PROACTIVE FIRE TRENDS

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for Asia Pacific Building Industry Professionals

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Strategic Synergy Clinches Contract

For Tokyo's New Immersed Tube Tunnel

Acknowledging the strategic benefits accrued by Promat's specialised global leadership in Proactive Fire Protection for Tunnels, Phoenix Trading Co. (Promat's long-standing partner in Japan) – in concert with Promat International Asia Pacific and Promat Germany – has been awarded the contract to supply PROMATECT®-H to the Tokyo Bay Seaside Road (Rinkaidouro) immersed tube tunnel.

While the project itself incorporates involves huge engineering challenges, Promat participation should come as little surprise...the company has considerable worldwide experience with underground structures and proven international leadership in providing proactive fire protection for tunnels.

Japanese expertise in tunnel construction is second to none, the country uses an unusually high number of tunnels.

The application of PROMATECT®-H will give the Tokyo Port Seaside Road Tunnel a safe level of essential proactive fire protection.

Tunnels in Japan

We apparently react to tunnels on two separate and different levels.

Our first reaction is an instinctive one. It is the nature of tunnels to be hidden from view. They occupy space far from natural light. Not surprising therefore that tunnels usually inspire a sense of instinctive fear.

In direct contrast, our second reaction is usually one of awe at the sheer size, scale and achievement required to create underground structures in these out-of-the-way "unnatural" places. The creative solutions for the overpowering engineering challenges usually inherent in such projects only expand this sense of wonder.

At the other end of the same spectrum, anyone interested in glimpsing the future of urban environments should spend some time in Tokyo.

It doesn't take long to understand the dynamics of an intense built environment, the symbiotic significance of underground structures and the ready acceptance such structures quickly receive by the communities and people who use them.

Indeed, particularly in this crowded city of some 12 million inhabitants, it is quite easy to stay underground and never see the light of day.

Japan's unique geography of small and mountainous islands – most of its 126 million people live on just 20% of the country's land area – means that historically the country has had little choice but to build tunnels and other underground structures as more efficient means to other ends.

In densely populated and land-scarce Japan, tunnels are not seen as expensive luxuries but arteries vital to the lifeblood of this crowded economic superpower.

An Impressive Immersed Tube Tunnel

A good example of the combined benefits of technology and tunnels is the Tokyo Port Seaside Road Tunnel.

When this modern engineering marvel is complete it will integrate seamlessly with a new traffic system designed to cope with the demands of ever increasing traffic created by the continuing waterfront development of Tokyo Port.

Accessibility to a congested area will be improved and travel times significantly reduced.

The tunnel section stretches 1400 metres between Jonanjima and Outer Central Breaking Water Reclamation Area. Tokyo Port Seaside Road will cover the section from Jonanjima via Outer Central Breaking Water Reclamation Area to Wakasu crossing both the Tokyo West and East Sea Lanes.

Tokyo Port Seaside Road will be completed by Spring 2002. The Tokyo Port Seaside Road Tunnel shall make the smooth traffic and will be the longest and deepest Immersed Tube Tunnel in Japan.

Continued on page 3

Cover photograph courtesy of Bureau of Port and Harbor, Tokyo Metropolitan Government

F E A T U R E S

Point of View

EXPANDING TUNNEL VISION?

It is our continuing purpose to make PFT a relevant, broad-based and effective marketing tool for our people, our company and, above all, our standard-setting products and services. We have always been mindful of the interests of our core readers, as well as our enthusiastic and loyal business partners throughout the region.

We have from time to time adapted the content of PFT to circumstances. Not always easy to anticipate correctly, especially against regional dynamics, but at the end of the day we believe that PFT continues to be a useful supplement to our combined efforts to sustain Promat leadership in the fire protection industry.

In response to generally constructive feedback, we now believe it is appropriate to deliver more technical information throughout the pages of PFT. This can be used advantageously to maintain professional standards while also providing solutions for commonly encountered problems. Similar technical news will follow in the months ahead but, for now, we are pleased to dedicate this issue to fire protection in tunnels in general, and specifically to the new Tokyo Port Seaside Road Tunnel being built underwater across Tokyo Bay. The latter, an amazing feat of complex engineering, leads as our cover or theme story. It's use of innovation is an appropriate parallel for a company of Promat's calibre.

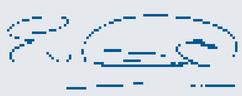
Indeed, it is this tunnel theme that could also add new meaning to the frequently (mis)used phrase, "tunnel vision". Usually employed to describe a state of mind suffering from self-imposed limitations, "tunnel vision" can also imply ignorance to other perhaps more important external factors. In the broad scheme of modern business, a company or individual suffering from "tunnel vision" is usually considered to be blind to other, more successful business strategies.

Conversely, Promat has, over the past few decades, built a significant knowledge bank in the business of fire protection in general in all kinds of structures, above and below ground. Our vision is the vision of business leadership focussed on the specialised but multi-faceted area of fire protection. We routinely take innovative solutions and extrapolate them into a matrix of specialised professional products, systems and value-added services which in turn are routinely employed in all sorts of applications, including tunnels. "Tunnel Vision" therefore becomes a much more meaningful and, in my opinion, accurate expression.

Complementing the same theme, under Network Reports, an experienced voice on tunnel requirements in Singapore can be heard, taken from a recent interview with Mr Donald van Olst, Manager of Fire Safety Industry, Promat Netherlands. Also on page 8, a Worldwide Tunnel Concrete Fire Protection Reference provides readers with reference of Promat's panels.

In Science & Research, an interesting Lifetime Fire Safety In Tunnels paper from a recent Fire Engineers' Conference on Long Road & Railway Tunnels is reviewed. In the same department but on page 8, a study of the Tunnel Fire Temperature Curves rounds out this issue of PFT.

In conclusion, THINK GLOBAL ACT LOCAL is clearly a realistic analogy for continuing and building on Promat leadership in Proactive Fire Protection in general while identifying and expanding specialist niche markets such as tunnels. The best of both worlds and a profitable new meaning for "tunnel vision" hopefully enhances the benefits of underground structures for all.



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NETWORK REPORTS

A Recent Interview with Donald van Olst - Manager of Fire Safety Industry, Promat Netherlands

Frequently Asked Questions on Tunnel Concrete Fire Protection Enhancement

Donald van Olst was born in Amsterdam in 1950. He joined Promat Netherlands in 1976, has accumulated almost 15 years experience working specifically with tunnel fire protection. He is renowned in the Netherlands as a veteran of tunnel fire protection.

As a member of the Tunnel Expert Group formed within the Promat International Organisation, Donald (represented as **D.** below) has given many technical talks internationally on this subject. His last visit to Singapore was for a presentation to the Land Transport Authority in 1998; presenting a paper entitled *Concrete Protection – A Need or An Exaggeration*.

1. Is tunnel fire protection required in the planning of new tunnels in many countries?

D. In the Netherlands, tunnel fire protection is required in newly built road tunnels under the responsibility of the Ministry of Transport. The cost of protection to tunnel structural ceilings and top 1 metre of tunnel walls, is less than 3% of the entire tunnel building cost and it can avoid a lot of future problems.

In France, they have since this year set up new standards for protection of tunnels against fire. They paid a high price for their learning curve with the Mont Blanc tunnel fire a year and a half ago still clear in their minds. With such a long tunnel repair closure, tunnel structure fire protection should be a major consideration for transport authorities.

Recent papers presented by Richard Machon, Consulting Ingenieur Services GmbH on *Reinstatement Strategy After A Tunnel Fire* discussed at length expected tunnel fire temperatures and structural limits and made specific mentioned further consideration be given to "enhancing the fireproof construction inside tunnels".

2. If required what temperature curve was selected by these countries?

D. In France, they have selected their own tunnel fire curve, similar to the RWS curve but lower by 50°C. In Germany they have the RABT curve, in Netherlands the RWS curve, in Japan the RWS curve all for 2 hours fire protection period. In Ireland they selected the HC curve for 3 hours fire protection period (see page 8).

