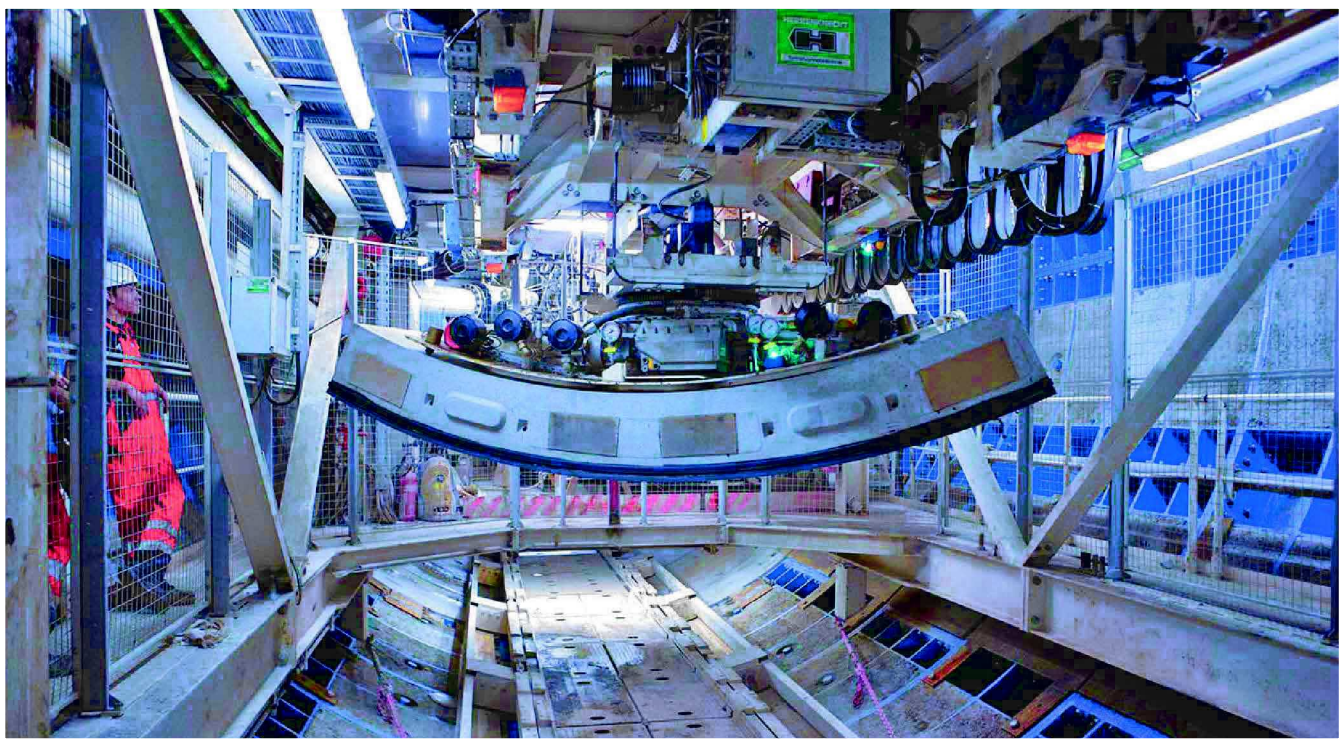
BUILDING EUROPE'S LARGEST TUNNEL

High-Tech Segments Ensure Key to Keeping Santa Lucia Tunnel Moving



The Segment Documentation System (SDS) from VMT manages data related to segments from fabrication to installation.

The A1 Autostrada in Italy connects Naples in the south to Milan in the north via Rome and Florence. The route is currently in the process of a major upgrade which includes widening and the construction of a number of tunnels to increase road capacity for the future. At around 750 km, it is the longest highway in Italy and is considered by many to be the spinal cord of the country's road network.

One of the many stretches of road that is currently being worked on as part of the A1 upgrade is the section between Barberino and Firenze Nord to the north of Florence. Here, a 59-km stretch of the A1 between Barbarino di Mugello in the north, and Firenze Incisa Valdarno in the south, is being widened in four sections (with one section already completed). The project allows for the construction of up to three new lanes for southbound traffic, with the existing four lane highway, two in each direction, ultimately being utilized solely, once completed, as the northbound route.

