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Mechanical stabilization of intermediate granular layers in pavement structures – laboratory study

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Abstract

A laboratory study aimed at the influence of a stiff geogrid placed on the intermediate granular layer between a cracked concrete base and the top asphalt layer was carried out. Five physical models 2x1x0.8m in size have been studied under cycling loading up to 2 million cycles. The paper describes the application of the crack propagation barrier with various layer thicknesses. The asphalt surface settlement, the movement of concrete panels and visual control of crack propagation was monitored during the loading of each model construction. After the loading termination, cylindrical cores were taken passing through the asphalt layer and the asphalt surface relief was evaluated. The achieved results were mutually compared and the optimal composition of layers was identified. Mechanical interlocking has been proven as the ruling mechanism of the stabilisation function and prevention of reflective cracking.

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Keywords: geogrid; mechanical stabilisation; interlocking; asphalt; reflective cracking

1. Introduction

In May 2013, the long-prepared and expected reconstruction of the D1 motorway from Prague to Brno, which had been built in 1967-1980, started. The reconstruction includes the replacement of the existing cement concrete and

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asphalt pavement with a new, modern concrete surface and, at the same time, partial widening of the roadway. The method chosen requires complete demolition and removal of the original, worn-out and uneven road surface, including the approximately 20-cm base course. This method, however, has its drawbacks, being mainly time consuming and costly due to the transfer of large volumes of material, but also not very favourable in ecological terms.

An interesting alternative to the above method seems to be using the road surface fragmentation in combination with surface milling [1]. The fragmentation consists in breaking up the existing concrete pavement slab into blocks, about one metre in size, followed by overlaying them directly with a thick layer of new asphalt instead of extracting them. The advantage of this method is the preservation of substantial volumes of high-quality material in the construction and an overall acceleration of works. A disadvantage, on the contrary, can be raising the elevation of the original road pavement grade line in sections adjoining bridge constructions, tunnels, etc., and also the fact that it can only be used in sections without the appearance of major failures in the subgrade.

Road pavements composed of cement concrete layers in combination with long-term intensive dynamic loading and temperature changes are prone to reflective cracking [2]. These failures are characteristic of rigid base courses. Reflective cracks arise in asphalt wearing courses of concrete road pavements thanks to horizontal deformations of individual concrete slabs due to their expansion and shrinkage caused by daily and seasonal temperature fluctuations. These changes imply high tensile stresses in asphalt, which can lead to cracking directly over joints in concrete [3].

In response to searching economically more beneficial methods for high-quality reconstructions of existing concrete road pavements damaged by cracks [4-7], a laboratory study verifying a potential effective application of geogrids in road repair works was conducted at the Faculty of Civil Engineering, CTU in Prague in 2014-2016. This article presents the description of this method and the findings obtained from investigations on a series of model constructions in laboratory conditions. Similar issues have been the focus of interest of other research establishments [8-11].

2. Materials and methods

The laboratory study was based on the assumption that two concrete slabs divided by a narrow gap representing the expansion gap or another crack in the road pavement concrete layer would be overlaid with a layer of asphaltic concrete in combination with a layer of granular material and a geogrid, the multi-layer composition thus arising would be exposed to long-term cyclic loading and the development of a reflective crack in the asphalt layer would be monitored. The objective was to verify whether the application of a geosynthetic material had a favourable effect on delaying the cracking and, further on, to optimize the composition of layers so that the construction would be able to resist the cracking as much as possible.

To verify the assumptions formulated above, 4 model constructions were assembled in a 1:1 scale in the Experimental Centre of the Faculty of Civil Engineering, CTU in Prague. Laboratory tests were performed in the experimental box with dimensions of 2.0 x 1.0 x 0.8 m, which consists of welded steel sections with removable walls of timber baulk with a cross-section of 100 x 150 mm. To minimize the track bed friction against the box walls, the timber walls were panelled with galvanized plate 0.55 mm in thickness. One lateral wall of the experimental box was half filled with a glazed frame allowing the monitoring of the construction's behaviour, while the other half of the wall was fitted with a "window" enabling access to perform direct measurements of the mutual settlement of concrete slabs during the loading process.

2.1. Sequence of works

A special resilient mixture composed of fine-grained sand with a grading of 1/4, rubber pellets with a grading of 2/3 and polyurethane binder was developed to simulate a real subgrade below the concrete layer. The mixture was placed in the experimental box lined with wax paper, levelled and consolidated with a manual compactor. A layer 58 mm in thickness had an average load-bearing capacity on the surface of 23.1 MPa after hardening measured by the light dynamic plate under ČSN 73 6192 [12].