Cesare Bianchi, Project Engineer, MAX STREICHER S.p.A., Italy, discusses the use of pilot drilling, raise boring, and microtunnelling within the Italian pipeline network.

On behalf of Snam Rete Gas S.p.A. MAX STREICHER S.p.A., the Italian subsidiary of the German STREICHER Group has carried out a 32.4 km long section of the Rimini-Sansepolcro pipeline. The new DN 750 (30 in.) pipeline replaces an existing DN 650 (26 in.) line and mostly traverses mountainous and geologically difficult terrain that is hard to access. Through meticulous preparation efforts, it has been possible to make good progress in a short span of time; work began May 2020 using efficient drilling procedures along many trenchless pipeline sections.

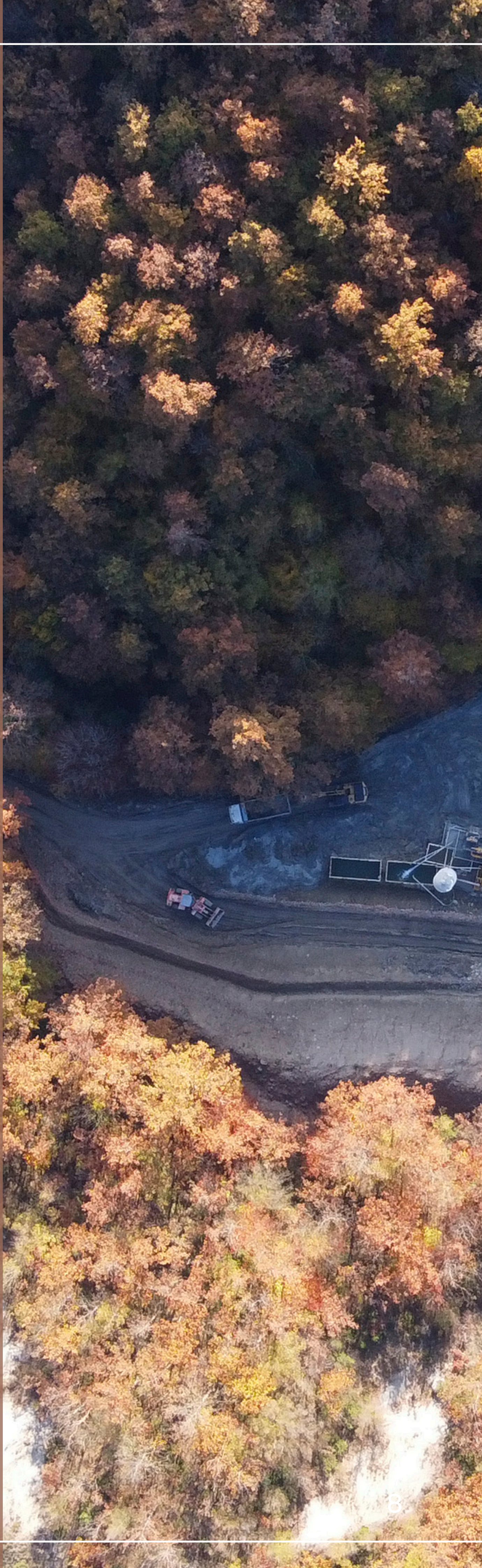
The approximately 75 km long pipeline between the communities of Rimini (Emilia-Romagna) and Sansepolcro (eastern Tuscany) constitutes an important connecting section of the Ravenna-Chieti and Montelupo-Sansepolcro courses within the Italian pipeline network. A new and larger gas pipeline is being planned for future developments of the network; this will ensure gas is transported more flexibly between the eastern and western parts of the country. Another benefit to this project is the increased safety in transportation, as the use of modern pipeline laying techniques ensures the pipeline is installed safely even in geologically challenging sections of the traversed terrain.

Snam Rete Gas has commissioned STREICHER with one out of three construction lots. This includes the construction of a 32.4 km long DN 750 pipeline section including four valve stations, a short section DN 650 pipeline and three DN 100 secondary pipelines with a length of 2.3 km. Numerous crossings, which were mainly executed with trenchless technologies, have also been part of the project. The new gas pipeline largely traverses on its existing route, specifically along the alluvial plain of the upper Tiber Valley. In various other sections of the pipeline, deviations and route optimisations were unavoidable, as local conditions prevented a re-laying of the line directly adjacent to the existing pipeline.

