

Burlington Skyway Electrochemical Chloride Extraction – 30 Years Later

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ABSTRACT

The Burlington Skyway consists of two parallel high-level bridges that allow Great Lakes cargo ships to cross under the Queen Elizabeth Way highway in Burlington, Ontario. The first bridge opened to traffic in 1958 and was the site of the first Electrochemical Chloride Extraction (ECE) project in North America. Years of leaking joints had allowed salt-contaminated water to penetrate the large concrete piers with chlorides to initiate corrosion of the reinforcing steel.

The ECE process uses an impressed current power supply and a temporarily installed anode system to electrochemically treat reinforced concrete structures. As with any impressed current system, the ECE process generates hydroxyl ions at the steel surface and reduces the concentration of chlorides around the steel such that the structure is left in a passive, non-corroding condition at the end of the treatment process.

In 1989, the Ministry of Transportation Ontario (MTO) authorized a demonstration of a relatively new technology which can passivate corroding steel and has subsequently become known as Electrochemical Chloride Extraction (ECE). This process is more accurately described as Electrochemical Passivation of Chloride-contaminated Concrete (EPCC). After monitoring the original pilot installation for eight years, MTO proceeded to implement the ECE process on major substructure rehabilitation projects on the Burlington Skyway in 1997 and 1999. These projects included application of the EPCC

process to approximately 20,000 ft² of chloride-contaminated, reinforced concrete bridge substructure components. MTO has also applied the process to five other bridges in Ontario.

The initial area treated in 1989 has been monitored for 30 years and the other EPCC rehabilitated substructure components have been in service for 22 and 20 years since they were treated. All treated sections were inspected in 2020, more than 30 years after the initial area was treated and are in good condition.

This paper provides an overview of the electrochemical passivation process, history of the Burlington Skyway, description of the installation process, treatment results and up to 30 years of monitoring results for the structure.

Key words: Electrochemical, Chloride, Extraction, passivation, chloride-contaminated, impressed current, service life

INTRODUCTION

In 1989 a then innovative, corrosion protection technology was demonstrated in the field on Pier S19 of the Burlington Skyway in Burlington, Ontario, Canada.



Figure 1: Burlington skyway, Burlington, Ontario, Canada

Electrochemical Passivation

Electrochemical passivation is a method where the temporary application of a direct current (DC) to the reinforcing steel as illustrated in Figure 1 results in the generation of alkali at the steel / concrete interface and causes negatively charged ions such as chloride (Cl⁻) to migrate away from near the reinforcing steel with some of this chloride migrating out of the concrete.

There are two principal electrochemical passivation techniques; Realkalization where the pH of carbonated concrete is increased and Electrochemical Chloride Extraction (more accurately described as Electrochemical Passivation of Chloride-contaminated Concrete) where the pH is increased and chloride ions are migrated away from the reinforcing steel.

Both techniques are intended to restore the concrete environment around the reinforcing steel and passivate corrosion of the reinforcing steel.

How the process works

The method works by applying a DC electric field between the reinforcing steel (the cathode) and an external anode attached to the concrete surface and embedded in an electrolyte as illustrated in Figure 2.

The external anode which can be steel or an inert material such as titanium is attached to the concrete surface and embedded in an electrolyte. The electrolyte is typically a non-toxic, biodegradable paste that can be spray-applied onto vertical, overhead, or horizontal surfaces. When a DC electric field is applied between the anode and the reinforcing steel, the reinforcing steel is negatively charged and the anode is positively charged. Electrons flow to the reinforcing steel and the cathodic reaction generates hydroxyl ions (OH^-) on the steel surface. Hydroxyl ions generated on the steel surface accumulate in the concrete adjacent to the steel and the pH in this region is increased.

Simultaneously, negatively charged chloride ions are repelled away from the negatively charged reinforcing steel and are attracted toward the positively charged anode. Chloride ions migrate through the pores of the concrete away from the reinforcing steel toward the external anode, with some of the chlorides exiting the concrete and collecting in the electrolyte paste on the surface.

Increased alkalinity and a lower concentration of chlorides at the steel surface results in passive, non-corrosive condition as the passive oxide layer is reformed and strengthened.