УДК 693.5:625.7/.8 DOI: 10.30977/AT.2219-8342.2018.42.0.126

ON THE ISSUE OF THE USE OF ROLLER-COMPACTED CEMENT-CONCRETE MIXTURES FOR CONSTRUCTION OF ROAD PAVEMENTS

Bugaevsky S.A., Korzun S.N., KhNAHU
Vinnikov A.V., Semyonenko V.S., LTD «SK Fortis Group»,
Bugaevsky M.S., Kharkiv National University of Radio Electronics

Abstract. Problem. *At present, on the existing roads of Ukraine the construction of road pavement does not meet the requirements for durability and load-carrying capacity, because of constant increase in traffic intensity, the emergence of new types of vehicles with increased axle loads and uncontrolled transport overload. The widespread use of roller-compacted cement mixes (RCC mixes) in the construction of road pavements for highways will solve these problems.* ***Goal.*** *The aim of the work is to study the effect of the components of a rigid cement-concrete mixture on the physical and mechanical properties of concrete, as well as the industrial introduction of the technology of RCC in Kharkiv.* ***Methods.*** *The methods for assessing RCC characteristics allow to carry out all necessary research on the basis of existing regulations in Ukraine.* ***Results.*** *As a result of the studies carried out, compositions of RCC mixtures on local materials with compressive strengths of 60 MPa were obtained, with a bending strength of more than 4.5 MPa, density of 2420 kg/m^3 and frost resistance of F200.* ***Novelty****. The scientific novelty of the construction works is in the selection of the compositions of RCC mixes by applying high-quality cement, fine sand, two (or three) fractions of rubble, mineral additives, complex additives and nonmetallic fibers, which leads to an increase in the density and strength of the RCC, and also increases the durability of the cement concrete coatings compacted.* ***Practical value.*** *Laboratory research and selection of cement-concrete mixes for production of RCC used in the construction of road pavements were carried out to prove the aims of the work, as well as industrial introduction of the technology of RCC mortar has been carried out by laying the road section on the territory of the enterprise in Kharkiv city.*

Key word: *composition of cement-concrete mixture, stiffness of cement-concrete mixture, roller-compacted cement concrete mix (RCC mix), compressive strength, tensile strength at bending.*

Introduction

At present, on the existing roads of Ukraine the construction of road pavement does not meet the requirements for durability and load-bearing capacity, because of the constant increase in traffic intensity, the emergence of new types of vehicles with increased axle loads and uncontrolled transport overload.

A consequence of this situation is the rapid destruction of asphalt-concrete road surface coatings and rutting. At the same time, it is necessary to repair the surface of non-rigid road coating more often, the repairing time is shortened, so the costs for the maintenance and subsequent repair of road clothes are increased.

Analysis of publications

Construction of monolithic cement-concrete coatings is carried out by concrete rollers on wheel-rail or sliding formwork, as well as of hard concrete mixes, which are compacted by rolling with heavy road rollers [1–10].

The disadvantages of the technology for the construction of monolithic cement concrete pavements with the compacting of concrete mixtures by concrete pavers on wheel-rail or sliding formwork include a longer term for the care of freshly laid concrete, which is at least 28 days, associated with the process of concrete strength hardening; high initial cost of the cement concrete pavement, in comparison with asphalt concrete, at the expense of additional expenses for the admission of motor transport with the existing network of roads, which is especially critical in the construction of road clothes in cities and towns; low comfort of travel on roads with cement concrete coating.

Roller-compacted concrete mixes, on the contrary, allow to obtain a variety of monolithic cement-concrete with the minimum possible water-cement ratio (W/C), at which the maximum degree of compaction of the material by rollers is possible which provides formation of a dense structure. The consistency of the cement-concrete mixture should be such that it can with-

stand the mass of the vibrating roller, and also provide the required degree of compaction [7–9].

