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Predicted temperature dependence of the road surface on the air temperature in a variety of road-climatic zones of the Russian

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ABSTRACT

The paper studies the temperature dependence of the surface of the asphalt concrete on the temperature of the environment of different Russian cities road-climatic zones with a view to determining the most effective method of calculating the temperature of the coating of the road. There are the materials of research, which shows that the fluctuation range of the surface temperature of asphalt pavement is roughly proportional to the range of air temperatures. Especially dangerous is winter and spring period, when the change in temperature occurs unevenly, as a result of which there is a decrease in strength and deterioration of transport performance indicators. Seasonal and diurnal variations of the temperature of pavement can be levelled by applying a special composition, which allows to maintain approximately the same temperature of the coating during the entire period of exploitation.

Content

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1. Introduction

The mechanism of improvement of technical condition of roads is a topical issue for many cities of Russia, which will help to achieve economic efficiency by increasing maintenance periods [1]. In order to avoid large-scale reconstruction projects of highways [2], the main problems encountered with their operation should be explored. That's why the main goal of our study is determination the best method of calculating the surface temperature of road clothes. The strength and durability of road constructions is influenced by many factors including weather and climate. It is known that asphalt is a thermoplastic material [3], therefore, one of the climatic factors that significantly affect rutting and also on the strength and deformation properties asphalt layers material in construction of road pavements is temperature. The stress-strain state and asphalt concrete lifetime pavements depend on the temperature [4]. Every year more urgent becomes the problem of the destruction of pavement. Expert assessment shows that currently, meet standards only 37% of Federal and 24% of regional roads [5].

Low operating characteristics of the materials used in road construction, lead to the fact that already for 3-4 year operation of the vast number of roads in Russia requires major repairs, while abroad, the average maintenance free life is 10-13 years [6]. Moreover, the road network built in the 1960-1970-ss, continues to deteriorate, and the total economic losses caused by the poor condition of pavements make up about 6 percent of GDP. A significant part of the road network has exhausted standard operation time. However, their service life can be significantly extended using various technologies, selection and justification which should be based on the results of detailed surveys of road condition and forecasting of development of different types of damage [7-11].

Clarification of the temperature dependency of asphalt concrete from operating conditions is important at the present time [12]. Important to remember, in different climatic conditions, the effect of ambient temperature on the pavement temperature affects differently. In the paper [13] is considered in detail the dependence of the properties of bitumen coatings from external influence, and measures ensuring the required quality of the material. The study [14] examined the problem of influence of seasonal climatic terms on the condition of the roadway on the example of the Khabarovsk territory.

Experimental and theoretical studies [15] demonstrated the mechanism of cracks formation and other damage to the road surface from the influence of not only external, mechanical influences, but also temperature changes. The coefficient of linear expansion of the asphalt depends on the temperature of asphalt concrete, type and content of binder in asphalt mixture [16]. The effect of temperature on the condition of the road also is considered in detail in papers [17-31]. Foreign authors also investigate the problem of road surfaces. In [32] carried out a comparative analysis of temperature of road constructions in different regions of Kazakhstan. In the paper [33] described the effect of temperature on the quality and service life of the pavement on the example road network in Oman. Thus, asphalt pavement's temperature mode is one of the key factors determining changes in its properties and service life in operation.

2. Methods and results.

Temperature of asphalt pavement is a function of air temperature [4]. It is important to consider the climate of the city, in which the road is. Factors such as temperature extremes and diurnal dependence of the air temperature can lead to decision the issue of roads durability.

To achieve the goal, it's necessary to perform the following tasks:

- To create a model sine wave oscillations of average monthly air temperatures for the period of 365 days.
- To determine the dependence of the surface temperature from air temperature for various road-climatic zones (RCZ).
- To produce a precise mathematical description of the heat transfer mechanisms in the structural layers of the pavement based on periodic diurnal and annual temperature changes of various RCZ.
- To determine the average temperature of the periods used to calculate asphalt pavement in various RCZ.

The city's location in the country, particularly its climatic features, affect the technical condition of the pavement as a whole. At high operating temperatures of the road surface the stability of asphalt concrete to the formation of deformations greatly decreases. In a cold climate, low-temperature pavement cracking happens [28]. Russia is among the five road-climatic zones: I, II, III, IV, V (Fig.1) and four climatic zones – Arctic (I), Subarctic (II), Moderate (III) and Subtropical (IV) (Fig. 2). The need to address the tasks required to study the climatic features of cities such as Omsk (Omsk region), St. Petersburg (Leningrad region), D. Akbasheva (Chelyabinsk region), Krasnodar (Krasnodar region), Astrakhan (Astrakhan region), respectively, belonging to I, II, III, IV, V RCZ.

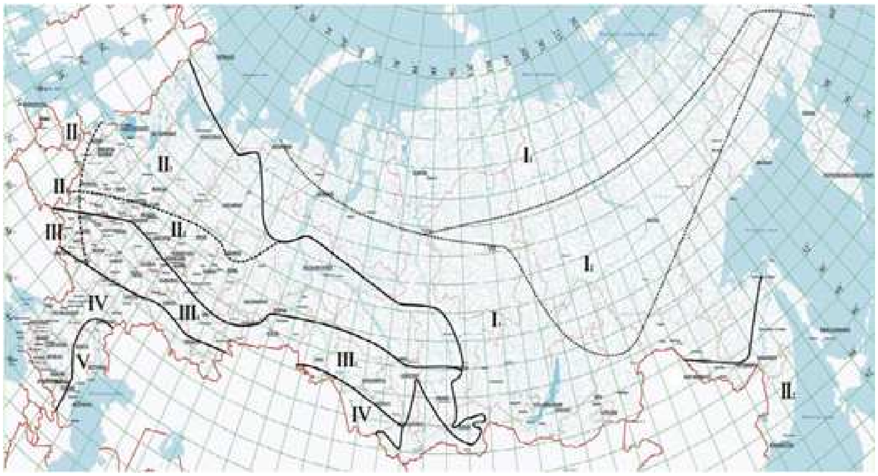

Figure 1. Road-climatic zones of the Russian Federation.

Figure 2. Climatic zones of the Russian Federation.

