

Grouting Reinforcement Mechanism of Fully Weathered Granite Water-rich Stratum and Its Application

Peng Gao^{1, 2, a, *}, Qingsong Zhang¹, Xuguo Xue¹, Jiaying Zhao¹ and Yujie Liu¹

¹Shandong University, Jinan, China;

²Shandong Shixin Construction Co.,Ltd., Jinan, China.

^aEmail: 1344630572@qq.com

Abstract

Granite, as a common stratum, is mostly distributed in southeast Guangxi, Guangdong, Fujian and southern Hunan. Affected by multiple factors such as humid and hot climate and rainy environment, granite has a high degree of weathering, which easily induces geological disasters such as surrounding rock collapse, water inrush and mud inrush in the process of underground engineering construction. Before grouting reinforcement, the stratum should be evaluated according to the stability of the end soil mass, and targeted reinforcement measures should be taken to ensure the stability of the soil mass when the portal is broken and prevent water gushing and sand gushing. To ensure the grouting treatment effect, the cement slurry should have good fluidity and stability, so as to achieve the ideal diffusion range and grouting reinforcement strength under the designed grouting pressure. In this paper, the law of physical and mechanical parameters of grouting reinforcement of completely weathered granite under different grouting pressures in water rich strata is discussed, and the mechanism and application process of grouting reinforcement of completely weathered granite water rich strata are analyzed.

Keywords

Granite, Weathering, Grouting reinforcement, Water-rich formation.

1. Introduction

Fully weathered granite has loose structure, poor water stability and small cohesion, and has high bearing capacity above the groundwater level. However, it easily softens, disintegrates and even flows when disturbed by water, which belongs to the category of unfavorable engineering geology and often brings great difficulties to the construction of tunnel engineering [1]. Granite, as a common stratum, is mostly distributed in southeastern Guangxi, Guangdong, Fujian and southern Hunan. Affected by multiple factors such as humid and hot climate and rainy environment, granite has a high degree of weathering, which easily induces geological disasters such as surrounding rock collapse, water inrush and mud inrush during underground engineering construction [2]. In the process of tunnel excavation in metal mines, various difficulties are often brought to excavation and support construction due to the bad lithology of surrounding rock, especially in water-rich weathered granite. In grouting reinforcement engineering, cement slurry has become the most widely used type of slurry due to its advantages of simple preparation, simple operation and economical cost. Before grouting reinforcement, the stratum should be generally evaluated according to the stability of the end soil mass, and targeted reinforcement measures should be taken to ensure the stability of the soil mass and prevent water gushing and sand gushing [5]. It is of great significance to the construction progress, quality and cost of the tunnel to select the appropriate construction

method in the process of tunnel construction so as to safely and rapidly pass through unfavorable geological strata.

In view of the unfavorable geological conditions of tunnel construction, grouting reinforcement technology is currently an effective, convenient, safe and fast method for stratum reinforcement. Due to the variability of engineering properties of weathered granite and the regionality of engineering geological factors, there are many potential safety hazards in the construction process, the construction speed is slow, and even the detour design and construction are needed again, resulting in high engineering cost [6]. In order to ensure the grouting treatment effect, the cement slurry should have good fluidity and stability so as to reach the ideal diffusion range and grouting reinforcement strength under the designed grouting pressure [7]. In the process of tunnel construction, granite strata with high weathering degree are often encountered. Due to its obvious characteristics of loose and weak, strong water-rich property, poor self-stabilizing ability and easy disintegration in case of water [8]. Geological disasters such as water inrush, mud inrush and landslide are easily induced during construction. Influenced by humid and hot climate, granite is highly weathered, with developed fissures, poor self-stabilizing ability and strong disintegration in case of water. Geological disasters such as collapse, water inrush and mud outburst are easy to occur during tunnel and underground engineering construction [9]. Among many physical parameters of cement slurry, viscosity is the key index that affects the fluidity and stability of the slurry, which is directly related to the diffusion radius, grouting pressure and grouting rate of the slurry in the formation, and ultimately affects the grouting reinforcement effect [10]. This paper discusses the variation law of various physical and mechanical parameters of fully weathered granite grouting and solid under different grouting pressures, and analyzes the reinforcement mechanism and application process of grouting in water-rich strata of fully weathered granite.

2. Grouting Simulation Analysis

The grouting simulation test system consists of a test generation unit, a grouting unit, a water pressure and water quantity supply unit, and can realize single-liquid grouting simulation tests of completely weathered granite media under different grouting pressures. As shown in Table 1, the basic physical parameters of granite are selected for the experiment.

