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CORROSION BEHAVIOR OF STEEL IN FLY ASH MORTAR MIXED WITH SEAWATER UNDER DIFFERENT CURING METHODS

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Abstract: Due to the increasing demand and cost of construction materials, many alternatives are being studied for sustainable use. The use of fly ash is proven to be an effective partial substitute for cement due to its cementitious properties and a good resistance to corrosion from its very fine structure. Another is the use of seawater for mixing and curing due to the current water crisis and the abundance of seawater in the Philippines. However, the use of seawater for mixing and curing promotes corrosion of the rebar due to its high chloride content. This paper focuses on the corrosion behavior of the steel embedded in mortar specimens in terms of polarization resistance, corrosion current density and chloride content. Another aspect explored was the relationship between fly ash and seawater, for the two are known to resist and influence corrosion, respectively. Mortar specimens of constant cement, water and sand ratio of 1: 0.5: 2 were mixed with seawater and freshwater. A constant 20% fly ash replacement to cement was also used. Mortar specimens were cured by submerging in seawater, submerging in freshwater, using wet burlaps, and exposing to ambient room condition. The corrosion current density and the polarization resistance were measured every week for 18 weeks using the corrosion monitor CT-7. The chloride content surrounding the steel bar of the specimens was also measured using the "washing the bar" method. Results show that seawater is suitable for mixing as long as it is cured by freshwater or seawater wet burlaps due to the high compressive strength of up to 43 MPa and with low corrosion activity. Seawater for curing will promote high compressive strength on the early stages; however, is not suitable regardless of the mixing water used because chlorides from the seawater environment ingress to the mortar and initiate corrosion of the steel bars and decrease in strength due to salt crystallization. The use of wet burlaps for curing can help achieve high compressive strength, low corrosion potential and low corrosion rate for it resulted to the lowest chloride content among the seawater mixed specimens. The corrosion activity was dependent on the type of curing used regardless of the type of water used for mixing.

Key Words: corrosion; curing; seawater; fly ash

1. INTRODUCTION

Due to the increasing demand and cost of construction materials, many alternatives are being studied for sustainable use. The use of fly ash is proven to be an effective partial substitute for cement due to its cementitious properties and a good resistance to corrosion from its very fine structure. Another is the use of seawater for mixing and curing due to the current water crisis and the abundance of seawater in the Philippines. However, the use of seawater for mixing and curing promotes corrosion of the rebar due to its high chloride content.

2. METHODOLOGY

Figure 2.1 shows the rectangular prism specimen used for corrosion monitoring. The specimen is of size 4 cm x 4 cm x 16 cm with ten millimeter diameter round steel bars suspended at a constant cover of 5 mm in order to accelerate the corrosion process.

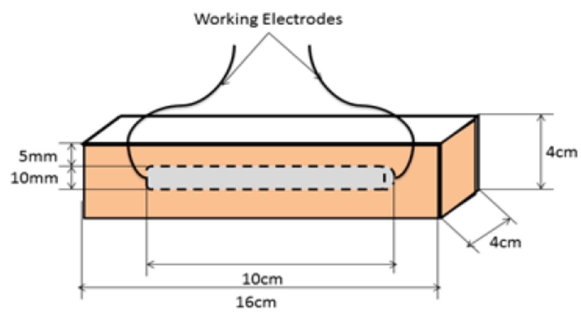

Figure 2.1 Rectangular prism specimen for corrosion measurement

The experimentation involved a total of four different curing conditions: submerging in seawater (SW), submerging in freshwater (FW), using seawater wet burlaps (WB), and exposing to ambient room condition (AR). The effects on the specimens' compressive strength and the corrosion on the rebar were tested. The compressive strength of each specimen was tested at the 7^{th}, 14^{th}, 21^{st}, 28^{th} and 84^{th} day while the corrosion current density and corrosion potential were measured every week upon casting using the CT-7. The chloride content of the specimens was determined after 18 weeks using the "washing the bar" method (Odchimar and Otsuki, 2011). The data gathered were analyzed on the basis of compressive strength and corrosion on the rebar. This paper, however, focuses on the results of corrosion monitoring conducted.

The criterion that was used for evaluating the corrosion potential was based on ASTM C846-91 (Test Method for Half Cell Potentials of Uncoated Reinforcing Steel in Concrete) whereas the measurement of the corrosion current density was based on ASTM G59-91 (Practice for Conducting Potentiodynamic Polarization Resistance Measurements).

3. RESULTS AND DISCUSSION

The corrsoion behavior of the specimens in this study was evaluated based on corrosion potential, corrosion current density and chloride content.

Figures 3.1 and 3.2 show the corrosion potential and the corrosion current density of all specimens, respectively. Both graphs concur with one another signifying that those specimens cured in SW (FWSW and SWSW) had high corrosion potential and current density values as compared to those specimens cured in FW, WB, and AR condition. This is due to the presence of chlorides in the environment. Chlorides penetrate the steel bar thus promoting corrosion.

