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# Evaluation of Asphalt Pavement Using Ground Penetration Radar

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## ABSTRACT

This paper presents a status report on evaluation of the asphalt pavement using the ground penetration radar device (GPR) in one of the University of Technology streets about 92 m length. The technique of GPR is a nondestructive geophysical method that gives information about the thickness of asphalt pavement layers, existence of drainage pipes, rutting places and produces a continuous cross-sectional profile or record of subsurface features without drilling, probing, or digging.

Three samples of asphalt were taken from different places of the street. The thickness of asphalt layers were measured from these samples. One of the samples consists of two layers and the others of one layer.

Comparison of the two results of the thickness from the device and the sample indicate that there was very slight difference between them.

## تقييم التبليط الاسفلتي باستخدام تقنية رادار الاختراق الارضى

**الخلاصة**

هذا البحث يقدم تقريراً عن استخدام تقنية رادار الاختراق الارضي كوسيلة لتقييم التبليط الاسفلتي حيث قمنا باخذ مقطع من طريق طوله 92 متر في احد شوارع الجامعة التكنولوجية. تقنية الرادار الارضي هي طريقة جيوفيزيائية غير متلفة حيث انها تمكننا من الحصول على العديد من المعلومات منها سمك الطبقات للتبليط وكذلك وجود انابيب تصريف المياه والاماكن التي فيها هطول في الطبقات وكذلك انشاء مقطع عرضي وطولي مستمر للطريق من غير حدوث اضرار في سطح الطريق كالحفر.

وفي نفس المقطع قمنا بفحص الطريق من خلال اخذ ثلاث عينات اسفلتية في اماكن متفرقة من الطريق وقد تمكنا من معرفة سمك طبقات التبليط من هذه العينات وقد ظهر لدينا عينة واحدة تتكون

من طبقتين تبليط والعينات الاخرى تتكون من طبقة واحدة هذا يدل ان الطريق قد تعرض الى اعادة تبليط عن طريق اعادة اكساء من خلال وضع طبقة من مادة رابطة ومن ثم وضع طبقات التبليط.من خلال مقارنتنا لنتائج الفحصين الحقلي والنظري نجد هناك فرق بسيط جداً في قياس السمك مابين العينة والجهاز.

## OBJECTIVES

The main objectives of this research are:

Measurement of asphalt pavement layer thickness.

Identify to the debonding of bituminous layers.

Knowledge of the existence of the voids in the field asphalt layers.

Rutting measurement in the field asphalt layers.

Position of buried services such as pipes under the surface of the selected street.

## INTRODUCTION

The basic theory of GPR is that ultra high frequency radio waves (generally 10 MHz to 1,000 MHz) are transmitted into the ground through a transducer or antenna. The transmitted waves are then reflected from various buried objects or different materials (i.e. soil, pavement layers, water). An antenna then receives the reflected waves and stores them in the digital control unit. This process is known as electromagnetic wave propagation and scattering and it is used to image, locate and quantitatively identify changes in electrical and magnetic properties within the ground (Beres and Haeni, 1991; Daniels et. al., 1995).

The depth that GPR can be used varies from less than a meter to over 5,400 meters, depending upon material properties. Ground penetrating radar waves can reach depths up to 100 feet (30 meters) in low conductivity materials such as dry sand or granite (Do, 2003). Clays, shale, and other high conductivity materials, may attenuate or absorb GPR signals, greatly decreasing the depth of penetration to 3 feet (1 meter) or less. The sensitivity of detection of a subsurface feature depends upon contrast in electrical and magnetic properties, and the geometric relationship with the antenna. Once received, the data can be interpreted to derive information such as depth, orientation, size and shape of buried objects, density and water content of soils, and much more (Olhoeft, 2000; Beres and Haeni, 1991).

Existing pavement layer thickness measurement methods include coring and test pit excavations. These measurements are input to assess the stiffness (and/or strength) of the layered system, using falling-weight deflectometer (FWD). These direct methods are both time consuming and expensive. Furthermore, they only provide information at the test location, i.e., they are point measurements. In contrast, GPR surveys are much less time consuming and provide a continuous description of the road structure. Thus, determination of pavement layer thickness is one of the more successful applications of GPR. The American Society for Testing and Materials (ASTM) Standard D 4748-87 [ASTM Standard Designation: D4748-

87, 1987] presents detailed procedures for determining the thickness of pavements using GPR (Cao et al, 2007).

