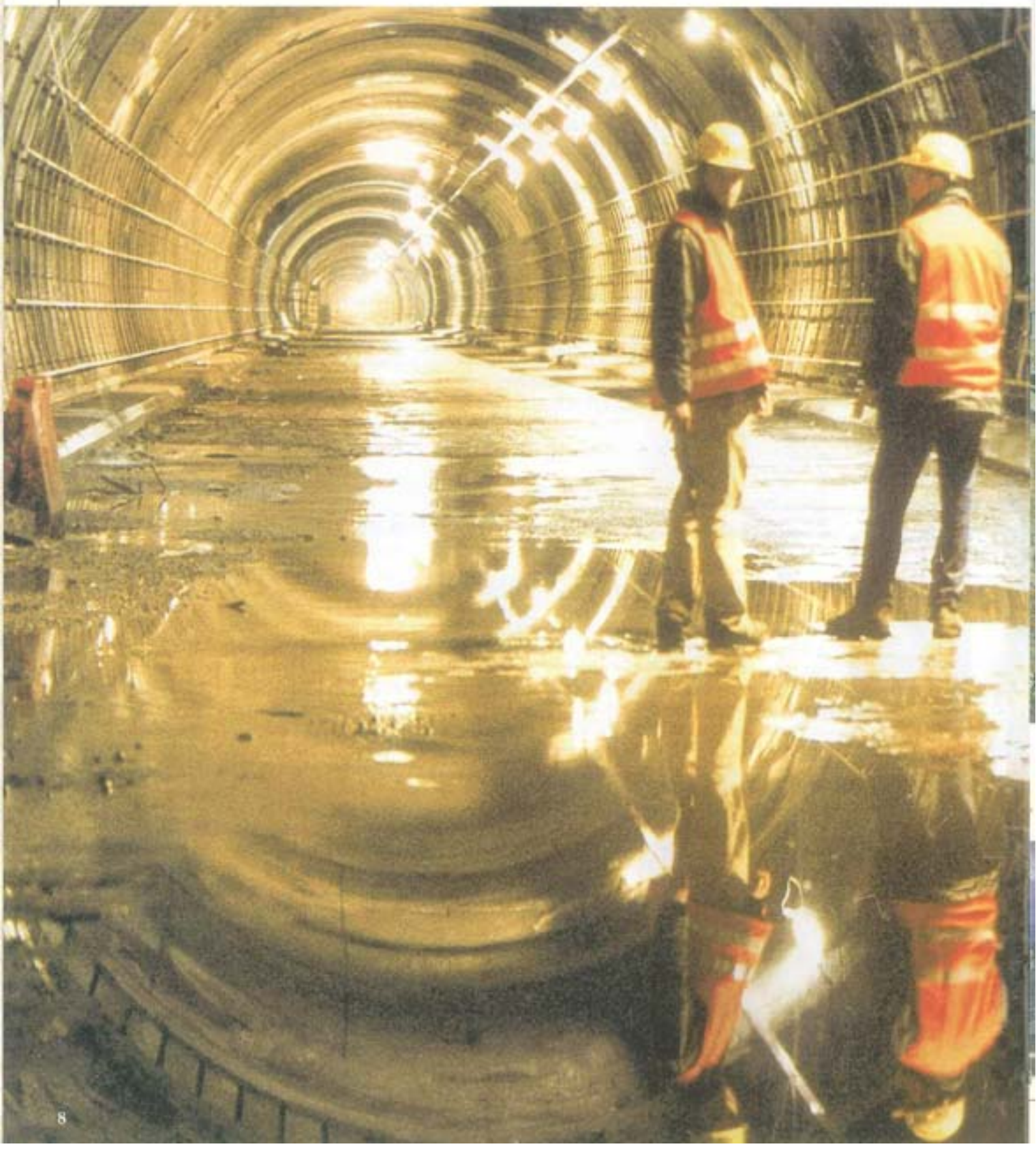
Monte Bianco Tu

For a year now, the Monte Bianco Tunnel has been restored to its irreplaceable role as a communications route between Italy, France and the whole of north-eastern Europe beneath the tallest peak in Europe.



