UDC 691.32 DOI: 10.31650/2786-6696-2024-7-109-117

DURABILITY OF RIGID PAVEMENT CONCRETE REINFORCED WITH BASALT FIBER

[1]**Kroviakov S.O.,** Doctor of Engineering, Professor,
skrovyakov@ukr.net, ORCID: 0000-0002-0800-0123
[1]**Shestakova L.E.,**
shestakova_luba@ukr.net, ORCID: 0000-0002-3449-8498
[1]*Odessa State Academy of Civil Engineering and Architecture*
4, Didrichsona street, Odessa, 65029, Ukraine

Abstract. The purpose of the work is the development of fiber-reinforced concrete compositions for rigid pavements with properties of high strength, frost resistance and wear resistance due to the use of polycarboxylate type superplasticizer and dispersed reinforcement. The experiments were conducted according to an optimal 3-factor 15-point plan. The following composition factors were varied: the amount of Portland cement CEM I 42.5 R (from 290 to 350 kg/m^3); the amount of basalt fiber BAUCON®-bazalt (from 0.9 to 1.5 kg/m^3); the amount of polycarboxylate superplasticizer STACHEMENT 2570/5/G (from 0.6 to 1 % by weight of cement). The workability of all developed mixtures was S1, which corresponded to a cone slump 2...3 cm.

Research results shows when increasing the amount of cement and the amount of superplasticizer to 0.9 – 1.0 %, the W/C of the mixtures decreases. The amount of basalt fiber practically does not affect the W/C of the mixture.

Due to increase in the amount of Portland cement, the strength of fiber-reinforced concrete is increases, as expected. With an increase in the amount of basalt fiber to 1.3 – 1.4 kg/m^3, the tensile strength in bending of concrete increases by 12 – 21 %, while the compressive strength changes insignificantly. Fiber concrete with a superplasticizer content of about 0.9 % has the highest compressive and tensile strength in bending.

Moreover, due to increase in the amount of Portland cement from 290 to 350 kg/m^3, the frost resistance of concrete increases to about 100 cycles. Due to the increase in strength of that composition, the wear resistance of concrete was increased. With an increase in the amount of basalt fiber from 0.9 to 1.3 – 1.4 kg/m^3, the wear resistance of concrete increases by 11 – 16 %, and frost resistance increases to approximately 50 cycles. The change in the amount of superplasticizer has little effect on the wear resistance of concrete. However, with an increase in the amount of additive STACHEMENT 2570/5/G from 0.6 to 0.9 % by weight of cement, the frost resistance of fiber-reinforced concrete increases to about 50 cycles.

Fiber concretes with a rational amount of dispersed reinforcement (1.3 – 1.4 kg/m^3) and superplasticizer (0.9 %), depending on the amount of cement, have compressive strength from 43 to 60 MPa; tensile strength in bending from 4.9 to 6.4 MPa; wear resistance from 0.31 to 0.37 g/cm^2 and frost resistance from F200 to F300. This ensures the high durability of the developed fiber-reinforced concrete for rigid pavements.

Keywords: rigid pavement, frost resistance, wear resistance, basalt fiber, superplasticizer, experimental-statistical modeling.

Introduction. To ensure the effective function of the transport system, the task of arranging structurally and functionally stable road surfaces is important. It is known that asphalt concrete coatings are the most widespread today. However, in the conditions of gradually increasing of traffic intensity and high loads on the vehicle axle, rigid cement-concrete coatings became more popular in many countries of the world. Such pavements distributing the load on the base layers and soil more effective, they are not prone to rutting and practically do not change their properties depending on the temperature of the surrounding environment. Also, a significant advantage of cement-concrete pavements is their high durability, which allows to prolong intervals between repairing maintenance. However, to achieve such important result for the economic and ecological benefits, it is necessary to use concrete with high durability for arranging of road clothes.

In the climatic conditions of Ukraine and most European countries, main indicators that ensure the durability of rigid pavements are frost resistance and wear resistance of concrete. It is possible to achieve a simultaneous increase in these indicators, in particular, due to the use of effective superplasticizers and dispersed reinforcement. However, the raw material base of the concrete industry is not constant: cement production technologies are changing, chemical additives are being improved, and new types of dispersed reinforcement are being designed. Therefore, the task of developing of concrete for rigid pavements with high durability and a guaranteed level of strength remains relevant.

Analysis of Research and Publications. Due to a number of advantages of roads with rigid pavements from cement-concrete comparing with roads with asphalt-concrete surfaces, the share of first is increasing annually [1]. For Ukraine, an additional advantage of cement-concrete rigid pavements, especially in the conditions of post-war reconstruction, is that their production does not require using bitumen, which must be imported [2].

