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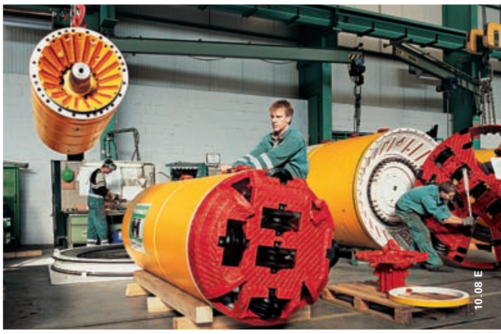

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Tunnelling Systems

Projet hydro-electrique de Chamera, Inde

Chamera Hydro-electrical project, India

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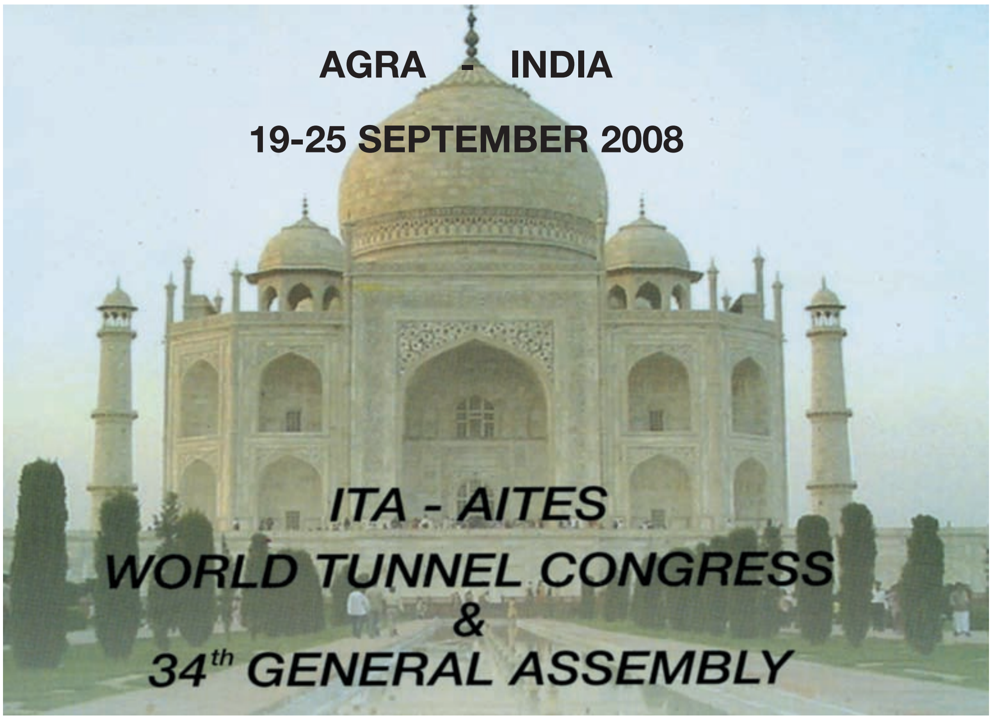


EDITORIAL

The location of various facilities underground will be the order of the day in the future to ensure sustainable life for future societies by providing necessary infrastructure to accommodate transportation, communication utility networks and complexes for handling, processing and storage of many kinds of materials. Application of new technologies besides use of sophisticated equipment for underground construction works would be warranted for execution of works in a cost effective manner conforming to sustainable development. With rapid growth of underground structures anticipated, there will be tremendous scope for evolution of new technologies and innovative construction practices.

The worldwide tunneling activity continues to increase to develop and upgrade the infrastructure and facilities needed to meet the ever-growing demands from irrigation, hydropower generation, drinking water, industrial needs, highway and railway tunnels etc., and at the same time preserving urbanized areas, natural resources and the environment. The huge development of the mining industry stimulated the imagination of engineers and encouraged them to extend and adapt mining methods for construction of communication tunnels.

For a fast developing country like India, it is now envisaged to provide "Power for all by 2012" and capacity addition in hydropower sector is expected to play an important role in this vision. It is proposed to add about 16,500 MW hydropower by end of 11th plan (3/2012) and 30,000 MW by end of 12th plan (3/2017) and such development have opened avenues for construction of tunnels, underground caverns and other connected infrastructure on a much larger scale. Considerable activities in the field of tunnelling are therefore in progress or envisaged for the execution of water resources projects for irrigation and hydropower generation, building of roads in mountainous area etc. With the growing need to accelerate the tempo of water resources and hydropower development, new projects are being taken up, which involve construction of more than 1,000 km length of tunnels , practically in every type of strata and sizes varying from 2.5 m dia to 14 m dia besides underground excavation of caverns for the power houses. Many of these projects are planned to be taken-up on priority for completion by end of 2012. Subsurface excavation for the construction of the metro in the city of Kolkata and New Delhi has been done successfully. Such works are being planned in other metropolitan cities like Mumbai, Bangalore, Hyderabad, Lucknow, Pune, Chandigarh etc. as well. In view of the large scale tunnelling works to be undertaken for metro, rail, road and the development of water resources/hydropower projects in the near future besides other underground structures being planned in the country, there is a vast scope for the agencies within as well as outside the country, to demonstrate their capability either in providing services or equipment and also find new joint ventures for execution of works.

Considerable tunnelling activity is involved in the hydropower projects located in the Himalayan region which occupies a unique position having substantial hydropower potential constituting 73% of the total hydro potential. However, development of hydropower in the Himalayan region is a big challenge due to complex geological set-up, and difficult terrain conditions. Attempts are therefore being made to introduce latest technological advancement in the field of design and construction. Construction of tunnels in unique geological condition in itself would be a good experience and shall help in updating the know how for new construction equipments. Many international construction companies in the field of hydropower have set up their base in India and their unique experience would definitely be of help for future projects in the world.

The present 34th General Assembly of ITA-AITES and World Tunnel Congress is scheduled to be held from 19-25 September 2008 at Agra, India for the first time. The theme of the congress is "Underground Facilities for Better Environment and Safety" During the event you will also have an opportunity to see cultural and historical landmarks of the city of Agra, which is globally renowned as the city of the Taj Mahal, the most beloved monument and number one of the wonders of the World .

We are looking forward to seeing you all at the 34th General Assembly of ITA-AITES and World Tunnel Congress at Agra.

V.K. Kanjlia
Secretary General
Tunnelling Association of India

Focus on India

1. INTRODUCTION

India is a land of lofty mountains and mighty rivers. A vast land with such varied relief is inhabited by more than one billion people. The country consists of three main physical divisions. These are the great mountains of the north and north- east, the great plains of northern India and the great southern plateau of Peninsular India. The southern plateau is flanked by the narrow coastal strips which are a part and parcel of the peninsular land mass. India has diverse geology too. Different regions of India contain rocks of all types belonging to different geological periods. Some of the rocks are badly deformed and transmuted while others are recently deposited alluvium that are yet to undergo digenesis. Mineral deposits of great varieties are found in the subcontinent in huge quantity. India's geographical land area can be classified into Deccan trap, Godwana and Vindhyan. The deccan covers almost all of Maharastra, a part of Gujarat, Karnataka, Madhya Pradesh and Andhra Pradesh marginally. The rocks found in this region are generally igneous. The Godwana and Vindhyan include within its fold parts of Madhya Pradesh, Chattishgarh, Orissa Andhra Pradesh , Maharastra, Jammu and Kashmir, Punjab Himachal Pradesh, Rajasthan and Uttaranchal.

India has a very old history. Indus civilization is well known. Tunnels had their own roles to play in any civilization and it was no different for Indian civilization. Tunnelling dates back to prehistoric times. Primitive people made cavities or widened the natural caves for shelter against weather, enemies and wild life. Archaeological research establishes that men even in the stone age excavated cavities. Very old tunnels built several thousand of years ago have been found in India. Tunnel construction in India dates back to almost 10,000 years during Mahabharat period when Pandavas constructed escape tunnel. History also reveals that many kings got constructed escape tunnels from their forts to safer places to be used during emergencies. Earlier tunnels were constructed manually.

Man's insatiable passion to achieve more and more progress and production to meet the ever increasing requirement of mankind has driven him to design and improve upon the production of basic tunneling tools into more efficient and productive ones.

Modern tunnel construction in India has its origin mainly in the nineteenth century when a number of railway tunnels were constructed for extension of rail network in the various parts of the country for crossing of hill ranges - in Western Ghats, Vindhayas and in the foothills of Himalayas for connecting few hill resorts like Shimla and Darjeeling. Barring few tunnels in the soft rock formations of Himalayan Foothills in the North, most of the tunnels were bored in hard rock strata in Peninsular India. Also generally the dimensions of the tunnels were limited to the requirement of accommodating single broad gauge railway track. There were a few instances of tunnels being constructed for roads and other purposes. Early in the present century, a major tunnel was built in Shiwalik ranges in connection with first major hydro power project in Punjab.

Construction of tunnels received a big boost after Indian Independence in 1947 when large programmes for exploitation of water resources were taken up which involved construction of tunnels for water conveyance and other underground works. In the last six decades, large number of tunnels have been constructed in connection with multipurpose projects in the Himalayan region. Amongst the important projects, where tunnels have been built include Beas Sutlej Link, Baira - Siul, Giri and Sanjay Projects in Himachal Pradesh, Lakhwar and Maneri Bhali Projects in Uttaranchal, Jaldhaka Project in West Bengal and Chukha Hydel Project in Bhutan. In the North-East, important tunnel jobs have been executed at Loktak and Umium Hydroelectric Projects. In the Peninsular India too, there was spurt in tunnelling activity connected with the execution of Koyna, Nagarjunasagar, Sirisailam, Kalinadi, Malaprabha, Balimela, Sabirigiri, Idduki, Lower Periyar, Perambikulam Aliyar and Kadamparai Projects in the Southern States. Tunnels with bore diameter of as much as 9 m and length up to over 25 km at Beas - Sutlej Link have been built in this period. The details of the tunnels built in different States of India are given in the table below:

N°	State	N°of Schemes	Length of Tunnels (km)
1	Anddhra Pradesh	4	12.795
2	Arunachal Pradesh	2	16.365
3	Assam	3	15.435
4	Bihar	3	04.113
5	Gujarat	1	01.839
6	Himachal Pradesh	11	94.036
7	Jammu & Kashmir(J & K)	5	28.239
8	Karnataka	6	60.517
9	Kerla	10	81.688
10	Manipur	1	07.125
11	Meghalaya	1	07.125
12	Nagaland	1	00.428
13	Orrisa	2	05.995
14	Sikkim	1	03.216
15	Punjab	3	07.765
16	Rajasthan	3	03.379
17	Madhya Pradesh	5	17.157
18	Maharastra	12	71.072
19	Tamilnadu	14	71.702
20	Uttar Pradesh	4	58.127
21	West Bengal	1	03.250
22	Bhutan	2	03.675
23	Uttrakhand	1	12.000
	TOTAL		586.948

Apart from tunnels for hydroelectric works, a few tunnel projects were executed for roads and water supply schemes, the notable projects being the Banihal Road Tunnel (J&K) and Tunnels for Bombay Water Supply. Another very important railway and Metro (Urban tunnel) projects executed by the Indian engineers, and presently in operation are Konkan Railway, Calcutta Metro Railway and Delhi Metro Railway.

2. CURRENT STATUS OF TUNNELLING TECHNOLOGY IN INDIA

2.1 Tunnelling Technology

A review of tunneling methods shows that the conventional drill-&-blast method remains practically the dominant practice for excavation of tunnels in India.. The tunnelling rates achieved using the conventional method of excavation vary from 7.5 m to 81 .0 m on monthly average basis depending upon the size of tunnel, geology encountered etc which is comparably much lower than the rates achieved otherwise using mechanized tunnelling else where.

Attempts have been made in the past on some projects to use Tunnel Boring Machines (TBMs) with success in some and failure in others.

Till recently, barring a few cases, the use of steel ribs with backfilling by tunnel muck or lean concrete was practically the only method of supporting in India. This being a passive support system, a considerable damage is done to the rock mass before the ribs interact with it. The combination of the drill-&-blast method of excavation and steel rib support system delays the supporting action, allows opening of the existing joints, creates new fractures, permits loosening of the rock mass in the roof, mobilizes higher tunnel closures and greater rock loads which require larger excavation and thicker support. All these problems result in increased cost and completion period. Lately, there has been considerable increase in the use of shotcrete as a support system, particularly for large underground cavities. The use of steel fibre reinforced shotcrete (SFRS) has also been made at a few projects, such as, Uri (J&K.) and Koyna Project (Maharashtra).

2.2 Tunnelling Projects in Himalayan region.

In India, considerable tunneling activity is involved in the hydropower projects and it is bound to accelerate since, of late, major thrust has been laid by the Govt. of India for harnessing available hydropower potential of the Himalayan rivers in order to strike a balance between total demand and supply in power sector. Himalayan region occupies a unique position having substantial hydropower potential. Out of the total 1,50,000 MW hydropower potential in India, major share lies in the Himalayan rivers constituting about 73% of the total potential. The pace of hydropower development in Himalayan region is facing many challenges related to complex geological setup, difficult terrain conditions and high seismicity. Besides, adverse climatic conditions, forest and environmental issues and rehabilitation problems are some more hurdles. In order to achieve an ideal hydro-thermal mix of 40:60 against the present ratio of 25:75, serious efforts are being put by the Govt. of India to focus on harnessing of hydropower potential of Himalayan rivers in Uttaranchal, Himachal Pradesh, Jammu & Kashmir and the North-Eastern states where 527 hydel projects (413 run of the river and 114 storage schemes) have been identified. Construction of these Hydel projects will involve extensive tunneling.

2.2.1 Use of Tunnel Boring Equipments in Himalayas. With a view to accelerate the hydropower development, two projects viz. Dul-Hasti and Parbati were taken up in the North-West Himalayan region in Himachal Pradesh and Jammu & Kashmir, where with foreign collaboration, construction firms have deployed most modern tunnelling equipment for excavation of tunnels and underground works. There is, for the first time, the opportunity to obtain realistic ground data regarding work performance on these projects for evolution of updated tunnelling technology in our country in the complex soft rock formations of Himalayas, where over fifty percent of the future tunnelling jobs are to be executed.

For the first time, a Tunnel Boring Machine (TBM) was deployed for Tunnel for Bombay Water Supply Scheme earlier in 1984, relatively for a smaller tunnel of 3.5m diameter. For hydroelectric project, TBM was used for the first time by a French Contractor on tunnel excavation in Dulhasti Project in the State of Jammu & Kashmir for tunnel boring in Himalayan Strata. Subsequently, it has been used in Parbati Project Stage-II in the State of Himachal Pradesh.

2.2.2 Dul-Hasti Hydroelectric project. First time, a TBM has been used for excavation of head-race tunnel 8.3 m dia and 10.6 km long at Dul-Hasti Project in Jammu and Kashmir. The geology in the tunnel reach consisted of Quartizite in a reach of 4.5 km, Phyllites in a reach of 3.5 km and Gneiss/Schist in a reach of 2.6 km.

The tunnel boring with gripper type hard rock TBM on this project was started in April 1991. The rock was predominantly very hard and highly abrasive quartzite. Early problems encountered were high wear of cutters and later on flooding of tunnel twice due to artesian conditions in the tunnel which subsequently buried the whole TBM. This experience in Himalayan geology was not encouraging. The TBM could bore only 2.86 km and got buried and was finally abandoned. The work has since been completed after re-routing of the tunnel. In the starting phase, a progress of 50 to 156 m per month only could be achieved on tunnel excavation due to teething problems.

2.2.3. Nathpa Jhakri Hydroelectric project. Another recent job in Himalayas is the Head race tunnel of Nathpa Jhakri Project in the State of Himachal Pradesh. After evaluating alternative options, it was decided to use drill and blast method for tunneling in preference to use of TBM for 27.4 km long tunnel.

2.2.4. Parbati Stage -II. TBM is currently being used in Parbati Hydroelectric Project Stage-II in Kullu District of Himachal Pradesh which is under construction by NHPC as a run of the river scheme on river Parbati. The project mainly comprises construction of a 85m high Concrete Gravity Dam across Parbati, 31.50 km long 6.0m diameter Horse Shoe/circular shaped Head Race Tunnel, 3.5m diameter 2 Nos. inclined Pressure Shafts and a Surface Power House. To augment the power generation, the discharge of 5 Nallahs including Jiwa Nallah is proposed to be diverted into main HRT by constructing Trench Weirs, Feeder Tunnels, Desilting Chambers and Drop Shafts. The Power House utilizes a gross head of 862m and shall have installed capacity of 800MW (4 x 200MW). Four Nos. 60m long Tail Race Channels ultimately discharge water into river Sainj, a downstream tributary of river Parbati. The Project envisages generation of 3108.6 million units of power annually at 90% dependable discharge. Out of total 31.50 km of HRT the work of excavation of 9.05 km was proposed to be done using TBM and the remaining using D&B.

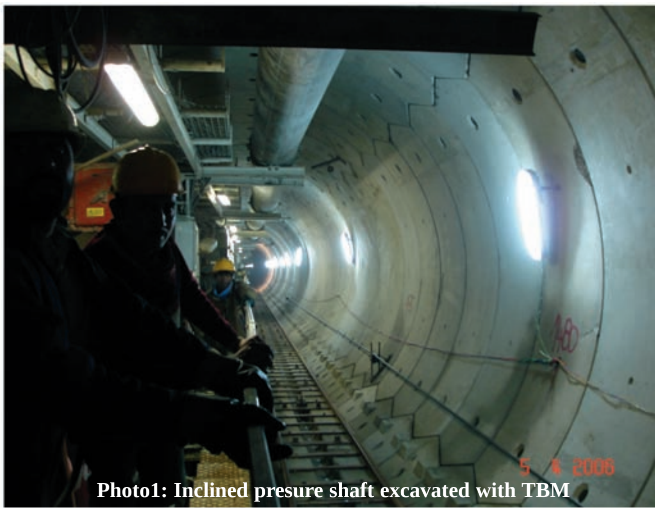


Photo1: Inclined presure shaft excavated with TBM

As on date 4060 m has been bored with TBM and 2752 m excavated with DBM. Maximum progress of tunnel excavation achieved with TBM was more than 500 m in one month. A considerable length of HRT in this reach is passing through a high cover zone ranging beyond 800m to 1350m, in which incidents of rock bursting have been observed. The average progress achieved in Pressure Shaft I was 128 m per month whereas in Pressure Shaft II the work was completed in 6 months. Two nos. of inclined pressure shafts of 1546 m each were excavated by using TBM. The average progress


Photo2: Breakthrough in inclined pressure shaft with TBM

achieved was 257 m per month and maximum achieved was 388 m per month. On 4 occasions the progress achieved was more than 320 m per month. First time in the world such long inclined pressure shafts were excavated using TBM. Photo 1 & 2 shows inclined pressure shafts excavated with TBM

2.2.4.1 Excess Flow of Sand, Silt & Water. While drilling a probe hole (51mm dia) on 18th November, 06 at Face-4 (TBM) of HRT, a sudden flow of water with sand and silt was observed and in two hours approximately 120 cum sand and silt came and got deposited around the TBM and also on the floor for a distance of about 200m. This probe hole was later on plugged and the silt and sand were removed. After discussions with contractor, a decision was taken to explore further before restart of the boring operation of the TBM, to ensure that TBM is boring in a medium which does not have hidden water reservoir, which if intercepted by the TBM would be catastrophic. Another probe hole was drilled in the vicinity of the original probe hole (11 O' Clock position) which intercepted the alignment of the original probe hole and silted water along with sand with high discharge started coming in and this was regulated by a flexible hose pipe to the conveyer belt of the TBM and silt alongwith sand was loaded in the muck cars and taken out of the tunnel. The situation however went out of control when the discharge increased beyond 2500 litres/minute, which could not be contained in the system evolved by the Project. The discharge went beyond 7000 litres/minute. Initially, the silt and sand (approximately 25% of the water volume) came in and got deposited around the TBM and its back up system to the depth varying between 3 to 6 m. Experts views are being obtained for furher course of action in regard to the methodology to be used for further excavation including the options of (i) use of the present TBM after restoration and necessary addition of more facilities needed to encounter further more surprises (ii) use of some other TBM & (iii) D&B.

2.3.Water supply and drainage projects

2.3.1 Malabar Hill tunnel, Mumbai. This was the first water supply tunnel driven in India using a hard rock TBM. The tunnel of 3,870m length was driven with 3.5m dia gripper type TBM. The tunnel was reported successfully driven in 450 days with best monthly advance of 376m.

2.3.2.Bandra and Worli sea outfall tunnels. Two 3.5m dia tunnels of 3.4 km and 3.7 km length were driven using open face gripper type TBM with precast concrete segmental lining. Tunnel faced unstable ground with a number of rock falls and heavy ingress of water. A peak output of 555m per month was reported in driving Bandra tunnel.

2.3.3. Ghatkopar sewer tunnel. This 2,670m long tunnel of 2.5m dia was excavated using fully shielded TBM. Segmental precast concrete lining was used as a support. Many different geological strata including sand, boulders, clay as well as rock were reported to be encountered along with heavy ingress of water. The tunnel was completed in 13 months with best monthly progress reported as 306m and average monthly progress of 220m.

2.4. Tunnelling for Konran railway

Modern tunnelling equipments were also deployed by Konkan Railway Corporation for construction of 760 km long Konkan railway which has over 83.6 km of tunnels, mostly in hard rock.. The 760km line now connects Maharashtra, Goa and Karnataka - a region of criss-crossing rivers, plunging valleys and mountains. The task was formidable. As Karlis Goppers pointed out in his Swedish International Development Cooperation Agency (SIDA) report in July 1997: "*With a total number of 2,000 bridges and 92 tunnels aggregating to a total length of 83.6 km and nine tunnels of these were longer than 2 km, to be built through this mountainous terrain containing many rivers, the project is the biggest and perhaps most difficult railway undertaking during this century, at least in this part of the world.*

Out of these, 74 km was through hard rock, 8.4 km through soft soils and the balance 1.2 km, through cut and cover construction. Coming to the execution of the works, the powerful drilling and loading equipment imported from Sweden was deployed at Natuwadi, Sawarde, Karbude, Tike, Berdewadi, Barcem and Karwar tunnels. Use of this technique meant drilling of 75 holes 45 mm dia for a full face of 33 sq. m. A pull of 3.5 m of full face was obtained in an average cycle time of 12 hours. However, a record of minimum cycle time of 4.5 hours was accomplished at Natuwati tunnel. At the remaining hard rock tunnels, the conventional drilling and blasting technique was adopted. On the whole 74 km of hard rock tunnelling was accomplished without much difficulty except for problems due to the shear zone in Natuwadi, culumanar basalt leading to chimney formation at Sawarde, water ingress and face collapses in the Parchuri tunnel.

