Journal of Engineering Science *Vol. XXVI, no. 1 (2019), pp. 91 - 95*
Fascicle *Architecture, Civil and Environmental Engineering* *ISSN 2587-3474*
Topic *Architecture, Urbanism and Cadaster* *eISSN 2587-3482*

DOI: 10.5281/zenodo.2649980
CZU 666.972.16

MANAGEMENT OF CEMENT-CONCRETE ROAD PAVEMENT STRUCTURE

A. V. Mishutin*, M. V. Zavoloka, L. Kintia

Odessa State Academy of Civil Engineering and Architecture

*Corresponding Author: A. V. Mishutin, *mishutin52@ukr.net*

Received: January, 17, 2019
Accepted: March, 10, 2019

Abstract. The aim of the research is to study the effect of operating factors on the pavement and optimize the composition of the modified additive for controlling the structure of concrete. The choice of modifiers for concrete mixtures is mainly made empirically and specifically tied to specific engineering tasks. The specifics of the material work is associated with the unilateral action on the design of the operational load. There are significant gradients of humidity and temperature over the cross section and height of structures. Analysis of the experimental data of the planned experiment made it possible to optimize the composition of the modified additive in order to control the structure to obtain durable concrete.

Keywords: *Cement concrete road pavement, modified additives, structure of concrete, durability of concrete.*

Introduction

Cement concrete road pavements are influenced by the simultaneous and uneven influence of various operational and climatic factors. The list of factors includes frequent changes in temperature, cycles of freezing and thawing, moistening and drying, effects of salts, as well as pressure and dynamic effects from transport are shown in (Figure 1).

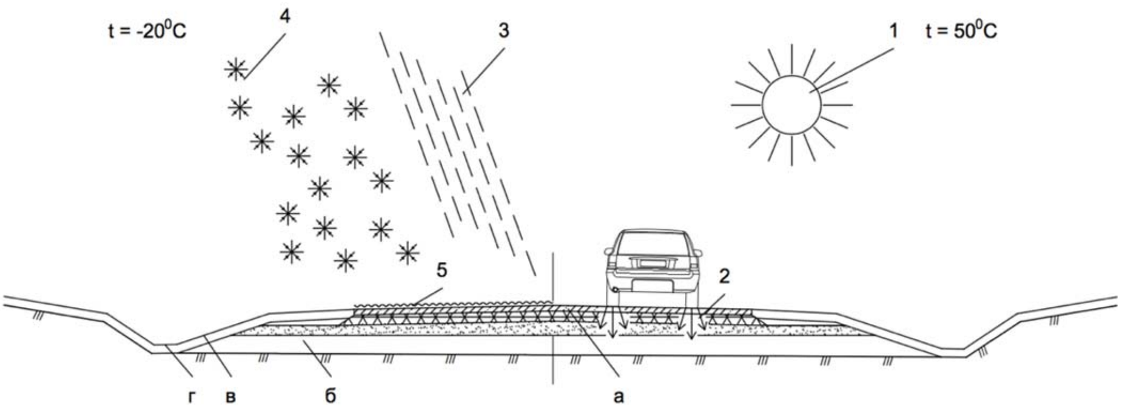

Figure 1. External impacts on road coverage.
a - road pavement; b - earth bed; c - railroad slope; d - road ditch
1 – temperature, t=+50˚...-20˚C; 2 – load from automobile transport, P; 3 – rain; 4 – snow; 5 - salt ingredients.

The specifics of the material work is associated with the unilateral action on the design of the operational load. There are significant gradients of humidity and temperature over the cross section and height of structures.

The alternating volumetric deformations degrade the structure of the material, which leads to a change in the initial (design) structural parameters that provide the necessary values for water tightness and frost resistance.

The thickness of the cement concrete pavement construction does not exceed 25 cm. For concretes of these structures, "fat" compositions with mobility are used depending on the M-3, M-4 concrete pavers used and with W / C values ⩽ 0.45.

In order to solve technological problems of workability and mobility of the concrete mix, to reduce the setting time of concrete, as well as regulating the structure and physico-mechanical characteristics of concrete, additives - modifiers are introduced into its composition.

The purpose of the work. In fact, the choice of modifiers for concrete mixtures is mainly made empirically and specifically tied to specific engineering tasks. Therefore, the requirements for the development of concrete, taking into account the environment of their operation, design and methods of obtaining, modified concrete with the necessary performance characteristics and predicted durability are relevant. The problem of durability of such concretes includes a large list of questions: studies in the process of operation taking into account the environment, setting requirements for raw materials, selection of compositions of modified concretes, increasing their structural and, as a result, quality indicators and operational characteristics.

