THE USE OF MODERN TECHNOLOGIES FOR THE EXECUTION OF CIVIL AND INDUSTRIAL CONSTRUCTION WORKS

A. M. G. COSTINAŞ[1], M. HERBEI[1], A. ŞMULEAC[1]

[1] University of Life Sciences "King Mihai I" from Timisoara, 300645, 119, Calea Aradului, Timisoara, Romania

Coresponding author -mail: adrian_smuleac@usvt.ro

Abstract: *The civil and industrial construction works, which include the topographic survey of the land and the staking of the construction elements, were carried out using modern equipment to ensure the necessary precision. In the case of the civil construction, which consists of three buildings with a basement, ground floor, and four stories, the topographic surveys were performed with the help of a Trimble R8 GNSS GPS, which allowed obtaining precise measurements due to its compatibility with several GNSS networks (GPS, GLONASS, Galileo, BeiDou). The staking of the construction elements was carried out with a robotic total station Trimble S7, ensuring efficiency and precision. For determining the elevations and performing the leveling, a Leica Sprinter 250M digital level was used. For the industrial constructions, the topographic survey of the land was also performed with the GNSS Trimble R8 GPS, and the staking of the prefabricated elements was done with the same robotic total station Trimble S7. The Leica Sprinter 250M digital level was used for establishing the elevations. All elevations were referenced to the project's elevation 0, which is defined by a specific value, tied to the level of the Black Sea, thus providing a well- established reference point. The obtained data was processed and organized in AutoCAD for a clear and detailed representation of the works. The coordinate system used was Stereographic 1970, and the final data processing was done in AutoCAD to ensure an accurate result.*

Key words**:** *GNSS, Trimble R8, Trimble S7, Leica Sprinter 250M, AutoCAD, civil constructions, industrial constructions, Stereografic 1970*

INTRODUCTION

In recent decades, the field of surveying has seen a significant shift from the use of traditional equipment, such as theodolites and optical levels, to cutting-edge technologies. These incorporate GNSS (Global Navigation Satellite System) systems, robotic total stations, and digital levels, which greatly enhance the accuracy and efficiency of measurements. This transition has been essential to meet the increasingly complex demands of modern civil and industrial construction projects (KENNIE, 2014; PASCALAU ET AL., 2021).

The adoption of modern equipment, such as the Trimble R8 GPS, Trimble S7 robotic total station, and Leica Sprinter 250M digital level, has revolutionized the way on-site measurements are conducted, offering increased precision and operational flexibility.

Compared to traditional methods, these instruments enable quick data collection and simplify processes, optimizing every stage, from design to execution.

The Trimble R8 GPS is a high-precision GNSS receiver (Fig. 1.a), used for establishing geodetic reference points and performing high-accuracy measurements in various terrain conditions. This device is essential in surveying for obtaining precise data, crucial in construction and infrastructure (VU ET AL., 2023; ŞMULEAC ET AL., 2012, 2017).

The Trimble S7 robotic total station (Fig. 1.b) combines the advantages of traditional total stations with automated functionalities, enabling remote control and 3D measurements. It is ideal for stakeout and monitoring of sewer networks, roads, and other structures, where accuracy and efficiency are essential (COPLEY, 2019; CASIAN ET AL., 2019).

The Leica Sprinter 250M digital level (Fig. 1.c) is used for leveling and determining elevations, valued for its high accuracy and ease of use. Replacing the classic optical level, it allows rapid data recording and is useful in work requiring precise height measurements (SĂLĂGEAN ET AL., 2017; HERBEI ET AL., 2013, 2018).

Modern surveying equipment has been used on various civil and industrial construction sites in Timisoara, Arad, Barzava, and Oradea, contributing to the accurate and efficient data acquisition crucial to project success.

Fig. 1 a – R8 gnss survey, b – Trimble s7 total station, c – Leica sprinter 250m

MATERIALS AND METHODS

Each stage of the measurement process is essential for obtaining precise data and ensuring the correct execution of the project. Thus, civil and industrial construction sites are divided into three main stages (Fig. 2): the initial topographic survey, the creation of the geodetic network, and the stakeouts, along with as-built surveys.