Aperio Limited have developed a systematic method of determining pavement construction information using GPR along with calibration data that has been used successfully on roads in Northern Europe to capture accurate and reliable data on pavement layer thicknesses (KOAC-WMD, 2004).

Many aspects of pavement engineering and road management require accurate information on pavement layer thicknesses (Maser et al, 1993). Mechanistic analysis techniques require pavement layer thickness data for input to be able to model pavement performance. Pavement thickness measurements are also required for quality control purposes during mill and/or overlay rehabilitation projects. Furthermore, layer thicknesses represent an important element of a Pavement Management System (PMS) database and are needed for load rating and overlay designs (Hartman et al, 2004).

Traditionally, pavement layer thicknesses have been determined by digging testpits or machining cores from the pavement (Irwin et al, 1994). Layer thicknesses have also been determined using Dynamic Cone Penetrometer (DCP) measurements but difficulties to distinguish interfaces between base and subbase layers and penetration refusal through stabilized layers have limited DCP use to weak pavement structures. These procedures are not only time consuming and expensive but also result in major traffic disruptions. Also, depending on the test intervals, uncertainty remains regarding the variation in thicknesses between test points.

It has been reported (HD 29/94, 2001) that an under estimate of as little as 15% in layer thickness, which is not uncommon given road construction tolerances, can result in an overestimation of over 50% in back calculated layer stiffness values. According to Jooste et al (1998) back calculation results for thin stiff layers are particularly sensitive to small variations in layer thicknesses. Accurate layer thickness data is thus required at deflection test positions to ensure adequate modeling of the pavement structure and rehabilitation requirements.

For a number of years ground penetrating radar has been implemented for the evaluation of subsurface condition of transportation facilities (Maser, 1994; Morey, 1998; Lahouar et al, 2002; Shin and Grivas, 2003). The literature suggests that this method of measurement is able to capture accurate layer thickness data at short intervals and at relatively high traffic speeds.

Al-Qadi et al 2011 have been used ground penetrating radar (GPR) to measure in-situ asphalt mixture density accurately, continuously, and rapidly. It was found that the prediction accuracy of the GPR was better than that of the traditional nuclear gauge. For the asphalt mixtures without slags, the average density prediction errors of GPR were between 0.5% and 1.1% with two calibration cores, while those of the nuclear gauge were between 1.2% and 3.1%.

## DATA COLLECTION AND ANALYSIS

Ground penetration radar technique was used in the evaluation of the asphalt pavement in one of the University of Technology streets and measurement of the thickness of the asphalt layers. Also core samples device was used in order to take samples from the selected street. Figure (1) represents the selected street. Figure (2) represents longitudinal section of the selected street using GPR device.

Three core samples were taken from the selected location. The first sample was 3 m far from the beginning of the street. The second sample was 5 m far from the beginning of the street and the third one was 7 m far.

The street was surveyed transversely using the GPR device as illustrated in Figures (7 through 13). Figure (7) illustrates that the old asphalt layer has been distorted and rehabilitated with a new asphalt layer; sample No.1 was taken in this section as in Figure (4). The thickness of the asphalt layer from core device was 4.9 cm whereas the thickness was 5 cm from the GPR device.

The second sample thickness of the asphalt layer was 10 cm from the GPR device whereas from the core device was 9.6 cm. The third sample thickness of asphalt layer was 5 cm from the GPR device and 4.4 cm from the core device.

Figure (8) illustrates the transverse section No.2 using GPR device. In this figure the new rehabilitated layer represented in a prominent dark black line and its thickness was approximately 10 cm. whereas the underneath layer it is clear that the deformation was symmetric across the layer because of the existence of drainage pipe. The deformation in transverse section No.4 in Figure (10) was also symmetric because of the existence of drainage pipe.

Figure (9) illustrates the third transverse section using GPR device. In this figure the new rehabilitated layer represented in a prominent dark black line and its thickness was approximately 5 cm. whereas the underneath layer it is clear that the deformation was unsymmetrical across the layer because the distortion was in the layer. The deformation in transverse sections in Figures (11, 12 and 13) was also unsymmetrical because the distortion was in the layer itself.

