TRIBUNE

ASSOCIATION INTERNATIONALE DES TRAVAUX EN SOUTERRAIN
AITES

ITA
INTERNATIONAL TUNNELLING ASSOCIATION

ITA newsletter - la lettre de l'AITES

N° 23 - OCTOBRE 2002 - ISSN 1267-8422

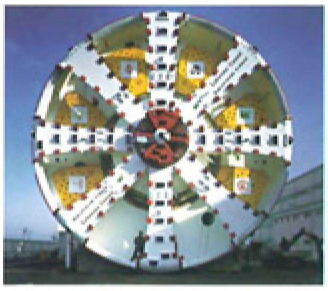
PROJECT LEFORTOVO

From a single source.

For the tunnelling of the 2km long highway tunnel in the district of Lefortovo in Russia's capital Moscow Herrenknecht not only provided the world's largest Mixshield (Ø 14.20m). In cooperation with affiliated companies Herrenknecht also provided the complete peripheral site equipment such as trucks, dumpers, separation plant, compressor station, grout mixing plant and cooling tower.

In August 2002 the tunnelling machine has already excavated 1,108m, more than half of the tunnel route. The project development, which has run smoothly so far, shows that Herrenknecht possesses the opportunities, the experience and the know-how to perform as a „Full Service Provider“ in the field of mechanical tunnelling technology.

Herrenknecht. The Trailblazer.



Contractor:
AO Corporation Transstroy
Geology:
fine to coarse sand, clay, limestone (medium strength, partially very fissured)

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www.herrenknecht.com

HERRENKNECHT
Tunnelling Systems

The Matsesta tunnel, 1316 m long, is situated on the Black Sea Coast road. It has been completed and put into operation in 2001.

Le tunnel de Matsesta (1316m) est situé sur la route de la côte de la Mer Noire. Ila été mis en service en 2001.

2.600 copies of this issue have been printed

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la lettre de l'AITES

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Nous sommes heureux de vous communiquer la nouvelle adresse du secrétariat en Suisse:

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ITA IN BRIEF • L'AITES EN BREF

FOUNDED IN 1974

ITA has 50 Member Nations and 280 Affiliate Members.

The aims of ITA are to encourage planning of the subsurface and to promote advances in the preparatory investigations for tunnels and in the design, construction and maintenance of tunnels by bringing together information thereon and by studying questions related thereto.

The Association fulfils its mission :
- by facilitating the exchange of information among its members,
- by holding public or other meetings,
- by organising and coordinating studies and experiments,
- by publishing proceedings, reports and documents.

FONDÉE EN 1974

L'AITES compte 50 Nations Membres et 280 Membres Affiliés.

Les buts de l'AITES sont d'encourager l'étude de l'utilisation et de l'aménagement du sous-sol et de promouvoir les progrès dans les reconnaissances préalables, la conception, la construction et l'entretien des tunnels en rassemblant les informations ainsi qu'en étudiant les questions qui s'y rapportent.

L'Association remplit sa mission :
- en facilitant l'échange d'informations entre ses membres,
- en organisant des réunions publiques ou non,
- en organisant et en coordonnant des études et des expérimentations,
- en publiant des comptes rendus, rapports et documents.

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FOCUS ON RUSSIA & CIS COUNTRIES

1 • THE RUSSIAN TUNNELLING ASSOCIATION

L'Association Russe des Travaux en Souterrain a été créée en 1990 avec l'aide de la société Transtroy et sous l'égide de l'AITES. L'évènement principal de 2002 est la tenue du congrès "Travaux souterrains en Russie et dans les pays du CIS à l'aube du siècle : expérience et perspectives".

Author : V.A Brezhnev, Chairman of the board, Russian Tunnelling Association; President Corporation Transtroy OJSC, Moscow

Transport construction industry in Russia has historically developed as a multi-lateral and highly science-consuming branch characteristic with a sound production, scientific and technical potential. This is why, the scientific and technical progress has always been and remains to be among our day-to-day priority activities. It is on the basis of this progress that the traditional engineering construction practice in the field of tunnels, subways, bridge and hydraulic structures, highways and airports, railways and transport infrastructure projects is developed.

During the drastic change of economic relations accompanied with the elimination of construction industry ministries including the Transport Construction Ministry, we came across a challenge to elaborate efficacious instruments enabling to preserve vitally important technological and creative links between companies and enterprises, between the science and the production. Hence, it was a well-considered and well-realized step on the part of Corporation "Transstroy", legal successor of the Transport Construction Ministry, to participate in forming and promoting activities of professional public associations whose basic aim was to unite the community of scientists, designers, manufacturers and contractors and to show them Russian transportation system development ways. It is not by chance that during last 10 years we evidence fruitful activities of the Russian Transport Academy Transport construction division, Scientific/technical Association of transport construction specialists, Association of bridge builders (Almost Found) and Russian Tunnelling Association.

Russian Tunnelling Association, professional public union of specialists and organizations active in the field of underground construction and development, was formed in 1990 with immediate participation of Corporation "Transstroy" and under support of the International Tunnelling Association.

Tunnelling Association's organizational structure is built in such a way that its branches composed of specialists active in design and construction of tunnels and other underground structures are formed in organizations and companies of the tunneling sector. It makes possible to get reliable site information on projects under design and construction, on tunneling equipment manufactured and on scientific research programs, that is to be in the course of companies' affairs and of various underground construction problems.

The Presidium and the Board Directory, Association's managing bodies, have concentrated on several main activities.

Holding conferences, symposia, technical sessions, seminars and meetings of specialists to discuss scientific, technical and practical issues is a key activity direction for the Russian Tunnelling Association.

In 2001, the Association born main load of preparing the "Urban development technologies of the XXI-st century" scientific and practical conference held by the Union of scientific and engineering public organizations. "New water-proofing materials and technologies for underground works" was held too.

A seminar on the application of new technologies was held early this year in the course of which the following issues were discussed : soil stabilization technologies for tunnels and other underground construction projects, building road tunnels under railway lines on the basis of forwarding pipe screens ; experience of tunneling on the basis of face support tunnel boring machines.

Visits of currently built projects and acting enterprises, site demonstration of new construction techniques and management methods are indispensable attributes of such events.

The 2002 most important event is "Tunneling in Russia and in CIS countries early this century : experience and prospects" International research/ practical conference with the participation of tunnelers from CIS countries and specialists of several foreign companies. Thorough preparation to this conference is currently under way and it is expected that the conference will promote broad exchange of opinions on various issues related to design and construction of underground works.

"Metro and Tunnels", Russian Tunnelling Association's scientific research and information magazine, has become today a regular and important source of information and communication. We strive to make each individual member of the Association, reader of the magazine, feel that through reading its publications he is involved into activities of the Association.

The Association plays a very important role in the search of new technologies, in pushing them to the market and in providing their practical implementation with informational and normative support. Microtunnelling, tunnelling under protection of forwarding pipe screens, lining waterproofing on the basis of Monoflex and other materials, New Austrian construction method, new cast-in/pressed concrete linings, new face support tunneling complexes and other advanced technical solutions were found, examined and recommended for particular projects by Tunnelling Association specialists. Among these projects there are Severomouisky tunnel at the Baikal-Amur Railway Main Line, Nanhchul tunnel at Abakan-Mezhdurechensk railway line, Matsesta road tunnel at Sochi Bypass, Irganay Hydropower Station hydraulic tunnel in Dagestan, underwater tunnel crossing of the Neva River for the Baltic pipeline system, sophisticated transportation tunnels in Moscow including the Lefortovo tunnel.

Subway construction remains to be one of major activities carried out by Investmetro subway construction association and Metro, association of subway operating companies in close cooperation with the Russian Tunnelling Association. In 2001, a section of Moscow Subway length over 1.5 km and its 163rd station (Anino) were completed. Length of Novosibirsk Subway increased by 2.0 km including new Sibirskaya Station. New subway is being built in Kazan with its first line length almost 8 km planned for operation in 2005. One proceeds with construction of subways in St.-Petersburg, Ekaterinburg, Nizhny Novgorod, Krasnoyarsk and Omsk.

Tunnelling Association specialists took immediate part in writing a comprehensive analytical work on subway development scientific research and technical problems prepared by Corporation "Transstroy" and reviewed by RF Gosstroy Scientific and Technical Council.

Another very important Association's activity direction Association consists in developing and issuing new normative documents, tunneling specialists being broadly drawn to this work. Parts of the new SniP (Russian Codes of Construction Practice) and "Subways" Regulations Book are under development. Last year, "Safety Rules for Underground Construction Projects" and norms on trenchless utility laying techniques on the basis of microtonneling complexes and special equipment were completed, other normative documents and manuals are being prepared.Tunnelling Association's scientific / technical advisory Board and experts regularly participate in examining new designs.

Russian Tunnelling Association's scientific / technical advisory Board, a very authoritative body, regularly reviews designs for new projects and issues its conclusions on the subject. Thus, the Board has twice gathered to review issues related to largest urban road tunnel passing through Lefortovo protected zone in Moscow, the sittings being attended by representatives of the Government of Moscow and personally by Mr. Yu.M.Luzhkov, Mayor. The tunnel, diameter 14.2 m and length over 3.2 km, is being executed in cooperation with specialists from Germany and France using a special tunnel boring machine.

Prospective projects are also within Tunnelling Association experts' involvement field : optional investment feasibility reports for tunnel from the mainland to Sakhalin Island have been examined, draft proposals for a tunnel under the Bering Straits were prepared.

To give a more full idea of the Russian Tunnelling Association, the kernel of this collective should be mentioned : Mr. S.N.Vlasov, Executive Director; Professor N.S.Bulychev, Russia Representative in the International Tunnelling Association ; Professor D.M.Golitsinsky, head of the RTA St.-Petersburg regional branch ; Board members : Mrs. S.F.Pankina, Mr. V.N.Alexandrov, Mr. P.G.Vasilevsky, Mr. V.N.Zhukov an many other specialists.

I believe this brief review will give "Tribune" readers certain idea on the Russian Tunnelling Association.

2 • ACHIEVEMENTS IN MOSCOW UNDEGROUND CONSTRUCTION SPHERE

Moscou est une mégalopole dynamique et l'urbanisme souterrain y joue un rôle primordial tant dans les tranports que pour la construction de nouveaux centres d'affaires.

Authors : V.G. Lerner, First Deputy General Director, Mosinzhstroy OJSC
E.V. Petrenko, PhD, Deputy Chairman Scientific and Expert Council, Russian Tunnelling Association

The capital of Russia is at present among world most dynamically developing megapolices. This is a city where large-scale underground space development projects are successfully implemented.

