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Using Artificial intelligence to analyze the failure mechanism of rubber concrete in sandstone soils

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Abstract.
The failure mechanism of rubber concrete in sandstone soil is an important research content in civil engineering. This paper discusses the failure mechanism and interaction mechanism of rubber concrete in sandstone soil by artificial intelligence analysis method. The mechanical properties of sandstone soil and rubber concrete are described in detail and their interaction is analyzed. Through the application of artificial intelligence, the prediction model of the failure mechanism of rubber concrete in sandstone soil is put forward, and the corresponding methods and steps are given. Finally, the potential application of artificial intelligence analysis method in studying the failure mechanism of rubber concrete in sandstone soil is summarized, and the future research direction is prospected. Through this study, the failure mechanism of rubber concrete in sandstone soil can be understood more comprehensively, and it can provide reference for civil engineering practice.
Key words: rubber concrete; Sandstone soil; Failure mechanism; Artificial intelligence; Mechanical property

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I. Introduction

1.1 Application background and significance of sandstone soil and rubber concrete

Sandstone soil has a wide range of application background and important significance, while rubber concrete as a new material also has its unique application value. Sandstone soil is widely used in soil mechanics and geotechnical engineering. Sandstone soil is a medium particle size soil type, which has excellent engineering properties and good bearing capacity. Due to its reasonable pore structure, it can provide good drainage performance and high shear strength, so it is widely used in the field of foundation treatment, slope stability, tunnel engineering and so on. In addition, sandstone soil can also be used as an engineering material for filling, backfilling and drainage projects, with good water stability and frost resistance.

Rubber concrete, as an important way of rubber recycling, has the significance of environmental protection and sustainable development. Rubber concrete is a kind of composite material which is mixed with cement, sand and other materials after recycling waste tires. Compared with traditional concrete, rubber concrete has lower density, excellent shock absorption performance and good durability. Therefore, rubber concrete is widely used in road, railway, bridge and other traffic engineering, can effectively reduce noise and vibration, and improve road traffic safety and comfort. In addition, rubber concrete can also be used in landfill cover layer and shock absorber layer of underground gas storage engineering, which has positive significance for environmental protection and resource recycling. [1]

When rubber concrete is combined with sandstone soil, it can improve the mechanical properties and anti-erosion ability of sandstone soil, and has important application value. By using rubber concrete as reinforcement material, the shear strength and compressive strength of sandstone soil are strengthened, the mechanical properties and anti-erosion ability of soil are further improved, and the stability and reliability of soil are improved. In addition, the combination of rubber concrete and sandstone soil can also promote the interface interaction between the two, and further improve the mechanical properties and durability of the material.

The application of sandstone soil and rubber concrete has a wide background and important significance, which can not only meet the engineering needs, but also realize the sustainable utilization of resources and environmental protection. In the future research, it is necessary to further explore the interaction mechanism and optimization design method between the two in order to achieve better engineering results and environmental benefits.

1.2 Research status of the failure mechanism of rubber concrete in sandstone soil

At present, the research on the failure mechanism of rubber concrete in sandstone soil has made some progress, but there are still some problems and challenges to be solved. Rubber concrete can significantly improve the mechanical properties and erosion resistance of sandstone soil. The experimental results show that the addition of rubber concrete can improve the shear strength and compressive strength of sandstone soil, reduce the strain softening characteristics of soil, and enhance the overall stability of soil. In addition, rubber concrete can also reduce the void ratio of soil particles, strengthen the bonding effect between soil particles, and improve the anti-erosion performance of soil.

Current research also focuses on the interface interaction between rubber concrete and sandstone soil. The interfacial interaction is one of the key factors to exert the enhancement effect of rubber concrete in sandstone soil. Some studies have shown that the interfacial friction between rubber concrete and sandstone soil has a significant effect on the mechanical properties of soil. The addition of rubber concrete can reduce the interface friction, increase the contact area and adhesion of soil particles, and improve the overall strength and stability of soil.

