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EXPERIMENTAL STUDIES ON REALIZING A ROAD CONCRETE USING THE FLUICON 858 W SUPERPLASTICIZER ADDITIVE

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Abstract: *Within this study, concrete mixtures were created for which different percentages of additive were used, from 0.5% to 2% of the cement mass. Following the testing, correlations were established between admixture dosage and different characteristics of fresh and hardened concrete such as: volumic mass, water/cement ratio, content of entrained air, compression strength, and tensile strength. The obtained strengths certify the favourable influence of using this additive to obtain a Bcr 4.0 concrete, for a percentage of 1.5% of the cement mass. Building roads using road concrete is an advantageous and reliable solution, adapted to the current traffic values.*

Key words: *additive, concrete, strength, characteristic.*

1. Introduction

Road concretes must meet the same standards as the other concretes used in civil and industrial constructions, considering the nature of traffic or atmospheric solicitations. Concerning both their composition and their application, it is necessary to adopt solutions that lead to sustainable and stable concrete road systems [1].

From the perspective of building roads made of road concrete, the quality of works depends on the following factors:

- type of aggregate used;
- cement type and dosage;
- mixing water and water/ cement ratio;
- use of plasticizers and of other admixtures;
- concrete compacting method;
- subsequent protection of concrete, during the setting and hardening period [2].

2. Experimental Program

2.1. Materials Used for Obtaining Road Concrete

Natural aggregates

For road concrete production, aggregates obtained by stone crushing are the most common ones.

By their origin, natural aggregates fall into the following categories:

a) gravel natural aggregates according to SR EN 12620:2013 [3]:

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- natural sand, category 0-4;
- crushed gravel, categories 4-8, 8-16, 16-25.
- quarry natural aggregates, according to SR EN 13043:2013 [4]
- gravel, sorts 4-8, 8-16, 16-25.

Aggregates must be based homogeneous stones in terms of mineralogical composition, without visible traces of physical, chemical, or mechanical damage, without pyrite, limonite, or soluble salts. It is forbidden to use aggregates from stones containing mono-crystalline or amorphous silica, which may interact with the alkalis of cements. The sand used for road concrete production river quartz sand, with round grains, (0-4 granularity).

In order to obtain enduring and sustainable concretes, it is important to limit the content of fine, clayish sand. It is preferable to use natural, not man-made sand, because it has a high specific surface, which reduces the efficiency of fresh concrete and it increases the amount of necessary water.

For this experimental program, we used an aggregate made of natural river sand and gravel from the Turcoaia Quarry (situated in the Măcin Mountains, in the Tulcea County).

Cement

For preparing road concretes, the following types of cements are used:

- Portland EN 197-1-CEM I 42,5 R cement
- Portland EN 197-1-CEM I 42,5 N cement
- Portland EN 197-1-CEM I 32,5 R cement

Generally, cements with admixtures are not used currently for road concrete production because the concretes thus obtained are prone to cracking with rapid shrinking during the setting stage and they have low resistance to wear. [5]

For these lab testing, CEM I 42 R cement produced by Carpatcement Bicaz was used.

For obtaining Bcr 4.0 concrete, 390 Kg/m^3 were used.

Water

Water quality is important because impurities may have negative influences upon the setting time, as well as upon the mechanical characteristics of concrete [6]. In addition, chemical substances present in the water may lead to rebar corrosion.

Within this study, drinking water from the public water supply network was used.

From a quantitative perspective, water influence is highlighted by the W/ C ratio. If the amount of aggregates and the cement dosages remain constant, the increase in the W/ C ratio leads to the reduction of the most important characteristics of road concrete: mechanical strength, compactness, durability [7].

Strengths reach maximum values for stiff concretes, but a decrease below an optimal level of the W/C ratio leads to less workable concrete, which cannot be properly compacted. Considering these aspects, W/C ratio must be reduced as much as possible, but it should not be omitted that one must obtain workable and easily compactable concrete (with proper mechanical characteristics).

Admixtures

For improving workability, for reducing the segregation tendency during transportation and for increasing resistance to repeated frosting-defrosting operations, when preparing road concrete it is compulsory to use a plasticizing additive, along with an air agent. Depending on the meteorological conditions during execution, one may use either a set-accelerating or a set-retarding agent.