3. How relevant are the temperature curves for a given tunnel?

D. The temperature curve is very important. If the temperature curve selected exposes the material to a lower temperature than the temperature in the fire in reality, the protection material will be under-specified. The Eureka fire tunnel project has revealed temperatures of vehicular fires of up to 1300°C. Even if a lower fire exposure curve is specified, the protection material should have melting temperatures above the potential worse case temperature.

4. The Mont Blanc tunnel is rather long and the fire occurred in a remote area. In such a case fire brigade response time may be longer. In an urban environment, where accessibility to the tunnel may be easier and fire fighting / rescue response time shorter. In this respect, is fire fighting & rescue response time relevant to the protection period of the tunnel structure? Should the protection period be determined this way?

D. The Channel, Mont Blanc and Tauerntunnel and many other tunnel fires, reports severe temperatures above 1000°C. It is not easy to predict the speed of development of the fire. However tunnel fire reports, time and again reveals similar problems of fire fighter access to the fire source, due to the intense heat and poor visibility. The length of tunnel does not relate directly to the fire occurrences. The Sankt-Gotthard Tunnel is 15km long. Between 1992 to 1998, there were 42 fires occurrences involving damages to 21 cars, 14 trucks and 7 buses. Therefore fire protection period could not be determined by fire service response time but by the fire severity planned for. Instead rescue efforts should make provision for inhibited fire rescue due to the concrete spalling behaviour of tunnel fires.

5. Does the length of tunnel influence the protection period required?

D. The longer the tunnel, the higher the risk and the more serious the evacuation efforts, the risks and hazards compound themselves.

6. What are the types of protection available in market?

D. Boards type and spray type material. Some research fire tests were carried out on Polyethylene fibre reinforcement in concrete. However it is known that in certain fire tests carried out in Germany, such material did not perform to expectations.

7. Should the vertical tunnel walls be protected as well?

D. This depends on the assessment of the risk by the relevant authorities and fire consultants. In the Netherlands up to 1 metre of the wall from the tunnel soffit requires fire protection.

8. How is the tunnel structure fire protection material installed?

D. PROMATECT® boards has been installed as lost shuttering and as a post cladding material.

9. Which is the best protection method that will minimise servicing requirements after the tunnel is completed - post cladding is easier to remove, while lost shuttering is more difficult?

D. The Netherlands has 14 years of experience, and there has not been a requirement to totally remove PROMATECT® boards for servicing. It is true that post cladding facilitates ease in retrieval.

10. How are cracks in the concrete during fixing of protection material treated?

D. Cracks in the concrete pose no problem to the PROMATECT® boards. If the cracks need to be repaired, boards can be removed, or drilled through to gain access to the concrete for grouting repairs.

11. Does the PROMATECT® protection inhibit the regular inspection and maintenance procedures of the tunnel, especially for water seepage and concrete spalling?

D. Water seepage is expected especially in the sub-sea tunnels in the Netherlands. For example, Westerschelde tunnel has a 65m water column. PROMATECT® can be wet by the water seepage but it is unaffected by water. Wet spots are therefore visible and hence do not inhibit inspection. However leakage problems should always be addressed seriously and not left alone.

12. How about reinforcement bar carbonisation? How would a PROMATECT® lining affect the treatment of this concrete problem in tunnels?

D. The concrete cover should be designed for addressing this aspect, although logically the PROMATECT® lining shields the concrete from direct contact of aggressive car pollution. An examination of the 9-years old PROMATECT® board cladded to Velsertunnel in Netherlands was conducted. PROMATECT® showed negligible lost in strength and the no rebar carbonisation was visible in the concrete.

13. How will the protection material react to the chemicals in the water seepage?

D. PROMATECT® Boards are inert and will not react to chemicals.

14. How will the protection material react to alternating pressure from vehicular traffic?

D. A test has been carried out in Germany's IBMB subjecting PROMATECT® specimens to 110,000 cycles of alternating pressures 3 times more than normally encountered in vehicular tunnels. No displaced of the board occurred.

15. How will the protection material behave when thorough saturated from water seepage - will it fall off?

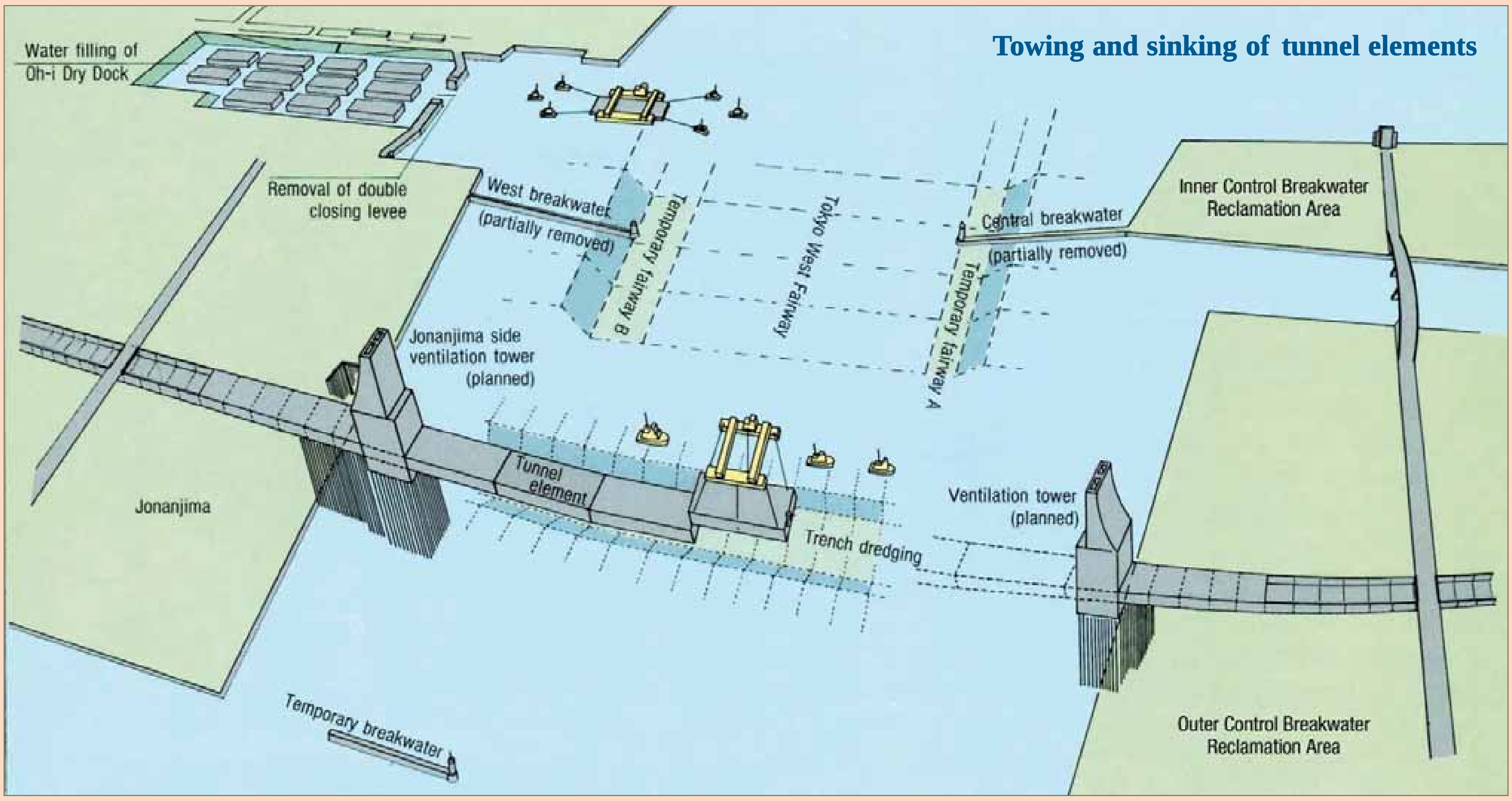
D. From the 14 years of experience in the Netherlands, no PROMATECT® boards have fallen off.