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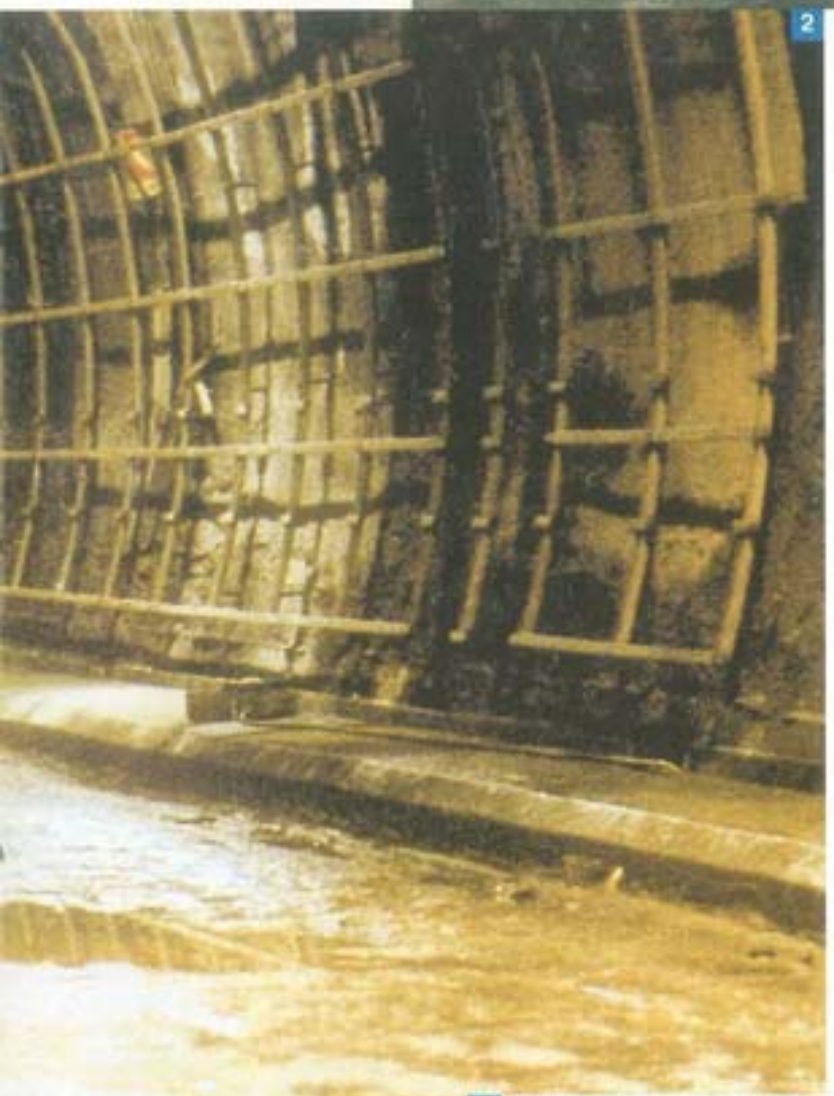


Monte Bianco Tunnel re-opened in March 2002 after three years' work: a constant, unstoppable stream of light and commercial vehicles resumed its unbroken flow from Aosta Valley to Chamonix Valley and vice-versa, transporting hundred of thousands of people and millions of tons of goods to open-up fresh opportunities for growth and competitiveness on big markets for the Italian economy.
The accident on 24th March 1999 that resulted in its closure seemed to have caused its premature and unexpected death, ending a dream dating back to even before the French Revolution. The tunnel was actually built in 1965 and over 46 million vehicles had travelled along its 11,600 metres over a period of 35 years.
The accident was caused by a Belgian lorry carrying flour and margarine that set off a fire that spread from the French side of the tunnel until it really burst into flames half way through.
Dozens of other vehicles behind the lorry were enveloped in the smoke and fumes, eventually catching fire, and despite the rescue attempts 39 people died in a matter of minutes. The blistering heat taking the temperature in the tunnel up to 1000°C and the poisonous fumes resulting from the combustion of materials caused considerable damage to the tunnel. An initial survey soon showed that the heat had

