# TRIBUN

ASSOCIATION INTERNATIONALE DES TRAVAUX EN SOUTERRAIN
AITES

ITA
INTERNATIONAL TUNNELLING ASSOCIATION


## ITA newsletter - la lettre de l'AIT

N° 25 - FÉVRIER 2003 - ISSN 1267-8422

*HSL: The new high speed line will link the Belgian border and Amsterdam. The line includes four tunnels.*

*TGV : La ligne à grande vitesse reliera la frontière belge à Amsterdam. La ligne comprend quatre tunnels.*




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# TRIBUNE

*ITA newsletter*
*la lettre de l'AITES*

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# ITA IN BRIEF • L'AITES EN BREF

## FOUNDED IN 1974

ITA has 52 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 52 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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# EDITORIAL

As the Minister of Transport, Public Works and Water Management of the Netherlands, I am very pleased that Amsterdam has been chosen to host the 2003 ITA World Tunnelling Congress (WTC). The ITA is the world's leading expert organisation on underground spatial planning.

Few cities in the world would be a more suitable venue for an important event like the ITA/WTC Congress. Throughout its history, the Netherlands has had to protect itself from the encroaching sea and has even created new land previously covered by the sea. As a result, we have built up a tremendous know-how in civil engineering as well as a vast amount of expertise in land reclamation. Not many people are aware, however, that the Netherlands is also an expert in the use of underground space, sometimes even below reclaimed land.

With a population of 16 million in an area of only 34,000 square kilometres, the Netherlands is a country where space is crucial. The land that is available is used ever more intensely, and as the need for space grows, it is becoming increasingly attractive to create additional space in underground construction projects. Existing examples include the Willemsspoortunnel, a railway tunnel in Rotterdam, and the underground railway station in Rijswijk. There are also ambitious plans to convert the World Trade Centre station in Amsterdam-Zuid into an underground railway station as part of a large-scale urban development programme.

The ITA/WTC Congress has always been a major event in the tunnelling world. It receives strong support from the sector and attracts a wide range of entrepreneurial and creative engineers and researchers. In this day and age a conference may seem slightly archaic, as there are much swifter means of spreading information. Nevertheless, an occasion like this offers a wonderful opportunity to find out the latest about new ideas, new structures and new projects that have been developed over the past years in the disciplines covered by this congress.

It is becoming ever more important to come up with creative solutions in the utilisation of underground space, also in response to the growing demand for transport facilities and the need for safety, in all its aspects. Indeed, safety is one of the most important conditions in underground construction.

In the Netherlands, the field is characterised by close cooperation between academic, technical and business partners, including universities, research institutes such as the Netherlands Concrete Society and the Centre for Underground Construction, contractors, the Dutch cement industry and many others. The government provides additional support by encouraging further developments in underground construction.

I look forward to welcoming you in April 2003, when the Netherlands is at its best as tulips and a host of other flowers transform the country into a splendid garden. Needless to say, I am confident that all the ingredients are there to ensure that the ITA/WTC Congress becomes a unique and enjoyable event.

Roelf H. de Boer
Minister of Transport, Public Works and Water Management

# EDITORIAL

En tant que ministre des transports, des travaux publics et de l'eau des Pays-Bas, je suis très heureux qu'Amsterdam ait été choisie pour accueillir le congrès mondial des tunnels 2003. L'AITES est l'organisation mondiale experte dans l'utilisation du sous-sol.

Peu de villes dans le monde auraient été aussi propices pour la tenue d'un tel évenement que le congrès mondial des tunnels ITA/WTC. Au travers de son histoire, les Pays-Bas ont eu à se protéger de la conquête des terres par la mer et ont même créé de nouvelles terres à des endroits où il y avait auparavant la mer. En conséquence, nous avons développé un savoir-faire en génie civil ainsi qu'une vaste expertise en ce qui concerne l'assèchement des terres. Peu de gens sont au courant, cependant, que les Pays-Bas sont également experts dans l'utilisation de l'espace souterrain, parfois même sous les terres récupérées sur la mer.

Avec une populationde 16 millions d'habitants sur une surface de seulement 34 000 km², aux Pays-Bas, l'espace est crucial. Les terres sont utilisées encore plus intensivement à mesure que la demande d'espace augmente et il devient de plus en plus intéressant de créer de l'espace supplémentaire avec des projets en souterrain. Les exemples existants incluent le Willemsspoortunnel, un tunnel ferroviaire à Rotterdam et la gare souterraine de Rijswik. Il y a également un projet ambitieux de convertir la gare du World Trade Center d'Amsterdam-Sud en une gare souterraine dans le cadre large programme de développement urbain.

Le congrès de l'AITES a toujours été un évenement majeur dans le monde des travaux souterrains. Il reçoit un large support de l'ensemble du secteur et attire des ingénieurs entrepreneurs et créatifs et des chercheurs. Par les temps qui courent, une conférence peu sembler archaïque en comparaison avec d'autres moyens de diffusion de l'information. Cependant, une occasion comme celle-là offre une merveilleuse opportunité de découvrir les dernières idées, les dernières structures, les derniers projets développés pendant les années récentes sur l'ensemble des disciplines couvertes par les thèmes du congrès.

Il devient de plus en plus important de développer des solutions créatives d'utilisation de l'espace souterrain, pour faire face à la demande croissante en moyens de transport et en sécurité. Bien entendu, la sécurité est l'une des conditions primordiales de la construction en souterrain.

Aux Pays-Bas, ce domaine est caractérisé par une étroite collaboration entre les partenaires universitaires, techniques et commerciaux, incluant les universités, les centres de recherche, comme la Société Néerlandaise du Béton, le Centre pour la Construction en Souterrain, les entrepreneurs, l'industrie cimentière et bien d'autres. Le gouvernement apporte un soutien complémentaire en encourageant les futurs développements dans la construction en souterrain.

J'attends avec impatience le moment de vous accueillir en avril, quand les Pays-Bas sont sous leurs meilleurs jours, alors que les tulipes et de nombreuses autres fleurs transforment le pays en un jardin splendide. Il est inutile de dire que je suis confiant que tous ces ingrédients feront en sorte que le Congrès mondial des tunnels ITA-AITES sera un évènement unique et très agréable.

