EXAMINATION OF CONCRETE MIXTURES – PART II PHYSICAL-MECHANICAL CONCRETE PROPERTIES

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Summary: *Concrete mixtures are made, or prepared with aggregates, binders and water, and in some concrete chemical additives are used to improve the properties of concrete mixtures. The paper presents the results of the physical-mechanical properties testing of fresh and hardened concrete for three different mixtures where an aggregate of three fractions is used. Cement CEM II A-M (S-L) 42.5R is used for all of three concrete mixtures. According to test results it can be concluded that all of three types of concrete can be used for concrete pavement production, as for residential-commercial buildings, bridges and other objects in civil engineering.*

Keywords: *phisical-mechanical properties, fresh concrete, hardened concrete*

1. INTRODUCTION

Concrete mixtures are made mainly from aggregates, cement and water, and with chemical admixtures that are added to improve the properties of concrete. Depending on the literature review, it is found that all works first show the properties of the material, and then give the results of the concrete mixtures testing. The paper [1] gives an overview of the properties of the material before the preparation of concrete mixtures. The limits are set based on the defined standards used for this scientific area. The subject of this paper research is laboratory testings of the physical and mechanical properties of both fresh and hardened concrete for the building structures and road constructions in

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civil engineering. The physical-mechanical properties of concrete (comressive strength at 7 and 28 days, bulk density, freezing and thawing resistance using salt or without the use of salt for defrosting and watertightness of concrete) allows their application under conditions of required strengths over 40 MPa.
The aim of this paper is based on tests of various mixtures and to find out where these mixtures can be applied in practice.

2. EXPERIMENTAL RESEARCH

For the preparation of concrete mixtures water from the city water supply was used, and also a certain quantity of additives was used. LaFarge CEM II / A-M (S-L) 42,5 R was used from the Beočin cement plant. Crushed stone aggregate was used, and it was made of three fractions. The compositions of concrete mixtures M1, M2 and M3 are shown in Table 1.

Table 1 – Quantities of ingredients for 1m^3 of concrete

Mixture ingredients [kg/m^3]		M1		M2		M3	
Cement		450		420		400	
Aggregate	0/4	43 %	1750,00	45 %	1710,00	40 %	1785,00
	4/8	25 %		20 %		25 %	
	8/16	32 %		35 %		35 %	
Admixture 1		4,99		3,80		3,60	
Admixture 2		-		0,063		0,060	
Water		192,5		191		176	
Water-cement factor		0,424		0,452		0,440	
Admixture 1 – Sika ViscoCrete 3070; Admixture 2 – Sika Aer							

First, the fresh concrete test was done, as follows: determining the temperature of fresh concrete, air content in concrete, consistency of concrete. The tests of the physical-mechanical properties of concrete are as follows: compressive strength on cubes dimensions 15x15x15 cm, at 7 and 28 days, bulk density, at 7 and 28 days, detrmination of water penetration under pressure, resistance to freezing and thawing - damage of the internal structure, and resistance to freezing and thawing with the effect of salt.

2.1. The properties of fresh concrete

2.1.1. Temperature of concrete

The temperature of the concrete was measured after preparation and after 45 minutes according to standard SRPS U.M1.032 [2]. The thermometer is placed in the center at a depth of about 10 to 15 cm.

2.1.2. Air content

The test was carried out using the standard SRPS ISO 4848 [3]. The concrete mixture was poured into a mold of known volume. The filling was carried out in three layers and each was pressed using a bar with 25 strokes per layer.

2.1.3. Consistency of concrete

Consistency of fresh concrete is determined by the method of sagging in accordance with the standard SRPS EN 12350-2 [4]. The fresh concrete mass was poured into three layers in the Abrah's cone and compaction was performed with 25 strokes per layer. After that, the measurement for each concrete mixture was measured separately.

2.2. The properties of hardened concrete

2.2.1 Compressive strength

The compressive strength was tested on concrete blocks 15x15x15cm that were cured in a wet chamber and tested at 7 and 28 days, and the concrete mark was defined as the average stress in the sample exposed to fracture force of axial pressure. The compressive strength test was performed according to the standard SRPS ISO 4012:2000 [5].