- The initial topographic survey represents the first essential stage in the construction design process. This activity involves collecting land data using modern measuring equipment. The process includes identifying points of interest, measuring distances and angles, and documenting the geomorphological features of the area. This data forms the foundation for the subsequent design of the constructions, ensuring an accurate understanding of the terrain conditions (BOTNARU, 2024; Mita et al., 2020; Pascalau et al., 2020).
- The creation of the geodetic network is a crucial stage that involves establishing a system of precise reference points. These points are used to coordinate all subsequent measurements conducted on-site. The process includes determining the exact position of each point through advanced GNSS measurement techniques, thereby ensuring the integrity of the collected data and facilitating the accurate stakeout of the project on the terrain (Moldoveanu, 2004).
- Stakeouts involve marking the outlines and structural elements on the ground according to the design plans. This stage is essential for verifying the correct implementation of the project. As-built surveys are subsequently conducted to compare the completed structure with the initial plans, thus ensuring conformity and quality of the work performed. These final measurements are important for project documentation and any necessary adjustments (Bondrea et al., 2016).

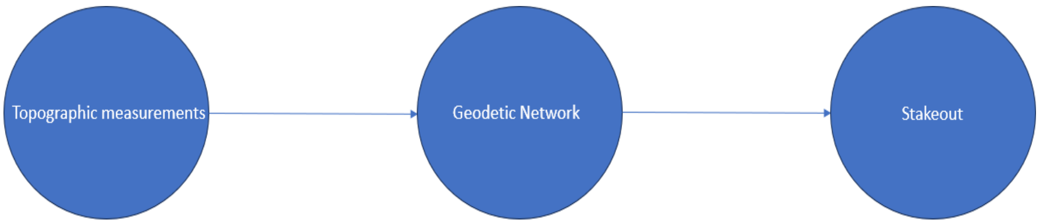

Fig. 2 Cronological steps of workflow in construction field

RESULTS AND DISCUSSIONS

For the execution of civil and industrial construction works, modern surveying technologies are essential to ensure the precision required in both design and implementation. Thus, the Trimble R8 GPS receiver was employed for the initial topographic survey and the establishment of control points for the geodetic network.

The first stage involved conducting the initial topographic survey (Fig. 3), which provided a detailed representation of the terrain. The collected data, including elevations and configurations, were essential for adapting the project to the actual conditions of the site.

Fig. 3 Topographic measurments overlaped with architect plan

Subsequently, four control benchmarks were established (Fig. 4) using the Trimble R8 receiver, configured in the Stereo 70 coordinate system. Measurements were performed with RTK (Real-Time Kinematic) corrections from ROMPOS fixed stations, achieving a precision of ±2 mm horizontally and ±3 mm in elevation by stationing for 15 minutes at each point and recording 900 observations.

The Trimble S7 robotic total station was essential for the precise and rapid stakeout of all the structural elements required for the project. Thanks to its advanced robotic functionalities, the Trimble S7 provided increased efficiency and reduced work time, while also offering high precision, which is crucial for the correct execution of civil and industrial constructions.

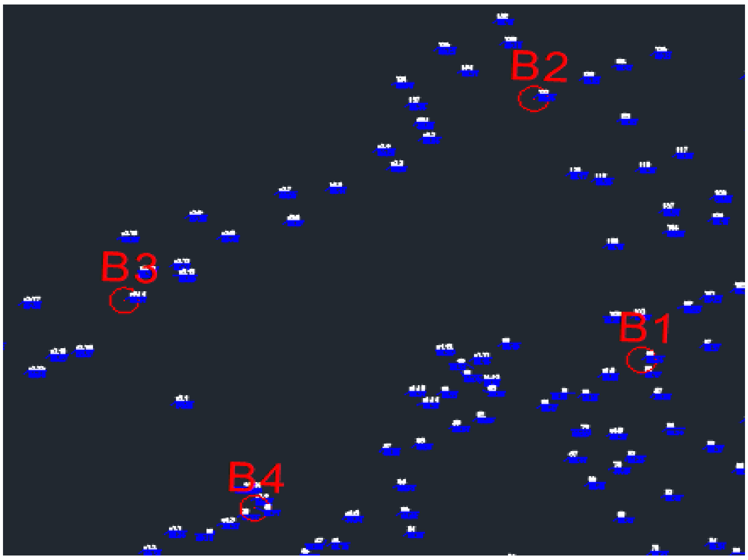

Fig. 4. GNSS determined points used for creating the geodesic network

To meet the complex requirements of the project, the total station was used in various stakeout modes, depending on the specifics of each element. Among these were:

