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Non-Destructive Test of Concrete Structures Using: FERROSCAN

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Abstract

The non-destructive testing (NDT) industry is reviewed, the major techniques being described and current development directions and challenges identified. One of the most common techniques (ferroscan) is explained briefly below.

Ferroscan is a non-destructive measuring method based on the generation and detection of electromagnetic fields in conductive materials. In concrete structures, the strength of this induced field depends on the diameter and the cover of the reinforcement. The techniques has been shown to find location and orientation of reinforcement bars, stirrup, or other metal pipe, in the concrete, measure thickness of concrete cover over reinforcement bar, and to determine the bar diameter.

In this paper Ferroscan FS 10, a portable detection, was used for measuring and mapping system which provides an immediate liquid crystal image of the reinforcement within a survey area which include reinforcement concrete beam (1000*200*120)mm.

The great advantage of measurements with ferroscan, compared to existing detection systems, is that the measurements can be carried out far quicker and more accurately, accurate mapping out of reinforcement and verification of reinforcement in old building.

Keywords: Nondestructive test, ferroscan, reinforcement beam structure.

الفحص الغير تدميري للخرسانه المسلحه بأستخدام جهاز :Ferroscan

الخلاصه

يعتبر الفحص الغير تدميري من الفحوصات الاساسية التي تستخدم في المجال الانشائي والصناعة . احد التقنيات الشائعة الاستعمال للفحص الغير تدميري هو جهاز (Ferroscan) والذي يعتمد مبدء عمله على توليد حقل كهرومغناطيسي بين الجهاز والمادة الموصلة ومن ثم الكشف عن المادة الموصلة.في مجال الخرسانة المسلحه يقوم جهاز (Ferroscan) بالاعتماد على الحقل الكهرومغناطيسي الذي يولده بالكشف عن حديد التسليح (قطر حديد التسليح المستخدم و سمك طبقة الخرسانة التي تغطي حديد التسليح .

في هذا البحث تم استخدام جهاز (Ferroscan) لتحديد موقع وقطر حديد التسليح لنموذج من الخرسانة المسلحه بأبعاد (1000*200*120)ملم وقياس سمك طبقة الخرسانة التي تغطي حديد التسليح للنموذج ، كذلك يزودنا الجهاز صورة كرستالية عن توزيع حديد التسليح في النموذج.

الفائدة الاساسية للفحص الغير تدميري تتلخص يكون الفحوصات تكون اسرع واكثر دقة واقل كلفة من الفحوصات التقليديه الاخرى ، كذلك يفيدنا جهاز (Ferroscan) لفحوصات حديد التسليح التي تجري للابنية القديمة .

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Introduction

At present, the usual way to inspect and diagnose facilities with high precision is to perform strength testing and material analysis on samples removed from an existing facility. This method, by definition, consumes part of an existing facility, so it is difficult to apply it to the entire structure of an aged existing facility. Furthermore, in large-scale facilities like tunnels, the conditions often vary with the measurement position, so it is difficult to evaluate the condition of the whole facility from local measurements. On the other hand, non-destructive testing evaluates the condition of a structure without damaging it, so it has two advantages: it can be applied to the whole of a large-scale structure and can efficiently evaluate the degradation condition of that structure. Likewise, in the case of concrete structures, it is important to take effective action at the stage before visible degradation of the concrete occurs. If highprecision facility evaluation by non-destructive testing were available, it would be possible to continue operating and maintaining existing facilities for a long time[4] .

Non-destructive testing can be applied to both old and new structures, for new structures the principal applications are likely to be for quality control old structures- renovation purposes.

1. 1 Typical Applications of Non-destructive test[7]

1. For quality control of pre-cast units and construction in situ.
2. The workmanship involved in hatching, mixing, placing, compacting or curing of concrete.
3. Monitoring of strength development.
4. Location and determination of the extent of cracks, voids, etc.
5. Determine the position, quantity or condition of reinforcement.
6. Increasing the confidence level of a smaller number of destructive tests.

