



# 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 and 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 ( $M/\theta$ ) 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 UHPFRC 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 ( $M/\theta$ ) 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

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Date

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# TABLE OF CONTENTS

ABSTRACT.....	i
STATEMENT OF ORIGINALITY.....	iii
ACKNOWLEDGEMENTS.....	iv
TABLE OF CONTENTS.....	v
LIST OF FIGURES.....	xi
LIST OF TABLES.....	xxiii
LIST OF PUBLICATIONS.....	xxv
<b>CHAPTER 1: INTRODUCTION.....</b>	<b>1</b>
1.1 Introduction .....	1
1.2 Objectives and Tasks.....	8
1.3 Structure of Dissertation.....	9
<b>CHAPTER 2: LITERATURE REVIEW.....</b>	<b>11</b>
2.1 An Historical Perspective of Ultra-high Performance Concrete .....	11
2.2 Advantages and Applications of UHPFRC .....	13
2.3 Mix Design and Production Methods of UHPFRC.....	15
2.3.1 Mixture composition .....	15
2.3.1.1 Cement.....	17
2.3.1.2 Aggregate.....	18
2.3.1.3 Silica fume .....	19
2.3.1.4 Steel fibers .....	20
2.3.1.5 Superplasticizer.....	22
2.3.1.6 Water.....	23
2.3.2 Mixing procedure .....	23
2.3.3 Casting and curing regimes .....	25
2.4 Rheological Properties of UHPFRC.....	27
2.4.1 Effect of superplasticizer content .....	28

2.4.2	Effect of fiber type and content.....	29
2.5	Hardened Properties of UHPFRC .....	30
2.5.1	Axial behaviour in compression.....	30
2.5.1.1	Method of measurement .....	31
2.5.1.2	Ascending branch or peak behaviour .....	32
2.5.1.3	Softening branch.....	34
2.5.1.4	Size effect responses.....	36
2.5.1.5	Influence of steel fiber type and amount .....	44
2.5.2	Dilation behaviour in compression.....	45
2.5.2.1	Method of measurement .....	45
2.5.3	Test rig and instrumentation.....	46
2.6	Summary .....	46
<b>CHAPTER 3: MANUFACTURING UHPC UTILISING CONVENTIONAL MATERIALS AND METHODS (Journal paper).....</b>		<b>48</b>
	Abstract .....	54
3.1	Introduction .....	55
3.2	Experimental Program.....	57
3.2.1	Material specifications .....	58
3.2.2	Mixing procedure, sample preparation and testing .....	62
3.3	Results .....	62
3.3.1	Behaviour of fresh concrete without coarse aggregate .....	64
3.3.2	Behaviour of fresh concrete with coarse aggregate.....	66
3.3.3	Hardened material properties .....	68
3.3.4	Discussion of compressive strength results.....	69
3.3.5	Influence of coarse aggregate.....	73
3.3.6	Stress-strain relationship .....	76
3.3.7	Influence of slag as a sand replacement .....	80
3.4	Conclusion.....	80

Acknowledgements .....	82
References.....	83
<b>CHAPTER 4: MIX DESIGN AND METHODS OF ULTRA-HIGH PERFORMANCE FIBER REINFORCED CONCRETE .....</b>	<b>87</b>
4.1 Introduction .....	87
4.2 Series – I: Conventional Sand as a Replacement of Expensive Silica Sand ...	88
4.2.1 Materials and mix proportions .....	90
4.2.1.1 Cement.....	91
4.2.1.2 Silica Fume .....	91
4.2.1.3 Aggregate.....	92
4.2.1.5 Steel Fibers .....	94
4.2.1.5 Superplasticizer and Water .....	95
4.2.2 Mixing Procedure .....	95
4.2.3 Specimen preparation and curing regime .....	97
4.2.4 Test set-up and instrumentation .....	99
4.2.4.1 Slump cone test (Filling ability) .....	99
4.2.4.2 Slump spread measurement (Flowability) .....	101
4.2.4.3 J-ring test (Passing ability) .....	102
4.2.4.4 Uniaxial compression test.....	105
4.2.5 Test results and observations.....	107
4.2.5.1 Influence of superplasticizer (SP), water and fineness modulus (FM) of sand on slump values of UHPFRC .....	107
4.2.5.2 Influence of SP, water, FM and time on slump spread of UHPFRC .....	111
4.2.5.3 Influence of SP, water, FM and Time on J-ring spread of UHPFRC .....	116
4.2.5.4 Comparison of slump and J-ring spread test results .....	122
4.2.5.5 Compressive test results on hardened UHPFRC properties .....	125
4.3 Series – II: Coarse Aggregate as Partially Replaced with Fine Aggregate on UHPFRC .....	137



