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DEVELOPMENT AND MECHANICAL BEHAVIOUR OF

SELF-COMPACTING GEOPOLYMER CONCRETE

by

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DEVELOPMENT AND MECHANICAL BEHAVIOUR OF SELF-COMPACTING GEOPOLYMER CONCRETE

by

FAREED AHMED MEMON

A Thesis
Submitted to the Postgraduate Studies Programme
as a Requirement for the Degree of

DOCTOR OF PHILOSOPHY

CIVIL ENGINEERING DEPARTMENT
UNIVERSITI TEKNOLOGI PETRONAS
BANDAR SRI ISKANDAR,
PERAK

JANUARY 2014

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DEDICATION

This Thesis is Dedicated

To

My Beloved Late Father

Allah Warayo Memon

ACKNOWLEDGEMENTS

Prior to acknowledgment, I would like to deeply praise the Almighty ALLAH, the Most Merciful and the Most Beneficent, who bestowed me the opportunity, wisdom and courage to successfully complete this project. I appreciate the opportunities I got and the space to develop both a new material and myself. Doing research in Malaysia was an interesting opportunity and experience. Indeed, this research project would not have been possible without the support and contribution of many people. Thanks and gratitude is owed to many kind individuals for their help in various ways in completion of this project. First among whom, I wish to express my sincere gratitude and appreciation to my supervisor, Prof. Ir. Dr. Muhd Fadhil Nuruddin, for his scholastic and technical advice, skill assistance, continuous encouragement, inspiration and strong support throughout this research. His devotion, patience and focus on excellence allowed me to reach this important milestone in my life. I am equally deeply indebted and grateful to my co-supervisor Associate Prof. Dr. Nasir Shafiq, for his dedication, thoughtful insights, magnificent ideas, extensive guidance and valuable suggestions during the research.

Experimental work always demands many hands to be carried out and this research was not the exception. I am equally indebted to the concrete laboratory technicians Mr. Muhammad Hafiz b Baharun and Mr. Johan Ariff bin Mohamed for their time, help and support given to me whenever I needed it the most. I am forever grateful to Mr Samuel Demie, MSc Research student, for his help and contribution during the first phase of the research. I also acknowledge and sincerely thank all my fellow friends, who helped me during all stages of my experimental work.

I sincerely appreciate and gratefully acknowledge Ministry of Science, Technology & Innovation, Malaysia, MOSTI for awarding the grant and Universiti Teknologi PETRONAS for providing the financial support and excellent research facilities to carry out this research. I also wish to express my heartfelt gratitude to Vice-chancellor

Mehran University of Engineering and Technology, Jamshoro, Pakistan for his encouragement and for graciously granting study leave, which enabled me to complete my PhD in Malaysia.

I would like to express my loving appreciation to my family, my siblings and my brothers and sisters, especially to my mother and my elder sister for their unconditional love, encouragement, moral support and each and every word of motivation and prayers throughout the course of my study. My wife and my children deserve special mention for their inseparable support and prayers. Indeed, no acknowledgement can ever do justice to their continuous support. I can never repay all they have done for me or express how much it has meant to me. I thank them for staying with me throughout all of my pitfalls and for supporting and having patience with me during my doctoral studies.

Finally, I would like to thank everybody who was important to the successful realization of this research, as well as express my apology that I could not mention personally one by one. I offer my regards and blessings to all of those who supported me in any respect during the completion of the study.

ABSTRACT

High consumption of natural resources, environmental concern of CO_2 emission due to cement production and improvement on concrete performance has become a driving force behind the search for alternative materials. An effort made in this regard is the development of self-compacting geopolymer concrete (SCGC). SCGC is a novel material that involves innovation in the production and casting of concrete. It is a type of concrete that does not require compaction for placing it and can be produced by completely eliminating ordinary Portland cement. So far several studies have been done on the characteristics of self-compacting concrete and that of geopolymer concrete in both fresh and hardened state. However, no work has been conducted on SCGC. This research study was therefore aimed to explore the possibility of producing SCGC made with locally available materials by examining its basic physical and mechanical properties. This study dealt with the manufacture of fly ash-based SCGC that could achieve 28 days compressive strength of 40 MPa and fulfill the requirements of concrete in both fresh and hardened state. The essential workability properties of freshly prepared SCGC were assessed through Slump flow, V-Funnel, L-Box and J-Ring test methods. The hardened properties included compressive strength, splitting tensile and flexural strength, modulus of elasticity, Poisson's Ratio, and creep and drying shrinkage. In addition, density and water absorption characteristics of hardened SCGC were also examined. The study produced encouraging results and confirmed the production of satisfactory SCGC. The results indicated that SCGC up to 50 MPa of 28-days compressive strength could be produced. Test results showed that the mechanical properties of SCGC are competitive with those of OPC-based conventional concrete. It is anticipated that the outcomes of this study will extend the scope of SCGC and thus generate new opportunities for the construction industry.

