GROUND PENETRATING RADAR IN THE TASK OF FLOOD PREVENTION

Sylwia TOMECKA-SUCHOŃ[1]

[1]*AGH University of Science and Technology, Faculty of Geology Geophysics and Environmental Protection, Department of Geophysics, al. Mickiewicza 30, 30- 059 Krakow, Poland; tomecka@agh.edu.pl*

Introduction

The GPR (Ground Penetrating Radar) method in research on flood embankments has been extensively described in the scientific literature, however, there are still many unresolved problems that can be solved by scientists improving further on the existing approaches which is the focus of this paper.

One of the main problems that arise with prospective flooding after a heavy rainfall is the strength of flood embankments. When the high flood water comes, the only hope is that the embankments will withstand and the water will not overflow the cultivated fields and human settlements that lie behind them.

Most of the existing embankments in Poland were built many years ago. They have already confirmed their usefulness during floods that have occurred in the past, but this fact does not guarantee that the embankments will prove effective also during the floods that will come in the future. The external inspection of the embankment does not reveal the greatest threats, which are potentially zones of looseness inside the embankment. The origin of these zones may be different - for example, there are burrows of animals hollowed inside embankment and weakening its structure, erosion effects, sometimes also errors made during the construction of the embankment.

It is worth emphasizing that the zones of loosening often occur very low in the structure of the embankment, sometimes even close to the foot of the embankment, so when the water of the flood begins to wade through them the typical methods of flood defenses, consisting in laying sand bags on the shaft's crown, are ineffective. It is because the water goes to the bottom, destroying the structure of the embankment's interior at the same time.

The most important matter for analysis of the possibility of the anomalies in the structure of the embankment detection using electrical and electromagnetic techniques is the assessment of alteration of the electromagnetic properties of the ground caused by the presence of loose zones. Of utmost importance is the relative dielectric permittivity ε_r [-], electrical conductivity σ [S/m] and a seemingly negligible magnetic permittivity μ_r[-], which is usually taken as 1.

The material most often used for the construction of levees is clay sands and sandy dust. Due to the high attenuation of the GPR signal, resulting from high conductivity of clay material, the results of GPR measurements carried out on flood embankments are usually difficult to interpret. This article aims to present the methodology of GPR signal processing allowing the separation of anomalous zones within flood embankments. To detect anomalies in the structure of the embankment, it was decided to use Ground Penetrating Radar, which can reveal all anomalies in the structure of the embankments.

Samples and methods

The measurements were carried out on Vistula embankments along few profiles, radiogram for one of them is shown on the Fig 1. The RAMAC/GPR georadar of the firm of MALA Geoscience was used with 200MHz antenna.

All radargrams were processed using ReflexW program (SandmeierGeo, Germany) with the following procedures: phase correction, time zero correction, amplitude declipping, dewowing, DC-shift, gain, background removal, Butterworth filter, deconvolution, smoothing. Subsequently, we used additional advanced processing procedure to highlight barely visible anomalies or to extract additional information (example on Fig.2.).

Results

Some of the results of GPR surveys of selected flood embankments in the vicinity of Kraków are presented on Fig. 1. The zones of loosening in the embankment, regardless of whether they are dry or filled with water, caused an increase in reflectivity (larger amplitudes of registered signal). In addition, randomly distributed high amplitude anomalies probably indicate loose zones, which are usually selectively distributed in the body of the embankment (otherwise it is in case of hydraulic breakdown). Such anomalies on the echogram, after processing, can be seen from x = 38m to x = 50m, in the sub coronal zone and from x = 76m to x = 100m at the embankment roof. It is highly probable that the aforementioned areas of the embankment associated with the anomalies on the echogram were responsible for the subsequent leakage of water through the embankment.

Strong, horizontal, shallow anomaly between x = 8 m and x = 27 m is probably gravel/rubble interface in the embankment, which is generally made of a mixture of sandy-clay, with a large proportion of clays. This is evidenced by observable leakage. These zones can be amended by replacing the embankment's material with more competent permeable materials that can withstand water leakage.

