Influence of Crack Density on the Corrosion Resistance of UHPC

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Abstract

What is UHPC?

- Ultra-High Performance Concrete (UHPC) is different from traditional, normal strength concrete in that it provides higher durability and strength.. Although UHPC is typically more durable than normal strength concrete, structural components built in UHPC may be deteriorated during longer-term service, resulting in occurrence of cracks. Cracks could act as pathways for harmful compounds to penetrate UHPC and cause further damage for the embedded steel reinforcements.

What Does Past Literature Say?

- Previous research has demonstrated that chloride is the leading compound that causes pitting corrosion for reinforcement concrete structures exposed to coastal and marine environment. However, past studies regarding the effect of crack density on corrosion rate of embedded steel rebar are still mixed. After initiation of corrosion by chloride, corrosion rate is not only related to the electrical resistivity between cracked regions, but also depends on the cathodic reaction during corrosion propagation, influenced by the oxygen supply.

How Do We Plan to Test This?

- Thus, non-destructive electrochemical methods including open circuit potential (OCP)test, linear polarization resistance (LRP) test, and electrochemical impedance spectroscopy (EIS) are adopted to measure the corrosion resistance of cracked UHPC and normal strength concrete with different crack densities.

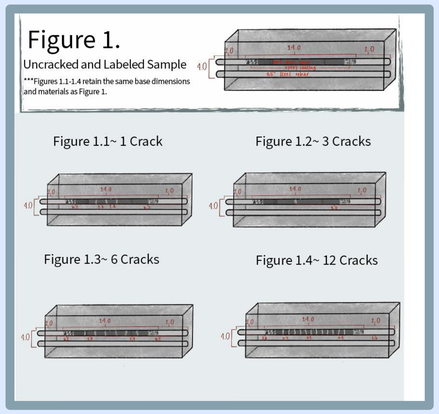


Figure 1. Demonstrates the dimensions and set up for the UHPC specimens. The measurements for the structure itself and the steel rebar are included.

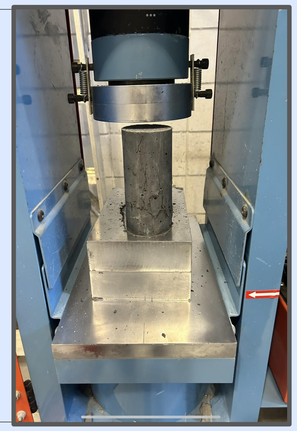
- No. 4 steel rebar embed in the UHPC- length of 12 inches
- Cylinder size 4 x 8 inches.
- Multiple figures include predicted crack measurements

Background

- UHPC has been widely adopted in America due to its high durability which is three orders of magnitude greater than Normal Strength Concrete (1,000 times).
- UHPC has demonstrated no corrosive tendencies on its own but UHPC can experience corrosion due to chloride propagation occurring to the steel reinforcements.
- These cracks act as a flow channel for chloride ions which have demonstrated corrosive properties on normal strength concrete in past literature. However, the effects or extent as to which the UHPC would experience pitting corrosion (corrosion due to chloride ions) is still unknown.
- This study aims to fill the knowledge gaps of how UHPC is affected by cracks.

Methods

- UHPC specimens were casted with specific measurements and then cured for 60 days in a control humidity and temperature of 50% and 68~73 F, respectively.
- Measure compressive strength to ensure the samples are UHPC (Greater tensile strength than 18,000 psi).
- Artificial cracks were generated with a wet cutting saw
- A wire was soldered onto the end of the steel rebar.
- UHPC specimens were then exposed to sodium chloride solution for a 3 day period and a 7 day period
- The open circuit potential (OCP) and linear polarization resistance was then measured over time via electrical chemical methods.



Results

Conventionally, the open circuit potential can be related to corrosion rate and be used to evaluate corrosion risk.

- The corrosion potential on samples 1-3 (0-2 cracks) decreased throughout the testing period.
- The corrosion potential on sample 4 (4 cracks) increased on days 1-3, and then decreased.

When comparing the results from past literature's definitions of corrosion rates, the samples are indicated to have a passive corrosion rate.

# of sample	Day 1	Day 3	Day 7
	mV vs. Ag/AgCl electrode		
1	-120.9	-69.83	-49.58
2	-499.6	-487.2	-500.5
3	-499.9	-460.8	-517.6
4	-531.7	-540.7	-524.4

Table of the results, and picture of test setup

Conclusion

- While these results indicate that the corrosion rate is low or passive, we cannot make a concrete conclusion from these results.
- These results could be caused by the electrical resistivity uncracked region between cracks on the samples which would hinder the completion of the open circuit. (Steel rebar-NaCl solution).
- The insufficient supply off oxygen may also hinder the corrosion rate and factor into the results.
- Additionally, the tafel constant which was used to help achieve these results was derived from past literature. A new tafel calculation may be required in order to get the most accurate results

Acknowledgments

I would like to thank Dr. Zhang and Peizhi Wang for mentoring me and letting me be apart of this research. Although the research is ongoing, it was such a privilege to be allowed to learn about the project and to have the opportunity to learn from such intelligent people.

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