Hydraulic electric jumbo drilling machines and Haggloaders were used and this, to some extent, helped in tackling tunnels with rocky strata. These machines could only excavate 19,060 m in 10 tunnels (13 faces) but they did help in reducing work that would otherwise have to be tackled manually through conventional methods. In the case of tunnels with soft soil strata, however, there was no method apart from the conventional heading and benching by manual labour, a very slow process indeed. Soft soil was encountered in seven tunnels, three in Karnataka and four in Goa. There were some tunnels wholly in soft soil such as the ones in Old Goa and Honnavar, while others had a considerable length in soft soil – Byndoor, Bhatkal, Padi, Verna and Pernem. In the soft soil tunnels, excavation was almost impossible; the clayey soil, saturated with water, flowed like mud slurry, making the face totally unstable. Before the excavated portion


Honnavar Tunnel

IMPORTANT TUNNELS (Table 2)

Name of Tunnel	Length of tunnel (m)
Hard Rock Tunnels	
Natuwadi	4389
Chiplun	2033
Sawarde	3404
Parchuri	2628
Karbude	6506
Tike	4077
Berdewadi	4000
Barcem	3343
Karwar	2950
Critical Soft Soil Tunnels	
Pernem	1561
Old Goa	544
Padi	1917
Bhatkal	863
Byndoor	1962

could be supported, there were collapses. Even where supports were provided, the load exerted on the temporary supports was so heavy that it yielded, collapsed or settled and the whole process had to be repeated. Sometimes the work had to be redone several times and the progress was virtually at a standstill. The work became particularly difficult during the monsoon, when collapses occurred frequently, and tunneling became very slow and difficult. Most of the casualties that took place during the construction of the Konkan Railway occurred during soft-soil tunneling. While the shaft for the tunnel at Honnavar was being lowered, it sank suddenly due to sand blowing, leaving eight workers trapped underneath. It was a major disaster. Similarly in the Pernem tunnel, eight people lost their lives at different times, owing to collapses. The support system for temporarily holding the excavated tunnel section has to be very carefully done. Uneven loading, incorrect strutting, small movement of support, and short cuts could cause large differences between calculated and real load, leading to failures which took months to rectify. There were, inevitably, some human errors too. The soft soil tunnels were the last to be completed. It was only in 1997 that tunnels at Byndoor, Bhatkal, Padi, Verna, Old Goa were completed. The Pernem Tunnel could be completed only in January 1998. Table 2 shows length of some important tunnels and Photo - 4 shows a portion of finished tunnel.

Honnavar Tunnel

2.5.Delhi Metro

Delhi has experienced phenomenal growth in population in the last few decades. Its population has increased from 5.7 million in 1981 to about 16.5 million at present and is poised to reach 19 million by the year 2011. For want of an efficient mass transportation system, the number of motor vehicles has increased from 0.54 million in 1981 to 5.1 million in 2007 and is increasing at the rate of 0.6 million per annum. The result is extreme congestion on Delhi roads, ever slowing speeds, increase in road accidents, fuel wastage and environmental pollution with motorized vehicles alone contributing to about two thirds of atmospheric pollution.

To rectify this situation, the Government of India and the Government of National Capital Territory of Delhi, in equal partnership have set up a company named Delhi Metro Rail Corporation Ltd which has already commissioned a 65.10 km route in Phase -1 and is proceeding ahead with another 125 km in Phase-II. The first section of the Delhi Metro was opened to public on 25th December,2002. Over the next four years, newer sections were regularly opened. The last section of phase I was opened on 11th November 2006 and today this phase is fully operational. Today, the Metro network spreads across 65.1 km in New Delhi and some of its most populated areas. Of this, 47.43 km are elevated, 13.17 km are underground and 4.5 km at grade. It is the largest urban intervention in the transportation sector in India since independence which has completely changed the way the city travels.

Dehli Metro station

Construction of Delhi Metro is a landmark which has given a good insight into problem of tunnel construction in urban areas.. Some of the technological difficulties and construction problems encountered during the execution of Delhi Metro are given below:

2.5.1 Technological difficulties. Construction of the Metro was not an easy task and several technological difficulties were encountered. Tunnelling below the historic Old Delhi area posed a major challenge, as the buildings there have weak foundations. It was therefore decided to construct the tunnel at a depth of more than 20 m. Tunnelling difficulties were also encountered in some sections due to hard rock. Special cutter heads were procured for Tunnel Boring Machines (TBM) to tackle this problem.

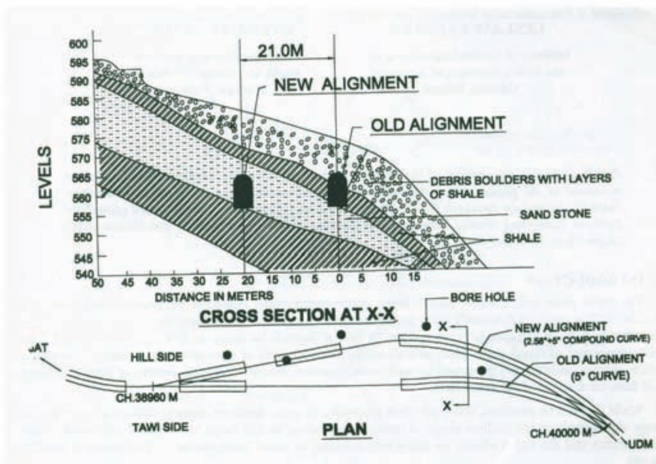
2.5.2 Construction of Phase II progressing swiftly Construction of phase II of the project is currently underway. This phase consists of 125 km of which 92 km will be elevated, 29 km underground 4 km at grade. 23 km distance between the city centre to the international airports. will be covered in 15 minutes. Phase II of the Delhi Metro is very ambitious because the entire project has to be completed before the Commonwealth Games in October 2010. This means that while Phase I was completed in seven years and nine months, Phase II has to be constructed in just three and a half years. Phases III and IV are planned to be taken up after 2010. It is envisaged that the Delhi Metro will spread across 413 km by 2021 making it one of the biggest Metro systems in the world.

2.6 Jammu-Udhampur- Srinagar Baramulla Rail Link

The new railway line, prestigious and the most challenging Jammu-Udhampur-Srinagar Baramulla (340 km) under construction in the Himalayan Mountains in Jammu & Kashmir State will connect Jammu to the border town of Baramulla, passing through Katra and Srinagar, the State capital. The difficult terrain and geological features of the area and the Govt. directive to complete the line in a short period of five years have played an important role in deciding the layout and location, and design of tunnels. The mountains are rugged dissected by streams, forming sharp ridges and steep khads. Because of the terrain, the line shall be laid mostly in tunnels along the mountain slopes, with bridges spanning the khads between tunnels. Except the tunnel through which the line crosses the Pir Panjal range, the tunnels have been kept of small to medium length to reduce the construction time to about five years. 76% line passes through the tunnels and 10% shall be laid on bridges. Thus, only 14% of the line shall be in formation. Even in formations, there shall be high cuttings requiring special measures for safety of train operation. The adverse geology has led to increase in tunnel length because it was not possible to locate bridges and tunnel portals in slide zones and other unfavourable locations. The rocks range from loose conglomerates and severely folded and crushed sand-clay-silt stones in the Katra-Sangaldan region to slates, schist and phylites beyond Sangaldan. The line shall cut across three major thrust zones. These are Reasi Thrust between km 30-50, Murree thrust between km 103-109, and Pir Panjal thrust between km 114-122. On account of high tectonic activities in Himalayas, the rocks along the proposed alignment in these stretches are heavily folded, over-thrusted and faulted at many places. Due to this, rocks are highly jointed and crushed.

Between Katra-Quazigund section (142 km), there are 42 nos. of tunnels with total length of tunnels 107.96 km (76%) and the length of longest tunnel is 6.574 km. In this section 118 nos. of bridges with total length of 14.22 km (10.01%) and the length of longest bridge is 1355 m on Chenab river which is world's highest single largest arch span railway bridge. Road Header Technology for accelerated underground construction has therefore been incorporated especially for long tunnels (> 5.0 km) keeping in view the nature of geological setting existing in project area.

Jammu-Udhampur Rail Link (53.4 km) which has completed and made operational recently, forms a part of the prestigious and the most challenging project. The alignment traverses along the river Tawi on left bank and crosses over to the right bank at Manwal. Track traverses the domain of Shiwalik ranges of young Himalayas which is highly undulating and difficult hilly terrain. Construction of railway line involved 85.22 lac cum of earthwork and rock cutting; 21 tunnels with total length of 10.680 km, longest tunnel being



Geological cross section across the most critical location (fig 1)

2.445 km. and 158 bridges with spans up to 102 m (in pre-stressed concrete) and 154 m (in steel) and pier heights up to 68 m above river bed. Indian Railways, have conquered the mighty and unpredictable Himalayas on JURL with Broad Gauge line. Inadequate knowledge of strata in Himalayas makes tunneling an extremely complex, arduous, hazardous and painfully slow work.. Certain problems were also faced while implementing this project

2.6.1.Change of Alignment. Tunnel No. 10-E, F is in close proximity of Dhar-Udhampur Road in some stretches. The alignment in this stretch passes across the hill with lateral ledge of about 20 mtrs only on the river side. When the work was progressing in this stretch, some movement of ground was noticed on the road side hill slope and the work had to be suspended. The detailed geo-technical investigations in this stretch were carried out by boring 5 bore holes on the alignment. The bore holes showed that the over burden in this reach of the alignment consisted of loose boulders/debris of about 10-12 mtrs thickness. Luckily the hard rocky strata was sloping steeply towards river Tawi. The geological cross section across the most critical location is shown in the Fig 1. It was decided to change the alignment towards the up hill side by about 21 mtrs which ensured safe tunneling. The tunnel was in 5˚ curve for some length. The change in alignment was adjusted with the help of a compound curve. With this change in the alignment, tunneling could be completed without much problems. The tunnel has since been made through.

2.6.2 Seepage of Water During tunneling, heavy seepage of water was encountered in some patches in tunnel No. 8 and 10-A. The hill top at these locations was surveyed. It was found that the hills have small nallahs flowing across the alignment in these locations and there were some cracks in the bed of nallah. The diversion of nallahs was not feasible. It was decided to lay a thick layer of about 300 mm thick mass concrete well vibrated in about 50 m length, 25m on either side of the tunnel alignment. Another source of water seepage was infiltration water which was controlled by contact and pressure grouting. This resulted in reducing the seepage considerably and enabled boring of tunnel with least problems.

2.7. Road Tunnels

Road tunnel projects were also executed in different parts of the country. The details of some of the projects already constructed and under construction are indicated in the Table 3.

ROAD TUNNELS (Table 3)

Tunnel	Length (m)	State	Notes	Remarks
Rohtang	8900	HP	Under the 3978m high Rohtang pass on Manali Leh road	planned construction not started
Banihal	2576	JK	Jammu-Kashmir road 2209 m above sea level	
Jawahar	2500	JK	Srinagar-Jammu	
Kamshet-1	1843	MH	Mumbai-Pune expressway 2 tubes, 3 lanes each	
Bhatan	1658	MH	Mumbai-Pune expressway 2 tubes	
Gokhale Nagar	1000	MH		under construction
Khambatki Ghat	890	MH		under construction
Madap	646	MH	Mumbai-Pune expressway 2 tubes	
Khamshet2	359	MH	Mumbai-Pune expressway 2 tubes	
Khandala	330	MH	Mumbai-Pune expressway	

3. TUNNELLING PROBLEMS

3.1.Difficult Terrain & Inadequate Investigations

Almost every aspect of a tunnelling project, from its conception to commissioning, is influenced by the geology of the area. Reliability of the predicted geology, therefore, plays an important role in the success of the project. Inadequate geological investigation and poor anticipation of the nature and the magnitude of problems result in delays and higher cost of construction. Inadequate investigations need not necessarily be due to an inadequate effort by the geologist but it could also be attributed to financial, technical and site constraints etc . At many places, such as the Himalaya, the terrain does not permit desired number of boreholes upto the tunnel grade.

The nature of major construction problems which have been experienced in the past due to inadequate investigations are :

i) Buckling of steel ribs requiring rectification under squeezing ground conditions in lower Himalaya.
ii) Roof falls and chimney formations
iii) Water ingress(Chhibro-Khodri tunnel)
iv) Methane explosion (Giri-Bata tunnel, Loktak tunnel)
v) Running ground conditions

3.2.Deficiencies in Contracting Practices

For successful and timely completion of a tunnel project, correct contracting practices are very important. Essential contracting practices include all operations and procedures involved from fixing up an agency for execution of the work, getting a contract agreement signed and effective follow up and monitoring the progress of works till completion of the job.

Practically, all the tunnelling projects in the country are executed through contractors only and it has been experienced that there are invariably time and/or cost overruns on almost every such project due, among other things, to deficiencies in the contracting practices which is generally found to be indifferent to the project needs.

3.3.Inadequate Finances

It is often seen that finances for the tunnelling projects if not provided in time are leading to delays in construction of tunnels.

3.4.Delay in Decision Making

Large delays in decision making often result in delaying the completion of the projects. The case of Kadabagatti tunnel in Karnataka may be cited here. After a collapse in the tunnel, the work was held up for 7 years for want of a decision while several alternatives for rectification of the collapsed zone were being examined and discussed. However, once the decision was taken, the rectification was completed within a couple of months.

3.5. Factors responsible for tunnelling problems

The following are some important attributes which in combination adversely influence, one way or other, speed of tunnelling on the project sites particularly in Himalayan region.

3.5.1 Geological complexities. The difficulties during tunnelling posed by the geological features like thrust zones, shear zones, folded rock sequence, in-situ stresses, rock cover, ingress of water, geothermal gradient, ingress of gases etc. have been experienced on different project sites in Himalayan region.

3.5.1.1 Thrust Zones. These are the major tectonic features, having a strike length of more than 100 km and affected zone of more than 100m, characterized by highly deformed, water charged, crushed, brecciated, pulverised rock mass sandwiched between two undeformed litho tectonic blocks. The rock mass conditions within the thrust zones usually pose multiple problems while driving tunnels through these sections. During construction of head race tunnels in Yamuna stage-I Hydropower project (240 MW +120 MW) and Maneri Bhali stage-II Hydro power project (304 MW) in Uttarakhand such thrust zones were intercepted.

The Yamuna stage-II Hydropower project in Dehradun District, the Chhibro - Khodri portion of the head race tunnel (7m dia) was the most problematic zone, as it crossed two thrust zones at a close distance – Krol thrust between Mandhalis and Subathus and Nahan thrust (MBT) between Subathus and Siwaliks. The tunnel alignment was given a Kink to cut short the poor reaches of these thrust zones, but while driving actual tunnel these two thrusts were found to have been displaced by oblique faults repeating the Subathus thrice at tunnel grade. The tunnelling problems were related to extremely poor/crushed rock mass having low stand up time, high closure rate of the order of 10-150mm leading to distress of steel support and very high rock load. The difficult rock mass conditions were encountered between RD 3234m and 3334 m from Khodri end and was successfully tackled by trifurcating the tunnels of 4.2m dia each and excavating by multiple drifting methods and providing massive and heavy steel support with cover plates. However, it took nearly 7 years for construction of these trifurcated tunnels through unreliable, poor rock mass of thrust zone. In this reach, flexible lining was provided to accommodate about 50cm of adjustment in 100 years period. For monitoring, instrumentation was carried out in a special gallery constructed parallel to this reach.

In Maneri Bhali stage-II Hydropower project in Uttarkashi District, the head race tunnel (6.8m dia) section from Dharasu end intercepted Srinagar Thrust Zone at RD + 1870m onwards for about 200m, where heavy ingress of water was recorded. The rocks were highly pulverised and sheared. Here, circular section was provided instead of horseshoe section.

3.5.1.2 Shear zones Shear zones are characterised by highly deformed, sheared, water charged, poor rock mass conditions. These are minor tectonic features and usually have affected zone of less than 10m thickness. Serious tunneling problems have been experienced when the rockmass is affected by multiple shear zones. The problems are mostly related to loose fall, chimney formation, squeezing/heaving and collapses due to less standup time of rock mass of class VI and beyond Class VI (Q=0.01, RMR <20). Such situations are very common and generally encountered while driving tunnels in Himalayan region, for example, in Tehri Dam Project, Maneri Bhali Hydel Scheme Stage-I and II, Vishnuprayag Hydel Scheme, Koteshwar Dam Project, Nathpa Jhakri Hydro electric project, Ranganadi Hydel Project, Loktak Hydel Project, Tala Hydro electric project (Bhutan) etc. In these adverse tectonised zones the tunnels have been driven with utmost care by fore poling, multiple drifting, and controlled blasting followed by instant rock bolting, at times, by self driving anchors (SDA), reinforced shotcreting (using steel fibrer) and provision of drainage holes. Sometimes, steel rib supports at very close interval have also been provided as additional measures.

3.5.1.3 Folded rock sequence In Himalayas, rock sequences are folded and refolded, regionally and locally, due to polyphase deformations. The rocks are tightly folded due to high compression in the close vicinity of major tectonic features like thrusts. The rock mass present at the closures of synclinal and anticlinal structure behave differently when tunnels are driven through them. In anticlines the rock mass is highly fragmented/jointed at the closure and structurally controlled failures are anticipated at the crown of the tunnels, whereas in the synclinal troughs the rock mass is mostly water charged and at times act as huge water aquifers. The fold axes are usually traversed by numerous shear zones and present difficult ground conditions for tunnelling due to extremely poor rockmass. In Maneri Bhali stage-II Hydel project in Uttaranchal, during tunneling for HRT through the folded sequence heavy ingress of water (about 500 litres/second) was recorded in the synclinal trough and frequent structural wedge failures were experienced in the anticlinal structure. These problems adversely affected the tunneling schedule.

3.5.1.4 In-situ stresses In-situ stress in Himalayan region varies from place to place. A major uncertainty lies in forecasting the magnitude of the stresses in different sections of tunnel alignment. In view of the high rock cover and closer valley side associated with poly phase deformations in Himalayan region, it becomes sometimes necessary to measure in-situ stresses by means of hydraulic fracturing or flat jack test. The thrust zones, other tectonised zones, high cover reaches are the areas of high in-situ stresses and here the rock masses are heavily stressed. The phenomenon of squeezing and swelling, which cause an inward movement of the tunnel periphery due to dilation or distressing needs to be accounted to ensure safety of tunnel support. In several hydroelectric tunnels in Himalayas, squeezing phenomenon has been recorded when tunneling through difficult ground conditions specially where the in-situ state of stress is high and the tendency to heave and large displacements along periphery of tunnels have been found difficult to control like in Maneri Bhali stage I and II Hydel projects, Giri-Hydel tunnel, Chhibro Khodri tunnel, Ranganadi Hydel tunnel, Tala Hydel tunnel (Kali khola – Mirchingchu section) etc.

3.5.1.5 Rock cover The problems associated with the vertical and lateral rock cover are indeed very serious during tunnelling. The vertical rock cover above the tunnel periphery has direct influence on in situ stress (vertical) which in turn has significant bearing on the behaviour of rock mass around the opening.

3.5.1.6 Ingress of water Tunnelling through rock mass which is highly charged with ground water faces major problems like :

• Heavy ingress of water in tunnel hampers the construction activities inside.

• The saturated rock mass looses its strength as the shear strength (cohesion and friction) gets reduced due to lubrication, and failure of rock mass occurs from the crown and above spring level. Virtually it is flowing ground condition.

• The high pore water pressure behind the tunnel periphery adversely affects the support system provided leading to distress.

• Installation of rock bolts and reinforced shotcreting becomes an uphill task.

In Maneri Bhali stage-I Hydel project in Uttaranchal, the head race tunnel was driven through metabasic (60%) and quarzite (40%) occurring as synformal structure. At the core of synform, heavy ingress of water 2500-10,000 lit/minute was encountered between RD 541m and 549m resulting into flowing ground conditions and large collapses. This compelled for local diversion of the tunnel and further tunnelling was continued with elaborate drainage and grouting arrangements. Similar conditions were encountered during tunnelling in Maneri-Bhali stage-II Hydroelectric Project in Uttaranchal and other projects like Dulhasti Hydel project (J&K), Loktak Hydel Project (Manipur), Rangnadi Hydel Project (Arunchal Pradesh) etc. in Himalayan region.

3.5.1.7 Geothermal gradient The occurrence of hot water springs and high geothermal gradient is mostly associated with the Higher Himalaya which is marked by young granitic intrusions and deep seated faults. When deeper geothermal sources/aquifers are connected with the avenues like faults, shears and joints, the hot water oozes out in the form of hot springs. Tunnelling through hot water or high geothermal zones is very difficult due to deteriorations in working conditions because of high temperature and humidity. The chemicals present in hot water have corrosive effect on concrete lining. In Nathpa-Jhakri Hydel Project in Himalachal Pradesh, zones of hot water springs were encountered during tunnelling for 27.4 km long, circular (10.15m dia) head race tunnel. In the HRT, downstream of Wadhal Junction, hot water (54° C) was encountered between RD 16950m and 17047m with a discharge of 60 lit/sec. The high temperature inside the tunnel was brought down by mechanical ventilation and sprinkling cold water and placing ice blocks near the working face. Similar conditions are anticipated in the proposed Hydel projects located in the Higher Himalaya in Uttaranchal.

3.5.1.8 Ingress of gases. In some of the hydro projects in Himalaya like Ranganadi Hydel Project (405 MW) in Arunachal Pradesh and Loktak Hydel project (105 MW) in Manipur high inflammable gas methane was encountered during tunnelling for head race tunnels. In Loktak project the loss of human lives was reported due to the inflammable gases. To cope up with the adverse conditions special flameproof equipments were used.

3.5.1.9.High level of seismicity. From the tectonic model of Himalaya discussed above, it is clear that Himalaya is in a state of persistent compression due to continuing northward movement of Indian plate towards the Asian plate and there is contemporary crustal adjustments which is evident from recurrent seismicity. Hence, the rate of convergence between the Indian plate and Eurasian plate has a direct bearing on the seismicity in Himalayan region. The seismically sensitive Himalayan belt has been witnessing earthquakes of different magnitudes and intensities. Some of the catastrophic earthquakes like the Great Assam Earthquake (1887), Kangra Earthquake (1905), Nepal-Bihar Earthquake (1934) and Assam Earthquake (1950) find special mention in the scientific records as these earthquakes were of 8+ magnitude and had caused several trails of destruction. Based on the seismic history of the entire Himalayan belt, this region has been classified into zone IV and Zone V of the Seismic Zoning Map of India published by Bureau of Indian Standards. For the engineering structures in the high seismic zones, the main concern lies with the safely of the structures in the event of any seismic activity.

3.5.1.10 Difficult terrain conditions The rugged terrains of Himalayan region which are characterized by high mountains, deep gorges, undulating slopes, steep slopes, overburden slopes, bad land and mass wasting activities pose various problems while accommodating the project features as per the proposed layout. In case of run of the river schemes, the main problem lies with the adjustment of tunnel alignments, which run for kilometers, with the topographic variations; and there is always a possibility of encountering situations when the tunnel either passes through very high rock cover (more than 1000m) or very low cover reach (3-4m) and even at times get day lighted. All these problems require corrections in design decisions.

