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Possibilities of ground penetrating radar usage within acceptance tests of rigid pavements

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ABSTRACT

Within the road pavement acceptance tests, destructive as well as non-destructive tests of individual road layers are performed to verify the standard requirements. The article describes a method for providing quick, effective and sufficiently accurate measurements of both dowel and tie bar positions in concrete pavements, using a two-channel ground penetrating radar (GPR). Measurements were carried out in laboratory and in-situ conditions. A special hand cart for field measurements, set for the testing requirements, was designed. It was verified that following the correct measuring and assessment method, it is possible to reach accuracy of determining the in-built rebar up to 1 cm in vertical direction and up to 1.5 cm per 11.5 m of measured length in horizontal direction. In the in-situ tests, GPR identification of possible anomalies due to the phase of concrete pavement laying was presented. In the conclusion, a measurement report is mentioned. The standard requirements for the position of dowels and tie bars cover maximum possible deviation of the rebar position from the project documentation in vertical and horizontal direction, maximum deflection of rebar ends to each other, and maximum translation of rebar in the direction of its longitudinal axis.

1. Introduction

Management and construction of concrete road pavement in both road and airport system require a large number of acceptance tests. The types and frequency of the tests are given by technical regulations and standards. Destructive tests particularly attempt to identify concrete strength, density, resistance against freezing/thawing, resistance against defrosting agents, etc. Non-destructive tests attempt to identify road surface parameters, such as evenness, deviation from project heights, deviation from cross-fall, skid resistance properties, etc. Apart from these tests, the measurement of the position of built-in dowels and tie bars is performed. Correctly installed dowels and tie bars guarantee a long life span of concrete pavement and required load transfer at joints between individual slabs.

Measurements of the position of built-in dowels and tie bars in concrete pavements are performed by different non-destructive methods. Ground penetrating radar (GPR) and MIT Scan-2 device (Heft S65, 2010; NCHRP report 637, 2009) are among the most common methods.

GPR techniques used herein are based on the measurement of travel time and reflection amplitude of an electromagnetic pulse transmitted through a pavement and then partly reflected from electrical interfaces within the structure. Typically, the systems have the following three components: a pulse generator which generates a single pulse of a given central frequency and power, an antenna which transmits the pulses into the medium and captures the reflected signal, and a recorder which samples the reflected signals and converts them into a form for computer storage (Saarenketo and Scullion, 2000). For different applications, systems with single or multiple antennae of different frequencies are used, or the whole field of antennae for 3D applications is used (Kordina et al., 2009).

GPR can be used for a wide range of applications in non-destructive diagnostics. Regarding the transportation infrastructure, this device is particularly used for the continuous determination of thickness of road construction layers (Al-Qadi and Lahouar, 2004), for localization of built-in objects (Porsani et al., 2012), non-homogeneities, layer delamination, and spots with increased moisture, and for determination of crack depths, etc. (Saarenketo, 2006). Regarding the reinforced concrete and pre-stressed constructions, GPR is used for diagnostics of bridge beams (Beben et al., 2012), bridge decks (Benedetto et al., 2012), and retaining walls (Hugenschmidt and Kalogeropoulos, 2009), for void detection beneath reinforced concrete (Cassidy et al., 2011), or possibly

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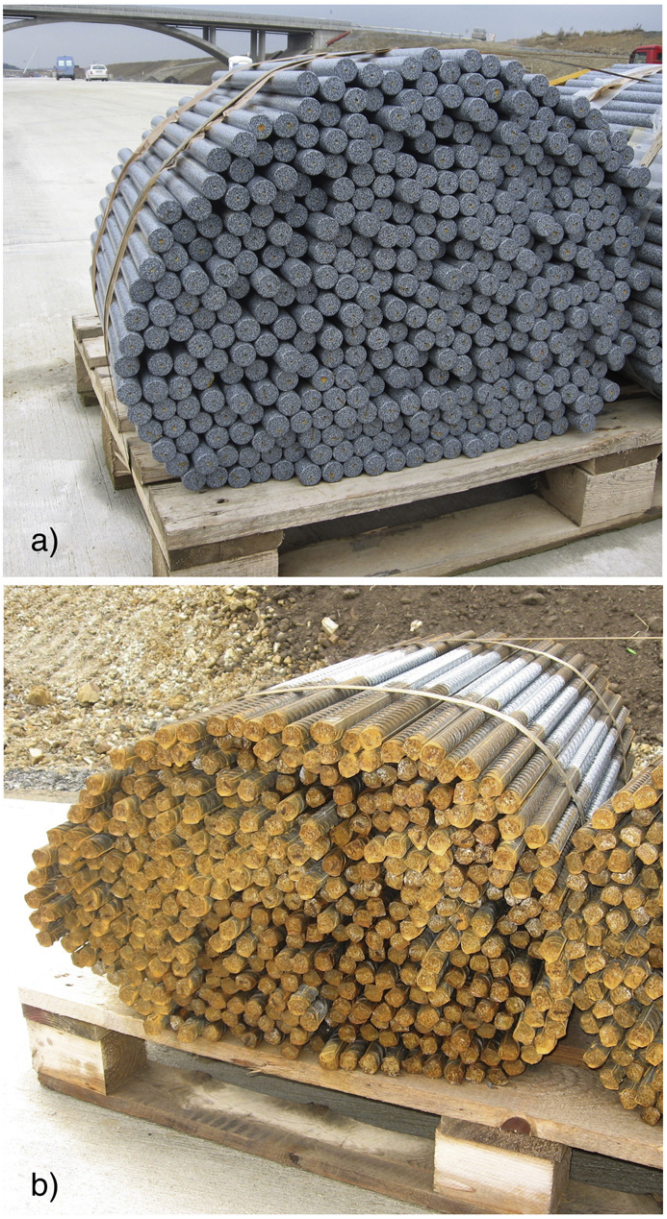

