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**Press Release No: 1589 GB****Kontakt:** Putzmeister Concrete Pumps GmbH  
**Contact:** Jürgen Kronenberg  
Max-Eyth-Str. 10  
D-72631 Aichtal  
Tel. +49 7127 599-353  
Mobil: +49 172 2957 869  
Fax: +49 7127 599-140  
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### **Shotcreting in 32 km long high mountain tunnels**

**In Western China, at an altitude of 3,380 m, two parallel railway tunnels 32.6 km long are currently being driven through the Guanjiao mountains. It is the longest tunnelling project that has ever been undertaken in China. Putzmeister technology was commissioned to secure the excavation under extreme conditions using wet-shotcrete.**

The spectacular structure is being constructed in a mountainous region that is difficult to access, and is set to replace the older Guanjiao Tunnel (length 4 km) currently in use and situated 300 m higher, but which is only accessible via very windy access tracks. Thanks to the perfectly straight route through the mountain situated at a lower altitude, journey times will be shortened considerably, and fuel savings will be significant as each train will have three diesel locomotives at the front. The sections of the new Guanjiao Tunnel have been designed for train speeds of up to 160 km/h.

### **Faster to Tibet**

The tunnels form part of the transportation route (814 km) inaugurated in 1984 connecting Xining, capital of the Qinghai Province, and the city of Golmud situated further west. From 2000 to 2005, the railway line was extended by 1,142 km from Golmud to Lhasa, capital of the Tibet Autonomous Region ("Tibet Railway").

The China Railway 16 Bureau Group is commissioned with building over 17.3 km of tunnel – more than half of the entire Guanjiao Tunnel Project. The two single-track tunnels 40 m apart will be driven up from all four entrances to create an excavated cross section of approx. 90 m<sup>2</sup>. Progress will be made both with the use of tunnel boring machines as well as with drilling and blasting techniques. As part of tunnelling operations - once excavated and with the calotte strengthened with shotcrete - the side wall and base are built moving a few meters at a time. The construction costs for the new Guanjiao Tunnel come to 2.5 billion RBM (approx. € 250 million). The construction time is estimated to be 53 months, and completion is planned for 2012.

### Concrete wet spraying machine with special spray arm kinematics

Initially, a Putzmeister SPM 500 PC concrete wet spray manipulator will be used to secure the excavation. In late 2009 a second machine of the same type will be put into operation on the construction site. The all-wheel-drive and all-wheel-steered concrete wet spray systems have a concrete pump which delivers an extremely even supply of shotcrete via hydraulic control. The shotcrete is applied with a highly mobile spray nozzle in combination with special spray arm kinematics. The hydraulic parallel guide of the front telescopic spray arm makes it possible to automatically keep the complete telescopic spraying arm with nozzle in a horizontal position, - regardless of the angle of the first boom arm.

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### Technical data for the SPM 500 PC concrete wet spray system (separate block)

Working height of the SA 14 telescopic spray arm:	4.5 to 16 m
Delivery rate of the double piston shotcrete pump:	4 to 30 m <sup>3</sup> /h
Volume of the additive tank:	1,000 l
Delivery rate of the additive metering unit:	30 – 700 l/min
Compressor output:	9 m <sup>3</sup> /min.
Volume of the water tank:	195 l
Power cable:	50 m (100 m optional)
Pump and boom operation:	cable remote control (radio remote control optional)
Drive output of the carrier vehicle, inter alia with 4-wheel-steering, all-wheel drive, rotating cab	75 kW

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### Low temperatures and “thin air” take their toll

At temperatures as low as -36°C and atmospheric pressure reduced by one-third, the tunnelling operations at an altitude of 3,380 m put a strain on workers and machine operators. Typical symptoms experienced by site staff include shortness of breath, exhaustion, headaches and nausea. In case of emergency, there is oxygen equipment available at the construction site.

The compressor output of the shotcrete unit at this altitude is still at 100% (the result of air volume times pressure remains constant), and the low static pressure has an effect on the suction in the shotcrete pump, at least in theory. However, at a maximum delivery rate of 30 m<sup>3</sup>/h, this loss in output cannot be detected in practice.

Of course, the low temperatures are a problem (the annual average is below 0° C), - especially during the winter months. This also results in the formation of ice in the tunnels. This means that the shotcrete aggregates are stored in such a way that they do not freeze, and that the additive and water for the concrete batches and for cleaning purposes “free-flowing”...

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## **Subtitles**

### III. 1589-1

Transport of the Putzmeister shotcrete unit SPM 500 crossing a pass situated in about 3.500 m altitude

### III.1589-2

This Chinese operator familiarize himself with the remote control of the modern Putzmeister concrete wet spray system

### III. 1589-3 GB

The map illustrates the windy course of the old, 300 m higher running track and the position of the two new single track tunnels which are considerably longer (ill. China Railway 16 Bureau Group)

### III. 1589-4

Survey of the main Chinese rail lines (Abb. China Rail)

### III. 1589-5

After having taken an „oxygen shower“ work is going on...

### III. 1589-6

Chinese job site staff just before starting up the Putzmeister shotcrete unit

### III. 1589-7

Clearly one can see that the side wall and base construction is moving a few meters behind after the calotte is excavated

### III. 1589-8

The living quarters on the job site are densely occupied