One of the main parameters, which affects the technical condition of the road surface, is the impact of the ambient temperature, which in large measure harms the coating. Each zone, in its turn, has its own natural features, but the structure of the asphalt pavement designing and its physical and mechanical properties remain the same, although for each temperature regime should choose the most suitable materials [34-36]. This approach to the construction of roads is incorrect, and, consequently, lifespan is reduced.

Based on long-term measurements, it is possible to propose a mathematical description of the mechanisms of heat transfer in constructive layers of road clothes. Herewith, certain and measured quantities are temperature and time. Since radiation was not measured, in the formulas modeling the temperature of the road surface, time acts as an independent variable. In itself time is not a factor influencing the temperature, but with it it's possible to describe changes of the technical condition of the road. Also important is the creation of models of the sine wave oscillations of average monthly air temperatures for the period of 365 days, which gives an indicative forecast of the course of temperatures (Fig.3).

The sine wave is calculated according to the formula [4]:

$$t_{ik} = 13.23\, sin\left(2\pi\frac{(pv-109.4)}{365}\right) - 0.7\, sin\left(2\pi\frac{(pv-30.2)}{182.5}\right) + 2.05 \quad (1)$$

pv – the ordinal day number from January 1st.

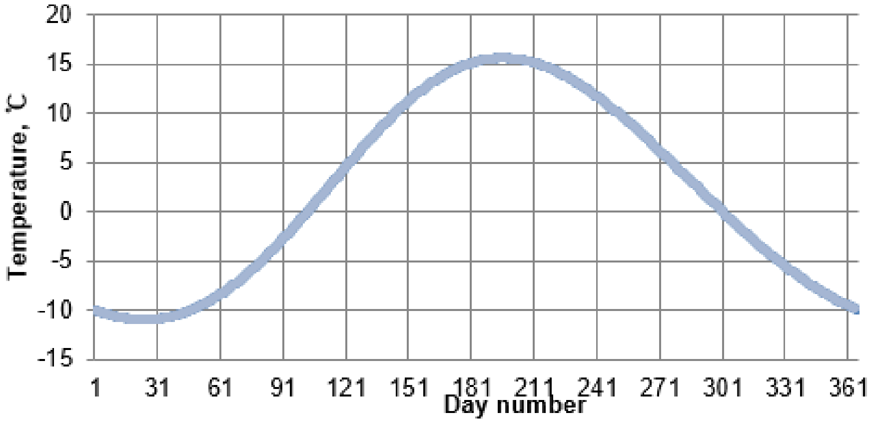

Figure 3. Sine wave oscillations of average monthly air temperatures for the year.

The graph shows that the temperature in the course of a year roughly goes along a certain trajectory of a sinusoid, based on which you can orient the plans, progress and completion dates for the construction of road.

After receiving tentative schedule fluctuations in mean monthly temperatures, it is necessary to proceed directly to the calculation of the coating temperatures. At definition were taken into account all the data hourly temperatures during the measurement period, the number of samples - 7982. The formula (2) is easy to use, but the accuracy of the results is small [4].

$$t_p = 1.017t_i + 1.593 \quad (2)$$

Where:

t_p - temperature of the road surface, °C;

t_i - air temperature, °C.

Figs. 4-6 illustrate graphs of temperature distribution of coatings various road-climatic zones of Russia (each chart corresponds to a certain time of day). It is seen that in various RCZ temperature of the coating at the same time will differ greatly. Based on these data, it can be concluded that the temperature difference can reach 40°C. The greater the difference, the responsibility should approach the construction of roads, their reconstruction and exploitation.

Justification of differentiation the day on three intervals is that according to American scientists, the highest daily temperature observed at 4:00 p.m., the lowest night is at 4:00 a.m. Also, for purposes of our research, was allocated an additional value at 10:00 p.m.

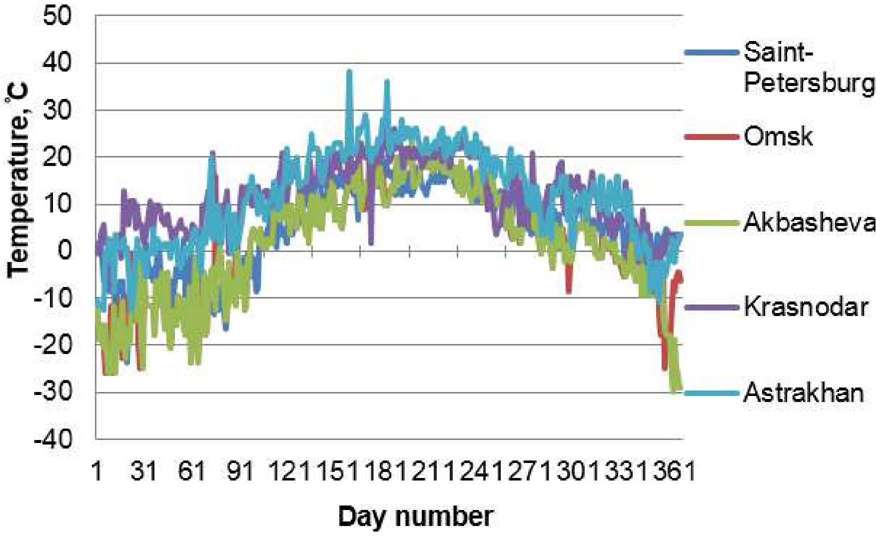

Figure 4. A graph of the temperature distribution of the coating asphalt for 365 days in 2013 in 4:00 a.m.

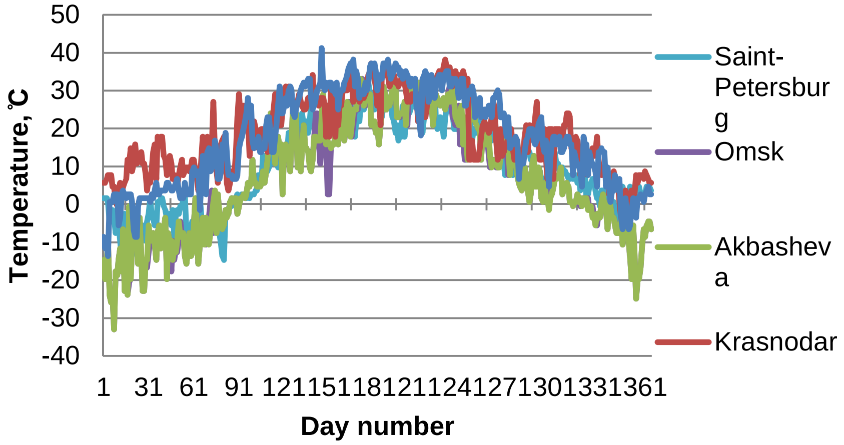

Figure 5. A graph of the temperature distribution of the coating asphalt for 365 days in 2013 in 4:00 p.m.