2.2.2 Determination of water penetration under pressure

The testing of water penetration under pressure in concrete depends on the degree of hydration of cement, the porosity of cement stone, the pore structure and the properties of cement and individual aggregates. Watertightness of concrete is defined on the basis of watertightness class using the method with free side water penetration. Classes are V-2, V-4, V-6, V-8 and V-12, where the numbers indicate pressure in the bar. The penetration of the water under pressure was tested on 15x15x15 cm cube samples. Concrete is considered to be watertight if the penetration depth is less than 5 cm [6].

2.2.3 Resistance to freezing and thawing

Resistance to freezing and defrosting means the ability of concrete to undergo cyclic freezing and defrosting in water saturation. Resistance to cyclic freezing and defrosting was examined on 15x15x15 cm cube samples [7], whereby the test was performed in every 50 cycles in order to achieve the most accurate test results. The testing of concrete blocks was carried out on 250 cycles and if the loss of compressive strength exceeds 25%, it is considered that the concrete is not resistant to cold and can not be applied for production of concrete pavements and structural elements (bridges).

2.2.4. Resistance to freezing and thawing with the effect of salt

Freezing and defrosting resistance testing with the effect of salt was performed by placing the frame on the surface of the sample, after which a 3% salt solution (NaCl) was poured in 3 mm height, and maintained at that height until the start of the test. According to standard SRPS U.M1.055 [8], the prescribed samples are precisely defined according to the mode of exposure of such a solution. After 25 cycles, weight loss was measured, as well as the depth and surface of the peeling of the concrete under the influence of salt solution.

3. RESULTS AND DISCUSSION

This chapter provides an overview of the test results for fresh and hardened concrete with comments.

3.1 The properties of fresh concrete

3.1.1. Temperature of fresh concrete

The temperature of the concrete was measured after preparation and after 45 minutes for each concrete mixture. The temperatue values for fresh concrete are shown in Table 2.

Table 2 – Temperature of concrete

Mixture	Testing results [°C]	
	After mixing	After 45 min
M1	21,9	22,0
M2	21,2	21,4
M3	21,7	22,1

The results of the analisys show that the temperature for all concrete mixtures ranges from 21 to 22°C immediately after preparation, and that after 45 minutes the temperature increased by 1% maximum for all three mixtures.

3.1.2. Air content

During the determination of concrete mixtures compositions, the exact mass of all components per $1m^3$ of concrete was determined, with the assumption that the maximum amount of recirculated air was 4% of the presumed quantity. The results of testing the value of air content are given in Table 3.

Table 3 – Air content for concrete mixture

Mixture	Testing results [%]	
	After mixing	After 45 min
M1	2,5	2,3
M2	5,0	5,2
M3	3,9	4,3

It can be seen a deviation in the mixture number M2 where the amount of recirculated air is about 5% which can lead to a decrease in physical-mechanical properties, but in a small percentage.

3.1.3. Consistency of concrete

Consistency of fresh concrete is determined by the method of sagging in accordance with the standard SRPS EN 12350-2 [4]. Table 4 shows the results of determining the consistency of concrete.

Table 4 – Slump test for concrete mixture

Mixture	Testing results [mm]			
	After mixing		After 45 min	
M1	170	S4	195	S4
M2	170	S4	200	S4
M3	150	S3	180	S4

Based on the measured results, it can be concluded that mixtures belonging to the class S4. On all concrete mixtures a liquid consistency is obtained ranging from 150 to 200 mm. The participation of additives leads to such poor consistency.

3.2. The properties of hardened concrete

3.2.1. Compressive strength

Figure 1 left shows the compressive strength values at 7 days and at 28 days the values are shown in Figure 1 right. M3 concrete has a much lower value at 7 and 28 days compared to the M1 and M2 concrete. The maximum values were recorded on M1.

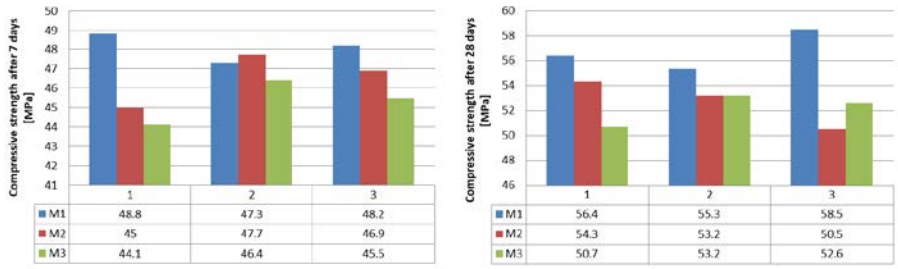


Figure 1 – Compressive strengths: at 7 days (left) and at 28 days (right)

3.2.2. Bulk density

The results of the test for hardened concrete samples at 7 and 28 days are shown in Figure 2. The maximum values at 7 and 28 days were achieved in concrete M1 and the minimum values for concrete M2. The deviation of the results between maximum and minimum values is about 2%.

