3D Tunnel Inspection with Photogrammetric and Hybrid Systems

Michael Mett  
*Dibit Messtechnik GmbH*

Heiner Kontrus  
*Dibit Messtechnik GmbH*, heiner.kontrus@dibit.at

Nina Müller  
*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/10](https://dc.engconfintl.org/shotcrete_xiv/10)

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.
3D tunnel inspection with photogrammetric and hybrid systems

Dibit measuring technique

Dr. Michael Mett (Head of Research and Development)
Dipl.-Ing. Heiner Kontrus (CEO)

November 19th 2019
Content

- Dibit introduction
- 3D tunnel scanning - overview
- Conventional tunnel inspection
- Requirement for modern inspections
- Dibit highspeed scanning system
- Operation of the highspeed system
- Results
- Outlook
Dibit Introduction

- Established: 2001
- Office Locations: Innsbruck, Austria (Headquarter) and in Bellevue (Seattle), USA
- Employees: Around 50 survey engineers, geologists and technicians
- Services: Tunnel surveying, monitoring and 3D scanning
- Projects: More than 300 tunnel projects in Europe, North-America, Australia, Africa and Asia
- Scanning experiences: More than 1000 miles of tunnel scanned world wide
3D tunnel scanning - overview

- Sustainable and objective documentation of tunnel conditions
- True color, high resolution 3D model of the tunnel surface (independent of scanning system)
- Tunnel scans for as-built documentation, inspections and during construction (shotcrete applications)
- Local or global coordinate system for referenced 3D model
- Detection, measurement and mapping of any defects and tunnel components (electrical, geotechnical, geological)
- Data management in TIS (Tunnel Information System)
  - Centralized, structured database for various construction epochs or inspection intervals
- Comparable results due to open data format (LAS, OBJ, ASCII, BIM)
Conventional tunnel inspection

- Manual crack detection
  - No exact determination of crack location
  - Impossible to map all cracks and defects

- Disadvantages
  - Time consuming (multiple days or weeks)
  - Long tunnel shut downs
  - High personnel expenditures
  - Supporting equipment e.g. manlift
State-of-the-art 3D tunnel scan

- “Stop & Go” system
  - Recording speed: up to 200 – 300 m/h
  - Hybrid system (laser scanner + camera)
  - Precision: up to 5 mm
  - 1 x 1 mm resolution
State-of-the-art 3D tunnel scan

- Dynamic system
  - Recording speed: up to 4 km/h (2.5 miles/h)
  - Hybrid system (laser scanner + cameras)
  - Precision: up to 10 mm
  - 1 x 1 mm resolution
Requirements for modern inspections

- Fast data acquisition
  - Minimized shut down times
  - Minor traffic obstructions
- Objective and reasonable data
- Minimized personnel expenses
- Economic measurement system
- Short inspection intervals (e.g. every 6 months instead of every 6 years)
- Development of the new dibit High Speed Scanning System
Dibit highspeed scanning system

- Highspeed industrial cameras
  - Cameras: > 30 (frames per second) triggering

- Special design of high performance LED technology

- 360° scanning area

- Technical data:
  - Precision: up to 10 mm
  - Recording efficiency: up to 80 km/h (50 miles/h)
  - Resolution: 1 x 1 mm (1/25 inch)

- Modular construction (camera, laser-scanner, additional sensors (thermal, multispectral..))

- Patenting procedure is pending
Dibit highspeed scanning system
Operation of the highspeed system

- Measurement system can be mounted on various vehicles
Operation of the highspeed system

- Up to 30 frames per second for each camera (300 fps in total)
Operation of the highspeed system
Results 1: General features

- True color photo textures
- **Sub-millimeter resolution on the surface** (cracks smaller than 0.3 mm visible)
- Measurement accuracy ± 10 mm
- **Objective analyses of tunnel features in a virtual environment**
  - Decoupled from the site
  - Manual categorization of damage (cracks, flaking, etc.)
  - Localization (Local, respectively global (georeferenced) 3D tunnel data)
  - Extent (3D-poly lines; length), Area, Clearance profile
  - Deformation
3D model with true colour photo texture
Results 2: Analyses

- Processing and analysis of 3D data in “Dibit” software
  - Photogrammetric 3D reconstruction of the tunnel
  - Texturing of existing 3D tunnel models
  - Analyses of tunnel features
- Quantification of damages (cracks, etc.) and inventory of tunnel components
- Semi-automated crack capturing
- Change detection
Inventory of tunnel components
Semi-automated crack capturing
Damage monitoring
Change detection
Results 3: Data management

- Comparable results due to open data format (LAS, OBJ, ASCII)
- Data management in TIS (Tunnel Information System):
  - Centralized, structured database for various construction epochs, inspection intervals, etc.
- Compatibility with BIM software (Building Information Modelling)
- Automated generation of reports and plots

- Compliance with safety standards due to periodically monitoring of tunnel constructions
TIS database (Tunnel Information System)

- Crack uncritical
- Crack critical
- Influx
- Spalling
- Block joint
- Structured database
  - (TIS: Tunnel Information System)
- Measurements
Compatibility with BIM Software
Damage report

Follow up Inspection 2011

Inspection Photo 2001

Comments
Crack in Crown

Scanner Inspection 2001

Scanner Inspection 2011

Condition Analysis Inspector:

RF_B/GL1_2001-0004

Deficiency Name

SymID
TDwDB/EPaPP/EHST

Position ID
65585, 5550, 5547, 0080, 01, 3570

Station/GLR:
117.45-74, 3.45-74, -0.55-77

Length
11.0777

Surfcast Area
0.0000

SRR - Length
0.0000

SRR - Width
0.0000

SRR - Surface Area
0.2380

SRR - Circumference
3.2380

SRR - Rotation
0.0000

Width
0.4000

Depth
0.0000

Degree of Leakage
Damp

Condition
Heavy

Identified
0

Inspection

Inspection Date
30051001

Comments
Crack on Wall

Condition Analysis Inspector:

Tunnel Information System

created: 16.07.2013, Page 11 of 21
Outlook

- Fully automated detection of defects, e.g. cracks (self-learning algorithms)
- Statistical analysis of tunnel parameters over time – 4D (occurrence, categorization)
- Implementation of multi / hyperspectral sensors (thermal properties, recognition of materials)
- Interface between TIS (Tunnel Information System) and BIM (Building Information Modeling)
Thank you for your attention