VILNIUS GEDIMINAS
TECHNICAL UNIVERSITY

LABORATORY OF INNOVATIVE BUILDING STRUCTURES

TEST REPORT

Head of the Laboratory
______________________ dr. *Viktor Gribniak*
07/02/2018

Contractor: *Low & Bonar NV*

Title of the work:

PLASTIC SHRINKAGE CRACKING TEST OF FIBRE REINFORCED CONCRETE

The test is performed according ASTM C1579-13 “Standard Test Method for Evaluating Plastic Shrinkage Cracking of Restrained Fiber Reinforced Concrete”

Number: ISKL 2018-02-01/01/05
Stage: Experimental study

Research areas: *Civil Engineering* (*02T*); *Material Engineering* (08T)

Executors

Dr *Aleksandr Sokolov*

Dr *Arvydas Rimkus*

Dr *Gintautas Skripkiūnas*

Mindaugas Macijauskas

Vilnius, Lithuania
2018

1. Introduction

The plastic shrinkage tests are carried out in accordance with the standard requirements of **ASTM C1579-13 “Standard Test Method for Evaluating Plastic Shrinkage Cracking of Restrained Fiber Reinforced Concrete”**. The test results of three paired panels (six test samples) are reported. Two panels were made of plain concrete. They are referred to as “Control panels”, while the remaining four panels were reinforced using different fibre types and dosages.

2. Description of material

The test specimens were produced on 2017-10-10. Three concrete mixtures were prepared for the test. Composition of all mixtures are given in **Table 1**. The panels were stored within the controlled environmental conditions according to ASTM C1579-13. The drying conditions, i.e. evaporation rate, temperature, relative humidity, and wind velocity were monitored. Setting time of the concrete was determined as requested by ASTM C1579-13.

3. Preparing the specimens

A standard prismatic 355 × 560 × 100 mm mould was made of 18 mm laminated plywood with hydrophobic surface (reducing the moisture absorption). The stress risers were made of 5 mm steel plate in accordance with the geometry specified by ASTM C1579-13. The trapezoidal risers were fixed to the bottom surface of the mould with M8 steel bolts (**Fig. 1**). In order to reduce adhesion between mould and concrete, the mould surface was oiled; the excess oil has been removed before placing the concrete. The mould was filled with concrete in one layer and placed on a vibrating table. After that, the specimen was screed perpendicular to the stress riser (three times) and positioned in the environmental chamber.

Table 1. Concrete mixtures

Material	Dosage, kg/m^3		
	Control panels	*Crackstop M Ultra*	Hooked steel fibres
Cement *CEM I 42,5 R*	471	471	471
Fly ash	95	95	95
Crushed gravel 4/16 mm	680	680	680
Sand 0/4 mm	869	869	869
Superplasticizer *MapeiXTend*	0.47	0.47	0.47
Water	245	245	245
Microfibre *Crackstop M Ultra*	0	0.9	0
Hooked steel fibres	0	0	10

Fig. 1. A standard mould

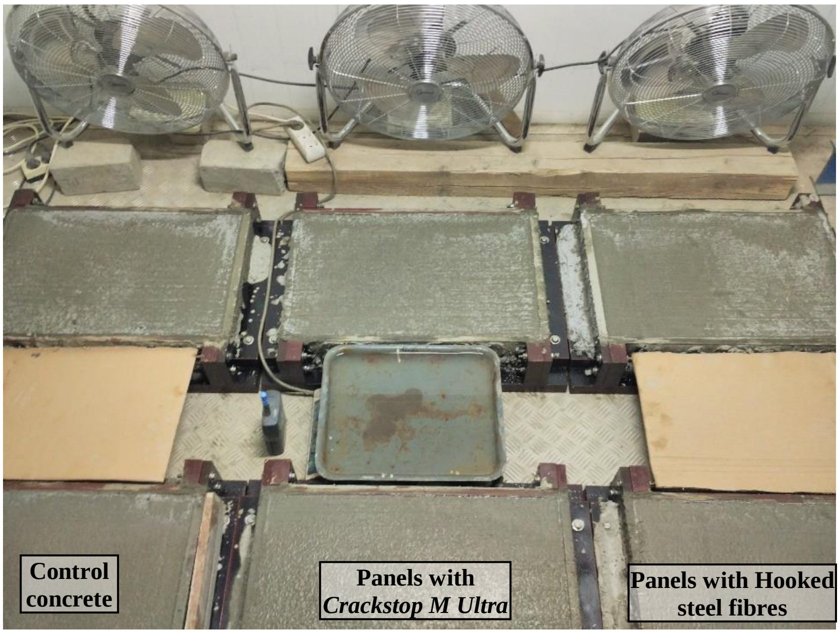
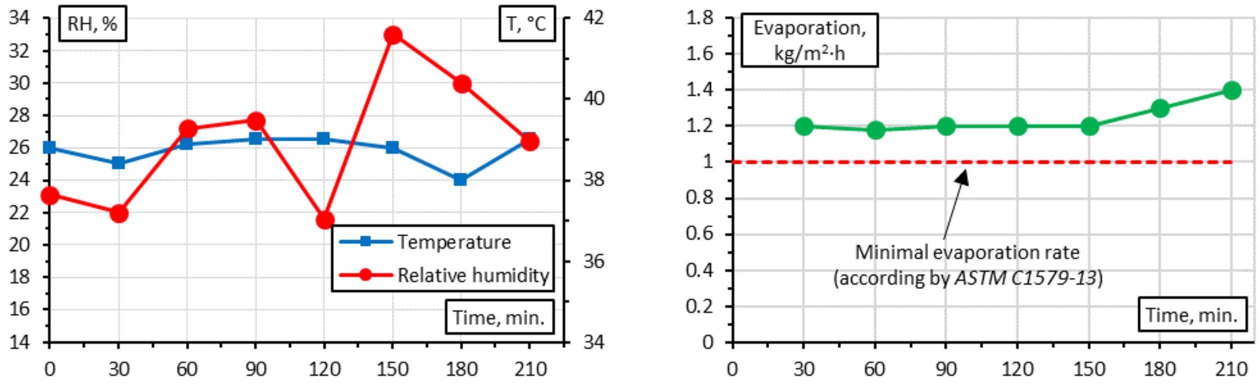