The GPR method is effective in the measurement of the thickness of the new asphalt layers and the old underneath layers. The method was also effective in specifying the distortion location in the new and old layer without surface distortion and measuring the rutting thickness. The core sample method was effective in measuring the thickness of the new and old asphalt layers with the existence of surface distortion and refills the holes.

## CONCLUSIONS

From this paper the following conclusions are drawn:

The GPR method is fast, non-destructive and has high accuracy.GPR has the potential to be used for a variety of pavement applications, including:

Measuring the thickness of asphalt pavement, base and sub-grade.Assisting in the analysis of rutting mechanisms.

Calculating and verifying material properties.

Locating subsurface objects.
Detecting stripping and/or layer separation.
Detecting subsurface moisture; andGPR works best for near-surface; dry surface conditions where the dielectric contrast is greatest, and conversely does not work well in wet surface conditions where the dielectric contrast is negligible.
GPR provides 100 percent pavement coverage at a small fraction of the cost of taking conventional core samples.GPR minimizes the exposure of highway workers to dangerous situations.GPR pavement thickness data are accurate to within 5.5 percent of data obtained through conventional core samples.
Ability of collecting field data in order to obtain a factor combined the lab work with field.

## RECOMMENDATIONS

The GPR method saving time in collecting data it is recommended to use it in the practical work.
It is recommended to use the GPR method in the pavement and foundation survey works because it is more economic than other devices.

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**Figure (1) Selected Street in the University of Technology.**

