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Job Report Surface Mining

Surface Miners at work in international tunnelling projects

Wirtgen Surface Mining:

Surface Miners at work in international tunnelling projects – an overview

Bernhard Schimm, Windhagen, January 2005

The advantages of Surface Miners in tunnelling projects

When a tunnel is built 80 % of the actual construction time is consumed for major earthmoving work and the other 20 % are required for the fine tuning steps.
There are always many time consuming steps involved to build the final tunnel profile, a job where a high level of precision is absolutely necessary.
This is true for projects where a new tunnel is built or an existing tunnel is reconstructed.
Since 1990 Wirtgen offers the Surface Mining technology for tunnel floor dinting, precise floor cutting and also mechanical excavation of the lower half of the tunnels.
In 1990 the Arlberg Tunnel, a two-track railway tunnel in Austria was modernized.
The extension of the tunnel height in one particular section was part of this job. On a 3.7 km long section the tunnel floor had to be equalized and lowered up to 30 cm deep in a width of 3 m.
A Wirtgen Surface Miner 1900 SM was used to carry out this job.
The machine removed 2,507 bcum of gneiss rock in less than 3 months and at the same time cut the floor exactly in the depth and profile as required.
This method, i.e. the cutting and loading of the material directly onto trucks, required on the equipment side only the mentioned Wirtgen Surface Miner and a truck.
Thus the building time could be considerably reduced.
This is not only a time saving and cost effective method. It is also a very precise working method. Only a small number of machines is necessary to carry out the job and thus this method is considered a valuable option, particularly when tight working conditions are given at the jobsite. This reference project led to further tunnel construction operations in which Wirtgen Surface Miners proved their strengths.

Tunnel operations in Sydney, Australia

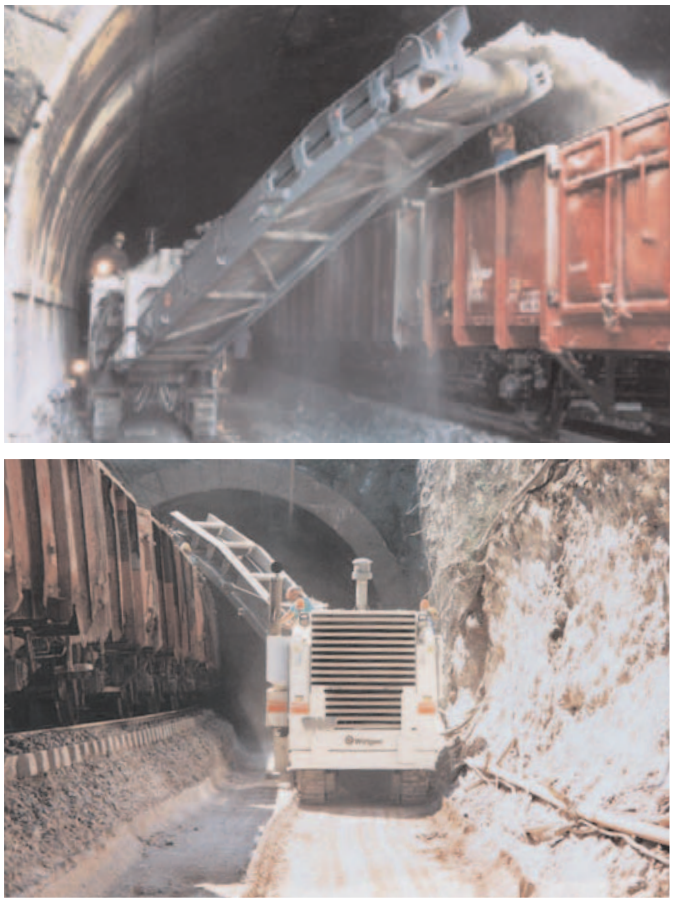
Since 1997 it has become the norm to cut the tunnel floor in the newly built tunnels around Sydney.
Examples are the Sydney Harbour Tunnel, the Sydney M5 East Tunnel and the Sydney Eastern Distributor Tunnel.
The main tunnel profile of these tunnels was excavated using road headers.
However these machines left a rough floor, typically 100 to 300 mm above the desired end level.
As a consequence, the levelling work had to be carried out with specially equipped Wirtgen milling machines of the machine type 2100 DC.
Special cutting tool patterns, water sprinkling systems for dust suppression and laser beams have been provided so that the hard sandstone could be cut successfully.

