

## Influence of Migration Corrosion Inhibitor on Corrosion of Steel Bars Embedded in Concretes exposed to External and Internal Source of Chloride

Ampadu Kwasi Osafo, Kanazawa University, Member of JSCE, Takashi TAKADA, Mentex Co. Ltd. Kazuyuki Torii, Kanazawa University, Member of JSCE.

### 1. INTRODUCTION

The preventive maintenance strategy that is cost-effective for reinforced concrete structures exposed to saline environment is to carry out the repair at the corrosion initiation stage at which time the concrete cover may still be sound. The use of migrating corrosion inhibitors in this regard is the most appropriate since the concrete cover need not be removed. This study aims at investigating the effectiveness of some of these new-type migrating corrosion inhibitors with the trade names of MCI 2020, MCI 2005 and MCI 2023. These inhibitors are designed to migrate through even the densest concrete and seek out the steel reinforcing bars embedded in the concrete structure. MCI is a mixed cathodic and anodic corrosion inhibitor, based on amines reacted with carboxylic acids [1].

### 2. EXPERIMENT

Two series of experiments were performed. In both experiments, concrete specimens of dimensions 300mm x 200 mm x 50 mm were cast with two mild steel bars (SS 400) and one stainless steel bars (SUS 304) each of length 170mm and diameter 10 mm embedded at a cover depth of 20 mm and placed at 90mm interval. A wire sensor was also inserted in specimen Ext-2 to monitor the potential difference between the normal steel bar and the sensor using a multimeter. The two mild steel bars served as working electrodes whilst the stainless steel bar served as the auxiliary electrode for the electrochemical measurements used to monitor corrosion. Table 1 shows the method of specimen preparation. After casting, the specimens were cured in water for 7 days at a temperature of 20 °C before applying the inhibitors. The specimens for experiment 1 were immersed in a 5% salt solution for 3-day period followed by 4-day exposure to the atmosphere and then immersed in the salt solution again in a cyclic manner, whilst that of experiment 2 were placed in an environmental chamber under repeated wetting and drying cycle that comprises 3-day wetting at a temperature of 40 °C and relative humidity of 95 %, followed by a 4-day drying period at 40 °C and 50 % relative humidity. After 266 days of ponding in the salt solution, MCI 2020 and VCI 386 were applied simultaneously to the surface of specimen Ext-4 and then placed together with specimen Ext-3 in the environmental containing the specimens of experiment 2.

**Table 1** Method used to prepare specimens exposed to external source of chloride

	Ext-1	Ext-2	Ext-3	Ext-4	Int-1	Int-2	Int-3	Int-4
Control Specimen	x		x		x			
MCI 2020 applied on surf. of concrete						x		
MCI 2020 + VCI 386 applied on surf. of concrete				x				
MCI 2005 mixed with concrete							x	x
MCI 2023 applied on surface of steel								x
3 kg/m <sup>3</sup> Cl mixed with concrete		x			x	x	x	x

w/c = 0.65 for all specimens except Ext-1 and Ext-2 which were made with w/c = 0.45

### 3. RESULTS AND DISCUSSION

**Fig. 1** shows the corrosion current versus exposure time of the specimens used in both experiments. It is seen that for the specimens exposed to external chloride source (experiment 1), the corrosion current of specimen Ext-4, the surface of which was applied with MCI 2020 and VCI 386 is almost similar to that of Ext-3, the control specimen with the same w/c of 0.65. Also, the corrosion current of specimen Ext-1, the control specimen with w/c of 0.45 is lower than that of specimen, Ext-1, the corresponding control specimen with w/c of 0.65. On the other hand the corrosion current of all the specimens exposed to only internal source of chloride (experiment 2) lies within the noble region.

**Keywords:** migrating corrosion inhibitor, chloride ions, steel corrosion, linear polarization resistance, half cell potential, wire sensor.