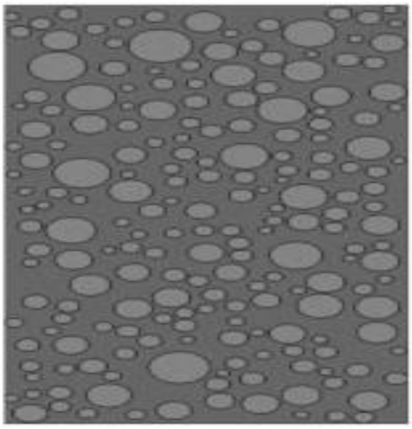
There are still some problems that need further study. [2] The interaction mechanism between rubber concrete and sandstone soil is not fully understood and needs to be further understood through more experiments and theoretical analysis. Most of the existing studies focus on the influence of a single factor, and lack of research on the comprehensive effect of multiple factors. Therefore, the future research can consider the comprehensive influence of rubber concrete content, particle size, solid content and other factors on the mechanical properties of sandstone soil. In addition, the study on the microstructure and chemical reaction of the interface between rubber concrete and sandstone soil also needs to be further developed.

II. Characteristics of rubber concrete and sandstone soil

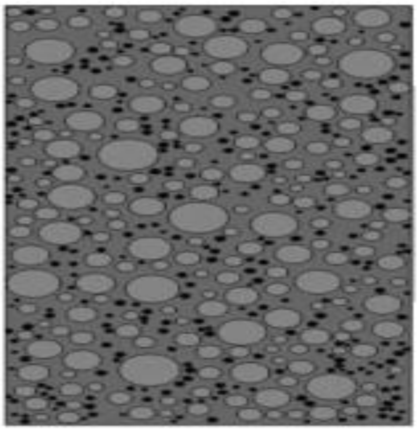
2.1 Mechanical properties of rubber concrete

The elastic modulus of rubber concrete is low, which can absorb the impact load, reduce the structural force, and improve the seismic performance of the structure. Due to the high-energy vibration absorption and energy dissipation capacity of rubber particles, rubber concrete can effectively reduce vibration propagation and energy reflection, and reduce the impact of noise and vibration on the structure and the human body. Rubber concrete has excellent durability and can resist the erosion of time and environmental factors. The addition of rubber particles makes concrete have better anti-aging, anti-freezing and anti-chemical corrosion ability, and reduces the shrinkage and cracking of cement-based materials.

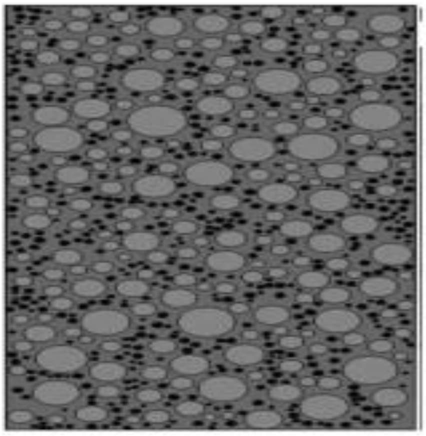
The strength of rubber concrete can be adjusted according to actual needs. By adjusting the concrete mix parameters such as rubber content, rubber particle size and solid content, rubber concrete of different strength grades can be obtained to meet different engineering requirements. The mechanical properties of rubber concrete make it a kind of material with good shock absorption, durability and regulation, and it has a wide application prospect. However, it is necessary to further study and explore the relationship between the performance parameters and the microstructure of rubber concrete to further improve its mechanical properties and ensure its reliability and economy in practical engineering.