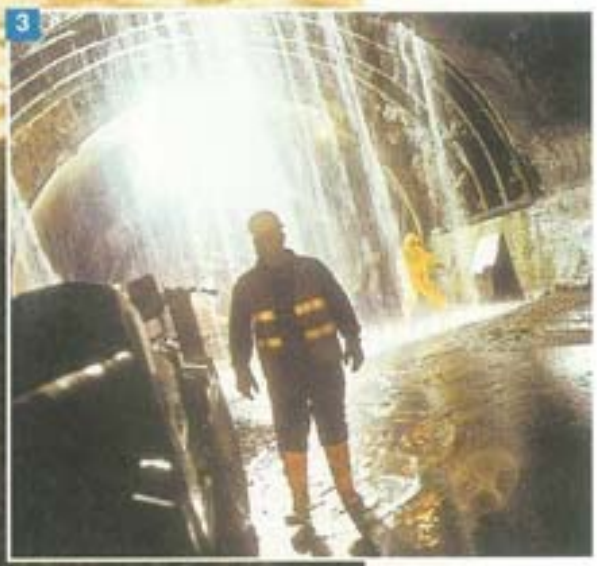
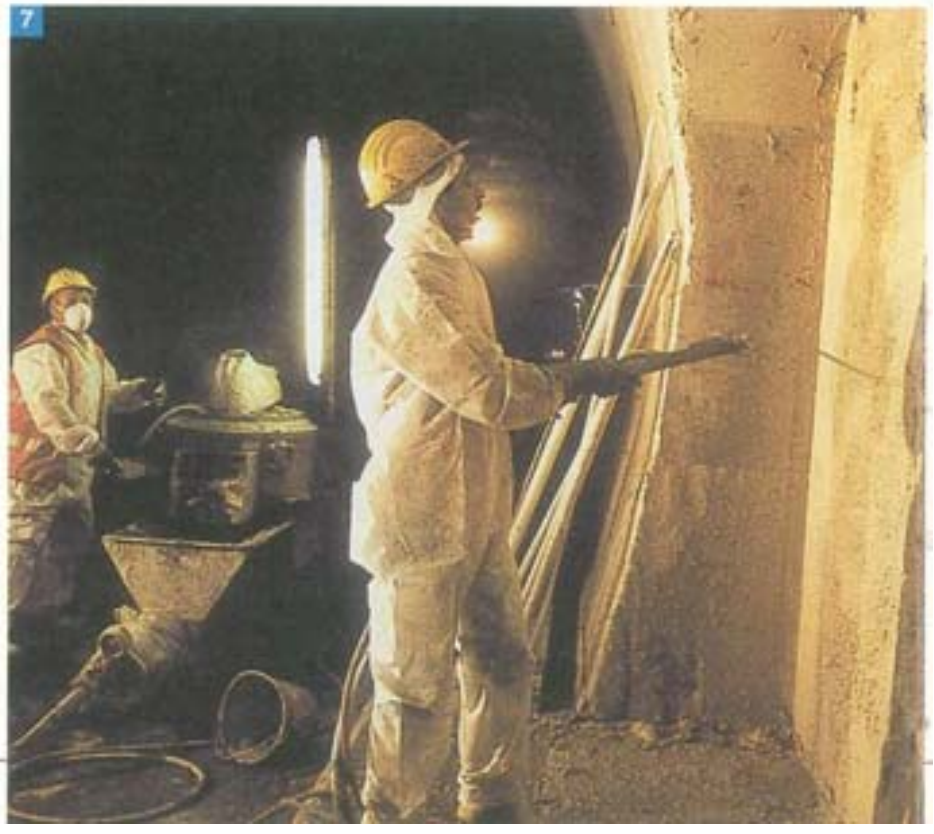


Photo 1. The entrance to the tunnel while the works were going on.

Photo 2. Two technicians study a section of the Monte Bianco Tunnel rebuilt after a fire. Cutting-edge systems and technology were used to rebuild the tunnel to make it as safe as possible. (The photo is taken from Sette no. 26, 28th June 2001; our thanks go to the magazine for letting us use it).

