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WAYS TO INCREASE THE IMPORTANCE AND EFFICIENCY OF GEODETIC WORKS IN THE CONSTRUCTION OF HIGH-PRESSURE GAS PIPELINES (ON THE EXAMPLE OF THE FERGANA REGION)

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Annotation

Geodetic support is a fundamental element in the construction of high-pressure gas pipelines, ensuring spatial accuracy, structural safety, and long-term operational reliability. This research explores scientifically grounded approaches to enhancing the role and efficiency of geodetic works throughout the planning, construction, and monitoring phases of high-pressure gas pipeline projects, with particular reference to the Fergana region. Special attention is given to the application of modern geodetic technologies such as Global Navigation Satellite Systems (GNSS), electronic total stations, and digital leveling instruments. Field-based investigations and comparative analyses of conventional and advanced surveying techniques were carried out in selected pipeline sections.

Keywords

Geodetic works, high-pressure gas pipelines, construction accuracy, GNSS technology, geodetic monitoring.

Аннотация

Геодезическая поддержка является фундаментальным элементом в строительстве газопроводов высокого давления, обеспечивая пространственную точность, структурную безопасность и долгосрочную эксплуатационную надежность. В данном исследовании рассматриваются научно обоснованные подходы к повышению роли и эффективности геодезических работ на этапах планирования, строительства и мониторинга проектов газопроводов высокого давления, с особым акцентом на Ферганский регион. Особое внимание уделяется применению современных геодезических технологий, таких как глобальные навигационные спутниковые системы (GNSS), электронные тахеометры и цифровые нивелиры. На отдельных участках трубопровода были проведены полевые исследования и сравнительный анализ традиционных и современных методов геодезической съемки.

Ключевые слова

Геодезические работы, газопроводы высокого давления, точность строительства, технология GNSS, геодезический мониторинг.

Annotatsiya

Geodezik ta'minot yuqori bosimli gaz quvurlarini qurishda asosiy element bo'lib, fazoviy aniqlik, strukturaviy xavfsizlik va uzoq muddatli operatsion ishonchlilikni ta'minlaydi. Ushbu tadqiqotda yuqori bosimli gaz quvurlari loyihalarini rejalashtirish, qurish va monitoring qilish bosqichlarida geodezik tadqiqotlarning roli va samaradorligini oshirishga ilmiy asoslangan yondashuvlar, xususan, Farg'ona viloyatiga e'tibor qaratilgan. Global navigatsiya sun'iy yo'ldosh

tizimlari (GNSS), umumiy stansiyalar va raqamli darajalar kabi zamonaviy geodezik texnologiyalardan foydalanishga alohida e'tibor qaratilgan. Tanlangan quvur uchastkalarida dala tadqiqotlari va an'anaviy va zamonaviy geodezik tadqiqot usullarining qiyosiy tahlili o'tkazildi.

Kalit so'zlar

Geodezik tadqiqotlar, yuqori bosimli gaz quvurlari, qurilish aniqligi, GNSS texnologiyasi, geodezik monitoring.

Introduction

The development of high-pressure gas pipeline systems is a strategically significant task that directly influences energy security and socio-economic stability. Such infrastructure facilities require strict adherence to design parameters, as even minor deviations during construction can result in technical failures, environmental hazards, or safety threats. Within this context, geodetic works represent a critical scientific and technical foundation for ensuring construction accuracy and reliability. Geodetic activities form the spatial basis for all stages of gas pipeline construction, including route selection, engineering surveys, layout works, alignment control, and deformation monitoring. Precise determination of planimetric and height parameters allows the pipeline to be positioned in accordance with project documentation, terrain characteristics, and regulatory standards. In regions with complex natural and anthropogenic conditions, the significance of high-quality geodetic support increases substantially. Traditionally, pipeline construction relied on classical geodetic instruments and manual data processing techniques. Although these methods provided acceptable accuracy, they often required considerable time and labor resources and were susceptible to human-induced errors. Recent advancements in geodetic science—particularly the development of GNSS technologies, electronic total stations, digital leveling systems, and GIS-based data processing—have created new opportunities for improving both efficiency and accuracy. The Fergana region is characterized by diverse relief, intensive land use, high population density, and seismic activity, all of which complicate construction processes. Under such conditions, the application of advanced geodetic technologies becomes essential for reducing construction risks and optimizing project performance. The integration of modern instruments and automated processing ensures rapid data acquisition, improved precision, and reliable geodetic control throughout the construction lifecycle.[4]