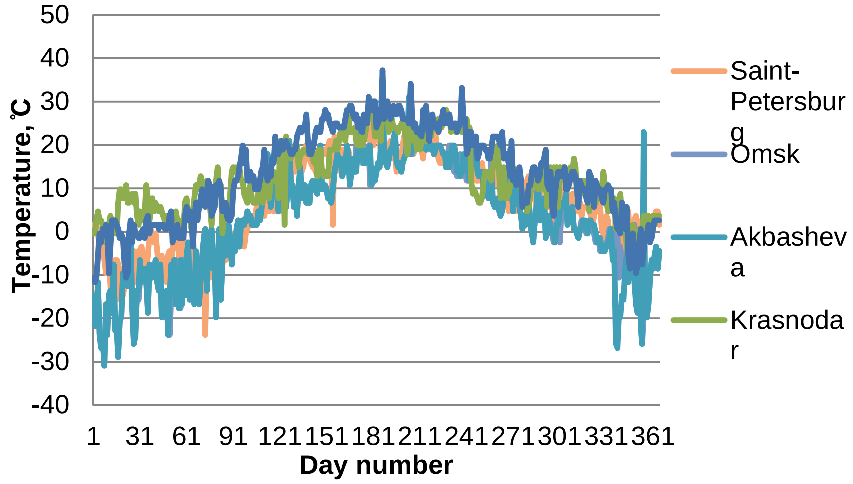

Figure 6. A graph of the temperature distribution of the coating asphalt for 365 days in 2013 in 10:00 p.m.

On the example of Krasnodar city (Fig. 7) you may see a significant change in the temperature of the coating.

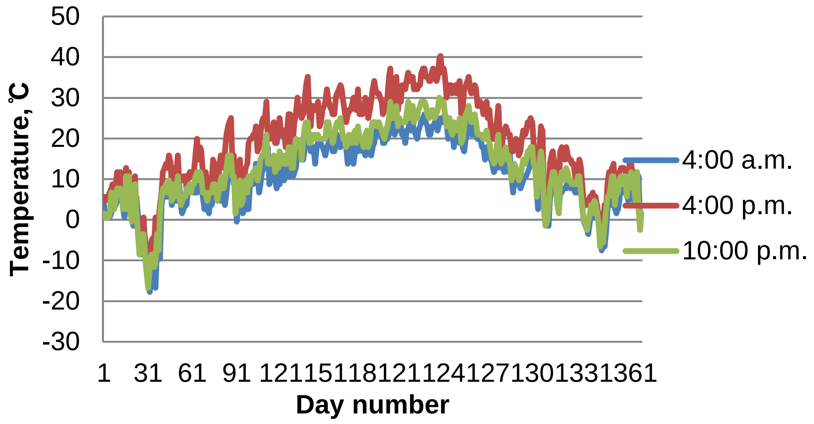

Figure 7. A graph of the surface temperature of asphalt concrete in 4:00 a.m., 4:00 p.m., 10:00 p.m. in Krasnodar in 2015.

There are many methods for calculating the surface temperature of asphalt concrete. Compare the 3 most famous: the method Kovalev Y. N. (Russia) [4], the Method of "Superpave" (USA) [4], as well as the method used in Finland.

According to Kovalev Y. N. [37] the minimum temperature of asphalt pavement is determined by the formula:

$$T_{п}^{min} = 0.7T_{min} \tag{3}$$

Where:

$T_{п}^{min}$ – the calculated minimum surface temperature of asphalt pavement, °C;

T_{min} – the minimum outdoor temperature, °C.

Maximum temperature:

$$T_{п} = T_{в} + T_{экв} \tag{4}$$

Where:

$T_{п}$ – the calculated minimum surface temperature of asphalt pavement, °C;

$T_{в}$ – air temperature, °C;

$T_{экв}$ – equivalent temperature, °C;

$$T_{экв} = (1 - A)\frac{I}{\alpha_n} \tag{5}$$

Where:

A – the albedo of a surface coating, characterized by its reflectivity;

I – the intensity of solar radiation, W/m^2;

α_n – the heat transfer coefficient, W/(m^2·°C);

«Superpave» method:

$$T_{п}^{min} = 0.859T_{min} + 1.7 \tag{6}$$

Where:

$T_{п}^{min}$ – the calculated minimum surface temperature of asphalt pavement, °C;

T_{min} – minimum air temperature in average year established on meteorological data, °C.

$$T_2^{max} = 0.9545(T_{в7} - 0.00618Ш^2 + 0.2289Ш + 42.2) - 17.18 \tag{7}$$

Where:

T_2^{max} – the maximum design temperature of the coating at a depth of 2 cm, °C;

$T_{в7}$ – average weekly maximum air temperature, °C;

Ш – the latitude of the object in degrees

Thus, the method of "Superpave" is governed by the estimated maximum temperature of the coating for the upper layer at a depth of 2 cm from the surface and lowest design temperature at the surface of the coating.

The method used in Finland:

$$T_{AB\ keski} = 0.470\sin\frac{2\pi(4.681 - h)}{24} - 1.212sin\frac{2\pi(108.6 - p)}{365} + 0.917T_p + 0.308 \tag{8}$$

Where:

$T_{AB\ keski}$ – the average temperature of the layer of pavement (100 mm), °C;

T_p – the surface temperature of the road surface (t_{pl} – surface temperature in the warm season (March 31-October 15), t_{pk} – surface temperature in the cold season (October 16 – March 30), °C;

Thus, the average temperature coating thickness of 100 mm are defined.

In Figs. 8-9 presented the plots of the estimated minimum and maximum temperatures of the coating according to various methods.