Table 1. Basic physical parameters of fully weathered granite

	Dry density /(g·cm ⁻³)	Moisture content /%	Liquid limit /%	Plastic limit /%	Porosity /%
1.85	1.72	8.1	38.9	17.9	35

Weathered granite will disintegrate rapidly when it is completely immersed in water, causing instability and collapse of surrounding rock on the face and causing great harm to the project. In completely weathered granite formation, the diffusion of cement single liquid slurry is mainly in the form of splitting, while compaction and infiltration are supplemented, and the diffusion range and reinforcement effect of slurry are closely related to grouting pressure. When the water cement ratio increases, the viscosity of the cement slurry decreases, the fluidity increases, the diffusion range in the formation increases, but it is difficult to control, and the slow rise in pressure tends to cause slurry waste. At the same time, the slurry is prone to segregation in the diffusion process, the retention rate in the stratum is low and uneven distribution, which affects the grouting reinforcement effect. When the water cement ratio decreases, the viscosity of cement slurry increases, the fluidity decreases, and the retention rate increases [11]. However, the grout diffusion distance and grouting reinforcement range are

limited, resulting in a rapid increase in grouting pressure, affecting the safety of engineering structures and construction personnel.

For splitting grouting, the reinforcement effect and mechanism of slurry pulse splitting zone on loose soil are significantly different from those of non-slurry pulse compression zone. On this basis, single-fluid grouting simulation tests of fully weathered granite under different grouting pressures are designed and implemented. Brief description of the test steps: 1. Drying the undisturbed soil of completely weathered granite and sieving out lumps with particle size over 8mm; 2, according to the measured moisture content (8.1%), configuration filling soil samples; 3, using density (1.72g/cm³) control compaction degree, layered filling soil samples into the model barrel, each layer filling height of 6cm, each layer filling quality is 5279 g; 4. Pressurized water is stably injected into the test body through an air compressor and a pressure stabilizing barrel in the water quantity and pressure control unit, and the water pressure is controlled to be 1.0MPa; 5, after the soil body is soaked and saturated, a manual grouting pump in the grouting unit is used to inject cement single liquid slurry into the test body through a grouting pipeline, the grouting rate is controlled, and grouting is stopped under the preset final pressure of the test; 6. Take out the test body, and sample each physical test block in the splitting area and the compaction area 6cm away from the central grouting pipe. See Table 2 for main parameters of grouting simulation test.

Table 2. Main parameters of grouting reinforcement simulation test

Test sequence	Grouting time t/s	Grouting quantity Q/L	Grouting rate qg/(L·min ⁻¹)	Final grouting pressure p/Mpa
1	76	3.2	3.73	0.6
2	85	4.3	3.86	1.1
3	87	4.5	3.79	1.6
4	117	5.2	3.87	2.0

3. Viscosity Control of Cement Slurry

After the grouting simulation test is completed, the splitting area and the compaction area are sampled respectively for uniaxial compression test, direct shear test, permeability test and wetting test. The effects of different grouting pressures on the strength and deformation characteristics, permeability and water-resistant disintegration of fully weathered granite and the strengthening mechanism were studied [12]. In the grouting reinforcement project, the water cement ratio of cement slurry is usually 0.6:1-1.4:1. Within this range, seven kinds of cement slurries with water cement ratios of 0.6:1, 0.7:1, 0.8:1, 0.9:1, 1:1, 1.2:1, 1.4:1 were prepared. The viscosity and fluidity were measured respectively. For example, the table shows the viscosity and fluidity of cement slurries with different water cement ratios. As can be seen from Table 3, with the increase of water cement ratio, the viscosity of cement slurries gradually decreases while the fluidity continuously increases.

Table 3. Viscosity and fluidity of cement slurry with different water-cement ratios

water cement ratio	0.6:1	0.7:1	0.8:1	0.9:1	1:1	1.2:1	1.4:1
Slurry viscosity /s	25.6	24.9	23.2	20.8	18.5	17.6	16.9
Slurry fluidity /mm	161	171	183	192	207	220	234

After building blocks are generated, the mutual occlusion of building blocks is usually determined only according to the plane relation or the section relation in some places. This analysis method is only completed as a symbolic task in architectural design, due to its limitations and fuzziness. By investigating the data parameters obtained, the statistical data can be used to analyze some computers or other data that cannot be determined. There are many different softwares for the statistics and processing of these parameters by the computer, and the corresponding softwares shall be used for the processing of different data parameter types [13]. Based on the structural and design characteristics of landscape architectural engineering, the parametric modeling ideas of road alignment, building structure and components are analyzed, and the specific parametric model solutions are put forward. The application of parametric design method in landscape architecture engineering is analyzed. Finally, combined with engineering cases, Jiang landscape architecture parametric modeling and design ideas are applied to specific engineering projects.

