Advanced approaches for total station-based deformation monitoring

Wednesday, 09.04.2025, 12:45 - 14:15, Room Haller

L. García-Asenjo, R. Luján, S. Baselga

Mitigation of the refraction error in surveying techniques by using a network of meteorological sensors and a 3D refractivity model

Different geomatic techniques and instruments can be used for deformation monitoring from a nearby control network, including electro-optical distance meters (EDM), terrestrial laser scanners (TLS), total stations (TS), and Global Navigation Satellite Systems (GNSS). However, atmospheric refraction can largely diminish the attainable accuracy of angle and distance measurements especially in long ranges, that is, those from few hundred meters to several kilometers, thus hampering the proper integration of the measurements into a highaccuracy reference frame and the subsequent reliable determination of possible displacements. This work describes the approach used in a long-term deformation monitoring project in Cortes de Pall´as (Spain), where a network of meteorological sensors was deployed in selected points and subsequently used to build a 3D refractivity model. The consistency of the model is verified by using a robotic TS and well-known coordinates, and then applied to long-range TLS data. The results show that a few meteorological sensors well distributed in selected points of the area can mitigate the refraction error better than the traditional approach based on only measuring the meteorological parameters at the station and, when it is feasible, at the target point.

Keywords: Atmospheric refraction, EDM, TS, TLS, meteorological sensors

---

A. Knöpfler

Deformation measurements on emergency sites

In the early 2000s, deformation measurement systems were successfully tested to get reliable information about the stability of damaged structures on emergency sites. Actually, about 50 teams of THW (Federal Agency for Technical Relief) all over Germany are equipped with a tachymeter-based monitoring system in order to provide valuable information for specially trained structural engineers and decision-makers. Until now, hundreds of different emergency sites like dams, buildings after explosions or collapses,

instable cranes or landslides have successfully been observed by honorary teams. With the information about the actual stability of e.g. walls or rooftops, assessment of the safety of personnel, working in the danger zone, can be performed more precisely. Even changes in the situation can be monitored very fast and evacuation can be done quickly. This paper deals with different examples of emergency sites, the challenges for the teams and the experience of more than ten years of using this Emergency Site Safety System.

Keywords: Emergency site, THW, honorary work

F. Schulte, L. Schneider, M. Lösler, S. Printz, D. Czerwonka-Schröder

Automatic geodetic monitoring with total stations based on open source software library JAG3D – Case study of a rockfall in Trier/Germany

This paper presents an advanced methodology for automatic geodetic monitoring using total stations, employing the open-source software library JAG3D. As part of the BMBF-funded AImon5.0 research project, an extensive installation of geodetic measuring systems was set up in Trier (Germany). In addition to a permanent laser scanner, GNSS, inclination sensors and numerous meteorological sensors, a total station has been installed, whose data acquisition and evaluation has been further developed as part of an automated pipeline based on open data interfaces and open-access analytical software. Our approach demonstrates the practical application of JAG3D in geodetic monitoring by detailing the system's setup, data acquisition processes, and analysis procedures. The results underline the software's capability to handle large datasets and provide accurate deformation measurements. This automated system enhances efficiency and reliability, allowing for timely responses to geological hazards. In the Trier case study, the system successfully detected hourly displacement magnitudes in the rock formation, which were critical for early warning and mitigation strategies. This paper examines the challenges encountered, including environmental influences and complexities in automation, and discusses the approaches taken to address them. The findings highlight the potential of open-source solutions in geodetic monitoring, promoting wider accessibility and adoption in various geotechnical applications.

Keywords: Deformation analysis, Monitoring, Total station, JAG3D

J. Zaczek-Peplinska, M. E. Kowalska

Principles and Case Study of IMSGeo: Automatic Displacement Monitoring System for Construction Sites

Displacement monitoring is a crucial aspect of the construction process, spanning all its stages. Surveying the changes occurring in the structure and its surroundings according to a suitable schedule is fundamental to ensuring work safety and mitigating investment risks. In this article, we highlight the distinctive features of the IMSGeo system, developed jointly by GEOalpin Ltd. and the Warsaw University of Technology (Department of Engineering Geodesy and Measuring Systems). The innovative solutions proposed in the system are characterized by the following integrated features:

- utilization of advanced adjustment algorithms within a cohesive system,
- adjustment of a multi-station network,
- analysis of reference system stability as an integral component of each measurement epoch,
- reflectless measurement of surfaces and structural elements of objects, presented as a unified 2D or 3D entity,
- capability to position measuring instruments (motorized/robotic total station) without the need for additional monitoring devices to ensure station stability,
- implementation of a fully mobile WEB platform for the presentation, interpretation, comprehensive analysis, and archiving of geodata,
- use of Internet cloud computing for data collection, analysis, presentation, and distribution of monitoring results, ensuring independence from local server infrastructure,
- user platform functionality designed based on survey research conducted among investors, contractors, inspectors, building supervision representatives, and property managers.

The IMSGeo system does not require additional capital investments in infrastructure from investors or contractors and is highly available and scalable. The practical section of the article introduces the IMSGeo system's WEB platform and its implementation on a selected site in Warsaw, Poland.

Keywords: Structural health monitoring, Geodetic displacement monitoring, Geodetic services for investments, Construction site safety, Engineering geodesy.