Photo 3. Experts trying to stop water from seeping into the tunnel. Eventually stopped with the help of Mapei's RESCON T.

even damaged the underground engineering works, jeopardising their safety.
A survey carried out by Italian-French experts in July that year recommended 41 measures to be abided by and carried out before re-opening the tunnel: repair work on the damaged concrete of the vault and its support columns; collecting and channelling out water that had flowed into certain points of the vault, columns and ventilation channels and, most significantly, the reconstruction of the ventilation and smoke evacuation system in case of fire with a capacity of 150 m^3/second over an area of 600 metres. The tunnel, whose re-opening was officially authorised by the Bonneville magistrates (the accident took place in a section under Italian control but in French territory) in summer 2000, was first decontaminated and then strengthened in its damaged parts. 1,350 metres of tunnel were re-built using special materials and introducing all the safety systems proposed by experts, so that when it was re-opened on 9th March 2002, technicians were entitled to claim that the Monte Bianco was the safest two-way tunnel in the whole of Europe. The repair work was not only carried out on tunnel structures, additional work was also undertaken to raise the safety standards to the very highest levels by means of innovative control and operating systems. This included four fire extinguishing tanks, 116 S.O.S. points fitted with emergency telephones, 37 ventilated and pressurised fire shelters, 116 suction vents placed at 100-metre intervals, and 116 new fume suction conduits in case of fires. While waiting to begin the civil engineering work, after carrying out a number of tests (including the fireproof test the French legal authorities asked for), the Società Italiana Traforo del Monte Bianco commissioned the Società Condotte d'Acqua to extend and construct 12 fire shelters and 3 garages along the Italian section of the tunnel; works that were quickly completed in a just a few months in 2000. The Italian-French consortium Scetauroute and Spea Ingegneria Europea were asked to put forward a project for all the repair and safety enhancement work, starting work on the utilities and other networks (radio, electricity and telephone systems).
The work, which kept to the design guidelines jointly drawn up by Scetauroute/Spea for the entire tunnel, began first on the Italian part commissioned to Cossi Costruzioni and then on the French part of the tunnel assigned to the Bonygues TP/GTM Dumez/Impregilo Consortium. All the work was carried out in accordance with specific "safety, quality control and environmental protection plans" agreed to by the commissioning firms; the specialist sub-contractors directly involved and those which won tenders for the works ensured everything was carried out in workmanlike fashion to the highest safety standards for workers on the building sites.



Photos 4 and 5.
After carefully analysing the state of the tunnel, the concrete surfaces were water-scrubbed to remove the layer of concrete damaged by the fire and reveal the reinforcing bars.

Photo 6.
Two different admixtures, MAPEFLUID N200 and MAPEFLUID X404, were used to obtain a durable and highly fluid concrete ideal for spraying on the surfaces.

Photo 7.
The picture shows MAPEGROUT BM being sprayed on to repair the concrete.

Photo 8.
An application of concrete set more quickly using MAPEQUICK AF100.

Photo 9.
Mapei products stored on the building site near the tunnel entrance, also open in winter.

Photo 10.
MAPEGROUT BM, a two-component cementitious mortar with low modulus of elasticity specially designed for repairing concrete, was used on the tunnel.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Repair Work

Mapei was one of the firms that supplied materials for the building operations, developing over the years a range of products designed specially for the underground building sector used both for constructing new works and repairing damaged structures (even badly so, as in this case) by means of troubleshooting carried out on site, chemical/physical tests on materials and a special study into the mixes of concrete tested out directly in company laboratories.

At the beginning, an in-depth preliminary study had to be carried out to gather the necessary information required for designing the project, including the hydrogeological state of the tunnel so as to accurately gauge the amount of water that had seeped into it and its chemical characteristics, a careful assessment of the physio-mechanical features of the materials used to build the tunnel, so as to assess the risk of decay and their behaviour in case of fire, and a mapping of the broken bits and a general analysis of the damage to the inside of the tunnel.

