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CONCRETE FLOOR INSPECTION WITH HELP OF SUBSURFACE RADAR

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ABSTRACT

The purpose of our investigation is to develop sounding radar for non-destructive inspection of buildings and structures designed for different uses, which can obtain high resolution radio-images representing the interior structure, objects and heterogeneities in load bearing and protecting construction. Our primary goal is to resolve problems dealing with the determination of strength of structures in service, repair and renovation of buildings.

Key words: Multi-frequency subsurface radar, Concrete floor, Plastic tube

INTRODUCTION

The necessity for detecting concealed details and hollow access areas in different parts of structures frequently arises during construction work on repair and renovation of buildings. Metal detectors are traditionally used to detect metal construction materials. However, the necessity to detect dielectric objects such as plastic tubes, technological access spaces, etc. is also of great importance.

The most sensitive method, which gives information about the interior structure of a building, is based on utilizing X-ray techniques. X-ray tomography has been lately used for this purpose. However, the necessity for a bilateral approach to an object (when the source of radiation and the detector should be placed on different sides of a sounded structure) and the potential danger of exposing the personnel operating the unit to the radiation are the primary drawbacks of the X-ray method. Very frequently, the requirement for a bilateral approach to a structure under investigation cannot be realized. The sounding of roadway and airstrip covering can serve as an example. It is also worth noting that X-ray tomographs are very expensive.

The radar sounding method is a technique that opens new possibilities. But up till now, this method did not have a sufficiently wide application in the sounding of building structures. The idea is based on the property of radio waves to reflect from medium or object interfaces with different permittivity e'. Media such as metal, water (or objects with increased humidity), dielectric materials with different values of e' as well as hollows have a contrast that causes reflection of an incident electromagnetic wave from the layer interfaces.

Generally, the peculiarity of sounding building structures as well as the roadway and airstrip covering consists a relatively small depth of sounding (0.2 - 0.5 m) and a relatively smooth outward surface of the structure under investigation. Furthermore, the humidity of sounded media in this case varies within more narrow limits than sounding the ground, i.e., the properties of construction materials are more predictable. All this makes it possible to employ the sounding of building structures and airstrip covering not only classical subsurface radars with impulse signals (Carter et al., 1992; Papaioannou, Papamarinopoulos and Stefanopoulos, 1996; Davidson and Chase, 1998), but the radar with a continuous multi-frequency signal (Vasiliev et al., 1998), which despite its simplicity has high efficiency.

In comparison with impulse GPR sounding of building structures, the main advantages of the continuous wave radar proposed are the following:

- The possibility to obtain structure images with high resolution in the plane of sounding
- The simplicity of equipment realization and low cost

MULTIFREQUENCY SUBSURFACE RADAR

A mock-up of the MiRascan subsurface sounding radar (Ivashov et al., 1999) was developed with the chief purpose to detect the antipersonnel and antitank mines in the ground during humanitarian mine clearing. This radar allows the detection of near-surface (up to 20 cm) objects and identification of their shape. Another application of this device would be the sounding of a concrete floor of a building.

The radar design is based on the principle of a multi-frequency sounding of condensed media (such as building structures, grounds, etc.). This is radar operating by reflection, i.e., the transmitting and receiving antennae are located on one side of the sounded surface. The radar range of frequencies varies from 1.5 to 2.0 GHz. The device uses an electromechanical scanning method with remote control to drive the antenna and cart. The input of information into a computer from the radar was realized by means of a special interface connected to the parallel port. In this case the computer itself does not need any modification. The radar driver must be loaded into the computer. The information is displayed in real time on the computer monitor as a grayscale image, where a certain gradation of brightness corresponds to a certain level of the signal received. A more detailed description of MiRascan radar will be presented at this Conference by Ivashov et al., (2000). Figure 1 shows the sounding of a concrete floor using an experimental MiRascan unit.

EXPERIMANTAL RESULTS

The MiRascan radar mounted on a three-wheel chassis was used to examine the concrete floor of a Moscow home when it was prepared for covering with parquet. The purpose of the examination was to precisely determine the location of plastic tubes positioned under the cement floor covering in its claydite coating at a depth of 5-10 cm. The tubes were used to supply hot water to heating radiators placed on the walls of the building. A cut of the plastic tube is shown in Figure 2. A drawing of the tube location was given to repair workers to avoid damaging the plastic tubes while mounting the underlying surface of the parquet floor.

Four rooms with an area of approximately 30-40 m^2 each, a kitchen and a hall with an area of 70 m^2 were examined. Inaccessible areas (such as narrow corridors, corners, doorways) were examined with the help of a separate antenna system, which was moved manually. In this case, the tube location was determined by co-ordinate rules laid on the surface under investigation.

In order to obtain a high efficiency, the examination was carried out with the help of a chassis moved by electric motors in rooms with large areas. The location of tubes was determined relative to the radar antenna by a local co-ordinate system. The position of the tubes was marked in chalk on the floor surface as the radar was moved along the investigated route (see Figure 3).