16. How do we build in maintenance and service procedure for PROMATECT® after the protected tunnel is operational?

D. PROMATECT® boards need no maintenance.

See page 8 for Worldwide Tunnel Concrete Fire Protection Reference PFT

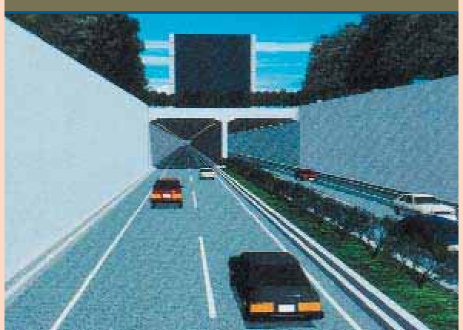
STRATEGIC SYNERGY CLINCHES CONTRACT FOR TOKYO'S NEW IMMERSED TUBE TUNNEL *(continued from cover)*

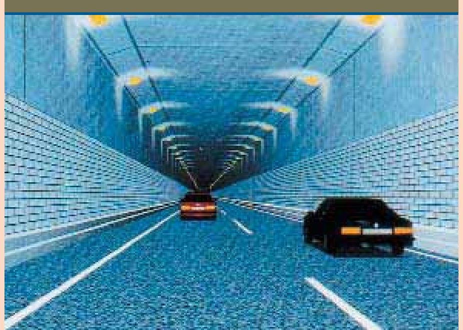


All Drawings courtesy of Bureau of Port and Harbor, Tokyo Metropolitan Government
Pictures by Phoenix Trading Co.

Tokyo Port Seaside Road Tunnel under the Fairway

Artist's impression (from top to bottom) of tunnel section, whole tunnel, portal and ventilation tower, and tunnel interior.





Special Design Features

The Tokyo Port Seaside Road Tunnel will be comprised of some eleven 120m long tunnel elements. Each pre-stressed concrete tunnel element is divided longitudinally into seven blocks. Each block, about 17m long, will be fabricated in three parts – the lower slab, the walls and the upper slab.

Each standard section tunnel element, 32m wide and 10m high, will weigh approximately 40,000 tons. The waterproof nature of each element and the tunnel in general will be ensured by 8mm steel plates on both sides and the element bottom, working with a watertight rubber shell on top of the element.

High grade concrete and joint connecting cables complete a general installation picture.

The elements will be connected to each other via a system of flexible, waterproof joints ensuring flexibility and resistance to earthquakes. Each element has first been fabricated on land in a dry dock, sealed with watertight bulkheads, floated to site, positioned and then sunk onto temporary holding brackets.

As each element is drawn up the previous elements, rubber gaskets (rather like the common O-Ring used to waterproof most underwater equipment) located at each element end are joined together to form a primary water seal.

The water between bulkheads is drained through the preceding elements and hydraulic pressure of about 6000 tons acts on the immersed element to ensure a proper connection between the elements.

This sequence is repeated with each of the immersed elements.

Influential Factors For Fire Protection in Immersed Tube Tunnel

The nature of fire protection depends to some extent on the construction of the tunnel itself. Fire protection requirements in turn are also influenced by the daily usage of the tunnel.

The expected atmosphere in tunnels, the suction loads caused by traffic, and the crack width and compressive strength of the concrete used, all play leading roles in the choice of fire protective cladding and its method of fixing.

Concrete is used in virtually every conceivable form of construction and is generally perceived to be a solid and dependable material with inherently good fire resistant characteristics.

Nevertheless, it is necessary to protect concrete with fire-resistant cladding such as PROMATECT®-H because laboratory, empirical evidence and actual fire indicates that concrete structures subject to stress generally fail when their compression strength is exceeded.

This occurs, for example, in the event of fire which in turn creates a phenomenon called spalling which can eventually work its way through the entire concrete ring-lining in a tunnel, layer by layer.

Substantial research clearly demonstrates that concrete structures suffer surface spalling as a result of high compression stresses in the heated outermost layers and the generation of water vapour at high pressure behind those layers. Spalling further impairs the performance of concrete by then exposing steel reinforcement or tendons to fire or by reducing the cross-sectional area of concrete.

In some situations, and of particular concern in tunnels, explosive spalling occurs when the internal moisture content of concrete heats rapidly and converts to vapour which creates huge pressures under the surface of the concrete.

A fire resistant lining such as PROMATECT®-H, attached to the inside surface of the tunnel with the appropriate purpose-built fixing devices, will provide concrete with as much as two hours fire resistance.

A lining of PROMATECT®-H is capable of coping with the unusual high suction loads created by vehicular traffic in tunnels.

The Benefits of PROMATECT®-H in Tokyo Port Seaside Road Tunnel

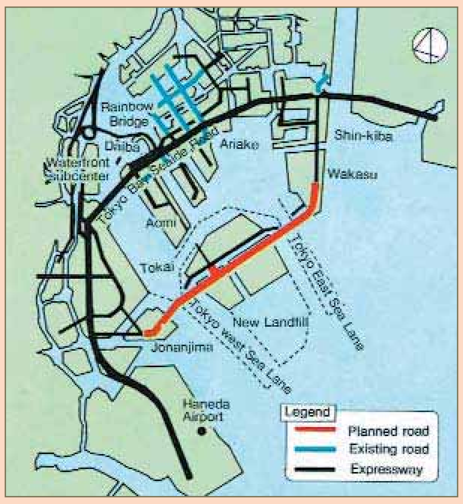
The choice of fire protection used in tunnels depends on a number of factors.

The application of a flat board protection system such as PROMATECT®-H is preferable for a number of reasons including:

- Easy to work and to install;
- Thickness can be easily checked and application can be guaranteed to meet specifications in tested constructions;
- Suction and wind loading from passing traffic has no effect when boards are correctly installed;
- Completely unaffected by vehicular combustion by-products of traffic passing through tunnel;
- No affect by ingress of water and/or condensation;
- Act as a form of filter during exposure to fire, ensuring that corrosive gases do not have direct and destructive access to the concrete and reinforcement of the tunnel linings;
- Little maintenance required but where periodic access is required to inspect concrete substrate, boards can be quickly removed and reinstalled, maintaining a fire protective layer at all times;
- Can be easily combined with wall linings, decorative claddings and in sandwich panels which are easy to clean and maintain.

Above: Cladding construction method using PROMATECT®-H boards in Tokyo Port Seaside Road Tunnel.

Little wonder that general contractors of the Tokyo Port Seaside Road Tunnel chose a PROMATECT®-H fire resistant tunnel lining. They know that PROMATECT®-H provides the required safety performance to make Tokyo Port Seaside Road Tunnel a safe underpass for vehicular traffic.



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A project by

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Contractors:

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PHOENIX

See page 8 for Worldwide Tunnel Concrete Fire Protection Reference

PFT

Fire Engineers' Conference Review on Long Road & Railway Tunnels

Lifetime Fire Safety in Tunnels

by **J.F.L. Lowndes** / *Consultant*, Londesconsult Ltd.
and **M. Shipp** / *Principal Consultant*, FRS,
Building Research Establishment

Road and railway tunnels have a very long lifetime – potentially half a century or more; and it is important that fire safety systems must continue to work and be available at an instant, should they be needed. Fires in tunnels, such as Mont Blanc and the Channel tunnel, have illustrated the consequences of a fire occurring; this article touches on issues fundamental to fire safety in tunnels.

1. Introduction

At the start of nearly all new major tunnel projects, fire safety is the responsibility of the designer and the development engineer. But the safety system they are constructing must last and work effectively, for the whole lifetime of the tunnel.

Constructing a tunnel is a large undertaking, taking a long period of time from conception to completion. In an ideal world, the project team would be put in place at the beginning, and stay complete until normal operation is underway. This team would include the owner, designer, operator and regulators – with the constructor entering the team whenever contractual arrangement requires. However, in practice, this rarely happens.

For example, in a city which has never had such a project before, at the early stages, the client team would consist largely of planners and engineers, probably with a business input. The team will, of course, report to politicians – either local or national, depending on the scale of the project.

It is difficult to raise an interest in operations which will not happen for several years, but is important that the designer has sufficient experience to ensure that the system as designed is operable in an industry standard manner.