"A large section of the pipeline route leads across the Apennines, a mountainous area with sand and calcareous rock composition. The slopes here have an average gradient of more than 44.5% and are usually forested. Because the pipeline route here mostly runs along the ridges of the hills, we had to cope with some very steep sections and, among other things, take protective measures against falling rocks," explains Samuele Luzietti, Project Manager.

Detailed construction site planning and expansion of access roads

In order to minimise risks related to the composition and texture of the rock, geognostic surveys were carried out in advance. In addition, STREICHER worked on a detailed



THE TRIALS OF MICROTUNNELS

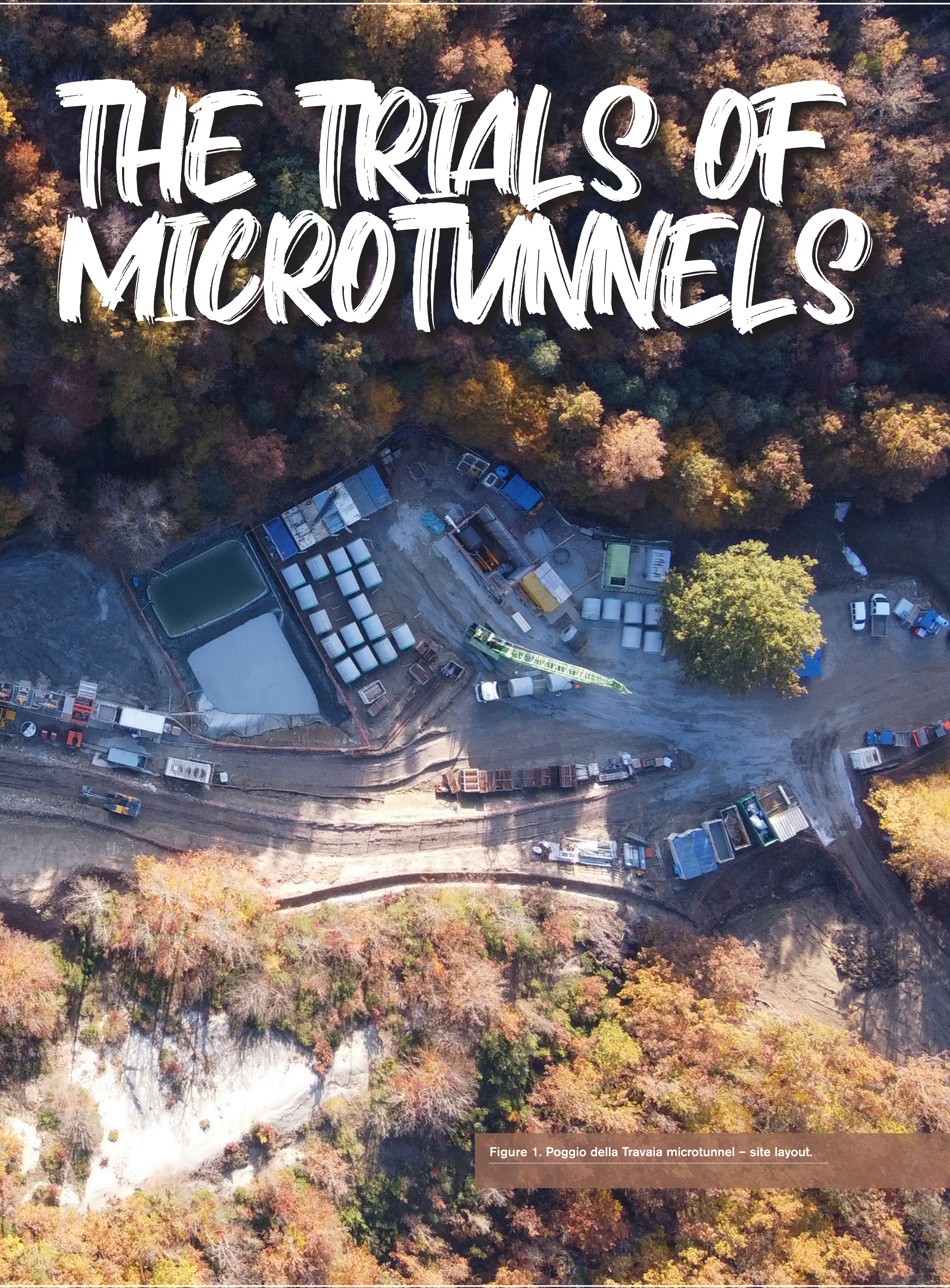


Figure 1. Poggio della Travaia microtunnel – site layout.