To document the results of investigation, the images of tubes obtained on the radar display were recorded in files. The utilization of multi-frequency sounding in every case makes it possible to select the most suitable frequency, where the object under investigation has the highest contrast. Figure 4 presents a pattern of location of plastic tubes at one of such frequencies in the largest room. The routes of tube location in the form of dashed lines can be seen clearly in the picture. The variation in contrast along the lines is explained by the variation in the depth of their laying. The examination of the rooms with total area of 300 m^2 was accomplished in six hours. In this case 30 routes of tubes with the total length of 200 m were identified.

CONCLUSION

The results presented allow us to address the potential of subsurface radar sounding when buildings and structures are repaired and reconstructed. The main advantages of using subsurface radar is the use of non-destructive control, which is of prime importance for restoring unique structures and historical monuments, as well as its relatively low cost and high efficiency of work.

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Figure 1: MiRascan radar at work.

Figure 2: A cut of the plastic tube.

Figure 3: The position of tubes was marked in chalk on the floor surface.

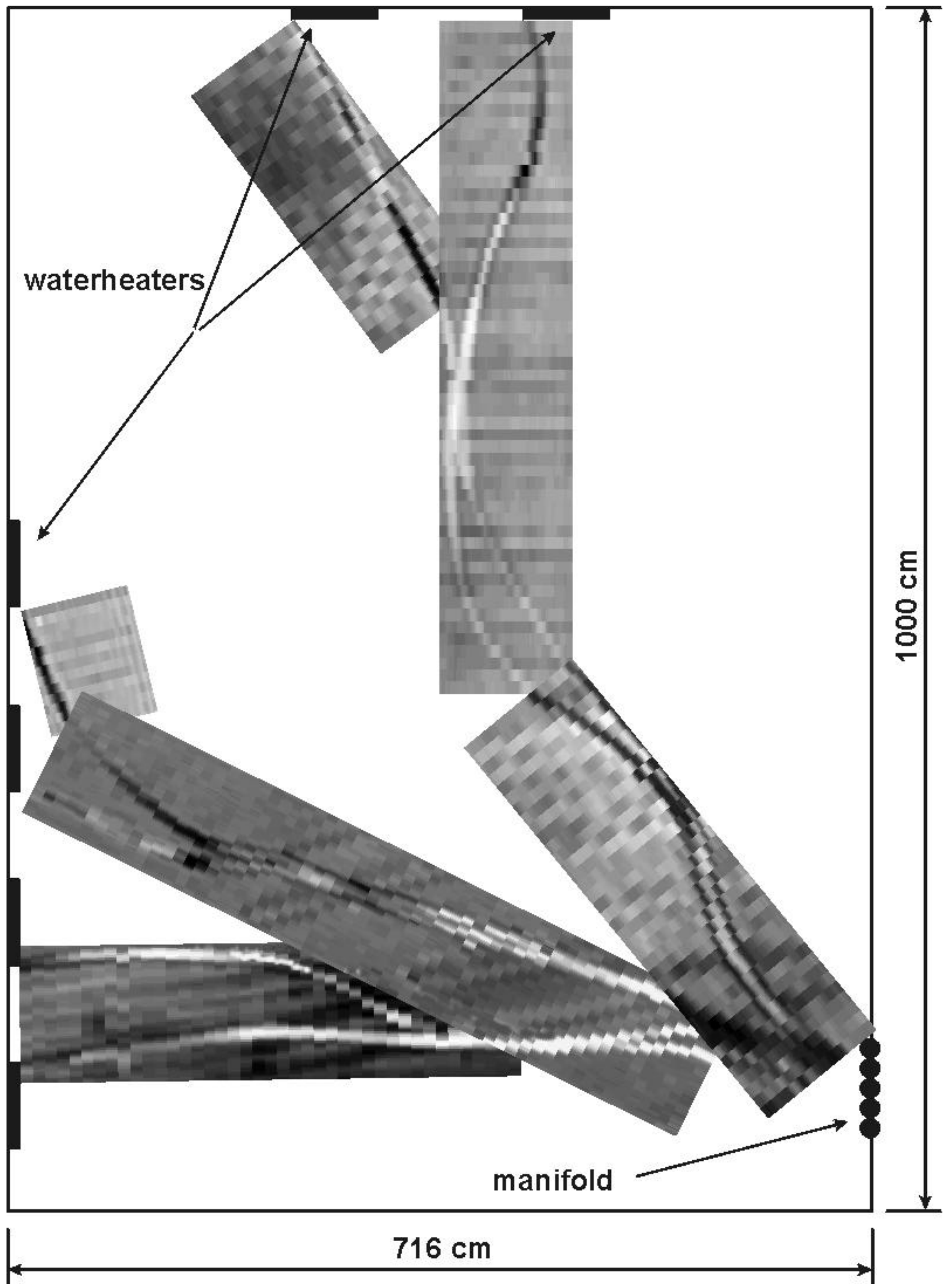

Figure 4: Radio-image of plastic tubes under a concrete floor covering.