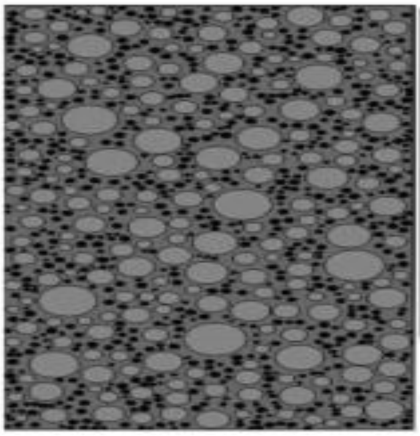
(1) Rubber content is 0%



(2) rubber content is 10%



(3) Rubber content is 20%



(4) rubber content is 30%

2.2 Mechanical properties of sandstone soil

Sandstone soil is a type of soil formed by the combination of sand and rock particles through cement sandstone soil is composed of sand and rock particles, and its particle shape is usually more regular and uniform. The particle distribution in sandstone soil is usually relatively close, and the particles are in close contact with each other, which makes the sandstone soil have high shear strength and stability. The mechanical properties of mortar are shown in the figure below. [4]

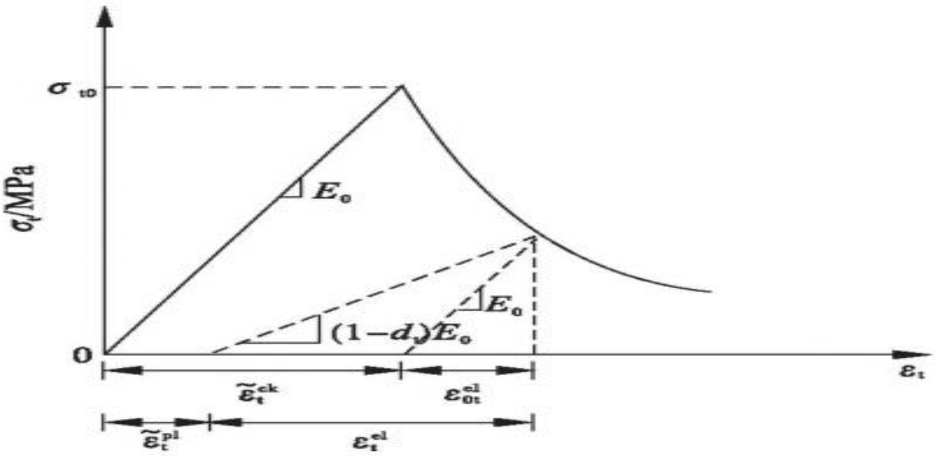


FIG. 4 Tensile constitutive model of mortar and interface

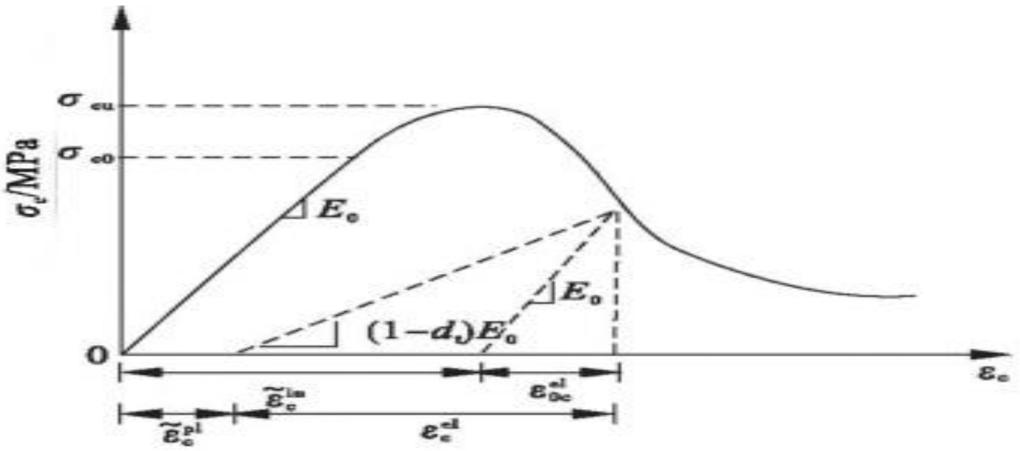


FIG. 5 Compressive constitutive model of mortar and interface

Sandstone soils usually have high shear strength. The friction between particles and the adhesion between particles and cement make the cohesion and friction of sandstone soil larger, thus increasing the shear strength and bearing capacity of the soil. However, the shear strength of sandstone soil is affected by the friction Angle between particles, particle size and limiting stress. Sandstone soil usually has good permeability and water drainage. The gap between the particles in sandstone soil is large, which makes the water pass through the soil faster and has low hydraulic resistance. Sandstone soil has good drainage performance, which can quickly remove excess water in the soil and avoid the stability problem of the soil.