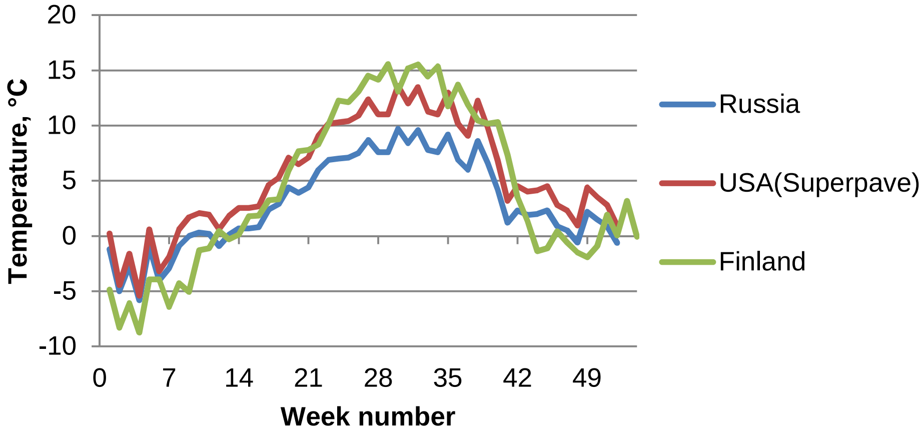

Figure 8. Comparison the minimum temperature of the pavement.

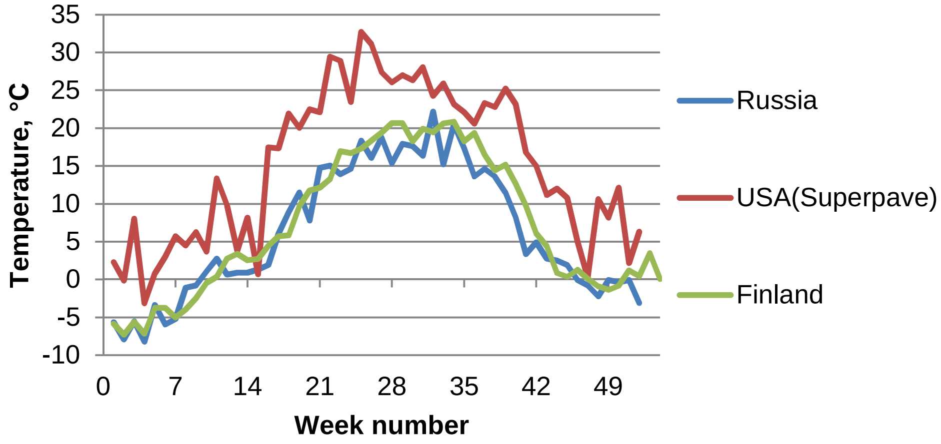

Figure 9. Comparison the maximum temperature of the pavement.

From Fig. 8-9 we see that the difference of temperature is present. After analyzing the data, it can be concluded that in the case of determining the minimum temperature, the lowest calculated values obtained according to eqs. 3-4, Kovalev Y. N.. In the case of determining the maximum temperature of the asphalt to extreme calculated values obtained by the method of "Superpave", and the difference is significant.

3. Discussion.

In the paper was carried out a comparative analysis of the road constructions' temperature in different RCZ of Russia. There was investigated road sections located in areas with dramatically different climatic conditions. The data was used to determine the temperature dependency of the roads from the ambient temperature, taken from hydrometeorological station cities of the corresponding zones. It was found that, depending on the location in various RCZ of Russian Federation, the temperature limits of work asphalt concrete in our country have enough differences. Indeed, during the day the temperature varied considerably. Such factors adversely affect the condition of the roads. It turns out that the asphalt concrete can "breathe" warm air that affects the temperature of the "body", which adversely affects longevity and the quality of the coating [38-40].

4. Conclusions.

Temperature mode monitoring and theoretical analysis of the impact on the condition of the asphalt pavement allows to draw the following conclusions:

1. During the year, the time and technology of work execution it is possible to adjust, based on the influence of temperature;

2. During winter time, the asphalt coating maintains higher temperature than the minimum ambient air temperature;

3. The surface temperature of asphalt pavement varies with the time of day in the considerable interval that has a negative impact on the physic-mechanical properties of asphalt concrete;

4. The range of fluctuation of the surface temperature of asphalt pavement is approximately proportional to the range of air temperatures, which confirms their interconnection to each other;

5. In winter and spring there is a sharp and uneven temperature changes in the pavement layers, causing a reduction in strength, and then the deterioration of transport performance indicators, such as flatness, roughness, adhesion of wheel and coating.

References

[1] Transportnaya strategiya Rossiyskoy Federatsii na period do 2030 goda [Transport Strategy of the Russian Federation through 2030]. Available at: http://www.mintrans.ru/documents/detail.php?ELEMENT_ID=19188. Date of access: 10.10.16.

[2] Lazarev Yu.G.,Sobko G.I. Rekonstruktsiya avtomobilnykh dorog [Reconstruction of roads]. Saint-Petersburg: SPbGASU. 2013. (rus)

[3] Podol'skij V.P., Nguen V.L., Le V.Ch. Povyshenie jekspluatacionnyh parametrov zemljanogo polotna s ispol'zovaniem geomaterialov v uslovijah V'etnama [Improvement of performance parameters of road beds by means of geo-materials in the environment of Vietnam]. Vestnik MGSU. 2013. No. 1. Pp. 139-147.

[4] Kiryukhin G.N. Temperaturnye rezhimy raboty asfal'tobetonnyh pokrytij avtomobil'nyh dorog [Operating temperature ranges of asphalt road pavement surfacings]. Dorogi i mosty. 2013. No. 2. Pp. 309–328. (rus)

[5] Uglova E.V. Teoreticheskie i metodologicheskie osnovy ocenki ostatochnogo ustalostnogo resursa asfal'tobetonnyh pokrytij avtomobil'nyh dorog [Theoretical and methodological assessment of residual fatigue life of asphalt concrete pavement roads]. dis. … d-ra tehn. nauk: [PhD diss.]: 05.23.11. VolgGASU , Volgograd. 2009. (rus)

[6] Belyaev P.S., Malikov O.G., Merkulov S.A., Polushkin D.L., Belyaev V.P. K voprosu o kompleksnom reshenii problem ehkologii i kachestva dorozhnyh pokrytij [On the complex solution of environment and road surface quality problems]. Voprosy sovremennoj nauki i praktiki. 2012. No. 39. Pp. 184–189. (rus)

[7] Lazarev Yu.G. Research of processes of improving soil properties based on complex ash cement binder. Applied Mechanics and Materials. 2014. No. 584. Pp. 1681–1686.