When hydrating cement, about 15 % of the water from its mass is needed. Therefore, at a cement consumption of 300–400 kg/m^3, 45–60 liters of water are required for chemical interaction. The rest of the water gives the cement-concrete mixture such technological qualities as workability and handling. Reduction of water consumption reduces shrinkage and temperature deformations of cement concrete [7, 10].

Another advantage of using rigid cement-concrete mixtures is the possibility of compacting with the help of the most common machines: motor graders, rubble-spreaders and asphalt rollers. There is no need to use expensive concrete rollers, as well as reinforcement with flat or rolled welded nets.

The technology of RCC includes the following: mixture preparation, transportation, packing, compaction and maintenance. A large spread of RCC received during the construction of dams and retaining walls of dams.

In the countries of Europe and the USA RCC mixtures in road construction are used in the arrangement of layers of road coating intended for the movement of heavy vehicles (container trucks, military vehicles, forestry machinery); container terminals, car parking; access roads, rural, forest roads with high traffic loads; minor roads and lanes, local roads and highways, road access to airports, runways of airfields; as a reinforcement layer in the reconstruction of old road surfaces [9].

Such road coatings are much stronger and more durable than asphalt concrete, in addition, much less time is spent on their compacting than in traditional technologies of monolithic cement-concrete coatings [7–10].

In the road construction, the cement mixes used include Portland cement with the addition of a microfiller, in many cases fly ash (15–20 % of the cement consumption). Such cement-concrete mixture should have a rigid consistency (the workability index on a standard technical viscometer is not less than 30 s), so that it can be laid with asphalt pavers and compacted to the required density by rollers. In Germany, this consistency is classified from earthy-damp to hard, in the USA – as «non-slump». The components of cement-concrete mixture are joined in stationary concrete mixing plants, and after delivery the mixture is placed and pre-compacted by asphalting machines having a large mass. Final compaction is achieved by means of vibrating, pneumatic or combined rollers [7–10].

The existing experience in the production of road pavements of RCC mixes has shown the possibility of their application in the construction of roads on which vehicles with a large axial load move, for example, in the construction of access roads for super-heavy vehicles on industrial enterprises; sites for parking of fueling and military vehicles, including military and transport aircraft [7–10].

Compressive strength of the RCC can be obtained at the rate of more than 50 MPa. The flexural strength is directly related to the compressive strength and, depending on the type of concrete mix, is 3.5–7.0 MPa. The modulus of elasticity is similar or slightly higher than that of conventional cement concrete, if the mixtures have the same cement content. The abrasion of the coating from the RCC and ordinary cement concrete is also similar. A higher percentage of the mortar (micronutrient, cement and sand), as compared to conventional cement concrete, will allow mechanical processing to cure the surface. The bond strength at the joint of layers is sufficient for the placing of layers of the road surface during 1 hour, but may require a reduction in the interval in warmer weather. The mark for the frost resistance of the RCC is higher than that of the conventional concrete, the shrinkage values are usually lower because of the lower W/C, and the permeability (the SP test showed less values) is comparable to that of conventional concrete [9].

To assess the consistency of the cement concrete mix, a modified WEBE device is used. Effective roller compaction of a rigid cement-concrete mixture is achieved with the rigidity of the mixture by a modified WEBE device from 30 to 40 s [7].

To assess the compatibility of the cement-concrete mixture, the modified Proctor method is used, which is usually applied to determine the compactness of the cement mortar [7].

One of the main advantages of using rigid cement-concrete mixtures as a material for the construction of road coating is the possibility of opening for traffic vehicles in 2 days at temperatures above 20 °C and in 3–4 days at lower temperatures (5–20 °C) [9].

Aims and stating the problem

The aim of the work is to study the influence of the components of a rigid cement-concrete mixture on the physical and mechanical properties of concrete, as well as the industrial applica-

tion of the technology of RCC in Kharkiv. The main task is to obtain the compositions of roller-compacted cement-concrete mixtures for production of coating and foundation of road pavements using local materials.

The Basics of Acquiring RCC

One of the vectors for obtaining cement-concrete mixes for RCC is the use of various industrial wastes to minimize the cost of the final product [11–13].