2. Difference Between Road & Railway Tunnels

When considering the life safety aspect of taking a tunnel project from concept to service, rail and road tunnels need to be separated.

Firstly, in the UK there is a Railways Inspector; however, there is no highways tunnels inspector. In road tunnels, the fire officer has a regulatory role and clearly is heavily involved in emergency planning, smoke control and evacuation routes – but on design matters his role is not adequately defined. Examples of differences in legislation are shown on the diagram as below.

LEGISLATION – ROAD & RAIL

Because national standards and legislation differ, sometimes significantly, it is not possible to cover this in detail. Key legislation in the UK is shown here, as an example, that highlights the differences in regulations between road and rail tunnels.

RAIL REGULATIONS

In the UK, the Railway Inspector – first appointed in 1840 – is the regulator for rail projects, His office has now joined the Health and Safety Executive, and he works in close conjunction with the fire officer who advises him on all fire-related matters. It is the responsibility of the owner to demonstrate to the Railway Inspector how he intends to operate the railway in an acceptably safe manner. In the UK, there were two statutory regulations introduced in 1994:

Railway Safety Case Regulations

These regulations require all operators, whether they cover infrastructure or trains, to have the way in which they will manage and arrange their safety responsibilities accepted by the Regulator. The Inspectorate has published a suite of documents entitled **Railway Safety Principle s and Guidance** [2] – this title is carefully chosen to infringe or usurp the owner's responsibility.

The document contains advice on aims and good practice. Good practice allows for a little lateral thinking by both the promoter and the regulator, with resultant innovation and development.

Railway & Other Transport Systems Regulations

The **Railway and other Transport Systems (Approval of works, plant and equipment) Regulations** [4] are all embracing and cover all aspects of the procurement of a new railway or replacement equipment for an existing railway.

ROAD TUNNEL REGULATIONS

In the UK there is no highway tunnels inspector as there is a railways inspector. The fire officer does not have a regulatory role in highway tunnels, and is heavily involved in emergency planning, smoke control and evacuation routes – but on design matters his role is ill-defined.

ROAD TUNNEL REGULATIONS

The concept of fire safety engineering is now being widely applied to relevant standards. For example, in the USA, NFPA has a recommended practice document, soon to be a standard – NFPA 502 **Limited Access Highways Tunnels, Brigades, Elevated Roadways and Air Right Structures** [6]. The latest 1997 version recognises the disadvantages of an over-codified approach, and now encourages engineering analysis of the ventilation system *"which shall include a validated subway analytical simulation program augmented as appropriate by a quantitative analysis of airflow dynamics produced in the fire scenario, such as would result from the application of validated computational fluid dynamics (CFC) techniques"*. In the UK, the Highways Agency has recently issued design guidelines.

The second major difference is that it is not possible to define the fire loads of the vehicles using the highway tunnels. On a railway, consideration can be and is given to the carriage of hazardous goods through a tunnel. In some cases, certain classes of goods are banned. A number of studies have been carried out to compare the societal risks of hazardous goods being taken through a road tunnel, or around an alternative route – perhaps through a town. In some cases certain goods are escorted, but many tunnels are considered as normal highways (with a roof).

The third significant difference between rail and road tunnels is staffing. An underground railway station will almost always have staff present during operational hours. Most trains have a driver and perhaps more crew. On highway tunnels, however, whilst some heavily-used urban tunnels are patrolled by trained personnel, in many cases tunnels are rural and remote. In these cases it can take significant time for either tunnel staff or the fire brigade to attend. Although often the population in a highway tunnel may be smaller than in a rail tunnel, the problem of organising escape in the most appropriate direction remains.

3. Design & Construction

In the design and construction of trains, fire safety factors include limitation of fire load, ignition sources and fire spread. Smoke removal evacuation and evacuation routes need to be looked at, in the event that a fire occurs. These are all areas where analytical methods have been, and are being developed further, to allow a fire safety engineering solution to be presented. With regards to emergency systems, the designer should try to provide equipment which, wherever possible, is in use as part of the normal running of the tunnel.

Marketeers, image makers, financiers (perhaps even politicians) will quite properly have a major input at the formative stages. As railways can be run a commercial business, cost is an issue; and operators will clearly want an attractive looking train. The outcome of these deliberations may well affect exit routes from the train, particularly in an emergency, and this may lead to the provision or otherwise of walkways in tunnels.

4. Preparation of Procedures

Once solutions have been produced, we must consider the control of emergency evacuation – the procedures, their proper preparation and implementation. The team approach and continuity are important throughout the project; decisions made by very disparate disciplines possibly early in a project can make life difficult for someone else much later on.

Operating procedures must be properly carried out if safety in operation is to be achieved. The role of the fire safety manager will be discussed in Section 5; but fire safety is only one aspect – however important – of the overall management of any facility.

Once the facility has been designed and constructed, and the equipment procured, there is a long process to be carried out in parallel, involving recruiting, training, practice and rehearsing.

In a major project, possibly several hundred scenarios need to be considered. The original designer must know that the equipment can handle each of these. The operational response to each must also be considered. The trainers must understand the philosophy behind each response and prepare appropriate training programmes.

4.1 Training

The selection and recruitment of candidates for operational training is of vital importance. Should they stolidly follow the procedures, or should they be of sufficient technical and intellectual level to use some interpretation? There is also a significant decision concerning the main-machine interface. How much of the response should be built into the computer and how much should be operator led? Once operator training has begun, it must be built up gradually so that the simplest incident, up to a major emergency, can be handled.

The emergency services are key players in the project team in the development of procedures. Any plans produced for a particular facility must be dovetailed into fire brigade, ambulance and police standard operating procedures. Rehearsals are important. Full scale exercises were among the recommendations of the Fennell Report [5], following the Kings Cross fire.

4.2 Fire Safety Manual

The fire safety manual is a crucial element in the communications between designer, engineer and manager. The essential components of this document are required by the Construction (Design and Management) (CDM) regulations [7].

One would be expected to provide a means of recording and logging a greater range of information, including training records, drill records, "near miss" events, as well as information relating to changes in the safety systems – or indeed to operating systems that will impact on fire safety.

Monitoring and review of the fire safety manual needs to be carried out at regular intervals and will involve reviews of the testing procedures, a review of all plant and equipment interface controls, to ensure that maintenance procedures. It is also appropriate to carry out checks of the record as-built drawings and specifications for all fire protection measures; and take advantage of feed-back from staff and passengers, who might be involved in drills or in false alarm evacuations.

4.3 Safety Management System Audit

The safety management system should be subject to a regular audit, ideally carried out by an independent third party. Periodic audits should review current fire safety management procedures, the effect of changes in personnel, usage of the building and the effectiveness of automatic fire-safety systems, i.e. to ensure that they are suitable even after a change in use or major restructuring.

5. The Fire Safety Manager

A tunnel complex will have a safety officer for whom fire safety will be part of the job. Whatever the overall job of the individual who is given this responsibility, he must have a clearly defined position in the management hierarchy – with defined authority, powers of sanction, and resources.

It is essential to remember that this job will need to be carried out diligently over the whole working life of the tunnel system, and certainly at all times that members of the public are present.

It is most likely that a fire safety manager will never have to deal with a life-threatening event; this means that he is likely to find it difficult to motivate himself, let alone other members of staff. Performance management and other motivational techniques will need to be employed to maintain the quality of the management. Where management systems procedures are certified using schemes such as ISO 9000, these should include fire safety as a stated element.

5.1 Responsibilities

The scope of responsibilities of the fire safety manager will depend upon the nature of the tunnel complex: road or rail, passenger carrying or freight, high density or low. In most cases these responsibilities will include the following:

- Day-to-day operation of the tunnel complex;
- Understanding fire safety features provided and their purpose;
- Appointment of fire marshals/fire wardens;
- Care for the protection of the public in the system;
- Liaison with the fire authority;
- Inspection. maintenance and testing of fire safety equipment;
- General maintenance and works;
- Supervision and instruction of contractors and sub-contractors in the complex;
- Issuing hot work permits;
- Changes to the complex – extensions, alterations, refurbishment;
- Maintaining fire safety provisions during major restructuring, disuse and demolition; and
- The fire (if it ever happens).