3.5.2. Design related issues. The orientation of the tunnel or cavern plays a vital role in deciding the support requirement as well as the excavation sequence. In ideal condition, orientation of the tunnel or cavern should be such that the strike of foliations/bedding, joints and other discontinuities should be across the axis of the tunnel. The worst case is noticed where the strike of foliation/bedding is parallel to the axis of the tunnel which resulted into excessive deformations at the crown level and one wall. In Tehri Dam Project, the orientation of penstock assembly chamber and butterfly valve chamber is parallel to the strike of the foliations which led to instability in the rock pillar between these two openings. The problem was further aggravated by simultaneous excavation of these chambers

3.5.3. Construction methodology. The tunnelling activity in various hydroelectric projects in Himalayas are beset by diverse geological problems such as thrust zones, shear zones, folded rock sequence, in-situ stresses, rock cover, ingress of water, geothermal gradient, ingress of gases etc.

In view of huge tunnelling activity involved while exe-

TUNNEL EXCAVATION RATES ACHIEVED ON SOME INDIAN PROJECTS (Table 4)			
Project	Method of excavation	Average rate per face	Max rate per face
Pandoh Baggi tunnel	Full face		120m/month
Beas tunnels	Full face		3.46m/day
Uchari-Chibbro tunnel (Yamuna)	Full face	Face 1:37.4m/month Face 2:49m/month	81m/month 124m/month
Lakhwar Diversion Tunnels (Yamuna)	Full face	Tunnel1: 18m/month Tunnel2: 21m/month	23m/month 23m/month (supported) 45m/month (unsupported)
Tehri Tunnel 3	Heading Benching	30m/month (afer removal of bottlenecks) 73m/month	48m/month
Koyna Head race tunnel		104m/month	120m/month
Maalabar tunnel	Full face (TBM)	2.4m/hour	417m/month

cuting many proposed hydroelectric projects in Himalayan region where challenges are more, attempts are being made to induct modern techniques of engineering geological investigations in order to unravel geological complexities and adversities well in advance, so that geological surprises are minimized during construction. Besides, numerical modelling for design, fast tunnelling technology using Tunnel Boring Machine are being considered to reduce time and cost over run and ensure safety and stability of the structures.

Although tunnel construction in India has gained lot of momentum and as a result there has been considerable build-up of expertise in this field, yet our tunnelling methods and techniques and equipment deployed continue to be rather old in many projects. As a result, the progress rates generally achieved on tunnels for water resources are extremely low-in the range of 20 to 50 m/month (Table 4). In situations where problematic strata was met with, speed of tunnel driving was further reduced.

In case of mining projects, which involve large amount of underground excavation for drivages (drifts), we have been relatively more successful with regard to introduction of modern tunnelling technology. In connection with ambitious targets laid for increase in coal production, rapid strides were made in mechanization of tunnel driving. For the first time Tunnelling machines-Road Headers were introduced during 1970s for drift driving through coal. In 1979, there were 44 Road Header Machines in use in Indian Coal Mines.

Compared with the great advances made in methodology for tunnelling all around the globe, it is obvious that we have still a long way to go to catch up with modern tunnel construction technologies. With new tunnelling techniques, extensive developments have taken place in the field of special excavation equipment - hydraulic jumboos, Tunnel Borers, Road Headers, explosives, methods of ground stabilization, methods for rock support, special equipment for concrete lining, which enable realization of tunnel construction at rates hitherto unimaginable.

3.5.4.Non induction of modern tunnelling equipment

There is validity in the point made in the past that use of high technology in tunnelling entails high costs, which the job owner should be prepared to bear. The use of such equipment has been possible where high rates have been allowed for the tunnelling work compared to what are normally allowed for such jobs, using conventional methods. In case of use of TBM for tunnel for water supply, this method was adopted due to requirement of contractor indemnifying owner against any possible damage to buildings at surface due to tunnel construction. Further use of TBM was facilitated due to owner giving substantial funds for purchase of TBM. The ultimate justification for incurring high cost on tunnel construction is the promise of realization of early benefits from the scheme. This issue is linked with the wider question of finding a rational viability criteria for acceptance of projects executed at higher cost with imported `know-how' compared to those built with indigenous resources. With the new policy of privatization i.e. private sector participation in power generation, higher costs has to be accepted to induce higher foreign investment in this sector. For this we have to evolve a criteria for allowing higher initial cost on execution of works. Obviously, any such criteria would have to simultaneously ensure time bound execution of jobs and early fruition of planned benefits.

While cost of modern equipment is a major inhibiting factor, the experience has shown that this is not the sole reason for our not keeping pace with the modern technology. Our construction agencies do not always find it easy to use new equipment and methods. A case in point is use of such equipment at Chamera Project, where most of our well known construction firms have participated for its construction. Although, the project had provided a three boom hydraulic jumboos for tunnel excavation, in most situations, work was carried out using only two booms. Another example which is generally true of all projects, is contractors' reluctance to go for wet shotcreting despite its known advantages.

4.FUTURE SCENARIO FOR TUNNELLING

4.1.Hydroelectric projects

For a fast developing country like India, a need has been felt to enhance the power generation, a basic necessity for any developmental activity. Existing electrical power being considered insufficient for the requirement of the country, it is now envisaged to provide " Power for all by 2012" and big plans to achieve this target are on the anvil. Hydro power addition is expected to play an important role in this vision. Not only in 11th five year plan but also in the 12th five year plan ending March 2017, hydro power development has been emphasized. It is proposed to add about 16500 MW hydropower by end of 11th plan and 30000 MW by end of 12th plan and such development have opened avenues for construction of tunnels, under ground caverns and other connected infra structure on a much larger scale. Considerable activities in the field of tunnelling are therefore in progress or envisaged for the execution of water resources projects for irrigation, hydropower generation, building of roads in mountainous area, subsurface excavation for underground railway and for mining purposes. With the growing need to accelerate the tempo of water resources and hydropower development, new projects are being taken up, which involve construction of more than 1000 km length of tunnels, practically in every type of strata and sizes varying from 2.5m dia to 14 m dia besides underground excavation of caverns for the power houses. These projects are planned to be taken-up on priority for completion by end of 2012. A brief detail of HRT and TRT which are proposed to be taken up for construction in different states of India are in indicated in the Table 5.

It is also planned to develop 31,000 MW in the 13th Plan ending 2022 and remaining about 36,500 MW by end of 14th Plan ending 2027. All these developments would provide scope for tunnel construction in a big way.

4.2.Metro and Rail net work

4.2.1. Metro network. For extension of rail and metro network, Indian Railways and concerned Metro organizations have undertaken a number of projects which involve construction of tunnels. Details of tunneling for the extension of Metro Rail Network in different Metro cities in India which are planned to be undertaken in near future are indicated in the Table 6.

Metro work is also contempleted in other cities namely Hyderabad, Pune, Chandigarh, Kanpur, Lucknow etc.

4.2.2 Rail Network. For Jammu-Udhampur- Srinagar Baramulla Rail Link, between Katra-Quazigund section (142 km), there are 42 nos. of tunnels with total length of tunnels 107.96 km are to be executed in short span of five year period

METRO NETWORKS (Table 6)

Project	Length of tunnelling (km)	Remarks
Dehli metro		
Phase I	12.5	Completed (TBM + C&C)
Phase II	13.7	Planned by 2009
Phase III	6.0	Subsequent phase
Kolkatta metro		
E/W Line	9.3	DPR completed
Mumbai metro	32	DPR completed - Planned in 3 phases; Phase 1 includes 12 km of tunnelling
Bangalore metro	6.7	DPR completed

DETAIL OF HRT AND TRT PROPOSED IN DIFFERENT STATES OF INDIA (Table 5)

State	N° of schemes	HRT	TRT
Arunachal Pradesh	40	185 km; 2.4-10.5 m dia	16 km; 3.7-10.5 m dia
HimachalPradesh	15	138 km; 2.6-9.45 m dia	3.7 km; 2.6-9.45 m dia
Jammu & Kashmir	6	81 km; 3-12 m dia	1.5 km; 10-14 m dia
Kamataka	5	31 km; 6.5-8.3 m dia	11 km; 5-9 m dia
Kerala	2	18 km; 3-3.5 m dia	-
Manipur	3	29 km; 3.5-7.5 m dia	-
Meghalaya	11	43 km; 2.8-4.5 m dia	8 km; 3.-4.75 m dia
Mizoram	3	72 km; 3.5-9.5 m dia	-
Nagaland	1	4 km; 5 m dia	-
Orissa	2	17 km; 6.7-8.5 m dia	-
Sikkim	10	63 km; 3.3-6 m dia	4 km; 3.3-6 m dia
Uttarakhand	33	74 km; 2.5-8.35 m dia	10km; 2.5-12 m dia
TOTAL		855 km; 2.4-12 m dia	54 km; 2.5-12 m dia

4.3 Road Tunnels

4.3.1 Rohtang Tunnel Project The work on Rs 17 billion Rohtang Tunnel project, aimed to provide an all-weather alternative route to Leh-Ladakh region, besides Himachal's snow-bound tribal district of Lahaul and Spiti, will commence this year-end. Because of heavy snow at higher reaches of Rohtang pass during winter, the road connectivity for Lahaul and Spiti and Leh from Himachal Pradesh remains disrupted for almost four to five months. The snowfall is heaviest at the 3980 m-high Rohtang Pass. This tunnel will be built below the pass so that it avoids the heavy snow and provides all weather road, besides reducing the distance by 44 kilometre. The BRO has planned to use latest tunnel boring machines and engage best companies of the world for the tunnel work. The tunnel's north and south portals are likely to be at 3055 m and 3080 m altitude above sea level. The north portal will be above the snow line having a round the year glacial snow accumulation. The tunnel alignment marks a very high overburden of about 1800 m with more than 60 degrees of steep ground slope along the valleys. The tunnel is proposed to be constructed as a 10 metre diameter closed tube, portal to portal. The size of the overburden means there is no potential for any ventilation shaft and the latest technologies for construction, ventilation, lighting and safety will be required. The 8.8 km-long tunnel located through the Pir Panjal mountain range in the higher Himalayas. The tunnel is likely to be completed in 2014.

4.3.2 Three Tunnels to ease Aizwal Traffic. Mizoram will build three tunnels in Aizwal next year to ease traffic congestions in the mountainous capital city. The work on the three tunnels is likely to begin shortly and to be completed in 30 months. The construction of the main tunnel 2.1 km long – is likely to cost Rs. One billion. The Geological Survey of India (GSI) and the Mizoram Government's Department of Geology and Mining jointly prepared the unique project for smooth flow of vehicular traffic. The necessary surveys, feasibility studies and geo-technical specifications for tunnelling in the city had already been conducted by a six-member team of experts comprising geologists and architects and technocrats etc.

4.4.Canal Tunnel

4.4.1 World's longest bored tunnel: Srisailam Left Bank Canal Tunnel Scheme. The much-delayed Srisailam Left Bank Canal Tunnel Scheme (SLBCTS) of Alimineti Madhava Reddy Project is finally becoming a reality which will be a big relief for people of Nalgonda, one of the poorest and most drought-prone districts of Andhra Pradesh. SLBCTS of Alimineti Madhava Reddy Project envisages carrying 113.28 cumec (4,000 cusecs) of water from Srisailam Reservoir to the plains of Nalgonda through two tunnels of total length of 50.75 km. comprising of Tunnel-1 having a length of 43.5 km with 9.2 m dia. crossing the Amrabad plateau with a maximum cover of about 500 m opens into Dindi valley and Tunnel-2 having a length of 7.25 km with 9 m dia for crossing the hill range between Dindi and Peddavagu valleys with a maximum cover of 350 m.

However, one of the most sensitive issues of this project is that the Tunnel-1 would have to cross wild life sanctuary and Rajiv Gandhi Tiger Reserve. Therefore, it has been decided to use the TBM for tunnelling.

The tunnel is being bored below the Srisailam Reservoir. It is a big challenge to avoid flooding of the tunnel during construction and also to ventilate the 22-km long tunnel. Removal of cut rock from the tunnel face continuously in large volumes and at high speed is also a challenge as the TBMs are expected to bore a combined length of over 1 km a month.

In view of more no of tunnel projects are contemplated in the different States in India for the different sectors in near future, there is a possibility that 1000 km length of tunnels as mentioned above may even be exceeded.

5.STRATEGY FOR FUTURE TASKS IN TUNNEL CONSTRUCTION

Tunnels are generally located in difficult environments – in rocks of various types or softer media – and the alignment may traverse zones of various complexities. It is important that such engineering projects are properly conceptualized and planned systematically to ensure smooth implementation. Since one of the fundamental measures to ensure fast track construction is the choice of a safe alignment, careful consideration is required to be given to avoid all types of hazards as far as possible and these include treacherous soil conditions, subterranean water streams, strata bearing hazardous gases such as methane, etc. In addition, it is also to be ensured that adequate investigations have been done, proper selection of tunnelling equipment has been made, appropriate contracting practices are available, environment and forest clearances have been taken, competent construction agencies are available, social issues have been taken care of and similar other issues are duly considered. If these are not properly accounted, the implementation will not be smooth and many problems are likely to arise from various affected agencies during the construction leading to delay and cost over-runs.

5.1Tunnel construction and selection of equipment

Keeping in view that number of tunnels would be needed for overall development in hydropower, road, railway and metro sectors, it is planned to use mechanized methods and latest tunnelling techniques which would help in speeding up the work with much higher productivities as compared to manual working besides facilitating overall quality and safety. For drilling and blasting, instead of the earlier employed jack hammers and pusher legs, boomers or drilling jumbos would be used to the extent possible. For large tunnels two or three boom rigs can be used and holes can be drilled for greater depths, with much better accuracy and with much faster rates. The boomers also come with additional buckets, which can be raised and lowered to enable other activities to go on in parallel, such as shotcreting, rock bolting, installation of steel supports etc. Boltec types of machines which are available for installing long rock bolts with good accuracy and faster speeds, even in locations difficult to access are also to be considered. Shotcreting machines with robot arm which are available for fast spraying of the shotcrete at various heights and in difficult locations, with very minimal ill-effect to the operator are also programmed to be used.

5.2.Survey and investigations

Another grey area, which has long been identified as being a major factor responsible for delays in tunnel construction, is lack of adequate investigations. Some of the important parameters which govern the choice of an appropriate method for construction of a tunnel are the topology of the site and the geological / geotechnical conditions. It is important to have a very good assessment of these conditions before hand to optimize the construction activities. A detailed topographic survey would be required to finalize the alignment of the tunnel and location of adits, if any. Locations of intermediate significant features such as streams or nallas, visible fault zones etc. need also be identified. For tunnels of long lengths or going through a large spread of land, faster methods of survey than the traditional Total Station-based surveys would be resorted to. The modern tools of surveys such as Aerial surveys, photo-grammetry-based surveys, GPS based systems which have very good accuracy are proposed to be used. This would facilitate the rapid surveying of large areas of land to plot alignments of the tunnels and the adits as well as locate all intermediate significant features within a short time.

It is sometimes very difficult to locate shear zones or fault zones or other significant features which have a large impact on the tunnel construction by the conventional exploratory methods. Though bore hole data, the traditional method of geological exploration provides useful information, it may not be sufficient for overall assessment of the geological features along the tunnel alignment. Exploration by drifting is a classical method of investigation and gives reliable information for large projects. Since the overburden depths and rock cover over the tunnels are very large, drilling deep bore holes from ground level to intercept the tunnel alignment is quite expensive as well as time consuming. This would limit the number of bore holes which can be drilled along the tunnel alignment to get adequate details. Further, many technical problems arise while drilling deep holes, requiring extra time and cost. Also the cores which are recovered from these bore holes pertain only to a single location along the tunnel alignment and would not be representative of the strata prevailing at various locations along the tunnel alignment. Exploration by drifting which gives reliable information is to be considered.

Nowadays many advance methods of investigation are available. Geophysical methods of investigation are now well developed and are available for predicting underground conditions in advance and are proposed to be used in future in addition to bore hole investigation methodology. Some of the methods involved are electrical resistivity tests, seismic reflection and refraction techniques, geophysical tomography techniques, bore hole logging, cross hole seismic tomography, geo radars, etc. Other modern techniques include assessment of in-situ stresses by hydraulic fracturing techniques, etc. These methods would be able to give data on underground layers with investigation from the ground level itself. During tunnelling itself probe holes would be required to be drilled on a continuous basis to understand the type of strata in advance. Once the locations of significant features are identified by various macro investigations, more detailed investigations can be conducted around these locations to get more details.

The actual occurrence of geological surprises can many times lead to cessation of activities. Sudden collapses or rushing in of loose materials, formation of chimneys, sudden large ingress of water etc. are some of the common surprises which are encountered while tunnelling. The ability to anticipate and avoid "geological surprises" will dictate the success of the tunnelling project. It is therefore necessary to move with time and use new techniques of investigations to get the maximum possible reliable and dependable data. Since surprises all together can not be stopped, the construction organization should also have capabilities to properly address such surprises if they are encountered and put in place rapidly all required mitigative measures.

5.3.Contracting practices

Most of the hydropower projects involves construction of tunnels. For successful and timely completion of a tunnel project, correct contracting practices are very important and essential. Contracting practices include all operations and procedures involved for fixing up the agency for execution of the work, getting a contract agreement signed and effective follow-up and monitoring the progress of works till completion of job. Deficiency in the contracting practices is likely to lead to time and /or cost over runs. Important deficiencies affecting hydropower projects in India are:
- Processes for selection of contractor and consultants;
- Deficiencies in Contract documents;
- Deficiencies in Contract Administration;
- Shortcomings related to Valuation of changed conditions;

• Shortcomings related to Time Extensions;
• Shortcoming related to Dispute Resolution

Keeping in view the delay being caused in accelerated development of hydropower projects due to deficiencies in the contract document, an International Conclave on “Contract Management for Accelerated Development of Indian hydropower Projects” was organized on 16th November 2007 at New Delhi. Based on one of the recommendations of this Conclave, a high level Task Force has been constituted by Govt. of India for formulation of a set of following Model Contract Documents which could be adopted uniformly by project developers. These documents will serve as guidelines for adoption by all associated agencies:

i. Standard Bidding Document Guidelines
ii. Works Manual Guidelines
iii. Arbitration Manual Guidelines
iv. Schedule of Rates and Construction Cost Indices Guidelines
v Guidelines for grading of construction agencies

5.4.Environment and forest clearances

In some of the projects, bids are invited before obtaining the Environment and Forest Clearances. Even the Letter of Award of Works is issued incorporating the completion period say 45 - 60 months stating that the period of completion starts from the day of receipt of the letter of award by the contractor. This being the situation, the successful bidder starts mobilization of machineries and manpower immediately. When he lands on the site of work, he is informed that the forest clearance for the project is yet to be obtained and the same will be done within a week or so. However, with the revised procedures of Ministry of Environment and Forests, “Single Window” clearance has been adopted wherein cases related to environment and forest clearances are to be processed and finalized simultaneously

5.5.Resettlement and rehabilitation

Hydropower projects are located mostly in remote and hilly terrain, the submergence involves flora and fauna in addition to affecting socially and economically backward people living in such areas. The resettlement & rehabilitation (R&R) off these families is undoubtedly a very delicate and sensitive issue. By and large people have a deep attachment to their land, tradition, culture and way of life and do not want to part with them. However, the water resources planners have been aware of these issues and various measures have been taken for R&R of the affected people, even in the earlier river valley projects.

Initially, the compensation was paid to the displaced persons mainly under the Land Acquisition Act of 1894 since the formal rehabilitation guidelines did not exist. Efforts made for resettlement of the displaced persons varied from state to state and project to project. There were no clear-cut guidelines for defining the project affected people (PAPs). Later, some of the State Governments started formulating policies for resettlement of PAPs within their jurisdiction.

Considering the need for broad guidelines on R&R of PAPs to help the State/Project authorities in formulating their policies, the Govt. of India have formulated the National Policy for R&R of persons affected by reservoir projects in 2003, recently superseded by the Policy of 2007. The objective of R&R is that the oustees should enjoy a better quality of life at the place of resettlement than that enjoyed by them at the original habitat. For this purpose, master plans should be drawn based on the State/Project R&R Policy. With the policy in place, it will help in proper R&R and it is expected that problem on this account shall get minimized.

5.6. Construction materials

Various materials involved in the construction of tunnels such as supporting systems (rock bolts, rock anchors, steel ribs etc.), grouting materials, concrete etc. should be procured well in time, as and when required and with appropriate quality. Testing of these materials in advance to ensure proper quality and suitability for the given local conditions is an important step. Adequate provisions should also be made to take care of special contingencies which may occur if geological surprises are encountered so that valuable time is not lost for lack of financial resources. Govt. of India has already set-up specialized testing facilities for this purpose for example CSMRS.

5.7.Financing

For large projects, it is important that financial closure be effected before commencement of the actual construction to ensure that proper cash flows are available at all times during the construction.

With more emphasis being laid on development of Infrastructure projects including tunnel projects, the Govt. of India is taking due care to ensure proper cash flow to the State funded projects for construction. The Govt. of India has liberalized the policy to encourage the private sector participation. As a result, large no. of investors are coming forward either individually/Joint venture with State govt. agencies for funding and development of projects. More over, Govt. of India has also set-up special agencies for project finances for accelerated development. The market conditions are favourable for funding of various projects. Presently, practically no project is suffering due to financial constraints.

5.8 Construction agencies

Construction Industry in India is growing at a faster pace. Keeping in view the execution of large no. of projects for accelerated development of tunnel projects, sufficient and competent agencies are not available in the country. To enable more construction agencies to enter in the field, Policies and procedures have been simplified by Govt. of India. With the change in policy and procedures, some international reputed companies have already started operation in India in recent past.

5.9.Technology

To further accelerate the progress of works, latest technology should be introduced for execution of the works. It is therefore necessary while formulating the contract documents, that the client should incorporate provision of the various latest equipments in the market to achieve faster progress of works. These equipments should be mentioned and should be made mandatory so that the contractor can take the same into account while working out his price bid. In the recent past, more and more construction agencies are using latest technology for accelerated development.

5.10 Documentation of experience on tunnelling

On some of the recent projects, we have in collaboration with foreign agencies introduced modern techniques and State-of-the Art equipment for construction of tunnels. On these projects, underground excavations have been carried out with ASTM technique using various kinds of rock support systems and deploying the most modern equipment which are available for Tunnelling, such as Road Headers, Tunnel Boring Machines, three boom hydraulic Jumbos etc.

