THE KORALM CONNECTION

Austria's Koralm tunnel is part of a new alpine link in Europe. **Keren Fallwell** reports

WHEN AUSTRIA'S new Koralm high-speed railway line opens in December 2023 another piece of the Trans-European Transport Network (TEN-T) will be in place.

The line is part of the 2,400km trans-European Baltic-Adriatic Corridor linking the Baltic and Adriatic coasts and connecting 40 million people. It stretches from Gdansk and Gdynia on the northern coast of Poland to Bologna in northern Italy, crossing through the Czech Republic and Slovakia along the way and providing a direct link between the capital cities of Warsaw and Vienna.

Aerial view of the job site with gantries visible in the distance

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Above: ***Panorama photograph inside the tunnel***

The 130km-long Koralmbahn, being built for ÖBB-Infrastruktur, will provide a direct rail link between the cities of Klagenfurt and Graz, the capitals of the states of Carinthia and Styria respectively, reducing the current travel time of three hours to less than one hour. It will also allow heavy freight trains of up to 2,000 tonnes to be pulled by only one locomotive. The line will carry up to 256 trains a day running at a maximum speed of 250kph.

"The line will serve as a missing link from north-east Europe to northern Italy," says Dietmar Schubel, head of Koralm tunnel KAT 2 for ÖBB. "It also provides a new alpine crossing line and a connection between Styria, especially the Graz area, and Italy, as well as the Carinthian area and Hungary."

This improved access is expected to bring economic benefits to the two Austrian regions, he adds.

Carinthia and Styria are separated by the Koralpe mountains so a key feature, and the largest infrastructure element, of the new railway is the 33km-long Koralm tunnel under this range. It will be the longest railway tunnel located entirely within Austrian territory.

The tunnel comprises twin running tubes – the north and south tubes – 40m apart and connected by cross-passages every 500m. There are 42 cross-passages in total and there will also be a 900m-long emergency station and refuge at the mid point.

Before the main excavation for the tunnel, 130 exploration wells and a 10km-long exploratory tunnel system were excavated to carry out in-depth analysis of the geological and hydrogeological conditions.

CONTRACT DETAILS

The tunnel construction is divided into three main sections: KAT1, KAT2 and KAT3. KAT1 comprises the east portal in Styria and includes a 3.2km open land route, four bridges and a 2.3km tunnel section built by drill and blast using NATM. Work began in 2008 and was completed in 2013.

KAT3 involves widening the existing 7.6km-long sounding tunnel and building an additional 3.3km of new tunnel for the south bore.

KAT2 is the middle and longest contract section – and the largest construction contract ever awarded in Austria. It covers works from the access shaft, 3km from the eastern portal, west towards KAT3.

The EUR 570M (USD 621M) construction contract was awarded to the joint venture of Austrian companies Strabag and Jäger Bau in 2010, just as Strabag was finishing work on the Gotthard Base Tunnel in Switzerland.

The contract length is 37.2km for the two bores –19.7km for the south tunnel and 17.5km for the north. Of this, a total 4.43km (2.57km south and 1.86km north) are being excavated by NATM and 32.7km (17.1km south and 15.6km north) by TBM. The maximum overburden of the tunnel is 1,250m.

Work started on site in January 2011 with site installation and twin shaft construction.

The NATM works started in April 2011 and were completed in December 2012.

A month later the first TBM started in the south tunnel, followed by the second TBM in the north tunnel in April 2013.

One of the first technical challenges was launching the two Aker Wirth (now CREG-Wirth) double shield TBMs. Establishing a construction base near the eastern portal was ruled out for environmental reasons so instead a 60m-deep shaft was sunk

and this provided the access for the TBMs to the assembly cavern below. The shaft is a double-cell excavation and each cell has an 18m diameter.

The two TBMs feature the typical Aker Wirth wing-type gripping system in the rear sections of the shield which provides optimal support via the secure three-point bearing to produce high-performance boring with little vibration and the main benefit, to use gripping in soft geologies. The cutterhead is driven by electric motors with an overall power rating of 4,800kW and a maximum cutting torque of 30,000kNm.

The TBMs are around 175m long and weigh more than 1,800 tonnes.

GEOLOGY

Each TBM is making an average monthly advance of between 500 and 700m and so far the greatest daily progress has been 44m.

However, the mountains' hard rock geology has meant the average daily gain is 12m rather than the predicted 17m. Despite this slower than expected progress, Schubel says the project will still be finished in time for test runs in early 2023 and for full service in December of that year.

