Bulletin of Electrochemistry 6 (4) April 1990, pp 385–386

Electrochemical nondestructive testing of reinforcement corrosion in existing concrete structures

K Saravanan, S Srinivasan, R H Suresh Bapu, N U Nayak, T M Balasubramaniyan, N S Rengaswamy and K Balakrishnan

Central Electrochemical Research Institute, Karaikudi - 623 006, INDIA

Premature failure of R.C. structures due to corrosion has become a threat to the building industry, especially in the case of structures situated in the coastal areas. It becomes necessary to assess the present condition of the structures, at least in a qualitative way, before taking up any remedial steps. This paper explains the various methods adopted for this purpose. The data collected in the various existing corrosion affected structures and the conclusions drawn from them are also presented. It is also explained how to interpret the data thus collected to decide the course of remedial steps to be planned.

Key words: Open circuit potential, reinforced concrete corrosion, surface potential, resistivity, corrosion cell ratio

INTRODUCTION

Before suggesting any remedial measures for deteriorated structures, it is quite essential to assess the existing condition of those structures. This paper discusses the electrochemical data collected for some representative buildings and bridge structures and points out the usefulness of such data.

ELECTROCHEMICAL NONDESTRUCTIVE TECHNIQUES

Open circuit potential measurements (OCP)

Corrosion potential of the reinforcing steel embedded in concrete is measured with respect to an external saturated calomel reference electrode by a high impedance voltmeter. The reference electrode is moved over the various nodal points on the surface of the concrete structure. The potential value more negative than −275 mV vs SCE indicates 90% probability of rebar corroding inside [1].

Surface potential measurement (SP)

This measurement is made with two electrodes, one kept fixed on a symmetric point on the structure and the other moved on the nodal points as in the case of OCP. The values are plotted on the drawing and equipotential counter lines are drawn for identifying the anodic and cathodic regions.

Resistivity measurement (ρ)

Resistivity of the concrete cover is measured by portable battery operated instrument developed by CECRI based on Four Probe Technique. Higher value of resistivity generally indicates the undeteriorated condition of the concrete.

Corrosion cell ratio (CCR)

The ratio of maximum potential difference between the anodic and cathodic regions to the average resistivity in the anodic region gives a parameter known as corrosion cell ratio. When this value exceeds 5 micro amperes, severe corrosion conditions may be envisaged in the anodic region [2,3].

Electrical resistance of the prestressing cables

Periodic measuremets of electrical resistance of the prestressing wire will indicate the progress of corrosion in the prestressing wire. A constant direct current of the order of 100 mA is impressed through the current terminals of the meter and a potential drop across the end of the cable is sensed, suitably amplified and displayed as resistance in milliohms. In this method, the contact resistance is eliminated and the resistance of the connecting wire is not included.

RESULTS AND DISCUSSION

Typical data collected on some structures during corrosion survey are given in Table I. It can be seen that there is good correlation between OCP values, CCR values and corrosion rate. OCP is more positive where there is no apparent corrosion and is highly negative where corrosion rate is maximum. The resistivity shows lower values in many of the structures wherever corrosion rate is more, indicating deterioration of concrete. In some structures, such as G, higher resistivity values have been obtained. This may be attributed to only the porosity of the concrete, since the corrosion rate is higher. In the case of structure H, a very high resistivity value of 525 k-ohm-cm is obtained since the surface had been epoxy painted. Lower CCR

0256-1654/90/$ 3-50/

TABLE–I: Data collected in the various existing structures

Structure	Most –ve OCP (mV)	Average resistivity (k-ohm-cm)	Max. CCR	Corr.rate (mmpy)
A	–11	190	0.22	No apparent corrosion
B	–235	96	2.82	—
C	–283	88	1.83	0.154
D	–380	52	4.90	—
E	–430	44	8.41	0.267
F	–588	12	13.33	0.294
G	–217	433*	0.75	0.230
H	—	525**	0.36	0.053

* Porous concrete ** Painted surface

values, higher resistivity values and more negative OCP values have to be judiciously interpreted.

Table II shows the reduction in percentage of the diameter of the prestressing wires using electrical resistance measurements of some cables anchored at deck and the direct measurements of the diameter of existing wires in some other snapped wires in the bottom of girders. A good correlation seems to exist between these direct and indirect methods.

TABLE–II: Percentage reduction of prestressing wires in different structures

Structure	Percentage reduction		Aging in yrs.
	By cable resistance	By direct measurement	
I	25	26	18
II	35	30	22
III	41	42	17

CONCLUSIONS

(1) Several methods have to be combined and the data have to be interpreted with utmost care to assess the corrosion damage of the structures. (2) Electrical resistance measurement of the cables may throw some light on the condition of the prestressing wire and the progress of corrosion, if measured periodically.

REFERENCES

1. ANSI/ASTM-C 876-80, Standard test method for half cell potentials of reinforcing steel in concrete - Annual Book of ASTM Standards.
2. R F Stratful, *Corrosion*, **13** (1957) 173t
3. H Arup, *Steel in Concrete* - Newsletter; Korrosion Scentralen, The Danish Corrosion Centre, Denmark (1982)