# Table of contents

1. **INTRODUCTION**  
   1.1 Preliminary issues  
   1.2 Research goals  
   1.3 Outline of the Ph.D. Thesis

2. **STATE OF ART ANALYSIS**
   2.1 Introduction  
   2.2 UHPFRC concepts  
      2.2.1 What is UHPC-UHPFRC?  
      2.2.2 Basic principles  
      2.2.3 UHPFRC technology nowadays  
      2.2.4 UHPFRC manufacturers and applications  
   2.3 State of art analysis  
      2.3.1 HPFRC-UHPFRC types, commercial dosages  
      2.3.2 Database of dosages  
      2.3.3 Analysis of the database dosages designs  
      2.3.4 How to design a UHPFRC dosage?  
   2.4 Mixing and casting  
      2.4.1 Mixers  
      2.4.2 Mixing process  
      2.4.3 Casting  
      2.4.4 Curing system  
      2.4.5 Reasons to precast  
   2.5 Properties  
      2.5.1 Rheological properties  
      2.5.2 Hardened state  
   2.6 Design methods  
      2.6.1 Recommendations  
      2.6.2 From bending tests to constitutive law  
   2.7 Connections where UHPFRC takes part  
      2.7.1 Introduction  
      2.7.2 Shear keys  
      2.7.3 Cast in place joints  
      2.7.4 Bolted joints
3. MATERIALS AND METHODOLOGY

3.1 INTRODUCTION

3.2 COMPONENTS USED

3.3 MIXERS

3.3.1 1 LITER MORTAR MIXER

3.3.2 30 LITER TILTING DRUM MIXER

3.3.3 50 LITER ROTATING PAN MIXER

3.3.4 75 LITER INTENSIVE MIXER

3.3.5 110 LITER PLANETARY MIXER

3.3.6 1 m³ INDUSTRIAL MIXER

3.3.7 2 m³ INDUSTRIAL MIXER

3.4 RHEOLOGICAL TESTS

3.4.1 MINI-SLUMP CONE TEST

3.4.2 SLUMP FLOW TEST

3.4.3 RHEOMETER

3.5 CASTING PROCESS

3.6 CURING PROCESS

3.7 HARDENED STATE TESTS

3.7.1 COMPRESSIVE TESTS

3.7.2 ELASTIC MODULUS

3.7.3 FLEXURAL TESTS

3.7.4 MICROSCOPY

3.8 COMPUTATIONAL PROCESSES

3.8.1 BACK ANALYSIS

4. ON THE INFLUENCE OF SEVERAL VARIABLES IN THE UHPFRC DOSAGE

4.1 INTRODUCTION AND MOTIVATIONS

4.2 OBJECTIVES AND STRUCTURE

4.3 UHPC BINDER PROPORTION ANALYSIS

4.3.1 MOTIVATION AND OBJECTIVES

4.3.2 EXPERIMENTAL PROGRAM

4.3.3 RESULTS AND DISCUSSION

4.3.4 CONCLUSIONS OF THE UHPC BINDER ANALYSIS

4.4 INFLUENCE OF THE W/B RATIO ON THE RHEOLOGY AND HARDENED STATE
4.4.1  Effect of W/B on the hardened state: Experimental program  123
4.4.2  Results of the effect of W/B on the hardened state  124
4.4.3  Influence on the rheology: The critical slump flow  127
4.4.4  Conclusions of the W/B ratio effect  129
4.5  Active addition effect  129
4.5.1  Experimental program  130
4.5.2  Results  131
4.5.3  Conclusions of the active addition effect  137
4.6  Limestone coarse aggregate effect  137
4.6.1  Experimental program  138
4.6.2  Results  140
4.6.3  Conclusions of the limestone coarse aggregate effect  144
4.7  Particle packing theory effect  144
4.7.1  Definition of the dosage criteria  145
4.7.2  Experimental program  147
4.7.3  Results  147
4.7.4  Conclusions of the particle packing theory effect  150
4.8  Mixer effects  151
4.8.1  Experimental program  151
4.8.2  Results  153
4.8.3  Conclusions of the mixer effect  158
4.9  Statistical analysis of the influence of the parameters  158
4.9.1  Experimental program  158
4.9.2  Results  161
4.10 General recommendations for VHPFRC-UHPFRC: Dosage, mixing and pouring  163
4.10.1  Dosage components  163
4.10.2  Dosage rheology  165
4.10.3  Mixing process  166
4.10.4  Pouring of the concrete  167
4.11 Implementation of the previous concepts: Dosages for different requirements  168
4.11.1  Objectives  168
4.11.2  Definition of the dosages  169
4.12 Summary and final remarks  177

5.  UHPFRC bolted connections  179
5.1  Introduction  181
5.2  UHPFRC bolted joints. Failure modes  182
5.3  Preliminary tests for bolted connections  186
5.3.1  Test set up  186