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**GETTING  
THE BEST FROM  
SPRAYED CONCRETE**

# Getting the best from SPRAYED CONCRETE

**As the use of sprayed concrete advances, so must the skill of those applying it and the testing regimes used to check it. That's where EFNARC comes in, reports Kristina Smith**

**IT TAKES A CERTAIN** sort of person to be a good nozzleman. "They have to really care about the job," says spray master Adam Barker, a nozzleman with an impressive 18 years experience. "People who have been doing it for a long time, it gets into their blood. They love it."

For proof of the difference a nozzleman can make, take a look at two samples (photo to the right), taken from the same tunnel and the same concrete batch, but applied by two different nozzlemen. As sprayed concrete linings move from the realm of temporary works into permanent works, designers need assurances that their wall will look like the sample on the right, not the one on the left.

Yet until recently, there was no way of knowing how good your nozzlemen were.

Enter EFNARC, once a group of national associations set up to reach technical agreement on the new Euro Norms, now a group of manufacturers and other experts setting guidelines on how to best use developing concrete technologies. EFNARC's guidelines are recognised around the industry, more often than not forming the basis for the next generation of standards.

In October 2009, EFNARC, (which now defines itself as an international association of Experts for Specialised Construction and Concrete Systems), launched its nozzleman certification scheme (see Box p41). Although still in its infancy, the scheme is already gaining recognition, with some clients asking for EFNARC-certified nozzlemen in their tender documents. EFNARC has also been talking to Crossrail about how the scheme can be



applied at their Tunnelling and Underground Construction Academy (TUCA).

Recognising how crucial the role of nozzleman is becoming, EFNARC members Normet, who Barker joined in 2009, Mapei, Putzmeister, Sika, Stratacrete and TAM, have been among the first to send employees on the examiners courses. Normet, for example, wants to have 12 spray masters, like Barker, on its books in five years' time: practical and technical experts who can provide troubleshooting, training and certification services to its customers.

#### Supporting innovation

Like the new residual flexural strength test for sprayed concrete which one of its technical committees has just published (see Box p44), the nozzleman scheme demonstrates what EFNARC is all about: bringing the latest practical experience, technical knowledge and research together to ensure that contractors and designers get the best out of the materials they are using.

"The companies in EFNARC understand that they can't introduce new technologies and innovations, without some sort of history or performance or backing," says EFNARC



# Five steps to a certified nozzleman

**1** Experienced nozzlemen, often already trainers, attend an assessment course at the Hagerbach Test Gallery in Switzerland. During the 2.5 day course, they receive a technical refresher course and learn how to test nozzlemen on their spraying skills and technical knowledge.

**2** Armed with the nozzleman course notes and slides, theory exam questions and practical assessment forms and checklists, the examiners can now begin assessing nozzlemen in their workplaces.

**3** Over two days, an examiner will take the

nozzleman through the course notes and spend time with them at the workplace before the practical and technical assessments.

**4** The practical assessment covers pre-application tasks, start-up procedures, spraying application procedures, shut down procedure, troubleshooting and problem solving and HSE issues. The practical assessment has a higher overall weighting than the theoretical one.

**5** The theory assessment takes the form of a multiple choice, given orally or in a written test. The course notes contain all the information needed to answer the questions correctly.

Here are three examples of the theory questions which the nozzleman might be asked to answer. We have not included the answers as we don't want to give anyone an unfair advantage!

**1. Tick 3 actions to ensure good bond strength between successive layers of sprayed concrete.**

- sand blasting
- use internal curing agents
- apply a bonding agent
- hydro-jetting
- detergent application
- high volume water jet
- dampen surface

**2. Order the following actions (1 to 7) to be taken immediately a blockage occurs.**

- point nozzle down
- stop accelerator
- stop air
- reverse concrete pump
- stop concrete pump
- locate blockage if in line
- release line clamps/couplings

**3. Tick 3 ways that excess water will most affect the properties of sprayed concrete.**

- reduce the in-place cost
- lower the durability
- improve long term strength
- increase the setting time
- reduce strength



secretary Roland Harbron. "By producing guidelines and standards, they are giving assurances to the industry and protecting their interest by making sure their products are being used correctly."

