The hole that will save a city

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Improving Chicago's stormwater management

THERE are many profound and romantic quotations about floods. Many popular ones use flooding as a metaphor for overwhelming love or spiritual enlightenment. These flowery quotes make perfect refrigerator magnets, t-shirts or — as penned calligraphy — an inspiration to hang framed and prominently displayed at home. Water and sewer workers have a more pragmatic view of flooding. If there's a quote hanging in their offices, it is probably more like this ditty from an unknown source:

> *One of the scariest things ever is flushing a toilet and seeing the water coming up instead of going down.*

During heavy rainstorms, a large metropolitan area's waste treatment facility can be pushed to its capacity. The overflow becomes an issue and the community's homes and businesses get flooded.

In Chicago, the Metropolitan Water Reclamation District (MWRD) is taking steps to reduce the harm caused by flooding — what it terms to be "the destruction caused by future strong weather systems in our region." MWRD is currently undertaking an expansion project at the wastewater treatment facility located in the nearby village of Lemont. The Lemont plant will benefit from a new $30m wet weather treatment facility to help improve storm water management at the site. The project will be completed by summer 2015.

The project includes a new pump station, a diversion structure for emergency high level overflow, separator and disinfection, and yard piping and tie-ins to an existing electrical and controls distribution system. Additionally, a significant component of the project is the construction of a diversion structure for emergency high-level overflow. The wet weather reservoir and wet well is a large in-ground concrete structure that measures 65.5x50x9m deep. The concrete walls are up to 1m thick and the base is 1.2m thick. It is expected to be solid, leak-proof, and capable of handling overflow from the biggest storms.

The site is predominately rock — a mixture of aged dolomite, limestone, and slurry. Contractors JJ Henderson first used a robotic total station to set control points throughout the site as a basis for registering the 3D laser scanner point cloud data. Survey control was also used for the blasting operations, to layout the blasting limits to match the final excavation configuration. Approximately 42,000m^3 of rock and soil was removed from the site in eight-foot lifts.

The construction of the concrete wet weather reservoir structure began by pouring a 30cm thick mud slab as a level footing for the base slab varying between 1-1.5m in thickness. A total of 600 rock anchors measuring 10m long and approximately 4cm in diameter were driven 9m into the ground. The rock anchors are designed to secure the base from uplift-pressures, since the reservoir is only full during major storm events.

The GLS-1500 laser scanner (left) and total station (right) keeping track of deformation on site.

Monitoring

The sheer excavated walls were monitored weekly to verify that the wall surfaces hadn't shifted, causing safety concerns for workers in the deep pit who were constructing the reservoir structure. A Topcon GLS-1500 laser scanner was used to collect the data for the monitoring operations. Scan data recorded from different control points was registered using ScanMaster 3.0 software. The registered point clouds were then exported in a .pts format to Bentley's Power GEOPAK, where the point clouds were overlaid onto the project engineers' site model. This workflow was then used to compare the excavation dimensions to the site design, verifying that enough rock had been removed.

Weekly surface to surface comparisons of the registered point clouds were carried out looking for deformation in the rock walls. The ScanMaster volume mesh function was used heavily for this. Volume meshes were created of scan areas identified by the project's geotechnical engineer and then compared on a weekly and biweekly basis, looking for major rock displacement.

Building a big hole.

The data being collected is not only critical for meeting current needs, but both the engineering firm and the client have asked for copies. It was originally planned to keep a 6x4m section of wall accessible for future expansion, but then the decision was taken to keep it sealed. Nevertheless, MWRD has asked for the point cloud data in case it ever needs to expand the reservoir.

Software

Software has made it easier for the contractors to collaborate with the various stakeholders in the Lemont project. GEOPAK's thematic mapping function was indispensable for looking at changes in different planes. It was also useful to be able to view the scan data relative to the Illinois State Plane coordinate system used on the project. This will become more important for the as-built surveys of new utility lines as the project progresses.

Importing point cloud data using ScanMaster's .pts export function supported the need to import the point intensity values along with the X-Y-Z coordinates. Different export formats were used to share point cloud data with the geotechnical engineer using AutoCAD Civil 3D. For development of presentation materials, the .dxf format was used, while the .las format was used for importing X-Y-Z coordinates with intensity values. In each case, using a drop box became standard operating procedure to enable the upload and download of point cloud files that in some cases exceeded 1,000,000 points.

A changing site

Weekly scans of the rock walls are now being conducted using the laser scanner's occupation and back sight scanning techniques to register the data. The site is growing more crowded as the project progresses. A few of the hubs that had been set up have become inaccessible as equipment moves throughout the course of the project. In one instance, a key control point was blocked by a crane moving rebar. To accommodate this, another hub was set up with a clear line of site to the area of interest. Two known points were target scanned and ScanMaster used the tie points created from these to run a resection, enabling registration of the new scans.

On one occasion, a temporary set-up point that was used in lieu of an established control point led to a mis-registration. The scan had taken 1 hour and 40 minutes and contained critical data for monitoring. The only way it could be registered with a high degree of accuracy was with cloud-to-cloud registration. Because of the accuracy of the permanent points — they are all verified with a three-second total station — they could be used for cloud-to-cloud registration. Once the registration process was completed, the residuals report showed that all the points sampled and registered via cloud-to-cloud fell well within the acceptable range of error for this project. Without registration via cloud-to-cloud, the scan session would have been wasted and key data would have been missing. Cloud-to-cloud saved a day's work. Without the laser scanner, a different monitoring plan would have been needed, requiring a crew of surveyors.

As the new wet weather management reservoir in Lemont enters its final construction phase, the MWRD has restored confidence that the city will be safer from the destruction caused by future strong weather systems or — as we simply call it — flooding.

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