We know the methods of preparing a cement concrete mixture [11] for the construction of road and airfield coatings, including mixing cement, ash and slag waste incineration, fillers, additives, modifiers, detoxifying additives and water at the following ratio of components (wt. %): Cement 20–25; ash and slag wastes of incineration 40–60; filler 0–30; additive-modifier of concrete 0.02–0.075; additive-detoxicant 0–0.35 and water.

As a modifier additive, a mixture of additives is used: siliceous, plasticizing and curing agent in the ratio, wt. %: siliceous additive 0–58, plasticizing additive 17–35 and curing agent 25–65. In this case, the modifier MB 10–01 or microsilica or marshalite is used as a siliceous additive.

As additives, detoxicants the following substances are used: SDO, SNB, SGK or their double or triple mixtures, at a weight ratio of 1:(0.5–1) or 1:1:(0.25–0.3), respectively.

The disadvantage of this method of preparing cement-concrete mixture is the need for sorting and separation from metal inclusions and unburned fractions of waste incineration, as well as their detoxification. The instability of the physic-mechanical characteristics of waste incineration can lead to a significant spread of strength and frost resistance of the RCC.

The procedure of preparing a cement concrete mixture is known [12], which involves mixing cement, fly ash, sand, coarse aggregate and water with the following component ratio, wt. h.: cement 270–340; fly ash 60–130; sand 510; a large aggregate 1260 and water 200. Various functional additives are added to the ash slurry during the activation and/or after its termination: plasticizing and water-reduction, water-retaining or pumping improvers, retarders and/or accelerators of setting and curing, colmatizing pores, gas forming, air-entraining and anti-freezing.

The disadvantage of this method of preparation of cement-concrete mixture is a wide spread of cement consumption and fly ash, which affects the amount of fine and coarse aggregate. Additional activation of the ash is necessary for a twofold increase in the specific surface area of the ash particles. The composition uses a large amount of water (W/C = 0.42–0.50), which reduces the stiffness of the concrete mixture, and therefore cannot be used as a high-strength roller-compacted cement mortar for road surfaces.

Another method of preparing cement-concrete mixture [13] for the construction of road and airfield coatings is to mix cement, activated fly ash, sand, coarse aggregate, fine fraction up to 3 mm and coarse fraction from 5 mm to 20 mm of asphalt concrete granulate (AG) with water at the following ratio of components, wt. h.: cement 356; fly ash 89; sand 561; large filler 685; AG (fine) 50; AG (large) 468; water 180. The superplasticizer C-3 is used as the plasticizing additive.

The disadvantage of this method of preparation of the mixture is a large number of components in its composition, the need for additional activation of the fly ash in the pebble mill, as well as crushing followed by screening along the fractions of the milled asphalt concrete. In this case, the strength class of concrete does not exceed B25, and the frost resistance of F100. The method of preparing a mixture of this type is very complex, along with the breakdown of all the aggregates into three parts and with the phased introduction of each component into the mixer, with the necessary subsequent processing.

To select the composition of the roller-compacted cement-concrete mix, laboratory tests were performed with different types of cements, gravel, sand and additives (Table 1).

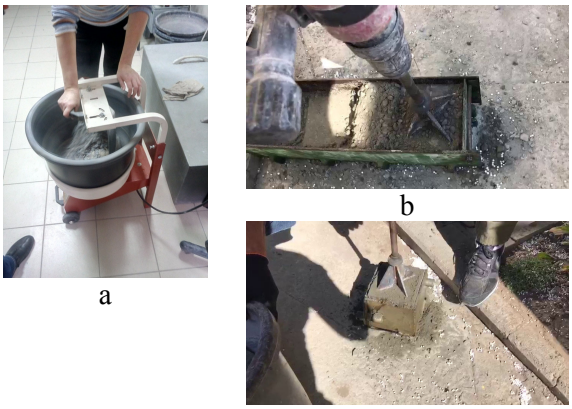
The optimum water-cement ratio was selected for the formation of samples from a rigid cement-concrete mixture (Fig. 1).

