PREPARATION OF TEMPLATES FOR UNDERGROUND UTILITY MAPPING USING GROUND PENETRATING RADAR SYSTEM

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Abstract: This paper discusses on Preparation of templates for underground utility mapping using ground penetrating radar (GPR) system for Indian soil conditions. Ground-penetrating radar (GPR) has been used for several years as a non-destructive method of locating subsurface anomalies. For a long time, there are so many baffling problems for GPR, such as to distinguish multiple pipes which are close together, to detect the material and diameter size of the pipe, the detection of small diameter non-metallic pipelines. Through analyzing radar images, the materials of the detected pipes and the materials inside the pipes can be distinguished and the diameters of non-metallic pipes can be calculated using the spacing of the intervals of radar reflected waves. In this paper, the history of GPR and methods used in GPR surveys are first discussed. Next, the Procedures to obtain, process, visualize, and interpret GPR data is discussed.. Research study is based on the components of GPR system and its principles. A study of RADAN software is performed to process the GPR data of a pre-determined survey site in VJTI-Mumbai campus for the determination of various metallic and non-metallic utility pipes using the utility scan module of GPR system. Obtained results taken up for preparation of standard template for mapping to enhance accuracy of the material and diameter detection which is of utmost important to avoid the damage of existing utilities and safety of the personnel.

Keywords: Ground Penetrating Radar (GPR) Utility scan, non destructive

1.INTRODUCTION

The ground penetrating radar GPR method, originally used for geophysical surveys such as sub-grade investigations, is a very effective technique for investigating the integrity of concrete structures. Recent developments in the area of Science and Technology have provided powerful tools such as Geographical Information System (GIS), Global Positioning System (GPS), Remote Sensing and Geophysics (including Ground Penetrating Radar).One of the most useful application of GPR in urban infrastructural engineering is mapping and detection of buried pipes. This unique application becomes imperative due to the ever growing urbanization in both developed and developing nations with its attendant demand for buried utilities.

2.OUTLINE OF WORK

To Preparation templates for underground utility mapping with Ground penetrating Radar (GPR) system and use it for locating & mapping underground utilities. To study GPR system software (RADAN) for Project and taking survey area for doing sample determination of various underground utility by using Utility scan GPR system. Collection and storing of entire scanned data followed by data analysis and processing to be performed. Preparation of standard templates from obtained results.

3.EXPERIMENTAL STUDY

3.1Principle

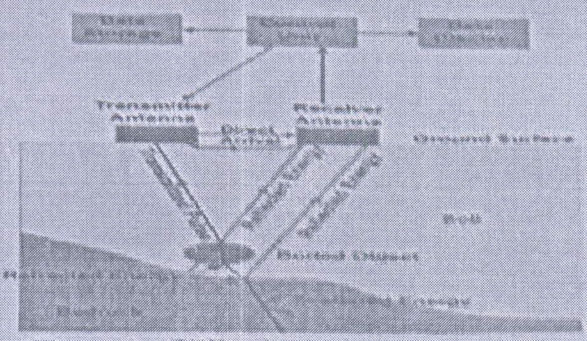

Figure 1 : GPR schematic

GPR is based on propagation of short electromagnetic impulses having a pulse duration

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of less than 1 ns ($1 * 10^{-9}$) sec. The emitted pulses are reflected at in homogeneities in the material. Propagation velocity of the pulses and the intensity of reflections are a function of dielectric properties of the material. Unger 1996 has defined complex permittivity of the materials E as:

$$E = E' - i E'' \qquad (1)$$

Where, E = Complex Permittivity, E''= Imaginary part of Complex Permittivity,

E' = Real Part of complex permittivity.

