ELECTRO-OSMOTIC PULSE TECHNOLOGY FOR CONTROL OF GROUNDWATER INTRUSION IN CONCRETE STRUCTURES

Groundwater intrusion into a building can cause serious structural degradation, corrosion of mechanical equipment, increased maintenance requirements, and can make areas uninhabitable or even unusable. Humid environments are known to promote growth of molds and bacteria that have an adverse effect on human health and worker productivity. As the molds and microorganisms proliferate, indoor air quality decreases and health problems increase. To improve air quality it is necessary to decrease relative humidity and lower the moisture level of the surfaces on which the molds and microorganisms grow.

In 1994, a team of researchers from the U.S. Army Engineer Research and Development Center (ERDC), DryTronic, Inc., and APS Materials began development of an innovative technology for the prevention of water intrusion in below-grade concrete structures. ElectroOsmotic Pulse (EOP) technology is based on the concept of electroosmosis; the movement of an electrically charged liquid under the influence of an external electric field. It not only eliminates water-seepage problems from the interior of the structure without excavation, but it further mitigates corrosion damage to mechanical equipment and reduces the interior relative humidity of the basements. The reduction in relative humidity or moisture content of the concrete interior surface also eliminates one of the primary sources of disease carrying molds and bacteria, which require a high moisture content to survive.

The system uses two sets of electrodes; one set is embedded into the interior concrete walls and the other set is embedded in the surrounding backfill/soil. A pulsing DC voltage is applied between the electrodes to produce an electric field in the walls/floors surfaces, which moves water from the dry side (interior) toward the wet side (exterior), preventing moisture from reaching the interior surface of the concrete. A representative pulsating electroosmotic sequence consists of a pulse of positive voltage (time "t") (as seen from the dry side of the concrete wall), a pulse of negative voltage (time "t-x"), and a period of rest when no voltage is applied. Laboratory and field tests were conducted at ERDC laboratories in conjunction with demonstrations and evaluations at selected Army installations to assess the feasibility and cost effectiveness of EOP technology in comparison with conventional dampness mitigation techniques.

The U.S. Army Construction Engineering Research Laboratory (CERL), DryTronic, Inc., and APS Materials have entered into a Cooperative Research and Development Agreement (CRADA) to combine and further develop EOP technology for below-grade construction materials other than concrete and to facilitate technical transfer to both public and private sectors. The CRADA has allowed Drytronic and CERL to both synergistically transfer EOP technology while continuing to innovate.

The most novel innovation within the EOP system is the use of a new electronic conducting ceramic-coated anode material, patented by CERL, and produced by APS Materials. This innovative approach is already being utilized in new EOP installations. The use of the ceramic-coated anode allows for higher current densities for the same anode shape and because the ceramic-coated anode does not change shape over time, allows for improved placement. This ceramic-coated anode material is dimensionally stable, in contrast to previous anode materials that used ionic conductive materials, such as graphite, which are subject to material loss during operation. By incorporating this anode technology into the EOP system, system lifetime was greatly increased. System lifetime ionic anode material was around 10 years, when the anodes needed to be replaced – system lifetime using the new anodes is virtually infinite. The U.S. Army Corps of Engineers has submitted a joint patent application titled "An Improved Method To Control Movement Of Water Through Capillary Materials Utilizing Electro Osmotic Pulse And Ceramic Coated Anode Material" (COE Case 514) during 2001.

An equally important innovation of the EOP system is the asymmetric dual polarity pulse waveform, patented and developed by DryTronic, Inc. This waveform is a significant advancement over the constant dc waveform that was used in the past, and failed. The positive electrical pulse causes cations (e.g., Ca^{++}) and associated water molecules to move from the dry side (anode) towards the wet side (cathode) against the direction of flow induced by the hydraulic gradient, thus preventing water penetration through a buried concrete structure. The negative voltage pulse allows for control of the amount of moisture within the concrete, which prevents over drying of the concrete matrix and subsequent degradation. The pulse of positive voltage will have the greatest time duration. The amplitude of the signal is typically on the order of 20 to 40 Volts DC (VDC). Use of the dual polarity pulse waveform prevents the concrete from becoming too dry and losing its structural integrity. ERDC is optimizing the waveform for additional application involving EOP technology.

A lifecycle cost analysis comparing EOP technology ($135 per linear foot) to conventional exterior excavation and repair technology ($350 to $1000 per linear foot) results in a minimum 40% cost savings. EOP technology has been successfully implemented within the DOD, Treasury, VA, Fish and Wildlife, and the private sector in both conventional and historic buildings.

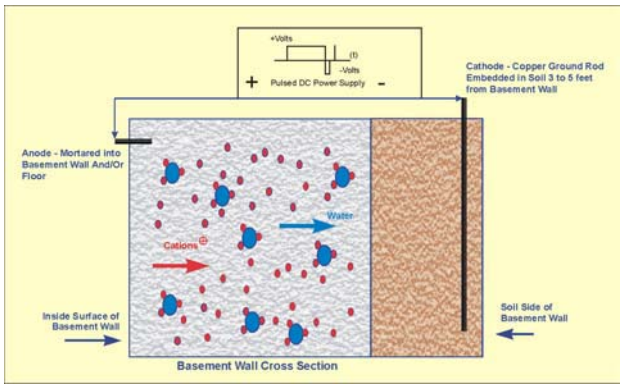
The Honorable Tommy G. Thompson, Governor of Wisconsin expressed his appreciation for EOP technology as a viable technology in a letter to LTG Ballard, Commander, Corps of Engineers. In this letter, cost savings resulting from the use of EOP technology were estimated to be in excess of $100 million nationwide. EOP technology was one of four finalists for the prestigious Civil Engineering Research Foundation's (CERF) Charles Pankow award for technology innovation in 1999.

Contact: Vincent F. Hock • U.S. Army ERDC-CERL • P.O. Box 9005 • Champaign, IL 61826-9005
217-373-6753 • Fax 217-373-6732 • v-hock@cecer.army.mil • www.cecer.army.mil/eop

EOP TECHNOLOGY FOR CONTROL OF WATER INTRUSION

Severe water intrusion

Severe mold problem



Schematic of EOP system operation

Installing positive electrode (anode) in groove at wall/floor junction of concrete

Basement mechanical/electrical room before, and six months after EOP system installation

Construction Innovation Forum • 43636 Woodward, Bloomfield Hills, MI 48302 • 248-409-1500 • Fax: 409-1503 • E-mail: info@CIF.org • www.CIF.org