Roelf H. de Boer
Ministre des Transports, des Travaux Publics et de l'eau

# INVITATION FROM THE ORGANIZER

The Netherlands member-society of ITA is honoured to invite the international tunnelling community to participate in the ITA World Tunnel Congress in Amsterdam.
This Congress, with the theme "(Re)claiming the underground space", is organised for the 12th-17th of April 2003 at the RAI Congress Centre in Amsterdam.
This event takes place precisely 10 years after the previous and very successful Dutch ITA World Congress "Options for tunnelling", in Amsterdam. The first tests of bored pilot tunnels in the Netherlands were presented at this congress. Since that time, tunnelling in the Netherlands has developed rapidly. Apart from the (Dutch) traditional way of tunnelling, by immersed tunnels, new types of tunnels have been constructed or are being constructed. Also, an extensive research programme into the behaviour and control of these bored tunnels was set up. Of all bored tunnel projects currently under construction in the Netherlands, the most impressive is the 7 km. bored road tunnel under the Westerschelde. Also the 7 km. bored tunnel, under the Green Heart Area, for the new high-speed railway, with the largest diameter to date (14,87 m) is now under construction. Close to the congress site, a new bored metro line, the Noord Zuid line, will be constructed.
In addition to these methods for soft ground tunnelling, the subjects of rock tunnelling, safety, financing, environment, spatial use and many more aspects will all be part of the congress programme in 2003.
The use and development of the underground space will be the major theme of the congress. Slowly, more examples are being realised, such as the parking garage under the canals in the mediaeval city centre of Amsterdam. This congress, with the theme, "(Re)claiming the underground space", will be an important stimulus for further development and realisation of techniques and knowledge of underground construction, for the Netherlands, as well as for the owners, clients, developers, consultants, researchers, scientists, contractors and suppliers, "all over the world".
In addition to the congress, an exhibition has also been organised. This gives the whole tunnelling industry the possibility to exhibit their services and products related to tunnelling and underground space construction. All activities will be organised in the Amsterdam RAI Congress Centre.
The climate in the Netherlands is free from extremes. In April the climate is mild and agreeable. The canals of Amsterdam and the cultural/historical sites are only a few of many good reasons to bring your partner to this event. Amsterdam, your congress location, offers all the facilities for a pleasant stay. The city, appreciated for its historical buildings and compactness, its diversity in citizens, its cultural wealth and famous painters, is a city, which is alive 24 hours a day. Interesting excursions have been prepared for you, in Amsterdam and its surroundings, at the famous tulip fields, which in April are in full bloom.
April in Amsterdam is a busy month! Please register as soon as possible and book one of the congress hotels as far in advance as possible.

Ir Henk J. C. Oud
Chairman Organizing Committee

## Supporting organisations of the ITA World Tunnelling Congress 2003

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Vereniging Ondergronds Ruimtegebruik

ASSOCIATION INTERNATIONALE DES TRAVAUX EN SOUTERRAIN
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## 1 • TUNNELLING IN THE NETHERLANDS

*Il y a 25 ans, les Pays-Bas comptaient 7 tunnels, 4 immergés et 3 tranchées couvertes. En 1999, parmi less 12 tunnels en construction, il y avait 2 tunnels immergés, 4 tranchées couvertes et 6 tunnels forés. Ce changement est en partie dû aux recherches menées par le COB.*

VOR
Vereniging Ondergronds Ruimtegebruik

The Dutch are renowned for their expertise in reclaiming land from the sea. What is less well-known is their expertise in reclaiming space from under the ground, sometimes even from under the ground that they have reclaimed.

Space is a crucial issue in the Netherlands, where the population of 15 million people live in an area of 34,000 km$^2$. With the need to effectively use space increasing, the possibility of creating space by tunnelling becomes an attractive alternative. This possibility is being used by designers to create designs that integrate buildings, underground motorways and parking facilities.

### ENVIRONMENTALLY ACCEPTABLE EXPANSION

Because of congestion and the increasing demand for public and private transport, there is a pressing need to expand the road and rail networks. Coupled to this is an ever increasing awareness of the environment. As the economy continues to expand and the standard of living continues to rise, the demand for environmentally acceptable transport, and therefore tunnels, will continue to increase. An example of this is the "Green Heart Tunnel". This tunnel forms part of the High Speed Rail Link between Amsterdam and Rotterdam. Several alternatives were available for this section of the rail link, however, the bored tunnel alternative was chosen for environmental reasons.

In 1974, approximately 4.5 km of tunnel was constructed, in 1999 this figure has risen to 10 km. This trend is likely to continue.

### INFRASTRUCTURE

In response to this increasing demand for transport, the Ministry of Transport and Public Works and Water Management has received a budget of 35 billion euro to improve the infrastructure in the period 1999 to 2010. A proportion of this budget will subsidise underground developments for environmental reasons, as above ground solutions, in the shape of bridges and embankments, are still cheaper than tunnelling.

### RESEARCH

Part of the Ministry's budget will go into research. Twenty five years ago, seven tunnels were being constructed. Of these, four were immersed tunnels and three cut-and-cover. In 1999, of the 12 tunnels under construction, two are immersed, four are cut-and-cover and six are shield driven. This change in emphasis is, in part, due to the co-ordinating research body, the Centre of Underground Construction (COB). In 1994, this institute received 18 million euro to fund a research program. One of its projects was the first large-bore shield driven tunnel in the Netherlands, the Heinenoord tunnel. The research aim of this project was to investigate boring tunnels in soft ground. Much of the knowledge gained has been subsequently used in other projects. As the research project got under way, its scope broadened and now includes the expansion and promotion of underground construction in general.

## 2 • THE LONGEST ROAD TUNNEL IN THE NETHERLANDS : THE WESTERSCHELDE TUNNEL

*Le tunnel du Westerschelde (Escault occidental) est un tunnel routier bi-tube de 6,6 km. Chaque tube a un diamètre extérieur de 11 mètres, foré dans un sol principalement constitué de sables et d'argiles. Le point le plus bas se situe 60 mètres sous le niveau de la mer.*

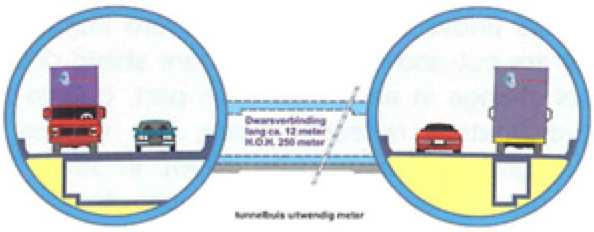
VOR
Vereniging Ondergronds Ruimtegebruik

The Westerschelde Tunnel is a bored tunnel with a length of 6.6 kilometres. A bored tunnel does not have the disadvantages of a bridge (limited clearance for shipping) or a traditional, submerged tunnel (anchors may damage the tunnel), and it is the cheapest solution. There are two tunnel tubes. In each tube, there are two road lanes. No expense or effort has been spared in making the tunnel as safe as possible. The construction of the tunnel was a technically unique project. Most tunnels in Europe are built in hard, rocky material. Never before in Western Europe has a tunnel so long or so deep been bored through relatively soft substrates such as sand and clay. The deepest point lies 60 metres below sea level.

### THE TUBE DESIGN

In cross section, two tunnel tubes can be seen, connected to each other by a transverse link about

Cross section of the tunnel tube




twelve metres in length. The external tunnel diameter is 11 metres, and the internal diameter is 10.10 metres. The tunnel wall is built up of rings. At each end of the tunnel, the distance between the tubes is reduced to about seven metres, so that the width of the roads leading into the tunnel has been restricted. In each tunnel tube there will be two lanes, each 3.5 metres wide. A cable channel will be installed under the road surface. Using a miniature vehicle, maintenance mechanics can negotiate this channel to reach any point of the 6.6-kilometre tunnel. The deepest point is sixty metres below sea level. Nevertheless, the gradient is never steeper than 4.5 percent.