These characteristics make sandstone soil have important application value in engineering practice. However, it should be noted that the characteristics of sandstone soil in different regions may be different, so it is necessary to conduct reasonable treatment and utilization according to the characteristics of local sandstone soil in the specific engineering design and construction. [5]

2.3 Interaction mechanism between rubber concrete and sandstone soil

The interaction mechanism between rubber concrete and sandstone soil is a complicated process, which involves many aspects of interaction and influence. When rubber concrete interacts with sandstone soil, the contact between the two forms an interface area, and the interface interaction plays a key role in the properties and mechanical behavior of the two. Rubber concrete has good deformation and cohesion, when it is in contact with sandstone soil, friction and bonding will occur. The interfacial interaction can increase the strength and stability of the whole soil mass and improve the shear strength of the soil mass.

The addition of rubber particles can fill the void in the soil and improve the volume stability and liquefaction resistance of the soil. The filling effect of rubber particles can reduce the gap between soil particles and improve the drainage performance and anti-erosion ability of soil. In addition, the elastic properties of rubber particles can also reduce the stress and deformation caused by earthquake or impact loads to achieve shock absorption effects.

The addition of rubber concrete changes the soil microstructure, affects the pore structure, particle arrangement and internal stress state. The rubber particles form a dispersed phase in the soil and form a secondary structure with the sand particles. The change of microstructure is closely related to the mechanical properties of sandstone soil. Rubber particles increase the internal friction Angle of soil and improve the shear strength and stability of soil. [6]

These factors work together to improve the mechanical properties, shear strength and stability of sandstone soil. To explore the interaction mechanism between rubber concrete and sandstone soil, geotechnical test, numerical simulation and microstructure observation can be further studied to provide scientific basis and technical support for promoting the application of rubber concrete in sandstone soil.

III. Failure mechanism of rubber concrete in sandstone soil

3.1 Interface interaction between rubber concrete and sandstone soil

The failure mechanism of rubber concrete in sandstone soil involves many factors, among which the interfacial interaction plays an important role. The bond strength between rubber concrete and sandstone soil is an important index of interface interaction. The bond strength directly affects the mechanical properties and stability between rubber concrete and sandstone soil. The bond between the cementing material in rubber concrete and sandstone soil particles determines the strength of the interface. The increase of bond strength can improve the shear strength and load bearing capacity of the interface, thus reducing the separation and stripping of rubber concrete from sandstone soil.

The friction characteristics of rubber concrete and sandstone soil interface is also an important factor of interface interaction. The frictional properties of rubber concrete and sandstone soil have a direct influence on the anti-sliding properties and stability. Higher friction coefficient can increase the friction resistance between interfaces and improve the overall shear strength and stability of soil. In addition, the friction characteristics are also related to the soil drainage and deformation characteristics.

Rubber particles in rubber concrete fill the void in sandstone soil and have an important effect on the interfacial interaction. The filling effect of rubber particles can reduce the gap between soil particles and improve the contact conditions and bonding properties of the interface. The filling of rubber particles can also improve the cohesion and friction of the interface, and enhance the strength and stability of the interface. In addition, the elastic properties of rubber particles can also reduce the effect of earthquake or shock loads and play a damping effect.