4.3.1	Materials and mix proportions .....	138
4.3.2	Mixing procedure .....	139
4.3.3	Specimen preparation and curing regimes .....	140
4.3.4	Test set-up and instrumentation .....	140
4.3.5	Test results and discussion .....	141
4.3.5.1	Influence of coarse aggregate on rheological properties of UHPFRC .....	141
4.3.5.2	Influence of coarse aggregate on hardened properties of UHPFRC.....	151
4.4	Series – III: Granulated Lead Smelter Slag (GLSS) as Fine Aggregate Replacement on UHPFRC.....	154
4.4.1	Materials and mix proportions .....	155
4.4.2	Mixing procedure .....	156
4.4.3	Specimen preparation and curing regimes .....	156
4.4.4	Test set-up and instrumentation .....	156
4.4.5	Test results and discussion .....	158
4.4.5.1	Influence of granulated slag on rheological properties of UHPFRC.....	158
4.4.5.2	Influence of slag on hardened properties of UHPFRC.....	166
4.5	Series – IV: Expensive Silica Sand as Fine Aggregate on UHPFRC .....	170
4.5.1	Materials and mix proportions .....	171
4.5.2	Mixing procedure .....	171
4.5.3	Specimen preparation and curing regime.....	172
4.5.4	Test set-up and instrumentation .....	172
4.5	Test results and discussion .....	172
4.6	Series – V: Conventional Sand and Expensive Silica Sand as Fine Aggregate on UHPFRC with Heat Curing.....	175
4.6.1	Materials and mix proportions .....	176
4.6.2	Mixing procedure .....	176
4.6.3	Specimen preparation and curing regimes .....	176
4.6.4	Test set-up and instrumentation .....	177

4.6.5	Test results and discussion .....	177
4.7	Stress-strain relationship of UHPFRC for all of the mixes .....	180
4.8	Summary .....	183

**CHAPTER 5: EXPERIMENT ON SIZE EFFECT AND COMPRESSIVE DUCTILITY.....185**

5.1	Introduction .....	185
5.2	Experimental Methodology .....	189
5.2.1	Material and mix proportion.....	190
5.2.2	Design of specimen .....	191
5.2.3	Specimen preparation .....	194
5.2.4	Test set-up and instrumentation .....	195
5.3	Test results and analysis .....	197
5.3.1	Rheological properties of UHPFRC.....	197
5.3.2	Compressive behaviour of UHPFRC with curing age .....	205
5.3.3	Axial behaviours of UHPFRC under concentric loading.....	210
5.3.3.1	Influence of specimen size on axial response of UHPFRC in compression .....	216
5.3.3.2	Influence of size effect on lateral response of UHPFRC in compression .....	223
5.3.3.3	Influence of fiber on axial response of UHPFRC in compression .....	229
5.3.3.4	Influence of fiber on lateral response of UHPFRC in compression .....	234
5.3.3.5	Crack pattern and failure modes of UHPFRC specimen .....	239
5.4	Summary .....	247

**CHAPTER 6: SEGMENTAL ANALYSIS OF UHPFRC.....248**

6.1	Introduction .....	248
6.2	Quantifying the Stress-Strain Behaviour from the Ductility Test Results ....	250
6.2.1	Idealisation of axial stress-strain relationship .....	250
6.3	Segmental Moment-rotation ( $M/\theta$ ) Analysis.....	276

6.3.1	Analysis method of segmental approach.....	278
6.3.2	Example of application of the segmental analysis for UHPFRC beams .....	281
6.3.2.1	Influence of specimen size on moment-rotation (M/θ) response of UHPFRC beams.....	281
6.3.2.2	Influence of fiber on moment-rotation (M/θ) response of UHPFRC beams .....	284
6.4	Summary .....	288
<b>CHAPTER 7: CONCLUSION AND RECOMMENDATIONS.....</b>		<b>289</b>
7.1	General Remarks .....	289
7.2	Manufacturing and Production Methods of UHPFRC .....	289
7.3	Size Effect and Ductility Responses of UHPFRC.....	292
7.4	Recommendations for Future Work .....	294
<b>REFERENCES.....</b>		<b>297</b>

