

Research on Engineering Investigation Methods and Remediation Measures for Karst Foundations

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Abstract: Delving into the mysteries of karst foundation engineering, this paper systematically investigates the key technologies of survey methods and remediation measures. The complex characteristics of karst foundations pose unique challenges to geotechnical engineering, making survey work crucial. Through geological surveys, geophysical exploration, and drilling sampling, the ground conditions can be fully revealed. In response to karst characteristics, this paper proposes effective remediation strategies aimed at significantly enhancing the stability and safety performance of foundations, providing solid technical support for engineering practice.

Keywords: Karst foundation; geotechnical engineering; survey methods; remediation measures

Introduction

Karst foundations, like a unique challenge bestowed by nature, with their distinctive karst landforms and complex geological conditions, pose numerous tests for geotechnical engineering. To conquer this challenge and ensure the stability and safety of structures above, it is imperative to explore the survey methods and effective remediation measures for karst foundations in geotechnical engineering. This paper aims to address this challenge by providing profound insights and practical solutions, assisting the field to move towards a more robust and secure realm in engineering practice.

1. Importance of Geotechnical Survey for Karst Foundation Engineering

Karst foundations, with their unique geological

background and complex karst formations such as caves, fissures, and stalactites, present a distinct challenge to the stability and safety of structures. In this particular geological environment, the bearing capacity and stability of the foundation become the core considerations in engineering construction. Therefore, geotechnical surveying on karst foundations is particularly important, serving not only as a crucial step in the early stages of engineering but also as the cornerstone for ensuring smooth subsequent design and construction. Thorough survey work allows us to systematically and comprehensively understand the geological characteristics of karst foundations, the development of karst phenomena, and their spatial distribution patterns. These invaluable primary data provide a scientific basis for subsequent engineering design, enabling engineers to develop rational and



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effective design plans and construction measures based on the actual conditions of karst foundations. Furthermore, surveys can promptly identify potential geological issues within karst foundations, such as connectivity of caves and trends in fissure extension. The acquisition of such information is of great significance for preventing geological disasters and ensuring construction safety. Therefore, it can be said that geotechnical surveying of karst foundations is a prerequisite and guarantee for ensuring the safety, economy, and feasibility of the entire engineering project. In engineering practice, it is essential to fully recognize the importance of karst foundation surveying and allocate sufficient energy and resources to ensure the accuracy and comprehensiveness of survey work.

2. Methods of Geotechnical Survey for Karst Foundation Engineering

2.1 Geological Survey

Geological survey plays a crucial role in the geotechnical survey of karst foundations, serving as the starting point for all survey activities and providing basic data support for subsequent in-depth geophysical exploration and drilling sampling. The main purpose of geological survey is to gain a preliminary understanding and grasp of the basic conditions of karst foundations, including terrain, lithology, and geological structures, through direct observation and description on-site. During geological surveys, the survey team first conducts reconnaissance of the overall terrain of the karst foundation, perceiving the undulations of the terrain, the trends of the mountains, and possible surface karst landforms such as caves, stalactites, and stone forests. These macroscopic landform features not only reveal the long-term tectonic history of the crust but also provide important bases for subsequent engineering layout and construction scheme design. Subsequently, surveyors delve into the exposed areas of the strata, carefully observing the characteristics of rock bedding, joints, fractures, and degree of weathering. Changes in lithology often signify different geological eras or tectonic activities, while the development of joints and fractures directly affects the stability and permeability of the foundation. Through detailed on-site descriptions and recordings, a comprehensive lithological distribution map of the karst foundation can be formed, providing intuitive reference data for

engineering designers. Additionally, investigation of geological structures is also indispensable. Geological structures refer to the spatial position and mutual relationship of rock layers or rock masses in the crust, which have a crucial influence on the deformation characteristics and seismic response of the foundation. In karst foundations, structural forms such as faults and folds may lead to stress concentration and exacerbate deformation, thereby increasing the uncertainty of the engineering. Therefore, surveyors need to carefully identify and mark the positions, scales, and attitudes of various geological structures, assessing their potential impacts on engineering safety.