construction site plan (ROW project) for the laying works on the mountain ridges. It includes an exact recording of the relevant sections (a total length of around 12.3 km), the areas with terrain layers to be removed and the designated volume of material to be required. The planning of stabilisation measures (i.e. concrete bored piles), which serve as supporting elements during and after the construction work, has also been part of the ROW project. In addition to the many narrow terrain strips available for construction work on the hills, often only 10 - 12 m wide, it has been another challenge to gain access to them at all. There had only been very few access roads in the area where steep slopes and abruptly interrupted paths had been making it difficult to get through. This also was the case with many of the sections where the pipeline had to be laid with trenchless technologies. In the initial phase of the project, STREICHER therefore expanded the existing roads, paths and trails to such an extent that they became traversable even for construction vehicles.

When scheduling all work on the pipeline, STREICHER had to take a number of factors into account. Among other things, the accessibility of construction routes during the winter months had been playing an important role. Temporary access bans to nature reserve areas, such as along the construction sections of 'Alpe della Luna' and 'Marecchia' (an imposed four-month closure during the spring/summer season), where complex crossings had to be executed, needed to be observed. A further obstacle was added by the COVID-19 lockdown, which lasted several months, meaning work onsite could not start until the end of May 2020. In order to be able to still meet the agreed deadlines, a decision was made to process several construction activities in parallel. A focused attention was given to the execution of special structure, such as two sub-vertical boreholes and the laying of some very long and trenchless pipeline sections while using the microtunelling method.

Application of the raise boring technique at two sections

A particular challenge had been the planning, preparation and execution of two raise boreholes. This method had been chosen because of the special geomorphological formations of the concerned sections – in this case it was the steep gradient of the areas that needed to be traversed. The sub-vertical method was made applicable as the construction sites had a stable and self-supporting rock formation. This avoided the need to find a longer alternative pipeline route or to perform the excavation of steep slopes for pipe laying that would require a subsequent surface restoration work.

Among the aims and advantages deriving from the application of the raise-boring technique, the preservation of the environmental integrity of valuable and protected naturalistic areas is also important. In particular, the raise-boring Viamaggio has been realised inside the SIC/ZPS 'Alpe della Luna' as one of the most important areas of uncontaminated naturalistic value in central Italy.

The process sequence during the execution of the raise boring method was essentially divided into three drilling phases and an installation phase, which is explained by using the example of the 'Viamaggio' section: first, a 163 m long pilot drilling was executed with an inclination angle of 45˚and a diameter of 10 in. from the summit crest along the axis of the sub-vertical borehole. A 288 m long horizontal base tunnel was built in accordance with the topographical survey made of the arrival point prior to the pilot drilling. It was driven at the base of the escarpment through the rock formation to the arrival point of the pilot drilling. Originally, this structure should have been established by employing traditional drilling technology and by the use of explosives. However, STREICHER suggested to its client to use a tunnel

Figure 2. Automatic welding.

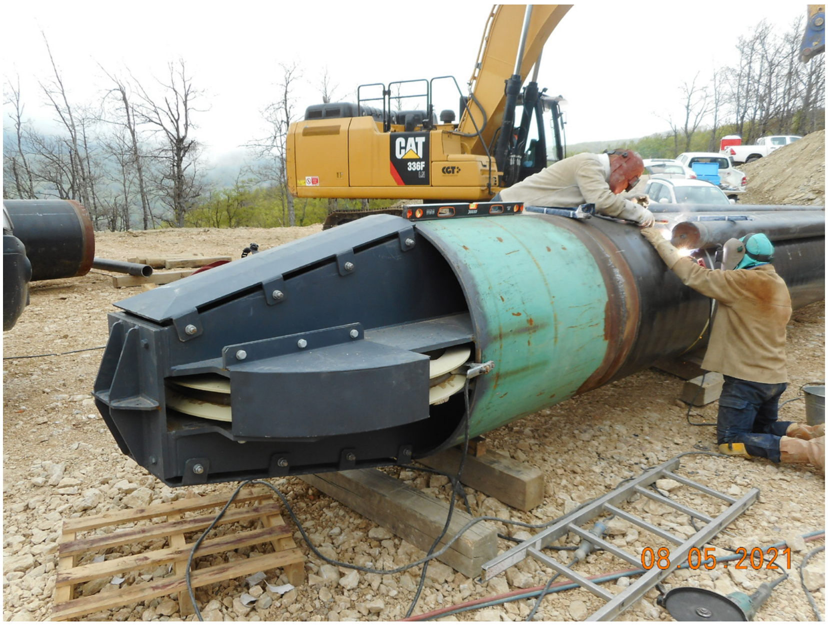


Figure 3. Launching head with welded first piece of pipe.

