Pergamon

Cement and Concrete Research, Vol. 25, No. 5, pp. 1115-1116, 1995

0008-8846/95 $9.50+.00

A Reply to a Discussion by P. Gu, P. Xie and J.J. Beaudoin of the Paper "ELECTRODE POTENTIAL MEASUREMENTS OF CONCRETE REINFORCEMENT FOR CORROSION EVALUATION"*

Raoul Francois, Ginette Arliguie and Didier Bardy
Laboratoire Matériaux et Durabilité des Constructions
I.N.S.A. - U.P.S. Complexe scientifique de Rangueil
31077 Toulouse Cédex - France

P. Gu et al. in their discussion of our paper explain that the classical measurement of potential can be interpreted with the ASTM recommendations which wouldn't be the case in certain conditions for the bi-electrode measurement. We would like to try to explain why we disagree with this point of view.

As demonstrated in our paper, for a half-cell potential measurement in a reinforced concrete system, the potential V measured is:

$$V = Pr - Ps + Pj \qquad (1)$$

Where (Pr) is the potential of the reference electrode (assumed to be a constant), (Ps) is the potential of the steel and (Pj) is a junction potential due to the different electrolytic environments. According to P. Gu et al, the corrosion of a steel surface can be evaluated using equation (1) in accordance with the American standard ASTM C876-91 [1]. But, this junction potential is difficult to evaluate since we need to take into account several interfaces occurring between the electrode solution and the moistening liquid, between the moistening liquid and the concrete interstitial solution which varies in its concentration of dissolved particles and between the concrete surface and the reinforcing rebar. Care is also required in this case because the values of potential recorded for the same embedded steel can varied in a vast field: from -100 mV to -600 mV against the Saturated Calomel Electrode (SCE) according to concrete moisture and cement characteristics [2]. When the concrete is dry, the value recorded cannot be stabilized and the measure is not representative of the state of corrosion of the embedded steel. When the concrete is too wet, very low potential data are recorded and are not representative of the state of corrosion of the embedded steel.

For a bi-electrode device which used two reference electrodes placed on the concrete surface, the value recorded is the difference of voltage of two cells formed by the two electrodes and the reinforcement. Then, when one electrode remains fixed, the potential V measured is:

* CCR 24(3) 401-412 (1994)

$$V = (Pr_2 - Ps_2 + Pj_2) - (Pr_1 - Ps_1 + Pj_1)$$

$$= (Ps_1 - Ps_2) + Pj \qquad (2)$$

When both electrodes are moving, the potential V measured is not the same but the numerical processing which is presented in the paper under discussion allows us to calculate V is the same way.

Of course, the problems which occur when the concrete is too dry or too wet are the same as those in the classical potential measurement with only one reference electrode. But this problem is not a new problem due to the use of a bi-electrode device. So, as in the case of classical measurement, care is required in the evaluation of reinforcing steel corrosion when the concrete is dry or wet.

If we consider the remarks (iii) and (iv) of P. Gu et al concerning the distance between the two reference electrodes, we can give some complementary information. We have performed some potential measurements with a large scale variation of the distance between the two reference electrodes. For example, the measurements recorded on a water-cooling reinforced structure of a power station were obtained with a distance between the two reference electrodes greater than 15 meters 3 and have shown an excellent correlation with the measurements obtained by the classical method.

So what is important in evaluating the steel corrosion is not the potential recorded but the **gradient** of the potential field. And the use of a moving bi-electrode device is nothing else than measuring the gradient of the potential field.

REFERENCES

1 . ASTM C 876-91 - Half-cell potentials of uncoated reinforced steel in concrete.

2 . R. FRANCOIS, J-C. MASO - Annales de l'I.T.B.T.P., n°457, 07/1987

3 . R. FRANCOIS, G. ARLIGUIE - Internationale Conference NDT Non-Destructive Testing in Civil Engineering, 14-16 april 1993, Liverpool.