SUMMARY

The study pointed out that knowledge of the exact thickness of road pavement layers allows both to reduce costs associated with road repairs and to increase the safety of road users. After a careful review of the literature on non-destructive pavement diagnostics, a list of applications, possibilities and limitations of non-destructive methods was made and the ground penetrating radar (GPR) method was found to be the best method for determining layer thickness.

The theory of the GPR method was discussed and it was shown that to determine the thickness of a layer it is necessary to know its dielectric constant, however, a number of factors influence the value of the dielectric constant. Based on literature studies, dielectric constants of materials used for road pavements were compiled and attention was paid to their broad scope. It was found that dielectric constants given in the literature should be control values of results obtained by other methods. It was realized that the value of the dielectric constant is usually determined on the basis of the cores thickness, however, the dielectric constant in other locations can be significantly different from that which is at the drilling point location. In addition, drilling is a destructive interference in the surface condition, which reduces its durability. It has been shown that the method of determining the dielectric constant in a continuous way is to determine its value based on the waves amplitudes reflected from the surface, in the current state of knowledge is requiring cores for calibration.

The aim of this study was to answer the questions: (1) whether the dielectric constants determined based on the amplitudes of waves reflected from the surface and the dielectric constants determined based on of the cores differ statistically, (2) whether the heterogeneities of the pavement, (3) atmospheric conditions and the corresponding surface condition have a statistically significant effect on the value of the determined layer thickness (4) whether advanced signal analysis gives the possibility of obtaining information that could increase the accuracy of layer thickness determinations using the GPR method.

Based on the literature review, a list of factors affecting the result of GPR measurements of layer thickness and accuracy of determinations was made. The application of advanced signal analysis: Fourier transform (Fast Fourier Transform, FFT and Short Time Fourier Transform, STFT) and wavelet analysis in GPR interpretation have been studied.

For the purposes of achieving the objectives set out in this dissertation, for tests it has been used: the Non-Destructive Testing Site of the Faculty of Civil Engineering, Warsaw

University of Technology consisting of 15 concrete slabs with controlled heterogeneities, the Non-Destructive Testing Site of TPA consisting of 5 three-layer asphalt slabs differentiated by the porosity of the wearing course and the Testing Road of TPA, 552 m long consisting of 3 sections with different asphalt layers structure and constant layer thickness. The verification of conclusions formulated based on tests under controlled conditions was carried out on a selected section of a public road of variable construction, 3,5 km long.

Using antennas of different construction and frequencies, the results of the dielectric constant determination based on the known thickness of tested medium and based on the amplitude of the EM wave reflected from the medium's surface were compared as part of my own research. The effect of heterogeneity of medium (delamination, decompaction, voids), highly conductive materials in and on sample (reinforcement, chlorides, moisture) and atmospheric conditions during GPR measurements and the resulting state of the sample's surface (water film on the surface, ice, layers of snow, layers of de-icing salt) on the result of thickness determination were investigated. Using the above dependencies, an algorithm for the determination of layer thickness by the GPR method was proposed, minimizing the required number of cores to be drilled and guaranteeing the desired accuracy of thickness determination. For selected mediums, correction coefficients were proposed for dielectric constants determined based on the amplitude of the wave reflected from the surface in different atmospheric conditions to dielectric constants determined based on boreholes and for correcting dielectric constants of medium without heterogeneity to dielectric constants with heterogeneity. Fourier transformation and wavelet analysis have been proposed as a tool for selecting the appropriate correction factor.

Based on the results obtained in controlled conditions, the answers to the questions posed in this dissertation were formulated. Their correctness was validated based on tests of the road of variable thickness.