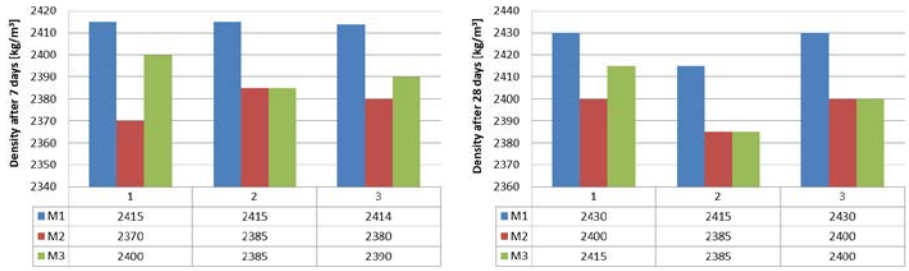
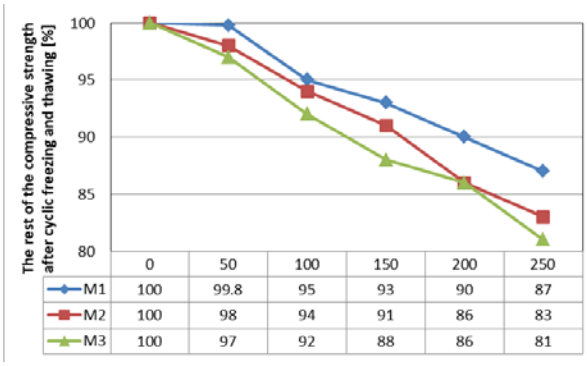


Figure 2 – Density at 7 days (left) and density at 28 days (right)

3.2.3. Resistance to freezing and thawing

Resistance to freezing and thawing is shown in Figure 3. All concrete fulfill the conditions, because the loss of strength is less than 25% [7]. Additional samples were made for each 50 test cycles, in order to compare the test results for compressive strength.



	0	50	100	150	200	250
M1	100	99.8	95	93	90	87
M2	100	98	94	91	86	83
M3	100	97	92	88	86	81

Figure 3 – Frost resistance

3.2.4. Resistance to freezing and thawing with the effect of salt

The results of testing are shown in Figure 4. The weight loss is significantly negligible in all three mixtures (M1, M2 and M3), so the depth of damage in the tested samples does not appear. The obtained results, degree of damage was 0 after 25 cycles, and compared to standard [8], show that tested samples were resistant.

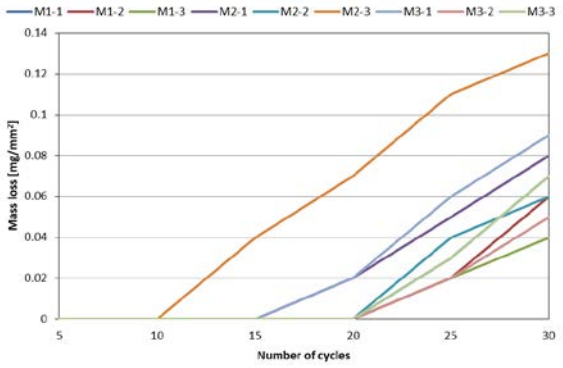


Figure 4 – Resistance to frost and salts mass loss

3.2.4. Water penetration under pressure

The test was made according to standard [6]. The required conditions for these types of concrete is that it should not be lower than V6 for concrete that is directly exposed to atmospheric influences. Figure 5 shows the results of the test, the water permeability of the concrete M2 is higher than on the concrete M1 and M3. All tested concrete fulfill the condition, because the penetration of water was less than 5 cm.

