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ARAŞTIRMA MAKALESİ

Manyetik Ölçüm Sistemi ile Betonarme Yapılardaki Demir Donatı Kusurlarının İncelenmesi

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Anahtar kelimeler
Manyetik Sistem, Tahribatsız Test, Demir Donatı Tespiti

Özet

Demir donatı, betonarme yapıların kritik bileşenidir. Doğrudan yapının gücü ile ilgilidir. Demir donatı, bu kuvveti uygun koşullar altında uzun süre korur ve kullanım ömrü boyunca doğru bir şekilde kontrol edilmelidir. Bu çalışmada, demir donatıyı incelemek ve yapıyı analiz etmek için manyetik bir sistem oluşturulmuştur. Oluşturulan manyetik sistem ile yapı üzerinde çeşitli testler ve deneyler yapılmıştır. Oluşturulan manyetik sistemin demir donatıyı ve üzerindeki kusurları tespit etmede başarılı olduğu görülmüştür.

Inspection of Defects on Rebar in ReinforcedConcretebyMagneticMeasurementSystem

Keywords
Magnetic System, Nondestructive Testing, Rebar Detection

Abstract

Rebar is the critical component of the reinforced concrete structures. It is directly related with the strength of the structure. Rebar protects this strength long-time under appropriate conditions and it should be inspect properly during its lifetime. In this study, a magnetic system has been constructed to inspect rebar and also to analyze structure. Several tests and experiments were done on structure with magnetic system. It was shown that the constructedmagnetic system was succeeded in detecting iron imperfections and imperfections.

1. Introduction

Rebar has been used in construction for many decades. It has important role for the strength of structure. There are some cases like earthquakes, fire, corrosion etc. that affect the rebar and the structure adversely. Rebar should be inspected especially after these events and at appropriate time intervals. Ground penetrating radar (GPR) (Flohrer and Bernhardt 1992, Halebe et. al 1997, Packman et. al 1969), ultrasonic (Drinkwater and Wilcox 2006, Lindley et al. 1978, Report and Roland 1992) and acoustic (Akamatsu et al. 2012, Karunanayake et al. 2014)are the commonly used non-destructive testing methods that can inspect the embedded rebar in the concrete. These techniques report general condition of the structure and they are still in progress to get effective results about rebar and concrete (LoandNakagawa 2013, de Alcantara et al. 2015). In this study, magnetic measurement system has been constructed to detect embedded rebar in the reinforced concrete structure. It is based on measuring the response of the rebar to the applied magnetic field. It has studied to obtain clear and reliable results from the magnetic system.

2. Material and Method

In order to estimate the response of rebar for the magnetic system, Vibrating Sample Magnetometer (VSM) results were obtained. During the VSM measurement rebar has been examined with increasing, decreasing and reverse magnetic fields. As seen in the M-H curve, rebar is magnetic material and magnetic system can easily detect the rebar in a presence of magnetic field.

Magnetic induction that is called rebar response is proportional with the applied magnetic field and it can be said that rebar has no remnant magnetization from hysteresis in Figure 1. It can be estimated that rebar will give a response only with a magnetic field and after a value of magnetic field, response remains stable where rebar saturate magnetically. It means that optimum magnetic field is enough to capture the signals from rebar without using extra power in the magnetic system. Towards saturation, only the magnitude of the captured data will be influenced. This case is important in respect to achieve the same information with less energy.

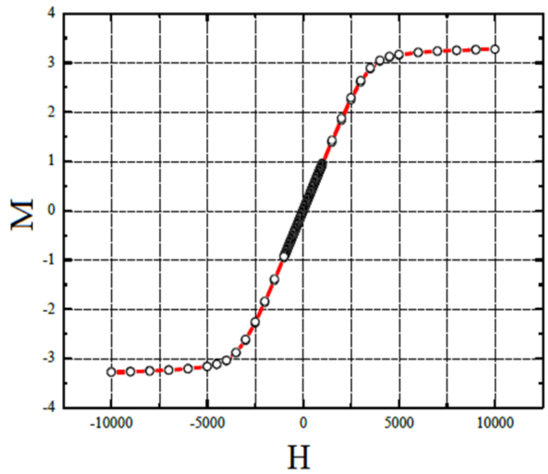


Figure 1. Hysteresis of rebar

A magnetic system has been constructed after explicating the rebar behavior by the help of hysteresis. Different types of magnetic field were tested with the system and finally a constant AC magnetic field was chosen as supplier. Sensor and the supplier can be moved in 6 axes by a computer controlled scanner system. Signals are captured by sensor and recorded with a data logger. A scheme of system is given in Figure2.