Analysis of research and publications

Professor Ivanov F.M. indicated that the design of the service life of structures should be based on the knowledge of the rate of corrosion processes [7]. Professor Verbetsky G.P. [8] considered that the main state for the durability of concrete in the aquatic environment is its high density, which impedes the penetration of aggressive agents, in particular water, into its capillary-porous system. Academic L.I. Dvorkin [9] noted that the required durability

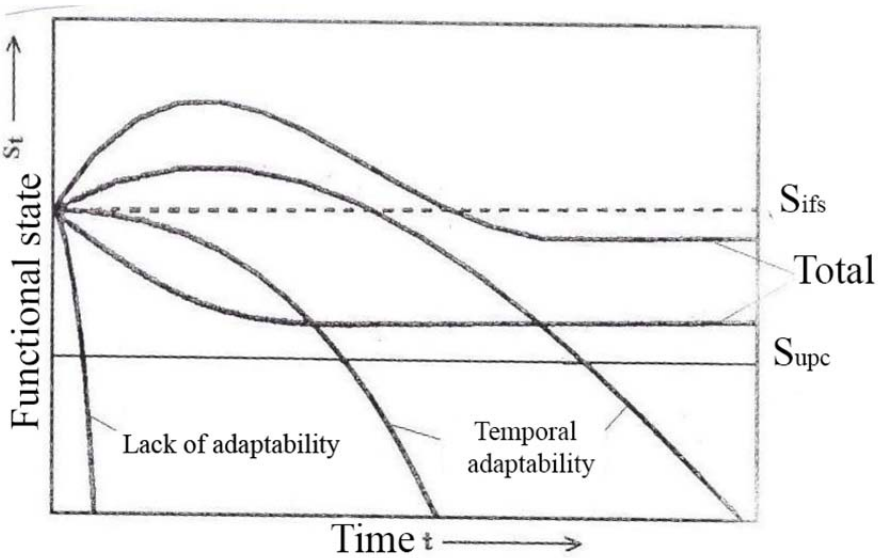

Figure 2. Variants of the trajectories of the functional state S1 of concrete in time t in the operational environment. S_{ifs} - the initial functional state, S_{upc} - ultimate permissible state. According to research of V.L. Chernyavsky [10].

of concrete is ensured in a comprehensive manner by designing the optimal structure and composition, the technology for producing the structure and the erection of structures, maintenance and protective measures.

Due to the fact that the freezing temperature of water in the pores, capillaries, internal interfaces and technological cracks (with dimensions of 10-5 ... 10-7 cm) are in structural form and its freezing temperature reaches -50 C, [6] based on this it can be concluded that when passing through the freezing point, physical processes in concrete are manifested mainly at the level of the macrostructure. In order to improve the durability of concrete from the effects of freezing and thawing, it is necessary to increase the level of its frost resistance (F). In [7], it was shown that for fine-grained and heavy concretes with approximately equal W / C, frost resistance may differ by an order of magnitude. The most frost-resistant are compounds with a system of closed pores with a size of 25..350 microns. In this case, the second factor determining the frost resistance is the factor of the distance between the pores, which should be from 02 to 03 mm.

The effect of coarse aggregate on frost resistance is studied, in particular, in [2]. It is shown that concretes on rubble, other things being equal, have three times greater frost resistance than concretes on gravel. This was explained by the fact that rubble due to its rough and angular shape "creates a more dense aggregate structure" than gravel, and also has better adhesion to the cement stone.

One of the most well-known ways to improve the frost resistance of concrete is the introduction of air-entraining additives. The effect is explained by the appearance of fine air emulsion in the concrete [4, 3] and the resulting change in structure. By creating a system of closed pores, there is a space for the growth of ice crystals with minimal damage to the body of concrete [3,5]. The highest rates of modified concrete frost resistance were observed when creating closed pores in the structure while simultaneously increasing the density of the cement stone. That can be considered the best system of closed pores of small size (diameter).

However, most often when using air-entraining additives, closed porosity increases with simultaneous increase and through porosity, which is undesirable for concrete pavements. Therefore, increasing frost resistance should be achieved by creating the most dense structure of concrete, that is, by creating small closed pores without increasing the overall (total) porosity.

Water penetrates into the concrete bears the salt ions, which gradually accumulate in the pores and capillaries of the material. This type of impact corresponds to the 3rd type of corrosion according to V.M. Moskvinu. At the same time, the main part of the salts is deposited from the side of the filtration effect, since penetrating through the smallest capillaries, the water is partially filtered and straightened from the bottom side of the thin-walled structure.

In recent years, prof. A.S. Faivusovich [1] developed a number of fundamentally new models describing the features of corrosion processes in fully or partially water-saturated concretes with the formation of a cylindrical front around capillaries and pores.