The experience gained on such tunnelling projects is being documented and made available to engineers all over the country so that appropriate guidelines can be evolved for future tunnel jobs. Accordingly, CBIP has started bringing –out the special publications highlighting therein the history, experiences of the experts from concept to commissioning of some of the major water resources projects executed in the different regions so that the field engineers are benefitted and can plan and execute the future projects on time. Accordingly, special publications on the projects like Tehri Dam Project (1000 MW) ; Indira Sagar Project (1000 MW); Chamera Hydroelectric Project Stage II (300 MW) and Omkareshwar (520 MW) were brought-out by CBIP. It has also been planned to have the special publications on the projects like, Sardar Sarovar, (1450 MW), Nathpa Jhakri (1500 MW) and Tala Hydroelectric project (1020 MW) where innovative technology and construction methodologies have been used for the execution of these projects.

5.11. Mampower and training

Another area which is engaging attention of Govt. of India relates to imparting training to appropriate manpower for design, engineering, manufacturing, erection and commissioning of power projects. Various specialists such as underground surveyors, geologists, hydro-geologists, geotechnical specialists, blasting experts, drilling experts, grouting experts etc., are required to be employed for large tunnelling projects. Even though various types of experts may be employed on the job, the project manager and key staff should have good all-round exposure to the various disciplines involved, so that decisions can be taken quickly and various contingencies solved effectively. It is very essential for the technicians and labour to be properly briefed and trained in the use of modern equipment so as to ensure safe and smooth working. Training of workmen and technicians is very important while using advanced types of plant & machinery or construction techniques if full benefits are to be realized.

Keeping in view the huge programme of construction of tunnels in future, additional trained manpower is required in concerned field. The existing manpower also needs to be provided training in the use of new technologies, equipments, methodologies etc. The training needs to be imparted about the new techniques and construction practices in tunnelling at the grass root level - geologist in the field, engineer in the design office and construction engineer at the job. Design engineers should know the latest methods to classify and characterize the rock mass, to know the basis for design of rock bolting & other support systems, and the construction engineer to know as to how to carry out the construction operations in the field. Intensive training has to be imparted on the `basics' involved in all aspects, which alone would encourage wide spread use of new technology.

Keeping in view, the new requirement of training of the manpower, Govt. of India, State Govts. and the Industry has taken many initiatives. Developers and construction agencies are also be required to play an important role in training the required manpower.

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AUSTRALIA

The ATS is a technical society sponsored by Engineers Australia, the Australian Institute of Mining and Metallurgy and the Institute of Professional Engineers New Zealand.

• There are chapters in Auckland, Brisbane, Melbourne, Perth and Sydney.
• The Australian Shotcrete Society is a specialist interest group of the ATS.
• Current membership of the ATS stands at 638 individual members and 52 corporate members.
• The ATS publish a journal « ATS Journal » This journal reports on all major tunnelling and underground activities in Australasia.

Major events during 2007 included:
• Collaboration with WorkCover NSW in the publication of "NSW Code of Practice for Tunnels under Construction". This publication was also the basis for the Queensland Government publication "Tunnelling Code of Practice"
• Attendance at the World Tunnelling Congress in Prague.
• Short Course on "Tunnel Design & Construction", Brisbane in September. This event achieved 100% attendance capacity.
Seminar on the "New Metrorail City Project", Perth in September.
• ATS first publication "A history of the development of performance predictions for hard rock tunnel boring machines"
All chapters held a program of technical sessions during the year with Brisbane in particular having a very comprehensive series.
• Planning for our 13th Australian Tunnelling Conference to be held over 4-7 May 2008, commenced.

2007, has been predominantly occupied with the new publication, Australian Shotcrete Guidelines », or as the document will eventually be called - « Recommended Practice – Shotcreting in Australia ». Release is anticipated for early 2008 and we believe this Australian guide to be the most comprehensive in the field. The AuSS, has decided on Queenstown, N. Zealand for the next International Seminar on Shotcrete, in 2010. The society held a very successful seminar in Perth in May, which was well attended. It is proposed to hold a minimum of two seminars in the mining regions in 2008.

In Brisbane the major projects include the North South Bypass Tunnel, the Gold Coast Desalination Project, the Boggo Road Busway and the Airport Link Northern Busway making Brisbane the current tunnelling hot spot in Australia. This has seen a strong growth in the ATS membership in this area.

• Sydney similarly has some good activity with the Lane Cove Tunnel opening, the Epping to Chatswood Rail Link in commissioning phase and the City West Cable Tunnel and the Sydney Water Desalination Plant under construction. New rail projects include the North West Rail Link 15km tunnel while new road tunnels are proposed as part of the M4 East Extension, 5.5km tunnel and the F3-M2 Link with 8km of tunnel.

• The big event in Perth has been the opening of the MetroRail City Project with a 5% increase in passengers from the city tunnel section alone.

• The focus in Victoria is very much on water with some 12.5kms of sewer under construction for Melbourne Water and Yarra Valley Water on the North Sewer Project and the 6.5km 1.8m diameter tunnel for AGL Southern Hydro on the Bogong Power Development.

• Auckland projects include the Northern Gateway Alliance twin bore, the 3km long 3.7m diameter Hobson Bay Sewer and the 3km long 2.8m diameter segmentally lined Rosedale Outfall while down on the West Coast of the South Island there is the 2.1km Pike River Coal Mine Access Tunnel.

• For a full list of current and proposed projects we refer interested parties to the data base on our web site www.ats.org.au

AUSTRIA

The Austrian national committee of ITA participated the World Tunnel Congress 2007 in Prague with about 20 colleagues.
In 2007 again several conferences concerning tunneling were organized in Austria. The most important conferences were the conference "TUNNELLING IN AN INTERDISCIPLINARY STRESSFIELD" and the traditional "GEOMECHANICS COLLOQUIUM" both organized by the Austrian Society for Geomechanics.
About 900 participants from 23 countries followed the very interesting topics presented by na-tional and international speakers. Both conferences took place in Salzburg in October 2007.

• In 2008 the most important conferences in Austria concerning tunnelling will be the "Austrian tunnel day" on 9th of October as well as the traditional "Geomechanics colloquium" on 10th and 11th of October 2007 both taking place in Salzburg.

Connecting to the work of the WG19 – Conventional Tunnelling – Austria is working on a paper called "NATM – the Austrian way of conventional tunnelling" which shall be ready end of 2008. In 2009 Austria's Mining University of Leoben, chair of Subsurface Engineering and the Technical University of Graz, chair of rock mechanics and tunnelling are going to offer a jointly organized postgraduate course in NATM engineering. Informations to the course can be seen on the homepages of subsurface@mu-leoben.at and natm@tugraz.at.

During the year 2007 in Austria a various number of tunnelling projects – including extreme long ones – were started, were under construction or have reached the preliminary and tender design step. Starting with railway tunnels of ÖBB the biggest projects in Austria in 2007 were the following ones:

• Several lots of the LAINZER TUNNEL including cut and cover sections but also mined sections were under construction. The Lainzer Tunnel will connect the western with the eastern and the southern routes of the Austrian railway network. So after having the Lainzer Tunnel ready it will be possible to travel from Paris to Budapest via Vienna without any change of the train.

• Along the high speed railway route connecting Vienna and St. Pölten the tunnel projects PERSCHLINGTAL and WIENERWALD were under construction; the break through of the 11,5km long WIENERWALDTUNNEL was celebrated by the consortium PORR / BILFINGER / ZÜBLIN / HOCHTIEF / SWIETELSKY / JÄGER end of 2007. Tunneling shall be finished in 2009. Construction work at Tunnel chain of PERSCHLINGTAL is done by STRABAB.

• Looking at the so called "Südbahn" the preliminary design for the SEMMERING BASETUNNEL, a tunnel project with a length of about 20km, which will close the missing link along the high speed railway line between Vienna and Graz, was started with an environmental impact study in order to find the best alignment for the project. 13 different alignment alternatives were studied. The preliminary design procedure ending up in the approval for construction is foreseen to be ready end of 2009.

• The KORALMTUNNEL, consisting of two single tubes with a diameter of about 10m and a length of more than 30km each and cross passages every 500m will close the missing link of the railway line between Graz and Klagenfurt. While construction work for the exploratory tunnels Leibenfeld and Mitterpichling has already been finished, tunneling at the exploratory lot of Paierdorf will last till about 2009.The main tunnel project has reached the tender design stage; construction work in the first lot of the main tunnel project should start end of 2008.

• In the western part of Austria, the UNTERINNTAL route in Tyrol, which is the northern access to the BRENNER BASE TUNNEL, the variety of chosen tunnel construction methods is very wide. BEG which is part of ÖBB, is responsible for realizing this project. The project UNTERINNTALBAHN which has a length of about 40 km consists of cut and cover sections and also mined tunnels. Following the very difficult alignment in this region in some parts of the route the use of compressed air had to be chosen. All at all there are 8 main lots. Lot H2-1 hase already been finished, for the lot H2-2 in 2007 the tender documents were prepared. PORR / BÖGL won the contract for the TBM lot H3-4; in lot H3-6 NATM is in use. Lot H4 is under construction by ALPINE / GPS; tunnelling work in lot H5 is almost ready but innerlining work is still under progress. Lot H6 has already been finished by STRABAG, in H7 tunneling work, done by STRABAG, HOCHTIEF, ZÜBLIN, was started by the use of compressed air. The contract in lot H8 was won by the same consortium STRABAG, HOCHTIEF, ZÜBLIN. The lot is constructed by the use of a shield TBM of HERRENKNECHT.

• In 2007 the preliminary design for the BRENNER BASETUNNEL – the worlds longest tunnel with a three tube tunnel system and a length of about 57km was optimized, the approval of the preliminary design of the main tunnel is expected for the end of 2008. Construction work for the exploratory lot Aicha – Mauls was already started in 2007.

Tunnelling for connecting the Arlberg motorway tunnel with the very old Arlberg railway tunnel – its name is Langener tunnel – by so called safety cross passages was continued in 2007.

• The biggest motorway tunnel projects in Austria were mainly ordered by ASFINAG. After the fire accidents in the Tauern- and the Mont Blanc Tunnel it was decided to raise up the safety level on all motorway routes in Austria. So in 2007 there were a lot of second tunnel tubes under design and/or construction. The main goal till 2020 is not to have any single tunnel tube left along the whole motorway net in Austria.

Starting in the eastern part of Austria the second tube of GANZSTEINTUNNEL, near Mürz-zuschlag, was under construction. Traffic jam problems along the "A10 Tauernautobahn" which are evident in every holiday season should turn to history after completion of the second tubes of KATSCHBERG- and TAUERNTUNNEL – both were under construction in 2007. In the western part of Austria the second tube of ROPPENER tunnel was under construction. The length of the this project is about 5 km and shall be finalized in 2010.

• Further more also complete new alignments for roads including huge tunnel projects were under construction in 2007. Some examples are 4 tunnels along the so called S35, which will raise up the safety level between Bruck and Graz. Further projects to be mentioned are the tunnel TRADENBERG and the tunnel GRÜNBURG in the eastern part of Austria and the ACHRAIN tunnel and the PFÄNDER tunnel in the western part of Austria. Construction for the PFÄNDERTUNNEL was started in 2006 and shall be finalized in 2012; the length of the whole project is about 6.7 km. The bypass tunnel for the city of HENNDORF near Salzburg, a tunnel project which has a length of about 3 km was started in 2006 and will be finalized in 2008.

• In Vienna, the main capital of Austria, the subway system is again growing a lot. In 2007 the metro sections of U2/1, U2/2 and U2/5 were under construction.

• In 2007 also huge hydro power plants using a lot of kilometers of underground facilities were under construction. Both LIMBERG and KOPS are situated in the western part of Austria.

BRAZIL

CBT is a committee of the Brazilian Society of Soil Mechanics and Geotechnical Engineering (ABMS). It is an open society based on membership. The board of directors is elected every two years. For the term 2007/2008, the board is composed by: Tarcisio Celestino (President), Hugo Rocha (Vice-President), Ricardo Telles (Secretary General), Flávio Kuwajima (Treasurer) and Francisco Ribeiro Neto (Executive Secretary).

CBT continues the distribution worldwide of the book "Tunnelling in Brazil" (328 pages), which reports 120 cases-histories of tunnels for energy (dams and pipelines), transport (motorways, railways and metros), public utilities (water supply, sewage and cables) and undercrossings. The main objective of the book was to promote the use of the underground space towards the general public and decision makers in Brazil, as well the achievements of the Brazilian tunnelling community.

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CBT is preparing the 2nd Brazilian Congress on Tunnelling and Underground Works and also the South America Tunnelling Seminar SAT-2008, both to be held on 23-25 June 2008. It is the major event on tunnelling in all Latin America and it is expected participants from all countries. As the ITA Executive Council will also meet in Sao Paulo at the same time, it is planned a meeting among EC members and representatives of Latin-American ITA Member Nations.

In 2007, CBT started a series of seminar, held in different cities of Brazil, in order to divulge themes related to tunnel engineering and incentive professionals to this field. Besides Sao Paulo, Salvador and Belo Horizonte hosted the CBT Seminar in 2007.

In 2007, CBT continued its task to promote mirror ITA WGs in Brazil. Seven Brazilian mirror groups have been quite active (WG-03, WG-05, WG-06, WG-12, WG-15, WG-18 and WG-19). The Brazilian mirror WG-03 has translated the ITIG code into Brazilian Portuguese. Also, the CBT has given full support for the activities of Tarcisio Celestino as animateur of the ITA WG-12 on Shotcrete, and to Andre Assis as chairman of the ITA Committee on Education and Training (ITA-CET)..

The year of 2007 continued to be very busy for underground works in Brazil, especially those related to hydroelectric power plants, with underground hydraulic schemes. It also is important to mention that Petrobras (The Brazilian Petroleum Company) has definitively moved towards tunnelling as a solution to underpass environmental protection areas, and bit the first TBM for rock to be used in Brazil (a shaft-tunnel solution, 6 km long, to underpass the rain forest in Sao Paulo state). Underground mass transit systems have continued in major cities such as Brasilia, Rio de Janeiro and Sao Paulo. But certainly, the major news in 2007 was the accident on Pinheiros Station of Line 4 of the Sao Paulo Metro. Seven people died during the collapse and an investigation has been called by the government and public attorney. The official report should be published by the mid of 2008. Despite the negative impact of the collapse, the society continued to support underground mass transit systems as solution for the transit problems in Sao Paulo, and the Metro company announced for 2008 the completion od Line 5 and a completely new line (Line 6), 13 km long..

BULGARIA

GEOTECHMIN LTD is the only official Bulgarian member of ITA. It is a prospering private company, constantly growing and developing. GEOTECHMIN LTD is on the way to asserting itself one of the most specialized in underground construction Bulgarian companies. GEOTECHMIN LTD is taking active part in the organization of all kinds of events (international meetings, trainings, experience exchange, etc) in the sphere of underground construction design and engineering activities, thus working on unifying companies and institutions to represent Bulgaria at a better level. The most important event's preparation was the International Scientific and Technical Conference "Tunnel and Metro Construction"10 Years from the First Line of the Sofia Metro, which took place end of January 2008 and ITA's Secretary General Mr. Claude Berenguier was present to help us promote the idea of making an organization at national level to participate in ITA as a member nation.

In Republic of Bulgaria there aren't structures of national working groups such as the rest of the official ITA members because of the relatively limited volume of underground construction. In the capital of Bulgaria there are plans for significant underground developments in the next several decades

GEOTECHMIN LTD, as main subcontractor of Taisei Corporation, continues the design and construction works - part of Sofia Metro extension with a metro station (planned date for completion May 2008) and a tunnel section (connection between an existing facility and a newly constructed station, planned day for completion May 2008) .

GEOTECHMIN LTD performs construction of a tunnel with length 550 m in neohomogenous material with protective umbrella method „ Symmetrix T".

GEOTECHMIN LTD makes hydrotechnical tunnel for dewatering of mine Elazite, 2100 m long.

Other important projects in process of design and construction in Republic of Bulgaria:

- driving a tunnel of Ist Metrodiameter of Sofia subway by TBM is still in progress with expected completion date end of 2008 and operation implementation mid of 2009
- the construction of tunnels at water-power system "Tzankov kamak" continues
- the procedure for selecting a contractor for the implementation of the second Metrodiameter of Sofia subway (6.5 km) and Geotechmin Ltd is the only Bulgarian company which has submitted an independent offer.

- There are several plans for rehabilitation and renovation of a number of railroad tunnels built in the last several years.

In conclusion it can be stated that in 2007 there was a significant growth in the underground construction in Bulgaria and there are new projects underway.

CANADA

An annual general meeting is held once per year with the executive committee meeting via conference call at least four other times throughout the year. Local chapter meetings are held in each region an average of 6 times per year. TAC also holds a national conference every second year with the next conference scheduled for the October 27-28, Niagara Falls, Ontario.

TAC has also been selected to host the 2010 WTC in Vancouver, British Columbia. www.wtc2010.org and planning is well underway for this event. For additional information on TAC and current and upcoming activities please go to our website at www.tunnel-canada.ca. Tunnelling in Canada is undergoing a resurgence with numerous major projects entering the construction phase in 2008.

MAJOR TUNNELLING PROJECTS

Canada Line LRT, Vancouver, BC

• 14 km long alignment from airport to downtown - Bored Tunnel Sections will be 6.0m diameter

• Contractor : SNC Lavalin – SELI Joint Venture

Bathurst / Langstaff Sewer, York Region, ON

• 8.3 km of 3.3m diameter Bored Tunnel - Tunnels will be excavated by TBM. Bored tunnels excavated by 80%

• Contractor: McNally AECON Joint Venture

Seymour Capilano Twin Tunnels, Vancouver, BC

• 2 No. tunnels at 7.1 km each 3.8M Diameter - To be excavated by TBM. Bored tunnels completed.

• Contractor: Bilfinger Berger

19th Avenue Sewer, York Region, ON

• 4.2 km of 3.3m diameter Bored Tunnel - Tunnels will be excavated by TBM. Bored tunnel 80% complete.

• Contractor: McNally AECON Joint Venture

Sir Adam Beck Additional Diversion Project, Niagara Falls, ON

• 10 km of 14m diameter Bored Tunnel - Tunnels will be excavated by TBM. Bored tunnel 25% complete

• Contractor: Strabag

Ashlu Hydropwer Project, Squamish, BC

• 4.2 km of 4m diameter Bored Tunnel - Tunnels will be excavated by TBM

• Contractor: Frontier Kemper

North East Sanitary Sewer (Edmonton)

• Construction underway

South West Sanitary Sewer W12 (Edmonton)

• Construction underway

UPCOMING PROJECTS

SouthEast Collector Sewer, York Region, ON

• Construction tender in 2008

Vancouver LRT, Evergreen Line, BC

Kicking Horse Pass Tunnel, BC

Spadina Subway Extension, Toronto, ON

Ottawa LRT Tunnels, Ottawa, ON

All Five Regional Directors (British Columbia, Alberta, Prairies, Ontario and Quebec) have continued to notice an increase in the amount of work both ongoing and in the planning stages. The TAC/ACT is looking forward to continued growth in the tunnelling sector for several more years with large infrastructure projects in the major urban centers and continued development of Hydro Electric Power in British Columbia, Quebec and Newfoundland. This combined with the surging natural resources sectors and the push for further development of underground mines will ensure continued growth in the tunnelling industry in Canada.

CZECH REPUBLIC

The main activity of the ITA/AITES Czech Tunnelling Committee in 2007 was the organisation of the ITA/AITES WTC 2007, which was held in Prague on 5th – 10th May 2007. The CtuC again extends its thanks to all of those who contributed to the successful course of the Congress and all of the accompanying events. In 2007, the CtuC continued to publish « Tunel » magazine; in November, the election of the new Board for the 2008 – 2010 term took place.

The CTuC Board set the promotion of education as one of the CTuC priorities for 2007. For that reason, it started to prepare an excursion to tunnel constructions in Germany and Denmark, which should take place at the end of May 2008.

At the same time, the Board is collaborating with D2 Consult Prague on the preparation of a one-day seminar, which is the third in the series of seminars on the topic: "New Trends in Tunnel Design and Construction".

The seminar will take place on Monday 16th June 2008, under the title : "Long Transport-Related Tunnels – Mechanised Excavation by TBMs". Like in the past, foremost foreign experts will present their lectures in the seminar, in both Czech and/or English languages, with interpretation from one language into the other.

In 2007, national working groups continued to work within the framework of the CtuC organisation, i.e. the WG for conventional tunnelling and, first of all, the WG for shotcrete. This WG prepared the 3rd volume of CtuC documents : "Shotcrete for underground construction", which will be published for the use by the CtuC members in the 1st half of 2008.

Two new WGs were established. The WG which was established first is focused on the design and structural analysis of underground structures. Its aim is to become a platform where the exchange of opinions among persons involved in this area will take place. The objective of the establishment of the WG for waterproofing of structures is to allow more effective exchange of

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information about new materials and procedures.

The work on the currently largest tunnel construction project in the Czech Republic, the Blanka complex of tunnels, commenced in Prague. The project consists of a 6.4km long section of the City Circle Road, comprising twin-tube tunnels 5.5km long in total. The work started on the longest tunnel section, the Královská Obora section, which is 3.09km long ; 2.23km of this length wil be constructed by mining methods. Till now, the excavation under the Vltava River and Císarsky Ostrov island, including an adjacent shipping canal has been successfully completed.

• Two new double-track railway tunnels under Vítkov Hill, which are parts of the New Connection Project, are being completed. The tunnels will significantly contribute to the improvement of the capacity of railway tracks coming to the main station in Prague from the east. Another project which is being finished in Prague is the Line IVC2 of Prague metro, which will extend the Line C in the north-eastern region of the city nearly by 4km. The line will be opened to traffic in May 2008.

• The work is also underway on motorway tunnels on the Prague City Ring Road (an outer circle road), namely the Lochkov tunnel (1620m) and Komorany tunnel (1930m).

• Northern Moravia will see the completion of the twin-tube structure of the 1080m long Klimkovice motorway tunnel. The tunnel is part of the D47 motorway, which is designed to connect the motorway network in the Czech Republic with the network in Poland, in the north-south direction.

• The preparation for the commencement of excavation of the Dobrovského tunnel was finished at the end of 2007. The tunnel is part of the Large City Circle Road in Brno. The over 1200m long twin-tube tunnel will be driven through the Brno Clay, which displays unfavourable geotechnical properties.

• The construction of utility tunnels in Prague, Brno and Ostrava also continued.

• Of the projects to be implemented in the future, the greatest attention is attracted by the preparation of the construction of the longest railway tunnel, from Prague to Beroun, which is to be nearly 25km long. The tunnel will be driven by TBMs.

DENMARK

The Danish Society for Tunnels and Underground Works has during the year 2007 arranged 6 member meetings including technical site visits to see the TBM in action for the service tunnel for district heating in the city center of Copenhagen and at the Malmø Citytunnel project in Sweden. Further more a technical site visit to the Marmaray project in Istanbul, Turkey for 27 tunnel engineers and planners took place from 24 to 28 October. The group had the pleasure to inspect the first 4 immersed tunnel elements placed at the seabed in a world record level of minus 45 m below the Bosphorus waterline from the Asian side in Üsküdar.

