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PUSHING THE LIMITS OF HIGH PRESSURE TUNNELLING

Just like the TBMs they serve, conveyors are being asked to cope with more and more demanding applications. Kristina Smith asked the industry's leading suppliers to tell us about their most extreme challenge to date.

EXTREME CONVEYORS

AGIR: the longest we have ever done

"It's not like going to the moon, but you certainly learn a few things along the way," says Agir engineer Carl Wassermann, of the conveyors the firm is supplying to the middle section of Austria's Koralm tunnel. "It's the most challenging thing we have ever done."

Currently around 13km long, the longer of two conveyors which are supporting the hard rock Wirth TBMs will eventually stretch to 18.8km. Carrying various types of gneiss, the conveyors must transport up to 1,000 tonnes of material.

"It is difficult to control when the whole thing gets so heavy," says Wasserman. Some sections of foliated gneiss have also broken into pointed pieces under pressure from the cutter head which has caused significant wear and sometimes breakages to the conveyor.

The conveyors will eventually have three booster drives, installed every 5.5km. The boosters are created using 355kW drives, doubled up or even tripled where more power is required. "We have a modular system so that all the elements are the same and those who install them already know how to do it," explains Wasserman.

Each booster drive takes between four and five days to install, according to Wassermann. The total drive power for each conveyor will be 1,775kW.

As well as the conveyors in the tunnels, there's a network of surface conveyors distributing spoil to one of three areas, the most distant 6 km away. All-in-all there are around 100 conveyors which must all be controlled by Agir's software.

Agir's Koralm Tunnel conveyor

The 33km Koralm twin-bore tunnel runs through the Koralpe mountain range and forms part of the 124km Koralm Line which will carry high-speed trains from Graz to Klagenfurt. It is also part of the Baltic-Adriatic axis known as TEN Corridor 23 which extends from Gdansk in Poland through to Bologna in Italy.

Contractor Strabag with partner Jägerbau is constructing the 19km middle section, KAT2, for owner ÖBB Austrian Railways. Work started in 2011 with the construction of short sections of tunnel using drill and blast and NATM, after which the two TBMs were assembled and began their drives.

One of the constraints for this contract is that access is via a 60m-deep shaft. A bucket conveyor transports the rock up the shaft; this was supplied by others during the NATM phase but is controlled by Agir's software.

There have been some sections of drive where too much water has meant that the vertical bucket conveyor cannot handle the spoil; it slips off and is a safety hazard.

One lesson Agir has learnt on this contract is that its heavy steel-coated conveyor expands significantly when such long lengths are involved. "For an 18km run, a conveyor like this behaves like a piece of rubber," says Wassermann. "It stretches, so that when you start the conveyor it gradually lengthens. That means you have to tell the software that the conveyor is getting longer up until a certain point when the length becomes stable."

Agir's software engineers and field staff solved that problem by close communication, carrying out tests to ensure that the software was controlling the conveyors as intended. "We can only really do this in-house," says Wasserman. "It takes a lot of discussion between our mechanical people and the software designers to ensure the theoretical model works in real life."

With the know-how it has gained from Koralm, Agir is now planning other long conveyors in various countries, one of which is a 16km conveyor to the Brenner tunnel between Austria and Italy.

JOY GLOBAL: our harshest ever application

SUB-ZERO TEMPERATURES, ground water inflows, snow, driving winds, dense fog. All these elements combined on the Kárahnjukar hydroelectric project in the North East of Iceland to create one of the most challenging environments for man and machine.

"Of all the jobs we have done, that was the most extreme," says Paul Bancroft, product director – conveyors for Joy Global, which supplied Joy conveyors internally and externally to main contractor Impregilo (now Salini Impregilo).

The Kárahnjukar project saw the construction of a huge dam to collect water from two glacial rivers to be transferred underground to a 690 MW power station which now runs Iceland's largest aluminium plant. The works required a variety of tunnels, some constructed using drill and blast, others using Robbins TBMs and all served by the Joy conveyors, 43km in total including surface conveyors.

Special measures were required to counter the low temperatures which reach depths of -5 degrees C in the heart of winter. "We had to have heating elements in the control system to make sure that we could accommodate the temperatures," says Bancroft. "And we also had to use a special type of steel for the conveyor support structure that could cope with the temperature range and allow for loadings we needed."