After assessing the state of the tunnel, work began on cleaning the concrete surfaces using a water-scrubber to remove the layer of concrete damaged by the fire and also seriously jeopardised by all the water that flooded in. The thickness of the concrete removed depended on the amount of damage and the need to restore the tunnel to a height of 4.30 metres near the walkways. In some areas this meant removing all the lining. The need to remove either part or all of the concrete lining meant Mapei


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technicians had to devise a number of different operations. The presence of so much water resulted in the anti-washout admixture, RESCON T*, being used in the concrete.

Removing all the lining

The rock in the areas where all the concrete was removed had to be reinforced in the wake of water-scrubbing operations. This was carried out by injecting cement-based slurries through the riveting in the rocks. The injections also contained EXPANFLUID*, a powdered admixture for making fluid cement-based slurries with low water-cement ratios, no segregation and no shrinkage. After this, the tunnel lining was reconstructed using electrically welded meshing sprayed with concrete. Two different admixtures, MAPEFLUID N200* and MAPEFLUID X404*, were used to obtain durable, impermeable and highly fluid concrete with low water/cement ratios and high mechanical strength.

MAPEQUICK AF1000* and MAPEQUICK AF2000 setting accelerators were also used to ensure the concrete set right after it was sprayed on,


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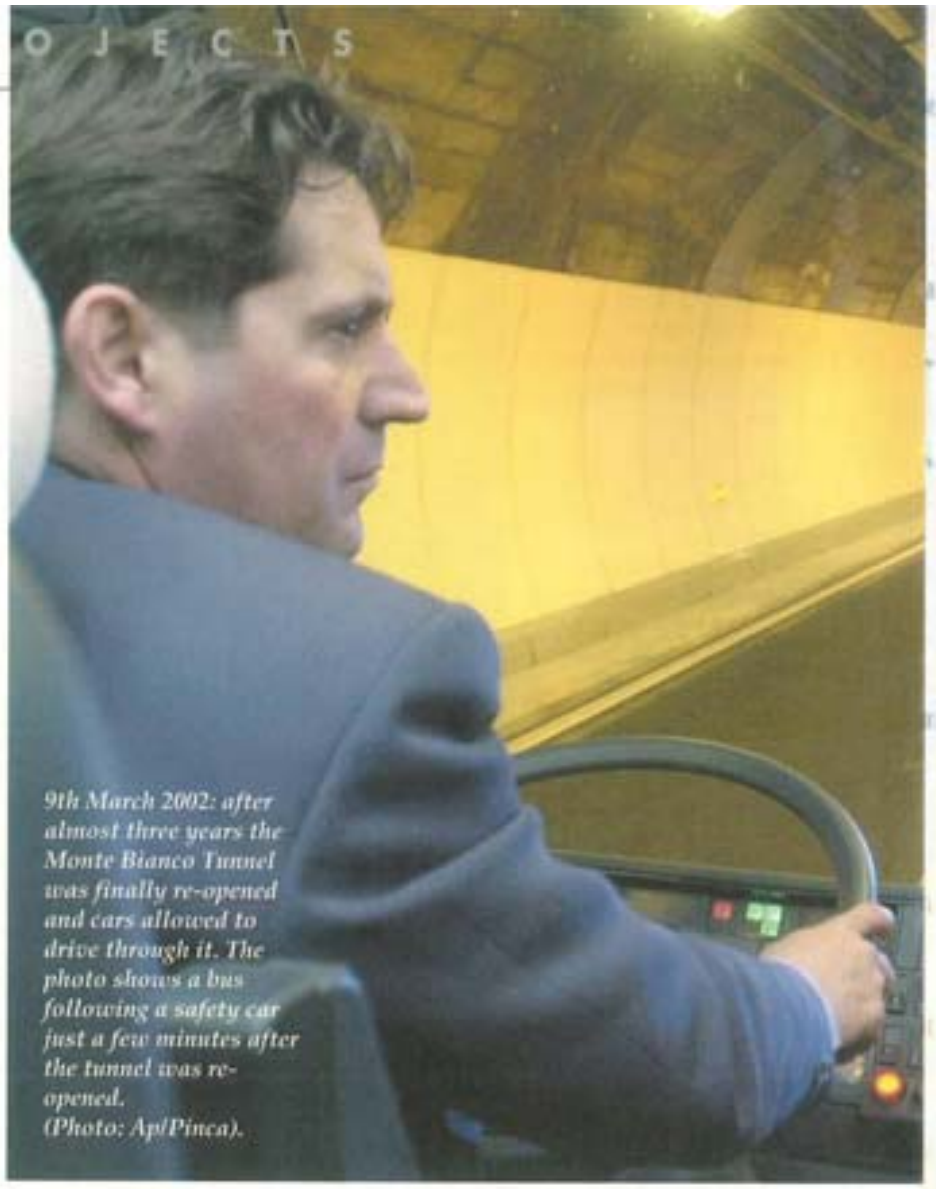
ensuring it was not washed away by any water seeping in and, most importantly, allowing it to stay in place on its own and not break off the support and fall to the ground.
These are alkali-free setting accelerators for making concrete with high mechanical strength that ensure safe excavations in order to apply permanent linings. MAPEPLAST SF*, a microsilica-based powdered compact admixture with pozzolanic action, was added to the basic mix to make the concrete harder wearing. After spraying, the tunnel was re-profiled by another layer of cast concrete made even more fluid by adding MAPEFLUID X404* and MAPEFLUID IF328* hyperplasticisers, used in winter to make the concrete set and harden more quickly.
ADESILEX PG1* was used for setting the rivets in place for holding up the electrically welded meshing, while the concrete was cured using MAPECURE E*, an anti-evaporant in water emulsion sprayed on concrete surfaces to stop the paste water from rapidly evaporating.
PLANITOP 100*, a light-grey rapid-setting fine mortar, was used for the final smoothing of the surfaces.