Members of the society have participated in ITA General Assembly in Prague, Czech Republic from 5 to 10 May 2007 including meetings in three ITA working groups. Three members have participated in activities within PIARC's Tunnel Committee until the closing congress in September in Paris for the period 2004 to 2007.

The year 2007 showed a major progress for the Copenhagen Metro with the inauguration on the 27 September of Phase 3 linking the Copenhagen Airport with the city centre. Phase 3 contains 4.5 km of Metro line of which 0.5 km is underground and 5 new stations. The Copenhagen Metro now operates 21 km of railway line of which 10 km is underground..

• In 2007 the Danish Parliament approved a new extension of the Metro. The Metro Cityring will be a circle line with 17 underground stations and 15.5 km twin tunnels and a link of 1.5 km to a new operation an maintenance centre. In total there will be 34 km of tunnels. Two multidisciplinary consultancy services contracts have been signed, one covering civil works and one for transportation systems. The design work started in November 2007 while geotechnical and archaeological site investigations were initiated in early 2007. The construction works of the Metro Cityring will start in 2010 with the line expected to be in full operation by 2018. The total cost is estimated to be 2 billion Euros financed by the municipalities of Copenhagen and Frederiksberg, the State and by users charges.

• A bored service tunnel as part of an updating of the district heating system in Copenhagen has successfully been performed in the Copenhagen limestone and with up to 40 m water pressure. The contract was granted to a joint venture of MT Højgaard A/S (DK) and Hochtief Construction AG (D) in 2005 with start mining in July 2006 and end mining in April 2007. The tunnel has been performed as a segment lined tunnel and grouted with 2 component grouting system in level - 35 m from a starting shaft at Amager Power Station over one middle shaft in inner town to a receiving shaft on the north side of Copenhagen City. The total length is 3.9 km, and the mining was performed with a 5.1 m Herrenknecht TBM with an EPB shield. Short NATM tunnels have been constructed at all 3 shafts for starting, receiving and re-launching the TBM after being turned into a new direction in the middle shaft. After the TBM has been recovered from the receiving shaft, work has proceeded with concrete inner lining in the shafts. Placing of pipes for district heating was initiated in October 2007, and the project is scheduled to be completed by mid 2009. Client: Copenhagen Energy. Consultants: COWI (DK).

• In September 2005 a proposal was published outlining a 12 km immersed road tunnel with 6 lanes linking the motorway system at the north with the motorway system at the south of Copenhagen. The alignment followed the Copenhagen Harbour Canal throughout and included an underwater parking facility. The cost was estimated to be close to 3 billion Euros and proposals for financing were included in the proposal. The proposal got a favorable reception from the public as well as local politicians, because it was design to remove a very substantial part of the road traffic from the center of Copenhagen as well as providing access to previously unreachable development areas to the east of Copenhagen Harbour. The scheme has been developed further by the Copenhagen Municipality together with the consultant Rambøll in 2007, and is now included wholly or partly in two alternative solutions.

• The proposed approximately 3 km new road link ("Northern Harbour Link") between Nordhavn and Lyngbyvej located north of Copenhagen has during 2007 been developed further. Four alternatives, comprising cut-and-cover and bored tunnels with a length from 0.5 to 2.5 km have been investigated. The project is being developed by Copenhagen Municipality and the consultant Rambøll. In early 2008 the consultant will perform further alignment and EIA studies on 2 of the alternatives. The project is planned to be tendered for construction works by 2010. The project is expected to take 7 years to complete.

• A new Harbour Tunnel in the city of Aarhus is under planning and Environmental Impact Assessment studies (EIA) have been completed. The tunnel will be 2.1 km long connecting the harbour terminal with the motorway E45 passing through the city center of Denmark's second largest city. It will be a unidirectional cut-and-cover tunnel with two tubes and 2 lanes in each tube for carrying up to 40 % of HGV traffic. The final planning based on i.e. public hearings will be performed during 2008 followed by a final political approval. Construction works are estimated to be close to 200 million Euros starting in 2010 with an opening year for traffic in 2015. The project will be financed by the Danish Government and Aarhus Municipality and supported by the EU. Consultants: Grontmij | Carl Bro Group.

• Copenhagen Municipality has awarded the contractor PIHL (DK) the contract of construction 3 underground facilities as fully automated parking basements with room for in total 840 cars. The locations of the 3 parking basements are on Nørrebro, Amager and Islands Brygge in the city center of Copenhagen. The three parking basements will be constructed by PIHL assisted by the company Westfalia (D) supplying and installing the elevator systems, which automatically will carry the cars to their correct spaces in the basement and pick them up again. On the street level, only light buildings will be visible. These will contain car elevators used by the car owners while parking the car in the basement. The largest of the three parking basements with four elevators and room for 408 cars will be situated under a green area of Islands Brygge. The second largest with room for 268 cars and three elevators will be situated in the street Under Elmene. The parking basement at Nørrebro with room for 164 cars will be constructed around the street of Nørre Allè just outside Skt. Johannes Church. This basement will be established with two elevators. The construction of the three parking basements will start in February and April 2008.

EGYPT

ETS is an NG organization including 299 individual & 10 corporate members. ETS publishes a periodical newsletter every 3 months in Arabic, but abstracts of its monthly technical lectures & presentations (7 in year 2007) are included in English. ETS participated in the activities of ITA Annual Congress no.33 in Prague , Czech - Republic, May 2007 and participated in the activities of numerous Working Groups of ITA

ETS held 7 lectures & presentations on the following topics :

• Analysis of TBM tunnelling using the Convergence-Confinement Method.

• Utilization of grouting techniques for construction of under ground structures in urban area

• Reliability-Based tunnelling design: An Overview.

• Numerical Simulation of TBM and NATM for Cairo metro-Line III

• Instrumentation at the CWO crossing – El Azhar road tunnels and its use in the design of future projects

• Deep pit excavation and its application for tunnel construction

• Cairo metro line 3 phase 1: optimised design and methods of construction)

The Greater Cairo Metro Line 3 is 30.5 km length of which nearly 28.5 km are underground together with 29 stations. The route extends from Cairo Airport to Imbaba. Additional branch to Mohandeseen of 3 Km, is added which shall be also constructed in underground. The line crosses the River Nile twice. The planned capacity of the line when completed is 2.1 million passengers / day. The works on of the Cairo metro line 3 phase I, had already started in July 2007.This phase includes 4.5km in deep tunneling & 5 underground stations. Phase 2 will start soon in parallel with phase 1& includes 6.5km. & 7 stations all underground.

The transportation study for Greater Cairo Area had been finished proposing 6 lines of metro till 2022. Three further metro lines are recommended in this study in addition to the already 3 basic lines [lines 1 & 2 being finished , line 3 is now under construction.

FINLAND

During 2007, different events to contribution of rock engineering with drill-and-blast method took place in Finland

• Management and coordination of R&D work of "Rock Engineering".

Finnish people are participating in four working groups: WG6, WG11, WG18, WG20

At the moment there are several large underground traffic tunnel projects under design or under construction in Finland. During 2007 excavation works have been finalized for a new 2,5 km long city centre service tunnel for service traffic of different stores and shopping centres in the city centre of Helsinki.

• There are several road tunnel projects under construction.

For instance 7 twin-tube motorway road tunnels, total length 5,2 km, have been included in the last 50 km long part of the new motorway line of E18 between Helsinki and Turku. The contract agreement of the whole project is based on life cycle model including construction works and 25 years financing and operation period, too. Construction works have been started during 2005 and have been continued during 2007. The hole project including 50 km motorway and 7 new twin-tube tunnels will be finalized and opened for traffic during 2008: www.tiehallinto.fi.

• In 2007 construction works of a 1,5 km long road tunnel and a 13,5 km long railway tunnel for the land traffic connections of Vuosaari harbour in Helsinki have been finalized. The harbour project construction has been continued several years for a new, modern harbour in Helsinki with cargo traffic due to move there from the West and North harbours in 2008. The harbour road will go under the Natura 2000 area through a 1.5-kilometre double tunnel, which already has opened for traffic during 2007. Having separate tunnels in each direction will increase safety. Railway traffic has been placed in tunnels to bypass the many city and dwelling areas underground so minimizing the negative environmental effects of the harbour traffic: www.vuosaarensatama.fi/en/index.html

• The new ring line with airport link connect the Helsinki Vantaa airport to city centre of Helsinki by railway connections in future. This project includes 18 km railway line of which 8 km will be in tunnels (http://keharata.net) The ring rail line project has been taken under planning and design during 2007

• During 2007 the planning and design of the new metro line from Helsinki to Espoo have been started. Construction works have been planned to start 2010 -2011.

• During 2004 the excavation works of Onkalo project, concerning the final disposal of used nuclear fuel in bedrock has been started in Olkiluoto, in western coast of Finland. This underground research and construction project will be continued about 100 years in future (http://www.posiva.fi/englanti). In the end of 2007 about 2,5 km of total 4 km long access and research tunnel had been excavated and investigated.

FRANCE

L'AFTES, Association Française des Tunnels et de l'Espace Souterrain, a pour but de promouvoir le plus large usage possible du sous-sol au bénéfice de l'urbanisme et de l'aménagement du territoire et de faire progresser la connaissance en matière de travaux souterrains dans les domaines scientifiques, techniques, juridiques, administratifs, économiques et sociaux.

Seize groupes de travail actifs représentent environ 250 membres.

Quatre recommandations ont été publiées dans TOS en 2007: Gestion et Valorisation des matériaux d'excavation - Comment maîtriser les coûts de son projet ? - Géométrie, béton, coffrage et bétonnage des revêtements de tunnels - Comptabilité des recommandations AFTES relatives aux revêtements des tunnels en béton avec les Eurocodes.
77 recommandations ont été publiées en français sur la revue Tunnels et Ouvrages Souterrains (T.O.S.) et seront progressivement mises sur le site de l'AFTES et téléchargeables.

Les principales réalisations en travaux souterrains en 2007: • Travaux d'une galerie de sécurité parallèle au tunnel Maurice Lemaire (Vosges - 6230m) • Travaux du tunnel routier bitube du Mont Sion (A41 – 3100m) • Travaux du second tube routier de Toulon (Var – 1000m) • Travaux de réhabilitation et de la mise en sécurité des ouvrages souterrains routiers de l'A8 • Achèvement des travaux d'équipements du nouveau tunnel routier du Lioran (Cantal – 1500m) • Achèvement de la mise aux normes de ssécurité du tunnel Maurice Lemaire existant(Vosges - 6872 m) • Travaux des descenderies du LTF (Lyon-Turin) • Travaux d'adaptation des ouvrages de la ligne TGV des Carpates (11 tunnels) • Travaux du tunnel LGV des Chavannes (LGV Rhin-Rhône - 1970 m) • Travaux de la ligne de métro de Marseille (2500 m) • Bassin et tunnels réservoirs parisiens TIMA 1 (L 750m, Ø4m) et TIMA 2 (L 2700m, Ø 6,8m) Volumes 80 000 à 240 000 m^3

Quelques études routières en cours : • Mise en sécurité du tunnel actuel de Tende (Alpes Maritimes) • Nouveau tunnel parallèle au tunnel de Tende (Alpes Maritimes – 3186m).• Galerie parallèle au tunnel de la Croix Rousse (Lyon - 1800 m).• Liaison autoroutière Lyon-St Etienne - 4 tunnels bi-tube (Rhône Loire 1380m, 630 m, 1700 m et 600 m).• Galerie parallèle au tunnel de Siaix (Savoie - 1500 m).• Galerie parallèle au tunnel du Fréjus (Savoie 12 000 m)

En juin 2007, la deuxième ligne du métro de Toulouse de 15 km de long et comportant 20 stations a été mise en service.

Le congrès international trisannuel se tiendra à MONACO, les 6,7 et 8 octobre 2008 avecx pour titre : « Le souterrain: espace d'avenir ». Thèmes du congrès : Le sous sol : espace de projets – Maîtrise des risques et des coûts – Innovations techniques en tunnel – Des tunnels perennes et sûrs.

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GERMANY

DAUB - the German Tunnelling Committee is a registered non-profit restricted association with up to 30 members coming from owners, scientific institutions and consultants as well as from contractors. 15 DAUB members took part in the annual traditional D-A-CH-meeting 2007 involving Germany (D), Austria (A) and Switzerland (CH). The host was Switzerland. The meeting took place in Flims. It was attended also by 18 Austrian and 12 Swiss colleagues. The 1/2 day technical seminar dealt with most challenging actual tunnel projects, with the maintenance and renewal of old railway tunnels as well as with safety aspects of road tunnels. The additional technical tour led to the 800 m deep access shaft and some various faces of the Gotthard base tunnel in Sedrun in the upper Rhine valley..

DAUB run 7 working groups during 2007:• Safety in tunnelling jointly with the Austrian and the Swiss National Tunnelling Committees • Asbestos in tunnelling • Financing of tunnels via PPP/BOT-projects.• Recommendations for the selection of appropriate TBMs.• Recommendations for designing prefabricated tunnel lining segments • Pre-running geological investigation for tunnelling.• Drainage methods and concepts.

These working groups are of temporary nature and will be closed as soon as they have finished their special task. Members of these working groups are mostly also members of DAUB, but specialists from outside are also involved in some cases.

The results of the working groups are published in technical journals, preferably in "Tunnel" (www.tunnel-online.info), but sometimes also in the German handbook of tunnelling (edited annually).

The following major tunnelling projects were running in Germany during 2007: • **New ICE high speed lines** (250 to 300 km/h): between Karlsruhe and Basel; partly upgraded and partly replaced, integrating two major bored tunnel projects of 9 and 6 km respectively in length. Each tunnel consists of two parallel single tubes with about 10.5 m excavation diameter. Inauguration is planned for 2011 to improve the traffic connections between Northern and Southern Europe via Lötschberg and Gotthard base tunnels in Switzerland. • **DB project Stuttgart 21** putting the above ground main station underground by simultaneously turning it over 90 ° in plan view; this project involves besides the new underground main station nearly 40 km single/double track tunnels; intensive design work was started in 1997. First construction works started during 1998. After an intermediate slow down the project is planned to be reactivated in 2008. The entire project will be finished around 2015. • **Blessberg tunnel** (8.3 km as part of the Ebensfeld -Erfurt high speed line) and Finne Tunnel (6.9 km as part of the Erfurt-Leipzig/Halle new high speed line) are some major construction sites that started in 2007 • In 2007 a major program of **refurbishing and modernising** more than 150 years old railway tunnels along the river Nahe in Western Germany started using a special machinery to conduct the construction works under onging operation

General details on tunnelling in Germany can be seen in the table below according to the latest statistics conducted by STUVA.

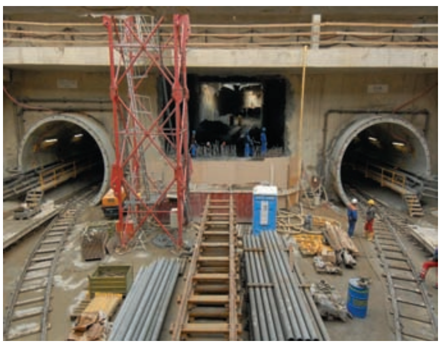
Type of tunnel	in operation	under construction	planned
metro	658	10	72
railway	489	53	222
road	233	27	149
Total	**1,380**	**90**	**443**

Further information is given in the publication “Unterirdisches Bauen Deutschland 2005 - Underground Construction Germany 2005” including 75 projects of road, rail, metro tunnels, and caverns. In addition a description of the basic conditions concerning geology, clients and structure of the operators, awarding of contracts, financing, research and development in tunnelling, industrial safety and health care as well as statistics is given. The 500 page publication is available from STUVA at a price of 25 € including mailing.

HUNGARY

Preparations for WTC 2009 in Budapest go continuously with the participation of organizing and scientific comtettee, harmonization with ITA Ex-Co, as well, e.g. in Pague, Madrid and Cologne.The ITA-AITES World Tunnel Congress 2009 "Safe Tunnelling for the City and Environment" will take place in Budapest/Hungary on 23-28. May, 2009. The Call for Papers and the main topics are in the Announcement on the Website

Scientific days with professional presentations in tunnelling on different construction-sites of the 4th metro line, (annual 6-8)



Started the first semester of the 4-semester professional education at the

Technical University Budapest on HTA's motion and active participation in it. HTA Members were present in great strength of tunnelling Conresses (Prague 50, Cologne 30)

News about the Metro network: In Budapest, the 4th metro line is under construction. Two parallel tunnels with inner diameter 5,2 m are being built with two TBM-s. The total length of the line is roughly 10 km, constructed in two stages. The first 7 km long stage consist of ten stations with connecting and ventilation tubes between them. The stations are constructed with diaphragm wall box structures as a cut and cover structure, but some of them has parts constructing with shotcrete supported method, as well. The TBM-s cross the structure-ready stations. Also the connecting and ventilation tubes/tunnels are constructed with mining, shotcrete supported method.

In 2007 the construction continued with structural works of five stations on Buda side and five stations on Pest side. The two TBM-s were started in the first half of 2007 and on their 7 km long way on the first break-through was in the Tétényi-station in the second half of the year. Photos will show the first break-through, tunnel and station-constructions.All ten stations are under construction, TBM-s will be pulled through the intermediate box-stations. More information available on the website : www.metro4.hu

The construction of Underground Storage Facilities in Hungary for low- and intermediate level radioactive waste disposal went on with the construction of an access tunnel.

ICELAND

The Icelandic Tunnelling Society which represents the ITA National Group Iceland is an indipendant group of tunnelling professionals with corporate and ordinary members. Members were heavily involved in investigations, design and construction of major hydro and road tunnels in Iceland in the year 2007.

The year 2007 was very productive in terms of tunnel planning, design and construction. Work continued on the Kárahnjukar Hydro Project, where only about 4 km are remaining of the total of 70 km of tunnels. Work continued on the 11 km long Hédinsfjördur road tunnel and half of the tunnel length had been excavated at the end of the year. The 5 km Óshlío road tunnel was sent out for tenders and work will start early 2008. Other road and hydro tunnels are being planned and investigated.

ITALY

Società Italiana Gallerie is an open association (approximately 750 members), that promotes, coordinates and spreads the results of studies and researches in underground works. It publishes the "Gallerie e grandi opere sotterranee/Tunnels and large underground works" magazine (in Italian and English).

The working group activity in Italy, is mostly focused on the participation to the international working group for the occasion of the International world tunnel Congress.

In the past year many important project were developed in Italy involving a lot of tunnelling works both conventional and mechanized.

Railway tunnels :

Milan-Naples High Speed/Capacity railway line, Bologna-Florence section. The excavation and lining of the tunnels on the line (about 90 km in total) was completed at the end of 2005; the final work on the accessory subterranean works is in progress to guarantee the safety of the operation of the line.

Malpensa airport - Cadorna Milan railway connection. The 'Castellanza' tunnel, with a double hole, and 1200 m in length, was completed a couple of months ago.

Milan-Naples High Speed/Capacity railway line, Bologna feed line. The construction of the following in an urban context is at an advanced stage:

• 6.2 km of natural tunnel EPB shield 9.40 m in diameter;

• 1.3 km of natural tunnel about 140 m^2 in section, through traditional excavation;

• Underground station of Bologna Centrale (platforms 12-17).

Brenner railway tunnel, the start of the first part, 10 km of the pilot tunnel (about 50 km overall) is imminent.

Genoa-Ventimiglia railway line – Doubling of the track between Andora and San Lorenzo al Mare. The excavation of 11 natural tunnels for an overall 15 km approx is in progress, partly via TBM of 11.84 m in diameter, partly by traditional excavation (section of about 125 m^2)

Metro tunnels :

Naples, Line 1, Dante-Garibaldi extension, excavation via two EPB shields of 6.70 m in diameter of the twin-tube tunnel of about 6 km and 5 stations (Garibaldi, Università, Duomo, Toledo and Municipio) is in progress. The stations are created after freezing the ground.

Naples, Line 6, the definitive project has been approved and financed by the CIPE and the construction design is about to start. It concerns:

• a single tube tunnel of about 3000 m to be created via an EPB shield of 8.30 m in diameter; • 6 stations.

Genoa metro(De Ferrari-Brignole section), the traditional excavation of the bored tunnel of about 1500 m and 9 m excavation diameter is in progress.

Milan metro Line 3 – Maciachini-Comasina extension, the excavation of the stations Affori and Comasina is in progress.

Milan metro Line 5 – Garibaldi-Bicocca section, work for the creation of the tunnel of about 8 m in diameter and 8 stations has started.

Rome metro Line B1 from Piazza Bologna to Piazza Conca d'Oro, the work for the creation of three stations (Annibaliano, Gondar and Conca d'Oro) and about 4 km of tunnel, to be excavated via two EPB shields of 6.5 m in diameter and able to operate with front pressure of up to 4.5 bar has started.

Brescia metro, the work for the section in the council area, which foresees the excavation of about 14 km line tunnel via an EPB shield of 8.10 m in diameter and the creation of 17 stations, 13 of which subterranean, is progressing.

Railway tunnels :

Modernisation of Motorway A1 Milan-Rome-Naples, Valico by-pass, six natural tunnels with double tubes of about 180 m^2 in section, including the base one 8700 m long, is in progress.

Modernisation of Motorway A1 Milan-Rome-Naples – Widening to three lanes between Florence North and Florence South. Five natural tunnels with double tubes for a total 5520 m in length are in progress.

Trento North - Rocchetta road connection, Zambana Vecchia section, junction on S.S. 43 to Fai della Raganella, Rupe tunnel, the Rupe tunnel of about 3700 m, traditionally excavated, is at an advanced stage.

Strada dei Marmi (Carrara ring road), the traditional excavation work of the Macina tunnel, about 1000 m in length and 13.50 m in diameter, and the M. Greco tunnel, about 2400 m in length and 13.50 m in diameter, has started.

Salerno-Reggio Calabria highway, work on the large areas sub-contracted for the creation of about 25 km of tunnels is in progress.

Asti-Cuneo – Verduno and Alba tunnel, the construction design of the tunnels to excavate traditionally (total length about 4.5 km) has started.

Quadrilatero (Umbria-Marche roadworks), the definitive project for the creation of about 10 tunnels has been approved.

A14, widening of 5 existing tunnels from two to three lanes + the hard shoulder.

Frejus safety tunnel, the definitive project, which provides for the creation of a tube about 8 m in diameter and 12.87 km in length, is going through the approval stage.

New tunnel at Colle di Tenda, the definitive project, which provides for the rialesatura of the existing tube and the creation of a new tube about 3200 m long has been approved.

Grande Viabilità Triestina (Large-scale roadworks in Trieste), creation of the Carso tunnel, 2830 m long and 130 m^2 in section, in the urban area is in progress.

Modernisation of Motorway A15 of Cisa, three tunnels completed, excavation of the Calcinara tunnel of about 400 m is in progress.

Other works :

.Hydroelectric installation in Val Passiria, tunnel 3.70 m in diameter, about 6 mm long, excavated via TBM, and other accessory works.

