Creating a Foundation for Success: The Use of Lidar in Tunneling Projects

By Carlos Gonzalez

Shotcrete placement requires close attention to safety; when combined with the difficult working conditions of a tunnel, overhead placement requires even greater awareness of potential hazards. As underground and tunneling projects become more common, collaborative partnerships between forward-thinking civil engineers, shotcrete contractors, and technological innovators are becoming more prevalent in an attempt to improve not only the way shotcrete efficiency is measured but also to reduce the risk for workers.

The dangers of underground construction methods are numerous. The whole premise of making tunnels safe often relies on placing workers at risk while the work is carried out. In March 2014, a shotcrete rig operator died while working on London's Crossrail tunnel project. Investigations into the incident led authorities to believe that the wet shotcrete lining collapsed as the worker approached the wall to trim excess concrete. As most experienced operators know, fallout from overhead placement is a potential hazard when working on underground applications that can never be entirely avoided by improvements in both safety and training practices.

COMBINING KNOWLEDGE

3D Laser Mapping (Now part of GeoSLAM) has been working with mining companies for over 20 years, creating solutions that address the challenges of those working in unstable environments. One such technology is LiDAR (Light Detection and Ranging), which visualizes and analyzes surroundings from a distance, using remote sensors to warn of impending dangers. When approached by Jetcrete Oz, an opportunity arose to create a solution with the aim of making the underground application of shotcrete safer, faster, and more efficient. Jetcrete has over 35 years of experience supporting and fortifying shafts and tunnels. With employees regularly working in the dark and difficult environmental conditions of a tunnel, it became a necessity to create an operational management system that would help Jetcrete to more effectively communicate job progress and compliance with application standards.

The majority of mine sites suffer from rockfall and slope instability, leading to the development of industry standard technologies which are now commonplace in many open pit and underground mining operations.

LIGHT AT THE END OF THE TUNNEL

Laser scanning has traditionally been used by civil engineers and surveyors to create three-dimensional (3-D) maps of large and potentially complex environments. Using a pulsed light from a laser, a LiDAR system calculates distance by timing how long it takes for each pulse to reflect back to the scanner. Capable of firing around 1,000,000 pulses per second, the most progressive systems can generate a millimeter-perfect representation of a target area. Once analyzed, this can reveal characteristics and features that can often be difficult or even impossible to see with the naked eye.

In an underground environment, these stations are often the surveyor's instrument of choice when it comes to monitoring movement. Great advancements in above-ground applications have now made LiDAR an even more powerful tool when it comes to measuring and monitoring changing landscapes. Thanks to its ability to map and pinpoint specific geological features, LiDAR is adept at identifying minute changes. It is this attribute that inspired the development of the underground shotcrete monitoring system, ProcessMonitor Live.

DEVELOPMENT FOR THE UNDERGROUND MARKET

While consulting with Jetcrete, it became clear that, as much as the application technology of shotcrete rigs and equipment had advanced, the measuring and reporting processes had not. Many experienced shotcrete contractors have relied on measuring the applied thickness using probes. This method can be as time-consuming and inconsistent as using stamps. Sometimes operators had to return to a shotcreted surface hours after application to check whether the desired thickness had been reached. If it had not, the rig would have to be returned to the deficient location to reapply. In addition to under-application, neither stamps nor probes allow for a rig operator to gauge if the shotcrete has been over-applied, meaning that the potential for wastage is high.

Another important consideration that arose in the initial consultation was safety. From exposure to heavy machinery, potential rockfall and fallout incidents, nozzlemen were

constantly placed in harm's way once they were out of the rig. With this in mind, the 3D Laser Mapping's research and development team considered three key objectives when developing ProcessMonitor Live: safety, time management, and efficiency. This combines the accuracy of LiDAR with advanced real-time data-processing software, allowing Jetcrete to assess each surface prior to application and then measure and monitor the thickness of shotcrete as it is applied.

SAFETY

The health and safety of workers is paramount in any industry, yet in heavy industrial environments such as mining, the hazards are often serious and potentially life-threatening. LiDAR's remote sensing capabilities and ability to automatically assess an environment from a distance allows users to create maps and models of transportation infrastructure or assess the integrity of slopes and cliffs. These capabilities help keep employees at a safe distance, reducing the risk of incidents and fatalities.

ProcessMonitor Live was initially designed to be mounted to a shotcrete rig, allowing the operator to provide inspections at each stage of the application process from the safety of the vehicle. The remote nature of the system also helps to complete initial risk assessments with the assurance for clients that additional safety measures will be taken while working on site.

