1. Introduction

The cost of corrosion of steel in concrete is very high.
- Value of concrete-based structures in the U.S. is $6 trillion.
- In 1997, the cost of corrosion damage in US highway bridges was estimated to be $150 billion per year.

Corrosion in cracked concrete
- Concrete is designed to crack
- Crack access
- Macrocell mechanism
- Most previous research has focused on corrosion of steel in uncracked concrete.

2. Mechanism of corrosion in cracked concrete

Reaction

Anodic: \[ \text{Fe} \rightarrow \text{Fe}^{2+} + 2e^- \]

Cathodic: \[ \frac{1}{2} \text{O}_2 + \text{H}^+ + \text{e}^- \rightarrow \text{H}_2\text{O} \]

Macroc当地el mechanism
- Small anode supported by large cathode surrounding the anode.
- Much higher corrosion rate than microcell.

3. Experimental Setup

Objectives
1. To study the macrocell mechanism of steel corrosion in cracked concrete.
2. To study the influence of external polarization (potential) on the response of the cracked specimen.

Specimen setup
- Embedded Ag/AgCl reference electrode

Measurements
1. Half-cell Potential in open mode
2. Polarization measurements in the open mode
3. Macrocell current and potential measurements in the closed mode.
4. Polarization of macrocell in the closed mode.

4. Experiment results

Half-cell Potential in open mode
The potential difference between the segment at crack and segments away from crack were 250 mV ~ 300 mV.

Polarization measurements in the open mode

Macrocell Measurements in the closed mode
- 20 µA after 10,000 seconds

Closed mode: macrocell under polarization

5. Discussion

Equivalent circuit
\[ R_{C1}, R_{C2}: \text{medium resistance from steel to concrete surface.} \]
\[ R_{p,A}, R_{p,C}: \text{polarization resistance of steel at and away from crack.} \]

Macrocell current
- Experimental data: 20 µA
- Model prediction: 25 µA

Macrocell undergoing polarization

Comparison of experimental data and model prediction

6. Conclusions

1. The corrosion of steel in cracked concrete is spatially inhomogeneous. The steel in the vicinity of the crack undergoes active corrosion, while the steel away from the crack is in a passive state.

2. The current imposed by the application of external polarization is confined to the active area close to the crack irrespective of the area of the counter electrode.

3. The equivalent circuit allows for predicting the macrocell current in cracked concrete.

4. Polarization response of the macrocell can be predicted using the equivalent circuit.