Within this section there is a requirement for the construction of a 7,528-m tunnel known as the Santa Lucia Tunnel through the Apennine mountain range. To complete this tunnel section, TBM manufacturer Herrenknecht built its largest TBM to come out of its Schwanau, Germany, manufacturing facility. The machine was an EPB machine measuring 15.87 m diameter, and is the third-largest TBM ever built.

The machine was designed to bore through the heterogenous geology of the mountainous region, using its drive power of 8,750 kN, and a torque of 101,296 kNm. The contractor for the project is Pavimental, with the project being owned by a joint venture company comprising Atlantia S.p.a 59.4%, Autostrade per l´Italia S.p.a 20%, Aeroporti di Roma S.p.a 20% and Astaldi S.p.a 0.6%.

Information on segments is available via barcodes and RFID tags.

CONSTRUCTION LOGISTICS

Of course, the boring of such an enormous tunnel comes with many potential problems, so the planning and control of the construction process are key issues to the success of the work.

Like all large construction projects, it does not matter how effective the TBM is as a stand-alone piece of machinery, the back-up and support of the excavation system is also part of the critical path to success. The need to 'feed the beast' with the right materials and equipment at the right time and in the correct order is vital to the process of ensuring that TBM downtime is kept to an absolute minimum. Not only is this required to minimize the construction time overall but also the potential for problems restarting the TBM after a stop.

Therefore, the client and contractor decided to utilize the most effective tunnel segment manufacture and control process available, VMT's Segment Documentation System or SDS, for the 32,000 segments required for the project. Maccaferri, an Italian construction and precast company with a precast factory based nearby in Bologna, was subcontracted to provide the segments. To meet the challenges of high quality standards and the application of RFID tags specified in the tender, the manufacturer decided to work with VMT, a German supplier of quality management and tracking systems for the tunneling industry.

Valeria Mainieri, Quality Manager for the Santa Lucia Tunnel project with Maccaferri Tunneling s.r.l., commented: "The SDS system allows us to manage the production process along with detecting some of the parameters linked to the traceability of materials. We could customize parts of the system and we are able to create a complete report with all the necessary information concerning data related to the raw materials used in each segment. This option allows us to drastically reduce the use of resources (people) allocated to data input in the PCQ cards for each segment, for example, on the client side of the process, which is one of the requirements demanded by our customer, Pavimental."

SEGMENT TRACKING

VMT's SDS system is designed to provide precise management of the whole segment handling process and, unlike other segment tracking systems available, the VMT SDS system offers far more than a simple documentation process. The SDS system enables the construction team to manage the life-cycle of the tunnel segments from rebar cage manufacture, segment casting through to storage and delivery thereby ensuring compliance with quality and documentation standards and optimum use of resources, while also minimizing risk, avoiding errors (particularly human ones) and reducing costs.

This level of control is possible due to the fact that all areas of the tunnel site are linked to an intelligent, efficient workflow network that is monitored stage by stage using individual bar codes and, in the case of the Santa Lucia Tunnel, RFID (radio frequency identification) tags. The link is achieved using a

wireless network covering the manufacturing facility, the storage areas and the transport system into the tunnel. The system also offers instant feedback to the workforce operator on site to ensure that the process is proceeding as planned. The bar codes and RFID tags are cross-referenced across the SDS.Production and SDS.Storage modules that form the basis of the SDS system database so that, for example, at the first stage of manufacture the barcode of the segment mold and barcode on the reinforcing cage can be registered in the system. The design process then checks and matches that the correct reinforcing system is being used with the correct mold for the planned segment. If the reinforcing cage does not match with that required within the database this information can be transmitted back to the production floor and the necessary changes made to ensure that there is no waste of time or materials by production of an incorrect segment.