### TRANSVERSE LINKS

Every 250 metres the tunnel tubes are connected by transverse links 2.10 metres high and 1.50 metres wide. Normally, the doors to the transverse links are locked. In the event of an emergency, they are unlocked automatically and one can walk to the other tunnel tube if one wishes to. Conversely, the emergency services can use this road to reach the site of an accident. The transverse links account for ten percent of the construction budget, which shows how important these emergency exits were deemed for safety. Construction is done by means of a freezing technique. This guarantees watertight transverse links, and it does not harm the environment. The Westerschelde Tunnel is the first time for the freezing technique to be used on such a large scale.

### FREEZING TECHNIQUE

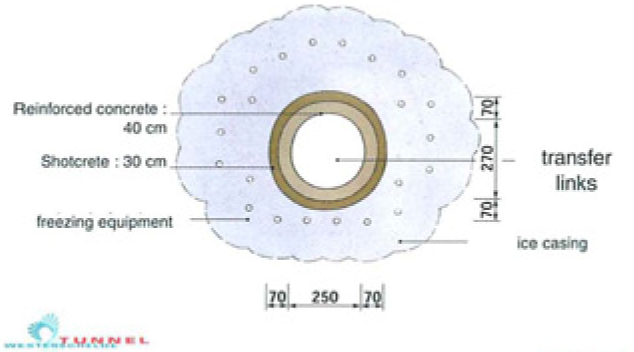
First, 25 pipes fitted with drill heads are bored from the eastern tube to the western tube. A brine solution that has been cooled to -35°C by a refrigeration unit in the eastern tube is pumped into 22 of these steel pipes, known as ice lances. Two of the pipes are used to monitor the progress of the freezing, and one pipe is for drainage. When the ice around the future transverse link is sufficiently thick, the installation of the link can begin.

# 2 • THE LONGEST ROAD TUNNEL IN THE NETHERLANDS : THE WESTERSCHELDE TUNNEL

VOR
Vereniging Ondergronds Ruimtegebruik

### INSTALLATION OF THE TRANSVERSE LINK

In the western tube, the future entrance to the link is opened. A steel emergency door is put in place, and the frozen ground is excavated step by step with a cutting machine. First, about a metre of soil is cut away at the top. To prevent the ice capsule from deforming under the great pressure, a layer of concrete is immediately sprayed under high pressure against the exposed ground. The underside is done next. In this way, metre by metre, a concrete outer wall is created. The soil is carried out of the tunnel by train. After that, reinforcement is applied. Shuttering is laid for the spraying of concrete for the inner casing that will form the wall of the transverse link. Only when this concrete has hardened can the freezing process be discontinued. The links are completed at a later stage.




### TUNNEL RINGS

6,600 tunnel rings are constructed for the entire tunnel, so 3,300 per tube. In turn, each tunnel ring is made up of seven segments and a keystone. A ring is two metres wide. The segments and keystones are made at a special, purpose-built concrete factory at the construction site at Terneuzen.

### APPROACH ROADS

Because of the differences in the ground composition, the tunnel approach roads at the southern and northern ends are built in quite different ways. For the southern tunnel approach road, an artificial polder was created. This is made of sheet pile walls that extend down into an impervious layer of Boom clay. On the northern side, on Zuid-Beveland, the Boom clay layer is too far down for a solution of this kind. For that reason, the ground was excavated to a depth of twenty metres below sea level to create a concrete basin, or caisson, for the road leading into the northern end of the tunnel. It is through the round holes in this caisson that the tunnelling machines emerge once more into daylight.

#### Southern road into the tunnel

In Zeeuwsch-Vlaanderen, the Boom clay played an important role in the construction of the approach road. The clay lies at about 25 metres below sea level. Starting from ground level, the builders installed cement-bentonite walls that extend a metre deep into this clay. Steel sheets were incorporated in the walls to make them watertight. The Boom clay provides a watertight seal on the underside. In this way, a watertight basin was created. Around the walls there are dikes, rising to 6.5 metres above sea level. As a result, the tunnel will not be flooded if there are floods elsewhere in Zeeuwsch-Vlaanderen. Conversely, in the event of a disaster in the tunnel, the dikes ensure that Zeeuwsch-Vlaanderen will not be flooded. When a car driver drives into the tunnel he will see, successively, green slopes that rise higher and higher as the road goes downward, an open basin structure 88 metres in length, and a covered tunnel entrance section of 50 metres.

#### Northern road into the tunnel

On Zuid-Beveland, it was decided to use a caisson 25 metres by 34.6 metres in size for the approach road. This gigantic concrete basin was built on the surface and fitted with a cutting edge on the underside. After the caisson was ready, the builders hosed the ground under it loose and sucked away the mud. The cutting edges sank into the ground under the caisson's own weight, until the bottom of the caisson came to rest on the ground. In this way, step by step, the caisson was lowered to twenty metres below sea level. On the inland side, the approach road was completed with a concrete basin structure. On the tunnel side, the two round openings were made watertight with a plug of fairly soft concrete. In the course of time, both tunnelling machines will cut through the plug and enter the caisson, where they will be dismantled. The approach road will be surrounded by a dike.

# 3 • BORED TUNNEL PANNERDENSCH CANAL

*Le tunnel du Pannerdensch Canal est situé sur la ligne ferroviaire de la Betuwe. il s'agit d'une ligne nouvelle entièrement dédiée au fret qui relie le port de Rotterdam à la Ruhr en Allemagne. Il s'agit d'un tunnel foré de 1615 mètres avec un diamètre intérieur de 9 mètres, prolongé de chaque côté par une tranchée couverte. Les rameaux de connexion sont construits grâce aux techniques de congelation.*

VOR
Vereniging Ondergronds Ruimtegebruik

After the river Rhine enters the Netherlands from Germany, it splits into the Waal and the Lower Rhine. The first part of the Lower Rhine is known as the Pannerdensch Canal. That part of the river and its foreland are on the Betuwe rail route just before it crosses the border.

## OVERVIEW OF THE PROJECT

The Pannerdensch Canal Railway Tunnel is situated in the eastern part of the Netherlands near Arnhem, about 10 kilometers from the German border. Here, the Betuweroute - a dedicated freight line from the Port of Rotterdam to Germany - crosses the Pannerdensch Canal, a branch of the river Rhine. The main reason for making a tunnel is the fact that the landscape has great scenic and ecological importance. The tunnel is located in a mainly rural landscape that is dominated by the Pannerdensch Canal.

About 1600 meters of the tunnel are situated between the flood embankments of the Pannerdensch Canal, all below the initial ground level. Other landmarks at the site are a brickworks situated on the west bank of the river on an elevation, a deep former sandpit on the east bank, and a sensitive natural landscape east of the flood embankment.