The high strength and elasticity of rigid pavements allows better redistribution of the load from transport on the soil. Cement concretes have stable properties under changes in ambient temperature and better color indicators of surface visibility [3]. If the required quality of concrete and base layers is ensured, the intervals between repairs of roads with rigid pavements are two or more times longer than those of roads with asphalt concrete surfaces [1, 4].

However, the task of ensuring the necessary durability of concrete for rigid pavements remains relevant. This is due to the fact that it must be solved taking into account the need for rational use of resources and the available raw material base [3, 5].

For Ukraine, one of the main factors affecting the operational quality of the road surface is the damage caused by the cyclic effects of a dynamic influence and the action of freezing and thawing [3, 4, 6]. As the studies of many authors show, in such conditions, the most effective materials are fiber concrete with corrosion-resistant dispersed reinforcement [7-11]. Polypropylene, basalt, metal and glass fibers are most often used in road construction [8, 9, 11, 12]. The use of fiber allows to increase the frost resistance and wear resistance of concrete, as well as their tensile strength and crack resistance. In addition, dispersed reinforcement reduces the autogenous shrinkage of concrete. At the same time, basalt fibers have certain advantages that allow effective use of this fiber in road concrete. First of all, this is the relatively low cost of basalt fiber and its fairly easy distribution in the mixture during mixing [13-15]. It is also known that in nowadays conditions, concrete and fiber concrete of rigid pavements can provide the required level of strength and economic efficiency only with the use of modern additives, primarily superplasticizers [4-6, 8, 10, 12, 15].

Accordingly, the task of developing of effective dispersion-reinforced road surface concretes modified with polycarboxylate type superplasticizer is relevant for modern materials science. It is necessary to solve such a problem relying on the domestic raw material base, which is important for the post-war recovery of the country, taking into account the significant amount of destruction caused by aggression.

The purpose of this work is develop compositions of fiber-reinforced concretes for rigid road pavements with high strength, frost resistance, and wear resistance by using polycarboxylate type superplasticizer and dispersed reinforcement with basalt fiber.

Materials and methods of research. The experiment was conducted using an optimal 3-factor 15-point plan [16, 17]. The following factors of the fiber-reinforced concrete composition were varied in the experiment [18]:

– X_1, the amount of Portland cement CEM I 42,5 R (produced by PJSC "Dyckerhoff Cement Ukraine") from 290 to 350 kg/m^3;

– X_2, the amount of basalt fiber BAUCON®-basalt (fiber length 12 mm, diameter – 18 μm) from 0.9 to 1.5 kg/m^3;

– X_3, the amount of superplasticizer STACHEMENT 2570/5/G (based on polycarboxylates) from 0.6 to 1% of the cement mass.

Granite crushed stone fraction 5 – 20 mm and washed quartz sand with a fineness modulus of 2.0 were used as aggregates.

The workability of all investigated concrete mixtures was constant, cone slump was 2 – 3 cm, corresponding to the requirements of DBN V.2.3-4:2015 "Highways" [19]. This was achieved by adjusting the amount of water in the composition of the fiber-reinforced concrete mixture.

Table 1 shows the plan of the experiment and the compositions of the investigated fiber-reinforced concretes. The transition to coded values of factor levels (range from –1 to +1) was carried out according to the standard procedure [16].

Table 1 – Plan of the 3-factor experiment and compositions of the investigated fiber-reinforced concretes

Point No.	Factor levels			Fiber-reinforced concrete composition (kg/m^3)					
	x_1 Portland cement	x_2 Fiber BAUCON®-bazalt	x_3 superplasticizer STACHEMENT	Portland cement	Rubble	Sand	Basalt fiber	Superplasticizer STACHEMENT 2570/5/G	Water
1	-1	-1	-1	290	1225	830	0.9	1.74	126
2	-1	-1	1			837	0.9	2.90	122
3	-1	0	0			833	1.2	2.32	125
4	-1	1	-1			830	1.5	1.74	127
5	-1	1	1			834	1.5	2.90	124
6	0	-1	0	320	1215	803	0.9	2.56	133
7	0	0	-1			798	1.2	1.92	136
8	0	0	0			801	1.2	2.56	134
9	0	0	1			803	1.2	3.20	133
10	0	1	0			801	1.5	2.56	134
11	1	-1	-1	350	1205	765	0.9	2.10	146
12	1	-1	1			772	0.9	3.50	141
13	1	0	0			770	1.2	2.80	143
14	1	1	-1			763	1.5	2.10	147
15	1	1	1			768	1.5	3.50	144

Research results. Due to the fact that the mixtures of all investigated fiber concretes had equal mobility, their W/C depended on the composition. Based on the obtained experimental data, the appropriate experimental-statistical model (ES-model) was designed [16, 17]. According to ES-model, one-factor diagrams were built, they reflect the influence of various factors on W/C in the zones of minimum and maximum values (extremes). In the diagrams, the levels of two factors not displayed on each of them were fixed at the values that provide the maximum and minimum value of W/C, respectively (Fig. 1).

