ORTHOS
Laser Tunnel Scanner

HIGHLIGHTS

- 3-dimensional digital object registration (geometry and image) using a laser scanner in the 1-200 m measuring range
- Fast, simple and complete survey, independent of lighting or surface characteristics
- Combination with digital colour-camera allows several visualisations and analyses
- Survey time approx. 5 min. per 10 metre of tunnel (grid size 1 x 1 cm)
- Clear graphical and tabular display of results and analyses

Field of Application

The GEODATA tunnel scanner is a high-precision measurement and analysis system for complete and efficient documentation (geometry and image) of tunnels, galleries, caverns and shafts in all construction phases and during its entire life, e.g. as the basis for refurbishment or reconstruction.

It is, however, also excellently suited for 3-dimensional surveys of structures above ground such as pre-cuts, cut-and-cover tunnels, landfills and buildings and for determination of the geometries of building parts (e.g. nichess, etc.)

The ORTHOS laser tunnel scanner has advantages and potential applications of interest to builders and construction companies, including significant cost savings:

- Improved quality with respect to the accuracy of the contour of the excavated profile, the thickness of the shotcrete, etc.
- Control and optimisation of the construction activities (excavation, producing the shotcrete shell, etc.)
- Control and optimisation of the over-sizes to be adhered to
- Survey of the geologically caused over-excavation
System description

3D Laser scanning systems revolutionise the potentials for surveying, visualising and modelling tunnel surfaces and other objects. The ORTHOS laser tunnel scanner now allows surveying with a hitherto unequalled combination of accuracy, speed and completeness. In the course of this measurement, the tunnel surface is scanned by laser pulses in a dense grid pattern, in polar coordinates. Only a few minutes are required for the survey. The result is available immediately after the survey in the form of three-dimensional Cartesian coordinates and intensities for the pictorial representation. Thanks to positioning through free stationing (incl. accuracy specification), it is possible to perform quality control of the survey on site.

After the measurements, the data are transferred to a specially configured database and are available for a variety of analyses.

Possibilities for Analysis and Presentation

The DEDALOS software is used for the control, analysis and presentation of the tunnel scanner records.

Main functions:

- Input, managing and archiving of the project and measurement data and the results; interfaces to other programs
- Control of the measurement process, with online quality control
- Generation of a digital, three-dimensional surface model
- Documentation of the heading via an intensity image of the tunnel intrados (comparable to a grey-scale picture)
- Development of the tunnel intrados and representation of the radial placement as colour-coded iso-line plots (tunnel tape) with respect to different reference lines, or as 3-D model
- Creation of cross sections with indication of over- and under-profiles

Advanced features are available to achieve the pinpoint accuracy
Graphical comparison and calculation of the differential volumes in the profiles of two construction phases (computation of the concrete cubature)

Graphical and tabulated presentation of the results

Interface for data export and import for the EUPALINOS tunnel surveying software

Optimisation of concrete for the inner lining in accordance with project-specific requirements (cost saving “concrete”) – special solutions

In case of inventory documentation with digital camera:

- Geo-referenced inventory documentation with photo
- Export in CAD-format
- Definition of all possible installations prior to inventory survey (with individual labelling)
- Semi-automatic recognition of recurrent patterns (e.g. ceiling lamps, ventilators etc.)
- Simple referencing and recovering of the installations of the project
- Completion of installations with individual annotation text

Procedure

The RIEGL LMS-Z390i laser scanner rotates steadily around its longitudinal axis during the measurement. A rotating mirror simultaneously deflects a laser beam through 90° cone angles. If the scanner is mounted vertically, it is therefore possible to do 360° panoramic surveys (e.g. for landfill surveys).

For special tasks such as surveying the tunnel intrados, the measurements are carried out lying flat, i.e. the longitudinal axis is approximately horizontal and orthogonal to (positioning scan) and, in the second step, parallel to (intrados scan) the tunnel axis. The survey is based on the free stationing principle without external ancillary devices, i.e. all the data necessary for the analysis of the measurements are captured by the scanner. For capturing the reference points, retro-reflective targets (Bireflex targets), mounted on convergence bolts, are utilised. No special lighting is required. About 10 m of the tunnel intrados is captured in the course of the survey of a typical excavation profile (~ 80 m²). The grid size can be configured as required, starting from 1 x 1 cm upwards.

The ORTHOS laser tunnel scanner can be comfortably operated by one person, mounted on various platforms as required (e.g. tripod, transport trolley, measuring vehicle). A special instrument rack was developed for this purpose. The ORTHOS Scan survey software vir-

![Profil plot (cross section)](image)

![Inventory documentation with digital camera](image)

![Principle sketch of the scanning of the intrados](image)

![Automatic reference point identification and target detection](image)
tually automatically controls the measuring process and in general does not require project-specific entries such as stationing, point numbers or similar, on site. The time required for a survey is about 5 minutes. Apart from the tunnel intrados, the working face can also be surveyed using this system.

The results of the measurements are available immediately following the survey, in the form of 3D coordinates in the actual project coordinate system and also data on the quality of the survey, such as the accuracy of the location data. All further analyses and data archiving are carried out after the measurements, on a PC in the office.

The above described procedure is visualised in our animation video ORTHOS!

For inventory surveys with camera a system with integrated totalstation is used. The position measurement is done to prism-targets with automatic recognition and allocation of point-numbers according to the principle of free stationing. The measurement, the surface scan and the photos are done synchronised. All system components are calibrated to each other.

System components

- Riegl Laserscanner LMS - Z390i
- Geodata Instrument Mounting
- Tripod or measuring carriage
- Mobile control computer
- Power supply unit
- Control-, evaluation- and analysis software DEDALOS

For the work in the office (project setup, analysis, result output, data archiving, etc.) an appropriate PC working environment under Windows 2000 or higher is required.

Spezifications Laser Scanner RIEGL LMS - Z390i
(www.riegl.co.at)
- Measuring rate: up to 11,000 points/sec.
- Scan range: 80° x 360°
- Measuring range: 2 to 400 m
- Angular resolution: 0.001°
- Repeat accuracy: 2 mm (average)
- Temperature range: -10°C to +50°C
- Sealing class: IP 64
- Eye safety: Laser class 1
Alternative the lasercanner Z420i can be used.

Complementary system components

Digital camera Nikon D200

Resolution: 10.2 megapixel, 5.8mm by 10m exposure distance
Contrast: 4096 values per channel, 36 bit in colour
Lens: 14mm

Metz Meca-flash 76 MZ-5 digital

Motor zoom: 24-105mm
Wide angle diffusion disc: 20mm
Steps for partial light output: 25
Measuring angle of photo-sensor: 25°

Totalstation Leica 1202 TCRP or similar

The following other data sheets are associated with this data sheet:

Services: Inventory Surveying
           Profile checks
Software: DEDALOS
Visualisation Examples

Scanner evaluation example (cross section)

Cross section shotcrete thickness
Visualisation Examples

Scanner evaluation example (cross section)

Scanner evaluation example (tunnel band)
Visualisation Examples

Contour plot shotcrete thickness

Scanner evaluation example (evenness of shotcrete)
Visualisation Examples

Bestandsdokumentation mit Digitalkamera