Railway tunnels in Triest, Italy

A few two-track railway tunnels in Italy, which were built more than 100 years ago, had to be enlarged for modern trains.
It was decided to carry out the headroom enlargement by lowering the floor by approximately 0.8 m.
For the precise floor dinting Wirtgen Surface Miners of the type 2100 SM were used.

The working sequences were as follows:

- The tracks and the gravel bed of one railway track were removed and the floor lowered by using a Wirtgen Surface Miner.
- The cut material was loaded directly onto train wagons travelling on the second railway track.
  This job was carried out by using the integrated conveyor of the Wirtgen Surface Miner.



The 2100 SM was able to load the cut material directly onto train wagons travelling on the railway track.

The Roughcastle Tunnel in Scotland

In the UK tunnel floor preparation jobs were carried out in the 90s for a road tunnel in Cornwall and in a tunnel on the Channel Tunnel Rail Link in Kent.

A different kind of application came up when the Roughcastle Tunnel had to be driven under the main Edinburgh-Glasgow railway line and below the historic Antonine Wall, which is the most northerly boundary of the Roman Empire. This tunnel is an integral part of the new Falkirk canal interchange.

The tunnel has basically a 7.5 m diameter horseshoe shape with a flat level invert and sprayed reinforced concrete final lining. The contract running for 38 weeks was started in early May 2000.

The crown was driven by a tunnelling excavator fitted with a breaker and bucket. Originally it was planned using breakers and excavators to muck out the invert in 2 m sections.

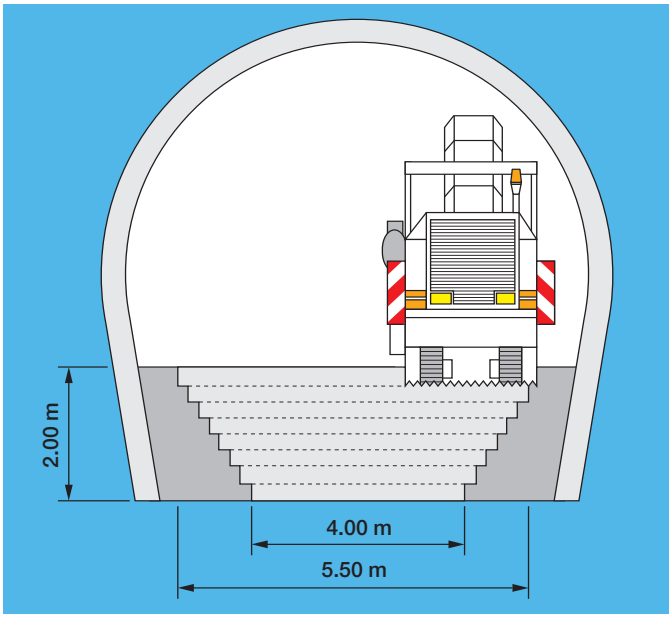
The material to be cut was hard dolomite with up to 160 MPa uniaxial compressive strength. Because of the hardness the Wirtgen Surface Miner cut 5 to 15 cm deep slices until the full depth of 80 cm had been reached.

Since there was a tight deadline to finish the construction project, two Wirtgen Surface Miners 2100 SM were used in this operation. The machines worked in tandem operation: one machine cut from east to west.

When this machine had finished the cutting operation it returned to the starting point by reverse travelling.

At the same time the second machine started the cutting process at the western portal cutting towards east.

Approximately 3,000 bcum were removed in a total of 280 operating hours.



A Surface Miner cuts the material step by step to the required level.

The 2100 SM cut series of stepped layers down to the final width of the tunnel floor. The result is a precise surface cut true to line and level.

But for time saving reasons the contractor chose the more effective Surface Mining method for cutting a trough.
The machine worked in a series of cuts from one end of the tunnel to the other, turning around outside the portals for the return runs. The excavated, well-graded spoil was discharged from the Surface Miner's conveyor directly into a team of 9 t dumpers for placing a subbase outside the tunnel. The machine cut three parallel cuts with an initial 5.5 m wide swath in a series of stepped layers down to a final width of 4 m in the bottom, leaving a flat, level and precise surface. So 1.360 m^3 of sandstone with up to 120 MPa uniaxial compressive strength were cut out.

However the major time and cost savings could be reached by the work process following the trough cutting done by the Wirtgen Surface Miner.
Cutting out a trough down the middle of the invert improved safety and increased the stability of the walls while the tunnelling contractor followed on breaking out the remainder of the rock each side of the invert and completing the sprayed concrete lining. Having three unconfined faces to work along each end of the walls, made it much easier and faster to break out the remaining rock in a staggered operation. It was possible to triple the production of the remaining invert to 3 m/shift. So it was also possible to break out a

section, erect reinforcing and spray on the concrete lining in one day before moving to the other end of the tunnel to repeat the operation. By the time of finishing the second section and moving back again, the sprayed lining had cured with enough strength to break out the next section and continue repeating the alternate cycle. So the tunnel construction could be finished well in time.