[8] Lazarev Yu.G. Effectiveness of Soil Reinforcement Based on Complex Ash-Cement Bonder. Applied Mechanics and Materials. 2015. No. 725. Pp. 208–213.

[9] Dulin M.O., Vatin N.I., Barabanshchikov Yu.G. Modelirovanie nabora prochnosti betona v programme ELCUT pri progreve monolitnykh [Modeling a set of concrete strength in the program ELCUT at warming of monolithic structures by wire]. Magazine of civil engineering. 2015. No. 2. Pp. 33-45. (rus)

[10] Yu.G. Obosnovanie deformacionnyh harakteristik ukreplennyh materialov dorozhnoj odezhdy na uchastkah postroechnyh dorog [Justification deformation characteristics of the strengthened materials of the pavement on sections of roads built]. Vestnik grazhdanskih inzhenerov. 2015. No. 4. Pp. 140-146. (rus)

[11] Zaretskaya E.N. Formirovanie perechnya pokazatelej dlya ocenki kachestva proektirovaniya dorozhnyh odezhd nezhestkogo tipa [Developing a list of indicators for assessing the quality of the design of road pavement of non-rigid type]. Sovremennye tendencii razvitiya nauki i tekhnologii. 2016. No. 3-2. Pp. 109-113. (rus)

[12] Teltaev B.B., Kaganovich E.V., Izmajlova T.T. Uchet klimaticheskih uslovij ehkspluatacii pri vybore bituma dlya asfal'tobetonnyh smesej [Taking into consideration the climatic conditions of operation at choice of the bitumen for asphalt concrete]. Nauka i tekhnika v dorozhnoj otrasli. 2008. No. 2. Pp. 17–20. (rus)

[13] Gohman L.M. Bitumy, polimerno-bitumnye vyazhushchie, asfal'tobeton, polimerasfal'tobeton [Bitumen, polymer-bitumen binders, asphalt, polymer asphaltic concrete]. Moscow: «EKON-INFORM», 2008. 117 p.(rus)

[14] Morina M.O. K voprosu dorozhno-klimaticheskogo rajonirovaniya habarovskogo kraya i EAO po dinamike temperatur vozduha i pochvy [On the issue of road-climatic zoning of the Khabarovsk Territory and the Jewish Autonomous Region on the air temperature and soil dynamics]. Politematicheskij setevoj ehlektronnyj nauchnyj zhurnal Kubanskogo gosudarstvennogo agrarnogo universiteta. 2006. No. 21. Pp. 1-23. (rus)

[15] Mel'nikova I.S. Modelirovanie i vozdejstvie temperatury i transportnyh nagruzok na vozniknovenie i razvitie treshchin v asfal'tobetonnyh dorozhnyh pokrytiyah. [The modeling and the effects of temperature and traffic load on the emergence and development of cracks in asphalt pavements]. Nauka i tekhnika. 2012. No. 4 . Pp. 44-52. (rus)

[16] Kravchenko S.E., Serikov D.L. Nizkotemperaturnye napryazheniya kak kriterij vliyaniya komponentov asfal'tobetonnoj smesi na treshchinostojkost' asfal'tobetonnyh pokrytij [Low-temparature stress as criterion of asphalt mix components impact on crack resistance of asphalt cover]. Avtomobil'nye dorogi i mosty. 2010. No. 2. Pp. 70-77. (rus)

[17] Kychkin V.I., Yushkov V.S. Nerazrushayushchij dinamicheskij metod kontrolya dorozhnyh odezhd [Not destroying dynamic quality monitoring of road clothes]. Internet-zhurnal «NAUKOVEDENIE». 2013. No. 1. Pp. 1-8. (rus)

[18] Leonovich I.I., Mel'nikova I.S. Metodika i rezul'taty ocenki ehkstremal'nyh temperatur dorozhnyh pokrytij v razlichnyh regionah respubliki Belarus' [The method and outcomes of an extreme road surface temperatures estimation for various regions of the republic of Belarus]. Avtomobil'nye dorogi i mosty. 2012. No. 1. Pp. 9-25. (rus)

[19] Leonovich I.I., Mel'nikova I.S. Innovacii v sisteme ehkspluatacii avtomobil'nyh dorog, napravlennye na preduprezhdenie i likvidaciyu poverhnostnyh defektov [Innovations in the system of exploitation of roads, aimed at the prevention and elimination of surface defects]. Trudy BGTU. Lesnaya i derevoobrabatyvayushchaya promyshlennost'. 2012. No. 2. Pp. 130-133. (rus)

[20] Mel'nikova I.S. Modelirovanie vozdejstviya temperatury i transportnyh nagruzok na vozniknovenie i razvitie treshchin v asfal'tobetonnyh dorozhnyh pokrytiyah [Modeling the effects of temperature and traffic load on the emergence and development of cracks in asphalt pavements]. Zhurnal Nauka i tekhnika. 2012. No. 4. Pp. 44-52. (rus)

[21] Giyasov B.I., Zubkov A.F., Andrianov K.A. Opredelenie temperatury nagreva poverhnosti vyboiny dorozhnogo pokrytiya pri proizvodstve remontnyh rabot s primeneniem goryachih asfal'tobetonnyh smese [Determination of the heating temperature of potholes surface on road pavement in the process of repairs using hot asphalt concrete mixes]. Vestnik MGSU. 2014. No. 11. Pp. 118-127. (rus)

[22] Knyazeva A.G. O raspredelenii temperatury, napryazhenij i deformacij v sisteme "material-pokrytie" pri uslovii neideal'nosti teplovogo kontakta mezhdu veshchestvami [On the temperature distribution of stresses and strains in the "material - coating" ideality provided thermal contact between the substances]. Fizicheskaya meomekhanika 3. 2000. No. 1. Pp. 39-51. (rus)

[23] Davydov V.A. Osobennosti izyskanij i proektirovaniya avtomobil'nyh dorog v rajonah vechnoj merzloty [Features survey and design of roads in permafrost regions]. Omsk: Omskij politekhnicheskij institut, 1979. 67 p. (rus)

[24] Nikolenko M.A., Besschetnov B.V. Povyshenie dlitel'noj treshchinostojkosti asfal'tobetona dorozhnyh pokrytij [Increase the duration of the crack resistance of asphalt concrete road pavement]. Inzhenernyj vestnik Dona. 2012. No. 2. Pp. 665-671. (rus)