Outside the conveyors were covered to protect them from the snow. "We had to design the support structures of the external surface conveyors to take into account the additional factors associated with strong cross-winds and lots of snow," says Bancroft.

The conveyors, which were carrying basalt out of the tunnels, were supported by a variety of means, depending on the geological conditions and the configuration of the tunnels: some were hung from the tunnel roof, some supported from the wall and some on free-standing stanchion supports. The tunnels were un-lined which meant that when the miners hit fissures; there were often severe inflows of water.

"At times there was so much water that the shuttle cars which travel up to the back of the TBM were generating a bow wave as they moved through the tunnel," says Bancroft.

Construction of the dam and tunnels began in 2003, with the conveyors installed in 2004. The plant started producing electricity in 2009.

Tough conveying conditions in Iceland

TERRATEC: solution to a slippery problem

IN BANGKOK, Thailand, a Terratec EPB shield has just finished the first of two 2.8km drives for contractor Italian-Thai Development (ITD). The conveyor system, also supplied by Terratec has a challenging trio of conditions to deal with: a downward gradient, slippery spoil, and two tight curves – added after the contract began.

The 6.44m-diameter tunnels, lined with segments to an internal diameter of 5.7m, pass through a complex geology: stiff clay, Bangkok's aquifer sand with coarse gravel and sandstone at the deepest part of the alignment. There is also high ground water pressure.

Terratec designed the conveyor to cope with a radius of 180m which occurs at the start of the tunnel where there is also a downhill gradient of 3%. However, ITD altered the alignment of the tunnel as it passed through the first of two stations it will construct, Wat Mangkorn. This introduced two sharper radius curves – less than 160m and the tightest Terratec has ever done - at the entry and exit of the station location.

These changes caused teething problems. "This type of muck is sticky, and it flows rather than sitting static on the belt," explains Anton Jurasovic, engineering manager & managing director of Terratec. "Therefore, it is hard to contain on the belt, especially in tight radius curves. The two extreme curves caused the muck to spill easily from the side of the belt and it was very difficult to control the tracking alignment."

Terratec's solution, installed in a few days, was to add extra side rollers on every installed support bracket, which effectively lifted the side of the belt. Muck protection plates were also added to prevent spillage at transfer points, where the muck is transported into skip bins and lifted by crane to the pit top.

ITD's project is one of five contracts that will add 27 km to Bangkok's Blue Line, 5.4km of which are underground. There will be four new underground stations and 15 elevated stations.

Reaching a maximum length of 3,200m, the conveyor system supported average excavation rates of 18m per day. In mid-October, Terratec was installing the belt ready for the second drive which was due to begin soon after.

MARTI TECHNIK: regenerative braking feeds electricity to grid

Various solutions were required for a host of challenges during construction of the Nant de Drance Hydroelectric Project in Switzerland

THE CONVEYOR FOR AN ACCESS adit and cavern constructed at the New Nant de Drance hydroelectric power plant in Wallis, Switzerland had a number of tricky requirements. Individually, each requirement is readily achievable, but combined they make for a technically challenging project.

Feeding a 9.4m-diameter hard rock TBM, the 5.6km belt had a maximum conveying rate of 1000 tonnes per hour; it had to accommodate curves down to a radius of 800m; it fell by a distance of 580m over its length; and finally it had to be able to carry aggregates into the tunnel for a later phase of work.

But what makes this conveyor unique for tunnelling is that it was able to take the energy created by braking and return it to the grid. "That's very unusual, at tunnel jobsites," says Marti Technik's head of project development Peter Rufer. "We have never done it before."

This was an idea proposed by Marti Technik, for both environmental and economic reasons, says Rufer. When at its maximum length and fully loaded, the conveyor was returning 850kW to the grid, which would rise to 1,500kW should the conveyor need to be stopped. "It created a lot of energy," says Rufer. "If the conveyor is full you have 550 tonnes of material on the conveyor, that's like stopping half a train."

The biggest concern for Marti Technik related to safety: what happened if the power supply failed? The answer was to install a mechanical braking system at each of drives which together supplied 2,170kW of power: the tail drive on the TBM and three boosters.

"The brakes had to work in parallel with each other and exert the same force," says Rufer. "That meant that we needed a communication system between the brakes and a battery which would work if there was a power failure."