The tunnel is mainly located in medium dense to dense gravely sand. However, at some locations on the west bank of the river there is a 2- to 3-m-thick layer of stiff to very stiff organic clay. At two locations, a thick layer of stiff organic clay was encountered. This layer reaches a thick thickness of some 12 m, completely covering the tunnel cross-section.

The water level of the river fluctuates a great deal. Because of the permeability of the soil, these fluctuations have an instant effect at a great distance from the river. The piezometric level can be higher even than the ground level. In winter, when the discharge of the river Rhine increases, the whole stretch of land between the flood embankments is flooded.

## PRELIMINARY TUNNEL DESIGN

When it was decided to build a tunnel, several designs were considered, including a concrete immersed tube tunnel, a steel shell immersed tunnel and a bored tunnel. Because of the shallowness of the river it is not possible to use one of the building docks in the western part of The Netherlands. For this reason a building dock would have to be built at the site. The wide variation in water levels made this solution relatively expensive. Considering the

costs and environmental aspects and hindrance during construction, it was decided to further develop the bored tunnel into a final design.

From the west to the east, the tunnel has the following features:

• an approach is built in concrete with the help of temporary sheet piles, tension piles and underwater concrete;

• after passing a local road, the tunnel continues as a cut-and-cover tunnel with a central wall

• a service building is situated on the west side of the dike, this building provides room for the necessary tunnel equipment, as well for the vertical gate in every tube, which can be lowered to restore the water barrier in case of emergencies

• the launching shaft, from which both tubes will be bored, is located about 60 m past the dike, the tubes have an internal diameter of 9 m and a length of 1615 m. Concrete lining segments will be used with a length of 1,8 m and a thickness of 0,4 m.

## 3 • BORED TUNNEL PANNERDENSCH CANAL

•the bored section crosses a brickworks with brick storage, and the Pannerdensch Canal
* at the lowest point of the tunnel a shaft is located between the tubes, it is to be used for technical equipment and a sump, and will accommodate a cross-passage, a second cross passage is located on the east bank
•the reception shaft is to be built on the edge of a sandpit, which will be refilled
•from the shaft the tunnel continues again as a cut-and-cover tunnel, with a service building and an approach up to ground level
•the overall length of the tunnel is 2.680 m

The tunnel is provided with all the necessary technical systems, such as:
•lights
•safety systems such as fire detection, fire extinguishing facilities, sprinkler system, ventilation, escape routes etc.
•means of communication, such as television cameras, intercom, etc.
•power supply from the grid
•pump installation for discharge of water
•flood gates

### METHOD OF CONSTRUCTION

The approaches of the tunnel are constructed as a concrete box or trough, in watertight, cast in situ concrete. The structure is realised in strutted and anchored building trenches with sheet piles and underwater concrete. The tunnel has a foundation of pre-stressed concrete piles and vertical steel ground anchors. The bored tunnel will be constructed using a slurry shield with bentonite face support. The cross-passage will be built using freezing techniques

## 4 • HSL, THE TRANSPORT OF THE FUTURE

*La ligne ferroviaire à grande vitesse s'étirera aux Pays-Bas sur environ 100 km entre la frontière belge et Amsterdam. De nombreux ouvrages sont nécessaires et notamment le tunnel foré du Groene Hart d'une longueur de 8,5 km et le tunnel du Oude Maas, tunnel construit en partie en tranchée couverte et en partie immergée.*

VOR
Vereniging Ondergronds Ruimtegebruik

### FEWER PLANES, FEWER CARS

In the future, more people will travel, and they will travel with greater frequency than they do today. The research is there to prove it. Congested roads in Holland's western conurbation, the Randstad, and a full-to-bursting Schiphol Airport are finding it increasingly difficult to cope with the growing flood of passengers. From 2006, the Dutch High-Speed Line (HSL-Zuid) linking the country to the European network of high-speed rail links will offer an attractive alternative.

No appetite for traffic jams and delays in getting to school or work? A comfortable trip to the summer sun, or perhaps to snow-covered slopes? Visiting European cities, on business or for pleasure? Soon everyone, young and old, will be able to get away from it all, gliding effortlessly along the HSL. Thirty minutes from Amsterdam to Rotterdam, three hours from our capital to the centre of Paris. And getting from Breda to Rotterdam or Antwerp will take only twenty minutes. Who's going to choose to drive or fly then? Forecasts indicate that some six to seven million people a year will use domestic high-speed links. And about the same number will catch the high-speed train for destinations outside the country. Before long we shall be able to travel on the High-Speed Line at speeds of up to three hundred kilometres per hour, and the Netherlands will have a new and alternative mode of transport that is set to push back frontiers. Comfortably, safely and fast.

### CAREFUL PREPARATION

In a country as densely populated as the Netherlands the construction of a new railway line calls for more than ordinary care in the preparation, both at the preliminary decision-making stages and during construction itself. That is why a careful look has been taken to see which other projects can be carried out simultaneously and in conjunction with construction of the High-Speed Line. Take the widening of the A4 motorway, for example. And the A16, which will also be rerouted.

Following the government's decision in principle to go ahead with the project, taken in 1997, the minister of Transport and Water Management and the minister of Housing, Spatial Planning and the Environment approved the final route for the line in 1998. In consultation with landowners, house owners, local businesses and municipalities, the government then purchased the land needed for the HSL and alterations to the A4 and A16.

Before the first spade could go into the ground, however, it was necessary to establish whether the soil would be capable of bearing the load, whether it concealed cables or gas or water pipelines, whether it contained items of archaeological interest or importance, and, last but not least, whether it was polluted in any way. In short, time was needed for geotechnical, archaeological and environmental soil surveys. Then there were the many thousands of permits and consents — environmental consents, demolition and tree-felling permits, and of course building permits — for which the project organisation had to apply to the three provinces and twenty-two municipalities concerned. Work on the High-Speed Line has been proceeding apace since 2000.

### RELATIONS WITH LOCAL RESIDENTS AND COMMERCE

Building a new railway line is not something that can be done surreptitiously, but the HSL Project Organisation is doing its utmost to prevent or minimise all forms of disruption and nuisance that the construction and operation of the line may entail. Ever since the early stages of the project, local residents and businesses close to the line have been involved in the decision-making process. The landscaping of the line, environmental remediation and mitigation and reducing noise are some of the subjects about which consultation takes place with local and provincial authorities, water and river authorities, local residents and interest groups.

Local residents have an important part to play, not only before construction begins but also very much while the project progresses. In many of the municipalities along the route of the line 'sounding-board' groups have been set up in which residents, contractors, project organisation and local authorities are all represented. The chief aim is to minimise the disruption caused by construction work and ensure effective communication. In this way all parties work together in an open atmosphere to find the best solution.

### Restrained yet distinctive

The basic premises for the aesthetic design of the High-Speed Line in the Netherlands are restraint and distinction. Restraint, because in a country as congested as ours there's no room for a variegated collection of attention-grabbing infrastructural works. On the other hand, it is not the intention to hide the High-Speed Line away from view. Quite apart from a spectacular piece of engineering like the bridge over the Hollandsch Diep, the more visible elements of the HSL such as catenary pylons and noise barriers will definitely be recognisable for what they are.