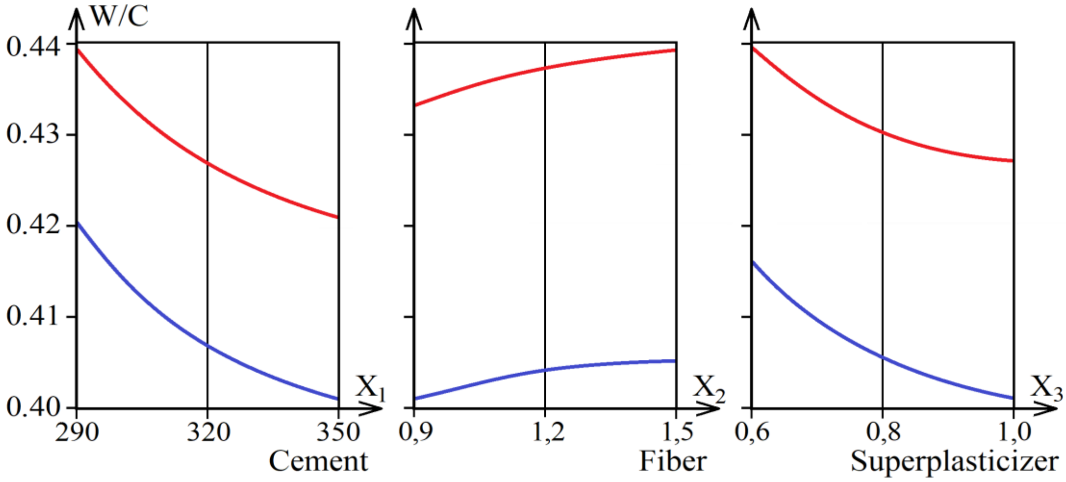

Fig. 1. Influence of varied factors on the W/C of mixtures with equal workability in zones of minimum and maximum values

Analysis of the diagrams presented in Fig. 1 shows that all varied factors nonlinearly affect the W/C of mixtures with equal workability. When the amount of cement increases, the W/C predictably decreases. Increasing in the amount of superplasticizer STACHEMENT 2570/5/G to 0.9 – 1.0 % allows for a 3 – 3.5 % reduction in the W/C of the mixture without losing its workability. The limited decrease in the W/C with changes in the amount of superplasticizer in this experiment takes place due to the fact that even at an additive amount of 0.6 % of the cement mass, it has a sufficiently high effectiveness [15, 18]. When varying the amount of basalt fiber within the experiment, the W/C of mixes changes by no more than 1.5 %.

For all investigated fiber-reinforced concretes, compressive strength, tensile strength in bending, wear resistance and frost resistance were determined (Table 2).

Table 2 – Mechanical properties of the investigated fiber-reinforced concretes

Point No.	Compressive strength, f_{cm} (MPa)	Tensile strength in bending, $f_{c.tf}$ (MPa)	Wear resistance, G (g/cm^2)	Frost resistance
1	36.1	3.68	0.41	F150
2	39.3	3.97	0.40	F150
3	40.4	4.58	0.38	F200
4	38.8	4.46	0.39	F150
5	40.7	4.60	0.38	F200
6	49.7	5.23	0.38	F200
7	48.2	5.50	0.36	F200
8	52.2	5.68	0.34	F300
9	51.8	5.62	0.34	F200
10	51.5	5.67	0.32	F200
11	54.3	5.29	0.37	F200
12	58.5	5.56	0.36	F300
13	59.6	6.35	0.32	F300
14	56.4	6.11	0.32	F300
15	59.8	6.30	0.32	F300

Based on the data from Table 2, ES-models were designed, which describe the influence of varied composition factors on the compressive and tensile strength of fiber-reinforced concretes for rigid pavements. Using these ES-models, one-factor diagrams were built, which are shown in Fig. 2 and illustrate the influence of varied factors on the strength of fiber-reinforced concretes in zones of minimum and maximum values.