2.2 Non-destructive Methods

In the case of non-Destructive testing on concrete structures, various techniques can be applied:[6]

1. Visual Inspection
2. Schmidt rebound hammer test
3. Resistivity measurement
4. Radiographic testing
5. Pulsevelocity test
6. Ferroscan
7. Impact echo
8. Ground penetration radar
9. The Ultrasonic shear wave test method

2.3 Ferroscan

One of the most common techniques (ferroscan) is explained briefly below.

Ferroscan is a non-destructive measuring method based on the generation and detection of magnetic fields in conductive materials. In concrete structures, the strength of this induced field depends on the diameter and the cover of the reinforcement. Following detection of this induced magnetic field, the following characteristics can be determined for concrete structures[4]:

- Amount and location of reinforcement
- Reinforcement diameter
- Cover
- Accurate mapping out of reinforcement
- Verification of reinforcement in old buildings

The Ferroscan as shown in figure (1) can locate ferrous materials(i.e. structural steel such as re-bar and post-tension cables) in concrete to an effective depth of 150 mm or 6 inches, this instrument can give a good approximation of the depth of an object as long as it is within the top 100 mm of concrete. The diameter of re-bar or cable can be ascertained accurately within the top 50 mm. Metal conduit can also be detected as long as it is near the surface and there is not too much interference from structural steel. The display may be undertaken using either of two main modes of operation:

Quickscans

In the Quickscan mode, the data recorded includes the position and cover to reinforcing bars that cross the direction of the scan. Scans can be of up to 30 m in length.

Image Scan

Image scans produce a full image of the reinforcement within the scanned area.

The data gathered can be used to supply the following information:-

1- arrangement and position of reinforcement
2- depth of cover
3- indicative bar diameter

The images may be evaluated by viewing transverse and longitudinal sections, layers at different depths or by producing statistical information. All scanned data can be downloaded onto a personal computer for further analysis [3], interpretation and printed output.

2. Methodology and Results

The principle of operation of ferroscan techniques is (electromagnetic surveys),

Most electromagnetic (EM) systems employ an active transmitter so that the source geometry and wave frequency (or the transient pulse duration) can be controlled during the field operations [1].

The main function of the artificial field electromagnetic (EM) methods is the detection of bodies of high electrical conductivity. Most favorable targets are: environmental, geotechnical, structural problems, underground pipes and cables, delineating faults, shear and thin conducting veins and groundwater studies.

The major advantage of these methods over the electrical resistivity methods is that they do not require conductive ground connections, and many systems can be used from aircraft.

Following are the basic equations for the propagation of electric and magnetic field vectors in an isotropic, homogeneous medium with physical properties[8].

Electric conductivity is defined as the reciprocal of resistivity. By using these relationships we can reduce Maxwell s equations in terms of only two vectors E &H. the vertical equations for E and H are

$$\Delta^2 E = I\,\omega\mu\sigma E - €\mu\omega^2 E \quad \text{........(1)}$$

$$\Delta^2 H = I\,\omega\mu\sigma H - €\mu\omega^2 H \quad \text{.......(2)}$$

Where I $\omega\mu\Sigma e$= conduction currents

$€\mu\omega^2 H$= displacement currents, where $I = \sqrt{(-1)}$

There are three relationships connecting these field vectors:

D=€E

B=μH

I=σe

Where:

I= the electric current (A/m^2)

€=the dielectric permittivity (F/m)

μ=magnetic permeability (H/m)

σ=electric conductivity(S/m)of the medium.

These are basic equations for the propagation of electric and magnetic field vectors in an isotropic, homogenous-medium with physical properties €,μ and σ. The terms in above equations involving (I ω μ σ) are related to the conduction currents, whereas the terms involving (€μ ω^2) are related to the displacement currents. The rock properties ((€,μ and σ) and angular frequency ω (where ω=2πf) can be grouped into one terms K^2 given by

The quantity

$$K = \sqrt{(= €\mu\,\omega^2 - I\,\omega\,\mu\,\sigma)} \quad \text{.....(3)}$$

is called the "complex wave number "or the "propagation parameter".