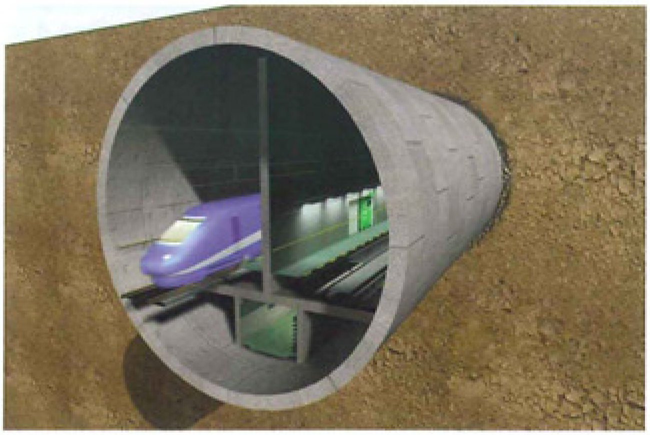
## THE STATION AS AN ENGINE OF THE ECONOMY

In the Netherlands the HSL will link Amsterdam and Schiphol Airport to Rotterdam and Breda. As envisaged by the government, it is important that when the line is opened the stations and their surroundings should be a magnet for economic activity. Shops, offices, parking facilities, and the public transport to take people there – the stations along the High-Speed Line will have all of these.

The HSL will bring in the public in two complementary senses: both literally, on the trains, and metaphorically, by attracting people to the stations: people with jobs or appointments at or near a station, people going shopping, placing orders or just out for the evening. So there are two reciprocally reinforcing quantities: the HSL and the station environment. Engines of economic activity and employment.

## SAFETY ABOVE ALL ELSE

Travelling by train is a good deal safer than driving, and research shows that rail transport is at least as safe as flying. In France and Japan, high-speed trains have been running for years without a single major accident. Nevertheless, the HSL Project Organisation is taking every possible precaution to ensure the safety of the new line. After all, prevention is better than cure.



Maximum safety is guaranteed by such inbuilt features as: • a separate track with a minimum of curves and carrying no other traffic; • no level crossings; • derailment guides; • fences and/or moats for total isolation of the track from both human and animal interference; • ultramodern electronic safety system intervenes automatically when speed limit is exceeded or distance to preceding train falls below safe limit.

The soil in the Netherlands is soft. That is why the HSL is being built on a ribbon of interlocking concrete slabs supported by piles. This method of construction will ensure that the line does not sink into the ground, and thus guarantees a stable bed for the track and catenary system — essential for the highest standards of safety and comfort for a high-speed railway line. And it offers the added bonus of reducing the need for maintenance.

## CHALLENGING CONTRACTS

The HSL is being built to last at least a hundred years. By having contracts which cover not just construction but also design and maintenance the government can be sure that any mistakes made at the construction stage will not subsequently lead to the project becoming unnecessarily expensive.

The concrete substructure for the HSL will be financed by the government. These works — including some 170 flyovers and road bridges, four tunnels, an aqueduct and a long bridge over water – are let in six large contracts. Each of these primary contracts entails expenditure of around € 400 million. Contracts of this magnitude mean that it is worth the contractors' while to invest in the development of industrial construction techniques involving a degree of prefabrication.

The Project Organisation will not be laying down the law when it comes to the details of the design. Instead, there is a schedule of requirements which the design will have to meet before construction begins and to which the line will have to conform when it is built. In this way, contractors are challenged to come up with the best engineering solutions and keep a close watch on costs and completion times. Besides the six primary contracts for the concrete substructure, contracts have also been concluded with other contractors which will link the new high-speed line to the existing rail network.

All the Netherlands' principal engineering contractors and a number of firms from abroad are involved in the construction of the Dutch High-Speed Line.

### MORE VALUE FOR LESS MONEY

For the first twenty-five years the government has contracted a specialised company for the design, construction, financing and maintenance of the HSL's rail systems — that is, in essence, the track, the catenary power supply system and the safety and security systems. This more maintenance-sensitive part of the HSL will be built on the concrete track bed or substructure. The management and maintenance of concrete structures will also be the responsibility of the same contractor.

Only after the line has been completed will the government start paying this company an annual fee for making the HSL available. Having design, construction, financing and maintenance all carried out under a single contract is a guarantee of the most effective rail system possible. Instead of investing taxpayers' money in maintenance-sensitive parts of the HSL, the government will be inviting the private sector to supply a service: line availability. Whatever the private sector has to do in order to deliver that service is all part of the commercial risk. In this model of Public/Private Partnership (PPP), annual expenditure on the availability of the HSL will be offset by revenues generated by selling licences to run trains on the line. This means that the train operator will soon be paying for the exclusive right to carry domestic and international passengers on the High-Speed Line.

### A QUICK SPIN DOWN THE HSL

The route of the High-Speed Line in the Netherlands is a hundred kilometres of gently curving line stretching from Amsterdam to the Belgian border. Where possible the new line will run parallel to existing railway lines or motorways. In Amsterdam and Rotterdam and at Breda the line will have interchanges with


the conventional rail network to give trains access to stations. From Rotterdam, high-speed trains will travel on conventional track to The Hague (Central Station).

#### Haarlemmermeer polder

From Amsterdam Central Station high-speed trains will use conventional track through Schiphol to Hoofddorp, where the dedicated high-speed track will start. At Nieuw Vennep the line will curve eastwards, leaving the Schiphol line and passing through the countryside of the Haarlemmermeer polder.

#### Ringvaart Aqueduct

To the west of the aqueduct carrying the Ringvaart over the A4 motorway a new aqueduct is being built so that the HSL too can pass below it.

#### Infrastructure bundle HSL - A4 motorway

From the Ringvaart aqueduct the HSL will run beside the west side of the A4 motorway. While the HSL is under construction this section of the A4 will be widened from 2 x 2 lanes to 2 x 3 lanes. The coming of the HSL and the widening of the A4 also mean that alterations will be necessary to the N445 trunk road, including the interchanges with the A4.

#### A4 underpass

At Hoogmade the HSL will cross the A4 at ground level. Here the motorway will be carried under the line in an underpass some seven metres below sea level.

#### The Groene Hart Tunnel

To minimise the line's impact on the characteristic fenland landscape of the Groene Hart (the Green Heart of Holland) a tunnel is being driven under it. Seven kilometres long (8.5 km including approaches), the tunnel will allow the line to follow the fastest route between Amsterdam and Rotterdam while leaving the countryside largely undisturbed.

### Bleiswijk – elevated section

In the area given over to glasshouse horticulture near Bleiswijk the HSL will travel for six kilometres on an elevated section of track carried on pylons. Most of these will be 17.5 metres apart. Average height above ground level will be six metres. The flyover carrying the track over the A12 motorway will be a striking ten metres high.