The basis for obtaining a cement-concrete mixture is the use of high-cement cement, fine sand, two (or three) fractions of rubble, mineral additives, complex additives and nonmetallic fibers, which will lead to an increase in the density, RCC compressive strength, waterproofness and frost resistance, and also increase the durability of the produced road coatings.

As complex additives, depending on the temperature conditions of laying the roller-compacted cement-concrete mixture, there can be the following components: plasticizing and water-reducing; water-retaining or improving pumping capacity; retarders of setting and curing; accelerators for setting and curing; colored pores; gas-forming additives; air-entraining and anti-freezing components.

Table 1 – Selection of the composition of the roller-compacted cement-concrete mixture for coating and base

Components	Composition variations									
	I	II	III	IV	V	VI	VII	VIII	IX	X
Cement PC I-500R-N Ivano-Frankivsk	+	+	+	+					+	+
Cement PC II/B-S-400 Krivoy Rog					+	+				
Cement PC II/A-S-500 Belorus							+	+		
Sand Mk = 1.4-1.6 Kremenchuk	+	+								
Sand Mk = 0.6-0.9 Unspecified			+	+	+	+	+	+	+	+
Crushed granite. 5-10 mm "Quartz"	+		+		+		+		+	
Crushed granite. 5-20 mm "Quartz"	+	+	+	+	+	+	+	+	+	+
Ground granulated slag									+	
Universal Additive-Accelerator Universal-BM (metakaolin)	+	+	+	+	+	+	+	+		
Quantec PL-421 Additive	+	+								
Polyplast additive PFM-NLK			+	+						
Complex additive Plasticent BV-41 (lignosulfanate with air-entraining component)					+	+	+	+	+	+
Basalt fiber 24 mm	+								+	
Propylene fiber 10 mm			+		+		+			
Strength (class) of concrete, MPa	69.4 C50/60	21.8 C16/20	66.7 C50/60	21.2 C16/20	66.6 C50/60	20.2 C16/20	61.4 C50/60	20.8 C16/20	62.8 C50/60	20.4 C16/20



a b c

Fig. 1. Selection of the composition of the roller-compacted cement-concrete mixture: a – mixing cement-concrete mixture in the laboratory; b – laying of the cement-concrete mixture in the form-prism; c – laying cement-concrete mixture in a cube-shape

In the method of preparing cement-concrete mixture, which received the patent of Ukraine [14], the order is as follows: two fractions of rubble 5–10 and 5–20 mm are mixed with sand and nonmetallic fiber 10–25 mm long, then cement and mineral additive with a specific surface of not less than 3–5 thousand cm^2/g is taken, followed by mixing, Subsequently, mixing water with a complex additive is added and all the components are finally mixed.

Compositions of rigid cement-concrete mixtures, offered for the construction of road coatings for motor roads, are given in Table 2.

Table 2 – Compositions of rolled cement for concrete and coating

Components and properties of concrete	Units of measurement	Composition	
		1	2
Cement PC 500	kg/m^3	420	180
Crushed stone 5–20 mm	kg/m^3	770	1400
Crushed stone 5–10 mm	kg/m^3	480	–
Sand	kg/m^3	550	702
Mineral additive	kg/m^3	25	–
Complex additive Plasticent BV41	kg/m^3	2.1	1.1
Basalt fiber 24 mm	kg/m^3	1.5	–
Water	kg/m^3	151	58
Density	kg/m^3	2420	2350
Characteristic cubic strength 3 days	MPa	12.0	6.0
Characteristic cubic strength 28 days	MPa	60.0	20.0
Tensile strength for bending 28 days	MPa	4.5	2.0
Frost resistance	brand	F200	F100

In the laboratory of the Department of Building Constructions of the KhNUUE named after O.M. Beketov tests were conducted with cement concrete-type prism specimens, molded in an in-sheet metal formwork during the laying of the experimental section of the road from the rolled concrete, located at: Babayi, Soborna st., 18. Experimental site is chosen at the entrance to the territory of industrial warehouses, where intensive traffic of freight transport is carried out.

