Rock tunnelling

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INTRODUCTION.

As a member of the ITA Open Session Panel I was given the task to give a brief presentation with the title “The Past, Present and Future of Rock Tunnelling.” This has been done in a 11 pages paper with 6 figures, where the development over the last 50 years is discussed. In this Summary version I have restricted myself to the Future as I believe this may be the most interesting. Rock as a material can be just anything from the strongest gabbros and granites to the softest shales and friable sandstones. My presentations are based on a simple definition of rock tunnelling as construction in a material which can not be excavated by ordinary digging tools.

FUTURE TUNNELLING METHODS.

What will the future bring to the tunnellers? When it comes to excavation of the rock tunnel itself, I believe that for many years to come the conventional drill & blast method on a global scale still will be the dominating method. Not least will that be true in countries where the cost of equipment is more important for the final result than the cost of labour. The great advantage of this method in addition to relatively low investment costs, is the flexibility of the method. With the same equipment different sizes and shapes of tunnels can be made in very varying ground conditions. But also this method will be further developed.

The computerized drilling rig is already here. It is just a matter of imagination how to utilise this new rig for all it is capable of. Tunnel contours can be precisely mapped, and information about drilling rates and thrusts can easily be logged for each meter (or centimetre) of each drillhole in a round. How can such information best be used for instance for planning of the support? For the drilling of the next round? Or the planning of the next project?

The drill & blast method is a typical sequential production procedure, and the advance is strongly related to the length of each blast round. We have already seen successful experiments with the computerized drilling rigs where the length of the blast rounds has been extended to 9.0 m (30 feet). And new explosives are producing less toxic fumes which reduces the need for ventilation which again allows longer drives to be excavated.

Even if I believe that the drill & blast method for a long time to come will be the dominating rock tunnelling method, I am likewise convinced that the TBM - method will continue to increase its share of the rock tunnel market, particularly in urban areas and in countries with high labour costs. We will certainly see stronger and more flexible machines which can cope with varying ground conditions. To increase the effective boring time from around 50 % today more durable cutters are needed as well as improved hauling systems. Recent installations of conveyor belt systems have indicated effective boring time of 60 %.

Completely new tunnelling machines may evolve. In Norway with several thousand kilometres of unlined tunnels for hydropower schemes the “dream machine” is the machine that can go into these tunnels and quickly smoothen the rough rock surfaces and thus increase the conveying capacity of the tunnel and reduce the head loss. The best would, of course, have been if this could be done while the water was still running.

SUPPORT AND LINING.

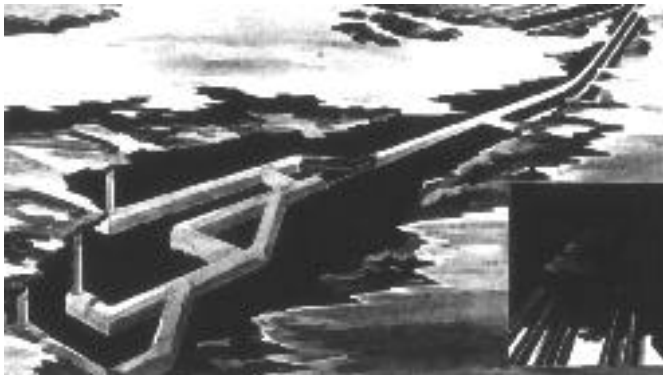
The cost of support and lining as well as the time needed for these operations may even for rock tunnels exceed the cost and time needed for the excavation of the tunnel. Further progress in our business is therefore to a large extent dependent on new development within this sector. Such development will have to be based on products of higher quality as well as on improved methods for the installation or application of the support and lining elements. I expect new rock bolts and new bolting machines and improved shotcrete and shotcreting machines to come on the market. Increased use of prefabricated concrete segments instead of in situ placed concrete is also a clear trend that I believe will continue.