3. Experimental Method and apparatus

In this research, one sample used for test by the ferroscan FS10 technique as shown in figure (2).

The dimensions of samples was (1000x200x120)mm, rectangular reinforced concrete beam. The details of reinforcement as shown in figure (5).

The reading which obtained from ferrroscan FS10 transferred to Ferroscan PC Software which is an application that permits data to be transferred from the Ferroscan RV 10 monitor to a personal computer for further processing or evaluation. Where two methods of surveying have been adapted,

First -Quick Scan

Quickscan mode is used to rapidly locate reinforcing bars and to check theminimum depth of coverage. So the number of reinforcing bars perpendicular to the direction of the scan, their location and depth of coverage as well as the length of the scan is recorded. Figure (3) shows diameter of reinforcing bars in the top (10mm) and depth of concrete cover.

Second- Image Scan

An area of (1000 x 200) mm is scanned in a series of perpendicular paths. The monitor uses this data to produce a graphical representation of the reinforcement in the concrete. The depth of coverage and diameter of the reinforcing bars can then be determined. As shown in figure (4).

4. Conclusions

- The development of a wide variety of nondestructive testing methods has provided engineers with numerous possibilities for evaluating structures.
- The engineer faces the challenge of dealing with hundreds to many thousands of possible test locations.
- Time and cost constraints work to limit the test number to minimum while the desire to accurately assess the state of the structure argues for the maximum number of tests.
- The methods described provide fast and accurate tools for quality- control and diagnosis of infrastructure, industrial and civil structure.
- The results have high reproducibility, and may be cross-checked through different methods.
- The great advantage of measurements with ferroscan, compared to existing detection systems, is that the measurements can be carried out far quicker and more accurately.

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Figure (1) Ferroscan (HILTI FS10)

