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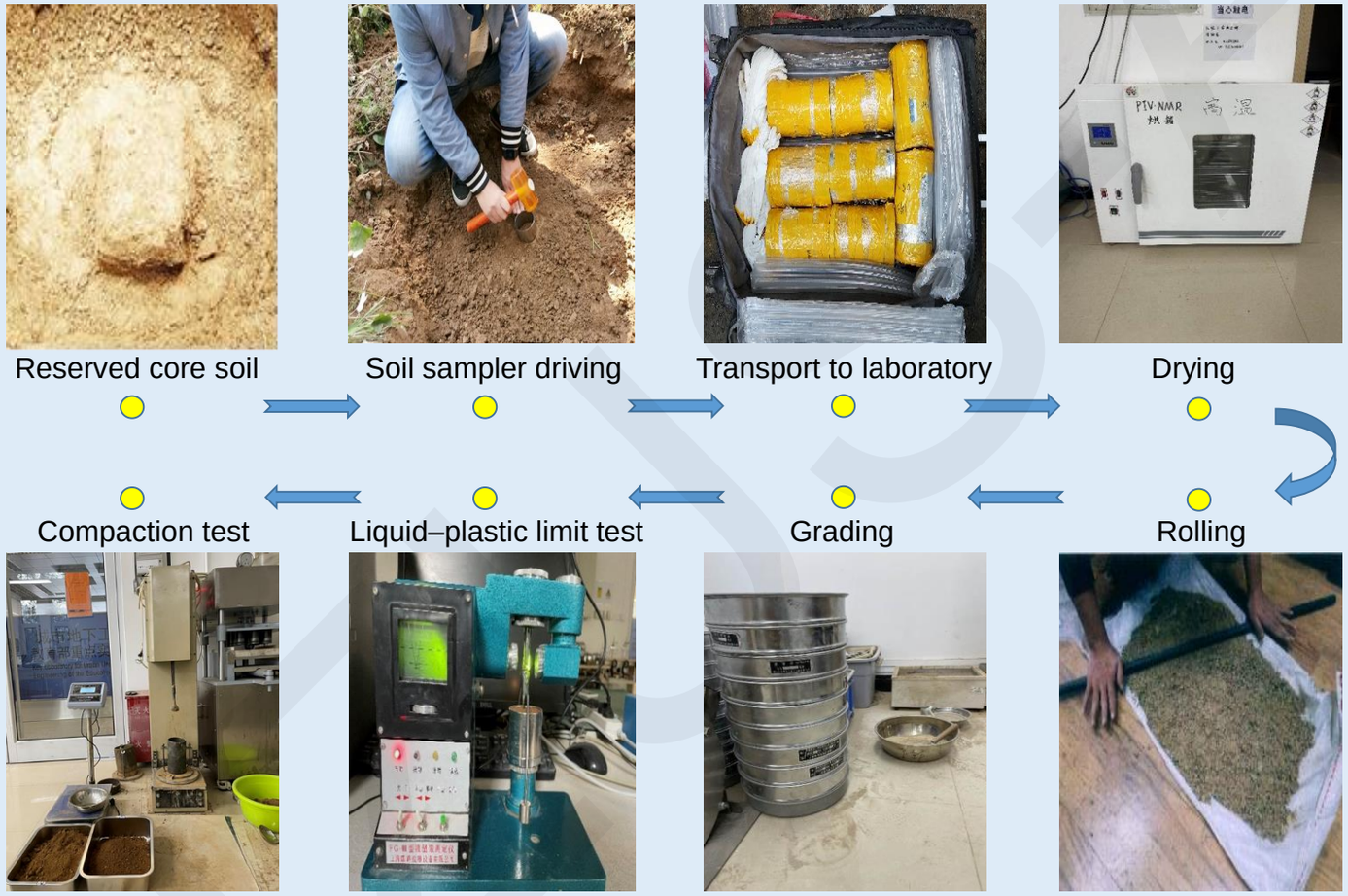
Effect of dry–wet cycles on the mechanical properties and microscopic characteristics of fine breccia soil from karst areas

