Condition Assessment of Corroded Prestressed Concrete Bridge Girders

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Motivation

According to the American Society of Civil Engineers in 2017, about 40% of the reinforced and prestressed concrete bridges in the US reached the end of their designated life cycle or beyond, the direct cost of resolving the durability problems is approximately estimated at 13.6 billion dollars per year. The development of durable cementitious material is not only a way to improve the durability performance of the bridges, but it is also imperative to develop a systematic framework to evaluate the remaining structural performance damaged by corrosion with high accuracy. This research highlights:

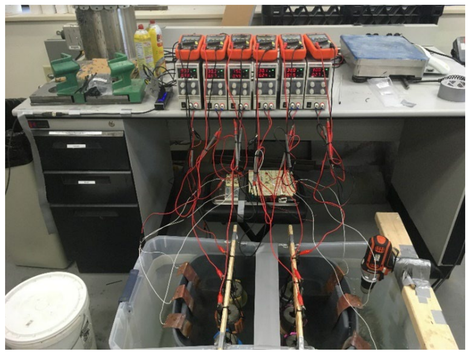
- **Characterization of corrosion degree**, and
- **Exploring degradation bond-strength of concrete due to corrosion.**

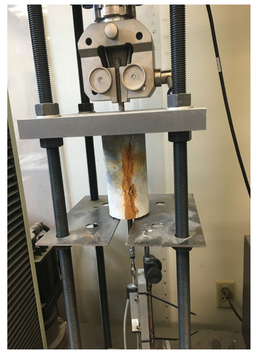
Experimental Setup

- Electrolyte is distilled water with 3% weight of sodium chloride. (i.e., simulating sea water)
- #3 rebar is embedded into 3"x6" concrete cylinder.

Mixture Proportion of Concrete (4,500 psi @ 28 days) used for this research

W/B	Cement (lb)	Water (lb)	Fine Agg. (lb)	Coarse Agg.(lb)	Air (%)
0.45	783	353	1630	1087	3.0





Accelerated Corrosion Chamber (Left) and Pull-Out Test Apparatus (Right)

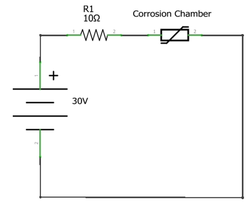
Characterization of Corrosion Degree and Damage of Surrounding Concrete

- **Degree of corrosion** is defined by:

$$\tau = \frac{1}{\tau_u}\int I(t)\,dt$$

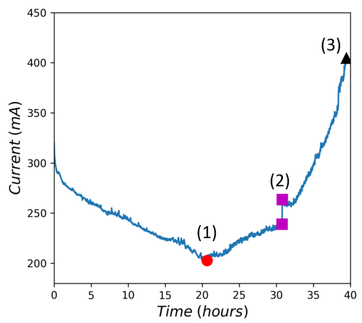
where I(t) = current (A) at time t (days) and τ_u = corrosion degree where a given structural capacity is neutralized.

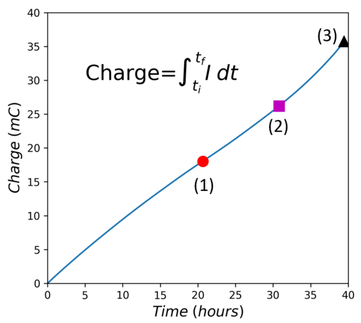
- **The current of corrosion cell is measured** by using **Voltage divider circuit** with 30V of DC current and 10Ω.

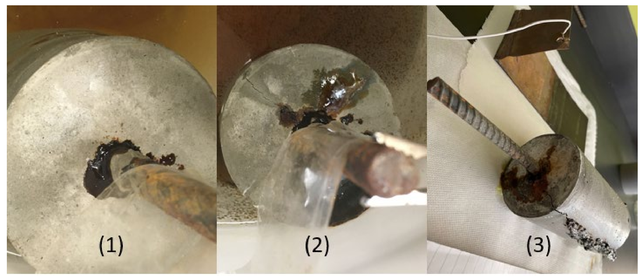


- **Damages due to Corrosion**

State (1):	• $Fe(OH)_2$ is leaked from the top surface. • No visible crack is observed.
State (2):	• Visible radial failure is observed. • Continuous leakage of $Fe(OH)_2$.
State (3):	• Longitudinal splitting crack is formed.



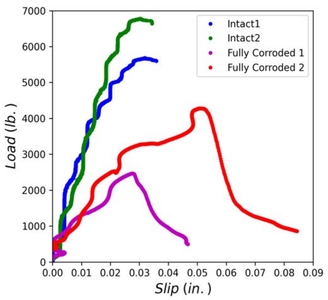




Evaluation of Bond Strength of Damaged Concrete Exposed to Corrosion

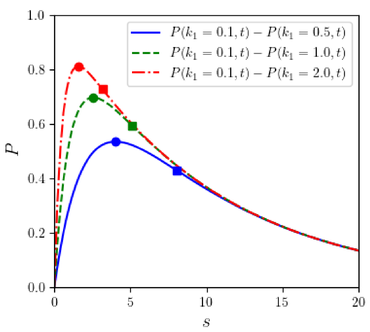
As compared to the response of intact specimen:

- **Degradation of Stiffness**
- **Lower ultimate bond stress**
- **Longer post-peak behavior (Softening of Concrete)**



Future Research

- **Modeling of bond-strength degradation due to corrosion.**
- **Calibration of the model based on multi-level corrosion data.**



Kinetics-based Model (left) and Specimens exposed to multiple levels of corrosion

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