However, in experiment 2, there is not much difference between the corrosion current of the control specimen and that of the specimens, which the inhibitors were applied to as at about 300 days of exposure. **Fig. 2** also shows the graph of the half cell potential versus the potential difference between the wire sensor and the normal steel bar embedded in specimen Ext-2, measured with a multimeter. It is seen that there is a good correlation between the two, indicating that an ordinary multimeter could be used to monitor corrosion of steel bars if a wire sensor is also embedded in the concrete. Additional data are being collected in order to come up with a calibration procedure for measuring half cell potentials with a multimeter.

#### 4. CONCLUSIONS

It should be mentioned that it is too early at this stage of the experiment to make a firm conclusion however from the results so far the following conclusions may be drawn.

1. The migrating corrosion inhibitor, MCI 2020, seems not to be effective when applied to reinforced concrete structures exposed to a severe saline environment.
2. It may however, be effective in preventing corrosion of steel embedded in concrete with a constant amount of premix chloride such as the use of sea sand as a fine aggregate in concrete.
3. A multimeter could be calibrated to measure the half-cell potential of steel bars embedded in concrete structures if a mini-sensor is also inserted at the time of construction.

#### ACKNOWLEDGEMENTS

The authors give thanks to Mr. Junji Yao, Manager, Nagase Chemicals Co. Ltd., for supplying the migrating corrosion inhibitors and also giving the useful advise in both the planning and execution of the experiments.

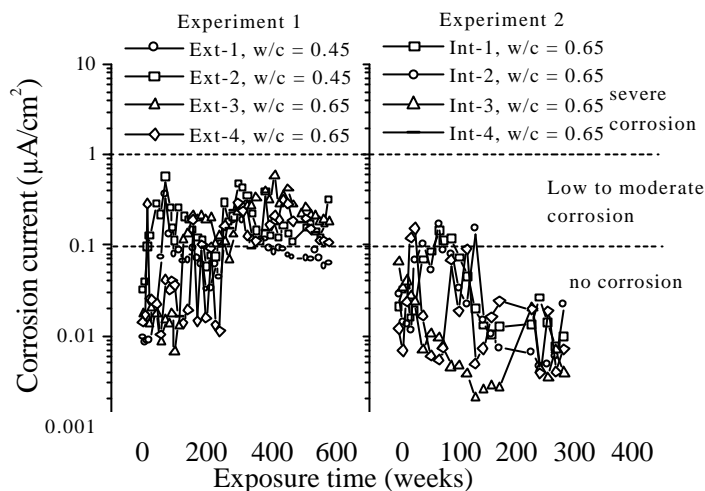


Fig. 1 Corrosion current versus exposure time of specimens exposed to external chloride and internal chloride

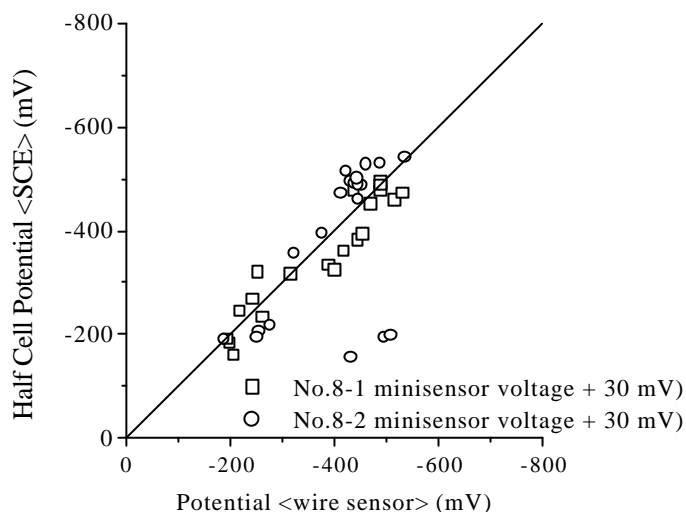


Fig. 2 Comparison of the half cell potential to the potential difference between the embedded wire sensor and the steel bar measured with a multimeter

#### REFERENCES

- [1] Miksic B.A., "Use of Vapour Phase Inhibitors for Corrosion Protection of Metal Products", Corrosion '83, The International Corrosion Forum NACE, Anaheim, California, (1983)