The Plabutsch Tunnel in Austria

The Plabutsch Tunnel is the longest tunnel of the 230 km long Pyhrn motorway A 9.
Construction work at the tunnel, which is located to the north of the town of Graz, began in 1983. Because of heavy traffic it was decided to double the capacity by digging a second tunnel.
In July 1999 the construction of the second tube of the Plabutsch Tunnel started.
While the tunnel in general was excavated using drilling and blasting, the fine tuning steps had to be carried out by precisely working machines.
After the completion of the conventional tunnelling work, an additional recess of 3.80 m width and 0.8 m to 1.4 m depth had to be excavated into the 8 m wide tunnel floor for the subsequent accommodation of service ducts. This was an ideal job for a Wirtgen Surface Miner.
The Surface Miner 2200 SM cut the material 2,2 m wide and up to 30 cm deep in one pass and placed it in a windrow behind the machine where it has been picked up by wheel loaders and loaded onto trucks.
The trucks removed the material from the tunnel and put it on an interim stockpile.
After the excavation had been completed, the trench was refilled with the material until the time the service ducts were laid, thus ensuring that the total tunnel width could be trafficked until the tunnel tube was completed.
The windrowing system had been selected for uncoupling the cutting from the loading process to avoid waiting times for the trucks.
The integrated levelling system of the Wirtgen Surface Miner ensured that the trench was cut precisely true to line and level. This accuracy, as well as the exceptional cutting power demonstrated by this mighty machine, could never have been achieved with conventional equipment, such as hydraulic hammers or trench cutting excavators.

The cut, small-sized material was placed in a windrow behind the Surface Miner. Wheel loaders can easily pick it up and load it onto trucks.

The terrain mainly consisted of dolomite rock, but quartz and dolomite sandstone had to be cut, too.
Depending on the hardness of the material to be cut, an hourly cutting performance of between 100 m^3 and 300 m^3 could be achieved.
Even in hard and abrasive material, the cutting capacity of the machine, which is equipped with a powerful mechanical cutting drum drive, never fell below 50 m^3/h.
So the calculated daily cutting volume of approximately 600 m^3 could be reached easily.
The Surface Miner was cutting the trench while the tunnelling work was still in full progress. No compromises were necessary with regard to safety when working with the Surface Miner. Without any “flying” chunks of rock, a danger that often impairs the safety of workers when using conventional methods, the Surface Miner smoothly followed its track. The development of dust was reduced to an absolute minimum.

Stammham tunnel in Germany

During the construction of the new railway line for the high-speed ICE train between Munich and Nürnberg several tunnels had to be built in the sections near the city of Ingolstadt. The Munich based construction company Alfred Kunz GmbH looked for possibilities of how to improve their productivity and to reduce the cost.
One area for technical improvements and cost reduction was the tunnel floor dinting using a Wirtgen Surface Miner 2100 SM. The Wirtgen Surface Miner 2100 SM had been equipped with an integrated laser controlled levelling system. Thus the surface of the tunnel floor could be cut precisely to the required level.

The advantages of the Surface Mining technology in this case:

- The tunnel floor could be cut quickly and precisely, the result was a very solid surface. The time consuming break out of material with hydraulic hammers, digging with excavators and compaction could be eliminated.
- Only a thin concrete surface was required. Instead of a 30 to 50 cm thick sectional concrete base now only 12 cm were required. So only 3,000 t of concrete had to be used.

After blasting the surface was uneven and had to be cut up to 80 cm in depth. The 2100 SM was equipped with an integrated laser controlled levelling system and cut the surface precisely to the required level.

Baregg Tunnel in Switzerland

The Baregg Tunnel was built as a two-tube motorway tunnel and is located west of Zürich. The increase of the traffic volume required a third tube to be built.

However blasting was prohibited. So it was decided to use a road header for the digging of the tunnel. With this road header the upper part of the tunnel, the crown, was driven through the mixture of marl, siltstone and sandstone. The road header also started to dig out the invert. This caused several difficulties.

The concrete lining for the entire tunnel profile had to be fitted immediately after digging out the invert. The construction operation for the lining placement did not allow any equipment or material to be brought in or out at this side of the tunnel. That meant that everything concerning the invert removal had to be transported in and out from one side using the top surface of the invert. Logistic problems were the consequence: The road header had to sit on the floor of the invert and cut material from the face of the invert.

