Research on the Electrical Resistivity Characteristics of Statue Remolded Soil

Liping Qiu¹, Yaogui Yang¹,*, Linyan Ma² and Jiawei Qiao¹

¹Key Laboratory of Subsurface Hydrology and Ecological Effect in Arid Region, Ministry of Education, School of Water and Environment, Chang'an University, Xi'an 710054, China
²Shaanxi Provincial Institute of Archaeology, Xi'an 71005, China

*Corresponding author: yaogui_yang@chd.edu.cn

Abstract. In order to study the electrical resistivity characteristics of the statue remodeled soil and make it play a role in the theory and related engineering applications, the electrical resistivity measurement of the statue remodeled soil was carried out using the a two-electrode method. This paper analyzes the law and characteristics between the electrical resistivity of the coarse and fine mud layers of the statue and the water content and dry density, and establishes the empirical model of the electrical resistivity of the coarse and fine mud layers. The measurement indicate that the electrical resistivity of the coarse and fine mud layers of the remodeled soil of the statue shows a power function decrease with the increase of mass water content, and with the increase of dry density. And under the conditions of the same mass water content and dry density, the electrical resistivity of the coarse mud layer is always lower than that of the fine mud layer. Based on the experimental results, the electrical resistivity model of the coarse and fine mud layers of the statue remodeled soil and the relationship model between the electrical resistivity of the earthen plaster of statue and the mass water content are proposed. This will provide reference for the non-destructive testing of the moisture content of the precious cultural relics of the statue and the engineering research and practical engineering application of similar materials such as the reinforced soil slope protection, retaining wall and foundation, etc.

Keywords: electrical resistivity, mass water content, statue remodeled soil, coarse mud layers, fine mud layers, statue earthen plaster

1. Introduction

The statue remodeling soil is a special reinforced soil, which is made by mixing soil, sand, and reinforced materials (wheat straw or hemp) in a certain proportion. As an effective soil improvement technology, reinforcement is characterized by adding a certain proportion of special materials to the soil to enhance the strength and stability of buildings [1]. In ancient times, it can be used to make statues, build cities and other buildings, and has broad application prospects in modern times, such as in civil construction, road engineering and other fields.
As a common geophysical method, the electrical resistivity method measures the soil electrical resistivity by recording the voltage drop across the soil and the intensity of the current passing through the soil. This method has low cost and fast test speed, which can realize fast and non-destructive detection of objects with specific structures. It is widely used in various aspects, including moisture content measurement [2, 3, 4], detection and measurement of pollutants [5, 6, 7], exploration of soil micro-structure and its mechanical properties [8, 9, 10], The structure detection of tombs in archaeology and the location of cultural relics [11].

Soil is generally a three-phase body composed of solid phase, liquid phase and gas phase, and the important factors that affect the resistivity result include soil type [12], mass water content [4], porosity [13], water saturation [14], Temperature [15], salt concentration [16, 17], organic matter content [18], etc [19]. Dry soil becomes an insulating material due to its very low ion mobility. The current flowing through the pore water in the wet soil makes the mobility of ions higher, and flows through the surface of the particles with a large amount of high specific surface area, so the wet soil is a semiconductor material. It can be said that the water content of the soil directly affects the soil resistivity, and for a certain soil with a specific structure, the electrical resistivity changes depend on the changes in its water content and temperature. And at the same temperature, the electrical resistivity depends on the mass water content [4, 20].

In recent years, scholars have achieved certain theoretical results and have been initially applied to guide engineering practice on the resistivity characteristics of many kinds of soils, such as sandy soil [21, 22], loess [23, 24], saline soil [25, 26], clay [8, 27, 28], marine clays [29], expansion soil [30, 31], contaminated soil [15, 32], frozen soil [33], refuse soil [34], etc. In view of the special composition of the statue remolded soil and the distinct layering of the statue earthen plaster, there are few records on the electrical resistivity characteristics of the statue remolded soil. Therefore, it is necessary to conduct systematic research on the influencing factors and changing laws of electrical resistivity, model theory, and the quantitative relationship between electrical resistivity and its physical and mechanical properties.

