



Silent Sentinels Stand Guard in the Netherlands



An artist's rendering of the south entrance portal of the Rotterdamsebaan tunnels under construction beneath The Hague..
Credit: BAM Infra.

Using integrated solutions to monitor tunnel construction under The Hague

Advanced instrumentation provides reliable, accurate performance

Solution

- Trimble® S9 Total Station
- Trimble Precision Software Development Kit



overview

To address congestion in densely populated cities, transportation engineers and city planners are increasingly turning to tunnels. The Rotterdamsebaan tunnel currently under construction beneath The Hague exemplifies the new era in urban tunnel construction. It is efficiently built, environmentally friendly and designed to mitigate any impact on urban centers. The approach includes extensive monitoring to detect any surface motion resulting from the tunneling process.



Location
NETHERLANDS



While modern tunnel boring machines (TBMs) are designed to minimize ground movements caused by the tunneling process, there will always be some ground reaction. Monitoring the Rotterdamsebaan construction put a premium on the instrumentation and skill of the monitoring teams. The Hague city council contracted Fugro to oversee the monitoring process. An international leader in geospatial measurements, Fugro would monitor the impact of the project on infrastructure along the tunneling corridor.

BEST PRACTICES FOR MONITORING

To monitor large projects, Fugro utilizes multiple robotic total stations such as the Trimble® S9 arranged in networks in and around features to be monitored. On a

project of this magnitude, forty or more total stations may be in use at any given time. The total stations are situated to have clear views of all building and surface features monitored for deflection. Typically each total station is mounted on a small platform bolted to the sides of buildings or poles where they can capture a panoramic view from above the site. When the mounts are close to businesses or residences, noise generated by frequent rotations of the total stations may be irritating to the occupants. This isn't a problem with the Trimble S9 though, which uses MagDrive™ technology to provide silent operation.

To connect the total stations into the reference networks, Fugro placed target prisms on buildings and chimneys that can be seen by at least two total stations. "We form networks that can be constantly measured and checked with the least squares adjustments," said Richard Bun, Fugro project manager and geodetic engineer.



Monitoring robotic total stations were mounted on solid posts in secure enclosures along the route. These self-contained monitoring units have robotic total stations, communications radios/-modems, rain/snow hoods, and sometimes cameras. They operate as a connected network of instruments and common inter-visible monitoring/control points.



Left: To monitor the “soft” areas of the tunnel corridor, iron rods with prisms were driven into the open fields/parks in dense arrays.

Right: In the port areas above the tunnel route, arrays of monitoring prisms were driven into the open fields/parks in dense arrays.



The instruments are remotely controlled by monitoring software taking preprogrammed cyclical measurements with millimeter precision. Data analysis can identify long- and short-term trends as well as producing real-time results as the TBM passes under each segment of the tunnel corridor.

Fugro developed its own monitoring software, GeoRiskPortal®, which has been successfully used on a variety of projects worldwide. The software

connects to many types of monitoring instruments, including strain gauges and extensometers. For this project, the company wanted to include Trimble total stations for the automated monitoring. Fugro used the Trimble Precision software development kit (TPSDK) to integrate the Trimble total stations with GeoRiskPortal. The TPSDK enables software control of the instruments, allowing developers to combine the high-precision total stations with their own custom software and instrumentation.



STABLE RESULTS

With the automated monitoring network in place, the total stations can continuously take measurements while compensating for any movement. Based on these measurements, the GeoRiskPortal software can model any movements of the surface or structures in real-time. When working in harmony, the Trimble S9 total stations serve as silent sentinels keeping a watchful eye on property and infrastructure above the tunneling.

In late 2018 the TBM was nearly done with the first of the two parallel 1640-meter tunnels and preparing to begin the second tunnel. Bun noted that while there was an initial investment to modify Fugro’s software, the benefit of being able to use a wider selection of instruments—especially on a project of this scope—far outweighed the costs. Fugro has already expanded its capabilities on other monitoring projects and looks forward to continuing this momentum moving forward.

The Trimble S9 Total Station provides quiet, high-precision measurement for monitoring applications.

“With the measurement performance of the Trimble S9, the support of Trimble engineers and the ability to efficiently integrate it into the GeoRiskPortal system, Trimble could provide a compelling solution.”

— Richard Bun, Project Manager and Geodetic Engineer, Fugro

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