The Manufacture and Compressive Ductility of Ultra-High Performance Fiber Reinforced Concrete Utilising Conventional Materials

Prepared by

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ABSTRACT

Concrete is a revolutionary material and has been used in civil engineering applications since the ancient Romans period. In the past century concrete has undergone significant change with the development of high strength concretes, and more recently self-compacting and fibre reinforced concretes. In the past decades, significant effort has been devoted to the development of ultra-high performance concrete and one of the latest developments is the ultra-high performance fiber reinforced concrete (UHPFRC). UHPFRC is characterised by high strength and ductility. This advanced concrete is currently used in some structural elements; however the high cost of manufacture, required production control sand lack of industry training has precluded its potential structural applications. Based on the above explanations, the first main goal of this thesis is to develop a wide range of UHPFRC utilising conventional materials and production methods. An experimental investigation is then conducted in order to quantify the size dependent stress-strain compressive behaviour and ductility of UHPFRC. It is then shown how this can be incorporated into a numerical segmental moment-rotation (M/θ) approach to allow for the simulation of flexural ductility of reinforced UHPFRC beams. It is expected that this advancement will aid in the design of UHPFRC structures.

A large-volume of experimental work has been conducted in this thesis to achieve the aforementioned goals. The first part of the experimental investigation involved developing a significant number of UHPRFC mixes to confirm the potential to manufacture using conventional materials and production methods, that is, the use of conventional aggregates, mixers and curing techniques. The main focus of the first part of research was to quantify the variation in rheological and strength properties of UHPFRC with changes the fineness modulus by using conventional aggregates. Additionally to further reduced the financial and environmental cost of production the use of granulated slag and coarse aggregate as a full or partial replacement for conventional fine aggregate was investigated in this research. The results of this study were then compared to the results of mixes designed with expensive silica sand and which were subjected to heat curing technique as this is the current convention for the manufacture of UHPFRC in the construction industry.

The second part of the experimental study investigated the size dependent stress-strain behaviour of UHPFRC under concentric loading including different types of fibers (3D, 4D and 5D) and different volume-fractions (0-3%). This was done as quantifying the stress-strain behaviour and therefore ductility is essential for the design of structural elements. In the last portion of the thesis it is then shown how the flexural ductility of reinforced UHPFRC beams can be simulated with segmental moment-rotation (M/θ) approach by utilising the size dependent stress-strain relationships.

STATEMENT OF ORIGINALITY

I am Md. Habibur Rahman Sobuz, certify that this work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

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Md. Habibur Rahman Sobuz	Date

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LIST OF PUBLICATIONS

Based on the research work, one journal paper has been submitted for publication from the first part of research and another one is preparing from the second part of research.

Sobuz, H.R., Visintin, P., Mohamed Ali, M.S., Singh, M., Griffith, M.C., Sheikh, A.H. (2016) Manufacturing Ultra-High Performance Concrete Utilising Conventional Materials and Production Methods, *Construction and Building Material, Vol. 111, pp. 251–261.*

Sobuz, H.R., Visintin, P. and Oehlers, D. J. (2016) "Hinge Rotation Capacity of Reinforced Concrete Beams with Ultra-high Performance Fiber Reinforced (UHPFRC)" (Under Preparation).