2. Another section of your paper

The water content has a profound impact on the aging and damage speed of cultural relics, and the statue will produce different degrees of disease under the influence of factors such as humid environment or slow penetration of capillary water [2, 35]. It is of great significance to carry out research on the electrical resistivity characteristics of statue remolded soil and its relationship with water content for disease prevention and research of statue relics. This research will not only help to recognize the basic electrical characteristics of the statue remolded soil, but also provide certain theoretical and experimental support for the non-destructive testing of the water content of the precious cultural relics like statue. It can also provide references for engineering research and practical engineering applications of similar materials such as reinforced soil slope protection, retaining walls and foundations [36]. This paper mainly studies the electrical resistivity characteristics of statue remolded soil, while controlling the water content and dry density of the soil for electrical resistivity measurement. Finally, according to the experimental observations, the electrical resistivity model of the coarse and fine mud layers of the statue remolded soil and the relationship model between the electrical resistivity of the earthen plaster of statue and the mass water content were proposed.

2.1. Materials

The remolded soil sample of the statue used in the experiment was taken from a cliff around a certain clay sculpture cultural relic. At the same time, the local river sand, wheat straw and raw hemp are taken, and the raw materials taken are processed and tested.

The soil sample is air-dried, desalinated, dried, and passed through a 0.5mm sieve before the test. The sand is washed repeatedly and passed through a 0.5mm sieve. Store all materials after processing. Since the earthen plaster of statue is mainly composed of coarse and fine mud layers, in order to ensure that the experiment is more reasonable and perfect, the test blocks of the simulated statue earthen plaster and
coarse and fine mud layers is made according to the existing statue production process. Table 1 shows the basic physical indexes of the prepared soil samples.

**Table 1.** The basic physical indicators of the coarse and fine mud layer of the statue remodeled soil

| Type            | Optimal moisture content (%) | Maximum dry density (g/cm³) | Material mass ratio                |
|-----------------|------------------------------|----------------------------|-----------------------------------|
| Coarse mud layer| 15.23                        | 1.94                       | Soil: sand: wheat straw=98.5: 3.2: 1 |
| Fine mud layer  | 14.90                        | 1.97                       | Soil: sand: hemp=74.25: 24.75: 1   |

The soil, sand, fiber, and water with corresponding mass water content are weighed according to the material mass ratio, and mixed evenly, and then placed in a plastic bag and allowed to stand for more than 24 hours to make them fully mixed. The test soil sample was pressed into a shape by a pressure sampler with an inner diameter of 50 mm and a height of 100 mm. After the test block was made, the side of the soil block was wrapped with plastic wrap to prevent water loss from the side of the soil block. For the control of the dry density of the test block, the quality of the required water and dry soil is calculated according to the required moisture content and the volume of the test block, and the uniformly mixed material is filled into the sample press for sample compression. For the control of test block mass water content, the test block is immediately destroyed after the sample compression and electrical resistivity measurement are completed. The sample core is taken for mass water content measurement, and the obtained mass water content is the actual mass water content of the test block.

2.2. Theory

The electrical resistivity of soil is actually the electrical resistance exhibited when the current passes through a cubic soil with a side length of 1 m vertically. Its unit is Ω·m. It is the basic parameter to characterize soil conductivity and has important theoretical significance and application value, which can reflect the basic physical and mechanical properties and structural characteristics of soil [20, 37]. Soil electrical resistivity testing methods can be divided into two-electrode method and four-electrode method [37], and Figs. 1-2 show the specific test method.

![Two-electrode method](image1)

**Figure 1.** Two-electrode method

![Four-electrode method](image2)

**Figure 2.** Four-electrode method

The four-electrode method has power supply electrodes A, B and measurement electrodes M, N. The power supply electrodes are mainly used for current flow and the measurement electrodes are inserted into the soil sample to determine the voltage drop of the soil sample. In the two-electrode method, the
potential difference between the two ends of the soil sample is directly measured by a high impedance voltmeter, the current intensity is measured by an ammeter, and then the electrical resistivity of the soil is calculated by the formula. The electrodes A and B are both power supply electrodes and measurement electrodes. It has the advantages of simple operation and little disturbance to the soil sample. The main disadvantage is that the measurement result may include contact resistance, and the soil near the electrode will be polarized when the current passes. In order to reduce the experimental error, a layer of material with excellent conductivity can be applied to the contact surface between the electrode and the soil, such as conductive paste, graphite, etc., and the contact resistance can also be corrected [38].

Considering the experimental conditions and the particularity of the simulated statue earthen plaster test block composed of coarse and fine mud layers distributed up and down, the two-electrode method was used in this experiment. Fig. 3 shows the GDM-8261A type 6 1/2 digital dual display measuring multimeter, which is used to measure soil resistance.

