College of Engineering and Computer Science

Propagation of Corrosion in Dry-Cast Reinforced Concrete Pipes after Corrosion Initiation

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Dry-cast reinforced concrete pipes (D-C-RCP) are used as drainage pipes by the Florida Department of Transportation (FDOT) and other DOTs. Some of these pipes are located in Florida areas where there is a low water table. The time to corrosion initiation period could be shortened by chloride transport due to capillary absorption and diffusion. However moderate or no corrosion has been observed on dry-cast reinforced concrete pipes placed in soils containing high chloride concentration and high moisture conditions. Moreover, the high moisture of the soil could result in low oxygen availability. This investigation is being carried out to better understand the propagation stage on corroding dry-cast reinforced concrete pipes. Experiments were conducted on two different types of D-C-RCP provided by FDOT. These pipes were segmented, instrumented and solution reservoirs installed in horizontal and vertical orientations. Potentiostatic, galvanostatic and migration methods were used to initiate the corrosion. Once the off-potential of the steel reached a value more negative than -250mV Vssce after 24 hrs. Those specimens considered active were transferred to 95~98% high humidity chamber, then to fully or partially buried in simulated saturated soil. Electrical Impedance spectroscopy was performed to obtain the solution resistance. So far these specimens show no visual signs of corrosion. Reason could be that since both concrete types have high porosity the products are moving through interconnected pore structure. From the preliminary results no increase in Rpapp in time has been observed. Upon further exposure there could be an increase in Rpapp.

Corrosion Propagation of dry-cast reinforced concrete pipes after initiation

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INTRODUCTION

Dry-cast reinforced concrete pipes (D-C-RCPs) are used as drainage pipes by the Florida Department of Transportation (FDOT) and other DOTs. . The D-C-RCPs are prepared with a low water to cementitious ratio. However, the curing process results in concrete with a high degree of absorption. Some of these pipes are located in Florida areas where there is a low water table that allows soil to saturate (seasonal). Additionally, at sites close to the ocean the soil could contains significant chloride concentration, which could be transported to the surface of the steel reinforcement and once it exceeds a critical concentration then corrosion initiates and then propagates. However, field surveys indicate that moderate or no corrosion has been observed on the D-C-RCPs. This observation might be due to the high moisture/saturation of the soil and low oxygen availability.

OBJECTIVE

This investigation is being carried out to better understand the propagation stage once corrosion has initiated on dry-cast reinforced concrete pipes.

Materials and Methods

Experiments were conducted on two different types of D-C-RCPs. Type F contains 20% of fly-ash and type C contains only ordinary Portland cement in two different geometrical orientations (horizontal and vertical)

Accelerated Chloride Transportation Methods to Shorten Time to Corrosion Initiation


Figure 1 Potentiostatic


Figure 2 Galvanostatic

Figure 3 Migration

Figures 1 – 3 show the three different accelerated transport methods used. The chloride concentration used is within the range found in the field.

Exposure Environments During Corrosion Propagation

After corrosion initiation the specimens were subjected to different environmental exposure conditions as to replicate the field exposure. Tested exposure are shown in Figures 4 - 8


Figure 4 Environmental chamber


Figure 6 95-98 %R.H


Figure 6 1/3RD covered in sand


Figure 7 covered in sand

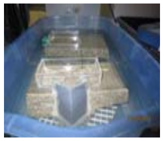


Figure 8 immersed in water

RESULTS

D-RCPs Specimen and Concrete Characterization Results

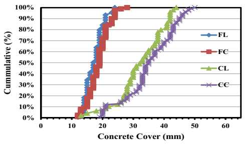


Figure 9 Concrete cover distribution

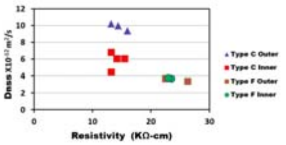
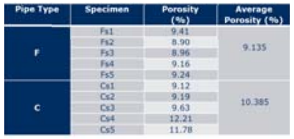


Figure 10 D*nssm* vs. resistivity



Pipe Type	Specimen	Porosity (%)	Average Porosity (%)
F	Fs1	9.41	9.135
	Fs2	8.90	
	Fs3	8.96	
	Fs4	9.16	
	Fs5	9.24	
C	Cs1	9.12	10.385
	Cs2	9.19	
	Cs3	9.63	
	Cs4	12.21	
	Cs5	11.78	

Table 1 porosity of concrete porosity tests in accordance with ASTM 642-01 25

Figure 9 shows the concrete cover distribution in both directions (L-Longitudinal, C-Circumferential) .