The manager will need to be aware of any statutory requirements under the relevant legislation and any legal duties – for example, in relation to the maintenance of means of escape, fire warning systems, portable fire extinguishers, escape lighting.

He will be responsible for fire safety instruction to staff, ensuring the correct competencies, organising training, and maintaining records and organising drills. As mentioned above, full emergency simulations which can test every element of the safety systems and procedures should be carried out and the lessons learned fed back into the procedures, but such exercises are expensive both in direct resources and in business interruption.

Lessons Learnt – Channel Tunnel Fire

The Channel Tunnel fire provided a useful example of the interactions and interdependence of fire safety engineering and fire safety management.

The fire that occurred was, at least in the early stages, one that had been considered as a potential scenario during the design stage and the risk analysis, and one with which the safety system had been designed to cope.

In the event, the safety provisions, as a system, worked effectively; but the incident highlighted a number of issues regarding fire safety management of interest to the fire safety engineer (in no particular order of importance):

- The detection and alarm provisions need to be re-assessed once a structure is in operation;
- Staff (both one's own and others using the system) need to be well trained in a range of emergency procedures;
- Communication systems need to be tested under "realistic" emergency conditions; and
- Engineering systems that depend upon appropriate human action during the emergency may be less reliable than remain in continuous operation.

Reference: Summary of the Eurotunnel internal inquiry into the fire on 18th November 1996. Measures to be taken for the resumption of the HGV service. Eurotunnel, 1997.

5.2 Scope of Job

The job of the fire safety manager may be divided into 4 interrelated areas:

- The prevention of fire;
- Ensuring systems respond properly in an emergency;
- Planning for a fire; and
- Actions in the event of fire (emergency actions).

> **"In all tunnel projects, be they rail or road, the lifetime of the complex will overtake the individuals involved in the design, commissioning or implementation... Continuity of knowledge and experience will be lost and the new safety manager will need the records and manuals to guide him in keeping the tunnel safe."**

5.2.1 The Prevention of Fire

This essential task is to manage and maintain the operations and equipment to minimise the risk of a fire starting or, if it starts, spreading. It comprises a programme of everyday tasks which will seek to achieve this aim. A significant part of these tasks is the need for good "housekeeping":

- To regularly and routinely monitor and maintain the means of escape; the maintenance of furniture, furnishings, decor and equipment;
- Monitoring, and where necessary controlling, contents – including hazards of combustible contents, furnishings and materials, components and elements of construction;
- Maintenance and testing of heat-dissipating equipment; and
- The review, testing and maintaining of the fire safety manual.

The task also includes the fire safety training and education of staff, maintaining security, to reduce the risk of arson, and overseeing security issues where there might be conflicts between security and means of escape.

5.2.2 Ensuring Systems Respond Properly In An Emergency

These tasks involve ensuring that the special equipment that has been provided in the complex for fire safety will actually work as intended when the fire happens. The important factor is that it is unlikely that these systems will ever be needed "in anger", and unlike most other systems, which will be in regular use, any faults will not be readily apparent. Regular maintenance and testing is essential.

The tasks here include:

- Maintenance integration with other systems (e.g. ventilation, communications);
- Ensuring compliance with appropriate codes or regulations;
- Maintenance of structural safety systems;
- Routine inspection, maintenance and testing of all safety systems, including testing under simulated "emergency conditions";
- Safety audits and inspection;
- Responding to false alarms;
- Learning from the performance of the equipment during drills, false alarms and near-miss events;
- Revising and keeping safety plans and the safety manual up-to-date;
- Issuing work permits

Good communications are essential. The maintenance of these involves both the hardware and the procedures, especially if there is a complex structure such as cascade systems where a number of control room staff are involved in the decision processes. The maintenance of the communications systems requires routine testing and testing under "emergency conditions" as well as contingency planning – for example, for mechanical faults or for absent key staff.

Is it possible for the designer or safety engineer to learn from the manager's experience in carrying out these tasks? In the ideal world, there would be a well defined feed-back loop between manager and engineer, so that the design of new tunnels – or indeed tunnel refurbishment – could constantly be improved as problems and solutions were identified. Issues such as the reliability of the equipment, ease of inspection, maintenance, repair and testing, and the availability of spare parts, will become evident to the manager, and this valuable information could lead to improvements in future projects.

5.2.3 Planning For A Fire

One of the main elements in ensuring that the "people" part of the safety system is always ready for an emergency is training and fire drills. As well as permanent staff, this includes some training outside contractors and organising post-occupation evacuations. Records need to be kept from all training exercises, including feedback from participants.

The training needs to ensure that all staff are familiar with the fire routine so that in an emergency they know what to do without instruction. This is not necessarily as easy as it might seem; in particular for staff – such as control room operators – who need to carry out an often complex and event-driven series of essential tasks when an emergency occurs. Who might be competent to train such staff? How can the quality of the training be assured? As already suggested, it may be that the designer or engineer who developed the system should be involved in compiling training programmes.

A key issue for such training and the fire routine will be how to decide if the fire service should be called in. Many minor fires will not be appear to be (and will not be) life threatening and might be successfully extinguished with portable first-aid fire fighting equipment. But nearly all big fires start off as small fires; and if this initial judgement is faulty, then disaster can follow.

Other issues to be included within the fire routine are:

- Fire control centre functions;
- Evacuation management;
- Evacuation procedures for phased evacuation;
- The response of any site fire team;
- Liaison with the external fire brigade;
- Care for displaced passengers (who may be separated from their companions or have left their belongings behind);
- Emergency accommodation;
- Security/salvage and damage control; the impact of bad weather;
- Contingency and re-start planning; and
- The mitigation of potential environmental impact of fire (e.g. water run-off).

Maintaining te emergency plan requires:

- Consideration of evacuation plans, emergency accommodation plans, testing and walk-throughs;
- Monitoring and control of refurbishments;
- Contingency plans for the building that affect the plan;
- Maintaining access for those with disabilities;
- Monitoring contractors;
- Continuous inspections and system testing (including major incident simulations) and recording near-miss events.

The evacuation plan and evacuation procedures will need to include evacuation procedures for people with various disabilities; the management and control of evacuation lifts; temporary refuges or intermediate places of safety and phased evacuation procedures.

In major incidents, communications and the maintenance of communications are essential. Contingency planning must be carried out to consider failures in equipment or the absence of key personnel. Such plans must include means of copying when fire safety systems are disabled (e.g. for repair) or when the systems has an abnormal occupancy level (e.g. holiday traffic).

Safety plans and systems must be subject to reviews and risk assessment, especially after major works or refurbishment.

5.2.4 Emergency Actions

Planning needs to be consider the actions in the event of fire (emergency actions). These include:

- Action to be taken on discovery;
- When is the fire brigade called, and who does it?;
- Communications during the emergency;
- General evacuation procedures and fire evacuation procedures;
- Action to be taken by senior fire marshal, deputy senior fire marshal and other fire marshals;
- Dealing with the public (e.g. people with luggage);
- First aid fire fighting, other fire fighting, managing the on-site fire team (if any) and liaising with the external fire brigade and advising them;
- Managing control room operations;
- Ensuring active systems have activated; ensuring that non-essential equipment is off;
- Organising, managing and controlling the evacuation, including mustering occupants, motivating people to move, dealing with reverse flows (e.g. parents searching for their children) and evacuation of non-ambulant people/people with mobility difficulties, crowd management and crowd control;
- Interaction with other personnel (in particular security) or other agencies;
- Legal duty of the fire officer.

On completion of evacuation, consideration will need to be given to care for the displaced occupants, particularly if the weather is bad. Later, it will be important to review the lessons learned and record them in the fire safety manual.

6. Summary

In seeking to carry out the tasks detailed in the previous section, it is evident that fire safety manager needs to have a full and thorough understanding of the fire safety engineering that has been provided in the tunnel complex, and an intimate knowledge of the assumptions regarding the fire safety management that underpin the engineering. The fire safety manual is a primary means of providing this knowledge, but on a large project the complexities of the design may make a full understanding impossible.