For materials with very low electric conductivity such as concrete and masonry in dry

condition, the imaginary part E'' can be neglected. Then by approximation, the relationship

between propagation velocity v between the electromagnetic impulses and the permittivity E can be established (Unger , 1996). This relationship is expressed as follows;

$$v = c / E^{(1*2)} \qquad (2)$$

Where v = propagation velocity of electromagnetic impulse

c = speed of light in vacuum ($3 * 10^8$)

If the permittivity of the material under investigation is known, the depth of the reflectors, and thus their position, can be determined from the propagation time (Christiane Maierhofer'). The fact that the permittivity is influenced by the following parameters must be taken into account- Temperature of material; Moisture content of material; Salt content of material (only dissolved salt ions are important); Pore structure; Pulse frequency (Christiane Maierhofer').

4.CASE STUDY

Introduction: Detailed Experimental Work

A detailed experimental study performed of underground utility using utility scan module of GPR system in two phases, Based on Known and Unknown information. The known information about utility pipes in the phase 1 is explained which is performed in VJTI Campus behind civil engineering department and the phase 2 consisting of unknown information about the utility pipe being performed outside the VJTI premises on road in front of the main gate.

4.1 Experimental Study: Phase 1

4.1.1 Introduction:

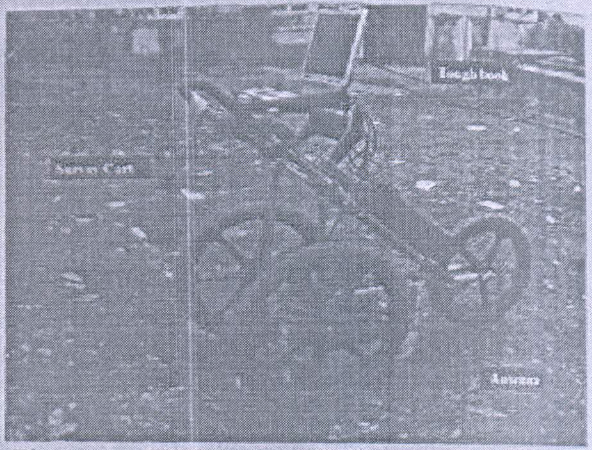

Figure 1 : Utility scan GPR

- Location: Behind civil engineering department V.J.T.I.
- Area: 1.5mx5m
- Depth: 0.3m
- Type of utility: PVC, CI, CEMENT
- Grid specifications: Spacing: 0.5m

No of profile line along x-direction: 4

- No of profile line along y-direction: 11
- Dielectric constant: 5 (as survey was carried out over soft murum soil)

4.1.2 Equipment used:

The study is conducted using GSSI's Ground Penetrating Radar Utility scan module. Antenna used-ground coupled 400MHz. Control unit-SIR 20. Data processing software-RADAN6.5

4.1.3 PROCEDURE

- Locate the site of required size.
- Draw the grid of 1.5mx5m of spacing 0.5m.

- Excavate AA' - BB' - CC', EE' - FF' - GG', II' - JJ' - KK' upto 0.3m depth.
- Pipes were inserted according to the following table:
- After backfilling, the grid was redrawn by taking 4 profile line in X-Direction and 11 profile line in Y-direction with 0.5m spacing shown in (Fig.3.2.c)

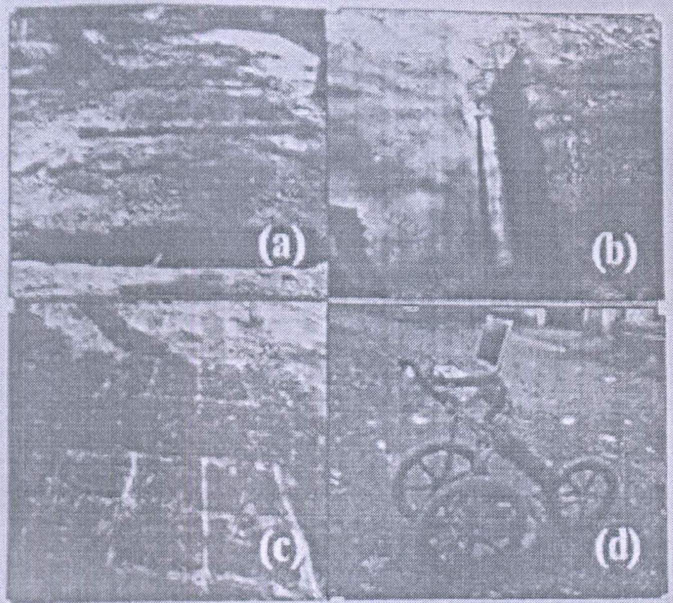

Figure 2: Experimental Procedure(a, b, c, d)