Partial removal of the lining
Different repair work was carried out on the areas where the lining was only scrubbed very superficially. This involved first knocking off the concrete and then cleaning the reinforcing bars to prevent them from rusting. Two layers of MAPEFER*, an anti-rust mortar, were then painted on all the reinforcing bars, and the lining was then restored by spraying on MAPEGROUT T60*, a sulphate-resistant thixotropic fibre-reinforced mortar. Work was completed by applying MONOFNIISH*, a normal-setting cementitious mortar for smoothing concrete.

Repairing the air-supply tunnels
The air-supply channels placed beneath the road surface in the new project were converted into safe exit routes, and MAPEGROUT BM*, a two-component cementitious mortar with low modulus of elasticity, was used for repairing the concrete involved.
For other parts of the tunnel, the lining was repaired using shrinkage-compensating concrete with EXPANCRETE* expansive agent for concrete added or spraying on



9th March 2002: after almost three years the Monte Bianco Tunnel was finally re-opened and cars allowed to drive through it. The photo shows a bus following a safety car just a few minutes after the tunnel was re-opened.
(Photo: Ap/Pinca).

MAPEGROUT T60*, whose special properties allowed all the gaps left after waterscrubbing operations to be suitably filled.

Other work
Part of the concrete road surface was also water-scrubbed, and the iron work was treated with MAPEFER* and then repaired by applying MAPEGROUT THIXOTROPIC*, a controlled-shrinkage fibre-reinforced grout. EPORIP*, an epoxy-based brush-on adhesive, was first applied to improve bonding ready to handle heavy loads. MAPEGROUT TIXOTROPIC* was then applied to this layer while it was still fresh to reconstruct the original road section. Everything was then covered with asphalt. Other operations carefully followed by Mapei also included waterproofing (before constructing the walkway) the connection between the road surface and supports using IDROSILEX PRONTO*, a heavy-duty cementitious mortar ideal for combating all kinds of humidity. Before carrying out this operation, water was prevented from seeping in using LAMPOCEM*, shrinkage-free fast-setting hydraulic binder, and LAMPOSILEX*, ultra fast-setting and drying binder. For safety reasons, a metal channel was also fitted to collect any rain water dripping around the base of the supports. The channel was attached to the base using IDROSTOP*, a hydrophilic expandable rubber section, and IDROSTOP MASTIC*, a one component adhesive for fitting the section.
Finally, the surfaces of the concrete walls of the shelters were smoothed using clear-coloured MAPELASTIC*.
It all took three years' hard and brave work, a genuine battle

