2017-2018 Awardee

***Émile Blouin-Dallaire**, Jr. Ing., holds a bachelor's degree in civil engineering from Laval University, Quebec City, QC, Canada, where he is currently completing his master's degree in the same field of study. His ongoing research project aims to optimize curing techniques and their impacts on shotcrete shrinkage and cracking. This project is part of the effort to reduce the cracking potential of shotcrete repairs and to improve their durability. He is working on one of several projects of the Collaborative Research and Development grant supported by King Shotcrete Solutions and the Canadian Natural Sciences and Engineering Research Council.*

MASTER'S RESEARCH PROJECT

Curing Techniques and Their Impacts on Shotcrete Shrinkage and Cracking

Shotcrete placement pneumatically accelerates concrete onto a surface where the high-velocity impact of the paste and aggregates achieves sufficient compaction on the receiving surface.[1] Shotcrete is a concrete application method frequently used in the concrete repair industry as well as the mining/ground support field.[2] One of the most important parameters to consider is the compatibility of the deformations within the concrete matrix.[3-7] Because shotcrete can cover large surface areas (for example, a wall or abutment repair) without the use of formwork, the results are a large surface of fresh concrete exposed to the environment. With insufficient protection, it will quickly lead to differential shrinkage between the concrete substrate through the relatively thin shotcrete layer. If not cured and protected properly, this shrinkage will inevitably lead to cracking.

One of the main objectives of this project is to give the industry a greater understanding of methods for reducing the cracking potential of shotcrete repairs and subsequently enhancing their durability. Knowledge needs to be improved on the methods to perform adequate protection during the curing of shotcrete repairs. Furthermore, the shotcrete industry has seen a considerable increase over the years in durability and aesthetic quality requirements. This project is part of the effort to reduce the cracking potential of shotcrete repairs, and to in turn improve their durability. Such improvements must include enhanced curing and protection practices to fully take advantage of the shotcrete process.

Curing techniques are an area that needs serious research. Indeed, current practices in North America go from minimal protection for only a few hours to extensive curing and protection for up to 14 days. As expected, the success level of these approaches is quite variable, as are the related costs and constraints on the jobsite. Much research remains to be done and explored in curing to determine what really works, and at what cost. The obvious question, and by extension the objective of the project, is to find out how much is enough. An investigation needs to be conducted to identify curing methods that minimize effects of shrinkage on shotcrete. Many environmental factors can influence the cure, including items such as temperature and humidity in addition to the methods and products used.

To achieve the previously defined objectives, the project's scientific objectives are to:

- Develop a reliable early shrinkage measurement method that allows the application of curing and sealing compounds to exposed surfaces without compromising shrinkage measures;
- Independently assess the impacts of external curing techniques on shrinkage of shotcrete;
- Explore internal curing techniques and assess their impact on shrinkage of shotcrete; and
- Define various complete curing scenarios and quantify their effects on shrinkage of shotcrete.

Many studies have been conducted to assess the influence of curing on shotcrete mechanical properties, but there are many unanswered questions about curing and protection practices as applied directly to shotcrete placement. The lack of comprehensive research on this subject leaves room for a lot of interpretation (and misconceptions) when trying to determine what really works.

Finally, this master's project seeks sustainability of better cured and protected shotcrete at both the environmental and economic levels. Indeed, this research ultimately aims to limit the environmental impacts of our infrastructure by increasing their lifetime. This project is also part of the effort to extend the useful life of structures because the main objective is to enhance shotcrete repair's resistance to cracking and increase their durability. Also, shotcrete greatly reduces the quantities of materials used and disposed of on a repair project. Moreover, maintenance is reduced by increasing the durability, further reducing CO_2 emissions. For the economic aspect, it goes without saying that producing more durable repairs bring significant economic benefits by increasing the useful life of the structures as well as reducing the frequency of maintenance.

References on following page >

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