Plasticizing additives

These are substances adsorbed at the surface of solid particles, thus lowering superficial tension and allowing a better workability of fresh concrete, a reduction of water quantity and of W/C ratio, for the same consistency of concrete. The consequences of using such water-reducing additives are the following: improvement of mechanical resistances, reduction of shrinking, and improved resistance to repeated frosting-defrosting operations.

Superplasticizers

Superplasticizers are highly effective surface-active additives, used in dosages between 1% and 3% of the cement mass, with immediate repercussions upon the setting process and upon the structural frame.

The use of superplasticizers for obtaining road concretes leads to [8]:

- concretes with improved workability, 3–5 times for the same water/ cement ratio.
- concretes with increased resistance: 30-140% (after one day) and 20-60% (after 28 days) for the same cement ratio;
- reduction by 10-30% of the cement ratio, for the same workability and resistance;
- increased freeze proofness, of up to 300 repeated frosting-defrosting operations, due to the lower amount of water necessary for the mixing;
- making highly-enduring concretes in efficient conditions. [9]

Within this paper, the FLUICON 858 W superplasticizing additive was used; it is produced by the Draco Company in Turkey [10]. This additive is a strong superfluidizer with high molecular weight, based on synthetic polymers. It enables easier application of concrete because of its fluidizing effect (reduced shrinking and deformations). It is free from chlorides or other ingredients that accelerate the corrosion of concrete steel constructions.

Air agents

They are surface-active substances which – when added in small amounts within the concrete – form a high number of air micro-bubbles measuring between 20 and 60 μm, evenly distributed on distances of 0.1–0.2 mm. Air agents improve the workability of fresh concrete and they increase the strength repeated frosting-defrosting operations. Their downside is that they reduce by up to 10% the mechanical strength of concrete.

It is very important for the superplasticizers additive and the air agent to be compatible and not to interact with each other.

For preparing the concrete used within these trials, the Aermix air agent produced by Draco-Turkey was used.

The recipe for the Bcr 4.0 concrete use during these determinations is as follows:

- river sand 0-4 ....564 kg/m^3
- gravel 4-8............423 kg/m^3
- gravel 8-16..........426 kg/m^3
- gravel 16-25........410 kg/m^3
- cement I/42.5.........390 kg/m^3
- superplasticizer..............0.5; 1; 1.5; 2% of the cement mass
- air agent..............0.14...0.8% of the cement mass
- water.........................167.7 kg/m^3

2.2. Purpose of testing

By adding different percentages of superplasticizer (0.5–2% of the cement mass), the various characteristics of road concrete were analysed, as well as other aspects such as workability, the possibility of good compacting, and the W/ C ratio [11], [12], [13], [14].

For each type of concrete mix, 4 prism samples were made for tensile strength trials and 4 cube samples for compressive strength trials.

The purpose was to obtain a compaction close to 0, necessary for road concrete applied using a concrete finisher with a vibrating roller.

In addition, a W/C ratio of 0.43 was determined appropriate. As for occluded air, it was established for each sample and the temperature of concrete was measured. The density of concrete was calculated for each sample.

2.3. Obtained results

The obtained results are synthetized in the following tables and graphs.

Variation of concrete density by the amount of Fluicon 858 W Table 1

Amount of Fluicon – % of the cement mass	0.5	1	1.5	2
Density of concrete, in kg/m^3	2333	2390	2407	2429

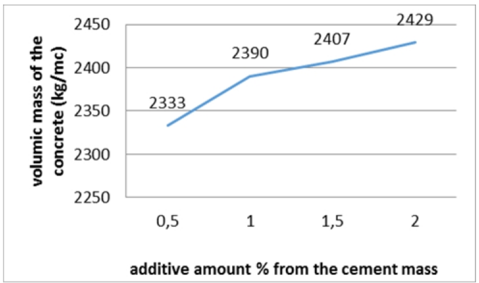

Fig. 1. *Volumic mass variation*

Variation of concrete temperature by the percentages of Fluicon 858 W Table 2

Amount of Fluicon – % of the cement mass	0.5	1	1.5	2
Temperature of concrete, in ^{0}C	13.3	14.6	15.1	15.5

