CORREÇÃO DO MÓDULO ELÁSTICO REAL DE ACORDO COM A TEMPERATURA DO PROJETO

REDUCTION OF THE ACTUAL MODULUS OF ELASTICITY TO THE DESIGN TEMPERATURE

ПРИВЕДЕНИЕ ФАКТИЧЕСКОГО МОДУЛЯ УПРУГОСТИ К РАСЧЕТНОЙ ТЕМПЕРАТУРЕ

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RESUMO

A correção do módulo elástico real do revestimento de estradas de acordo com a temperatura de projeto é uma tarefa bastante demorada, que depende do clima e das condições meteorológicas. O artigo apresenta o resultado da generalização da experiência prática nessas manipulações, aplicado a regiões com flutuações significativas nas temperaturas diárias. Assim, o uso de flutuações diárias de temperatura ao medir a deflexão em um ponto de controle em regiões com atividade solar suficiente torna possível isolar efetivamente o fator em estudo (temperatura) que influencia a resistência do revestimento da estrada e simultaneamente otimizar o custo de operação do equipamento de laboratório. O índice de resistência do revestimento da estrada (deflexão reversível) pode mudar significativamente, não apenas no dia a dia, mas também durante o dia, especialmente durante o período de cálculo. Nestas condições, os resultados de testes lineares de estruturas rodoviárias devem ser corrigidos de acordo com uma forma comparável.

Palavras-chave: *módulo de elasticidade real, revestimento da estrada, ponto de controle.*

ABSTRACT

Reduction of the actual modulus of elasticity of road pavement to the design temperature is a rather labor intensive task. Besides, it depends on the weather and climatic conditions. Here we present the result of generalizing practical experience on this task as applied to the regions with considerable fluctuations of daily temperatures. It was found that application of fluctuations of daily temperatures when measuring deflection at the check point in the regions with sufficient solar activity makes it possible to efficiently separate the studied factor of influence on road pavement strength (temperature) at simultaneous optimization of expenses on operation of laboratory equipment. A road pavement strength indicator (invertible deflection) may vary quite considerably not only from day to day but during a day as well, especially during the design period. Under these conditions the results of linear tests of road constructions have to be reduced to the comparable ones.

Keywords: *actual modulus of elasticity, road pavement, check point.*

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АННОТАЦИЯ

Приведение фактического модуля упругости дорожной одежды к расчетной температуре является достаточно трудоемкой задачей, к тому же зависящей от погодно-климатических условий. В статье изложен результат обобщения практического опыта по данным манипуляциям, применительно к регионам со значительными колебаниями суточных температур. Таким образом, использование суточного колебания температур при измерениях прогиба на контрольной точке в регионах с достаточной солнечной активностью позволяет эффективно выделить исследуемый фактор влияния на прочность дорожной одежды (температура) при одновременной оптимизации затрат на эксплуатацию лабораторного оборудования. Показатель прочности дорожной одежды (обратимый прогиб) может весьма существенно изменяться не только изо дня в день, но и в течение суток, особенно в расчетный период. В этих условиях результаты линейных испытаний дорожных конструкций должны быть приведены к сопоставимому виду.

Ключевые слова: *фактический модуль упругости, дорожная одежда, контрольная точка.*

INTRODUCTION

The actual value of the modulus of elasticity at the surface of road pavement is an objective indicator of its strength properties (Uglova *et al.*, 2016). According to the technological normative documentation and specialized methodology, the actual value of the modulus of elasticity is determined for the design (residual) reliability level for the road pavement structure (Gonchar, 2018; Reinhardt and Mielich, 2013). For this purpose, field tests of road pavements are performed. They are divided into linear tests and checking tests. The linear tests make it possible to set the sufficient number of measurements for statistical treatment. For such tests, there is no need in exact connection to location of the specific measurement. The checking tests are performed at a fixed point whose location can be restored in the middle term prospect to reduce the groups of linear tests happening at different times to a single temperature-humidity state of road pavement (Formalev *et al.*, 2017).

A road pavement strength indicator (invertible deflection) may vary quite considerably not only from day to day but during a day as well, especially during the design period. Under these conditions the results of linear tests of road constructions have to be reduced to the comparable ones (Kolesnik *et al.*, 2015; Sekatsky and Grigorieva, 2008). The necessary corrections are to be added from the results of tests at the check points.

MATERIALS AND METHODS

A check point is chosen at each typical section in the growth areas of strengthening defects inherent in the considered road section. The check points should be placed at traffic lane that is nearest to the road coating edge. The check point location on the road coating is marked with a wear-proof paint (Gorsky, 2014; Ermakov, 2008).

The data obtained at the check point at different temperature factors of road coating make it possible, in particular, to reduce deflection values to the design temperature. The following design temperatures are adopted for road coatings made of materials containing an organic bonding agent: +10°C – for the road-climatic zone (RCZ) I; +20°C – for RCZ II; +30°C – for RCZ III; +40°C – for RCZ IV and +50°C – for RCZ V.

The main complexity in measuring at the check point is that it is rather difficult to keep a rather sufficient temperature interval during optimal time. As a rule, the investigations have to be performed by the deadline. Sometimes the typical sectors are far from location of laboratory equipment which makes long-term observations at the check point uneconomical. Besides, off-season measuring is characterized by a wide variation range of roadbed humidity which hampers obtaining "pure" deflection dependences on road coating temperature.