### Bergschenhoek – concrete-sided cutting

In Bergschenhoek the HSL will largely disappear from sight thanks to the construction of a semi-sunken concrete U box cutting about three kilometres long. On its east side the land will be built up to provide a park-like appearance and serve as an acoustic barrier.

### Rotterdam Noordrand Tunnel

To prevent high-speed trains interfering with operations at Rotterdam Airport and to ensure that land immediately to the north of the city can still be used for other purposes, at this point the line will run through a tunnel four kilometres in length.

### Links to existing track

Near Diergaarde Blijdorp (Rotterdam Zoo) the HSL will make a sharp bend to join the existing track entering Rotterdam Central Station. Leaving the station travelling south trains will again use existing track to rejoin the dedicated high-speed track at Barendrecht.

### Oude Maas Tunnel

A tunnel some 2,500 metres in length will be built to carry the HSL under the Oude Maas. Due to local geological conditions this tunnel and that under the Dordtsche Kil will be built by a mixture of cut-and-cover and immersed tube construction.

### Dordtsche Kil Tunnel

The tunnel under the Dordtsche Kil will be constructed by the immersed tube method. Totalling some 2,500 metres, this tunnel will also pass beneath the Rijksstraatweg and the A16 motorway.

### Hollandsch Diep Bridge

A new railway bridge will carry the HSL sweeping over the Hollandsch Diep. The slender bridge will rise to the west of the existing railway bridge, crossing the largest expanse of water on the route to Paris.

### Infrastructure bundle HSL - A16 motorway

From here to the Belgian border the line will run parallel to the A16 for a distance of some twenty kilometres. Before construction of this part of the line commences, between the Hollandsch Diep and the Galder interchange the motorway will be moved towards the west and widened to three lanes in each direction. The HSL will then be built largely along the present route of the A16.

### Prinsenbeek – "cityducts"

The concrete-lined cutting at Prinsenbeek will be covered at two places with bridges a hundred metres wide. These "cityducts" will carry not only roads and cycle tracks but also gardens and paths.

### Galder U box

At the Galder interchange the HSL will pass under the A16 motorway in an open concrete U box. The crossing is needed to allow the HSL to join up with the Belgian section of the line.

### European network

At the Belgian border the HSL will join the Belgian section of the line, thereby becoming part of the European network of high-speed rail links. From 2006 it will be possible to operate direct services to cities such as Brussels, London, Paris and on to the south of France.

## THE CHANNEL TUNNEL RAIL LINK

Since the opening of the Channel Tunnel Eurostar trains have travelled on existing track from the Cheriton portal in Kent to the International Terminal at Waterloo Station in London. Following a bidding process, London & Continental Railways won the franchise in 1996 to design, build, operate and finance a dedicated railway to a new International Terminal at St Pancras.

Union Railways, a subsidiary of LCR, is responsible for the overall provision of the link. Rail Link Engineering, a consortium of Arup, Bechtel, Halcrow Group and Systra, is responsible for the design and project management of the link.

The link is being constructed in two sections - Section 1 from Cheriton to Southfleet in North Kent, from where the link continues on existing track into Waterloo, and Section 2 from Southfleet beneath the River Thames to a new International Terminal at St Pancras. The civil works for the 74km long Section 1 are complete and the line is on programme to be opened in the Autumn of 2003. Section 1 will reduce the travelling time between the Channel Tunnel and Waterloo by around 20 minutes.

The civil works for the 38.5km long Section 2 started on site in July 2001 and the complete line is programmed to be opened at the beginning of 2007. The journey time between the Channel Tunnel and London will be reduced by a further 15 minutes, giving a journey time between London and Paris of around 2 hours 15 minutes and 2 hours to Brussels. There will be intermediate stations at Ebbsfleet, in north Kent, and at Stratford in east London Fast commuter trains will also use the link between Ashford, Ebbsfleet, Stratford and St Pancras, which will have separate platforms at these stations.


In Section 1 there is only one bored tunnel which passed under the North Downs. The 3.2km long tunnel passes through the Upper and the Middle Chalk. The twin track tunnel has a gross free area of 96.2m2 and is designed for train speeds up to 275km/hr with the potential to increase the speed to 300km/hr. The tunnel was excavated by roadheader from both ends with a crown heading, bench and invert. In addition Section 1 had 10 cut and cover tunnels with an overall length of 2.4km.

More than 50% of Section 2 is underground, with approximately 22km of the route in twin bored or cut and cover tunnel. The table gives details of the route lengths for contracts with underground works in Section 2.

The single track tunnels for Section 2 are designed for trains travelling at 235km/hr and have an internal diameter of 7.15m. The 1.5m wide bolted rings have 9 segments and a wedged key. The concrete segments are cast on site with 60Mpa concrete, 30 or 37.5kg/m3 of steel fibres and 1kg/m3 of polypropylene fibres.

Two of the casting yards have carousel systems and the third yard has a fixed mould system. Cross passages are provided at 350 to 750m centres

Six of the eight Tunnel Boring Machines manufactured for the project are currently driving tunnels. The table gives details of the TBMs and the progress before the 2002 Christmas break. For all six EPB machines the excavated spoil is being removed from the back of the TBM by conveyor to the portals. In addition there is a short 650m drive of running tunnel near St Pancras which will be constructed with a shield and roadheader.

| CONTRACT | TYPE OF SHIELD | MANUFACTURER | PROGRESS |
|---|---|---|---|
| 220 1st drive | EPB | Kawasaki | 1,230m |
| 220 2nd drive | EPB | Kawasaki | 215m |
| 240 1st drive | EPB | Wirth | 132m |
| 240 2nd drive | EPB | Wirth | Feb 2003 |
| 250 1st drive | EPB | Lovat | 373m |
| 250 2nd drive | EPB | Lovat | 10m |
| 320 1st drive | Slurry | Herrenknecht | 1650m |
| 320 2nd drive | Slurry | Herrenknecht | Summer 2003 |

There are six shafts along the alignment which have been constructed with secant piling or diaphragm walls. One of the shafts has diaphragm walls 54m deep, the deepest in the UK.

| CONTRACT | LOCATION | LENGTH | CONTRACTOR |
|---|---|---|---|
| 103 | Kings Cross | 650m bored and 105m C&C | Kier/Nuttall |
| 220 | Stratford toGifford Street Portal | 7.5 km bored and 45 m C&C | Nishimatsu Cementation Skanska |
| 230 | Stratford Box | 1,070m open cut | Skanska |
| 240 | Stratford to Barrington Road | 4.68 km bored | Costain/Skanska Bachy Soletanche |
| 250 | Ripple Lane portal to Barrington road | 5.25km bored and 150m C&C | Nuttal/ Wayss & Freytag/Kier |
| 320 | Thames tunnel | 2.5 km bored and 730 m C&C | Hochtief/Murphy |
| 342 | Thames tunnel to Southfleet | 305 m C&C at Pepper Hill | Hochtief/ Norwest Holst |

The box for Stratford Station is 1,070m long and has been constructed with diaphragm walls. The two ends of the box are the launch chambers for the two TBMs driving to the east and for the two TBMs driving to the west towards St Pancras.

