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FACULTY OF CIVIL ENGINEERING AND ARCHITECTURE BUILDING MATERIALS AND STRUCTURES RESEARCH CENTRE

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UAB Betono Mozaika 2020-07-22, No DV19-F-09-00051-26

RE: EXPERIMENTAL FREEZE/THAW RESISTANCE TESTING ON CONCRETE PAVING BLOCKS MANUFACTURED BY UAB BETONO MOZAIKA AT FACTORIES IN VILNIUS, KAUNAS, KLAIPĖDA AND ŠIAULIAI AFTER 28, 56 AND 72 FREEZE/THAW CYCLES

At the request of the customer UAB Betono Mozaika, the Kaunas University of Technology (KTU) Building Materials and Structures Research Centre performed freeze/thaw resistance tests according to LST EN 1338:2003 Annex D on the concrete products delivered – concrete paving blocks which were formed at factories in Vilnius, Kaunas, Klaipėda and Šiauliai. A total of two blocks from the factory in Vilnius (No VLN-1 and VLN-2), two from Klaipėda (No KL-1 and KL-2) and two from Šiauliai (No Šiau1 and Šiau2) were delivered. Four blocks were delivered from the factory in Kaunas (No K-1, K2, K3 and K4). Photographs of the delivered blocks before and after the freeze/thaw resistance testing are presented in the annexes. The essence of this freeze/thaw resistance test is to insulate the blocks with a 3 mm thick layer of flexible rubber on all sides, except for their working surface (the rubber is extended approximately 20 mm above the working surface so that the freezing agent/solution can be poured on it later). The edges of the block surface with the rubber are sealed using special purpose water- and cold-resistant silicone. Analogously, a 20 mm thick thermal insulation layer of polystyrene foam is additionally attached on the rubber glued to all sides of the specimen. This ensures that the block is completely insulated on all sides and the bottom from the surrounding environment, except for its working surface, which is then subjected to freeze/thaw cycles. The freezing agent is a 3% NaCl aqueous solution, which is poured onto the surface of the block, forming a 5-7 mm layer of this solution. A solution of this concentration is used for the testing because it is much more aggressive than ordinary water, i.e. during freezing, this solution does more damage to the concrete. To prevent this solution from evaporating during the test, the top of the block is covered with a polyethylene film (at least 200 μm thick). Prepared in this way, the sample blocks are placed in an automated freeze/thaw chamber where a special automatic temperature mode is maintained, i.e. over the course of the day,

the temperature in the chamber changes from a maximum of +20 ˚C to - 20 ˚C according to the corresponding schedule. In this way the so-called "freeze/thaw cycle" takes place. During the freeze part of the cycle, the NaCl aqueous solution freezes on the surface of the block, and the solution absorbed in the capillary pores of the concrete freezes as well. Ice has more volume than water, so as the water turns to ice, pressure builds up in the capillary pores of the concrete which can begin to damage it. During thawing, the ice melts and the damage process is repeated during the next freezing. In this way, after a certain number of freeze/thaw cycles, crumbling – also called mass loss – can occur on the concrete surface. According to the requirements of LST EN 1338:2003, LST EN 1338:2003/AC:2006 and LST EN 1338:2003/P:2008, poor-quality concrete paving blocks are those which have a mass loss of more than 1 kg/m2 of surface area after 28 days of freeze/thaw cycles. The paving blocks presented in these tests were frozen for as long as 72 days, and their surface crumbling was evaluated after 28, 56 and 72 freeze/thaw cycles. The results obtained from the experimental testing are presented in Tables 1-3. Photographs of the concrete paving blocks before and after the freezing are presented in the annexes.

1 Table. Concrete paving block freeze/thaw resistance testing data after 28 freeze/thaw cycles

Specimen No	Test surface area *A*, mm^2	Total mass of broken off material *M*, mg	Mass loss per unit area of the specimen *L*, kg/m^2	Mean mass loss of the specimens, kg/m^2	LST EN 1338:2003, LST EN 1338:2003/AC:2006, LST EN 1338:2003/P:2008 requirements
VLN-1	15470	120	0.008	0.009	≤ 1.0 kg/m^2
VLN-2	15480	150	0.010		
KL-1	16150	140	0.009	0.009	≤ 1.0 kg/m^2
KL-2	16235	160	0.010		
Šiau1	16095	170	0.011	0.012	≤ 1.0 kg/m^2
Šiau2	15725	190	0.012		
K-1	16095	110	0.007	0.007	≤ 1.0 kg/m^2
K2	17290	120	0.007		
K3	16920	100	0.006		
K4	16095	110	0.007		