Over the life of an operating tunnel complex there are very likely to be changes, probably improvements, in the operating design which will have an impact on the fire safety provisions. It will be the job of the fire safety manager to monitor these changes and ensure that the standards of safety are maintained. It is essential that the information available to the manager be sufficiently accessible for such a task to be effective.

Soon after commissioning it is possible that the design team may be approachable to discuss the details of the design, but as time passes so these designers and engineers will become more remote and unavailable, and the various fire safety managers will, in any case, be far removed from the original thinking. It becomes essential that the detailed concepts behind the fire safety engineering, in all its complexity and with all of its assumptions and interactions described, be stated and recorded, to be available for the whole working life of the complex.

But as mentioned above, these various functions will vary between different tunnel systems; for rail tunnels the managers' job might be more complex involving both the tunnel infrastructure, and the railway vehicles using the tunnel and their interactions.

The populations at risk may be very high and of high density. In road tunnels, the likelihood of fire is greater but the occupant density is likely to be much lower. However, in the rail complex the line of responsibility and control are probably better defined. As mentioned, in road tunnels it is much more difficult to control the loads, or the mechanical state of the vehicles.

In all of these projects, be they rail or road, the lifetime of the complex will overtake the individuals involved in the design, commissioning or implementation. Indeed the very organisations that were involved at the start may disappear and be replaced, or change beyond recognition. Continuity of knowledge and experience will be lost and the new safety manager will have only the records and manuals to guide him in keeping the tunnel safe.

7. Conclusion

However impressive, sophisticated or technological the fire safety systems appear at the onset of a project, these same systems must continue to work and be available at any time in the lifetime at the tunnel. These systems, and the management tasks that support them, must be viewed from this perspective if the tunnels are to remain safe for the travelling public and the staff who tend them.

The enthusiastic and skilled designers and engineers who develop these systems do not and cannot retain control or involvement over this time-scale but they must do their utmost to ensure that the systems they are installing will last.

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CASUALITIES IN WORLD TUNNEL FIRES

Salang Tunnel, AFGANISTAN 700 dead	**Tauern Tunnel, AUSTRIA** 12 dead
Vierzy Tunnel, FRANCE 108 dead	**Caldecot Tunnel, USA** 7 dead
Mont Blanc Tunnel, FRANCE 42 dead	**Nihonzaka Tunnel, JAPAN** 7 dead
BOSNIA Tunnel 35 dead	**Isola delle Femmine, ITALY** 5 dead
Hokuriku Tunnel, JAPAN 34 dead	**Palermo Tunnel, ITALY** 5 dead
Kings Cross, UK 31 dead	**Velsen Tunnel, NETHERLANDS** 5 dead
O'Shimizu Tunnel, JAPAN 16 dead	**Pfänder Tunnel, AUSTRIA** 3 dead

See page 8 for Worldwide Tunnel Concrete Fire Protection Reference PFT

● Tunnel Finishing With Fibre Reinforced Cement Board

Introducing GLASAL® – The Reliable Material for Aesthetic Tunnel Lining

GLASAL® is a fibre reinforced cement board with an all-mineral enamel coating designed initially for exterior cladding applications. The panels installed on projects dating from the early 1960s still retain their structural adequacy and original colour.

GLASAL® has been used in a wide range of building types: institutional, commercial and residential. Applications include wall cladding, fascias, soffits, window inserts and balcony panels. The product's durability and ease of maintenance has made it a standard product used by international companies for petrol stations, convenience stores and service centres.

State-of-the-art manufacturing technology

A broad range of natural and designer tones

Graffiti resistant and easy to maintain

GLASAL®'s high performance properties are the result of a unique manufacturing process which combines a permanent inorganic, semi-matt finish with a rigid reinforced cement base sheet. A broad range of natural and designer tones, plus an array of light colours specifically developed for large surface areas are available.

The Choice For Discerning Designers

- Broad spectrum of colours
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- Graffiti resistant
- Easy to maintain
- Non combustible
- Easy to install
- Highly chemical and reagent resistant
- Bacteriological clean
- Water and moisture resistant
- Proven durability
- Economical
- Impact resistant when backed by a solid substrate

Many Advantages For Tunnel Concrete Lining

GLASAL® is a preferred choice as a tunnel lining because of its many advantages: non combustibility, attractive colour range, freedom from corrosion, ease of maintenance and non-toxic in the event of fire.

It has excellent optical properties which allow perfect diffusion of light and completely eliminate the risk of glare. Economical lighting is also possible because of GLASAL®'s properties for light diffusion and reflection.

Installation & Maintenance Guide

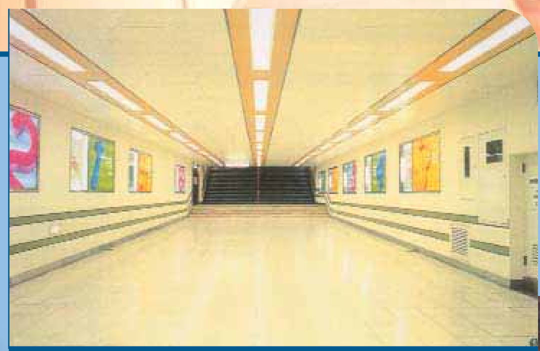
With concrete diaphragm wall or blasted tunnel construction, extremely rough surfaces can be transformed into inexpensive smooth, highly functional linings which are easy to maintain. The hard, smooth surface of GLASAL® can withstand mechanical brushing and high-pressure washing.

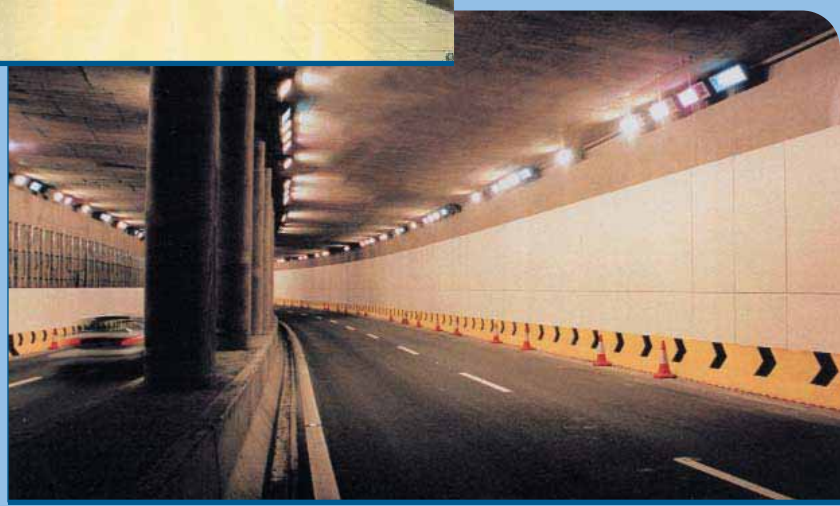
There are 4 basic GLASAL®'s installation systems depending on "Rectangular" or "Circular" shaped tunnels:

1. **Rectangular Smooth Concrete Tunnel**
   The main structure of the tunnel can be made of smooth concrete. This can be the result of on-site poured concrete or pre-fabricated submersed concrete surface, the supporting framework required for GLASAL® panels is minimal and of low cost..
2. **Rectangular Diaphragm Tunnel**
   In instances where a diaphragm wall (cut and cover) is used, the concrete surface is often rough and irregular. Framing systems have been developed to ensure the provision of a smooth secondary lining in conjunction with GLASAL® panels.
3. **Circular Smooth Concrete Tunnel**
   GLASAL® panels can be curved on site to follow the curvature of the tunnel. Where there is a smooth concrete, the supporting framework required to support the GLASAL® is simple and low cost.
4. **Circular Diaphragm / Rock Blasted Tunnel**
   Tunnels blasted through rock have surfaces which may be very irregular. EAP has the experience and skill to develop fixing systems to overcome such difficulties. The installed GLASAL® tunnel lining will result in a smooth, long-lasting, durable and easy-to-clean surface.