against nature and bureaucratic/legal slowness, often inadvertently helped along by environmental/safety scruples and a fear of taking risks that were hard to calculate. 85% of the 700 billion old lira spent on the repair work was invested in tunnel traffic control systems drawing on all the world's latest and most sophisticated technology. The Tunnel through Monte Bianco became a "prototype"; it has been studied and analysed as a concrete example of the resourcefulness of the Italian business and labour markets, proof of the nation's great ingenuity.

TECHNICAL DATA

Monte Bianco Tunnel
Works: reinforcing, repairing and waterproofing of the tunnel's inside surfaces.
Carried out: 2000-2001
Client: Società Italiana Traforo del Monte Bianco, Rome
Designed by: Spea Ingegneria Europea, Milan and Scetauroute (France)
Works manager: A. Selleri, engineer at Spea Ingegneria Europea
Builders: Cossi Costruzioni, Sondrio
Mapei products: ADESILEX PG1, EPORIP, EXPANCRETE, EXPANFLUID, IDROSILEX PRONTO, IDROSTOP, IDROSTOP MASTIC, LAMPOCEM, LAMPOSILEX, MAPECURE E, MAPEFER, MAPEFILL, MAPEFLUID N200, MAPEFLUID IF328, MAPEFLUID X404, MAPEGROUT BM, MAPEGROUT T60, MAPEGROUT THIXOTROPIC, MAPELASTIC, MAPEPLAST SF, MAPEQUICK AF100, MAPEQUICK AF2000, MONOFINISH, PLANITOP 100, RESCON T.
Mapei coordinator: Mapei Underground Technology Team

"The products mentioned in this article belong to the "Underground Technology" line. The technical data sheets are contained in the "Mapei Global Infonet" CD, and at the www.mapei.com website.

Adesilex PG 1: *thixotropic epoxy adhesive for structural bonding.*
Eporip: *epoxy-based adhesive for binding and monolithic sealing of cracks in screeds.*
Expancrete: *expansive agent for concrete.*
Expanfluid: *expanding agent for preparing fluid slurries with compensated shrinkage for injection.*
Idrosilex Pronto: *ready-to-use heavy-duty waterproofing cementitious mortar.*
Idrostop: *hydrophilic expandable rubber section for watertight joints, available in two sizes.*
Idrostop Mastic: *one-component adhesive for the installation of Idrostop.*
Lampocem: *ready-to-use shrinkage-free hydraulic binder with rapid setting and hardening.*
Lamposilex: *hydraulic binder with ultra fast setting and drying for plugging water leaks.*
Mapecure E: *curing compound in water emulsion.*
Mapefer: *two-component anti-rust mortar for reinforcing rods.*
Mapefill: *high-flow shrink-free grout for anchoring.*
Mapefluid N200: *superplasticising admixture for concrete*
Mapefluid IF328: *hyperplasticising admixture for concrete*
Mapefluid X404: *hyperplasticiser for concrete with low loss of workability*
Mapegrout BM: *two-component cementitious mortar with low modulus of elasticity for repairing concrete*
Mapegrout T60: *sulphate-resistant thixotropic fibrous mortar for repairing concrete.*
Mapegrout Thixotropic: *controlled-shrinkage fibre-reinforced grout for repairing concrete.*
Mapelastic: *two-component flexible cementitious mortar for the waterproof protection of concrete, swimming pools and balconies.*
Mapeplast SF: *microsilica-based powdered additive with pozzolanic action for high-quality mortar and concrete*
Mapequick AF100: *"alkali-free" setting accelerator for shotcrete and sprayed mortar.*
Mapequick AF2000: *"alkali-free" setting accelerator for concrete and sprayed mortar.*
Monofinish: *one-component normal-setting cementitious mortar for smoothing concrete.*
Planitop 100: *light-grey rapid-setting fine mortar for repairing and smoothing concrete and renders.*
Rescon T: *anti-washout admixture for underwater casting.*