

CEMENTNO BETONSKI CESTOVNI KOLNICI

ROAD PAVEMENTS OF CEMENT CONCRETE

Irina Petrovna Solonenko

Stručni članak

Sažetak: U radu se razmatra utjecaj na fizikalno-mehaničke pokazatelje svojstva modificiranog sitnozrnatog betona, dodavanjem u njegov sastav plastifikatora C3, aditiva za stvaranje zračnih pora (aeranta) PT-1 i polipropilenskih vlakana MAPEFIBRE NS 12 / NS 18.

Ključne riječi: plastifikator, cementni beton, abrazija, vlakna, čvrstoća.

Professional paper

Abstract: The paper examines the impact on physical and mechanical properties of modified fine-grained concrete by adding into its composition C3 plasticizer, air-entraining additive PT-1 and polypropylene fibers MAPEFIBRE NS 12/ NS 18.

Key words: concrete pavement, plasticizer, cement mix, abrasion, fiber, durability

1. PROBLEM FORMULATION

The quality and durability of roads substantially depend on physical and mechanical properties of the road pavement, which in turn depends on the material it is made of. [1] Currently, the most common two types of pavement are asphalt (A.) and cement (C.).

Researches carried out by the author [2] show that Ukraine is on one of the last positions in Europe for construction of highways (H.) with C. pavement (A. and C. H. together don't exceed 3,2 km of the total length of roads). Comparative analysis reveals that the pace of construction of roads with A. and C. has recently increased. The number of highways with hard cover pavement in France is 14,2 km per 1000 inhabitants. In Russia there have been built and successfully operated more than 6 thousand km of roads with A. or C. pavement. In the U.S. 60% of the interstate highways, with heavy traffic are paved with concrete [3, 4].

This is because the concrete pavement increases the durability of roads at a minimum cost of maintenance, assuring at the same time high transportation and operating quality. [4].

The quality of concrete pavement depends on the proper selection of components, as well as on the use of additives and fillers that improve their physical and mechanical properties.

The purpose of this paper is to determine the impact of C3 plasticizer and fillers on the physical and mechanical properties of the concrete when being introduced in its composition.

2. THE PURPOSE OF THE STUDY

The purpose of the study is to evaluate the impact on the physical and mechanical properties of roads paved with concrete of the addition into pavement composition of C3, air-entraining agent PT-1 and polypropylene fibers MAPEFIBRE NS 12/ NS 18 [5].

In order to achieve this goal, the following objectives have been set and accomplished:

- Preparation of concrete mixture [6];
- Manufacture and test of experimental samples of road pavement (RP) (compression, bending, abrasion, impact resistance);
- Recommendations on the selection of the composition of cement for the RS.

The samples used in the experiment were made up according to the method described in [2, 6], using the following materials:

- Cement PC-I-500 N ("Yugcement");
- washed silica sand, (Voznesensky quarry, Mykolaiv region), particle size (MCR) 2,5;
- Screening of crushed granite (0,14 to 5 mm).

In the concrete mixture included the following additives ::

- Plasticizer C3 ("Poliplast");
- air-entraining admixture, PT-1, («Mapel»);
- polypropylene fiber - MAPEFIBRE NS 12/NS 18 (diameter – 0,34 micron, fiber length 12-18 mm, density – 0,91 kg/m³, tensile strength - 700 MPa), («Mapel»).

Preliminary tests conducted by the author and described in [6] served as theoretical ground for choosing the composition of the concrete mixture, which was used in the manufacture of the samples (table 1).

Table 1. The composition of prototypes

| Components | Concrete pavement mixture | | | | | | | | |
|----------------------------|---------------------------|------|------|------|------|-------|------|------|------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Cement, kg/M ³ | 521 | 521 | 521 | 518 | 520 | 518 | 516 | 518 | 521 |
| Sand, kg/M ³ | 473 | 473 | 473 | 473 | 473 | 473 | 473 | 473 | 473 |
| Macadam, kg/M ³ | 1050 | 1050 | 1050 | 1050 | 1050 | 1050 | 1050 | 1050 | 1050 |
| Water, l/M ³ | 255 | 195 | 195 | 197 | 197 | 195 | 195 | 195 | 195 |
| V/C | 0,48 | 0,37 | 0,38 | 0,38 | 0,37 | 0,38 | 0,37 | 0,37 | 0,37 |
| C-3, % | -- | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| PT-1, l/M ³ | -- | -- | -- | 1,2 | 1,2 | -- | 1,2 | -- | 1,2 |
| Fp, % of C. | -- | -- | -- | 0,2 | -- | 0,2 | 0,2 | 0,2 | -- |
| OC, cm | 16 | 20 | 20 | 19,5 | 20 | 19,67 | 20 | 19 | 20 |

