A Research on Physical and Mechanical Indexes of Granite Residual Soil in Eastern Guangzhou

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Abstract. Granite residual soil is widely distributed in Guangzhou, mostly are sandy sticky clay, even though its mechanics characteristic differs largely but has a certain regularity. This paper takes the granite residual soil in eastern Guangzhou as the research object, and obtains a large amount of data through field research, laboratory test and in-situ soil test, carrying out the statistical analysis of many physical and mechanical indexes, such as unit weigh, water content, void ratio, plastic limit, liquid limit, plasticity index, liquidity index, compression coefficient, compression modulus, cohesion, internal friction angle. Also gives out the statistics and the range of physical and mechanical indexes and analyzes the correlation between various indicators, which provides a geological basis for related engineering construction.

Keywords: eastern Guangzhou; granite residual soil; physical and mechanical index; statistical analysis; correlation analysis.

1. Introduction

Granite residual soil formed under the physical and chemical weathering of the fresh granite rock, and its structure, composition and properties had produced different degree of variation. When the degree of weathering was strong, it would become weathering product which was not influenced by the role of horizontal and vertical transportation. Compared with other sedimentary soil, granite residual soil has larger differences in its physical and mechanical properties, structural, disturbance, softening and so on [1]. Due to the different of rock materials and environment of weathering, the composition and physical and mechanical properties of granite residual soil are different. So the statistical analysis of the physical and mechanical parameters of granite residual soil in different areas has great engineering significance. For many past years, some research about many aspects of granite residual soil were carried out by many domestic scholars. For example, Wang Qing (1990, 1991) [2-3] and Chen Hong-jiang (1995) [4] studied the engineering geological characteristics of the granite residual soil.Hu Hong-mei (2001) [5], Chen Hong-jiang (2001) [6] and Yang Fa-qing (2002) [7] had a research on the physical and mechanical characteristics and the engineering properties of granite residual soil. Zhang Yong-bo (1997) [8] carried attention on the engineering classification on granite residual soil. Wei Ke-he (1991) [9] and Zhang Yong-bo (1997) [10] carried out a research on shear strength and bearing capacity of foundation of granite residual soil. Zhu De-chang(1999) [11] researched the test of granite residual soil.

In this paper, granite residual soil in eastern Guangzhou is taken as the research object and the most commonly used engineering application indexes are selected to the statistical analysis. Moreover, it gives out the statistics of physical and mechanical indexes of granite residual soil and studies the correlation between these indexes. Finally, the empirical formulae between the parameters are established and the general characteristics of granite residual soil are taken out.

2. Analysis of physical and mechanical properties index

Yanshanian granite residual soil layer was widely distributed in eastern Guangzhou. The physical and mechanical tests were taken out in Tian-he, Zeng-cheng and many other places. Research shows that granite residual soil in eastern Guangzhou is given priority to clay and quartz sand grain and the colour of granite residual soil are grey yellow, brown yellow or grey. The change of thickness of eluvial soil is large. It is generally that the deeper the buried depth, the bigger the thickness, and particle content has great change as the different of parent rock.

Taking sandy clay as representative , the physical and mechanical indexes of granite residual soil were obtained through geotechnical test. The statistical analysis of the natural density, water content, void ratio, compression modulus, internal friction angle, cohesion, plasticity index and liquidity index are shown in Table 1. These indicators can reflect the main physical and mechanical properties of granite residual soil, and they are not only the most important indicators but also commonly used in the engineering application. The physical and mechanical properties of indexes were mainly determined by laboratory test of soil samples which were obtained through the drilling of rock. Futhermore, mathematical statistics was used for statistical analysis. As shown in Table 1, coefficient variation of natural density is minimum and it is only 0.02, which indicates that natural density of soil is slightly different. On the other hand, it also has a lot to do with the test method because the measured value of natural density is the result of the parallel test specimens and test data error also has a regulation. In this way, the test results inevitably are concentrated and variation coefficient decreases significantly. Variation coefficient of liquidity index is largest because it is influenced by natural water content. The calculation of liquidity index is according to natural water content, liquid limit and plastic limit: $I_L = (\omega - \omega p) / (\omega_L - \omega p)$. Due to the influenced of climate condition, the change of natural water content is large along with depth and liquidity index also changes with depth. Among four mechanics indexes, variation coefficient of compression coefficient and compression modulus are smaller while variation coefficient of internal friction angle and cohesion are larger, which indicates that the disturbance of four mechanics indexes are different. That is in keeping with the conclusion of literature [12].