JAPAN

Japan Tunnelling Association is a non-profit association composed of 425 corporate members and 1,810 individual members as of March 2007. Its research activities cover various fields of tunnel construction technology such as D&B, TBM and C&C methods. It publishes monthly journals "Tunnels and Underground" in Japanese with English abstracts.

Activities of more than ten technical committees focused on various issues of tunnel construction technology. For instance ;

- Mucking systems, such as truck systems and conveyor systems, for mountainous tunnelling.
- Renewal and update of information about materials for shield tunnelling.
- Investigation on geotechnical features of tunnels which encountered enormous tunnel deformation.
- Q&A about shield tunnelling technique. These articles was serialized in the monthly journal.
- Design and construction of Shinkansen tunnels
- Study on materials of urban tunnels from the viewpoint of environmental protection

Construction Works

- YAMATE Tunnel, the Central Circular Route of Tokyo Metropolitan Expressway

Almost all the western part of the Central Circular Route is being planned by underground structures which will be 20 km in length. For the first time, the section of 6.3 km from Ikebukuro to Shinjuku was opened to traffic in December, 2007. The YAMATE Tunnel is 5 km long, a twin tube with 2 x 2 lanes and is carrying more than 30,000 veh./day. The tunnel is well equipped and operated carefully from the view point of safety in the tunnel and environment around the tunnel.

The route will be extended by 4.3 km to Shibuya in 2009 (fiscal year), and by 9.3 km to Shinagawa in 2013.

- The Tokyo Metro FUKUTOSHIN Line

The new line of the Tokyo Metro was opened in June, 2008. It links major subcenters of Tokyo (FUKUTOSHIN), Ikebukuro, Shinjuku and Shibuya. The length of the line is 8.9 km and the total of the Tokyo Metro Network amounts to 267 km. This project overcame very complicated circumstances such as crossing underground structures and adjacent buildings in densely developed areas.

- HIDA Tunnel, the Central Nippon Expressway

HIDA Tunnel under construction on the Tokai-Hokuriku Expressway is the world's eighth longest road tunnel, with a length of 10.7 km. Its construction work by D&B and TBM began in 1996, and after overcoming a lot of difficulties such as a large quantity of water ingress under high pressure and squeezing of poor ground, it will finally open in July, 2008.

KOREA

KTA has put effort to increase domestic and international activities during the year of 2007. Two national conferences were successfully held in April and October. As part of international collaboration KTA concluded MOU with China in August. A total of 10 delegates took part in the MOU ceremony held in Kunming.

Six working groups are currently actively working in KTA. The active working groups include Standard & Specification, Shotcrete, Physical Survey, Mechanised Tunnel

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Construction, Urban Tunnelling, and IT in Tunnelling. WGs held meetings as well as small group seminars on a regular basis. The working group “Mechanized Tunnelling” decieded to have the first two day training course in Februray, 2008 and initiated a task force team. The working group “Urban Tunnelling” held a seminar on Urban Mechanized Tunnelling in September in which five project sites in Seoul reported their work progresses and exchanged up-to-date information

Korean Tunnelling Association (KTA) is currently conducting a government-funded 5-year research under the supervision of Prof. In-Mo Lee, the president of KTA. The project was granted by the Korean Ministry of Construction and Transportation (KMCT) and is aimed at developing relevant design and construction techniques especially for large section-underground space including tunnel. The research program covers a wide range of design and construction aspects of underground space such as development of high performance support systems, IT-based design methods, and innovative construction techniques in difficult construction environment.

Sappae Tunnel has been completed and opened in December 2007. The 18.8 m wide, 10.6 m high tunnel has a length of 4 km and is believed to be the longest in its size. The tunnel was constructed as part of the 127 km long ring way around the city of Seoul..

A river-bed tunnel was completed with a shield TBM as part of Budang Subway Line. The main contractor was Hyundai E&C.

The first immersed tunnel is now being constructed in Busan area. The tunnel is part of Geoga Bridge which connects Gaduck and Geoje Island. A total of 18 segments, 180 m long and 26.5 m wide each, will form the tunnel. Ecah tunnel segment weighs 45000 tons and was designed to withstand 50 m of hydraulic head and to resist a magnitude 8.0 earthquake. The 8.2 km long whole project started in 2004 and consists of a suspension bridge and the immersed tunnel. The poject costs 2.2 billion USD and is expected to be completed in 2010. The main contractor is Daewoo E&C

THE NETHERLANDS

Member Nation representative is the Department of Tunnelling and Underground Works of the Royal Institution of Engineers in the Netherlands. On their behalf all activities are co-ordinated and carried out by COB – Netherlands Centre for Underground Construction.

COB is a public private partnership to further the development of knowledge in the field of underground space and further the use of underground space. The COB vision places the use of underground space central to spatial development in such a way that liveability is maintained and often increased at surface level. COB achieves her activities by activating her network of participants coming from all sectors of the construction industry and spatial development.

Besides the Department of Tunnelling and Underground Works, COB also supports the Schreuders Foundation –responsible for the annual underground space awards in the Netherlands-, the National Tunnel Safety Committee –a government appointed body for tunnel safety- and CARUS –the Centre Applied Research Underground Space, a university research group part of a partnership of three Universities of Applied Science in the Netherlands, and the chair of Underground Construction at Delft University.

Hanzelijn - Zwolle In 2007 ProRail has started building a new railway between Lelystad and Zwolle. As of December 2012 the North and Northeast of the Netherlands will become closer to the Randstad due to reduced travelling time. A tunnel will be made between Dronten and Kampen , beneath the Drontermeer..

Hubertus Tunnel – Boring the Hubertus Tunnel has been completed. Monday 4 June 2007 at 17.50 De-Boora, the Tunnel Boring Machine, broke through completing the 1.500 m twin tube tunnel. Boring was exceptionally fast. The maximum progress in 24 hours was 28 metres of tunnel. .

North-South Metroline Amsterdam – On Monday 9 July and Tuesday 10 July 2007, two enourmous immersed tunnel segments of the North/South Metroline were transported over the river IJ from the building dock at Sixhaven to a temporary parkingplace in the Suezharbour (Western Harbour area). The tunnel segments that will be immersed under the Central Station in 2010 cover the whole future metrostation of Central Station

Velsertunnel - Haarlem – On Friday 28 September 2007 it was exaclty 50 years ago that the Velsertunnel was opened for traffic. It is the oldest tunnel of the Netherlands and the first underground passage for motorised traffic. The Velsertunnel is known worldwide as typically Dutch example of immersed tunnelling. The cost of the tunnel were 130 million guilders (about 60 million Euros). The decision to build the tunnel was made in 1939. Construction began in 1941, but was stopped in 1942. Not until 1952 construction continued. Then the decision was made to expand the tunnel to two lanes in both directions.

Railzone Delft - Delft - Construction of the Railway Tunnel in Delft will cost 20 million Euros extra, as the tunnel will be longer than originally planned. The Railzone is the area around the station and the railway through Delft. By constructing the railway – and the demolition of the current elevated railline – important barriers in the city will disappear. The ambition is to develop the Railzone into a sustainable spatial area. The construction will start in 2009 and will take more than 10 years.

CARUS – Renewing education and initiating research. The 'Centre Applied Research Underground Space' – or CARUS in short – will in 2007 enter its fifth year. Over the last year, CARUS has expanded from a research group at Zeeland University of Professional Education to an education provider and research group collaborating closely with the Netherland Centre for Underground Construction and Underground Space – COB. From 2007, CARUS will be an unique partnership of three universities of professional education, Zeeland University in Vlissingen, Utrecht University in Utrecht and Avans University in Tilburg and Breda. In the past years special consideration was given to developing curricula in the field of Tunnel Facility Management and Project Enabling. Tunnel Facility Management is the application of Asset Management in the field of Tunnel Maintenance & Operation. Project Enabling focuses on the need for a community based approach to make projects work. This approach holds especially true for Underground Space Development as this is often done within the confines of densely populated urban areas where community involvement is essential to the success of these projects.

COB – Netherlands Centre for Underground Construction. COB finalised a study into the Masterplanning of Underground Infrastructure at the end of 2007. The publication was presented at the National Underground Space Day (Part of the Festival of Underground Space) held 31 January 2008 in Amsterdam. At the International Congress (28 & 29 January 2008) another publication was presented: Thinking Deep in the Netherlands – a photobook of beautiful underground projects, presented in a surrealistic way, in which the seperation between above and underground seems to have disappeared. As the preserving of knowledge of the underground is becoming very important the Department of Transport and Public Works asked COB to develop a knowlegde management system on onderground construction and use the archives from the Civil Engineering Department as a pilot.

NORWAY

2007 was a busy year for the Norwegian Tunnelling Industry. A total volume of more than 4 million m^3 of rock was excavated from underground projects. Due to many projects at the planning stage, this activity will continue in the next coming years. The number of members of the Society is stable around 920. Mr. Eivind Grøv, menber of the board of our Society was elected vice president of ITA.

The ongoing activity within the Society is mainly carried out by 6 working committees. In brief these committees are issuing handbooks and publications covering new technology and/or presentations for assisting members in marketing their activities abroad. Other committees are taking care of professional congresses and a seperate committee offering post educatuin to shot firers. Another committee is working with public and press relations, including marketing the use of the underground for construction purposes. Lastly there is one committee responsible for financial matters and book-keeping. The major achievements for 2007 are the issue of one handbook in the Norwegian series and one publication in the English series. This wasdistributed at the ITA 207 General Assembley in Prague.. .

The year 2007 was an active year for the Norwegian tunnel builders.

The main ongoing projects are:

- Breidalen water transfer tunnel to the Øvre Otta HEP , 14 km, approx. 25 m^2
- Sauda HEP, all together about 30 km of tunnels, shafts and underground power station
- Kjøsnesfjorden HEP, about 25 km of small section tunnels and shafts
- Leirfossen HEP underground
- The Reinskar HEP underground
- E10 Lofast road tunnel, about 6 km of tunnel in the Lofoten region
- Eiksund sub-sea road tunnel, approx. 7 km long and down to 284 m below sea level (world record)
- E16 Voldum - Borlaug highway tunnel
- Halsenøy sub-sea road tunnel, length about 3 km
- The PPP highway project Grimstad - Kristiansand
- Finnfast sub-sea road tunnel, about 6 km long
- Narvik harbour, new underground iron ore ship loading facility
- The Bjørvika connection in Oslo, incl. 900 m of submerged tunnel
- The RV 456 Kjørrefjord – Ulland highway tunnel
- Ringroad west, Bergen
- E6 Vinterbro, highway tunnel outside Oslo
- Storage caverns for waste material in Odda
- Storage caverns at Falconbridge factory, Kristiansand
- New railway tunnel between Lysaker and Sandvika
- The Atlantic ocean highway tunnel in Ålesund

Some major underground projects were completed in 2007

- E18 highway tunnels in the Vestfold region
- The PPP project E39

Member Nations Report 2007

The activity among the members of the Society is at a record level. Almost all recourses are utilized and sometimes the companies are facing problems with recruitment of personnel.

The collapse of the Hanekleiva highway tunnel has intensified the discussion on how to build safe tunnels in Norway. The Public Roads Administration has issued new guidelines

POLAND

Polish Group of ITA is a member of ITA since 1978; includes 65 individual members and 6 group members.
PG of ITA publishes in 3 technical magazines: "Mine and Tunnel engineering", "Geoengineering - Roads, Bridges and Tunnels" & "Engineering and Construction". We are preparing the Xth International Conference Underground Urban Infrastructure 2008 to be held in Wroclaw, 23-25.10.2008 in cooperation with the Polish Group of Trenchless Technology

Due to rather small number of members the Polish Subcomittee has not created permanent Task Groups in the manner following AITES-ITA organisational structure. If necessary ad hoc work groups are formed in order to deal with a specific issue.

The conference 'Underground Construction 2007', organized by the AGH-UST (University of Science and Technology, Cracow) and co-organized by the Polish National Group of ITA, the Association of Mining Engineers and Technicians and the Polish Society of Rock Mechanics was held at the AGH-UST (University of Science and Technology), Cracow, Poland from 20th to 22nd September 2007. Many specialists from technical universities, scientific research centres, designing departments, mines and underground construction companies took part in the Conference. 48 papers were presented, covering the following subjects: • staff training for the needs of underground construction, • underground construction in practice, • design of underground excavations and structures, • execution technology of underground excavations and structures; monitoring lining, • geotechnical problems in underground construction. During the conference technical trips were organized, among others to the salt mine which is now a museum

In 2007 the construction of the 1st line of Warsaw metro will be completed. The length of the line after completion will be 23 kilometres.

A tender was also announced for the designing and construction of the central section of the 2nd metro line. The length of the section will be 6.3 km and there will be 7 stations. Completion of the new section is planned in the beginning of the year 2012 so that it is possible to transport football fans to the stadium in which matches of European Football Championships will be played. There are 5 international consortia taking part in the tender. The winner of the proceedings will be announced in the 2nd quarter of this year. It is presumed that the tunnels will be built with the use of Tunnel Boring Machines whereas the stations – with the use of the cut and cover method

Conceptions of several transportation tunnels are currently being developed, such as:
• tunnel under one district of Warsaw, with the length of approx. 2.5 km;
• tunnel under the river Swina in Swinoujscie, which will probably be built by sinking prefabricated elements;
• a similar tunnel under the Martwa Wisla in Gdansk;
• several tunnels (in rock) in southern Poland with lengths of approximately 1 km each.

PORTUGAL

The Portuguese Tunneling Commission (CPT) is a group of SPG-Sociedade Portuguesa de Geotecnia. SPG is the Portuguese Geotechnical Society, aiming at promoting research and development in the Geotechnical field and cooperation with foreign similar organisations. CPT is the branch of the SPG devoted to cooperation with ITA. SPG has 988 members, 146 of them being members of ITA and CPT. In 2007, CPT organized a one day course on Concrete for Tunnel Linings (Lisbon, March 16, 2007).

Databasis on Portuguese Tunnels – the data collection is in progress and a Seminar is under organization (Lisbon, May 29,30,2008).Concrete for Tunnel Linings – a one day course on the theme was organized (Lisbon, March 16, 2007). Other national Working Groups corresponding to those active in ITA are being organized

The construction of the Red Line of the Lisbon subway in the stretch Alameda – S. Sebastião went on, involving a 9,8 m in diameter and 1400 m long TBM tunnel, and a 800 m NATM tunnel. Two underground stations, Saldanha and S. Sebastião, with a total excavation of 180 000 m3 and five access and ventilation shafts with 240-750 m2 cross sections were also under construction. The design of the Red Line between the East Railway Station and the Airport was also in progress.

The old Rossio railway tunnel, in Lisbon 2,5 km long, built up in 1895, that was closed to traffic for refurbishment works, was reopened to the public by the end of the year.

Design studies for the refurbishment of the old masonry railway tunnels of Fátima (650 m), and Albergaria (661 m) were carried out too.

The design studies for the high-speed railway lines Lisboa-Porto and Lisboa-Madrid, which will require a significant length of tunnels in the approach of densely urban areas, have also been ongoing.

Member Nations Report 2007

The construction of the 8 km Odelouca-Funcho and of the 4 km Sabugal-Meimoa hydraulic tunnels, 3m in diameter, has been in progress too.

The last but not the least, relevant activity concerning the design and construction of road tunnels in Madeira Island was carried out. Under construction were, among others, four tunnels in the expressway Fajã da Ovelha – Ponta do Pargo, three tunnels in the expressway Ribeira de S. Jorge – Arco de S. Jorge, with a total length of 4170 m, and two tunnels in Madalena do Mar, with a length of 1910 m and 1535 m respectively.

ROMANIA

A new special issue of "Constructii Subterane" Magazine has been published. The 6th National Conference of ART will be held in october 2009.

Working group "Research" " is reviwing two national norms, according to European Norms: « Guidelines for civil defense measures in Bucharest Metro » and « Guidelines for fire prevention measures in Bucharest Metro »

Continuing works to the hydropower development of the river Jiu on the sector Livezeni-Bumbesti includes 2 HPP located in the gorges area, connected by a headrace tunnel having a length of 20 km.

• Continuing works to the urban rehabilitation works, in the 1 Mai – PLS Pod Constanta area (undercrossing of the Rosu-Nord and Arcuda aqueducts, by the metro line by special pipe jacking technology).

• The Municipality of Bucharest organised tenders in a PPP system contract for 5 major underground parking facilities to be constructed in the central in order to ease traffic congestions in the city.

• The Municipality of Bucharest finished the feasibility studies for new underground road passages in Bucharest:- Interchange Modal Crossroad Razoare 2 (2.2 km in length) - Sudului Square (South part of Bucharest, 1.5 km in length) - Romana Square (City Center, 800 m in length) - Aerogari Blvd. (near « Aurel Vlaicu » Baneasa Airport)

• The Municipality of Bucharest finished the feasibility studies for new new underground pedestrian passages in Bucharest :- Triumph Arch Square (400 m in length) - Romana Square (400 m in length)

• The Municipality of Bucharest organised tender for construction works for a new underground road passage (1 km in length), near Romanian Military Academy : Interchange Modal Crossroad Razoare 1

• Metrorex, the Bucharest metro operator, will put into operation a new section of 4.13 km with 4 new stations in the east part of the city, on 1st of September 2008 (EIB loan).

• The EIB loan agreement for construction works of Metro Line 5 (Drumul Taberei – Pantelimon, first section with 9 km long and 13 stations, totaly in underground, between Drumul Taberei area and center of the city) will be approved this month by the Romanian Public Finance Ministry.

• The board of Japan Bank for International Cooperation (JBIC) will approve in March, 2008 the loan for construction of a rapid link interconnection line from the international airports Otopeni and Baneasa with the metro network of Bucharest, in Victoriei Square area. The metro link will have 17 km long and 19 stations, totaly in underground

• The construction works the for the modernization of "Eroii Revolutiei" plaza, including a new underground intermodal transfer and a pedestrian passage tunnel will be finished in May

RUSSIA

Russian Tunnelling Association is a social organization which joins more than 90 corporate members and more than 400 specialists, individual members. More than 90 papers were published in 7 issues of "Metro and Tunnels", RTA journal. The International Exhibition "Underground City 2007" was held in Moscow on 23-24 October. In its frame the International Scientific and Technical Conference "Cities underground space development" was held on 23-24 October, Moscow, 2007 with publication of the reports theses. The competition for the best utilization of progressive technologies, structures and materials during underground construction (October, 2007).

Development of appraisals by experts on industrial safety and consideration of difficult technical problems of tunnel construction in Russia.

• The scientific and technical report on design and construction of transportation tunnels in Moscow (Serebrianiy Bor district) was expanded.

• Development of recommendations on sprayed-concrete structures use with new materials and equipment.

• Development of the Enterprise Standard "Materials and solutions for tunnel face slurry pressure and cement grouting behind the tunnel lining while using shields with active tunnel face pressure balance".

• Development of the Enterprise Standard "Ground consolidation and creation of a screen against water-filtration using jet-grouting".

• Preparation and participation of the delegation of Russian Tunnelling Association in the World Tunnel Congress 2007 and the 34th ITA General Assembly in Agra (India)

Underground activities in Russia: • In Moscow Transinzhstroy ltd applied mechanizing and conveyor transport of the excavated soil constructing running tunnel of Mitino-Strogino line of Moscow subway for the first time in Russia. • The construction of transport structure - Serebrianiy Bor tunnel was completed in December, 2007. • The following tunnels built at the beginning of the twentieth centuries are being reconstructed and maintained under the heavy conditions of train operation: • Rachinsky tunnel (Far East railroad) • The third Petlevoy Tunnel (North Caucasus railroad) • Lagar-Aulskiy railway tunnel (Far East railroad) • Highway tunnel of total length 409m was built under Moscow canal.• Leningradskiy prospect which will be a highway without traffic control signaling connecting the centre of the city and Sheremetievo is now under reconstruction.• In St. Petersburg the construction of the first Russian underwater tunnel 770 m in length was completed under the Neva.

SAUDI ARABIA

Even though MOT is one of the newest members in ITA, it has been very active one. MOT has participated in several conferences and activities held by the ITA. In addition, MOT organized a workshop in November 2006 entitled "Safety in Tunnels and Underground Structures"

MOT has not joined any of the working groups yet. However, the working groups activities are very important. MOT is interested in joining some of the working groups

Several projects are under study and construction throughout the Kingdom. Two major projects will be briefly discussed herein.

The East-West Railroad: This railroad connects the cities of Jubail, Dammam, Riyadh and Jeddah. 14 tunnels totalling 20 km. in length are being executed in this project. In addition to the construction of tunnels, this project includes the construction of road over and under bridges retaining walls, protection and diversion works for utilities, level crossing etc. The general functional requirements of tunnels include: • Even though the track is to be constructed as a double line, the design of the tunnel assumes twin single track tunnels which will carry double-stack container wagons. On single track sections, a single track will be provided. • Walkways have been provided to allow an emergency egress of railway personnel and passengers. • Tunnel alignments have been designed to allow gravity drainage. • In average the external and internal areas of the tunnels are 90.026 m2 and 67.661m2 respectively. In terms of excavation, drill and blast excavation in rock is required for most tunnels and support is provided by rock bolts and an in-situ lining concrete.

Deleh Descent Road:This project is located in Ad darb road in Abha province and connected between Abha/ Jazan areas.

This road suffered extensive structural damage as a consequence of two impressive floods triggered on 1982. One tunnel flooded as a result of these events. Therefore, two new tunnels (335.35m & 225.5m long) were suggested to overcome this problem. The construction of the tunnels included the following tasks: • Excavation: Top heading and bench. • Rock bolts : Sysmatic bolts 4-5m. long spaced 1-1.5mm. • Shotcrete: 150~200 mm. in crown, 150mm. in sides, and 50mm. on face. • Steel sets : Light to medium ribs, spaced 1.5m. • In general, the tunnel consist of the tunnel (under mountain), the artificial gallery and the protection walls. The new Austrian Tunnelling method is followed for drilling and excavation.

SINGAPORE

Technical seminars were held monthly at the SMRT auditorium at North Bridge Road by speakers covering a wide range of topics related to tunnelling and underground construction. The technical seminars, generally conducted on the 3rd Thursday of each month, were free and open to TUCSS members and to the public. As at December 2007, a total of 97 seminars had been conducted by TUCSS.

• TUCSSalso organised the Underground Singapore 2007 (UGS 2007) Conference from 29 –30 November 2007 which was held at the National University of Singapore. The purpose of the Conference was to provide a forum for contractors, engineers, owners and researchers to share their experiences and to discuss issues relevant to the design and construction of underground works in Singapore. A total of 17 technical papers were presented and a special session on Baseline Reporting comprising 5 papers was also held.