On the construction site, prism samples were made in an inventory metal formwork measuring 15x15x60 cm, which were stored in conditions close to reality. The seal was carried out using a HILTI TE 76 perforator with a special packing (two layers 7–8 cm thick, Fig. 2).

Fig. 2. Forming of a prism sample

Tests of cement-concrete prism samples on stretching during bending as well as on compression were carried out at a temperature of 18 °C on a hydraulic press PSU-250 in accordance with the requirements of DSTU B V.2.7-214: 2009. The compression test was carried out by means of two metal plates measuring 15 cm by 15 cm in thickness, 1 cm thick by loading the end part of the half-prisms (Fig. 3).

a b

Fig. 3. Strength tests: a – sample-prism; b – sample-cube

Below in Figures 3 and 4 the processing data of the test results for cement-concrete samples are shown.

To assess the consistency of a rigid cement-concrete mixture, only the WEBE device was used, the Krasnyi device and the Skramtaiev method did not allow to obtain reliable data for determining the grades of concrete mixes according to the workability of L3-L4. Effective placement of cement concrete mix with a vibration plate was achieved with a stiffness of 25–30 s.

The main technological operations performed during the laying of the roller-compacted cement-concrete mixture on the test site:

1. Cutting old asphalt concrete on an area of 36 m^2.
2. Overplacement and leveling as the base of the crushed stone, with thickness of 20 cm.
3. Compacting of crushed stone with a vibration plate weighing 450 kg (Fig. 4, a).
4. Irrigation of the upper layer of the base before placing the cement-concrete mixture (Fig. 4, b).
5. Delivery of cement concrete mix covered with a tarpaulin to the construction site with an onboard dump truck (Fig. 4, c).
6. Unloading cement-concrete mixture in the middle of the compacted section (Fig. 4, e).
7. Leveling the cement-concrete mixture and cutting off the surplus small-sized caterpillar excavating machine (Figure 4, f).
8. Compacting RCC mix with a vibration plate weighing 450 kg (Fig. 4, e).
9. After compaction, apply RCC Surfase Pro (grouting agent) to improve surface treatment and cure it (Fig. 4, g).
10. Mechanical surface treatment was carried out using a two-rotor concreting machine with a disc diameter of 900 mm. In places where old asphalt-concrete is interfaced with a new cement-concrete coating, the mechanical treatment was carried out by a single-rotor concrete cutting machine with a disk diameter of 600 mm (Fig. 4, h).
11. To enhance the bond strength, the surface of the coating was applied with a special metal brush.
12. After the processing of concrete machines and the creation of a smooth surface, the Sinak S-102 concrete care agent was applied to prevent early evaporation of water and additional hardening of the surface, which is equivalent to 14 days of watering (Fig. 4, k).

Table 3 – Determination of the strength of cement concrete for bending elongation

№	Area A, cm^2	Moment of resistance W, cm^3	Destructive force P, kgs	Bending moment M, kgs·cm	Bending tensile strength kgs/cm^2 (MPa)
1	225	562.5	4800	24000	4.27
2	225	562.5	5700	28500	5.07
3	225	562.5	5200	26000	4.62
The average value of the tensile strength at bending					4.65

Table 4 – Determination of the compressive strength of cement concrete

№	Area A, cm^2	Destructive force P, kgs	Compressive strength, cube R_i, MPa	$(R_i - R_m)$, MPa	Mean square deviation, MPa	The coefficient of variation , %	Strength (class) of concrete , MPa
1	225	132000	58.7	-0.9	2.83	4.8	54.7 (C40/50)
2	225	142500	63.3	+3.7			
3	225	129000	57.3	-2.3			
4	225	132500	58.9	-0.7			
5	225	127500	56.6	-3.0			
6	225	141500	62.9	+3.3			
The average value, R_m			59.6				
The coefficient of variation for heavy cement concrete is adopted, %						5.0	

Fig. 4. Compacting of cement-concrete mixture using technology of roller-compacted cement-concrete in the experimental section: a-i – sequence of technological operations

After a set of 70–75 % concrete strength on the fourth day, the traffic was opened on a stretch of road laid with the roller-compacted cement mix.