The experiments were conducted in the laboratories of the construction materials and design, construction and operation in Highways and airports department in Odessa State Academy of Construction and Architecture, according to the methodology described in [7-10]. The samples were of size 4x4x16 cm (bending (f_{ctk})) and the size 10x10x10 and 7x7x7 cm (compression ($f_{ck,cube}$), abrasion (G) and bump (T)).

After fabrication, the samples gained strength in normal solidifying conditions ($t = 20^{\circ}C$, 80% humidity) for 28 days. They were then tested. The strength of samples has been tested by the press machine STU-250 [8]. Bending test was carried out on the device MII-100 [7]. Abrasion test of the 7x7x7 cm samples has been carried on LCI-3 [9], the impact tests – on laboratory impact machine. [10].

The results of the experiment are presented graphically in Figures 1, 2, 3, 4.

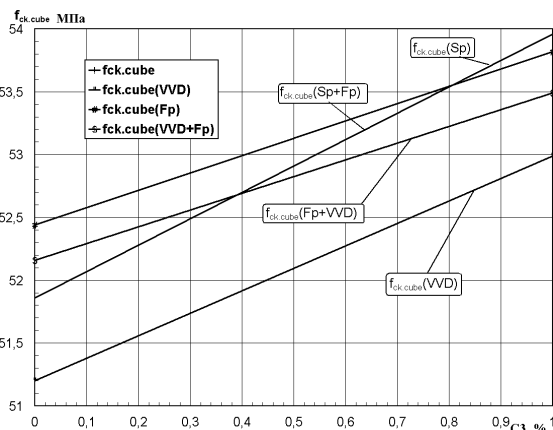


Figure 1. The dependence of the compressive strength on the added substance: super-plasticizer C3 (Sp), air-entraining agent PT-1 (VVD) and polypropylene fibers (Fp)

The relations illustrated in figure 1 prove that 1% of SP C3 added into C. increases the $f_{ck,cube}$ strength of the sample up to 4,05%. The introduction of SP C3 into concrete with air-entraining agent (PT-1) increases the strength by 3,5%. When added into C. with

polypropylene fiber, C3 increases the strength by 2, 7 %. C3 addition into C. already containing both polypropylene fiber and air-entraining agent (PT-1) increases the C. strength by 2,54%.

The tests of bending strength (fig. 2) demonstrate that the use of Sp C3 at 1% increases in the strength of concrete sample by 15,23%. The introduction of the same quantity of Sp C3 into cement with air-entraining agent (PT-1) increases the bending strength by 9,06%. The addition of Sp C3 into C. with polypropylene fiber increases the strength by 15,52%. The addition of Sp C3 into cement with polypropylene fiber and air-entraining agent (PT-1) increases the strength by 8,59%.

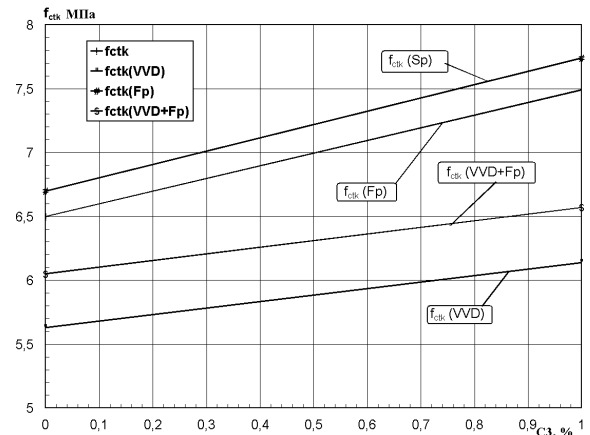


Figure 2. Dependence of the bending strength of concrete on the additives: super plasticizer C3 (Sp), the air-entraining agent, PT-1 (VVD) and polypropylene fibers (Fp)