![GDM-8261A type dual display measuring multimeter](image)

**Figure 3.** GDM-8261A type dual display measuring multimeter

2.3. **Experimental method**

After the test block is prepared, a conductive paste of about 2mm thickness on the surface of the test block is evenly spread on the surface of the test block, and a thin copper electrode sheet with a thickness of approximately 2 mm and a diameter of 50 mm was tightly attached to the upper and lower ends of the test block. The test block is placed on the insulating pad and then connected to the measuring circuit, and the resistance value displayed by the digital multimeter is read. After repeating the measurement 3 times, the arithmetic average is taken as the final test result. After calculating the electrical resistivity of the test block according to the electrical resistivity formula, the test block is immediately destroyed, and the mass water content of the sample core is measured by geometrical method. Electrical resistivity tests are all completed within 1 minute to avoid errors caused by long-term energization and heating of the soil. Check the test equipment before the start of the test, and formulate a set of standardized operating procedures to check and correct or redo observations with obvious errors. The electrical resistivity of the test block is calculated as

$$\rho = \frac{RA}{L}$$

Where $\rho$ is the electrical resistivity, $R$ is the resistance value of the test block, $L$ is the distance between the measuring electrodes, and $A$ is the cross-sectional area of the test block along the current direction.

All the electrical resistivity in this paper are the standard resistivity at 18°C calculated by the temperature correction formula. The temperature is corrected as [39]

$$\rho_T = \frac{\rho_{18}}{1 + \alpha (T - 18)}$$

(2)
Where $\rho_T$ and $\rho_{18\,\degree C}$ are the electrical resistivity of the test block at the test temperature and 18°C respectively; $T$ is the test temperature; $\alpha$ is the test constant, usually $0.025\,\degree C^{-1}$.

3. Organization of the Text

3.1. Contact resistance

The contact resistance is mainly caused by the irregularity of the soil particles and the incomplete contact with the electrode. This experiment uses the two-electrode method to measure the electrical resistivity of the soil. Although the conductive paste has been applied, the test result still contains the contact electricity. In order to reduce the experimental error, the contact resistance needs to be corrected. Under the conditions of the same dry density and mass water content, the coarse mud and fine mud test blocks with heights of 1, 2, 4, 5, and 6 cm were made and measured for resistance. Drawing a straight-line fitting curve between the resistance and the length of the test block, the intercept obtained is the contact resistance $R_0$ by extending the straight line to intersect the resistance axis. And the $D$-value between the measured resistance $R$ and the contact resistance $R_0$ is the resistance value of the sample after the contact resistance correction. In order to avoid the influence of the contact area between the electrode and the soil, the full cross-sectional contact between the copper sheet and the test block was used for measurement. All the electrical resistivity data in this paper are the actual electrical resistivity after contact resistance correction.

![Figure 4](image1.png)

**Figure 4.** Test result of contact resistance of fine mud layer

![Figure 5](image2.png)

**Figure 5.** Test result of contact resistance of coarse mud layer
Figures 4, 5, 6 respectively present the test results of the contact resistance of the fine mud layer, coarse mud layer, and simulated test block of the earthen plaster of statue. There is a good linear relationship between the measured resistance and the length of the test block, and the correlation coefficient is greater than 0.95. As the mass water content increases, the contact resistance becomes larger, which may be due to the increase in the moisture content that makes the contact between the test block and the electrode better.

3.2. Mass water content

In order to analyze the electrical resistivity characteristics of the statue remodeled soil, this paper measures the electrical resistivity of coarse and fine mud layers with different dry densities and different mass water contents based on the analysis of previous research results. The mass water content of the test is 3%, 5%, 7%, 10%, 12%, 13%, and the dry density is 1.5, 1.65, 1.8, 1.95, respectively.

Figure 7. Fitting curve of relation between electrical resistivity and mass water content of fine mud test block
Figures 7, 8 are the fitting curves of the electrical resistivity of the fine and coarse mud layers of the statue remolded soil with the mass water content. The electrical resistivity decreases with the increase of mass water content. The trend of the curve reflects that the water content is an important factor affecting the change of soil resistivity, especially when the water content is low, a small increase in water content will bring about a significant drop in soil electrical resistivity. When the mass water content changes from 2% to about 6%, the electrical resistivity drops sharply from a few hundred ohm·m to tens of ohm·m; When the mass water content changes from 6% to about 11%, as the mass water content continues to increase, the electrical resistivity gradually decreases, and the decline becomes smaller than when the mass water content is lower.

