

# PUSHING THE ENVELOPE

By Claire Symes

Many residents in northern Italy are known locally as “frontalieri”, which literally means they cross the frontier for work – in this case into Switzerland where salaries are often higher. These daily migrants will be the main beneficiaries of work currently under way to upgrade the rail link between Arcisate in Italy and Stabio in neighbouring Switzerland.

The upgrade will involve the upgrade of a section of single track rail line to dual lines and extended to reach Switzerland. This might not sound anything special, but the upgraded lines are being built within the same space that the original single track occupied.

Main contractor Claudio Salini is calling on foundations specialist Trevi’s geotechnical skills to overcome the space constraints, ground conditions and limitations from existing infrastructure to deliver this challenge for Italy’s rail operator Rete Ferroviana Italiana.

The work is part of a long-term aim to create a rail link between Zurich and Milan – there is no date set for achieving this but the Arcisate to Stabio line is a key part of the route. The 8.2km section on which Trevi is currently working for Claudio Salini finishes at the Swiss-Italian border but Salini’s work extends into Switzerland too.

“This is one of the largest projects under

way in Italy at the moment,” says Trevi site manager Giovanni Traettino. Underlining the complexity of the project, Traettino explains that there are 129 Trevi employees working on the Arcisate to Stabio rail upgrade.

The project is using a number of different foundations solutions to allow the new double track route to squeeze into the same “envelope” that once carried the single track line. In most parts this is being achieved by removing the embankment that carried the single track line and creating a retaining structure to allow the track level to be lowered with the new dual track to be built on a floor slab.

But there are a few elements that complicate this – such as a 19th century tunnel that cannot be widened, working in close proximity to homes and businesses in the three towns the line passes through and the need for a new tunnel to be built.

## MULTIPLE TECHNIQUES

The result is a project where Trevi is using a combination of jet grouting, diaphragm walls, ground anchors, micropiles, case augured piles and bored piles to meet the challenges.

Trevi started work on the €24M foundations contract in October 2010 and Traettino says the job will take two years to

**Tunnel vision** Ground improvement from the floor of the existing tunnel will allow the new one to be built below.



## IN SUMMARY

Use of geotechnical techniques is enabling a new twin track to be fitted within the same ground take as the original single track to improve services to towns in northern Italy and avoid the need to bypass the communities.

## WHERE?



## FIGURES

**8.2km**

Length of the upgraded and extended rail line

**523m**

Length of ground improvement for the Induno Tunnel

## “THIS IS ONE OF THE LARGEST PROJECTS UNDER WAY IN ITALY AT THE MOMENT”

Giovanni Traettino, Trevi

complete. Claudio Salini's contract for the scheme is worth around €160M and includes excavation of the new tunnels, bridges, station platforms and floor slabs. Trevi is undertaking all the foundations work, soil improvement and shoring as well as the installation of retaining walls and ground anchors.

Initial designs for the work were produced by Salini, but Trevi provided technical input.

The railway line has been closed for the duration of the work with trains replaced by buses, but despite the disruption and building work going on in the centre of the local communities, the scheme has the full support of residents.

“They can see the benefits of it and the potential for more investment that the upgrade will bring,” says Traettino. “The other big factor is that one of the rail company's previous plans for the upgrade was to bypass the towns and leave them without local stations – the residents campaigned hard to retain the rail link, so they are happy to pay the price of disruption for the long-term results.”

The redeveloped rail line will have three stations – Induno Olona, Arcisate and Gaggiolo – a twin bore tunnel with the new bore directly below the existing tunnel, which will be strengthened; a new tunnel



### WHO?



Trevi is doing foundations work and ground improvement for main contractor Claudio Salini. Trevi site manager Giovanni Traettino (left) is overseeing the work.

### CHALLENGES

Trevi is having to work very close to residential and business properties in Induno Olona, Arcisate and Gaggiolo, but the community wants the improved rail service so is fully supporting the project. The company is also working closely with the main contractor due to the overlapping work to install micropiles in the crown of the tunnels just ahead of excavation.

### MORE INFO

[www.claudiosalinispa.it/infrastrutture.php](http://www.claudiosalinispa.it/infrastrutture.php)

[www.italferr.it](http://www.italferr.it)

◀ excavated through improved ground; and two new bridges to take the route up to the Swiss border.

