Unmanned and Secure

An automated monitoring system featuring a robotic total station keeps subway trains on track while construction takes place nearby.

▲ A robotic total station was mounted on a custom-built pedestal permanently attached to a concrete bridge abutment and housed in a shed for protection

By Vicki Speed

For the last 100 years, the Metropolitan Transportation Authority (MTA) subway system has transported millions of passengers to and from the boroughs of Manhattan, Brooklyn, Queens, and the Bronx in New York City. Today, the average number of passengers exceeds one hundred million every month.

Keeping this complex, vital network of railways secure and safe presents a constant challenge, especially in the wake of new highrise and multi-story commercial and residential construction ongoing throughout the region. Of specific concern to MTA authorities is deep foundation pile driving, which causes impact and vibration to surrounding structures, creating the potential for movement of nearby train tracks that could cause derailment.

MTA frequently looks to the surveying community to monitor these subtle shifts. Traditional methods of continuous track monitoring have proven costly and time-intensive. But Maine Technical Source, with offices in Maine, Massachusetts, and New York, has supplied equipment at the request of Tectonic Engineering and Surveying Consultants, based in Rocky Hill, Connecticut, to develop an improved solution. This combines some of today's most advanced survey solutions, including robotic and reflectorless technologies, into a complete, unmanned geodetic-level monitoring system with 24/7 operational capabilities. The system was recently put in place as part of the construction of a commercial building and parking garage on a 32-acre site in Queens.

Adolf Jonietz, PLS, technical support specialist with Maine Technical Source, says, "This is the first time we have ever combined this particular series of instruments, and it has worked great. It's accurate, near maintenance-free, and provides regular movement information via the Internet through a continuous online DSL connection, all at a cost of about one quarter of conventional methods."

Pile Driving Causes Concern

Construction of the commercial building in Queens is taking place about 25 feet from MTA subway tracks, a bridge, and a highway. The bridge has four train tracks that cross over a four-lane roadway and a river. The tracks then continue underground, with the roadway splitting to either side of a tunnel.

To meet MTA criteria, Tectonic Engineering and Surveying Consultants needed to monitor the movement of the bridge, tunnel walls, and retaining walls during nearby pile driving as part of construction of the commercial building. The building construction team anticipated daily pile driving at the construction site over the course of 15 months beginning in 2006 and ending in fall 2007.

▲ Surveyors set up a monitoring network to track movement of subway tracks and a bridge during construction of a building

▲ Reflective prisms were installed with construction glue to the subway and bridge support structure

▲ Subway officials feared driving steel piles might cause track movement

After review of the site, the engineering team concluded they needed to monitor approximately 32 points, including onsite buildings and bridges as well as concrete walls and steel columns close to the subway system's bridge and tracks. A network of 32 prisms were mounted, each with a beam clamp or bolt at ten feet or higher above the ground, onto the face of concrete walls, bridge girders, bridge columns, or a building. Each was secured with construction glue for added stability and safety.

Tectonic Engineering and Surveying Consultants then selected a Leica Geosystems TCRP1201 robotic total station with power search and Pinpoint R300 reflectorless distance measurement. A laptop would run Leica Geosystems GeoMoS automatic monitoring software to monitor each of the 32 prisms. The total station and laptop were mounted on a custom-built pedestal permanently attached to a concrete abutment of the bridge. A shed was built around it for weather protection and security.

Finally, for 24/7 operation, this unmanned monitoring system required a power source and telephone hookup for Internet access. Technicians ran a 1,500-foot phone line and power line from a construction trailer on the site to the shed. As a precaution, a battery backup was installed with a five-hour capability. At the time of construction in early 2006, dialup Internet access was the only online service available. By early 2007, DSL access became available and is now the primary hookup for the site monitoring system, with dialup as a backup.

By placing equipment on a bridge abutment with an eight-foot-high chain link fence around it and a locked gate and then building a shed with a locked door on the abutment, the survey team made the site as secure as possible. The construction site also has 24/7 video surveillance cameras, which calmed many fears.

According to Michael Lacey, PLS, Tectonic's chief surveyor, "The entire network is unmanned 24 hours a day, seven days raw data through our FTP site, from anywhere at any time.

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▲ Michael Lacey, PLS, chief surveyor for Tectonic Engineering and Surveying, says the system keeps surveyors out of harm's way

Even if the Internet signal goes down, the GeoMoS software continues to gather data from the prisms. The entire monitoring effort is controlled by the GeoMoS software onsite using a laptop computer."

Continuous Operation

Operational since June 2006, the monitoring system records data from each prism every hour. For two months prior to the first pile driving work, Tectonic Engineering and Surveying Consultants established a baseline by collecting data continuously around the clock.

MTA stipulated at the beginning of the project that monitoring be done once in the morning and once at night. The required morning and afternoon readings would then be compared to the initial results and a report generated. "We've gone well beyond that requirement with this system for one quarter of the cost of having a field crew get the same information twice a day. The monitoring system records on the hour every hour from 6 a.m. to 6 p.m.," Lacey explains. If movement falls outside the defined safety range, the GeoMoS software triggers an email notification to Tectonic Engineering and Surveying's office and a text message to the surveyor in charge.

"Beyond the cost savings and service we've been able to provide our customer, this system offers a measure of safety to our field crews," adds Lacey. "They don't have to step around active train tracks and highways, especially in bad weather such as rain, sleet, or snow."

To date, the GeoMoS monitoring system has not indicated any unusual movement as a result of the pile driving. In fact, survey teams have noted that weather conditions and time of day have much greater impact on the shift of tracks and surrounding structures than driving piles.

Lacey concludes, "This unique combination of robotic total stations, reflectorless lasers, and automatic monitoring has paid for itself on this project. We've probably used one tenth of the overall program's capabilities. We look forward to working with Adolf Jonietz and Maine Technical Source in putting a similar system together on future projects." ▼

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