TIME MANAGEMENT

Laser Mapping's research and development team used a software algorithm with the potential to almost instantly detect change between each scan of the surface. The laser scanning system was connected to a tablet, which the operator used to capture a color-coded image showing the profile of the target surface in real time. Each time a layer of shotcrete was applied, the operator could then repeat the scanning process and visualize any under-sprayed areas before the rig moved on. With the ability to scan immediately after application and with each scan taking around a minute to perform, the rig operator was able to improve the accuracy of the process as well as shortening the time to cover the area correctly.

EFFICIENCY

Material wastage is difficult to quantify when applying shotcrete, particularly when shotcrete tunnel linings can run into thousands of square feet. A wastage tolerance of as little as one percent can have huge cost implications for both the principal contractor and shotcrete contractor. ProcessMonitor Live can measure the applied thickness of shotcrete down to the millimeter, helping to reduce waste.

Measuring and monitoring potential overspray can also help to prevent dangerous instances of fallout, a common occurrence when working in tunnels. Underspraying can have equally large safety ramifications if areas prone to rockfall are not adequately protected. The digital data collected by the scanner and software allows ProcessMonitor Live users to ensure that their shotcrete placements comply with regulatory requirements by providing documented data to prove work has been carried out to specified requirements.

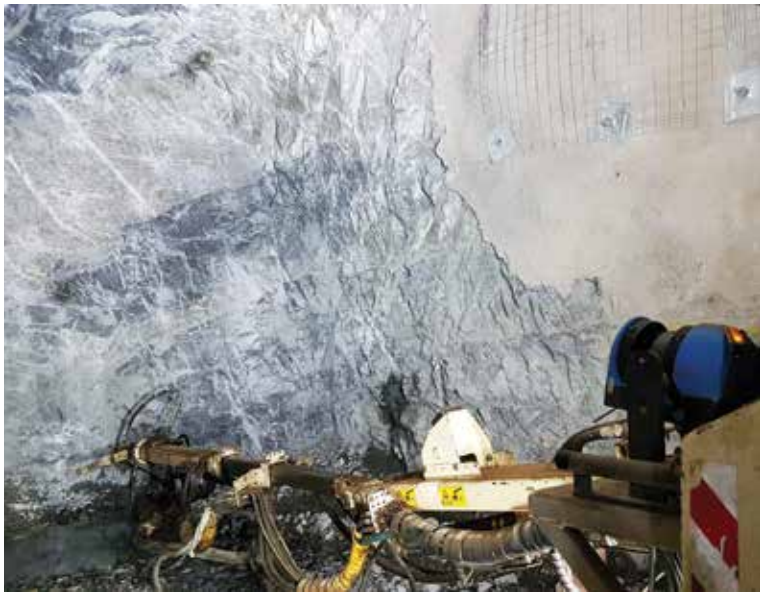

Fig. 1: Monitoring equipment on a shotcrete rig

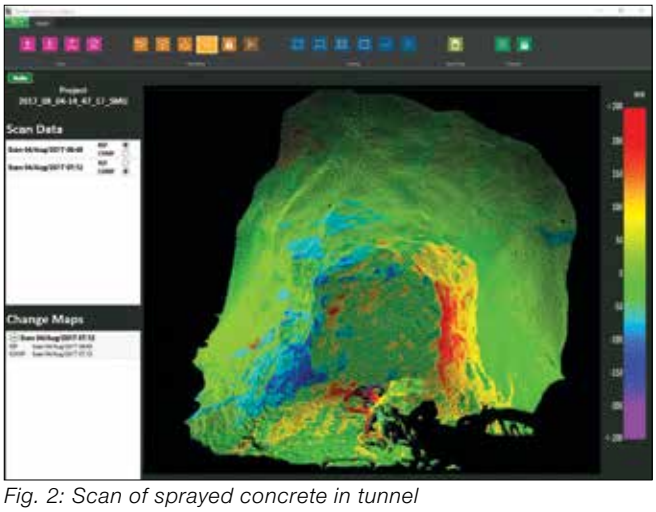

Fig. 2: Scan of sprayed concrete in tunnel

Since joining in 2014, ***Carlos Gonzalez*** *has been the key contact in Australia for 3D Laser Mapping. His experience is in product engineering, geodesy, and surveying in different environments and industries such as oil, gas, and mining. He has held positions as a Survey Manager, Product Engineer, and Senior Surveyor and specializes in monitoring solutions and mining services.*