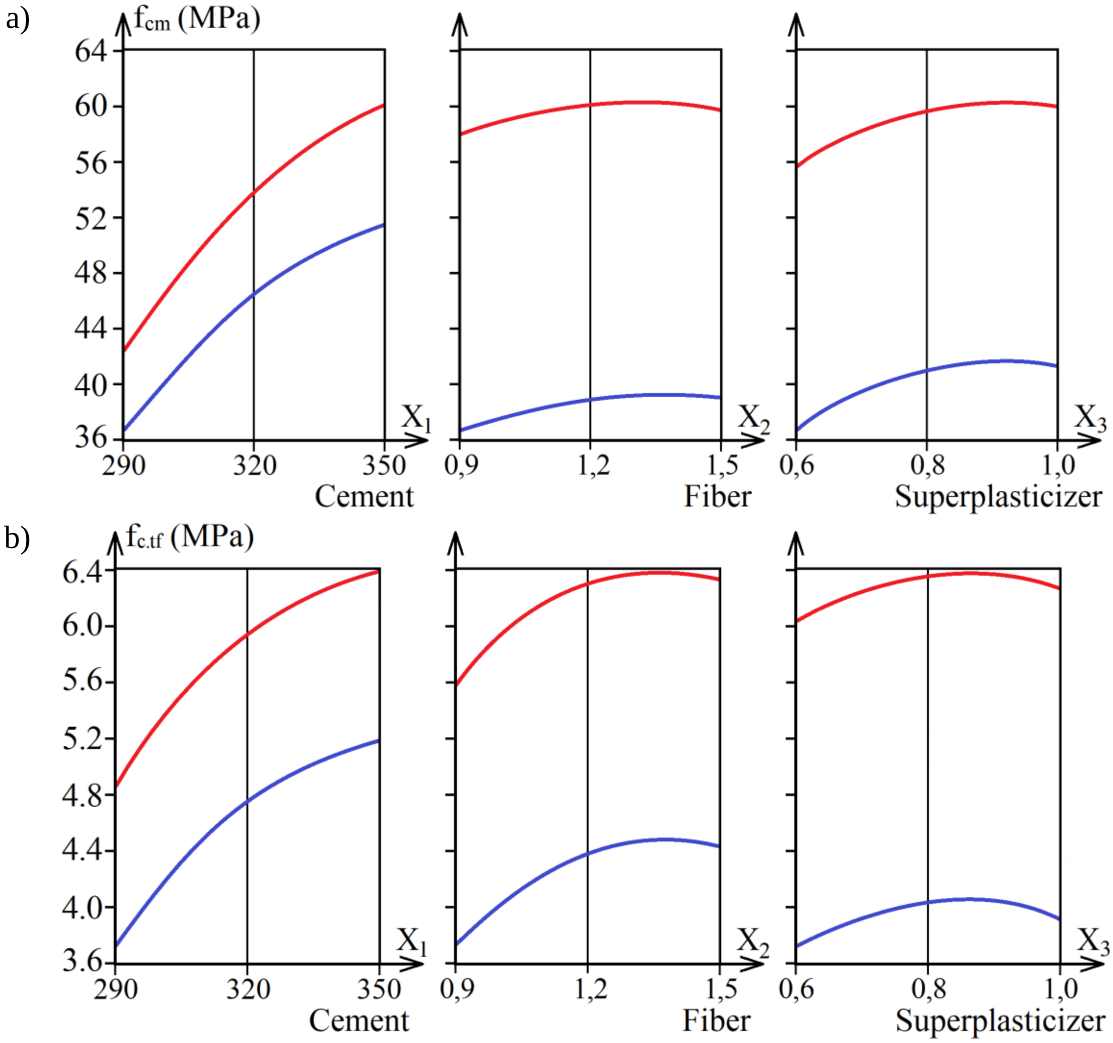

Fig. 2. Influence of varied factors on the compressive strength (a) and tensile strength in bending (b) of fiber-reinforced concretes in zones of minimum and maximum values

Analysis of the diagrams from Fig. 2 allows us to conclude that due to the increase in the amount of Portland cement, compressive and tensile strength of fiber-reinforced concretes expectedly increases. Increasing in the amount of binder from 290 to 320 kg/m^3 causes a more noticeable growth in strength than after binder increasing from 320 to 350 kg/m^3.

Variation in the amount of basalt fiber within the experiment has a negligible effect on the compressive strength of fiber-reinforced concretes. With an increase in the amount of fiber from 0.9 to 1.3 – 1.4 kg/m^3, the level of f_{cm} increases on average by only 4.5 %. The amount of basalt fiber has a more noticeable effect on tensile strength in bending. Due to the increase in its amount to 1.3 – 1.4 kg/m^3, the $f_{c.tf}$ level increases by 0.7 – 0.8 MPa, or by 12 – 21 %.