2.2 Geophysical Exploration

Geophysical exploration plays a pivotal role in the geotechnical survey of karst foundations. This method mainly utilizes physical principles such as electrical, magnetic, gravitational, and seismic methods to indirectly obtain key information such as the development degree, spatial distribution, and scale of karst in karst foundations by measuring changes in physical fields on the surface or in boreholes. Electrical exploration is commonly used, which infers the morphology and distribution of karst bodies based on the electrical differences in different media in karst foundations by measuring changes in the natural electric field or artificially established electric fields. Magnetic exploration utilizes the magnetic differences in rocks in karst foundations to detect the presence of karst bodies by measuring changes in the magnetic field. Gravity exploration infers the distribution and scale of karst bodies in karst foundations based on gravity anomalies caused by rocks of different densities. Seismic exploration also has unique advantages in karst foundation surveys. It utilizes the propagation law of artificially generated seismic waves in strata to detect karst morphology, scale, and distribution in karst foundations by measuring parameters such as seismic wave velocity, amplitude, and frequency. This method is particularly effective for detecting deep-seated karst bodies and determining the three-dimensional morphology of karst bodies. The advantages of geophysical exploration methods lie in their non-invasiveness, efficiency, and economy. They can quickly obtain extensive information about karst foundations without damaging the surface, providing strong support for engineering design and construction. However,

geophysical exploration also has certain limitations, such as the ambiguity of interpretation results and restrictions imposed by site conditions. Therefore, in practical applications, it is usually necessary to combine geological surveys and other survey methods for comprehensive analysis and interpretation to improve the accuracy and reliability of survey results.

2.3 Drilling and Sampling

Drilling and sampling are indispensable and important stages in the geotechnical survey of karst foundations. Through drilling technology, we can penetrate underground and directly obtain core samples of karst foundations, which reveal the true face of the foundation's interior. During the drilling process, engineers select appropriate drilling methods and equipment according to geological conditions and engineering requirements. They carefully operate drilling machinery to ensure that each core sample is extracted intact and accurately. These core samples are like the "diaries" of the foundation, recording the formation and evolution of the foundation. Through meticulous observation and analysis of core samples, we can gain in-depth understanding of the lithological characteristics of the foundation. Different types of rocks and soil layers differ in color, structure, and texture, providing important bases for judging the stability and bearing capacity of the foundation. At the same time, core samples may also expose karst phenomena such as caves and fractures, which are potential factors affecting foundation safety. In addition to lithological characteristics, drilling also helps us understand the groundwater conditions in the foundation. The presence of groundwater has significant effects on the stability of the foundation and construction. Through drilling and sampling, we can determine the burial depth, fluctuation, and water quality of groundwater, providing necessary hydrogeological data for subsequent engineering design and construction. Sampling testing is a powerful complement to drilling work. By conducting physical and mechanical property tests on the extracted rock and soil samples, we can obtain key indicators such as density, moisture content, and shear strength. These data not only provide scientific basis for evaluating the bearing capacity and deformation characteristics of the foundation but also provide strong support for subsequent foundation treatment and reinforcement design.

3. Remediation Measures for Karst Foundations

3.1 Reinforcement Treatment

In dealing with karst foundations, reinforcement treatment is a commonly used and effective measure. When there are karst phenomena such as caves and fissures in the foundation, these adverse geological structures significantly affect the bearing capacity and stability of the foundation. Therefore, taking appropriate reinforcement measures is particularly important. Grouting reinforcement is one of the common methods for reinforcing karst foundations. This method involves injecting materials such as cement grout or chemical grout into voids such as caves and fissures in the foundation to fill and solidify them, thereby enhancing the overall integrity and strength of the foundation. Grouting reinforcement not only improves the mechanical properties of the foundation but also effectively prevents the infiltration of groundwater, thereby enhancing the foundation's resistance to seepage. In practical applications, grouting reinforcement has shown significant effects and is widely used in the treatment of various karst foundations. In addition to grouting reinforcement, anchoring reinforcement is also an effective method for treating karst foundations. Anchors are rods that penetrate into the rock and soil mass, with one end connected to the engineering structure and the other end fixed in stable rock and soil mass. By applying prestress, anchors can tightly connect the engineering structure to stable rock and soil mass, forming an integral whole, thereby enhancing the bearing capacity and stability of the foundation. In karst foundations, anchoring reinforcement can effectively transmit the upper load to deep stable rock and soil mass, avoiding excessive settlement and instability of the foundation. When carrying out reinforcement treatment, it is necessary to select appropriate reinforcement methods and materials according to the specific conditions of the foundation and engineering requirements. At the same time, construction operations should strictly follow the design requirements and construction specifications to ensure the quality and effectiveness of the reinforcement treatment. Through reasonable reinforcement treatment, the engineering performance of karst foundations can be effectively improved, and

the bearing capacity and stability of the foundation can be enhanced, providing strong guarantees for the safety and stability of the project. In future geotechnical engineering, with the continuous progress and innovation of technology, reinforcement treatment techniques for karst foundations will become more mature and perfect, providing better services and support for engineering construction.