The main reason for the phenomenon is that the pore water in the test block can not form an effective conductive path when its mass water content is small. The increase of mass water content will improve the connectivity of pore water, resulting in a sharp drop in electrical resistivity. When the mass water content is greater than about 11%, the electrical resistivity decline trend tends to be flat. This is mainly because as the mass water content continues to increase and exceeds a certain value, the pores are almost filled with pore water, and the conductive path has reached a good state. Continuing to increase the mass water content of the soil sample has little effect on the connectivity of pore water, so that the increase in mass water content has almost no effect on the electrical resistivity.

By comparing Figures 7, 8, it is found that the electrical resistivity of the coarse mud test block is always lower than that of the fine mud test block under the same mass water content and dry density conditions. The reason may be that the fine mud layer contains a large proportion of sand, which reduces its inter-particle conductivity. Moreover, due to the porosity of the wheat straw fibers in the coarse mud layer compared to the hemp fibers in the fine mud layer, there are more water storage pores inside the coarse mud sample and more pore water conductive pathways are formed, resulting in the electrical resistivity of the coarse mud layer being smaller than that of the fine mud layer.

Table 2 shows the fitting results and correlation between soil electrical resistivity and water content under different dry density conditions. The law that the electrical resistivity decreases with the increase of mass water content accords with the power exponential decay, and the curve fitting correlation coefficients are all greater than 0.97.
Table 2. Fitting formula for the relationship between soil electrical resistivity and mass water content

| Mud layer     | Dry density(g/cm³) | Fitting formula          | Correlation coefficient |
|---------------|-------------------|--------------------------|-------------------------|
| Coarse mud layer | 1.50              | $\rho = 184224\omega^{-1.609}$ | $R^2=0.99$               |
| Coarse mud layer | 1.65              | $\rho = 136457\omega^{-1.582}$ | $R^2=0.99$               |
| Coarse mud layer | 1.80              | $\rho = 116673\omega^{-1.605}$ | $R^2=0.98$               |
| Coarse mud layer | 1.95              | $\rho = 117444\omega^{-1.732}$ | $R^2=0.99$               |
| Fine mud layer    | 1.50              | $\rho = 163883\omega^{-1.523}$ | $R^2=0.99$               |
| Fine mud layer    | 1.65              | $\rho = 140953\omega^{-1.699}$ | $R^2=0.99$               |
| Fine mud layer    | 1.80              | $\rho = 901.76\omega^{-1.609}$ | $R^2=0.99$               |
| Fine mud layer    | 1.95              | $\rho = 640.98\omega^{-1.570}$ | $R^2=0.99$               |

3.3. Dry density

Dry density is one of the important soil structure parameters that affect the electrical resistivity of the soil. The greater the dry density of the soil, the closer the contact between the particles, which is more conducive to the conduction between the solid particles, thus affecting the electrical resistivity.

Figure 9. Fitting curve of relation between electrical resistivity and dry density of fine mud test block

Figure 10. Fitting curve of relation between electrical resistivity and dry density of coarse mud test block
Figures 9, 10 are the fitting curves of the relationship between the dry density and the electrical resistivity of the fine and coarse mud layers of the statue remolded soil. The electrical resistivity decreases exponentially with the increase of its dry density, and with the increase of water content, the trend of its electrical resistivity changing with the dry density gradually becomes gentle. The main reasons are: ① When the dry density is small, the contact between soil particles is poor. With the increase of dry density, the contact between soil particles becomes tighter, making the originally dispersed pore water in the soil easier to form conductive paths, and ultimately reducing the electrical resistivity. The dry density has a small variation range, so when it increases to a certain extent, a stable pore water conductive path is formed, which makes the electrical resistivity value gradually stabilize; ② The conductive mode in the soil is mainly pore water conductivity and soil particle conductivity. Under the condition of low mass water content, soil particles have certain advantages in electrical conductivity. As the dry density increases, the soil particles are in close contact, which greatly enhances the conductivity of soil particles. Therefore, when the mass water content is low, the electrical resistivity changes significantly with the dry density; ③ As the mass water content continues to increase, the electrical conductivity of soil particles becomes negligible relative to the electrical conductivity of the pore water. Therefore, under the condition of high mass water content, the electrical resistivity change caused by the change of dry density becomes weaker and weaker.