• TUCSS is co-organising with the Land Transport Authority (LTA) and Association of Consulting Engineers Singapore (ACES,) the International Conference on Deep Excavations (ICDE) 2008 which will be held in November, 2008. Er. Ow Chun Nam, Er. Tang Sek Kwan, Mr. Kulaindran and Mr Y S Go represented TUCSS in the joint organising committee meetings. The theme of the conference is "Challenges and Risk Management of Underground Construction". The conference will be focusing on the planning, design and execution process, especially in heavily-urbanised areas, to address challenges in subterranean development to meet the demand for space..

• GIKEN Asia arranged a technical Site Visit for the TUCSS members to view the Joan Road Outlet Drain Improvement Works on 22 January 2008 and had a turnout of 7 people. Examples of activities observed were: Sheet Piling Works being carried out under Tight Working Space Condition (GRB Narrow Access Method), Demonstration of Press-in Piling technique and GRB Systemized Equipment and Completed Sheet Piles using the Silent Piler method.

• TUCSS 10th Anniversary Annual Dinner was held on 21 September 2007 at the Meritus Mandarin Hotel. The Dinner was attended by 60 TUCSS corporate members, 49 TUCSS members and 75 non-TUCSS members. During the dinner, the winners of the Hulme Prize 2007 were presented with cash prizes; first prize winner received $500 and the two second prize winners were given a cash prize of $250 each. At the Dinner, TUCSS also recognised and thanked their Bronze, Silver, Gold and Platinum Sponsors..

• TUCSS Annual Lecture was held on 25 October 2007. The lecture was entitled "The 2007 Rankin Lecture: Soil-environment interactions in Geotechnical Engineering". The speaker was Professor Antonio Gens from the Technical University of Catalonia, Barcelona, Spain. The lecture gave participants insights into the following: 1) a number of developments incorporating the effects of new phenomena and new variables on the behaviour of soils, 2) recent developments in Unsaturated Soil Dynamics, 3) engineering behaviour of unsaturated soils and the effects of suction and moisture changes, and 4) soil behaviours with the effect of high and low temperatures as well as of chemical variables..

• TUCSS Golf Tournament was held on the 28 August 2007 at the Raffles Country Club. The event was attended by more than 300 TUCSS as well as non-TUCSS members. The sponsors were Sambo Tosfoc, Samsung Corporation, Taisei, Arup, WH-STEC-AM JV, Bachy Soletanche, Chang Ding Engineering Pte Ltd, Eng Lim Construction, Gammon, Herrenknecht, Mott MacDonald, Nishimatsu, Pan-United, Parsons Brinckerhoff, Penta- Ocean, Samwoh, Sato Kogyo, Sembawang, Shimizu Corporation, Technik- Soil, TriTech, WAK, YongNam and Tobishima Corporation..

SLOVAKIA

The report is more extensive than it was in the previous years as we conclude one electoral period of our work and I feel obliged to review in this report our collective work as from the vote of the new committee and the new chairman dated July, 3rd 2003. The committee met at 18 meetings during its electoral period and the general assembly was convened every year. The first meeting of the committee after the vote was held on November, 19th 2003 with the objective to establish system and order in all of the association's activities. The committee started to prepare the conference „The importance of tunnels in traffic“. The conference took place from June, 16th to June, 18th 2004 in Podbanské and achieved international success. In the same year, i.e. 2004, the statutes approved by GA STA were modified with the objective to implement non-profit invoicing of professional events; therefore the approval by the founder, i.e. the Ministry of Interior, was issued. Close cooperation with the Czech tunnelling committee was established and I strongly believe that it will continue in the future. Symposia on the shotcrete technology were organized both in the Czech and the Slovak Republic (April, 14th 2005 – construction of tunnel Sitina). In 2004, numerous activities took place and higher quality and the number of articles in the magazine Tunel was achieved especially thanks to some members of the association. Participation of members of the association in worldwide tunnelling congresses was particularly highlighted by presence of the chairman of the association at every congress and his respective reports. At the same time started the preparation of the conference „Subterranean construction“ in 2006 in Prievidza. Although STA generally contributed to preparation of the conference, the bulk of preparation was done by SKANSKA BS; representatives of the company SKANSKA BS deserve thanks for the exemplary organization. As a result of the initiative of the company Slovenské tunely, a calendar was prepared and published for the year 2006 with professional motif of tunnel construction. As soon as in 2005, preparation of web page of STA started and it was guaranteed by the company Alfa 04; it was successfully launched in 2006. However, it is necessary to keep the web page alive which is a task for the future. The year 2006 could be characterised by cooperation in preparation of the congress WTC 2007 in Prague. STA had had such financial strength that it could provide CTuK with one million crowns to prepare the congress. Strengthening of the STA's financial situation enabled it to introduce intensive cooperation with Slovak universities. This task is one of the most important as far as the future is concerned as education of the young generation in our profession is considerably deficient. STA has offered numerous opportunities for professional growth for students, even with financial support. Compensation for students and teams was established and approved by GA STA. There is much potential as far is this cooperation is concerned. Universities have numerous possibilities how to help professionally and lecturers themselves should suggest these tasks instead of waiting and hesitating. Well, our „craft“ is beautiful and at the same time discredited by politicians as excessively expensive, etc. Why don't we change it together? We can talk about this when we talk about perspectives for the future. In 2006, first students participated in the workshop connected to preparation of the congress in Prague in 2007. We need to go back to 2007, the year when the successful congress WTC 2007 in Prague took place, and to its success and congratulate our brothers Czechs. The Czech Republic and Prague earned even more reputation than it had already had. In January, we participated in a lecture symposium „Tunnel Hnevkovsk“ in Prague (January 16th 2007). At the same time, we gave five students the opportunity to directly participate in the congress WTC 2007 and we received a very positive feedback. Last, but not least, we handed over a diploma with financial reward to the best graduate from the Faculty of Construction at Zilinská University .

SLOVENIA

Slovenian Association had General assembly in Ljubljana in March 23, 2007. General assembly had changed the name of society. Present official name is SLOVENIAN SOCIETY FOR UNDERGROUND STRUCTURES. .2) Slovenian Association together with representatives from ITA - AITES will organize International Workshop: TUNNELLING FOR HIGHSPEED RAILWAY PLANNING - AIS (Austria, Italia, Slovenia). The place of International workshop will be in PORTOROZ on May 30, 2008.Slovenian Association together with University of Ljubljana decided that 9th International Symposium on Tunnel Construction and Underground Structures, will be held in September 17-19, 2009 in Ljubljana, Slovenia.Members of Slovenian Association presented papers at various international meetings and conferences in Europe and overseas contries.

Our members participate in WG 17 and WG 5.

The complex of Sentvid Tunnels which include two three lanes tunnels, two lanes tunnels, entrance and exit tunnels and two underground bifurcation caverns, located close to Ljubljana motorway ring, will be finished till June 30, 2008. The main rock structure in the area, where tunnels were built, belongs to Permian-carboniferous rock series with low bearing capacity. The main engineering challenge was the construction of two underground caverns (cross sections in the wider one measures more than 320 m^2)

• The new tunnel Ljubno, 260 m long, with three lanes i.e. two traffic lanes and retreat lane, which is part of the road connection Karavanke – Obre'je, was finished and is now under operation. Technical solutions of the new tunnel construction were conditioned with specific properties of the hard soil named "sivica" which has swelling potential. The old existing tunnel tube, constructed more than 40 years ago, will be reconstructed next year..

• Also two double-tube road tunnels Barnica (280 m) and Tabor (590 m) on the Razdrto – Vipava highway section is now under construction. The main rocks are flysh series with sandstone and marl layers which built bedrock matrix. The end of all civil and electromechanical works is planned at the end of the year 2008

• Tunnel CENKOVA is a part of motorway section Lenart - Beltinci, i.e. subsection Sp. Senarska – Cogetinci in Slovenske Gorice area. Motorway run first through Cut&Cover section (230 m) than through tunnel and further on the opened alignment. The distance between tunnel tube axes is about 12 m and has specific requirement regarding to central reinforced concrete wall. The length of tunnel is 370 m. Basic characteristic of tunnel construction is that the ground space, where tunnel is built, mainly consists of soil layers with clayey sands, silts and clays with different consistencies.

• The similar twin road tunnel VODOLE, long about 225 m is under construction near Maribor contemporary. Ground conditions, from construction point of view, are better against CENKOVA tunnel. .

• The twin tube Markovec Tunnel, approx. 2.2 km long on the motorway section between Koper and Izola near Adriatic coast will start with construction very soon, in next months. Rock structure of the tunnel consists of flysh rocks with sandstone and marl layers which are tectonically disturbed in some parts.

• Geological and geotechnical exploration works on the new second track railway alignment between DIVACA and KOPER will start very soon. At the sometime working activities on idea design of new alignment which include about 20 km railway tunnels, will be still active. Special requirements will be present at the connection point with railway from Triest.

• 8) In future can expect some new projects on railways and road tunnels, and rehabilitation works on old tunnels either on rails and roads too.

SPAIN

In November 2007 AETOS organized the International congress of Tunnels: "International Congress "Tunnels, drivers of change" which was attended by 480 persons of 10 countries. Simultaneously a technical exhibition was celebrated with 82 stands, representing organizations and enterprises of the participant countries

Construction works

• During the period 2003-2007 the Community of Madrid has carried out successfully the biggest extension of the Network of **MADRID METRO** until the moment. 83.5 km of lines have been constructed, of which 55.7 km are of conventional Metro and 27.8 km of Light Metro, and 80 stations, which has supposed an increase of 35% of the total of the network. Of 83.5 executed km of line, almost 50% have been made with TBM, thanks to the use of 10 TBM working simultaneusly. The rest of tunnels has been constructed by means of the Madrid method or by cut and cover method.

• On the **SEVILLE METRO** in the past year 3.5 km with TBM of 6.10 m diameter have been made (double tube), 4 km by cut and cover and 100 m of tunnel in mine and in the MÁLAGA METRO were made 2.5 km of tunnel by cut and cover.

• The **GUADARRAMA BASE TUNNEL** is the most important work of the new Spanish High Speed Rail Network. The 179 km line Madrid-Segovia-Valladolid, inaugurated on December 22, 2007 includes a 17.4-mile-long (28 km) tunnel that is the fourth longest railway tunnel in Europe, fifth worldwide and one of 14 projects classified as priority by the European Union, and which forms part of the Atlantic Axis of European Railways. The work consists of a base tunnel of length 28.7 km whose route crosses underneath the mountain range of the Sistema Central at a maximum elevation of 1,200 m above sea level, with a maximum overburden of 992 m underneath the massif of Peñalara. The design consists of two main tubes for single track, excavation diameter 9.51m, with separation among axis centrelines of 30 m and connection galleries of 24 m2 every 250 m, the construction of which is being carried out simultaneously with that of the main tubes for safety reasons Finally, in the central part of the route the galleries will be excavated every 50 m, adding a parallel tunnel of about 500 m in order to form an emergency area with capacity for 1,200 passengers. The construction of the civil work on the main tubes, was completed by May 2005, after solving a series of problems, and the knowledge of these solutions will aid the development of the technology of TBMs for extra-hard and abrasive rock. The GUADARRAMA BASE TUNNEL is in operation satisfactorily from December 23, 2007."

• In the **BARCELONA METRO** the works of the B9 line continue at a good pace, with 40 km in length.

• In the construction of the peripheral belt of Madrid **(MADRID CALLE30**) diverse works in tunnel with different systems have been made, emphasizing specially a double tunnel of 4200 m that was constructed using a TBM of 15.20 m outer diameter and 13.40 m inner diameter.

Member Nations Report 2007

SWITZERLAND

En 2007, le GTS a non seulement assuré ses tâches habituelles mais s'est également chargé de quelques travaux supplémentaires et ouvert de nouveaux dossiers. L'activité au sein du Comité directeur a été empreinte d'engagement et de coopération collégiale. C'est pourquoi j'aimerais tout d'abord exprimer mes plus vifs remerciements au Comité directeur et à l'assistant de son président. J'espère aussi que notre travail a répondu aux attentes des membres du GTS

Après une forte augmentation du nombre de membres au début des années 90, les effectifs du GTS se sont quelque peu stabilisés en 2007. Il convient toutefois de noter un réel tassement des membres collectifs compensé par une extension des membres individuels. Le Comité directeur va s'efforcer d'augmenter le nombre de membres au cours des prochaines années. Les idées ne manquent pas.

Le GTS a organisé pour la sixième fois le Swiss Tunnel Congress, pour la troisième fois au KKL de Lucerne. Nous pouvons affirmer avec fierté que cette manifestation est devenue l'événement phare de notre activité associative. Avec plus de 740 participants, nous avons enregistré un record de participation absolu, ayant contribué à remplir presque intégralement la salle lucernoise. Les exposés ont été intéressants à tous égards et le public s'est montré extrêmement intéressé. Les réactions enregistrées ont été très positives, y compris de l'étranger. La démonstration technique de très haute volée des difficultés importantes rencontrées en matière de construction de tunnel a été particulièrement appréciée. À cet endroit j'aimerais tout particulièrement remercier les responsables de domaines et leurs nombreux aides qui ont rendu possible, comme l'année dernière, la tenue d'une manifestation d'un très haut niveau qualitatif..

Le domaine STC sous la direction de Heinz Ehrbar et de Martin Bosshard a élaboré à l'été et à l'automne 2007 un concept de développement des STC au cours des prochaines années. Ce concept se présente actuellement sous la forme d'un scénario complet décrivant dans le détail les différentes tâches et responsabilités. En se fondant sur le succès actuel, le STC se développe par étapes pour augmenter l'attractivité du congrès. Comme déjà évoqué dans le bulletin 2/2007 du GTS, nous avons déjà franchi pour le STC 2008 une première étape avec la création d'un Advisory Board pour le choix des exposés et des présentateurs. Cet Advisory Board est constitué de représentants de différentes nations, ce qui garantit la qualité technique des exposés. Avec la tenue pour la première fois d'un colloque la veille du STC, nous tentons une autre évolution en 2008. Ce colloque 2008 est organisé autour du thème «Les injections comme mesures d'aide à la construction lors de l'avancement». Georg Anagnostou et François Bertholet ont préparé un programme présentant des aspects théoriques comme pratiques sous une forme attrayante.

Cette année encore, le GTS a organisé deux excursions. Ces visites ont eu pour thème le contournement de Saas le 19 avril 2007 et le contournement de Lugano le 8 novembre.

Selon la tradition, le mois de septembre a vu se dérouler la rencontre au sommet des associations professionnelles allemande, autrichienne et suisse, manifestation organisée cette fois par le GTS. La rencontre a eu lieu à Flims, avec visite du chantier de Sedrun. Notre rencontre avec nos collègues français de l'AFTES a eu lieu en novembre à Moutier, manifestation également organisée par nos soins cette année. Les visites ont concerné les tunnels de Moutier et de Graitery. Le lendemain, nous avons eu de plus la possibilité de parcourir le tunnel de Raimeux, peu avant son ouverture. Les contacts avec l'ITA ont eu lieu dans leur cadre normal, comme chaque année. Le Professeur Aurèle Parriaux, EPFL, a été intégré comme représentant officiel de la Suisse au GT 20 «Urban problems, underground solutions» de l'ITA.

La bourse de stages pour collégiens et étudiants a été mise en place à l'automne 2007 sur la page d'accueil du site GTS. Certains de nos membres ont déjà indiqué des places de stages vacantes. Nous avons également reçu quelques demandes de la part d'étudiants. Notre intervention se limite à la publication des annonces de demandes et d'offres de stages sur notre site, la prise de contact entre étudiants intéressés et entreprises étant laissée à l'initiative des intervenants. Dans la mesure où la nouvelle page d'accueil n'a été mise en place que peu avant Noël, il est trop tôt pour tirer un premier bilan. Je remercie néanmoins déjà toutes les entreprises qui ont proposé des places de stages.

La participation aux travaux d'élaboration et de révision de normes et de standards constitue l'une des tâches essentielles du GTS. La relecture corrective, financée par le GTS, de la version anglaise des normes de travaux souterrains du SIA (SIA 197, 197/1 et 197/2, 198, 118/198, 199) a été commandée à l'été 2007 et les traductions révisées devraient être disponibles au printemps 2008.

L'un des grands objectifs que le GTS s'était fixé pour l'année 2007, à savoir la réorganisation complète du site web, a pu être réalisé peu avant Noël. Le nouveau site a été inauguré par l'envoi d'une newsletter de Noël. Les premiers échos sont largement positifs et nous nous réjouissons de disposer d'un site particulièrement réussi.

TURKEY

The name of the Organization is TURKISH ROAD ASSOCIATION (TRA). There are seven National Working Groups in the Association. TRA is an independent and open Association. The members are combined of individuals, organizations and companies of public and private sector. TRA published several books and some national conferences are at planning phase.

The working groups and important events of the year 2006:1) Planning Working Group, 2) Road Construction Working Group, 3) Bridges and Tunnels Working Group, 4) Maintenance Working Group, 5) Trafic Safety Working Group, 6) Highway and the Environment Working Group, 7) Intelligent Transport Systems Working Group. The working groups organized various meetings, national conferences, exhibitions and published some books, reports and booklets.

Member Nations Report 2007

Significant projects of underground constructions: The total number and length of tunnels on the state highways and on the motorways:

	Number	Length
In operation :	95	47.150 m.
Under construction	83	99.500 m.
In the design phase :	51	53.400 m.
Total :	229 :	200.050 m.

There are 5 railway tunnels 24.365 m. are under construction

Nowadays, the Marmaray, is a very important project in Istanbul. This project will connect two sides of Bosphorous. Important figures of this project:

Total length	: 76,3 km.
Surface Metro	: 63,0 km.
Total length of the tunnels	: 13,3 km.
(8,6 km. excavated 1,8 km. immersed, 2,3 km. cut and cover)	
Number of stations	: 37

UNITED KINGDOM

The British Tunnelling Society continues to be active in providing its extensive membership with a range of professional, technical and social activities throughout the year. Monthly meetings are held at the Institution of Civil Engineers in Westminster and are open to non-members. Tunnelling engineers on visits to London are particularly welcome. In addition the BTS continues to produce technical guidance on a range of tunnelling-related topics.The BTS was delighted that Martin Knights, a long-standing member of the BTS committee, was elected President of ITA and will support him in this role.

During 2007, BTS working groups • have drafted guidance of reducing exposure to nitrogen monoxide - to be published shortly, • are drafting guidance on best practice for monitoring of underground construction, • are capturing knowledge on timber support techniques. • The Compressed Air Working Group has met to consider issues affecting work in compressed air. • BTS has assisted in setting up an employers' training forum to deliver National Vocational Qualifications in tunnelling at operative level. • BTS has continued to interact with MPs through its Parliamentary Lobby Group. • BTS interfaces with other UK professional groups interested in geotechnical matters through membership of the Ground Forum. • BTS supports the ICE's Panel for Historic Engineering Works – Tunnels sub-panel. • BTS contributes to the work of various British and CEN standards relating to tunnelling and tunnel machinery

Construction Construction is well advanced on the Glendoe Hydro scheme. The powerhouse cavern was completed in Summer 2007 and the 17km of tunnels are nearing completion.

• Tunnelling was completed below the Thames for the extension of the Docklands Light Railway Extension to Woolwich.

• Cable tunnels under construction as part of site preparation for the 2012 Olympics were completed earlier this year

• Various tunnels were being designed or constructed for water, sewerage and cable utility services including extensions to Thames Water's London Water Ring Main and a number of cable tunnels for National Grid

• The Channel Tunnel Rail Link and associated access tunnels at the Kings Cross/St Pancras Station development were formally opened by the Queen in November 2007..

• Major tunnel refurbishment works were underway on the Blackwall Tunnel and on tunnels on the M25 motorway

• Work has begun onsite for the A3 Hindhead tunnel.

• A major interceptor sewer tunnel was under construction in Belfast to collect sewage currently being discharged into Belfast Lough. This investment is a direct outcome of the "peace dividend" arising from the end of IRA terrorist activity there.

• Unfortunately the new Scottish Government has cancelled plans for the Edinburgh Airport Rail Link tunnel.

• The CrossRail project has been given government approval and it is hoped that the relevant legislation will receive Royal Assent in2008.

BASF

Delhi Metro Phase II at present is under full swing of construction in three different lines:

 # Central Secretariat to Mehrauli (BC 15 to BC 19 A&C)-

Approximately 18.5 km of underground work comprising of 9 stations and 15 km TBM Tunneling, rest cut and cover. In coming couple of months, a total of 6 TBM's shall be running in full swing. The major tunneling job (TBM tunneling) has been awarded to M/s Metro Tunneling Group (MTG- BC 18) - 3.25 KM twin tube with 2 TBM's and M/s Continental Engineering Corporation- Soma JV (BC 16) - 4 km twin tube with 4 TBM's.

BASF is involved in this section with PVC Waterproofing (Flagon BFRSL- 90,000 sq. mt.), Admixtures for Pre- cast Segments (Glenium ACE 30- 100 M.T.), Soil Conditioning Foams for TBM's (Meyco Fix SLF 30- 200 M.T.), Tail Skin Greases for TBM (Meyco Fix TSG 7 & 6- 100 M.T.) and some Segment Repairs (Emaco S88C T). We have been involved with an emergency situation wherein we successfully completed the injection job with 1.5T Meyco MP 355 A3 (PU Foams) to stabilize a cavity above the TBM.

 # Central Secretariat to Badarpur (BC 24)-

Presently on this line, the only contract has been awarded to M/s ITD- ITD Cem JV (BC 24) which comprises of approximately 4.5 km twin tube tunneling with 4 TBM's and 4 Stations by cut and cover method. The actual boring is expected to start by end of July' 08.

In BC 24, BASF is involved in PVC Waterproofing of all 4 stations (75,000 sq. mt.), Soil Conditioning Foams (200 M.T.), Pre- cast Concrete Admixtures (Glenium ACE 40i- 100 M.T.). Further for Concrete Repairs and Tail Skin Greases, the discussions are going on and is expected to finalize by June' 08.

New Delhi Railway Station to International Airport (Airport Metro Express Link)-

This package is approximately 19 km in length partially Underground and partially Elevated with 5 stations in total. The main contractors doing this job are Alpine Samsung HCC JV, Alpine HCC JV, L&T, IJM- IJMII JV, Senbo Engineering and Afcons Infrastructures. Major tunneling is done by Alpine Samsung HCC JV (AMEL C1) - 4 km twin tube with TBM, Alpine HCC JV (AMEL C6) - 2.5 km NATM twin tube and L&T – 1.2 km TBM twin tube. Rests of the jobs is elevated and cut & cover.

Presently we are involved in complete cast in situ admixture for Diaphragm Wall concreting and pile concreting (Rheobuild 5614- 2000 MT) with all the contractors, Pre- cast Concrete Admixtures (Glenium ACE 40i) with Alpine Samsung HCC JV- 100 MT. Alpine HCC has purchased 4 Meyco Potenza's for their NATM Spray Concrete. We are actively participating in providing all support for Spray Concrete Mix Designs and suggesting the use of Glenium B233 and Meyco SA 160/ 167. Project is in initial stages and hence discussions are going on for further use of Products.

