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Summary of Ongoing and Proposed Research for Kelso Coatings

The cost of repairing reinforced concrete structures in Canada affected by corrosion-induced deterioration is estimated to be $74 billion. Despite the best efforts of many researchers, solutions for new construction in the form of cathodic protection or epoxy coatings have shown little long term success in preventing corrosion, and alternative reinforcement materials such as stainless steel or fibre-reinforced polymers may be cost-prohibitive for many applications. The development of CN2000 coatings distributed by Kelso Coatings has been a substantial step forward in rebar protection for corrosion mitigation. Unlike epoxy, the CN2000 coatings possess self-healing properties; if cracks do form in the coating layer they will close themselves naturally in the presence of moisture. Furthermore, the CN2000 coatings engage in a continuous hydration process allowing the coating particles to react with the surrounding concrete to seal pores and reduce permeability over time. Coated steel rebar also presents advantages over FRP reinforcement such as lower cost, higher elastic stiffness and ductility.

Ongoing research at Queen's University in collaboration with Kelso Coatings has highlighted the potential of CN2000 coatings for reinforced concrete applications where corrosion of internal steel reinforcement may be a concern. A total of 94 specimens comprised of steel reinforcing bars embedded in concrete mortar cylinders have been subjected to an accelerated corrosion process by immersing them in a saltwater bath. The high water-cement ratios used for the concrete mortar (0.5 and 0.7) in conjunction with the high chloride concentration of the bath have been designed to create an especially aggressive environment conducive to electrochemical corrosion in order to achieve corrosion in a short time frame. Hence, the control samples (uncoated rebar in concrete cylinders) showed signs of corrosion within only a few days, whereas in most typical applications with good quality concrete the first signs of corrosion may not occur for 30 years or more.

The results of these tests have been very promising; while many of the uncoated bars showed signs of corrosion almost immediately, bars with CN2000 coating types B+C or C+D survived these extreme conditions for periods ranging from approximately three to six months or more. In fact, some specimens have yet to show any signs of corrosion after exposure to the saltwater bath for 230 days to date. It is clear that the coated bars have demonstrated an exceptional ability to resist corrosion compared to uncoated bars.

In order for engineers to design structural elements with the coated rebar, the effect of the coating on the bond between the reinforcement and the concrete must be investigated. It is hypothesized that the coatings will change the bond behaviour of the steel rebar by altering the bond transfer mechanisms in two primary ways: first, the coatings will alter the bar surface by covering over the rebar lugs and second, the coatings will engage in an ongoing hydration reaction allowing them to permeate into the concrete pores. As a result, although the coatings may slightly reduce the mechanical bond (anchorage achieved by the rebar lugs bearing against the concrete at the bar-concrete interface) it is likely that they will enhance adhesion and chemical bond through an active reaction with the surrounding concrete. It is worth noting that a small net reduction in bond strength will not diminish the potential of the CN2000 products as the primary objective is corrosion prevention, just as epoxy-coated rebar enjoyed a period of considerable success despite having a reduced bond strength. The goal of the proposed study is rather to quantify the net effect of the coatings on bond strength to ensure safe and efficient structural designs.

Bond pullout tests are proposed with the objective of developing an equation to calculate the development length of the coated rebar for use in design. This step is imperative to gain approval by entities such as the Ministry of Transportation of Ontario for using CN2000-coated rebar in the construction of concrete bridge decks.