Because all the members of EFNARC's technical committees are involved directly in the industries they serve, they can work out where the next gaps in knowledge and information are likely to be and act accordingly. Once the nozzleman scheme is fully established, EFNARC has plans to look at a similar style certification scheme related to the design of permanent sprayed concrete linings in tunnels.

The nozzleman scheme takes expert practitioners from around the world and trains them to be examiners who can then certify already-experienced nozzlemen. These examiners test nozzlemen on

More information from [www.efnarc.org](http://www.efnarc.org) and [secretary@efnarc.org](mailto:secretary@efnarc.org)

## SPRAYED CONCRETE



**“One of the most important things with wet spray is the material. They need to know if it is right, and if it isn’t right, they need to know the reason why”**

their practical skills and top up their technical knowledge. The result is certified nozzle men who are not only competent applicators but who also have the confidence to challenge when problems occur.

“One of the most important things with wet spray is the material. They need to know if it is right, and if it isn’t right, they need to know the reason why,” says Paul Brown, senior contracts engineer with BAM Ritchies. Brown, who has 38 years of spraying concrete under his belt, is not an EFNARC member but he is one of the 23 new examiners, having attended one of the first courses. “Arming them with technical knowledge is a great thing. It is something I have had to glean along the way.”

As is the norm in construction, nozzle men tend to fall into the job by a combination of chance and family connections. Barker, an Englishman who moved to Australia when he was eight, got his first spraying job through a girlfriend’s father. For Brown, it was his uncle who introduced him to the industry.

In times of boom, almost anyone will be given the nozzle. “Take Australia before we had the economic crash: if anyone looked like he could do it, they would get him in there and start him doing it,” says Barker who was working in Australian mines before Normet



**A montage of pictures showing nozzle men in action, both at work and in the Hagerbach Test Galleries in Switzerland. Comparing the right photos to the one on the left gives a good indication of the different quality surfaces a sprayer will have to contend with**

recruited him. “When a lot of people got laid off, those that hadn’t been doing it for long fell by the wayside.”

Both Barker and Brown are agreed that the ideal nozzle man needs a combination of dedication and endurance. “We tend to bring people into the industry as machine operatives and graduate them onto the nozzle if they are suitable,” says Brown. “Part of that suitability is conscientiousness. They are a pretty unique breed.”

“To be a nozzle man, you can’t be afraid of hard work,” adds Barker. When blockages occur, a nozzle man must wrench apart the pipes by hand to unblock them. And he must be prepared to stay at his post until the job is done, however many hours it takes.

Although years of experience are often a good indicator of a competent nozzle man, Barker says that he has come across men with a decade on the tools but the wrong attitude – which can be just as disastrous as an inexperienced sprayer.

The fact that sprayed concrete is applied by robotic arm these days does not negate the possibility of problems and errors. There are

still plenty of things that can go wrong, from the blockages already mentioned, to incorrect mixes, to the actual application.

Barker spent time hand spraying before he started working with robots, experience which stood him in good stead. “You have a much finer technique when you have done hand spraying,” he says. “Spraying concrete is all about the angles. You have to spray at 90 degrees to the surface you are spraying on.”

In a tunnel with its uniform cross-section, angles are less of a problem. But in mines, where blasting has made the way, there are angles everywhere. If a nozzle man tries to spray everything from one position, there will be voids which are weak points.

### **Soaking up the knowledge**

To date 26 nozzle men have been certified. And while you can find the names of all the EFNARC examiners on its website, you won’t find the names of the nozzle men. Although they originally intended to list them, EFNARC soon realised that this would form a shopping list for contractors.

Barker has certified seven men, in Anglo

American's Lisheen Mine and Boliden's Tara Mine, both in Ireland. His experience has shown how eager the nozzlemen are to gain technical knowledge – even though there are over 100 EFNARC training slides to work through, taking the nozzlemen from the batching plant all the way through the process to application and testing.