3.2 Stress distribution of rubber concrete in sandstone soil

The stress distribution of rubber concrete in sandstone soil is a complex process closely related to interface interaction, pore structure and mechanical properties, as shown in the figure below. The stress distribution at the interface between rubber concrete and sandstone soil is affected by interface bond strength, friction characteristics and interaction between particles. Under the action of external load, the stress at the interface will be gradually transferred to the rubber concrete and sandstone soil. Better interfacial bond strength and friction characteristics help to evenly distribute stress, make stress transfer between the interface and the soil more stable, and reduce local stress concentration. [7]

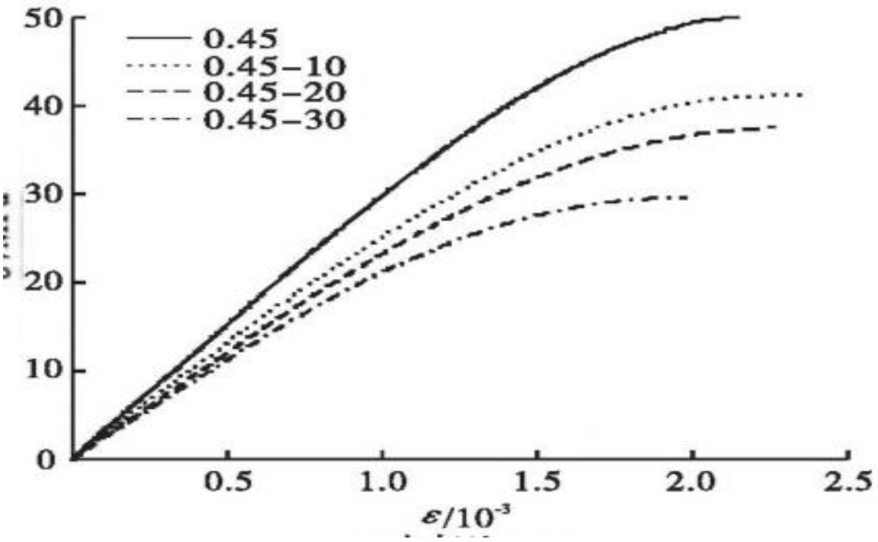


FIG. 6 Stress-strain curve of rubber concrete

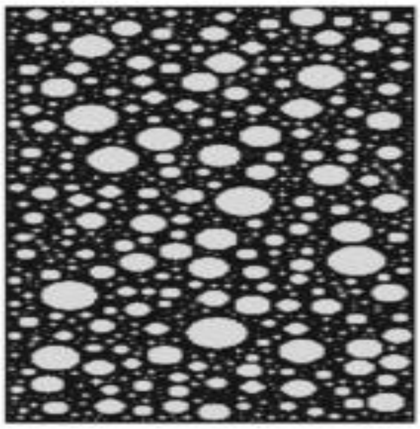
The addition of rubber concrete will change the pore structure of sandstone soil and affect the distribution of stress. The filling effect of rubber particles can reduce the gap between soil particles and improve the compactness and stability of soil. In this way, stress can be more efficiently transferred and dispersed into the pore structure, reducing local stress concentration. In addition, due to the special shape and elastic characteristics of rubber particles, they can absorb and disperse a part of the stress and reduce the degree of stress applied to the sandstone soil particles.

The interaction between rubber concrete and sandstone soil also plays an important role in stress distribution. The strength and stiffness of rubber concrete are high, and it can bear part of the external load. The interaction with sandstone soil will make the stress distribution change in the transition region between them. In this transition area, the stress gradually transitions from rubber concrete to sandstone soil, and gradually decreases with the increase of depth. The size and characteristics of this transition zone are related to the characteristics between rubber concrete and sandstone soil.

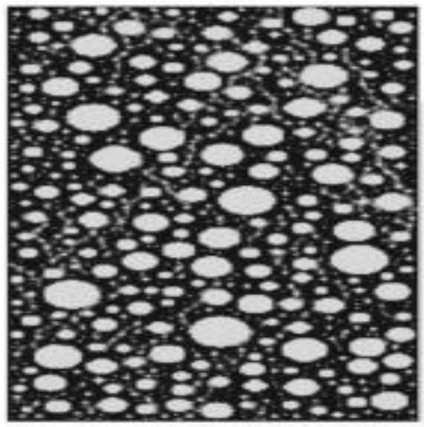
3.3 Deformation characteristics and failure forms of rubber concrete and sandstone soil