Table 3. Fitting formula for the relationship between soil electrical resistivity and dry density

| Mud layer     | Mass water content (%) | Fitting formula | Correlation coefficients |
|---------------|------------------------|----------------|--------------------------|
| Coarse mud layer | 3.17       | $\rho = 759.11\rho_d^{-2.403}$ | $R^2=0.99$ |
| Coarse mud layer | 4.80       | $\rho = 446.37\rho_d^{-2.827}$ | $R^2=0.98$ |
| Coarse mud layer | 5.90       | $\rho = 311.06\rho_d^{-2.947}$ | $R^2=0.99$ |
| Coarse mud layer | 7.08       | $\rho = 255.47\rho_d^{-2.955}$ | $R^2=0.98$ |
| Coarse mud layer | 10.12      | $\rho = 204.23\rho_d^{-3.297}$ | $R^2=0.99$ |
| Coarse mud layer | 12.03      | $\rho = 152.75\rho_d^{-3.128}$ | $R^2=0.97$ |
| Fine mud layer  | 2.77       | $\rho = 1561.69\rho_d^{-3.773}$ | $R^2=0.98$ |
| Fine mud layer  | 3.96       | $\rho = 102305\rho_d^{-4.004}$ | $R^2=0.99$ |
| Fine mud layer  | 5.13       | $\rho = 756.88\rho_d^{-4.44}$  | $R^2=0.99$ |
| Fine mud layer  | 6.70       | $\rho = 543.52\rho_d^{-4.399}$ | $R^2=0.99$ |
| Fine mud layer  | 10.15      | $\rho = 376.42\rho_d^{-4.557}$ | $R^2=0.99$ |
| Fine mud layer  | 11.57      | $\rho = 335.42\rho_d^{-4.881}$ | $R^2=0.98$ |

Table 3 shows the fitting results and correlation between soil electrical resistivity and its dry density under different mass water content conditions. The electrical resistivity of soil decreased exponentially with dry density, and the correlation coefficients of curve fitting were all greater than 0.97.

3.4. Coarse and fine mud layer resistivity model

3.4.1. Model building. Archie [39] first studied the relationship between soil resistivity and its structure, and proposed a electrical resistivity structure model suitable for saturated non-cohesive soil and pure sandstone and established the relationship equation between electrical resistivity and pore water electrical resistivity. The relation equation of resistivity change with pore water resistivity is calculated as
\[ \rho = \alpha \cdot \rho_w \cdot n^{-m} \]  

(3)

Where \( \alpha \) is the soil parameter; \( m \) is the cementation coefficient; \( n \) is the porosity; \( \rho_w \) is the pore water resistivity.

However, this model ignores the influence of the conductivity of the particles adsorbed on the surface of the soil particles on the entire conductivity of soil, but it is still suitable for saturated sands with low pore water electrical resistivity and low viscosity components. In order to expand the adaptability of the Archie model, Keller [40] carried out further theoretical analysis and experimental research on the resistivity model, and proposed to use the promoted Archie model to express the electrical resistivity. The promoted Archie model is calculated as

\[ \rho = \alpha \rho_w n^{-m} S_r^{-b} \]  

(4)

Where \( S_r \) is medium saturation; \( \alpha, m, b \) are soil parameters; \( \rho_w \) is pore water electrical resistivity; \( n \) is porosity.

For the low saturation medium with the same structure, its saturation and porosity can be expressed by dry density and mass water content. Therefore, this paper draws on the improved Archie formula to derive the electrical resistivity model of the coarse and fine mud layers. Electrical resistivity is calculated as

\[ \rho = \alpha \rho_w n^{-m} S^{-b} = K \rho_d^{-a} w^{-b} \]  

(5)

Where \( K \) is a comprehensive parameter of soil, which is related to pore water resistivity \( \rho_w \) and soil porosity \( n \); \( a \) and \( b \) are test parameters; \( \omega \) is soil mass water content; \( \rho_d \) is dry density.