## LIST OF FIGURES

Fig.1.1 Layout of the thesis .....	9
Fig.2.1 Graphical representation of UHPFRC composition.....	16
Fig.2.2 (a) Effect of different types of fiber on UHPFRC production (Camacho Torregrosa, 2014) (b) Effect of fiber types and amount on UHPFRC preparation (Kim et al., 2011) .....	21
Fig.2.3 Mixing procedure of UHPC (Graybeal, 2005).....	24
Fig.2.4 Curing process (a) Specimen stored at 20 <sup>0</sup> C (b) The specimens cured with steam (Camacho Torregrosa, 2014). .....	27
Fig.2.5 Typical stress-strain curves from compressive tests of different cylinder sizes (Kazemi & Lubell, 2012) .....	37
Fig.2.6 Size dependent stress-strain behaviour of concrete by Chen et al. (2013).....	39
Fig.2.7 Stress-strain response of cylinders with variation of sizes (Chen et al., 2013) .....	41
Fig.2.8 Typical stress-strain behaviour for range of height-to-diameter ratio (a) Normal strength (b) High strength concrete (Jansen & Shah, 1997) .....	41
Fig.2.9 Typical stress-strain behaviour for range of height-to-diameter ratio with size effect on peak strength (Del Viso et al., 2008).....	42
Fig.2.10 Stress-strain curve under compression for different length of specimen (Hillerborg, 1990).....	43
Fig.2.11 Complete stress-strain curve of different slenderness ratio (Sangha &Dhir, 1972).....	43
Fig.3.1 Grading of sands.....	59
Fig.3.2 Slump flow (without J-ring) of mixes before and after fibre addition.....	65
Fig.3.3 Slump flow of mixes with and without fibres.....	66

Fig.3.4 Change in concrete flowability with CA addition.....	67
Fig.3.5 Compressive strength gain over time for mixes without CA.....	69
Fig.3.6 Influence of sp:c ratio of compressive strength.....	70
Fig.3.7 Influence of FM on compressive strength.....	72
Fig.3.8 Influence of FM on $f_c$ .....	73
Fig.3.9 Increase in 7 day compressive strength due to CA addition.....	75
Fig.3.10 Compressive strength gain over time for mixes with CA.....	76
Fig.3.11 90 day axial and lateral stress strain relationships.....	77
Fig.3.12 Normalised axial and lateral stress strain relationships.....	78
Fig.4.1 Grading of fine and coarse aggregate.....	94
Fig.4.2 (a) Steel fiber used in UHPFRC (b) Single part of fiber with hook.....	95
Fig.4.3 (a) Mixing of constituents of UHPC (b) After mixing of UHPC.....	96
Fig.4.4 (a) Cylinder being filled (b) Cylinder placed on level surface after filled (c) Specimen put on the table after demoulding (d) Marked the specimens (e) Put wet hessian and plastic sheets after demoulding (f) Curing the specimens in fog room ..	98
Fig.4.5 Slump measurement (a) Without fiber (b) With fiber.....	100
Fig.4.6 Slump flow measurement (a) Without fiber (b) With fiber .....	101
Fig.4.7 Without fiber (a) J-ring blocking Step (b) J-ring flow measurement .....	103
Fig.4.8 With fiber (a) J-ring blocking index (b) J-ring flow measurement.....	103
Fig.4.9 (a) Testing of cylinders using Seidner compression machine (b) Test set up and instrumentation by Amsler for UHPFRC specimens.....	106
Fig.4.10 Slump versus superplasticizer (SP) content .....	108
Fig.4.11 Slump versus water content .....	108
Fig.4.12 Slump versus fineness modulus (FM) of sand .....	109
Fig.4.13 Slump spread versus superplasticizer content.....	111
Fig.4.14 Slump spread versus water content .....	112