Figure (2) Testing of sample by Ferrscan

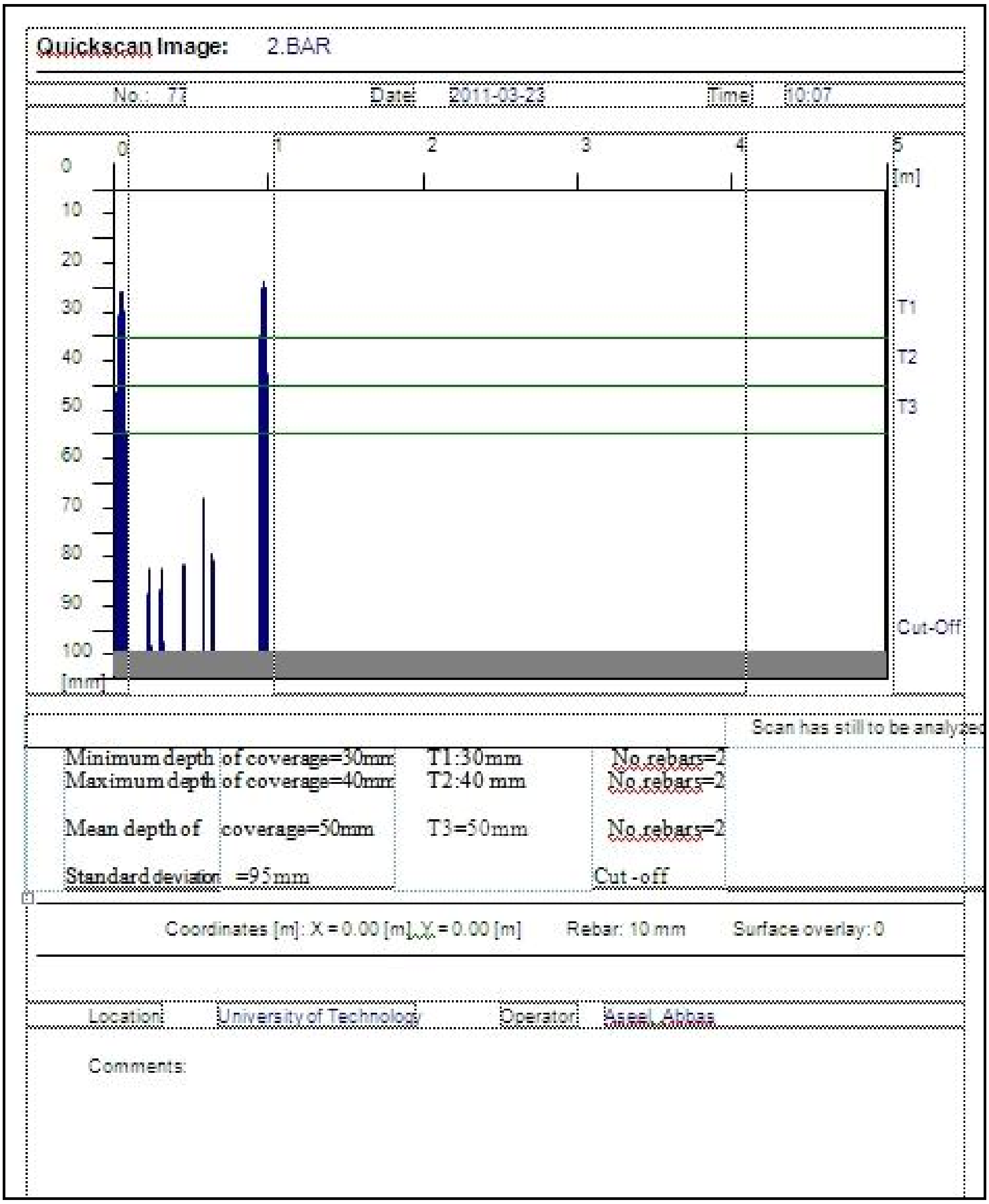
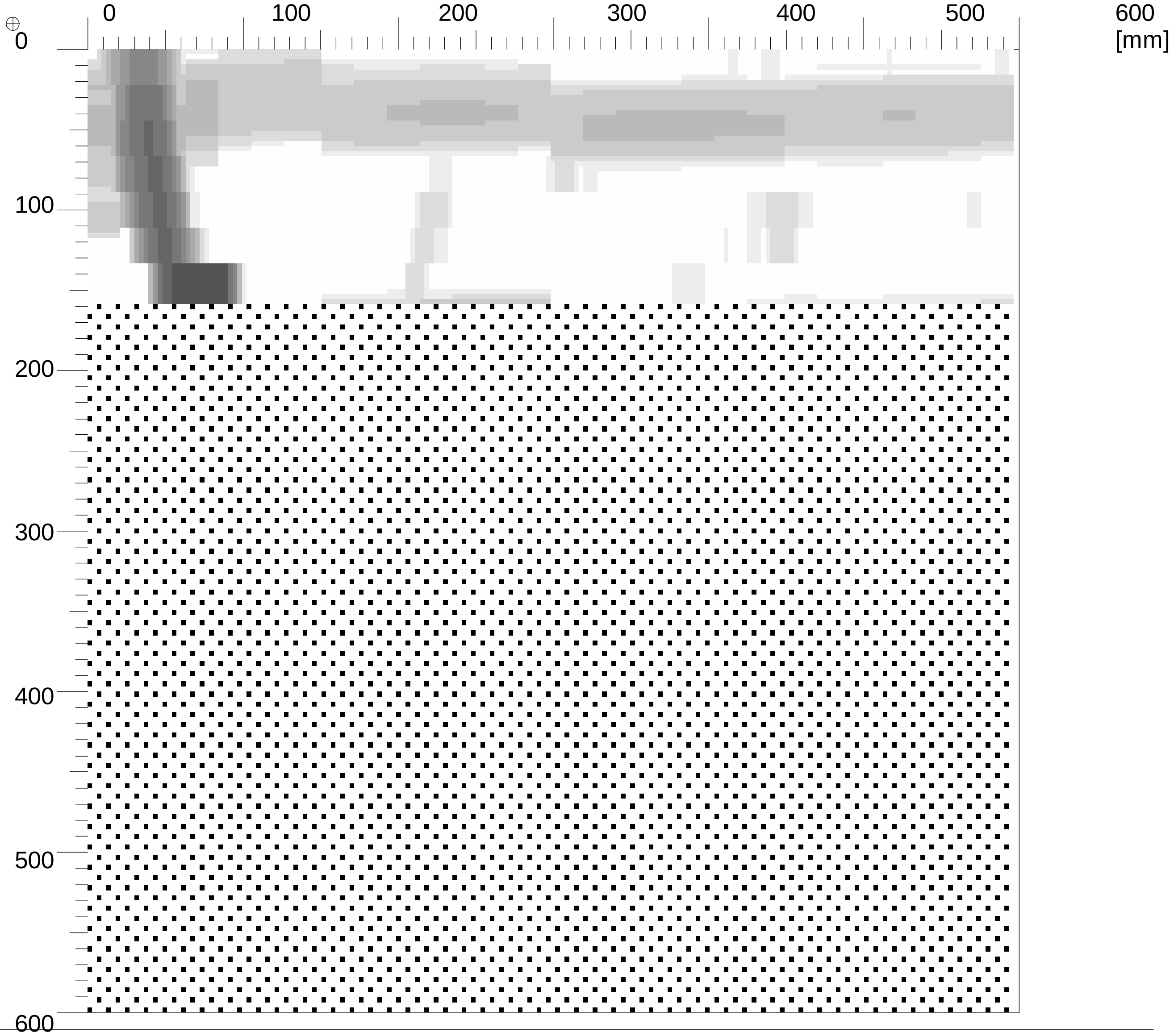


