

Industry: Mining Construction

Task: Tunnel Lining Mould & Segment Inspection

Measurement systems: 3D Laser Tracker, PCMM (Arm), & Industrial Total Station) with metrology software SpatialAnalyzer (SA).

Tunnel linings are made out of large size (trapezoidal or rhomboidal) precast concrete segments that are required to fit together correctly and easily (good ring build & shape) for good load transfer and watertight properties (operational performance). These precast segmental linings are usually associated with Tunnel Boring Machine (TBM) tunnelling and designed to provide a smooth bore in rail transport, water pipeline, electricity and other utility tunnels.



ADS provides **Dimensional Metrology Services** for the various Stages of tunnel lining production, transport, installation and tunnel operation that require quality control to verify compliance to design within relevant tolerances.

These Stages each contribute to the overall specified Tolerances

1. Mould Fabrication

- a. **Mould inspection** is usually carried out on-site at the Manufacturer's factory or workshop to verify compliance to design.
- b. Mould inspection may also be carried out at the segment casting plant on delivery or after a period of production to monitor its operational integrity and to provide maintenance management options.



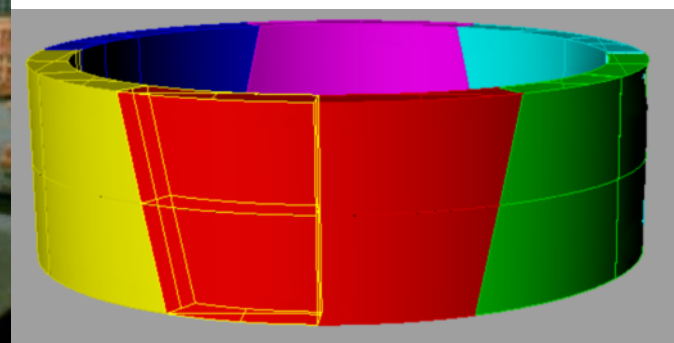
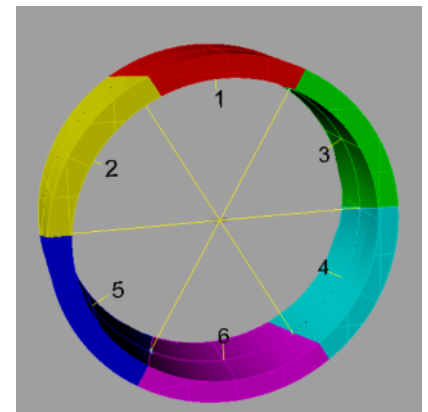
2. During and after Segment Production, segment geometry is affected by deformation due to temperature and shrinkage from the production procedures, and subsequently from temperature, shrinkage and dead weight during storage, transport, and final tunnel lining installation and operation. Segment geometry needs to be verified and monitored efficiently to ensure compliance at critical stages.

a. **Segment Inspection** is initially required for each Segment making up the segmental lining ring. This is then followed by sample batch checks at regular intervals during production and just prior to installation.

i. The most appropriate portable technology for large segments and initial stages is the 3D Laser Tracker and for subsequent checks the PCMM (Arm) for smaller segments or the Industrial Total Station for batch checks of critical dimensions and geometry.

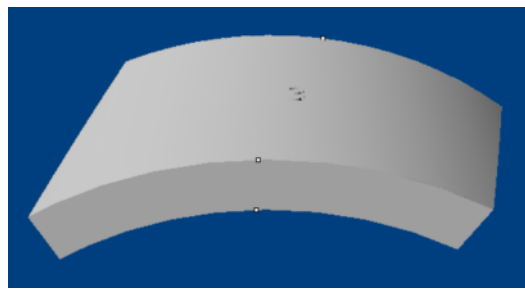
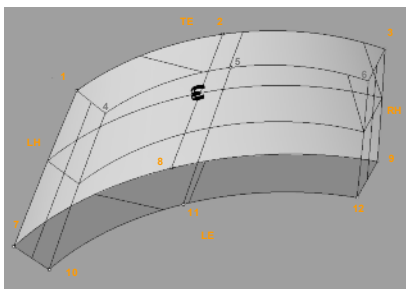


b. The **assembled segments**, as a short pipe (in this case sitting horizontally), can be measured in a single 3D coordinate system and then analysed for geometrical dimensions and fitting of segments into segmental lining rings (internal and external diameters, dimensions, deviations, and concentricities etc).