Fig. 1. Rebar before its use: a) dowels, and b) tie bars.

for radius measurement of reinforcing steel bar in concrete (Chang et al., 2009).

MIT Scan-2 device was developed specifically for locating dowels. It uses magnetic tomography technology and consists of three main components: a measuring unit with five sensors that emits electromagnetic pulses and detects the induced magnetic field, an onboard computer and a plastic rail system that guides the sensor unit along the joint. The main advantage is that the device can be used on fresh concrete (FHWA-IF-06-006, 2005).

This paper deals with the diagnostics of concrete pavement with reinforced joints, without continuous reinforcement (jointed unreinforced concrete pavement), which is provided as two-layer one in the total thickness ranging from 230 to 300 mm. It describes a method for providing quick, effective and sufficiently accurate measurements of both dowel and tie bar positions in concrete pavements by GPR method. A special hand cart for field measurements, set for the testing requirements, was produced. Designed GPR procedure and accuracy of measurement are based on the results of laboratory experiments and in-situ tests.

2. Requirements for dowels and tie bars

A dowel is made from plain steel bar, with applied coating. It is inserted in transversal joint in between adjacent concrete slabs, in order to transfer wheel load and prevent different drops of slabs (Fig. 1a). Dowel diameter is most commonly around 25 mm and its length around 500 mm.

A tie bar is a comb-shaped steel bar, with applied protection coating against corrosion in the middle along the length of approximately 200 mm, keeping narrow joints. It is usually embedded in the longitudinal joint of concrete pavement (Fig. 1b). The diameter of tie bar is most commonly around 20 mm and its length around 800 mm.

Dowels should be inserted in such position that the dowel axis is at the height of $h/2$ (where h is thickness of concrete pavement), in one plane parallel to the concrete pavement surface and to the longitudinal axis of the concrete lane (Fig. 2). The distance of dowels on heavy loaded traffic lanes is 250 mm. This distance can be doubled on less loaded traffic lanes and hard shoulders. The distance of an edge dowel from the slab edge may not be lower than 250 mm (CSN 73 6123–1, 2006).

Tie bars are placed so that the tie bar axis would be at the height of $h/2$, perpendicular to the longitudinal joint, parallel to the concrete

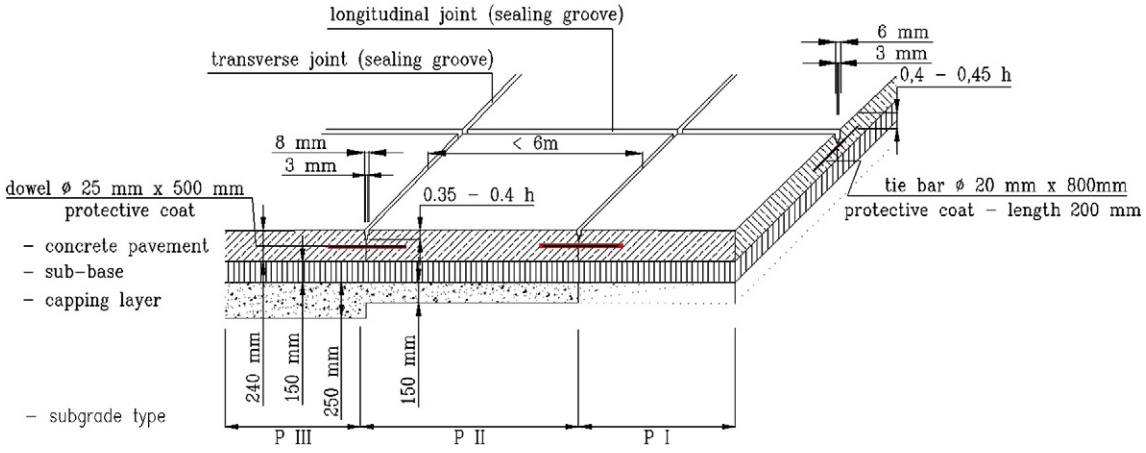

Fig. 2. Scheme of embedded dowels and tie bars in concrete pavement.