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To cite this article: Zhen Li *et al* 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **300** 022131

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The Applicability of Soil Density Gauge in The Detection of Non-Cohesive Soil

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Abstract: With the needs of engineering construction, non-cohesive soil has been widely used in important fields such as dams and roadbed filling. The strength and compressibility of non-cohesive soil mainly depend on the compactness. However, it has so far been difficult to find a method for determining the compactness of non-cohesive soil quickly, accurately and safely. In order to cope with this problem, this paper focuses on the working principle and operation process of the SDG200 soil densitometer. At the same time, on the basis of summarizing the previous research, it is pointed out that the difference between the operation of clay soil and non-cohesive soil density is tested by SDG soil densitometer, and the parameter setting problem in the non-cohesive soil compactness test is solved. Therefore, it can be predicted that the SDG soil densitometer will have a good application prospect in the detection of non-cohesive soil compactness.

1. Introduction

In recent years, with the rapid development of the economy, China has increased its investment in engineering construction. The quality of the engineering fill is usually controlled by the compaction index, and the compaction performance of different soils is quite different [1]. In general, the compaction effect of non-cohesive soil is better. When the non-cohesive soil is in a compact state, the structure is stable, the compressibility is small, and the strength is large, which can be used as a good natural foundation, and has great research significance and use value.

In theory, the methods currently available for the detection of non-cohesive soil compactness include damage methods (ring knife method, sand filling method and irrigation method) and non-destructive [2] method nuclear density meter method. However, since the viscosity of the non-cohesive soil is poor and loose, when the traditional damage method is used, the soil sample is not easy to form, the operation is difficult, and the test result is inaccurate. The non-destructive testing method is a method for indirectly detecting the degree of compaction. Such a method can maintain the integrity of the soil to be tested, reduce the damage to the compacted roadbed and the compacted dam, and can greatly improve the detection [3] efficiency. However, the use of the nuclear density meter method is complicated and there is a danger of nuclear radiation. Therefore, there is an urgent need for a method capable of non-destructive, safe and accurate detection of the density of non-cohesive soil. The SDG Soil Density Meter is a non-destructive fill density detector developed based on electromagnetic principles. It is not only



easy to operate, but also safe and reliable. It can be predicted that the SDG soil densitometer will have a good application prospect in the detection of non-cohesive soil compactness.

2. Working principle and parameter setting of SDG200 soil density meter

The SDG200 Nuclear Soil Densitometer is a non-destructive testing instrument for soil compactness testing introduced in recent years. Compared with various traditional lossy measurement methods and other non-destructive measurement methods, SDG200 shows excellent advantages and is the current advanced soil density detection instrument [4]. The physical picture is shown in Figure 1.

SDG200 adopts electrochemical impedance mapping technology, which can distinguish soil density from water content when measuring electromagnetic field. Its compactness is achieved by non-destructive testing by electromagnetic induction field response to electrochemical impedance of material matrix. The SDG200 uses the built-in data processor to calculate the density, compaction and soil moisture content of the compacted fill data, and realize real-time rapid non-destructive testing of the fill density on site. The SDG200 can be used on compacted fills up to 30 cm [5] deep and 28 cm in diameter. Comparing other test methods at home and abroad, SDG has the following advantages:

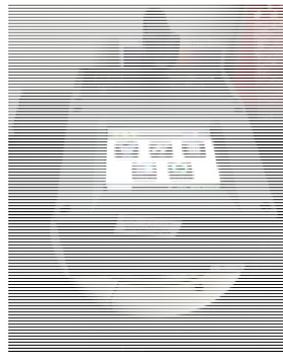


Figure 1. SDG200 Soil Densitometer Before the test of SDG non-cohesive soil compactness, the front parameters of the soil to be tested are first input into the instrument, including the maximum dry density

- (1) There is no radioactive source, it can replace nuclear instrument;
- (2) User-friendly interface and simple operation;
- (3) Fast, reliable, accurate, lightweight, easy to use and support 12 hours of portable operation;
- (4) Lossless and repeatable measurement, the internal data logger stores a large number of readings;
- (5) The pre-parameter setting is simple.