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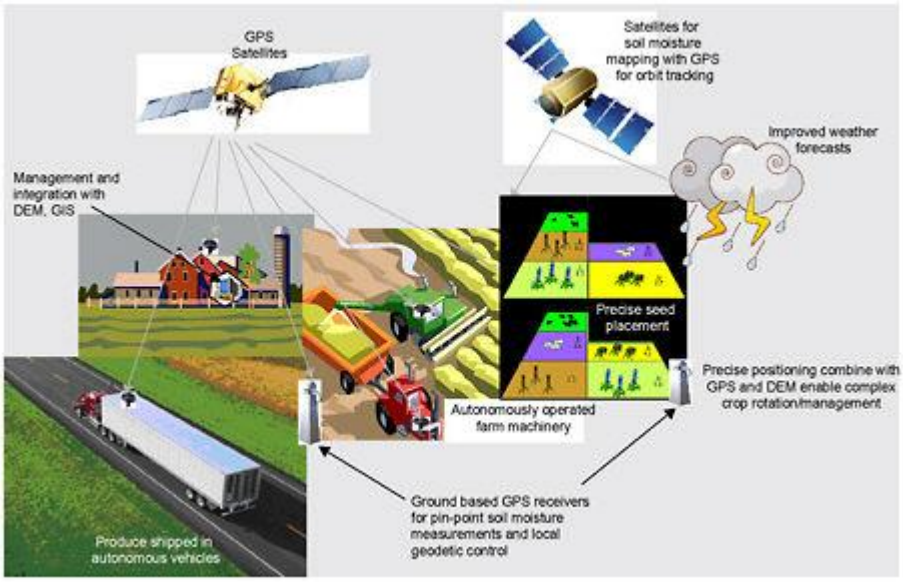

Figure-1 Current benefits of the geodetic infrastructure

Current geodetic infrastructure enables precise positioning, supports sustainable development, improves safety and governance, advances scientific knowledge, and forms a critical foundation for modern geospatial and digital technologies. [1]

The purpose of this study is to identify and scientifically substantiate effective methods for increasing the importance and efficiency of geodetic works in the construction of high-pressure gas pipelines, using the Fergana region as a representative case. The research focuses on technological modernization, organizational improvements, and enhanced geodetic control mechanisms aimed at improving construction quality, safety, and economic effectiveness.

Methods

The research methodology was designed to evaluate the effectiveness of geodetic works in high-pressure gas pipeline construction and to identify ways to enhance their role within the construction process. The study employed a combination of analytical review, field measurements, and comparative assessment of traditional and modern geodetic techniques. Initially, design documentation, regulatory requirements, and technical standards governing high-pressure gas pipeline construction were analyzed to determine permissible tolerances and accuracy requirements for geodetic works. Based on this analysis, appropriate surveying methods were selected for route investigation, setting-out operations, and construction control. Field studies were conducted on selected sections of gas pipeline routes within the Fergana region. The scope of geodetic works included topographic surveys, determination of pipeline axis alignment, elevation control, and verification of trench depth. Measurements were carried out using conventional surveying instruments, such as optical theodolites and automatic levels, alongside modern technologies including GNSS receivers, electronic total stations, and digital levels.[2]

GNSS static and RTK techniques were employed to establish and densify geodetic control networks along the pipeline corridor. Electronic total stations were utilized for precise positioning of alignment points, bends, and intersection nodes, while digital leveling ensured accurate determination of vertical parameters. All measurement data were processed using specialized geodetic software, enabling automated calculations, error analysis, and graphical representation.

Efficiency was evaluated through indicators such as measurement accuracy, duration of

fieldwork, labor requirements, and frequency of detected errors. Additionally, continuous geodetic monitoring was implemented during pipeline installation to assess compliance with design specifications and construction tolerances.[3]

Results

The analysis demonstrated that the use of modern geodetic technologies significantly enhances both the efficiency and functional importance of geodetic works in high-pressure gas pipeline construction. In the conditions of the Fergana region, the application of GNSS methods and electronic total stations reduced field survey time by approximately 25–35% compared to conventional approaches. A marked improvement in measurement accuracy was observed, particularly in horizontal positioning and elevation control. GNSS-based geodetic networks provided stable reference frameworks along the pipeline route, effectively minimizing cumulative alignment errors. Digital leveling ensured consistent control of trench depth, which is essential for maintaining pipeline integrity and safety. The frequency of construction deviations identified through geodetic monitoring decreased, indicating improved conformity with project requirements. Automated data processing reduced computational errors and enhanced the reliability of survey results. Consequently, the need for corrective construction works was minimized, leading to reduced material losses and improved economic efficiency.

Furthermore, the implementation of continuous geodetic control strengthened the role of geodetic specialists within the construction process. Their involvement in operational decision-making increased, especially in areas with complex terrain and dense infrastructure. This approach contributed to improved construction quality, higher safety standards, and increased long-term stability of high-pressure gas pipeline systems in the Fergana region.[2]

Conclusion

The conducted study confirms that geodetic works are a key scientific and technical component in the construction of high-pressure gas pipelines, directly affecting accuracy, safety, and operational reliability. The results demonstrate that technological modernization, combined with improved organizational approaches and continuous geodetic monitoring, significantly increases the efficiency and practical importance of geodetic support. In the specific conditions of the Fergana region, the application of advanced geodetic technologies allows construction risks to be reduced while improving quality and economic performance. Strengthening the role of geodetic works throughout all construction stages contributes to sustainable infrastructure development and ensures compliance with modern engineering and safety requirements.

The findings of this research may serve as methodological recommendations for optimizing geodetic support in future high-pressure gas pipeline projects both within the Fergana region and in similar geographic and engineering conditions.

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