Construction personnel play a very important role in the construction of construction projects. In the whole construction management process, the management of construction personnel is also a link that cannot be ignored. Judging from the management of civil construction sites in the construction field in our country at this stage, the environmental protection and site management of most construction projects are not standardized. Improper execution system and operation of process management will reduce the construction quality of actual projects and greatly affect the safety of construction projects. The problems that may exist in the construction cannot be predicted in time, and the construction awareness is weak. On the other hand, the poor comprehensive quality and low educational level of construction personnel are the characteristics of construction personnel engaged in construction projects at this stage. In the process of construction, they do not know enough about specific construction and have poor awareness of prevention of construction safety accidents. There are many problems in building engineering materials, such as disorderly stacking and placing, insufficient protection measures for materials, random access to materials, chaotic management of materials, etc. It not only affects the construction progress, wastes the construction raw materials and increases the construction cost, but also lays a potential safety hazard for the construction safety.

In the process of parametric analysis of grouting reinforcement, with the continuous in-depth development, there are some problems that need to be effectively solved or reformed. This paper compares the four aspects of design ideas, design platforms, design methods and collaborative design, analyzes the advantages of parametric design methods compared with traditional design methods, and analyzes the feasibility of applying parametric design methods to grouting reinforcement construction projects. Assume that the capacity of intra-domain links is the capacity of inter-domain links. Performance illustrated by three different scenarios. As shown in Table 4.

Table 4. Excess cost ratio of single domain strategy

Charge number	10	15	20	25	30
Stope	5%	8%	12%	16%	21%

The first development in parametric design of grouting reinforcement layout in water-rich strata is geometric modeling, which deals with basic problems such as geometry and shape representation of objects, research on graphic data structure, etc. The path density, node number and center potential are analyzed. As shown in table 5. With the increase of path density, the shortest path between nodes increases.

Table 5. Parametric design structure analysis of building layout

Network	Path density	Number of nodes	Central potential
Encounter information	1421	2164	0.726
Mutual information	2237	2023	0.579
Weighted summation	639	2637	0.681

After the grouting slurry is pressurized by the grouting pump, it enters the stratum of the slurry injection hole in the grouting pipe section of the sleeve valve pipe in grouting pipe through the connecting pipe. When the pressure gradually increases to a certain degree, the re-pressurized slurry will generate initial splitting flow along the stratum structure. The subsequent slurry makes the splitting cracks continuously extend outwards under the action of continuous pressure, and the slurry compacts the original soil body in the soil body and forms a strip-shaped or tree-forked pile consolidation body to reinforce the soil body. Grouting shall be carried out in sequence according to the sequence of forming holes and the arrangement of drilling holes, and shall be encrypted one by one.

4. Conclusions

Weathered granite has extremely poor water stability and will disintegrate rapidly in a short period of time once completely immersed in water. In water-rich areas, how to effectively control the discharge of groundwater and improve the strength of rock mass becomes the key to construction. With the increase of slurry viscosity, the shear strength of soil samples generally increases, the internal friction angle continues to increase, but the cohesion has certain discreteness. Compared with the soil layer, the weathered fractured zone rock mass has the characteristics of relatively high strength, high water permeability, low cohesion and easy deformation. In the reinforcement of shield entry and exit door soil mass, high pressure jet grouting pile is generally used as the waterproof curtain. After the grouting slurry is pressurized by the grouting pump, it enters the stratum of the slurry injection hole in the grouting pipe section of the sleeve valve pipe in grouting pipe through the connecting pipe. When the pressure gradually increases to a certain degree, the re-pressurized slurry will generate initial splitting flow along the stratum structure. In fully weathered granite, the grouting diffusion mode is mainly split grouting, supplemented by compaction grouting. With the continuous increase of grouting pressure, the strength characteristics of soil samples are significantly improved. In the process of grouting construction, on the basis of comprehensively considering the bearing capacity of surrounding rock and lining structure, properly increasing grouting pressure is of great significance for improving the overall strength of surrounding rock and ensuring the reinforcement effect.

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