Fig. 2. Specimens (from left to right): two control panels, two panels made of concrete with *Crackstop M Ultra* fibers, and two panels made of concrete with Hooked steel fibers

4. Shrinkage test

Three variable speed fans (**Fig. 2**) and two convection fan heaters were used to secure a uniform airflow over the panel surface and maintain the temperature in the environmental chamber. A standard pan with water with surface of 0.1 m^2 was used to assess the evaporation speed. A weighting-scale with capacity of 6 kg and accuracy of 1 g was used for this purpose. The evaporation rate, air temperature, and relative humidity at the distance of 100 mm above the test panel were monitored each 30 min. The atmospheric characteristics are presented in **Figure 3a**, evaporation rate – in **Figure 3b**. Airflow speed was measured several times during the test: the average speed was found equal to 5.1 m/s.

After the final setting of the concrete (t = 210 min.), the atmospheric variables and the total water loss of the monitoring pan were determined and fans were removed. All test panels were stored under plastic sheets to minimize evaporation until time of crack width measurement.



a) b)

Fig. 3. Drying conditions: a) atmospheric parameters, b) evaporation rate

Fig. 4. Crack width measurement

Fig. 5. Final crack patterns

Crack width at the surface of the panel was measured after 24 hours of the concrete mixing. The crack widths were measured using an optical microscope as shown in **Figure 4**. The cracks were measured along the cracking path over the stress riser with 10 mm intervals along the length of the crack (with exception of the 25 mm boundary area of the test panel in order to avoid the effects of the surface restrain). The final crack patterns are shown in **Figure 5**. The average crack width of control panels was found equal to 0.23 mm and 0.59 mm, while panels with concrete mixture with Hooked Steel fibers – 0.25 mm and 0.20 mm. No crack was observed in the panels with *Crackstop M Ultra*.

Compressive strength of the concrete was determined for all concretes at the age of 28 days using 100 mm cubes. The mean compressive strength (averaged of four cube specimens) was equal to 57.5 MPa, 53.7 MPa, and 56.2 MPa for the control concrete, and for the concretes made using *Crackstop M Ultra* and Hooked Steel fibres, respectively.

Conclusion

Table 2 summarizes the results of the plastic shrinkage tests. The observed evaporation rate was equal to 1.24 kg/m^2·h that corresponds to the minimal requirement by ASTM C1579-13. Wind velocity (5.1 m/s) maintained the evaporation rate at the required standard level (the minimum allowable level is equal to 4.7 m/s). The average crack width is equal to 0.41 mm in the control panels (the minimum required value is equal to 0.5 mm), no crack in the panels made with *Crackstop M Ultra* fibres, and 0.35 mm in the panels made with Hooked steel fibres. The corresponding cracking reduction ratio calculated through the ASTM C1579-13 standard requirements is equal to 100% and 46%, respectively.

Table 2. Results of the plastic shrinkage test

Parameter	ASTM C1579-13	Test results					
		Control		***Crackstop M Ultra***		**Hooked steel fibrse**	
		Panel 1	**Panel 2**	**Panel 1**	**Panel 2**	**Panel 1**	**Panel 2**
Wind velocity, m/s	≥4.7	5.1		5.1		5.1	
Evaporation rate, kg/m^2·h	≥1.0	1.24		1.24		1.24	
Cracking value of each panel, mm	≥0.4*	0.23	0.59	0	0	0.25	0.20
Average crack width, mm	≥0.5*	0.41		0		0.22	
Cracking reduction ratio (CRR), %	–	–		**100**		**46**	

* Valid for control panels