

# Road tunnel

Blasting - Micropiles - Ground anchors - Struts - Pipe roofing - Sprayed concrete

## T 33 TUNNEL MONACO



### Road tunnel excavated through rock, 55 to 85 m<sup>2</sup> excavated section



Photos : E. Giffard

The T33 tunnel in Monaco was excavated through rock with an excavated section of 55 to 85 m<sup>2</sup>. The 140 m long tunnel links the place du Canton to the Monaco South exit towards Nice.

As part of a larger joint venture, Solétanche SAM and Solétanche Bachy Tunnels, both subsidiaries of Solétanche Bachy, were awarded the contract for the specialist geotechnical works and for excavating and concreting the tunnel.

CLIENT:	SERVICE DES TRAVAUX PUBLICS DE MONACO
SUPERVISING ENGINEER:	COYNE-ET-BELLIER
EXTERNAL CHECKER:	SOCOTEC
JOINT VENTURE:	RICHELMI (MAIN CONTRACTOR) - SOLÉTANCHE SAM SOLÉTANCHE BACHY TUNNELS - SIVIA'M
DURATION WORKS:	NOVEMBER 2005 - OCTOBER 2006

#### MAIN QUANTITIES:

- Excavation using explosives: 8,900m<sup>3</sup>
- Waterproofing 3,500m<sup>2</sup>
- Reinforcement: 307 t
- Tunnel concrete: 3,350m<sup>3</sup>
- 300 micropiles
- Sprayed concrete: 6,322m<sup>3</sup>
- 280 type GEWI 25 to 32 rockbolts
- 115 temporary ground anchors
- 40 permanent ground anchors
- Struts: 100 t



The site and its surroundings



The upstream head, intersection between the service tunnel and the T33 tunnel

The immediate, highly sensitive environment required strict compliance with vibration restrictions and the development of innovative excavation techniques. An extensive ground monitoring system was put in place and used to monitor the reaction of adjacent structures during the different phases of the works.

### The upstream drive heads

Once the retaining walls had been constructed for the two drive heads, excavation began with the upstream head which intersected the cliff obliquely, and immediately beneath the portal of the existing rising tunnel. In line with the rising tunnel head (T7). An innovative pre-cutting technique was deployed: preliminary cutting using secant boreholes designed to isolate the section of rock

to be removed, followed by milling of the rock (highly abrasive dolomitic limestone) assisted by micro-mining splitting techniques.

### The downstream head

The geological conditions required the installation of specific support structures in the form of pipe roofing and of heavy duty 220mm arched ribs. Excavation works were carried out using a hybrid technique combining milling and drill and blast. Disturbance was reduced by forming a large decompression void by milling in the centre of the drive in advance of the drill and blast. The blasting pattern was governed by the requirement for a very low instantaneous charge. This required a very tight pattern with a large number of blast holes and the use of the entire range

of micro delays on the 10 sequential lines of each blast. Sections of tunnel passing close to sensitive structures were bored by milling the upper half of the tunnel and removing the bottom half by drill and blast. This increased use of milling reduced the vibrations transmitted to the rock mass.

### Concreting

Once the complex dewatering and sealing works had been completed, work was started on the permanent concrete lining. One of the specific features of the T33 tunnel is that it has 2 different cross-sections over a short linear length. A formwork tool that could be assembled and modified in the tunnel was designed to cover these 2 sections.



The Robofore used for drilling from the downstream tunnel



View from the Robofore operator's cab