Key words:

Karst area; Micro–macro properties; Railway subgrade performance; Dry–wet cycles

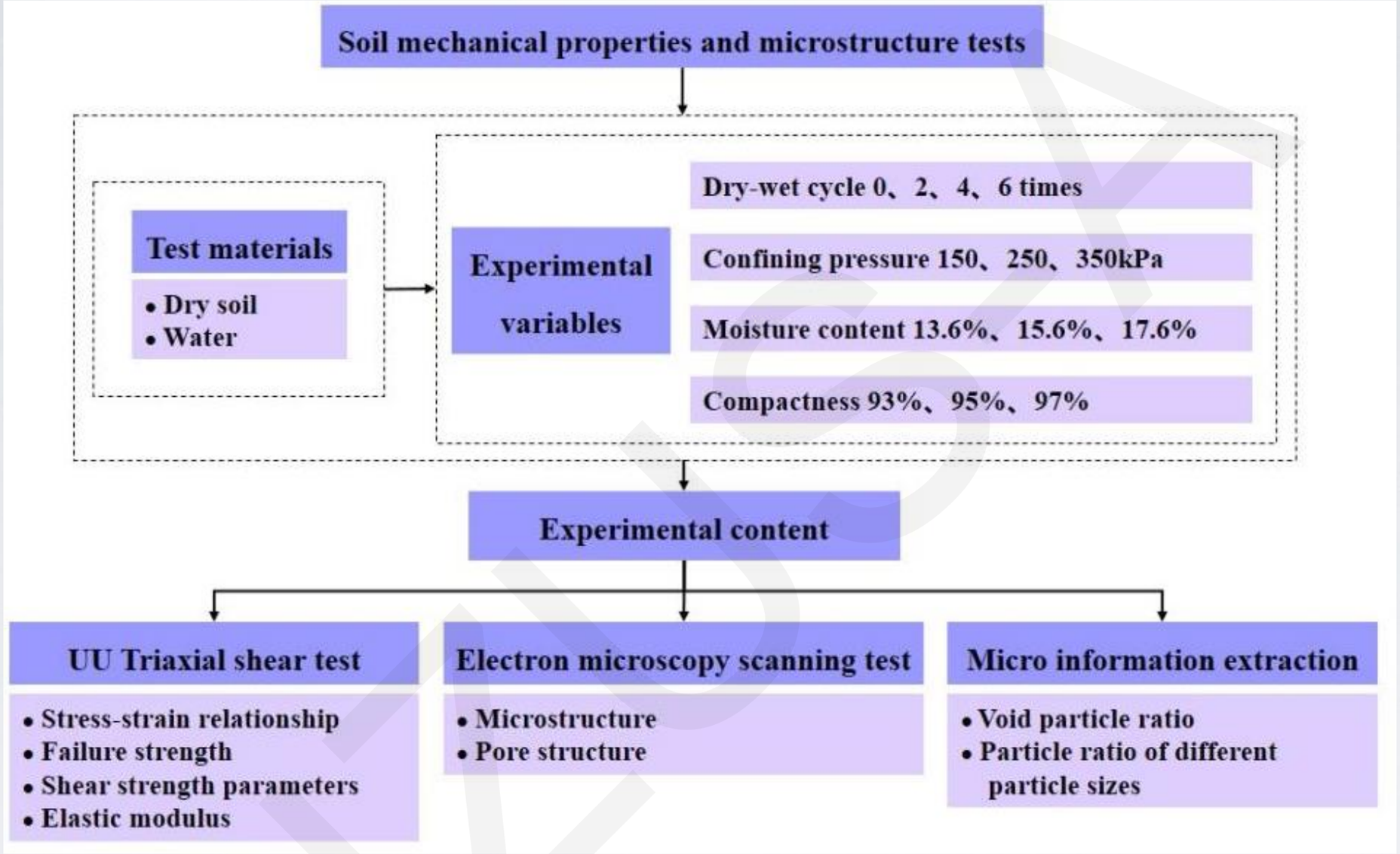
On site collection and processing of experimental materials



Soil was excavated from a depth of 1.5 m in developed karst areas and transported to the laboratory.

