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The Influence of Hot Water on UHPC Boards with Different Types of Textiles Armatures

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Abstract. In this article the hot water test is presented on thin UHPC slabs that are reinforced by a new type of armature. It is a textile armature, which should replace the classic metal (steel) armature. Textile armature should not only reduce the cost of production, but, because it is not susceptible to corrosion as conventional steel armature, panels can be designed with significantly less cover thickness in achieving similar or longer lifetime of these elements. The combination of UHPC concrete with a minimum thickness of cover and textile armature allows design elements weighing up to 70 % lower compared to conventional concrete elements with conventional armature. This can achieve significant savings and benefits not only in economic aspects, but also in environmental aspects.

Introduction

Ultra High Performance Concrete (UHPC) is ultra-high-grade concrete with fine-grained macrostructure and high consistency. This implies its high resistance to the penetration of liquids and high durability. Due to its high compression strength greater than 150 MPa and improved durability, these represent significant advances in concrete technology. This highly advanced and sophisticated material offers a number of interesting applications such as the production of facade panels, which promotes more abroad.

This material is tested in difficult stressful environments to determine samples resistant due to external conditions. In the past, it was tested strength depending on the resistance to freez-thaw [2]. It is also important to test the material characteristics in aggressive environment, which has in the real situation big influence on changes in the cements properties, especially on the porosity and chemical composition [3]. Burt this article is focus on one of the other influences of environmental specifically temperature of water. Samples were storage in distilled water at 60 ± 2 °C.

The Test Specimens

The 6 concrete test boards with sizes 700x300x25 mm were produced for comparative experiments on December 12, 2013. All 6 boards were made from the same type UHPC with similar composition. The only difference was in the type of textile armature.

The recipe matrix for 1 cubic meter did consist: cement CEM II 42,5 R (690 kg), milled silica (100 kg), sand, max. fraction 1,6 mm (1267 kg), slag (80 kg), water (160 kg), superplasticizer (40 kg).

The first boards used alkali-resistant glass fibre mesh fabric with mesh dimension 5 mm (marked P), the second boards used the 2D glass alkali-resistant armature with mesh dimension 20 mm (marked 2D) and the third plate used the 3D glass alkali-resistant armature with mesh dimension 20 mm (marked 3D). Each board was further cut into 6 smaller thin specimens with dimensions: width 150 mm, length 232 mm and thickness 25 mm. A set of 12 test specimens was created from one with the specific type of armature. There were thus prepared 36 test samples. Half of them were then subjected to put into hot water, half served as a reference.