The deformation characteristics and failure forms of rubber concrete and sandstone soil are determined by their material properties and interaction characteristics. Rubber concrete and sandstone soil will have different deformation when subjected to external load. Rubber concrete has good elastic characteristics and ductility, which can absorb and disperse part of external force through deformation. Under the action of load, rubber concrete can be deformed in a limited way, such as bending, compression and shear deformation. The sandstone soil has relatively low compressibility and deformability, and its deformation is mainly manifested by compression, expansion and shear. The difference of deformation characteristics between the two will affect their application and interaction in practical engineering.

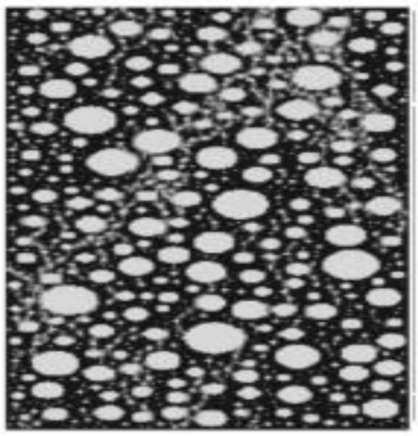
Rubber concrete and sandstone soil may be damaged when subjected to large loads. The failure modes of rubber concrete are mainly fracture and shear failure. When rubber concrete is subjected to large tensile or shear forces, the rubber particles and cementing materials inside it may fracture, resulting in overall damage. The damage morphology of sandstone soil mainly depends on the internal forces between particles and between particles. When sandstone soil is subjected to load, there may be fracture, friction and slip among its particles, resulting in overall failure.



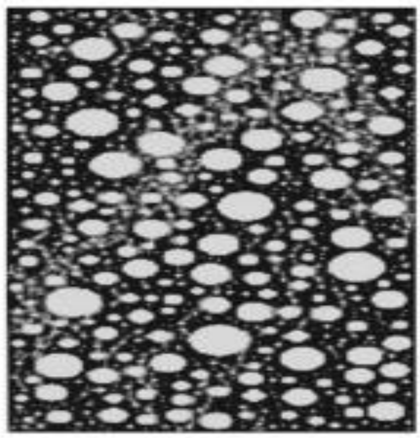
(a) Initial loading stage



(b) Second loading stage



(c) Loading the third stage



(d) loading the damage stage

The interaction between rubber concrete and sandstone soil also has an important influence on deformation characteristics and failure forms. Elastomeric and malleable properties of rubber concrete reduce the local stress concentration at the contact with sandstone soil and reduce the possibility of failure. In addition, the filling effect of rubber particles can improve the pore structure of soil and increase the stability and deformation resistance of soil. The improvement of the interaction makes the deformation and failure between rubber concrete and sandstone soil more stable and controllable, which helps to improve the stability of the project

IV. Application of artificial intelligence in research

4.1 Application status of artificial intelligence in civil engineering field

The application of artificial intelligence in the field of civil engineering is developing rapidly. Artificial intelligence can be used to assist in structural design and optimization in civil engineering. Through machine learning and deep learning and other technologies, a large number of structural design data can be analyzed and simulated, so as to provide more reasonable and efficient structural design schemes. Artificial intelligence can also realize adaptive optimization of the structure, adjust parameters according to real-time data, and improve the reliability and economy of the structure. [8]

Ai is also widely used in civil engineering for structural health monitoring and prediction. Through smart sensors and iot technologies, combined with machine learning and data mining algorithms, the health of structures can be monitored and diagnosed in real time. Artificial intelligence can also predict the life of structures, damage evolution and remaining life, providing scientific basis for structural maintenance and repair.

Artificial intelligence can play an important role in the construction and management of civil engineering. Through intelligent construction planning and risk prediction, the construction efficiency and safety of the project can be improved. Artificial intelligence can also use big data and analysis methods to optimize and manage the construction process and improve the quality and efficiency of the project. In addition, artificial intelligence can also assist and coordinate the communication and decision-making between different participants, and improve the overall management level of the project.