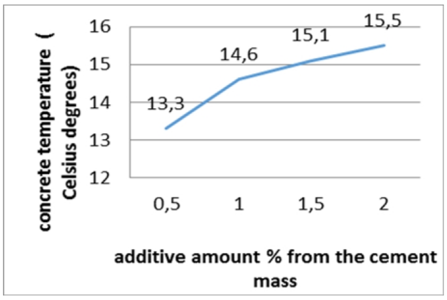

Fig. 2. *Concrete temperature variation*

Occluded percentage variation by the percentage of Fluicon 858 W used (for the same percentage of air agent) Table 3

Amount of Fluicon – % of the cement mass	0.5	1	1.5	2
Percentage of entrained air air %	4	3.5	3	3

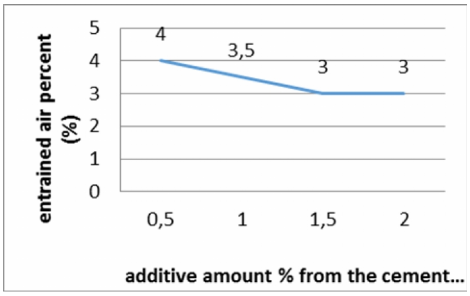

Fig. 3. *Entrained air percent variation*

Variation of tensile strength at 28 days, by the percentage of Fluicon 858 W additive Table 4

Amount of Fluicon – % of the cement mass	0.5	1	1.5	2
Tensile strength, in N/mm^2	4.49	4.72	5.28	4.73

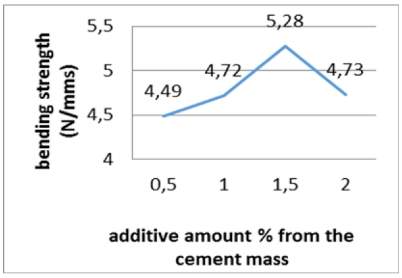

Fig. 4. *Variation of tensile strength at 28 days, by the percentage of Fluicon 858 W additive*

Variation of compressive strength at 28 days, by the percentage of Fluicon 858 W additive Table 5

Amount of Fluicon – % of the cement mass	0.5	1	1.5	2
Compressive strength, in N/mm^2	52.6	61.0	69.8	73.1

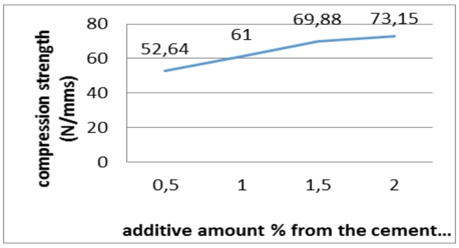

Fig. 5. *Compression strength variation*

3. Conclusions

Concrete density increases between 0.5% and 1% of additive from 2.333 to 2.390 kg/m^3, while when using a percentage of 2% it reaches 2.429 kg/m^3. In terms of concrete temperature, it is worth underscoring an almost linear increase, from values of 13.3^0 C to 15.5^0 C. This is a normal evolution, caused by exothermic reactions that occur with fresh concrete.

The testing on occluded air are much closer to recommended values, in case of the samples made using concrete mixed with Fluicon 0.5 %: values of 4% were obtained.

When increasing the additive dosage, tensile strength increased to 5.28 N/mm^2, on a 1.5 % dosage of additive compared to cement mass. For a 2% dosage of the cement mass, tensile strength decreased below 5 N/mm^2, but it still ranged within the limits stipulated by the norms in effect.

Concerning compressive strength, the most suitable dosage proved to be 1.5% of the cement mass.

At the same time, we found an excessive growth of strengths, exceeding considerably the values required by the norms in effect for the concrete class in question. Therefore, it may be concluded that the optimization of concrete amount to use is an issue worth reconsidering. In addition, altering the content of man-made aggregates may also be reconsidered, in order to obtain ideal values for mechanical characteristics and to optimize cement intake.

These findings attest that building roads using road concrete is an advantageous and reliable solution, adapted to the current traffic values.

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