Point Stakeout**:** The point stakeout method allowed for the precise determination of critical points throughout the entire site (Fig. 5), serving as a reference for the accurate placement of structural and architectural components. This method was used to mark the corner points of buildings, the connection points for prefabricated metal or concrete structures, and other essential elements requiring exact placement. With the help of Trimble S7 technology, a millimeter-level precision was achieved, thus contributing to efficient coordination and preventing deviations that could affect the quality of the structural assembly.

Fig. 5 Point stakeout method to determine pillar corners

Line Stakeout: The line stakeout method facilitated the establishment and marking of constructive axes (Fig. 6) and alignment lines, which were essential for configuring the building's perimeter and delimiting different functional areas. This method was applied to ensure the correct positioning of load-bearing walls, beams, and other structural elements, maintaining exact alignment along the axes established in the project. The robotic station allowed for continuous and rapid marking of the lines, with a precision that ensured the consistency and uniformity of the construction.

Fig. 6 Axis stakeout using stakeout line method in order to determine the center of the prefabricated structure

Arc stakeout: This stakeout method was essential for creating curved architectural and structural elements (Fig. 7), including circular staircases, ramps, and other arched shapes integrated into the building's design. Arc stakeout allowed for the precise configuration of these complex elements, ensuring that they conformed to the design specifications without variations. By using the Trimble S7 technology, curved lines were staked out with extremely high precision, which reduced the risks associated with incorrect installation of elements and eliminated the need for subsequent adjustments.

Fig. 7 Pedestrian Road stakeout using Arc stakeout method

3D Line Stakeout: The 3D line stakeout was indispensable for elements that require precise positioning in three dimensions (Fig. 8), such as complex structures involving the overlap of multiple planes and vertical alignment at various elevations. This method was particularly applied to elements that extend beyond the ground plan, such as metal structures and large scaffolding, where spatial precision in all directions is critical. The Trimble S7 total station enabled rigorous three-dimensional stakeout, adhering to the project parameters and ensuring the coherent integration of each element into the overall construction assembly.

Fig. 8 Road border stakeout using 3d line stakeout method

With the help of the Leica Sprinter 250M digital level, the initial elevations necessary for pouring the raft foundation and leveling concrete (Fig. 9) were measured, ensuring a leveled base for the placement of prefabricated components. This process allowed for correlating the designed elevations with the actual terrain conditions and facilitated fine adjustments to the foundation, guaranteeing perfect alignment and an even weight distribution. The leveling ensured the uniform thickness of the raft foundation, providing an optimal surface for pouring the leveling concrete, which allowed for correct alignment of the prefabricated elements according to the execution plan.

Fig. 9 Pouring the leveling concrete after leveling

Modern GNSS systems provide superior accuracy and increased efficiency compared to traditional measurement technologies. They enable rapid data collection through real-time corrections (RTK), thereby reducing the time required for measurements. Additionally, GNSS technologies are less affected by weather and terrain conditions, making them ideal for use on complex construction sites and in areas with difficult access (Joubert et al., 2020; Șmuleac et al., 2020).

Robotic total stations offer significant advantages over traditional total stations and theodolites. They enable automated measurements and can be remotely controlled, improving the efficiency and accuracy of stakeout tasks. Due to their ability to perform real-time measurements and store data directly in the system, robotic stations facilitate project management and reduce the risk of human error. Furthermore, using robotic technology minimizes the need for handling equipment, allowing teams to focus on data analysis and verification tasks (Zhou et al., 2021; Paunescu et al., 2020).

Digital levels offer considerable advantages over traditional optical levels. They provide better accuracy and eliminate reading errors associated with manually observing the scale. Digital levels allow for the rapid recording of data, thus facilitating the leveling process and ensuring more efficient execution of tasks. Additionally, digital equipment is equipped with advanced calculation and memory functions, which contribute to better management of the information collected on-site (Pirti et al., 2019; Popescu et al., 2016, 2019).