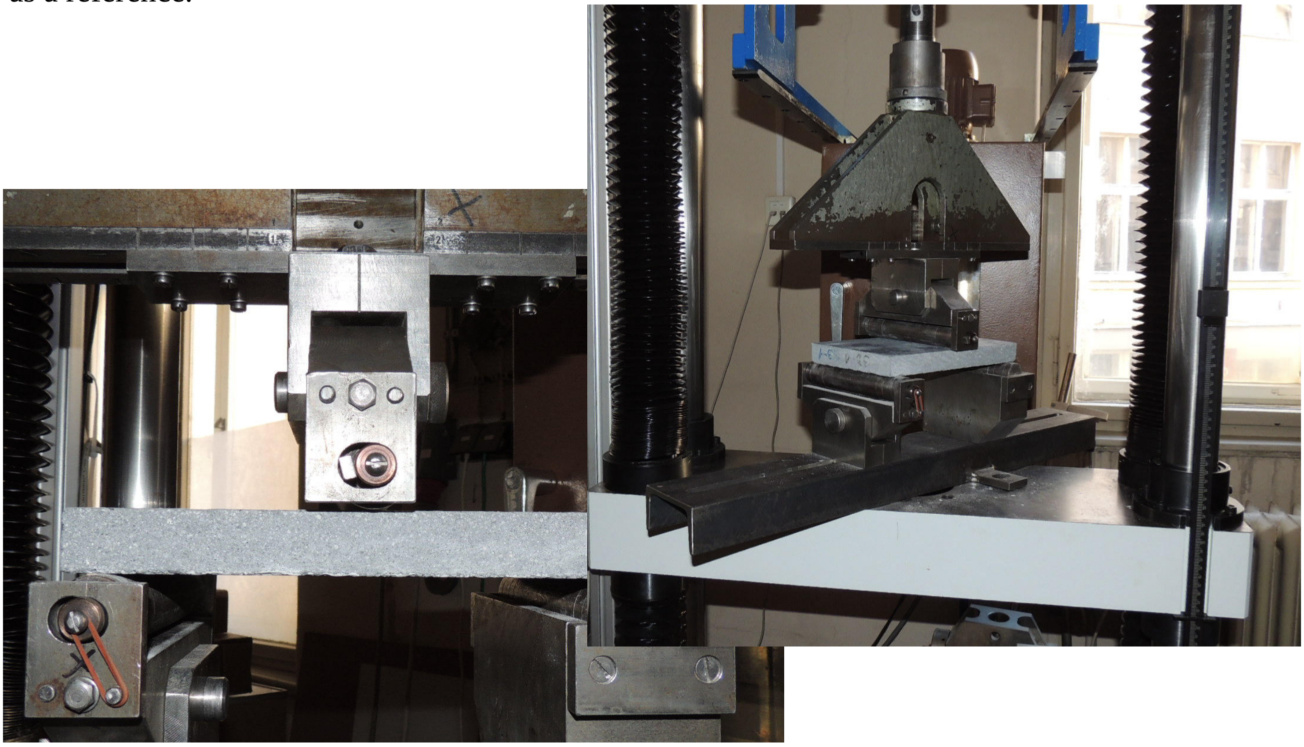

Fig. 1. Testing device for bending strength TIRATEST 2300 during test.

Test Description

The procedure of hot water test – the purpose of this test was to specify tensile bending strength when the specimens were put into hot water. The tensile bending strength was determined according standard ČSN EN 12467 in three-point bending strength. The tests were performed on the test device TIRATEST 2300 (see Fig. 1). The support distance was 200 mm. The rate of loading of specimens was 1 mm/min, the rupture did occur in time between 10 and 30 seconds.

The results were determined by comparing the two sets of samples:

- 1. set – unexposed (reference) testing plates after storage in water at 20 ± 2 °C,
- 2. set – exposed testing plates after storage in water at 60 ± 2 °C.

The testing plates were divided into two sets. After conditioning, the first set was tested for tensile bending strength. The second set of testing plates was put into water with the temperature of 60 ± 2 °C for 56 days in climatic chamber. After this time and conditioning, the testing samples were tested for tensile bending strength. The test was conducted according to the above – mentioned standard [1,2].

The Result and Discussion

Results were determined by comparison of the two sets of test specimens, the results of testing are the ratio of tensile bending strength the testing samples (of both sets 1+2):

$$\mathbf{MR_i = MOR_{fi} / MOR_{fci}} , \qquad (1)$$

MOR_{fi} – tensile bending strength of the testing sample *i* from 2. set (exposed sample), **MOR_{fci} –** tensile bending strength of the testing sample *i* from 1. set (unexposed sample), **MR_i –** ratio of the tensile bending strength for the *i* pair of exposed and unexposed (reference) testing samples

A summary of the results of mechanical tests are shown in Table 1 and in Fig. 2 and Fig. 3.

Table 1. The results for the exposed (2. set) and unexposed (reference – 1. set) samples.

