Some aspects of current shotcrete practice in South Africa – Part 1 Civil

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The first major use of Shotcrete in a ‘civils’ tunnel in South Africa was probably on the 83 km long Orange-Fish Tunnel in the 1960’s.

Initially it was used in thin layer to seal the degradable mudstones through which much of the tunnel was driven.
• Subsequently it was widely used as an integral component of the initial or ‘temporary’ support systems, before the tunnel was lined with an in-situ concrete lining

• This was done over an aggregate length of 54.9 km of the tunnel
• The first major use of shotcrete as a permanent structural support component was probably on the Drakensberg Pumped Storage Scheme some ten years later.

• Notably the major cavern vaults made use of two 50 mm thick layers of reinforced shotcrete.
Shotcrete practice in SA – Part 1 - Civil

DPSS Machine Hall
• Both wet and dry shotcreting methods were used on the DPSS
Since then the use of wet mix shotcrete has grown and currently mechanised (robotic) use of wet mix concrete is being used extensively on the Gautrain Rapid Rail Link.
Shotcrete practice in SA – Part 1 - Civil

Gautrain – Single track running tunnel
Shotcrete practice in SA – Part 1 - Civil

Sandton Station Cavern
...........and on the Ingula Pumped Storage Scheme
Shotcrete practice in SA – Part 1 - Civil

Ingula Pumped Storage Scheme – Access Tunnels
With the increased use of shotcrete for permanent shaft and tunnel linings there has been an increasing focus on the performance and quality of the end product – something I’ll be dealing with in more detail in another presentation later today.
This has also led to a growing need for the proper and adequate training of shotcrete nozzlemen – another topic which will be addressed in the course of this conference.
Useful accounts of current shotcreting technology in SA are given in a paper to be given in the next session and in Chapter 23 of Fulton’s Concrete Technology.
Nomenclature

In SA the term ‘Shotcrete’ is widely used although the term ‘Sprayed Concrete’ is preferred by many designers.

The term ‘Shotcrete’ is generally used in North America and Australia.
In Europe the term ‘Sprayed Concrete’ is the norm and is used in the EN standards.

Shotcrete work carried out on the OFT and the DPSS was referred to as ‘Pneumatically Applied Concrete’ (PAC), although the term ‘Shotcrete’ also appears in the technical literature of the day.
• The authoritative SA handbook ‘Fulton’s Concrete Technology’ uses ‘Shotcrete’

• The majority of specifications for major underground ‘civil’ projects use the term ‘Sprayed Concrete’
The term ‘Sprayed Concrete’ although a mouthful is really better – it helps to reinforce the idea that one is referring to a high quality structural medium that just happens to have been placed by ‘unconventional’ means
The debate continues………….

In the meantime for the purposes of my presentations I use both terms interchangeably.
Specifications

The shotcrete specifications for most major projects in Sn Africa have been written around the needs of the project concerned
When smaller projects come up it is inevitable that these tested specifications get literally taken off the shelf, are reviewed for applicability, and then plugged into the relevant documentation.
SANCOT Specification?

In the late 1970s/early 1980s the SABS 1200 series of standard construction specifications came into being. These were widely adopted and this led to consideration being given by SANCOT to develop a national standard for shotcrete.
SANCOT Specification?

In 1992 SANCOT’s Shotcrete WG drafted a document entitled:

‘Particular Specification for Civil Engineering Construction : PG Shotcrete’
SANCOT Specification?

The intention was to have this submitted to SABS for inclusion in the SABS 1200 series of specifications.
SANCOT Specification?

The draft spec was circulated throughout the industry for comment.

But the reaction was very mixed and it was almost impossible to reconcile the widely differing comments.
SANCOT Specification?
This led to the matter not being taken forward at that time
So the things have tended to continue as before – take the spec off the shelf and modify it as necessary in the light of experience – which is fine if done responsibly
On the Gautrain project reference was initially made to the BTS/ICE Specification for Tunnelling (2000), which includes a section on sprayed concrete.

The trouble with the BTS spec is that it is of a generic nature and requires the designer to add such additional clauses as he requires.
and inevitably this also leads to the deletion of the clauses that are not liked!

This can result in the documentation being fragmented and difficult to use.

As the Gautrain project moved on project specific shotcrete specifications were developed and used.
Experience on some major projects

LHWP Phase 1A : 45 km Transfer Tunnel

The tunnel was excavated using 3 hard rock TBMs and was subsequently lined with an in-situ concrete lining.
LHWP Phase 1A : 45 km Transfer Tunnel

Problems were initially experienced in meeting the specified durability parameters of BA & VPV. These did not have a single identifiable cause but were overcome by implementing a number of measures as described in the paper.
The Matsoku Tunnel is probably only one of three water conveyance tunnels in South Africa which has been provided with a permanent shotcrete lining.

Experience gained on this project will be described in a presentation tomorrow.
Permanent shotcrete linings are being used for all the access tunnels, galleries and ventilation shafts together with the cavern vaults and sidewalls of the Machine and Transformer Halls.
Shotcrete practice in SA – Part 1 - Civil

Ingula PSS – Layout of underground works
Shotcrete practice in SA – Part 1 - Civil
Ingula Pumped Storage Scheme

The waterways tunnels and shafts will see the use of sprayed concrete as a component of the initial support systems prior to their being lined (for hydraulic reasons) with in-situ concrete or steel linings.
Gautrain Tunnels

Sprayed concrete is being used extensively for surface and underground work on the Gautrain Rapid Rail Link Project.
Shotcrete practice in SA – Part 1 - Civil

Gautrain – Single track running tunnel
Gautrain Tunnels

15 km of the rail system is underground as are three of the stations – at Park, Rosebank, and Sandton

This work is fully described elsewhere at this conference
Common problems ( - still !)

- Adequate curing
- Durability – lack of appreciation of the importance of workmanship
- Energy Absorption – Testing
- Adhesion to non-durable rocks
Adequate curing & Durability

• The subject of a separate paper at this conference
Energy Absorption Capacity (EAC) testing

There is growing acceptance of the ASTM C 1550 round panel test over the EFNARC square panel test which lacks repeatability.
Adhesion to non-durable rocks

This matter is addressed in another paper at this conference which deals with the problem of adhesion to Kimberlite
Training of Shotcrete Nozzlemen

At present there is no national or industry standard for the training and certification of shotcrete nozzlemen in South Africa.
Training of Shotcrete Nozzlemen

SANCOT supports the idea of introducing a training and accreditation scheme for Shotcrete Nozzlemen in South Africa.
Training of Shotcrete Nozzlemen

We are fortunate in having several overseas speakers at this conference who will be telling us about a number of different schemes that either exist – or are in the process of being introduced in other parts of the world.
Thank you!