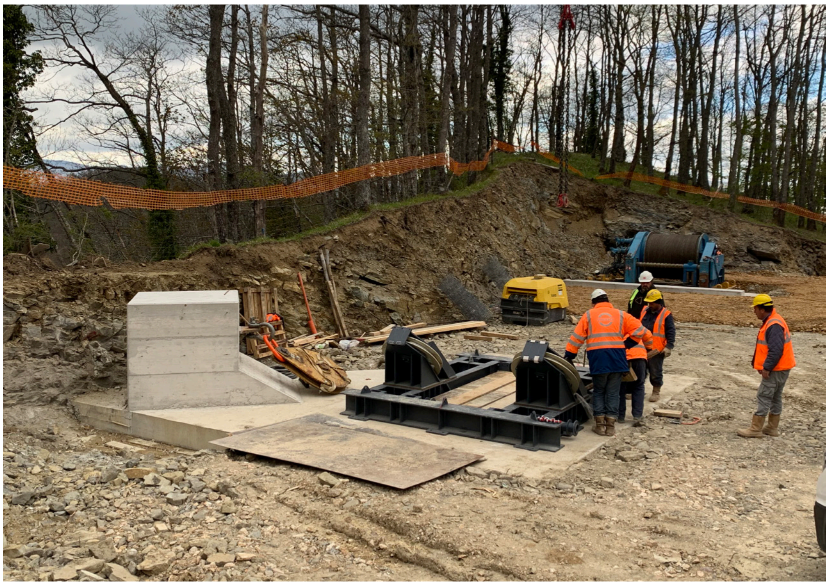


Figure 4. Preparing the pipe installation from the ridge: anchor block (left) and steel frame (middle) with pulleys.

boring machine (TBM) with a removable shield. This method saved a considerable amount of time and also ensured a higher level of working safety during the procedural work.

In a third step, a reamer was installed in the connecting chamber between the two boreholes and the pilot drilling was then widened from bottom to top to a desired diameter of 1800 mm. The resulting rock material was then transported through the horizontal tunnel to the outside.

Complex pipe installation from top to bottom

The next step was to install the DN 1050 casing protection pipes into the sub-vertical hole, namely from top to bottom. At the beginning, the first pipe was welded to a specially designed launching head, which was held in position by a steel cable. The cable was attached to a 150 t heavy-duty winch, which stood on a suitably dimensioned concrete slab that was securely anchored in the ground. For installing purposes positioning the winch required a pulley to deflect the rope 90°. In order to provide the necessary retention strength, one anchor block was made of concrete. Additionally, a steel frame with two additional deflection pulleys was built around the borehole, to which the short end of the steel cable could be firmly and stably anchored.

The winch was then used to lower the launching head, by and by, deep enough into the borehole until the rear part of the casing pipe still protruded from the hole at around 1.5 m. Then the second pipe was moved with a crane to the same spot and welded manually to the first pipe. The launching head was then lowered a few meters further down. This process was repeated until all the casing pipes were connected, and the launching head had reached the bottom of the borehole. After the annular spacing between the borehole and the casing pipe had been filled, the DN 750 pipeline pipes were installed into the casing pipes by using the same method.

When the sub-vertical pipe construction was completed, STREICHER installed the pipeline in the horizontal base tunnel and connected the main pipeline to the sub-vertical section via a connecting piece. To complete these complex tasks on time, on the two different sub-vertical borehole sections (the same TBM had to be used both times), work sometimes had to be carried out in several shifts and 24 hours a day.

Long and steep microtunnels successfully completed

In addition to the raise borings, the pipeline project also included several other crossings: in addition to two water crossings in an open construction method, STREICHER carried out 11 thrust borings, two HDD drillings, five microtunnels with steel pipes and further seven microtunnels with reinforced concrete pipes. Three of these microtunnels were not only particularly long (1256 m, 982 m and 820 m), but also challenging due to geological soil conditions. As the tunnel boring head was in danger of getting stuck, it was necessary to foresee a switch to the TBM Segmental Lining Tunnel method in case of necessity.

In order to guarantee a successful drilling, STREICHER set up a push-module unit system specially designed for microtunnels with an internal diameter of 2000 mm.