Last years, tunnel and other underground construction projects have gained in scale and became functionally more varied. Thus, a unique commercial/recreational complex called "Okhotny Ryad" on Manezhnaya Square, four-level underground parking lot under Teatralnaya Square were built ; the following works are currently under construction : transport interchange under Gagarin Square and Kutuzovsky Avenue, "Tsariov Sad" (Tsar's Garden) at Sofiyskaya Embankment and "Moscow-City" International business center unique multi-functional and multi-level complexes with their underground parts, the Lefortovo tunnel (diameter 14.2 m) built with Herrenknecht tunnel boring machine, new Moscow Metro stations. According to assessment made by experts of the International Tunnelling Association, the "Okhotny Ryad" multi-functional underground commercial/recreational complex on Manezhnaya Square (total area 70 000m²) built close to Moscow Metro and considered to be among Europe largest structures of this type has been entered into the list of world largest underground works of XX century.

At present, Moscow largest construction project is creation of the central kernel part of the Moscow City International business center. This complex comprises the following main functional zones :

- metro transition junction,
- multi-level underground parking lot,
- "underground city",
- congress-hall complex,
- complex for cultural and entertainment events,
- 50-storey hotel high-rizer,
- "Park-City" with a group of fountains, walking ways, flower beds, lawns, recreation zones.

Underground part of the Moscow-City complex is designed in six levels :

- two lower floors as part of the metro transition junction and Mezhdunarodnaya metro station, area of the first and second floors making 90 000 m²,
- three parking lot medium floors for 2,500 cars,
- first upper floor to accommodate "underground city", commercial public space.

For environment protection considerations, protective bearing and anti-filtration wall as thick as 0.9 m is built along the pit circumference. Bearing walls as thick as 0.8 m are being built along metro tracks, utility collectors being provided along pit sides. The protective bearing and anti-filtration wall (length 1768 m, total area 40 000 m², depth 24-26m) is one of Europe largest closed reinforced concrete walls of this type.

Since the earth-moving work commenced, monitoring has been arranged to supervise safety of the earth work and condition of the surrounding built-up areas. No deformation of structures or setting resulted from the Moscow City complex underground construction work has been detected so far.

Technical and technological construction improvements in the field of tunnels and other underground structures have become new reality in Moscow resulting in increased functional safety of the conquered underground space, better underground construction work safety and higher living standards of the citizens. While driving road and utility tunnels and other underground structures as well as while constructing metro structures, special attention is paid to preserve buildings, structures and utilities located above the underground structures and adjacent to underground construction sites. So far as laying of communal utilities is concerned, increased importance and implementation are given to trenchless technologies resulting in saving of the habitation environment and safety of buildings and structures adjacent to utilities laid.

Moscow underground space development early XXI century demands that management and technological schemes used for underground construction projects get more and more perfect, although they have already become essentially intelligent.

Reliability of tunnels and other underground structures is provided through special measures, through combination of different underground construction techniques including those highly mechanized and through monitoring of geological conditions.

Mosinzhstroy construction holding as Moscow leading organization in the field of infrastructure construction projects carries out a good deal of work related to Russian capital underground space development both in newly built housing regions and in built-up parts of the city center.

Experience gained by Mosinzhstroy in Moscow demonstrates that the use of up-to-date underground technologies makes it possible to build tunnels and other underground structures under constrained megapolice conditions bringing the scope of open excavation and influence to road traffic to minimum.

In order to quickly and safely solve the problem of building tunnels under unfavorable Moscow conditions on the basis of mechanized tunneling techniques and without settings, Mitsubishi and Bessac boring machines are used. Lining of precise reinforced concrete segments was used for a collector diameter 4.3 m driven with Bessac shield.

Accuracy and truthfulness of hydrogeological and other survey data are factors most important to increase reliability of construction projects built under conditions of Moscow. With this aim at end and for the first time in domestic construction practice, Mosinzhstroy has implemented a tunnel georadar enabling to scan soils through which collector in the region of Kotelnicheskaya Embankment passes and to forecast irregular or failure zones.

Last year experience has shown that sinking wells, slurry walls and secant bore piles are very feasible if used for Moscow underground space development projects.

Urban environment protection requirements and in particular, needs to isolate pits of underground and surface structures from ground water have initiated development of various techniques and equipment making it possible to build anti-filtration curtains (AFC) after construction procedures essentially similar to those used to build bearing slurry wall structures.

While building two transport tunnels, the secant bore pile techniques (diameter of piles 1 m) were used to construct a wall as deep as 18 m under protection of which soil was excavated down the tunnel vault elevations and B30 W12 concrete was cast to the ceiling. Subsequently, excavation is made under protection of the ceiling and road traffic is restored, the latter being very important for cities overflown with vehicles.

Conclusion

Moscow is one of world dynamically developing megapolices where large-scale underground development projects are implemented on the basis of up-to-date architectural trends and newest achievements in the field of science and engineering as well as construction technologies and equipment.

By removing various communal services, utilities and structures under the surface, cities can increase open urban areas for housing, parks, green squares and recreation zones, that is to improve their architectural appearance and to create more healthy environmental conditions.

3 • NEW URBAN ROAD TUNNEL IN MOSCOW

Le troisième périphérique de Moscou est en cours de construction. L'ouvrage le plus important de cet axe est le tunnel de Lefortovo, de 3246 m de long, permettant de passer sous un parc et une zone historique. Le tunnel est construit avec un tunnelier de 14,2 m de diamètre.

Authors : V.A bessolov, Chief Lefortovo Tunnels Construction Board
V.P. Grachov, General Director Transtroytonnel JSC

In conformity with a decree of the Government of Moscow, the 3rd Transportation Ring construction project is under way since 1998, the project being an expressway of the top city rank characteristic with uninterrupted road traffic flows, 3 to 4 lanes each direction, multy-level stream-traffic type transport interchanges and non-level pedestrian passages.

The largest structure of the 3rd Transportation Ring which will close the ring in 2003 is a road tunnel under the "Lefortovo – Nemetskaya Sloboda", vast protected park zone with historic monuments (XIII-century buildings), fountains and reservoirs (lakes).

The tunnel is as long as 3246 m, design traffic intensity of its three lanes makes 3600 vehicles per hour.

Resulting from latest decisions taken with respect of the 3rd Transportation Ring, traffic from point "B" to point "A" will be accommodated by one of initially planned two deep Lefortovo tunnels. The tunnel will provide for the complete safety of historical buildings, and structures as well as of utilities, fountains and reservoirs. Local underground water flow pattern will be disturbed in lesser extent, there will be no any barrage effect.

The tunnel will be built under adverse geological and urban development conditions subject to special attention while implementing the project.

Soil massive along the tunnel alignment is vertically composed of mixed strata of the Quaternary, Jurassic and Coal periods represented by oddly stratified alluvial soils, water-bearing sands, moraine loams of varied depth and Jurassic clays and loams.

Below the Jusrassic sediments there are limestone/dolomite and clay/clay-stone formations.

Hydrogeological conditions of the region are characteristic with a high table of ground water coming from the Perkhour and Ratmir sources. Hydrostatic pressure on the lining may reach 0.3 MPa.

Alignment of the road tunnel starts from Spartakovskaya Square, crosses Bakuninskaya, Bolshaya Pochtovaya and Malaya Pochtovaya Streets and the Yauza River, passes under the Lefortovo region and reaches Entouziastov Chaussee through Prolomnaya Street.

Scheme of the 3rd road in Moscow
1 - big ring (blue)
2 - small ring (red)

At the protected area through which the tunnel route passes there are the following historical and cultural monuments situated along the route : the first military hospital built in XVIII–XIX centuries, 4 "Widow houses" and greenhouse (XVIII century), military medical attendants school (1820), Ekaterina's Palace (XVIII-XIX centuries), St. Peter and Paul church, 1711 (with XIX century fence and gate) in the Soldiers settlement and the 36-ha Lefortovo park with fountains.

Tunnel structure

The tunnel is a complex of underground structures built at various depths in various techniques :

• deep part built in closed techniques is a 2211 m long round cross-section tunnel, outer diameter 13.75 m and internal diameter 12.35 m, lined with precast reinforced concrete segments, depth 0.7 m, width of the ring 2 m ; sealing is provided with two rows of elastomer rubber joint gaskets,

- shallow part at points A and B, total length 700 m, built in cut-and-cover techniques of cast-in-situ reinforced concrete frame sections sealed with special film cover,
- tunnel approach ramps, length 155.0 and 180.0 m, of cast-in-situ reinforced concrete including water-sealing and drainage systems.

A carriageway platform is provided for the traffic all along the tunnel, the under-carrageway space being used to accommodate utilities and tunnel maintenance services.

Work execution

Taking into account severe site hydrogeological conditions including increased hydrostatic pressure, the tunnel is built using Herrenknecht tunnel boring machine, diameter 14.2 m, the face being actively supported with thixotropic bentonite slurry. In the course of tunneling, face stability is permanently secured by bentonite slurry cushion pushed with adjustable compressed air.

Cutting Head installation of the Herrenknecht shield

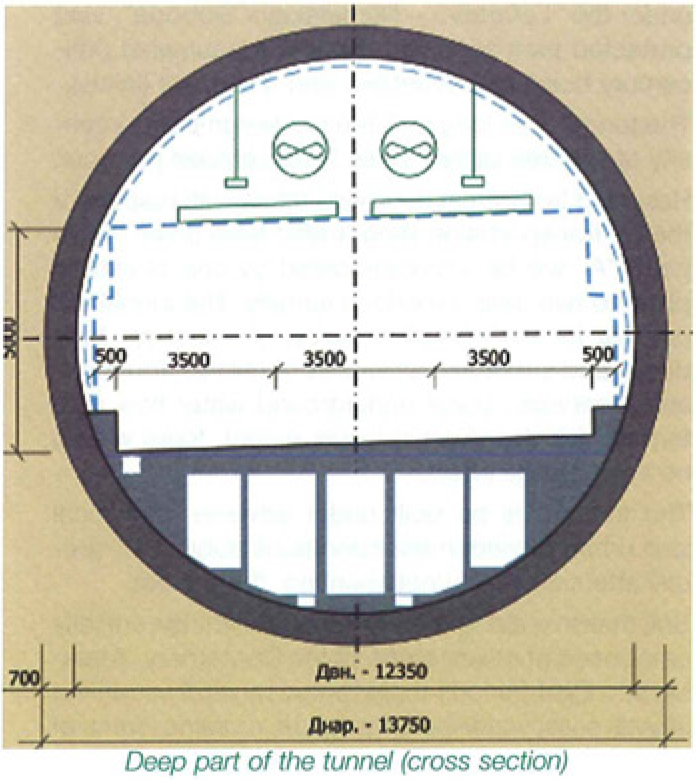
Soil developed in the face is caught by the bentonite slurry and delivered through pipelines to a surface separator unit where hard soil fractions are separated from the slurry and the latter is returned to the face zone.

Reinforced concrete segments are delivered to the erector by mine diesel locomotives and installed into the lining rings.