Conclusions

The use of high-strength Portland cement with a mineral additive in the form of metakaolin or ground granulated slag, nonmetallic fiber, fine sand and two (or three) fractions of

coarse aggregate made it possible to obtain the compositions of the roller-compacted cement mix for the construction of road coating of highways with high strength and density of cement concrete.

It should be noted that the use of such a concrete mix requires a low energy intensity, provides less shrinkage due to a low water-cement ratio (V/C = 0.23–0.36), increases the distance between the expansion joints, and, most importantly, shortens construction time.

The conducted laboratory and pilot tests confirmed the possibility of widespread use of roller-compacted concrete mixtures for the construction of cement concrete roads in Ukraine and the need to develop local regulatory documents for the selection of the composition and technology of laying on the basis of the experience of the United States and European countries.

References

1. Левицкий Е.Ф. Бетонные покрытия автомобильных дорог / Е.Ф. Левицкий, В.А. Чернигов. – М.: Транспорт, 1980. – 288 с.
2. Толмачев С.Н. Строительство автодорог с цементным покрытием в Украине – реальность сегодняшнего дня / С.Н. Толмачов // Автомобільні дороги. Будівництво: науково-виробничий журнал. – 2013. – №4 (234) липень–серпень. – С. 36–40.
3. Радовский Б.С. Цементобетонные покрытия в США / Б.С. Радовский // Дорожная техника, 2009. – С. 50–58.
4. ДБН В.2.3-4:2015. Автомобільні дороги. Частина І. Проектування., Частина ІІ. Будівництво. – К. Мінрегіон України, 2015. – 104 с.
5. ГБН В.2.3-37641918-ххх:201х (остаточна редакція). Автомобільні дороги. Дорожній одяг жорсткий та з жорсткими прошарками. Проектування та будівництво. – К.: Державне агентство автодоріг України, 201х. – 84 с.
6. СТО НОСТРОЙ 2.25.41-2011. Устройство цементобетонных покрытий автомобильных дорог. – Москва, 2011. – 44 с.
7. ACI 325.10R-95 (Reapproved 2001). Report on Roller-Compacted Concrete Pavements. Reported by ACI Committee 325. – 32 p.
8. ACI 309.5R-00 (Reapproved 2006). Compaction of Roller-Compacted Concrete. Reported by ACI Committee 309. – 19 p.
9. ACI 327R-14 (Reapproved 2015). Guide of Roller-Compacted Concrete Pavements. Reported by ACI Committee 327. – 55 p.
10. Современное состояние и перспективы применения технологии укатываемого бетона. Обзорная информация. Автомобильные дороги и мосты. 6-2004. – 87 с.
11. Патент 2311236 Российская Федерация. Способ утилизации золошлаковых отходов мусоросжигания / Рахманов В.А., Мелихов В.И., Казарин С.К., Козловский А.И., Амханицкий Г.Я., Горбовец М.Н.; патентообладатель ОАО Технологический институт «ВНИИЖЕЛЕЗОБЕТОН». – № 2005103327/03; заявл. 10.02.2005; опубл. 20.07.2007, Бюл.№33.
12. Патент 2351563 Российская Федерация. Способ приготовления бетонной смеси / Суханов М.А., Сальтонс В.Н., Лепеев В.Ф., Синицын А.А.; патентообладатель Суханов М.А. – № 2007123258/03 ; заявл. 21.06.2007 ; опубл. 10.04.2009, Бюл. № 10.
13. Патент 2463271 Российской Федерации. Бетонная смесь / Николаенко В.Л., Балабанов В.Б.; патентообладатель Николаенко В.Л., Балабанов В.Б. – № 20111111955/03 ; заявл. 29.03.2011 ; опубл. 10.10.2012, Бюл. № 28.
14. Патент 122712 Україна. МПК С04В 28/00. Спосіб приготування бетонної суміш / Бабаєв В.М., Бугаєвський С.О., Вінников О.В., Семененко В.С., Прилуцька С.П.; власник ХНУМГ ім. О.М. Бекетова. – № u2017 07257 ; заявл. 10.07.2017 ; опубл. 25.01.2018, Бюл. № 2.