Fig.4.15 Slump versus fineness modulus (FM) of sand .....	112
Fig.4.16 Slump flow time (T50) versus fineness modulus (FM) of sand.....	113
Fig.4.17 Slump flow versus flow time (T50) for UHPFRC .....	113
Fig.4.18 Slump versus superplasticizer of UHPFRC .....	116
Fig.4.19 Slump versus water content .....	116
Fig.4.20 Slump versus fineness modulus (FM) of sand .....	117
Fig.4.21 Measurement of J-ring spread with T <sub>50J</sub> for UHPFRC .....	119
Fig.4.22 Measurement of J-ring spread with T <sub>50J</sub> for UHPFRC .....	120
Fig.4.23 Blocking step versus superplasticizer content of UHPFRC.....	121
Fig.4.24 Blocking step versus water content of UHPFRC.....	121
Fig.4.25 Blocking step versus fineness modulus (FM) of UHPFRC .....	122
Fig.4.26 All of the measurement J-ring and slump spread values of UHPFRC.....	123
Fig.4.27 All of the measurement J-ring T50 and slump spread values of UHPFRC	124
Fig.4.28 All of the measurement blocking step and J-ring spread of UHPFRC .....	125
Fig.4.29 Compressive strength gain over time for mixes with conventional fine aggregate .....	129
Fig.4.30 Compressive strength gain over time for mixes with conventional fine aggregate .....	129
Fig.4.31 Influence of sp:c ratio of compressive strength .....	132
Fig.4.32 Influence of sp:c ratio of compressive strength .....	132
Fig.4. 33 Influence of FM on compressive strength.....	134
Fig.4.34 Influence of FM on compressive strength.....	134
Fig.4.35 Influence of FM on f <sub>c</sub> .....	136
Fig.4.36 Measurement of (a) slump height without fiber (b) slump height with fiber (c) slump spread without fiber (d) slump spread with fiber (e) J-ring blocking step	

without fiber (f) J-ring spread without fiber (g) J-ring blocking step with fiber (h) J-ring spread with fiber .....	141
Fig.4.37 Slump versus superplasticizer (SP) content .....	142
Fig.4.38 Slump versus water content .....	142
Fig.4.39 Slump spread versus superplasticizer (SP) content.....	144
Fig.4.40 Slump spread versus water content.....	145
Fig.4.41 Slump spread versus slump spread time, T50.....	145
Fig.4.42 J-ring spread versus superplasticizer content.....	146
Fig.4.43 J-ring spread versus water content .....	147
Fig.4.44 J-ring spread versus slump spread time, T50.....	148
Fig.4.45 J-ring spread versus slump spread .....	149
Fig.4.46 J-ring spread time versus slump spread time .....	148
Fig.4.47 Blocking step versus J-ring spread.....	149
Fig.4.48 Change in concrete flowability with CA addition .....	150
Fig.4.49 Increase in 7 day compressive strength due to CA addition.....	152
Fig.4.50 Compressive strength gain over time for mixes with CA.....	153
Fig.4.51 Granulated lead smelter slag (GLSS) used in UHPFRC.....	155
Fig.4.52 Measurement of (a) slump height without fiber (b) slump height with fiber (c) slump spread without fiber (d) slump spread with fiber (e) J-ring blocking step without fiber (f) J-ring spread without fiber (g) J-ring blocking step with fiber (h) J-ring spread with fiber .....	157
Fig.4.53 Slump spread versus superplasticizer (SP) content.....	158
Fig.4.54 Slump spread versus water content.....	159
Fig.4.55 Slump spread versus superplasticizer (SP) content.....	160
Fig.4.56 Slump spread versus superplasticizer (SP) content.....	160
Fig.4.57 Influence of time (T50) on spread flow measurement.....	161

Fig.4.58 Slump spread versus superplasticizer (SP) content.....	162
Fig.4.59 Slump spread versus water content .....	163
Fig.4.60 Influence of time (T50) on spread measurement .....	163
Fig.4.61 J-ring spread versus Slump spread.....	164
Fig.4.62 Influence of J-ring time and slump spread time.....	164
Fig.4.63 Blocking step versus J-ring spread.....	165
Fig.4.64 Compressive strength gain versus time with slag addition .....	168
Fig.4.65 Compressive strength gain versus time with slag addition .....	168
Fig.4.66 Compressive strength gain versus time with slag addition .....	169
Fig.4.67 Influence of time on the compressive strength of UHPFRC with silica sand .....	174
Fig.4.68 Influence of SP:c on the compressive strength of UHPFRC with silica sand .....	174
Fig.4.69 Compressive strength vs time of silica and washed river sand by heat curing .....	179
Fig.4.70 90 days axial and lateral stress strain relationships.....	180
Fig.4.71 Normalised axial and lateral stress strain relationships	181
Fig.5.1 (a), (c) and (e) Steel fiber used in UHPFRC (b), (d) and (f) Single part of fiber (31, 60 and 63mm length respectively) .....	191
Fig.5.2 Preparation of specimen (a) 3D and 5D fiber types (b) 4D fiber type.....	195
Fig.5.3 Rectangular UHPFRC specimens set-up and instrumentation (b) Cylindrical UHPFRC specimens set-up and instrumentation (c) Test chamber for UHPFRC specimens (d) Computer record data system.....	196
Fig.5.4 Slump height versus fiber amount .....	199
Fig.5.5 Slump flow versus fiber amount .....	199
Fig.5.6 J-ring flow versus fiber amount .....	200