One of the most interesting elements of the scheme is the stacked twin-bore tunnel that will reuse the existing 19th century tunnel. "The tunnel is 323m long and is very old," says Traettino. "It is one of the first railway tunnels to be built in northern Italy."

Trevi is currently carrying out jet grouting from the floor of the existing tunnel to improve the ground before Salini excavates the new tunnel above it.

"There are five rigs working in the tunnel and we are working 24 hours a day with three shifts to deliver the work in the time available," says Traettino. "So far this has not caused any problems with our neighbours."

#### GROUND IMPROVEMENT

Trevi is drilling rows of 114mm diameter boreholes raking from vertical in the tunnel centre out to 40° for the grout to be injected.

"The ground the new tunnel will pass through is glacial with highly variable sands and gravels with a major boundary into the limestone that is also variable," says Traettino. "The solution is to inject a polymer grout formed with glass fibre reinforcement."

Once the borehole is drilled, the casing is pulled out and a specially designed tube is placed into the hole. The grout is placed in a two-stage process: the first fixes the tube into position with packers placed at the top and bottom of the hole; the second is carried out 24 hours after the initial grouting and injects the grout into the tube.

"The sacrificial tube has a series of 'bubbles' – individual injection points – located at different heights in the tube through which the grout is injected sequentially starting from the lowest bubble," explains Traettino. "The bubble allows the grout injection into the ground surrounding the borehole to be controlled to ensure maximum compaction."

"The new tunnel will be created by excavators and drilling booms," says Traettino. "It will be supported by a precast concrete lining installed as work progresses. There is very little separation between the roof of the new tunnel and the floor of the existing one, so we will be installing a series of raked semi-sacrificial micropiles through the roof of the new tunnel just in



**Double bubble**  
The grout is injected  
in two stages

advance of the excavation to create a 'shield' around the roof of the tunnel."

The new tunnel is significantly longer than the existing one, so at the northern end Trevi will be working from existing ground level to improve the ground below over a distance of 200m. Salini will use mechanical excavation techniques and precast concrete sections to form the new tunnel.

From the end of the excavated tunnel the route will progress northwards in a cut and cover tunnel built with 1.2m diameter CFA piles bored to 26m from the surface level to create the retaining walls, to found between 9m and 15m below the finished tunnel floor.

"Salini will then excavate the tunnel and

cast the base slab. Some sections will just be braced, others will be covered and a few sections will be open," says Traettino.

From the end of the tunnel the route will be built using diaphragm walls which are 800mm, 1m or 1.2m thick depending on the location, or by installing 800mm, 1m or 1.2m diameter CFA piles.

"The CFA piles can be used close to surrounding buildings with no impact," says Traettino. "The diaphragm wall is cheaper, but is not suitable for use close to buildings."

Just before the route reaches the site of the new station at Arcisate, Trevi will switch from CFA piles to micropiles before returning to CFA piling for another 400m beyond the station. Beyond this point the railway will follow a new route.

"The first part of the new section will pass into a 700m cut and cover tunnel that will be built by Salini," says Traettino.

Trevi's foundations work also includes construction of footings for two bridges – the 40m long Pont Baranzella and the 437m Pont Bevera – on the new section. It is also doing

