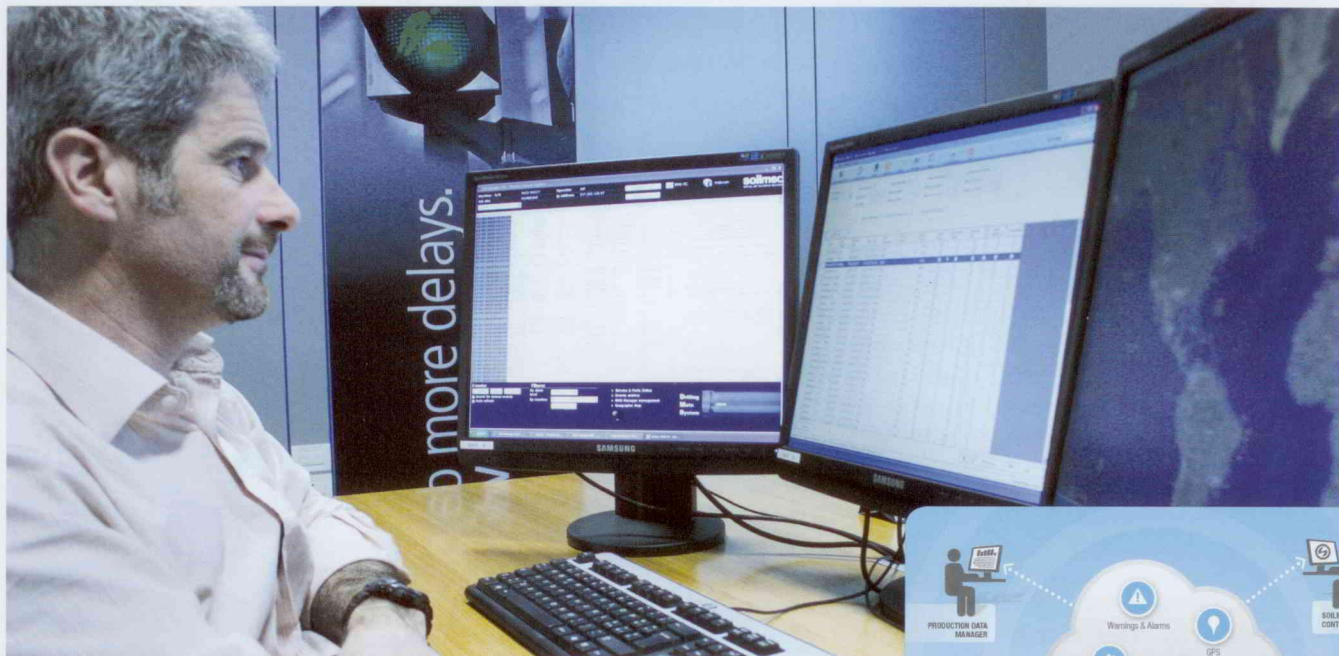


Construction in Copenhagen

THE ADVANTAGE OF MONITORING WITH THE DRILLING MATE SYSTEM

BY PAOLO CAVALCOLI AND VINCENT JUE



DMS service manager Saverio Santucci at the Soilmec Control Center in Cesena, Italy. Expert 24/7 live assistance is also available at two Soilmec Control Centers in North America.



Data flow of Soilmec's Drilling Mate System. DMS allows rig operators, project managers, and Soilmec service managers to monitor machines in real time and analyze data offline.

As the cultural, economic, and governmental center of Denmark, Copenhagen is experiencing a tremendous population growth due to a rise in birth rates and a surge of young people moving to the city. In order to meet the increase in transportation needs, Copenhagen is constructing a new underground metro line called "Cityringen." Cityringen will consist of a twin-tunneled 15.5 kilometre (9.6 mile) metro line circling the centre of Copenhagen with 17 stations that will connect to the existing underground transit network. The new metro construction sites are wedged in between existing residences, narrow streets, and historic buildings throughout the heart of the city.

As the primary subcontractor responsible for construction of the permanent supporting walls for all the metro stations and service shafts, Trevi S.p.A. is coping with difficult sub-surface conditions, strict environmental regulations, and challenging jobsite restrictions in

Copenhagen. Trevi has maintained its production schedule with a perfect safety record with the help of a large fleet of Soilmec rigs equipped with Soilmec's Drilling Mate System (DMS).

The DMS is a high-tech, fully integrated, interactive tool whose interface is located in the cabin of the drill rig, allowing rig operators and jobsite personnel to monitor and control the machine in real time. The performance of both the drilling/excavation production and the diesel engine are monitored using data from an array of sensors and safety devices, which are located throughout the rig, transmitted to the cab, and displayed on a DMS touchscreen interface. Operators can use the DMS to monitor the overall operation of the machine, record alarms, perform troubleshooting, and plan maintenance.

The DMS is available on all new Soilmec machines, and older Soilmec equipment can

be retrofitted to accommodate the DMS. Standard DMS monitors and records various machine production parameters and drilling data, including depth, inclination, rotary speeds, and crowd pressure, to assist in drilling a quality pile. Soilmec has also developed specialized DMS software packages to optimize the performance of a wide range of technologies: large diameter piles, micropiles, continuous flight auger piles, cased secant piles, diaphragm walls, hydromill excavation, jet grouting/tie-back anchors, and soil mixing.

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A Trevi worker uses Soilmecc's Drilling Mate System to monitor the hydromill diaphragm wall construction in Copenhagen.

