# Science upgrade

After two years of service interruption for the first planned long shutdown, the Large Hadron Collider, the world's largest and most powerful particle accelerator, was restarted on March 12. Preparation work for an upgrade of the collider and its testing infrastructure is gathering speed

*The Large Hadron Collider is the world's largest and most powerful particle accelerator*

*Photo: CERN/ Maximilien Brice*

The Large Hadron Collider (LHC) is the largest instrument ever designed and built for scientific research. Built by the European Organisation for Nuclear Research (CERN) from 1998 to 2008, the collider is contained in a circular tunnel at the Franco-Swiss border near Geneva, with a circumference of 27km, at a depth ranging from 50m to 175m.

Since 2010, thanks to 7,000 scientists from over 60 countries, the LHC has been exploring the new high-energy frontier. The crowning achievement was announced in July 2012, with the first empiric evidence of the long-sought Higgs boson, the cornerstone of the Standard Model of particle physics. But while particle physics pushes the limits of human knowledge about the universe and its origin, studies are under way at CERN for an upgrade of the LHC (called the High Luminosity LHC) to further increase its potential.

The CERN Council approved the HL-LHC project in June 2014. Upgrading such complex, large-scale machinery is a challenging task that will involve a number of innovative technologies, as well as serious infrastructure development. One crucial aspect of the project is upgrading the capacity of the test station known as SM18 (building 2173).

## TEST FACILITIES

The 7,200m² SM18 was constructed to test the magnets that compose the LHC and that can reach almost 30t in weight. Before the superconducting magnets can be lowered underground, they are all tested at their operating temperature of 1.9K (-271.3°C). (The LHC is also the largest cryogenic facility in the world at liquid helium temperature and one of the coldest places on Earth). The testing facilities of the SM18 are therefore equipped with special benches for testing superconducting magnets in horizontal or vertical position at very low temperature and up to high currents (20kA).

Today, the HL-LHC project requires an upgrade in terms of powering these clusters so that it can test larger prototype magnets with higher currents (>20kA). The strategy includes modifying the testing facilities and building new ones for the period 2015-2020.

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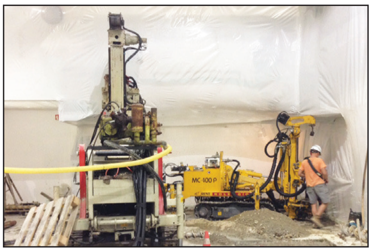
*The Comacchio MC 8 D performing auger drilling and the drill pipes*

## RETAINING WALL

As a part of this project, a new vertical test station will be built in cluster D of SM18 in 2015-16 – an upgrade that will require serious civil-engineering works.

The first part was undertaken in late March 2015 by the Italian engineering company Gruppo Dimensione, based in Grugliasco (Italy), under the supervision of project manager architect Francesco Canepa and eng. Dario Portè.

The company has been working with CERN for several years as general contractor in charge of construction works and technical systems. The drilling works were ►



*Near right: transportation of the Comacchio MC 8 D drill rig inside the SM18 using one of the CERN's electrical vehicles*

*Centre column: the Comacchio rigs working inside the SAS*

▶ commissioned to the subcontractor Terracon, supervised by CERN project manager Helena Botella.

"We were commissioned to build a retaining berlinese-type wall for the vertical excavation that will be carried out in cluster D," explains Marco Framarin, project manager at Terracon.

The work was carried out inside the building and involved the execution of micropiles of different diameters: 220mm-diameter piles, 6m and 11.5m long, reinforced with steel pipes with 139.7mm diameter; and 150mm-diameter piles, 11.5m long, reinforced with steel pipes with 101.6mm diameter.

The geotechnical data showed an upper layer of backfill material with gravel, pebbles and limestone blocks up to 2m depth, followed by clay with very hard boulders up to about 9.5m and molasse-type sedimentary rocks up to 11.5m depth.

"The molasse sandstone turned out to be very well cemented, which led to an increased consumption of drilling material," says Framarin. However, this was not the biggest challenge.

"The main difficulty was related to the strict environmental requirements that were far beyond what we've experienced on any previous site. The equipment was supposed to release zero emissions during operation: no dust, water, exhaust gas, cement dust or any other element that a micropile job normally involves was allowed to contaminate the testing facilities."

## DRILLING CONDITIONS

During the first drilling, it was immediately clear that the work environment was very difficult because of the high temperature inside the SAS decontamination chamber (over 40°C) and the overheating of the diesel engines, due to having two power packs working simultaneously all day.

It was therefore decided under the supervision of general contractor Dimensione that the two machines should work in separate shifts. Furthermore, an additional inlet ventilation fan was installed within the SAS. The original design of the chamber included only one air outlet to ensure that the job site would remain in negative pressure. Before adding a ventilation inlet, tests were undertaken to check



## Confined spaces

The entire job site was confined within a Safety Airlock System (SAS) decontamination chamber, access to which was controlled through a decontamination hall. All equipment and materials (pipes, cement, drilling accessories and tools) were taken inside the SAS chamber with switched-off engines and wrapped up (excluding the drill rig). CERN electrical vehicles performed all transport inside.

"The testing facilities of SM18 include some clean rooms where the staff works in a sterile environment as if it were an operating room," says Framarin.

The drilling had to be performed in confined spaces, part of it with overhead space lower than 240cm, hence the decision to use a Comacchio MC 4 D in the 'short mast' version, featuring a 2,127mm-long mast with 943mm feed stroke. "We used two Comacchio drill rigs of the seven in our fleet to meet the challenging requirements of the project: an MC 4 D and an MC 8 D," says Framarin.

Both of these rig models feature separated power packs and are designed for operation in confined spaces,. The use of separate power packs made it possible to evacuate the exhaust gas, which was vented to the outside, crossing the laboratory, by means of a fixed pipe and aspirator.

"The separated power packs proved essential in order to meet the project requirements, because without placing the engines in a stationary point, it would have been impossible to extract exhaust gas without losing time in the trimming and set-up phases."

that the room would still remain in negative pressure, ensuring that no dust could be vented outside.

"To avoid vibrations, only rotary drilling was allowed, even if the most appropriate methodology according to the soil study would have been rotary-percussive drilling," explains Framarin.

Drilling was performed both with water circulation, using tri-cone and tri-blade type bits, and with augers combined with claw bits.

The augers proved to be a more effective technique and offered simpler handling of drilling spoils, which were placed in buckets and taken outside when full. When drilling with water circulation, two tanks were used for the collection and decantation of the fluids, as well as a pump station to evacuate the mud to the outside, where it was filtered.

"Finding the most effective drilling technique and drilling tools was not an easy task," says Framarin. "We managed to find the right solution for the 220mm micropiles thanks to one of our longstanding suppliers of drilling tools. But for the 150mm drilling, we had to adapt a tri-blade chevron-type bit with special claws to manage drilling through the harder layers (molasse), but mostly because the gravel at the upper layers was difficult to extract."

A peak production of 69m was achieved in a shift with the MC 8 D. In total, 1,272m was drilled during April, (598m of 150mm diameter and 674m of 220mm), 144m of which was in extremely low overhead conditions.

To avoid cement dust, a separate SAS decontamination chamber was dedicated to the cement-mixing equipment, with CERN staff transporting materials and spoils with its lifting systems and electric carts.

Eng. Portè states that, after overcoming all challenges, work was completed by Gruppo Dimensione and its subcontractor successfully on time and achieved a positive response from the CERN engineers. ▾

**"The strict environmental requirements were far beyond what we've experienced on any previous site"**

*The MC 8 D performing auger drilling inside the SAS*