Table 1 shows that the average porosity of granite residual soil in eastern Guangzhou is large and it will be about 0.8.But the average water content is not big and it is between 25% and 30%. The soil is usually in hard plastic or plastic state and its compression modulus is generally close to 4 MPa, so granite residual soil has high compressibility. Moreover, cohesion and internal friction angle of granite residual are large, which leads to high shear strength. For common soil, the cause and effect relationship between large void ratio and high compressibility is normal but it is impossible to have both high compressibility and high shear strength. Cohesion is always large because the microstructure of soil does not usually been completely destroyed. In addition, the content of clay and silt in the granite residual soil are very high, and internal friction angle is large because of high coarse fraction content. This suggests that granite residual soil has both the properties of clay and sandy clay.

Table1. Statistic table of physical and mechanical properties of silt sandy clay

name	statistical index	ω/ %	ρ/ g/cm3	e	ωL/ %	ωp/ %	Ip	IL	a/ MPa-1	Es1-2/ MPa	c / kPa	φ/ °
sandy clay	sample	97	97	97	97	97	97	97	96	96	96	96
	minimum	25.6	1.8	0.825	38	20.6	13.2	0.08	0.4	3.82	16.5	18.4
	maximum	31.3	1.9	0.93	45.6	28.9	18.6	0.3	0.48	4.71	24.6	26.3
	average	29.1	1.86	0.864	41.8	26.3	15.5	0.18	0.44	4.22	19.9	23.2
	standard deviation	1.86	0.03	0.03	3.01	3.01	1.89	0.08	0.03	0.35	2.9	2.74
	variation coefficient	0.06	0.02	0.04	0.07	0.11	0.12	0.42	0.07	0.08	0.15	0.12
	standard value	30.3	1.88	0.887	43.8	28.3	16.8	0.23	0.46	3.99	17.9	21.3

3. Granite residual soil has significant structural

As for nonstructural and weak structural soil, the cohesion increases with the increase of clay content in the soil. This simply mean that the greater the plasticity index, the greater the cohesion. But Figure 1.1 illustrates that cohesion and plasticity index are not relevant but a little contrary trend.

Similarly, the reduction of coarse fraction content and angle of internal friction must be relative with the increase of clay content and cohesion. But Figure 1.2 shows that most of angle of internal friction are about 20° and there is nothing to do with the change of cohesion. On one hand, this shows that granite residual soil has significant structural and the cohesion of soil mainly depends on the strength of structure while the influence of clay content is small. On the other hand, various links of test on soil have generated disturbance but the degree of the disturbance is not the same. This result is the same as the conclusions of the study on engineering problems and structural properties of granite residual soil by Wu Neng-sen [12].

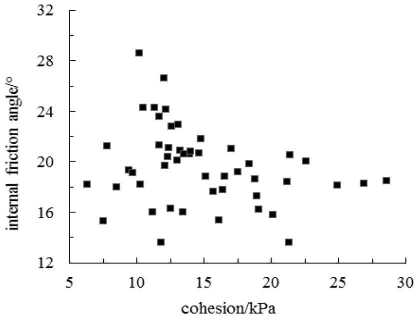

Figure 1.1 Relationship between internal friction angle and cohesion

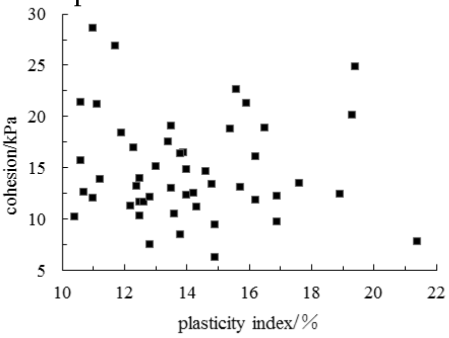

Figure 1.2 Relationship between cohesion and plasticity index

4. Correlation analysis between parameters of granite residual soil

There is an interior relationship between the physical and mechanical properties of indicators of granite residual soil. It is significant to study the relationship between soil parameters. Because it is conducive to a comprehensive understanding of engineering properties of granite residual soil and provides the basis for rational selection of geotechnical parameters. Monadic linear regression analysis and nonlinear regression analysis were set up through the test report of 220 granite residual soil samples. And then put the minimum residual mean square as the best fit. Finally obtain the regression equation between localized parameters.

We can get the following conclusion from Table 2 and Figure 2

1) As for granite residual soil, there is a positive correlation between water content and plasticity index, void ratio, liquid limit, plasticity index, void ratio, liquid limit, plastic limit, compressibility, and correlation index(R^2) ranges from 0.7051 to 0.9698. But as the increase of water content, the natural density and compression modulus are reduced.

