC and UHPPRC beam at age of 28 and 90 days	186
Figure 4.24	Influence of PET fibre in strain capacity of UHPPRC and UHPPRC at age of 28 and 90 days	188
Figure 4.25	Effect of PET fibres on UHPPRC and UHPPRC stiffness (K) at age of 28 and 90 days	192
Figure 4.26(a)	Load-deflection curves for UHPC slab	194
Figure 4.26(b)	Load-deflection curves for U50-SF20-UHPGC slab	195
Figure 4.26(c)	Load-deflection curves for UHPPRC slab	195

Figure 4.26(d)	Load-deflection curves for U50-SF20-UHPPRC slab	196
Figure 4.27(a)	Failure mode of UHPC slab	196
Figure 4.27(b)	Failure mode of U50-SF20- UHPGC slab	197
Figure 4.27(c)	Failure mode of UHPPRC slab	197
Figure 4.27(d)	Failure mode of U50-SF20-UHPPRC slab	198
Figure 4.28	Influence of PET fiber inclusion on UPV values of UHPPRC and UHPPRCG containing UPOFA and SF at age of 7, 28 and 90 day	201
Figure 4.29	Relationship between UPV and compressive strength for fiberised UHPC and UHPGC	205
Figure 4.30	Relationship between UPV and porosity % for fiberised UHPC and UHPGC	205
Figure 4.31	Effect of PET fibre inclusion on porosity percentage of UHPC and UHPGC at different ages of 3, 7, 14, 28 and 90 days	208
Figure 4.32	Relative porosity percentage of UHPC and UHPGC at 3, 7, 14, 28 and 90 days (with UHPC as reference)	208
Figure 4.33	Effect of PET fibres inclusion on water absorption of UHPC and UHPGC at different age of 3, 7, 14, 28 and 90 days	212
Figure 4.34	Relative water absorption of UHPC and UHPGC at different age of 3, 7, 14, 28 and 90 days (UHPC as reference)	212
Figure 4.35	Influence of addition of PET fibres on initial surface absorption of UHPC and UHPGC with different durations at age of 3 days	215
Figure 4.36	Influence of addition of PET fibres on initial surface absorption of UHPC and UHPGC with different durations at age of 7 days	216
Figure 4.37	Influence of additional PET fibres on the initial surface absorption of UHPC and UHPGC with different durations at 28 days	216

Figure 4.38	Influence of additional PET fibres on the initial surface absorption of UHPC and UHPGC with different durations at 90 days	217
Figure 4.39	Effect of PET fibres on the water permeability coefficients of UHPC	221
Figure 4.40	Relative water permeability of UHPC and UHPGC at 3, 7, 14, 28 and 90 days (UHPC as reference)	221
Figure 4.41	Effect of PET fibres on rapid chloride permeability of UHPC and UHPGC at 3, 7, 14, 28 and 90 days	224
Figure 4.42	Relationship between compressive strength and porosity of fiberised UHPC and UHPGC at 3, 7, 14, 28 and 90 days	228
Figure 4.43	Relationship between compressive strength and water absorption of fiberised UHPC and UHPGC at 3, 7, 14, 28 and 90 days	228

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 Laboratoires 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
UHPRC	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
K_w	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. Penyelidikan 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 (UHPC). Kajian berkaitan kesan gentian PET dalam UHPC dan UHPC 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 UHPC 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 UHPC. 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 (UHPPRC). Keputusan kajian menunjukkan bahawa kehadiran gentian PET dapat mengurangkan aliran dan kelikatan UHPPRC dan UHPPRC berbanding dengan campuran kawalan UHPC. Selain itu, kandungan gentian PET meningkat dengan ketara dalam sifat mekanik UHPC dan UHPC. Berbanding dengan campuran kawalan UHPC, kekuatan mampatan, rintangan tegangan dan lenturan terbesar diperolehi dalam UHPPRC 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 mengandung 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 mengandung 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 ketahananlasakkan yang tinggi.

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

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