The particle size distribution was determined using a screening method, and the soil was characterized in terms of its liquid and plastic limits, compaction, and chemical composition.

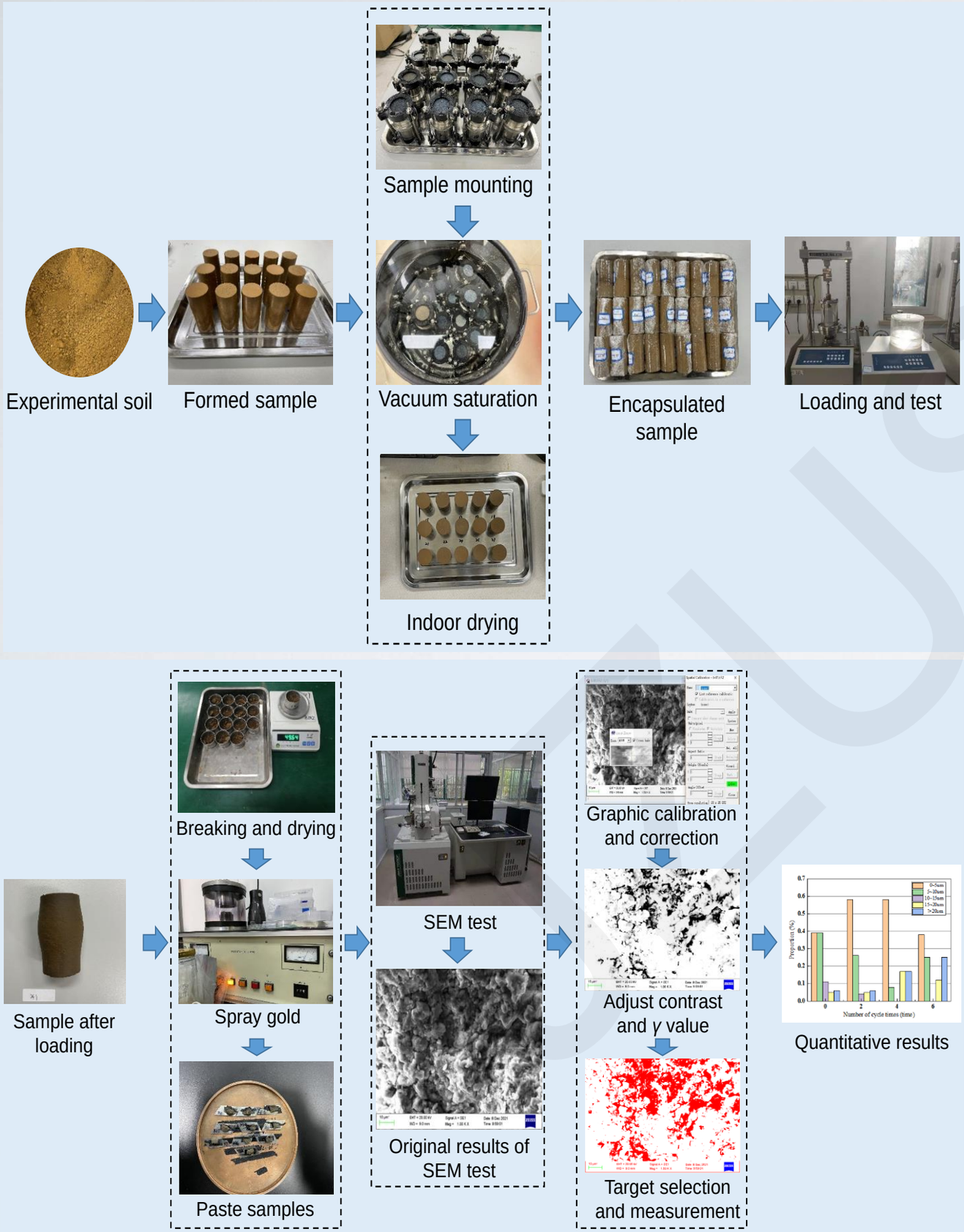
Experimental design



Test methods

- Undrained and unconsolidated triaxial shear tests
- Select representative samples for electron microscopy scanning test and microstructure information extraction and analysis

