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BITUMINIZED CEMENT CONCRETE FOR HIGHWAYS

Goncharova Natalia Ivanovna
Candidate of Engineering Sciences, Associate Professor, of the
Department of Construction of Buildings and Structures
E-mail: n.goncharova@ferpi.uz,(ORCID 0000-0001-8846-4392)
Fergana Polytechnical Institute, 86 Fergana str., Fergana 150107, Uzbekistan

Abstract
The article considers the issue of increasing the strength and deformability of cement–concrete road surfaces by using an effective technological method - the introduction of bitumen emulsion into the concrete. The experimental data of the developed cement concrete with bitumen emulsion are presented, confirming the positive effect of bitumen emulsion on the performance properties of road concrete and increasing its strength and deformative properties.

Keywords. Cement concrete roads, feasibility of construction, dry hot climate, aggressive media, road limit state criteria, elastic modulus.

Introduction

The design of urban streets and roads in Uzbekistan is conditioned by natural and technical peculiarities, which primarily include: the combination of long hot and arid summers and wet winter-spring periods; the predominant distribution of low-water-resistant saline loess soils; the wide development of irrigation network, which contributes to improving the microclimate and serves for the drainage of surface water; the presence (mainly under the carriageway) of water supply and sewerage underground network, whose accidents lead to the following.

Expediency of cement concrete roads construction on vast territories of the country is determined by their capitalisation. Compared to asphalt concrete pavements, cement concrete pavements do not have seasonal strength fluctuations, which is especially important in the dry hot climate of Uzbekistan. On the contrary, the strength of such pavements increases with time.

Concrete road pavements, in addition to severe operating conditions associated with the movement of vehicles on them, also experience the impact of various aggressive environments. In particular, in the vast areas of Uzbekistan with saline soils, such aggressive environment is salt, which causes corrosion of concrete.

The main initial indicator determining the pavement design and pavement type is the prospective traffic intensity by the end of the service life of the structures before the next overhaul. The traffic intensity is determined by the number of vehicles travelling per day along one of the busiest lanes.

Method

The introduction of small amounts of bitumen to increase the density and aggressive resistance of road concrete in dry hot climate conditions is justified by the fact that the resulting material has properties inherent to both cement and, to some extent, asphalt concrete. Since in cement systems hard crystallisation bonds formed as a result of cement hydration are predominant, and in asphalt systems - bonds of coagulation type due to adhesive properties of bitumen, the presence of both is expected in modified cement concrete with bitumen addition.

The physical and technical processes of bituminized concrete (concrete with bitumen emulsion) are represented by the following sequence: on the one hand, cement grains, as they hydrate, take away the water that is part of the bitumen emulsion. The chemical binding of water and a decrease in its amount in the composition of the emulsion with the simultaneous appearance of calcium hydroxide in the solution leads to the decomposition of the emulsion; on the other hand, the decomposition of the emulsion can also be observed as a result of an exchange chemical reaction between Ca(OH)2 and sodium cations of the diffuse layer of the emulsified bitumen emulsion. Due to the orientation of the hydrocarbon part of the RCOOCa type compound with the formation of sliding planes ("molecular pile"), the surfaces are hydrophobized, which prevents excessive evaporation of water and contributes to the normal course of the hydration process of cement clinker minerals. At the same time, when the bitumen emulsion disintegrates, bitumen droplets are distributed in the form of the thinnest films by particles.

The expediency of using bitumen emulsion (BE) as a damping component of concrete is also due to the fact that BE not only plasticizes the concrete mixture, but also ensures its viability and non-delamination. At the same time, depending on the quantitative content of BE, the deformative ability of concrete should also change. Coagulation-type bonds are known to resist the effects of repeated cyclic loads due to the appearance of relaxation qualities, which is especially valuable when hardening and operating concrete in a dry, hot climate.

It is shown that at the loss of 1.5% of mixing water in the initial period of curing the flexural strength of concrete at the age of 7 days is reduced by about 30-35%, and at the loss of 2.5% of water the reduction of the index reaches 40% of the design strength. When 2.4% BE was introduced into the concrete mixture, the water yield in the first 3 hours decreased by one third compared to the reference one, and at 4% it decreased by half.

Reduction of water consumption of concrete mixture and water yield contributes to a significant (by 45-50 %) reduction of plastic shrinkage of concrete during hardening under LWC conditions. Regulation of structural stresses in concrete under the influence of BE favourably affects its strength properties (Table 1).

Table 1 **Increase in compressive strength of concrete over time**

Concrete class	BE content, %	Concrete ultimate strength, MPa, at age, days				
		3	7	28	90	180
B15	-	8,4 40	14,0 66	21,2 100	24,3 115	26,5 125
	2,4	6,3 25	12,0 54	22,4 100	26,9 120	29,3 131
B25	-	13,5 44	21,7 71	30,6 100	33,7 110	36,7 120
	2,4	9,8 31	17,8 56	31,8 100	36,9 116	40,7 128

Reduction of water consumption of concrete mixture and water yield contributes to a significant (by 45-50%) reduction of plastic shrinkage of road concrete during curing in dry hot climate conditions. Regulation of structural stresses in concrete under the influence of bitumen emulsion favourably affects its strength and deformative properties.

In the construction laboratory of Fergana Polytechnic Institute, the modulus of elasticity of concrete in compression and flexural tension was experimentally found, the change of which at different content of BE is shown in Figure 1.

Analysis of the data of Fig.1 shows that at the strength rational dosage of BE, equal to 2.4%, the modulus of elasticity in compression decreases by 14%, and in tension - 22%. The difference in performance in this case is 8%. The average value of the modulus of elasticity is sufficiently described by a second-order equation: where Eo and Ee are elastic moduli of concrete without and with BE, 105, MPa.

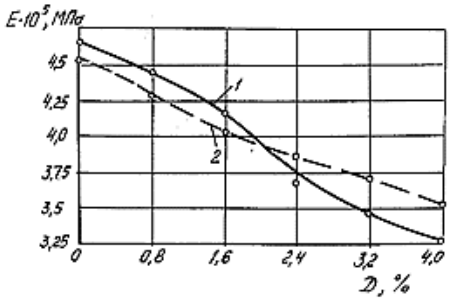

Figure1. Variation of elastic modulus of concrete depending on BE addition: 1- in compression; 2- in bending

Conclusions

Thus, the conducted studies confirmed the increase of damping ability of bituminous concrete in comparison with ordinary concrete, which is due to the formation of other structural bonds. The consequence of which is the improvement of technological properties of the mixture, structure, strength, deformative properties of concrete, which finally provides the concrete of roads with increased water resistance and durability.

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