The structure of the pore space of concrete is considered as a system of cylindrical parallel pores or capillaries of radius r0, located at equal distance from each other in a staggered manner, with the boundary R0 of the zone of influence of each pore or capillary considered impenetrable. In addition, it is assumed that to cross sectional longitudinal capillaries and pores, there are a significant number of differently oriented capillaries, along which moisture or mass transfer in the radial direction is possible.

The results of research

In order to determine the possibility of controlling the structure of the physicomechanical characteristics of modified concrete to cover the roads, a 5-factor planned experiment was conducted.

As factors there were taken:

1. Consumption of portland cement
2. Modifiers:

a.) Concrete curing accelerator (CCA);

b.) Superplasticizer (SP) - MC Power Flow 5695;

Additive consumption 0.6% by weight of cement, cone slump 2-4 cm

c.) Air entraining additive (AEA) - Air 207

Additive consumption 0.35-0.4% by weight of cement

Air entrainment 5.5% by volume.

3. Polymer Fiber

The main structural indicator that we studied is the porosity of concrete. In particular, the magnitude of the material open porosity (in terms of the maximum absorption) was investigated. According to the EU model, which describes the influence of composition factors on the open porosity of the material (% by volume), charts have been plotted. The influence of the amount of cement and Peterona A (fixed levels of factors x2 = 0, x4 = -1 - i.e. formulations supplemented with C-3 in an amount of 0.8%).

The smallest porosity has the compositions with the maximum amount and with the maximum content of the modifier Penetron A. However, it should be noted that the addition of Penetron A reduces the open porosity of the material by no more than 7-8%. Thus, it can be suggested that the effect of the additive is formed not only in clogging (filling in cracks and pores), but also in redistributing the shape and size of pores and “treating” cracks and capillaries. That is, the reduction is mainly not total, but “effective” porosity.

Parameters of the conditionally-closed porosity of modified complex additive concrete were evaluated on microscopic polished sections by the linear method (secant chord).

The developed complex modifying additive (CCA + SP + AEA) allows not only to reduce the total volume of open pores, but also to increase the uniformity of pores in size. Due to the use of the complex additive with a filler (ground sand with a specific surface of 300 m2 / kg), it is possible to obtain microporous (λ⩽ 0.5) concrete and fiber concrete with high uniformity of pores (0.7 ‹α⩽ 1.0), as shown in Table 1.

Table 1.

Changes in the pore structure of modified fiber concretes

Porosity characteristic	Concrete without additives	With additive SP-3	With complex additive	With fiber and complex additive
Total open porosity %	10-12	8.5-10	7-9	7.5-9,0
The average size λ	2-5	0.6-1,1	0.4-0.7	0.4-0.6
Pores of the same size α	0.3-0.6	0.6.-0.8	0.7-0.9	0.8-0.95

Conclusions

The analysis of the experimental data of the planned experiment made it possible to optimize the composition of the modified additive in order to control the structure and obtain durable concrete for hard road coverage.

The use of complex modifiers allows to reduce the open porosity by 10-20% and achieve a reduction in the average pore size of 1.2-2 times. It is shown that the main action of the colmatating additive is the formation of crystals that grow into the pores and capillaries.

References

1. Faysovich, A.S. The foundations of the mathematical theory of concrete corrosion processes. —M .: Scientific world, 2006. — 40 p.
2. L. Y. Dvorkin, O.L. Dvorkin, V.S. Dorofev, A.V. Mishutin. Hydraulic and road concrete. - Odessa, Even, 2012-214 p.
3. V. V. Stolnikov. Air-entraining additives in hydraulic concrete — M .: State Energy Publishing House, 1953–168 p.
I. Stark, B. Viht. Concrete durability —K: Oranta, 2004. — 301 p.
4. Guidelines for predicting the frost resistance of concrete on the parameters of its pores. —M., NIIZHB, IISS, 1984. —48 p.
5. Vyrovoy V.N., Dorofeev V.S., Fitz S. B. Concrete in states percussive implications. - Odessa: Vneshreklamservice, 2004. — 270 p.
6. V.G. Batrakov Modified concretes. - M.: Stroyizdat 1990. — 400 p.
7. Ivanov F.M. Protection of reinforced concrete transport facilities from corrosion. —M .: Stroizait, 1968.-176 p.
8. Verbetsky G.P. Strength and durability of concrete in the aquatic environment. - M: Stroyizat, 1976. - 128 p.
9. Bolshakov V.I., Dvorkin L.I., Dvorkin O.L., Fundamentals of the Theory and Methodology of a Multi-Parameter Design of the Composition of Concrete. Dnipropetrovsk: PASA, 2006. - 364 p.
10. Chernyavsky V. L. Adaptation of concrete. - Dnepropetrovsk: New ideology, 2002. — 216 p.