Recent Advances of Engineering Survey Operations for Tunnel Construction in Hong Kong

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Topics:

1. Engineering survey operations for tunnel construction
2. Geodetic control and deformation monitoring
3. Topographic mapping and geometric modeling
4. Setting-out and as-built surveys
5. TQM under ISO 9001
6. Conclusions
7. Q & A
1. Engineering survey operations

- Geodetic Control Networks
  - 2D + 1D
- Total Quality Management
  - Standards, Specifications, Contracts
  - SQP, ITP, WI, QC Records
- Detail Mapping
  - Digital Terrain Models
  - Digital Strata Models
  - GIS for Construction
- Geometric Modelling
  - Alignment Design
  - Cogo Computations
- Deformation Monitoring of Infrastructures
  - Ground Displacement
- As-built Surveys
  - Alignments, Profiles, Geometric Tolerances
  - Material Quantities
- Setting-out
  - 3D Models; Formwork
  - Laser Guidance System
  - Drill & Blast Machines
  - TBM

2. Geodetic control and deformation monitoring

- **Horizontal control** by a combined network of triangulation, trilateration, traverse and GPS
- **Vertical control** by geodetic leveling, and by GPS heighting w.r.t. local geometric geoid
- **Structural Health Monitoring (SHM)** by a combined geodetic and geotechnical model.
- From measured displacements and vibration, stiffness of structural element is determined by reverse engineering analysis
- Rely more on geodetic data because it is difficult to re-calibrate geotechnical instruments after installation
- Use of **airborne InSAR** in monitoring apron areas is highly cost-effective
3. Topographic mapping and geometric modeling

- Details on ground surface and underground are mapped according to ISO 19100 into GIS/CAD for project planning/appraisal, engineering design, geometric modeling and construction.
- GIS data: lot boundaries, buildings, roads, utilities, topography, street directory maps, borehole records, geological maps, rainfall records, ground water conditions, etc.
- Mobile Mapping System integrates data from GPS receiver, IMU, laser scanners and digital camera which can be mounted on trucks, hydro vessels or aircrafts.

4. Setting-out and as-built surveys

- Setting-out of TBM, Drill & Blast Machine, laser guidance system, precast liners and slipform by auto-tracking total station.
- As-built surveys by:
  1. Reflector-less total station, profiler software (e.g., Leica/Amberg’s TMS)
  2. Mobile Mapping System, (e.g., Swiss Trolley of Terra International), equipped with inclinometers, track gauge, odometer, reflector, GPS receiver, LIDAR scanners, digital camera and data collector
  3. LIDAR/imagery scanner, needs tunnel software (e.g., Optech’s ILRIS-3D, Topcon’s Imaging System)
Low-cost profiler from second-hand electronic theodolite, distometer, PC

MSc Geomatronic Project

5. TQM under ISO 9001

- Reported in:
- Proceedings, FIG Congress 2010, Sydney, Australia, 11-16 April, 2010
6. Conclusions

- Recent advances of tunnel surveying in Hong Kong include:
  - Combined geodetic and geotechnical approach in SHM
  - Use of mobile mapping system in detail surveying and mapping
  - GIS for construction
  - New models of auto-tracking total station for setting-out tunnel liners and tunneling machines
  - New models of reflector-less total station, tunnel software, survey trolley and LIDAR scanner for as-built surveys
  - TQM of the survey operations under ISO 9001 (2008)

7. Questions & Answers

Thank you.