A hydraulic excavator had to lift the material on top of the invert. From there another hydraulic excavator had to pick up the material again and load it onto trucks.

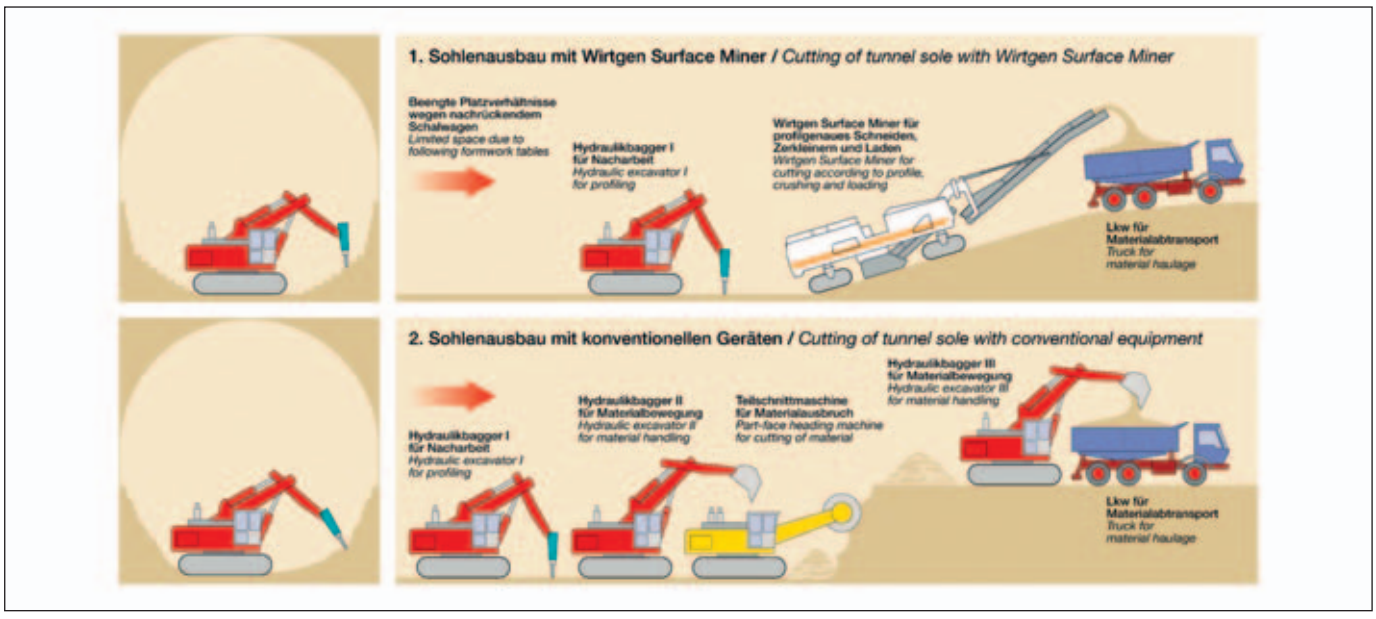
Furthermore it was difficult to serve and repair the machines which were located on the floor of the invert.

Everything needed for the operation of the machines, fuel, oil and spare parts had to be lifted down to the “trapped” machines. With the Wirtgen Surface Miners the “trap” situation could be solved. Wirtgen and the construction company developed a special working method:

The Wirtgen Surface Miner 2100 SM built a plane and continued cutting a permanent slope. This slope connected the upper and the lower part of the invert. The result: all machines had permanent access from the top to the bottom of the invert. The Wirtgen Surface Miner loaded directly the cut material onto the trucks. Since the Wirtgen Surface Miner profiled the side walls and the floor of the invert area, a small hydraulic hammer was only necessary for auxiliary work. Apart from a better access, the number of machines involved could also be reduced.

The Wirtgen Surface Miner continuously cut and loaded the rock. In one shift operation approximately 550 bcum of rock could be removed every day. This was more than required to prepare the full tunnel profile for the following concrete lining equipment. In this project the Wirtgen Surface Miner was the main tool for the acceleration of the construction process for the third tube.

In all of the mentioned tunnelling projects the work was carried out by contractors which own Wirtgen Surface Miners. Wirtgen provided the respective support to these contractors and to the tunnel construction companies in charge, along with information on the working procedures and the respective cutting tool selection.



The diagram highlights how the tunnel sole was cut by applying an alternative method with a Surface Miner.

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