Another difficulty arose when installing the pipeline in some microtunnels with particularly high gradients of up to 18%. In these cases, the pipeline was installed by using

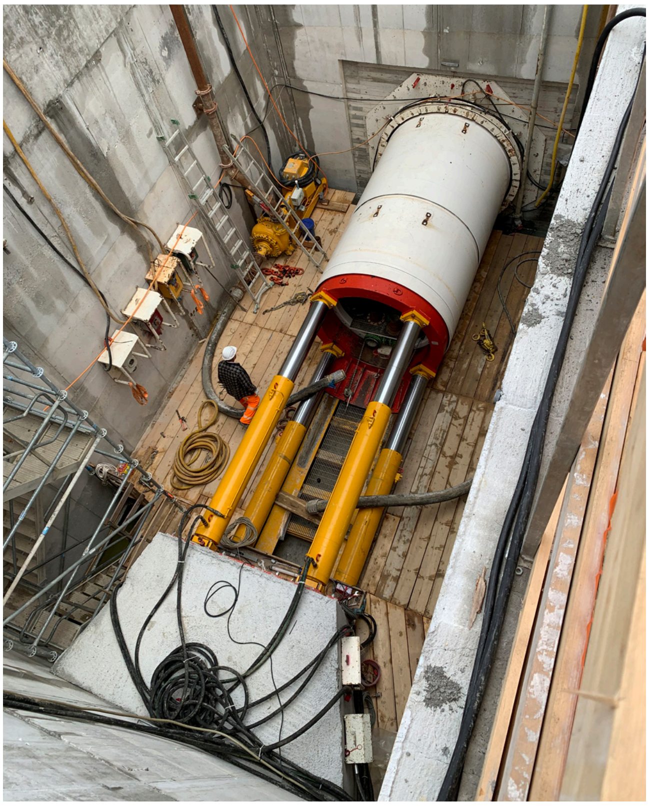


Figure 5. Poggio della Travaia microtunnel.

a winch and appropriately designed collars upon making the calculation of the maximum stresses expected during installation.

Despite the project's great complexity, STREICHER has managed to entirely complete its part of the pipeline project by May 2022. This means that the contractually agreed deadlines for the completion of all construction phases have been significantly overfulfilled in good timing. Particularly, it was between 30 and 60% fewer calendar days that were required than originally planned.

It is only the dismantling of a 15 km section of the old DN 650 pipeline that is still pending. This task can only be carried out once the other two building sections of the new pipeline have been completed. They are expected to be available by August/September 2022.

Crossings performed in lot 2 of the pipeline

- 11 thrust borings, total length 392 m.
- Seven microtunnels with steel concrete pipes, total length 4221 m.
- Five microtunnels with steel pipes, total length 494 m.
- Two raise borings, total length 877 m.
- Two HDD drillings, total length 608 m.
- Two river crossings, total length 1112 m.

Product focus: electrically driven welding tractors

Coming to MAX STREICHER S.p.A.'s construction vehicle unit; electrically driven welding tractors for onsite pipeline construction projects, providing increased energy efficiency, operational safety and savings on resources. This innovative technology has originated from our parent company, MAX STREICHER GmbH & Co. KG aA, which has been developing electric-driven construction vehicles under the label of 'ecotec'. The STREICHER Group has already leased and sold these items, and successfully employed them on our company-run building sites. Our portfolio includes the all-electric horizontal drilling rig HDD 80-E, which has proven itself in several projects, as well as the HDD 45-E, which is currently under construction. Both versions have been developed by an interdisciplinary team from STREICHER, just as with our welding tractor, together with our inhouse participation of experienced device operators.

An important feature of our drilling rigs is their fully electric drive systems; both CO_2 emissions and noise pollution can be significantly reduced, which is a great advantage when used in nature reserves and populated areas.

Systems can be supplied by the public power grid, while a built-in energy storage device allows stored energy to be accessed whenever required. Due to an intuitive operating concept and large operating touch panel, the system units also provide a good overview of the drilling process and its drilling parameters. The HDD80-E has already won some awards - IPLOCA New Technologies Award 2021, IPLOCA Health & Safety Award (Runners Up) 2021 and the Red Dot Design Award 2022 category 'Excellence in Business to Business - Machines & Engineering'.

The PW 150-E welding tractor is similarly innovative and has been redesigned completely; it features an electric drive system with two electric motors that significantly reduces the system unit's energy consumption and operating and maintenance costs. Its new chain units ensure a larger footprint that reduces the ground pressure of the tractor, whilst a radio remote control operation provides the vehicle operator with an excellent field of vision and high level of safety. STREICHER also offers all its machines of the 'ecotec' series to external customers in the construction industry.