TBM driving along the alignment set in the design is controlled automatically or semi-automatically.

This is a high tunneling technology without tunnel drivers, trammers or any hand labor. The work is governed by computers managed by people.

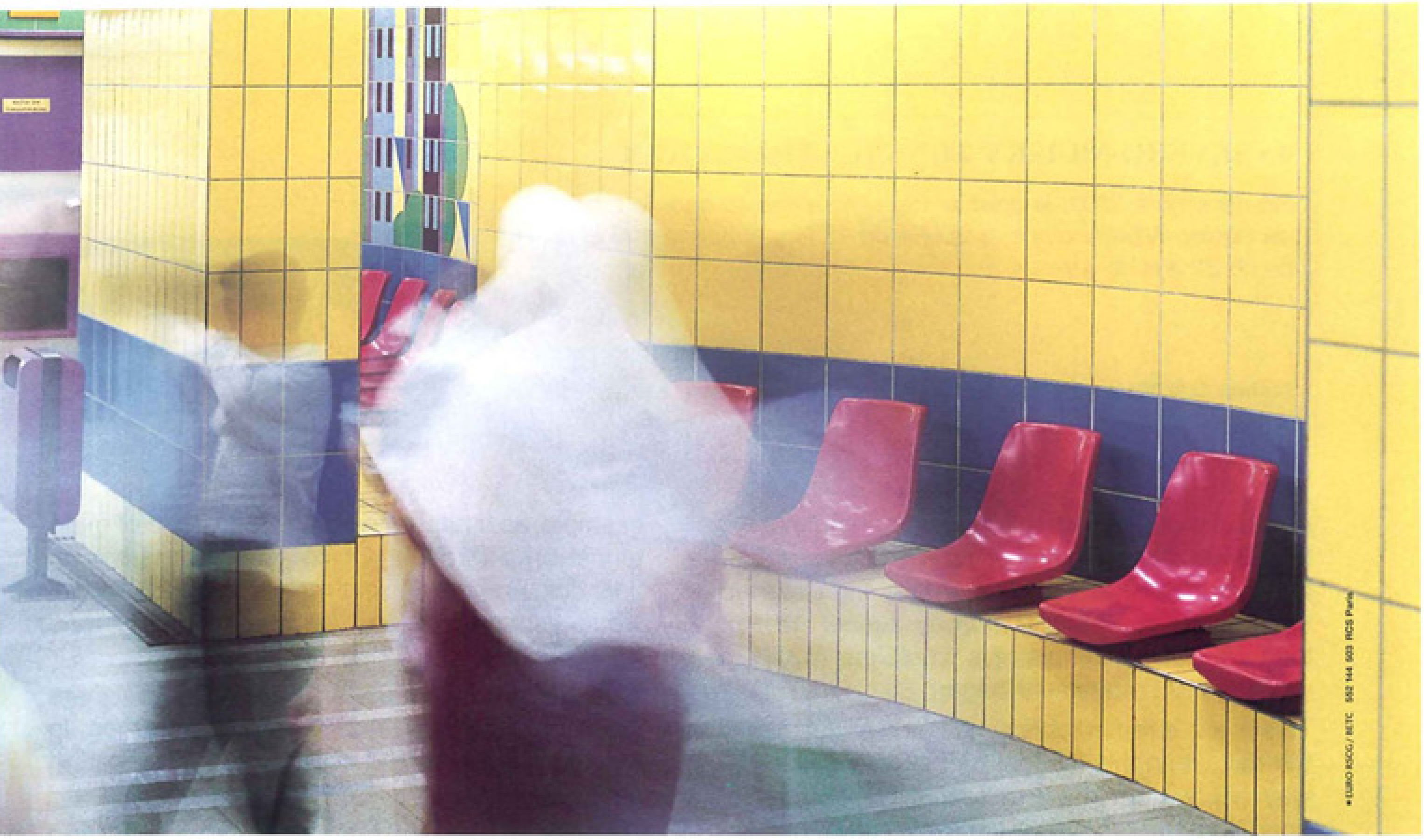
So far as TBM diameter and tunnel cross-section width are concerned, this is Europe and Russia largest road urban tunnel. Special settlement-free tunneling technology combined with water-proof precast reinforced concrete lining eliminates any negative effect of the tunnel to the surface of the Lefortovo protected zone both during construction and operation.



Deep part of the tunnel (cross section)

Resulting from tender held by the Government of Moscow and on behalf of the latter, design and construction of this tunnel are carried out by :

- Organizator Ltd. as Client ;
- Corporation "Transstroy" as General Contractor with participation of several foreign companies (Herrenknecht and VINCI) as well as some Moscow construction and design companies.



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4 • SEVERO-MUISKY TUNNEL : TRAINS RUN

Fin décembre 2001, le premier train test a circulé dans le tunnel de Severo-Muisky d'une longueur de 15 km, annonçant ainsi la fin de 20 ans de travaux.

Author : S.N. Vlasov, Russian Tunnelling Associatin, Moscow

At the end of December 2001 a remarkable event happened for the tunnel engineering and technical community of Russia : a test train started through Severo-Muisky railway tunnel 15 km long on Baikalo-Amurskaya trunk-line (BAM), a working train movement began.

This event is remarkable as at last it brings closer the day when this longest tunnel of Russian railway net will be made available for permanent operation in 2002 and an intensive labour of BAM tunnellers during 20 years will be completed.

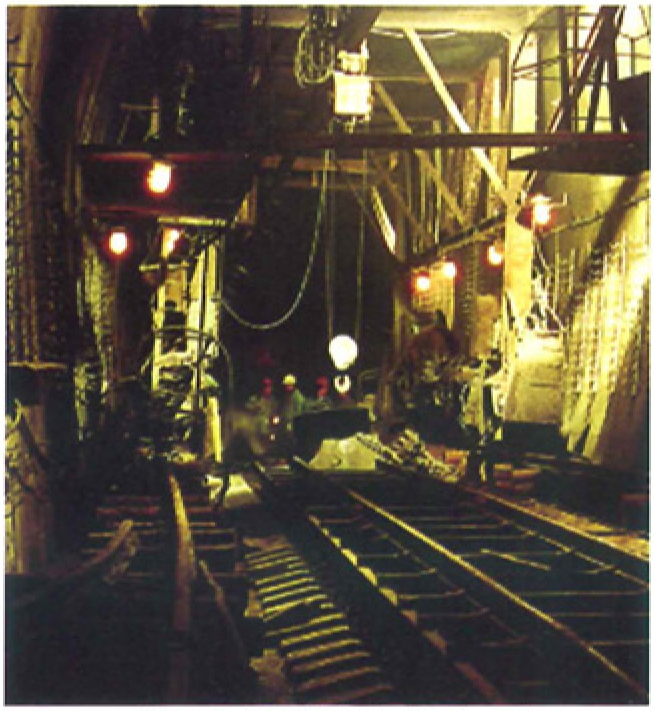
Severo-Muisky tunnel is among ten largest world tunnels, if to take into consideration the length and the complexity of driving and construction work and unfortunately the duration of construction.

World tunnel history knows such situations when tunnels have been constructed during very long periods of time because of difficult geological and technical conditions, sometimes the works were stopped, tunnel routes were changed, new technological decisions developed and used. Among those difficult tunnels there are such ones as Tun two-way tunnel 7.8 km long in Japan that have been constructed during 20 years, Big Apennine tunnel 18,5 km long in Italy that has been constructed during 16 years and at last Seikan. This is a unique tunnel 53.0 km long under Seikan Strait, which construction was begun in fifties and completed in the middle of eighties. First of all the duration of Severo-Muisky tunnel construction was connected with extraordinary difficult geological and hydro-geological conditions : granites of various strength and stability cut by water-bearing zones of tectonic fractures where rocks were razed to water-bearing debris which mostly have high hydrostatic pressure at long length. Already during the construction it was necessary to change to new technologies, to use special equipment and no-standard and labour-consuming decisions in some cases, for example, as it happened at the last stage of main tunnel breakthrough. Of course some stops in financing and insufficient means to complete the works especially during last 10 years influenced the duration of the tunnel construction.

At the same time Russian tunnellers, designers and scientists acquired a great experience in mountain tunnel driving under difficult engineering and geological and hydro-geological conditions.

The tunnel happened to be a peculiar testing ground to perfect the newest methods of underground openings construction, to employ new technologies, structures and layout solutions, to introduce the most perfect of domestic and foreign equipment, which enriched Russian tunnelling.

So to get an additional information on engineering and geological conditions a cosmic photography was used. Employment of this informa-



Permanent rail laying in the tunnel

tion on Severo-Muisky tunnel helped to reveal the forth fractured zone 800 m long. Unfortunately it was made during construction.

For the first time a service adit with cross section 18 m² was constructed parallel to the railway tunnel and as far as 15 m. The adit was of exploring, transport and drainage use, and during tunnel construction it was excavated 200/300 m ahead of the tunnel face and was used for exploring, drainage and water removal from the rock mass, for opening of new faces for the main tunnel driving and for improvement of ventilation during construction.

While the tunnel could be used permanently, the adit would be used to repair and serve the main tunnel.

The tunnel structures and their outlines were designed of various types depending on engineering and geological conditions along the route. At the portals and in fractured zones the tunnel cross section is round and has its diam. 8,5-9,5 m ; in some tunnel parts the tunnel lining consists of cast-iron tubbings ; in fractured zones the horseshoe lining of reinforced concrete with closed tunnel base is used as possible seismic activities have been taken into consideration. In stable grounds horseshoe-shaped

The tunnel view from the west Point

concrete or reinforced-concrete linings are used.

Special attention was paid to supply tunnelling organizations with modern special tunnelling equipment. With this purpose high-productive drilling gantries, self-propelled mechanized formworks 12 m long, muckers and rock loaders, self-propelled road trains, vans of big load-carrying capacities, concrete pumps were provided to the construction sites in necessary quantities.

For the first time in our country during Severo-Muisky tunnel construction mechanized tunnel boring machines (TBM) with 4.5 and 5.5 m diam. of Robbins and Wirth companies were used to drive transport and drainage adit from the East portal to the forth fractured zone direction.

Of course all these circumstances influenced the works rate.

Under favorable geological conditions the tunnel driving rate was up to 200 m per month, and the excavation rate of the transport and drainage adit was up to 308 m per month.

Works to overcome big fractured zones were very difficult. Ground grouting technology was used and perfected. It helped to excavate the adit and several parts of the tunnel in fractured tectonic zones 1600 m long in total. Such a volume of grouting works in one project is the highest volume of grouting in underground construction of Russia and past Soviet Union.

To fulfil the works of ground water lowering in Angarakansky wash-out drilling rigs for horizontal drilling for the lengths of more than 500 m were used for the first time.

