

## In search of the ideal shotcrete mix

South Africa's construction and mining industries work to far more rigorous specifications than those generally adopted in Europe. This is the conviction of Cyril Attwell, concrete and research manager at Murray & Roberts, who states quite categorically that South Africa is an uncontested world leader in cement technology.

"We were requested by our French partners in the Bombela Consortium, Bougues, to design specifications for shotcrete for the Gautrain tunnels," he explains. "The shotcrete specification designed was based on the solution used in South African mines and the French were taken aback by what they considered requirements that were far too severe. In South Africa, we lay great emphasis on safety as a priority, in fact, at Murray & Roberts, it is our strongest motto. So our specifications are consistent with the work conducted underground."

Among the main differentiators was the size of the stone used in the aggregate. "Our standard size is 6.7 mm," continues Attwell. "We find this size particularly suitable for spraying under high pressure because there is minimum rebound and greater homogeneity. Finer particles agglomerate more easily. For instance, using a 4,5 mm bedding mortar and the 6,7 mm stone, the wall readily accepts all the material, easily covering the smaller stone."

Since aggregate of this size was not readily available in South Africa, Murray & Roberts approached AfriSam to produce it specifically for the purpose. AfriSam was able to produce according to the requisite size and some 100 000 tons was eventually produced.

Attwell believes the motivation for using the larger stone lay in the understanding that a 9,5 mm stone would provide greater stability to the shotcrete. "Where concrete itself is concerned," he admits, "It is true that the larger the stone, the more stable the concrete. But this is not necessarily the case with shotcrete. Larger aggregate will also lower shrinkage in concrete and absorb more heat."

The shotcrete manufactured to French specifications was used in the southern section of the Gautrain in the tunnels between Park Station and Rosebank and from Sandton to Marlboro. "The shotcrete with the 6,7 mm stone was also used as a finishing surface to help limit the amount of weeping from underground water," Attwell adds.

"The 9,5 mm stone was also used in the concrete in the precast section because of congestion. This size stone facilitates the movement of concrete around the steel elements and thus promotes stability." In designing the most suitable solutions for the different conditions,



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considerable art is necessary as well as pure science. "It is important to strike the right balance," Attwell says. "One can also refine on designs in an attempt to improve them."

The use of advanced recrystallisation technology (ARC) technology also places South Africa on a level above the rest of the world. "This is technology which considers all the materials in concrete: cement, water, sand and stone, and how they all interact with each other, considering synergies and therefore strengths. It leads to huge savings in cement without compromising quality or strength. One can save as much as 140 kg per cubic metre of cement for any operation. Such savings are extremely important in environmental terms, since the production of 1 kg of cement yields 1 kg of CO<sub>2</sub>."

The French are among those sending concrete technologists to South Africa to learn about this technology and how to apply it. ■