SmartMeasures

Tough projects call for smart measures.

Project

- **Name:** ZhangJihuai High Speed Railway Project
- **Total length:** 246 km (91.3% of which are tunnels and bridges)
- **Longest tunnel:** 12 km (double track)
- **Excavation method:** Drill and blast
- **Cross section size:** Up to 120 m²
- **Contractor:** China Railway Tunnel Group
- **Investment:** 38.24 billion Chinese Yuan / 4.9 billion EURO

Duration

- 2016 - 2021

Tasks

- Profile measurement
- Quantity statistics of concrete
- Concrete lining thickness inspection
- Image of tunnel surface
- 3D tunnel navigation based on scan point cloud

Using Amberg Tunnel to optimise Tunnel Surveying in China's ZhangJiHuai High Speed Railway Project

The ZhangJiHuai High-Speed Railway Line includes 168 bridges and 124 tunnels, accounting for over ninety-one percent of the entire railway line. Located in Hunan province, the railway line passes through spectacular landscapes and complex geological conditions. In such regions, environmental protection is a top priority for any construction project. Amberg Tunnel was first deployed in the construction of the Jishou Tunnel, one of the first tunnels constructed on the project. Owing to the clear value provided by Amberg Tunnel in the Jishou Tunnel, the construction team swiftly deployed the solution project-wide.

Concerning both contractor and project owner, building a tunnel to within specified construction tolerances is of fundamental importance in terms of project handover acceptance, construction quality, and cost control. With zero under-break acceptance criteria on the fast-moving ZhangJiHua construction project, a complete and streamlined tunnelling survey solution was critically important to ensure the project was being built according to the design intent.

Field Data Acquisition

3D laser scanners are the perfect tool for capturing 3D geometry of the various stages of a tunnel under construction. Amberg Tunnel supports advanced point cloud editing and tunnel-specific data analysis such as shotcrete thickness, surface smoothness, measured vs measured profiles, and measured vs design profiles.

AMBERG TECHNOLOGIES

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Challenges

- "Zero under-break" requirement
- Strict environmental protection and conservation requirements

Products Used

- Amberg Tunnel
- Faro X330 Scanner

On this project, laser scanners were used to capture 3D geometry in the tunnel. Once captured, the scans were imported into Amberg Tunnel and analysed based on the project requirements.

Prediction Analysis of Initial Shotcrete Quantity

One such analysis used in the project was to measure and estimate the required quantity of shotcrete for stabilising the tunnel excavation. This was achieved in Amberg Tunnel by defining an analysis where the measured profiles were automatically extracted from the point cloud data and compared to the relevant theoretical design, yielding shotcrete volumes at specified intervals. Table 1 shows the volume statistics of a selected ten metre section of tunnel. The column shown with a red border shows the estimated quantity of shotcrete for each 0.2 metre interval. Depending on the user requirements, the analysis can be easily configured to produce estimates of higher or lower precision.

Range			Volume			
Start heading stationing [m]	End heading stationing [m]	Description	HS diff [m]	Reference [m³]	Overprofile [m³]	Underprofile [m³]
115,710.000	115,710.200		0.200	22.603	3.016	0.000
115,710.200	115,710.400		0.200	22.603	3.016	0.000
115,710.400	115,710.600		0.200	22.603	3.095	0.000
115,710.600	115,710.800		0.200	22.603	3.173	0.000
115,710.800	115,711.000		0.200	22.603	3.173	0.000
115,711.000	115,711.200		0.200	22.603	3.173	0.000
115,711.200	115,711.400		0.200	22.603	3.173	0.000
115,711.400	115,711.600		0.200	22.603	3.127	0.000
115,711.600	115,711.800		0.200	22.603	3.081	0.000
115,711.800	115,712.000		0.200	22.603	3.081	0.000
115,719.000	115,719.200		0.200	22.603	1.850	0.166
115,719.200	115,719.400		0.200	22.603	1.850	0.166
115,719.400	115,719.600		0.200	22.603	0.932	4.595
115,719.600	115,719.800		0.200	22.603	0.014	9.024
115,719.800	115,720.000		0.200	22.603	0.014	9.024
Result			10.000	1,130.131	143.642	23.388

Table 1: Calculated vs. actual usage of concrete

Tunnel Point Cloud Navigation

In addition to Amberg Tunnel office software is Amberg Navigator tablet software, a user-friendly tunnel application for measuring, navigating, and evaluating survey results directly in the tunnel. The comprehensive tablet software has over thirty tunnelling-specific measurement and navigation tasks. One such task used on the project was the Critical Areas task. This task allows the tunnelling crew to navigate to and pinpoint specific areas of interest based on analysis results from Amberg Tunnel Office Software. Figure 1 shows the Critical Area task in use in Amberg Navigator Tablet Software. The red regions in the graphical view show insufficient areas of shotcrete thickness. By tapping on the red regions, Amberg Navigator will control and orientate the connected total station to the corresponding point on the tunnel wall using the instrument's red laser pointer.
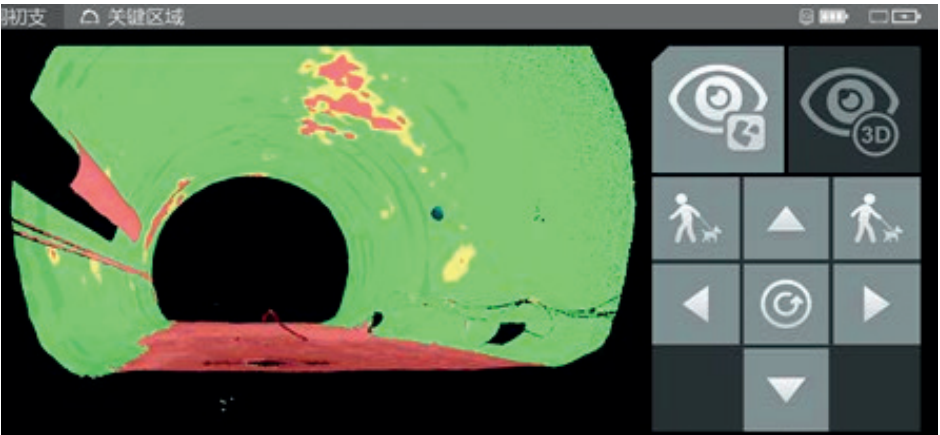

Figure 1: Tunnel critical area by "Amberg Navigator" software

Conclusion

3D laser scanning is fast becoming the standard for measuring, evaluating, and documenting 3D geometry in the tunnel. Amberg Tunnel Office Software can easily consume both high fidelity and high accuracy scans and produce meaningful and valuable deliverables for both construction contractor and project owner. By using Amberg Tunnel together with Amberg Navigator Tablet Software, a complete two-way data loop cycle in formed, from tunnel to office, and from office to tunnel.

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