Prof. Eivind Grøv
Vice President of ITA
Research Manager SINTEF

ITA Working group No.12
Sprayed concrete Use

Shotcrete for Africa
Towards an improved use of underground space

Visit to Gautrain
1st of March 2009

Sprayed concrete as final lining in a major tunnelling project

Utilizing the capacity and capability of both the rock mass and the sprayed concrete

Photo. Andre Assis
Cradle of Human-Kind
Cradle of Wet Mix
Sprayed Concrete

Sterkfontein caves
The vision of ITA (from Strategy 2000) is to be:

« the unquestioned leader in the use of subsurface space »
Towards an improved use of underground space

To be able to fulfill this vision: the presence of Working Groups is important, active working groups which are providing useful material to the professionals.

1. COLLECT
   • From/By WGs
   • From WTC & Workshops
   • From Training courses
   • From University Network
   • From Sister Organizations
   • From Web

2. ORGANIZE/PROCESS
   • By:
     • WGs
     • Task Forces
     • Committees
     • Meetings

3. DISSEMINATE
   • Web/WTC
   • Meeting/Training/Workshops
   • Publications
     • ITA@News
     • Tribune
     • WG documents
     • ITA Reports

Shotcrete for Africa
Established in 1989 (ITA meeting in Toronto)

Animateurs:  
Tomas Franzén (Sweden) 1989~2000
Knut Garshol (Norway) 2001~2004
Tarcísio Celestino (Brazil) 2005 ~

Vice Animateur:  
Atsumu Ishida (Japan) 2005 ~

Current Tutor:  
Eivind Grøv (Norway) 2004 ~
25 members from 15 countries: Brazil, Canada, China, Czech Republic, France, Israel, Italy, Japan, Korea, Luxembourg, Norway, Singapore, South Africa, Sweden and Switzerland

Meetings are annual in conjunction with the World Tunnel Conference (normally 2 times)

Some times ad-hoc meetings in conjunction with conferences (e.g. Lillehammer 08, Whistler 07)
Subjects of publications released:
- State-of-the-Art Reports
- Guidelines and Recommendations
- Health and Safety
- Shotcrete for Final Lining
- Waterproofing
Some recent (?) publications of WG 12 works

**T. Franzén (1992)**
“Shotcrete for underground support a state-of-the-art report with focus on steel-fibre reinforcement”

**B. Malmberg (1993a)**
“Shotcrete for rock support: Guidelines and recommendations – a compilation”
International Tunnelling Association Working Group on Shotcrete Use, published by the Swedish Rock Engineering Research Foundation

**B. Malmberg (1993b)**
“Shotcrete for rock support: a summary report on the state of the art in 15 countries”
*Tunnelling and Underground Space Technology, 8 (4) 441-470.*

**K. Ono (1996)**
“Health and safety in shotcreting”

“Sprayed concrete for final linings: ITA working group report”
*Tunnelling and Underground Space Technology, 16 (4), 295-309.*
Towards an improved use of underground space

“Lining of Tunnels under Groundwater Pressure”
T. Celestino (2005)
“Shotcrete And Waterproofing For Operational Tunnels”
ITA Workshop on Waterproofing - Sao Paulo
K. Garshol (2002)
“State of the art report WG12”
Proceedings of Fourth International Symposium on Sprayed Concrete
C. Larive (2006)
“Sprayable mortars for fire protection”
London, Workshop on Fire protection engineering
C. Hauck (2009)
“ITA Sprayed Concrete Tests at Hagerbach Testgallery Longterm Effect on Fibres in Sprayed Concrete”
5th Symposium on sprayed concrete. Lillehammer
C. Larive (2009)
“Certification of shotcrete nozzlemen around the world”
Shotcrete for South Africa
K. Garshol (2006)
“Shotcrete for rock support – a summary report on the State of the art presented by ITA WG12 on Shotcrete Use”

www.ita-aites.org

The last State of the Art Report was given “go-ahead” at the WTC in Durban 2000

Covers the period 1992 until about 2005
Shotcrete for Africa

- As always, WG publications are highly dependent on contributions from the member nations
- 21 countries contributed to the Report
- The content varied in length and scope between short notes and extensive detailed reports
Australia: A two-page presentation given by the Australian Shotcrete Society
Belgium: Three different papers, primarily covering aspects of steel fibre reinforcement in shotcrete
Brasil: A three-page presentation covering temporary and permanent tunnel linings, shotcrete materials, standardization and rock mass – shotcrete interaction.
Canada: The contribution presents shotcrete usage in mining in Western Canada and in the Sudbury Basin. The use of boltless shotcrete in mining is described.
Czech Republic: Delivered a six-page contribution describing general shotcrete usage, following the outline given by the WG12 for Task 1.
Germany: About German tunneling technology over the last 20 years.
Italy: A SIG National Working Group Report with a good coverage of the most important issues of shotcrete usage in Italy.
Japan: A Japan Tunneling Association Shotcrete Working Group contribution containing a comprehensive seventeen-page coverage of the Japanese shotcrete market. The special aspects of shotcrete methodology in Japan are well illustrated. Also the new airless spraying method is presented.
Korea: A three-page contribution was received, giving an overview of the extensive tunneling in South Korea and the development of shotcrete for rock support for this purpose.
Lesotho: A ten-page paper on the Matsoku Diversion tunnel was submitted. The paper gives an in-depth presentation of the use of shotcrete at this 5.6 km tunnel project (part of Lesotho Highlands Water Project).
Mexico: A two-page report about usage of shotcrete in Mexico with a focus on the need to bring more users up-to-date with modern shotcrete technology.