Fig.5.7 J-ring flow versus slump flow .....	200
Fig.5.8 Slump flow versus flow time .....	201
Fig.5.9 J-ring flow versus flow time .....	202
Fig.5.10 J-ring flow versus slump flow time.....	202
Fig.5.11 Blocking step versus fiber percentage.....	204
Fig.5.12 Blocking step versus j-ring flow .....	204
Fig.5.13 Comparison of compressive strength with curing age for different types of fiber type and amount.....	207
Fig.5.14 Comparison of compressive strength with fiber percentage with curing age .....	208
Fig.5.15 Strength comparison with curing age for different fiber type.....	209
Fig.5.16 Strength comparison with curing age for different fiber type.....	209
Fig.5.17 Axial and lateral stress-strain response of 3D fiber with different amount	212
Fig.5.18 Axial and lateral Stress-strain response of 4D fiber with different amount .....	213
Fig.5.19 Axial and lateral Stress-strain response of 4D fiber with different amount .....	213
Fig.5.20 Axial and lateral Stress-strain response of 5D fiber with different amount .....	214
Fig.5.21 Axial and lateral Stress-strain response of 3D fiber with different amount .....	214
Fig.5.22 Axial and lateral Stress-strain response of 4D fiber with different amount .....	215
Fig.5.23 Axial and lateral Stress-strain response of 5D fiber with different amount .....	215

Fig.5.24 Influence of size on axial stress-strain response of 3D fiber with different fiber amount .....	217
Fig.5.25 Influence of size on axial stress-strain response of 4D fiber with different amount .....	217
Fig.5.26 Influence of size on axial stress-strain response of 5D fiber with different amount .....	218
Fig.5.27 Influence of size on axial stress-strain response of 4D fiber with different amount .....	218
Fig.5.28 Influence of size on axial stress-strain response of 4D fiber with 1% fiber content .....	219
Fig.5.29 Influence of size on axial stress-strain response of 4D fiber with 2% fiber content .....	219
Fig.5.30 Influence of size on axial stress-strain response of 4D fiber with 3% fiber content .....	220
Fig.5.31 Influence of size on axial stress-strain response of different fiber with 1% fiber content.....	220
Fig.5.32 Influence of size on axial stress-strain response of different fiber with 2% fiber content.....	221
Fig.5.33 Influence of size on axial stress-strain response of different fiber with 3% fiber content.....	221
Fig.5.34 Influence of size on axial stress-strain response of different fiber and content .....	222
Fig.5.35 Influence of size on axial stress-strain response of 3D fiber with different amount .....	224
Fig.5. 36 Influence of size on axial stress-strain response of 4D fiber with different amount .....	224

Fig.5.37 Influence of size on axial stress-strain response of 5D fiber with different amount .....	225
Fig.5.38 Influence of size on axial stress-strain response of 4D fiber with different amount .....	225
Fig.5.39 Influence of size on lateral stress-strain response of different fiber with 1% fiber content.....	226
Fig.5.40 Influence of size on lateral stress-strain response of different fiber with 2% fiber content.....	226
Fig.5.41 Influence of size on lateral stress-strain response of different fiber with 3% fiber content.....	227
Fig.5.42 Influence of size on lateral stress-strain response of 4D fiber with 1% fiber content .....	227
Fig.5.43 Influence of size on lateral stress-strain response of 4D fiber with 2% fiber content .....	228
Fig.5.44 Influence of size on lateral stress-strain response of 4D fiber with 3% fiber content .....	228
Fig.5.45 Influence of size on lateral stress-strain response of different fiber and content .....	229
Fig.5.46 Influence of fiber on axial stress-strain response of 3D fiber with different content .....	230
Fig.5.47 Influence of fiber on axial stress-strain response of 3D fiber with different content .....	230
Fig.5.48 Influence of fiber on axial stress-strain response of different fiber with 1% fiber content.....	231
Fig.5.49 Influence of fiber on axial stress-strain response of different fiber with 1% fiber content.....	231