Keywords: Geopolymer concrete, Self-compacting concrete, Self-compacting geopolymer concrete, Mechanical Properties

ABSTRAK

Peningkatan penggunaan sumber asli, kesan keatas alam sekitar disebabkan oleh pelepasan CO_2 daripada pengeluaran simen dan peningkatan prestasi konkrit telah menjadi penggerak di sebalik pencarian bahan-bahan alternatif. Satu usaha yang dibuat kearah ini ialah dengan menghasilkan konkrit geopolymer terpadat sendiri (SCGC). SCGC adalah bahan unik yang melibatkan inovasi dalam pengeluaran dan pembuatan konkrit. Ia adalah sejenis konkrit yang tidak memerlukan pemadatan untuk menghasilkannya dan ianya boleh dihasilkan tanpa simen Portland biasa sepenuhnya. Setakat ini beberapa kajian telah dilakukan ke atas ciri-ciri konkrit terpadat sendiri dan konkrit geopolymer dalam kedua-dua keadaan; segar dan keras. Walaubagaimanapun, tiada kajian telah dijalankan ke atas SCGC. Oleh itu kajian penyelidikan ini bertujuan untuk meneroka kemungkinan menghasilkan SCGC dibuat dengan bahan-bahan tempatan yang sedia ada dengan memeriksa sifat-sifat asas fizikal dan mekanikal. Kajian ini meliputi penghasilan SCGC menggunakan abu terbang yang boleh mencapai kekuatan mampatan 28 hari sebanyak 40 MPa dan memenuhi keperluan konkrit di kedua-dua keadaan; segar dan keras. Ciri-ciri penting kebolehkerjaan SCGC segar dilakukan melalui *Slump flow*, *V-Funnel*, *L-Box* dan kaedah ujian *J-Ring*. Sifat keras termasuk kekuatan mampatan, tegangan belah dan kekuatan lenturan, modulus keanjalan, Nisbah Poisson, dan rayapan dan pengecutan kering. Di samping itu, kepadatan dan penyerapan air ciri-ciri keras SCGC juga telah diperiksa. Kajian ini telah menghasilkan keputusan yang menggalakkan dan mengesahkan pengeluaran SCGC yang memuaskan. Keputusan menunjukkan bahawa SCGC sehingga 50 MPa 28 hari kekuatan mampatan boleh dihasilkan. Keputusan ujian menunjukkan bahawa sifat-sifat mekanik SCGC bersaing dengan konkrit konvensional berasaskan OPC. Adalah dijangka bahawa hasil kajian ini akan meluaskan skop SCGC dan dengan itu menjana peluang-peluang baru untuk industri pembinaan.

Kata Kunci: Konkrit geopolymer, Konkrit terpadat sendiri, Konkrit geopolymer terpadat sendiri, Ciri-ciri mekanikal

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LIST OF ABBREVIATIONS AND NOTATIONS

Abbreviations

ACI	American Concrete Institute
ASTM	American Society for Testing Materials
BET	Brunauer Emmer Teller
BS	British Standard
BTU	British Thermal Unit
CSH	Calcium Silicate Hydrate
DEMEC	Demountable Mechanical
EFNARC	European Federation of National Associations Representing Producers and Applicators of Specialist Building Products for Concrete
GGBS	Ground Granulated Blast-Furnace Slag
HRWR	High Range Water Reducer
IPC	Inorganic Polymer Concrete
JSCE	Japan Society of Civil engineers
LOI	Loss on Ignition
LVDT	Linear Voltage Differential Transducer
MOR	Modulus of Rupture
NVC	Normal Vibrated Concrete
OPC	Ordinary Portland cement
SCC	Self-Compacting Concrete
SCGC	Self-Compacting Geopolymer Concrete
SEM	Scanning Electron Microscopy
SSD	Saturated Surface Dry
VBI	Visual Blocking Index
VMA	Viscosity Modifying Admixture
XRD	X-Ray Diffraction
XRF	X-Ray Fluorescence

Notations

Al	Aluminum
Al_2O_3	Aluminum Oxide
CaO	Calcium Oxide
CO_2	Carbon dioxide
Fe_2O_3	Iron Oxide
K_2O	Potassium Oxide
MgO	Magnisium Oxide
Na_2O	Sodium Oxide
NaOH	Sodium Hydro Oxide
O	Oxygen
P_2O_5	Phosphorus pentoxide
Si	Silicon
SiO_2	Silica
SO_3	Sulpher trioxide
TiO_2	Titanium dioxide
OH^-	Hydroxide
L	Liters
M	Molarity
GPa	Giga Pascal
MPa	Mega Pascal
Max.	Maximum
Min.	Minimum
Temp.	Temperature
cm	Centimeter
cm^2/g	Square centimeter per gram
^oC	Degree centigrade
dia.	Diameter
ft^3	Cubic feet
gm	Gram
g/cm^3	Gram per cubic centimeter
hrs	Hours
in.	inch

kg	Kilogram
kg/m^3	Kilogram per cubic meter
m	Meter
m^2/g	Square meter per gram
m^2/kg	Square meter per kilogram
mm	Millimeter
min.	Minutes
sec.	Seconds
μm	Micron meter
με	Microstrain
%	Percentage
<	Less than
>	Greater than

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