Figure (3) Details of Quick scan survey

Imagescan Image: 1.BAR

No.: 78 Date: 2011-03-23 Time: 10:10



Coordinates [m]: X = 0.00 [m] Y = 0.00 [m] Depth [mm]: max. [mm] Surface overlay: 0

Location: University of Technology Assel Abaas
Operator:

Figure (4) Details of Imagescan

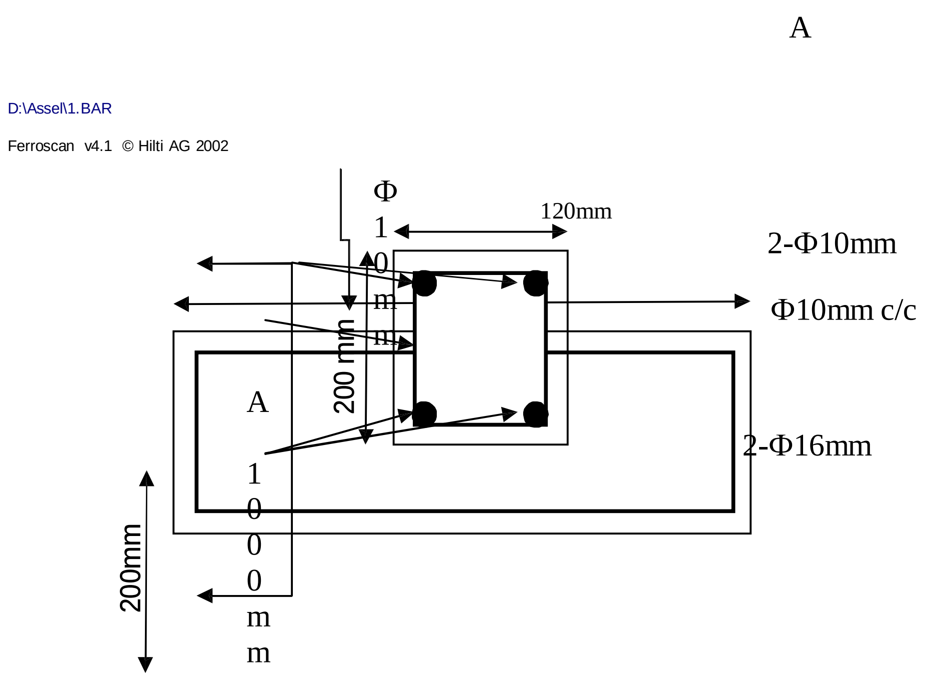


Figure (5) Layout and details of the beam with total length 1000mm