[25] Istomin B.C. Prakticheskoe rukovodstvo po tekushchemu remontu asfal'tobetonnyh pokrytij gorodskoj dorozhnoj seti [Practical guide for maintenance asphalt concrete pavement urban road network]. Moscow : Prima-Press-M, 2001. 146 p. (rus)

[26] Lukashevich V.N. Sovershenstvovanie tekhnologii asfal'tobetonnyh smesej dlya uvelicheniya sroka sluzhby dorozhnyh pokrytij [Extend the life of asphalt concrete covered by a two-stage administration organic binder in the production process of asphalt concrete mixtures]. Stroitel'nye materialy. 1999. No. 11. Pp. 5-7. (rus)

[27] Storozhenko M.S. Sovershenstvovanie tekhnologii uplotneniya asfal'tobetonnyh pokrytij s cel'yu povysheniya prochnosti i dolgovechnosti [Improvement technology sealing asphalt concrete pavement in order to increase the strength and durability]. Vestnik Har'kovskogo nacional'nogo avtomobil'no-dorozhnogo universiteta. 2008. No. 40. Pp. 1-3.

[28] Gladkikh V.A., Korolev E.V. Tehniko-jekonomicheskaja jeffektivnost' primenenija seroasfal'tobetonov [Technical and economic efficiency of sulfur-asphalt-concrete application]. Vestnik MGSU. 2013. No. 4. Pp. 76-83. (rus)

[29] Radovskij B.S. Tekhnologiya novogo teplogo asfal'tobetona v SSHA [New technology of warm asphalt concrete in the United States]. Dorozhnaya tekhnika. 2008. No. 8. Pp. 24-28. (rus)

[30] Bratchun V.I., Stolyarova N.A., Bespalov V.L, Rybalko I.F. Litye asfal'tobetony povyshennoj dolgovechnosti [Cast in-situ asphalt concrete durability Increase]. Visti avtomobilno-dorojnogo instituta. 2007, Vol. 1. No. 4. Pp. 143–146.

[31] Leonovich I.I., Reut ZH.V., Sobolevskaya S.N. Soderzhanie i remont avtomobil'nyh dorog [Maintenance and repair of roads]. Minsk: BNTU, 2013. 68 p.

[32] Teltayev B. B., Aitbayev K. A., Suppes E. A. Sravnitel'nyj analiz temperatury v dorozhnyh konstrukcijah v raznyh regionah Kazahstana [Comparative analysis of temperatures in road structures in different regions of Kazakhstan]. Vestnik KGUSTA. 2016. No. 1. Pp. 124-130. (rus)

[33] Hassan H.F., Al-Nuaimi A.S., Taha R., Jafar T.M.A. Development of Asphalt Pavement Temperature Models for Oman. The Journal of Engineering Research. 2005. Vol. 2, No. 1. Pp. 32-42.

[34] Diefenderfer B.K., Al-Qadi I.L., Diefenderfer S.D. Model to Predict Pavement Temperature Profile: Development and Validation. Journal of transportation engineering. No. 132. Pp. 162-167.

[35] Diefenderfer B.K., Al-Qadi I.L., Reubush S.D., Freeman T.E. Prediction of daily temperature profile in flexible pavements at multiple locations using ltpp data. Transportation research board. 2002. No. 1. Pp. 1-21.

[36] Denneman E. The application of locally developed pavement temperature prediction algorithms in performance grade (pg) binder selection. SATC-2007. 2007. Pp. 257-266.

[37] Kovalev Ja.N. Dorozhno-klimaticheskoe rajonirovanie territorii BSSR dlja stroitel'stva asfal'tobetonnyh pokrytij [Road-climatic zoning of the territory of the Belorus SSR for the construction of asphalt concrete pavement]. Primenenie mestnyh materialov v dorozhnom stroitel'stve. 1966. Pp. 64-71. (rus)

[38] Paliukaite M., Vaitkus A. Analysis of temperature and moisture influence on asphalt pavement strength. Environmental engineering: The 8th International Conference. 2011. Vol. 3, No. 1. Pp. 1160-1165.

[39] Wang D., Roesler J.R., Guo D. Analytical Approach to Predicting Temperature Fields in Multi-Layered Pavement Systems. Journal of engineering mechanics. 2009. Vol. 135. No. 4. Pp. 334-344.

[40] Matić B., Tepić J., Sremac S., Radonjanin V., Matić D., Jovanović P. Development and evaluation of the model for the surface pavement temperature prediction. Metalurgija. 2012. Vol. 51. No. 3. Pp. 329-332.

Прогнозируемая температурная зависимость дорожного покрытия от температуры воздуха в различных дорожно-климатических зонах Российской Федерации

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КЛЮЧЕВЫЕ СЛОВА

дорожно-климатическая зона;
дорожное покрытие;
асфальтобетон;
разность температур;
дорога;
шоссе;
дорожные технические условия;

АННОТАЦИЯ

В статье исследуется температурная зависимость поверхности асфальтобетона от температуры окружающей среды в дорожных климатических зонах разных городов России с целью определения наиболее эффективного метода расчета температуры покрытия дороги. Имеются материалы исследований, которые показывают, что диапазон колебаний температуры поверхности асфальтового покрытия примерно пропорционален диапазону температур воздуха. Особенно опасным является зимний и весенний период, когда изменение температуры происходит неравномерно, в результате чего наблюдается снижение прочности и ухудшение показателей эффективности перевозок. Сезонные и суточные изменения температуры дорожного покрытия можно выровнять, применяя специальный состав, который позволит поддерживать примерно такую же температуру покрытия в течение всего периода эксплуатации.

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Литература

[1] Transportnaya strategiya Rossiyskoy Federatsii na period do 2030 goda [Transport Strategy of the Russian Federation through 2030]. Available at: http://www.mintrans.ru/documents/detail.php?ELEMENT_ID=19188. Date of access: 10.10.16.

[2] Lazarev Yu.G.,Sobko G.I. Rekonstruktsiya avtomobilnykh dorog [Reconstruction of roads]. Saint-Petersburg: SPbGASU. 2013. (rus)

[3] Podol'skij V.P., Nguen V.L., Le V.Ch. Povyshenie jekspluatacionnyh parametrov zemljanogo polotna s ispol'zovaniem geomaterialov v uslovijah V'etnama [Improvement of performance param

[4] eters of road beds by means of geo-materials in the environment of Vietnam]. Vestnik MGSU. 2013. No. 1. Pp. 139-147.