"They really absorb all the technical stuff they are not exposed to in their every day working lives," says Barker. "They are like sponges."

And that knowledge will have a big impact, says Barker, citing water/cement ratio as an example. "If the concrete turns up and it's a bit dry, a nozzleman would usually add a bit of water," he says. "Now they realise how bad that is: what they do to that mix could be

**Instructors and attendees work together at the EFNARC Nozzleman training course in Switzerland's Hagerbach Test Galleries, not only to improve actual spraying practices, but to further their theoretical understanding of concrete**

detrimental to its strength. That's something concrete sprayers really need to be aware of."

The thirst for technical knowledge also applies to the examiners. Originally a two-day course at the Hagerbach Test Gallery in Switzerland, the session was extended to two-and-a-half days so that they could learn more about concrete technology with the researchers.



## Why accurate tests are vital

The existing test for checking the residual flexural strength of sprayed concrete linings needs updating: it's complicated to do, doesn't match the updated international standard and may not give accurate results. That's why EFNARC's Fibres Technical Committee has spent over four years developing a new test method, now published, which has addressed all those issues.

"Testing is very important. And now that some contractors, especially in the UK, are promoting the use of SCL as a final lining it becomes even more important," says Benoit de Rivaz, chair of the committee and global tunnelling manager for Bekaert. "Residual strength is a key material property. That's why we need such an accurate residual strength value."

There are two main tests used for sprayed concrete. Energy absorption is measured by testing a small panel which can be sprayed at the job site. But energy absorption, although useful for comparing different products with the same mode of failure, is not used as a design value.

The test for residual flexural strength, EN 14488-3, requires a much larger panel to be sprayed, from which beams must then be cut. In practice, says de Rivaz, this test is often not very often used because it is not really practical.

EFNARC's new test employs exactly the same size of panel as the energy absorption test. These can be sprayed on site alongside the energy absorption ones and then go straight to the laboratory to be tested on standard equipment. The panel size ensures that



the distribution of fibres in the matrix is as close as possible to that in the real structure, in contrast with the sawn beams, which cuts through fibres, creating a false situation.

The new test method also defines residual flexural strength in the same way as the updated international code, fib Model Code 2010. And the scatter of results this test produces is lower than that produced by the existing one – which means it is more accurate.

EFNARC hopes that its test method will go on to become an official EN Standard, as is the case with many of

the guideline it produces. This will take at least a year, says de Rivaz, as more results from the field must now be gathered. But the method has already been presented to the ITA's Working Group 12 on Sprayed Concrete Use which should smooth its passage to becoming an EN and/or ASTM.

The next task for the Fibres Technical Committee, whose members come from Bekaert, Adfil, CUC, Grace and Maccaferri, is to assess all the available test methods for fibre reinforced sprayed concrete to check their relevance and accuracy.

## SPRAYED CONCRETE



"On the examiner's course, you get told a lot of things you probably already know, but it's beneficial to have it all in front of you," says Barker. "It confirms what you have learnt from years of experience and takes you up to the next level. You are gaining experience from people who have studied it."

The fourth examiner's course – which experience has shown runs best with eight people or less, says Harbron – will take place in October this year. The notes for the course, which are given to the examiners and the nozzlemen, will also be updated, as EFNARC's

goal is to keep pace as technology and practice moves on.

Examiners outside Europe have already been trained from Australia, Asia, North and South America. The next steps will see the notes translated into other languages, starting with Spanish, German and Italian.

Although all examiners and nozzlemen must be re-assessed every three years, Harbron will be setting up an auditing system to provide an extra level of assurance that the same standard of certification applies wherever the examiners are working. And he

is talking to ITA about gaining the association's approval for the certification process.

Looking further to the future, Barker believes that clients will require that all nozzlemen be EFNARC-certified. Crossrail's stated ambitions to up the competency of the industry through TUCA can only help speed that process. But in the mean time, those contractors who can offer EFNARC-certified nozzlemen will definitely be flagging it up at tender time as an additional guarantee of quality.

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