ИМК INSTITUTE OF MATERIALS AND STRUCTURES

Phone +381 11 33 70 152
+381 11 32 18 505
Fax +381 11 33 70 253
Email: office@imk.grf.bg.ac.rs

UNIVERSITY OF BELGRADE
FACULTY OF CIVIL ENGINEERING

Bulevar kralja Aleksandra 73
11120 Belgrade, Republic of Serbia
P.O.B. 35-42
Phone+381 11 3218 606, +381 11 3370 102
Fax +381 11 3370 223
Tax Id. No: 100251144, Reg. No 07006454
Serbian National Treasury Account No:
840-1437666-41
Email: dekanat@grf.bg.ac.rs
www.grf.bg.ac.rs

REPORT - Nº 402/2021

ON MECHANICAL AND PHYSICAL PROPERTIES OF ULTRA HIGH PERFORMANCE CONCRETE ForteCrete150 (UHPC) REINFORCED WITH HIGH STRENGTH STEEL MICROFIBERS

Client	**Fortecrete d.o.o. Negotin** Miomira Radosavljevića Pikija 20 19300 NEGOTIN
Subject	Tests for determination of mechanical and physical properties of **ForteCrete150®** UHPC premix reinforced with high strength steel microfibers
Nº of contract / offer	Contract Nº 132408-21 dated 25.10.2021. (number of Faculty of Civil Engineering in Belgrade)

The report approved by

Technical Manager of the Laboratory:

Associate Prof. Dimitrije Zakić, Ph.D.B.C.E.

IMK INSTITUTE MANAGER

Associate Prof. Branko Milosavljević, Ph.D.B.C.E.

DEAN OF THE FACULTY OF CIVIL ENGINEERING

Prof. Vladan Kuzmanović, Ph.D.B.C.E.

CONTENT

Based on The Law on Planning and Construction ("Official Gazette of the Republic of Serbia", no. 72/09, 81/09, 64/10 US, 24/11, 121/12, 42/13 US, 50/13 US, 54/13, 98/13 US, 132/14 and 145/14) is issued a

CONFIRMATION

Members of the Institute of Materials and Structures, employees of Faculty of Civil Engineering, University of Belgrade

Responsible person:	Associate Prof. Dimitrije Zakić, Ph.D.B.C.E.
Execution of tests:	Savo Stavnjak, lab technician
Analysis and Conclusion:	Associate Prof. Dimitrije Zakić, Ph.D.B.C.E.
	Assist. Stefan Ž. Mitrović, M.Sc.B.C.E.

have created TECHNICAL DOCUMENTATION titled:

REPORT - Nº 402/2021

ON MECHANICAL AND PHYSICAL PROPERTIES OF ULTRA HIGH PERFORMANCE CONCRETE ForteCrete150® (UHPC) REINFORCED WITH HIGH STRENGTH STEEL MICROFIBERS

Prompted documentation made according to Client requirements and mentioned law regulation.

Belgrade, October 2021

IMK INSTITUTE MANAGER

Associate Prof. Branko Milosavljević, Ph.D.B.C.E.

DEAN OF THE FACULTY OF CIVIL ENGINEERING

Prof. Vladan Kuzmanović, Ph.D.B.C.E.

R E P O R T

1. INTRODUCTION

The Institute for Materials and Structures of the Faculty of Civil Engineering, University of Belgrade, according to the Contract N° 132408-21 dated 25.10.2021, sent to the company Fortecrete d.o.o. Negotin (referred to as the "Client" from here on), has carried out tests on physical-mechanical properties of UHPC specimens made using ForteCrete150® premix provided by the client. The report was prepared based on the obtained test results.

ForteCrete150® was supplied in bags as a blended premix (all dry constituents) that included the proprietary proportions of portland cement Lukavac CEM I 52.5N, microsilica, fine quartz, and quartz sand already pre-mixed. (Picture 1.1, Annex 1). The premix was then mixed with water and additives in two stages for an appropriate period of time as recommended by the Client. Mixes were made with steel fibers (Picture 1.2, Annex 1), i.e with specific volume percentage of microfiber reinforcement of 2%.

The specimens were prepared in the forms of standard cubes and prisms, as required by relevant standards. The tests were performed at different ages (1, 3 and 28 days), and according to the standards listed below. The tests were done according to the following parameters: workability of mix, bulk density, compressive strength and tensile strength. Based on the test results, the report has been prepared and photos of the samples and the tools used for testing shown as part of the attachments at the end of the report.

2. BASIC PHYSICAL-MECHANICAL PROPERTIES

The basic physical-mechanical characteristics of the tested materials (density, compressive and flexural strength) were obtained using standard methods by testing cubes and prisms with dimensions of 10x10x10 cm and 4x4x16cm, respectively. At the time of testing, the specimens were 24 hours, 3 days and 28 days old. Slump method for examination of consistency was used. The test results are shown in tables 1,2 and 3.