The geology includes gneiss and mica schist as well as marbles, amphibolites, eclogites, quartzites and pegmatites.

"We're mining through different layers of gneiss, partly heavily fractured with high contents of schist, marble and quartz," says Strabag mechanical engineer Robert Goliasch.

There have also been areas with cataclastic rock with overbreak and "challenging squeezing of the TBM". In summer 2014 the JV Arge Kat2 had to free up the south TBM after clocking the cutterhead and squeezing the shield.

"After a rock stabilisation programme using several umbrella forepoling and injections of foam and cement, we could free up the shield and cutterhead manually," said Goliasch.

"By using the cutterhead's maximum torque of 30,000kNm and maximum propel force of 150,000kN the TBM could finally be driven out of this zone."

An ongoing challenge is the blocky rock areas and the fractures and rock burst that damage the cutters and the cutterhead. As a result, several cutterhead revisions have had to be made, says Goliasch.

In February 2015, a fire on the back-up generating set at the rear of one TBM stopped work in the north tube for two weeks. Fortunately no-one was injured and Schubel was pleased with the way the emergency evacuation procedures were implemented.

"The execution of the rescue concept worked well," he says. "There were 25 people on the machine when the fire started; 13 rescued themselves using the rescue train; five were able to reach the next cross heading by foot and the remaining seven men were evacuated by the rescue team."

To ventilate the tunnel during construction JV ARGE Kat2 is using a system similar to that employed on the Gotthard base tunnel.

"Because of the length of the tunnel we use one tunnel, the south tube, for blowing in fresh air. The fresh air is distributed from the last finished cross-passage to the TBM north and south and the exhausted air diverted out via the north tunnel. Crucial for such a ventilation system is a complex control system for all fans, flaps and lock gates, to fulfil the guidelines of the emergency plan," Goliasch explains.

According to the latest schedule

the TBM in the north tunnel will finish in summer this year and in the south tunnel in spring 2017.

The 9.93m-diameter TBMs are installing a 350mm-thick segment lining. Along the NATM sections a double lining of shotcrete and a second concrete lining is installed.

Managing this stock of segments with the constraints of a jobsite has been helped by VMT's Segment Documentation System. By linking the digital modules for calling up segments for the TBM from stock with their placing in the tunnel the system means stockpiling is avoided and product picking is correct.

Each of the tubes has its own segment plant, with room to stock around 300 rings. A total of 103,500 segments will be used for the rings and another 17,250 larger invert segments.

Mobile Baustoffe, a subsidiary of Strabag, has supplied 1.2 million m3 of concrete required for the prefabricated elements of the first two sections and exploration galleries. Some 82,000 tonnes of additives and 350,000 tonnes of cement were delivered by rail from Lafarge, tailoring the chemical composition of the cement for the geology.

SPOIL

The two TBMs working in parallel mean that every hour a maximum of 2,000 tonnes of spoil has to be mucked and screened online. Over the course of the contract KAT2 will produce 8.6 million tonnes of excavated material, 60 per cent of which will be reused, including 1.5 million tonnes for on-site concrete production which will provide 1 million m3 of concrete for the tunnel's inner lining.

Some of the spoil will also be reused in the landfill required to build the new high-speed line.

Above: ***Conveyor setup with temporary storage areas***

Below: ***The base of an access shaft on the project***

The aggregates for the concrete are produced in the on-site gravel plant, the largest that Marti Technik has supplied outside its home country of Switzerland. The three-stage crushing installation implemented by METSO minerals has a downstream wet-classification and a sand-processing unit. The plant feed rate is 300 tonnes per hour and the three sand silos each have a capacity of 1,000 tonnes.

The 1.2 million tonnes of excavated material destined for external recycling is removed by rail.

The muck is carried out of the tunnel through two exits – the eastern portal of KAT1 to the Grub depot, or through the vertical 60m shafts to the Hollenegg depot. During the initial drill and blast phase the mucking out was done by trucks but now, with the TBMs in place, 99 per cent is done via the 52km network of conveyors supplied by Agir Group of Switzerland. There are 82 conveyors in total. In the two bores the longest conveyors measure 18.8km and 17km, while the longest outdoor conveyor is 6km.

"Our conveyors bring the muck to the two landfill sites, the screening site, the aggregates production site and back from there to the concrete works, as well as to the railway loading site," says Agir's Carl Ulrich Wassermann.

In the tunnel the conveyors are kept out of the way by being suspended from the roof but outside they are ground standing or on bridges