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NON-DESTRUCTIVE COVER THICKNESS MEASUREMENTS USING EDDY CURRENT PRINCIPLE

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Measurement of cover thickness of concrete over steel is an important aspect of study in any reinforced/prestressed concrete structure which is under distress. Inadequate cover is often one of the factors contributing to accelerated deterioration.

A portable battery operated cover thickness meter based on eddy current has been developed. This instrument is useful in measuring the actual concrete cover provided over embedded steel reinforcement. Orientation and profile of embedded steel in case of non-prestressed reinforcement or longitudinal profile of prestressing cables in case of prestressed members also can be ascertained. It is also possible to determine the diameter of the rebar, if not known previously.

Key words: Cover thickness, Bar diameter, Eddy current, Metal detector.

INTRODUCTION

The barrier effect of concrete cover over steel reinforcement depends not only on its quality but also on its thickness. The thickness used for concrete cover is usually about 100 to 400 times that of painting, just as the thickness used in painting is about 50 to 100 times that used for metallic coating. However, as a protective cover for steel, concrete allows water, oxygen, salts to pass through it, notwithstanding its very valuable property as a load bearing material especially when reinforced with steel. The corrosion rate is generally high when the concrete cover over the reinforcement bar is thin and permeable. Hence the primary prerequisite of corrosion prevention in concrete is a concrete cover of good quality and adequate thickness. The concrete cover must be of adequate thickness to prevent carbonation and also the penetration of aggressive solution to the reinforcing steel.

Corrosion survey conducted in a number of bridges revealed that inadequate cover was one of the factors contributing to accelerated deterioration [1]. Lot of variation in cover thickness was also observed. An imported instrument called "profometer" was used in all these surveys. Thus the measurement of cover thickness assumes practical significance.

Development of an indigenous metal depth detector was discussed earlier [2]. The instrument developed was calibrated to determine the

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maximum cover of upto 80mm for a rebar of 10mm diameter. This paper discusses further improvements made in the instrument in terms of measuring range.

EDDY CURRENT: THE BASIC PRINCIPLE

When a metallic object is placed in the varying magnetic field of a coil this field induces Eddy currents in the metallic object. These Eddy currents in turn produce an additional a c magnetic field in the vicinity of the metallic object. The magnetic fields are superimposed. Thus the magnetic field near the coil is modified if a metal is present. This field modification has exactly the same effect as would be obtained if the characteristics of the coil itself has been changed.

The change depends upon the electrical conductivity, dimension ie. diameter of the rod, magnetic permeability, presence of discontinuities such as cracks or cavities, frequency of the field of the coil, size and shape of the coil and distance of the coil from the metallic object.

It is possible to measure the cover thickness for a known dia. by keeping all the other parameters constant. By placing the coil at two different distances from the rebar, both the cover thickness and dia. of the rebar can be found out.

INSTRUMENT

The electronic circuit consists of an oscillator, probe coil and amplifier. The oscillator generates a stabilized sine wave of 1kHZ frequency. This is applied to the probe coil through a resistance. The probe coil has an inductance and along with a condenser forms a parallel resonant circuit. The voltage across the probe coil is connected to a voltage follower which acts as a high impedance buffer. The AC voltage is rectified and a dc amplifier stage follows.

When there is no metallic object in the vicinity of the probe coil, the voltage across the probe coil is maximum and the output of the amplifier stage is maximum. Now the cover thickness is infinity. When the probe is placed over a concrete cube containing a rebar, the voltage across probe coil is reduced and output of DC amplifier is also reduced. This reduction depends on the cover thickness and dia of the rebar. Less the cover thickness, less the output voltage and less the dia. more the output voltage.

RESULTS

Fig. 1 gives the relationship between the output of the DC amplifier and the cover thickness for various rebars with diameter 6, 10 and 16mm. The relationship is nonlinear as expected. It is also seen from the graph that the sensitivity decreases as the cover thickness increases.

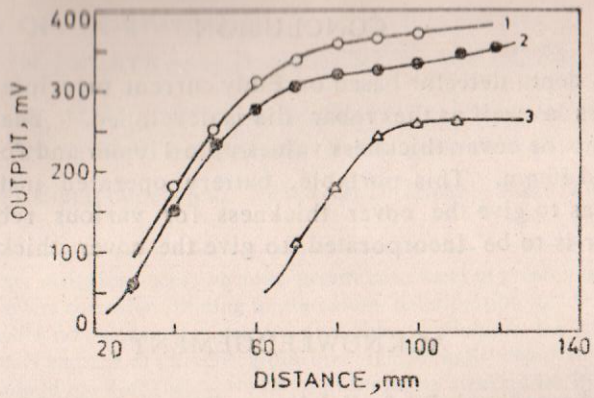

Fig. 1. The relation between cover thickness (Distance in mm) with output voltage (mV).
1) 6mm dia 2) 10mm dia 3) 16mm dia rebar.

If the rebar dia. is known test probe is placed on the concrete surface. From the output voltage of DC amplifier Fig [1] the cover thickness can be calculated. For example, if the DC amplifier output is 275 mV for a rebar of dia 10mm, the cover thickness is 60mm.

When both the cover thickness and rebar dia. are not known, the following procedure is to be adopted. The probe is placed on the concrete surface and the output of DC amplifier stage 'E_1' is noted. Then a 20 mm spacer is placed between the test probe and the concrete surface. The output voltage 'E_2' is noted. Then from fig. 2, the line on which the point (E_1, $E_2 - E_1$) lies is the diameter of the rod. For example if $E_1 = 275$ and $E_2 = 315$ then $E_2 - E_1 = 40$. The point (275, 40) lies in line 2 of Fig 2 *ie.* 10 mm dia. Then the cover thickness can be found out. For the output voltage $E_1 = 275$ mV for 10mm dia rebar (Curve 2) in Fig. 1 gives the cover thickness of 60 mm. It was possible to get cover thickness upto 110 mm for the rebar having dia 6, 10 and 16 mm.

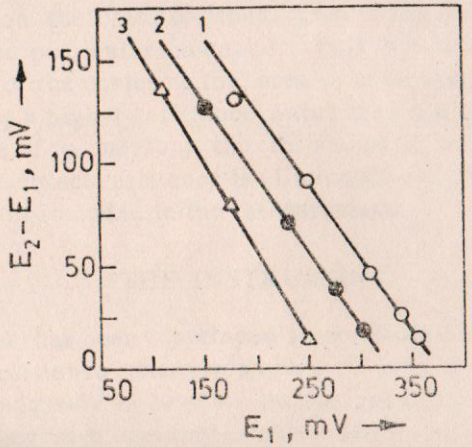

Fig. 2. Relation between E_1 and (E_2–E_1) to get rebar dia
1) 6mm dia 2) 10mm dia 3) 16mm dia

CONCLUSION

A metal depth detector based on Eddy current principle to measure the cover thickness as well as the rebar dia is developed. The results are in good agreement for cover thickness values upto 110mm and for rebars having dia of 6, 10 and 16mm. This portable, battery operated instrument is to be calibrated so as to give the cover thickness for various rebar dia. Also a microprocessor is to be incorporated to give the cover thickness and other rebar dia.

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