4.2 Potential application of artificial intelligence in the analysis of failure mechanism of rubber concrete in sandstone soil

The application of artificial intelligence in the research provides a new potential application way for the analysis of the failure mechanism of rubber concrete in sandstone soil. By processing a large number of test data and measured data, artificial intelligence can extract effective information and carry out accurate analysis. Through techniques such as machine learning and data mining, artificial intelligence can learn and identify the interface interaction patterns and laws between rubber concrete and sandstone soil. It can help researchers to quickly analyze and interpret experimental or measured results, extract key features and related factors, and reveal the failure mechanism of rubber concrete in sandstone soil.

Based on artificial intelligence technology, complex models can be constructed to describe the failure mechanism of rubber concrete in sandstone soil. By training and optimizing these models, the mechanical behavior of rubber concrete and sandstone soil interface, such as bond strength, friction characteristics and stress distribution, can be accurately predicted. Through the establishment and prediction of the model, the failure mechanism of rubber concrete in sandstone soil can be better understood, and scientific basis and guide engineering practice can be provided.

With the help of artificial intelligence technology, the test data and simulation results can be displayed in a visual way to promote the understanding of the interface interaction between rubber concrete and sandstone soil. Ai can translate the analysis results and model output into intuitive graphics, images or animations to help researchers and engineers better understand and explain the failure mechanism of rubber concrete in sandstone soil. This visualization can also provide support for engineering decisions and help engineers develop more rational design schemes and construction strategies.

4.3 Methods and steps of artificial intelligence analysis of failure mechanism of rubber concrete in sandstone soil

The method of artificial intelligence analysis of the failure mechanism of rubber concrete in sandstone soil can be expanded from the following five key points:

Data collection and arrangement: A large number of experimental and measured data are collected, including the physical properties and mechanical properties of rubber concrete and sandstone soil, as well as the mechanical behavior data of the interface between rubber concrete and sandstone soil.

Feature extraction and selection: Through statistics and machine learning methods, key features such as contact characteristics, stress distribution, etc. are extracted from the collected raw data, and the extracted features are selected to reduce redundancy and noise.

Model construction and training: Use artificial intelligence technology to build models suitable for failure mechanism analysis, such as neural networks, support vector machines, etc. By training and optimizing the model, the prediction ability and accuracy of the model are improved.

Model analysis and interpretation: The trained model is used to analyze the failure mechanism of

rubber concrete in sandstone soil, predict the key mechanical behaviors, such as bond strength and friction characteristics, and interpret the prediction results of the model.
Model validation and application: Validate the model with validation datasets to assess its accuracy and robustness. The model is applied to practical engineering design and construction to provide scientific basis and technical support for engineering decision-making.

V. Conclusion

Through artificial intelligence analysis of the failure mechanism of rubber concrete in sandstone soil, the following conclusions are drawn:

The bond strength of rubber concrete and sandstone soil interface is an important factor affecting the failure mechanism. The artificial intelligence model can accurately predict the bond strength of rubber concrete and sandstone soil interface, and reveal the relationship between bond strength and interface temperature, interface stress and other factors. The failure of rubber concrete in sandstone soil is mainly manifested as interfacial shear failure. The artificial intelligence model can predict key parameters such as the location of shear failure, the shape of the failure surface and the expansion rate of shear failure. The quality and mechanical properties of sandstone soil have significant influence on the failure mechanism of rubber concrete. Through the analysis of artificial intelligence model, the failure characteristics of rubber concrete under different sandstone soil types and mechanical properties can be obtained, and provide a reasonable reference for engineering design and construction.

These conclusions have important guiding significance for designing suitable rubber concrete for sandstone soil engineering and evaluating its reliability and stability in different environments. Through the analysis of artificial intelligence, we can deeply understand the failure mechanism of rubber concrete and sandstone soil interface, and provide scientific basis for optimizing engineering design and construction.

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