Figure 10 shows A modified rapid chloride migration test (NT BUILD 492) the diffusivity of type C cores (RMT) with the outside curvature exposed to chlorides was higher than for cores with the inner curvature exposed to chlorides.

Table 1 shows the porosity of both types of D-RCPs. Type C has a slightly higher porosity than type F concrete.

Propagation Monitoring results(Figures 11-14)

Laboratory humidity - high humidity - saturated sand

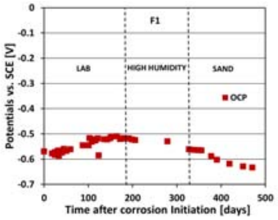


Figure 11. Potential vs. time for Specimen F1

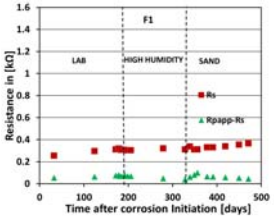


Figure 12. Linear Polarization Resistance and Rs vs. time for F1

Laboratory humidity - saturated sand – immersed in water

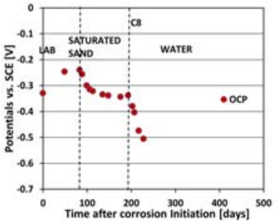


Figure 13 C8 OCP vs. time

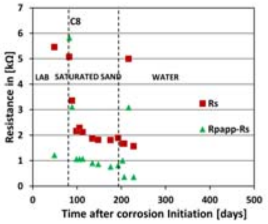


Figure 14 C8 Resistance vs. time

Figure 13 shows the potentials vs. time. The potential of the reinforcement increased gradually in laboratory conditions; when covered in saturated sand the potentials decreased to ~-330 mVsce and then remain stable. Once the specimen was immersed in water the potential decreased further and at a faster rate than that in saturated sand. However, the Rpapp-Rs continues to decrease suggesting that the corrosion is now higher. Figure 14 shows the change of Rpapp - Rs during the three exposure conditions.

Laboratory humidity – high humidity

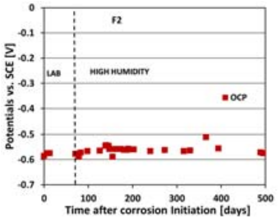


Figure 15. Potential vs. time for specimen F2

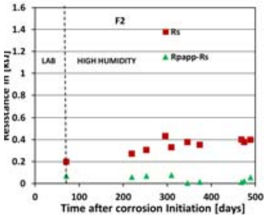


Figure 16. Linear Polarization Resistance and Rs vs. time for F2

Figure 15 shows the potential vs. time for specimen F2. The specimen potential has remained at about -0.5Vsce during the propagation stage. Figure 16 shows the linear polarization resistance vs. time has remained the same the last 200 days.

Cathodic Potentiodynamic scan

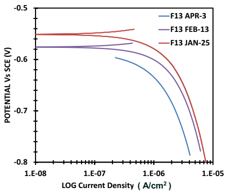


Figure 17. Cathodic scan for specimen F13

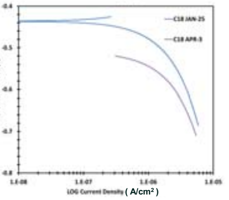


Figure 18. Cathodic scan for specimen C18

A reduced current density has been observed upon prolonged exposure as shown in Figures 17&18.

CONCLUSIONS

- Several methods had been developed to monitor the corrosion propagation stage.
- During exposure in water and in saturated sand conditions the reinforcement potentials shows values as negative as -700mV vs. SCE.
- Currently no increase in Rp observed so far for the specimens exposed to high humidity for a prolonged period.
- Effect of current limiting factor observed in range of -800mV vs. SCE

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