[5] Kiryukhin G.N. Temperaturnye rezhimy raboty asfal'tobetonnyh pokrytij avtomobil'nyh dorog [Operating temperature ranges of asphalt road pavement surfacings]. Dorogi i mosty. 2013. No. 2. Pp. 309–328. (rus)

[6] Uglova E.V. Teoreticheskie i metodologicheskie osnovy ocenki ostatochnogo ustalostnogo resursa asfal'tobetonnyh pokrytij avtomobil'nyh dorog [Theoretical and methodological assessment of residual fatigue life of asphalt concrete pavement roads]. dis. … d-ra tehn. nauk: [PhD diss.]: 05.23.11. VolgGASU , Volgograd. 2009. (rus)

[7] Belyaev P.S., Malikov O.G., Merkulov S.A., Polushkin D.L., Belyaev V.P. K voprosu o kompleksnom reshenii problem ehkologii i kachestva dorozhnyh pokrytij [On the complex solution of environment and road surface quality problems]. Voprosy sovremennoj nauki i praktiki. 2012. No. 39. Pp. 184–189. (rus)

[8] Lazarev Yu.G. Research of processes of improving soil properties based on complex ash cement binder. Applied Mechanics and Materials. 2014. No. 584. Pp. 1681–1686.

[9] Lazarev Yu.G. Effectiveness of Soil Reinforcement Based on Complex Ash-Cement Bonder. Applied Mechanics and Materials. 2015. No. 725. Pp. 208–213.

[10] Dulin M.O., Vatin N.I., Barabanshchikov Yu.G. Modelirovanie nabora prochnosti betona v programme ELCUT pri progreve monolitnykh [Modeling a set of concrete strength in the program ELCUT at warming of monolithic structures by wire]. Magazine of civil engineering. 2015. No. 2. Pp. 33-45. (rus)

[11] Lazarev Yu.G. Obosnovanie deformacionnyh harakteristik ukreplennyh materialov dorozhnoj odezhdy na uchastkah postroechnyh dorog [Justification deformation characteristics of the strengthened materials of the pavement on sections of roads built]. Vestnik grazhdanskih inzhenerov. 2015. No. 4. Pp. 140-146. (rus)

[12] Zaretskaya E.N. Formirovanie perechnya pokazatelej dlya ocenki kachestva proektirovaniya dorozhnyh odezhd nezhestkogo tipa [Developing a list of indicators for assessing the quality of the design of road pavement of non-rigid type]. Sovremennye tendencii razvitiya nauki i tekhnologii. 2016. No. 3-2. Pp. 109-113. (rus)

[13] Teltaev B.B., Kaganovich E.V., Izmajlova T.T. Uchet klimaticheskih uslovij ehkspluatacii pri vybore bituma dlya asfal'tobetonnyh smesej [Taking into consideration the climatic conditions of operation at choice of the bitumen for asphalt concrete]. Nauka i tekhnika v dorozhnoj otrasli. 2008. No. 2. Pp. 17–20. (rus)

[14] Gohman L.M. Bitumy, polimerno-bitumnye vyazhushchie, asfal'tobeton, polimerasfal'tobeton [Bitumen, polymer-bitumen binders, asphalt, polymer asphaltic concrete]. Moscow: «EKON-INFORM», 2008. 117 p.(rus)

[15] Morina M.O. K voprosu dorozhno-klimaticheskogo rajonirovaniya habarovskogo kraya i EAO po dinamike temperatur vozduha i pochvy [On the issue of road-climatic zoning of the Khabarovsk Territory and the Jewish Autonomous Region on the air temperature and soil dynamics]. Politematicheskij setevoj ehlektronnyj nauchnyj zhurnal Kubanskogo gosudarstvennogo agrarnogo universiteta. 2006. No. 21. Pp. 1-23. (rus)

[16] Mel'nikova I.S. Modelirovanie i vozdejstvie temperatury i transportnyh nagruzok na vozniknovenie i razvitie treshchin v asfal'tobetonnyh dorozhnyh pokrytiyah. [The modeling and the effects of temperature and traffic load on the emergence and development of cracks in asphalt pavements]. Nauka i tekhnika. 2012. No. 4 . Pp. 44-52. (rus)

[17] Kravchenko S.E., Serikov D.L. Nizkotemperaturnye napryazheniya kak kriterij vliyaniya komponentov asfal'tobetonnoj smesi na treshchinostojkost' asfal'tobetonnyh pokrytij [Low-temparature stress as criterion of asphalt mix components impact on crack resistance of asphalt cover]. Avtomobil'nye dorogi i mosty. 2010. No. 2. Pp. 70-77. (rus)

[18] Kychkin V.I., Yushkov V.S. Nerazrushayushchij dinamicheskij metod kontrolya dorozhnyh odezhd [Not destroying dynamic quality monitoring of road clothes]. Internet-zhurnal «NAUKOVEDENIE». 2013. No. 1. Pp. 1-8. (rus)

[19] Leonovich I.I., Mel'nikova I.S. Metodika i rezul'taty ocenki ehkstremal'nyh temperatur dorozhnyh pokrytij v razlichnyh regionah respubliki Belarus' [The method and outcomes of an extreme road surface temperatures estimation for various regions of the republic of Belarus]. Avtomobil'nye dorogi i mosty. 2012. No. 1. Pp. 9-25. (rus)

[20] Leonovich I.I., Mel'nikova I.S. Innovacii v sisteme ehkspluatacii avtomobil'nyh dorog, napravlennye na preduprezhdenie i likvidaciyu poverhnostnyh defektov [Innovations in the system of exploitation of roads, aimed at the prevention and elimination of surface defects]. Trudy BGTU. Lesnaya i derevoobrabatyvayushchaya promyshlennost'. 2012. No. 2. Pp. 130-133. (rus)

[21] Mel'nikova I.S. Modelirovanie vozdejstviya temperatury i transportnyh nagruzok na vozniknovenie i razvitie treshchin v asfal'tobetonnyh dorozhnyh pokrytiyah [Modeling the effects of temperature and traffic load on the emergence and development of cracks in asphalt pavements]. Zhurnal Nauka i tekhnika. 2012. No. 4. Pp. 44-52. (rus)