A special method using neural networks was developed for the detection and location of anomalies. The essence of this method is presented in (Szymczyk et al., 2015) and (Szymczyk et al., 2014).

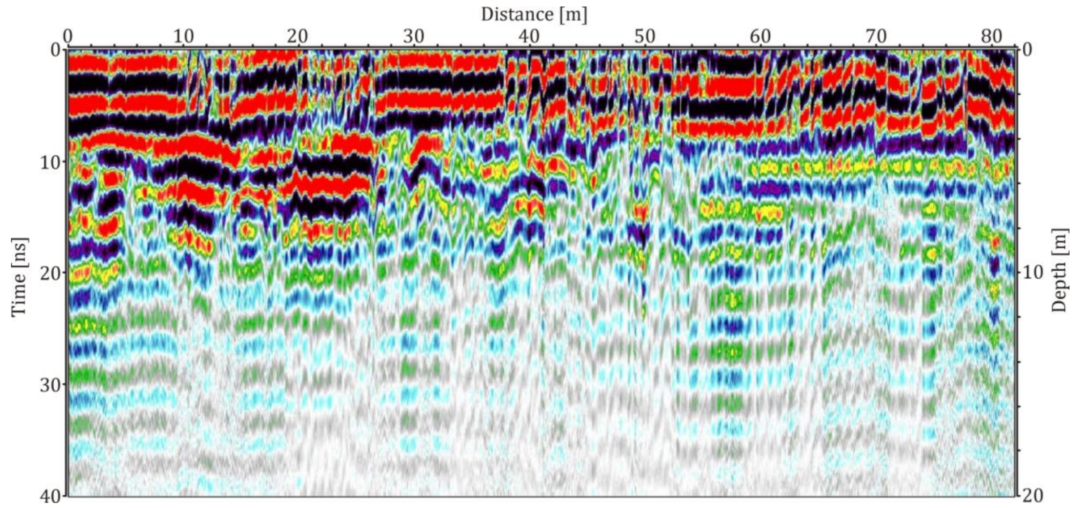

Figure 1. *Distribution of anomalies for exemplary profile from Vistula Embankments - processed GPR data.*

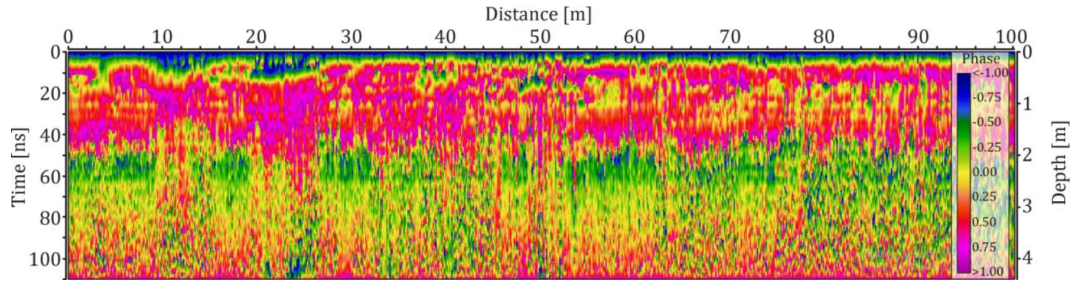

Figure 2. *Instantaneous frequency from envelope (20 - 26 m of profile – big anomaly).*

Conclusions

The article specifies the problem of creating a method of analyzing GPR signals aimed at detecting zones of looseness under the flood embankments. Methods of automatic recognition of elements of destruction restricting the strength of shafts were created.

References

Annan A.P., 1999. Practical Processing of GPR Data. Sensor and Software Inc., Canada.

Szymczyk P., Marcak H., Tomecka-Suchoń S., Szymczyk M., Gajer M., Gołębiowski T., 2014. Zaawansowane metody przetwarzania danych georadarowych oraz automatyczne rozpoznawanie anomalii w strukturach geologicznych. Elektronika: konstrukcje, technologie, zastosowania, 55/12, 56-61.

Szymczyk P., Tomecka-Suchoń S., Szymczyk M, 2015. Neural networks as a tool for georadar data processing. International Journal of Applied Mathematics and Computer Science, 25(4), 955-960.