Table No.1: Phase 1 survey Details

SR.NO.	TYPE OF PIPE	DIAMETER OF PIPE	LENGTH OF PIPE	LOCATION
1	PVC	13cm	2m	AA'- BB'- CC'
2	CI	9.5cm	1.62m	EE'- FF'- GG'
3	CEMENT	10cm	1.7m	II'- JJ'- KK'

- Profile lines along X-direction was marked as 0-3 and those in Y-direction as A-K.
- Simultaneously, the position, origin and the pipe is mapped by considering suitable benchmark
- The survey was carried out in unidirectional mode to form the grids
- All the data was collected in 2-D format
- All the profiles were collected in both X and Y direction and then the processing were done to find out the closest approximate location of utilities
- After laying the pipes according to the above mentioned procedure, Data is acquired with the help of RADAN software by means of GPR Utility Scan Module with antenna SIR 20 (Fig No. 3.2.d)
- The entire acquired data was collected and stored in Toughbook with SIR 20. Data analysis and processing was done using GSSI's RADAN software 6.5 version. When scans are collected one gets a number of 2-dimensional profiles for scanned work area which represents the location of pipes underground in the form of hyperbolas (Fig- No.3.3)
- After performing a 2D analysis, 3D processing is carried out to locate underground utilities as 3D mode is the best option to get X,Y and Z dimensions of any utilities.

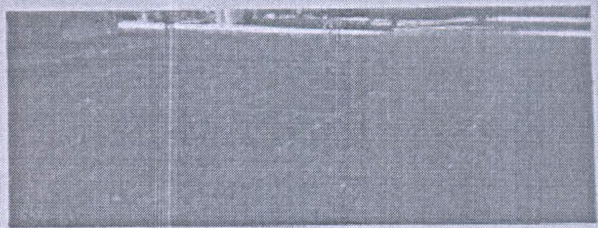

Figure 3 : Phase 1 Results in 2D and 3D images after Processing in RADAN software

4.2: Experimental Work: Phase 2

4.2.1: Introduction:

- Location: V.J.T.I Main Gate Road.
- Area: 3mx3m
- Depth: Unknown
- Type of utility: Unknown
- Grid specifications:
- Spacing: 1m
- No of profile line along x-direction:4
- No of profile line along y-direction:4
- Dielectric constant: 5 (as survey was carried out over soft murums soil)

Figure 4 : Utility scan GPR

4.2.2:Equipment used:

The study is conducted using GSSI's Ground Penetrating Radar Utility scan module. Antenna used-ground coupled 400MHz. Control unit-SIR 20. Data processing software-RADAN 6.5

4.2.3 Procedure:

- The site of required size was located.

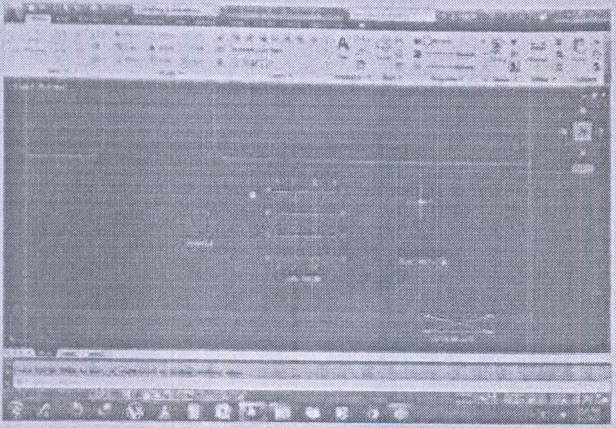

Figure 5: Site Map(VJTI Main Gate Road)

- Grid drawn by the following procedure:

a. Profile lines in X-Direction and 4profile lines in Y-direction were selected with 1m spacing.