The highest strength is observed in fiber-reinforced concretes with an amount of superplasticizer STACHEMENT 2570/5/G around 0.9 % by cement mass. An increase in the amount of superplasticizer from 0.6 to 0.9 % has a greater effect on compressive strength than on tensile strength.

As mentioned above, during operation, concrete for rigid pavements are subjected to constant wear from vehicle wheels, and in the winter period, they are also subjected to repeated freezing and thawing. Accordingly, in typical weather conditions for Ukraine and other countries with a temperate climate, the durability of rigid pavements is primarily determined by abrasion resistance and frost resistance of concrete.

Based on the data provided in Table 2, an ES-model (1) was designed, which reflects the influence of varied composition factors on the wear resistance of the investigated fiber-reinforced concretes.

$$G\ (g/cm^2) = 0.340 - 0.027x_1 + 0.009x_1^2 - 0.006x_1x_2 \pm 0x_1x_3 - 0.019x_2 + 0.009x_2^2 \pm 0x_2x_3 - 0.005x_3 + 0.009x_3^2 \quad (1)$$

One-factor diagrams constructed according to ES-model (1), and illustrate the influence of varied factors on wear resistance in zones of minimum and maximum values (Fig. 3).

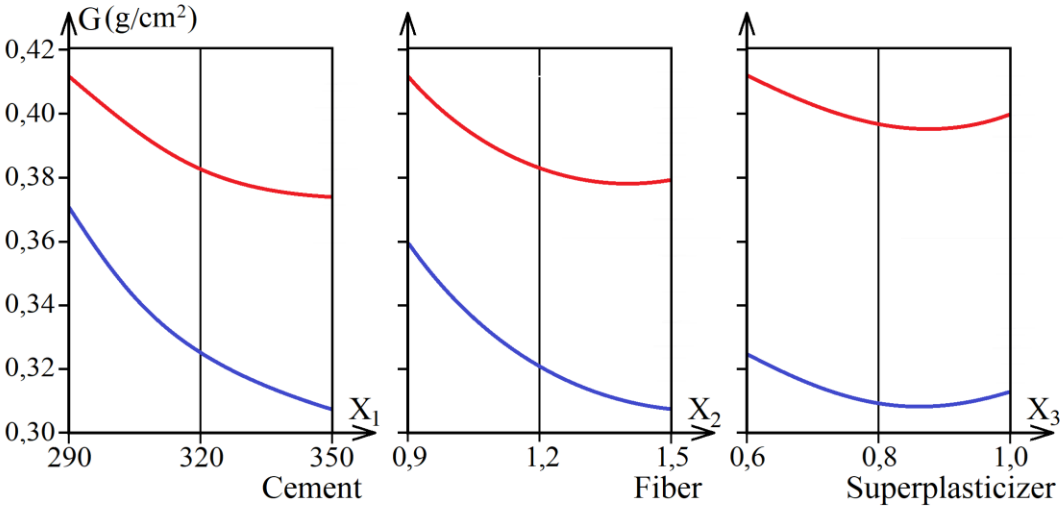

Fig. 3. Influence of varied factors on the wear resistance of fiber-reinforced concretes in zones of minimum and maximum values

Analysis of the diagram and data from Table 2 show that with an increase in the amount of cement in the composition of fiber-reinforced concretes, their wear resistance increases due to the increased strength of the material. Increasing in the amount of basalt fiber from 0.9 to 1.3 – 1.4 kg/m^3 reduces the abrasion of concrete by 11 – 16 %. The variation in the amount of superplasticizer within the experiment has a negligible effect on the abrasion resistance of concrete. When using a rational amount of dispersant and superplasticizer, the wear resistance of fiber-reinforced concretes increases to 0.31 g/cm^2 for concretes with the maximum amount of cement. The wear resistance for concretes with the minimum amount of cement (290 kg/m^3) is 0.37 g/cm^2. Thus, such fiber-reinforced concretes are characterized by sufficiently high wear resistance, ensuring their durability for road pavement structures under the influence of vehicle wheels.

The ES-model designed based on the data from Table 2, which reflects the influence of varied factors on the frost resistance of fiber-reinforced concretes, is as follows:

$$F\ (grade) = 240 + 55x_1 + 25x_1^2 \pm 0x_1x_2 \pm 0x_1x_3 + 15x_2 - 25x_2^2 \pm 0x_2x_3 + 15x_3 - 25x_3^2 \quad (2)$$

It should be noted that the accuracy of this ES-model is limited by the significant discreteness of determining of the frost resistance level using the accelerated method according to DSTU B V.2.7-49-96 [20] for freezing up to –50 °C and thawing in saline water. According to this methodology and according to Table 3 of DSTU B V.2.7-47-96 [21], concrete for road and airport pavements is classified only by grades F100, F150, F200, F300, F400 and so on. Accordingly, the experimentally determined values of the grade by frost resistance of the investigated fiber-reinforced concretes were within the values operated by the accelerated method. However, this did not significantly affect the identification of general trends in the influence of varied factors on the level of concrete frost resistance due to the approximation that occurs when designed ES-models [16].