There are cut and cover sections in four of the other contracts with a total length of 1,335m. On three of the contracts diaphragm walls have been used and in the fourth contract the cut and cover section has been constructed within a sheet piled cofferdam. On Contract 320 there are cut and cover and retained open cut sections at both ends of the twin tunnels. The target cost for the overall length of 730m of cut and cover and 310m of retained open cut for that contract represent two thirds of the contract value.

R. Craig, BTS

## First Masterclass at JTA in 6th COB-JTA Joint Technical Meeting
### Japan, Oct 7-11, 2002

JTA (Japan Tunnelling Association) and COB (Netherlands Centre for Underground Construction) have held the Joint Technical Meeting annually in Japan and the Netherlands by turns since the both concluded the MOU (Memorandum of Understanding) in 1997 to exchange and share the tunnelling technology of the both country. The report on the Masterclass in the 5th Technical Meeting in 2001 held in the Netherlands was introduced in page 21 of Tribune N.21, February. 2002.

In 2002, this Technical Meeting was held from October 7 to October 11 in Japan. 19 Engineers from COB including H.M.Schroten, Chairman of the board of supervisors of COB, H.J.C.Oud, President of COB, participated in this meeting. 40 Engineers from JTA including H.Hagiwara, President of JTA, K.Miyaguchi, Executive Director of JTA, and some young engineers joined it.

In the first and second days, the first Masterclass at JTA was held, which was chaired by H.Takasaki (Professor of Nihon University), and co-chaired by O.Kiyomiya (Professor of Waseda University), H.Mashimo (Dr.Eng. from Public Works Research Institute) and J.H.van Oorschot (from Royal Volker Wessels Stevin).

The main topics of the Masterclass were "Immersed Tunnel" and "Fire Protection of Road Tunnel". The Netherlands has much experience and high technology on these. Japan is much interested in these technologies and has developed the technology on these recently and been involved in some projects regarding these.

Masterclass comprises short presentation of experts from the both countries in the first session and long discussion by attendees in the last session. The target of it is to transfer the technology of experts to young engineers. Many engineers including experts joined the Masterclass in the Technical Meeting, which was the first one in Japan and the fruitful meeting. Masterclass is a good measure on technology transfer and will be positively upgraded in the future.

In the Workshop on October 9, the state-of-the-arts reports on five topics shown in Table-1 were presented. On October 10, we had site visits of the high-speed railway project and the underground station. Then, the fruitful technical discussion was done in the sites.

The Cultural Program in the last day features the Joint Technical Meeting by JTA and COB. The target of it is to experience the culture, tradition and history of the both countries. Both of JTA and COB think

| DATE | EVENT | CONTENTS |
|---|---|---|
| Oct 7 | Masteclass 1 | Immersed Tunnel<br>Connecting joints<br>Maintenance<br>Management of construction |
| Oct 8 | Masterclass 2 | Fire prevention of road tunnels<br>Design concept<br>Risk & crisis management<br>Fire tests introduction |
| Oct 9 | Workshop | Spatial planning & exploration<br>Environmental problems<br>Maintenance of existing tunnels<br>Management of construction procedure<br>Value engineering |
| Oct 10 | Site visits | High speed railways - Subways |
| Oct 11 | Cultural programm | |

not only exchange of technology but also one of culture is important to make better international communication because engineer is also a member of society.

We had the successful COB-JTA Joint Technical Meeting in 2002 including the first Masterclass at JTA and we think that this Meeting will be continued in the future. We highly appreciate the exertion of COB who dispatched many experts to Japan.

Korehide Miyaguchi, Executive Director, Japan Tunnelling Association

## Road tunnel design, construction and operation
### Beijing, China, November 6-8, 2002

As requested to all technical committees of PIARC, the technical committee of road tunnel operation (C5) had to organize 2 seminars during the intercongress cycle 1999-2003. The first was organized in Chile in April 2002, and the second one in Beijing (China) on 6-8 November 2002. The Chinese authorities shifted however the general title to "Road tunnels design, construction and operation", which lead C5 to implicate ITA in the preparation of some parts of the seminar.

At the opening ceremony and opening session, we had exhaustive presentation of PIARC as the World Road Association, and the Road Tunnel Operation Committee C5. It was also stressed that PIARC and ITA were fully complementary, as the last one deals mainly with construction as well as the use of the underground for all possible purposes.

The general presentations gave an excellent overview about tunnel and road construction achievements and projects in China, including Hong Kong SAR. They also recalled the basic principles for the safety of human beings in case of accidents in road tunnels, as seen after the dramatic catastrophes in European tunnels in 1999 and 2001.

The basic principle "Safe your life, not your car" should remain present in every driver's memory. The technical sessions, in parallel rooms, allowed the 6 Working Groups of C5 to present the work they have managed to do since Kuala Lumpur World Road Congress in 1999.

Next to this we can divide the presentations, both from Chinese side and from overseas, in the 2 indicated topics: tunnel design and construction on the one side and road tunnel operation and management on the other side.

As far as tunnel design and construction is concerned, there were presentations about shield tunnelling, TBM tunnelling, conventional drill & blast tunnelling, immersed tunnelling, arch tunnelling and so on. Cut-and-cover tunnelling was not quoted, despite the fact that it remains an important method in urban areas.

China is on the eve of building a lot of new road and other tunnels, some of them very long, and has really its place in the international tunnelling world. The Quinling Zhongnan Mountain tunnel will become the second longest tunnel in the world.

Examples of carried out achievements and on going projects were shown from Shangai, Guiling, Quinling, Zougnam, Er'langshan, Zhegushan, Da Ban, Dalian and Changhong, as well as from Japan. We also evoked in the discussions the Laerdal tunnel in Norway, 24 km long, and the Westershelde tunnel in the Netherlands, now under construction.

The importance for the road authorities to take the tunnels whole lifetime into account was described. The upgrading and renovation of the San Bernardino tunnel in Switzerland after 35 years of operation will cost more than the original construction of the tunnel. The work will take 7 years, partly due to the fact that one traffic lane has to pass the working site at all times, and that all traffic lights have to be placed outside the tunnel. This is one lesson learnt from the Tauern tunnel fire.

On the scientific level, there were a lot of presentations about geological phenomenon and their analysis and monitoring. Also materials, testing methods and special techniques were presented.

As far as road tunnel operation and management is concerned, and this is by far the most important point for the C5 committee as organism body, the conclusions were given in amore general way.

Despite the recent catastrophes in Europe, serious accidents remain very seldom. The consequences are however very large and dramatic especially when fire occurs. This justifies the wide research activities in the last years particularly with the financing of the European Commission.