Marti Technik also made some modifications to accommodate the curves. Rufer says: "800m is not a tight radius, but because it was a downhill conveyor with high forces being exerted on the belt, that did make it challenging."

To accommodate the curves and the 10.5 percent gradient, Marti Technik used belt support units angled at 50 degrees for the upper belt and 30 degrees for the lower belts on the curved sections. The conveyor was also hung at an angle as it went round the bends.

Marti Technik's contract with main contractor GMI Groupement Marti Implenia encompasses the supply of the conveyor, the supply of a reconditioned TBM and the installation and operation of a gravel plant. Of Marti Technik's CHF50m total contract price, the conveyor accounts for CHF7m of that.

The conveyor began work in 2010 behind the TBM and ran until September this year when dismantling began. Around halfway into that five-year period, the contractor had finished the adit and began to excavate the cavern using drill and blast.

For this second phase of work, the conveyor had to bring rock out of the cavern and aggregate in, to feed a concrete plant installed in the cavern. At this point Marti Technik made some modifications, installing a fixed rear drive to replace the tail drive on the TBM and introducing a crusher to break up the rock from the drill and blast construction.

The aggregate entering the tunnel was delivered on the lower belt. That was necessary because it's not possible to reverse the direction of a conveyor with boosters because of the way the belt runs round the rollers at the booster locations.

For Rufer, the mechanical aspects of this project have been relatively straightforward. It's the electrical control aspects that have been most interesting. "We learnt a lot, especially on the electrical side: the programming and the recovery system with the frequency converter to give energy back to the grid. This is definitely something we will look to offer on future projects, where appropriate."

ROBBINS: two 90 degree bends and multiple s-curves

THE PLAN OF THE TUNNELS that make up the Indianapolis Deep Rock Tunnel Connector (DRTC) project confirms the challenge for the conveyor system which served the TBM: it's curvy.

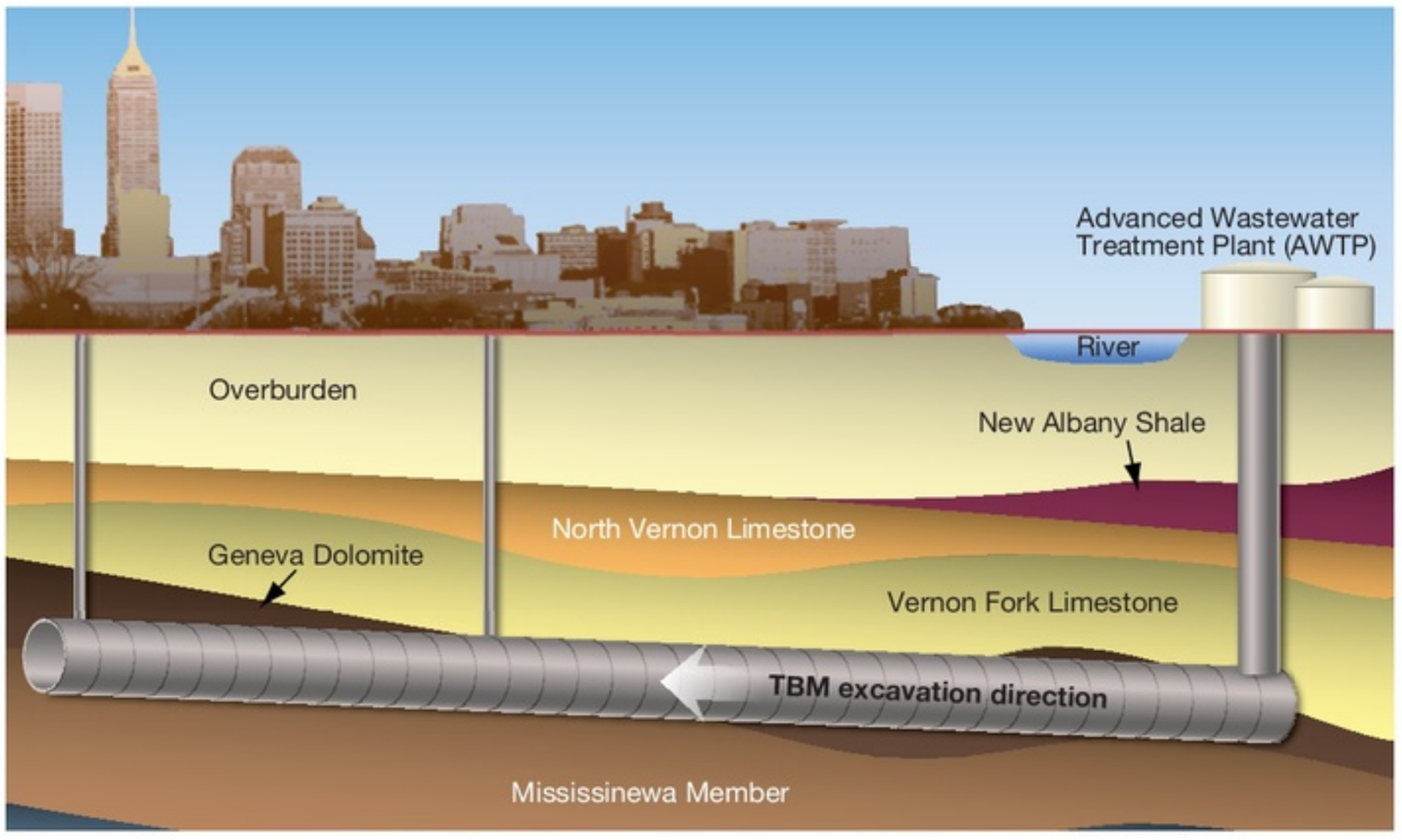
"Indianapolis was the most difficult that we have ever done – and we've supplied 99 conveyor systems to date," says Dean Workman who heads up Robbins' conveyor division. "It has two 90 degree bends in it and multiple S-curves."