The field where, however; I see the strongest need for continued development is within grouting of tunnels to prevent leakage and thus draw down of groundwater. The problem is an old one. The very first metro tunnel in Oslo, which was constructed in 1912, caused local settlements of streets and buildings of up to 350 mm and a series of breaks of water and gas pipes during the years 1913 - 1916.

The new 14 km long railway tunnel, Romeriksporten, between Oslo and the new airport which will be opened in August , is delayed by 9 months and has a considerable overrun in costs mainly because of groundwater problems. This tunnel project has caused more negative news media focus on our profession than all other tunnel projects in this country put together. And the main reason for this is the way the tunnel interfere with the groundwater both under built-up areas and under recreational areas. As more and more tunnels will be constructed in urban areas, the need for a better understanding of groundwater movements and how to control such movements by the use of grouting techniques is obvious to this author. I see this as perhaps the greatest challenge to our industry in the immediate future.

NEW TUNNELS.

Rock tunnels are today utilised for a wide variety of purposes. Are there still some transport, communication or conveyance purpose for which rock tunnels have not been taken into use?



More than ten years ago we discussed very seriously to construct a 70 -100 km long tunnel system from the West coast of Norway out to one of the offshore oil and gas fields, the socalled Troll-field. The long tunnel going all the way out to the offshore fields has still to come, but several shorter tunnels for oil and gas pipes have been constructed along our coast.

An investment group has developed serious plans for a tunnel to be used by medium sized ships to avoid the most dangerous part of the west coast of Norway. The 3 km long tunnel will be excavated in solid gneiss rocks and have a cross section with approximately 20 m width and 30 m height. A ship or boat tunnel is, however, in fact a rather old idea. Boat tunnels were of crucial importance when the vast inland canal system was developed during the early days of the industrial revolution in England. Thus good old ideas are being revived.

Other challenging future rock tunnel projects which have been discussed for some time are for instance the several strait crossings like the Gibraltar strait, the Bering strait and tunnels connecting Japan with Korea.

NEW ENVIRONMENTAL REQUIREMENTS.

It is not easy to foresee all the challenges tunnel planners and tunnel builders will be facing in the future, but one thing I feel absolutely certain about, is that new environmental requirements will be implemented all over the world. And this will be related both to the effect that tunnelling works may have on the ground above the tunnel and to the working conditions in the tunnel itself.

I have already mentioned the groundwater problems related to the Romeriksporten railway tunnel here in Oslo. The environmental related problems our Swedish colleagues have experienced with their railway tunnel in HallandsÂsen are certainly not smaller. As many of our future tunnels will be in urban areas, the influence of our work on the environment will be easily exposed to an increasingly sceptic public audience. Comprehensive pre-investigations and careful planning will therefore be needed to secure successful projects. In addition to this a proper education of the public to avoid all kinds of misconceptions about the work we are doing in the underground will become of vital importance. This is a field where ITA could play an important role in the future.

I have had the good fortune during the years to visit tunnel sites on all continents. I have thus seen tunnels with considerably different inside environment from the more or less disorganised, smoky, damp and wet tunnel headings where I have felt uncomfortable and unsafe, to well organised and properly ventilated tunnels. ITA has already done excellent work within the health and safety field, and should continue and enhance this for the benefit of our industry on a global basis.

CONCLUDING REMARKS.

At ITA General Assembly three years ago I promised that we will show you tunnels build by female tunnel ´foremenª and engineers. And we will certainly stand by our promise. There are several tunnels under construction here in the Oslo area where our lady colleagues play important roles. And if you check the organisation charts for this congress you will also see that many of them are heavily involved. So they have come to stay in the underground business. And we have already experienced their positive influence.

Recruiting qualified and dedicated people for all levels of the planning and construction of tunnels and underground works may become a key question for the continued development and success of our industry. This

is becoming more and more obvious in this part of the world, and I am sure that it will gradually be observed in other parts as well. This is also a field where internationally combined efforts through an organisation like ITA could be of benefit for all of us and for the society in general.