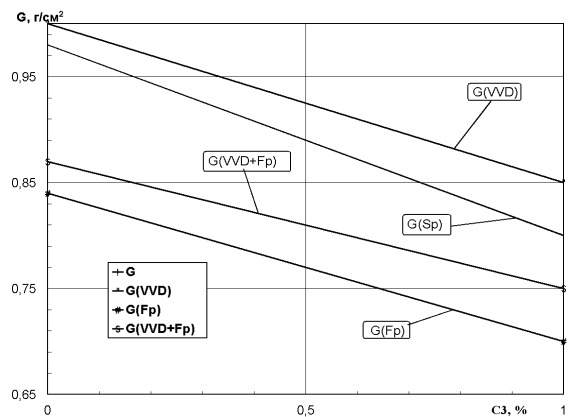


Figure 3. Abrasion samples (G, g/cm²): super plasticizer C3 (SP), the air-entraining agent, PT-1 (VVD) and polypropylene fibers (Fp)

The relations presented in Figure 3 prove that the addition of 1 % of SP C3 into the sample reduces abrasion by 8,9% (to 0,8 g/cm²). The introduction of the same quantity of SP C3 into cement with air-entraining agent (PT-1) reduces abrasion by 7,6% (to 0,85 g/cm²). The addition of SP C3 into C. with polypropylene fiber reduces the abrasion by 20% (to 0,7g/cm²). The addition of SP C3 into cement by polypropylene fiber and air-entraining agent (PT-1) reduces abrasion by 16% (to 0,75g/cm²).

As can be seen from the graphical dependences (Fig. 4), the use of Sp C3 at 1% increases the impact strength of concrete by 19,6%. The addition of Sp C3 into concrete with air-entraining agent (PT-1) increases impact strength by 27,8%. The addition of Sp C3 into C. with polypropylene fiber increases impact strength by 12%. The addition of Sp C3 into cement with polypropylene fiber and air-entraining agent (PT-1) increases impact strength by 24,8%.

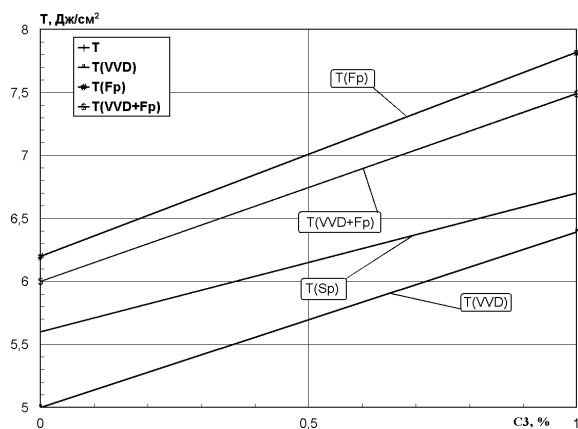


Figure 4. Impact test: super plasticizer C3 (Sp), the air-entraining agent, PT-1 (VVD) and polypropylene fibers (Fp)

3. CONCLUSIONS

Based on the research, the following conclusions have been drawn:

- The use of additives C3 increases the compressive strength by 4.05%, bending strength – by 15.23%, impact strength – by 19.6% and reduces abrasion with 8.9% (0.8 g/cm^2).
- The addition of air-entraining additive PT-1 into concrete leads to a decrease in strength with respect to the addition of the modified with C3 concrete: compressive strength – by 5%, bending strength – by 10%, impact strength – by 27%, abrasion is increased by 20% (1 g/cm^2).
- The use of polypropylene fibers in concrete results in a reduction in strength considering the addition of the modified C3 concrete: compressive strength – by 5.2%, bending strength – by 18.5%, abrasion - by 20% (0.7 g/cm^2) and increased strike strength by 26.12%.

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Author's contact:

Irina Petrovna Solonenko, M. Eng. C.E.
Odessa State Academy of Construction and Architecture, Ukraine
+380974666579
e-mail:odarina08@rambler.ru