Electrochemical Corrosion Monitoring of Steel in Reinforced Concrete Member Bonded with Conductive Layer

Kyoto University Student Member O Phanuphan PIBOONSAK
Member Takashi YAMAMOTO, Atsushi HATTORI Fellow Toyoaki MIYAGAWA

1. INTRODUCTION

The research aimed to study the effect of conductive epoxy resin to the electrochemical steel corrosion monitoring measurements, which are half-cell potential (HCP) and polarization resistance (PR), by direct measurement on the surface of the strengthening materials. Moreover, the effect of drilled hole on the strengthening material to concrete surface and the effect of gap were also considered.

2. METHODOLOGY

The 100x50x400mm size of specimen was cast with placing a D10 steel at the center as shown in Fig.1. The experiment factors are shown in Table 1. The epoxy resin, used in this research, is conductive by additional mixing with 8% of carbon black powder and the resistivity of the conductive epoxy resin is $5x10^{-3}$ KΩ·cm. The 60x60x2mm plastic plate was buried into the concrete at the center on top surface in some specimens in order to make the artificial gap. The conductive layer was used as the counter electrode in PR measurement (by double rectangular pulse method) so that each type of conductive layer was connected with the electrical lead wire. After bonding the strengthening material, the holes were drilled on the conductive layer to the concrete surface as shown in Fig.2. In order to accelerate corrosion, $3.0kg/m^3$ of Cl^- was mixed when cast the concrete specimen. Beside that the wet and dry cycle (3day-wet/4day-dry) was employed by submerging the specimens into 3% of NaCl solution to the top of reinforced steel in wet cycle. Two types of electrochemical corrosion monitoring techniques, HCP and PR, were employed as shown in Table 2. HCP measurement was automatically obtained when PR was measured by AC impedance method. For PR measurement, two methods, which are double rectangular pulse method and AC impedance method, were used. In the case of AC impedance method, PR was measured both guard-on and guard-off were employed. The PR measurement by AC impedance method was done in the 1st day of dry cycle while the measurement by double rectangular pulse method was done in the 2nd day of dry cycle.

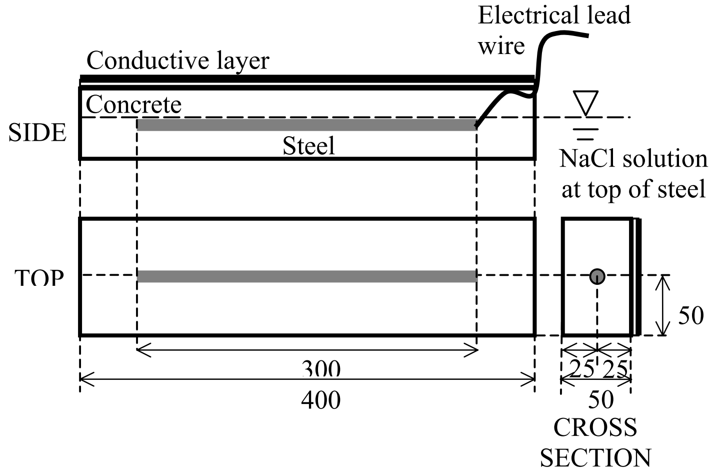
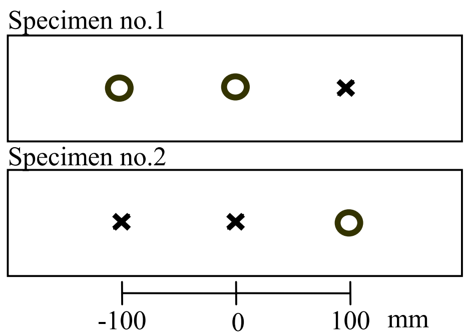


Fig.1: Testing specimen (Unit in mm.)

Table 1: Experiment's factor

W/C	0.45,0.65
Surface type	A: no attaching B: Coating with conductive epoxy resin C: Conductive CFs D: Conductive AFs E: Steel plate F: Steel plate with art.gap G: Conductive CFs with art.gap
Hole	2 holes in specimen no.1 and a hole in specimen no.2 (See Fig.2)



O: 6mm-diameter drilled hole on conductive layer to concrete surface, **X**: No hole

Fig. 2: Drilled hole of specimens in series B to E (For F and G, the central hole was not drilled)

Keywords: half-cell potential, polarization resistance, conductive epoxy resin, conductive layer
Contact: Yoshida-Hommachi, Sakyoku, Kyoto 606-8501 **Tel:** 075-752-5102 **Fax:** 075-752-1745

3. EXPERIMENTAL RESULTS

(1) Visual observation (both surfaces): The cracks have not shown up on the concrete surface yet. The steel plate bonded on the specimen severely corroded while no obvious change was observed on resin/FRPs, only the white portions of NaCl appear on the surface.