With a maximum conveyor length of 39,362 ft (12km), this system has 82,000 ft (25km) of belt in total with a vertical belt to carry the muck up a 250 ft (76m)-high shaft and a radial stacker to deposit the muck. Robbins also needed 10 drives to accommodate the sewer's twists and turns.

Contractor Shea/Kiewit drove a main drive with its refurbished 20.2 ft (6.2m) Robbins Main Beam TBM, then reversed to create two branches off that drive. All-in-all the project has created 9.8 miles (15.7km) of tunnel which will eventually be able to hold 250 million gallons (946 million litres) of storm water.

The curves were tackled using Robbins' patented curve system, which allows the idlers carrying the belt round the curve to move – rather than be fixed in one place. Workman explains: "Our carrying idlers are self-adjusting. They automatically super-elevate depending on the tension and the load on the belt."

Robbins' patented system has been in use for years, says Workman, although recent improvements have seen changes to the idler mechanism so that it adjusts more easily, making it more sensitive to changes in belt conditions. Other systems set their idlers at a fixed angle, a compromise between the minimum and maximum angle required, says Workman, which can result in more wear on the belt and more resistance which eats up more power.



Accommodating the curves was not the most challenging aspect of this project, however, according to Workman. The biggest task was modelling and designing the system.

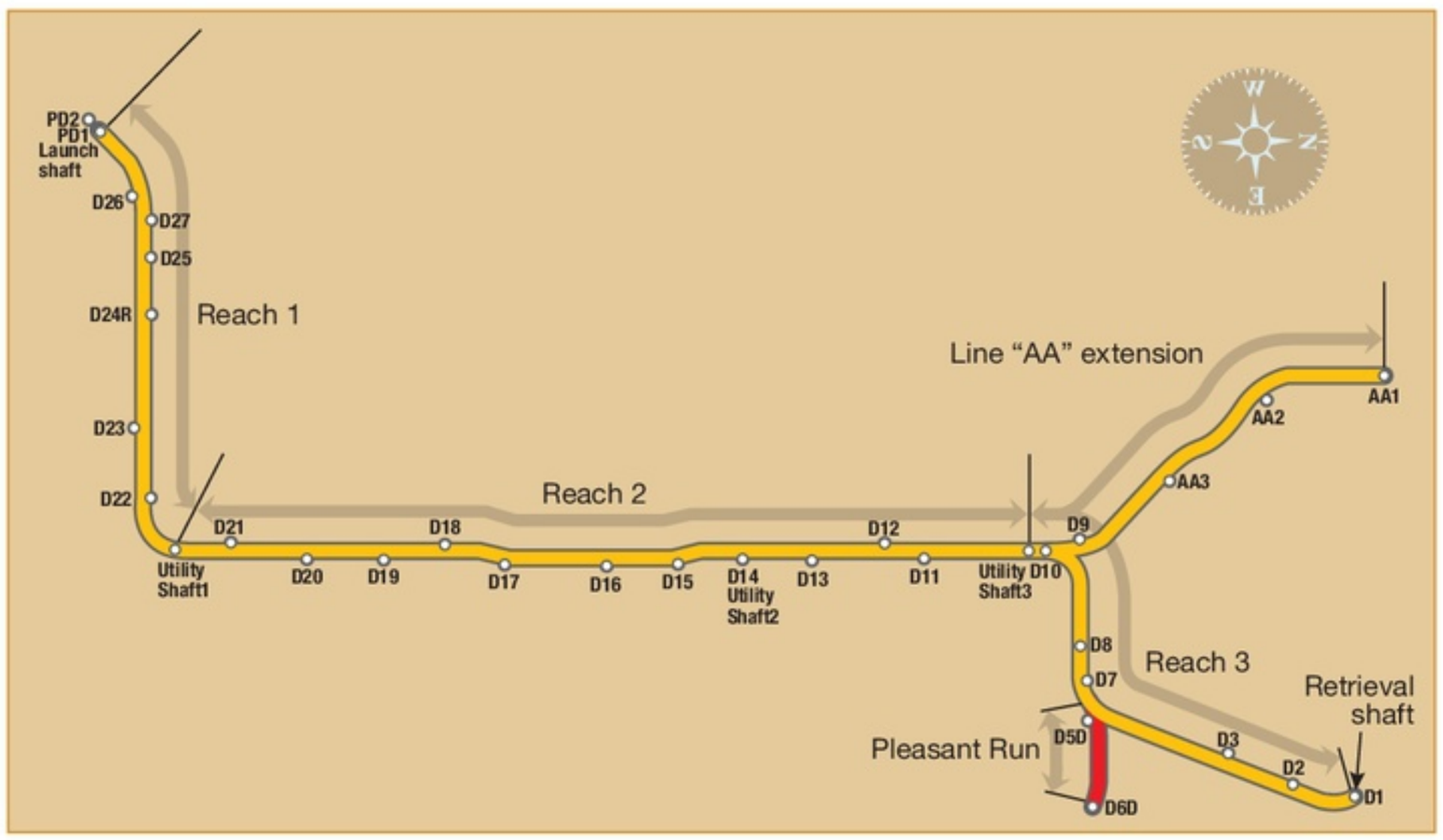
"It takes a lot of hours to go through the layout of the belt conveyor system," he says. "You have to make sure the conveyor can carry the material and not be over-tensioned at every set of conditions it will face through the years of mining, with those conditions changing daily."