One-factor diagrams were built based on the ES-model (2), which are shown in Fig. 4 and illustrate the influence of varied factors on the frost resistance of the investigated fiber-reinforced concretes in zones of minimum and maximum values.

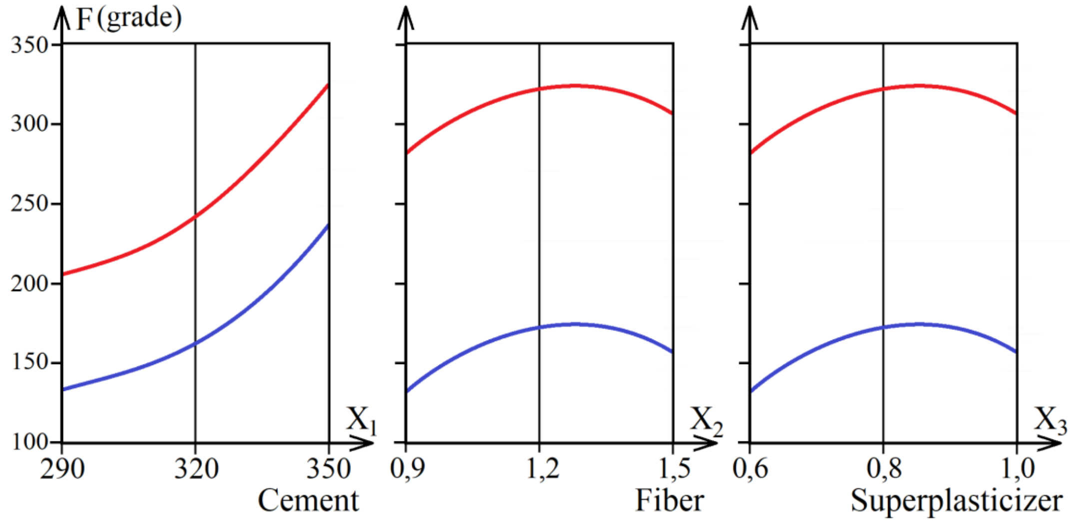

Fig. 4. Influence of varied factors on the frost resistance of fiber-reinforced concretes in zones of minimum and maximum values

Analysis of the diagrams shows that an increase in the amount of Portland cement in the composition from 290 to 350 kg/m^3 increases the frost resistance of fiber-reinforced concretes by approximately 100 cycles. Increasing of the amount of basalt fiber from 0.9 to 1.3 kg/m^3 increases the frost resistance of rigid pavement concretes by approximately 50 cycles. A similar increase in frost resistance occurs with an increase in the amount of superplasticizer from 0.6 to 0.9 % by weight of cement. When using a rational amount of basalt fiber and superplasticizer STACHEMENT 2570/5/G, fiber-reinforced concretes already provide frost resistance of F200 with a cement content of 290 kg/m^3, which meets the requirements for materials of road pavements [19].

Conclusions and prospects for further research. The best quality indicators of the investigated fiber-reinforced concretes, namely the highest compressive and tensile strengths, the highest frost resistance and wear resistance, are achieved when using BAUCON®-bazalt basalt fiber in an amount of 1.3 – 1.4 kg/m^3 and superplasticizer STACHEMENT 2570/5/G in an amount of 0.9 % by weight of cement. Concretes with this amount of dispersant and superplasticizer, depending on the cement content, have compressive strengths ranging from 43 to 60 MPa, tensile strengths in binding ranging from 4.9 to 6.4 MPa, abrasion ranging from 0.31 to 0.37 g/cm^2, and frost resistance ranging from F200 to F300. This ensures high durability of the developed fiber-reinforced concretes for rigid pavements under typical operating conditions in Ukraine.

In further research is planning to implement the developed fiber-reinforced concrete compositions on an experimental-industrial scale to assess their performance in road pavement structures under natural conditions.

References

[1] E. Hoxha, H.R. Vignisdottir, D.M. Barbieri, F. Wang, R.A. Bohne, T. Kristensen, A. Passer, "Life cycle assessment of roads: Exploring research trends and harmonization challenges", *Science of the total environment*. 759, 143506, 2021. https://doi.org/10.1016/j.scitotenv.2020.143506.