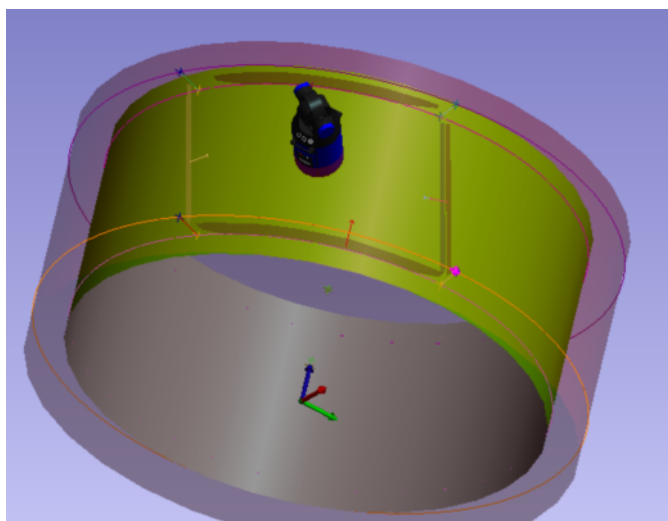


Standard Mould Inspection Method Statement:

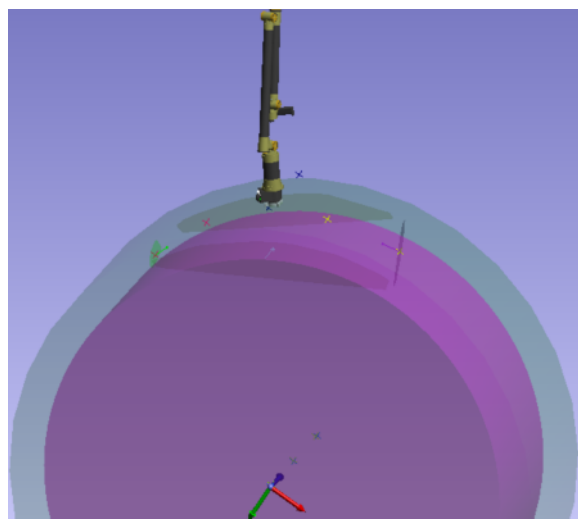
1. Mould data acquisition is made with a 3D Laser Tracker Measurement System. These systems have Calibration certification with Traceability to international standards.
2. Each mould is verified by measuring the relevant geometric shapes of its whole makeup by scanning or individual point measurement on the surfaces.
3. Analysis of the standard geometric shapes of these surfaces and their relationships to each other provides the derived dimensions, angles and positional information required for verification (Joint Face flatness, warping, angles; segment dimensions) [All data is scaled to standardized temperature].
4. Verification is the data evaluation by comparison with design (nominal or CAD model) values and relevant tolerances. Tabulated Deviations (the differences between Actual and Nominal data) are provided with checks for compliance with these tolerances. Shape deviations can also be provided as graphical output such as coloured deviation vectors from best fit or nominal geometric surfaces. The deviations can also be compared directly to the 3D CAD model imported into SA.
5. A network of reference targets provides precise control of the 3D coordinate system for each mould and the estimated uncertainty of all points (Internal quality criteria concerned with error propagation) and the stability of the instrument relative to the mould.



The assembled segments as a short pipe (in this case sitting horizontally) can be measured in a single 3D coordinate system and then analysed similarly (internal and external diameters, dimensions and deviations, concentricities etc).



3D Laser Tracker for large Mould and Segment Inspection



PCMM (Arm) for smaller Mould and Segment Inspection