This difficult construction comes to its completion. It is necessary to fulfil waterproofing in the transport and drainage adit, in shafts and ventilation centers, to install permanent units, to make start adjustment and alignment.

The first train has run through Severo-Mmuisky tunnel in the year of the century of Great Trans-Siberian trunk-line operation. The train ran through the tunnel 15.3 km long from the West to the East portal during 32 min.

Opening of trains movement through Severo-Muisky tunnel will help to cut down operational expenditure of load transportation, to increase speeds and safety level of trains movement along the whole Baikalo-Amur trunk-line.

5 • BLACK SEA COAST ROAD TUNNELS

Une route comprenant plusieurs tunnels est actuellement en cours de construction le long de la côte Caucasienne de la Mer Noire. Le tunnel de Matsetsa, de 1316 m de long, a été mis en service en 2001.

Authors: A.P. Golyshev, P.G. Vassilevsky, Bamtonnelstroy OJSC
P.V. Pugolovok, Yuzhnaya Gorno-Stroutelnaya Kompania (Southern Mining Construction Company)

At present, a road with several tunnels is being built along the Black Sea Caucasian coastal line.

This trunk road makes the Black Sea ports – Central Russia – Northern Caucasus transport corridor shorter by 220 km. Largest are the Matsesta tunnel, length 1316 m, and the Shaumyan tunnel, length 1418 m.

The Matsesta tunnel was completed and put into operation in 2001. The tunnel crosses western slope submountain zone in the southern part of the Main Caucasian Ridge formed under strong influence of neotectonic movements and a complex of physical and geological phenomena.

Geological composition of the mountain ridge in its south-north cross-section is characteristic with Paleogene sediments represented by complex mixture of hard quartz/limestone sandstone massives and soft argillite/mudstone sediment strata. The soils are gray and brown-gray, fissurated and stratified. The sandstone is broken with vertical cracks to separate blocks of varied length.

Hydrogeological conditions along the route are characteristic with the absence of a permanently available and continuous water-bearing layer. Water is local met primarily close to tectonic fracture zones in the free-flow regime. Average water inflow varied from 0.05 to 16 m^3/h.

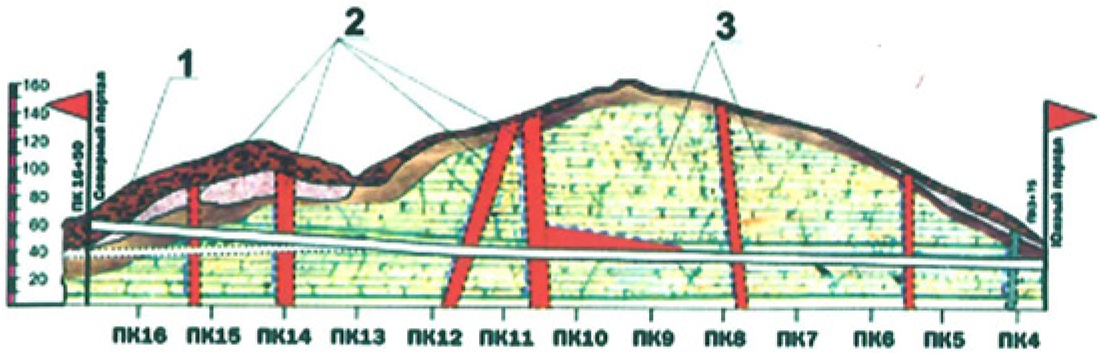
In order to enable tunneling through the longest water-filled fault zones with inflow up to 16 m^3/h, water welling was arranged and hydrostatic head reduced. To do that, fan-set boreholes length up to 240 m were drilled from both the oncoming faces and from side chambers, inflowing water being drained to pump chambers.

Cutting into rock massives at the portals proved to be among most challenging tunnel construction stages.

For safety reasons, tunnel cutting-in was carried out under protection of a forwarding steel pipe screen. Essence of the method consists in drilling rock front bore-holes diameter 146 mm and length up to 30 m over the outer outline of the future tunnel temporary support using Tone-Boring horizontal drilling rig (Japan). Then steel pipes were inserted into the holes using the same rig and cast with cement mortar. While cutting into the rock from the southern portal, the screen was made of 55 pipes diameter 144x7.

In order to prevent possible landslides in the northern portal zone, a drainage adit length 488 m was drilled parallel to the tunnel, space between axes making 20 m. In order to dry the soil up and to relieve the landslide-prone slope of

Matsestinsky road tunnel



Engineering and geological section : 1. alluvial desposits near portals 2. zones of tectonic distrubances and crushing 3. sandstones, aleurolit and argillite excess hydrostatic head, side drifts were bored every 6 m as soon as the adit was completed, filtering columns of steel pipes diameter 76 mm and length from 6 to 51 m being subsequently installed into the drifts.

At the operation stage, the drainage adit will serve as emergency exit in case of fire or other accidents in the tunnel.

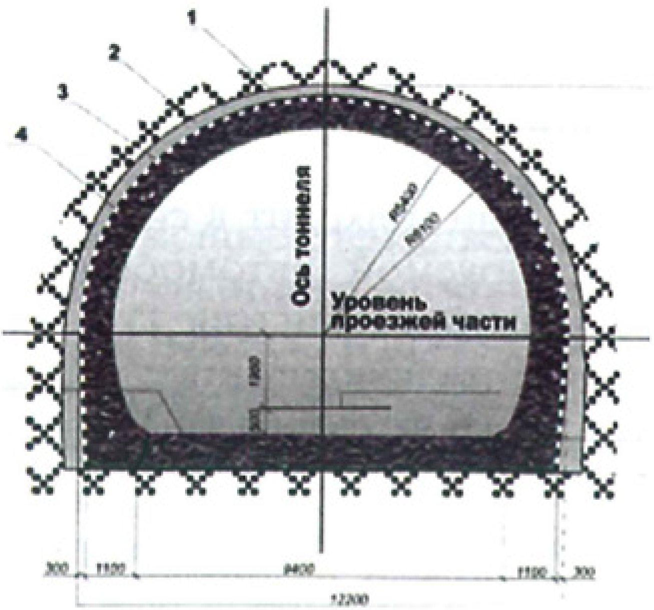
Two-layer precast concrete lining was used almost all along the Matsesta tunnel, film insulation pad being laid between the layers. Depending on rock hardness, arch/concrete or concrete systems were used for external (temporary) lining.

While erecting the permanent lining, data of both geotechnical support and the wide-lane sounding method were taken into account making it possible to use several lining types :

• reinforced concrete lining at 1200 kg/m specific reinforcement rate ;

• similar lining at specific reinforcement rate 1500 kg/m ;

• concrete lining within sections of favorable mining and geological conditions.



Lining structures of Matsestinsky tunnel :
1. tunnel outline
2.exterior (temporary) tunnel lining
3. waterproofing layer (geotextile and Agruflex)

For the first time in domestic tunnelling practice, a two-layer film insulation was provided between the permanent and the temporary lining courses. Essence of the techniques consists in gunning a geotextile, locally manufactured material, to rough concrete of the temporary lining, the material subsequently serving as drainage course. Further, Agru Flex water-proofing film is fixed to special plastic washers (rondels) provided as the first layer fixture elements. The insulation layers are welded together to form a water-tight umbrella-form shell. Water-proofing system built in this way prevents water to leak through the lining even under certain hydrostatic head.

In order to predict the mine and geological condition of the massive and to take timely measures to get prepared to the tunneling techniques chosen, a complex of prospective survey work was realized including :

• forwarding prospective boring along with taking undisturbed samples immediately from the face using Diamek rig (Sweden) ;

• wide-strip geophysical sounding techniques.

Depending on geotechnical conditions come across along the tunnel route, several tunnelling techniques were used.

Drill-and-blast techniques were used in the southern portal part of the tunnel ; large calotte, cross-section area 68.2 m², was open in hard rock massives, while unstable rock was developed in drill-and-blast techniques by dividing the face into a small calotte and a bench height up to 6 m, forwarding anchor support being also used.

Face blast-holes and blast-holes for the forwarding anchor support were drilled using Tamrok boring rig (France).

Muck was loaded to MoAZ (Belorussia) high-capacity dump-trucks by mine loaders PNB-3D2 and PNB-4 and transported to intermediate dump sites arranged close to the portals.

The northern portal part of the tunnel was developed using P-11 (Ukrainia) jumbo equipped with a selective jib working instrument.

Vault part permanent lining along the southern length of the tunnel was installed using Saga-Kogio (Japan) movable steel formwork length 9m.

For the portion of the tunnel beginning from the northern portal, steel formwork length 6m with a set of inserts to change cross-section size was used in the enlarged part of the tunnel and in the smoke evacuation chamber, the formwork having been developed by the design department of Yuzhnaya Gorno-Stroutelnaya Kompania and manufactured by the repair/mechanical shop of this company.

Shield complex PStch-3.7 used to drive the drainage adit was immediately followed with erector of precast reinforced concrete permanent lining diameter 3.6 m.

The tunnelling was carried out simultaneously from three faces : from the southern portal, from the northern portal and from the drainage adit. Connection took place on 24 November 1999, that is 28 months since the main mining work had begun. Axis deviation of two opposite faces made 5 mm in plane and 7 mm in profile.

Inside view of Matsestinsky tunnel

In conformity with international requirements, the Matsesta tunnel is equipped with up-to-date tunnel operation, automatic ventilation, lighting and teleinspection systems.

6 • UNDERGROUND COMPLEX OF IRGANAY HYDRO POWER

Le compexe hydro-électrique d'Irganay compte 25 km de tunnels et plus d'1 million de mètres-cube de terres excavées. Le premier tunnel a été creusé avec un tunnelier de 8,5 m de diamètre entre 1989 et 1995.

Author : V. Zhukov, Institute Gidrospetsproekt, Moscow

Irganay Hydro Power, located in the Northern Caucasus mountains, is known for its extensive underground complex. The total tunnels length is more than 25 km and volume of underground excavation is over 1 million m³.

The most sizable underground structures are two headrace pressure tunnels 5,2 km long each and Gimri road tunnel 4,3 km long, which provides access to Irganay valley. The road tunnel is two-way with 60 m² section and traffic lanes 3,5 m wide each. There is a service adit parallel to the road tunnel in 20 m from it, which is designed for the tunnel ventilation and emergency exit.

"Robbins" TBM dia. 8,5 m was used for driving of the first headrace tunnel. The tunnel driving started in 1989 and was completed only in 1995. The construction rate was affected by poor financing during the period of the USSR dissolution. At the places of mudstone and siltstone with low strength properties there was a rock failure during excavation at the tunnel depth of 800-1000 m. Per average 100 m of tunnel the volume of rock failure was about 80 m³. Considerable plastic deformations took place at the tunnel section over 50 m long in few days after excavation, so that chute block rose up to 40 cm, steel arcs of temporary supports were crumpled and the rock, destructed to coarse crushed stone, was extruded between arcs.