(2) HCP (both surfaces): The results obtained on conductive layer were in the same tendency as one obtained on concrete surface. Its magnitude was quite different at the beginning and became closer in the long term in almost cases; except in the case of steel plate, the reading seemed to diverge again after it became closer for some period that might be the effect of the corrosion on the plate. (Fig.3 (a) and (b))

(3) PR by AC impedance method (both surfaces): The values obtained on conductive layer were fluctuation and some came out in negative value and/or enormous value both in case of guard-on and guard-off. Before plotting the graph as shown in Fig.3 (c), the negative value and/or enormous value were omitted. The readings obtained on conductive layer were much fluctuation than those obtained on conductive layer with hole in all cases. Their magnitudes were much larger than those reading on concrete surface at the beginning and gradually decreased with time. Therefore some relations may be obtained between the PR reading on conductive layer and one reading on concrete surface. Gap did not show the obvious difference from the one of conductive layer.

(4) PR by double rectangular pulse method (both surfaces): The PR obtained on conductive layer with hole and without hole were steady, and had the same tendency with one obtained from concrete surface as shown in Fig.3 (d). But PR of one with hole was closer to one of concrete surface than one without hole. In the case of steel plate, the PR obtained from all conditions was in the same tendency and magnitude. And similar to the AC impedance method, gap did not show the obvious difference from the simple conductive layer.

Table 2: Measurement Method

1) HCP
2) PR with AC Impedance method, Guard-ON
3) PR with AC Impedance method, Guard-OFF
4) PR with Rectangular pulse method

Note: The measurement was done 3 points both on top (conductive layer) and bottom (concrete surface)

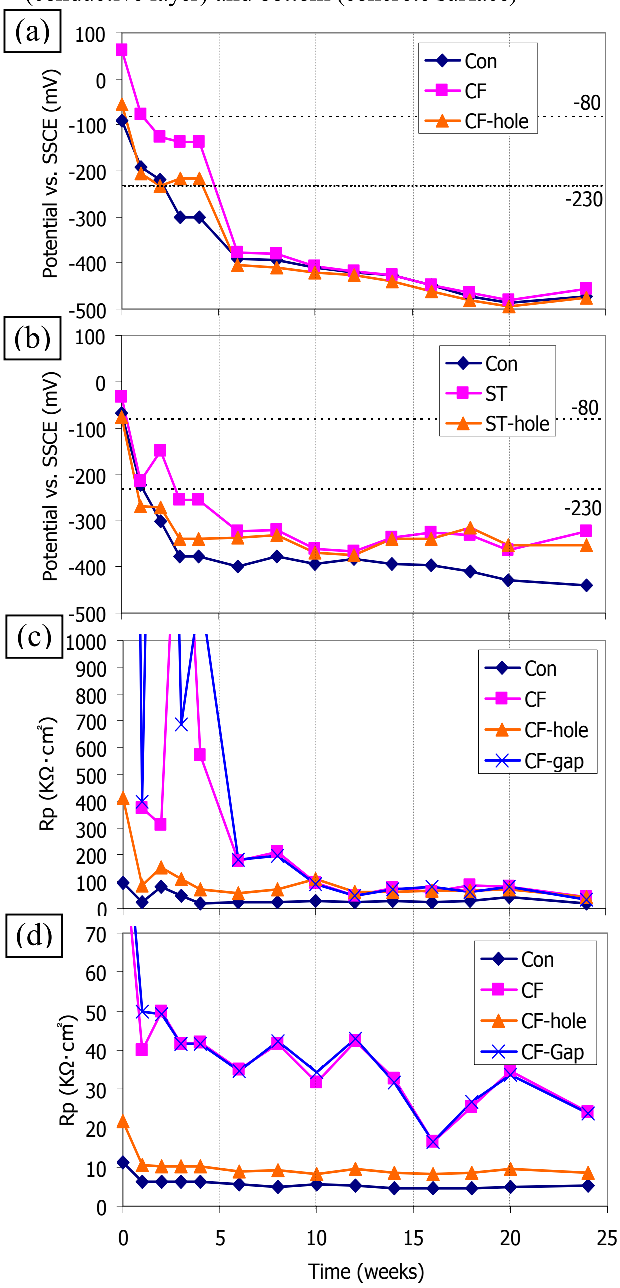


Fig.3: Experimental results

4. CONCLUSIONS

(1) HCP obtained on conductive layers, both hole and without hole, used in this research are in the same tendency and slightly different in magnitude to the one obtained from concrete in all cases, except in case of steel plate. Gap has no obvious effect in HCP measurement.

(2) PR obtained by AC impedance method, the relation between PR reading on conductive layer (with hole and without hole) and one of concrete surface may be obtainable after omitting the negative and/or enormous values.

(3) PR obtained by double rectangular pulse method, PR obtained on conductive layer is in the same tendency but different in magnitude with the one obtained from concrete. PR obtained at hole is closer to the one obtained from concrete than the one obtained on conductive layer without hole.