[2] S.P. Voznyy, "Perspektyvy rozvytku tsementobetonnykh dorih v Ukrayini", *Suchasni tekhnolohiyi ta metody rozrakhunkiv u budivnytstvi*, 6, pp. 47-55, 2017.

[3] V.V. Stʹozhka, P.P. Borkovsʹkyy, "Pidvyshchennya dovhovichnosti tsementobetonu dlya pokryttya avtomobilʹnykh dorih", *Visnyk Natsional'noho transportnoho universytetu. Seriya «Tekhnichni nauky»*. K.: NTU, 1 (46). pp. 324-332, 2020. https://doi.org/10.33744/2308-6645-2020-1-46-324-332.

[4] V.V. Stʹozhka. "Pidvyshchennya dovhovichnosti tsementobetonnoho pokryttya dorih za rakhunok zastosuvannya hidrofobnykh khimichnykh dobavok", *Dorohy i mosty*, 22, pp.

128-137, 2020. https://doi.org/10.36100/dorogimosti2020.22.128.

[5] M.F.M. Tahir, M.M.A.B. Abdullah, S.Z.A. Rahim, M.R. Mohd Hasan, A.V. Sandu, P. Vizureanu, C.M.R. Ghazali, A.A. Kadir, "Mechanical and durability analysis of fly ash based geopolymer with various compositions for rigid pavement applications", *Materials*, 15, 3458, 2022. https://doi.org/10.3390/ma15103458.

[6] S.M. Tolmachov, O.A. Byelichenko, D.S. Tolmachov, V.M. Datsenko, M.YE. Marchenko, "Vlastyvosti dorozhnikh betoniv iz sumishey riznoyi rukhomosti", *Suchasni tekhnolohiyi ta metody rozrakhunkiv u budivnytstvi*, 14, pp. 160-168, 2020. https://doi.org/10.36910/6775-2410-6208-2020-4(14)-16.

[7] I. Hussain, B. Ali, T. Akhtar, M.S. Jameel, S.S. Raza, "Comparison of mechanical properties of concrete and design thickness of pavement with different types of fiber-reinforcements (steel, glass, and polypropylene)", *Case Studies in Construction Materials*, 13, e00429, 2020. https://doi.org/10.1016/j.cscm.2020.e00429.

[8] Ž. Kos, S. Kroviakov, V. Kryzhanovskyi, A. Crnoja, "Influence of fibers and hardening accelerator on the concrete for rigid pavements", *Magazine of Concrete Research*, 75(17), pp. 865-873, 2023. https://doi.org/10.1680/jmacr.22.00181.

[9] S.M. Tolmachov, O.A. Byelichenko, R.V. Dyadyushko, "Vplyv polipropilenovoyi fibry X-Mesh na vlastyvosti dorozhnʹoho betonu", *Zbirnyk naukovykh pratsʹ UkrDUZT*, 198, pp.58-65, 2021.

[10] A. Vaitkus, J. Gražulytė, O. Šernas, M. Karbočius, R. Mickevič, "Concrete modular pavement structures with optimized thickness based on characteristics of high performance concrete mixtures with fibers and silica fume", *Materials*, 14, 3423, 2021. https://doi.org/10.3390/ma14123423.

[11] A. Sikandar, M. Ali, "Composition of engineered cementitious composite with local materials, composite properties and its utilization for structures in developing countries", *Engineering Proceedings*. 53(1), 16, 2023. https://doi.org/10.3390/IOCBD2023-15179.

[12] A. Nobili, L. Lanzoni, A.M. Tarantino, "Experimental investigation and monitoring of a polypropylene-based fiber reinforced concrete road pavement", *Construction and Building Materials*, 47, pp. 888-895, 2013. https://doi.org/10.1016/j.conbuildmat.2013.05.077.

[13] H. Wu, X. Qin, X. Huang, S. Kaewunruen, "Engineering, mechanical and dynamic properties of basalt fiber reinforced concrete", *Materials*, 16, 623, 2023. https://doi.org/10.3390/ma16020623.

[14] Sj. Jin, Yh. Yang, Ym. Sun, X. Li, Jy. Xu, "Experimental research on anti-freezing and thawing performance of basalt fiber reinforced fly ash concrete in the corrosive conditions", *KSCE Journal of Civil Engineering*, 27, pp. 3455–3470, 2023. https://doi.org/10.1007/s12205-023-1969-9.

[15] S. Kroviakov, L. Shestakova, "Influence of basalt fiber and air-entraining admixture on the properties of rigid concrete pavement", *Romanian Journal of Materials*, 53 (2), pp. 170-175, 2023.