As 270 m long end section is weakly inclined , it was preliminary drove by drilling and blasting. Temporary concrete lining was made for TBM grippers thrust. TBM came out to the surface along this section using its own gripping system.

The Client (The Russian Stock Company Power Grid) resumed financing of Irganay Hydro Power project in 2001. To lift water level in the reservoir, that is expected to be in the end of 2003, it is necessary to construct two road tunnels above dam crest 750 m and 450 m long and about 1,5 km of access and hydro tunnels. The most difficult tunnel to be constructed is the inclined overflow spillway with 170 m² section.

At present TBM is erected at the outlet portal of the second headrace tunnel and is ready to start driving of this 5.2 km long tunnel. In April-May this year the Client is going to take final decision upon expediency of the second headrace tunnel construction, which is intended to supply water for the 3rd and the 4th Hydro Power units.

TBM Robbins is ready to start driving of the first headrace tunnel

Jumbo Boomer-353 is used for excavation of Road tunnels

7 • DEVELOPMENT OF METRO SYSTEMS IN UKRAINE

Ukrmetrtonnelstroy a été créé il y a 10 ans. La construction des métros représente 80 à 90 % de ce groupement de 18 sociétés. L'Ukraine compte 104,5 km de lignes de métro.

Author : V.I. Petrenko, Ukrmetrotonnelsytroy, Ukrainian State Corporation, Kiev Ukraine

Ten years have passed since Ukrainian Cabinet of Ministers took decision to form Ukrmetrotonnelstroy, Ukrainian State Construction Corporation for metro and tunnels. The corporation amalgamates 18 companies and enterprises different in the form of ownership. Among them there are six open joint-stock companies, four closed joint-stock companies, two design/survey institutes. Other enterprises who are of other ownership statute deal with special types of work including water welling, soil freezing, soil chemical stabilization, pit wall protection, track and equipment installation, architectural work, facing and finishing. The companies are technically so well equipped and their personnel is so scientifically and technically experienced that the corporation is capable of solving most challenging metro and tunnel construction problems, the share of metro construction making 80 to 90 per cent of the total scope of construction and assemblage activities of the corporation.

All these metro construction companies own their production bases from where the companies are supplied with all needed to be a success in construction activities : tunnelling, general construction and transportation machines are assembled, repaired and maintained there, precast reinforced concrete lining elements are produced as well as internal structural components, bulk concrete, etc. There are over 7000 highly qualified specialists employed by the corporation making the latter possible to complete various underground and open construction projects at high quality standards and within the agreed schedules independently on geological conditions.

Examination of activities undertaken by the corporation last years proves that decision to form the corporation was crucial to provide for high development rates and improved work quality in the Ukrainian underground construction sphere, since it is companies and enterprises of the corporation who most essentially contribute to solve transportation problems in major cities of Ukraine by creating sophisti-

No.	Parameter	Unit	Kiev	Kharkov	Dnepro-Petrovsk	Total for Ukraine
1	Number of lines	pcs.	3	3	1	7
2	Number of transition centers	pcs.	3	3	-	6
3	Number of stations, including :	-	40	26	6	72
	• built in closed techniques	pcs.	19	6	5	30
	• built in cut-and-cover techniques	pcs.	15	20	1	36
	• surface stations	pcs.	6	-	-	6
4	Construction length of lines	Km	57.7	37.8	9.0	104.5
5	Operational length of lines	Km	51.6	33.0	7.1	91.7
6	Station platform length	M	102	102	102	-
7	Number of cars in train	pcs.	5	5	5	-
8	Train traffic frequency					
	• design	pairs/h	40	40	40	40
	• actual	pairs/h	40-58	32	8	27
9	Average daily passenger traffic	mln.	1.27	0.9	0.07	2.24
10	City population	mln.	2.5	1.65	1.2	51.43
11	Density of metro lines	km/mln	19.47	20.0	5.91	1.78
12	First line takeover year		1960	1975	1995	-

cated metro transportation systems. Main characteristics of metro systems at present under operation in Ukraine are demonstrated in tableabove (as per 1 January 2002).

Worth attention is that metro construction rates have for last ten years reached 3 to 4 km a year. Metro construction projects in Ukraine are financed through municipal and provincial budgets and supported by the State.

Within the time span from 1949 to 2001, the corporation member organizations built and put into operation :

a) metro lines (in two-track measurement) : 104.5 km ;

b) railway, road, hydraulic, pipeline, utility, passenger tunnels, vine-repositories and other underground structures : 82 km.

Stations of various designs have been built : surface ones, underground stations built after cut-and-cover techniques (both of the column and the one-vault types), underground stations built after closed techniques (both of the pylon and the column types waterproofed with both of cast iron, reinforced concrete and combined linings). Special types of particularly watertight concrete and rubber joint gaskets have been widely used.

Workings have been protected against underground water inflow on the basis of up-to-date techniques using new roll-type insulating materials and mastics both locally manufactured and imported.

Owing to combined efforts of scientists, engineers and specialists of the Institute of Mechanics, the Academy of Sciences, Ukraine, Kievmetrostroy OJSC and Ukrmetrotunnelproekt State Design Institute, an umbrella of new design needed to protect passengers against water infiltration was developed, manufactured, implemented at Lukianovskaya Station and used there from 1996 to 1999. Similar umbrella of advanced design characteristic with better water resistance and fireproofing properties, light weight and installation simplicity as well as perfect aesthetics was developed and installed at Dorogozhychi Station. Besides, it was made of ecologically favorable materials.

A series of studies aimed at the improvement of existing construction methods used for large-size underground workings and at further mechanization of production processes have been carried out during last 10 years by the corporation together with scientific research and design institutes as well as with some universities.

In order to provide for higher reliability standards of man-made workings, the following methods of driving vertical, raked and horizontal large- and medium-size workings have been developed and implemented for new metro lines :

- vertical workings driving methods on the basis of special techniques including immersion of lining sections, pipe-jacking, installing secant cast bore piles, using earth-supported excavation techniques, pushing shaft lining sections from ring pits dug above ground water tables (so-called shaft driving man-free soil excavation techniques) ;
- whole-face raked driving techniques used for escalator tunnels diameter 10.1 m in preliminary frozen water-saturated soils to provide for a protection media around the working ;
- whole-face driving techniques for large-size horizontal workings (station tunnels, ramp chambers, blocks of service premises, combined traction substations, etc.) developed in cohesive and poorly cohesive soils.

Besides, under way are most important construction projects including underground structures of Dnestrovskaya pump-storage hydroelectric station, recreation underground complexes in Kiev and in other cities.

Among most important domestic developments there is a design of precast reinforced concrete lining combined with insulating rubber gasket elements; implementation of this system has made it possible practically everywhere to do without cast iron tubing linings. The rubber gaskets are developed and manufactured by DINTEM Unitary Design and Technological Institute, Dnepropetrovsk.

For underground projects built under unfavorable hydrogeological conditions, and for metro projects in particular, special methods have been scientifically substantiated and widely implemented including :

- soil freezing ;
- water welling ;
- weak soil chemical stabilization and plugging ;
- slurry-wall techniques ;
- wells for various underground structures elements of which are made ready at the surface to be subsequently sunk to the design depth ;
- pit wall anchor and pile protection.

Within the corporation there is a company which is Ukraine largest organization for integrated construction of metro projects, special underground structures and tunnels. This is Kievmetrostroy OJSC whose 50th anniversary was celebrated in 1999. In the course of its life span, the company has built 57.7 km tunnels and 41 stations for three Kiev metro lines.

Several advanced tunneling methods and new tunnel support structures have been developed by Kievmetrostroy in cooperation with Ukrmetrotonnelproekt and other design and research institutes and implemented for Kiev metro and other tunnel construction projects.

It is for the first time in world tunneling practice that technique was developed to jack precast reinforced concrete shaft lining from a ring pit cut around the shaft outline at an intermediate level above the ground water table. The new technical solution was approved and realized to transfer shield tunnel boring machine through a ready section of Dorogozhichi Station with no need in dismantling and assemblage chambers.

There is progress in using up-to-date TBMs for Kiev metro construction projects. International tender was carried out for TBMs manufactured by world leading companies to be used to extend Sviatoshino-Bavarskaya Line from Sviatoshin Station to Prospekt Pobedy Station. The contract was awarded to WIRTH, Germany, for the lowest bid among five other offers. This is a hydraulically operated air-supported rotary cutter-head TBM, external diameter 5.6 m, internal diameter 5.1 m, equipped with a screw and belt muck removal system, sluice chamber and other advanced features. Shield head part may change drive direction up to 5°; as soon as seven-segment lining ring is installed, grouting is provided to plug external cavities and to stop any surface settlement. Decision in favor of TBM tunneling was taken after thorough examination of previously proposed solution based on cut-and cover and soil freezing techniques, both time/cost-consuming and environmentally unfavorable, and finally considered unacceptable.

On order of Kievmetrostroy, KT-6.2A24 first Ukraine-made earth-pressure tunnel boring machine, diameter 6.2 m, equipped with excavator cutting device has been built at Bolshevik plant, Kiev.

Corporation's specialists continuously work hard to develop and further improve technical and technological solutions making it possible to cut construction project costs, to gain construction time on the basis of advanced techniques, new and more efficient materials, articles and structures.

Metro will be built in Ukraine in accordance with "General Metro Development Scheme for Ukraine up to 2005" initiated by Ukrmetrotonnelstroy corporation. The Scheme is currently worked out by Ukrmetrotonneproekt Institute together with many Ukrainian design, research and technological organizations. Construction and development issues related to metro systems in Kiev, Kharkov, Dnepropetrovsk, Donetsk and in other major cities of Ukraina are considered in this scheme.

Ukrmetrotonnelstroy corporation is a member of the Intenational Tunnelling Association (ITA).

Ukrmetrotonnelstroy corporation renders consulting services on various underground construction issues ; the corporation is ready to establish successful cooperation in order to build metro projects, various tunnels and other underground and surface structures both integrally (from design to "turn-key" takeover) and on the basis of individual projects, works and services. High work quality, completion within the agreed time schedule and reliability of completed structures are warranted.

COMPLETION OF THE EUPALINOS 2000 FRENCH NATIONAL PROJECT

The final review meeting for the EUPALINOS 2000 French National Project took place in Paris on 2 October 2001. Seventy persons attended.

This project followed on from the TUNNEL 85-90 National Project launched by our much missed friend Henri Béjui, AFTES Vice President, profiting from the opportunity offered him at the time by the construction of five major tunnelling projects using closed-face shields. For the full five years, he ran this national project which mobilised 58 participants around a 30 million francs programme.

