2016-2017 Awardees

Father of two ***Thomas Jacob-Vaillancourt*** *received his bachelor's degree in civil engineering from Laval University, where he now pursues his master's degree. The goal of his ongoing research is to optimize curing and protection methods for shotcrete. The study will provide a better understanding of the curing impact on hydration and overall durability of dry-mix and wet-mix shotcrete. He is working on one of the projects of the Collaborative Research and Development grant supported by King Shotcrete Solutions and NSERC at Laval University.*

RESEARCH: OPTIMIZATION OF CURING AND PROTECTION METHODS FOR SHOTCRETE

Background and Industry Problem

The market for high-performance construction and repair materials is in continuous growth, and shotcrete has proven to be a method that produces durable, high-quality concrete at a low cost. Shotcrete, however, generally has a very high ratio of exposed area to volume. Once in place, it is rapidly exposed to the drying produced by local environmental conditions and can therefore be subjected to a great loss of water at a young age. In addition, the curing methods used for traditional concrete are ill-suited for shotcrete projects that have curved or overhanging shapes.

Objectives

The study takes place in two stages. The first objective aims at characterizing the effects of the cure in terms of durability of the in-place shotcrete. The second attempts to identify which of the market-available curing methods is best suited to extend the quality and service life of the sprayed concrete structures. In the present context, durability is defined as the potential for cracking and the quality of the surface produced in terms of porosity and abrasion resistance.

Research Significance

Because much of the study will be done on chemical curing agents (curing compounds and evaporation reducers/retardants), it is interesting to determine their effectiveness in limiting the loss of water from concrete depending on environmental conditions. For evaporation reducer agents, in addition to determining their effectiveness in reducing the evaporation of water from concrete, it is important to determine the length of efficacy of the protective film. To do this, precise scales were installed in a wind tunnel to allow us to monitor the loss of the concrete mass following the application of a curing compound or an evaporation reducer agent.

Pierre Siccardi *is currently completing his master's degree in civil engineering at Laval University. Siccardi received his bachelor's degree in mechanical and industrial engineering from Arts et Métiers ParisTech, France, and his research project on shotcrete equipment allows him to take advantage of the diversified knowledge he has acquired along his university career. His research aims at developing shotcrete equipment technology that could bring together the shotcrete process and advanced mixtures such as UHPFC or CSA cement-based materials.*

RESEARCH: THE INFLUENCE OF EQUIPMENT ON SHOTCRETE PERFORMANCE

Background

Improvement of shotcrete is generally based on two main aspects: the mixture design and the equipment. Most of the research has been focused on the first item and the second hasn't really been studied in university laboratories.

My research project continues a series of research efforts established at Laval University in the last 5 years, and which has been profitable for advancements in the industry. Characterization of the spray pattern in dry- and wet-mix was one of the first challenges faced and had been overcome by using a high-speed camera. With the data collected, we are now able to understand the effect of multiple parameters that impact the shooting process. This promising information opens the doors for many research projects.

Objectives

The project aims to enhance the performance of shotcrete equipment in terms of versatility, rebound, and material uniformity. The study especially focuses on the nozzle and the water ring. In fact, a new dry-mix nozzle technology is currently being tested. This device has been designed to work with new mixtures such as very high early-strength shotcrete or ultra-high-performance fiber-reinforced shotcrete, and the results are already very encouraging. The long-term objective lies in the automation of the process, which would ensure that shotcrete consistency and consolidation is adequate while making shotcreting safer and less of a physical challenge for the nozzlemen. Moreover, this initiative combines productivity, safety, and sustainable development.

Research Significance

There are two main aspects explaining the need for development of new shotcrete equipment: first, it hasn't evolved in many years, and second, there are many complex components involved in the shotcrete process. Thus, there are numerous ways for us engineers to improve the shotcrete equipment.