The workability of fresh mixture was tested according to SRPS EN 12350-2:2010 (*Testing fresh concrete - Part 2: Slump-test*) by using Abrams cone as a standard aparature for this test. Result of this test is the measured slump of the fresh mixture.

The procedure to find out the bulk density of samples involved: determination the volume of the sample, the mass of the mold and the fresh concrete that was poured in. After all of these steps were complete, the density of fresh concrete was calculated by taking the mass that was obtained and dividing by the volume. The same procedure was repeated for the hardened state, after the specimens were kept in a humid environment for 24 hours. In table 2, the average values of density (based on 3 results) are given.

The compressive strength was tested according to SRPS EN 12390-3:2014 (*Testing hardened concrete - Part 3: Compressive strength of test*). The sample testing was performed with the steel fibres (2%), at different ages of 1 day, 3 days and 28 days. The test was performed on a

compression machine that was manufactured by the company *Matest* (Capacity 2000 kN), where pressure was applied constantly until the samples were crushed (Figures 3.1 and 3.3, Annex 3).

The flexural strength was tested according to the standard SRPS EN 1015-11:2008 (*The method to test the mortar specimens- part 11- Investigating the Tensile strength and compressive strength of the hardened mortar specimens*). The testing was carrid out on samples with the addition of steel fibers (2%), using standard prisms with size 4x4x16 cm. The tests were performed on the flexural testing machine manufactured by *Amsler* (Figure 3.2 Annex 3), where the force applied was controlled until sample failure (Figure 3.2 and 3.4, Annex 3)

Table 1. Workability of fresh concrete mixture

Tests	Measumerent (cm)
Diameter of cake	**31.5**
Slump of mixture	**24.8**

Table 2. Density of concrete in fresh and hardened state

State	Density (kg/m^3)
Fresh	**2500**
Hardened (after 24h)	**2480**

Table 3. Value of flexural and compressive strenght

Sample number	Bending strength (MPa)	Compressive strength (MPa)
	f_{zs}	**f_p**
Sample age 24 hours		
1	14.8	96.2
2	13.0	94.4
3	11.0	94.9
Average	**12.9**	**95.2**
Sample age 3 day		
1	15.1	116.7
2	12.2	119.7
3	14.6	123.2
Average	**14.0**	**119.8**
Sample age 28 day		
1	18.0	171.4
2	17.5	165.7
3	17.5	149.5
Average	**17.7**	**162.2**

Values of mixture slump and cake diameter are shown in table 1. Examination of slump test is shown on figures in Annex 2. Mean value of density in both fresh and hardened state, are presented in table 2 **Based on results shown in table 3 mean value of compressive strength obtained at 28 days is 162.2 MPa, while maximal value is 171.4 MPa. Maximum flexural strength obtained was 18.0 MPa, while mean value was 17.7 MPa for specimens aged 28 days.** In Annex 3, one can view photos of equipment and shape of specimens after test.

3. CONCLUSION

Based on the results of the tests conducted, it can be concluded that the tested composite ForteCrete150® can be classified as Ultra High Performance Concrete (UHPC), reinforced by steel fibres (fiber reinforced concrete – FRC). During preparation, the liquid consistency of the fresh concrete was observed, which allowed concreting without vibration or with short-term compaction of the mixture, which conditionally classifies this concrete in the group of self-compacting concretes (SCC).

It was shown that the mean value of the concrete compressive strength after 28 days was **162.6 MPa**, while the maximum value was **171.4 MPa**, which corresponds to concrete with ultra high strength. Also, the tensile strength is significantly larger (**4-6 times larger**) than for normal concrete and amounted on average to **17.7 MPa**. Test resuts showed that the tested fresh concrete belongs to the class **S5**, which corresponds to **liquid workability**.

.

COMPILED:

Associate Prof. Dimitrije Zakić, Ph.D.B.C.E.

Assist. Stefan Mitrović, M.Sc.B.C.E.

- END OF REPORT -

The REPORT has 3 Appendices (1-3)

APPENDIX 1

Preparation and treatment of samples

Figure 1.1.Preparation of components for making the mixture and precise weight measurement

