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# Steel Fibrous Cement Based Composites

Part one: Material and mechanical properties  
Part two: Behavior in the anchorage zones of  
prestressed bridges

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# Abstract

This PhD thesis is divided into two parts. Part one deals with the development of the material and the mechanical properties of Steel Fibrous Cement Based Composites (SFCBC) for improving bridge design and construction. It familiarizes the hydration mechanisms of the high performance concrete with the help of Powers' and Jensen's models. Concretes with different water-cement ratio were compared with each other with respect to degree of hydration and hydration products. This analysis showed that high performance concrete has higher strengths not because it has more gel solid, but due to it having less porosity and higher filler content compared to ordinary concrete.

A number of experiments were performed to achieve a mix design method for a SFCBC, which has good workability, high early and long-term strength and good durability characteristics. A Self-compacting and self-leveling fibrous composite, which has ultra high strengths (Compressive strength  $f_c = 180 \sim 220$ MPa and flexural tensile strength  $f_{lu} = 14 \sim 32$ MPa depending on the volume fraction of fibers) was produced. This composite was also tested under different curing conditions in order to investigate the effect of curing on hydration and self-desiccation shrinkage. These tests showed that SFCBC should not be water-cured under a long period and self-desiccation influences the compressive strength negatively. Test of scaling at freezing showed that SFCBC has very good durability characteristics.

Part two deals with the behavior of SFCBC in the anchorage zones of prestressed bridges. The prismatic composite specimens were tested for different volume fractions of fibers under different concentrations ratios of strip loading. The results of these tests showed that the ultimate strength of the SFCBC specimens was approximately twice that of ordinary concrete with the same size ( $f_c = 60\text{MPa}$ , reinforced with stirrups). Therefore, SFCBC has good possibility to replace the traditional rebars in the anchorage zones of prestressed bridges.

This composite has different behavior than the traditional concrete e.g. crack formation, failure criteria, effective strength and angle of friction. A vertical crack on the centerline was occurred while wedge developed under the loading plate. In contrast to ordinary concrete, the cracks could not reach to the bottom of the blocks.

The tests results gave the ideas of that this material acts like metals or plastics in the high fiber content. This material is neither very brittle as concrete nor very ductile as metals but it is somewhere between them.

Upper-bound plasticity solutions were utilized for modeling the bearing capacity of SFCBC. Predictions of this method are good enough to estimate the bearing capacity of SFCBC in the anchorage zones of prestressed bridges.

**Keywords:** Process improvement of bridges, Prestressed concrete, High performance concrete, Ultra high performance concrete, Hydration, Cement based composites, Fibers, Self-compacting concrete, Bearing capacity, Anchorage zones, Tests

# Contents

Abstract	iii
Preface	v
Notations	xiii
Abbreviations	xix

## Part one

### MATERIAL AND MECHANICAL PROPERTIES

<b>Chapter one</b>	<b>Introduction</b>	<b>1</b>
1.1	Background and motivation	1
1.2	The terminology	3
1.3	Aims and scope	5
1.4	Limitations	6
<b>Chapter two</b>	<b>Some properties of high performance concrete</b>	<b>7</b>
2.1	Cement reactions	8
2.2	Hydration in early age	10
2.3	Powers' model of cement hydration	13
2.4	Modification of Powers' model by Jensen	19
<b>Chapter three</b>	<b>Steel fibrous cement based composites</b>	<b>23</b>
3.1	Factors affecting SFCBC	24

3.1.1	Water	26
3.1.2	Supplementary cementitious materials	26
3.1.3	Aggregate	29
3.1.4	Fibers	30
3.2	Self-compacting concrete	31
3.3	Experimental program	35
3.3.1	Materials used in the tests	35
3.3.2	Mix design and workability	38
3.3.3	Mechanical properties	50
3.3.3.1	Cubic compressive tests	52
3.3.3.2	Cylindrical compressive tests	54
3.3.3.3	Flexural strength tests	56
3.3.3.4	Modulus of elasticity tests	58
3.3.3.5	Strength development with time	61
3.3.4	Scaling at freezing	62
3.3.4.1	Introduction	62
3.3.4.2	Objectives and description	63
3.3.4.3	Results and discussions	67
3.3.5	Curing conditions	68
3.3.5.1	Introduction	68
3.3.5.2	Objectives and description	70
3.3.5.3	Results and discussions	72

## Part two

### BEHAVIOR IN THE ANCHORAGE ZONES OF PRESTRESSED BRIDGES

Chapter one	Literature review	75
1.1	Model of Mörsch (1924)	75
1.2	Improvements to model of Mörsch	76
1.3	Investigations by Lenschow and Sozen (1965) and Hawkins (1970)	78

1.4	Theory of plasticity	84
1.5	Tests performed by Ibell	89
1.6	Tests on fiber reinforced plastics	93
<b>Chapter two Experimental investigation</b>		<b>95</b>
2.1	Experimental setup	95
2.2	Tensile strength	97
2.3	Compressive, splitting tensile strength, modulus of elasticity and angle of friction	108
2.4	Bearing capacity	115
2.4.1	Experimental results	123
2.4.1.1	Series I, III, V, UHPC-matrix	123
2.4.1.2	Series II, IV, VI, UHPC-matrix with artificial cracks	145
2.4.1.3	Series VII, unreinforced HPC-matrix	147
<b>Chapter three Analytical plasticity solutions to the anchorage zone failures</b>		<b>151</b>
3.1	Assumptions	151
3.1.1	Yield and failure criteria	151
3.1.2	The internal angle of friction	158
3.1.3	The effective strength of concrete	159
3.2	Rotation of outer blocks about a point during failure	164
3.3	Comparison of experimental results with models found in literature	171
3.3.1	Hawkins' method	171
3.3.2	The method of Swedish handbook for concrete structures, BBK 94	173
<b>Chapter four Needs for further research, discussions and conclusions</b>		<b>179</b>
4.1	Needs for further research	179
4.2	Discussions	181
4.3	Conclusions	184
4.3.1	Conclusions from the material tests	184

4.3.2	Conclusions from anchorage zone studies	186
	References	189
Appendix A	Results of cubic and cylindrical compressive and flexural strength tests	199
Appendix B	Modified Mohr-Coulomb failure	209
Appendix C	Energy dissipation in a plane of discontinuity	213
Appendix D	Results of bearing capacity of SFCBC in the anchorage zones	217-234