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Evaluation of Functional Safety of Cement Concrete and Composite Pavements Exposed to Weather Conditions

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Abstract

This paper is intended to study the mechanism of strains and fractures emerging in pavement structures, give suggestions and recommendations to increase the robustness of different types of road pavements with the most appropriate design solutions. The subject of the research is the evaluation of strain mechanisms in cement and composite pavements caused by weather conditions. The scope of the research is to analyze the impact of ambient temperature variations and water and thermal state of the subgrade on different types of road structures. These are the most critical factors which give rise to adverse environmental effects causing dangerous stresses and strains in the pavements. The research results are represented as follows: analysis of the regularities of strains of different types of pavements exposed to weather conditions, modern methods of reduction of temperature and humidity factors on different types of road structures, providing recommendations to improve the robustness of different types of pavements to improve the usability of roads which will result in lower operating costs (repair and maintenance of pavements) and higher traffic safety (reduction of the number of road accidents).

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Keywords: Pavement, design solution, fracture risk, temperature and moisture strain.

It shall be noted here that ambient temperature variations and water and thermal state of road structures are one of the most critical factors which give rise to adverse environmental effects causing dangerous stresses and strains in the pavements. Resistance of the base course to free changing in length and width of the pavement during heating and

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cooling causes eccentric expansion or contraction in the pavement, because forces of resistance to free movement of linear dimensions act in the plane of contact of the bottom of the pavement with the base course. Great temperature changes and long length of a continuous section of the pavement causes stress in it which may exceed the strength of the material and will result in discontinuity or cracking. This process is particularly adverse with restrained shortening of the pavement during cooling and freezing which cause tensile stresses. Expansion joints shall be provided in the cement to control the stress and strain state. Today's science and engineering are deficient in an up-to-date regulatory framework for controlling the stress and strain states and improving the design and process solutions for pavements accordingly.

The stress and strain state of pavements depends on their design features, structure and properties of materials, strength of the subgrade, traffic intensity and composition. In addition, the stress and strain state is different for pavement courses with contact, coagulative and crystallization structures.

Change in temperature along the width make the plates buckle (downwards at night and upwards during the day) depending on the direction of a thermal flow (Fig. 1)[Sidenko (1973)].

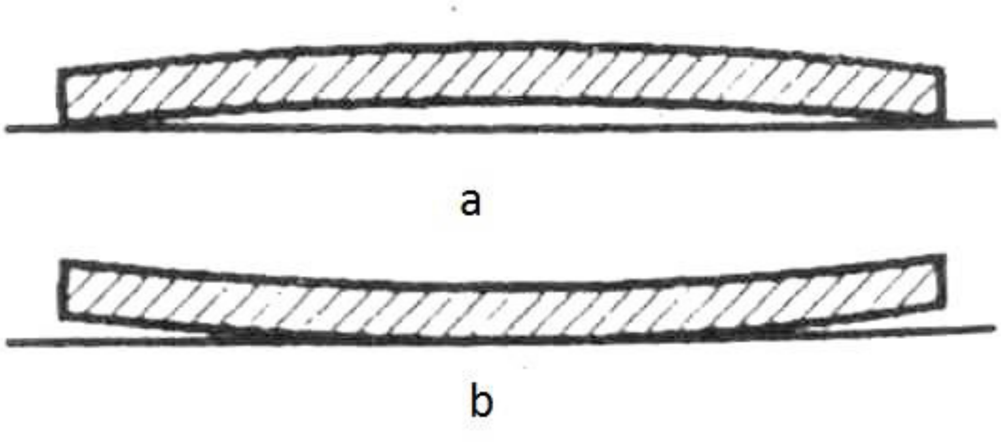

Fig. 1. Driving temperature buckling concrete: a – day, b – night.

The value of temperature stresses depends on the weight and dimensions of plates. The area of contact loss of the bottom of the plates with the base course depends on the dimensions of the plates, buckling strain size and strain properties of the base course which affect the cracking resistance. Cracking resistance of the pavement plates is higher if the base courses function in an elastic stage without accumulating the residual strains.

There are two kinds of temperature strains in concrete structures of pavements: strains related to the changes in the length of the plates as a result of heating or cooling due to the resistance to movement of the frictional forces, adhesion, and in some cases, freezing when there is an reaction between the plate and the base course; strains associated with the plate buckling due to the uneven temperature distribution in the plate thickness arising out of its own weight counteraction and connection with the wedges in the joint edges (Fig. 2.) [Sidenko (1973)].