Analysis of the Influence Law of In-situ Testing Parameters for Building Foundation Rock and Soil and the Quality Control of Testing

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Abstract: The various mechanical indicators of foundation rock and soil are the core basis for the design of building foundation schemes, bearing capacity determination, and settlement prediction. Indoor sampling tests can easily disrupt the original stress state of the soil, while in-situ tests can maintain the natural structure and stress level of the soil layer and obtain true mechanical parameters. When conducting in-situ detection on site, the soil layer's own structure, the operation process of the test, on-site construction disturbances, and the supporting conditions of the instruments will continuously interfere with the final collected parameters. Systematic deviations in the indicators will directly mislead the design values of the foundation. This article focuses on three fundamental theories: maintaining the in-situ stress state of rock and soil, coupling changes of in-situ test parameters, and closed-loop control of on-site testing quality in geotechnical engineering. It sorts out various parameter interference factors existing throughout the entire process of on-site in-situ testing. A complete implementation control path is established from four aspects: pre-treatment of soil layers, standardized in-situ test operations, multi-parameter mutual verification mechanisms, and a full-process detection quality control system. This approach weakens the parameter distortion caused by external conditions, enhances the stability of in-situ test data for foundation rock and soil, and provides reliable technical support for the design and safety review of building foundation engineering.
***Keywords*:** building foundation, In-situ geotechnical test Detection parameters; Influence law; Quality control

1. Introduction

All kinds of civil and industrial buildings have strict requirements for the stability of the foundation. In-situ geotechnical testing, as the mainstream method for obtaining the natural mechanical properties of soil layers, can avoid the damage to the soil structure caused by sampling and transportation. Objective conditions such as disturbances at the construction site, uneven distribution of strata, and differences in personnel operation scales will alter the core indicators output by in-situ detection. If there is a lack of supporting control measures, the parameter dispersion will increase significantly. Clarifying the influence laws of various factors on in-situ detection parameters and simultaneously establishing a quality control system covering the entire chain from pre-preparation, on-site testing to data verification can reduce the probability of parameter distortion and ensure the compliant and stable progress of foundation engineering construction. The scale of modern construction projects continues to expand, and the load forms of superstructures are becoming increasingly complex. The true mechanical properties of the foundation rock and soil directly determine the safety reserve and service life of the overall building structure. In-situ testing technology, with its advantages of not disturbing the original soil, high detection efficiency and data closely adhering to the actual engineering situation, has become an indispensable core technical means in the geotechnical engineering investigation stage. Its detection accuracy and data stability play a decisive role in the rationality of engineering design.

2. Basic theories related to in-situ testing of foundation rock and soil

Under the long-term action of the overburden self-weight load, the underground soil layer forms a stable initial stress field, and the interlocking state of soil particles, pore water pressure and compaction degree are all in a balanced state. The process of soil sampling, transportation and sample preparation indoors will relieve the original stress, and the internal pore structure of the soil will undergo irreversible changes. The final test indicators cannot represent the true mechanical level of the stratum.

In-situ tests rely on the direct deployment of probes and the penetration of components on site for testing. The entire process does not change the original stress balance system of the soil layer. The collected indicators such as bearing capacity, lateral friction resistance, and deformation modulus are in line with the natural service state of the stratum. This theory clearly defines the core advantages of in-situ detection over indoor testing, and also indicates that all on-site operations must be based on maintaining the original structure of the soil as the core criterion. It serves as the fundamental theoretical basis for analyzing the sources of various parameter interferences. The stress equilibrium state of soil mass has extremely strong stability and dependence. The particle arrangement and pore structure formed by long-term natural sedimentation cannot be restored on their own once disturbed by external forces. The stress relief defects in indoor tests cannot be remedied through later corrections, while in-situ tests fully preserve the original mechanical environment of the soil layer and can truly reflect the bearing characteristics and deformation features of the foundation soil, providing a fundamental theoretical support for precise engineering design [1].

3. The main influence laws of in-situ test parameters for foundation rock and soil

The soil layer distribution within the same construction site is not in a uniform and homogeneous state. There are natural differences in the clay content, density and groundwater level of the soil at different vertical depths and different horizontal points. Even if completely consistent test operations are adopted, the parameters collected at different points will still fluctuate within a reasonable range. The dissipation rate of pore water pressure in soft clay formations is slow. During the penetration test, pore water cannot be discharged in time, which will continuously reduce the end resistance detection value. The sand layer has strong water permeability, and the pore water pressure dissipates rapidly. The lateral friction resistance index will be significantly higher than that of the clay stratum.