This programme had a considerable impact through the importance of the results acquired and progress achieved, enabling French tunnelling contractors to catch up. It must be remembered that two French shield manufacturers (Fives Cail-Babcock and Neyrpic Framatome Mécanique) pioneered the French shield industry, under foreign licence, it is true, but at the same time incorporating characteristic refinements. It should also be remarked that the Channel tunnel subsequently benefited from the experience acquired on these projects.

The EUPALINOS 2000 National Project was officially launched by the Ministry of Planning (Research and Scientific and Technical Affairs Directorate DRAST) and AFTES in October 1995.

It addressed two areas :

- mechanised tunnelling in non-uniform ground,
- earth pressure balance shields.

The programme was organised around five themes :

- Theme A : Investigation ahead of the face,
- Theme B : Control of earth pressure confinement,
- Theme C : Contact grouting behind segmental linings,
- Theme D : Control of settlement and ground displacements,
- Theme E : Sticky clay.

The jobsites selected for the relevant research and trials were as follows :

- Lyons metro, line D (1993-1995),
- Paris metro, Meteor line, Bastille-Madeleine section (1993-1996),
- RER suburban metro (EOLE), tunnels joining Magenta and Haussmann Saint Lazare railway stations (1993-1996),
- Lyons North ring road (BPNL), Caluire tunnel (1994-1998),
- Sydney underground railway, Australia, airport link (1997-1999).

AFTES collected 43 participants around this programme : developers and engineers, laboratories, consulting engineers and research institutes, tunnelling contractors and industry.

The total cost of the EUPALINOS 2000 Project was 24 million French francs, mostly met by the participants and the remaining 20 per cent from the Ministry of Planning.

AFTES has thus run, over a period of nearly ten years, two National Projects and successfully mobilised fifty to sixty professional users concerned by these programmes.

A National Project is in fact an association of partners sharing a common research objective and funding the corresponding activities ; the government also contributes because these projects are considered matters of national importance. The Ministry of Planning therefore calls upon its incentive funds to finance the feasibility studies, preliminary research and the representations necessary to find potential sources of funding around a precisely stated research programme.

The EUPALINOS 2000 Project has now drawn to a close and this is the time to recall the words of AFTES President Pierre Pronost to the final review meeting on 2 October 2001 : "Technology marches on and the performance of closed-face tunnelling machines seems limitless. The collective effort undertaken so far should be pursued. Stopping now would be as wasteful as letting a fine tool gather rust."

Underground Works and the Environment

The creation of the International Tunnelling Association Working Group No. 15 under the name 'Underground Works and the Environment' was approved at the General Assembly of the International Tunnelling Association (ITA) in Stuttgart in May 1995. The Working Group was officially launched in Washington in April 1996, with Julia Perez-Cerezo, from Spain, as Animatrice, and Jose Manuel Serrano, also from Spain and a Member of the Executive Council of the ITA, as Tutor. The main objective of the Working Group is to help decision makers to take advantage of the many environmental benefits that tunnels and all underground works offer and to minimise the risks associated with the environmental hazards.

The initial investigations of the Working Group, between 1966 and 1998, were based upon two main topics :

- A review of the opportunities and constraints associated with the environment.
- An analysis of selected Case Studies that demonstrate the environmental benefits that can derive from the construction of underground works.

In order to develop the review, a questionnaire was sent out to all ITA Member Nations. Replies were received from 17 of the 42 Member Nations (40%) and from these replies 13 representative case histories were studied from 7 Member Nations with projects in Brazil, Egypt, Finland, Japan, Spain, Sweden, and the Netherlands.

Environmental Legislative Framework

In the European Union (EU) major projects are subjected to a regulated Environmental Impact Evaluation Procedure (EIEP) prior to their approval and execution, while in the United States (USA) the environmental legislation imposes a regulated process on all major works called Environmental Impact Statement (EIS) which was instigated in the late 1970s.

The EIEP and the EIS are very similar and both require that an environmental study is carried out covering a number of fundamental features, which include :

- A project description and the environmental impact,
- Alternative solutions and a justification for the chosen scheme,
- The environmental elements likely to be altered and the irreversible and irretrieveable commitments (EIS),
- A description of the impacts which cannot be avoided,
- Description of the corrective measures
- The relationship between local short-term uses of the environment and the maintenance of enhancement of long term issues (EIS).

Guidelines for an Environmental Legislative Framework

For those countries who do not have an environmental legislative framework the following brief summary gives the main points which should be incorporated :

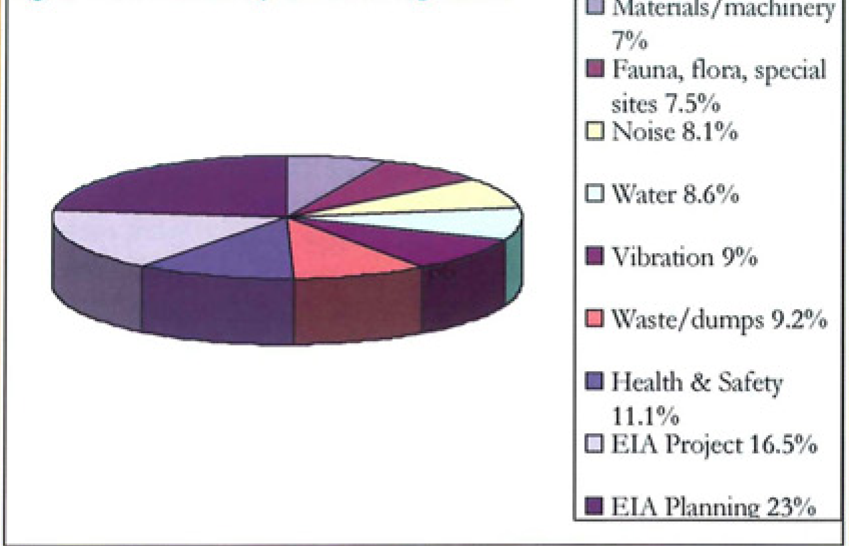
- Legislative directives similar to those developed by the United States Congress and the European Union.
- Guidelines based upon economic and environmental equilibrium.
- The importance of the concept of 'sustainable development' applied to underground work and its environmental responsibility.
- Protection of the environment and natural resources according to accepted underground works management.
- A desire to the levelling out of differences between International and National legislation in order to unify regulations and legal codes.
- Co-operation between public and private organisations in order to create awareness of the importance of the environment and the need to co-operate on environmental problems and sustainable development.
- A desire to foster greater public dialogue and to develop educational materials clearly describing the solutions for environmental problems and the direct and the indirect advantages of underground works.
- The development of local and national regulations based upon the principles embodied in the EU 'EIEP' and the USA 'EIS' with improvements and refinements which will generate fair and competitive solutions for underground works.

Characteristics of Environmental Legislation in Surveyed Countries

The characteristics of environmental legislation for underground works of the 17 Member Nations, who responded to the questionnaire, and on their 13 case histories, can be summarised as follows :

- Generally environmental authorities are dispersed (77%) ;
- The environmental regulation framework that does exist is strictly applied (71%) ;
- A regulation framework specifically for underground projects does not exist (69%) ;
- Where a regulation framework does exist it is clear and accurate (54%) ;
- Most countries had regulations on Environmental Impact Assessments and on Health & Safety which had a high relative importance. However, regulations on materials and machinery, protection of fauna, flora and special areas and regulations on noise are not considered to be so important.

Figure 1 :The relative Importance of Regulations



Views of the Different Sides of the Industry on Environmental Legislation

The Questionnaire asked each Member Nation to identify the effects considered to be as a direct consequence of environmental legislation in order of relative importance for each side of the industry. The effect of environmental legislation on the different groups are summarised, in Table 1.

The percentages in Table 1 show differences in priorities between the different sides of the industry. However, when taken as a whole the majority of Member Nations considered that the high standards of environmental preservation included in environmental legislative framework will mean benefits for companies across the industry on account of a higher demand for their services.

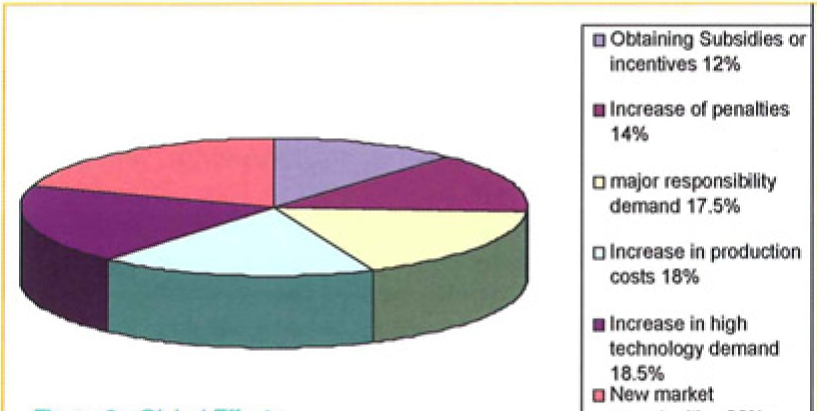


Figure 2 : Global Effects

	Criteria %	Consultants %	Contractors %	Overall %
• New Market opportunities	17	20	20	20
• Increase in high technology demand	15	16	18	18.5
• Major responsibility demand	22	16	18	17.5
• Increase in production costs	19	20	17	18
• Obtaining subsidies or incentives	12	12	14	12
• Increased penalties for unfulfilled regulations	15	16	13	14

Inventory of Environmental Aspects

Across the world, it is generally accepted that the construction of projects underground is more beneficial to the environment than the construction on or above the surface. However, this benefit will nearly always be at additional cost.

The level of acceptance varies greatly with some countries constructing no underground works and others several hundreds kilometres a year. The reasons for this may be political, financial, topography, geological, spread of population or many other reasons.

At the same time underground works vary greatly:

- Of small size or diameter to large caverns
- Of short length to 50km
- In very soft ground to hard rock
- At shallow depth or at great depth
- Above or below the water table
- Under congested sensitive urban area or in a rural environment
- Under or through contaminated land
- And many other differences

Details of technical and engineering solutions to minimise environmental impacts over the whole range of underground works would be a thesis based upon many hundreds of case histories. This brief study of 13 representative case histories has enabled the main environmental aspects to be identified.

Placing a project underground will dramatically reduce many of the environmental impacts of the project, but at the same time will increase, often locally, other impacts.

The Working Group considered the main environmental aspects under three heading : inert, biotic and human media.

The following sub-sections give the groups of environmental aspects that need to be considered and minimised and where appropriate risk assessments should be carried out.