Worldwide Record In Tunnel Application

Asia Pacific Projects





Above: Shi Huang Tunnel, Chongqing, China

Left: Yokohama Sakuragicho Pedestrian Tunnel, Japan

Below: Damansara Utama Tunnel, Petaling Jaya, Malaysia

Europe Projects

Above: AZCA Tunnel, Madrid, Spain

Right: Kennedy Tunnel, Antwerp, Belgium

For further information, please contact info@eternit-ap.com or refer to the Business Reply Coupon on page 7.

For our readers based in Japan, South Korea and Taiwan, please contact us at the address on the right for details of your local distributors of the GLASAL® panels.

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Asia Pacific Regional Headquarters
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51200 Kuala Lumpur, Malaysia
Tel: (60-3) 6250 2880 Fax: (60-3) 6250 1159
Website: www.eternit-ap.com
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特集 連携戦略により，東京の新設沈埋トンネルで受注

[illegible]

沈埋トンネルの効果

[illegible]

設計上の特徴

[illegible]

沈埋トンネルにおいて耐火のために影響力をもつ要素

[illegible]

臨海道路トンネルでの PROMATECT®-H の利点

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PFT

推介GLASAL® – 帶有天然無機冷瓷塗層的纖維水泥隧道圍壁板

GLASAL® 是一種帶有天然無機冷瓷塗層的外裝飾纖維水泥加強板。在19世紀60年代初就有用這種建材的工程了，至今仍保持其原有的結構和顏色。

GLASAL® 應用廣泛：公共設施、商業機構、居民住宅。牆面、店鋪招牌、陽台、窗格都可用它。該產品經久耐用和便於維護的特性已使其成爲加油站、便利店、服務中心等跨國公司指定型標準建材。

GLASAL® 的高品質是通過其獨特生產過程而得的，將無機的亞光天然冷瓷與堅固的加強水泥基片結合在一起。這種產品具有多樣的設計格調和專爲大牆面設計的亮色組合。其持久、美觀、易於維護和中檔的價格等優勢使 GLASAL® 成爲理想的內裝飾材料。它平滑結實的質地又是用作天花板的可選材料。

設計師的明智選擇

- 豐富的顏色
- 抗沖擊性
- 耐磨品質
- 易於維護
- 不可燃性
- 易於安裝
- 優良的抵抗化學藥品腐蝕的性能
- 抗菌性
- 防水、防潮及抗凍特點
- 超長的品質保證
- 經濟實惠

GLASAL® 之所以成爲受歡迎的隧道圍壁板是因爲其突出的優點：不燃、引人注目的顏色、不腐爛、保養方便、無毒。

GLASAL® 是優秀的選擇材料，其對光線的漫反射作用徹底消除了鏡面反射的危險。GLASAL® 的亮色可反射 87% 的光線，所以可節約用燈。

當用 GLASAL® 作爲隧道圍壁時，根據 GLASAL® 擔保條約，任何用於清潔的產品或清潔劑以及清潔方法必須得到**埃特尼亞洲板材公司**的同意。

1 平滑混凝土牆

隧道的主要結構可由平滑的混凝土構成。
而 GLASAL® 所需的支撐結構正是這種低成本的灌注或水澆的混凝土。

2 控光裝置牆

控光裝置牆的混凝土表面粗糙並且大部份情況下是不規則的。對此開發了新的安裝系統從而使 GLASAL® 應用於這類隧道圍壁。

3 平滑混凝土牆面

GLASAL® 可在施工現場被彎曲以配合隧道的曲率。在平滑的混凝土表面上支撐結構是簡單而便宜的。

4 堅硬受損的混凝土牆面

其表面必須轉化成平滑的、有效的易於維護的內表層。GLASAL® 的堅硬平滑的表面能夠低御機械或高壓洗涮。

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封面內容 東京灣沉管隧道雙贏局面

結合專業策略及良好合作意願，保全(亞太)有限公司，聯合保全德國及其日本經銷商 Phoenix Trading 公司，成功取得了爲東京灣 (Rinkaidouro) 沉管隧道提供被動防火系統保護的項目合同。
該項目是對工程技術的一個巨大的挑戰。選擇保全公司參與該項目是經過充份考慮的結果，主要取決于保全公司在全球地下建築的豐富經驗，以及在隧道防火技術領域的領先地位。

一條引人注目的沉管隧道

東京灣海底隧道是一個隧道設計與先進技術完美結合的典範。該隧道預計于2002 完工，將成爲一條新干線的一部份。這條新干線將解決由於東京港的發展而造成的日益增長的交通量的要求。
由於受到成田 (Haneda) 機場的限制，東京灣 (Rinkaidouro) 隧道建成後大約有 1400 米長，它將跨越東京灣的西海岸和東海岸，連接 Jonanjima 與東京港一邊的 Wakasu。

設計特點

東京灣海底隧道是有大約11節120米長的混凝土管段連接而成。每一節增強混凝土管段在長度方向由7段管體組成，每個管體17米長，由三部份：上板，牆及下板澆築而成。
每一節標準隧道管段截面爲32米寬，10米高，約40,000噸重。各節管段通過之間的防水密封系統及伸縮縫系統連結，從而保証其水密性和抗震性。
隧道管段首先在陸上碼頭澆築，兩端作防水封閉。然後被牽引到預定沉管位置，用臨時固定件固定。水密由於每一節管段在水壓作用下頂住前一節管段，通過它們之間的橡膠連接件固定在一起，同時形成縫。然後水將從管段中抽出，排水壓力將達到越6,000噸，從而保証沉管之間的緊密聯結。這一過程對每一節沉管重復進行。

沉管隧道消防措施的影響因素

盡管混凝上通常被認爲具有良好的強度及耐火性能，在某些特定環境下，還是有必要對它進行防火保護，例如採用保全防火板 PROMATECT®-H 作防火內褥。
在火災中混凝上會產生一種現象：爆裂 (Spalling)，這種現象往往在隧道的整個環形表而發生。非常肯定的是，爆裂現象的產生是由於混凝土內含水在溫度迅速上升時轉變成水蒸氣，從而在混凝土表面下形成巨大的膨脹壓力。此時，一個有效的防火內褥，例如採用正確的安裝方法安裝在隧道內的保全防火板 PROMATECT®-H 系統，可以提供混凝土長達2小時的耐火極限；同時，還可以抵抗隧道內車流風壓和吸力對隧道表面造成的破壞。

保全防火板 PROMATECT®-H 在東京灣隧道中的應用優勢

在隧道中應用消防系統需考慮眾多因素。
而選擇類似保全防火板 PROMATECT®-H 的平板系統的好處在於：
- 易於操作安裝
- 易於控制厚度，從而保証達到與檢測系統一致的質量要求
- 板材爲固定連接，不受隧道中通行工具造成的風壓或吸力的影響
- 板材壽命不受隧道中汽車尾氣等廢氣的影響
- 板材使用性能不受水滲的影響
- 火災中，板材保護層相當於過濾層，隔絕腐蝕性廢氣接觸混凝土及其增強鋼筋
- 使用過程中基本不需維護保養。當定期檢查混凝土時，可以很方便地取出某片板材，完畢後再安裝
- 上去，隨時保証混凝土受到保護
- 板材可以進行各種表面裝飾，易於清潔保養

毫不奇怪，東京灣隧道的業主及管理方，還有他們的兩個承包/安裝公司 Taisei 和 Kajima，都不約而同地選擇保全防火板 PROMATECT®-H 作爲隧道防火內褥系統。他們了解保全防火板 PROMATECT®-H 不僅具有良好的防火性能，而且可以給各種交通工具提供一條安全的東京灣地下新干線。PFT

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Company: ______________________
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Country ______________________
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Business Tel: ______________________ **Fax:** ______________________
Personal Tel: ______________________ **Email:** ______________________