In sections where there are interlayers and lens bodies locally, when the probe passes through different soil boundary positions, various mechanical parameters will undergo sudden changes. Such fluctuations are inherent characteristics of the stratum and not operational defects in the test. If the natural variation laws of stratum parameters are not mastered, it is easy to judge the fluctuation of normal indicators as the failure of the test, or to ignore the sudden change in performance caused by the interlayer, resulting in a misjudgment of the rock and soil performance of the entire site. The sedimentation process of natural foundation soil is characterized by randomness and complexity. Thin layers and interlayers, as well as uneven soil distribution, are common geological features of the site. The corresponding fluctuations in detection parameters are normal geological responses. A thorough understanding of such natural change laws can effectively distinguish the real geological changes from human detection errors and avoid the risk of misjudgment in engineering investigation [3].

4. The implementation path for the full-process quality control of in-situ tests to weaken parameter distortion

4.1 Conduct a pre-investigation and zoning of the site strata to avoid disturbances and interlayer interference

Before the formal in-situ test is carried out, a preliminary investigation of the entire site should be completed. A simple map of the vertical stratification, horizontal interlayer and groundwater level distribution of the soil layer should be drawn. The original stratum sections and the sections disturbed by the previous construction should be divided. All test points should be set up in the original soil layer range without loading, compaction and precipitation disturbance, avoiding the influence zone of the foundation pit excavation and the area beneath the temporary construction access road.

Allocate the number of test points according to the stratum distribution zones, increase the number of measurement points in areas with dense interlayers and lens bodies, and moderately reduce the number of points in uniform strata to fully capture the lateral and longitudinal changes in the soil layer performance of the site. After the layout of the points is completed, the site image records should be retained, and the corresponding stratum conditions of the points should be marked. During the later data verification, the inherent fluctuation laws of the stratum should be combined to distinguish the normal index fluctuations from the distorted data caused by operations, thereby reducing the probability of misjudgment caused by stratum conditions from the source.

4.2 Unify the standardized operation details for in-situ tests to reduce human operation deviations

Compile a complete set of in-situ test operation specifications suitable for building foundation engineering, clearly defining the rigid requirements such as the probe entry calibration cycle, the standard for probe rod splicing and sealing, the unified penetration rate across the entire stratum, and the pause time for data reading at each depth. All on-site operation personnel must strictly follow the unified procedures to carry out the tests. Before setting up the probe, clear the surface floating soil and loose backfill soil at the measurement point to ensure that the probe directly contacts the original soil. Control the verticality of the probe rod throughout the process to avoid tilting friction interfering with the side friction resistance collection.

Set key control requirements for operation by soil layer. For clay strata, strictly control the penetration speed to avoid the accumulation of excessive pore water pressure. For sand layers, moderately shorten the pause time to reduce friction interference. During the test process, a dedicated person was assigned to supervise the operation procedures in real time. If problems such as unbalanced penetration rate or probe deviation occurred, the test was immediately terminated, the points were cleared and the test was resumed. Standardized operations were relied on to eliminate parameter deviations caused by human procedures.

5. Conclusion

The geotechnical mechanical parameters obtained from in-situ tests of building foundations are the core basis for foundation engineering design. Four types of factors, namely the inherent distribution characteristics of strata, the disturbance caused by the construction of the site in the early stage, the operation scale of on-site tests, and the control of instruments and data processing, will interfere with various detection indicators according to fixed rules. Various distortion parameters will directly affect the determination of foundation bearing capacity and the conclusion of settlement prediction. The theories related to the maintenance of in-situ natural stress in rock and soil, the coupling changes of in-situ detection parameters, and the closed-loop quality control of on-site detection provide clear theoretical support for clarifying the influence laws of parameters and establishing a complete quality control system. At present, on-site in-situ tests generally have prominent problems such as point layout not avoiding disturbance areas, insufficient standardization of operation procedures, lack of multi-parameter cross-verification, and absence of instrument operation and maintenance as well as full-process control. These issues continuously lead to high dispersion of detection data and difficult identification of distorted indicators.

References

[1] Guo Jiang. Application of Geotechnical Investigation Technology for Soft Soil Foundation in Highway Engineering [J] Urban Construction Theory Research (Electronic Edition), 2025, (34): 107-109.

[2] Zhang Yongtao. Analysis and Evaluation of Geotechnical Characteristics of Building Foundation Based on In-situ Testing [J]. Construction Machinery, 2025, (11): 61-63+71.

[3] Zong Junxiu. Geotechnical Engineering Investigation Methods and Treatment Approaches for Karst Foundation [J]. Residential and Real Estate, 2020, (35): 139-140.

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