



# MOUNTAIN PASS DEVIATION

WORKS WERE COMPLETED AT THE BASE TUNNEL, THE LONGEST TUNNEL OF THE NEW MOUNTAIN PASS DEVIATION ALONG THE A1 FLORENCE-BOLOGNA MOTORWAY

The stretch of the A1 motorway running through the Apennine Mountains between Bologna Casalecchio and Barberino del Mugello is a strategic infrastructure that connects the North and South of Italy. For more than thirty years increasing the capacity of this stretch, which every day is used by 89,000 vehicles, has been considered a priority to increase the capacity of Italy's motorway network. With the objective of modernising Italy's transport system in an area with highly complex geological features, all Mapei's experience and most up-to-date technology has been used to the full in this project, with various cutting edge solutions which have facilitated the execution of the work and enabled the scheduled targets to be met. Out of all the activities carried out by Mapei, two examples in particular highlight how important the company's innovation was for this major project: the Sparvo tunnel excavation with highly sophisticated TBM's (Tunnel Boring Machines), for which a decisive role was played by the MAPEQUICK CBS SYSTEM (a two-component system for cement-based mixes for injection), and the choice of materials used to cover the surface of the sidewall in the Base Tunnel, for which thin porcelain tiles were installed using KERAFLEX MAXI S1 adhesive.

# A WINNING TEAM FOR THE TUNNEL DIGGING CHALLENGE: MAPEQUICK CBS SYSTEM AND TBM

At the end of July 2013 the main contractor, TOTO Costruzioni Generali S.p.a., successfully completed tunnel excavation operations for the Sparvo Tunnel located in the lots no. 6 and 7 of the Mountain-Pass Deviation, the new and modern segment along the A1 Milan-Naples motorway. Tunnel excavation was carried out with a 15.625 m diameter TBM-EPB machine built by Herrenknecht AG. The twin-bore tunnel was bored out in geologically difficult soil in the Tuscany-Emilian Apennine Mountains where, apart from the geo-

logical complications, methane gas was widely diffused throughout the clay formations that needed to be crossed during the excavation work.

Mechanized tunnelling consists in the use of TBM's (Tunnel Boring Machines), which bore out the whole section of the tunnel in one go. As the machine advances, the gap between the outside diameter of the mole's shield and the outer face of the blocks used to line the tunnel leave an annular gap that needs to be filled while tunnelling operations are being carried out.

Recently, mechanized tunneling designers and contractors have chosen the so-called "two-component" backfilling system more and more frequently, which comprises the following:

- component A: a highly fluid cementitious slurry which makes it very easy to pump, whose stability and impermeability is increased thanks to the use of bentonite. To guarantee the slurry workability up to 72 hours from mixing, a liquid retarding admixture with a plasticising effect is added, in this specific case MAPEQUICK CBS SYSTEM 1.

- component B: this is made up of a liquid activator admixture, MAPEQUICK CBS SYSTEM 2, which is added to component A just before it is injected into the annular gaps that need to be filled. This admixture is an efficient neutraliser of the set-retarding action of MAPEQUICK CBS SYSTEM 1 and turns the mixture into a gel almost immediately, in a time that can also be modulated (from 5 to 25 seconds).

The main advantages of this system compared with other materials are:

- its super-fluid consistency and maintenance of workability, which reduce the



**ABOVE.** The TBM used for the Sparvo Tunnel of the Mountain Pass Deviation project.



## A FEW FIGURES FOR THIS MEGA PROJECT

**41** NEW TUNNELS (57.3 KM OF ROAD)

**41** NEW VIADUCTS (16.4 KM OF ROAD)

**7.9 MILLION M<sup>3</sup>**

SOIL DUG FROM THE TUNNEL

**14.5 MILLION M<sup>3</sup>**

OF SOIL MOVED

**ABOUT 30 MILLION** MAN-HOURS WORKED

**4.1 BILLION EUROS**

TOTAL COSTS

risk of clogging in the transport lines and pumping hoses;

- its capacity to completely fill the annular gap behind the ring, thereby minimising any movement in the ground and, as a result, the risk of collapse during tunnelling;

- it hardens very quickly so that, even if water is present, its initial mechanical

strength develops very quickly, thereby “blocking” the ring in its specified position. The progressive hardening of the system is due to its passing rapidly from a liquid state to a gel-like state, which also helps reduce ingress of the injected material into the area being excavated by the TBM.

### STUDY OF THE MIX-DESIGN

The composition of the backfilling mix injected behind the concrete segments must be designed to meet the specified performance characteristics, while also being cost-effective. Each project has its own particular set of problems and it is important, therefore, that the two-component mix is designed according to the specific requirements of each single site. After taking into consideration all the specific requirements of the site, preliminary tests were carried out at the Mapei Research & Development Laboratories in Milan. Once the mix had been designed and tested in the Lab, the Technical Services Department of Mapei UTT (Underground Technology Team) tested and checked the mix on site during the first few weeks of TBM operations, and then every week during its round-the-clock work regime.

The aim was to check that the results achieved on site were comparable to those obtained during the Lab tests and, if necessary, to intervene on the parameters measured to bring the ma-

terial in line with project specifications.

### EXCEPTIONAL RESULTS

The constant control and technical support work provided, along with the numerous tests carried out in the laboratory and on site, allowed a mix to be obtained that fully complied with all the various requirements that had appeared, guaranteeing a final result in line with the high expectations of the project team.

The volumetric stability of component A was demonstrated by the lack of clogging in the transport lines from the mixing units to the TBM.

The special characteristic of the system is that it guarantees a rapid change in state from liquid to gel to solid, which allowed the annular gaps to be completely filled while preventing, in the case of water being present (a common occurrence when excavating underground), leaching and weakening of the mix.

In the particular case of the Sparvo Tunnel, the effectiveness of the mix-design was verified, particularly after the rotary/translation movement of the TBM before excavating the second tube. Also, the fact that the mix was pumped for more than 5 km clearly demonstrates that it performed consistently well and according to the expectations of the project team, while also minimising costs due to down time to clean out or replace clogged pumping hoses and injection lines.

### IN THE SPOTLIGHT MAPEQUICK CBS SYSTEM

It is a system specifically designed for use in cementitious mixes that need long workability. It is made up of MAPEQUICK CBS SYSTEM 1, a liquid retarding agent, and MAPEQUICK CBS SYSTEM 2, a liquid activator admixture. MAPEQUICK CBS SYSTEM 1 is a low viscosity solution able to retard cementitious mixes maintaining mix workability. In addition the solution assists in reducing bleed of the grout and decreases the grout viscosity. MAPEQUICK CBS SYSTEM 2 is suitable for activating cement setting in mortars or slurries used in injections. It also increases the viscosity of cement-based mixes, even where there is a high water/cement ratio. The main application field of MAPEQUICK CBS SYSTEM is for the injection of cementitious mixes used in back-fill grouting behind the precast concrete segments in tunnels excavated by means of TBM (“Tunnel Boring Machines”).