PFT

Worldwide Tunnel Concrete Fire Protection Reference

YEAR	COUNTRY	AREA/CITY	NAME	TYPE	PROMAT'S PANELS
1973	Germany	Hamburg	Elbtunnel (1.-3. tube)	Road	PROMATECT®, PROMABEST®-H 2*8
1981	Belgium	Antwerp	Craeybeckx Tunnel	Road	PROMATECT®-H, GLASAL® NT
1982	Belgium	Bruges	'I Zand Tunnel	Road	PROMATECT®-H, GLASAL® NT
1984	Germany	Hamburg	Elbtunnel (1.-3. tube)	Road	PROMATECT®-H
1985	Belgium	Brussels	Rogier Tunnel	Road	PROMATECT®-H, GLASAL® NT
1986	Belgium	Antwerp	Jan de Voslei Tunnel	Road	PROMATECT®-H, GLASAL® NT
1986	Netherlands	Local area	Schiphol	Road	PROMATECT®-H
1987	Germany	Hamburg	Elbtunnel (1.-3. tube)	Road	PROMATECT®-H
1987	Netherlands	Haarlemmermeer (A4)	Schiphol	Road	PROMATECT®-H
1988	Belgium	Antwerp	Kennedy Tunnel	Road	PROMATECT®-H, GLASAL® NT
1988	Belgium	Brussels	Leopard II Tunnel	Road	PROMATECT®-H
1988	Germany	Hannover	Local traffic tunnel (H)	Underground	PROMATECT®-H, PROMASEAL®-PL
1989	Netherlands	Hendrik I. A.(A15)	Onder de Noord	Road	PROMATECT®-H
1989	Netherlands	Amsterdam (A10)	Zeeburgtunnel	Road	PROMATECT®-H
1990	Netherlands	Barendrecht (A29)	Heinenoord	Road	PROMATECT®-H
1990	Belgium	Ghent	Hoge Weg Tunnel	Road	PROMATECT®-H, GLASAL® NT
1990	Belgium	Antwerp	Liefkenshoektunnel	Road	PROMATECT®-H, GLASAL® NT
1990	Belgium	Antwerp	Thysmanstunnel	Road	PROMATECT®-H, GLASAL® NT
1990	Germany	Frankfurt	U-Bahn Tunnel	Subway	PROMATECT®-H
1991	Belgium	Antwerp	Bevrijdingstunnel	Road	PROMATECT®-H, GLASAL® NT
1991	Germany	Munich	Munich Airport Station	Sub-railway	PROMATECT®-H
1991	Netherlands	Kruiningen (A58)	Vlaketunnel	Road	PROMATECT®-H
1992	Netherlands	Grouw (N32)	Aquaduct Grouw	Road	PROMATECT®-H
1992	Germany	Mülheim	S-Bahn Station	Subway	PROMINA®
1992	Netherlands	Haarlemmermeer (A4)	Schiphol	Road	PROMATECT®-H
1993	Germany	Bielefeld	Tunnel Bielefeld (B61)	Road	PROMATECT®-H
1993	Netherlands	Beverwijk (A9)	Wijkertunnel	Road	PROMATECT®-H
1994	Belgium	Brussels	Belliard Tunnel	Road	PROMATECT®-H, GLASAL® NT
1994	Netherlands	Barendrecht (A29)	Heinenoord	Road	PROMATECT®-H
1995	UK		Channel Tunnel	Railway	PROMATECT®-H
1995	Germany	Düsseldorf	Local traffic tunnel	Underground	PROMATECT®-H
1996	Netherlands	Akrum (N32)	Aquaduct Akrum	Road	PROMATECT®-H
1996	Belgium	Brussels	Montgommery Tunnel	Road	PROMATECT®-H, GLASAL® NT
1996	Germany		Rendsburg Tunnel	Road	PROMATECT®-H
1996	Belgium	Brussels	Vier Armen Tunnel	Road	PROMATECT®-H, GLASAL® NT
1997	Netherlands	Alphen ann de Rjin	Aquaduct Alphen aan de Rjin	Road	PROMATECT®-H
1997	Netherlands	Delft	Aquaduct Delft	Road	PROMATECT®-H
1997	Germany	Bad Godesberg	Road Tunnel (part 1)	Road	PROMASEAL®-PL joint elements
1997	Netherlands	Kaagbaan	Schiphol	Road	PROMATECT®-H
1998	Belgium	Brussels	Bailly Tunnel	Road	PROMATECT®-H, GLASAL® NT
1998	Belgium	Brussels	Cinquantenaire Tunnel	Road	PROMATECT®-H, GLASAL® NT
1998	Switzerland		Eggflue Tunnel	Road	PROMATECT®-H
1998	Germany		Engelberg Tunnel (bab A81)	Road	PROMATECT®-L500
1998	Germany		Königshaimer Berge Tunnel (bab 14)	Road	PROMATECT®-L500
1998	Germany	Hamburg	Krohnstieg Tunnel	Road	PROMATECT®-H
1998	Australia	Perth	Northern Bypass Tunnel	Road	PROMATECT®-H
1998	Germany	Berlin	Tunnel Feuerbachstrabe	Road	PROMATECT®-H
1999	Netherlands	Rotterdam (A4)	2e Benelux Tunnel	Road	PROMATECT®-H
1999	Japan	Tokyo	Dainikouro Tunnel	Road	PROMATECT®-H
2000	Netherlands	Voorburg	Aquaduct Onder de Vliet	Road	PROMATECT®-H
2000	Netherlands	Betuwerroute	Botlektunnel	Railway	PROMATECT®-H
2000	Netherlands	Leidschedam	Viaduct Railway	Railway	PROMATECT®-H
2001	Japan	Tokyo	Tokyo Port Seaside Road Tunnel	Road	PROMATECT®-H

For further information, please contact info@eternit-ap.com See page 5 for Casualities In World Tunnel Fires PFT

IMPORTANT

Letter From The Dutch Government Tunnel Safety Department

Van
Jelle Hoeksma
Datum
03-05-2001
Onderwerp
The use of Promatect-H in tunnels

Doorkiesnummer
+31 30 2857759
Bijlage(n)

Dear Mrs. Chong Swee Lin,

Promat the Netherlands, Mr. D van Olst, asked me to inform you about the use of Promatect-H in Dutch tunnels.
We used Promatect-H plates for the first time in 1989 for an application test in the Zeeburgertunnel, an immersed tunnel in the A10 ring road around Amsterdam, which was under construction at that time.
Promatect-H boards have been used in a thickness of 27mm over a length of about 50m over three lanes at the end of the exit part of the west tunnel tube.
The boards are fixed with stainless steel anchors.
Till to day no damage has been shown in the boards and fixations.
During the renovation of the Velsertunnel Promatect-H plates were used as protection material; in summer 1990, 8000 m2 in the east tube and in summer 1991, 8000 m2 in the west tube.
Many tunnels in the Netherlands have been protected since using Promatect-H plates.

I hope this information is sufficient for you; if not please don't hesitate to call me.

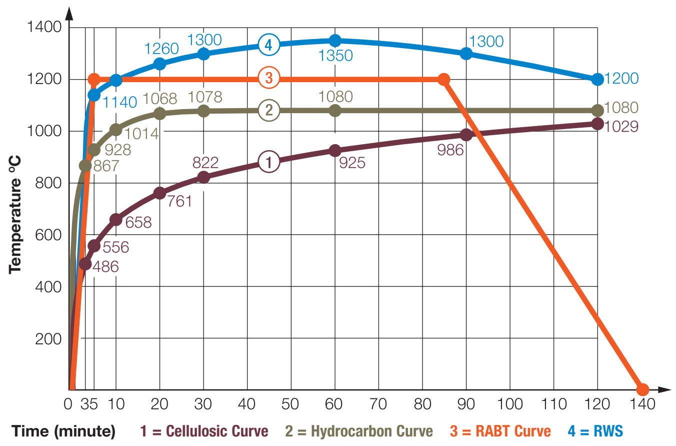
With kind regards,

Ing Jelle Hoeksma
Tunnel Department
Specialist Centre for Tunnel Safety

SCIENCE & RESEARCH

Tunnel Fire Temperature Curves

In recent years, a great deal of international research has taken place to define the types of fire which can occur in tunnels and underground spaces. It has taken place in both real, disused tunnels, and under laboratory condition. As a consequence of the data obtained from these tests, a series of time/temperature curves for the various exposures for tunnels have been developed and outlined below (see RABT and RWS Curve). For further information, please refer to the Business Reply Coupon on page 7. PFT



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