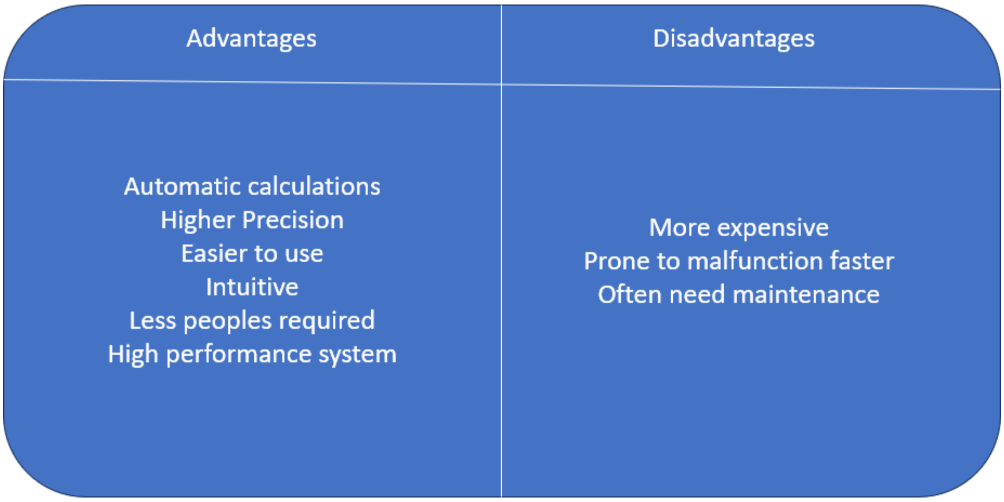

Fig. 10 Modern instruments advantages and disadvantages schema

CONCLUSIONS

The significant impact of modern measurement equipment on the precision and efficiency of surveying work is evident. The transition from traditional instruments, such as theodolites and optical levels, to advanced GNSS systems, robotic total stations, and digital levels has demonstrated that these technologies not only improve measurement accuracy but also facilitate the automation of processes, thus reducing time and resources required for construction project execution.

By implementing GNSS technology for the initial topographic survey and establishing the geodetic network, an efficient correlation was made between the designed data and the actual conditions of the terrain. At the same time, the use of robotic total stations allowed for automated measurements and remote control, thus increasing efficiency in managing construction sites. Digital levels contributed to ensuring precise and rapid measurements, facilitating the leveling process and optimizing the execution of works.

The study area included various construction sites in Timişoara, Arad, Barzăva, and Oradea, demonstrating the applicability of these technologies in different terrain conditions. In conclusion, the adoption of modern technologies in the field of surveying not only meets the current demands of the industry but also represents a crucial direction for the future of civil and industrial construction, with the potential to revolutionize the way design and execution work is carried out.

BIBLIOGRAPHY

BONDREA, M. V., NAȘ, S., FĂRCAȘ, R., DÎRJA, M., AND SESTRAȘ, P. J. I. M. S. G. S., 2016, Construction survey and precision analysis using RTK technology and a total station at axis stake-out on a construction site, v. 2, p. 155-161.

BOTNARU, A., 2024, Lucrări topo–geodezice la proiectarea și trasarea rețelelor inginerești: Universitatea Tehnică a Moldovei.

CASIAN, ALEXANDRU, ADRIAN ȘMULEAC, AND MIHAI SIMON. "Possibilities of using the UAV photogrammetry in the realization of the topo-cadastral documentation." (2019): 96-106.

COPLEY, M. K., 2019, Comparison between robotic total station reflector-less measurement and terrestrial laser scanning for building modelling.

HERBEI MIHAI VALENTIN, ADRIAN ȘMULEAC, COSMIN-ALIN POPESCU, Cartografie digitală & Mobile GIS, Ed. Mirton, 2018.

HERBEI, M., ROXANA HERBEI, L. DRAGOMIR, AND A. SMULEAC. "The analysis of cartographic projections used in Romania." Research Journal of Agricultural Science 45, no. 2 (2013): 127-136.