Initial exposure to chloride using SW for mixing (SWFW, SWWB and SWAR) resulted to low potential and current density values based on the criteria of the ASTM standards used. Exposing SW mixed specimens to FW led to low values because the amount of chloride ions present in FW is very low compared to SW. Exposing to AR condition also resulted to negligible amounts of chloride ions. Using seawater WB also did not result to high values because the burlap sack absorbed the water and the specimens were not directly exposed to the seawater.

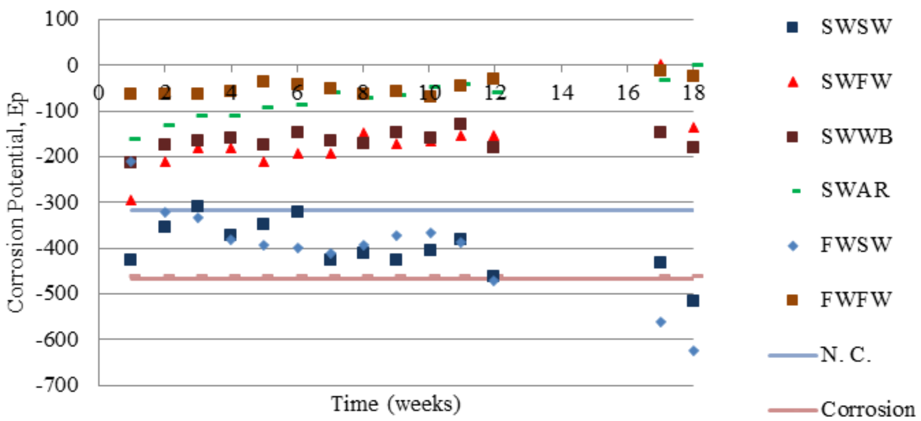

Figure 3.1: Corrosion Potential of All Specimen

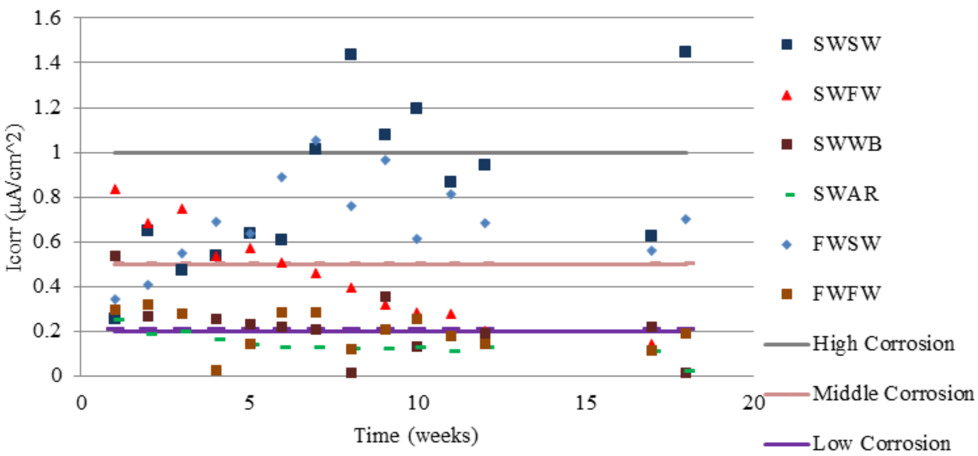

Figure 3.2: Corrosion Current Density of All Specimens

The results from the corrosion potential and corrosion current density also concur with the chloride content of each specimen and with the previous study by Kaushik and Islam (1995) as seen in Figure 3.3. The figure indicates that the specimens with most chlorides were those that were cured with SW because of the ingress of chlorides into the mortar.

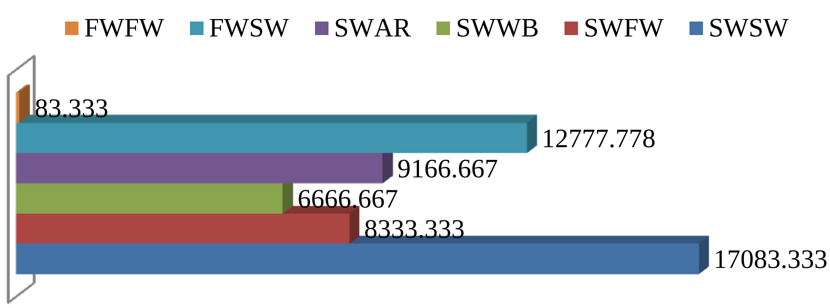

Figure 3.3: Chloride Content of All Specimens

4. CONCLUSIONS

The following conclusions can be drawn based on the results of this study:

1. Seawater is suitable for mixing as long as it is cured in freshwater, wet burlaps and ambient room condition.
2. Seawater curing is not suitable because it greatly affects chloride diffusion and promotes corrosion of the rebar even if freshwater is used for mixing.
3. Using freshwater, wet burlaps and ambient room condition as curing methods decrease the rate of corrosion as well as the corrosion potential and reduce the amount of chloride ions surrounding the steel bar.

4. Freshwater curing greatly reduces the amount of chloride when mortar is mixed with seawater.
5. Using wet burlaps as curing will yield a high compressive strength and will help decrease the potential and rate of corrosion for it showed the lowest chloride content among the seawater mixed specimens.

5. ACKNOWLEDGMENTS

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6. REFERENCES

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