ρ_{dmax} , the optimal moisture content ω_{op} , the liquid limit ω_L , the plastic limit ω_P , and the uneven coefficient C_u , curvature coefficient C_c , Gravel, Sand, Fines. This is an important step in the operation of the instrument.

The physical parameter interface of the SDG200 is shown in Figure 2. It is worth noting that the input parameters must be 100% of the sum of % Gravel, % Sand and % Fines [6]. Because the non-cohesive soil is different from the cohesive soil, there is no liquid limit and plastic limit. Therefore, when the density measurement of the non-cohesive soil is performed, the above two parameters can be set to 0.

3. Geotechnical test parameters required for SDG to detect non-cohesive soil compactness

Since the most important physical state parameter of the non-cohesive soil is its compactness, the relative compactness D_r is introduced into the soil mechanics as an index for judging the state of the non-cohesive soil. Relative density D_r expression is as follows:

$$D_r = \frac{(\rho_d - \rho_{dmin})\rho_{dmax}}{(\rho_{dmax} - \rho_{dmin})\rho_d}$$

In the formula: ρ_{dmax} — Maximum dry density of cohesive soil;

ρ_{dmin} — Minimum dry density of non-cohesive soil;

ρ_d — Natural dry density or dry density of non-cohesive soil.

According to the preliminary research, the maximum dry density and the optimum moisture content of the clay soil can be obtained by the compaction test. However, because the difference between non-cohesive soil and cohesive soil is large, how to obtain the maximum dry density (minimum void ratio)[6] and optimal water content of non-cohesive soil becomes a difficult point to detect the density of non-cohesive soil using SDG200 soil densitometer. In this paper, the maximum dry density (minimum void ratio) of non-cohesive soil is measured by vibration method, and the problem is solved by the conversion relationship between maximum dry density (minimum void ratio) and optimal water content, which ensures the accuracy of test data and rationality.

3.1. Vibration test for maximum dry density test of non-cohesive soil

The maximum dry density ρ_{dmax} is the dry density of the soil sample in the most dense state. During the test, the dried sample is placed in the container, and when the sample is hammered in the vertical direction and laterally vibrated in the horizontal direction, the sample weight M_s is weighed when the sample reaches a constant volume V . You can get

$$\rho_{dmax} = \frac{M_s}{V}$$

Since the maximum dry density ρ_{dmax} of the non-cohesive soil is known, the optimal moisture content ω_{op} can be derived from the following formula.

$$\rho_d = \frac{\rho}{1 + 0.01\omega}$$

In the formula: ρ_d — Dry density, g/cm³;

ρ — Wet density, g/cm³;

ω — Moisture content, %.

The wet density ρ of the vibrating soil is calculated from the volume of the measuring cylinder and the total mass of the vibrated soil in the cylinder. Since the vibration test has measured the maximum dry density, the optimum moisture content ω_{op} can be obtained by substituting this equation [7].

3.2. screening method particle analysis test

According to the particle size and gradation of the soil in this test, the sieving method is selected as a method for performing particle analysis test, which is suitable for analyzing particle compositions having a particle diameter of more than 0.075 mm and less than 60 mm.

4. Conclusion

SDG soil densitometer is the latest generation of nuclear-free density meter at home and abroad. Its appearance makes up for the limitations of various methods for measuring soil density. It uses completely non-destructive testing methods and has no damage to the soil. It is the most advanced soil density testing instrument. It has the advantages of fast measurement, accurate data, simple operation, easy to carry, and repeatable operation, so as to realize dynamic real-time inspection and control of on-site compaction quality. Moreover, it does not pose a safety hazard to the engineering and operation personnel during the testing process, and provides great help for the compactness detection of various

soils. The test and laboratory tests are carried out according to the characteristics of the densitometer. The SDG densitometer has good stability and reliability, and the prediction will be applied to the rapid non-destructive testing of non-stick soil compactness.

5. Acknowledgement

The paper was supported by the national natural science fund project (51678221), Education Department of Heilongjiang province (No.12521409), Application technology research and development plan to guide project in Heilongjiang province (GZ16B013), and science and technology project of Heilongjiang sanjiang engineering construction administration (HGZL/KY-01)

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