Fig.5.50 Influence of fiber on axial stress-strain response of different fiber with 2% fiber content.....	232
Fig.5.51 Influence of fiber on axial stress-strain response of different fiber with 2% fiber content.....	232
Fig.5.52 Influence of fiber on axial stress-strain response of different fiber with 3% fiber content.....	233
Fig.5.53 Influence of fiber on axial stress-strain response of different fiber with 3% fiber content.....	233
Fig.5.54 Influence of fiber on lateral stress-strain response of different fiber with different content .....	235
Fig.5.55 Influence of fiber on lateral stress-strain response of different fiber with different content .....	235
Fig.5.56 Influence of fiber on lateral stress-strain response of different fiber with 1% fiber content.....	236
Fig.5.57 Influence of fiber on lateral stress-strain response of different fiber with 1% fiber content.....	236
Fig.5.58 Influence of fiber on lateral stress-strain response of different fiber with 2% fiber content.....	237
Fig.5.59 Influence of fiber on lateral stress-strain response of different fiber with 2% fiber content.....	237
Fig.5.60 Influence of fiber on lateral stress-strain response of different fiber with 3% fiber content.....	238
Fig.5.61 Influence of fiber on lateral stress-strain response of different fiber with 3% fiber content.....	238
Fig.5.62 Failure pattern of 3D fiber specimens (Test series -1).....	240
Fig.5.63 Failure pattern of 4D fiber specimens (Test series -1).....	241

Fig.5.64 Failure pattern of 5D fiber specimens (Test series -1).....	242
Fig.5.65 Failure pattern of 3D fiber specimens (Test series -2).....	243
Fig.5. 66 Failure pattern of 5D fiber specimens (Test series -2).....	244
Fig.5.67 Failure pattern of 4D fiber specimens (Test series -3).....	245
Fig.5.68 Failure pattern of 4D fiber specimens (Test series -4)	246
Fig.6.1 Deformation in a compression test.....	250
Fig.6.2 Variation of axial deformation with applied stress .....	251
Fig.6.3 Shear friction material properties.....	252
Fig.6.4 Idealised compression stress-strain relationship.....	254
Fig.6.5 Experimental values of Stage 1 ascending branch for 100x200mm specimen .....	256
Fig.6.6 Experimental values of Stage 1 ascending branch for 100x300mm specimen .....	257
Fig.6.7 Experimental values of Stage 1 ascending branch for 100x400mm specimen .....	257
Fig.6.8 Quantification of secant stiffness for test series – 1 specimens .....	258
Fig.6.9 Quantification of secant stiffness for test series – 2 specimens .....	258
Fig.6.10 Quantification of secant stiffness for test series – 3 specimens .....	259
Fig.6.11 Quantification of secant stiffness for test series – 4 specimens .....	259
Fig.6.12 Quantification of peak strength for test series – 1 specimens.....	261
Fig.6.13 Quantification of peak strength for test series – 2 specimens.....	261
Fig.6.14 Quantification of peak strength for test series - 3 .....	262
Fig.6.15 Quantification of peak strength for test series - 4 .....	262
Fig.6.16 Quantification of strain at peak stress test series -1 .....	264
Fig.6.17 Quantification of strain at peak stress test series -2 .....	264
Fig.6.18 Quantification of strain at peak stress test series -3 .....	265