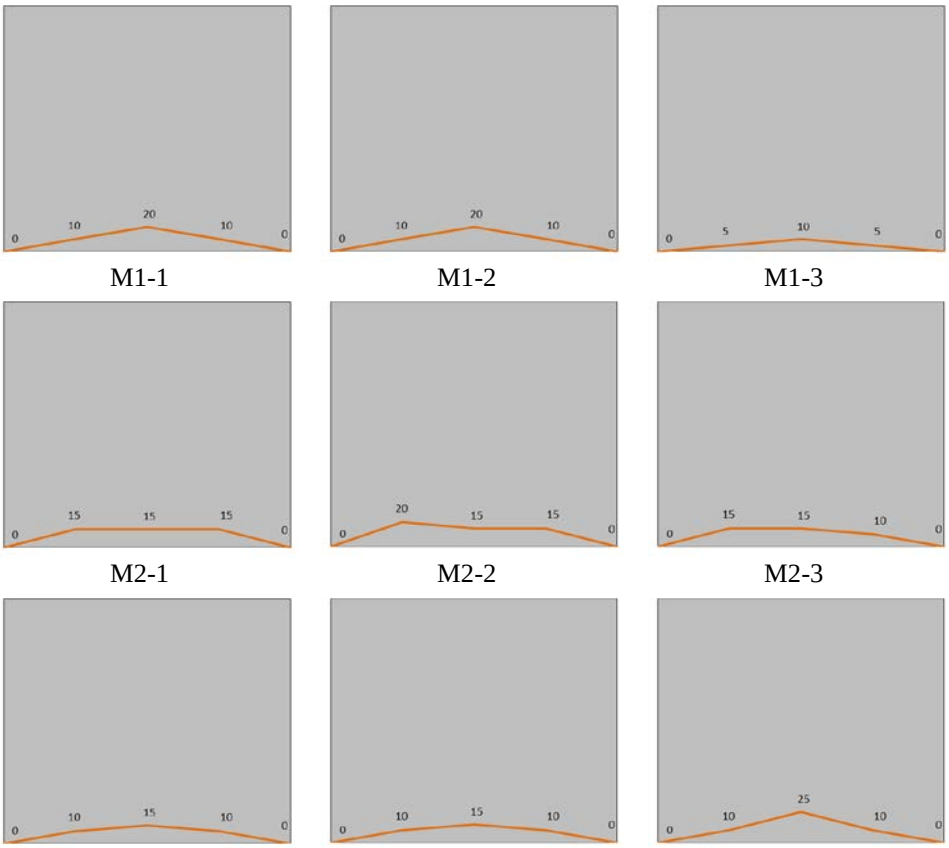


Figure 5 – Graphical presentation of results for water penetration under pressure

4. CONCLUSION

After analysis of the mixtures and the shown results, the following can be stated:

- the tested mixtures M1, M2 and M3 were made in normal laboratory conditions with a temperature of about 22°C, as ideal condition for the preparation,
- consistency of fresh concrete mixtures is done by the sagging method, on the basis of which it is found that the mixtures belong to category S4,
- the M2 mixture has a higher amount of air/cavity content compared to the assumed value of 4%,
- the compressive strength is high and all three mixtures have achieved average strength at a pressure of 50 MPa, after 28 days,
- all concrete have good resistance to cold, with a loss smaller than 25%,
- the test for freezing and thawing with the effect of salt in all concrete have not shown any damage to one of the tested samples,
- after a watertight test is performed, it is noticeable the penetration of water is less than 5 cm on all tested samples.

The presented concrete mixtures can be used for the production of concrete pavements, as well as for the construction of buildings that are exposed to aggressive environments such as residential-commercial buildings, bridges and other objects in civil engineering.

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ИСПИТИВАЊЕ БЕТОНСКИХ МЕШАВИНА – ДЕО II ФИЗИЧКО-МЕХАНИЧКА СВОЈСТВА БЕТОНА

Резиме: *Бетонске мешавине се израђују, односно справљају помоћу агрегата, везива и воде, а код неких бетона се користе и хемијски додаци како би побољшали својства бетонских мешавина. У раду су приказани резултати испитивања физичко-механичких својстава свежег и очврслог бетона за три различите мешавине где се кориси трофракцијски агрегат. За све три мешавине је коришћен цемент CEM II / A-M (S-L) 42,5 R. Након урађених испитивања констатовано је да све три врсте бетона могу да се користе за израду бетонског коловоза, као и за израду стамбено-пословних зграда, мостова и других објеката у грађевинарству.*

Кључне речи: *физичко-механичка својства, свеж бетон, очврсли бетон*