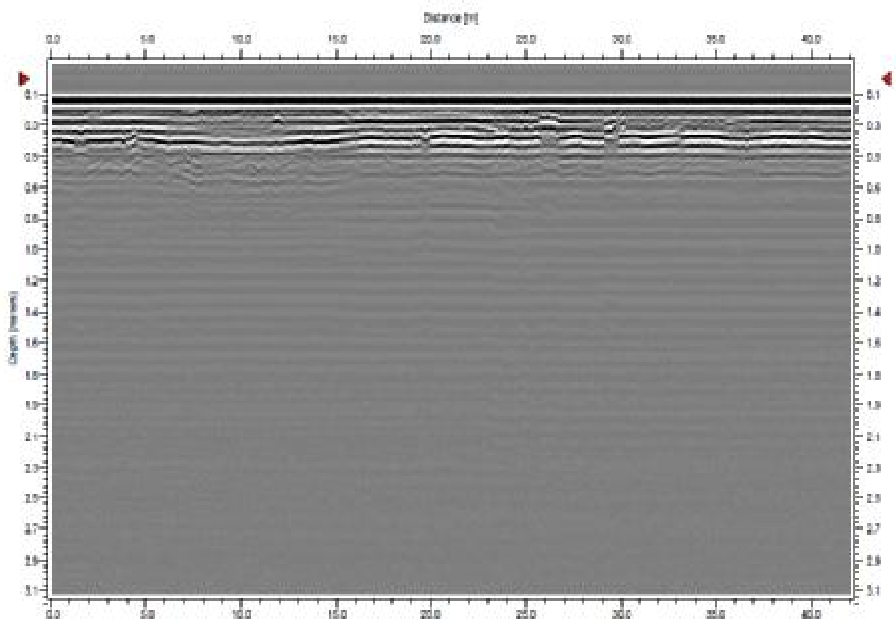


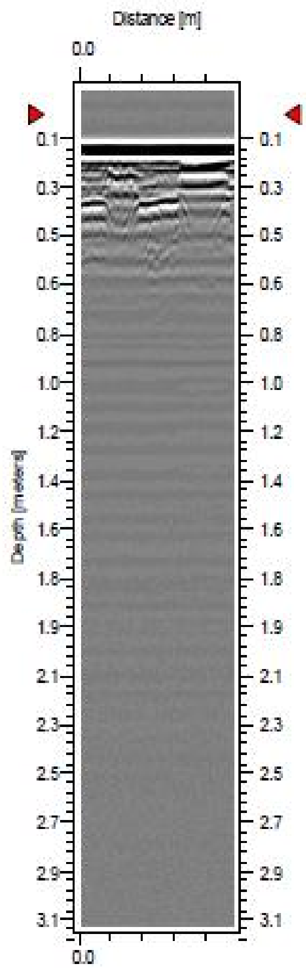

**Figure (2) Longitudinal Section of the Street Using GPR Device.**

**Figure (3) The Street After Coring**.

**Figure (4) Sample No.1**

**Figure (5) Sample No.2.**

**Figure (6) Sample No.3.**



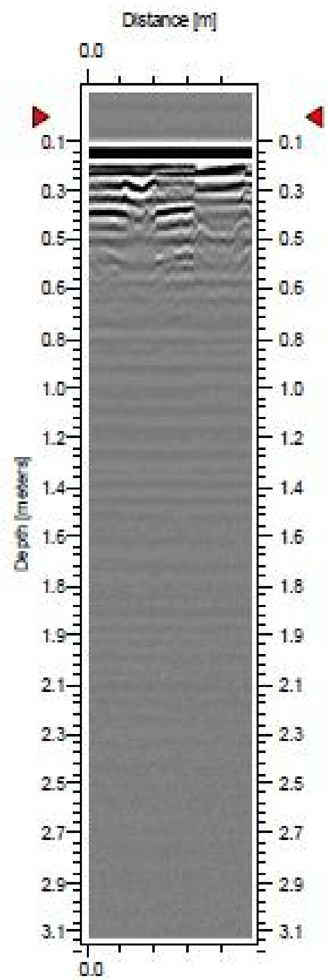




**Figure (7) Transverse Section No.1 Using GPR Device.**

**Figure (8) Transverse Section No.2 Using GPR Device.**

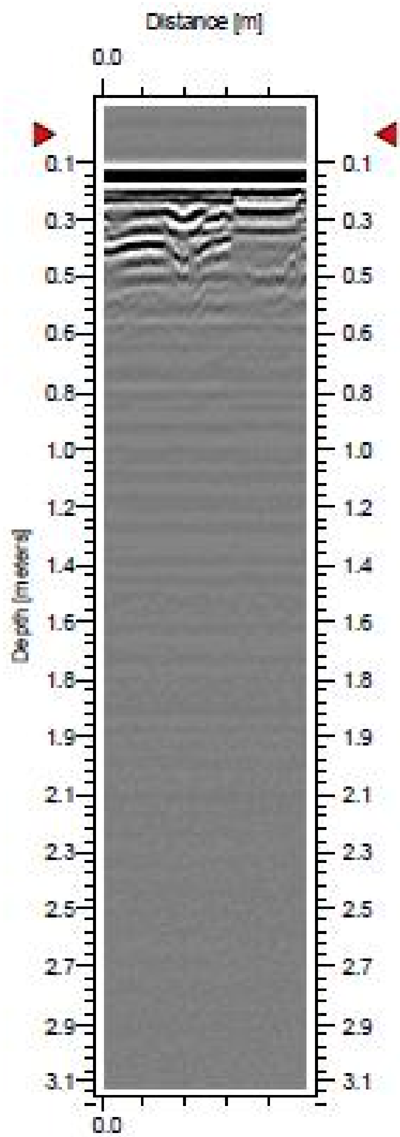