Shotcrete for Africa
North America: "Guide Specification for Shotcrete for Underground Support" under preparation by the ACI 506 Shotcrete for Underground Support Committee. This is a comprehensive document covering all aspects of shotcrete usage of more than 100 pages in total.

Norway: Contributions were received in three steps. The final document contains seven pages, where the first two are summarizing the current status of shotcrete usage in tunneling and the next 5 pages give highlights about eight different tunnel projects. One of them is about the World’s longest road tunnel between Aurland and Laerdal.

S. Africa: The twenty-page document gives a comprehensive presentation of shotcrete in deep level hard rock mining, rounding it off with three selected practical examples. The section about identified support mechanisms of shotcrete deserves special attention and credit, for being highly useful and educational.

Sweden: Submitted two papers on the Southern Link road tunnel project and the main document contains eight pages primarily about rock support and shotcrete. There is also a section about blast vibration effects on shotcrete and research on shotcrete durability and corrosion problems.

Switzerland: A set of five project-description papers were submitted, covering a range of practical shotcrete application examples.

Turkey: A five-page paper describing the Bolu Tunnel project was submitted. The paper compares wet mix shotcrete with two different types of accelerator and the influence on long term Young’s modulus and compressive strength.
Subjects covered in the state-of-the-art

- Permanent tunnel linings (acceptance of use may vary)
- Method of reinforcement (fibre types, mesh)
- Equipment/application methods (wet mix vs. dry)
- Concrete technology (accelerators)
- Guidelines, specifications, standards (ASTM, EFNARC, national standard)
- Design (of tunnel linings) (Empirical, observational method, Q)
- Health and safety (dust handling, work at tunnel face)
Publications available at

www.ita-aites.org
Towards an improved use of underground space

Current Activities of ITA WG 12

- Nozzleman certification (to be presented)
- Sprayable mortars fire protection
- Tests on fiber-reinforced shotcrete
- Waterproofing
- Suggested methods for panel test preparation
- Accidents related to shotcrete
- Photo collection of nozzleman around the world
- Shotcrete curing and durability
- Preparing an ITA-report on state of the art
Experimental program on Fiber-reinforced Sprayed concrete
Influence on energy absorption of:

• Fiber type (steel, synthetic)
• Fiber content (to reach 1000 J)
• Age (early to 3 years)
• Commenced in March 2006
Towards an improved use of underground space

Motivation

Shotcrete for Africa
Longterm Effect on Fibres in Sprayed Concrete

• Took place at the Hagerbach test facility in Switzerland
• Invited suppliers to participate
• Suppliers provided material and paid the testing
• WG 12 is managing and administering the project
• WG 12 is reporting the results
• Uniform and common test series, neutral
• Long term test scheme, up to 3 years
• Planning to restart with new tests
Tests performed with
• Same shotcrete (40-50 MPa)
• Same tests

  Fresh concrete properties
  Compressive strength
  Energy Absorption (Circular panels)
  Fibre content

• Same procedures
• Comparable tests
Shotcrete for Africa

Different fiber types

- Planned 2 steel fibres and 3 syntethic
- Managed to attract one of each for a full test series
- Decided to go ahead with a new invitation
Suppliers were invited to participate and follow the batching, spraying and the initial testing.
Shotcrete for Africa

Spraying panels for testing
Hagerbach Test
March 2006 Gallery,
Switzerland
Towards an improved use of underground space

**Shotcrete for Africa**

- Details to be reported at a convenient time!

Filled symbols mark ITA tests

- M = macro
- S = steel fibre

Empty symbols mark literature study

---

ITA • International Tunnelling and Underground Space Association • Association Internationale des Tunnels et de l’Espace Souterrain • AITES
Welcome to join us, in a friendly, international and professional environment sharing technical up-dates
WG 12: An active meeting point for professionals in the sprayed concrete technology

WG 12: Promoting the application of sprayed concrete as permanent lining and documentation

Wishing you a successful conference here in South Africa, and hoping to see you all again in Budapest, or elsewhere to learn your experience of sprayed concrete

Thank you!