Specimens	**Volume weight [kg/m^3]**	**MOR_f [MPa]**
Specimens with glass fibre mesh fabric armature – marked P – average from three tests		
specimens P – reference	2365	15,6
specimens P – after storage in water	2336	20,8
Coefficient of hot water resistance - specimens P – ratio of bend. str.		**1,34**
Specimens with 2D glass fabric armature – marked 2D – average from three tests		
specimens 2D – reference	2536	16,2
specimens 2D – after storage in water	2327	18,8
Coefficient of hot water resistance - specimens 2D – ratio of bend. str.		**1,23**
Specimens with 3D glass fabric armature – marked 3D – average from three tests		
specimens 3D – reference	2358	14,0
specimens 3D – after storage in water	2373	20,1
Coefficient of hot water resistance - specimens 3D – ratio of bend. str.		**1,45**

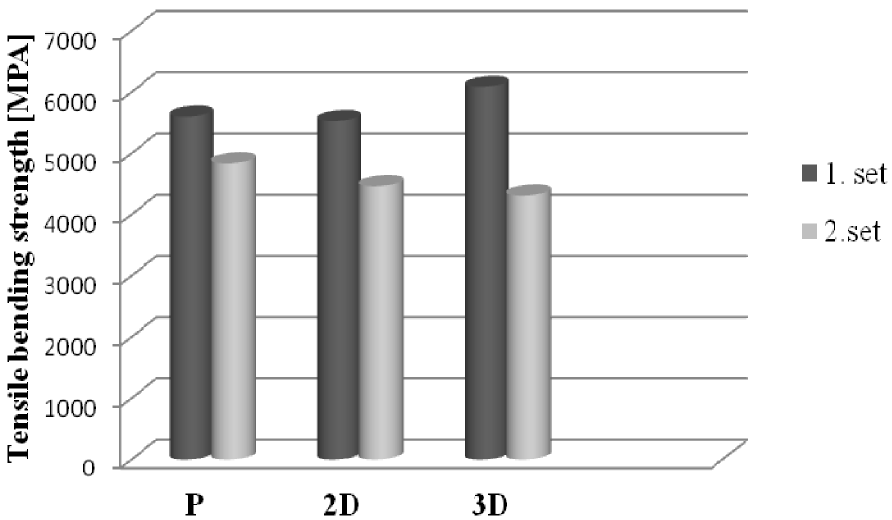

Fig. 2. The hot water test – comparison of average values of tensile bending strength.

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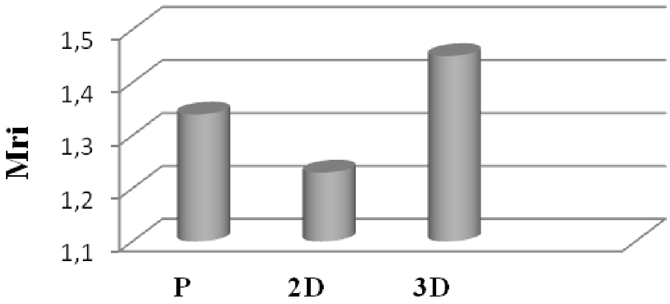

Fig. 2. Coefficient of hot water resistance – the ratio of tensile bending strength (set 1+2).

From the measured values we can see that the greatest tensile bending strength values were obtained for samples with 3D glass fabric armature, then the samples reinforced with glass fibre mesh armature and the lowest values were obtained for samples with 2D glass fabric armature.

Comparing 1.set (reference – exposed) and 2. set (unexposed), it is clear that exposed sets have lower strength values, but the differences are not so significant. For specimens with 3D glass fabric armature was bending strength higher by 29 %, for specimens with 2D glass fabric armature was bending strength higher by 19 % and samples with glass fabric armature by 14 %. The best results of value of tensile bending strength were from the specimens with 3D armature.

Conclusion

The results of hot water tests of thin UHPC plates were presented in this article. The UHPC plates were reinforced with different types of textile armatures: glass fibre mesh fabric, 2D glass fabric and 3D glass fabric. Each type of test samples was divided into two sets, unexposed (reference) and exposed samples. The best results of value of tensile bending strength were from the specimens with 3D armature.

Acknowledgement

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