JOUBERT, N., REID, T. G., AND NOBLE, F., Developments in modern GNSS and its impact on autonomous vehicle architectures, in Proceedings 2020 IEEE Intelligent Vehicles Symposium (IV)2020, IEEE, p. 2029-2036.

KENNIE, T. J., 2014, Engineering surveying technology, CRC Press.

M. S. G. S., 2017, Research on vertical displacements analysis of concrete dams, v. 17, p. 555-560.

MIȚĂ, R., SIMON, M., COPĂCEAN, L., ȘMULEAC, A., HERBEI, M. V., & POPESCU, G. (2020). Using geographical information systems in order to achieve the urban cadastre in the subcetate neighborhood of Arad with the help of modern technologies. Research journal of Agricultural science, 52(4).

MOLDOVEANU, C. J. C., BUCURESTI, 2004, Retele geodezice de sprijin– modul. Sisteme de referinţă şi de coordonate.

PAȘCALĂU, R., S. STANCIU, LAURA ȘMULEAC, A. ȘMULEAC, MIRELA AHMADIKHOIE, ANDREA FEHER, C. SALĂȘAN, M. DANCI, M. BAKLI, AND M. AMARA. "Academic vocabulary in teaching english for agriculture." Research Journal of Agricultural Science 52, no. 2 (2020).

PAȘCALĂU, R., STANCIU, S., ȘMULEAC, L., ȘMULEAC, A., SĂLĂȘAN, C., & URLICĂ, A. A. (2021). Protecting nature through languages. Research Journal of Agricultural Science, 53(2).

PAUNESCU, ROXANA-DENISA, M. SIMON, LAURA ȘMULEAC, R. PAȘCALĂU, AND A. ȘMULEAC. "Topocadastral works regarding the realization of the gas distribution network in the locality of Constantin Daicoviciu." Research Journal of Agricultural Science 52, no. 3 (2020): 145-152.

PIRTI, A., HOSBAS, R. G. J. G., Cartography, 2019, Evaluation of some levelling techniques in surveying application, v. 68, no. 2.

POPESCU, G., C. A. POPESCU, M. HERBEI, AND A. SMULEAC. "Measuring the parameters that influence the phenomenon of displacement and deformation of the ground at Mina Livezeni." (2016): 147-155.

POPESCU, GEORGE, COSMIN ALIN POPESCU, MIHAI HERBEI, LUCIAN DRAGOMIR, ADRIAN SMULEAC, AND

SILVIU DOROBANTU. "Monitoring of Excavation Works Using Modern Measuring Technology." Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca. Horticulture 76, no. 2 (2019): 236-244.

SĂLĂGEAN, T., MOSCOVICI, A., PĂUNESCU, V., CĂLIN, M., AND ŞUBA, E.-E. J. I.,

ȘMULEAC, A., POPESCU, C., BĂRLIBA, L., CIOLAC, V., & HERBEI, M. (2017). Using the GNSS technology tothicken geodesic network in Secaș, Timiș county, Romania. Research Journal of Agricultural Science, 49(3).

SMULEAC, ADRIAN, MIHAI HERBEI, AND COSMIN POPESCU. "Creating the digital terrain model of the Usamvb Area using modern technology." (2012): 282-287.

ȘMULEAC, L., C. RUJESCU, A. ȘMULEAC, F. IMBREA, I. RADULOV, D. MANEA, A. IENCIU, T. ADAMOV, AND R. PASCALAU. "Impact of climate change in the Banat Plain, Western Romania, on the accessibility of water for crop production." Agriculture 10, no. 10 (2020): 437.

ȘMULEAC, L., IMBREA, F., CORODAN, I., IENCIU, A., ȘMULEAC, A. AND MANEA, D., 2017. The influence of anthropic activity on Somes River water quality. AgroLife, p.178.

VU, N. Q., NGUYEN, V. H., AND VAN, H. T., A Comparative Study of UAV Lidar, UAV, and GNSS RTK on Infrastructure Survey, in Proceedings IOP Conference Series: Materials Science and Engineering2023, Volume 1289, IOP Publishing, p. 012098.

ZHOU, J., SHI, B., LIU, G., AND JU, S. J. P. O., 2021, Accuracy analysis of dam deformation monitoring and correction of refraction with robotic total station, v. 16, no. 5, p. e0251281.