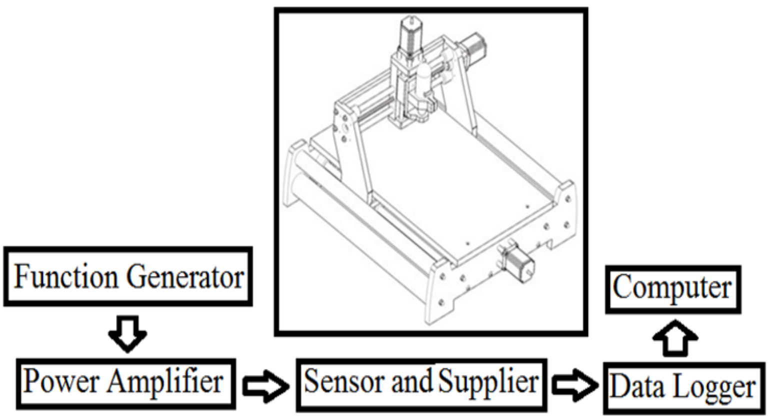


Figure 2. Scheme of magnetic measurement system

3. Results

Magnetic measurement system was verified with the VSM results. It is estimated that sensor can catch rebar under a constant magnetic field. After the construction of system, basic signals of rebar in the reinforcement mesh have been recorded. Rebar has two different positions (perpendicular and parallel to sensor) which are shown with the signals in Figure 3.

It is an important case that system has one type signal which is received above rebar. In other words, sensor output varies with a presence of rebar under the magnetic field. When sensor gets closer to the rebar, the sensor output increases. It makes a peak on the rebar and after the rebar it starts to decrease.

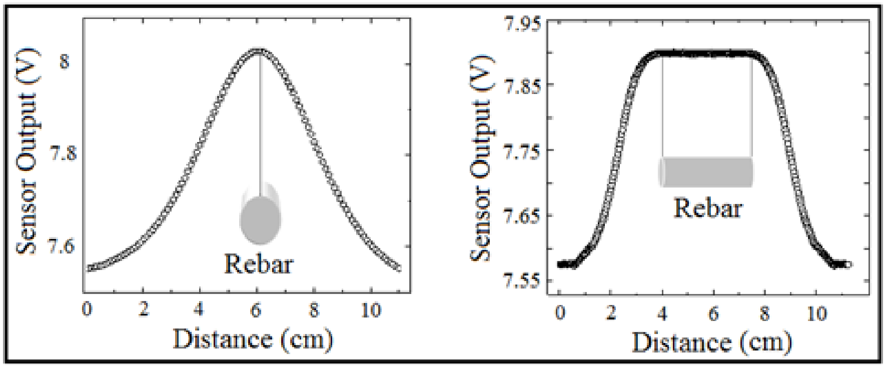


Figure 3. Rebar signals

Physically, the addition to sensor output arises from magnetization of rebar under the magnetic field. When magnetic field loses effect on the rebar, magnetization decreases so that sensor output. Magnetic induction that is called rebar response changes from B=μH to B=μ (H+M). M is the magnetization of rebar that occurs under the magnetic field. Intensity of magnetic field only changes the amplitude of sensor output. It does not affect the character of the signal. Sensor output can be modified to magnetic induction with Equation 1.

$$\hat{B} = \frac{V_{av}}{4.4NfA} \text{ (Tesla)} \quad (1)$$

Where V_{av} is the average voltage in sensing coil, N is the number of coil, f is the frequency and A is the cross-sectional area of sensor. Each data was converted to magnetic induction with Equation 1.

