2022 – 2023 Awardee

Aimerick Vincent *is currently an M.Sc. candidate in the Department of Civil and Water Engineering at Université Laval, Québec City, QC, Canada where he is studying and developing shotcrete mixtures with cellulose nanofibers. Prior to this, he obtained his bachelor's degree in civil engineering from the Instituto Tecnologico de Durango, Mexico in 2018, after which he worked 3 ½ years in mining and tunneling with a large contractor, Fresnillo PLC Corporation. Aimerick is from Haiti. He worked for a few years in the mining business and decided to pursue an M.Sc. in shotcrete technology recently at Université Laval. He is highly determined, very curious, and rigorous in his work. His M.Sc. project explores the use of micro and nano natural fibres in shotcrete, hoping to further control rebound and early-age cracking.*

MASTER'S RESEARCH PROJECT
Use of cellulose nanofibers in shotcrete

Shotcrete is well known and well placed in the current context of construction; in fact, the technique, by its versatility, has made it possible to carry out a rapid and economic intervention in the construction and repair of large and small structures. Like almost every other technique used in construction, shotcrete is constantly evolving.

The great characteristics of versatility and high productivity of this placement technique can unfortunately make it vulnerable to plastic shrinkage cracking, particularly when large surface areas are placed. Therefore, to find solutions to this challenge and to improve robustness of mixture designs, numerous scientific and technological research studies have attempted to develop new mix designs to incorporate fibres to better resist cracking. At Université Laval, research has also focused on the problem of cracking and the performance of concrete[1,2,3]. Moreover, solutions are increasingly seeking to address the ecological and sustainable aspect of cementitious materials by using natural resources available locally throughout the world.

Thus, several researchers have worked on natural microfibres and nanofibers in cast concrete[4,5,6]. These studies demonstrated the potential to significantly improve the mechanical performance of concrete. Hence, natural fibres became an interesting ecological alternative in mixture designs in order to generate a more durable and economical material. However, there is still not much research on this subject, especially in shotcrete[7]. It is therefore necessary to advance our understanding of shotcrete reinforcement with cellulose nanofibers, particularly in the current context of sustainable development.

This sparked the interest and focus on this innovative study to discover the potential of adding natural nanofibers in shotcrete. The objective is to develop shotcrete mixes with natural nanofibers that offer better pumpability and placement characteristics while at the same time improving mechanical performance and durability. The objectives for this research project include:

- Develop a mixture design for both dry-mix and wet-mix shotcrete that incorporates cellulose nanofibers.
- Establish/adapt a mixing procedure for incorporating cellulose nanofibers in both shotcrete processes.

- Evaluate and study the characteristics of wet-mix and dry-mix shotcrete developed with cellulose nanofibers.
- Formulate recommendations for their use on site.

To test the contribution of natural fibres in shotcrete, several concrete spraying experiments will be performed in the Shotcrete Laboratory at Université Laval with existing measuring instruments and analysis tools and according to corresponding ASTM (American Society for Testing and Materials) standards.

This project is directly linked to the sustainable development issues of today's society. Indeed, it has a huge potential for improving shotcrete placement, especially regarding the risks of cracking, but also on the durability and mechanical properties. In this sense, the mixtures to be developed will improve the efficiency of shotcrete used in construction, which will lead to more durable and economical applications, thus reducing additional costs in the long term.

RESEARCH SIGNIFICANCE

A new rebound model will provide a better understanding of the behavior of shotcrete and therefore offer more parameters to define the rules of shotcrete mixture design. This will make it possible to allow the shotcrete mixture design to be optimized.

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