3.4.2. Model verification. In order to further verify the accuracy of formula (5), according to the data of the change in electrical resistivity of coarse and fine test block with mass water content and dry density in this experiment, an empirical three-parameter fitting model of the relationship between the electrical resistivity of the fine and coarse mud layer, the mass water content and the dry density is obtained after statistical analysis of the data. Figs. 11-12 show the fitted surface diagram.

\[ \text{Figure 11. Fitting results of the relationship between electrical resistivity, mass water content and dry density of fine test block} \]
The three-parameter fitting model of the relationship between the electrical resistivity of the fine and coarse mud layer, the mass water content and the dry density is expressed as

$$\rho_F = 8010.40 \rho_d^{-3.949} w^{-1.526} \quad R^2 = 0.97$$

$$\rho_C = 5381.33 \rho_d^{-2.448} w^{-1.685} \quad R^2 = 0.99$$

(6)

Where $\rho_F$ is the electrical resistivity of the coarse mud layer; $\rho_C$ is the electrical resistivity of the fine mud layer.

The fitting result is ideal, which verifies the rationality and accuracy of the theoretical model.

### 3.5. Electrical resistivity model of statue earthen plaster

The measured electrical resistivity of a homogeneous soil is isotropic. The simulated statue earthen plaster test block produced by the laboratory includes a fine mud layer of 1 cm in the upper layer and a coarse mud layer of 4 cm in the lower layer (see Fig.13), which makes the entire soil sample uneven in the vertical direction, so the measured electrical resistivity is anisotropic. And since the current flows into the fine mud layer and then into the coarse mud layer during the actual test, this paper only conducts the vertical electrical resistivity test on the statue earthen plaster test block. According to the resistivity theory of layered media, for anisotropic media, when current flows through the direction of the layering, the measured electrical resistivity is called its lateral electrical resistivity. And the lateral electrical resistivity can be expressed as

$$\rho = \frac{\rho_F h_F + \rho_C h_C}{h_F + h_C}$$

(7)

Where $h_F$ is the length of the coarse mud layer; $h_C$ is the length of the fine mud layer.

Then the electrical resistivity of the statue earthen plaster can be expressed as

$$\rho = \frac{\rho_F \cdot 1/5L + \rho_C \cdot 4/5L}{L} = 1/5\rho_F + 4/5\rho_C$$

(8)

Where $L$ is the total length of the simulated statue earthen plaster test block.
By comprehensive formula (6-7, 8), the electrical resistivity model of the statue earthen plaster can be expressed as

\[ \rho = 160207\omega^{-1.526} \rho_d^{-3.949} + 4305.07\omega^{-1.685} \rho_d^{-2.448} \]  

(9)

Figure 13. Schematic diagram of simulated statue earthen plaster test block

In order to further verify the formula (9), the electrical resistivity of simulated statue earthen plaster test blocks with dry densities of 1.775 and 1.65 and mass water content of 3%, 5%, 7%, 10%, and 12% were tested. And the measured value was compared with the electrical resistivity model curve of the statue earthen plaster.

Figure 14. When \( \rho_d = 1.65 \), the measured value and the model curve of the relation between electrical resistivity and mass water content

Figure 15. When \( \rho_d = 1.775 \), the measured value and the model curve of the relation between electrical resistivity and mass water content
Figures. 14-15 show the comparison results. The measured value is basically consistent with value calculated by the relationship model between the electrical resistivity and mass water content of the statue earthen plaster. This model can better characterize the quantitative relationship between the electrical resistivity of the statue earthen plaster and the mass water content.

4. Conclusions
This paper takes the statue remolded soil as the research object, and analyzes the law of the electrical resistivity of the statue earthen plaster with the mass water content and dry density through the indoor electrical resistivity measurement. The research conclusions are as follows:

① The electrical resistivity of the coarse and fine mud layers of the statue remolded soil decreases exponentially with the increase of mass water content. At low mass water content, a small increase in mass water content will bring about a significant drop in electrical resistivity. And under the same conditions, the electrical resistivity of coarse mud layer is always lower than that of fine mud layer.

② The electrical resistivity of the coarse and fine mud layers of the statue remolded soil decreases exponentially with the increase of dry density. With the increase of soil mass water content, the trend of electrical resistivity changing with dry density gradually becomes gentle, which reflects that the dry density is an important factor affecting the electrical resistivity changes of the statue remolded soil.

③ According to the test results, based on the promoted Archie electrical resistivity model and layered medium electrical resistivity theory, the electrical resistivity model of the coarse and fine mud layers of the statue remolded soil and the model of the relationship between the electrical resistivity and mass water content of the statue earthen plaster are deduced.

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