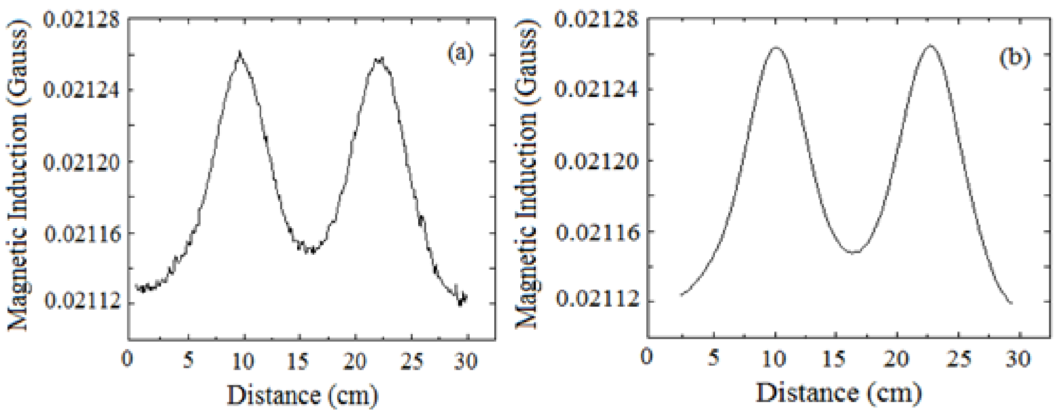


Figure 4. The analyzed rebar signals

In consequence of conversion, small shifts around the signal have emerged in Figure 4 (a). In order to get the pure rebar signal, it is necessary to subtract the back ground signal after canceling small shifts. These shifts have been removed by moving average method that is given in Equation 2. Optimum number of iteration has been chosen to obtain Figure 4 (b).

$$y_s(i) = \frac{1}{2N+1}(y(i+N) + y(i+N-1) + \cdots + y(i-N)) \quad (2)$$

Raw sensor signals that are recorded with the system have been converted to pure rebar magnetic induction with signal analysis. It is proved that system is capable of the rebar detection under the concrete.

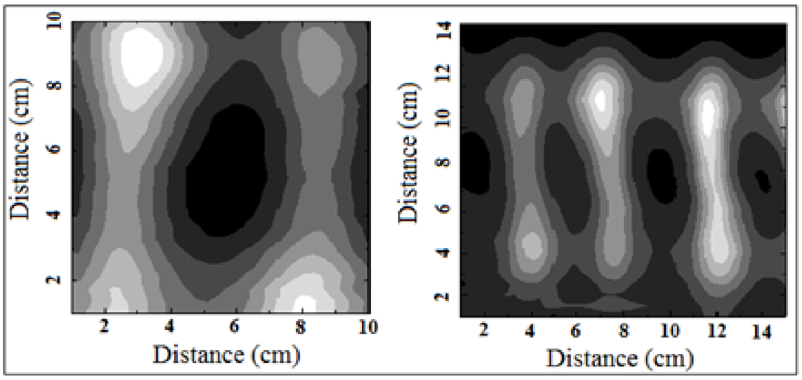
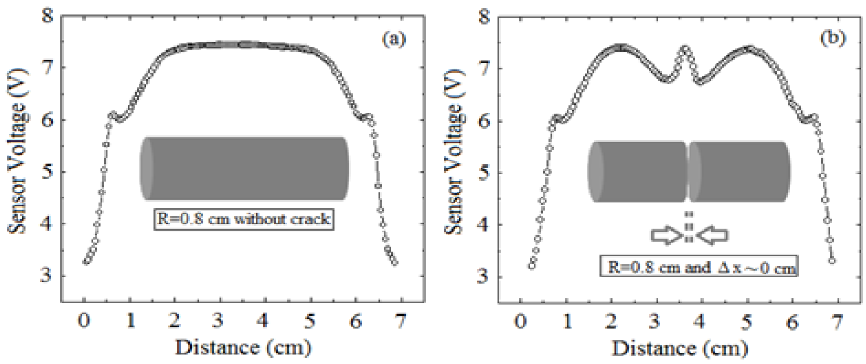


Figure 5. Grey scale of rebar meshes

After that more complicated mesh designs were scanned and captured with system that is given in Figure 5.A general scan was performed with the system and image is given in Figure 5. Rebar can be seen easily in this image. In addition to general scan, customized scans can be carried out on a small square. By this, all the points can be scanned carefully, if needed.Stability of a structure can be determined with the general scan by magnetic measurement system, but it is necessary to focus on the unclear regions to get reliable results.



