PROJECT: Italian river crossing

Landmark crossing in Italy

A major Italian gas pipeline project provided the opportunity to set a new landmark for pipejacking and micro-tunnelling in Italy. Cheng Chin Keong reports

STRETCHING an impressive 84km across northern Italy, the Minerbio to Gavarzere DN36-inch Methane Gas Pipeline Project has necessitated a 1,271m crossing, encompassing a major river, three canals and environmentally-sensitive areas.

Italian micro-tunnelling contractor ICOP SpA, based in Basiliano (Udine), Italy, successfully completed its longest drive in a single crossing in record time and with minimum environmental impact. A slurry pressurised micro-tunnelling machine was used with a highly sophisticated guidance system, and careful selection and mixing of additives for optimum lubrication.

PROJECT OVERVIEW

The Minerbio to Gavarzere DN36-inch Methane Gas Pipeline Project is designed to meet the increasing supply requirements in Italy and neighbouring countries for methane gas imported from Russia. Edison Stoccaggio SpA, owner of the project, awarded the construction work to Bonatti SpA to lay the 75bar pressure methane gas pipeline which connects the offshore re-gasification terminal near Rovigo to the national network of gas pipelines.

General contractor Bonatti awarded ICOP the task of installing the DN2400 RC jacking pipe (i.d. 2,400mm/o.d 3,000mm) using micro-tunnelling. This included the design and construction *in situ* of the concrete launch pit measuring 15m in length, 6.2m in width and 6.6m in depth, with a toe of 13.4m. The design profile of the crossing was optimised to achieve a depth of between 13m and 15m below the existing ground level, which provided sufficient ground cover to cross beneath both the river and the canal.

The DN2400 RC pipe being jacked into position under the Reno River

MACHINE SELECTION

Ground conditions along the path of the crossing were predominantly clay layers with medium to high plasticity, although additional geotechnical surveys were carried out as necessary. ICOP proposed to commence the crossing with a Herrenknecht AVN-2000D micro-tunnelling machine which was 'up-skinned' to a 3,000mm outside diameter (o.d). The TBM is a slurry pressurised balance machine with clay cutting-head of 3,070mm o.d. Given the nature of the medium to high plasticity clay, the cutting structure of the head was modified in order to provide effective cutting results yet minimise wear on the tools.

TUNNELLING FOR ACCURACY

To cope with the different profile curves and slope along the crossing, ICOP investigated two methods of controlling the alignment and guidance of the micro-tunnelling machine: VMT Laser Guidance System – SLS-RV, and Gyro North Seeking Guidance System.

ICOP decided to install the VMT Laser Guidance System – SLS-RV for the entire crossing. "We needed an increased degree of accuracy for the given line, grade and curvature, so we always apply the most suitable guidance system for all our works," said Vittorio Petrucco, technical director of ICOP.

A standard pipe laser was used during the commencement of Section 1, then the remaining sections were advanced by swapping to the laser guidance system, SLS-RV and mounting of the TCA box in the launching pit. As the tunnel advanced, the unit was moved into the tunnel.

ADDITIONAL EQUIPMENT

In addition to the standard system used in normal operation, other accessory systems and equipment were installed as back-up in the event of failure or unforeseen breakdown.

a) **400V/10KV step-up transformer**

The main electric supply to the tunnel was connected via a step-up transformer sited alongside the launch pit. The 400-10,000V step-up was delivered into the tunnel where, at about 50m behind the TBM, a step-down transformer was sited to drop the voltage to 950V for supply to the main cutting head motor of the machine. The sets of transformers eliminate the changes resulting from any voltage drops during the progress of the crossing, while the nominal size of main supply cable is also reduced.

b) **Stand-alone power pack module**

Two sets of stand-alone power pack modules were installed in the tunnel, set up 450m apart. The modules were connected to the intermediate jacking stations located inside the tunnel. The stand-alone power pack modules were connected to the remote operation board at surface, with which the operator could control the operation of each station. Each module could be connected to up to six sets of individual intermediate jacking stations. Ten sets of intermediate jacking stations, each consisting of 16 x 80t hydraulic cylinders, were installed along the tunnel.

c) **Back-up push module**

The Herrenknecht Push Module System could be used should there be failure of the main jacking station, or under conditions where the installed jacking capacity exceeded the allowable jacking force of the pipe. The Push Module System changes the operation of the TBM from conventional pipe jacking to a segmental lining operation.

Herrenknecht designed and manufactured the Push Module System specially for ICOP and it consisted of a steel can equipped with hydraulic jacks, erector, power pack and other supporting equipment to carry the lining segments into place and fix them behind the TBM.

SEPARATION PLANT

In order to meet European regulation standards for environmental control, ICOP used comprehensive slurry separation and recycling plant. The slurry separation plant was equipped with a primary shaker plate, two secondary sets of desanders, a tertiary centrifuge system and, finally, a filter press system.

Slurry additives were recommended and supplied by Baroid Industrial Drilling Products, through its joint venture manufacturing and distribution company Cebo Holland. The slurry for the TBM was fully recycled and re-used in the micro-tunnelling operation, minimising any discharge to the environment.

TUNNEL LUBRICATION

ICOP consulted with Baroid IDP to formulate the optimum lubrication slurry which was formulated to stabilise and inhibit the clay soil, maintain a properly-filled annular space and minimise skin friction on the pipe to reduce jacking force requirements. The lubrication mix comprised Tunnel-Gel Plus – a specially formulated bentonite product; EZ-Mud polymer emulsion; and Dinomul liquid friction-reducing additive. Careful mixing and control of additive concentration was maintained throughout the tunnelling operation to help ensure consistent performance.

Along the length of the tunnel, the lubrication mix was injected through the lubrication ports via an automatic lubrication system which used pneumatic valve control. The duration of injection, the volume of lubrication slurry injected and the pressure of injection were precisely controlled by the operator from the remote control room on the surface. →

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MICRO-TUNNEL CROSSING RESULTS

As per schedule, the micro-tunnelling machine was launched at the end of August 2007 in order to cross a major river and three canals and to run under agricultural land, over a distance of 1,271m. The AVN2000D machine broke through into the reception pit at the end of October 2007. The total construction period was 106 days including set-up. Tunnelling took 73 days and was completed at an average rate of 17.41m/day.

Only minor equipment breakdowns occurred during the crossing. With careful preparation and planning, and availability and stock of spare parts prior to the work commencing, the site crew managed to minimise downtimes and controlled the project through to completion. The selection of quality additives supplied by Baroid IDP through Cebo Holland to provide optimum lubrication fluids and their preparation and maintenance on site played a major role in the tunnel's progress. Average jacking pressures registered throughout the entire crossing were only 400t, with the maximum recorded at 550t on restart after the minor breakdown.

None of the ten intermediate jacking stations were used. The back-up push module installed at the back of the TBM was not brought into service.

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