As the optimal approach, several measurements can be made at the check point during one or two days in the coldest time (6.00…7.00) and maximally possible hot time (14.00…16.00). To illustrate, when measuring in the Krasnodar Territory, the temperature range in the spring-summer period may be 14°C … 16°C. Inspection of the system of federal motor roads in the Krasnodar Territory in the spring time made it possible to get temperature ranges from 15°C to 23°C (Korenevsky, 2016), from 10°C to 22°C (Korenevsky, 2017a; 2017b; 2017c; 2017f) and from 12°C to 26°C (Korenevsky, 2017g). In the summer time the fixed temperature ranges were from 25°C to 37°C (Korenevsky, 2017d), from 32°C to 43°C (Korenevsky, 2017e) and from 24°C to 28°C (Korenevsky, 2017h).

RESULTS AND DISCUSSION:

The dependences of road pavement deflection on road coating temperature for the studied constructions (Figure 1) were built in accordance with the point 3.2.1 of Specialized Road Standards 218.1.052-2002 "Strength estimation for non-rigid road pavements" and the point 5.7 of Specialized Road Methodological Guide 218.2.024-2012 "Methodological recommendations for estimating strength of non-rigid road pavements" (2013).

Approximation of the experimental data with a linear function $y = Ax + B$ makes it possible to perform a comparative analysis of the presented dependences. The following regularities are revealed:

- the A parameter of the approximating equation characterizing rapidity of function changing shows that the higher are absolute temperatures of road coating, the more substantially changes deflection with each degree (the dependences are built from the data of SR 3.36.05.52-17 (Korenevsky, 2017g), SR 3.36.05.66-17 (Korenevsky, 2017d) and SR 3.36.05.67-17 (Korenevsky, 2017e)). The A parameter changes from 0.0018 for the temperature range from 12ºC to 26ºC up to 0.0079 for the temperature range from 31ºC to 43ºC;

- whatever the general actual strength of road pavement, the relative influence of temperature of cohesive layers of road coating on strength properties is the same (the dependences built from the data of SR 3.36.05.52-17 (Korenevsky, 2017g) and SR 3.36.05.54-17 (Korenevsky, 2017a)).

At the stage of reducing the results of linear tests to the comparable ones, the "deflection-road coating temperature" diagram built from the results of measurements at the check point makes it possible to calculate conversion coefficient that is applied to the measured value of elastic deflection obtained at off-design temperature (Nedoseka, 2012; Shchepeteva *et al.*, 2010). In particular, for RCZ III the general equation to get conversion coefficient to the design temperature is Equation 1:

$$K_t = \frac{A \times 30 + B}{A \times t + B} \qquad \text{(Eq. 1)}$$

Here *A* and *B* are parameters of the obtained approximating linear dependence $y = Ax + B$ (Figure 1); 30 is the design temperature for RCZ III, ºC; *t* is the temperature of performing the main cycle of linear tests, ºC.

CONCLUSIONS:

Hence application of fluctuations of daily temperatures when measuring deflection at the check point in the regions with sufficient solar activity makes it possible to efficiently separate the studied factor of influence on road pavement strength (temperature) at simultaneous optimization of expenses on operation of laboratory equipment.

In addition, a comparative analysis of the experimentally obtained values of elastic deflection makes it possible to estimate numerically the time history of road pavement strength indicators depending on temperature of cohesive layers for different road pavement constructions and temperature ranges.

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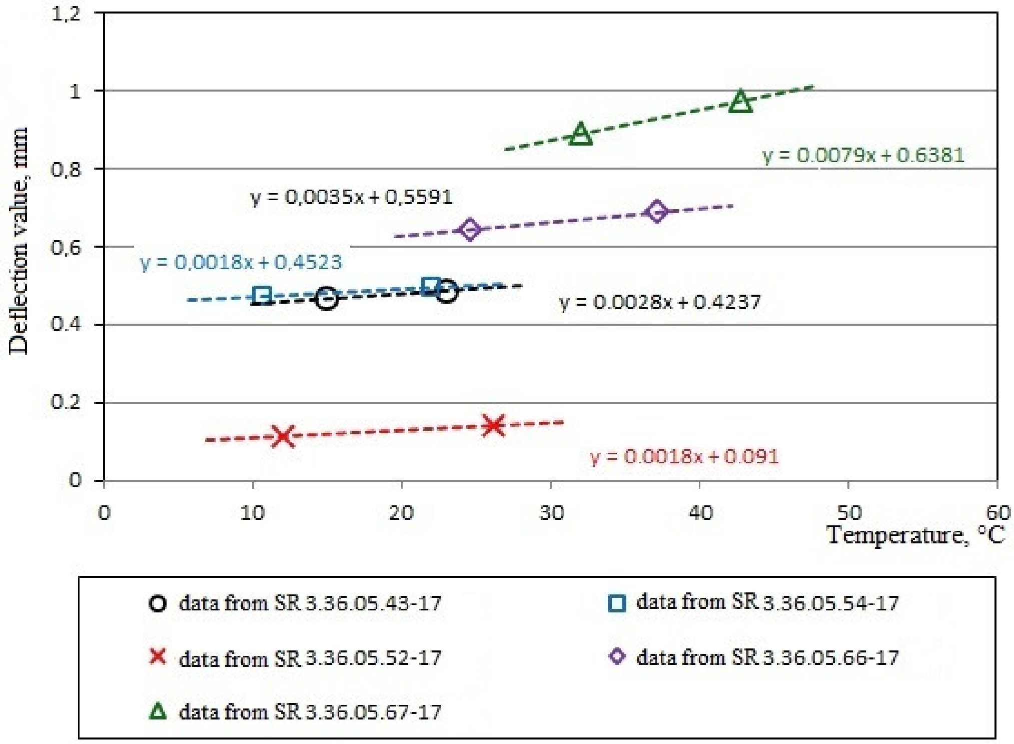

Figure 1*. Temperature dependence of elastic deflection of road pavement for different road sections (SR stand for Study Report) (Korenevsky, 2016; Korenevsky, 2017a; 2017d; 2017e; 2017g)*