Inert Media

- Geology and geotechnical properties of the land
- At the location of portals ; side slopes and the potential for soil erosion
- Changes in the ground stresses during the excavation
- The effect of ground stabilisation
- Hydrological and hydrogeological
- Protection of the ground water aquifers, both quality and quantity
- The effect of the construction method on the ground water
- Pollution of underground and surface water-courses
- The effect of ground movements on the foundations of buildings and surface structures
- Atmospheric pollution
- Dust
- Smoke and exhaust gases
- Impact of noise and vibration during construction and operation

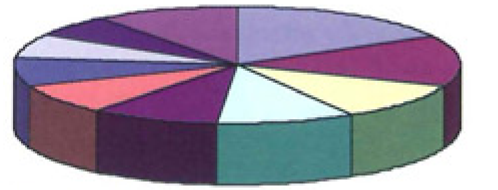


Figure 3 - Magnitude of Importance of measures for Underground Works

Biotic Media

- Visual intrusion
- Acoustic intrusion
- Protection of fauna
- Protection of the landscape
- Removal of waste materials
- Excavated material
- Removal of contaminated materials
- Removal of construction water

Human Media

- Minimising surface land use
- Protection of any archeological sites and cultural heritage
- Protection of existing underground works

Environmental Benefits of Underground Works

There are many principal factors, based upon environmental impact, which may show that an underground structure is a more acceptable solution than the alternative surface or elevated option.

The main benefits of underground works are :

- Little or no effect on future use of surface land.
- Landscaping only required at portals and shaft areas.
- Respect of the geological, geomorphological and paleontolical wealth.
- Little or no soil erosion and runoff, except at portals and shaft openings.
- Atmospheric pollution is limited to portals and shafts openings which can be arranged to limit environmental impact.
- Reduction in noise and vibration levels
- Limited stockpiling of soil for future landscaping.
- Visual impact can be minimised.
- Minimal impact on surface fauna and flora.
- Minimal impact on landscape.
- Additional works during operational phase are minimised.
- Mulches to the soil required only at portals and shafts.
- Minimise the effect on future of surface land and infrastructure building uses.
- Increases the development of depressed rural areas in mountainous zones.
- The public generally accepts underground solutions on efficiency considerations, and on environmental and safety reasons.
- Socio-economic benefits for underground works.
- In urban areas allows the development of pedestrian zones.

Likely Future Demand of Underground Projects for Environmental Reasons

The Working Group also focused on the future underground works in the different sectors.

There is likely to be an increase in road tunnels in mountainous areas, under rivers and estuaries and in urban areas where there are environmental reasons for going underground. However, following the recent incidents in these type of tunnels, particular attention will be required to other aspects such as twin tunnels and emergency egress.

The increase in high speed railways, for both passengers and freight, may mean that more alignment are likely to be placed underground particularly in urban areas to reduce environmental concerns. In rural areas there may also be an increase in the number of tunnels to avoid environmental impacts. There is also an emphasis for more public transport in urban areas which in central areas has to be underground for environmental reasons.

The increase in populations in urban areas is likely to require more aqueducts to supply clean water and more wastewater tunnels to improve sanitary conditions and to reduce flooding. The supply of electrical and other services to urban areas may also require more tunnels to reduce unsightly pylons and poles.

There may be an increase in underground space for recreation, hospitals, sports, culture, multi-purpose facilities, parking and storage as urban areas become more congested and in certain circumstances for these to be placed underground to protect the environment.

Strategic facilities for oil, petroleum, liquids and gases are also likely to increased. The jury is still out about the underground storage of nuclear waste, but with more and more strict legislation for environmental reasons underground storage is likely to be the only long-term answer.

As environmental legislation becomes more and more strict, underground works will be shown to have more environmental benefits. The survey showed that with the increase in environmental sensitivity and legislation there would be a positive influence in the development of underground works.

Present Work of the Working Group

In 1999 Jose Manuel Serrano completed his term on the ITA Executive and Harvey Parker, from the USA, became the Tutor. Rodney Craig, from the UK, was appointed the Vice Animateur.

In early 2000 Julia Perez-Cerezo resigned as Animatrice, as her personal circumstances had changed and she was not then working in the environmental sphere. At the meeting of the Working Group in Durban in May 2000 Rodney Craig was appointed the Animateur and at the meeting in Milan in June 2001 Jan Rohde, from Norway, was appointed the Vice Animateur.

The Working Group is currently collecting data on projects which have been placed underground for environmental or sustainable development reasons. The report on this work will be published in 2003.

Other work of the Working Group include the collection of data on projects whose construction or operation have affected the environment ; those where there have been major environmental constraints during the construction ; and those projects which have had to take into account major environmental constraints during the design and the construction.

FIRE IN TUNNELS NETWORK

Thematic Network 'FIT – Fire In Tunnels' launches 6 Consultable Databases

FIT was launched on the 1st March 2001 following the catastrophic fires that occurred in 1999. FIT aims to establish and develop European networking and optimise efforts on fire safety in tunnels; the network's ambition is to enhance the exchange of knowledge and develop a European consensus on fire safety for road, rail and metro tunnel infrastructures.

As an essential step towards achieving these goals, FIT has introduced six (6) consultable databases on fire and tunnel. The six databases are on-line at the FIT website www.etnfit.net: research projects, test facilities, numerical computer codes, data on safety equipment, tunnel fire accidents, upgrade activities of tunnels.

The databases will grow to become a unique instrument for use by tunnel operators, contractors, consultancy firms, research centres as well as regulators.

The Thematic Network 'FIT - Fire in Tunnels' encourages you to consult and feed the different databases – to make them as valuable as possible.

Every expert organisation working on fire and tunnel is invited to register as a FIT corresponding member and enjoy privileged access for input and consultation of the 6 consultable databases. On-line registration is possible at www.etnfit.net.

INTERNATIONAL CONFERENCES

Santiago Seminar
Santiago, Chile - 14-16 December 2001

The Executive Council (EC) of the International Tunnelling Association (ITA) met in Santiago (Chile) last December. The meetings were held on 15 and 16 of December in Santiago, following an International Tunnelling Seminar, held on 14 of December and organised by the Chilean Geotechnical Society (Sochige). This seminar aimed to introduce the ITA to the Chilean tunnelling community, as well to learn the tunnelling projects in progress in Chile. The opening addresses were presented by the presidents of the ITA and Sochige, André Assis and Issa Kort, and by Luis Valenzuela, chair of the seminar and former vice-president of the International Society for Soil Mechanics and Geotechnical Engineering for South America. André Assis highlighted the importance of Chile for South America and its great demand for underground works, related to mining, transportation and environment. Chile was also invited to become an ITA member nation, what was confirmed in the 28th ITA General Assembly in Sydney. Technical presentations were split between members of the ITA EC and Chilean society. ITA EC members spoke about underground space development in urban areas, field investigation, tunnelling methods and fire and safety in tunnels. Our Chilean colleagues presented lectures about design and construction aspects of the Santiago Metro, design criteria for concrete linings and underground mining. During the closing get-together party, the great success of the seminar could be easily measured by the enormous satisfaction of the participants, which summed 120 (50% more than initially expected). In addition, a technical visit was made to the works of the Santiago Metro. For ITA, this seminar was very important for the opportunity to introduce itself to the Chilean tunnelling community and also learn the projects in progress and the future demand of underground works in Chile. Chile is now a brand-new ITA member nation and certainly will play an important role in South America towards the fulfilment of the ITA aims in that part of the world.

NAT 2002
Seattle, USA - 18-22 May 2002

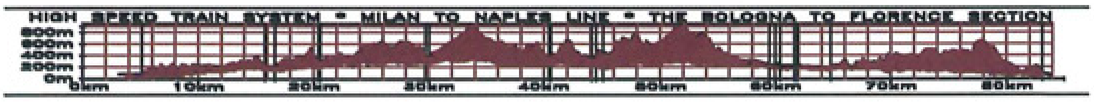
The North American Tunnelling conference, NAT' 2002, organised by the American Underground Construction Association (AUA), in cooperation with the Tunnelling Association of Canada (TAC) and the Mexican Association of Tunnelling and Underground Works (AMITOS), was held in Seattle, USA, last May 18-22. This conference may be considered highly successful for several reasons. First of all, it gathered more than 500 participants and 50 exhibitors, a number well above than that initially expected. But much more important than the number of participants and exhibitors itself, it was the quality of the audience. All-important American designers, contractors, institutions etc. were represented; in summary, the overall mood was vibrant, exciting and very positive. Also, many attendees and exhibitors came from oversees. Among the participants were the president and the past-president of the ITA, André Assis and Alfred Haack, and other members of the ITA family (Executive Council and Working Groups). Another reason for the success of the NAT' 2002 was the highly qualified content, including short courses, keynote addresses, technical sessions and technical tours. The keynote address was presented by Doughas MacDonald, Secretary of Transportation for the State of Washington (USA), who highlighted the importance of underground structures for Washington and the States. The keynote was followed by the presentations on the State of the Underground Construction Industry by the presidents of the North American tunnelling associations, as well as the president of the ITA, André Assis. The technical sessions were split into three main themes: Managing Underground Projects, Public Policy and

Underground Facilities, and Advances in Technology. Finally, a session was held on Fire and Life Safety, chaired by Alfred Haack. The closing session was an interesting open discussion on the tunnelling industry issues, moderated by George Yoggy, president of the AUA. A final reason accredited for the success of the NAT' 2002 was the good interaction between the AUA and ITA during the conference, which allowed an enormous exposure of the ITA inside the North American market. An example of that was a roundtable recorded during the conference, involving the presidents of the ITA and AUA, and the chair of the conference, Richard Robbins, former vice-president of the ITA, and published in the TBM magazine (June issue), well distributed in North American. This is a highly desirable win-win situation, because it strengthens the AUA position in the US tunnelling market, and consequently brings to ITA an increasing North American participation and support. A final word of congratulations to Dick Robbins, chair of the conference, and Susan Nelson, Executive Director of the AUA, for the excellent job done.

Shangai Workshop
Shangai, China - 1st July 2002

The International Workshop on Tunnelling was organised in conjunction with the ITA Executive Council Meeting in Shanghai, on 1 July 2002. The Workshop was attended by more than 120 people from Shanghai and other parts of China. The Workshop was organised by the ITA and the Shanghai Civil Engineering Society, sponsored by the Shanghai Urban Construction Group. Mr Huang Xing An, President of Shanghai Civil Engineering Society made the welcome address. He welcomed the ITA Executive Council to meet in Shanghai and appreciated the presentation of the ITA Executive Council members at the Shanghai Workshop. Prof. Andre Assis, President of ITA, made Opening Speech and thanked the Shanghai Civil Engineering Society and Mr Bai Yun, Chief Engineer of the Shanghai Urban Construction Group, for hosting the ITA Executive Council Meeting in Shanghai and for the organisation of the Shanghai Workshop. He hoped ITA's presence will strengthen the relationship with China. During the morning session chaired by Mr Wang Zeng Xin, Formerly Chief Engineer of the Shanghai Metro Co., presentations were made by Mr Claude Berenguier on the International Tunnelling Association, by Prof. Alfred Haack on fire and safety issue, and by Dr Harald Wagner on segment design. In the afternoon session chaired by Prof. Sun Jun, Academician of China Academy of Sciences, presentations were made by Dr François Vuilleumier on fire in tunnel, by Prof. Jian Zhao on tunnelling boring machine and the Tunnelling and Underground Space Technology journal, by Dr Harvey Parker on planning and site investigation, and by Mr Jean-Paul Goddard on urban underground space. It was followed by an active discussion session chaired by Prof. Jian Zhao. The Workshop was well received by the Chinese participants. The Workshop was followed by tunnelling site visits in Shanghai. The ITA Executive Council members also made tunnelling site visits. In addition, they had a meeting with the Shanghai Tunnel and Rail Transit Research and Design Institute and had a technical discussion on various tunnel design and construction issues.