Fig.6.19 Quantification of strain at peak stress test series -4 .....	265
Fig.6.20 Sliding deformation at 0.5fc for test series – 1 specimen .....	267
Fig.6.21 Sliding deformation at 0.5fc for test series – 2 specimen .....	267
Fig.6.22 Sliding deformation at 0.5fc for test series – 3 specimen .....	268
Fig.6.23 Sliding deformation at 0.5fc for test series – 4 specimen .....	268
Fig.6.24 Derivation of limiting Stage 3 deformation for test series – 1 specimen...	271
Fig.6.25 Derivation of limiting Stage 3 deformation for test series – 2 specimen...	271
Fig.6.26 Derivation of limiting Stage 3 deformation for test series – 3 specimens .	272
Fig.6.27 Derivation of limiting Stage 3 deformation for test series – 4 specimens .	272
Fig.6.28 Failure strength determination of test series – 1 specimen .....	274
Fig.6.29 Failure strength determination of test series – 2 specimen .....	274
Fig.6.30 Failure strength determination of test series – 3 specimen .....	275
Fig.6.31 Failure strength determination of test series – 4 specimens.....	275
Fig.6.32 Segmental moment-rotation analysis for RC beams.....	278
Fig.6.33 Segmental moment-rotation analysis for half section.....	278
Fig.6.34 Flow chart diagram to perform the segmental analysis .....	280
Fig.6.35 Influence of size on moment-rotation response of RC beams with 3D fiber .....	282
Fig.6.36 Influence of size on moment-rotation response of RC beams with 4D fiber .....	283
Fig.6.37 Influence of size on moment-rotation response of RC beams with 4D fiber .....	283
Fig.6.38 Influence of size on moment-rotation response of RC beams with 5D fiber .....	284
Fig.6.39 Influence of fiber on moment-rotation response of RC beams with 1% fiber .....	285

Fig.6.40 Influence of fiber on moment-rotation response of RC beams with 2% fiber	285
Fig.6.41 Influence of fiber on moment-rotation response of RC beams with 3% fiber	286
Fig.6.42 Influence of fiber on moment-rotation response of RC beams with 1% fiber	286
Fig.6.43 Influence of fiber on moment-rotation response of RC beams with 2% fiber	287
Fig.6.44 Influence of fiber on moment-rotation response of RC beams with 3% fiber	287

## LIST OF TABLES

Table 2.1 Typical composition of UHPFRC (Graybeal, 2007).....	16
Table 2.2 Properties of different types of steel fibers (Kim et al., 2011).....	21
Table 2.3 Properties of different types of steel fibers (Yoo& Yoon 2015).....	21
Table 2.4 Properties of different types of steel fibers (Camacho Torregrosa 2014).....	30
Table 3.1 Chemical Composition of undisified silica fume.....	58
Table 3.2 Mix designs to investigate grading of fine aggregate.....	59
Table 3.3 Mix designs to investigate the influence of coarse aggregate.....	61
Table 3.4 Workability of UHPC with and without coarse aggregate.....	63
Table 3.5 Compressive strength of UHPC without coarse aggregate.....	68
Table 3.6 Compressive strength of UHPC with coarse aggregate.....	74
Table 3.7 Mechanical properties of mix designs.....	79
Table 4.1 Mix designs to investigate grading of fine aggregate.....	90
Table 4.2 Grain size distribution raw data for fine and coarse aggregate .....	93
Table 4.3 Grain size distribution raw data for expensive silica sand .....	93
Table 4.4 UHPFRC compressive test results with conventional fine aggregate .....	126
Table 4.5 Mix designs to investigate the influence of coarse aggregate .....	139
Table 4.6 Compressive strength of UHPFRC with coarse aggregate .....	151
Table 4.7 Mix designs of UHPC to investigate the influence of GLSS .....	156
Table 4.8 Compressive strength of UHFRPC with GGBFS .....	167
Table 4.9 Mix designs to investigate the influence of expensive fine aggregate (silica powder and silica sand) .....	171
Table 4.10 Compressive strength of UHPFRC with silica sand .....	172
Table 4.11 Mix designs to investigate the suitable mix .....	176
Table 4.12 UHPFRC compressive test results with conventional fine aggregate....	178
Table 4.13 Mechanical properties of mix designs.....	182



Table 5.1 Basic composition of ultra-high performance concrete mixture.....	190
Table 5.2 Types and properties of steel fibers.....	191
Table 5.3 Experimental design.....	192
Table 5.4 Specimen quantities.....	193
Table 5.5 Compressive strength of UHPFRC with different fiber type and amount .....	206
Table 5.6 Axial stress-strain results of UHPFRC.....	210
Table 6.1 Axial stress-strain compressive ductility test results of UHPFRC.....	255
Table 6.2 Secant stiffness results for regression analysis .....	260
Table 6.3 Peak strength results for regression analysis.....	263
Table 6.4 Strain at peak stress results for regression analysis.....	266
Table 6.5 Sliding deformation results for regression analysis .....	269
Table 6.6 Deformation Limit results for regression analysis .....	273
Table 6.7 Failure strength results for regression analysis.....	276

## **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.

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