2) There is a good correlation between void ratio and natural gravity, compression modulus, compression coefficient. Among them, the compression coefficient increases with the increase of the ratio of pore while compression modulus and natural gravity decrease with the increase of void ratio. In addition, liquid limit and plastic limit also have a strong correlation, and their correlation index achieves 0.9589.

Table 2 Correlation of physical and mechanical indexes of granite residual soil

number	sample	independent variable	dependent variable	regression equation	correlation coefficient	correlation test
1	180	ω	e	e=0.0254ω+0.1149	0.9698	significant relation
2	180	ω	γ	γ=-0.0102ω+2.1706	-0.7549	significant relation
3	110	ω	Es	Es=-0.0549ω+5.8588	-0.6452	significant relation
4	110	ω	a	a=0.0135ω+0.0759	0.8163	significant relation
5	180	ω	ωL	ωL =0.6886ω+18.392	0.8508	significant relation
6	180	ω	ωp	ωp=0.4737ω+11.310	0.8224	significant relation
7	220	ω	Ip	Ip=0.2149ω+7.0827	0.6051	significant relation
8	220	ωL	ωp	ωp=0.6775ωL -0.9302	0.9589	significant relation
9	220	γ	e	e=-0.1276γ+3.2480	-0.6245	significant relation
10	220	E	Es	Es=-1.8954e+5.7756	-0.6635	significant relation
11	220	e	a	e=0.5258a+0.0203	0.8328	significant relation

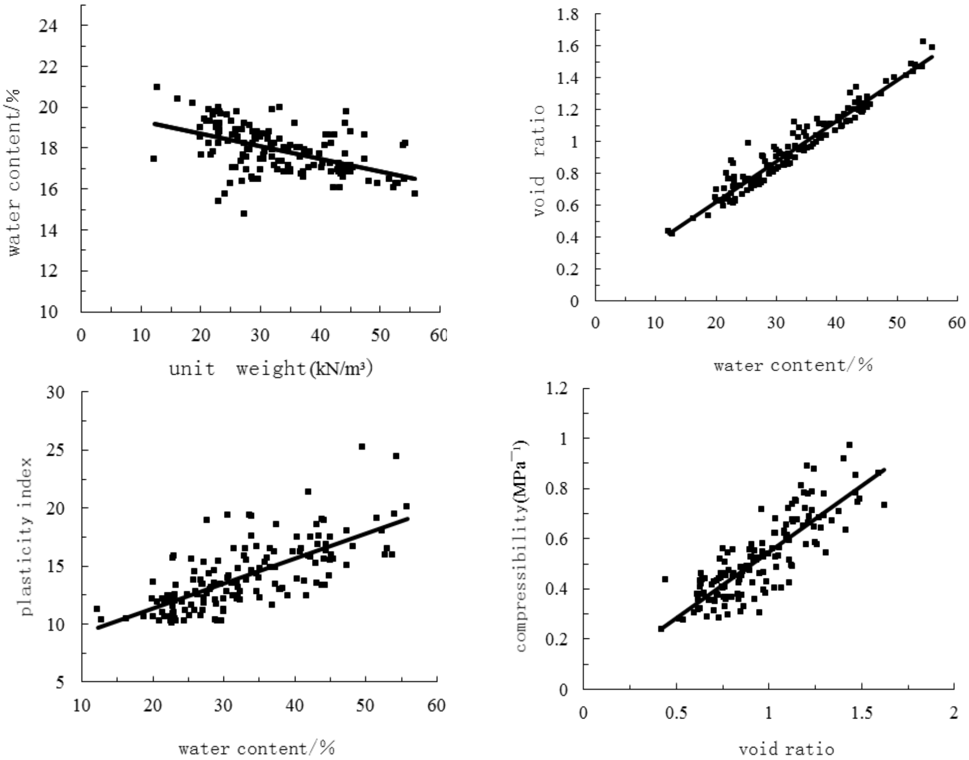

Figure 2 Curve of correlation of physical and mechanical indexes of granite residual soil

5. Conclusions

1. The variation coefficient of physical and mechanical indexes of granite residual are diversity because geotechnical experiment and the influence of sampling disturbance are different, among them, variation coefficient of internal friction angle , cohesion, liquidity index and plasticity index are large while variation coefficient of the natural density, water content, void ratio, compression modulus and coefficient of compression are small, which can be a reference index of the engineering application.

2. Granite residual soil has a strong structural, and there is a big difference between granite residual and non structural soil in terms of the physical mechanics indexes. Cohesion is not only associated with clay content but also depends on the structural strength of soil.

3. The statistical analysis points out that there is positive correlation between water content and plasticity index, void ratio, liquid limit, plastic limit, coefficient compression.

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