Cleaning and maintenance were an important aspect on this project with Robbins installing a belt wash box which uses sprays and air knives, which do not contact the belt directly. Running this at the end of a shift leads to less dust in the working environment once the conveyors are started up again.

However the cycle time for such a long belt was around two hours, which has to be taken into account, says Workman. Time was also a factor when making vulcanised splices. "You need to be able to stop the belt at the right point so that the splice can be done at the belt splice stand located on the surface," says Workman. "Otherwise you will be waiting for a long time for it to come round again."

Curves aside, this conveyor had to tackle another extreme element: the climate. Those parts of the belt at the surface were subjected to sub-zero temperatures, which caused difference in operation when the conveyors were re-started after a break.

"We could see the effect of the cold belt going through the system because it created a lot more resistance," says Workman. "For extremely long conveyors like this, you can see a big difference due to a cold system. Next time it would probably serve us well to add in creep drives so that we never shut the system down."

Despite the possibilities for fine–tuning, this is a conveying system which has supported world records from the TBM. According to Robbin, it has achieved the most feet mined in one day, in one week and in one month for a 20 to 23 ft (6 to 7m) machine.

For Shea/Kiewit, persistent good rates meant that the TBM completed its first tunnel ahead of schedule in July 2014 and was then able to complete an extension tunnel added to the original scope by March 2015, still within the original programme. That's not too bad a feat for a 35-year-old TBM and a conveyor which had been used on four projects before this one.