When an accident occurs, the human behaviour in the first minutes is a determining factor guiding the extent of the event. Users behaviour is therefore the essential factor in saving lives, and has to be based on the principle of self-rescue. But in many cases also the rescue teams need a better knowledge of what equipments are available in each tunnel.

There is a need for international action in the field of information of the public – the road tunnel user – on behaviour in tunnels, as well in normal and daily situations as in case of accidents, emergencies, fires, etc. It should be done by education in the driving schools, by training with brochures and leaflets etc.

There were a number of interesting questions, interventions and comments from the floor, showing its real interest to the presentations.

An attendance of more than 600 participants from 18 countries shows that there is interest in countries like China both for the formula and for our subjects of tunnel operation and tunnel design and construction.

It was noticed that there was less attendance at the operation sessions than at the design and construction ones. This can have to do with the fact that China is on the eve of tremendous transport infrastructure projects, and focuses on them, perhaps giving already now to less attention to the unavoidable maintenance and operation.

This seminar shows also that there seems to be difficulties of transmission of the available information. All technical publications of C5 are available to the public, as well as on the web site of PIARC as on paper. This is however only in the two official languages, French and English. It would be of interest for China to explore the possibility of translating some of them into Chinese, perhaps as a special collaboration with PIARC, especially the "best-seller" about "fire and smoke control" published just before the Kuala Lumpur congress. Next year, the same could be done with the content of all our ' sessions in the Durban congress.

Article prepared by Willy de Lathauwer, secretary of the PIARC Technical Committee of Road tunnel operation (C5), former Vice-President of the ITA.

Since the adoption of the reform and opening policy highway transportation in China has been changing. By the end of 2000 China has 1,684 road tunnels with a total length of 628 km. By the end of 2001 the mileage of highway in operation amounts to 1.430.000 km including 190,000 km expressway with a road density 14.6 km / 100 km$^2$. A highway network of good linkage, rational distribution and a radiation in every direction has been preliminarily established. According to the 10th Five-year plan (2001 – 2005) by 2005 the anticipated total mileage of highway in China will reach 1.6 Mio. km among which 25,000 km will be expressway. Traffic and transportation industry in China is developing very rapidly and so obviously there is a vast amount of need to finance technology, human resources and information.

ITA has been asked to send 2 experts, namely Harald Wagner presenting an introduction of ITA and 2 papers and Makoto Kanai to cover aspects of PIARC C5 which is dealing with tunnel geometry, equipment, safety, operation and environment. Chinese representatives have expressed their interest in stability of surrounding rocks of road tunnels, structure of support and lining of road tunnels, tunnel water proofing and drainage, monitoring, communication and tunnel boring machines.

The Conference has been very successful with most interesting interdisciplinary discussions and ITA representatives did express their appreciation and gratitude for the excellent organization and very thoughtful well-being in the Beijing Friendship Hotel.

Article prepared by Harald Wagner, Member of the ITA Executive Council.

## Shotcrete for Underground Support IX
## Kyoto, Japan, November 17-20, 2002

The Japan Tunnelling Association (JTA) and International Tunnelling Association (ITA) sponsored the Shotcrete for Underground Support IX Conference held in Kyoto, Japan, from November 17-20 2002. It is a cooperative conference with the United Engineering Foundation, New York, which sponsored the previous eight conferences, the first of which was held 30 years ago. A total of 35 papers were presented at the Conference, 34 of which are published in a proceedings available from the Japan Tunnelling Association. The conference was chaired by Dr. Koichi Ono, Professor at Kyoto University Japan, ITA Executive Council Member and co-chaired by Dr. D. R. (Rusty) Morgan, Chief Materials Engineer at AMEC Earth & Environmental Limited, Vancouver BC Canada.

The conference was a resounding success. It was attended by over 70 delegates, with papers from Japan, South Korea, Vietnam, India, Canada, Brazil, France, Finland, Norway and Switzerland. Keynote addresses were given Dr. Koichi Ono from Japan on Shotcrete Use in Tunnelling Works in Japan, (over 2 million cubic meters per annum) by Minema Ikoma from the Japan Railway Construction Public Corporation (JRCPC) on Development of Shotcrete Technology in the JRCPC and by Knut Garshol from Norway, Animateur of ITA WG "Shotcrete Use in Tunnelling", on *Admixtures and Other Factors Influencing the Durability of Sprayed Concrete and Sprayed Concrete: A Modern Holistic Approach*. In addition, Dr. Harvey Parker, from Seattle, Washington, USA, a member of the ITA Executive, gave an overview of ITA activities.

The Conference was subdivided into six sessions. The first session was on Shotcrete Materials, with five papers on new alkali free accelerators, two on slurry type accelerators and one paper on a new dust-control agent. The impetus for much of this work is the new Japan Ministry of Health Guidelines for Dust Reduction in Tunnel Construction, which has set a dust concentration limit of 3 mg/m3 at 50 m from the face during tunnel construction (including shotcreting operations). Most of the new shotcreting technologies were able to satisfy these new limits.

Nine papers were presented in the second session on Properties and Durability. Five of these papers dealt with the effects of accelerators on early and later age strength and/or durability of shotcretes. One paper looked at the effects of shotcreting velocity on various properties of shotcrete and there was an interesting paper from Brazil on the use of electrical gradient to increase early age compressive strength in shotcrete in tunnels. Two paper were presented in the third session on Support Mechanisms. One paper focused on adhesion between shotcrete and the rock mass and the other looked at the failure mechanism of bonded shotcrete installations.

The fourth session had the theme of New Shotcrete Systems. Six papers were presented in this session. Four of these papers dealt with various aspects of a new airless shotcrete system, which utilizes an impeller in a centrifugal sprayed system to apply shotcrete. This system generates very low dust emissions. Two of the papers in this session looked at mechanized shotcrete reinforcing erection systems and/or dust collection systems.

A variety of different papers were presented in the fifth session on Shotcrete Application. Papers ranged from shotcreting in conjunction with shield tunnelling methods, to the use of fly ash in shotcrete tunnel linings to Experiences with Shotcrete Support in Underground Openings in India. In addition there was a very interesting paper on a new-sprayed type waterproof membrane for single shell lining. In the final session four papers were presented dealing with various aspects of fiber reinforcement in shotcrete linings. Papers dealt with both steel fiber reinforcement and new types of synthetic fiber reinforcement.

To summarize, having this Conferences in Japan, in English, provided the opportunity for Japan and its neighbors to showcase the state-of-the-art of their Shotcrete for Underground Support technology. It is apparent that with over 1500 tunnels, with a total length of nearly 1700 km being constructed in Japan in 2001 alone, there is a great incentive to develop optimized tunnel lining systems. The Japanese have made great strides in developing mechanized shotcrete lining systems and this Conference provided an excellent opportunity for technology transfer to the tunnelling community around the world.

Finally, delegates were treated to the spectacular fall colours in Kyoto and surrounds and an opportunity to visit Buddhist and Shinto Temples designated as United Nations World Heritage sites - A truly memorable experience!

Dr. D. R. Morgan, P.Eng, Conference Co-Chair

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