Abstract
Coupling devices that mechanically splice reinforcing bars are used regularly in reinforced concrete construction. Epoxy-bonded couplers are one type of coupler available, but have unique long-term performance considerations. The adhesive material used in these couplers is a two-part, field-mixed, ambient-cure epoxy system, originally designed for anchorage to concrete. Many of the adhesive systems used for anchorage to concrete, including the system used with couplers, are epoxy systems. The mechanical properties of these types of epoxies have been shown to degrade over time, in the presence of moisture. A variety of commercially available adhesive systems, for anchorage to concrete, were studied to assess their relative resistance to moisture-based degradation (i.e., systems A-F). From the material properties of two of the adhesive systems deemed promising (both of which are epoxies), the performance of the rebar-couplers was then measured over a sixteen-and-a-half-month period of exposure. This included a variety of environmental conditions, such as water immersion at temperatures ranging from 23°C to 60°C. Using these results, material degradation models were used to predict the long-term properties of the adhesive while in-service. A finite element analysis (FEA) model was developed to simulate the tensile failure of the epoxy-bonded rebar-coupler system and correlate degrading adhesive material properties to changes in the coupler system’s behavior throughout its service life.

Achievement
This research has shown that not all adhesive systems, designed for adhesive anchorage to concrete, and certified by ASTM C881, have equal resistance to moisture driven degradation. However, extensive studies and analysis based upon system A (US Anchor HS-200) and C (CIA Gel 7000) indicates an epoxy-bonded rebar-coupler should be able to achieve its service-life goals. While the System F epoxy seemed acceptable, results of coupler testing showed excessive slip (or creep) during the test. The question then becomes how to effectively and efficiently determine the relative resistance, to moisture-driven degradation, of epoxy adhesive systems. While all ASTM C881 certified systems must meet standard requirements in their nondegraded state; several additional tests should be performed to roughly assess their long-term performance, and resistance to moisture-driven degradation. Based on the results of this research it is recommended that an ASTM C 881 epoxy system not be used unless the following test results are found:
– The tension or compression, strength and modulus of the material maintains at least 50% of its initial level, after 1 week immersed in 60°C de-ionized water
– The glass transition temperature of the material, after 1 week immersed in 60°C de-ionized water, is at least equal to the expected maximum environmental service temperature + 30°C
– The Fickian diffusion coefficient is lower than $10^{-6}$ mm²/s, measured by moisture uptake due to immersion in 60°C de-ionized water

Lastly, numerical modeling of the experimental data indicates the original failure mode of the rebar-coupler for systems A & C should remain unchanged after a seventy-five year service period in moist, 23°C conditions.

Conclusion & Recommendation
California Test Method 670 should be modified to: (a) allow the use of a long-gauge extensometer as an option to measure slip; and (b) include an adhesive material pre-screening test for epoxy-bonded rebar-couplers to ensure the adhesive system would not be extremely vulnerable to moisture-based degradation.

Implementation Recommendations
• Modify California Test Method 670 in accordance with report recommendations

Implementation Measures Taken
• Recommendation has been referred to the Reinforced Concrete (Rebar) Committee for resolution.