Next year seems promising in terms of the use of new technologies like Spray Applied Waterproofing Membranes (Masterseal 345), Injection of Colloidal Silica (Meyco MP 320), Microfine Cements (Rheocem 650), etc. This project is going to add another feather to the UGC crown.

BILFINGER BERGER

As a leading Multi Service Group, internationally active in infrastructure, industrial processes and real estate management, it is our objective to enhance our current strong position within both domestic and global markets. Our innovation, experience and technical capabilities are the basis for our success and enable us to solve challenging problems and to handle complex projects. In 2007 our Tunnelling Division was awarded following contracts:

SBB Transit-Line Section 3 Weinberg Tunnel

The Weinbergtunnel is the central section of the Zurich Transit-Line a double track railway line that links the stations Altstetten, Zurich Central and Oerlikon. The Contract consists of Lot 3.1 a most sophisticated underground crossing of Zurich Central Station and Lot 3.2. a 4,400 m long double track TBM tunnel with a diameter of approx. 11 m. The project value is approx. 210 M Euros and project completion is scheduled for 2013.


Site installation Central Station Zurich Transit-Line

Wehrhahn-Line Duesseldorf Lot 1

The Wehrhahnline is a 3.5 km long double track subway tunnel with 6 underground stations and 2 aboveground stops. The tunnel connects the light rail stations Bilk and Wehrhahn and will be constructed with a slurry TBM Ø 9.50 m. Upon completion in 2015 this 300 M Euro project will significantly improve inner-city traffic.

Brenner–Base–Tunnel, Exploratory Tunnel Aicha–Mauls

For better financial and geological assessment of the 55 km long Brenner–Base–Tunnel Aicha–Mauls represents the first section of a smaller exploratory tunnel that runs parallel to the main tunnel. It is 10.5 km long and will be excavated by a hard rock double shield TBM Ø 6.30 m. Project value is approx. 80 M Euros and project completion is anticipated for 2010.

Further recent tunnel projects of Bilfinger Berger are:

- City Tunnel Malmö (Sweden)
- Combined Sewer Overflow Tunnel Portland (USA)
- Dortmund-Berghofen Road Tunnel (Germany)
- Exploratory Tunnel Saint Martin la Porte (France)
- Gotthard Base Tunnel, Lot Sedrun (Switzerland)
- Krichenwaldtunnel (Switzerland)
- Light Rail Cologne (Germany)
- Motorway E18 Grimstad-Kristiansand (Norway)
- North South Bypass Tunnel (Brisbane, Australia)
- Seymour-Capilano (Canada)
- Wienerwaldtunnel (Austria


TBM Shied North South Bypass Tunnel

HERRENKNECHT

Herrenknecht AG located in Germany is a technology and market leader in mechanized tunnelling. As the only company worldwide, Herrenknecht delivers cutting-edge tunnel boring machines for all ground conditions and with all diameters – ranging from 0.10 to 19 meters. The Herrenknecht product range includes tailormade machines for traffic and transport tunnels (Traffic Tunnelling, Ø > 4.2 meters) and supply and disposal tunnels (Utility Tunnelling Ø ≤ 4.2 meters). The company also provides state-of-the-art deep drilling rigs, to bore to a depth of 6,000 meters (Herrenknecht Vertical). The most recent subsidiary (Bohrtec Vertical) supplies small drilling devices for the use of shallow geothermal energy.

Traffic Tunnelling

Since 2006 two tunnels are being excavated with the world's largest tunnel boring machines to date in the huge Chinese city of Shanghai. The two Herrenknecht Mixshields measure 15.43 meters in diameter and are crossing beneath the Yangtze River to connect to the Changxing River Island with two 7.47 kilometer, three-lane road tunnels. The first of the two giants, the Herrenknecht S-317, reached its target shaft on May 21, 2008 after high tunnelling rates of up to 144 meters per week .

Utility Tunnelling

Herrenknecht's innovative new pipeline laying technology, Direct Pipe, greatly simplifies the underground laying of long pipelines. With the Direct Pipe technology, the borehole is drilled in one single operation and a prefabricated and tested pipeline is inserted. And was nominated for the international technology prize, the Hermes Award 2008. It celebrated its world premier in the fall of 2007 with the laying of a 464 meter long protective steel pipe under the Rhine at Worms, Germany, in one single continuous operation in just 13 days.

HOCHTIEF

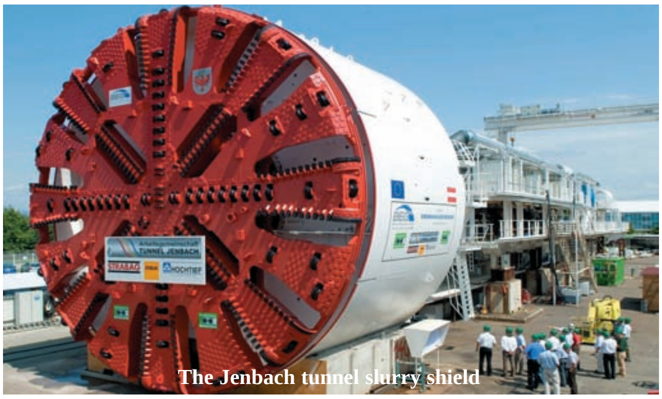
With decades of experience in international heavy civil engineering structures, the Civil Europe Division of HOCHTIEF Construction is concentrating its know-how in the field of complex infrastructure projects on the growth market Europe. Our clients profit from the highest technical competence in all types and all conventional and fully mechanised methods of tunnelling as well as from our local presence, for instance in Eastern Europe. Some recent tunnelling projects:

• in the Czech Republic we build together with partners a section of the Prague Ringroad 514, including a 1.100m long drill & blast tunnel. Actual grade of completion 40% approx..

• in Glendoe, Scotland, we are realizing a 100 MW hydroelectric power plant comprising design and turnkey construction of an underground powerhouse, 8km hard rock TBM tunnel, 8km aqueduct tunnel and 4km pipeline tunnel, drill & blast each. Actual grade of completion: 60% approx..

• in Austria, HOCHTIEF is involved in two tunnel joint ventures:
- the Lainzer Tunnel, 3km twin track conventional rail tunnel through Vienna, actual grade of completion: 40% approx. and
- the Jenbach Tunnel as part of the Brenner Traffic Feeder Line, a 4km twin track rail tunnel, driven with a 13m diameter slurry shield and concrete segment lining, actual grade of completion: 25% approx..

• in Germany HOCHTIEF is leading the joint ventures building:
- the NST (New Schluechtern Tunnel), a 10,24m TBM is carrying out that 3.950m long rail tunnel, working in open or EPB mode through hard rock and soft soil. Actual grade of completion: 65% approx.,
- the metro line U4 Hafen City in Hamburg. The project was awarded in 2007 and includes 2x 2.800m of tunnel by a slurry shield. The project is in start-up and preparation phase.


The Jenbach tunnel slurry shield

LOVAT

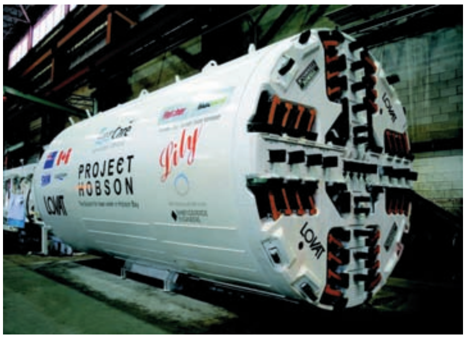
For over 35 years, LOVAT has specialized in the custom design and manufacture of Tunnel Boring Machines (TBMs) utilized in the construction of metro, railway, road, sewer, water main, penstock, mine access and telecommunications tunnels. LOVAT’s extensive experience, advanced technology and commitment to continuous development has provided solutions on over 700 tunneling projects worldwide.

On April 2nd, 2008, LOVAT was officially acquired by Caterpillar Inc., joining Caterpillar’s Global Mining Division. LOVAT customers will further benefit from the strength of Caterpillars global purchasing organization, its research and development initiatives, and experience in large-scale manufacturing processes.

LOVAT offers a complete selection of highly versatile TBMs, ranging from 2 to 14 meters in diameter, and related products customized to suit project requirements:
- Single and Double Shield Rock TBMs
- Earth Pressure Balance TBMs
- Slurry TBMs
- Semi-pressurized and Non-pressurized Soft Ground TBMs
- Pipe Jacking TBMs / Systems
- Rolling stock
- Full complement of accessories and fully integrated auxiliary equipment designed to maximize TBM productivity

In addition to traditional manufacturing LOVAT also provides additional services to our customers including:
- TBM refurbishment, available at LOVAT’s facilities or locally
- Turnkey’ project solutions, including customized tunneling and

segment systems design;
• Buyer training for TBM operation and maintenance;
• On site assistance for TBM Operation, TBM assembly / disassembly, Hydraulic & Electrical/PLC Servicing and general TBM Troubleshooting
• Spare parts support including stocking of critical items and 24 hour worldwide shipping.



2007 at A Glance

• LOVAT entered the burgeoning Chinese market with the sale of three new EPB TBMs for Metro expansion projects:
- Beijing Urban Construction Group (B.U.C.G.) purchased a 6.3m diameter LOVAT EPB TBM to bore a 3,593m tunnel for the construction of the Beijing Metro Line 9, Lot 6.
- China Railway Group (CRTG) purchased two EPB TBMs for the construction of the Shenzhen Metro and Guangzhou Metro projects located in Guangdong Province, China. A total of 6,251 metres of tunnel will be excavated.
• FCC/OHL/COPISA Joint Venture: Purchased two new 6.9 metre EPBs for the construction of the Terrassa Railways Tunnel Project. The TBMs will bore twin 3,727 metre long tunnels.
• Construcciones Sando S.A.: Purchased a refurbished 4.7m diameter EPB TBM for the construction of the Coslada Sewer Tunnels in Madrid, Spain. The TBM will bore 3,650 metres of tunnel. Third project for this TBM, following successful drives in North America and in U.K.
• McConnel Dowell: Purchased a new 3.3 meter EPB TBM, to be used in the construction of the Rosedale Wastewater Treatment Plant Outfall tunnel project in Auckland, New Zealand.
• Spetstonnelsyroy: Purchased a new 3.3 meter mixed face EPB TBM for the construction of the Babushkin Substation Cable Tunnel Project tunnel. A total of 682.5 metres of tunnel will be excavated.
• Morgan Est: Purchased a new 3.5 meter EPB TBM for the construction of Thames Water Ring Main Extension Brixton to Honor Oak. A total of 4,900 metres of tunnel will be excavated.
• Jay Dee/Coluccio/Taisei Joint Venture: Purchased a new 4.7 metre diameter EPB TBM for the construction of the Brightwater Conveyance System, located in Seattle, USA. A total of 6,400 metres of tunnel will be bored.
• Ghella: Purchased two new 7.9 meter soft ground EPB TBM for construction of the 14,200 meter long Arroyo Maldonado flood control tunnel in Buenos Aires, Argentina.
• Microtunel S.A.: Purchased a refurbished 4.0 meter EPB TBM for construction of the Bogota Sewer Tunnels in Bogota, Columbia.
• Celikler Construction Group: Purchased a refurbished 3.1 meter EPB TBM for construction of the BEYLERBEYI KÜÇÜKSU Waste Water tunnel in Turkey.
• McConnel Dowell: Purchased a new 4.3 meter EPB TBM, to be used for the construction of the Orakei Main Sewer Hobson Diversion (OMSHD) Tunnel project located in Auckland, New Zealand.

NORMET

Normet Group is a Finnish manufacturer of underground specialty equipment that is used in tunnelling and mining. Normet's range of machines covers concrete spraying, lifting, charging, scaling and transport. They can be used in small, mid-size and large underground spaces and depending on application, are fitted with one or two booms. Consequently, Normet is one of the most experienced suppliers of these types of equipment in the world. The company was founded in 1962 and is located in the town of Iisalmi in Finland. In 2007, Normet made a corporate decision to globalise its functions. The sales, marketing and customer service were moved to the town of Baar in Switzerland under the name of Normet International Ltd. Furthermore, regional offices were established as well as a new dealer network was worked out.

The Americas regional office is located in Miami, Florida. For Latin America, there is an office in Santiago de Chile. The Asian regional office is in Adelaide, South Australia. Other offices in the region are located in Shanghai, China and there are three additional branch offices in Australia. The European regional office is in Baar, Switzerland. The region Europe is also in charge of Africa and the Middle East. In Russia there are three offices and there is a subsidiary operation in Kazakhstan.
Normet enjoys a vast process and application experience in

underground projects. Recently Normet established a new concept called Life Time Care (LTC) to cater the customers' machines from start-up until the end so as to offer a lifetime support. The concept incorporates following aspects and functions: Start-up services, training, consultation, service and warranty contracts, spare parts, maintenance and repairs, diagnostic services, rebuilding and modernisation, rental services, second hand sales, concrete chemicals, and audit services. The objective is to make sure that customers get the optimum cost-efficiency from the equipment through its entire life.

ROBBINS

With more than 50 years of innovation and experience, The Robbins Company is the world's foremost developer and manufacturer of advanced, underground construction machinery. The past year was a particularly notable one, from entering the soft ground tunneling market to taking on some of the largest TBM projects ever.

Robbins continues to be the leading supplier of hard rock TBMs, and is now branching out to supply Earth Pressure Balance Machines worldwide. In addition to projects utilizing Robbins EPBs in China, the U.S., and Azerbaijan, the company has manufactured two 6.5 m EPBs for the New Delhi Metro Extension Project in India. The two machines, launched on 5 May 2008, are boring parallel 2.0 km tunnels between the Udyog Bhawan and Green Park areas.

In March 2008, Robbins honed its TBM assembly process first used on the Niagara Tunnel Project, called Initial Onsite Assembly (IOA). A 10.0 m diameter Double Shield TBM was assembled for the AMR Project in Andhra Pradesh, India. The TBM is the first of two machines that will bore a 43.5 km water tunnel—the world's longest tunnel without intermediate access. Assembly of the machine was completed onsite in a launch pit, without pre-erection in a manufacturing facility. IOA has been proven to save time on the construction schedule and money to contractors without compromising quality.

Also at the AMR Project, new strides have been made in Robbins continuous conveyor systems. The systems will run behind each TBM, stretching to 22.5 km in length with several shorter flights. The conveyor components will be identical to those designed for the nearby Pula Subbaiah Veligonda Tunnel #2, allowing for interchanging of components. The Veligonda conveyor system will be the longest single conveyor flight Robbins has yet provided (19.2 km). In addition to conveyors, Robbins will supply a third 10.0 m Double Shield machine and back-up system for the Veligonda Tunnel.

Robbins is on its way to another successful year in 2008, with major contracts signed for projects around the world. To find out the latest news about recent projects and breakthroughs, visit www.TheRobbinsCompany.com

SIKA

Sika AG, located in Baar, Switzerland, is a globally integrated company supplying specialty chemicals markets. It is a leader in processing materials used in sealing, bonding, damping, reinforcing and protecting load-bearing structures in construction and industry.

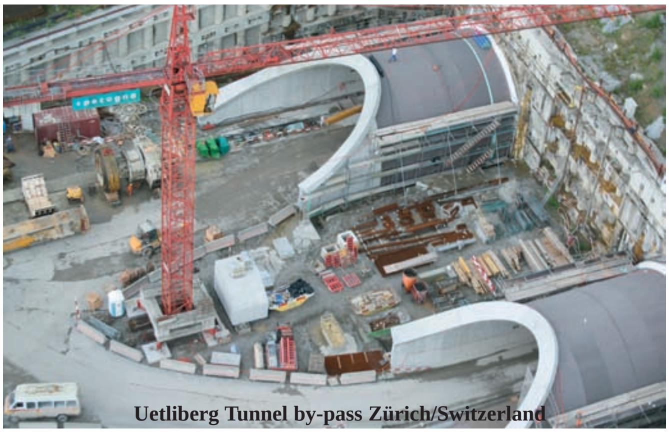
The company's product lines include high-grade concrete admixtures, specialty mortars, sealants and adhesives, damping and reinforcing materials, structural strengthening systems, industrial flooring and sealing films.

Sika systems replace dated technologies like screws, rivets and welds and provide customers with heretofore unheard of opportunities for innovation. The company's mission is to help customers create added value and to constantly keep one step ahead of the competition.

Subsidiaries in 71 countries worldwide and 11 700 employees link customers directly to Sika and guarantee the success of all of its business relationships. With this structure, Sika generates sales of approximately CHF 4.6 billion annually.

In all regions growth was butteressed by numerous major projects. Consolidation in the construction industry continues, primarily among cement and ready-mix concrete producers. The key account management is also of central significance among internationally active companies, because major projects such as new airports or bridges are often prepared at enterprise headquarters and then locally implemented. Here Sika can leverage all the advantages of its global organization and its wide array of products. Significant additional orders in various countries are the result of this successful strategic orientation.

Sika is known as a reliable partner in the tunneling business for safeguarding of excavation (Sigunit, Aliva, Sika-PM), waterproofing (Sika Plan), arch construction (Sika ViscoCrete) and for



Uetliberg Tunnel by-pass Zürich/Switzerland

concrete protection (Sika Guard). The individual solutions provider Sika, is known towards extraordinary requirements in the infrastructure domain e.g. with the Sika ViscoCrete Toolbox.

Sika made its admixture Sika ViscoCrete, which stems from the range of high-value concrete admixtures, marketable for mid-range quality applications and thereby extended its market penetration. This development is of substantial significance above all in the growth markets, since up-and-coming local competitor’s market share can thereby be contested and conventional admixture technologies supplanted.

STAJ

Rheological foam shield tunneling implemented under railway tracks in service

This project for Keio Railway located near Chofu Station in Tokyo is the relocation of approximately 3.3 kilometers long railway tracks and three stations existing all at grade to the underground. All works are executed maintaining railway tracks and stations in service.

The scope of an 861 meters long section between Kokuryo Station and Chofu Station includes the excavation of two bores by an EPB machine to install 6.7 meter outer diameter segmental rings and the construction of new underground Fuda Station while the existing surface loads are underpinned.

The machine bores through the layer of gravel with the anticipated maximum size of 300 millimeters and encounters the minimum cover of 4.8 meters. Rheological foam will be used for stabilizing face to prevent adverse effects to the operating railway tracks occurring.

A 12.94m diameter, 2,100 ton shield machine lift-down and U-turn work

A 12.94m diameter, 2,100 ton shield machine lift-down and U-turn work was successfully completed at Ohashi tunnel work, which builds 430m vertically parallel twin highway tunnels for MEX Central Circular Shinjuku Route in the Tokyo Metropolitan Area. After excavating the upper tunnel, slurry shield machine was lowered by 14m using 14 numbers of 400-ton hydraulic jacks mounted on eight numbers of 3m-height beams set on the arrival shaft wall. Then shield machine on the machine cradle made a 180 degree turn at the shaft bottom. Twenty-eight numbers of friction reduction units, steel boxes inside which 90mm diameter steel ball bearings are incorporated, were strategically arranged under the machine cradle in order to reduce the friction between the cradle and the steel plates on the shaft bottom.

STC

SWISS TUNNELLING CONSULTANTS is a partnership of **BG Consulting Engineers, Amberg Engineering Ltd.** and **Lombardi Engineering Ltd.** to contribute with their vast knowledge in deep and long tunnelling to the design and implementation for further similar underground works. The technology in this field shall help to cope with next challenges and tunnels to be driven even further and deeper.

In the past the partners have individually and jointly worked on long deep alpine tunnels, like the Gotthard Road Tunnel, Vereina Tunnel or Loetschberg Base Tunnel. Many of them record setting projects.

The partners are currently working on a number of special tunnels, like the Gotthard Base Tunnel, the Semmering Base Tunnel, the Koralmtunnel, or the Gibraltar Crossing.

These projects lead to the first project where all three of them contribute to, a priority project for the European Union: The new Lyon-Turin rail connection (LTF). Lying at the intersection between the north - south and east - west communication-axes between Italy and France this link will help to complete the European rail network, both for passengers and freight.

The focused joint Franco-Italian Stretch will include a major civil-engineering structure: the 52-km international "base" tunnel between Saint-Jean de Maurienne and Susa Valley. Actually Lombardi Ltd. is in charge of the site supervision of the main intermediate adit at Modane.

Based on the “Avant Project de Reference”, which was worked out by Amberg Engineering Ltd. in a JV with partners, STC was awarded with two consulting contracts for support in establishing the required studies for the railway infrastructure. The contracts cover the Safety and security subjects, as well as Civil Engineering, Geology and Environment.

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ITA "Supporters" Report 2007

BABENDERERDE ENGINEERS

As a German company, with subsidiaries in the US and in Brazil, we provide consulting services for tunnel and underground projects worldwide. Dedication and focus on quality has allowed us to deliver successful projects for Clients and Contractors.

Most recent services include design work for highway tunnels under water straits, technical specifications for mechanized tunnelling, construction management services for railway projects, as well as inspections and trouble shooting for TBMs in difficult situations. New projects around the world have broadened our experience in contracting modes such as DBB, D&B and PPP.

Our TPC software, engineered to monitor all aspects of mechanized tunnelling, has been enhanced to provide comprehensive and user friendly reports. Tunnelling data, shift reports, quality management data and production statistics – all can be easily accessed from a central client's computer or through the internet

VSH HAGERBACH TEST GALLERY

Hagerbach Test Gallery Ltd. is a 100% private research and development provider located in the east of Switzerland. With a unique gallery net with a dimension of 5 km and two geological units, one area of limestone and one area of slate, and a fire gallery of about 250 m length VSH Hagerbach Test Gallery Ltd. is able to execute a wide range of experiments for underground constructions. Therefore costumers of various countries come to the gallery, in order to expand their know-how. Blazing flames and hot air welcomed in 2007 Slovakian and Israeli fire brigade at VSH fire fighter training field for street and railway tunnels

The expert knowledge in large scale fire tests of tunnel equipment was used to test the behaviour of sealings for segmental linings. Even under high temperatures of more than 1'000°C in the tunnel the temperatures at the level of the rubber sealing remained at a low level.

For a running tunnel construction site, tests were done, in order to investigate the noise transmission due to blasting work through the rock. The investigation was necessary to enhance the well being of the neighbourhood of the construction site. To protect bentonit sealing a concrete with low-ph-value was applied under real scale conditions. The EU founded project L-surf (Large Scale Underground Research Facility for safety and security; www.l-surf.org) prepared the integration of further partners into the project. Man, machine, method, material and Mother Nature melt to successful and inte-grated research at VSH Hagerbach Test Gallery Ltd. in 2007 again.

Hard Fact No. 10

System Solution for Tunnel Construction

Your challenge: Building constructions in time with high application safety and efficient cost structure.
Our solution: Sika Systems from the excavation support to the tunnel surface coating.

For Information about the Sika Solutions and Products or additional Hard Facts, please visit *www.sika.com/hardfacts*

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