References

1. Levitskiy, E.F., Chernigov V.A. (1980). *Betonnyye pokrytiya avtomobilnykh dorog* [*Concrete Coatings of Highways*]. Moscow: Transport [in Russian].
2. Tolmachev, S.N. (2013). Stroitelstvo avtodorog s tsementnym pokrytiyem v Ukraine – realnost segodnyashnego dnya [Construction of roads with cement covering in Ukraine – the reality of today]. *Avtomobilni dorogi. Budivnitstvo,* 4 (234), 36-40 [in Ukrainian].
3. Radovskiy, B.S. (2009). Tsementobetonnyye pokrytiya v SShA [Cement-concrete coatings in the USA]. *Dorozhnaya tekhnika - Road machinery,* 50-58.
4. Avtomobilni dorohy. Chastyna I. Proektuvannia, Chastyna II. Budivnytstvo [Roads. Part I. Designing, Part II. Construction].

(2015). DBN V.2.3-4:2015. Kyiv: Minrehion Ukrainy [in Ukrainian].
5. Avtomobilni dorohy. Dorozhnii odiah zhorstkyi ta z zhorstkymy prosharkamy. Proektuvannia ta budivnytstvo [Roads. Road clothes are rigid and rigid. Design and construction]. HBN V.2.3-37641918-khkhkh:201kh (ostatochna redaktsiia). Kyiv: Derzhavne ahentstvo avtodorih Ukrainy [in Ukrainian].
6. Ustroystvo tsementobetonnykh pokrytiy avtomobilnykh dorog [Arrangement of cement-concrete coatings of highways]. (2011). STO NOSTROY 2.25.41-2011. Moscwa [in Russian].
7. Report on Roller-Compacted Concrete Pavements. ACI 325.10R-95 (Reapproved 2001). Reported by ACI Committee 325.
8. Compaction of Roller-Compacted Concrete. ACI 309.5R-00 (Reapproved 2006). Reported by ACI Committee 309 [in USA].
9. Guide of Roller-Compacted Concrete Pavements. ACI 327R-14 (Reapproved 2015). Reported by ACI Committee 327.
10. Sovremennoye sostoyaniye i perspektivy primeneniya tekhnologi ukatyvayemogo betona. Obzornaya informatsiya. Avtomobilnyye dorogi i mosty [Current state and prospects for the application of technology of rolled concrete. Overview information. Automobile roads and bridges]. (2004).
11. Sposob utilizatsii zoloshlakovykh otkhodov musoroszhiganiya [Method for utilization of ash and slag waste incineration]. (2007). Patent RF no. 2311236 [in Russian].
12. Sposob prigotovleniya betonnoy smesi [Method of preparation of concrete mixture]. (2009). Patent RF no. 2351563 [in Russian].
13. Betonnaya smes [Concrete mix]. (2012). Patent RF no. 2463271 [in Russian].
14. Sposib pryhotuvannia betonnoi sumish [Method of preparing a concrete mixture]. (2018). Patent UA no. 122712 Ukrainy [in Ukrainian].

Bugaevsky Sergey Alexandrovich, Ph.D., Associate Professor of Department Bridges and structures and structural mechanics, +38050-937-90-16, bugaevskiysa@gmail.com,

Korzun Sergey Nikolaevich, graduate student, +38050-756-62-99, asanstalker@gmail.com
Kharkov National Automobile and Highway University, 61002, Ukraine, Kharkov, Yaroslav Mudryi st., 25,

Vinnikov Alexey Vladimirovich, director, Semyonenko Vyacheslav Sergeevich, engineer, +38057-727-07-87, mailfortiskh@gmail.com
LTD «SK Fortis Group», 61001, Ukraine, Kharkov, Zdoroviya Naberezhnaya st., 12.