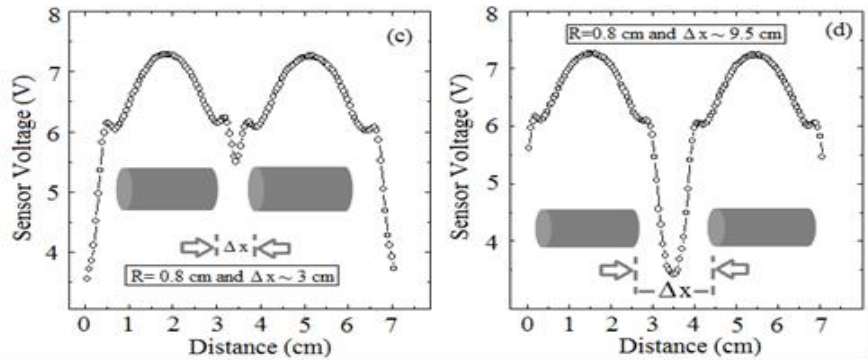


Figure 6. Discontinuities effects on rebar signal

It has been shown that the rebar beam cage can be detected by the magnetic measurement system which can be also used as a non-destructive testing. Besides, it has been also studied to detect defects that can be formed on the rebar by unnecessary drilling, fracture resulting from earthquakes, etc. It has been compared to the signals between rebar and cracked rebar as seen in the Figure 6. Figure 6 (a) shows the signal without crack. Sensor voltage remains constant at the same value in the sample without crack. Discontinuities due to various reasons cause to exhibit different signals of materials. A peak occurs like in Figure 6 (b) from a small pit on rebar to a certain discontinuity gap between rebar. Physically, it means that magnetic flux leaks from the side of pit on rebar and it can be reach to the other side for the distance under 30 mm. The peak direction changes opposite and system detect separated rebar from each other at 30 mm. That means magnetic flux leakage cannot reach the other side of rebar because of the gap. If this gap (Δx) increase, the sensor signal decreases dramatically that is shown in Figure 6 (c) and (d). It shows that captured magnetic flux leakage almost disappears.

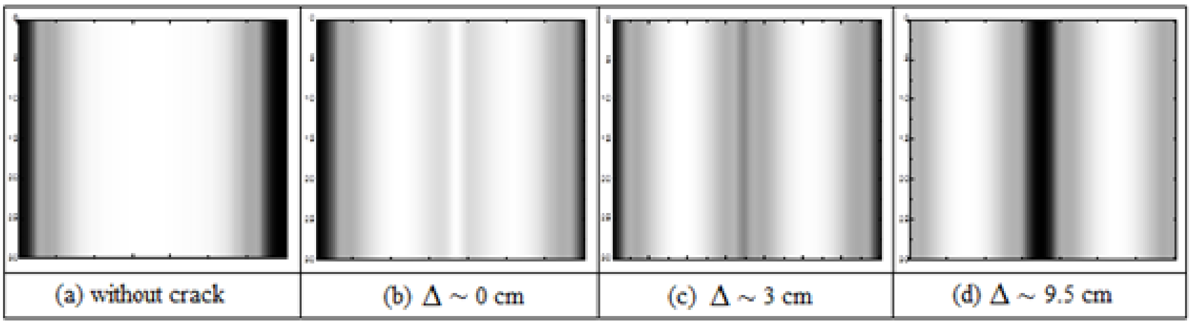


Figure 7. Discontinuities effects on grey scale

Figure 7 shows the gray scale of the discontinuities. Figure 7 (a) and (b) are similar but there is a fluctuation at the middle of the image on Figure 7 (b) which can be interpreted that rebar are not separated from each other. Fluctuation turns to grey on image Figure 7 (c) and it starts to capture a gap which is clearer in image Figure 7 (d).

4. DiscussionandConclusions

Consequently, magnetic measurement system has been constructed and usability of system as a NDT technique has been ensured. Clear and easy to understand graphics were obtained with the system and situation of rebar were investigated under magnetic field. Not only rebar but also defects on the rebar can be detected with the system in this study. The obtained results with this system are important for stability of structure.

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