Geological 3D Analyses of Tunnel Faces with Software and Hardware tools of DIBIT

Stefan Eder  
*ILF Consulting Engineers Austria GmbH*

Heiner Kontrus  
*Dibit Messtechnik GmbH*, michael.mett@dibit.at

Florian König  
*Dibit Messtechnik GmbH*

Stefan Eder  
*ILF Consulting Engineers*

Follow this and additional works at: [https://dc.engconfintl.org/shotcrete_xiv](https://dc.engconfintl.org/shotcrete_xiv)

Part of the Engineering Commons

**Recommended Citation**

[https://dc.engconfintl.org/shotcrete_xiv/5](https://dc.engconfintl.org/shotcrete_xiv/5)

This Abstract and Presentation is brought to you for free and open access by the Proceedings at ECI Digital Archives. It has been accepted for inclusion in Shotcrete for Underground Support XIV by an authorized administrator of ECI Digital Archives. For more information, please contact franco@bepress.com.
Geological 3D analyses of tunnel faces using dibit software and hardware tools

dibit measuring system / ILF Consulting Engineers
MSc. Stefan Eder (ILF Consulting Engineers, Head of Geology)
Dr. Michael Mett (dibit, Head of Research and Development)
Dipl.-Ing. Heiner Kontrus (dibit, CEO)
Dipl.-Ing. Nina Müller (dibit, Geologist and Survey Engineer)

November 20th 2019
Contents

- Introduction and general information about geological documentation
- Case studies – Perjen Tunnel, Karawanken Tunnel
- Introduction Shotcrete Scanning-Process during Drill&Blast Tunneling
- Innovations using digital data based on Shotscreen Scanning
- Scanning of rock mass – geology
- Scanning of different layers of shotcrete and inner lining
- Conclusion
Geologic Documentation – short overview
“Manual” geological documentation

- Generalised illustration
- Easy to understand and comprehensible
- Contains the “most important” information
Case study 1 – Perjen Tunnel, S16 Arlberg Expressway
Case study 2 - Karawankentunnel, A2 Southern Motorway
Geologic Documentation and Geotechnical Survey - Overview and scope
Geology and Geotechnical Survey - Overview and scope
3D scanning process

- FSC 5100 SRsF1 handheld scanner
  - High-resolution documentation of the rock face and the geol. situation using color pictures
  - Monoscopic photogrammetry system
  - Digital camera with fisheye
  - Recording distance: 1 to 20 m
  - Absolute measuring accuracy: ± 10 mm
  - True color resolution: up to 1 mm
  - Preparation and measuring time at the tunnel face is reduced to 2 minutes
Speed is everything!
Workflow

- **Ground control points**
  - Magnetic
  - 4 reflectors

- **Positioning**
  - Automatic tacheometer
  - dibit ACQ software
Workflow
Digital mapping and 3D Scanning

- Processing of textured 3D models
- Data analyses
Computation of the 3D model

- Computation using dibit
  - 10 photos
  - 4 GCPs
Scanning phases

- Visualisation of temporally and spatially different 3D measurements

  - Phase 1: rock face
    - Tunnel alignment
    - Tunnel face

  - Phase 2: shotcrete / sealing
    - Shotcrete 1 … n
    - Underground sealing 1 … n

  - Phase 3: final lining

  - Phase 4 … n: monitoring
Digital Modell and Geologic Documentation

- Geological tool
  - Software for annotating geological features
  - Structural measurements
  - Lithology
  - Geotechnical parameters
Geologische Dokumentation

General

Mapped by
- Rauth
- Zanon

Tunnel Face Information

Length of section (m) [ ] Overlay (m) [ ]

Partial Section
- Top Heading
- Bench
- Invert

Validation of Design

Are encountered ground conditions covered in support selection criteria?
- Yes
- No

Additional support recommended in this mapping interval?
- Yes
- No

General Rock Description

General (e.g. weathered / not weathered)
dibit TIS

- **dibit TIS** – “Tunnel Information System”
  - TIS is a core component of the tunneling software “dibit”. In combination with the dibit viewer, tunnel data can be analyzed and visualized.
  - Recording and mapping of components (blocks, niches, etc.), installations (lamps, signs), damaged areas (cracks, spalling, ingress of water, etc.) and geological details (separation areas, fault zones, etc.)
- **Main features of dibit TIS**
  - Structured, spatio-thematic assignment and visualization of information
  - Overlapping of photorealistic tunnel images of different eras - temporal-spatial changes (4D)
  - Measurement of objects (such as cracks, damaged areas) using polylines
  - Determination of volume and profile content
  - Linking with further information (e.g. measurement images, inspection and restoration protocols)
  - Use of geophysical measurements (thermal data, multispectral data, etc.)
Composition of the 3D model
Rock surfaces
Rock surfaces
Rock surfaces – Profile Control
Rock surfaces – Profile control
Rock surfaces – Profile Control

- Orthophoto plot
- Area plot
Rock surfaces

- Geometric features
  - Outbreak depth
  - Outbreak volume
  - Profile control (relative to reference profile)
  - Shotcrete thickness
  - Optimisations / internal controls
  - Work preparations (concrete quantities, etc.)
Rock surfaces

- Geological documentation
  - Calculation of orientations (dip and strike)
  - Tectonic / rock-mechanical characteristics
  - Lithology
  - Water ingress
  - Outbreaks
Rock surfaces

- Geological documentation
  - Extrapolation of analysis results
  - Predictions for parallel tunnel excavations
Rock surfaces

- Geological documentation of exposed tunnel wall during TBM excavation
Implementation in a BIM
Shotcrete & underground sealing

- Profile control of shotcrete
- Shotcrete thickness and quantity
- Profile and planarity control
Shotcrete & underground sealing

- Profile plot shotcrete
- False-color area plot of shotcrete thickness
Shotcrete & underground sealing

- Schematic diagram
- False-color area plot of planarity
Final lining

- Correlation of damages with geological characteristics or construction defects
Summary

- Robust hardware
- Simple application
- Fast recording
- High precision
- High resolution

- Fast in-situ documentation
- Standardised documentation

- Processing of 3D models
- Analysis of structures
- Export to common software
- Handling of other recording systems
  - and data formats
  - (Laser, Photogrammetry, LAS ...)

- BIM
- CAD
- GIS
- Statistical analyses
- ... and much more...

- Handheld scanner
- Geological tool
- dibit software
- Interfaces
Conclusion

- Fast, easy and robust system for 3D recording
- Precise 3D measurements: objective, reproducible results
- Temporal decoupling of the analyses from the construction process
- Statistical evaluation of structural data
- Calculation of volume (control, billing)
- Interface / export to common CAD, GIS and BIM software
- Economical system
- Valuable information for the construction and subsequent maintenance of tunnel structures