[22] Giyasov B.I., Zubkov A.F., Andrianov K.A. Opredelenie temperatury nagreva poverhnosti vyboiny dorozhnogo pokrytiya pri proizvodstve remontnyh rabot s primeneniem goryachih asfal'tobetonnyh smese [Determination of the heating temperature of potholes surface on road pavement in the process of repairs using hot asphalt concrete mixes]. Vestnik MGSU. 2014. No. 11. Pp. 118-127. (rus)

[23] Knyazeva A.G. O raspredelenii temperatury, napryazhenij i deformacij v sisteme "material-pokrytie" pri uslovii neideal'nosti teplovogo kontakta mezhdu veshchestvami [On the temperature distribution of stresses and strains in the "material - coating" ideality provided thermal contact between the substances]. Fizicheskaya meomekhanika 3. 2000. No. 1. Pp. 39-51. (rus)

[24] Davydov V.A. Osobennosti izyskanij i proektirovaniya avtomobil'nyh dorog v rajonah vechnoj merzloty [Features survey and design of roads in permafrost regions]. Omsk: Omskij politekhnicheskij institut, 1979. 67 p. (rus)

[25] Nikolenko M.A., Besschetnov B.V. Povyshenie dlitel'noj treshchinostojkosti asfal'tobetona dorozhnyh pokrytij [Increase the duration of the crack resistance of asphalt concrete road pavement]. Inzhenernyj vestnik Dona. 2012. No. 2. Pp. 665-671. (rus)

[26] Istomin B.C. Prakticheskoe rukovodstvo po tekushchemu remontu asfal'tobetonnyh pokrytij gorodskoj dorozhnoj seti [Practical guide for maintenance asphalt concrete pavement urban road network]. Moscow : Prima -Press -M, 2001. 146 p. (rus)

[27] Lukashevich V.N. Sovershenstvovanie tekhnologii asfal'tobetonnyh smesej dlya uvelicheniya sroka sluzhby dorozhnyh pokrytij [Extend the life of asphalt concrete covered by a two-stage administration organic binder in the production process of asphalt concrete mixtures]. Stroitel'nye materialy. 1999. No. 11. Pp. 5-7. (rus)

[28] Storozhenko M.S. Sovershenstvovanie tekhnologii uplotneniya asfal'tobetonnyh pokrytij s cel'yu povysheniya prochnosti i dolgovechnosti [Improvement technology sealing asphalt concrete pavement in order to increase the strength and durability]. Vestnik Har'kovskogo nacional'nogo avtomobil'no-dorozhnogo universiteta. 2008. No. 40. Pp. 1-3.

[29] Gladkikh V.A., Korolev E.V. Tehniko-jekonomicheskaja jeffektivnost' primenenija seroasfal'tobetonov [Technical and economic efficiency of sulfur-asphalt-concrete application]. Vestnik MGSU. 2013. No. 4. Pp. 76-83. (rus)

[30] Radovskij B.S. Tekhnologiya novogo teplogo asfal'tobetona v SSHA [New technology of warm asphalt concrete in the United States]. Dorozhnaya tekhnika. 2008. No. 8. Pp. 24-28. (rus)

[31] Bratchun V.I., Stolyarova N.A., Bespalov V.L, Rybalko I.F. Litye asfal'tobetony povyshennoj dolgovechnosti [Cast in-situ asphalt concrete durability Increase]. Visti avtomobilno-dorojnogo instituta. 2007, Vol. 1. No. 4. Pp. 143–146.

[32] Leonovich I.I., Reut ZH.V., Sobolevskaya S.N. Soderzhanie i remont avtomobil'nyh dorog [Maintenance and repair of roads]. Minsk: BNTU, 2013. 68 p.

[33] Teltayev B. B., Aitbayev K. A., Suppes E. A. Sravnitel'nyj analiz temperatury v dorozhnyh konstrukcijah v raznyh regionah Kazahstana [Comparative analysis of temperatures in road structures in different regions of Kazakhstan]. Vestnik KGUSTA. 2016. No. 1. Pp. 124-130. (rus)

[34] Hassan H.F., Al-Nuaimi A.S., Taha R., Jafar T.M.A. Development of Asphalt Pavement Temperature Models for Oman. The Journal of Engineering Research. 2005. Vol. 2, No. 1. Pp. 32-42.

[35] Diefenderfer B.K., Al-Qadi I.L., Diefenderfer S.D. Model to Predict Pavement Temperature Profile: Development and Validation. Journal of transportation engineering. No. 132. Pp. 162-167.

[36] Diefenderfer B.K., Al-Qadi I.L., Reubush S.D., Freeman T.E. Prediction of daily temperature profile in flexible pavements at multiple locations using ltpp data. Transportation research board. 2002. No. 1. Pp. 1-21.

[37] Denneman E. The application of locally developed pavement temperature prediction algorithms in performance grade (pg) binder selection. SATC-2007. 2007. Pp. 257-266.

[38] Kovalev Ja.N. Dorozhno-klimaticheskoe rajonirovanie territorii BSSR dlja stroitel'stva asfal'tobetonnyh pokrytij [Road-climatic zoning of the territory of the Belorus SSR for the construction of asphalt concrete pavement]. Primenenie mestnyh materialov v dorozhnom stroitel'stve. 1966. Pp. 64-71. (rus)

[39] Paliukaite M., Vaitkus A. Analysis of temperature and moisture influence on asphalt pavement strength. Environmental engineering: The 8th International Conference. 2011. Vol. 3, No. 1. Pp. 1160-1165.

[40] Wang D., Roesler J.R., Guo D. Analytical Approach to Predicting Temperature Fields in Multi-Layered Pavement Systems. Journal of engineering mechanics. 2009. Vol. 135. No. 4. Pp. 334-344.

[41] Matić B., Tepić J., Sremac S., Radonjanin V., Matić D., Jovanović P. Development and evaluation of the model for the surface pavement temperature prediction. Metalurgija. 2012. Vol. 51. No. 3. Pp. 329-332.

Telegina M.E., Barabash A.V., Naumova E.A., Zhuvak O.V., Lazarev Y.G. Predicted temperature dependence of the road surface on the air temperature in a variety of road-climatic zones of the Russian. Construction of Unique Buildings and Structures. 2017. 11(62)., Pp. 71-82.

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