Bugaevsky Mikhail Sergeevich, student, +38066-693-79-27, bugaevsky73@gmail.com
Kharkov National University of Radio Electronics, 61166, Ukraine, Kharkov, Nauki Ave., 14.

ДО ПИТАННЯ ПРО ЗАСТОСУВАННЯ ЦЕМЕНТОБЕТОННИХ СУМІШЕЙ, ЩО УКОЧУЮТЬСЯ ДЛЯ БУДІВНИЦТВА ДОРОЖНІХ ОДЯГІВ АВТОМОБІЛЬНИХ ДОРІГ

Бугаєвський С.О., Корзун С.М., ХНАДУ,
Вінников О.В., Семененко В.С.,
ТОВ «БК "Фортіс Груп"»,
Бугаєвський М.С.,
Харківський національний університет радіоелектроніки

Анотація. *У наш час на існуючих автомобільних дорогах України конструкції дорожнього одягу не відповідають вимогам за довговічністю і несучою здатністю, у зв'язку з постійним зростанням інтенсивності руху, вантажонапруженості перевезень, появою нових видів транспортних засобів зі збільшеними навантаженнями на осі й неконтрольованим перевантаженням транспорту. Широке застосування цементобетонних сумішей, що укочуються при будівництві дорожніх одягів автомобільних доріг, дозволить вирішити ці проблеми. Метою роботи є дослідження впливу компонентів жорсткої цементобетонної суміші на фізико-механічні властивості цементобетону, а також дослідно-промислове впровадження технології цементобетонну, що укочується в м. Харкові. Методика оцінки характеристик укочуваних цементобетонів виконувалася на основі діючих нормативних документів в Україні. В результаті проведених досліджень отримано склади укочуваних цементобетонних сумішей на вітчизняних матеріалах із міцністю на стиск 60 МПа, при розтягуванні на вигин більше 4,5 МПа, зі щільністю 2420 кг/м^3 і морозостійкістю F200. Наукова новизна роботи полягає в підборі складів укочуваних цементобетонних сумішей шляхом застосування високомарочного цементу, дрібного піску, двох (або трьох) фракцій щебеню, мінеральної добавки, комплексної добавки і неметалевої фібри, що приводить до збільшення щільності й міцності цементобетону, що укочується, а також підвищує довговічність покриттів, що зводяться. Проведено лабо-*

раторні дослідження і підбір складів цементобетонних сумішей для отримання цементобетону, що укочується та застосовується при будівництві дорожніх одягів. Виконано дослідно-промислове впровадження технології цементобетона, що укочується, шляхом укладання ділянки дороги на території підприємства в м. Харкові.

Ключові слова: *склад цементобетонної суміші, жорсткість цементобетонної суміші; цементобетон, що укочується, міцність на стиск, міцність на розтяг при згині.*

К ВОПРОСУ ОБ ИСПОЛЬЗОВАНИИ УКАТЫВАЕМЫХ ЦЕМЕНТОБЕТОННЫХ СМЕСЕЙ ДЛЯ СТРОИТЕЛЬСТВА ДОРОЖНЫХ ОДЕЖД АВТОМОБИЛЬНЫХ ДОРОГ

Бугаевский С.А., Корзун С.Н., ХНАДУ,
Винников А.В., Семененко В.С.,
ООО «СК “Фортис Групп”»,
Бугаевский М.С., Харьковский национальный университет радиоэлектроники

Аннотация. *Проведены лабораторные исследования и подбор составов цементобетонных смесей для получения укатываемого цементобетона, применяемого при строительстве цементобетонных покрытий. Выполнено опытно-промышленное внедрение технологии укатываемого цементобетона путем укладки участка дороги на территории предприятия в г. Харькове.*

Ключевые слова: *состав цементобетонной смеси, жесткость цементобетонной смеси, укатываемый цементобетон, прочность на сжатие, прочность на растяжение при изгибе.*