2 Table. Concrete paving block freeze/thaw resistance testing data after 56 freeze/thaw cycles

Specimen No	Test surface area *A*, mm^2	Total mass of broken off material *M*, mg	Mass loss per unit area of the specimen *L*, kg/m^2	Mean mass loss of the specimens, kg/m^2	LST EN 1338:2003, LST EN 1338:2003/AC:2006, LST EN 1338:2003/P:2008 requirements
VLN-1	15470	160	0.010	0.012	≤ 1.0 kg/m^2
VLN-2	15480	210	0.014		
KL-1	16150	200	0.012	0.013	≤ 1.0 kg/m^2
KL-2	16235	220	0.014		
Šiau1	16095	330	0.021	0.022	≤ 1.0 kg/m^2
Šiau2	15725	350	0.022		
K-1	16095	200	0.012	0.015	≤ 1.0 kg/m^2
K2	17290	210	0.012		
K3	16920	220	0.013		
K4	16095	330	0.021		

3 Table. Concrete paving block freeze/thaw resistance testing data after 72 freeze/thaw cycles

Specimen No	Test surface area *A*, mm^2	Total mass of broken off material *M*, mg	Mass loss per unit area of the specimen *L*, kg/m^2	Mean mass loss of the specimens, kg/m^2	LST EN 1338:2003, LST EN 1338:2003/AC:2006, LST EN 1338:2003/P:2008 requirements
VLN-1	15470	170	0.011	0.013	≤ 1.0 kg/m^2
VLN-2	15480	220	0.014		
KL-1	16150	240	0.015	0.015	≤ 1.0 kg/m^2
KL-2	16235	250	0.015		
Šiau1	16095	440	0.027	0.029	≤ 1.0 kg/m^2
Šiau2	15725	470	0.030		
K-1	16095	240	0.015	0.018	≤ 1.0 kg/m^2
K2	17290	270	0.016		
K3	16920	280	0.017		
K4	16095	430	0.027		

Conclusions:

1 After 28 days of freeze/thaw cycles, all of the tested concrete paving blocks from all of the UAB Betono Mozaika factories in four different cities met the requirements for freeze/thaw resistance and conformed with Class 3, D marking according to LST EN 1338:2003 Annex D. Even after extending the test to 72 freeze/thaw cycles, all of the blocks still met the above requirements.

2 Assessing the visual changes in the surface of the blocks after 72 days of freeze/thaw testing, the surface of the blocks from the Vilnius factory changed the least, and the ones from Šiauliai changed the most. Only one of the four blocks tested from the Kaunas factory slightly changed its initial surface (No K4). Photographs of all the blocks delivered to the KTU Building Materials and Structures Research Centre before and after the freeze/thaw resistance testing are presented in the annexes.