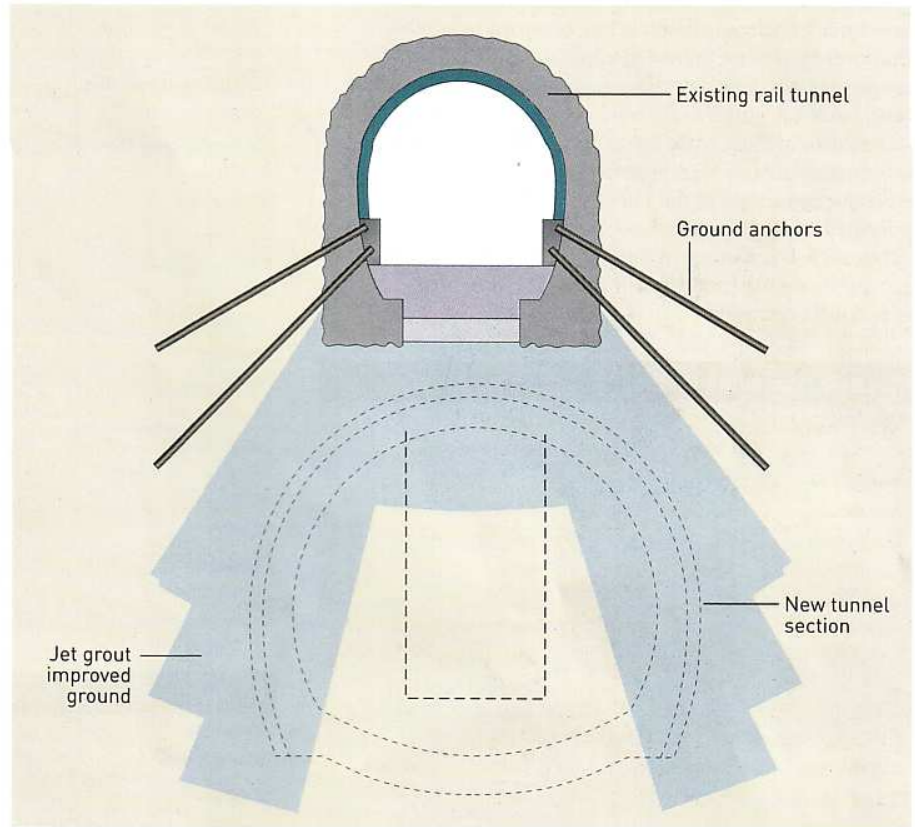
## "RATHER THAN BEING A SUBCONTRACTOR WE WILL BE WORKING MORE AS PARTNERS"

Giovanni Traettino, Trevi



**Ground control**  
A mix of shoring is being used on the scheme

**> INDUNO TUNNEL SECTION**



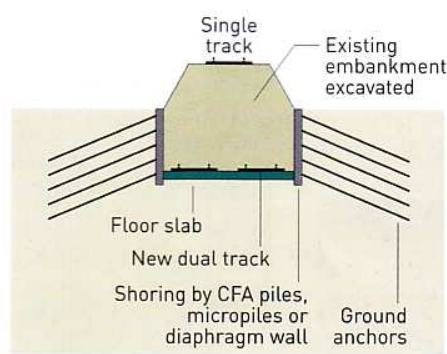
ground improvement for another tunnel. Foundations for the Baranzella bridge piers are being constructed using 1.5m diameter piles bored to 25m below ground level. For the Bevera bridge, Trevi will also use 1.5m diameter bored piles drilled to between 27m and 33m below ground level to socket 1.5m into the bedrock.

The Bevera bridge will carry the route to the next construction challenge on the scheme – the new 890m long Bevera tunnel. Like the other tunnel, ground improvement is needed to enable Salini to excavate this one too.

“For the first 225m of the tunnel the ground cover is low enough to allow us to carry out jet grouting from above ground using the same materials and techniques as the tunnel at Induno Olona. We will be installing 90mm to 115mm diameter boreholes spaced 1.2m apart with 1.5m centres to depths of 20m to 25m below ground level,” says Traettino.

Like the Induno Olona tunnel, Trevi will also install raked micropiles through the roof of the new tunnel as work progresses to

**> CONSTRUCTION METHOD**



shield the excavation. “The length will vary from 14m to 16m and the number also varies throughout the construction depending on the geology,” says Traettino. “We will also be installing drainage piles into the roof and carry out horizontal jet grouting.”

Beyond the zone that will be improved from above, Trevi will use the glass fibre reinforced polymer from within the tunnel.

“The geology here is a mix of sands and gravels but there are also bands of silt and

clay in this area,” says Traettino. According to Traettino, the main challenge of this part of the project will be co-ordinating the work with Salini. “Rather than being a subcontractor, we will be working more as partners,” he says.

Excavation of the Bevera tunnel will be advanced from both ends simultaneously. Beyond the north portal, the route will return to shoring using 1m diameter bored piles installed to 20m below ground level. “It was not possible to use CFA piles for this section because there are boulders in the glacial material,” says Traettino.

This construction method will carry the line to the final new station at Gaggiolo where micropiles restrained by five levels of ground anchors will be used.

From this point, the rail line passes over the Swiss border and Trevi’s work on the scheme ends. Salini is due to complete the whole project by January 2014.

With all the work so far going according to plan, Traettino is confident the project will be delivered on schedule.