b. Profile lines along X-direction were marked as 0-3 and those in Y-direction as A-D

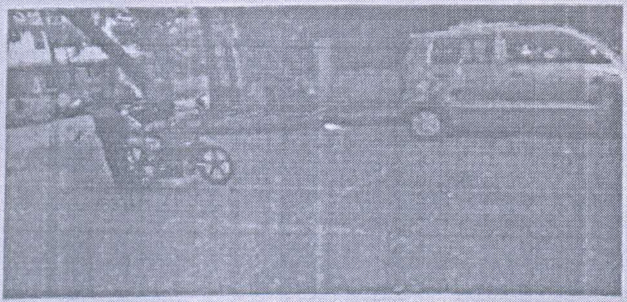

Figure 6: Grid drawing of Site map

- The survey was carried out in unidirectional mode to form the grids.

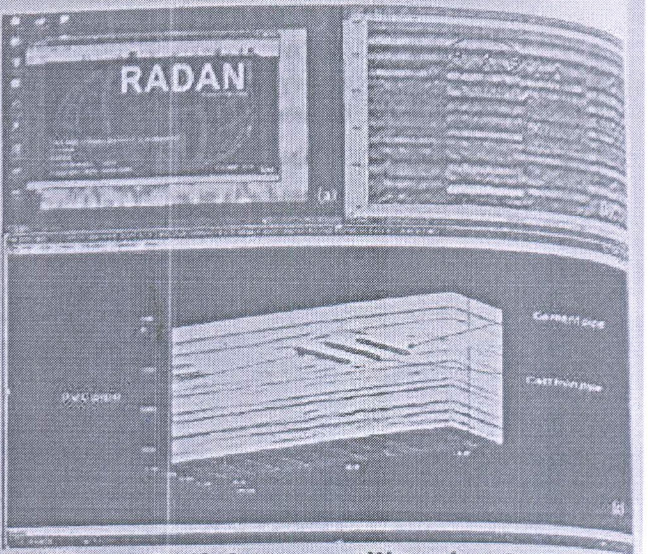

Figure 7: Unknown utility pipe data Collection using Utility scan Module

- All the data was collected in 2-D format .
- All the profiles were collected in both X and Y direction and then the processing was done to find out the closest approximate location of utilities
- The entire acquired data was collected and stored in Toughbook with SIR 20. Data analysis and processing was done using GSSI's RADAN software 6.5 version. When scans are collected one gets a number of 2-dimensional profiles for scanned work area which represents the location of pipes underground in the form of hyperbolas (Figure 8)

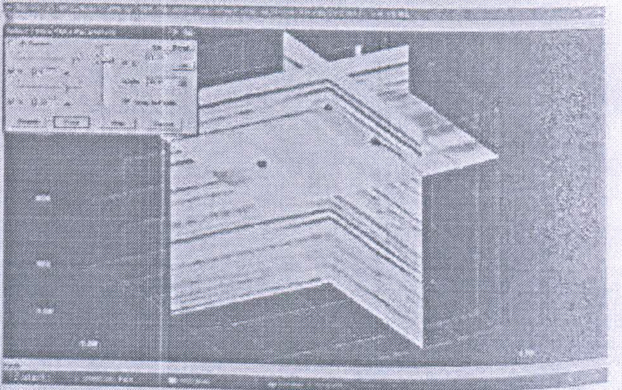

Figure 8: Impression of Hyperbola after 2D Processing

- After performing a 2D analysis, 3D processing is carried out to locate underground utilities as 3D mode is the best option to get X,Y and Z dimensions of any utilities.

- Better Accuracy: Achieving 10 to 15cm accuracy on utility feature locations, with the help of GPR system, not only helps in preventing damage to other utilities while excavating but also helps in finding features like valve boxes and manholes that are covered in deep snow during the winter season.
- Better Analysis and Time Savings: Data in GIS format facilitates better analysis of utility networks for capacity planning and capital improvement projects. Planning Committee group is greatly benefited by having the latest utility information for decision making on new facilities.

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