[16] V.A. Voznesenskiy, T.V. Lyashenko, ES-modeli v komp'yuternom stroitel'nom materialovedenii. Astroprint, 2006.

[17] T.V. Lyashenko, V.A. Voznesenskiy, Composition-process fields methodology in computational building materials science. Astroprint, 2017.

[18] S.O. Krovyakov, L.Y. Shestakova. "Vplyv bazalʹtovoyi fibry i superplastyfikatoru na mitsnistʹ betoniv zhorstkykh dorozhnikh pokryttiv", *Suchasne budivnytstvo ta arkhitektura*, 6, pp.99-108, 2023. https://doi.org/10.31650/2786-6696-2023-6-99-108.

[19] DBN V.2.3-4:2015. Avtomobilʹni dorohy. Sporudy transportu. Chastyna I. Proektuvannya. Chastyna II. Budivnytstvo. Kyiv, 2015.

[20] DSTU B V.2.7-49-96. Budivelʹni materialy. Betony. Pryskoreni metody vyznachennya morozostiykosti pry bahatorazovomu zamorozhuvanni ta vidtavanni. Kyiv, 1996.

[21] DSTU B V.2.7-47-96. Budivelʹni materialy. Betony. metody vyznachennya morozostiykosti. Kyiv, 1996.

ДОВГОВІЧНІСТЬ БЕТОНІВ ЖОРСТКИХ ДОРОЖНІХ ПОКРИТТІВ, АРМОВАНИХ БАЗАЛЬТОВОЮ ФІБРОЮ

[1]**Кровяков С.О.,** д.т.н., професор,
skrovyakov@ukr.net, ORCID: 0000-0002-0800-0123
[1]**Шестакова Л.Є.,**
shestakova_luba@ukr.net, ORCID: 0000-0002-3449-8498
[1]*Одеська державна академія будівництва та архітектури*
вул. Дідріхсона, 4, м. Одеса, 65029, Україна

Анотація. Метою роботи є розробка складів фібробетонів жорстких дорожніх покриттів з високою міцністю, морозостійкістю і зносостійкістю за рахунок використання суперпластифікатору полікарбоксилатного типу і дисперсного армування. Експеримент проводилися за оптимальним 3-х факторним 15-ти точковим планом. Варіювалися наступні фактори складу: кількість портландцементу ПЦ І-500Р-Н, від 290 до 350 кг/м^3; кількість базальтової фібри BAUCON®-bazalt, від 0,9 до 1,5 кг/м^3; кількість полікарбоксилатного суперпластифікатору STACHEMENT 2570/5/G, від 0,6 до 1% від маси цементу. Рухомість всіх сумішей була рівною, ОК = 2..3 см.

При підвищенні кількості цементу та кількості суперпластифікатору до 0,9-1,0% В/Ц сумішей знижується. Кількість базальтової фібри практично не впливає на В/Ц суміші.

За рахунок підвищення кількості портландцементу міцність фібробетонів очікувано зростає. При збільшенні кількості базальтової фібри до 1,3-1,4 кг/м^3 міцність на розтяг при згині бетонів зростає на 12-21%, при цьому міцність на стиск змінюється не суттєво. Найбільшу міцність як на стиск, так і на розтяг при згині, мають фібробетони з кількістю суперпластифікатору близько 0,9%.

При збільшені кількості цементу з 290 до 350 кг/м^3 морозостійкість бетонів зростає на рівень до 100 циклів, а також за рахунок підвищення міцності знижується стиранність бетону (зростає зносостійкість). При підвищенні кількості базальтової фібри з 0,9 до 1,3-1,4 кг/м^3 стиранність бетонів знижується на 11-16%, а морозостійкість зростає приблизно на 50 циклів. Зміна кількості суперпластифікатору несуттєво впливає на зносостійкість бетону. Проте при підвищенні кількості добавки STACHEMENT 2570/5/G з 0,6 до 0,9% від маси цементу морозостійкість фібробетонів зростає на рівень до 50 циклів.

Фібробетони з раціональною кількістю дисперсної арматури (1,3-1,4 кг/м^3) і суперпластифікатору (0,9%) в залежності від кількості цементу мають міцність на стиск від 43 до 60 МПа, міцність на розтяг при згині від 4,9 до 6,4 МПа, стиранність від 0,31 до 0,37 г/см^2 і морозостійкість від F200 до F300. Це забезпечує високу довговічність розроблених фібробетонів жорстких дорожніх покриттів.

Ключові слова: жорстке дорожнє покриття, морозостійкість, зносостійкість, базальтова фібра, суперпластифікатор, експериментально-статистичне моделювання.

Стаття надійшла до редакції 4.02.2024