Experimental design

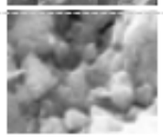
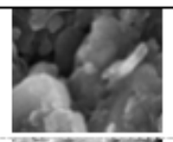
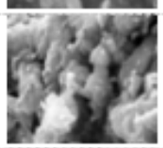
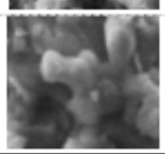
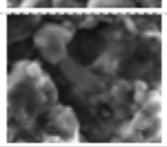


Experimental procedure

- After the in-situ soil is made into a triaxial test specimen, it is subjected to a certain number of dry wet cycles before conducting triaxial tests
- Extract the core soil of the triaxial specimen, dry it, and make it into an electron microscope scanning specimen. Conduct electron microscope scanning tests, extract data information from the scanning results using Image pro plus.V6, and quantitatively analyze the results

Correlation between Soil Mechanical Properties and Microstructure Characteristics

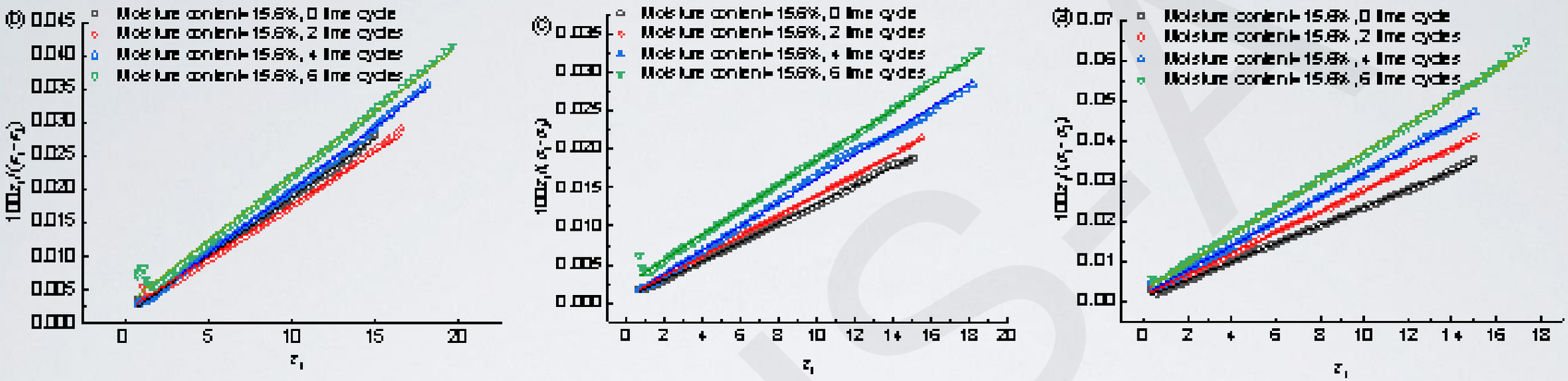
Table 2 Summary of soil properties and structural characteristics under different working conditions