THE SDS SEGMENT LIFE-CYCLE AT SANTA LUCIA

The production of liner segments for a tunnel operation such as Santa Lucia starts well in advance of the day any one segment is required at the face. This is because all segments have to undergo a 28-day full cure cycle to ensure they attain the correct concrete strength prior to installation. So, what is the life cycle following one segment through the SDS system?

The first step of producing a segment is to assemble the reinforcement cage. This has added to it a barcode and in the case of the Santa Lucia process, an RFID tag. The cage is then paired with the required segment mold in the segment production hall. The barcode for the mold – each mold has an individual barcode – is matched with the barcode of the reinforcement to ensure that the correct pairing is achieved prior to production of the segment.

The mold is then prepared for concreting and the carousel operator initiates the next cycle. Before entering the concreting chamber, SDS identifies the mold by reading an RFID tag that is mounted on every mold. Using an interface to the concrete batching plant, the system automatically orders a concrete batch according to the segment type to be produced in this mold. During the casting process, the batch information and raw materials will be transferred to the database and directly into the segment quality documentation.

Once this process is completed and the information passed to the SDS system to mark the time of concreting, the mold then passes into a heated curing tunnel. The mold stays in the heated tunnel to facilitate the initial cure of the concrete for about 5 hours. After exiting the tunnel the SDS system monitors the curing duration to ensure the correct time has been achieved.

The segment can then be removed from the mold and given its own unique barcode for future processing and the segment is added into the SDS system. The segment is then checked for damage or malformation before being cleared through the SDS system for transport to storage. Prior to transportation to the storage facility, a second scanner is used to check that the RFID tag, now located within the concrete of the segment, is still in working order. While not used as part of the production process, management and monitoring its future use means that each segment has to have a working RFID tag before installation into the tunnel.

The completed segment is then transported to the storage facility where the barcode is again checked and the segment's position in the store area is marked and logged on the SDS system.

Once the 28-day cure is completed and the segment is available to be called to site with its other liner ring partners, the SDS scanner is again used to indicate which segments are leaving the storage site and to generate a delivery note. The segments are loaded onto a delivery truck and transported to the TBM site. Once delivered, the TBM site signs off the delivery and this information is returned to the SDS system for closure of the system relating to that particular segment and the others that have been on the same delivery.

While not part of the Santa Lucia Tunnel arrangement, the SDS system also has facility if required on other sites to measure and store geometric data for segments once out of the mold to ensure quality and compliance with requirements.

The manufacture and storage systems also ensure that the correct rings are transported to the construction face in the correct order for installation so as to again minimize the potential for delays at the face as materials do not have to be re-ordered on arrival at their point of installation. The system also enables the transport team to ensure that should anything happen during the movement of the segments, such as damage while craning, this can be logged and dealt with at the earliest opportunity.

In the case of the Santa Lucia Tunnel, the requirement for the use of RFID tags was something requested by the client as the project was being designed. While not a vital component for the main construction and segment manufacture and handling process of the tunnel, it does ensure that at any time in the future (the tunnel has a minimum design life of around 100 to 150 years) each and every individual segment can be traced and accounted for from the construction database, particularly helpful for maintenance works or should damage occur due to unforeseen circumstances. For example, should it be discovered that a selection of segments were made using an incorrect concrete mix with one having shown signs of failure, then all segments affected by this can be found and tested individually by use of the RFID tag to identify their positions in the tunnel from the records and using an RFID scanner to locate them on site.

Commenting on the use of the SDS system with RFID tags for the Santa Lucia Tunnel project Florian Werres, VMT sales manager for the SDS system, said: "The implementation of the SDS system on tunneling projects such as this offers much more than simple segment management. Our system enables the workforce across the site to know that the segments have been manufactured to the highest quality, handled with the utmost care and delivered at the right time and to the right place. This is all achieved with the wireless interface and feedback process that means the SDS system is as much an active part of the tunneling process as the excavation of the ground by the TBM. Furthermore, with a beast of machine like the Herrenknecht EPB TBM that is boring the Santa Lucia Tunnel if it is not fed correctly it will simply stop working – and that is something that no-one on site wishes to see!"