**Figure (9) Transverse Section No.3 Using GPR Device.**

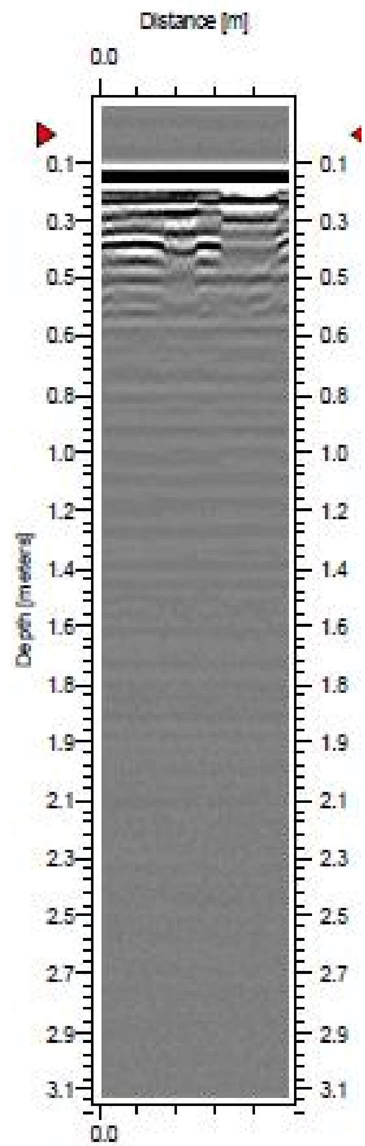



**Figure (10) Transverse Section No.4Using GPR Device.**

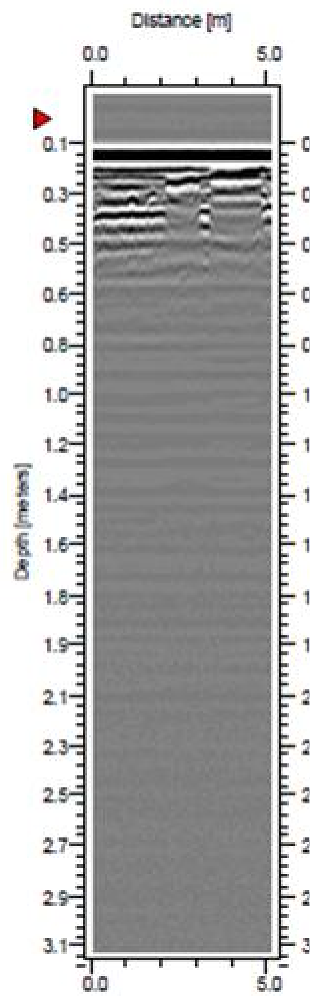



**Figure (11) Transverse Section No.5 Using GPR Device.**

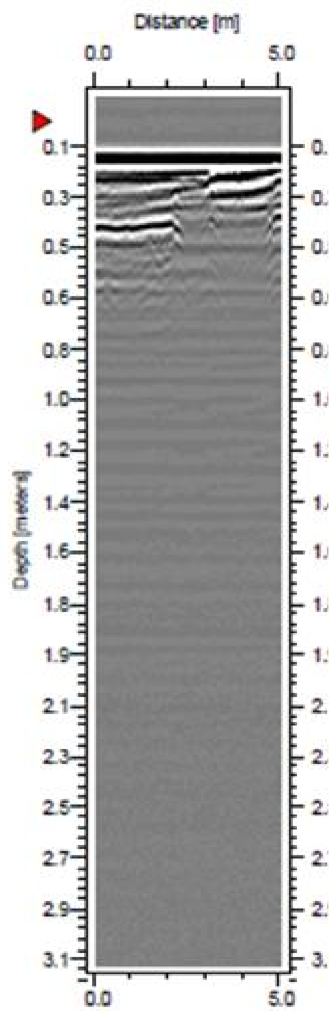



**Figure (12) Transverse Section No.6 Using GPR Device.**

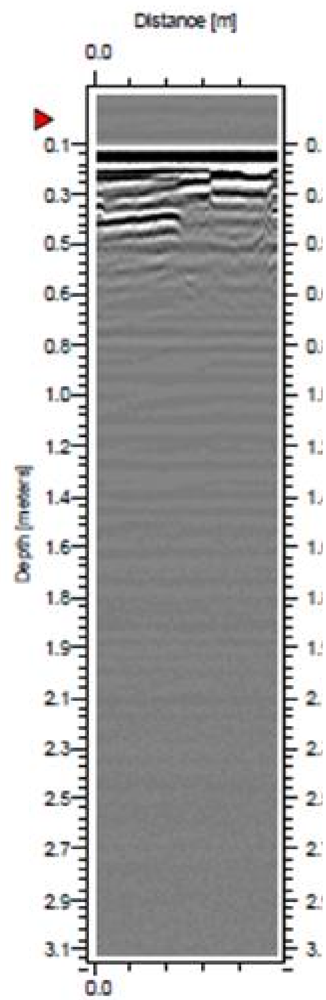



**Figure (13) Transverse Section No.7 Using GPR Device.**