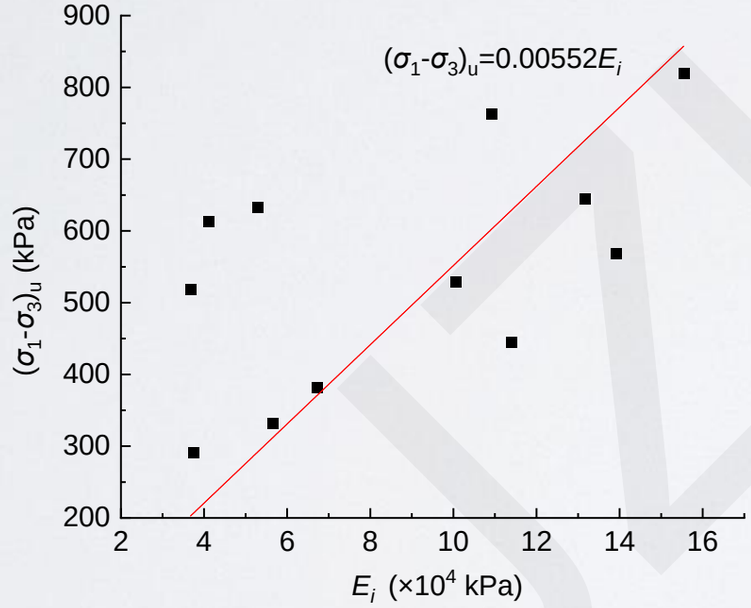
Variable	Value	Microscopic feature	Stress peak	Failure strength	Cohesion	φ	Elastic modulus
Compaction degree	93%		Small	Small	Small	Small	Small
	95%		Medium	Medium	Medium	Medium	Medium
	97%		Large	Large	Large	Large	Large
Initial moisture content	13.6%		Large	Large	Large	Large	Large
	15.6%		Medium	Medium	Medium	Medium	Medium
	17.6%		Small	Small	Small	Small	Small
Number of dry–wet cycles	0		Large	Large	Large	Large	Large
	2		Medium	Medium	Medium	Medium	Medium
	4		Small	Small	Small	Small	Small

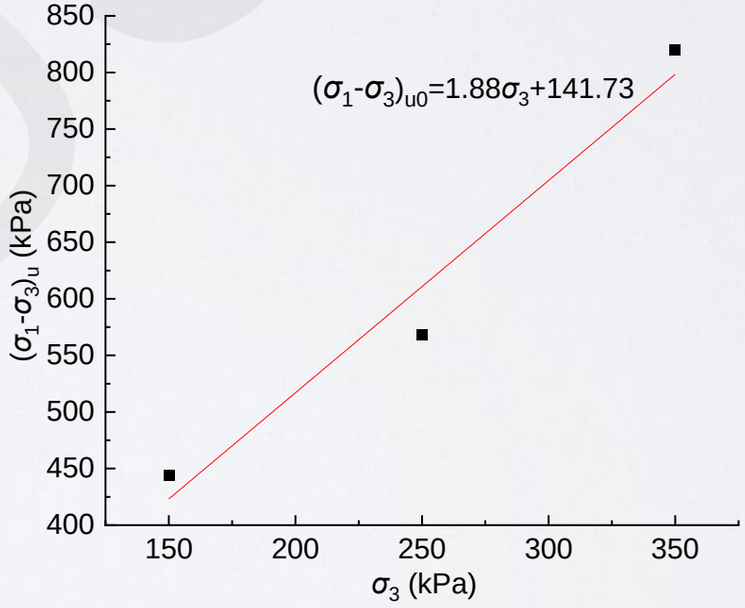
Construction suggestions

- In summary, when selecting fine breccia soil for foundation treatment, soil with a higher compaction degree and slightly lower initial moisture content should be selected for use as fill.

Normalization characteristics of soil under dry–wet cycles







Using the ultimate partial stress as the normalization factor, the stress-strain curve is fitted, and the residual strength ratio is defined to obtain the stress characteristics of fine angular gravel soil in karst areas.

Research conclusion

- Soil that underwent high-pressure compaction and maintained an initial moisture content close to the optimal value (15.6%) showed greater resistance to degradation from dry–wet cycles.
- For soil samples that underwent high-pressure compaction, the failure strength, shear strength, and elastic modulus remained relatively unaffected by the dry–wet cycles. However, the values of these properties decreased when the water content was high, and even more so when confining pressures were high.
- An increased degree of compaction improved the particle size distribution and skeleton density of the soil, enhancing the mechanical properties and performance indicators. Thus, greater soil compaction should make the railway subgrade more resistant to the erosive impact of dry–wet cycles, ensuring better stability, especially under frequent rainfall.
- A normalized stress–strain model was formulated from the results，to mitigate the effects of dry–wet cycles and achieve higher stability when using fine breccia soil from karst areas as railway subgrade fill, we recommend techniques that yield a higher compaction degree and a moisture content close to the optimal value.