OPERATORS CAN "SEE UNDERGROUND"

One of the challenges inherent with deep foundation systems is the inability to see what's being built at depth. The construction is hidden below ground, in soil or rock conditions that are only partially known. The DMS enables the operator to "see underground" as it monitors in real-time the operation and performance of the machine, providing the rig operator with active and precise instrument control.

Construction in Copenhagen's dense, historic downtown is being performed in very close proximity to existing buildings and structures. For example, the walls for the Marmorkirken (Marble Church) metro station are only 100 millimetres (four inches) away from the foundations of the 260-year old Marble Church, the largest domed church in Scandinavia. So it is vital for Trevi to set and monitor accurate drilling parameters during the foundation work to ensure that the neighbouring buildings are left undisturbed. Thanks to the DMS, Trevi has achieved high precision in reaching the target depths while maintaining the tight target verticality.

In addition, DMS provides real-time monitoring of the engine and its components, showing hydraulic oil pressure, fuel consumption, and power. This has allowed Trevi to perform its state-of-the-art foundation work in Copenhagen with low fuel consumption and minimal completion time, helping to save money and maintain the production schedule.

The DMS data can also be transmitted via radio, GSM/GPRS, WiFi, or satellite to a remote Control Center where DMS experts help troubleshoot in real-time. These Soilmecc service managers have a direct connection to the machine via the web, to see live what the operator sees on the DMS onboard display. The service managers can respond remotely to help fix most problems, rather than having to hop on a plane to visit the jobsite, which saves both time and money. All machines on the Cityringen project are monitored from the Soilmecc headquarters in Cesena, Italy. This rapid troubleshooting assistance has helped to ensure that the construction quality con-

sistently meets the demanding Copenhagen project specifications.

MAINTENANCE ALERTS REDUCE DOWNTIME

Minimizing equipment downtime is fundamental to maintaining productivity. Alarm signals triggered by the DMS alert operators when maintenance is needed. For cased secant pile construction, DMS displays alarms for coolant levels, low foot pressure, rotary gearbox lubrication, rotary head filter clog, mast inclinometer x-axis or y-axis failure, hydraulic oil filter clog, diesel engine parameters, and fuel level.

The DMS alerts and displays to the operator which component triggered the alarm, and it identifies the severity of the alarm. By pushing a button, the DMS also displays the history of the alarm so the operator can see if that component has been failing frequently.

In addition, the remote DMS Control Center is alerted when a maintenance alarm is triggered, so Soilmecc service managers can quickly call jobsites to help prevent larger problems from developing. This rapid troubleshooting assistance reduces maintenance times and helps create safer work conditions by ensuring that equipment works properly.

Monitoring maintenance issues using the DMS has been essential in Copenhagen, where the layers of hard boulders and flint rock have caused daily breakage of the cased secant piling tooling. The DMS has allowed Trevi main-



Trevi workers construct cased auger piles near the Marmorkirken (Marble Church). Monitoring with Soilmecc's Drilling Mate System helped ensure that this historic church was left undisturbed.

tenance managers to quickly identify and repair these equipment problems. Analysis of this data has also helped Trevi minimize downtime by improving their equipment and drilling techniques. For instance, intensive pre-drilling with a Wassara high-pressure water hammer has been used to break through the deep, hard layers of limestone rock and flint, which has doubled the production speed. Soilmec has also modified the cased secant piling tooling used in Copenhagen to reduce tool breakage – a more aggressive auger was developed using thicker, higher quality steel and an adjustable tool position. The DMS data collected from the Cityringen project has been crucial to the development of new technology and the reduction of job delays.

Proper maintenance has also improved the performance and longevity of the equipment used in Copenhagen. Trevi personnel plan routine maintenance using the DMS touchscreen, which records the machines' scheduled maintenance operations. In addition, the Spare Parts Online Center facilitates faster ordering of replacement parts.

JOBSITE MANAGERS UNDERSTAND OPERATIONS BETTER

All of this important data on machine operations, alarms, materials consumption, and maintenance can be streamed via cellular networks to a computer, so jobsite managers located in a field trailer or at a remote office can monitor and process the information. Even in the absence of GSM/GPRS or WiFi, the DMS retains all the data on a memory card or USB flash drive. The DMS software allows managers to create customizable jobsite, operational, and accounting reports – or the data can simply be exported as tables.

The DMS data can be analyzed offline and plotted graphically for easy interpretation. Managers can show bored piles or panels in order of completion status to check work progress. Data can be graphed as a function of either time or depth. For instance, hydromill production parameters – depth course, drilling speed, left motor pressure, right motor pressure, mud pressure, digging load, x-deviation and y-deviation – can be automatically plotted as a function of depth or time and can be displayed by clicking on the “depth” or “time” report tab using the DMS software.

Jobsite managers can also process and plot

critical parameters – pile profile, concrete pressure, and concrete flow – as a function of depth so they can analyze their construction quality. These graphs can identify potential construction problems like voids in the concrete, as well as provide an assessment of construction quality.

The ability to analyze the DMS data is crucial for complex jobs like the Cityringen project, where Trevi personnel are managing 21 jobsites with challenging subsurface conditions, environmental regulations, and jobsite restrictions. Offline analysis of the data re-

corded by DMS has allowed Trevi to construct high quality permanent supporting walls for the Cityringen metro system while saving time and money.

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