Robust M-Estimation in Analysis of Control Network Deformations: Classical and New Method

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Abstract: Robust M-estimation is very useful in the geometric deformation analysis of geodetic control networks, especially in the analysis of single-point displacements in these networks. In fact, a robust M-estimation allows one to identify the datum that resists individual displaced points. This paper describes and tests two competing methods for displacement analysis based on robust M-estimation. Both methods accept relative and absolute control networks. The first method is the classical robust method, in which the displacement vector is determined from differences in adjusted coordinates. The second method is a new and alternative robust method, in which the displacement vector is determined from differences in unadjusted observations. The proposed method was conventionally called Generalized Robust Estimation of Deformation from Observation Differences. Classical and proposed robust methods were tested on the basis of the simulated two-epoch observations of the absolute control network of the Montsalvens Dam in Switzerland (which is well known in the literature) and on the basis of Monte Carlo simulations. The test results showed that the proposed robust method, in some cases, might be more efficacious than the classical robust method, especially when low values of displacements that slightly exceed measurement errors are expected. Moreover, this paper showed that the proposed robust method might also be more broadly applied than the classical robust method. **DOI: 10.1061/(ASCE)SU.1943-5428.0000144.**

Author keywords: Monitoring; Displacements; Robust estimation; Monte Carlo simulation; Robust estimation of deformation from observation differences (REDOD).

Dynamic Deflections of a Stiff Footbridge Using 100-Hz GNSS and Accelerometer Data

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Abstract: The authors investigated the possibility of expanding the application of global navigation satellite systems (GNSS) into the monitoring of stiff civil-engineering structures from the current limit of dominant frequencies of 3–4 Hz to a new limit of 6–7 Hz. On the basis of experience from previous supervised learning experiments, the authors analyzed 100-Hz GNSS data collected with an optimal phase-locked loop and collocated accelerometer data, both describing the attenuation of forced excitations of a timber pedestrian bridge. Computed vertical apparent deflections were masked by noise, but it was still possible to accurately identify the natural frequency of the bridge, equal to 6.5 Hz, and weak fusion with accelerometer data led to accurate oscillation waveforms. The quality of the latter was assessed by structural constraints and by comparison of waveforms of acceleration and of damping ratios derived from GNSS and from accelerometers. These results made it possible to (1) assess the quality of 100-Hz data in monitoring real structures, (2) propose methods for deriving highly dynamic deflections on the order of a few millimeters, and (3) expand the application of GNSS into the measurement of three-dimensional dynamic deflections of stiffer structures, i.e., with natural frequencies of up to 6–7 Hz and vertical deflections of a few millimeters only—an important contribution to structural-health monitoring and structural identification. **DOI: 10.1061/(ASCE)SU.1943-5428.0000146.**

Author keywords: Global positioning systems; Timber bridge; Structural-Health monitoring; Displacement.

Case Study

Current Land Subsidence and Groundwater Level Changes in the Houston Metropolitan Area (2005–2012)

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Abstract: This article summarizes land subsidence and groundwater level changes that have occurred in the Houston metropolitan area during an eight-year period (2005–2012). The Chicot and Evangeline aquifers are the major aquifers that underlie the Houston metropolitan area. Subsidence measurements from 95 permanent global positioning system (GPS) stations and 11 borehole extensometers, as well as groundwater level measurements from 170 wells screened in the Chicot aquifer and 320 wells screened in the Evangeline aquifer, were investigated. The Evangeline aquifer is currently the primary source of municipal, agricultural, and industrial water for urban and rural areas in the western and northern regions of the Houston area. Global positioning system and extensometer observations indicate that the overall subsidence rate in the Houston area has been decreasing since 2005. This decrease is a result of groundwater withdrawal regulations enforced by the Harris–Galveston Subsidence District, the Fort Bend Subsidence District, and other local agencies. Currently, subsidence in downtown Houston and in the southeastern region of the Houston metropolitan area has nearly ceased (< 3 mm/year). Slight land rebound has been observed at several GPS and extensometer sites along the Houston Ship Channel area since 2005. However, subsidence is occurring at a rate as rapid as 2.5 cm/year in the western and northern regions of the Houston metropolitan area. This study indicates that the local preconsolidation heads, the groundwater levels of the Chicot and Evangeline aquifers before human pumping of groundwater began, were approximately 30–40 m below the land surface. Presently, the water level of the Chicot is close to the preconsolidation head throughout most parts of the Houston metropolitan area. However, the Evangeline water level is approximately 70 m below the preconsolidation head in the northern region and 50 m below the preconsolidation head in the western region. The land subsidence rate is decreasing in the areas where the water level is rising, but is still below the preconsolidation head. Some such areas include Addicks and Jersey Village. The rate of land subsidence is steady in the areas that groundwater head is declining and below the preconsolidation head, such as in The Woodlands area. It will take a long period of time (e.g., > 50 years) for the current groundwater level to rise to the preconsolidation level in the northern and western regions of the study area and for subsidence to cease. In general, groundwater and aquifer systems respond slowly to human actions. Therefore, a long-term perspective is needed to manage groundwater resources and control land subsidence. **DOI: 10.1061/(ASCE)SU.1943-5428.0000147.**

Author keywords: GPS; Houston; Subsidence; Precise point positioning; Single-receiver phase ambiguity.