Figure 1.2. Mixture with fiber content during mixer operation and poured samples

APPENDIX 2

Examination of workability

Figure 2.1. Equipment for slump test

Figure 2.2. Value of cake diameter

APPENDIX 3

Examination of basic physical-material properties

Figure 3.1. Equipment for compressive strength testing

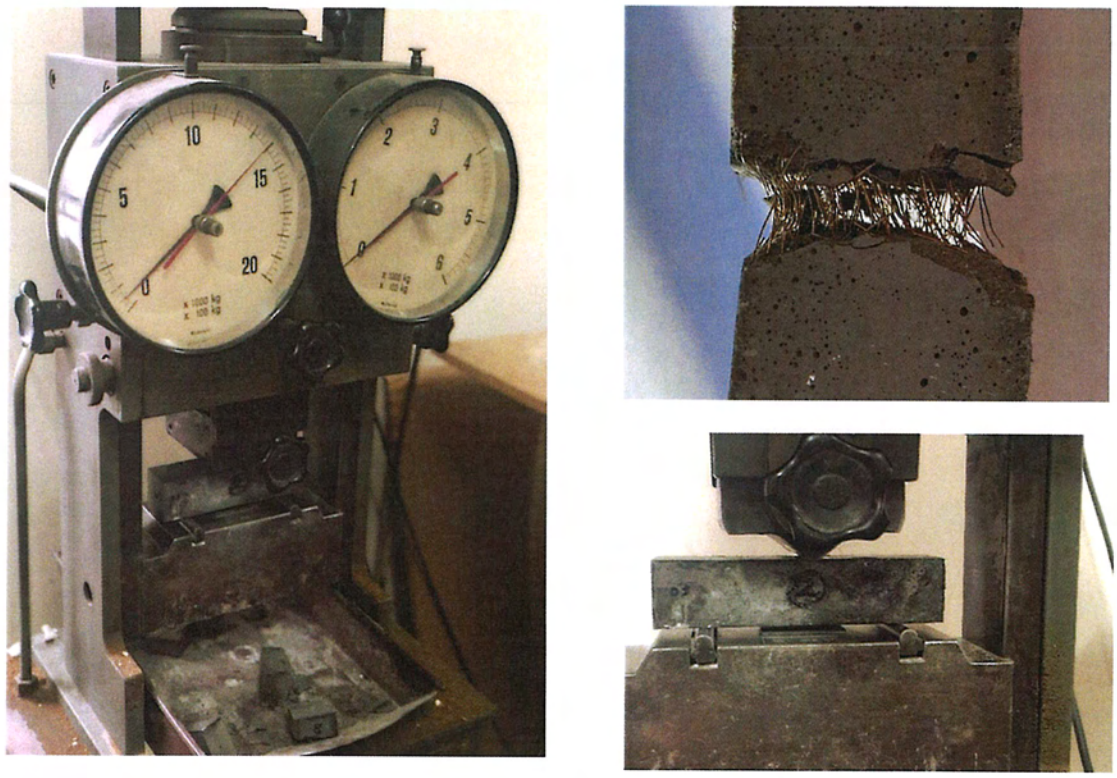

Figure 3.2. Equipment for flexural strength testing and broken samples made with addition of steel fibers (2%)

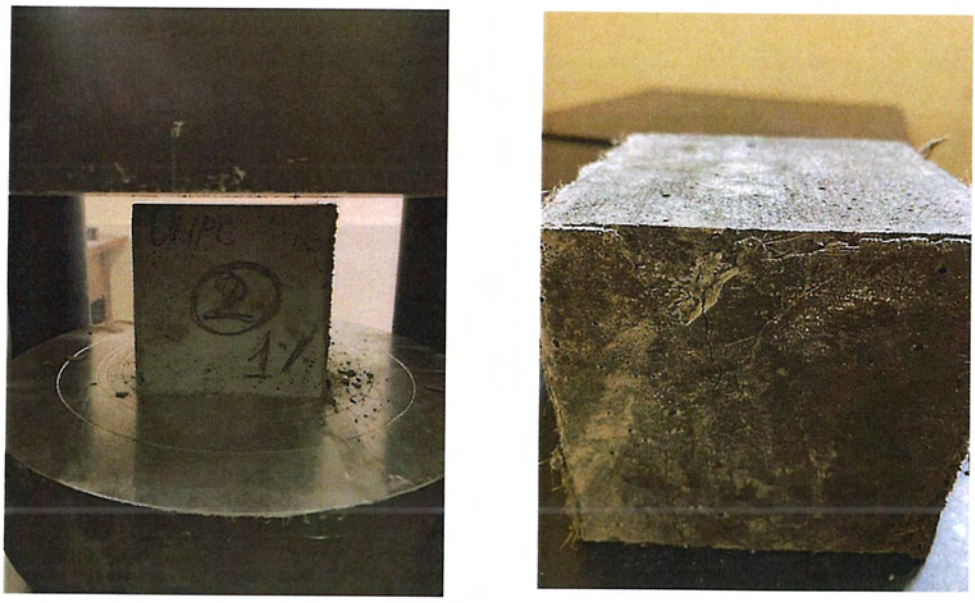

Figure 3.3. Prepared sample for compressive strength test and broken sample after testing

Figure 3.4. Appearance of samples with the addition of steel fibers after the flexural strength test