3.2 Replacement Treatment

In dealing with karst foundations, replacement method is a common and effective technical means. When karst phenomena are severe and the bearing capacity of the foundation is significantly insufficient, engineers often consider using replacement method for treatment. The basic principle of this method is to excavate part or all of the karst foundation and then replace it with sand, gravel, or other suitable materials that meet the engineering requirements. The implementation of replacement method requires careful design and rigorous construction. Firstly, detailed survey of the karst foundation is needed to determine the scope and depth of replacement. This step is crucial because it directly affects the safety and economy of the subsequent project. Then, based on the survey results, detailed replacement plans should be formulated, including the types, specifications, quantities, and construction methods of replacement materials. During the construction process, unstable parts of the karst foundation, such as soft soil layers, voids, and fissures, should be excavated. The depth and scope of excavation should be adjusted according to the actual situation to ensure that the replaced foundation can meet the engineering requirements. Then, materials such as sand and gravel that meet the requirements should be filled into the excavated foundation pit and compacted in layers. The purpose of this step is to ensure that the replacement materials can be tightly combined to form a stable and solid new foundation. The advantage of replacement method lies in its ability to significantly increase the bearing capacity and stability of the foundation. By replacing the original weak rock and soil, the mechanical properties of the foundation are fundamentally improved. In addition, replacement method can also reduce the settlement of the foundation and improve the overall stability of the project. However, this method also has some

limitations, such as high construction costs and certain environmental impacts.

3.3 Drainage Treatment

In dealing with karst foundations, the issue of groundwater cannot be ignored. Changes in groundwater level, water flow erosion, and other factors may pose potential threats to the stability and safety of the foundation. Therefore, adopting effective drainage treatment measures is one of the key steps to ensure the safety of karst foundations. For the groundwater problems in karst foundations, we can set up dedicated drainage systems for treatment. Among them, blind ditches and sump wells are two commonly used drainage facilities. Blind ditches are generally set around the foundation or at a certain depth underground. They use permeable materials inside the ditches to introduce and discharge groundwater, effectively reducing the groundwater level. Sump wells use pumps and other equipment to extract and concentrate groundwater for treatment and are usually installed in lower terrain or areas with large water volumes. In actual engineering, the choice of drainage treatment methods should be comprehensively considered according to the specific conditions. Firstly, detailed surveys of the geological conditions and hydrological conditions of the karst foundation are needed to understand the distribution, changes in water level, and flow rate of groundwater. Secondly, comprehensive analysis should be conducted based on engineering requirements, safety standards, and economic factors to determine a reasonable drainage plan. Finally, during the construction process, operations should strictly follow the design requirements to ensure the quality and effectiveness of drainage facilities. By setting up effective drainage systems, the groundwater level in karst foundations can be reduced, mitigating the adverse effects of water on the foundation. This not only improves the bearing capacity and stability of the foundation but also prevents problems such as seepage and softening of the foundation, ensuring the safety and reliability of the project. In addition, drainage treatment can also improve the soil environment of the foundation, increase the degree of consolidation and strength of the soil, and provide good geological conditions for subsequent construction.

Conclusion

In the journey of exploring the mysteries of karst foundation geotechnical engineering, this paper has delved into the key aspects of survey methods and remediation measures. Through diverse surveying techniques, we have gained insights into the complex geological structures and karst development of karst foundations. Based on this understanding, targeted remediation strategies such as reinforcement, replacement, and drainage have emerged, providing solid assurance for enhancing the stability and safety of the foundation. Looking towards the future, it is crucial for relevant engineering practices to deeply understand the uniqueness of karst foundations and adopt appropriate surveying and remediation schemes tailored to the specific conditions, ensuring robust and

cost-effective engineering construction.

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