NEWS FROM ITALY



HIGH SPEED TRAIN PERMANENT CONFERENCES • 7TH SESSION

The SIG (Società Italiana Gallerie - Italian Tunnelling Society) has been holding these sessions since 1998 and they have been very successful. As a result it has decided to continue with its commitment to keep operators up-to-date on sociological, environmental and technical topics connected with High Speed/AC construction by holding the 7th session of the "High Speed Train Permanent Conferences".

This session will discuss the question of safety on the construction sites along the more than 90 km. of tunnel currently at an advanced state of progress between Bologna and Florence. The theoretical principles underlying the safety engineering of the underground works will be described and compared with various applications of safety regulations that have been employed over the years at the work place.

As usual, there will be a visit to High Speed tunnels in Bologna in the afternoon.

As is known, the conferences are held alternately in Bologna and Florence in agreement with TAV and Italferr and with the assistance of the engineering faculties of the universities of the two cities. They are sponsored by the regions, the provinces and the universities.

HIGH SPEED TRAIN PERMANENT CONFERENCES
7th session - "Safety during construction"
EMILIA - ROMAGNA REGION - Auditorium Hall
Viale Aldo Moro, 18 - BOLOGNA • 22th November 2002

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Downer Engineering (Downer) has been awarded the contract for the design and construction of tunnel works for the 132kV cable network (cable access route) as part of EnergyAustralia's Sydney CBD and inner suburbs electricity supply augmentation project. Construction work on the EnergyAustralia cable tunnel, located in the southern reaches of the Sydney CBD, commenced in late December 2001 and contract completion is scheduled for April 2003.

Overview

Following a review by EnergyAustralia of the power requirements for Sydney's CBD it was concluded that additional supply capacity was required to maintain the appropriate reliability levels for the system in the future. The review investigated a number of alternative construction methods and in particular the option to dig up the city streets and install a series of pits and ducts. However, this option was finally rejected due to the considerable inconvenience it would have had on the local residents and businesses.

The project involves the construction of a tunnel to run under Sydney's southern CBD including parts of Haymarket and Surry Hills (see fig 1). The tunnel will house 132kV electricity cables for distribution of power by EnergyAustralia.

The 1,300 metre tunnel housing the 132kV feeders and related services such as communications, fire, and drainage systems will run between 12 and 30 metres below the public roads and not involve construction under private property. A minimum cross section of 3.2m x 3.2m concrete lined is required to accommodate the 8 feeder circuits.

Shafts are to be located at the City South substation and the Surry Hills substation for cable connections, access and ventilation requirements. Access from the Haymarket and Campbell Street substations will be portal access.

Design

The design consultants GHD on behalf of EnergyAustralia produced the design concept provided in the tender documents. It was Downer's responsibility to complete the design. Downer separated the design task into three areas with separate subcontracts issued to Halcrow Pacific for the structural design, Coffey Geosciences for the geotechnical design and Norman Disney & Young (NDY) for the service design.

Construction Methodology and Access

Tunnel Drives

The access for the construction of the tunnel is at the former Sydney Police Centre car park on the corner of Brisbane Street and Campbell Street, Surry Hills. The site will accommodate the removal of spoil from the tunnel, and be the supply point for the services and materials required in the tunnel in both the temporary and permanent status of the project.

A 46 metre open cut ramp and 83 metres of decline will gain access to the tunnel at chainage 1016. From this point the tunnel will be driven to the Haymarket substation at chainage 0 to complete separable portion 1. On completion of the Haymarket drive, excavation will commence on the Surry Hills drive to chainage 1294 to complete the tunnel excavation and separable portion 2 & 3.

The requirement to align the tunnel in the centre line of the road systems to maintain maximum clearance from building foundations resulting in 15m radius bends at road junctions, was a major factor in the choice for roadheaders to be used to excavate the tunnel. Additionally there is a requirement in the Deed that blasting will not be used in the construction of the works.

A Mitsui 200MA machine was chosen for the tunnel excavation. Although the machine will excavate a larger profile than what is required under the Deed, it was considered that the smaller roadheaders in the market would lack the cutting power for the high to very high strength sandstone anticipated in the tunnelling works. Approximately 20,000 BCM of tunnel spoil will be removed from the tunnelling works.

The steep vertical alignment necessary to facilitate passing under the existing Eastern Suburbs Rail Tunnel, and the future MetroPitt and MetroWest tunnels negated the use of rail to service the tunnel during excavation. Low profile articulated dump trucks have been chosen for muck haulage and servicing of the roadheader.

Rockbolting will be achieved using handheld rotary

machines from the roadheader platform. The tunnel size does not allow plant to pass the roadheader to access the face.

Shotcreting will be predominantly undertaken, at the completion of tunnel excavation, by robotic arm and small agitator. Shotcreting that may be required to support the face area during excavation will be achieved by handheld methods. Approximately 950 cubic metres of fibre reinforced shotcrete will be required on the project.

The concrete invert and floor will be formed and poured at the completion of the shotcreting and prior to

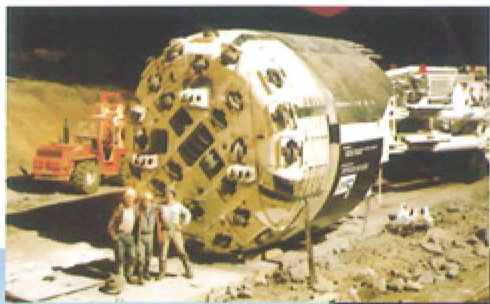
the installation of the permanent works and brackets. Approximately 900 cubic metres of concrete invert will be required in the permanent works of the project.

Shaft Construction

The shafts range in depth from 12m to 24m and have a maximum cross section of 5.5m x 3.0m. The shafts will be excavated utilising excavator and rockbreaker, with crane and kibble to remove the spoil from the shaft. Initially a 20 tonne machine will be used for the first 4 to 5 metres, followed by a five tonne machine for the remainder of the shaft sink.

Concreting of the upper shaft will be undertaken prior to the excavation of the rock section. Shotcrete lining of the rock section will be used for support in conjunction with rock bolts.

The shafts are programmed for completion in advance of the tunnel excavation to allow a controlled breakthrough.



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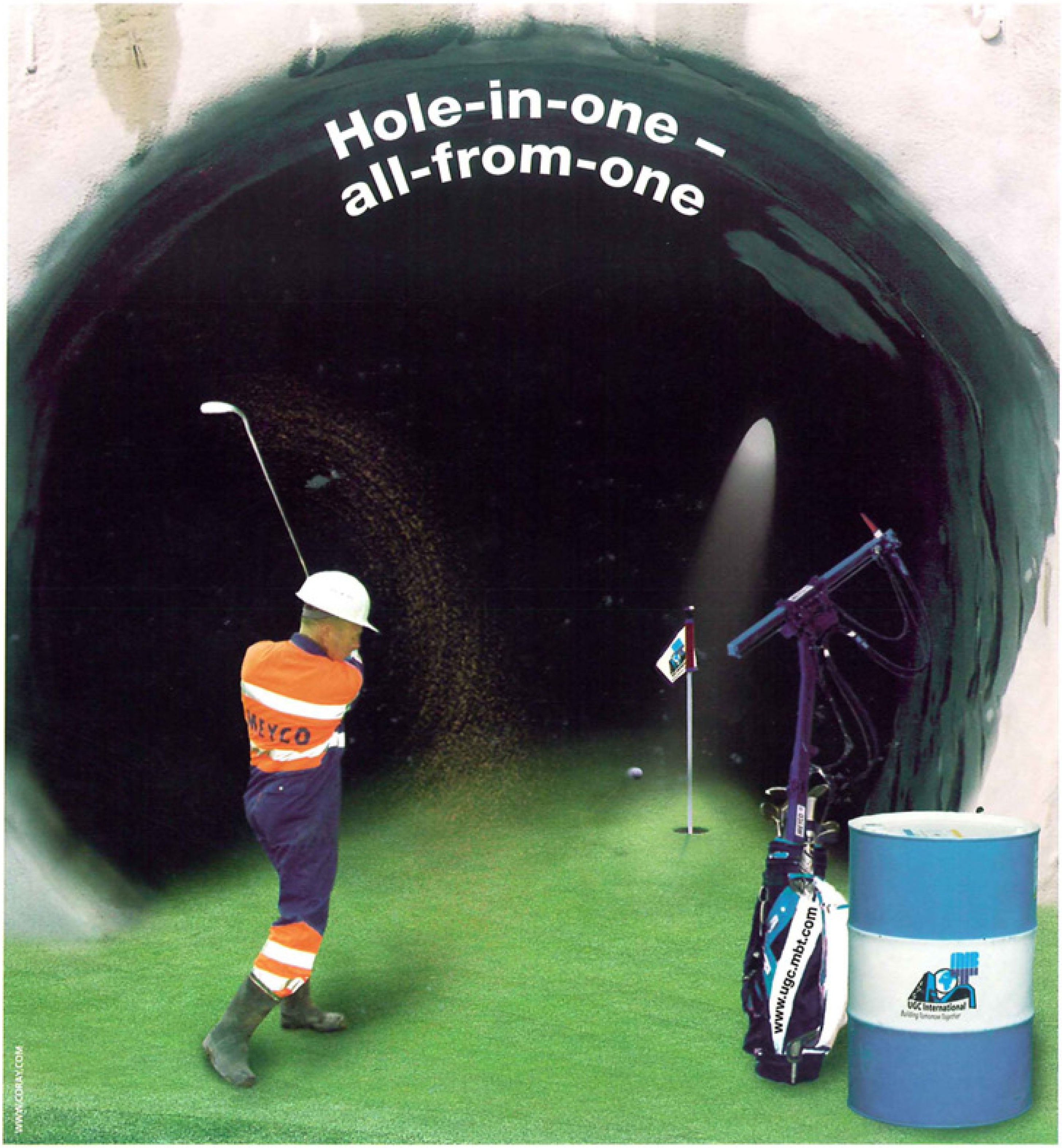
Construction Chemicals



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