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ANNEXE
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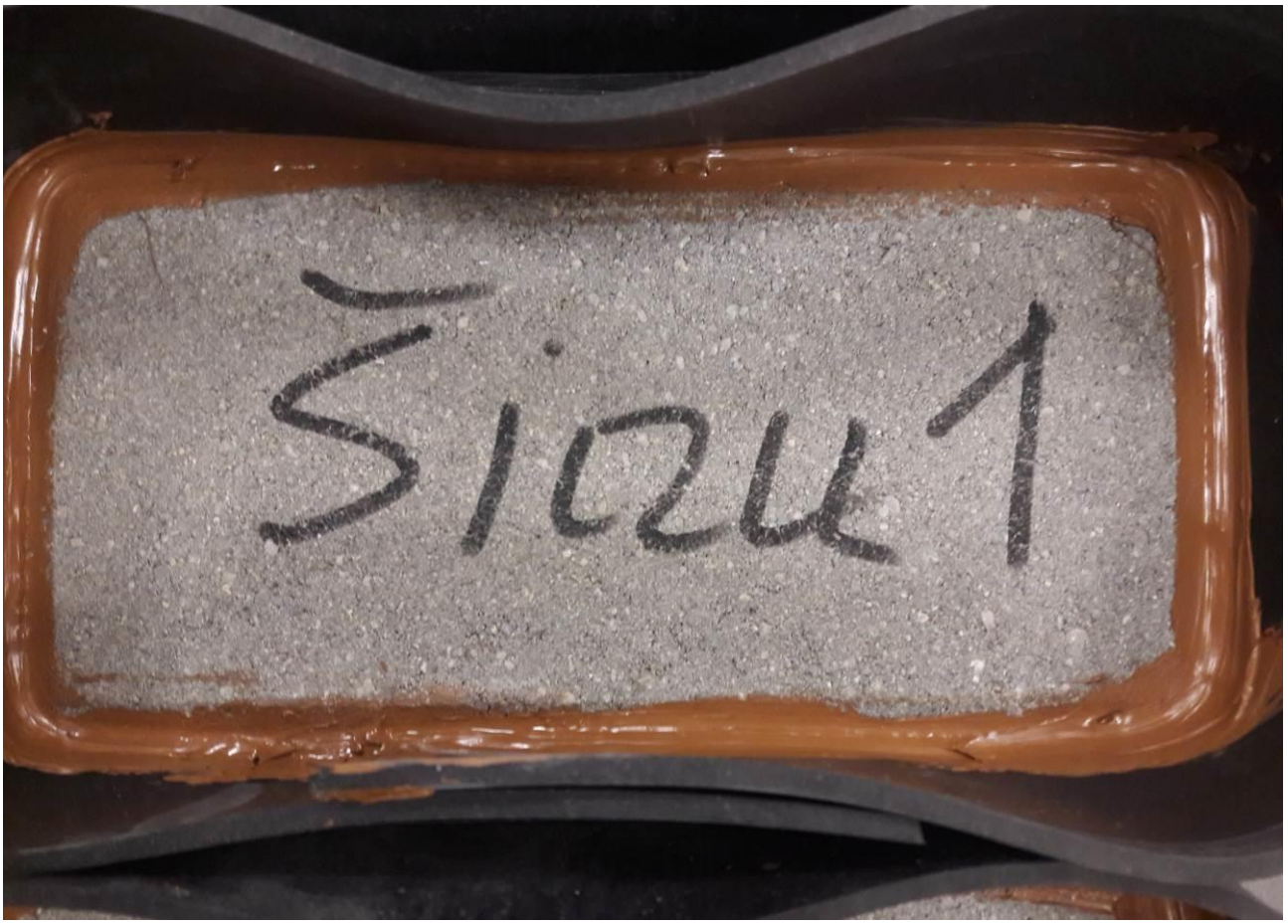
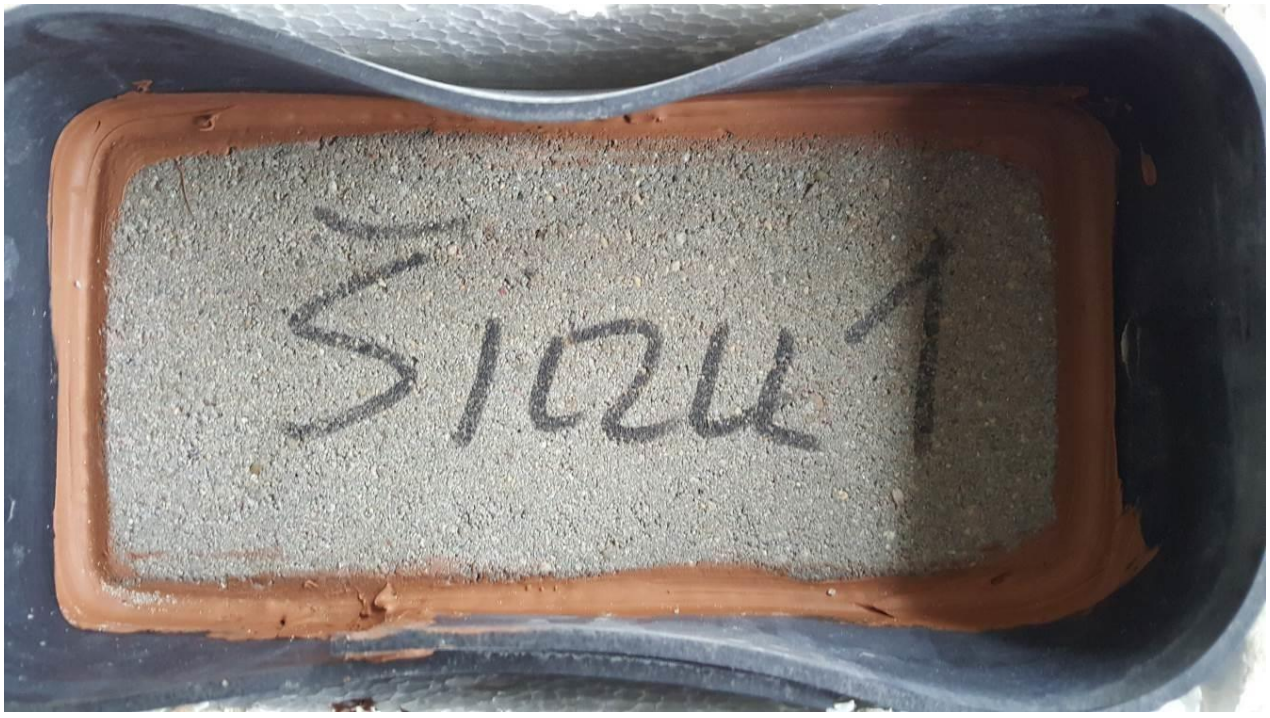
1 Figure Block VLN-1 before the freeze/thaw testing (top) and after 72 days of testing (bottom)

2 Figure Block VLN-2 before the freeze/thaw testing (top) and after 72 days of testing (bottom)

3 Figure Block KL-1 before the freeze/thaw testing (top) and after 72 days of testing (bottom)

4 Figure Block KL-2 before the freeze/thaw testing (top) and after 72 days of testing (bottom)





5 Figure Block Šiau1 before the freeze/thaw testing (top) and after 72 days of testing (bottom)

6 Figure Block Šiau2 before the freeze/thaw testing (top) and after 72 days of testing (bottom)

7 Figure Block K-1 before the freeze/thaw testing (top) and after 72 days of testing (bottom)

8 Figure Block K2 before the freeze/thaw testing (top) and after 72 days of testing (bottom)

9 Figure Block K3 before the freeze/thaw testing (top) and after 72 days of testing (bottom)

10 Figure Block K4 before the freeze/thaw testing (top) and after 72 days of testing (bottom)